Guidance for the field assessment of macrophytes of rivers within the STAR Project

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1. Introduction

Macrophytes are an important component of aquatic ecosystems and are required to be used broadly within the Water Framework Directive (WFD) (2000/60/EC)], to facilitate the establishment of good ecological status and the general monitoring of ecological status. In addition to their ecological role, macrophytes are indicators of ecological quality in running waters. In particular species and species groups of macrophytes are typical of specific types of running waterbody and the degree to which they are adversely affected by types of anthropogenic impact. The absence of aquatic macrophytes may however be characteristic of some running water habitats such as in highly active rivers with unstable gravel beds or in deeper rivers where their absence may due to the limitations of habitat such as light through water depth, water velocity, or turbidity. Absence of plants may equally be the result of some unidentified anthropogenic impact eg, chemical.

A wide range of sampling and survey methodologies have been developed by different nations for specific applications including conservation, ecological status, drainage impact, management, ecological habitat, river restoration or enhancement. The methodology required as part of the STAR programme is developed specifically for the surveying of macrophytes in natural and anthropogenically-altered running freshwaters for the purpose of monitoring ecological status.

The CEN standard has not as yet been made formally available (April 2002) but STAR has been commissioned to consider and to test a standard methodology for use throughout Europe.

The STAR macrophyte field survey procedure which is required to allow assessments to be made of the ecological quality of river using aquatic plants is based in the detail on the field sampling procedure used to assess the ecological status of watercourses in Britain, Mean Trophic Rank: A User's Manual R&D Technical Report E38. This was produced for the Environment Agency of England and Wales as produced by NTH Holmes, JR Newman, S Chadd, KJ Rouen, L Saint and FH Dawson of NERC Institute of Freshwater Ecology, with IACR Centre for Aquatic Plant Management, and Alconbury Environmental Consultants. The STAR procedure has attempted to integrate the standard field techniques from Germany, Portugal and France in particular, to allow a standard system on one type of field recording form which includes the individual range of parameters which during analysis will allow links or access to existing data collected by each countries existing methods.

1.1 Summary of the method

A summary of the STAR method is given below –

What is the STAR field survey methodology?		
1.	Purpose	to facilitate the establishment of good ecological status and the general monitoring of ecological status.
2.	Biota sampled	Macrophytes (plants identifiable with the naked eye).
3.	Watercourses sampled	Rivers and streams. The method is not suitable for standing waters, canals (unless water flow is constant in one direction) or tidal rivers.
4.	Underlying principles	Within the aquatic macrophyte flora there is a spectrum of tolerances to environmental perturbation, for example, nutrient enrichment will probably be expressed by assigning scores to species eg for STAR on a scale of 1–10: the higher the score the lower the tolerance to nutrient enrichment. The response of the macrophyte community to environmental perturbation such as change in the quality or quality of water should be able to be expressed by integrating the scores of the species present as a mean value, weighted according to the relative percentage cover of the individual species. The resulting value increases with decreasing environmental perturbation.
5.	Basis of operation	The macrophyte flora and physical character of defined lengths (100m) of watercourse are surveyed using a standard checklist (Appendix 8). The presence, absence and % area covered by each macrophyte are recorded and used to calculate a score. Physical parameters are recorded to aid interpretation.
For what purposes can the STAR field survey methodology be used?		
6.	Uses	The method can be used to give a qualitative assessment of whether a site is impacted by anthropogenic effects and (for physically similar sites) downstream changes in status. A model structure or typology will be devised to compare the status of physically dissimilar sites.
7.	Applications	The principal application for which the method has been developed and to be tested is to produce a standard methodology and dataset to allow pan-European comparisons for the Water Framework Directive (WFD) (2000/60/EC)], to facilitate the establishment of good ecological status and the general monitoring of ecological status.
Survey planning		
8.	Alternative methods	A STAR Diatom survey should be undertaken at the same time as the aquatic plant survey if possible.
9.	Sampling strategy	The location of survey sites varies according to the purpose of the survey. Less impacted ‘control’ or semi-natural sites may help determine impact.
10.	Logistics of sampling	A minimum of one survey per year for three years is recommended, each being undertaken at the same time within the hydrological cycle or survey season (mid-June to mid-September in central and northern Europe) and after several days of low or low–normal flow. Operator safety, shade, river flow and water clarity need to be considered when selecting a survey length.

	Survey equipment includes sampling aids, camera and protective clothing/equipment. Surveyors should be familiar with the provisions of national access and conservation laws and should follow appropriate health and safety guidance (appendix 1). Surveys can be undertaken by one operator, although multiple-staffing is recommended: surveyors should allow one person-day per survey although this may vary considerably.
11. Ancillary data collection	Background information on site geomorphology, pollution incidents and river management can be useful when planning and interpreting surveys.
How to carry out a star macrophyte field survey	
12. Pre-survey preparation	Consult equipment checklist and take appropriate equipment (appendix 2). Surveyors should be familiar with the necessary health and safety guidance (appendix 1).
13. Field survey	The stretch to be surveyed (the survey length, 100m) is selected or located and if suitable for survey it is measured out and marked. Standard field sheets are used to record site and survey details (Appendix 3). The macrophyte flora and physical character of the survey length are then surveyed by wading, boat, or walking along the bank. Sampling aids are used where necessary. All macrophytes present are recorded, together with the estimated percentage cover of each taxon (recorded as abundance classes) and the estimated percentage cover of overall macrophyte growth. Representative samples (algae, Ranunculus, Callitriche, and Potamogeton species) and species which are uncertain should are taken for laboratory identification and preparation of herbarium specimens. Physical parameters of the survey length are estimated, a sketch map drawn and a photograph taken (appendix 3).
13. Laboratory identification	Samples taken on the field survey are identified shortly afterwards and representative specimens retained in a 'herbarium' for future reference.
QUALITY ASSURANCE	
14. Error and variability	Variability between surveyors in data recorded in the field can be reduced by correct application of the method and adoption of quality assurance. The impact of natural background variation within the survey season and between physically dissimilar sites, can be reduced by careful timing of surveys and selection of survey lengths. Measures of confidence should be assigned to relate to the survey and the comparability of sites
15. Quality assurance procedures	Quality assurance comprises measures integral to the survey method itself (eg on-site checks and multiple-staffing), training requirements and audit surveys. Two alternative audit protocols are provided.

2 STAR macrophyte field survey procedure

This chapter describes the purpose of the methodology, the biota used, the watercourses for which the method is suitable, the principles on which the method is based and a summary of how it operates. It then provides guidance on the applications for which the method can be used.

2.1 What is STAR macrophyte field survey procedure

2.1.1 Purpose

The STAR macrophyte field survey procedure is part of a biological method to facilitate the establishment of good ecological status and the general monitoring of ecological status in Europe within the Water Framework Directive (WFD) (2000/60/EC)]

2.1.2 Biota sampled

The STAR macrophyte field survey procedure is based on the presence and abundance of species of aquatic macrophyte. A macrophyte is defined as 'any plant observable with the naked eye and nearly always identifiable when observed' (Holmes & Whitton 1977). This definition includes all higher aquatic plants, vascular cryptograms and bryophytes, together with groups of algae which can be seen to be composed predominantly of a single species.

Macrophytes were selected for this method for several reasons.

- Species composition can change with change in environmental conditions and so can be used as an ecological monitoring tool to determine and monitor areas affected by anthropogenic influences.
- These changes in the macrophyte community can be highly visible and may be deemed 'undesirable' particularly for example in terms of the definitions of euecologicalation. For example, they may result in the loss of conservation and amenity value, in addition to problems for abstraction licence holders and other water users.
- The macrophyte species recorded for these surveys are large and readily identifiable with the naked eye. There are relatively few species in a particular river area (approximately 20), so it is normally possible to identify all to species level when the necessary seasonal attributes are present.
- The rooted nature of many species means that absence of species is significant and this, as well as the presence of a species, can be used in the interpretation of survey data.

2.1.3 Watercourses sampled

The STAR macrophyte field survey procedure is part of a biological method designed for use in rivers and streams. The method is not suitable for assessing standing (lentic) waters, canals (unless the water flow is constant in one direction) or rivers with a tidal influence. Characterisation of seasonally dry rivers needs to be developed.

2.1.4 Underlying principles

The STAR macrophyte field survey procedure is seen as part of a biological methodology using a simple scoring system to derive a index describing the ecological status of a site. By analogy, the MTR system developed for use in the UK works by allocating an index called 'Species Trophic Rank' (STR) score to 128 aquatic plant species. The scores range from 1 to 10. High scoring plants are associated with water bodies which are low in nutrients. Low scoring plants are either tolerant of eutrophication or are cosmopolitan in their requirements, ie have no preference. The response of the macrophyte community to nutrient status can be expressed by integrating the STRs of the species present at a site as

a mean value, weighted according to the relative percentage cover of the individual species. The resulting value, the STAR, increases with decreasing eutrophy, with a theoretical maximum of 100 and a minimum of 10 (there is no score when scoring species are absent). This approach will expand to incorporate existing datasets and to describe good ecological status and the effects of anthopogenic perturbations. In undisturbed or un-degraded ecosystems, the plant community often contains many species, none of which tend to dominate to the detriment of any other, ie the system is in balance. Species with high indices will be present and a theoretical maximum score should be achieved based on the limits imposed by floristic diversity, flow regime (altitude), river size, catchment geology and water chemistry at a particular site. In degraded or disturbed ecosystems, the plant community may contain fewer species and one or two species with low indices may be dominant. In these instances, a score somewhat less than the perfect score will be achieved. There is a scale of degradation and in between these two extremes lie the majority of riverine ecosystems in Europe can be expected to exist.

The change from the perfect score can be used as a measurement of the impact or damage caused to the ecosystem by the disturbance. A predictive element to the score, allowing predictions of what index can be expected given a certain set of physical conditions (the 'perfect score'), is still only in the early stages of development. Never-the-less, the system should be used to make an estimate of how degraded the ecosystem is from the expected norm (taking into account all other factors), and give an indication of the change in the macrophyte community from that norm using the guidance on the interpretation of results.

2.1.5 Basis of operation

The method involves the survey of the macrophyte flora and physical character of defined lengths (100m) of watercourse using a standard checklist. The presence, absence and percentage area covered by each macrophyte are recorded and the data relating to scoring species (those assigned an STAR index) are then used to calculate the STAR score. Physical parameters are recorded to aid interpretation of results. Detailed procedural guidance is given

3 SURVEY PLANNING

3.1 Logistics of sampling

3.1.1 Timing of surveys

Macrophyte surveys should be carried out between mid-June and mid-September (the 'survey season') after several days of low flow or low–normal flow as opposed to high flow/spate. Although some macrophytes are visible outside this survey season, others are not and hence the STAR score will not be an accurate representation of the ecological status because of the missing species. Even within the survey season, differences in the growth patterns of individual species may result in changes in their relative abundance during the season, with consequent variation in the STAR score. To minimise such within-season differences in STAR score, surveys should be undertaken in close succession when comparing different sites on the same river within the same year, and at the same time of the survey season each year when comparing the same site in different years.

Rivers should not be surveyed at times of high flow as access is dangerous and turbid conditions mean complete and/or accurate data are unlikely to be obtained. Once spate water levels have dropped to, and remained at, more normal flow levels for several days, surveys can be resumed but the survey results may be affected and this will need to be taken into account when interpreting the data. The timing of the spate flow will determine which macrophyte species are able to grow back to their original abundance levels and which will be under represented for the remainder of the season.

Where surveys being compared cannot be undertaken at the same time of the survey season, caution should be applied when comparing results and allowance made for natural within-season variation. Macrophyte species have different seasonal growth patterns, some species exhibiting accelerated growth rates early in the season and others not attaining maximum size until late summer. This can result in changes in the STAR and the overall percentage cover from early to late summer.

3.1.2 Number of surveys per year

To assess a site for ecological status, it is recommended that a minimum of one survey per year for three years should be undertaken, with the surveys being carried out at the same time of the season each year.

A useful way to organise a survey programme to ensure that surveys are undertaken at the same time of the season each year, is to survey sites in the same order each year.

If a second survey is undertaken at a site within the same year, then there should be a minimum of seven weeks between surveys and allowance for within-season differences in growth must be made when interpreting results. It is recommended that such surveys are undertaken only for calibration purposes, to provide an indication of the within-season variation and to help when placing overall results into a wider context.

Although a minimum of three once-a-year surveys is recommended, to enable any inter-year variation to be taken into account, assessments of ecological status using STAR may be undertaken on the basis of a single survey in a single year. This may be particularly appropriate for catchment studies, where the aim is to gain an overview of the ecological status of a catchment in order to identify those areas which would most benefit from further investigation and/or eutrophication control measures.

The number of surveys per year is also subject to the following quality assurance recommendation. Each year, each surveyor must either undertake a set minimum of STAR or other macrophyte surveys

(the suggested minimum is five surveys per year), or attend a training course at which STAR surveys are undertaken. At the beginning of the survey season, surveyors who did not achieve the minimum requirement of [five] surveys in the previous year should not undertake further surveys until they have received STAR training.
(Note that this is referring to the number of individual surveys not the number of pairs/sets of surveys up- and downstream QDs. Refer to the glossary for definition of survey.)

3.1.3 Site and survey length selection

The **site** is the broad location where the survey is to take place, eg allocated STAR sample section.

The **survey length** is the sample area — the actual area of river channel surveyed, between two fixed points on the bank. The survey length is 100m long for standard STAR surveys (with an option to survey a 500m length in addition: see Box 4).

Factors which need to be considered when selecting a survey site/length and assessing its suitability or comparability for macrophytes with other assigned STAR sites are listed in Box 2.

A map of the location of the site and survey length should be retained on file so that the survey length can be accurately located on return or audit visits. This map may be the sketch map completed on a survey and/or a more general map (eg showing details of access, parking and other features outside the scope of the 100m sketch map).

On the first survey at a site, the reason(s) for the selection of the survey length location should be noted in the 'Comments' section of the field sheet and a record of these comments retained on file.

3.1.4 Conditions under which surveys should not be undertaken

Surveys should not be undertaken when survey conditions are atypical for the site or prevent an adequate survey, or when the suitability of the site has otherwise been compromised. Some examples of unsuitable survey conditions are listed in Box 3.

Box 2 Factors to consider when selecting STAR sites and survey lengths

1. **Operator health and safety**
   Follow health and safety guidelines in selecting the location of survey lengths.
2. **General physical character**
   The survey lengths chosen should be typical of the river, within the other constraints listed. If local knowledge is not available look further upstream and downstream of the proposed survey length to determine this.
3. **Water clarity**
   Try to avoid locating survey lengths where the visibility of the river bed is significantly impaired either because the water is deep or turbid. If the survey length is usually turbid or too deep to see the bottom of the channel then a 'best attempt' at surveying for macrophytes can be made.
4. **Shade**
   Although the degree of shade does not appear to influence the performance of MTR at assessing trophic status (Dawson et al 1999b), it is advisable to avoid heavily shaded areas when selecting survey lengths for ecological status.
5. **Water flow and velocity**
   Survey lengths should not be situated where water flows and/or current velocity compromise operator safety (refer to health and safety guidelines). Careful consideration should be given before undertaking surveys in circumstances where the flow from a point-discharge maintains river flows greater than would be expected, ie significantly more flow downstream of the discharge than upstream. In this situation, the physical conditions may affect the STAR score more than water chemistry.
6. **River management**
   Weed cutting and other associated maintenance activities including dredging will often have a major effect on the cover and biomass of plant communities. Over time, this may alter and maintain the dominance of different plant species from those naturally present. The frequency and timing of river maintenance should be considered when selecting sites and survey lengths, and the effects of the maintenance taken into account when interpreting results.
7. **Artificial structures**
   Survey lengths are often located in the vicinity of bridges for ease of access. It is preferable, however, if the length selected is situated so that it does not include structures such as bridges, gauging/siphon weirs, locks and concrete-lined channels within the survey length itself as these may affect the substrate type, marginal area type and flow pattern. Local trampling effects may also occur near such structures so an atypical vegetation pattern may be observed. Any structure is potentially dangerous to the surveyor(s). Where structures cause change in the flow regime of the river the survey length should be situated at a location most typical of the rest of the river.
8. **Comparability with other sites**
   The STAR score will be influenced by trophic status and the physical character of the survey length. Therefore, if a series of sites are to be surveyed along a river in order to assess downstream changes in ecological status, the sites to be compared should be as physically similar as possible. Assessment of site comparability is based upon degree of shading, substrate type, channel width, water depth, water velocity, water clarity and bed stability. If in doubt, use the suffix of confidence as a guide as to whether survey lengths chosen are comparable, noting that if the suffix is likely to be 'c' then this survey length is not suitable for survey and a new more comparable survey length should be found if possible.

(continues)

When surveying new sites, time is saved by looking for similar suitable survey areas before commencing any surveying.

If physically comparable sites are available, the downstream length in any consecutive pair of sites should be situated to reflect any observed change in vegetation. To assess if a noticeable downstream difference in the flora can be observed, the surveyor should walk along the bank or use a boat to carry out a fairly extensive assessment of at least 500m of river both upstream and downstream of the discharge. Note the position of any distinct observed change and describe briefly the difference in the downstream community as compared with the upstream macrophyte community.

If an effect is noticed but there is no similar upstream survey length then the effect should be photographed and commented on. If no downstream effect is noticed, survey lengths typical of the river should be selected.

When back channels and main navigation channels are present, survey lengths being compared should be positioned either all/both on a back channel or all/both on the main channel so the survey results are comparable.

Box 3 Conditions when surveys should not be undertaken

1. Do not carry out macrophyte surveys during steady/heavy rain and windy conditions as the disturbance of the water surface leads to reduced visibility and could affect operator safety.

2. Surveys should not be undertaken after spates because of dangerous conditions for wading and the probable loss of plant material and disturbance of habitat caused by high flows. Do not underestimate the potentially serious effects of flooding, as even minor flooding will cause temporary changes in the relative composition of species at a site. It is very important to either avoid surveying after flooding or at least to reflect the flooding in the suffix of confidence for the survey. It is always best to survey after a period of low flow as the water is usually clear and macrophytes are easily visible.

3. Where surveys are undertaken over a number of consecutive years, to gain an overall picture of the 'typical' ecological status over the period, periods of unusual flow should be avoided as they will not reflect the 'typical' situation.

4. Try to avoid surveying navigated rivers at holiday periods or peak of summer as high boat activity leads to increased turbidity and a more dangerous situation for the surveyors.

5. Do not survey macrophytes immediately after a weed-cutting operation or other management activity which may adversely affect the macrophyte community.

6. Do not carry out a survey if conditions are atypical for the survey site. Atypical conditions may relate to large floating masses of filamentous algae, excessive turbidity, or recent weed-cutting/dredging. If floating masses of algae or high turbidity are normal for the site then consideration should be given to using an underwater camera during surveys (see 4.5.3).

3.1.5 Survey equipment

The following is a list of equipment required to carry out an STAR survey; it is reproduced as a checklist with H & S considerations in Appendix 6.

- Safety equipment - refer to safety manuals and advice available from your manager or safety advisor
- Maps – scale 1:50 000
- GPS to locate site and record site-location
- Location and/or sketch map to enable accurate location of the survey length (if surveyed before)
- Standard record sheets + sketch map sheet (on waterproof paper if necessary)
- Summary of the STAR methodology and definitions reference sheets (optional)
- Substrate reference and % cover reference sheets (optional)
- Pencil and pen
- Clipboard with waterproof shield/cover or a large clear plastic bag (to protect record sheet and make writing possible in damp conditions)
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- Grapnel with depth markings on the rope
- Bank stick with depth markings
- Plastic bags, labels and tubes for small specimens

- Tape measure or measuring rope, stakes and mallet (to mark start and end of survey length)
- Identification and field guides (Appendix 3)
- Camera with a polarising lens and 200 ISO daylight film speed
- Hand lens (x10)
- Blackboard & chalk or wipe-clean board, non permanent pen and cloth (small, to include site details in the photographs)
- Underwater viewing aid (eg glass-bottom bucket or underwater TV camera,)
- Polarising sunglasses (optional)
- Optical range finder (optional)
- Boat and additional safety equipment as required
- Copies of previous survey sheet(s) for site(s) to be surveyed (optional).

3.1.6 Legal protection of macrophytes

Macrophytes may be protected under national laws eg the Wildlife and Countryside Act, 1981 in England. Whole plants should never be uprooted, and portions of scarce macrophytes should only be removed when absolutely necessary (under no circumstances must listed rare species have any parts whatsoever collected unless eg in UK a licence to collect has been issued). A list of relevant 'rare' species should be assembled for surveyor to consult.

Material collected should be confined to the minimum required for identification. If a rare plant is found, make records of it by photography, noting any distinguishing features of the plant in the field.

3.1.7 Health and safety (Appendix 9)

Surveyors should refer to health and safety guidelines before undertaking STAR surveys. Please note that the surveys always involve working in water, could involve contact with polluted water, could be undertaken by a lone worker (although this is not recommended) and/or could involve use of a boat.

3.1.8 Staffing level

Where resources allow, surveys should be carried out by a team rather than a single surveyor. A minimum of double-staffing is to be encouraged as contributing towards good practice, for the following reasons:

- it reduces inter-surveyor variation and thus improves the quality of the survey data collected;
- it improves the efficiency of the survey.

One of the most significant causes of inter-surveyor variation, and thus of reduced quality of results, lies in the estimation of percentage cover. The accuracy and consistency of these rather subjective estimates may often be improved by achieving consensus from a 'group decision' rather than relying on a single surveyor. Such group-conferring may also help resolve difficulties of macrophyte identification and survey length relocation.

Efficiency may be improved by allowing different tasks to be shared simultaneously. When assessing and recording the presence and abundance of macrophytes within the survey length, there are a number of items of equipment the surveyor is required to carry, and a number of tasks the surveyor is required to achieve. The surveyor must use a clip-board, glass-bottomed bucket and plastic bags/vials for specimens, whilst retaining a free hand to record items on the clip-board and another free hand to collect specimens. This can make the survey difficult and time-consuming, and as a result may also impair the quality of the results obtained. When two surveyors are present, the equipment and tasks can be shared. Other tasks may also be shared simultaneously in this way: for example, the sketch map, the assessment of the physical characteristics of the site, taking a photograph and taking a diatom sample.

Minimal extra time accrues from double-staffing compared to single-staffing. For sites which are double-staffed for safety reasons, it may not represent any additional resource investment.

In cases where surveys are undertaken by teams of two or more surveyors, one member of the team should be charged with overall responsibility for the survey. The initials of this 'principal surveyor' should always be listed first on the survey sheet, before those of the co-surveyor(s). The 'principal surveyor' should be fully trained in all aspects of the method. Co-surveyors should be similarly trained, but exceptions are allowed. When undertaking the survey, surveyors in a team should confer regarding definition of the survey length, definition of the channel, identification of macrophytes, abundance categories and overall percentage cover, and reach a consensus 'group' decision. This minimises problems of relocating the survey length and provides an immediate 'spot-check' on identification and cover estimation. Differences between surveyors can be discussed, and resolved if possible, on the spot. The 'principal surveyor' has the final decision in case of dispute.

3.1.9 Time required to carry out a survey

Assuming a survey team of two operators, the total time spent per survey (including preparation, travel to site, field survey, laboratory analysis and data analysis) is likely to take one person-day, although this may vary considerably depending on travel distance, ease of access to the site, the nature of the macrophyte community, the weather and the experience of the surveyors.

3.2 Ancillary data collection

Background information is needed about the macrophyte survey sites. The geological information will only need to be researched once for each site. The pollution and channel management information will need to be researched for each survey of a particular site. Find out what the geological type and operational management plan is for the area to be surveyed, and the nature of any known pollution incidents, before planning macrophyte surveys.

3.2.1 Geological and geographical information

The background data that should be researched from maps will include rock type, altitude and slope.

Underlying geology/rock type: the geology of a site may influence the macrophyte community both through lithology and baseflow.

Research the rock types in the areas proposed for survey, by referring to geological maps, so the geology of the area can be taken into account. If survey sites on a river are situated on the same drift and solid types, it is probable that neither the lithology nor the groundwater contribution to base flow, are causing any observed downstream change in vegetation. If the sites are on different geological types it may be that any observed change in vegetation pattern is related in some way to the geology of each site.

Record both drift and solid rock types. The cross-section given on the bottom of each map can be of use in deciding on the underlying solid rock type, if it is not labelled on the map.

Altitude: site altitudes should be taken from 1:50,000 maps. It is recommended that estimates be made to the nearest 5m.

Slope: A mean slope between the two contours either side of a site should be measured. The slope is expressed by the following equation:-

Slope = c / *x* m/km

where c = the difference in altitude (m) between contours on either side of the site, and *x* = the distance (km) between the two contours as measured along the course of the river. Use a map wheel to obtain this value.

3.2.2 Management work

Operational management work such as dredging and weed cutting have obvious effects on the results of macrophyte surveys. Before planning macrophyte surveys it is useful to find out if any work is planned or has been completed since the last survey. Surveying a site after extensive weed cutting or dredging will reflect the damage done to the macrophyte community by the activity. The timing of weed cutting is also important as different species grow at different rates and reach maximum size at different times of the growing season. Thus a weed cut early in the season will have a different effect than a later one and change the macrophyte community pattern.

Note the timing of any management work undertaken before the survey on the standard sheet. In subsequent years note any management work which has been carried out since the last survey as well as any planned work.

Types of management work:

- Dredging
- Piling: reinforcement of river banks with (usually) metal sheets, driven into the bank by a pile-driver
- Other types of bank reinforcement
- Bridge repairs
- Weed cutting

Source of information: Catchment Engineers and Flood Defence Engineers of the relevant authority. Work is planned in advance but is weather dependant.

3.2.3 Pollution incidents

Determine if any pollution incidents have occurred which may have affected the macrophyte community at a site. Note any pollution incidents that may have effected the macrophyte community on the standard sheet. Give details of date and nature of pollution.

Sources of information: Environment staff of the relevant regional or national water authority.

3.3 Limitations of the method

3.3.1 Uses and applications

The STAR score is influenced to some extent by the physical character of the river as well as the nutrient status. This means that the method cannot be used to make a quantitative assessment of the ecological status of an individual site — only a qualitative assessment — and should not be used to compare the ecological status of physically dissimilar types of sites. At the present stage of method development the STAR system can only show change in ecological status reliably over a relatively short physical distance, such as upstream and downstream of a discharge, without other complicating factors coming into play.

3.3.2 Operator health and safety

The method is limited to sites where operators can safely undertake a survey. For example, deep water, high current velocity and bed instability may render a site unsuitable for survey (refer to health and safety guidelines).

3.3.3 Site and survey conditions

The method is limited to sites and occasions where the conditions are suitable. Conditions which may reduce the efficiency and accuracy of the survey include:

- adverse weather conditions
- high flows, spates and flooding
- poor water clarity
- heavy shading
- presence of artificial structures
- river maintenance such as weed cutting or dredging
- navigation activity
- atypical conditions.

These factors should be considered when selecting site and survey lengths (Box 2).

3.3.4 Plant growth stages

Macrophyte survey methods can only be utilised during the summer months (mid-June to mid-September in central and northern Europe) due to the growth and dieback cycle of certain species (3.3.1). Differences in seasonal growth patterns between species may also result in variation in the STAR score within the survey season. Surveys undertaken at a site over a number of consecutive years can thus be compared with confidence only if taken at the same time of the survey season every year.

Surveyors should also be aware of natural fluctuations in the occurrence of certain species in rivers (eg *Ranunculus*). Care should be taken when interpreting absence of particular species that it is not a temporary absence. Detailed site knowledge and consultation with riparian owners may be necessary to determine this.

3.3.5 Difficulties resulting in surveyor error and/or inter-surveyor differences

The most common sources of surveyor error and variation between surveyors are: differences in estimates of macrophyte cover; mis-identification of macrophytes; missing species that are present only in isolated small patches; differences in judging whether specimens are 'in' and 'out' of the channel; and errors in accurately locating the survey length. All can be reduced by provision of adequate training, correct application of the method and adoption of quality assurance measures.

4 HOW TO CARRY OUT A STAR SURVEY

This chapter describes the survey methodology, starting with an overview (4.1), then progressing to detailed procedural guidance on preparation (4.2), the field survey itself (4.3–4.6) and laboratory analysis (4.7). The method is summarised in Figure 3 in the form of a flow chart and in Appendix 7 as a checklist, either of which can be used as a field 'prompt sheet'.

4.1 Overview of the methodology

The macrophyte survey method chosen can be summarised as follows.

1. A standard length of watercourse (100m) is selected or located and assessed to confirm its suitability for survey. If suitable it is measured out and the ends marked (the 'survey length'). Standard field sheets are used to record site and survey details.
2. The macrophyte flora and physical character of the survey length are then surveyed by wading, boat, or walking along the bank. Sampling aids are used where necessary.
3. All macrophytes present are recorded, together with the estimated percentage cover of each taxon (recorded as abundance classes and the estimated percentage cover of overall macrophyte growth. Representative samples are taken for laboratory analysis if identification is uncertain.
4. The physical character of the survey length is recorded by estimating physical parameters, drawing a sketch map and taking a photograph.

4.2 Preparation and pre-survey checks

Before going out on survey, surveyors should ensure that they have all the equipment they need, that they know the precise location of the survey lengths to be surveyed and that they are familiar with the necessary health and safety guidance. An equipment checklist is provided.

Upon arrival at the survey site, the surveyor should confirm that the site and/or survey conditions are suitable for an STAR survey (see Boxes 2 and 3). Think again if:

- the suffixes of confidence for the survey and comparability are C and/or III
- there has been a recent temporal perturbation (eg spate or weed-cutting)
- flows are high and/or the water is turbid
- there is heavy/steady rain and/or windy conditions
- an alternative method is more appropriate.

4.3 Site and survey details

The appropriate site details such as name, river, date, time and surveyor's initials are recorded on the standard survey record sheet. In cases where surveys are undertaken by teams of two or more surveyors, one member of the team should be charged with overall responsibility for the survey. The initials of this 'principal surveyor' should always be listed first on the survey sheet, before those of the co-surveyor(s), to help the auditing process

4.4 Marking the survey length

4.4.1 Length of river to be surveyed

For all applications, the standard survey length should be 100m, with macrophyte abundance recorded on the 9-point abundance scale C (see 4.5.5 for abundance scales). One exception is allowed for wide and deep rivers (Box 4). Where extra information would assist in the interpretation of data, the surveyor also has the option to undertake a 500m survey (Box 4).

When surveying a survey length for the first time, measure the actual length accurately using a tape measure. Mark each end of the survey length with a short stake or ranging pole which is clearly visible from the river channel.

If suitable details for relocation are included on the sketch map for subsequent surveys of the same length at the same site, then the length may be measured out using the system of pacing described below in conjunction with the sketch map, instead of using a tape measure. As an alternative to pacing, a 10m rope can be used, but this requires at least two people on site to make it an efficient method. If in any doubt, use a tape measure on each visit.

Regularly check on the number of paces needed to measure out the required survey length. This will vary for each surveyor and should be calculated before the beginning of field work. Mark out on the ground a 10m length and count the number of paces it takes to complete this distance. Repeat the exercise until confident that only a small variation occurs. Multiply up the figure obtained to determine the required number of paces for each survey length. If the error in pacing out the survey length is more than ± 10% then the actual length should be measured with a tape measure. This also applies where irregular pacing is anticipated due to obstructions or where pacing could only be undertaken in the channel.

4.4.2 Width of channel to be surveyed

The survey method covers those 'river' macrophytes contained within the 'channel area'. Records of 'bank' species are not made unless the survey is also for conservation purposes. Non-native and 'weed' species (Appendix 2) should be recorded.

Channel area definition:

All macrophytes seen submerged or partly submerged in the river, at low flow levels, within the survey length. These are considered to be 'river' plants. At the sides of the river all macrophytes attached or rooted on parts of the substrata which are likely to be submerged for more than 85% of the year are included for northern Europe. The normal morphological limits of the channel are to used in southern Europe when rivers are dry for extensive periods (>6 months)

Bank area definition:

The 'bank' is defined as that part of the side of the river (or islands) which is submerged for more than 50% but less than 85% of the time.

As it is best to survey macrophytes when the river has been at low flow for several days, the definition of channel area is fairly easy to interpret in a consistent manner. Obviously some degree of judgement and common sense is required to decide whether a macrophyte species is in the channel. Macrophytes overhanging the channel but not rooted in the defined channel area should not be counted. In general, records will be for those macrophytes which occur in the region of the river which is rarely uncovered, and those shallow sections which have an upper limit that may be exposed for a maximum of 50 days in any one year.

'Bank' macrophytes are those plants that occur above the limit of the river plants, and are thus out of the water for more than 50 days in any one year, yet will be submerged or partly so, during average flow periods.

4.4.3 Location of the survey length

If having completed a survey the results appear to have been affected by the physical constraints of the survey-length location, then consideration should be given to moving the location of the survey length within the guidance given in Box 2.

Quality assurance

If using the pacing system, each surveyor charged with determining the upstream and downstream limits of the survey length must check, at the beginning of each survey day, the number of their paces required to measure out the survey length. Do this for 10m as suggested above.

The survey length should agree with the relocation features marked on the sketch map.

Decisions regarding channel definition — which specimens are 'in' and which 'out' of the channel — are a common cause for inter-surveyor differences. Application of strict discipline is thus required: always check whether the roots of an overhanging specimen are in the channel or not, and do not be tempted to record specimens which are not rooted in the channel just because they 'score'. If a species is only recorded from the waterline, mark this on the field sheet (this will help clarify disputes between primary surveyor and auditor).

Box 4 Non-standard survey lengths

1. **Exceptions to the standard 100m survey length**

   If it is absolutely impossible, in a large river, to find two 100m sites of comparable character within proximity then choose 50m reaches of similar character, provided that the river is at least 10m wide (so that the survey area will be >500m^2).

2. **Optional surveying of survey lengths in addition to the 100m length**

   Where extra information would assist in the interpretation of data, the surveyor has the option to undertake a survey in addition to the standard 100m length survey. The length (which must include the original 100m survey length) is surveyed in its entirety as a separate survey, using a 5-point scale for recording macrophyte abundance rather than the 9-point scale used for 100m surveys. ***It is not possible to convert the data collected from the initial 100m to the 5-point scale and combine this with data collected for an additional length. The STAR score is not much affected by the use of the 5-point scale in place of the 9-point scale but more information and more resolution of abundance changes can be gained by using the 9-point scale.***

   The additional length can be placed at either end of the initial 100m or split either side of it according to site circumstances to give a continuous survey length. Gaps between the survey lengths are not allowed.

   The aim of carrying out the 500m survey in UK is to obtain a fuller species list in order to verify the interpretation of ecological status from the 100m survey. In many cases the 500m survey will act as a 'quality check' on the location of the 100m survey length. In such cases, a 'working' STAR score may be calculated from the 500m survey data, but this must only be used to compare with other 500m 'working' STARs (eg upstream-downstream pairs) and to verify that the interpretation of ecological status from the 100m survey(s) is correct. In most cases, the STAR score calculated from a 500m survey will not be significantly different from that derived from a 100m survey.

   If a 500m survey is carried out, this does not need to be re-surveyed every year but may be repeated every 5 years for comparative purposes **IF** great changes in the 100m survey data occur.

Box 5 Exceptions to surveying the full channel width

In all cases every reasonable attempt must be made to survey the full survey-length. There are a few exceptional cases where it is acceptable to modify the approach.

1. **Wide and deep rivers**

   In some very wide and deep rivers it may be impractical to carry out a survey of the full channel width on all surveying occasions. In such rivers, where the central channel may be devoid of vegetation or cannot be accurately recorded due to depth/turbidity even using an underwater camera, a 5m wide (minimum) strip down one side of the channel (ideally with little tree shading) can be surveyed. Where the impact of a discharge is being assessed, the downstream survey length must always be on the side into which the effluent discharges. In watercourses where an effluent tracks along one bank only for at least 500m downstream it may not be suitable to carry out a full width survey on all occasions either and, therefore, a 5m (minimum) strip can be surveyed. In such circumstances the whole river width must be surveyed initially so that results from the whole channel can be compared with the selected $500m^2$.

2. **Mature islands**

   Where the impact of a discharge is being assessed and a mature island is located within the survey length, only the side on which the discharge enters should be surveyed.

3. **'Black holes'**

   No gaps/'black holes' must be left in a survey length except under the following circumstances. If the majority (>80%) of a site can be surveyed by wading but the remainder is deep or rapid and it is not practical to survey using a boat and camera/glass-bottomed-bucket then this may have to be left as a 'black hole'. This must be clearly mapped and discounted in all future surveys. The 'black hole' should be totally excluded from the survey: it should not be included in estimations of plant cover or physical attributes (except for width).

4.5 Carrying out the macrophyte survey

Assess the presence and abundance (in terms of percentage cover) of macrophytes within the survey length and record this information using the standard field sheet (Appendix 5). In terms of survey technique, the majority of survey sites can be divided into two basic types: those that are wadeable and those requiring a boat to allow access to all areas of the site.

4.5.1 Survey technique: wadeable survey sites

At sites where it is assessed to be safe to do so, the full survey length and channel width is surveyed by wading. At the majority of sites a second operator will be required for safety reasons (but see 3.3.8).

Wading should be in an upstream direction so that any substrate disturbed does not obscure the visibility of the survey length both for ease of observation and safety reasons.

Where all but a small proportion (< 20%) of the survey length is accessible by wading it is acceptable to walk for a short distance along both banks observing the macrophytes and to investigate for submerged macrophytes using a grapnel.

The operator should wade in a zigzag manner across the channel, frequently investigating all habitat types present. The operator should cross the channel a minimum of 4 times in each 10m of the survey length as shown in Figure 1. Obviously this has to relate to visibility and is not prescriptive. For example, on wide but wadeable rivers with clear water it will not be necessary to cross the channel as frequently.

During wading, record the species present and think about the percentage of the survey areas covered by each species. Use sampling aids as appropriate (4.5.3). Include both STAR-scoring species and non-scoring species. Although only scoring species contribute to the STAR score, it is difficult to ignore non-scoring species and all species contribute to the overall percentage cover.

Take particular care to examine all small niches within the survey site to look for small ($\leq 25cm^2$) patches of species. Such patches are easy to miss but their non-recording can result not only in inter-surveyor differences but also an erroneous STAR.

Detached macrophyte material, except for actual floating macrophyte species such as *Lemna* sp and *Azolla*, should be disregarded. If a macrophyte is stranded above the water, eg in low flow conditions, then it should not be recorded on the standard checklist. A note of the species, should however, be made in the 'Comments' section along with observations of the amount stranded and any obvious reasons for stranding.

Where sites are being compared, specimens attached to artificial structures should only be recorded if a similar structure is present in both/all sites included in the comparison. A note should always be made of recorded specimens which were attached to artificial structures.

Once all macrophyte species in the survey length have been recorded wade/walk back along the survey length, specifically observing the amount of each species present and the overall percentage of the channel covered by macrophyte growth.

4.5.2 Survey technique: non-wadeable survey sites

At sites where the channel is narrow (about 5m or less wide) but the water is too deep to wade, if the channel macrophytes can be clearly seen by walking along both banks and using a grapnel to retrieve macrophyte species for identification then this is sufficient. In narrow channels it may be impractical to use a boat.

At sites where the water depth is too great to wade and flow is slow, a small boat should be used. Safety guidelines should be followed.

The boat used should ideally be light and very stable for ease of transport and operator safety. Rowing or paddling is the most useful form of propulsion while surveying as this causes minimal damage to the macrophytes and allows greater manoeuvrability throughout the survey length.

Traverse the river in a zigzag manner inspecting all the habitat areas frequently. A minimum of 4 angled crosses of the channel in each 10m should be undertaken so that the maximum distance from the surveyor to the channel surveyed is 2.5m (Figure 1). On wide rivers it may not be necessary to cross the channel as frequently.

While traversing the channel, record the species present and think about the percentage of the survey area covered by each species. As for wadeable sites, include both STAR-scoring species and non-scoring species, take particular care to examine all small niches within the survey site to look for small ($\leq 25cm^2$) patches of species, but disregard detached material except for floating species. Record specimens attached to artificial structures only if a similar structure is present in other survey lengths with which the results will be compared and make a note of recorded specimens which were attached to artificial structures. Use sampling aids as appropriate (4.5.3).

After recording all macrophyte species present in the survey length, return along the length specifically observing the cover provided by each macrophyte species and considering the overall cover (4.5.5). On the standard sheet (Appendix 5), enter the appropriate Species Cover Value (SCV) next to each macrophyte species and the overall percentage cover estimate.

4.5.3 Sampling aids

It is important that the bed of channel is clearly visible, to enable accurate assessment of the species present and their abundance. In circumstances where the bed is not clearly visible due to deep or turbid water, or due to reflections from the water surface, observation of submerged species can be aided and errors reduced by the use of a glass-bottom bucket, an underwater TV camera and/or a grapnel (Appendix 4), as described below.

General guidance

For wadeable surveys, it is strongly recommended that a glass-bottom bucket is used to aid observation of macrophytes. A grapnel may be used to retrieve submerged macrophytes for identification from small areas of deep water, if necessary.

At deep-water sites where it is not possible to see the river bed unaided and for surveys by boat, an underwater TV camera or a glass-bottom bucket must be used to locate the position and assess the abundance of any macrophytes which cannot be seen from the surface. Use a grapnel to retrieve submerged macrophytes for identification. Binoculars can also be useful to scan the margins so that species present in small quantities, particularly if amongst a large stand of other macrophytes, will not be missed.

In deep and or turbid water the estimates of percentage cover for submerged species may have to be based entirely on observations from a underwater camera and/or glass-bottom bucket. Submerged species present in very small amounts may still be missed if the water is turbid.

If the underwater camera and/or glass-bottom bucket is used for a survey at a particular site, then it must also be used at any other site with which this is being compared.

Where visibility is severely impaired, use an alternative site or survey length if possible. Otherwise use the same surveyor for sites which are to be compared. If clarity is poor, direct comparisons of overall percentage cover and submerged species percentage cover should be treated with extreme caution if used at all.

Underwater TV camera

When using an underwater camera it is possible to see an area of approximately 1–2m wide with reasonable clarity in very turbid water. During the survey the camera should be used every few metres across the deep section of the river channel, as necessary. The boat must be rowed very slowly to

ensure stability of the camera and accurate identification of submerged species. It is recommended that an estimate of the abundance of each species is made for each traverse of the river and the abundance estimates for that area combined to give a total estimate of percentage cover in the whole survey area.

The camera unit incorporates a light source which can help visibility in deep/turbid sites, but this should be used with care as it uses much more power so the battery time is greatly reduced. The clarity of the water will determine the number of times it is necessary to lower and rotate the camera lens so that 360 degrees can be observed. If necessary a small weight (see manufacturers guidelines) can be attached to the base of the camera to ensure greater stability and upright orientation. In silty/muddy sites avoid contact with the base of the river channel so no disturbance of the bed occurs leading to reduced visibility.

Grapnel

A grapnel may be used to retrieve submerged macrophytes for identification from areas of deep water. It is recommended, however, that the grapnel is NOT used to 'search' for macrophytes as a substitute for visual observation, due to the following problems:

- fine-leaved and deeply rooted macrophytes will not be found unless a direct hit is made, and therefore will either be missed entirely or under-represented;
- 'bushy' species such as *Elodea* will easily be collected by grapnel and their abundance may therefore be over-estimated.

Use of a grapnel alone will lead to high levels of inaccuracy in both the records of submerged species and the estimation of overall percentage cover.

Grapnel hauls should only be used when necessary, to retrieve macrophytes for identification or determine if macrophytes are present, as they can damage or uproot macrophytes. Particular care should be taken in an area with high conservation or aesthetic value.

4.5.4 Identification of macrophyte species

Identification should be to species level where possible. Take a field identification guide, which gives distinguishing features and shows which species are easily confused, into the field. Recent synonyms are listed in Appendix 5 (Table A1). It may also be useful to take into the field a copy of the survey sheets/results from the previous survey(s), as this may minimise gross identification errors and help ensure sparely-distributed plants are not overlooked. Previous results must be used with care, however, as the macrophyte community may have changed and/or the results may contain errors — they should only be used in a final check, and not as a first point of reference.

Certain species can only be identified when fruiting bodies or flowering parts are present; and even then only with difficulty. If identification to species cannot be achieved, for example due to absence of seasonal diagnostic features, and all other routes to identification fail (see below), then record only to the level to which you are confident (eg genus), even if this then renders the specimen 'non-scoring'.

Macrophyte species identified in the field should be checked for positive identification features. This takes an experienced surveyor very little time, ensures that rarer species are not overlooked and recorded as their more common counterparts, and reduces the likelihood of macrophyte species with superficially similar features being incorrectly identified.

Macrophyte species positively identified in the field should be recorded on the standard record sheet. When a species unfamiliar to a surveyor is found it should be identified in the field if possible but a representative sample should also be taken back to the laboratory for confirmation of the identification. A small, representative sample should be taken and placed in a plastic bag or tube without any

additional water, together with a waterproof label. Normally a slip of waterproof paper or semi-opaque matt film, labelled in pencil is sufficient; alternatively pre-marked consecutively-numbered strips can be used with the number recorded on the STAR field form. When using plastic bags, blowing air into the bag before sealing it also helps to maintain the specimen in a healthy condition. On the label, record site, survey number, date, sampler's initials and unidentified specimen name, eg 'unident. 1'. On the standard record sheet, the unidentified species should be recorded in the 'other species' section, using the same name for the labelled sample so there can be no confusion on return to the laboratory. This is particularly important when more than one macrophyte from the same survey needs further investigation.

Particular care should be taken over the identification of species of *Ranunculus Potamogeton and Callitriche*, as testing for the MTR methodology showed mis-identification of *Ranunculus* species to be a common cause of surveyor error, and thus of potential error in the STAR survey (Dawson et al 1999b). If in doubt, a representative sample should be taken back to the laboratory for confirmation of identification, or identification confirmed by an expert. Remember that if still in doubt, only record to the genus: '*Ranunculus* species indeterminate'. Where you are confident that two or even more species or apparently differing forms of *Ranunculus* are present, but you cannot be confident about the precise species, then it is allowable (or probably preferable) to record each species separately as '*Ranunculus* species indeterminate #1', '*Ranunculus* species indeterminate #2' etc, provided identification notes are made in the 'Comments' space and representative specimens are preserved in a herbarium for future identification/comparison.

Representative samples of algae and bryophytes should be taken to the laboratory for closer examination so that their that identification can be confirmed.

If the species identified is unfamiliar to all members of staff, is an unusual find for the river sampled or identification is not 100% positive, send the specimen to an expert for confirmation. If there is sufficient expertise in-house then an internal expert can be consulted. If such expertise is not available an external specialist must be contacted. BSBI county recorders are a useful source of local expertise. [Surveyors who have been on a training course run by Dr Nigel Holmes can currently send difficult specimens to him (Alconbury Environmental Consultants, The Almonds, 57 Ramsey Road, Warboys, Huntingdon, PE17 2RW) for verification, provided every effort has been made to identify the species beforehand.]

If possible, representative material of all species regularly encountered in surveys should be collected and maintained in a herbarium (see 4.7.2). This will make accurate identification of difficult material easier and will aid in the training of new staff.

Quality assurance

If possible, confer with survey colleagues to confirm identification. Preserve representative samples of 'difficult' specimens and place in a herbarium for future reference if necessary. Annotate the field sheet to indicate those taxa for which specimens have been placed in the herbarium.

4.5.5 Estimating macrophyte abundance

Macrophyte abundance is expressed in terms of the percentage of the survey length covered. This should be estimated by imagining a bird's eye view of the channel. For estimates of individual species, it is necessary to imagine the abundance cover of each, regardless of whether several species are intermingled or overlap.

Percentage cover estimation of filamentous algae can be particularly difficult. Determine whether the algae are forming a continuous or broken covering of the substrate.

For both overall percentage cover and individual species cover estimation it is useful to calculate what a one metre square patch of macrophyte represents for each survey length, eg 0.01%, 0.5% etc, before commencing surveying.

Overall percentage cover estimate

This is an estimate of the total percentage of the channel area covered by macrophytes, including both STAR-scoring and non-scoring species. Picture the survey area from above in two dimensions, ie length and breadth, and then use one of the methods in Box 6 to estimate the percentage cover.

Box 6 Methods of estimating overall percentage cover

Option 1

Imagine moving all the macrophytes to the one end of the survey length. The area covered will correspond to the overall percentage cover, for example in a 100m survey length an area of macrophytes completely covering a section which is 25m long × channel width will have 25% cover. If 500m was used then 25m × channel width would correspond to only 5% cover.

Option 2

If the majority of the vegetation is confined to strips along the margins of the river, the overall percentage cover may be estimated in the following manner:

marginal area covered, m^2 = length of marginal vegetation cover × width of marginal vegetation

total area covered, m^2 = marginal area + other areas

Total percentage cover = [(total area covered)/(total area of survey length)] × 100

Individual species percentage cover estimates

For all percentage cover estimates of scoring and non-scoring species, the whole survey area surveyed equals 100%, ie the individual species percentage cover estimates are a percentage of the whole survey area and **NOT** of the overall percentage cover estimated.

Estimate the percentage cover of each macrophyte species and allocate each macrophyte a cover score:-

Scale (for 100m survey length)	
1	<0.1%
2	0.1–1%
3	1–2.5%
4	2.5–5%
5	5–10%
6	10–25%
7	25–50%
8	50–75%
9	>75%

In the rare event that a percentage cover is estimated as being precisely on the border between two categories and a judgement cannot be made than a value for the upper category should be recorded, thus, for example, if exactly 1% then C3 is recorded.

When all species have been allocated a STAR index add up the percentages, in the field, to check that they correspond to the overall percentage cover estimated for that survey length (however, see Quality Assurance note).

When assigning percentage cover to macrophyte species it is strongly recommended that a systematic approach is adopted to make the process easier and more accurate. Use one of the methods described in Boxes 7 and 8. As a double-check when estimating small areas of cover, it may be useful to work out beforehand the area of pieces of survey equipment, and use these for reference: for example, an A4 recording sheet (0.06 m^2) or the base of a glass-bottom bucket.

Survey areas choked with vegetation

At sites where macrophytes are very abundant the site may become choked with vegetation. For surveys at these sites it is difficult to estimate percentage cover for individual species. The birds-eye view method of recording cover should be taken. It may be necessary to use a grapnel and underwater TV camera/glass-bottom bucket to search for submerged species which may be surviving under other macrophytes. Record any species found from such searches and estimate their abundance based on observations using the underwater camera or glass-bottom bucket. Grapnel hauls should NOT be used as a means of estimating abundance (4.5.3).

Box 7 Estimating percentage cover of individual species: width method

1. Stand on one bank facing across the river channel to the opposite bank. Imagine a rectangle made between the banks and channel width, as illustrated below:

2. The whole survey length multiplied by the channel width equals 100%. Work out how long the bank length needs to be to illustrate an actual area of channel corresponding to a particular percentage cover. Visualise dividing up the bank length so that rectangles of area represent the range of percentage covers described by the SCV classes, and use this to allocate the appropriate SCV for each species.

3. Using Scale C for the survey length a macrophyte must cover the following bank length × channel width areas:

Scale point (SCV)	Percentage cover	Corresponding length on bank for 100m survey length	Corresponding length on bank for 500m survey length
1	< 0.1	< 0.1	< 0.5
2	0.1 - 1	0.1 - 1	0.5 - 5
3	1 - 2.5	1 - 2.5	5 - 12.5
4	2.5 - 5	2.5 - 5	12.5 - 25
5	5 - 10	5 - 10	25 - 50
6	10 - 25	10 - 25	50 - 125
7	25 - 50	25 - 50	125 - 250
8	50 - 75	50 - 75	250 - 375
9	> 75	> 75	> 375

This method has the advantage that the lengths on the bank are constant for a particular survey length and cover scale used, regardless of channel width. The bank lengths MUST, however, be calculated for each combination of survey length and cover scale used. If the width varies considerable along the survey length, take this into account.

Example

For a 100m survey length using Scale C, a macrophyte covering an equivalent area of 6m × channel-width will be allocated an SCV of C5.

Box 8 Estimating percentage cover of individual species: square metre method

1. Estimate the approximate average width of the channel.
2. Calculate the equivalent square metre areas that need to be covered in order for a macrophyte to be awarded a particular SCV.

   For 100m surveys highlight the most appropriate width column and use this as a guide.
3. Estimate the number of square metres covered by each species within the survey length and allocate the appropriate cover value.

Example

For a 100m survey length, channel width 5m, using cover scale, a macrophyte must cover the following areas:

Scale point (SCV)	Percentage cover	Equivalent area (m^2)
1	< 0.1	< 0.5
2	0.1 - 1	0.5 - 5
3	1 - 2.5	5 - 12.5
4	2.5 - 5	12.5 - 25
5	5 - 10	25 - 50
6	10 - 25	50 - 125
7	25 - 50	125 - 250
8	50 - 75	250 - 375
9	> 75	> 375

A macrophyte covering $6m^2$ would be recorded as 3.

NB These figures need to be recalculated for ANY DIFFERENCE in survey length, channel width or abundance scale.

Quality assurance

Check the overall percentage cover estimate by estimating the percentage of bare substrate and adding this to the overall percentage macrophyte cover: the total should be 100%.

Check the SCV estimates of individual species, by adding up the individual percentage cover estimates to make certain that they at least equal the overall percentage cover estimate. If they differ check the estimations to discover where the under- or over-estimation has occurred. This MUST only be done at the survey site: NEVER re-evaluate estimates after departing from a site.

NB It is possible for the sum of the individual percentages to be legitimately greater than the overall percentage cover where macrophytes overlie each other. Indeed, it is possible to have more than 100% cover of macrophytes in terms of SCVs, where the channel is choked with vegetation (see above). It is recommended that all taxa (scoring and non-scoring) are recorded and their cover assessed; this will allow an assessment of the total percentage cover of species, to compare with the overall percentage cover.

Difference in percentage cover values is the most common source of difference between primary and audit surveys of the same survey length. It is very important that training is given in the estimation of percentage cover values and that all surveyors are familiarised with the training on an annual basis. Do not guess the percentage cover: make reasoned estimates consistent with observation.

4.5.6 Biomass of macrophyte taxa

It is recommended that quantitative or semi-quantitative assessment of biomass is NOT included in routine STAR monitoring. If a situation arises, however, whereby a particular species has the same cover at two sites being compared, but its biomass is obviously greater at one because the depth of the stand is greater, then a comment should be made in the 'Comments' section and suitable photographs taken if possible.

4.5.7 Assigning a measure of confidence in the survey

Having completed the recording of macrophytes the surveyors should assess, on a scale of A to C, how accurately they feel the results reflect the prevailing situation at the site. This is an assessment of the typicality of the results given the constraints of water chemistry, weather, together with impacts such as the effects of weed cutting or site management. For example, the survey may have been hampered and perhaps rendered meaningless by:

- temporal perturbations such as recent river management (dredging, weed cutting, herbicide application, disturbance due to flood defence works such as bank reinforcements) or extreme flooding events, which may have influenced the macrophytes;

  and/or

- survey conditions which reduce the accuracy of the survey, eg poor survey conditions (turbidity, high discharge due to recent rain or very wet or windy conditions) or excessive blanketing algae or floating vegetation growth obscuring the view or smothering other vegetation.

Note that confidence in the results of a survey may be restricted by either one or both of the above factors.

Surveyors should score on a scale of A to C the degree to which the above may have distorted their findings:

- A - data not affected or any effect limited to less than 25% of the site
- B - the accuracy of records in 25–50% of the site influenced to a considerable degree
- C - the accuracy of records in >50% of the site influenced to a considerable degree

This should be recorded on the record sheet (see Appendix 5). The factors which potentially distorted the accuracy of the survey should be identified in the 'Comments' section.

The importance of objective interpretation cannot be over-emphasised here. Decisions are based on an individual's interpretation of what are typical conditions, to what extent those conditions have been deviated from and whether this has had an effect.

It is strongly recommended that surveys with a suffix of confidence of 'C' should not be used for interpretation of ecological status, ie *there is sufficient cause for concern that the STAR results do not represent the prevailing ecological status at the site*.

4.6 Assessing the site SEE SITE PROTOCOL (with optional recording of physical variables for comparative purposes)

4.6.1 General method

After recording the macrophyte information the survey length may be re-traversed, observing and entering details of the physical variables on the form (see Appendix). The grapnel, bank stick/ranging pole and/or underwater camera/glass-bottom bucket can be used to confirm the general indications of the substrate type at sites where the channel bed cannot be directly observed. Mark the grapnel rope with 0.5m divisions and use it to determine the depth of the water, or use the bank stick/ranging pole. It should be obvious, from grapnel throws to retrieve macrophytes, if a change in depth has occurred within the channel.

The assessment of physical variables is NOT expected to be as precise as the macrophyte assessments, but merely an important element which should be used to help in:

i) assessment of how comparable sites are;

ii) providing information which in the future may help in more rigorously assessing the relationship between macrophytes and physical variables.

Orientation of the left and right banks is determined by the direction of flow. When facing downstream, the left bank is on your left hand side and the right bank on your right hand side.

In order to ensure that data are consistent, all variables should be recorded in a manner so that they relate to estimates in previous years. This may mean that the following categories/classes are recorded for some physical characteristics: 1 = <5%; 2 = 5–25%; 3 = >25% as well as actual percentages (actual percentages MUST be recorded). It is preferable to record percentages to the nearest integer value (ie no decimal places). If a particular feature is absent, then record this as 0% (category 0): do not leave data entry spaces/boxes un-filled.

Recording of features which are present in less than 0.5% of the survey area will not usually be required unless that particular habitat type contains the only occurrence of a scoring species. Such recording may also be required if TDI/DQI surveys are being carried out at the same site and the particular type of habitat is cobbles or boulders in amongst gravel or sand and that is the only suitable substrate for sampling diatoms. In either case, a note should be made under 'Comments' on the field sheet and care should be taken to mark the position of such small habitat patches on the accompanying sketch map.

Quality assurance

Check, before leaving the site, that all data entry spaces/boxes have been completed as required.

4.6.1 Sketch map

The purpose of the sketch map is to enable future relocation of the survey length and is not a record of individual surveys. It is not necessary to make detailed plans of each survey.

Fill in required details on standard sketch-map record sheet (Appendix 5), eg river name, site name, date etc.

Draw a sketch of the survey length, showing only in the broadest terms the general physical character of the site. This should include important vegetation stands and permanent reference features (such as a distance from a bridge or footpath sign) which would enable anyone else to find the survey length with great precision in the future. In addition, mark on any unusual features such as 'islands' of substrate supporting vegetation. In deep water, depth can be easily measured using a grapnel.

The distance markings on the standard sketch sheet do not indicate which direction the macrophyte survey should be undertaken. If starting at the upstream end of the survey length and moving in a downstream direction, the left side of the paper will correspond to the left bank and the direction of flow will be from the bottom to the top of the paper. If starting from the downstream end and moving in a upstream direction (this may be preferable for safety reasons - follow health and safety guidance), then turn the map upside down. It may be helpful to draw in 'landmark' features before starting the sketch map, or to mark on the bank the mid-point of the survey length, for reference.

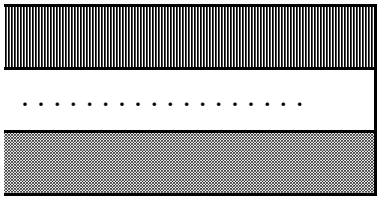
Main features to mark on sketch map:

Location of river and its pathway
NGR for the start and end of the survey length
Width of channel - the width included in the survey
Relocation features - for both ends of the survey length if possible
Shading position and type - broken or dense
Grid north (found from OS map)
Dominant macrophyte stands
Extent of riverbanks - riverbank (for the sketch map) is defined as the area before an adjacent land use starts
Adjacent land use - for example arable, pasture, factory, waste, set aside, houses/gardens
Depth of water - in m across the channel width

Broken shade should be indicated by:

Dense shade should be indicated by:

Macrophyte stands should be indicated by:



Label clearly.

Pace out 10m lengths and check that the relevant features are marked on the sketch map in the correct location. Check that the orientation is correct.

It may be necessary to redraw the sketch map on return to the office to ensure labels etc are legible. Do not use personal shorthand in the final map as others will not be able to correctly translate this.

File all sketch maps with their corresponding field records. It is recommended that a short description of each survey length location is appended to a map (preferably 1:10 000) showing the location of the survey lengths. It is useful if this includes notes on access.

When using sketch maps to relocate survey lengths take photocopies into the field and leave the original in the file.

4.6.2 Photograph

A colour photograph should be taken of the survey length to visually record its general character and should include a feature (eg ranging pole) for scale. The use of a polarising filter to reduce surface reflection and a date facility on the camera are recommended.

Write the date and an identifying code or site name and river name on a small blackboard or wipe-clean board and place this, unobtrusively, in the photograph. Depending on the direction of the sun stand at one end of the survey length and take a photograph along the length of the river to gain a representative impression. Record the identifying code on the record sheet.

Additional photographs may also be taken to illustrate a change in vegetation between sites. When photographing channel vegetation, it is useful to include a reference object to indicate scale.

Quality assurance

Note any distinguishing features of the photograph (it is NOT sufficient to rely on these type of features alone - use the suggested labelling method). Label films and have each film developed as soon as it is finished. On return of developed film, refer to the relevant survey sheets and label each photograph with river, site name, date and surveyors' initials. Catalogue all photographs: file in groups under (for example) river name or catchment name, in an album or index type box file so they can be easily retrieved.

If using a box file, place each photograph in an envelope which has previously had the river and site name, date and surveyors' initial marked on it. Include the unique database site reference number on the envelope.

Make sure it is simple to cross reference with survey sheets and any computer based data.

4.6.3 Comments

In this section report any unusual features of the survey length, eg excessive growth of a particular macrophyte or a lack of macrophytes with no obvious cause. Record any problems encountered while surveying. Note distinguishing features of the survey length so that it can be relocated on subsequent occasions.

4.6.4 Assigning a measure of confidence in the comparability of survey lengths

When undertaking surveys to assess downstream changes in ecological status, it is necessary to assess how physically comparable are the sites being compared. Having undertaken both the sketch map and the physical inventory, identify on a scale of 1 to 3 how comparable the sites are and record this on the standard record sheet (Appendix 5). This assessment should be recorded at the time of survey or shortly afterwards.

The factors under consideration for comparison are Width, Depth, Substrata, Habitats, Shading, Water Clarity and Bed Stability.

- If 5 or more of these characteristics are similar for more than 75% of the site for each pair of survey lengths then assign category **I**.

- If 3 or 4 of these characteristics are similar for more than 75% of the site for each pair of survey lengths then assign category **II**.

- If 2 or less of these characteristics are similar for more than 75% of the site for each pair of survey lengths then assign category **III**.

It is strongly recommended that surveys with a suffix of confidence of III should not be used for interpretation of ecological status — *ie there is sufficient cause for concern that any differences in STAR between sites may be due to factors other than nutrient enrichment*.

4.6.5 Width SEE SITE PROTOCOL (optional for comparison with existing datsets)

The width is the channel width for which macrophyte species have been recorded, as defined in section 4.4.2, including any area of substratum above the actual water level that has been surveyed.

The first time a survey length is surveyed the width of the channel should be measured using a tape measure/rope with 0.5m divisions or an optical range finder (Appendix 4). If the width varies noticeably along the survey length then several width measurements should be made.

Record varying widths by entering the actual percentage in the appropriate boxes on the standard sheet. More than one category may be recorded. For repeat surveys it should be sufficient to estimate the width by one of the methods described below.

i) Use of a calibrated optical range-finder.
ii) If the survey length is easily/safely wadeable or a convenient bridge is present at a deep water survey length, pace out the width.
iii) If (i) or (ii) are not practical, determine channel width using the following method. Place a reference point on the ground, estimate by eye the distance across the channel then pace a greater distance than the estimate of channel width from the reference point along the riverbank. Turn and face the reference point, compare the distance to the reference point with the channel width and decrease the distance to the reference point until it matches the channel width.

Quality assurance

Optical range finders are designed to measure certain ranges so check that the one used is suitable for the width being estimated. Check the calibration regularly.

If the width estimates vary greatly from the original width measurements it is necessary to use a measuring device to check the data recorded for present and future surveys.

If a bridge is used to pace out channel width make sure that the channel under the bridge is the same width as the channel in the length surveyed.

Pace-to-metre ratios should be calculated as under section 4.4.1 and regularly checked. Ratios when wading in water should be calculated separately from ratios determined on the bank, but pacing in water should be avoided if at all possible. All ratios are person-specific (non-transferable!).

4.6.6 Depth SEE SITE PROTOCOL (optional for comparison with existing datsets)

Record the depth by entering actual percentages in the appropriate boxes on the standard sheet (and categories if required for comparison with historical data). Measure the depth at various points along the survey length — the number and exact location of the measurement points should depend on the variability of depths encountered when surveying for macrophytes.

Measure the depth to the nearest centimetre by using a marked bank stick, ranging pole, metre rule or a grapnel with depth divisions marked on the rope. When recording depth, face the narrow edge of the measuring equipment into the current. In deeper water a grapnel rope with depth divisions at 0.1m intervals should be used to measure depth by lowering it vertically. When marking the grapnel rope the height of the grapnel must be included: for example, if the grapnel is 0.2m tall then the first mark on the grapnel rope should be 0.3m above that, representing a total depth of 0.5m.

Quality assurance

Ensure that depth markings on bank stick, ranging pole, metre rule or grapnel rope are clear and accurate before commencing the survey day.

4.6.7 Substrata SEE SITE PROTOCOL (optional for comparison with existing datsets)

Estimates should be based on an aerial or a 'birds-eye' view and should only include particles which are visible and the equivalent superficial layer 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. When the shapes of underlying particles are not distinct then the fine particles should be recorded. If the surveyor feels this is not sufficient then extra information can be recorded in the 'Comments' section.

The combination of substrata is recorded by placing the actual percentage cover in the appropriate box. As many substrata as are present should be recorded, although see 4.6.1 regarding features present at less than 1% cover. The percentage of each substrata category should be rounded to the nearest

percentage point. No decimal points should be calculated. This ensures satisfactory consideration of experimental and observational error in recording. Percentage classes/categories may be recorded in addition to actual percentage values, if required for comparison with historical data.

The substrata classes are as STAR hydromorphology classes (cp STAR site protocol):

Bedrock	-	exposure of underlying rock not covered by alluvial deposits
Boulders/Cobbles	-	> 64mm (half-fist size or larger)
Pebbles/Gravel	-	> 2–64 mm (half fist to coffee granule size)
Sand	-	> 0.0625–2mm (smaller than coffee granules and unlike silt/clay, abrasive to the hands)
Silt/	-	< 0.0625mm (have a soft texture)
Clay	-	< 0.0625mm (have a soft texture)
Peat	-	dead vegetation undergoing bacterial decay in stagnant deoxygenated water – strictly pure peat, not fine peaty deposits over more substantial substrate.

The actual measurements given relate to the longest axis of each particle. Any rock with one or more sides greater than 256mm long is classed as a boulder.

The particle size categories follow an adapted Udden-Wentworth system. When irregular shaped particles are observed the longest axis length determines category assignment.

Quality assurance

Take a copy of the reference sheet provided in Appendix 5 to each site.

Check that the total of classes estimated is possible. Total up the substrata percentage cover which should equal 100%. Check that changes in substrate composition have not occurred due to management or flooding events.

4.6.8 Habitats SEE SITE PROTOCOL (optional for comparison with existing datsets)

Allocate a percentage to the appropriate habitat types. Percentage categories may be recorded in addition if and SLACK, as defined as for the STAR hydromorphology surveys required for comparison with historical data. The habitat types are POOL, RUN, RIFFLE and SLACK, as defined as for the STAR hydromorphology surveys

Quality assurance

Surveyors should regularly familiarise themselves with habitat variable definitions by consultation with other STAR hydromorphology surveyors and by measurement of selected substrate types.

4.6.9 Shading SEE SITE PROTOCOL (optional for comparison with existing datsets)

This is the percentage of the channel area affected by shading, NOT the percentage of the bank on which vegetation causing shade stands. The shading for each bank is recorded separately.

For the left bank, estimate the percentage of the whole channel area surveyed that is shaded by vegetation/structures from the left bank when the sun is directly overhead (ie at 12 noon). In a similar manner, estimate the percentage of the whole channel shaded from the right bank. If the total shading of the channel is needed then the two figures can be added together (theoretically this can be more than 100%). Refer to Figure 2.

When estimating the amount of shading, refer also the sketch map (4.6.9).

Three shade categories are defined: none, broken and dense.

None	-	no shading
Broken	-	some direct sunlight hits the water surface in the shade-affected area when the sun is directly overhead.
Dense	-	5% or less of the shade-affected area receives direct sunlight when the sun is directly overhead.

Record the actual percentage in the relevant shade box. Percentage categories may be recorded in addition if required for comparison with historical data.

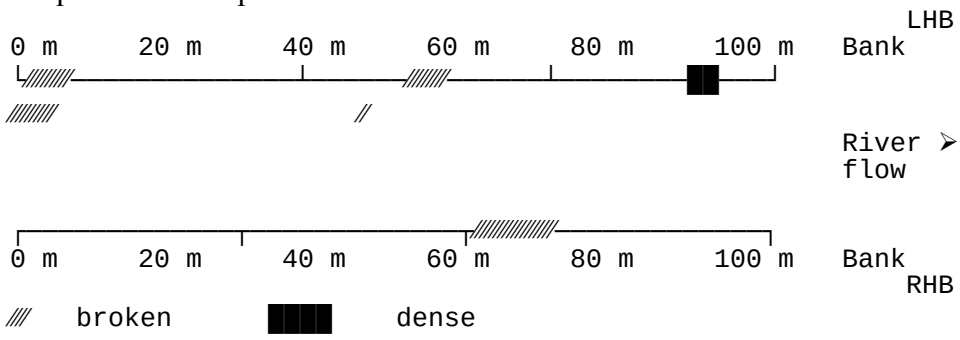


Figure 2 Illustration of shading

(Only shading affecting the channel is counted, therefore in Figure 2, where shading blocks cross the channel definition line they are counted as a half block)

The channel illustrated in Figure 2 would be recorded as:-

Shading	Left bank	None	**91**	Broken	**8**	Dense	**1**
	Right bank	None	**97**	Broken	**3**	Dense	**0**

Quality assurance

Carefully follow the method for estimating shade described and refer to the sketch map. If you are not sure about actual measurements, record the shading of the channel on the sketch map very carefully and on return to the office check with a colleague.

4.6.10 Water clarity or transmissivity SEE SITE PROTOCOL (optional for comparison with existing datsets)

Record the actual percentage of the channel in each water clarity category or use a Secchi disc. More than one category may be present as a survey length may be clear in the shallow margins and progress through cloudy to turbid as the water depth increases. Percentage categories may be recorded in addition, if required for comparison with historical data.

Clear - Channel substrate is clearly visible at all depths, as are macrophyte species.

Cloudy - Slightly discoloured with a moderate load of suspended solids 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.

Turbid - Strongly discoloured, carrying a heavy load of suspended solids and having greatly restricted 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.

Quality assurance

Consider the clarity throughout the length while surveying and assign percentages accordingly. It is likely that the same category will apply throughout a 100m survey length.

4.6.11 Bed stability SEE SITE PROTOCOL (optional for comparison with existing datsets)

The following 4 classes are used to define bed stability:

Solid/firmly bedded	-	eg bedrock/compacted clay, increased flow has little effect
Stable	-	eg boulders/pebbles/gravel, unlikely to be significantly altered by increased flows
Unstable	-	eg gravel/sand/silt/mud, likely to be dislodged by increased flows
Soft/sinking	-	eg deep silt/mud, makes channel unwadeable, bank stick penetrates easily into substrate.

Record the actual percentage of the channel in each of the above bed stability categories. Percentage classes/categories may be recorded in addition, if required for comparison with historical data.

4.7 Laboratory Analysis

4.7.1 Equipment

Binocular microscope, microscope slides
Hand lens × 10
White tray, forceps, dissecting needle
Identification keys
Plant press
Mounting paper and glue
Refrigerator

4.7.2 Reference collection (herbarium)

A reference collection of dried/pressed macrophyte specimens should be compiled and added to as new species are found in the area. Fruiting and flowering parts should be included. Verify identification of the fresh specimen with other experienced members of staff. Once pressed, label each specimen and list its key identification features. Do not include rare species in the collection but use photographs and annotated field drawings instead. The reference collection would be best kept in a cabinet with many shallow draws to avoid crushing of the dried specimens. As dried specimens are fairly brittle care should be taken when handling them. Slides of macrophytes can also be useful as part of a reference collection. Index the reference collection using an index card box file. Group the cards, but have a separate card for each species, detailing identification features and information available.

A collection of 'difficult' specimens, to which reference may need to be made for quality assurance purposes, should be compiled either as an integral part of the reference collection or as a supplementary collection in its own right.

4.7.3 Preservation of macrophytes

Refer to Bridson and Forman (1992) and Moore (1986) for full details of equipment and methods.

The majority of macrophytes are suitable for pressing. The identified macrophyte specimen should be floated in a shallow tray containing water. A piece of smooth, shiny, drying paper or good quality cartridge paper should be placed under the macrophyte and then lifted from the tray. Fine adjustments of the macrophyte position are then made, so that all attributes can be seen. A pipette and brush may facilitate such adjustments. A second piece of labelled (use a waterproof marker/pencil) drying paper is placed on top of the macrophyte. Layers of newspaper/other absorbent paper are placed either side of the macrophyte and paper sandwich, and the whole thing is placed in a flower press, which is then shut. Use a corrugate between layers if available to add air circulation and hence aid drying — keep the press size small if no corrugates are available. Pressure should be evenly applied. The press should be stored in a dry atmosphere. The absorbent paper should initially be changed after 24 hours and then after a further 48 hours. Regularly change the absorbent paper until the macrophyte specimen is completely dry.

Charophytes can be kept by preserving them in 4% formalin or by drying (Moore 1986, pp. 26–28). For mucilaginous species, the drying sheet should be covered with a piece of waxed paper or polythene so the specimen does not stick to the drying paper in the plant press.

4.7.4 Storage and identification

Macrophyte specimens collected in the field will persist in good condition for several days if placed in plastic bags or lidded tubes **without** additional water. Blowing into the bag before it is sealed prevents crushing and may help to preserve samples. The sealed bag/tube stops the specimen drying out; adding no extra water means the specimen does not turn into an unidentifiable soggy mass. On return to the laboratory store the samples in a refrigerator.

The exception to this is filamentous algae. A sample should be placed with a small amount of water into a labelled tube, ensuring that there is a large air space above the water. As above, the tube should be stored in a refrigerator on return to the laboratory. A few drops of ethanol may extend the period for identification but may extract the chlorophyll (formalin should not be used). Alternatively, Lugol's iodine may be used to preserve the sample (Jones 1979).

Identify specimens one at a time as it is extremely important that the correct macrophyte is recorded under the correct survey and abundance class.

In a filamentous algae sample the dominant species should be recorded. For example, a filamentous algae mass consisting mainly of *Cladophora* will also contain small amounts of other species, but only the *Cladophora* needs to be recorded.

5 QUALITY ASSURANCE

This chapter highlights the main sources of error and variation in STAR survey results, and the need for a quality assurance procedure to reduce these. It then gives detailed guidance on quality assurance for STAR surveys, including training requirements and protocols for audit surveys based on an assessment for MTR (Dawson et al 1999).

5.1 Introduction

5.1.1 Sources of error and variability

Surveyor error and differences between surveyors

The most common sources of surveyor error and variation between surveyors are:

- differences in estimates of macrophyte cover;
- incorrect identification of macrophytes, especially of *Ranunculus* species and some species of bryophytes;
- missed species, where present only in isolated small ($\leq 25 cm^2$) patches;
- differences in interpretation of which specimens are 'in' and 'out' of the channel;
- errors in accurately locating the survey length.

All can be reduced by provision of adequate training, correct application of the method and adoption of quality assurance measures.

At the survey stage, particular attention should be paid to strict adherence of the survey methodology, taking adequate time to estimate percentage cover values, retaining representative samples of 'difficult' specimens for subsequent confirmation of identification, looking out for small patches of macrophytes, ensuring that the sketch map is accurate, and ensuring that the survey length is located correctly.

At the data interpretation stage, allowance for surveyor variation is made in the guidance given in Chapter 6: the STAR score must change by at least 4 units or 15% for it to be deemed significant in terms of ecological status, this being greater than the median difference which may be expected from inter-surveyor variation. Individual species percentage cover estimates should be approached with care due to their semi-quantitative nature. Only gross changes in percentage cover should be considered worthy of note and it should be remembered that the estimation of SCVs can vary between surveyors by up to 2 units (abundance classes) for the majority of the time.

Background variation in STAR

The STAR score varies within the survey season, with a mean difference of 7.5% between surveys undertaken at the same site but at different times within the season (Dawson et al 1999b). Allowance for within-season variation is made in the guidance on survey timing and interpreting results: surveys in consecutive years at the same site should be undertaken at the same time of the survey season every year, and STAR score must change by at least 4 units or 15% for it to be deemed significant, this being twice the mean difference to be expected from within-season variation.

Other temporal changes in the STAR score which may arise, for example due to natural cycles of plant growth, river conditions or river management works, are allowed for by use of the suffix of confidence in the survey.

The STAR may also be influenced by the size of the river, its slope, substrate size, underlying geology and the altitude of its source, as well as by nutrient status or other chemical determinands. Allowance for this source of variation is made in the guidance provided on selecting survey lengths and interpreting results: site comparability is one of the factors to be taken into account when selecting survey lengths (Box 2) and survey lengths should only be compared if they are physically similar (as expressed by the suffix of confidence, 4.6.12).

5.1.2 The need for quality assurance

It is important that the sources of variation outlined above are reduced so that maximum possible confidence can be placed in the accuracy, or 'quality' of survey results. This is normally achieved by application of a quality control procedure, the aim of which is to minimise unavoidable errors in carrying out the survey methodology; set quality targets and determine whether these are being met; and provide a means for restoring quality if targets are not met.

Most standard quality control systems which are used for other biological surveys and chemical analyses, such as control charts, ring sorts and resorting of samples, are not appropriate for macrophytes. Macrophyte surveys produce data directly from a field survey. No samples are taken, except for those required for identification or confirmation purposes. Re-surveys alone are probably not sufficient, as they occur after the surveys have been undertaken and real changes may have occurred in the interim. In addition, the de-limitation of the 'sample unit' available to the re-surveyor (the upstream and downstream limits of the survey length and the definition of the 'channel') is itself integral to the methodology and open to error.

The requirement for STAR surveys is therefore for a system of quality assurance, aimed at minimising errors. Several aspects of STAR surveys can undergo quality assurance to a greater or lesser degree. These include:

- operation of the method
- number of species
- abundance categories
- overall percentage cover
- identification
- database entry accuracy

In addition, relocation of survey lengths can be audited if required. This is recommended where survey results at any one site are to be analysed from more than one visit (such as for UWWTD monitoring) and the surveys undertaken by different a surveyor(s) on each occasion.

Quality assurance measures relating to many of the above are described as an integral part of the implementation of the survey and the calculation of the STAR (shaded boxes in chapters 4 and 5). These MUST be adhered to as a very minimum. It is strongly recommended, however, that the following additional measures are also implemented to ensure the highest possible quality of data is maintained throughout the application of the method. These include:

- training (7.2)
- audit surveys (7.3)
- inter-calibration exercise (7.4)
- data storage (7.5).

5.2 Training

Each member of staff must have a personal training record with details of all courses and on-the-job training received.

All surveyors should receive basic safety training. This may also include boat handling courses and First Aid training if appropriate.

In addition to this basic training, training must be provided in the specific areas of STAR survey methodology, STAR calculation, database entry and interpretation of results.

5.2.1 New staff

The areas in which new staff must be trained are:

Identification

A basic macrophyte identification course is needed before any surveys are undertaken. This course should cover all the commonly occurring macrophytes found in the locality. The new staff member, or a surveyor transferred from another geographical region, should look through, and become familiar with, the reference collection and identification guides.

Method

New staff members must read this manual and accompany an experienced surveyor for field training. Resulting data and identification should be checked by another surveyor. Until the supervisor is confident of the proficiency of the new surveyor, the surveyor should accompany other surveyors for on-the-job training. All new members of staff should attend the annual method training and quality assurance exercises.

It is very important that new members of staff are made aware of the importance of the accuracy required when making estimates of percentage cover values for individual species. Regular training exercises should be carried out throughout the season.

Data handling

This should take the form of in-house training by an experienced member of staff.

5.2.2 Maintaining skills

Minimum requirements

Macrophyte surveys can only be carried out during the summer months, resulting in a lengthy gap between consecutive survey seasons. To improve and maintain survey quality, each surveyor must undergo the following essential training:

(i) each surveyor must read (or be trained in) this manual at the start of each survey season; and
(ii) each year, each surveyor must either undertake a set minimum number of STAR or other macrophyte surveys (the suggested minimum is five surveys per year), or attend a training course at which STAR surveys are undertaken (this may be the 'refresher' course described below).

At the beginning of the survey season, surveyors who did not achieve the minimum requirement of (five) surveys in the previous year should not undertake further surveys until they have received STAR training. (Note that this is referring to the number of surveys not the number of pairs/sets of surveys up- and downstream QDs. Refer to the glossary for the definition of survey.)

Annual 'refresher' course

It is recommended that all surveyors attend an annual 'refresher' course in survey techniques and identification skills each year. This course may contribute to the minimum training requirement cited above. The course should be held at the start of, or early in, the survey season and should encompass all aspects of the survey method with particular attention to the subjective estimates.

The course should include:

- an overview of how to carry out an STAR survey;
- at least one standard STAR field survey with discussions at each stage, including the identification features of macrophytes found in the survey length;
- a exercise designed to estimate percentage cover of macrophyte species in the field and to compare estimates between surveyors;
- an identification exercise whereby each surveyor individually identifies a set of specimens provided and the identifications are then discussed so everyone learns from the exercise.

5.2.3 On-going training

It is recommended that more experienced staff from each area office should attend an advanced macrophyte identification course(s). This should cover macrophytes which are 'difficult' to identify to species level, such as some *Ranunculus*, fine-leaved *Potamogeton*, *Callitriche* and Bryophyte species. These staff will then be able to help with identification confirmation.

5.2.4 Exceptions

The only exceptions to the above recommendations regarding training are where, in a team of three or more, a member of the team is assigned tasks not requiring macrophyte identification skills, ie assigned to neither the assessment of macrophyte presence/cover nor the drawing of the sketch map. Tasks to which this team member may be assigned include, for example, the recording of macrophyte presence/cover (not the assessment), the assessment of the physical characteristics of the site and/or handling of the boat. In such a case, there is no requirement for this team member to be trained in macrophyte identification. This is subject, however, to at least two members of the team being fully trained in all aspects of the methodology. All members of the team should be trained in the general operation of the method.

5.3 Audit surveys

5.3.1 General

Audit surveys (repeat surveys for quality assurance purposes) are useful in monitoring consistency of performance between surveyors/survey teams, highlighting mis-application or mis-interpretation of the method, and thus providing an additional means to minimise errors. Two re-survey protocols are described below — Level 1 and Level 2 — each delivering a different level of specification in terms of quality assurance, and each requiring a different resource investment. The choice of which level to adopt will depend on the purpose of the survey programme, the resources available and the cost-benefit/value-for-money. If a sufficient number of surveys are to be carried out within a survey season,

then it is possible to assign some surveys to Level 1 and other to Level 2 audit protocol, as appropriate. The audit programme for each level can be undertaken separately but concurrently.

The level of audit protocol adopted for each primary survey should be indicated by marking the relevant box on the field sheet. The standard field recording sheet should also be used for audit surveys and data should be archived and analysed as for primary surveys.

To avoid confusion with re-surveys undertaken as a result of action triggered by the QA process itself, re-surveys undertaken for audit purposes are hereafter termed 'audit surveys'. For simplicity, any reference below to 'primary surveyor' or 'auditor' may refer either to a single surveyor or a team led by a 'principal surveyor' (3.3.8, 7.3.6).

5.3.2 Level 1 Audit Protocol: high specification, 'very best practice'

This protocol provides a high specification quality assurance system which aims to ensure that quality never drops below a set threshold. It incorporates: an objective assessment of consistency; quality targets; and actions to take when targets are not met to ensure that a very high quality is maintained. It is most suitable in circumstances where the purpose of the survey demands maximum quality of results and where resources and time allow. In other circumstances it may be neither practical nor represent value-for-money.

The procedure to follow is described in Box 9. Note that the last primary survey of the season needs to be sufficiently early to allow the entire last batch of surveys to be re-surveyed before the end of the season if necessary. The criteria for differences between primary and audit surveys to be deemed as being significant (point 5 in Box 9) are based partly on the results collated as part of the evaluation of the STAR (Dawson et al 1999b) and partly on levels of difference found in a small study of re-surveys in Anglian Region of the Agency (Environment Agency 1996b), which found that 87% of scoring taxa were recorded within one SCV and 94% within two SCV. Criterion (v) is set at a level which is greater than the median difference between audit and primary surveys analysed by Dawson et al (1999b) and is assumed to be outside the normal deviation when sampled correctly by the same surveyor on different occasions.

5.3.3 Level 2 Audit Protocol: moderate specification, best practice

The aim of this protocol is to improve the quality of the results by improving the quality of the surveyor; with a 'safety net' to rectify gross mistakes. This provides a lower specification of quality assurance than the Level 1 protocol, incorporating: an indication of consistency; quality targets; and measures to both minimise identified errors being repeated in future surveys and to correct gross errors in previous surveys. It is most suitable in circumstances where maximum quality of results are preferred but resources and time do not allow Level 1 protocol; and/or where the purpose of the survey does not demand Level 1 protocol. All efforts should be made to comply with this level of QA protocol.

The procedure to follow is given in Box 9. The option to inform the primary surveyor prior to the audit survey means that if necessary the surveys can take place on the same day ('double-surveys'), which eliminates errors arising out of changes occurring in the time lapse between surveys. If survey length relocation is to be included as an element to be audited, then the primary surveyor and auditor must not confer about demarcation of the survey length limits; if not included, then conferring is allowed, thus eliminating a further source of error. Under no circumstances, however, is conferring or discussion allowed on any other element of the survey.

5.3.4 The auditor

The site **must** be relocated accurately. It is, therefore, essential that the auditor has a copy of the sketch map pointing out distinguishing features.

The auditor must be able to go out at short notice. Surveying is weather dependant, so although basic timing of the surveys is planned the actual timing may differ.

The auditor must be experienced both in identification skills and the method. The auditor must have attended an approved training course in the standard methodology.

More than one person will probably be needed to audit a site, depending on its physical nature.

Audit surveys may be undertaken by either an internal or an external auditor

Internal quality surveyor

This is an experienced member(s) of staff from within the same organisation. The advantage of internal quality surveyors is that they will have been trained to use the method in the same way as the primary surveyors and so this should lead to more consistency in the resulting audit; thus reducing the possibility that any differences recorded are due to different interpretations of the method. The disadvantages arise from conflicts of interest between the audits and other biology work. It is preferable if some of the audits are done by surveyors from other teams, to improve national consistency.

External quality surveyor

This is an external expert. This may be difficult to organise, however, especially as the audits need to be done at short notice. There may also be problems in ensuring the external surveyor is using the method in the same way as internal staff. They must, however, have read this manual and attended an approved STAR training course prior to commencement of the audit surveys. It may be necessary for an internal member of staff who is not involved with any STAR surveys to organise the audit surveys and to liaise between the primary surveyors and the external auditor.

5.3.5 Circumstances where an audit survey is not appropriate

Sites where the physical nature of the survey length makes it difficult to undertaken an adequate survey (eg the river bed is obscured due to turbidity/depth of water, or access is difficult) may be excluded from the selection of surveys to audit. The same methodology should always be used for the audit survey as was used in the primary survey. In cases where the survey length has become unsuitable for survey in the intervening period between the primary and audit survey, then the audit survey should not be undertaken. If sufficient surveys remain in the 'batch', then an alternative survey may be selected for audit.

5.3.6 Staffing level

A minimum of double-staffing is recommended as good practice (3.3.8). Where surveyors work consistently together in the same team, the 'surveyor-unit' to be assessed for QA purposes is the team, under the direction of the principal surveyor, rather than the individual surveyors. Similarly, an audit survey can be undertaken by a team, under the direction of a 'principal surveyor'. In such cases, read 'team' in place of 'surveyor', 'primary surveyor' or 'auditor'. Where the composition of the team is not consistent, then the 'surveyor-unit' to be assessed is the principal surveyor.

Box 9 Audit procedure

1. At the start of the survey season a surveyor not involved with the primary surveys is appointed as auditor (see 7.3.4). The auditor is provided with details of the planned survey programmes, including anticipated dates and a copy of the survey site sketch map and location description for each site. If the site has not been surveyed before then the map and description can be forwarded to the auditor immediately upon completion of the primary survey.

2. Before the survey programme begins, the auditor selects, at random, those surveys to be audited. One survey is selected for each 'batch' of 10 consecutive surveys (or part thereof), with a minimum of one survey audited per season for each primary surveyor/survey team [1].
   Level 1 protocol: the primary surveyor is not informed of the selection.
   Level 2 protocol: the primary surveyor may be informed of the surveys selected.

3. Immediately upon completion of the primary survey, the surveyor(s) informs the auditor that the survey has been completed and is available for audit. The auditor must then undertake a re-survey of the site as soon as possible after the primary survey, to reduce differences due to external factors (eg heavy rain, reduced flows, management work such as weed cutting, seasonal changes in abundance, level of identification possible due to presence or absence of flowers/fruiting bodies). If conditions remain unchanged an audit survey may be done up to two weeks from the time of the primary survey, although this may not be acceptable where floating species are present. The most reliable results will be obtained if audit surveys are done as soon as possible.
   Level 1 protocol: the audit survey is undertaken without the knowledge of the primary surveyor(s) and there is no conferring or discussion about the site/survey until that batch of primary surveys is completed.
   Level 2 protocol: the primary surveyor is informed immediately after the audit survey that the audit has taken place.

4. Audit survey results are compared with those of the primary survey and the differences identified. Parameters to compare are: number of species, species names, SCVs, STAR and overall percentage cover.
   Level 1 protocol: this takes place immediately after the batch of surveys has been completed, but not before.
   Level 2 protocol: this takes place immediately after the audit survey, regardless of whether the batch of surveys has been completed.

5. Differences between primary and audit surveys are deemed significant if any of the following criteria are met: [2]
   i) 3 or more species missed, recorded or identified incorrectly
      (or 4 or more missed, if 20 or more scoring species on the primary survey)
   ii) 10% or more of the SCV values differ by 3 or more SCV units
   iii) 20% or more of the SCV values differ by 2 or more SCV units
   iv) difference of more than 15 percent points in overall percentage cover
   v) difference of more than 4 in the STAR (either direction).

continued.....

Box 9 Audit procedure *(.....continued)*

6. If significant differences are found then the primary surveyor and auditor meet together to determine the reason(s) for the differences and whether they are attributable to surveyor error.

   Possible reasons for differences due to surveyor error include:
   - survey relocation
   - missed species
   - mis-identification of species
   - mis-recording of species
   - errors in estimation of abundances
   - mis-calculation of the STAR.

   Factors other than surveyor error which may cause differences include:
   - management work taking place between the two surveys
   - poor survey conditions on one of the surveys
   - natural changes in the macrophyte community, eg following a spate
   - change in nutrient concentration in the water (with the possible exception of species such as *Cladophora*, however, the flora is unlikely to respond to nutrient changes in the short time between primary and audit surveys).

   In some cases, the determination of the reason(s) may be relatively easy, for example: mis-identification of a specimen retained in a herbarium or re-calculation of the STAR. In other cases, it may be resolved by analysis of the sketch map and/or a return to the site: for example, confirmation of whether a particular isolated specimen was in the survey length or just outside; or confirmation of a dominant and abundant macrophyte. Reference to the suffix of confidence in the survey and to weather conditions between the two surveys should help eliminate, or otherwise, differences being due to changes in the physical conditions of the site. In yet other cases, however, determination of the reason(s) for the difference(s) may be impossible. In these cases, a re-survey may be required with both surveyors in attendance (this may be required anyway if using the Level 1 protocol). If the dispute is about % cover estimates, a qualified third party referee may be useful.

   Do not assume that the audit survey is necessarily the more correct of the two surveys being compared. The audit only identifies differences not errors. Only when inconsistencies are analysed by both surveyors, with a third party referee if necessary, can it be determined where actual errors lie.

7. Action is taken according to Table 2. Note that in cases of error by the primary surveyor, all surveys in the batch must be re-surveyed for the Level 1 protocol but only selected (if any) re-surveys are required for the Level 2 protocol.

1. Refer to the definition of survey in the glossary. Individual surveys are audited, not pairs/sets of surveys up- and downstream QDs.
2. It is recommended that these criteria are reviewed nationally in the future.

Table 2 Reasons for mismatch between primary and audit survey, with suggested actions

REASON	ACTION REQUIRED	EXAMPLE(S)
Changed conditions in the time lapse between the primary and audit survey.	The comparison is rendered invalid for quality assurance purposes. Another survey can be selected from the remainder of the batch for audit, if following the Level 2 protocol and the batch is not complete. Otherwise the batch of surveys must be deemed as not to have been subject to quality assurance. In either case, greater effort should also be placed in future into reducing the time lapse to a minimum.	Examples include where changes in flow conditions have either up-rooted macrophytes or caused a change in their abundance; or where species (eg *Enteromorpha*) have been washed from the site.
Survey length relocation error.	Unless the difference can easily be resolved by a return visit to the site by both primary surveyor and auditor, the comparison is rendered invalid for quality assurance purposes (actions as above). Greater effort should be placed in future on producing and using accurate location instructions.	
Error by the auditor.	The comparison is rendered invalid for quality assurance purposes (actions as above). Take measures to ensure that mistakes are not repeated in either future surveys or audits.	
Difference in STAR score due to mis-calculation of the STAR score on the part of the primary surveyor. *	Validate the STAR calculation on all surveys in the batch (for Level 1 protocol) or all previous surveys in the batch (for Level 2). Take extra care in future to ensure that such mistakes are not repeated (computerised calculation of STAR values will assist in the latter, especially if compared with hand-calculated values immediately after data input).	
Survey error(s) on the part of the primary surveyor.	Action required depends on level of audit protocol adopted. Level 1 protocol: Re-survey all surveys in the batch, compare with primary surveys and agree which results are correct. Level 2 protocol: Identify previous surveys in the batch which are likely to be in gross error due to the same mistake and validate the survey results. 'Gross error' is defined as an error which could significantly change the interpretation of ecological status. Validation may be achieved in the office/laboratory, or it may require the primary surveyor and auditor returning to the site without having to do a full re-survey. In other cases, where validation cannot be achieved with confidence, a full re-survey may be necessary. Verify or agreeing the 'correct' record and take steps to ensure that the mistake is not repeated in future surveys.	Examples of cases where re-surveys may be considered for Level 2 protocol: (1) if the error is a mis-identification, then only those surveys in the batch where the 'mis-identified' species has been recorded in abundance may need to be re-surveyed; (2) if the error is solely in abundance estimates, but relates specifically to, say, the estimation of a sparse but widespread cover of *Cladophora*, then the only surveys which may need re-surveying are those where a sparse widespread cover of *Cladophora* were present.

* *Note: as errors solely due to mis-calculation do not require re-survey, verify the accuracy of the calculation before investigating further/other reasons for the STAR difference, but remember that a difference in STAR could be due to both mis-calculation and some other reason(s).*

5.4 Inter-calibration exercise

It is recommended that each surveyor should attend an inter-calibration exercise every year. This is designed to assess the level of consistency between surveyors and has some similarities to a Level 2 audit survey, but involves more surveyors and the surveys are always done simultaneously on the same day. The inter-calibration may be between individual surveyors within a team, or between survey-

teams. Preferably, the exercise should be held once some macrophyte surveys have been completed rather than at the beginning of the survey season, although it can be combined with the annual refresher training. The difference between the refresher training and the inter-calibration exercise is that the former includes instruction in the method (even if only an overview of the key points), whereas the inter-calibration need only involve a field comparison of surveys. If the two are combined, then the inter-calibration can form the final part of the field training session.

All participants meet in the field, with one person having overall responsibility. A 100m survey length is then selected and marked, and each surveyor individually surveys this length. The exception to this is where surveyors consistently work together in teams, whereby the survey-team is the surveyor-unit being assessed. In these cases, individual teams survey the site under the direction of the usual 'principal surveyor'. Abundance of individual macrophyte species is recorded using the 9-point Scale .

Although the drawing of a sketch map is optional for assessment purposes, at least one sketch map should be drawn per exercise, with relocation features for future reference. Results of the surveys should not be discussed until after all surveys have been completed.

Data should be analysed afterwards to determine the level of consistency between surveyors. A report should be produced on the data, identifying inconsistencies and recommending measures to address them, eg any areas where further training is needed. As with the Level 2 QA protocol, this inter-calibration allows for an on-going assessment of the errors involved in all aspects of the surveying.

Where possible, different types of site should be surveyed in this manner. It should be remembered that results from turbid and/or deep water sites will not be as accurate as those where the bed is visible at all times.

5.6 Survey length selection

If there is any cause for concern that a survey length is not in an appropriate place to detect differences in STAR index due to a change in eg. habitat or nutrient concentration (or other factors) then due consideration should be given to changing the survey length within the parameters set out in the section for survey length selection (3.3.3 and Box 2). If this is not possible then discussion should be held to establish a better sampling site.

Survey length selection is essentially governed by a common sense approach to using the guidelines set down in this manual. If for any reason the survey length does not produce results which are useful for the intended purpose it may not be possible to use this method for an assessment of the ecological status of the water at that site and consideration should be given to using other methods.

6 STAR BEST PRACTICE CHECKLIST

This chapter summarises best practice for STAR surveys, as a "do" (_) and "don't" (×) checklist.

6.1 Uses of STAR macrophyte survey and score

_ The STAR may be used for the assessment of other point-sources of nutrients, but is not yet proven for applications other than UWWTD monitoring.

× Do not make direct comparisons of STAR values between rivers of different physical types.

× Do not use the STAR to assess the ecological status of standing waters, canals (unless the water flow is constant in one direction) or rivers with a tidal influence.

6.2 Survey planning

× Do not use STAR macrophyte methodology in isolation. Use all biological and chemical information available to decide the status of a site for WFD designation

_ Undertake whole catchment or sub-catchment studies wherever possible, to place STAR scores in context.

_ Continue to carry out STAR surveys after the introduction of nutrient reduction measures, including upstream and possibly 'control' sites to establish the natural background variation.

_ At each site, carry out at least one survey per year for a minimum of three years, between mid-June and mid-September in central and northern Europe (inclusive), at the same time of the season each year.

_ Select the survey site and survey length with care, selecting physically comparable sites where possible and taking into account the various factors which may influence the survey results.

_ Plan surveys so that they can be undertaken by a minimum of two operators.

_ Collect background information on geology, altitude and slope. Find out whether river management work is scheduled or has been undertaken, and whether pollution incidents have occurred.

6.3 Survey methodology

_ Check equipment list before departure to field sites and follow health and safety guidelines at all times.

× Do not survey during or after periods of high flow, flooding or management operations, nor in windy conditions, turbid water (unless normal) or periods when boat traffic is heavy.

_ Check that the survey length is correctly located and paced measurements are accurate.

_ Cross the survey length every 2.5m in a zig-zag manner, surveying the whole river width if possible.

× Do not guess percentage cover estimates. Estimate on the basis of observation, using one of the methods of estimation recommended in this manual.

_ Use a grapnel, glass-bottomed bucket and/or an underwater TV camera where appropriate, to aid observation and identification of macrophytes. Take particular care to look for small patches of macrophytes.

× Do not use grapnel samples to estimate percentage cover: only record percentage cover based on observation of plants *in situ*.

_ Identify macrophytes to species level where possible. Take representative specimens of 'difficult' species back to the laboratory for confirmation of identification. Maintain a herbarium.

× Do not record macrophytes overhanging, but neither attached nor rooted in the channel.

_ Record physical variables, make a sketch map and take a photograph.

_ Fill in all the details on the survey sheet at the time of the survey, except for the SCV total, CVS total, STAR score and data-archiving details. Assign a measure of confidence in the survey (A, B or C) and in the physical comparability of sites (I, II or III) before leaving the site or shortly afterwards.

× Apply extreme caution to STAR results assigned a suffix of confidence of 'C' and/or 'III'.

6.6 Quality assurance

_ Ensure that all staff involved in surveys have undergone the statutory training courses and annual refresher courses, and that for all the macrophyte species likely to be encountered, there is at least one member of staff who can identify them accurately.

× Do not undertaken STAR surveys unless you have attended a training course on the method and until you have read this manual.

_ Adopt one of the two recommended audit protocols: Level 2 is the recommended minimum.

_ Carry out audits of selected sites on a random basis within 2 weeks of the primary survey.

_ Take action immediately if audit mismatch criteria are met. Discuss significant differences between primary and audit surveys to establish the causes for differences and re-visit or re-survey the site if necessary to confirm the reasons for the differences (or as required by the audit protocol).

× Do not assume that the audit survey is always more correct than the original.

_ Check all results, database entries and audit survey results on a regular basis, and take appropriate action if errors are discovered.

7 REFERENCES see Mean Trophic Rank: A User's Manual R&D Technical Report E38., Environment Agency of England and Wales, NTH Holmes, JR Newman, S Chadd, KJ Rouen, L Saint and FH Dawson

APPENDICES

Appendix 1 Rare plants

Appendix 2 Foreign invasive plant species

Appendix 3 Identification guides and preservation manuals

Appendix 4 Equipment suppliers

Appendix 5 Standard record sheets

Appendix 6 Summary of methodology, definitions and equipment checklist and glossary terms

Appendix 7 Circulars to surveyors on development of STAR macrophyte methodology

Appendix 8

Appendix 9

Appendix 1 Rare plants - Example list for UK

Red Data Book ** and Nationally Scarce* macrophytes associated with running waters:

Potamogeton acutifolius **	Sharp-leaved Pondweed
*Potamogeton nodosus***	Loddon Pondweed
*Callitriche hermaphroditica**	Autumnal Water-starwort
*Carex aquatilis**	Water Sedge
*Ceratophyllum submersum**	Soft Hornwort
*Eleocharis acicularis**	Needle Spike-rush
*Myriophyllum verticillatum**	Whorled Water-milfoil
*Nymphoides peltata**	Fringed Water-lily
*Potamogeton coloratus**	Fen Pondweed
*Potamogeton compressus**	Grass-wrack Pondweed (listed as a priority species in the UK Biodiversity Action Plan)
*Potamogeton filiformis**	Slender-leaved Pondweed
*Potamogeton friesii**	Flat-stalked Pondweed
*Potamogeton praelongus**	Long-stalked Pondweed
*Potamogeton trichoides**	Hairlike Pondweed
Luronium natans	Floating-leaved Water-plantain (listed in Annexes II & IV of the EC Habitats Directive, Appendix I of the Bern Convention and as a priority species in the UK Biodiversity Action Plan)
Callitriche truncata	Short-leaved Starwort

Team leaders should provide surveyors with a list of important national species

Appendix 2 Foreign invasive plant species - example produced for UK

Several foreign species of macrophytes have become established in the British Isles. Some of which are considered to be nuisance vegetation as they have spread rapidly and compete with other native species. While surveying for river macrophytes it takes little time to note the presence of these species. The species to look out for are:

River species:

The following species are assigned a Species Ecological Rank. Their presence can affect the distribution/abundance of natives.

Canadian Pondweed	*Elodea canadensis*
Nuttall's pondweed	*Elodea nuttallii*
Water-fern	*Azolla filiculoides*
Sweet-flag	*Acorus calamus*

Others to note:

Australian Swamp Stone-crop	*Crassula helmsii*
Cape Pondweed	*Aponogeton distachyos*
Beggar-ticks	*Bidens frondosa*
Large-flowered Water-thyme	*Egeria densa*
Curly Water-thyme	*Lagarosiphon major*
Lupin	*Lupinus nootkatensis*
Pink Purslane	*Montia sibirica*
Winter Heliotrope	*Petasites fragrans*
	Petasites japonicus
Canary Grass	*Phalaris canariensis*
Swamp Meadow-grass	*Poa palustris*
Tape-grass	*Vallisneria spiralis*
Purple Iris	*Iris versicolor*
Indian Balsam	*Impatiens glandulifera*
Orange Balsam	*Impatiens capensis*
Giant Hogweed	*Heracleum mantegazzianum*
Japanese Knotweed	*Polygonum (Reynoutria) japonica*
Monkey flower	*Mimulus guttatus*

Information from SERCON lists and pers comm. Nigel Holmes.

Appendix 3 Identification guides and preservation manuals

IDENTIFICATION KEYS AND LIST OF CHECK LISTS draft proposals
compiled by Kvd Weyer, FHD, PDS TF & NH –
please send updates by country to FHD for addition to manual

Rhodophyta
GAMS, H. 1969: Makroskopische Süßwasser- und Luftalgen. In: GAMS, H. (Hrsg.): Kleine Kryptogamenflora, Band Ia, G. Fischer, Stuttgart
PASCHER, A.; SCHILLER, J., MIGULA, W. 1925: Heterocontae, Phaeophyta, Rhodophyta, Charophyta. Süßwasserflora von Mitteleuropa, Bd. 11
ROTHMALER, W. 1994: Exkursionsflora von Deutschland, Bd. 1, Niedere Pflanzen. 3. durchgesehene Auflage, Spektrum Akademischer Verlag, Heidelberg/Berlin

Characeae
KRAUSE, W. 1997: Charales (Charophyceae). In: ETTL, H., GÄRTNER, G., HEYNIG, H., MOLLENHAUER, D. (Hrsg.): Süßwasserflora von Mitteleuropa 18: 202 S., G. Fischer, Jena/Stuttgart/Lübeck/Ulm
WEYER, K. VAN DE, RAABE, U. 2001: Bestimmungsschlüssel für die bisher in Nordrhein-Westfalen nachgewiesenen Armleuchteralgen-Gewächse (Characeae), 3. Fassung, Stand: Februar 2001, Polykopie und www.lanaplan.de/makrophyten
WOOD, R. D., 1965: Monograph of the Characeae. In: WOOD, R. D. & IMAHORI, A.: Review of the Characeae I.: 903 pp., J. Cramer (Weinheim).

Bryophyta
FRAHM, J. P. 1998: Moose als Bioindikatoren: 187 S., Biologische Arbeitsbücher, Quelle & Meyer, Wiesbaden (mit einem Schlüssel „Wassermoose“)
FRAHM, J. P., FREY, W. 1992: Moosflora, 3. Auflage: 528 S., Stuttgart/UTB
SMITH, A. J. E. 1980: The Moss Flora of Great Britain and Ireland: 706 pp., Cambridge University Press/Cambridge, London, New York, New Rochelle, Melbourne, Sydney
SMITH, A. J. E. 1990: The liverworts of Great Britain and Ireland: 362 pp., Cambridge University Press/Cambridge, New York, Port Chester, Melbourne, Sydney
checklists: Mosses of the World (Missouri Botanical Garden):
http://www.mobot.org/MOBOT/tropicos/most/checklist.shtml
KOPERSKI, M., SAUER, M., BRAUN, W., GRADSTEIN, S. R. 2000: Referenzliste der Moose Deutschlands, Schriftenreihe für Vegetationskunde 34: 519 S., Bonn.
South Europe
CORLEY et al. (1981): Mosses of Europe and the Azores, J. Bryol. 11-609-689

Pteridophyta and Anthophyta
CASPER, S. J., KRAUSCH, H.-D. 1980/1981: Pteridophyta u. Anthophyta, 1. & 2. Teil, Süßwasserflora von Mitteleuropa, Bd. 23 & 24
HAEUPLER, H., MUER, T. 2000: Bildatlas der Farn- und Blütenpflanzen Deutschlands: 759 S. Ulmer/Stuttgart
HASLAM, S. M., SINKER, C. A., WOLSELEY, P. A. 1975: British Water Plants. Field Studies 1975 (4): 243-351
KRAUSCH, H. D. 1996: Farbatlas Wasser- und Uferpflanzen: 315 S., Ulmer
RICH, T. C. G., JERMY, A. C. 1998: Plant Crib: 391 pp.. Botanical Society of the British Isles, London

Proposals from Kvd Weyer
Angiosperms

Flora Europea

Bidens
RAABE, E. W. 1980: Über Bidens in Schleswig-Holstein und Hamburg, Kieler Notizen 12: 43-49

Callitriche
DERSCH, G. 1987: Zur Verbreitung der Callitriche-Arten (Wassersterne) in Niedersachsen. Gött. Flor. Rundbr. 20: 70-100
LANSDOWN, R. 2002: European Water-Starworts, BSBI Handbook, in press
SCHOTSMAN, H. D. 1967: Les Callitriches espèces de France et taxa noveaux d'Europe. 152 S., Paris
SCHOTSMAN: s. RICH, T. C. G., JERMY, A. C. 1998: Plant Crib: 391 pp.. Botanical Society of the British Isles, London

Gramineae
HUBBARD, C. E. 1985: Gräser, 2. Auflage: 475 S., Stuttgart/UTB
RAABE, E.W. 1975: Gramineen-Bestimmungsschlüssel. Kieler Notizen 7: 17-44

Hydrilleae
WOLFF, P. 1980: Die Hydrilleae (Hydrocharitaceae) in Europa. Gött. Flor. Rundbr. 14: 33-56

Lemnaceae
WOLFF, P., KLEINSTEUBER, A. 1998: Lemnaceae. In: SEBALD, O., SEYBOLD, S., PHILIPPI, G., WÖRZ, A.: Die Farn- und Blütenpflanzen Baden-Württembergs, Band 8: 266-279, Ulmer/Stuttgart

Myriophyllum
WIMMER, W. 1997: Myriophyllum heterophyllum Michaux in Niedersachsen und Bremen sowie seine Bestimmung im vegetativen Zustand. Flor. Rundbriefe 31: 23-31, Bochum

Nasturtium
BLEEKER, W., HURKA, H., KOCH, M. 1997: Zum Vorkommen von *Nasturtium sterile* (AIRY SHAW) OEF. in Südwestniedersachsen und angrenzenden Gebieten. Flor. Rundbriefe 31: 1-8, Bochum

Potamogeton
PRESTON, C. D. 1995: Pondweeds of Great Britain and Ireland. BSBI Handbook 8: 350 pp.
VAN WIJK, R. J., VERBEEK, P. J. M. 1986: De smalbladige fonteinkruidsorten in Nederland, Herkenning en oecologie. Wetenschappelijke medelingen K.N.N.V. 177: 37 pp., Hougwood
WEYER, K. VAN DE 1997: Untersuchungen zur Biologie und Ökologie von *Potamogeton polygonifolius* POURR. im Niederrheinischen Tiefland. Dissertationes Botanicae 278: 178 S. (Bestimmungsschlüssel für breitblättrige Sippen incl. Stängelanatomie)
WIEGLEB, G. 2002a: Familie Potamogetonaceae DMORT. – Laichkrautgewächse. In: ROTHMALER, Exkursionsflora von Deutschland, Band 4, Gefäßpflanzen, Kritischer Band, 9. Auflage: 739-746, Spektrum Akademischer Verlag, Heidelberg/Berlin

Ranunculus Subgenus Batrachium
WEBSTER S, RICH, T. C. G., JERMY, A. C. 1998: Plant Crib: 391 pp.. Botanical Society of the British Isles, London

WIEGLEB, G. 2002b: Ranunculus Subgenus Batrachium. In: ROTHMALER, Exkursionsflora von Deutschland, Band 4, Gefäßpflanzen, Kritischer Band, 9. Auflage: 156-158, Spektrum Akademischer Verlag, Heidelberg/Berlin

Utricularia

THOR, G. 1988: The genus Utricularia in the Nordic countries, with special emphasis on U. stygia and U. ochroleuca. Nord. J. Bot. 8: 213-225

Veronica anagallis-aquatica agg.

FOERSTER , E. 1967: Die Wasserehrenpreis-Gruppe. Gött. Flor. Rundbr. 1 (3): 10-11

Macrophyte Preservation:

Moore JA (1986) *Charophytes of Great Britain and Ireland*. BSBI Handbook No 5.

Bridson D & Forman L (1992) *The Herbarium Handbook Revised Edition*. Royal Botanic Gardens, Kew (ISBN 0 947643 45 1).

Books specific to Water Plants:

Haslam SM, Sinker CS & Wolsey PA (1982) *British Water Plants*. Field Studies Council, Nettlecombe, Taunton, Somerset.

Spencer-Jones D & Wade M (1986). *Aquatic Plants: A guide to recognition*. ICI Professional Products, Fareham, Surrey.

***Ranunculus* sp:**

Holmes NTH (1979) A Guide to Identification of Batrachium Ranunculus Species of Britain. Chief Scientist's Team Notes No 14. Nature Conservancy Council, Shrewsbury.

***Potamogeton* sp:**

Preston CD (1996) *Pondweeds of Great Britain and Ireland*. Botanical Society of the British Isles Handbook No. 8.

Course guides:

Holmes NTH. A Guide to Identifying British Aquatic Plant Species - accompanying guide to field course. (obtained through attending field course)

General books/keys:

Blamey M & Grey-Wilson. *Illustrated Flora of the British Isles*.

Clapham AR, Tutin TG & Moore DM (1989) *Flora of the British Isles*. CUP 3rd ed. (key)

Clapham AR, Tutin TG & Warburg EF (1981) *Excursion Flora of the British Isles* (3rd ed). Cambridge University Press. (key)

Garrard I & Streeter D (1983) *The Wildflowers of the British Isles*. Macmillan, London.

Keble-Martin W (1976) *The Concise British Flora in Colour*. Edbury Press and Michael Joseph.

Rich TCG & Jermy AC (1998) *Plant Crib*. BSBI, London, 392pp.

Rose F (1981) *The Wildflower Key*. Warne, London. (key)

Stace C (1997) *New Flora of the British Isles*. Cambridge University Press, 1130pp. (key)

Sedges:

Jermy AC, Chater AO & David RW (1982) *Sedges of the British Isles*. BSBI Handbook No 1.

Grasses:
Hubbard CE (1968) *Grasses* (2nd ed). Penguin.

Bryophytes:

Watson EV (1968) *British Mosses and Liverworts*. CUP, 495pp.
Smith AJE (1990) *The Moss Flora of Britain and Ireland*. CUP.
Smith AJE (1991) *The Liverworts of Britain and Ireland*. CUP.

Charophytes:
Allen GO (1950) *British Stoneworts (Charophyta)*. Haslemere Natural History Society.
Moore JA (1986) *Charophytes of Great Britain and Ireland*. BSBI Handbook No 5.

Algae:
Belcher H & Swale E (1976) *A Beginner's Guide to Freshwater Algae*. HMSO, London, 47pp.
Bellinger EG (1980) *A Key to Common British Algae*. Institution of Water Engineers and Scientists, London, 94pp.
Pentecost A (1984) *Introduction to Freshwater Algae*. Richmond Publishing Co., Surrey, 247pp.

BSBI handbooks are available for various macrophyte groups, eg umbellifers, willows and docks.

Appendix 4 Equipment suppliers in UK

This list is provided for illustrative purposes only. It includes examples of current suppliers at the time of writing, but may **NOT** include all suppliers of the equipment. No responsibility is accepted for the reliability or otherwise of the information given, nor any recommendation attached to any of the equipment listed.

1. Underwater TV camera Model FM-1000

The camera runs on a 12 volt battery - without the use of the light this provides power for approximately 3 hours, with the light on continuously the power lasts for only 0.5 hours. Spare batteries will therefore be needed, and the camera should be switched off when not in use. No further accessories are provided by the suppliers - cable reels which will be necessary can be bought from hardware/DIY stores.

Price Feb 1997 £2,200 + VAT for a complete system.
Available from Bansho Co Ltd, The Grainger Suite, Dobson House, Regent Centre, Newcastle, NE3 3PF. Tel 0191 284 2213, Fax 0191 284 0222. Contact Mr David Liddle.

2. Optical Range Finder

These are available from York Survey Supply Centre Tel: (01904) 692723. Short range models are no longer available from this outlet.

Model code 43130: This has a range of 10 to 75 m which would be suitable for the widest rivers only. Cost £45.96 + VAT.

Optional case for range finder (code 43132) £11.44 + VAT.

3. Glass-bottom bucket

No supplier for these has been found. It is suggested that you approach local chandlers to ask if they could supply anything suitable. Organisations with access to a workshop may be able to get one made.

Basically, the glass-bottom bucket can be of any size (bucket, swing-bin, washing-up bowl). The item should preferably be opaque. A section is removed from the base leaving a 2–5 cm lip on to which a piece of perspex or similar is sealed. The perspex is probably best placed on the outside of the bucket so that the lip provides some support as once pushed under water there will be some pressure which could dislodge the perspex if placed inside the bucket. Putty or some kind of bathroom sealant can be used to attach the perspex. The bucket should be stored with the perspex uppermost to avoid scratching the surface; the bucket should not be used for carrying field equipment.

4. Bathyscope

Obtainable from SEAC Direct, Sheffield.
Tel. 0114 270 1234 Fax. 0114275 8855
Price £35.95 (although a minimum order of £50.00).

Appendix 5 Standard record sheets

The following record sheets are appended:

Survey record sheet
Species checklist
Standard Sketch Map sheet, 100m survey length
Standard STAR location Sketch Map sheet, 500m
Reference sheet for % cover estimates
Reference sheet for substrata

STAR – Macrophyte field survey form [compatible with STAR hydromorphology]

Country/Region ..... **River** ..... **Site** ..... **Date**.....
Start time ..... **Surveyor name**..... **Site reference Map/GPS**: upstream.....
Indicate: Wadeable (0.7 m/1.3 m) /Non-wadeable / Bank survey /Boat :downstream /centre.....
Estimated Area-Cover – length 100 m or .....
A-I OPTIONAL see STAR site protocol

A. Water Width (m):
<1 .....%
1-5 .....%
5-10 .....%
10-20 .....%
>20 .....%

C. Depth(m):
<0.25 .....%
0.25-0.5.....%
0.5-1 .....%
>1 .....%

B. River width (m): bankfull/ inner bank

transect	1	2	3	4	5
left bank to water	....	....	....	....	....
left water to right water	....	....	....	....	....
right bank to water	....	....	....	....	....

D. Substrate (mm):
Bedrock .....%
Boulders/cobbles(>64) .....%
Pebble/gravel (2-64) .....%
Sand (0.06-2) .....%
Silt (fine) .....%
Clay (solid, sticky) .....%
Peat .....%
Artificial .....%
Not known .....%
None .....%
[**record** cover of silt over other substrates] .....%

E. Flow Types decreasing energy
Free-fall .....%
Chute .....%
Chaotic .....%
(= 2/3 high-energy flow types)
Broken standing waves .....%
Unbroken stand. waves .....%
Rippled .....%
Upwelling .....%
Smooth .....%
no perceptible flow .....%
None/no water .....%

F. Water Clarity:
Clear (visibility >2m) ☐
Cloudy (visibility 1-2m) ☐
Turbid (visibility <1m) ☐
OR Secci depth (m) = ...

G. Bed stability
Solid/Firm ___% ☐ Stable ___% ☐
Unstable ___% ☐ Soft/Sinking __% ☐

H. Shade of channel surface: Left Right
direct shade over water absent ☐ ☐
broken <33% (present) ☐ ☐
dense >33% (extensive) ☐ ☐

I. Channel Modifications: Affected by
Not Known .....%
None .....%
Resectioned .....%
Reinforced .....%
Dams/Weirs .....%
Ford .....%
Deflectors/groynes .....%
Other .....%

Location Sketch Map (1-2 km)**: mark** 100 m plant site, 500 m hydromorphology site, permanent site features eg road, trees, AND **Indicate** discharge(s), other inputs, tributaries, weirs & other artificial features, areas of dense shade.
u/s length (km) d/s

|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|

Site sketch Map(s) completed: 100 m ☐ 500 m ☐
Habitat Notes:

Photographs… Locations facing upstream/downstream, and numbers: total no:.....
Confidence in results - degree NOT modified: A ☐ (<25% affected); B ☐ (25-50%); C ☐ (>50%)
Measure of confidence for comparability of survey lengths in comparable pairs or sets of sites

Site name	Comparison Site name	Measure of confidence (I >75%; II 50-75%; III <50%)
1)	.....	.....
2)	.....	.....
3)	.....	.....

Quality Assurance Audit Protocol : Level 1 ☐ Level 2 ☐ None ☐ Is this an audit survey? Yes ☐ No ☐

[see also BSi prEN 14393]

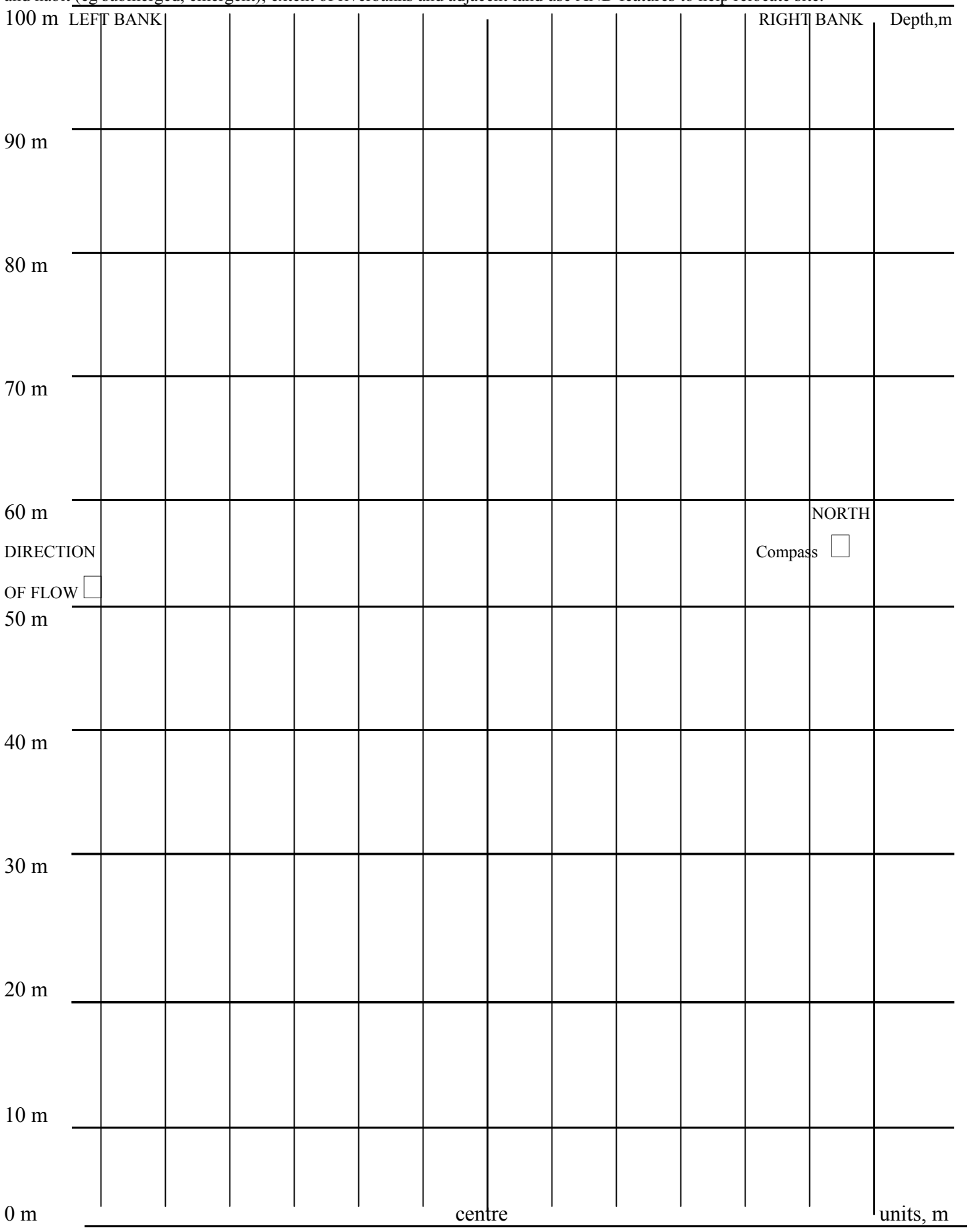
STAR– Macrophyte field survey form Country/Region ..... River ..... Site.....
Surveyor ..... Date/Time..... Map reference. up.....
Score system: DAFOR 5-9-10 point Percentage (circle) **down .....**
Survey length 100 m ....., other length(s).....Column 1= ..... 2=..... 3= ..... 4= ..... 5= ..... 6=.....
Calculator scales DAFOR 1, Rare, Area = ; 2; Occasional Area = ; 3, Frequent Area = ; 4, Abundant Area = ; 5, Dominant or very abundant Area = :
9-point scale <0.1%, 1; 0.1-1%, 2; 1-2.5%, 3; 2.5-5%, 4; 5-10%, 5; 10-25%, 6; 25-50%, 7; 50-75%, 8; >75%, 9,
Area, m^2 A= A= A= A= A= A= A= A= A=

Cover 1 2 3 4 5 6			
Length of sub-section	No of bryophyte packet		*Berula erecta*
Width of sub section	**VASC. CRYPTO** ...cover		*Bidens sp* .....
Total plant cover	*Azolla filiculoides*		*Callitriche* SAMPLE
Bare	*Equisetum sp(p)*.....		*Callitriche hamulata*
ALGAE ..... total cover			*Callitriche obtusangula*
Batrachospermum sp			*Callitriche* .....
Blue greens	**MONOCOTS** ..total cover		*Caltha sp(s)*.....
Cladophora agg or	*Acorus calamus*		*Ceratophyllum demersum*
Chlorophyta misc.....	*Alisma sp(p)*.....		*Ceratophyllum submersum*
Chara sp .....sample	*Alopecus geniculatus*		*Eupatorium sp* .....
Enteromorpha sp or	*Bolboschoenus maritimus*		*Filipendula sp* .....
Hildenbrandia (rivularis)	*Butomus umbellatus*		*Hippurus vulgaris*
Hydrodictyum reticulatum	*Carex acuta*		*Impatiens sp* .....
Lemanea (fluviatillis)	*Carex acutiformis*		*Lobelia sp* .....
Nitella sp .....sample	*Carex nigra*		*Littorella uniflora*
Stigeoclonium tenue	*Carex paniculata*		*Lotus pedunculatus*
Oedogonium sp	*Carex riparia*		*Lycopus sp* .....
Spirogyra sp.	*Carex rostrata*		*Lythrum sp* .....
Sponge	*Carex vesicaria*		*Mentha sp* .....
Stigeeoclonium tenue	*Catabrosa aquatica*		*Menyanthes trifoliata*
Vaucheria sp	*Cladium mariscus*		*Mimulus sp* .....
Verrucaria	*Descampsia*		*Montia fontana*
	Elatine hexandra		*Myosotis sp*.....
	Eleocharis palustris		*Myosoton sp* .....
ALGAL SAMPLE	*Elodea canadensis*		*Myriophyllum alterniflor..*
DIATOM SAMPLE	*Elodea nuttallii*		*Myriophyllum spicatum*
HEPATICAE.. total cover	*Eleogiton fluitans*		*Myriophyllum sp*.....
Anthelia julacea	*Glyceria maxima*		*Nuphar lutea*
Chiloscyphus	*Groenlandia densa*		*Nymphaea alba*
Conocephalum conicum.	*Hydrocharis morsus-ranae*		*Nymphoides peltata*
Dermatocarpon luridum	*Hydrocotyle sp*		*Oenanthe crocata*
Jungermannia. sp ...atrovi	*Iris pseudacorus*		*Oenanthe fluviatilis*
Lejeunea sp(p).....	*Juncus sp*.....		*Persicaria sp* .....
Marsupella sp.....	*Juncus sp*.....		*Petasites sp*.....
Nardia sp(p) compressa	*Juncus acutiflorus*		*Pilularia* .....
Pellia sp(p)	*Juncus articulatus*		*Polygonum amphibium*
Plagiochila sp(p).	*Juncus inflexus.*		*Potentilla erecta*
Riccardia sp(p) multifida	*Lemna sp*		*Pulicaria sp*.....
Riccia sp(p) fluitans	*Lemna trisulca*		*Ranunculus* SAMPLE
Ricciocarpus natans	*Ludwigia sp*.....		*Ranunculus aquatilis*
Scapania sp(p) undulata	*Molinia caerula*		*Ranunculus baudotii*
Schistidium sp	*Nardus sp.*		*Ranunculus circinatus*
	Narthecium ossifragum		*Ranunculus flamula*
	Phalaris arundinacea		*Ranunculus fluitans*
MUSCI.....total cover	*Poa palustris*		*Ranunculus hederaceus*
Amblystegium fluviatile	*Potamogeton SAMPLE*		*Ranunculus peltatus*
Amblystegium riparium	*Potamogeton lucens*		*Ran. penicillatus. ssp*
Blindia acuta	*Potamogeton natans*		*pseudofluit/penicil/vertum.*
Brachythecium sp(p).....	*Potamogeton obtusifolius*		*Ranunculus trichophyllus*
Cinclidotus sp.....	*Potamogeton pectinatus*		*Ranunculus sceleratus*
Cratoneuron filicinum	*Potamogeton polygonifol.*		*Rorippa sp* .....
Dichodontium sp(s).....	*Sagittaria sagittifolia*		*Rumex hydrolopathum*
Dicranella palustris	*Schoenoplectus lacustris*		*Sagina sp*.....
Drepanocladus sp(p).	*Scirpus sylvaticus*		*Stellaria sp(p)*.....
Eurhynchium sp	*Sparganium erectum*		*Utricularia sp*.....
Fissidens sp(p).....	*Sparganium emersum*		*Veronica sp(p)* .....
Fontinalis antipyretica	*Sparganium natans*		*Valeriana sp* .....
Fontinalis dalecarlica	*Triglochin sp*		*Viola sp(p)* .....
Fontinalis squamosa	*Typha latifolia*		
Hygrohypnum sp(p).	*Typha angustifolia*		
Hyocomium armoricum	*Zannichellia palustris*		
Philonotis fontana			
Plagiomnium sp(p).			
Polytrichum commune	**DICOTS.** ..... total cover		
Racomitrium aciculare	*Angelica sp(p)*.....		
Racomitrium aquaticum	*Apium inundatum*		
Spagnum sp .... sample	*Apium nodiflorum*		
Thamnobryum alopercum	*Baldelia ranunculoides*		

STAR– Macrophyte field survey 100m sketch map

Country/Region ..... River ..... Site..... Surveyor ..... Date.....

Mark and clearly **label** main features on sketch map, include: width of river channel (in m); depth of water (in m) and dry areas; substrates (hydro-morph classes) shade-position (dashed line) and density (hatch); dominant macrophyte stands with abbreviation of species (see list) and habit (eg submerged, emergent); extent of riverbanks and adjacent land use AND features to help relocate site.



STAR– Macrophyte field survey 500m sketch map for location of non-STAR macrophyte surveys
Country/Region ..... River ..... Site..... Surveyor ..... Date.....

Mark and **clearly label** main features on sketch map, include: position and width of river channel; depth of water at several positions; position and density of shade; (compass) direction - north; dominant macrophyte stands; extent of riverbanks and adjacent land use AND features to help relocate site.

500 m _____ .

LEFT BANK RIGHT BANK

DIRECTION

OF FLOW ☐

450 m _____ .

400 m _____ .

350 m _____ .

300 m _____ .

250 m _____ . centre

200 m _____ .

150 m _____ .

100 m _____ .

50 m _____ .

0 m _____

Table A2 Cover (m^2) for 100m Sections

		AVERAGE RIVER WIDTH (M)														
Cover Value	Equivalent %	1	2	3	4	5	6	7	8	9	10	11	12	15	20	25
1	<0.1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.5	2	2.5
2	0.1 - 1	0.1 - 1	0.2 - 2	0.3 - 3	0.4 - 4	0.5 - 5	0.6 - 6	0.7 - 7	0.8 - 8	0.9 - 9	1 - 10	1.1 - 11	1.2 - 12	1.5 - 15	2 - 20	2.5 - 25
3	1 - 2.5	1 - 2.5	2 - 5	3 - 7.5	4 - 10	5 - 12.5	6 - 15	7 - 17.5	8 - 20	9 - 22.5	10 - 25	11 - 27.5	12 - 30	15 - 37.5	20 - 50	25 - 62.5
4	2.5 - 5	2.5 - 5	5 - 10	7.5 - 15	10 - 20	12.5 - 25	15 - 30	17.5 - 35	20 - 40	22.5 - 45	25 - 50	27.5 - 55	30 - 60	37.5 - 75	50 - 100	62.5 - 125
5	5 - 10	5 - 10	10 - 20	15 - 30	20 - 40	25 - 50	30 - 60	35 - 70	40 - 80	45 - 90	50 - 100	55 - 110	60 - 120	75 - 150	100 - 200	125 - 250
6	10 - 25	10 - 25	20 - 50	30 - 75	40 - 100	50 - 125	60 - 150	70 - 175	80 - 200	90 - 225	100 - 250	110 - 275	120 - 300	150 - 375	200 - 500	250 - 625
7	25 - 50	25 - 50	50 - 100	75 - 150	100 - 200	125 - 250	150 - 300	175 - 350	200 - 400	225 - 450	250 - 500	275 - 550	300 - 600	375 - 750	500 - 100	625 - 1250
8	50 - 75	50 - 75	100 - 150	150 - 225	200 - 300	250 - 375	300 - 450	350 - 525	400 - 600	450 - 675	500 - 750	550 - 825	600 - 900	750 - 1125	1000 - 1500	1250 - 1675
9	> 75	>75	>150	>225	>300	>375	>450	>525	>600	>675	>750	>825	>900	>1125	>1500	>1675

$0.1\ m^2 = 32cm \times 32cm$
$0.2\ m^2 = 45cm \times 45cm$
$0.5\ m^2 = 71cm \times 71cm$
$0.8\ m^2 = 90cm \times 90cm$

$2\ m^2 \approx 1.4m \times 1.4m$
$5\ m^2 \approx 2.2m \times 2.2m$
$9\ m^2 = 3m \times 3m$
$20\ m^2 \approx 4.5m \times 4.5m$

$30\ m^2 \approx 5.5m \times 5.5m$
$50\ m^2 \approx 7m \times 7m$
$75\ m^2 \approx 8.5m \times 8.5m$
$90\ m^2 \approx 9.5m \times 9.5$

Appendix 6 Summary of methodology, definitions and equipment checklist

STAR SURVEY: SUMMARY OF METHODOLOGY

Before you go out

Ensure that you have all the equipment you need and are familiar with appropriate health and safety guidance.

Prior to commencing the survey

1. Confirm that the site is suitable for a STAR survey. Think again if:

- the suffixes of confidence for the survey and comparability are C and/or III
- there has been a recent temporal perturbation (eg spate or weed-cutting)
- flows are high and/or the water is turbid
- there is heavy/steady rain and/or windy conditions
- an alternative method is more appropriate.

2. Select/locate the survey length.

- Use the sketch/location map if the survey length has been surveyed before [take oringinal photographs].
- If this is a new site, select the most appropriate survey length, giving consideration to the factors influencing the STAR.
- The survey length is 100m long: measure (or pace) out and mark. For its width, see the definition of the 'channel'.

Exceptions to surveying the full survey-length are:

- if the river is very wide and/or deep and it is impractical to survey the full width, then a 5m wide (minimum) strip down one side of the channel may be surveyed instead (downstream length to be on the discharge side)
- if an effluent tracks along one bank for at least 500m, then a 5m wide (minimum) strip down that side of the channel can be surveyed, provided that a full-width survey is undertaken first;
- if a mature island is located within the survey length when assessing the impact of a discharge, then only the side on which the discharge enters should be surveyed;
- if there is a deep or rapid area(s), not exceeding 20% of an otherwise wadeable site, which is impractical to survey using a boat and a camera/bucket, then this may be left as a 'black hole' (mark clearly on the map and discount from all plant cover and physical attribute estimates except width).
- if it is impossible to find two comparable 100m sites near to the discharge being assessed, then 50m reaches of similar character may be surveyed, provided the river is at least 10m wide.

3. Complete the site and survey details on the standard field recording sheets.

The Survey

4. Aim to traverse the channel 4 times in every 10m length of river, either by wading or by boat as appropriate. In narrow, non-wadeable sites, the survey can be undertaken from the bank.

5. Assess and record all macrophytes present within the survey length, and their individual percentage cover class (SCV), using the standard field recording sheet.

- This includes: all macrophytes likely to be submerged for more than 85% of the time; both scoring and non-scoring plants.
- Do not record macrophytes overhanging but not rooted in the channel area, nor detached macrophyte material except for floating species. Include macrophytes on artificial structures only if a similar structure is present at both sites being compared.
- Use a glass-bottomed bucket or underwater camera to improve visibility, where appropriate.
- Take particular care to look out for small patches of species, which may otherwise be missed.
- Only use grapnels to retrieve specimens for identification.
-
- If you are unsure about the identification of a species, take a representative sample back to the laboratory to confirm identification: this is especially important for bryophytes, filamentous algae, *Callitriche* and *Ranunculus* species. Use of *Ranunculus species indeterminate #1* and *#2* is allowed provided identification notes on made under 'Comments' and a sample retained in the herbarium.
- Collect herbarium material if required (herbarium should include all regularly encountered species).
- Use one of the recommended methods to estimate the percentage cover of individual species. The standard abundance scale for 100m surveys is the 9-point Scale C.

6. Estimate the overall percentage cover of macrophytes in the survey length. Use as a double-check on the total of the percentage covers of individual species, but remember that the overall cover can be less than the total of the individual percentage covers if there are layers of macrophytes overlying each other.

7. Assign a measure of confidence in the survey (A, B or C: see definition).

8. Assess and record the physical character of the survey length, using the standard field recording sheet.
- Record either actual percentages and/or categories/classes in a manner which allows comparison with previous surveys. Record percentages to integer values (the nearest percentage point).
- If a feature is absent, record this as 0% (category 0): do not leave data entry spaces/boxes unfilled.
- If a feature is present at less than 0.5%, then ignore unless that particular habitat type contains the only occurrence of a scoring species, in which case note it under 'Comments' and mark its position on the sketch map.
- 'Width' means the channel width for which macrophyte species have been recorded. Use one of the recommended methods for measuring or estimating width.
- The shading for each bank is recorded separately. The percentage recorded for shading from each bank should relate to the whole channel width, not just half the width. The percentage of the channel affected by shading is recorded, NOT the length of bank on which vegetation causing shade stands. The percentage of the channel recorded as shaded is that shaded when the sun is directly overhead - midday.

9. Draw a sketch map of the survey length, using the standard field recording sheet.
- The purpose of this map is to enable a future surveyor to re-locate the survey length.
- If starting from the upstream end of the survey length, the left side of the paper corresponds to the left bank. If starting from the downstream end, turn the map upside down.
- Use the list on the back of the recording sheet as a guide as to what to record.
- Relocation features include any permanent features such as fences, hedges, walls, bridges etc. It may also be useful to mark (on a separate location map if necessary), the position of suitable parking and access, as this may also help re-location.

10. Take a photograph of the survey length to record its general character.
- The use of a polarising filter to reduce surface reflection is recommended.
- Write the date and an identifying code or site name and river name on a small blackboard or wipe-clean board and place this in the photograph. Record the identifying code on the record sheet.

11. If the results from the survey are to be compared with those from another site, assign a measure of confidence for comparability of the survey lengths (I, II or III: see definition).

12. Before you leave the site, check that all the data entry boxes/spaces on the field recording sheets have been completed, and that you have drawn a sketch map and taken a photograph.

Back at the Laboratory

Remember to keep representative specimens in a herbarium or 'voucher collection', for future reference or confirmation.

Appendix A8 - **STAR SURVEY: DEFINITIONS**

Channel

All macrophytes seen submerged or partly submerged in the river, at low flow levels, within the survey length are recorded. These are considered to be 'river' plants. At the sides of the river all macrophytes attached or rooted on parts of the substrata which are likely to be submerged for more than 85% of the time are included.

Macrophyte Cover

The Cover class scales for 100m survey length:

1 <0.1%
2 0.1-1%
3 1-2.5%
4 2.5-5%
5 5-10%
6 10-25%
7 25-50%
8 50-75%
9 >75%

D. Substrata Classes (as STAR Hydromorphology groups, based on RHS 1997/2002)

Bedrock	-	exposure of underlying rock not covered by alluvial deposits
Boulders/Cobbles	-	> 64 mm; half-fist size or larger
Pebbles/Gravel	-	> 2–64 mm; half-fist to coffee granule size
Sand	-	> 0.0625–2 mm; smaller than coffee granules and unlike silt/clay, abrasive to the hands
Silt	-	< 0.0625; has a fine soft texture
Clay		< 0.0625, solid, sticky texture
Peat	-	dead vegetation undergoing bacterial decay in stagnant deoxygenated water. Strictly pure peat, not fine peaty deposits over more substantial substrate.
Artificial		artificial bed
not known		Not determined

F. Water Clarity

Clear (>2m)	-	Channel substrate is clearly visible at all depths, as are macrophyte species.
Cloudy (1-2m)		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.
Turbid (<1m)	-	Strongly discoloured, carrying a heavy suspended solids load and greatly restricted 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.

G. Bed Stability

Solid/firmly bedded	-	eg bedrock/compacted clay, increased flow has little effect
Stable	-	eg boulders/pebbles/gravel, unlikely to be significantly altered by increased flows
Unstable	-	eg gravel/sand/silt/mud, likely to be dislodged by increased flows
Soft/sinking	-	eg deep silt/mud, making channel unwadeable. Bank stick penetrates easily into substrate.

H. Shading Categories

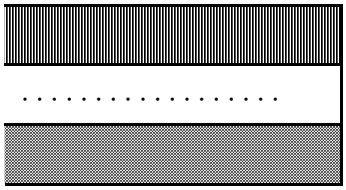
None	-	direct shade over channel absent
Broken (<33%)		some direct sunlight hits the water surface in the shade affected area when the sun is directly overhead.

Dense (>33%) - 5% or less of the shade-affected area receives direct sunlight when the sun is directly overhead.

On the sketch map - Broken shade should be indicated by:

Dense shade should be indicated by:

Macrophyte stands should be indicated by:



Habitat Notes (as STAR Hydromorphology groups, based on RHS 1997/2002)

Pool - Either a discrete area of slow flowing water, usually relatively deeper than surrounding water, or between faster flowing stretches, as in a sequence of riffle-pool- riffle. Pools are deep and often turbulent, and scoured during spate flows.

Riffle - Fast flowing, shallow water whose surface is distinctly disturbed. This does not include water whose surface is disturbed by macrophyte growth only.

Run - Fast or moderate flowing, often deeper water whose surface is rarely broken or disturbed except for occasional swirls and eddies.

Slack - Deep, slow flowing water, uniform in character.

Suffix of Confidence in the Survey

Assess how accurately you feel the results reflect the prevailing situation at the site. For example, the survey may have been hampered and perhaps rendered meaningless by:

- temporal perturbations such as recent river management (dredging, weed cutting, herbicide application or disturbance due to flood defence works such as bank reinforcements) or extreme flooding events, which may have influenced the macrophyte community; and/or
- survey conditions which reduce the accuracy of the survey, *e.g.* poor survey conditions (turbidity, high discharge due to recent rain or very wet or windy conditions) or excessive blanketing algae or floating vegetation growth obscuring the view or smothering other vegetation.

Note that confidence in the results of a survey may be restricted by either one or both of the above factors.

Assign a score according to the degree to which such events may have distorted the survey findings:

A - data not affected or any effect limited to less than 25% of the site

B - the accuracy of records in 25–50% of the site influenced to a considerable degree

C - the accuracy of records in >50% of the site influenced to a considerable degree.

Suffix of Confidence in the Comparability of Survey Lengths

The factors under consideration for comparison are Width, Depth, Substrata, Habitats, Shading, Water Clarity and Bed Stability. For each pair of survey lengths, assign one of the following categories:

I - 5 or more of these characteristics are similar for more than 75% of each site.

II - 3 or 4 of these categories are similar for more than 75% of each site.

III - 2 or less of these categories are similar for more than 75% of each site.

Appendix 9 - **STAR: EQUIPMENT CHECKLIST**

- Safety equipment - refer to safety manuals and advice available from your manager or safety advisor.
- Maps – scale 1:50 000
- Location and/or sketch map to enable accurate location of the survey length (if surveyed before)
- Standard record sheets + sketch map sheet (on waterproof paper if necessary)
- Summary of the STAR methodology and definitions reference sheets (optional, preferably laminated Appendix 5)
- Substrate reference and % cover reference sheets (optional)
- Pencil and pen
- Clipboard with waterproof shield/cover or a large clear plastic bag (to protect record sheet and make writing possible in damp conditions).
- Grapnel with depth markings on the rope
- Bank stick with depth markings
- Plastic bags, labels and tubes for small specimens
- Tape measure or measuring rope, stakes and mallet (to mark start and end of survey length)
- Identification and field guides
- Camera with a polarising lens and 200 ISO daylight film speed.
- Hand lens (x10)
- Blackboard & chalk or wipe-clean board, non permanent pen and cloth (small, to include site details in the photographs)
- Underwater viewing aid (eg glass-bottom bucket or underwater TV camera)
- Polarising sunglasses (optional)
- Optical range finder (optional)
- Boat and additional safety equipment as required.
- Copies of previous survey sheet(s) for site(s) to be surveyed (optional).

Appendix 10 - **GLOSSARY**

Audit survey	Repeat survey undertaken for quality assurance purposes.
Channel area	The part of the river channel where macrophytes are seen submerged or partly submerged at low flow levels. At the sides of the channel this includes all macrophytes attached or rooted on parts of the substrata which are likely to be submerged for more than 85% of the year or as defined for southern European countries.
Comparability	A measure of confidence in the physical comparability of a pair of sites based upon the similarity of width, depth, substrata, habitat, shading, water clarity and bed stability.
d/s	Downstream.
Macrophyte	Larger alga or higher aquatic plant (including bryophytes), observable to the naked eye and nearly always identifiable when observed.
STAR Index	Mean Ecological Rank. A numerical score assigned to a survey length based on its macrophyte presence and abundance characteristics.
Nitrate	Dissolved or soluble or non-particulate nitrate.
Phosphate	Dissolved or non-particulate phosphate, normally analysed as soluble reactive (SRP) or by the molybdenum-blue method.
Pool	Either a discrete area of slow flowing water, usually relatively deeper than surrounding water, or between faster flowing stretches, as in a sequence of riffle-pool-riffle. Pools are deep and often turbulent, and scoured during spate flows as STAR hydromorphology grouping
Primary survey	When a survey is repeated for quality assurance purposes, the initial survey is termed the 'primary survey' and the repeat survey the '*audit survey*'.
RHS	River Habitat Survey. A method for assessing the physical character and quality of river habitats and impacts upon them.
Riffle	Fast flowing, shallow water whose surface is distinctly disturbed. This does not include water whose surface is disturbed by macrophyte growth only - as STAR hydromorphology grouping.
Run	Fast or moderate flowing, often deeper water whose surface is rarely broken or disturbed except for occasional swirls and eddies - as STAR hydromorphology grouping.
Site	This is the broad location where the survey is to take place, eg *x*km downstream of a waste water treatment works.
Slack	Deep, slow flowing water, uniform in character - as STAR hydromorphology grouping.
STAR index	An Ecological Rank assigned to a species on a scale of 1 to 10, designed to reflect the tolerance of that species. Low scores indicate tolerance or cosmopolitan distribution (ie no preference). High scores indicate preference for natural or semi natural conditions or intolerance of perturbed conditions.
Survey	The collection of data at one site according to the prescribed methodology.
Survey length	This is the sample area — the actual river *channel area* surveyed, between two fixed points on the bank. The survey length is 100m long for standard STAR surveys.
Survey season	The STAR survey season is mid-June to mid-September in central and northern Europe inclusive .
u/s	Upstream.

Appendix A10 - **STAR– Macrophytes**

checklist of aquatics and riparian species for field surveys in Europe

*PCL= Lansdown, Cook, Lansdown European list

Algae

Species	Abbrev.	PCL* aquatics	PCL* possible aquatics	Aus	Fin	Fre	Ger	Hun	Por	Rom	Slvak	Slven	Notes
Audouinella sp. Bory de St Vincent	Aud sp					x							
Bangia sp. Lyngbye (atropurpurea)	Ban sp					x	x						
Batrachospermum sp. Roth	Bat sp	x				x	x						
Binuclearia sp. Wittrock	Bin sp					x							
Chaetophora sp. Schrank	Cha sp					x							
Chantransia sp. Bory de St Vincent	Chac sp					x	x						
Chara aspera Deth. Ex Wild.	Cha asp						x						
Chara braunii Gmel	Cha bra						x						
Chara canescens Desv. & Lois	Cha can						x						
Chara contraria A. Br.	Cha con						x						
Chara delicatula Ag.	Cha del						x						
Chara globularis Thuill.	Cha glo						x						
Chara globularis Thuill. Var. globularis (C. fragilis Desv.)	Cga glo glo						?						
Chara hispida L.	Cha his						x				x		
Chara intermedia A. Br.	Cha int						x						
Chara polyacantha A. Br.	Cha pol						x						
Chara sp. L, ex Vaillant	Char sp					x							
Chara vulgaris L.	Cha vul						x	x					
Chara vulgaris var vulgaris (C. foetida A. Braun)	Cha vul vul						?						
Chara vulgaris var. gymnophylla A. Braun (C gymnophylla A. Braun)	Cha vul gym						?						
Chlorhormidium sp. Fott	Chdm sp					x							
Chlorophyta spec.	Chyt sp						x						
Cladophora sp. Kützing	Cla sp	x				x				x		x	
Draparnaldia sp. Bory de St Vincent	Dra sp					x							
Enteromorpha sp. Link	Ent sp	x				x	x						
Heribaudiella sp. Gomont	Her sp					x							
Hildenbrandia rivularis Nardo	Hil riv	x				x	x						
Homeothrix sp. (Thuret) Kirchner (janthina)	Hom sp					x							
Hydrodictyon reticulatum Roth	Hyd ret	x				x	x						
Hydrurus foetidus C. Agardh	Hyd foe					x							
Lemanea fluviatilis	Lem flu	x					x						
Lemanea sp. Bory de St Vincent	Lem sp					x	x						
Lyngbya sp. C. Agardh	Lyn sp					x							
Melosira sp. C.Agardh	Mel sp					x							
Microcoleus sp. Desmazières	Micl sp					x							
Microspora sp. Thuret	Mica sp					x							
Monostroma sp. Thuret	Mon sp					x							
Mougeotia sp. C. Agardh	Mou sp					x							
Nitella capillaris (Krok.) J. groves et Bullock Webster	Nit cap						?						
Nitella flexilis L. Ag.	Nit fle						x						
Nitella gracilis (Smith) Ag	Nit gra						?						
Nitella mucronata (A. Br.) Miquel	Nit muc						x						
Nitella opaca Ag.	Nit opa			x			x						
Nitella sp. C. Agardh	Nit sp					x							
Nitella syncarpa Kutz	Nit syn						?						
Nitella tenuissima (desv.) Cosson et Germain	Nit ten						?						
Nitella translucens (Pers.) Ag	Nit tra						?						
Nitellopsis obtusa (Desv.) J. Groves	Nit obt			x			?						
Nostoc sp. Vaucher	Nos sp					x							
Oedogonium sp. Link	Oed sp					x							
Oscillatoria sp. Vaucher	Osc sp					x							
Species	**Abbrev.**	**Cnfmd aqs**	**Pssbl aqs**	**Aus**	**Fin**	**Fre**	**Ger**	**Hun**	**Por**	**Rom**	**Slvak**	**Slven**	**Notes**
Plectonema sp. Thuret	Ple sp					x							

Pseudendoclonium sp. Wille	**Pse sp**					**x**							
Radiofilum sp. Scmidle	**Rad sp**					**x**							
Rhizoclonium sp. Kützing	**Rhi sp**					**x**							
Rivularia sp. Roth.	**Riv sp**					**x**							
Schizomeris sp. Kütz.	**Schs sp**					**x**							
Schizothrix sp. Kützing	**Schx sp**					**x**							
Sphaerocystis sp. Chodat	**Sph sp**					**x**							
Spirogyra sp. Link	**Spi sp**					**x**							
Stigeoclonium tenue Link	**Sti ten**	**x**				**x**							
Tetraspora sp. Link	**Tet sp**					**x**							
Thorea sp. Bory de St Vincent	**Tho sp**					**x**							
Tolypella glomerata V. Leonhardi	**Tol glo**						**x**						
Tolypella hispanica Nordstedt	**Tol his**						**x**						
Tolypella intricata V. Leonhardi	**Tol int**						**x**						
Tolypella prolifera V. Leonhardi	**Tol pro**						**x**						
Tribonema sp. Derbès & Solier	**Tri sp**					**x**							
Ulothrix sp. Kützing	**Ulo sp**					**x**							
Vaucheria sp. De Candolle	**Vau sp**	**x**				**x**							
Zygnema sp. Agardh	**Zyg sp**					**x**							

Mosses

Species	Abbrev.	Cnfrmd aqs	Pssbl aqs	Aus	Fin	Fre	Ger	Hun	Por	Rom	Slvak	Slven	Notes
Amblystegium fluviatile (Hedw.)	Amb flu	x		x		x	?						
Amblystegium riparium	Amb rip	x				x							
Amblystegium sp(p).	Amb sp	x											
Amblystegium tenax (Hedw.) Jenn.	Amb ten					x	x						
Atrichum undulatum P. Beauv.	Atr und					x							
Aulacommium palustre (Hedw.) Schwaegr.	Aul pal					x							
Blindia acuta	Bli acu	x											
Brachythecium plumosum (Sw.) B. e.	Bra plu	x				x	x						
Brachythecium rivulare B.S.G.	Bra riv	x		x		x	x						
Brachythecium rutabulum (Hedw.) B.S.G	Bra rut	x		x		x	x						
Breutelia chrysocoma	Bre chr	x											
Bryum bimum Schreb.	Bry bim					x							
Bryum capillare Hedw.	Bry cap					x							
Bryum pallens Sw.	Bry paln					x							
Bryum pallescens Schreb.	Bry palc					x							
Bryum pseudotriquetrum (Hedw.) Schwaegr	Bry pse	x				x							
Bryum Schleicheri Schwaegr;	Bry sch					x							
Bryum sp(p).	Bry sp	x				x							
Calliergon cuspidatum (Hedw.)	Cal cus	x				x	x						
Calliergon giganteum (Schimp.)	Cal sch						x						
Calliergon sp(p).	Cal sp	x											
Cinclidotus aquaticus (Jaeg.) B. e.	Cin aqu					x	x						
Cinclidotus danubicus Schiffn. & Baumgartner	Cin dan					x	x						
Cinclidotus fontinaliodes (Hedw.) P.Beauv.	Cin fon	x		x		x	x						
Cinclidotus riparius (Brid.) Arnott	Cin rip			x		x	x						
Cinclidotus sp(p).	Cin sp	x				x							
Cirriphyllum crassinervium (Tayl.) Loeske & Fleisch.	Cir cra					x							
Climacium dendroides (Hedw.) F. Weber & D Mohr	Cli den						x						
Cratoneuron commutatum (Hedw.) Roth	Cra com					x							
Cratoneuron filicinum (Hedw.) Spruce	Cra fil			x		x	x						
Cratoneuron sp(p)	Cra sp	x											
Ctenidium molluscum (Schimp.) Mitt.	Cte mol					x							
Dichodontium flavescens (With.) Lindb.	Dic fla	x				x							
Dichodontium pellucidum (Hedw.) Schimp.	Dic pel	x				x	x						
Dicranella heteromalla (Hedw.) Schimp.	Dic het					x							
Dicranella palustris (Dicks.) Warb.	Dic pal	x				x							
Dicranella sp. (C. Müll.) Schimp. HG	Dic sp					x							
Dicranum scottianum Turn.	Dic sco					x							
Drepanocladus aduncus (Hedw.) Warnst	Dre adu						x						
Drepanocladus sp	Dre sp	x				x							
Eucladium verticillatum	Euc ver	x											
Eucladium verticillatum (Smith) B. e.	Euc ver					x							
Eurhynchium praelongum (Hedw.) Schimp.	Eur pra						x						
Eurhynchium stockesii (Turn.) B. e.	Eur sto					x							
Eurhynchium swartzii (Turn.) Curnow	Eur swa			x									
Fissidens adianthoides Hedw.	Fis adi										x		
Fissidens arnoldi Ruthe	Fis arn					x							
Fissidens bryoides Hedw.	Fis bry					x							
Fissidens cf. osmundoides	Fis osm						x						
Fissidens crassipes Wils ex B.S.G.	Fis cra			x		x	x						
Fissidens curnowii Mitt.	Fis cur					x							
Fissidens minutulus Sull.	Fis min					x	x						
Fissidens monguilloni Thér.	Fis mon					x							
Fissidens polyphyllus Br. Eur.	Fis pol					x							
Fissidens pusillus Wils.	Fis pul					x	x						
Fissidens rivularis (Spruce) B. e.	Fis riv					x	x						
Fissidens rufulus Br. Eur.	Fis ruf					x	x						
Fissidens sp. Hedw.	Fis sp	x				x							
Fissidens taxifolius Hedw.	Fis tax					x							

Species	Abbrev.	Cnfrmd aqs	Pssbl aqs	Aus	Fin	Fre	Ger	Hun	Por	Rom	Slvak	Slven	Notes
Fissidens viridulus (Sw.) Wahlemb	Fis vir					x							
Fontinalis antipyretica Hedw.	Fon ant	x(Aus)				x	x				x	x	
Fontinalis dalecarlica	Fon dal						x						
Fontinalis duriaei Schimp.	Fon dur					x							
Fontinalis hypnoides Hartm	Fon hyp						x						
Fontinalis squamosa Hedw.	Fon squ	x				x	x						
Heterocladium heteropterum	Het het	x											
Hookeria lucens (Hedw.) Sm.	Hoo luc					x	x						
Hygrohypnum dilatatum (Schimp.) Loeske	Hyg dil					x	x						
Hygrohypnum luridum (Hedw.) Jenn.	Hyg lur	x		x		x	x						
Hygrohypnum ochraceum (Wils.) Loeske	Hyg och	x				x	x						
Hyocomium armoricum (Brid.)	Hyo arm	x				x	x						
Isothecium myosuroides Brid.	Iso myo	x				x							
Leptodictyum riparium (Hedw.) Warnst.	Lep rip			x		x	x						
Leskea polycarpa Hedw.	Les pol	x		x			x						
Mnium affine Bland.	Mni aff					x							
Mnium hornum Hedw.	Mni hor	x				x	x						
Mnium medium B. e.	Mni med					x							
Mnium punctatum Hedw.	Mni pun					x							
Mnium undulatum Hedw.	Mni und					x							
Octodiceras fontanum	Oct fon	x					x						
Octodiceras fontanum (La Pyl.) Lindb.	Oct fon					x							
Orthotrichum rivulare Turn.	Ort riv					x	x						
Orthotrichum sp(p).	Ort sp	x											
Pachyfissidens grandifrons (Brid.) Limpr.	Pac gra					x							
Philinotis arnellii Husn.	Phi arn					x							
Philonotis (tomentella) marchica (Willd.) Brid.	Phi mar					x							
Philonotis caespitosa Milde	Phi cae					x							
Philonotis calcarea (B. e.) Schimp.	Phi cal					x	x						
Philonotis fontana (Hedw.)	Phi fon	x				x	x						
Plagiomnium sp(p).	Plan sp	x											
Plagiothecium denticulatum (Hedw.) B. e.	Pla den					x							
Plagiothecium silvaticum (Huds.) B. e.	Pla sil					x							
Plagiothecium undulatum (Hedw.) B. e.	Pla und			x		x							
Platyhypnidium lusitanicum (Schimp)	Pla lus						x						
Polytrichum commune Hedw.	Pol com	x				x							
Racomitrium aciculare (Hedw). Brid. (Rhacomitrium aciculare Hedw. Brid)	Rac aci						x						
Racomitrium aquaticum	Rac aqu						x						
Racomitrium sp(p).	Rac sp	x											
Rhizomnium sp(p).	Rhi sp	x											
Rhynchostegium riparioides (Hedw.) Cardot (Platyhypnidium riparoides (Hedw.) Dixon & Platyhypnidium rusciforme)	Rhy rip	x		x		x	x				x		
Schistidium apocarpum (Hedw.) B.S.G. em. Poelt	Sch apo			x			x						
Schistidium rivulare	Sch riv					x	x						
Sphagnum cuspidatum Hoffm. Em. Warnst.	Sph cus						x						
Sphagnum denticulatum Brid	Sph den						x						
Sphagnum fallax	Sph fal						x						
Sphagnum gr. inundatum Russ. (denticulatum)	Sph inu					x							
Sphagnum gr. palustre L.	Sph pal					x	x						
Sphagnum majus	Sph maj						x						
Sphagnum sp(p).	Sph sp	x											
Thamnium alopecurum (Hedw.)	Tha alo	x				x	x						
Tortella tortuosa (Hedw.) Schimp.	Tor tor					x							
Tortula latifolia Bruch et Hartm	Tor lat	x					x						
Warnstorfia exannulata (Schimp.) Loeske	War exa						x						
Warnstorfia fluitans Hedw	War flu						x						

Liverworts

Species	Abbrev.	Cnfrmd aqs	Pssbl aqs	Aus	Fin	Fre	Ger	Hun	Por	Rom	Slvak	Slven	Notes
Anthelia julacea	Ant jul	x											
Calypogeia arguta Nees & Mont.	Cal arg					x							
Calypogeia fissa (Sm.) Raddi	Cal fis					x							
Chiloscyphus pallescens (Ehrh. ex Hoffm.) Dumort.	Chi pal					x	x				x		
Chiloscyphus polyanthos (L.) Corda.	Chi pol	x				x	x						
Chiloscyphus rivularis (Schrad.) Nees	Chi riv					x							
Conocephalum conicum (L.) Dum.	Con con					x	x						
Dumortiera hirsuta (Sw.) Nees	Dum hir					x							
Jungermannia atrovirens Dumort	Jun atr	x					x						
Jungermannia cf. pumila	Jun pum						x						
Jungermannia exertifolia Steph	Jun exe						x						
Jungermannia obovata Nees	Jun obo						x						
Jungermannia sp(p).	Jun sp	x											
Jungermannia sphaerocarpa Hook	Jun sph						x						
Lejeunea sp(p).	Lej sp	x											
Lunularia cruciata (L.) Dum.	Lun cru					x	x						
Marchantia paleacea Bert.	Mar pal					x							
Marchantia polymorpha L.	Mar pol					x	x						
Marsupella aquatica (Schrad.) Schiffn.	Mar aqu					x							
Marsupella emarginata (Ehrh.) Dum.	Mar ema	x				x	x						
Marsupella sp(p).	Mar sp	x											
Nardia acicularis	Nar aci					x							
Nardia compressa (hook.) Gray	Nar com	x				x	x						
Nardia sp(p).	Nar sp	x											
Pellia endiviifolia (Dicks) Dumort	Pel end	x				x	x						
Pellia epiphylla L. Corda	Pel epi	x				x	x						
Pellia neesiana (Gottsche) Limpr.	Pel nee					x	x						
Plagiochila asplenioïdes (L.) Dum.	Pla asp					x							
Plagiochila sp(p).	Pla sp	x											
Porella cordeana (Hüb) Evans	Por cor					x	x						
Porella pinnata Lindb	Por pin					x							
Porella platyphylla (L.) Lindb	Por pla					x							
Porella sp(p).	Por sp	x											
Priessia quadrata	Pri qua	x											
Riccardia multifida	Ric mul						x						
Riccardia pinguis (L.) Gray	Ric pin					x							
Riccardia sinuata (Dicks.) Trev.	Ric sin					x							
Riccardia sp(p).	Ricd sp	x											
Riccia fluitans L.	Ric flu			x	x	x	x				x		
Riccia rhenana Lorbeer	Ric rhe						x						
Riccia sp(p).	Rica sp	x				x							
Ricciocarpus natans (L.) Corda	Ric nat	x(Aus)		x	x		x				x		
Scapania paludosa K. Müll.	Sca pal					x							
Scapania sp(p).	Sca sp	x											
Scapania undulata (L.) Dum	Sca und	x				x	x						
Solenostoma crenulatum (Sm.) Mitt.	Sol cre					x							
Solenostoma triste (Nees) K. Müll.	Sol tri					x							

Pteridophytes

Species	Abbrev.	Cnfrmd aqs	Pssbl aqs	Aus	Fin	Fre	Ger	Hun	Por	Rom	Slvak	Slven	Notes
Adianthum capillus veneris L.	Adi cap					x							
Athyrium filix femina (L.) Roth.	Ath flx					x	x						
Azolla caroliniana	Azo car	x								x			
Azolla filiculoides Lam.	Azo fil	x				x	x						
Blechnum spicant (L.) Roth.	Ble spi					x							
Ceratopteris thalictroides	Cer tha	x											
Dryopteris carthusiana (Villar) H.P. Fuschs	Dry car					x							
Equisetum arvense L.	Equ arv						x						
Equisetum fluviatile L.	Equ flu	x			x	x	x						
Equisetum maximum Lam.	Equ max					x							
Equisetum palustre L.	Equ pal	x				x	x	x					
Equisetum pratense	Equ pra						x						
Equisetum x litorale Kuhlew ex Rupr.	Equ lit	x					x						
Isoetes azorica	Iso azo	x											
Isoetes boryana	Iso bor	x											
Isoetes brochonii	Iso bro	x											
Isoetes echinospora Durieu	Iso ech	x			x	x							
Isoetes lacustris L.	Iso lac	x			x	x							
Isoetes longissima	Iso lon	x											
Isoetes malinverniana	Iso mal	x											
Isoetes velata	Iso vel	x											
Isoetes velata subsp. asturicense	Iso vel ast	x							x				
Isoetes velata subsp. tegulensis	Iso vel teg	x											
Isoetes velata subsp. tenuissima	Iso vel ten	x											
Isoetes velata subsp. velata	Iso vel vel	x							x				
Marsilea quadrifolia L.	Mar qua					x							
Osmunda regalis	Osm reg					x	x						
Pilularia globulifera L.	Pil glo	x			x		x		x				
Pilularia minuta	Pil min	x							x				
Salvinia natans (L.) All.	Sal nat	x			x	x		x		x	x		
Thelypteris palustris	The pal				x								

Monocotyledons

Species	Abbrev.	Cnfrmd aqs	Pssbl aqs	Aus	Fin	Fre	Ger	Hun	Por	Rom	Slvak	Slven	Notes
Acorus calamus L.	Aco cal	x(KJR)	x		x	x	x						
Acorus gramineus	Aco gra	x											
Agropyrum repens (L.) Beauv.	Agr rep					x							
Agrostis canina L.	Agr can						x						
Agrostis sp.	Agr sp					x							
Agrostis stolonifera L.	Agr sto	x(KJR)	x			x	x						
Agrostis vulgaris With.	Agr vul					x							
Alisma gramineum Lej	Ali gra	x					x			x			
Alisma lanceolatum With	Ali lan	x		x		x	x		x		x		
Alisma plantago-aquatica L.	Ali pla	x		x	x	x	x		x	x	x		
Alisma wahlenbergii	Ali wah	x			x								
Alopecurus aequalis Sobol	Alo aeq		x		x	x	x		x				
Alopecurus geniculatus Sobolewski	Alo gen		x			x	x		x				
Alopecurus pratensis L.	Alo pra						x						
Althenia filiformis	Alt fil	x											
Althenia orientalis	Alt ori	x											
Aponogeton distachyos	Apo dis	x											
Arundo donax	Aru don		x										
Baldellia alpestris	Bal alp	x							x				
Baldellia ranunculoides L. parl	Bal ran						x		x				
Baldellia ranunculoides subsp. ranunculoides	Bal ran ran	x											
Baldellia ranunculoides subsp. repens	Bal ran rep	x											
Beckmannia eruciformis	Bec eru		x										
Beckmannia syzigachne	Bec syz		x										
Blyxa japonica	Bly jap	x											
Bolboschoenus maritimus (L.) Palla	Bol mar	x(KJR)				x	x	x					
Bracharia eruciformis	Bra eru		x										
Butomus umbellatus L.	But umb	x		x	x	x	x	x	x		x		
Caldesia parnassifolia	Cal par	x											
Calla palustris	Cal pal		x				x						
Carex acuta L. (Carex gracilis Curtis)	Car acuta	x(KJR)	x		x	x					x		
Carex acutiformis Ehrh.	Car acu	x(KJR)	x			x	x						
Carex acutiformis et gracilis	Car acu gra						?						
Carex aquatilis	Car aqu	x(KJR)	x		x								
Carex buekii Wimm.	Car bue						x						
Carex diandra	Car dia				x								
Carex disticha	Car dis		x										
Carex elata All.	Car ela	x(KJR)	x		x	x	x						
Carex halophila	Car hal				x								
Carex hirta	Car hir						x						
Carex lasiocarpa	Car las	x(KJR)	x		x		x						
Carex limosa	Car lim	x(KJR)	x										
Carex nigra (L.) Reichard	Car nig	x(KJR)				x	x						
Carex paniculata L.	Car pan	x(KJR)				x	x						
Carex pendula Huds.	Cae pen					x	x						
Carex pseudocyperus L.	Car pse	x(KJR)	x		x	x	x						
Carex recta	Car rec	x(KJR)	x										
Carex riparia Curtis	Car rip	x(KJR)	x			x	x				x		
Carex rostrata Stokes	Car ros	x(KJR)	x		x	x	x						
Carex spicata Huds.	Car spi					x							
Carex vesicaria L.	Car ves	x(KJR)	x		x	x	x						
Carex vulpina L.	Car vul							x					
Catabrosa aquatica (L.) Beauv.	Cat aqu	x(KJR)	x		x	x	x						
Cladium mariscus	Cla mar	x(KJR)	x										
Coix lacryma-jobi	Coi lac		x										
Cyperus eragrostis	Cyp era					x							
Cyperus fuscus L.	Cyp fus					x	x						
Cyperus longus L.	Cyp lon					x							
Cyperus serotinus Rottb.	Cyp ser					x							

Species	Abbrev.	Cnfrmd aqs	Pssbl aqs	Aus	Fin	Fre	Ger	Hun	Por	Rom	Slvak	Slven	Notes
Damasonium alisma Miller	Dam ali	x(KJR)	x						x				
Damasonium bourgaei	Dam bou		x										
Damasonium polyspermum Cosson	Dam pol		x						x				
Deschampsia cespitosa (L.) P. Beauv	Des ces												
Echinocloa oryzoides	Ech ory		x										
Egeria densa Planch	Ege den	x				x	x						
Eichhornia crassipes	Eic cra	x											
Eleocharis acicularis (L) Roem et Schult	Ele aci	x			x	x	x				x		
Eleocharis austriaca Hayek	Ele aus					x							
Eleocharis mamillata	Ele mam				x	x	x						
Eleocharis ovata (Roth) Roem. & Schult.	Ele ova					x	x						
Eleocharis palustris (L.) Roem & Schult.	Ele pal	x(KJR)				x		x					
Eleocharis palustris subsp. palustris	Ele pal pal	x					x						
Eleocharis palustris subsp. vulgaris	Ele pal vul	x					x						
Eleocharis parvula	Ele par	x			x								
Eleocharis quinqueflora (F. X. Hartman) O. Schwarz	Ele qui					x							
Eleocharis striatulus Desv.	Ele str					x							
Eleocharis uniglumis (Link) Schultes	Ele uni					x	x						
Eleogiton fluitans	Ele flu	x				x			x				
Elodea callitrichoides	Elo cal	x											
Elodea canadensis L. C. Rich	Elo can	x										x	
Elodea canadensis Michx.	Elo can	x		x	x	x	x	x		x	x		
Elodea ernstiae	Elo ern	x				x							
Elodea nuttallii (Planch.) H. St. John	Elo nut	x		x		x	x	x		x	x		
Eriocaulon aquaticum	Eri aqu	x											
Eriocaulon cinereum	Eri cin	x											
Eriophorum angustifolium Honckeny	Eri ang	x(KJR)	x			x	x						
Fimbristylis annua	Fim ann		x										
Fimbristylis bisumbellata	Fim bis		x										
Fimbristylis squarrosa	Fim squ		x										
Fuirena pubescens?	Fui pub		x										
Glyceria aquatica (L.) Wahlb.	Gly aqu										x		
Glyceria declinata Bréb.	Gly dec	x(KJR)	x			x	x		x				
Glyceria fluitans (L.) R. Br.	Gly flu	x(KJR)	x		x	x	x		x				
Glyceria maxima (Hartm.) Holmb	Gly max	x(KJR)	x	x	x	x	x				x		
Glyceria notata Chevall	Gly not	x(KJR)	x		x	x	x						
Glyceria x pedicellata	Gly ped	x(KJR)	x										
Groenlandia densa (L.) Fourr.	Gro den	x				x	x				x		
Halophila stipulacea (marine?)	Hal sti												
Hemarthria altissima	Hem alt		x										
Holcus lanatus L.	Hol lan					x							
Hydrocharis morsus-ranae L.	Hyd mor	x		x	x	x	x	x	x	x	x		
Hydrocotyle ranunculoides	Hyd ran	x											
Iris pseudacorus L.	Iri pse	x(KJR)	x	x	x	x	x				x	x	
Iris sintenisii subsp. brandzae	Iri sin		x										
Iris spuria	Iri spu		x										
Iris versicolor	Iri ver	x											
Isolepis cernua	Iso cer	x											
Isolepis fluitans L.	Iso flu	x					x						
Isolepis setacea	Iso set	x				x							
Juncus acutiflorus Ehrh. Ex Hoffm	Jun acu					x	x						
Juncus alpinoarticulatus Chaix	Jun alp	x(KJR)					x						
Juncus ambiguus	Jun amb					x							
Juncus articulatus L.	Jun art		x(Aus)	x		x	x						
Juncus atratus Krock.	Jun atr							x					
Juncus bufonius L.	Jun buf					x	x						
Juncus bulbosus L.	Jun bul	x			x	x	x						
Juncus conglomeratus L.	Jun con					x	x						
Juncus effusus L.	Jun eff	x(KJR)				x	x						
Juncus filiformis L.	Jun fil					x	x						
Juncus heterophyllus Dufour	Jun het	x							x				

Species	Abbrev.	Cnfrmd aqs	Pssbl aqs	Aus	Fin	Fre	Ger	Hun	Por	Rom	Slvak	Slven	Notes
Juncus inflexus L.	Jun inf	x(KJR)				x	x						
Juncus maritimus Lam.	Jun mar					x							
Juncus subnodulosus Schrank	Jun sub					x	x						
Lagarosiphon major (Ridley) Moss	Lag maj	x				x	?						
Leersia aquatica	Lee aqu				x								
Leersia oryzoïdes (L.) Schwartz	Lee ory		x			x	x						
Lemna aequinoctialis	Lem aeq	x											
Lemna gibba L.	Lem gib	x		x	x	x	x		x	x			
Lemna minor L.	Lem mino	x		x	x	x	x	x	x	x	x	x	
Lemna minuta	Lem minu	x				x	x						
Lemna trisulca L.	Lem tri	x		x	x	x	x	x	x	x	x		
Lemna turionifera Landolt	Lem tur	x				x	x						
Lilaea scilloides	Lil sci		x										
Luronium natans (L.) Rafin.	Lur nat	x				x	x						
Marsilea aegyptiaca	Mar aeg		x										
Marsilea azorica	Mar azo		x										
Marsilea quadrifolia	Mar qua		x						x				
Marsilea strigosa	Mar str		x										
Molinia arundinacea Schrank	Mol aru						x						
Molinia caerulea (L.) Moench	Mol cae					x	x						
Monochoria korsakowii	Mon kor		x										
Murdannia blumei	Mur blu	x											
Najas flexilis	Naj fle	x			x								
Najas gracillima	Naj grac	x											
Najas graminea	Naj gram	x											
Najas marina L.	Naj mar	x		x	x	x	x	x	x		x		
Najas marina subsp. armata	Naj mar arm	x											
Najas marina subsp. intermedia	Naj mar int	x											
Najas marina subsp. marina L.	Naj mar mar	x					x						
Najas minor All.	Naj min	x				x		x	x				
Najas orientalis	Naj ori	x											
Najas tenuissima	Naj ten	x			x								
Oryza sativa	Ory sat		x										
Ottelia alismoides	Ott ali	x											
Paspalum dilatatum	Pas dil		x			x							
Paspalum paspaloides	Pas pas		x										
Paspalum urvillei	Pas urv		x										
Paspalum vaginatum	Pas vag		x										
Phacelurus digitatus	Pha dig		x										
Phalaris arundinacea L.	Pha aru	x(KJR)	x	x	x	x	x				x		
Phragmites australis (Cav.) Trin. Ex Steud	Phr aus	x(KJR)	x	x	x	x	x		x		x		
Pistia stratiotes L.	Pis str		x				x						
Pleuropogon sabinei	Ple sab		x										
Poa annua L.	Poa ann					x							
Poa palustris L.	Poa pal						x						
Poa pratensis L.	Poa pra					x							
Poa trivialis L.	Poa tri					x	x						
Pontederia cordata	Pon cor		x										
Posidonia oceanica (marine?)	Pos oce												
Potamogeton acutifolius Link	Pot acu	x				x	x			x			
Potamogeton alpinus Balbis	Pot alp	x			x	x	x						
Potamogeton berchtoldii Fieber	Pot ber	x			x	x	x						
Potamogeton coloratus Hornem	Pot col	x				x	x						
Potamogeton compressus	Pot com	x			x	x	x						
Potamogeton crispus L.	Pot cri	x		x	x	x	x		x	x	x	x	
Potamogeton epihydrus	Pot epi	x											
Potamogeton filiformis Pers.	Pot fil	x			x	x							
Potamogeton friesii Rupr.	Pot fri	x			x	x	x						
Potamogeton gramineus L.	Pot gra	x			x	x	x		x				
Potamogeton helveticus (G. Fischer) E. Baumann	Pot hel					x							
Potamogeton lucens L.	Pot luc	x		x	x	x	x	x	x	x	x	x	

Species	Abbrev.	Cnfrmd aqs	Pssbl aqs	Aus	Fin	Fre	Ger	Hun	Por	Rom	Slvak	Slven	Notes
Potamogeton natans L.	Pot nat	x		x	x	x	x		x	x		x	
Potamogeton natans var. prolixus Koch	Pot nat pro						?						
Potamogeton nodosus Poir.	Pot nod	x				x	x	x	x	x	x		
Potamogeton obtusifolius Mert. & Koch	Pot obt	x			x	x	x						
Potamogeton pectinatus L.	Pot pec	x		x	x	x	x	x	x	x	x	x	
Potamogeton perfoliatus L.	Pot per	x		x	x	x	x	x	x		x	x	
Potamogeton polygonifolius Pourret	Pot pol	x			x	x	x		x				
Potamogeton praelongus Wulfen	Pot pra	x			x	x	x						
Potamogeton pusillus L.	Pot pus	x		x	x	x	x	x	x		x		
Potamogeton rutilus Wolfg.	Pot rut	x			x	x							
Potamogeton schweinfurthii	Pot sch	x											
Potamogeton siculus	Pot sic					x							
Potamogeton trichoides Cham. & Schltdl	Pot tri	x				x	x		x				
Potamogeton vaginatus	Pot vag	x			x								
Potamogeton x angustifolius J. S. Presl	Pot ang					x	x						
Potamogeton x bennettii	Pot ben	x											
Potamogeton x bottnicus	Pot bot	x											
Potamogeton x cognatus	Pot cog						x						
Potamogeton x cooperi	Pot coo	x											
Potamogeton x fennicus	Pot fen	x											
Potamogeton x fluitans	Pot flu	x					x						
Potamogeton x gessnacensis	Pot ges	x					x						
Potamogeton x griffithii	Pot gri	x											
Potamogeton x lintonii	Pot lin	x											
Potamogeton x nerviger	Pot ner	x											
Potamogeton x nitens Weber	Pot nit	x					x		x				
Potamogeton x olivaceus	Pot oli	x											
Potamogeton x saliciifolius Wolfgang	Pot sal	x					x						
Potamogeton x schreberi	Pot x sch	x					x						
Potamogeton x sparganiifolius Laestad ex Fries	Pot spa	x					x						
Potamogeton x sudermanicus	Pot sud	x											
Potamogeton x suecicus	Pot sue	x											
Potamogeton x undulatus	Pot und	x					x						
Potamogeton zizii Koch ex Roth	Pot ziz	x				?			x				
Rhynchospora rugosa	Rhy rug		x										
Ruppia cirrhosa	Rup cir	x			x	x							
Ruppia drepanensis	Rup dre	x											
Ruppia maritima	Rup mar	x			x	x							
Saccharum ravennae	Sac rav		x										
Saccharum spontaneum	Sac spo		x										
Sagittaria latifolia	Sag lat	x					x						
Sagittaria natans	Sag nat	x											
Sagittaria rigida	Sag rig	x											
Sagittaria sagittifolia L.	Sag sag	x		x	x	x	x	x	x	x	x	x	
Sagittaria subulata	Sag sub	x											
Scheuchzeria palustris	Sch pal	x											
Schoenoplectus lacustris (L.) Palla	Sch lac	x		x	x	x	x				x	x	
Schoenoplectus lacustris subsp. lacustris	Sch lac	x											
Schoenoplectus pungens	Sch pun	x											
Schoenoplectus supinus	Sch sup		x										
Schoenoplectus tabermaemontani	Sch tab	x(KJR)	x		x				x				
Scirpoides holoschoenus	Sci hol					x							
Scirpus lacustris L.	Sci lac					x	x		x				
Scirpus sylvaticus L.	Sci syl					x	x						
Scirpus tabernaemontani	Sci tab					x							
Scirpus triquetrus	Sci tri	x(KJR)	x			x							
Scolochloa festucacea	Sco fes				x								
Sparganium angustifolium Michx	Spa ang	x			x		x		x				
Sparganium angustifolium x emersum	Spa angxeme	x											
Sparganium angustifolium/emersum x gramineum	Spa angxgra	x											

Species	Abbrev.	Cnfrmd aqs	Pssbl aqs	Aus	Fin	Fre	Ger	Hun	Por	Rom	Slvak	Slven	Notes
Sparganium emersum Rehmann	Spa eme	x		x	x	x	x		x		x	x	
Sparganium erectum L.	Spa ere	x		x	x	x	x				x		
Sparganium erectum ssp. erectum	Spa ere ere	x							x				
Sparganium erectum ssp. microcarpum	Spa ere mic	x											
Sparganium erectum ssp. neglectum	Spa ere neg	x							x				
Sparganium erectum ssp. oocarpum	Spa ere ooc	x											
Sparganium glomeratum	Spa glo				x								
Sparganium gramineum	Spa gra	x			x								
Sparganium hyperboreum	Spa hyp	x			x								
Sparganium natans L.	Spa nat	x				x	x						
Spartina alterniflora (marine?)	Spa alt	x(KJR)											
Spartina anglica (marine?)	Spa ang	x(KJR)											
Spartina densiflora (marine?)	Spa den												
Spartina maritime (marine?)	Spa mar	x(KJR)											
Spartina versicolor (marine?)	Spa ver												
Spartina x townsednii (marine?)	Spa tow												
Spirodela polyrhiza (L.) Schleid	Spi pol	x		x	x	x	x	x	x	x	x		
Stratiotes aloides L.	Str alo	x			x	x	x			x			
Typha angustifolia L.	Typ ang	x(KJR)	x	x	x	x			x		x		
Typha domingensis	Typ dom		x						x				
Typha latifolia L.	Typ lat	x(KJR)	x	x	x	x	x		x		x		
Typha laxmannii	Typ lax		x										
Typha minima Funk	Typ min		x			x							
Typha shuttleworthii	Typ shu		x										
Vallisneria spiralis L.	Val spi	x				x	x		x	x			
Wolffia arhiza (L.) Horkel & Wimmer	Wol arr	x				x	x		x				
Zannichellia contorta	Zan con	x											
Zannichellia major	Zan maj	x			x								
Zannichellia obtusifolia	Zan obt	x											
Zannichellia palustris L.	Zan pal	x		x	x	x	x	x	x		x		
Zannichellia palustris L. ssp palustris	Zan pal pal						x						
Zannichellia palustris ssp pedicellata (Wahlenb. & Rosen)	Zan pal ped						x						
Zannichellia pedunculata Reich.	Zan ped	x			x	x							
Zannichellia peltata	Zan pel	x											
Zizania aquatica	Ziz aqu		x										
Zizania latifolia	Ziz lat		x										
Zostera angustifolia (marine?)	Zos ang	x(KJR)											
Zostera marina (marine?)	Zos mar	x(KJR)			x								
Zostera noltii (marine?)	Zos nol	x(KJR)											

Dicotyledons

Species	Abbrev.	Cnfrmd aqs	Pssbl aqs	Aus	Fin	Fre	Ger	Hun	Por	Rom	Slvak	Slven	Notes
Achillea ptarmica	Ach pta		x(G)				x						
Aldrovanda vesiculosa	Ald ves	x											
Amaranthus sp.	Ama sp					x							
Angelica sylvestris L.	Ang syl					x							
Angelica archangelica ssp. Litoralis (Fr.) Thell.	Ang arc						x						
Apium inundatum L.	Api inu	x				x	x		x				
Apium nodiflorum (L.) Lag.	Api nod	x(KJR)	x			x	x						
Apium repens (Jacq.) Lag.	Api rep	x					x				x		
Apium x moorei	Api moo		x										
Atriplex calotheca (Rafn) Fries	Atr cal						x						
Bacopa monnieri	Bac mon		x										
Barbarea intermedia Boreau	Bar int							x					
Barbarea vulgaris R. Br.	Bar vul					x	x						
Bergia capensis	Ber cap		x										
Berula erecta (Huds.) Coville	Ber ere	x(KJR)	x			x	x			x	x	x	
Bidens cernua L.	Bid cer					x	x						
Bidens sp.	Bid sp					x							
Bidens tripartita L.	Bid tri					x	x	x					
Bryonia dioica Jacq.	Bry dio							x					
Cabomba caroliniana Gray	Cab car	x											
Callitriche sp(p).	Cal sp	x											
Callitriche brutia Pet.	Cal bru	x				x			x				
Callitriche cophocarpa Sendtn.	Cal cop	x			x	x	x				x	x	
Callitriche cribrosa	Cal cri	x							x				
Callitriche hamulata Kutz ex W.D.J. Koch	Cal ham	x		x	x	x	x		x				
Callitriche hermaphroditica L.	Cal her	x			x	x							
Callitriche hermaphroditica var microcarpa	Cal her mic	x											
Callitriche hermaphroditica var. macrocarpa	Cal her mac	x											
Callitriche lenisulca	Cal len	x											
Callitriche lusitanica	Cal lus	x							x				
Callitriche obtusangula Le Gall	Cal obt	x		x		x	x		x				
Callitriche palustris L.	Cal pal	x			x	x	x						
Callitriche platycarpa Kütz.	Cal pla	x				x	x						
Callitriche pulchra	Cal pul	x											
Callitriche regis-jubae	Cal reg	x											
Callitriche stagnalis Scop.	Cal sta	x				x	x		x				
Callitriche stagnalis/platycarpa agg.	Cal sta/pla	x											
Callitriche truncata Guss.	Cal tru	x				x			x				
Callitriche truncata ssp. occidentalis	Cal tru occ	x											
Callitriche truncata ssp. truncata	Cal tru tru	x											
Callitriche truncata subsp. fimbriata	Cal tru fim	x											
Callitriche x vigens	Cal vig	x											
Caltha minor auct. non Mill.	Cal min					x							
Caltha palustris L.	Calth pal		x		x	x	x		x				
Calystegia sepium (L.) R. Br.	Cal sep					x		x					
Cardamine amara L.	Car ama				x	x	x						
Cardamine hirsuta L.	Car hir					x							
Cardamine latifolia	Car lat					x							
Cardamine pratensis L.	Car pra				x	x							
Cardamine resedifolia L.	Car res					x							
Carum verticillatum	Car ver		x										
Ceratophyllum demersum L.	Cer dem	x(Aus)		x		x	x				x		
Ceratophyllum demersum var. apiculatum	Cer dem api	x											
Ceratophyllum demersum var. inerme	Cer dem ine	x											
Ceratophyllum muricatum	Cer mur	x											
Ceratophyllum platyacanthum	Cer pla	x											
Ceratophyllum submersum L.	Cer sub	x				x	x						
Chrysosplenium alternifolium L.	Chr alt					x							
Chrysosplenium oppositifolium L.	Chr opp					x							

Species	Abbrev.	Cnfrmd aqs	Pssbl aqs	Aus	Fin	Fre	Ger	Hun	Por	Rom	Slvak	Slven	Notes
Cicuta virosa L.	Cic vir	x(KJR)	x		x	x	x						
Cirsium arvense (L.) Scop.	Cir arv					x	x						
Cirsium oleraceum (L.) Scop.	Cir ole					x	x						
Cirsium palustre (L.) Scop.	Cir pal					x			x				
Corrigiola litoralis	Cor lit	x											
Cotula coronopifolia	Cot cor		x										
Crassula aquatica	Cra aqu	x			x								
Crassula helmsii (Kirk) Cockayne	Cra hel	x					x						
Drosera rotundifolia	Dro rot	x											
Eclipta prostrata	Ecl pro		x										
Eichhornia crassipes (Mart.) Solms-Laub.	Eic cra					x							
Elatine alsinastrum L.	Ela als	x			x		x		x				
Elatine ambigua	Ela amb	x											
Elatine brochonii	Ela bro	x											
Elatine hexandra (Lapierre) DC	Ela hex	x				x	x		x				
Elatine hungarica	Ela hun	x											
Elatine hydropiper L.	Ela hyd	x			x	x	x						
Elatine macropoda Guss.	Ela mac	x							x				
Elatine orthosperma	Ela ort	x			x								
Elatine triandra Schkuhr	Ela tri	x			x		x		x				
Epilobium ciliatum Rafin.	Epi cil						x						
Epilobium hirsutum L.	Epi hir					x	x	x					
Epilobium lanceolatum Sebast. & Mauri	Epi lan						x						
Epilobium palustre L.	Epi pal						x						
Epilobium parviflorum Schreb.	Epi par					x	x						
Epilobium roseum Schreb.	Epi ros					x	x						
Epilobium tetragonum L.	Epi tet					x							
Eryngium corniculatum	Ery cor		x										
Eryngium galioides	Ery gal		x										
Eryngium viviparum	Ery viv		x										
Eupatorium cannabinum L.	Eup can					x	x						
Fallopia dumetorum	Fal dum					x							
Filipendula ulmaria (L.) Maxim.	Fil ulm					x	x						
Fraxinus excelsior L.	Fra exc						x						
Galium aparine L.	Gal apa					x							
Galium mollugo L.	Gal mol						x						
Galium neglectum	Gal neg					x							
Galium palustre L.	Gal pal	x(KJR)				x	x	x					
Galium trifidum	Gal tri				x								
Galium uliginosum L.	Gal uli					x	x						
Glechoma hederacea L.	Gle hed						x						
Gnaphalium uliginosum L.	Gna uli						x						
Gratiola linifolia	Gra lin		x										
Gratiola neglecta	Gra neg		x										
Gratiola officinalis	Gra off		x										
Helodes palustris Spach	Hel pal					x							
Heteranthera reniformis	Het ren		x										
Hippuris tertaphylla	Hip ter				x								
Hippuris vulgaris L.	Hip vul	x		x	x	x	x	x	x	x	x	x	
Hottonia palustris L.	Hot pal	x				x	x			x			
Humulus lupulus L.	Hum lup					x							
Hydrilla verticillata	Hyd ver	x											
Hydrocotyle vulgaris L.	Hyd vul	x(KJR)				x	x		x				
Hypericum elodes L.	Hyp elo	x(KJR)	x				x		x				
Hypericum maculatum Crantz.	Hyp mac					x							
Impatiens glandulifera Royle	Imp gla						x						
Impatiens noli-tangere L.	Imp nol						x						
Isnardia palustris L.	Isn pal					x							
Lamium album L.	Lam alb					x							
Lamium maculatum L.	Lam mac						x						

Species	Abbrev.	Cnfrmd aqs	Pssbl aqs	Aus	Fin	Fre	Ger	Hun	Por	Rom	Slvak	Slven	Notes
Lilaeopsis attenuata	Lil att		x										
Limosella aquatica	Lim aqu	x(KJR)	x		x								
Limosella australis	Lim aus	x(KJR)	x										
Lindernia dubia	Lin dub		x										
Lindernia procumbens	Lin pro		x										
Littorella uniflora (L.) Ascherson	Lit uni	x			x	x	x		x				
Lobelia dortmanna L.	Lob dor	x			x		x						
Lotus pedunculatus	Lot ped	x											
Lotus uliginosus Schkuhr	Lot uli					x							
Ludwigia grandiflora	Lud gra		x			x							
Ludwigia palustris (L.) Elliot	Lud pal	x(KJR)	x				x		x				
Ludwigia peploides (Kunth)	Lud pep		x			x							
Lycopersicon esculentum	Lyc esc					x							
Lycopus europaeus L.	Lyc eur		x		x	x	x						
Lysimachia nemorum L.	Lys nem					x							
Lysimachia nummularia L.	Lys num		x(Aus)	x		x		x					
Lysimachia thyrsifloraL.	Lys thy	x(KJR)	x		x	x	x						
Lysimachia vulgaris L.	Lys vul					x	x	x	x				
Lythrum portula	Lyt por	x(KJR)	x		x								
Lythrum portula subsp. longidentata	Lyt por lon	x											
Lythrum portula subsp. portula	Lyt por por	x											
Lythrum salicaria L.	Lyt sal			x		x	x	x					
Mentha aquatica L.	Men aqu	x(KJR)	x	x		x	x			x	x	x	
Mentha arvensis	Men arv				x		x						
Mentha longifolia (L.) Huds. em. Harley	Men lon					x	x						
Mentha x rotundifolia (L.) Huds	Men rot					x	x						
Mentha x verticillata	Men ver					x	x						
Menyanthes trifoliata L.	Men tri					x			x				
Mimulus guttatus DC	Mim gut		x			x							
Montia fontana L. agg.	Mon fon	x(KJR)			x	x							
Montia fontana subsp. amporitana	Mon fon amp		x				x		x				
Montia fontana subsp. fontana	Mon fon fon		x				x						
Montia fontana subsp. minor	Mon fon min		x										
Montia fontana subsp. variabilis S. M. Walters	Mon fon var		x				x						
Myosotis laxa	Myo lax	x(KJR)			x	x	x						
Myosotis palustris (L.) Hill	Myo pal			x		x					x	x	
Myosotis scorpioides L.	Myo sco	x(KJR)					x	x					
Myosotis secunda Murray	Myo sec	x							x				
Myosotis stolonifera	Myo sto	x							x				
Myosoton aquaticum (L.) Moench	Myo aqu	x(KJR)				x	x						
Myrica gale	Myr gal						x						
Myriophyllum alterniflorum DC.	Myr alt	x			x	x	x		x				
Myriophyllum aquaticum	Myr aqu	x				x	x						
Myriophyllum exalbescens	Myr exa	x			x								
Myriophyllum heterophyllum	Myr het	x					x						
Myriophyllum spicatum L.	Myr spi	x		x	x	x	x	x	x	x	x	x	
Myriophyllum verrucosum	Myr verr	x											
Myriophyllum verticillatum L.	Myr vert	x			x	x	x		x		x		
Nelumbo nucifera	Nel nuc	x											
Nuphar advena	Nup adv	x											
Nuphar lutea (L.) Sibth. & Sm.	Nup lut	x		x	x	x	x	x	x	x	x	x	
Nuphar lutea x pumila	Nup lutxpum	x											
Nuphar pumila (Timm) DC.	Nup pum	x			x	x							
Nuphar x spenneriana	Nup spe	x											
Nymphaea alba L.	Nym alb	x		x	x	x	x	x	x	x	x		
Nymphaea alba x candida	Nym albxcan	x											
Nymphaea candida	Nym can	x			x								
Nymphaea lotus	Nym lot	x											
Nymphaea rubra	Nym rub	x											

Nymphaea tetragona	Nym tet	x			x								
Nymphoides peltata (S. G. Gmelin) O. Kuntze	Nym pel	x		x		x	x	x	x	x			
Species	Abbrev.	Cnfrmd aqs	Pssbl aqs	Aus	Fin	Fre	Ger	Hun	Por	Rom	Slvak	Slven	Notes
Oenanthe aquatica (L.) Poiret	Oen aqu	x(KJR)	x	x	x	x	x		x				
Oenanthe crocata L.	Oen cro	x				x							
Oenanthe fistulosa L.	Oen fis	x(KJR)	x				x		x				
Oenanthe fluviatilis (Bab.) Coleman	Oen flu	x				x							
Oxalis acetosella L.	Oxa ace					x							
Peplis portula L.	Pep por					x	x						
Persicaria amphibia (L.) Gray	Per amp	x		x	x	x	x		x				
Persicaria foliosa	Per fol	x			x								
Persicaria hydropiper L. Delarbe	Per hyd					x	x				x		
Persicaria lapathifolia L. Gray	Per lap					x	x						
Persicaria maculosa	Per mac						x						
Persicaria mitis Schrank	Per mit			x		x							
Petasites hybridus (L.) Gaertn.,Mey. & Scherb.	Pet hyb					x	x						
Peucedanum palustre (L.) Moench	Peu pal					x	x						
Potentiella anserina	Pot ans						x						
Potentilla erecta (L.) Räuschel	Pot ere	x				x							
Potentilla palustris (L.) Scop.	Pot pal	x(KJR)			x	x	x						
Pulicaria dysenterica (L.) Bernh.	Pul dys					x							
Ranunculus aquatilis L.	Ran aqu	x			x	x	x		x				
Ranunculus batrachoides	Ran bat	x											
Ranunculus baudoti Godron	Ran bau	x			x	x							
Ranunculus circinatus Sibth	Ran cir	x		x	x	x	x	x			x		
Ranunculus flammula L.	Ran fla	x(KJR)			x	x	x		x				
Ranunculus flammula subsp. flammula	Ran fla fla	x											
Ranunculus flammula subsp. minimus	Ran fla min	x											
Ranunculus flammula subsp. scoticus	Ran fla sco	x											
Ranunculus fluitans Lamk	Ran flu	x				x	x						
Ranunculus hederaceus L.	Ran hed	x				x	x		x				
Ranunculus hyperboreus	Ran hyp				x								
Ranunculus lingua	Ran lin	x(KJR)			x		x						
Ranunculus ololeucos Lloyd	Ran olo	x					x		x				
Ranunculus omiophyllus Ten.	Ran omi	x				x			x				
Ranunculus peltatus Schrank.	Ran pel	x			x	x	x						
Ranunculus peltatus subsp. fucoides	Ran pel fuc	x											
Ranunculus peltatus subsp. peltatus	Ran pel pel	x							x				
Ranunculus penicillatus Dum	Ran pen	x					x		x				
Ranunculus penicillatus subsp. penicillatus	Ran pen pen	x				x	x						
Ranunculus penicillatus subsp. pseudofluitans (Syme) S. D. Webster	Ran pen pse	x				x	x						
Ranunculus polyphyllus	Ran pol	x											
Ranunculus repens L.	Ran repe					x	x	x					
Ranunculus reptans	Ran rept	x			x		x						
Ranunculus rionii	Ran rio	x											
Ranunculus sardous Crantz	Ran sar					x							
Ranunculus sceleratus L.	Ran sce	x		x	x	x	x		x				
Ranunculus sphaerosphermus	Ran sph	x											
Ranunculus trichophyllus Chaix	Ran tric	x				x	x				x		
Ranunculus trichophyllus subsp. eradicatus	Ran tri era	x							x				
Ranunculus trichophyllus subsp. trichophyllus	Ran tri tri	x			x				x				
Ranunculus trichophyllus subsp.lutulentus	Ran tri lut				x								
Ranunculus trichophyllus x circinatus	Ran trixcir			x			x						
Ranunculus tripartitus DC	Ran trip	x				x			x				
Ranunculus x bachii	Ran bac	x											
Ranunculus x kelchoensis	Ran kel	x											
Ranunculus x levenensis	Ran lev	x											
Ranunculus x novae-forestae	Ran nov	x											
Rorippa amphibia (L.) Besser	Ror amp	x(KJR)	x		x	x	x		x	x	x		
Rorippa cf x armoracioides	Ror ery						x						
Rorippa cf x erythrocaulis	Ror arm						x						

Rorippa islandica (Oeder) Borbas	Rir isl					x							
Rorippa microphylla Boenn	Ror mic	x(KJR)	x				x						
Species	**Abbrev.**	**Cnfrmd aqs**	**Pssbl aqs**	**Aus**	**Fin**	**Fre**	**Ger**	**Hun**	**Por**	**Rom**	**Slvak**	**Slven**	**Notes**
Rorippa nasturtium-aquaticum L.	Ror nas	x(KJR)	x			x	x		x	x		x	
Rorippa palustris (L.) Besser	Ror pal						x						
Rorippa x anceps	Ror anc	x											
Rorippa x sterilis	Ror ste	x(KJR)	x										
Rotala filiformis	Rot fil		x										
Rotala indica	Rot ind		x										
Rumex aquaticus L.	Rum aqu	x(KJR)				x	x						
Rumex conglomeratus Murray	Rum con					x							
Rumex crispus L.	Rum cri					x	x						
Rumex hydrolapathum Huds.	Rum hyd	x(KJR)				x	x	x				x	
Rumex obtusifolius L.	Rum obt					x	x						
Rumex palustris Sm.	Rum pal					x	x	x					
Sagina procumbens L.	Sag pro					x							
Salix aurita L.	Sal aur						x						
Salix viminalis	Sal vim						x						
Samolus valerandi L.	Sam val	x(KJR)	x			x							
Scrophularia auriculata L.	Scr aur	x				x							
Scrophularia nodosa L.	Scr nod						x						
Scrophularia umbrosa Dum.	Scr umb					x	x						
Scutellaria galericulata L.	Scu gal					x	x	x					
Senecio aquaticus Hill.	Sen aqu					x							
Senecio sp(p).	Sen sp(	x											
Shinnersia rivularis	Shi riv						x						
Sibthorpia europaea L.	Sib eur					x							
Sium erectum Huds.	Siu ere										x		
Sium latifolium L.	Siu lat	x(KJR)	x			x	x						
Solanum dulcamara L.	Sol dul	x(KJR)				x	x	x					
Stachys palustris L.	Sta pal					x	x	x			x		
Stachys sylvatica L.	Sta syl						x						
Stellaria palustris	Ste pal	x											
Stellaria uliginosa	Ste uli					x							
Subuluria aquatica	Sub aqu	x			x								
Symphytum officinale L.	Sym off					x	x						
Teucrium scordium L.	Teu sco		x				x						
Thalictrum flavum L.	Tha fla						x						
Thorella verticillatinundata	Tho ver		x										
Trapa natans L.	Tra nat	x		x		x				x	x		
Urtica dioica L.	Urt dio					x	x						
Utricularia australis	Utr aus	x			x	x	x		x				
Utricularia bremii Herr ex Kölliker	Utr bre	x				x							
Utricularia gibba	Utr gib	x											
Utricularia intermedia Hayne	Utr int	x			x	x	x						
Utricularia minor L.	Utr min	x			x	x	x						
Utricularia ochroleuca R. Hartman	Utr och	x			x	x							
Utricularia spp.	Utr spp	x											
Utricularia stygia	Utr sty	x					?						
Utricularia vulgaris L.	Utr vul	x		x	x	x	x	x			x		
Valerina officinalis L.	Val off						x						
Veronica anagallis-aquatica L.	Ver ana-aq	x(KJR)	x			x	x		x			x	
Veronica anagalloides Guss	Ver ana		x						x				
Veronica beccabunga L.	Ver bec	x(KJR)	x	x		x	x		x				
Veronica catenata Pennel	Ver cat	x(KJR)	x	x		x	x		x				
Veronica filiformis Sm.	Ver fil						x						
Veronica scutellata L.	Ver scu	x(KJR)			x	x	x		x				
Veronica x lackschewitzii	Ver lac	x											
Viola palustris	Vio pal	x(KJR)				x	x						

Appendix A11 Development of methodology

STAR– Macrophytes - standardisation of field survey

Dear Macrophyte Field Surveyor

Attached is the agreed methodology and forms for your use. These forms have been improved to accommodate most uses and to be practical for use both in river surveying and to allow easy transfer of data to the STAR database

Data on the species and habitat of plants needs to be recorded during the survey. This data should relate to, or optimise, the plants ability to indicate ecological status for WFD 'rivers'. Good ecological status needs to be established for the river so that any departure from this defined level can be measured at survey sites. Thus the survey site should be representative of the river or alternatively comparable sites should be surveyed, and the species so the **species we need to include must interact with water and be indicative of water quantity and quality**.

The STAR standard methodology seeks to incorporate existing methodologies and to allow use of existing data collected by them. Thus, agreement is needed on the plant species which need to be recorded, the extent or cover of the channel or adjacent areas eg the riparian corridor, and recording of the habitat of the groups of plants.

A. The plant list is extracted from suggestions from CEN members and STAR members and was originally compiled by CEH for the April 2002 meeting of CEN– the full list is available by email:
[plant habitat division needed? Any species additions or removals?]

B. The definition of survey areas ie channel varies within the group especially between the north and south of Europe. The choice for recording includes:
a) flowing water aquatics - hydrophytes
b) aquatic and marginal/emergent - hydrophytes and some helophytes
c) most aquatic species - hydrophytes, helophytes, marginals and ruderals
d) aquatic, marginal/emergent, ruderals and flood-plain species,
e) separate list for ruderals and flood-plain species
f) all species list (perhaps 3 pages with 3 columns on each or g) some other combination.
This proposal for STAR surveys is for sites to be sampled as option c) (see attached form) although perhaps eventually reduced (2003) to include only likely indicators species from areas which are submerged for part of the year and not just during floods. Existing national methods which require more of the marginal areas ie side-enlarging, can use other columns on the survey form or shorter or longer lengths.
[The plant list on form – should the list be reminders of plant names or a tick-list of all species?]

C. Plant cover should be recorded using an absolute areal scale and not relative.

D. Habitat details to be recorded using the hydromorphology classes. Is more detail on the form of habitat features required by any method eg sizes for substrates eg xxxx 2-8mm, or is space required to record additional details, or features, etc – suggestions?
I propose we use form similar to that attached and any additional national survey details is recorded on additional form(s) [there is room on attached form for small additions]

The course is organised with an experienced trainer, surveyors, and field helpers for 4 teams of 8-10. To save time on travel we expect to run course in parallel with STAR hydromorphology field visits. READ the Health & Safety proposals and equipment list.

Please vote on content or if you have suggestions for altering any of the forms or the proposed methodology or updates for table 1. My email is fhd@ceh.ac.uk , telephone with messaging is 44-1305-213616 or fax me on 44-1305-213600
Please feel free to circulate to colleagues for comment, changes, advice – I have asked several!

Macrophyte standardised field survey work schedule

Upon arrival at each site the following schedule will be carried out to simulate real field surveys,
each macrophyte field surveyor will:

A. assess the site for safety of the surveyor(s) and surveying
including safe entry and exit from the river channel;
B. locate the designated sampling area using a map or GPS;
C. survey the sample area and record data on survey forms:
location map, 100m sketch, habitat, plant species and cover;
D. identify plants, or take samples especially of difficult groups, and mosses, liverworts and algae;
E. after surveying, prepare and send samples for identification to national specialists.

Macrophyte field surveyors will require to bring at least the following sampling equipment (see full list):

personal clothing and equipment for field sampling such as waders
relevant safety and first-aid equipment
writing and recording equipment - 'clipboard', pencils, camera
bags for plant samples

STAR– Macrophytes - standardisation of field survey

Introduction.
Macrophytes are an important component of aquatic ecosystems and are required to be used broadly within the Water Framework Directive (WFD) (2000/60/EC)], to facilitate the establishment of good ecological status and the general monitoring of ecological status. In addition to their ecological role, macrophytes are indicators of ecological quality in running waters. In particular species and species groups of macrophytes are typical of specific types of running waterbody and the degree to which they are adversely affected by types of anthropogenic impact. The absence of aquatic macrophytes may however be characteristic of some running water habitats such as in highly active rivers with unstable gravel beds or in deeper rivers where their absence may due to the limitations of habitat such as light through water depth, water velocity, or turbidity. Absence of plants may equally be the result of some unidentified anthropogenic impact eg, chemical.

A wide range of sampling and survey methodologies have been developed by different nations for specific applications including conservation, trophic status, drainage impact, management, ecological habitat, river restoration or enhancement. The methodology required as part of the STAR programme is developed specifically for the surveying of macrophytes in natural and anthropogenically-altered running freshwaters for the purpose of monitoring ecological status.

The CEN standard has not as yet been made formally available (April 2002) but STAR has been commissioned to consider and to test a standard methodology for use throughout Europe.

As there are several areas which need to be standardised, it is proposed to:

1. establish a consensus field methodology including as far as possible national methodologies but based on MTR as agreed by the partners. Data collection should include, as far as possible, detail of species individual, assemblages, and associations for the absolute areal cover of stream bed. Survey should be able to be undertaken concurrently with existing national systems by as simple as possible modifications to mainform. This may need to include, for example, the addition of percentage cover for some phyto-sociological methods. It is possible that extra time may be needed by some national methodologies to acquire the data to match the proposed species collection, identification, cover estimate or survey length,

2. determine indicator status by the use of individual species, assemblages and/or communities as indicators of departure from good ecological status and to relate these by relevant analytical techniques to environmental factors and other variables but also by extending existing national relationships to broader ones for Europe. Currently national systems often only assess trophic status or other limited range of anthropogenic impacts. Environmental factors for natural and modified habitats which need to be considered include water velocity, water depth, substrate (size and stability), general habitat, and water chemistry but also similarity between survey sites.

and in addition proposals for after the Metz workshop could include:
A. A state-of-the-art checklist of aquatics or aquatic and riparian species to be used in field surveys for all of Europe cp AQEM project taxa list for European freshwater macroinvertebrates (http://www.aqem.de/taxalist/taxa_text.htm). CEN has already implemented enquiries to its members and these have been put together by CEH for circulation April 2002.
B. compile a list of identification/determination literature (keys, floras, scientific papers)

Objectives for field meeting in Vosges, France

1. obtain a European-wide consensus on sampling methodology before the field meeting in Metz to provide an agreed sampling methodology allowing the incorporation of compatible national systems and implement sampling procedures. [this cannot be confirmed before the data has been analysed] .
[a. see comparison of known national aquatic plant survey techniques undertaken –
F, D, P and UK - see Table 1, and
b. continue to obtain details and additional countries field methodologies]

2. organise a field meeting for standardisation of field surveying for macrophytes including:
a. standard STAR macrophyte methodology
(MTR circulated – any copies required?– update STAR field sampling proposed for course)
b.. sampling equipment proposed/required with H&S
(draft list attached),
c. proposed survey forms on
i) macrophyte species cover of river bed
ii) macrophyte habitat (draft attached),
[requirements for macrophytes discussed with the trainers and based on input and work by CEH for CEN]
d. trainers

3. select a range of sites after local advice, discussion with the 'trainers' (selected) and in conjunction with requirements for hydro-morphological sites to reduce travel between sites and chosen from photographs. According to local information (CG), the vegetation at the probable survey sites has only been fully surveyed at 4 of the 8 sites. Proposed sites are smaller or headwater streams with a flora mostly composed of bryophytes (*Rynchostegium riparioides, Racomitrium aciculare, Hygrohypnum ochraceum, Fontinalis antipyretica, F. squamosa**) with *Ranculus peltatus, Callitriche sp. (C. platycarpa* and *C. hamulata*), some bryophytes such as *Fontinalis* and some macro-algae are present further downstream.
[The draft timetable of the field meeting with proposed sites sent to a) Phillipe Usseglio (JN Beisel) for approval and comment before b) circulation to national star reps for transfer to botanists]

4. Addition of community or assemblage analysis to individual species analysis.

Detail for field sampling - Current proposals for agreement on STAR macrophyte standardisation of field survey include:
a) length of sample site 100m, by standard STAR survey
and/or by national survey methodologies
if **shorter** then repeat for adjacent section for example if national surveys is 50m then
another adjacent survey of 50 should be undertaken
if **longer** than split at 100 m and then complete full distance eg 250 m.
b) use of absolute cover estimation using a 9/10 point scale or as percentage
or a letter of DAFOR scale, to match STAR proposed scale.
c) indicative (or memory-aid) list of aquatic species for field use
i) a list of species with habit has been prepared for CEN by CEH for circulation to CEN
[the current proposed list of species and sub species, taxa and groups contains: 52 Algae, 104 Mosses, 31 Pteridophytes, 231 Monocots and 295 Dicots - check lists - see appendix]
ii) it is proposed to transfer the commonest species to survey form for use at field
meeting; [in future each country could use their own national list – comments please]
iii) differentiate aquatic from bank species (or from marginal species?) (add 'habit' on form)
[MTR uses 80% of time in water (CEN is working on this for their mid April meeting), but limits vary from 80% inundated in N. Europe to 40% or less in S. Europe.
Current proposal is to record aquatic plants either:
- **cover by habit type at field site using labeled columns (3)** either as
- aquatic, marginal/emergent, bankside three columns. or
- hydrophytes, pleustophytes, haptophytes and 'aquatic' helophytes eg *Sparganium*),
(other helophytes recorded only if forming dominant stands).
d) identification (list of keys?)
e) method of confirmation of identification
- 'higher plants' herbarium sheets is proposed always for difficult species
always including - Ranunculus, Potamogetons, Callitriches,
(and others such as Charophytes)
- bryophytes, always, dried, labelled, and stored in small paper packets (folded A4 sheet)
- macro-algae - small sample to national specialist.
preserve in 0.1% alcohol

Appendix A12- STAR Standardisation of field survey for Macrophytes and Hydromorphology – draft for comment

Guidance with suggested list of safety, personal and sampling equipment with recommendations from CEN for macrophytes, MTR and RHS methodologies and reference to Biologische Gewassuntercuching Tumpling and Friedrich 1999 (safety based upon UK requirements) (draft at 28.03.2002, fhd)

Recommendation	CEN	MTR	RHS	Recommendation for STAR	STAR Macro/ Hydro	CEH notes Team of 4
Working in and around water is inherently dangerous **Users of CEN standard should ensure compliance with national safety legislation**				**Conform to Health & Safety requirements for higher of the standards of employer, nation or country of survey** by Assessment of Risk and the application of code of practice to minimise risk	**M/H**	PH
Leaders or Managers to make staff aware of potential dangers in field work and of procedures in case of accident			R	**Ensure that management and team members are aware of potential dangers and accident procedures. Each team member is responsible for their own safety and that of each the other members of the team. Establish and follow reporting procedure.**	**M/H**	JSW to assess completeness HD, PS, DH PH
Safety equipment - refer to safety manuals and advice available from your Line Manager or Safety Advisor.	**X**			Conform to highest standard of employer, national standards or country of operation		PH to check
Personal equipment – typical recommendations						PS, PH,
lifejacket	C	M	R	wear self inflating lifejacket with manual release override	M/H	4 +4 +4
and/or use safety harness & line (alternative)			R	(have available spare CO2 cartridge & arming device)		
or throw line available for use (alternative)			R	**carry personal first-aid kit** for use on abrasions near/in		
First aid equipment - first-aid kit:	?	?	R	water and containing: standard bandage plus choice of suitable personally-compatible items which may include	M/H	
				sun block cream, anti-histamine or similar, insect repellent, plasters or cover bandage eg micro-pore tape, and antiseptic wipes,	M/H	
				and easy access to **team first-aid kit** (eg in team's backpack or on vehicle) including bandages large (4) small (4), triangular (2), eye (4) micro-pore tape, saline	M/H	

				irrigation containers (4)		
Hand protection			R	Suitable waterproof gloves		1 pair of
- arm-length waterproof gloves (for polluted and potentially polluted waters)	?	?		(long-arm preferred especially for polluted water) Antiseptic Barrier cream for hands	M	disposable gloves/site)
Barrier cream	?	?		Surgical wipes and/or anti-bacterial soap & clean water	M/H	4 Debs
Surgical wipes	?	?		Waders - short 0.7m or long 1.3m	M/H	4 packs
Waders	?	?	R	and also walking boots for hydro-morphology	M	pair per person
or footwear to suit conditions			R	Protective clothing to suit expected range of conditions -	H	
Protective clothing to suit conditions			R	including waterproof clothing	M/H	
- Waterproof clothing	?	?	R			
High visibility jacket			R			
Eye protection			R	Hard hat for use where risk of falling rocks eg cliffs,		
Head protection				georges	H	
				Rucksac, small		
				Emergency communication equipment effective at field	H	
Emergency communication equipment and/or 'buddy' in proximity			R	site eg land-based or satellite mobile telephone or two-way radio and/or other responsible person in proximity	M/H	
			R	Audible and visual means of signalling alarm		
Air-horn, flares, electronic anti-personnel alarm						
Field Survey methodology and equipment						
General location of site						
Maps, with scales compatible with the objectives of the survey (MTR uses 1:50 000 scale map)	X	c		Map of area at scale of 1:50 000 or greater detail	M/H	HD
				Obtain permission to enter site and to sample	M/H	
				Obtain license for removal of plant material if necessary	M	
assessment of river conditions should include				Assess if the general area of site is safe to survey **before**	M/H	
1. avoid rivers in spate or flood			**R**	**entry** and check that any necessary safety equipment is		
– consider hydro-electric flow management				available,		
2. avoid access to river by steep or unstable banks			**R**	check that there is a safe exit from river.		
3. avoid entry and check water depth if river bed is not visible			**R**	The site assessment should include 1. avoidance of rivers in spate or flood	M/H	
4. watch for hazards especially in urban rivers eg broken glass, sharp metal decomposing deposits			**R**	– consider effects of hydro-electric flow management 2. avoidance of access to river by steep or unstable banks	M/H M/H	

5. work in pairs when rivers need to be crossed esp. if swift 6. avoid contact with water, banks or low vegetation before eating or drinking in the field			**R** **R**	3. avoidance of entry if river bed is not visible - check water depth 4. watch for hazards especially in urban rivers eg broken glass, sharp metal, or decomposing deposits 5. work in pairs when rivers need to be crossed esp. if swift flowing 6. avoid contact with water, banks or low vegetation before eating or drinking in the field	M/H M/H M/H	
Locate or record exact position of site - Global Positioning System (GPS)-instrument	x	c		Global Positioning System (GPS)-instrument (spare set of batteries) (recording GPS for position and altitude - optional)	M/H	2 + 8 batteries
Standard record sheets + sketch map sheet (on waterproof paper if necessary) clipboard in a clear cover; Indelible pens/pencils	x ? ?	x ? ?	x ? ?	Survey sheets Clipboard with waterproof shield/cover or a large clear plastic bag (to protect record sheet and make writing possible in damp or wet conditions) pencils and sharpener	M/H	PS 300 +300 macrophyte hydromorph forms PH 4 or 8 large polythene bags 12 + 4
Summary of the methodology and definitions reference sheets (optional) Substrate reference and % cover reference sheets (optional)	X			Brief waterproofed summary of methodology - definitions reference sheets - substrate reference - % cover reference sheets	M	PS
shallow water sampling:						
Bank stick with depth markings	X			Ranging pole 2m	M/H	PH 4 + 6 for training
Plastic bags and labels; tubes for small specimens	X	c		Plastic bags (5 large & 10 small), small specimen tubes and waterproof labels;	M	PH 4 x 5 + 4 x 10 = 50 + 100 bags 100 tubes for training
Tape measure or measuring rope, marking stakes and mallet (to mark start and end of survey length)	X	X		Tape measure calibrated in metres, marking stakes and mallet;	M	PH 1x 50 or 100m

Identification and field guides	X	c		Identification keys and field guides; local flora optional	M	PS list
Camera with a polarising lens and 200 ISO daylight film speed.	X	X		Camera with polarising lens (digital camera with minimum of 2m-pixel resolution recommended)	M/H	ISF, PH PS
Blackboard & chalk or wipe-clean board, non permanent pen and cloth (to include site details in the photographs)	X			Small Blackboard (c0.2by 0.3 m) & chalk OR record date & time on digital film or record number of picture from digital camera index on data sheet (spare batteries and/or battery charger)	M/H	PH 4
Underwater viewing aid (e.g. glass-bottom bucket or underwater TV camera)	X	c		Underwater viewing aid/aqua-scope (bucket or box with clear Perspex base)	M	PH 2
Polarising sunglasses (optional)	X	c		Polarising sunglasses	M	PH 4 buy
Optical range finder (optional)	X	X		Optical range finder (optional)		PS 4 test, take
Binoculars		c				
Copy of previous survey sheet.	X			(use for return to exact site location only)		
Hand lens (x10)	X	c		Hand lens, x10 magnification;	M	PS 4
White plastic trays.		c		White plastic trays.	M	PH 3
Plastic bag, small specimen tubes, waterproof labels		c		Plastic bags with waterproof labels for field collection Herbarium frame (*c*0.5 by 0.3m), with mounting & drying paper for larger plants - A4 paper for bryophytes	M	PH 4 + 40 mount +80 drying sheets
Equipment for sampling at remote field sites, may in addition include: torch, compass, hypothermia blanket pack, survival rations			R	**Equipment for sampling at remote field sites,** may in addition include: torch, compass, hypothermia blanket eg reflective foil pack, survival rations	M/H	
Equipment for sampling in deeper waters Boat and additional safety equipment as required.	X	c		conform to national code of practice for use of boat or diving Boat and necessary safety equipment		
Grapnel with depth markings on the rope or rake	X	X		Grapnel with (optional) depth markings (at 0.5m intervals) on the rope	M	PH 3
Wading suit or dry-suit and diving equipment.	X	c c		Wading suit		
Additional sampling equipment						
				Water sample for chemical or physical analysis		PH 4x 60ml

				clean high density plastic bottles (60ml), portable filtration equipment for 0.45mu cellulose nitrate filter material, cool-storage containers		per site = 60 8 filter membrane holders filter membranes = 80 8 plastic syringes 4 forceps 4 marker pens 8 spare O-sealing rings 2 cool boxes
				Diatom sampling clean high density plastic bottles (60ml), tooth brush, 1% formalin buffered to pH 7		PH to ask MTF or NK re diatom sample containers for training