NRA ANGLIAN 137

NRA

STANDARD METHODOLOGIES

Assessment of Freshwater Riverine Environments using Macrophytes

Final Draft
April 1994

National Rivers Authority
Anglian Region

NATIONAL RIVERS AUTHORITY ANGLIAN REGION BIOLOGY LABORATORY PROCEDURES MANUAL	SECTION C METHOD NO.2 Sheet 1 of 1 Issue No. Issue date: Issued by:
C. TEST METHODS AND PROCEDURES	

STANDARD METHODOLOGIES - Final Draft

Assessment of Freshwater Riverine Environments using Macrophytes

CONTENTS

STANDARD METHODOLOGIES - Final Draft

Assessment of Freshwater Riverine Environments using Macrophytes

1.0 Introduction

Aquatic macrophytes influence or are influenced by many areas of the NRA's duties and functions including navigation, recreation, conservation, flood risk and land drainage, fisheries, water resources and water quality. Macrophytes are becoming increasingly important as a water quality monitoring tool, with the need to determine and monitor areas affected by nutrient enrichment. Many of the rivers in the Anglian region suffer from severe eutrophication problems. Eutrophication can produce a progressive, and sometimes severe, deterioration in environmental quality, including loss of species diversity, loss of amenity and problems for abstractors and other water users (Royal Commission on Environmental Pollution, 1992).

Certain macrophyte species are tolerant to high levels of nutrients and this tends the community towards overall dominance and increase in abundance by one or more tolerant species and a decrease in diversity. The EC directive on Urban Waste Water Treatment, sets phosphorus limits on sewage works, >10,000 population equivalent, discharging into 'sensitive' areas. These are defined as waters where enrichment is causing or may cause an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water'. It is stated in the Water Quality 2000 (1992) that the NRA will:
"Limit nutrient levels, where possible and appropriate, using the guidelines in the EC UWWTD, in order to control and reduce eutrophication and protect designated ecosystems".

Under the Water Resources Act 1991 the NRA has duties which include a general duty to conserve and enhance the natural beauty and amenity of inland and coastal waters, and of land associated with them. The NRA is also specifically responsible for water quality in all controlled waters. Introduction of the Statutory Water Quality Objectives, in particular the Special Ecosystem class, for which nutrient level is a determinant, and other legislation including the EC UWWT, Nitrate and Habitat directives and PARCOM increase the need for macrophyte surveys. PARCOM (Paris Commission) is involved in monitoring nutrients in the North Sea, into which the rivers in the Anglian region drain.

Data from macrophyte surveys can be used to complement chemical and macro-invertebrate results so giving a more complete picture of the quality at a site. As a result of comparing results it may be possible to detect pollution problems or narrow down the source of poor water quality.

The majority of aquatic macrophytes are rooted so they may be affected by and reflect episodic pollution events, which macro-invertebrates may migrate to avoid. Chemical water spot sampling will not detect intermittent pollutions or substrate chemistry. Macrophytes can also be used to monitor the level of heavy metals.

2.0 Definition of Macrophyte

'Any plant observed by the naked eye and nearly always identifiable when observed' (Holmes and 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 (Standing Committee of Analysts, 1987).

3.0 Wildlife and Countryside Act. 1981

Macrophytes are protected under the Wildlife and Countryside Act, 1981. Whole plants should never be uprooted, and portions of scarce macrophytes should only be removed when absolutely necessary (under no circumstances must those rare species listed in Schedule 8 of the Act have any parts whatsoever collected). A list of the relevant Schedule 8 species is in appendix 7.

Material collected should be confined to the minimum required for identification.

If a rare plant is found make records of it by photography and noting any distinguishing features in the field.

4.0 Principle

Macrophytes are monitored for many reasons. Areas of study include the effects of discharges, channel maintenance, water management schemes including transfer schemes\flow implementation, navigation, water quality and river typing for conservation purposes. For

most of the monitoring in the past a variety of different methods of surveying have been used.

In order to gain useful, defendable results data must be collected in the same manner by all surveyors. It is therefore necessary to produce a standard methods manual so that any differing interpretations of a method can be eliminated. This also offers the opportunity to incorporate quality assurance measures and a system of quality control to ensure data are fully validated. The resulting data is usually used for comparative purposes and so it is important, especially if discharges are being monitored, that the same method is used.

The macrophyte species recorded for these surveys are large ie visible to the naked eye. There are relatively few species in a particular river area (approximately 50), so it is possible to identify all to species level, when the necessary seasonal attributes are present. Their rooted nature means that absence of species is significant and this, as well as, presence of a species can be used in interpretation of the data.

The distribution and abundance of macrophytes is dependant on several factors including substrate and water chemistry, shading from the banks, flow type and rate, previous spate flows, management and the cyclic growth patterns of certain species. The method must therefore account as far as possible for the variables so that substrate chemistry and water quality are being determined rather than any physical attribute.

The disadvantages to macrophyte surveying are the seasonal limits on survey time, physical limits on their distribution eg data cannot be obtained from heavily shaded areas and a suitable widely tested index is not available for the interpretation of data.

The macrophyte survey method chosen is based on the Blue Book Method B. This method results in semi-quantitative estimates of abundance and a list of species present in a representative length of the river.

Quality assurance and quality control measures are suggested.

5.0 Chemical Hazards associated with Collection and Laboratory Identification

5.1 Inventory of Chemicals

i) **Water.**
Although dilution and dispersion are considerable within the aquatic environments, where sewage or other discharges occur, localised pollution may pose a significant health hazard. The risks associated with Leptospirosis and other water borne diseases must be appreciated (Appendix 1). Physical contact should be avoided by use of appropriate clothing including long PVC/rubber gauntlets. All wounds should be covered with a waterproof dressing. Hands and forearms should be washed before eating and drinking.

ii) **Formaldehyde COSHH No. 0106.**
Used as a fixative/preservative for biological material, it is a hazardous material which requires careful handling see appendix 1A.

iii) **Chroma - FNC.** Formalin neutraliser for significant spills.

5.2 COSHH assessments

For detailed information on chemicals refer to relevant COSHH assessments and safety manuals, held in the laboratory.

6.0 Physical Hazards

It is not possible to cover all aspects of Health and Safety related to working on/near rivers in this manual - below are some of the areas of potential danger. Please refer to Safety documents and the Safety Advisor for further information.

Being near rivers, streams or any other body of water, for work or recreation, is potentially dangerous.

Safety should be an integral part of any biologist's training programme.

6.1 Riverbank and Water Channel

Refer to the NRA lone worker policy for information on designation of lone worker tasks, risk assessment, safety equipment and hazards.

It is recommended that surveyors work in pairs.

In all situations entailing a significant degree of risk to the person entering the water a life jacket must be worn and a second person should remain on the bank with a throwing line.

Surveying along riverbanks and in channels is potentially dangerous. Banks are often steep, uneven, overgrown and slippery with a tendency to subside at the edges. The distinction between bank and channel can be obscured by bank plants. Bank vegetation may hide a sudden drop in the bank or a drop directly into deep water. Both bank and channel can have additional dangers such as rubbish, exposed tree roots and holes. There may be sudden changes in depth, substrate and flow conditions. Water may be turbid hiding the river bed and other hazards. Soft substrates may be deep, particularly in slow flowing rivers, quick sands and bogs may also be a hazard - test all substrates for firmness before walking/wading.

Regulating structures such as weirs, syphon weirs, sluices, locks, intakes, pump discharges etc are potentially very hazardous.

Certain macrophyte species found along riverbanks and in the channel are highly poisonous and/or harmful, eg Giant Hogweed and Hemlock Water Dropwort. The Giant Hogweed should NEVER be touched as this will lead to painful blistering of the skin, often taking a long time to heal. Refer to field guides for further information on identification and avoid contact with these plants.

6.1.1 Clothing and Equipment

Clothing should be suitable for the worst potential weather, and if inclement weather is at all likely, additional clothing should be carried. In warm weather the possibility of sunstroke and sunburn should be borne in mind.

Some form of waterproof footwear with adequate tread should be worn.

All staff must wear life-jackets eg NRA approved automatic inflation - 'crewsaver', and not a buoyancy aid at all times on board a vessel or when working near water.

The operation of the jacket must be fully understood before departure. Life-jackets must be tested/serviced at least once a year.

A wading stick should be used to aid balance or test depth. The stick should be used on banks, and to test bed stability and depth before entering a water course and during wading. Water which is so turbid that the bottom cannot be seen should only be entered if prior knowledge of the site indicates that the depth/substrate does not present a significant risk.

Grapnels\grapples should be used with caution - check there is no one within range of the grapnel before throwing and keep to controlled low underarm throws to avoid injuries. Be aware of and avoid using close to overhead power lines and other structures/vessels where it may become entangled.

A basic first aid kit should be carried.

6.1.2 Procedures

A procedure exists for recording the time that a biologist(s) leaves for and is expected to return from field-work. Details of the route, locations and estimated times of departure and arrival should be recorded and left with a designated person, and on a movements board. Any significant changes from the plan should be reported, for example: delays of 1 hr or more, changes in the sites/area to be visited. When the work is completed the designated person should be told. If staff have not reported in by the expected time (+ 1 hour) then the designated person should set the emergency search procedure in motion. The procedure will involve search parties who will check the areas intended to be visited.

For each site and situation, assessment of the hazards should be made and suitable precautions taken. Such assessment should include prevailing weather and provision for abandoning work should conditions change. Do not proceed unless it is felt safe to do so.

Avoid steep or unstable banks.

Surveying near to regulating structures such as weirs, syphon weirs, sluices, locks, intakes, pump discharges etc should always be avoided. No surveying should be attempted on any section less than 500 m upstream of a weir, sluice, waterfall or rapids unless special safety measures have been provided. Refer to BS 3680:Part 3Q: 1993.

Further guidelines can be found in the Code of practice for safe practice in stream gauging, BS 3680: Part 3Q: 1993. Although this applies directly to the measurement of liquid flow in open channels, certain sections contain relevant information.

N.B. Refer to safety information held in the laboratory or see your safety advisor for further details.

6.2 Use of Boats

Only a brief outline of boat policy can be given in this manual, refer to the NRA Code of Practice - Marine activities:-

Part II: Boats - Type II - V

Working in a boat must be considered a dangerous activity.

Minimum manning levels for boats type II - V shall be two trained personnel. The skipper\leader of the boat should be trained to the level set out in the NRA Code of Practice II (as referred to above) for the type of boat being used. All other members of crew should be trained to RYA Level I. The crew should always include one member specifically assigned to the tasks of propelling and controlling the boat and that person should have no other function.

The skipper/leader is responsible for the overall safety of the boat and of all those on board, and for operating the boat within the NRA, Code of Practice, whilst taking into account the prevailing weather conditions.

There are some navigable rivers, where by virtue of the frequency of river traffic, the use of a boat for surveying is rendered impracticable or too hazardous to be attempted.

It is essential that all crew members should be confident swimmers in open water and capable of self rescue whilst wearing the appropriate personal protective equipment.

6.2.1 Clothing and Equipment

Safety and emergency equipment requirements are set out in the Code of Practice.

The wearing of chest waders whilst working from boats is absolutely forbidden. Chest waders should **NEVER** be worn, for boat work, as they can hold an operator in an inverted position.

It is not recommended that thigh waders are worn for boat work as their buoyancy properties may hold an operator in an inverted position if they were to fall in deep water.

All crew members must wear their personal life jackets when working on small boats. Life jackets should be automatic inflatable type ie Crewsaver "crewfit" for non-tidal work.

The operation of the jacket must be fully understood before departure. Life-jackets must be tested/serviced at least once a year.

6.2.2 **Procedure**

Before use, the Leader or most experienced person must judge if the boat is safe and adequate for the job, and is not overfilled either by people or equipment.

Basic safety precautions should be taken if surveying in the presence of river traffic. Guidance is given in BS 3680: Part 3Q: 1993 - Code of practice for safe practice in stream gauging section 5.6.9 and 5.6.10.

These include the use of warning signs on the banks not less than 200 m from the survey site, a team member positioned on the bank to warn of oncoming vessels, good communication between boat and bank personnel so warnings are heard, making the boat as conspicuous as possible and use of loud hailers to warn the approaching vessel.

No surveying should be attempted on any section less than 500 m upstream of a weir, sluice, waterfall or rapids unless special safety measures have been provided. Refer to BS 3680:Part 3Q: 1993.

Details of sites to be visited and estimated times of arrival etc must be left with a designated person as in section 6.1.2.

N.B. Refer to safety manuals held in the laboratory and consult with the Safety Advisor for further details.

7.0 Macrophyte Surveying Method

The method described in this manual is an adaption of the Blue Book Method B, (Standing Committee of Analysts, 1987). The results are semi-quantitative and the basic method principles can be adapted to suit the needs of individual surveys.

7.1 Basic Principles

The presence of macrophyte species within the channel area of the survey length are recorded, a semi-quantitative estimate of overall percentage cover is made and each species is allocated a percentage cover rank class dependant upon its abundance.

7.1.1 Definition of Terms

a) Site. This is the actual location where the survey is to take place eg d/s of a sewage treatment works.

b) Survey. This is the area of the site which has been surveyed - it may consist of one or more segments.

c) Segment. This is the basic survey unit - the actual length of river channel which is surveyed. One or more segments of the same or differing lengths may make up a survey. Segments should be numbered 1 - n in an upstream to downstream order.

7.2 Timing of Survey

Macrophyte surveys should be carried out between mid-June and mid-September after several days of low flow. (low/'normal' as opposed to high/spate)

Macrophyte species grow at different rates, some species exhibiting accelerated growth rates early in the season and others not reaching maximum size until late summer. This means that for survey results to be comparable, particularly with reference to abundance, they should be undertaken in close succession. A very different picture of the same watercourse can also be presented from early to late summer.

Rivers should not be surveyed at times of high flow as access is dangerous and turbid conditions mean complete and/or accurate data is unlikely to be obtained. Once spate water

levels have dropped to and remained for several days at more normal flow levels surveys canbe resumed but the data recorded will contain information about the extent of spate damage as well as any other quality considerations. 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.

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 operator safety.

Try to avoid surveying navigated rivers at holiday periods or peak of summer times as high boat activity leads to increased turbidity and a more dangerous situation for the surveyors. Do not survey macrophytes immediately after a flood defence 'weed' cut or other management activity which may effect the macrophyte community - see 9.2 Management work.

Macrophyte surveys should be completed by mid-September if possible, but this can be extended slightly in a mild autumn. Certain species will however have begun to dieback making identification and abundance estimation more difficult. Once the first autumn storms, leading to high flows, have occurred no further surveys can be carried out. Many macrophytes will have been damaged and swept away, and the resulting data will mainly reflect storm/spate flow damage.

7.2.1 Number of Surveys per Year

Ideally each site would be surveyed twice a year, once in the earlier part of the season and again in the latter part. Where this is not possible a survey in the earlier part of the season is best. (for UWWTD monitoring see section 7.8)

7.2.2 Subsequent Survey Timing

Subsequent surveys should be undertaken at the same time of year as the previous surveys. This is to reduce the changes in the macrophyte community recorded due to the differing seasonal growth pattern of certain macrophyte species.

7.3 Channel Definition

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.

Channel area definition:-
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 growing on parts of the substrata which are likely to be submerged for more than 85% of the time are included. As it is best to survey macrophytes when the river has been at low flow for several days this is fairly easy to interpret in a consistent manner.

In general records are 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.

Macrophytes overhanging the channel but not rooted in the defined channel area should not be counted.

The standard Anglian Region species lists can be used as a guide to which plants are to be included. Any macrophytes encountered which are growing in the channel area but are not on the list should however be identified and recorded.

7.4 Bank Definition

"Bank" species occur above the level of the "river" plants, these will only be recorded when data is wanted for conservation purposes.

Bank area definition:-
The 'bank' is defined as that part of the side of the river (or islands) which are submerged for more than 50% but less than 85% of the time. 'Bank' records are for 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 mean flow periods. Use the standard checklists as a guide to the species to include.

'Alien' and 'weed' species (appendix 8) should be recorded on the appropriate checklist.

7.4.1 Abundance of Bank Species

The abundance of bank species should be recorded using the DAFOR scale of relative abundance. The abundance recorded in this scale is the relative abundance of one species against all other species.

D = Dominant
A = Abundant
F = Frequent
O = Occasional
R = Rare

After recording the presence/absence of species on the standard checklist one of the above letters representing abundance should be allocated to each species. NB This scale does not produce an indication of percentage cover.

7.5 Survey Composition

The number of segments in a survey will depend on the purpose of the macrophyte survey. The options are either one or more 100 m or one or two 500 m long segments.

For water quality monitoring in a uniform habitat, to observe the impact of a discharge, a 100 m segment upstream and downstream of the discharge should be surveyed. If the downstream segment results are very different from the upstream segment, varying greatly in the type and species of macrophyte recorded, then it is advisable to carry out another 100 m segment further downstream. This should establish that the effect is not caused by a physical factor. In an ideal situation more than one 100 m segment would be surveyed, upstream and downstream of a discharge, to reinforce that any differences are caused by the discharge. This would only be possible if survey areas with similar physical features were present.

To determine recovery after a discharge then further 100 m segments downstream of the discharge should be surveyed. If time allows then five 100 m segments would be appropriate, otherwise survey a minimum of three. Survey segments should be spaced by 100 or 200 m lengths depending on the type of area being surveyed.

In order to obtain a general overview of a river a broad survey needs to be undertaken, this should be of 500 m segments spaced at 5-10 km intervals. If possible tributaries to the river should also be surveyed.

A minimum of one 500 m segment should be used if the data is being collected to discover the species richness of a site. For conservation purposes and to type the river using a key such as the classification method of Holmes (1983) two consecutive 500 m segments should be used. The classification also requires identification to species level of all macrophytes.

If detailed information on abundance is required as well as a more complete species list a combination of segment lengths can be used. The first 100 m within a 500 m segment could be recorded separately with a detailed abundance category and macrophyte species noted for the next 400 m, with abundance recorded on a less detailed scale if required.

The length of the segments and how variable the habitat is will determine the percentage of the total number of species that would be recorded if the whole river was surveyed. For further details and a summary table of length options see appendix 4.

7.6 Selection of Survey Area

Macrophyte distribution is dependant on several factors including:
substrate type, flow rate, the amount of shading from the banks, water depth and channel width.

The survey areas chosen should be typical of the river. In order to obtain easily comparable results segments must be as similar to one another as possible in terms of physical variables. Macrophytes reflect both physical and chemical characteristics therefore it is important to find sites with similar physical variables. This enhances the potential of the macrophytes to detect water quality differences. If surveys are intended to show differences u/s and d/s of a discharge this is even more important and the surveys should also be carried out on the same day. The downstream survey area should be far enough away from the discharge to ensure mixing of the effluent has occurred. When the effect of a discharge is being studied it will be necessary to take into account the position of any stormwater/emergency overflows, and position the survey area accordingly.

When back channels and main navigation channels are present if u/s and d/s sites are being assessed both survey areas should be positioned either on a back channel or the main channel so the survey results are comparable. The main channel may have a macrophyte community affected by boat traffic.

When surveying new sites, particularly u/s and d/s of discharges, time is saved by looking for similar suitable survey areas before commencing any surveying.

Survey areas are usually located in the vicinity of bridges for ease of access. The segment should however, be removed from any structures such as bridges, gauging and syphon weirs, locks, concrete lined channels etc. These may effect both the substrate type, marginal area type and flow pattern, and be subject to local trampling effects, so an atypical vegetation

pattern may be observed. Any structure is potentially dangerous to the surveyor(s). Where structures cause a change in the flow regime of the river the survey area should be situated in an area most typical of rest of the river. If local knowledge is not available look further upstream and downstream of the site to determine this.

7.7 Semi-quantitative Abundance Estimates

Percentage cover of both overall and individual macrophyte species are estimated. The individual species percentage covers are recorded as a rank class score. Different rank class scales can be used if more or less detailed information about a survey site is requested. A semi-quantitative scale of abundance is used as it allows a relatively rapid assessment of the amount of vegetation present.

7.8 Urban Waste Water Treatment Directive Monitoring - Intensive method

In this methods manual only a detailed, intensive method of surveying macrophytes is described. Refer to the *Guidance Note on Information Gathering for Future Designations. EC Urban Waste Water Treatment and Nitrates Directives. Sensitive Areas (eutrophic) and "Polluted Waters" (eutrophic)* before commencing the surveys.

7.8.1 Survey Area Selection

In order to assess if a noticeable difference in the flora upstream and downstream of a Qualifying Discharge (ie STW > 10,000 pe) can be observed the surveyor should walk along the bank/use a boat to carry out a fairly extensive survey in the area of the discharge. The purpose of this extensive survey is to observe any drastic changes in the floral community. Note the position, eg approximately 100 m d/s of the discharge, the observed change is first apparent and describe the difference in the downstream macrophyte community as compared with the upstream macrophyte community.

The selection of the survey area should still include consideration of all the factors in section 7.6. Having considered the physical variables, flow regime etc if a similar upstream and downstream survey area are available the downstream site should be situated to reflect any observed change in vegetation.

If an effect is noticed but there is no similar upstream survey area the effect should be photographed and commented on. It is important that the physical variables are as similar as

possible for an effective comparison of macrophyte data for water quality purposes. If no effect is noticed an u/s and d/s 100m segment typical of the river should be selected.

Surveying a further 400 m should be considered to see if any extra information can be gained from it, as this enables characterisation and classification of the site.

All segment lengths surveyed should be photographed.

7.8.2 **Survey Length**

The basic method for an intensive survey for the purpose of the UWWTD has been decided as: 100 m, 9 point abundance scale C, with the option of the biologist choosing whether or not to survey the next 400 m of river with abundance using the 3 point abundance scale B, upstream and downstream of the discharge.

The choice (re 400m) should be based on whether or not the information collected will provide further information both in the form of a fuller macrophyte species list and in support of the case.

Once a 100 m segment has been completed quickly walk/paddle in the boat along the river to determine if different macrophyte species are present in the next 400 m. Observe the river in this way around both the upstream and downstream sites. The 400 m segment should start at the end point of the 100 m segment ie with no space between the segment lengths. If it is necessary to survey an extra 400 m at the one site then an extra 400 m should also be surveyed at the corresponding upstream or downstream site so the resulting data is comparable. It would be best to survey the downstream site first so no sediment from upstream effects surveying downstream.

When surveying the 400 m segment the idea is to obtain a fuller species list where habitat is diverse, without a detailed account of abundance. In order to help with the interpretation of the data collected the abundance is recorded using the 3 point, scale B. In addition to this for species recorded as >5% cover the dominant sp(p) should be commented upon and a further guide to their percentage cover made eg species 1 is dominant covering 35-45% of the site. A maximum of 2/3 species should be referred to in this manner to give a better picture of the situation. Take a representative photograph of the 400 m segment but do not draw a sketch map.

7.8.3 Underwater rotating TV camera

The underwater camera should be used at all deep water sites, to locate submerged macrophytes so that comparable results are obtained. If the camera is used for survey at a particular site, then it must be used at the corresponding upstream or downstream survey too.

7.9 Equipment

Safety equipment - refer to sections 5 and 6, safety manuals and advice available from your line manager or Safety Advisor.
Maps - Ordnance Survey 1:50000
Standard record sheets + Standard sketch map sheet
Substrate reference sheet
Pencil and pen, clipboard and 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 and labels; tubes for small specimens
Tape measure, stakes and mallet (to mark start and end of survey length)
Identification and field guides (see appendix 2)
Camera
Hand lens x 10
Blackboard & chalk or wipe clean board (small, to include site details in photograph), non-permanent pen and cloth

Polarising sunglasses (optional)
Underwater viewing aid (optional)
Optical range finder (optional) - see appendix 12

Boat + required additional safety equipment (refer to section 7.11.2 for situations requiring a boat.)
Remote underwater rotating TV camera - see appendix 12 for details

7.10 Operation

The principle of the method is to observe, identify and record over a standard segment length the species of macrophytes present in the river channel, estimate the percentage cover of them

as a measure of abundance and record physical variables. 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 sp(p) should however be made in the comments section along with observations of the amount stranded and any obvious reasons for stranding.

7.11 Detailed survey method

Before commencing the survey the appropriate site details such as name, river, segment number, date, time and surveyor's initials are recorded on a standard survey record sheet (see appendix 5).

When surveying a segment for the first time measure the segment using a tape measure and mark each end of the stretch with a short stake which is clearly visible from the river channel. If suitable details for segment relocation are included on the sketch map for subsequent surveys, of the same length, at the same site, pace out the segment length with reference to the original sketch map.

The majority of survey sites can be divided into two basic types - wadeable (section 7.11.1) and those requiring a boat (section 7.11.2) to allow access to all areas of the site.

Macrophyte species positively identified in the field should be recorded on the standard record sheet.

If a macrophyte specimen is not readily identifiable a small, representative sample is taken, placed in a plastic bag or tube, without any additional water, and labelled for identification in the laboratory. On the label record site, segment 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, use 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 or segment needs further investigation.

Representative samples of algae and bryophytes should be taken so that identification can be confirmed in the laboratory.

After completing the surveying instructions given for wadeable (section 7.11.1) and non-

wadeable sites (section 7.11.2) estimates of overall percentage cover and individual macrophyte percentage cover should be made (section 7.11.6).

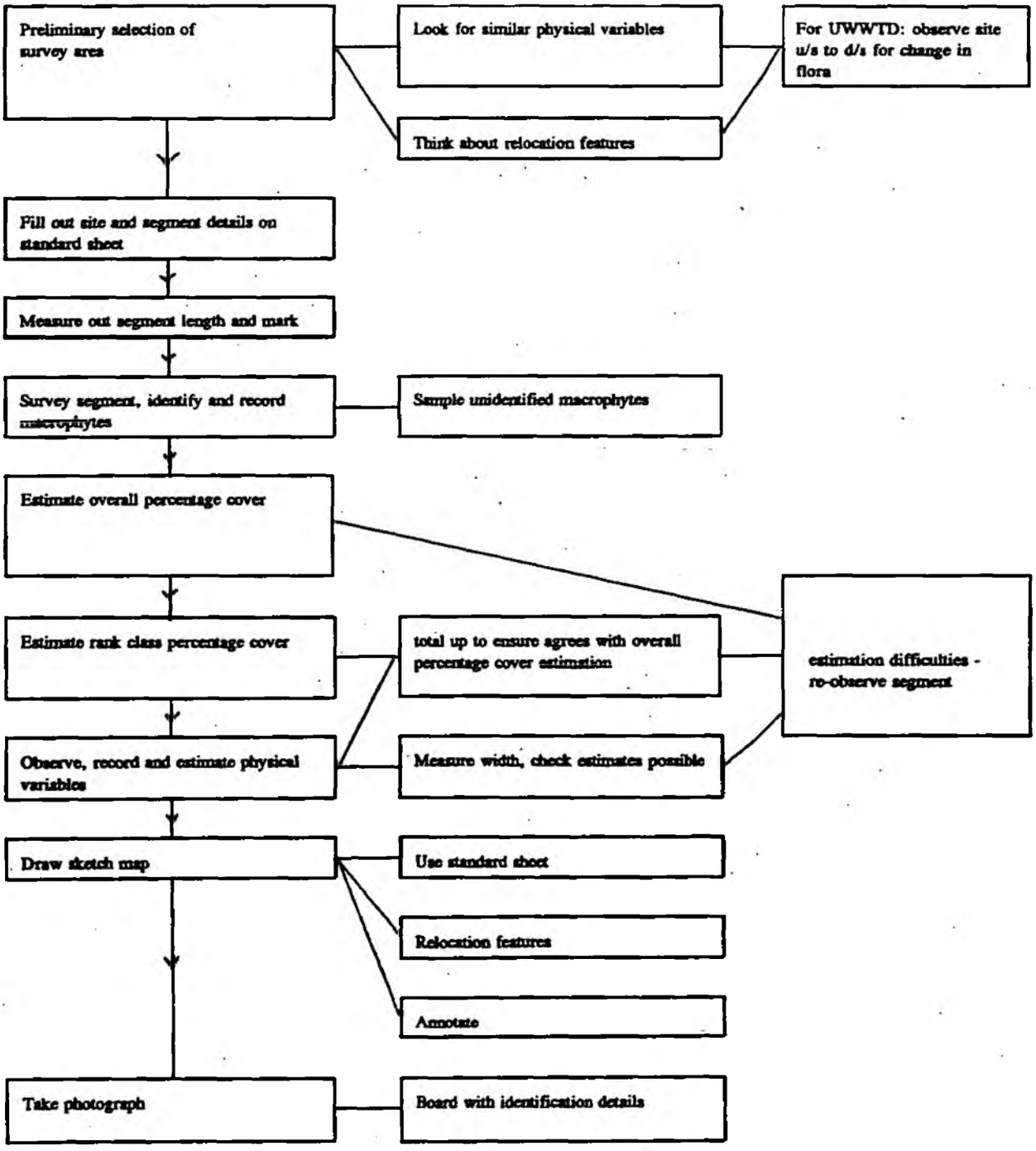
Physical variables including channel width, depth, shading, substrate type, water clarity and bed stability should be recorded on the standard sheet. After completing the macrophyte survey re-traverse the segment concentrating on the physical variables (see section 7.11.7).

If unsure of either habitat or macrophyte cover estimates walk back along the segment to check.

Photograph each segment and draw a simple sketch map.

Figure 1, sheet 19 shows a summary flow chart of the macrophyte survey method.

Figure 1 MACROPHYTE SURVEY FLOW CHART (also in appendix 6)



7.11.1 **Wadeable Survey Sites**

At sites where it is assessed to be safe for the operator to enter the watercourse the survey length is surveyed by wading the stretch. At the majority of sites a second operator may be required for safety reasons.

Where all but a small proportion (< 20%) of the segment 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 the grapnel.

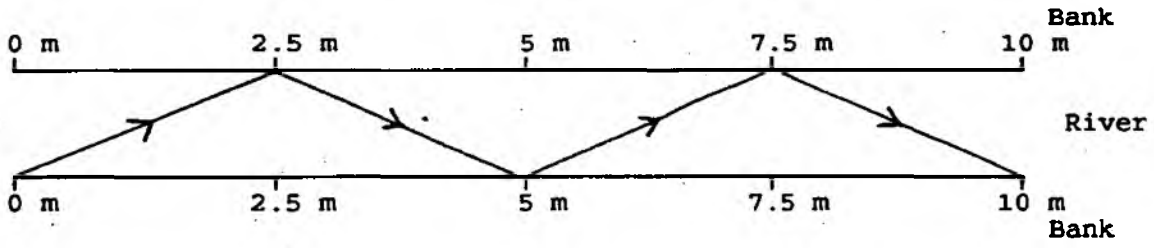


Figure 2. Diagrammatic representation of survey method.

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 10 m of segment length as shown in figure 2. During wading think about the cover of each species present.

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

After recording the macrophyte information re-traverse the site observing and entering details of the physical variables on the reverse of the standard sheet.

7.11.2 **Non-wadeable Survey Sites**

At sites where the channel is narrow (about 5 m 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 would ideally be light and very stable for ease of transport and operator safety. Rowing\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 10 m should be undertaken so that the maximum distance from the surveyor to the channel surveyed is 2.5 m, figure 2. Think about the amount of each species present.

An underwater rotating TV camera (see appendix 12) can be used to locate the position of any macrophytes which cannot be seen from the surface. Use a grapnel to retrieve submerged macrophytes for identification. 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 lessened. The number of times it is necessary to lower and rotate the camera lens so 360 degrees can be observed will depend on the clarity of the water. The camera should be used every few metres across the deep section of the river channel during the survey. 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.

If an underwater camera is not available submerged species will have to be searched for with a grapnel, this will lead to high levels of inaccuracy in both the submerged species list and estimation of overall percentage cover. A much better idea of the percentage cover of submerged species and confidence that all the submerged species have been recorded will be gained by use of the underwater TV camera.

Binoculars can be useful to scan the margins so species present in small quantities, particularly when amongst a large stand of other macrophytes, will not be missed.

After recording all macrophyte species present in the segment return along the length of the segment specifically observing the cover provided by each macrophyte species and considering the overall cover. Enter the overall percentage cover estimate and appropriate rank class, next to each macrophyte species, on the standard sheet.

Re-traverse the segment to observe the physical variables and enter the resulting data on the standard sheet. The grapnel and underwater camera can be used to give an indication of the substrate type at sites where the channel bed cannot be directly observed. Mark the grapnel rope with 0.5 m divisions and use it to determine the depth of the water. It should be obvious from grapnel throws to retrieve macrophytes if a change in depth has occurred. See also

section 7.11.7 (2).

7.11.3 **Segment Length**

The first time a segment is surveyed the actual length required should be measured accurately using a tape measure.

On repeat surveys of the segment use the system of pacing out described below, in conjunction with the sketch map.

Regularly check on the number of paces needed to measure out the required segment length. This will vary for each surveyor and should be calculated before the beginning of field work. Mark out on the ground a 10 m 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 segment length is more than ± 10% then the actual length should be measured with a tape measure.

Quality assurance

It will be necessary to check during the course of surveying each day that a constant pace length is being used. Do this for 10 m as suggested above.

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

7.11.4 **Wading Direction**

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

7.11.5 **Identification**

Identification should be to species level.

Certain species can only be identified when fruiting bodies or flowering parts are present; and even then can be "difficult".

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.

Take a field identification guide, which gives distinguishing features and shows which species are easily confused, into the field.

When a species unfamiliar to a surveyor is found identify it in the field if possible but also take a representative sample back to the laboratory for confirmation identification.

Unidentified macrophyte species are to be sampled and returned to the laboratory for identification using keys. Confirm identification of the species with another member of staff.

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. Depending on expertise within the region this could be internally to another area laboratory or to an external specialist. A list of people willing to check identifications is given in appendix 9.

Representative samples of algae and bryophytes are returned to the laboratory for closer examination so their identification can be checked by the operator.

7.11.6 **Abundance Estimation**

The percentage cover should be estimated by imagining a bird's eye view of the channel.

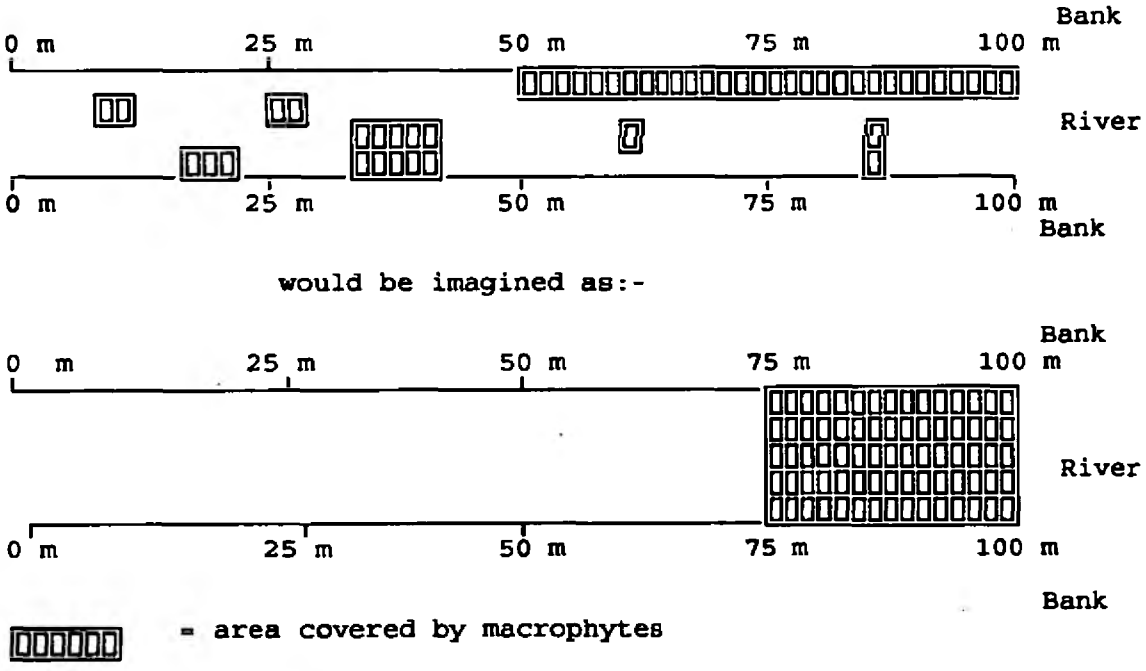
Percentage cover estimation of filamentous algae can be particularly difficult. Determine whether the algae is forming a continuous or broken covering of the substrate. For both overall percentage cover and individual species cover estimation it is useful to calculate what a one metre square patch of macrophyte represents for each segment eg it may be 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. Picture the segment area from above in two dimensions ie length and breadth. Then imagine moving all the macrophytes to the one end of the segment. The area covered will correspond to the overall percentage cover, for example in a 100 m segment an area of macrophytes completely covering 25 m x channel width section will have 25 % cover.

Figure 3 Illustration of the previously described example.

A survey segment with macrophyte cover as shown below



total area covered
by macrophytes = 25 m x channel width

= 25 %

NB This estimate only applies to 100 m segment. If 500 m segment was used then 25 m x channel width would correspond to

$$\frac{25}{500} \times 100 = 5\ \%$$

An alternative way to estimate overall percentage cover, if the majority of the vegetation is confined to strips along the margins of the river, is to calculate the amount of segment covered in the following manner:

marginal area covered, m^2 = length marginal vegetation covers x width of marginal vegetation

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

Total percentage cover = $\frac{\text{total area covered}}{\text{total area of segment}} \times 100$

Individual species percentage cover estimates

For all percentage cover estimates the whole segment surveyed = 100%, ie the individual species percentage cover estimates are a percentage of the whole segment and NOT of the overall percentage cover estimated.

Estimate the percentage cover of each macrophyte species, then, depending on the rank class percentage cover scale chosen, allocate each macrophyte a rank.

When all species have been allocated a rank class add up the percentages, in the field, to check that they correspond to the overall percentage cover estimated for that segment.

The alternative rank class scales are:-

Scale A		Scale B		Scale C	
A1	<0.1%	B1	<0.1%	C1	<0.1%
A2	0.1-1%	B2	0.1-5%	C2	0.1-1%
A3	1-5%	B3	>5%	C3	1-2.5%
A4	5-10%			C4	2.5-5%
A5	>10%			C5	5-10%
				C6	10-25%
				C7	25-50%
				C8	50-75%
				C9	>75%

Recommendations for use are in appendix 3.

In order to make rank class estimation easier and more accurate use one of the following methods:-

Square metre method

Calculate the equivalent square metre areas that need to be covered in order for a macrophyte to be awarded a particular rank class eg. For a 100 m segment, channel width 5 m using Scale C a macrophyte must cover the following areas:-

Scale point	Percentage cover	Equivalent area\m^2
C1	< 0.1	< 0.5
C2	0.1 - 1	0.5 - 5
C3	1 - 2.5	5 - 12.5
C4	2.5 - 5	12.5 - 25
C5	5 - 10	25 - 50
C6	10 - 25	50 - 125
C7	25 - 50	125 - 250
C8	50 - 75	250 - 375
C9	> 75	> 375

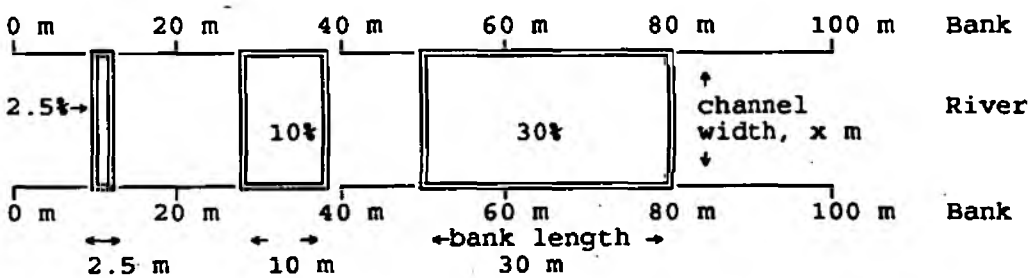
Estimate the number of square metres of each species within the segment and allocate the appropriate rank class. For example for the segment conditions defined above a macrophyte covering 6 m^2 would be recorded as C3.

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

Width method

Stand on one bank facing across the river channel to the opposite bank. Imagine a rectangle made between the banks and channel width, see figure 4.

Figure 4 Illustration of width method of estimating percentage cover for 100 m segment.



The whole segment length times 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 illustrate the range of percentage covers equating to the rank classes. Decide which area, and hence corresponding percentage cover, each macrophyte covers. Allocate the rank class which includes the estimated percentage cover in its range.

Using Scale C for the segment a macrophyte must cover the following bank length x channel width areas:-

Scale point	Percentage cover	Corresponding length on bank for 100 m segment length/m	Corresponding length on bank for 500 m segment length/m
C1	< 0.1	< 0.1	< 0.5
C2	0.1 - 1	0.1 - 1	0.5 - 5
C3	1 - 2.5	1 - 2.5	5 - 12.5
C4	2.5 - 5	2.5 - 5	12.5 - 25
C5	5 - 10	5 - 10	25 - 50
C6	10 - 25	10 - 25	50 - 125
C7	25 - 50	25 - 50	125 - 250
C8	50 - 75	50 - 75	250 - 375
C9	> 75	> 75	> 375

For example for a 100 m segment using scale C a macrophyte covering an equivalent area of 6 m x channel width will be allocated a rank class of C5.

This method has the advantage that the lengths on the bank are constant for a particular segment length and Scale of rank class percentage cover regardless of channel width.

NB1 The bank lengths MUST be calculated for each combination of segment length and rank Scale used.

NB2 The suggestions for ways of estimating percentage covers assume the channel width is constant. If the width varies considerable along the segment it would be necessary to take this into account.

Quality assurance

Add up the percentage cover rank class estimates while at the segment to make sure they correspond to 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 segment, NEVER re-evaluate estimates after departing from a segment.

Survey areas choked with vegetation

At sites where macrophytes are very abundant the site may become choked with vegetation. For segments 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 to search for submerged species which may be surviving under other macrophytes. Only record the amount of each species actually seen - DO NOT use grapnel hauls to estimate abundance. Any species observed using the underwater camera or grapnel haul should however be recorded as present in the segment. (This may mean that the individual percentage cover scores will add up to greater than 100%; this is acceptable under these conditions, as relative rank class estimates are still valid.)

Water clarity

Do not survey when turbidity at the site reduces visibility. If the site is usually turbid then a "best attempt" at surveying for macrophytes can be made. This also applies to sites where the water is too deep to see the bottom of the channel. The efficiency of the method may be reduced as the submerged macrophyte species will not be visible from the surface. Use of the underwater rotation TV camera should reduce the errors compared to only using the grapnel. The camera can locate macrophyte species, which can then be retrieved using the grapnel for identification if necessary. This means estimates of percentage cover for submerged species will be based on observations from the underwater camera. Submerged species present in very small amounts may still be missed if the water is turbid (see section 11.0)

The following problems are associated with using only a grapnel:-

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 may therefore be over estimated in their abundance.

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.

7.11.7 **Segment Details - Physical Variables**

Segment details should be filled in on the standard sheet. The amount of each physical variable present is recorded using the percentage cover scale of **1 = <5%, 2 = 5 - 25% and 3 = >25%** of the channel.

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

1) **Width**

Width means the channel width for which macrophyte species have been recorded as defined in section 7.3. ie including any area of substratum above the actual water level that has been surveyed.

The first time a segment is surveyed the width of the channel should be measured using a tape measure/rope with 0.5 m divisions or an optical range finder (appendix 12). If the width varies along the segment noticeably then several width measurements should be made.

Record varying widths by entering 1, 2 or 3 in the appropriate boxes on the standard sheet. More than one category should be recorded if width varies outside the given class ranges along the segment. Width is entered in five class ranges - <1 m, 1-5 m, 5-10 m, 10-20 m and >20 m.

For repeat surveys it should be sufficient to estimate the width by one of the methods described below.

i) Use of an optical range finder.

ii) If the segment is easily/safely wadeable or a convenient bridge is present at a deep water segment 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 the one used is suitable for the width being estimated.

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 surveyed segment.

Pace to metre ratios should be calculated as under section 7.11.3 and regularly checked.

2) **Depth**

Record the depth by entering 1, 2 or 3 in the appropriate boxes on the standard sheet. The depth classes are <0.25 m, 0.25-0.5 m, 0.5-1.0 m and >1.0 m. Measure the depth at various points along the segment - the number and exact location of the measurement points should depend on the variability of depths encountered when surveying the segment for macrophytes.

Quality assurance

Measure the depth by using a marked bank stick, 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. The grapnel rope with depth divisions should only be used to measure depth by lowering it vertically. When marking the grapnel rope the height of the grapnel must be included ie if the grapnel is 0.2 m tall then the first mark on the grapnel rope should be 0.3 m above that, representing a total depth of 0.5 m.

3) **Substrate**

Estimates should be based on 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, but record the data in substrate boxes in the manner described above.

The alternative substrate classes are:-

Bedrock	-	exposure of underlying rock not covered by alluvial deposits
Boulders	-	> 256 mm
Cobbles	-	> 64 - 256 mm
Pebbles	-	> 16 - 64 mm
Gravel	-	> 2 - 16 mm
Sand	-	> 0.0625 - 2 mm
Silt/mud	-	> 0.004 - 0.0625 mm - have a soft texture
Clay	-	≤ 0.004 mm -has a solid surface where flow does not remove substrate
Peat	-	dead vegetation undergoing bacterial decay in stagnant deoxygenated water. Strictly pure peat, not fine peaty deposits over more substantial substrates.

The actual measurements given relate to the longest axis of each particle ie any rock with one or more sides greater than 256 mm 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.

The combination of substrates is recorded by placing either 1,2 or 3 in the appropriate box. As many substrates as are present should be recorded.

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 substrate percentage cover estimates - it should not be over 100%. There cannot, for example, be five different substrates all in class 3.

4) Habitats

Allocate either 1, 2 or 3 to the appropriate habitat types. The habitat types are POOL, RUN, RIFFLE and SLACK.

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

RIFFLE - Fast flowing, shallow water whose surface is distinctly disturbed.

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.

Quality assurance

Regularly familiarise with habitat variable definitions.

5) Shading

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

The percentage of the channel recorded as shaded is that shaded when the sun is directly above in the sky ie at 12 noon. The percentage recorded for shading from each bank should relate to the whole channel width. If the total shading of the channel is needed then the two figures can be added together. The shade is recorded separately for each bank so that a better picture of the segment is built up. Refer to figure 5.

Three shade categories are defined none, broken and dense.

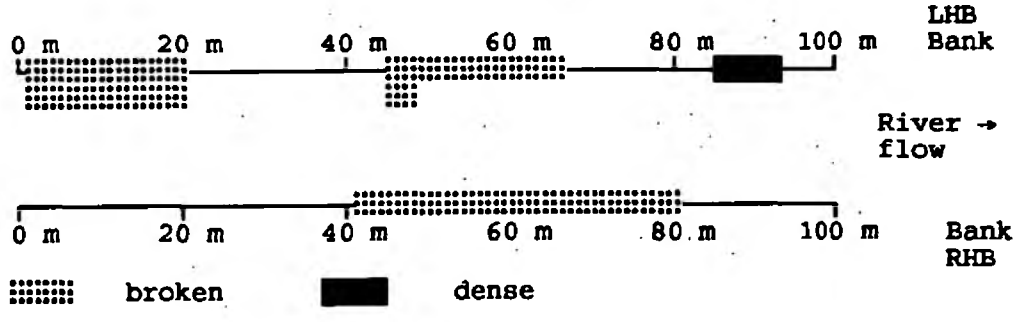
None - no shading

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 1, 2 or 3 in the relevant shade box.

Figure 5. Illustration of shading



(Only shading affecting the channel is counted, therefore on the diagram above, where shading blocks cross the channel definition line they are counted as a half block)

The channel illustrated above would be recorded as:-

Shading	Left bank	None	3	Broken	2	Dense 1
	Right bank	None	3	Broken	1	Dense 0

When considering the effects of shading the sketch map should also be referred to, as by estimating the shading as described above there may be a underestimation of the actual amount of shading at a segment.

Quality assurance

Carefully follow the method for estimating shade described and refer to the sketch map.

6) Water clarity

Assign 1, 2 or 3 in the appropriate category. These are necessary as a segment may be clear in the shallow margins and progress through cloudy to turbid as the water depth increases.

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

CLOUDY - Slightly discoloured with a moderate suspended solids load and partially reduced light penetration. All clumps of macrophyte species can be located on the substrate of the river channel but the view of them is partially distorted.
A small piece/single shoot of a macrophyte species may be missed.

TURBID - Strongly discoloured, carry a heavy suspended solids load and greatly restrict light penetration. The channel bed is obscured and submerged macrophyte species are indistinguishable from substrate and water. This will lead to a reduction in accuracy and efficiency of the method.

Quality assurance

Consider the clarity throughout the segment while surveying, and assign percentage classes accordingly.

7) **Bed stability**

The following 4 classes will be 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, making channel unwadeable. Bank stick penetrates easily into substrate.

8) **Sketch map**

Fill in required details on standard sketch map record sheet (appendix 5) eg river and site name, segment number, date etc.

Start drawing the sketch map from the upstream end of the segment, so that the left side of the paper corresponds to the left bank and the direction of flow is from top to bottom of the paper.

Mark on permanent features which should ensure the segment can be re-identified if a repeat survey is required eg a distance from a bridge or footpath sign etc. Try to find several such features in case one is removed before the next survey.

Sketch on and name any dominant macrophyte species, area influenced by shading and type of shading. In addition mark on any unusual features such as 'islands' of substrate supporting vegetation.

At deep segments actual centre channel depth can be easily be obtained from the grapnel and noted to add to the sketch map.

Main features to mark on sketch map:-

Location of river and its pathway.
Width of channel - the width included in the survey
Relocation features - for both ends of segment 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

Broken shade should be indicated by: 

Dense shade should be indicated by: 

Macrophyte stands should be indicated by: 

Label clearly.

The sketch map should be a guide to the segment, to aid relocation and give an impression of its main features, eg figure 6, sheet 37.

The distance markings on the standard sketch sheet do not indicate which direction the macrophyte survey should be undertaken, the conditions governing macrophyte surveying direction are detailed in section 7.11.4.

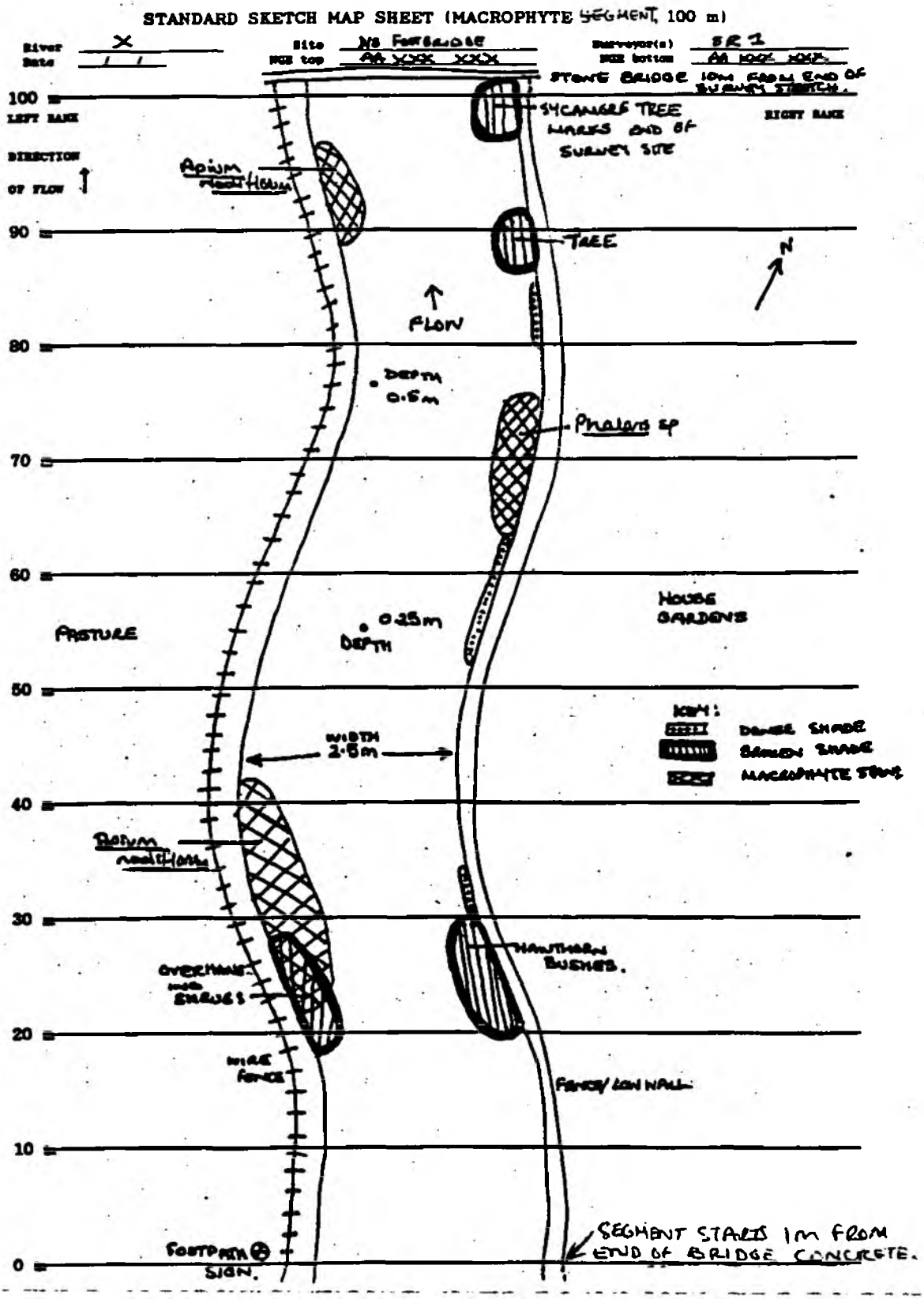
Quality assurance

Pace out each 10 m length and mark the relevant features on the sketch map.
Check orientation is correct.

It may be necessary to redraw the sketch map on return to the office to ensure labels etc are clearly readable - 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.
When using sketch maps to relocate segments take photocopies into the field and leave the original in the file.

Figure 6. Example sketch map



9) **Photograph**

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

Quality assurance

Note any distinguishing features of the segment eg a biologist on left bank (it is NOT sufficient to rely on these type of features alone - use the suggested labelling method.) Label film and have each film developed as soon as it is finished. On return of developed film referring to the relevant survey sheets label each photograph with river, site name, segment number, date and surveyors initials. Add the unique site code generated for the computer database to the labelling. Catalogue all photographs, file in groups under eg river/catchment in an album or index type box file so they can be easily retrieved.
If using a box file place each photograph in an envelop which has previously had the river, site, segment number, date and surveyors initial marked on it. Also mark each envelop with the unique code created for each site on the computer database.
Make sure it is simple to cross reference with the original survey sheets and computer based data.

10) **Comments**

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

7.11.8 **Data records**

Data is recorded onto a standard field sheet. File all information gathered for a site together. Once it has been entered onto the computer database the site code should be recorded on the first field sheet.

8.0 Laboratory

8.1 Equipment

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

8.2 Reference collection

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 a index card box file. Group the cards, but have a separate card for each species detailing identification features and information available.

8.2.1 Preservation of macrophytes

Refer to the Herbarium Handbook and Charophytes of Great Britain and Ireland (appendix 2) for full details of equipment and methods - below is a basic outline of the principles.

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 all attributes can be seen. 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 - refer to Charophytes of Great Britain and Ireland, J A Moore, p 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.

8.3 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. 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.

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

In a filamentous algae sample the dominant species should be recorded eg a filamentous algae mass consisting mainly of *Cladophora* will also contain small amounts of other species.

9.0 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.

9.1 Geological information

The background data that should be researched from maps is rock type, altitude, slope and distance from source.

1) Underlying geology/rock type

The geology of a site may influence the macrophyte community both through lithology and baseflow. The geological deposits comprise 'solid' pre-Quaternary rocks (eg chalk) and

Quaternary 'drift' deposits (eg glacial sands and gravels, boulder clay, alluvium) which overlie the solid geology. The nature of the exposed geology, whether it be solid or drift deposits, can effect the lithology of the river bed. In addition any permeable aquifer horizons may contribute groundwater (as baseflow or springflow) to the river, and may therefore influence the river water chemistry. Rivers at different points may have differing proportions of groundwater components and surface run-off components.

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 or the groundwater contribution to base flow, are causing any observed 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.

The maps for each Area are located in the Water Resources section of Area offices ie Lincoln, Brampton and Ipswich, and copies are also kept at Kingfisher House, Peterborough.

Modern British Geological Survey (BGS) maps at 1:50000 scale are available for large parts, but not all, of the Anglian Region. Other areas of the Region are generally covered by older maps, many belonging to the Geological Survey 1:63360 "Old Series" largely published in the 1880's. These geological maps all have OS grids but the sheet areas differ from those of the Ordnance Survey. The charts shown in appendix 11 depict which areas are covered.

Refer to the BGS 1:50000 map chart first, and use the Old Series maps for areas not covered by them.

The geological maps can either depict solid, drift or both solid and drift deposits. To find the information wanted in this instance a map combining both solid and drift types is most useful. Otherwise a combination of the single type maps can be used, drift being more useful than solid alone.

The maps indicate the rock type using different colours and symbols defined in the map key. Refer to the symbols rather than the colours as some appear very similar but represent a different rock type. Codes/symbols are given for both solid and drift types. Where the solid geology is hidden by overlying drift its nature is often indicated by the symbols.

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 5 m.

Slope

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

$$\text{Slope} = \frac{c}{x} \text{ m/km}$$

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.

9.2 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 only reflect the damage done to the macrophyte community by the activity. The timing of weed cutting etc 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 bank reinforcement schemes
Bridge repairs
Weed cutting

Source of information

Catchment Engineers
Work is planned in advance but is weather dependant.

9.3 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.

Source of information

Records of pollution incidents are kept in the district offices on the POLLEASE database. The district office database is constantly updated, area offices are updated monthly. Ask Water Quality staff for details.

10.0 Data Handling

All data should be handled in a standard meticulous manner. The results of the macrophyte surveys should be regularly inputed onto the database.

10.1 Standard record sheets

Data for both the consistent site information and macrophyte survey are recorded on standard record sheets. The standard record sheets can be found in appendix 5.

Quality assurance

Standard record sheets are used so that all surveyors record the same information to a similar level.

10.2 Database

A database is to be created specifically for macrophyte data storage. It will include site,

survey and segment details; and the ability to produce reports. Mandatory entry of certain variables will be programmed in.

Quality assurance

Only appropriate replies will be accepted ie for a 3 point abundance scale only 1,2 or 3 can be entered. Before any inputed data is saved the operator will be asked to confirm that the data entry is complete and correct.

10.3 Transfer to database

All survey information should be transferred to the macrophyte database. Each Area will have a separate database containing information about sites in their area and will input their own survey data. At the end of the macrophyte surveys when all the information gathered has been entered onto the database it will be loaded onto a floppy disc and transferred to RHQ. At RHQ a database will be set up containing information on macrophyte surveys for the whole region.

A separate manual will be produced containing information on the use of the macrophyte database.

Quality assurance

Enter macrophyte data regularly - mistakes are less likely to be made if there is not too much data to be entered at once so the operator does not become desensitised to the process.

Check each data entry is correct before starting the next entry.

File the original survey sheets in site order u/s to d/s the river so if a discrepancy is discovered at a later time it can be easily checked. Mark the survey sheets with the site code from the database for ease of cross reference.

11.0 Limitations of the method.

a) A major problem with macrophyte survey data is a lack of a comprehensive and widely tested water quality index to interpret the data. Previously suggested indices are described in the accompanying report. Macrophyte communities are very complex and influenced by numerous variables which increases the difficulty of interpretation. Until a suitable index is developed interpretation is limited to direct comparisons of species diversity and gross

changes in abundance.

b) As the measure of abundance is semi-quantitative comparisons between individual species percentage cover estimates should be approached with care. Only gross changes in percentage cover should be considered worthy of note. It should be remembered that the estimation of rank class of percentage cover can vary between surveyors, by up to 2 rank classes for the majority of the time.

c) Surveys are weather dependant - steady\heavy rain, strong winds and high flows after rain prevent surveys taking place, due to reduced safety and visibility of macrophytes.
d) More generally macrophyte survey methods can only be utilised during the summer months due to the growth and dieback cycle of certain species.

e) Water clarity is important as if the bed of the channel cannot be clearly seen it will mean a decrease in the accuracy of both species list composition and abundance estimates. The bed may not be visible due to the depth of water. Estimates of submerged species will have to be based on observations of species from the underwater TV camera. If the camera is not used estimates will have to be based on grapnel hauls leading to further inaccuracies. Use alternative sites if at all possible. Otherwise use the same surveyor for sites which are to be compared. Depending on the degree of clarity direct comparisons of overall percentage cover and submerged species percentage cover should be treated with extreme caution if used at all. The only alternative is to use a quantitative method of biomass estimation, which has many problems.

f) The method does not cater adequately for sites which are full of different species overlying each other, as the percentage cover estimates are based on birds' eye views. A comment should be made describing the river channel. The other alternative is to employ a quantitative method of biomass estimation - refer to other blue book methods (appendix 13).

g) Reductions in the efficiency and accuracy of the method occur as a result of c, e and f.

12.0 Quality control

Detailed records of all quality control procedures undertaken should be kept at each area office and at regional headquarters.

12.1 Annual training day

All biologists who are to undertake macrophyte surveys should attend a "refresher" training

course every year. This course should encompass all aspects of the survey method, with particular attention to the subjective estimates. A 100 m segment, 9 point scale C, should be completed with discussions at each stage. The identification of macrophytes found on the segment should be discussed with their identification features highlighted.

A ring sort identification should also be carried out during the day. Each surveyor should individually identify the species provided for the ring sort and hand in a completed record sheet eg Species A *Elodea nuttalii*. At the end of the day the identifications should be discussed so everyone learns from the ring sort.

12.2 Re-surveys

An independent surveyor should be contracted to re-survey x number of segments per year. This surveyor should also attend the annual training day.

Suggested 'action' levels for each segment are:-
i) More than 1/2 species missed or identified incorrectly.
ii) 95% of rank class estimates should be to 2 or less rank classes different
iii) 85% of rank class estimates should be to 1 or less rank classes different
iv) Overall percentage cover - difference of up to 15 percent points

These 'action' levels may need to be modified in relation to previous years' survey results and any likely natural variation.

12.3 Inter-calibration exercise

An inter-calibration exercise should be undertaken with all biologists involved in macrophyte surveys participating. A 100 m segment should be selected and each biologist should survey this segment. Abundance of individual macrophyte species should be recorded using the 9 point, Scale C. This survey should be undertaken once some macrophyte surveys have been completed rather than at the beginning of the survey season. The resulting data should be assessed so that the level of consistency between surveyors is found.

13.0 Training

Each member of staff should have a personal training record with details of all courses and on-the-job training received. A copy of these records should also be kept at regional headquarters for quality control purposes.

All biologists should receive basic safety training. Boat handling courses to the level required in the Marine Biology NRA Code of Practice, part II for undertaking macrophyte surveys by boat and First Aid training can be arranged through the Safety Advisor.

13.1 New staff

The areas in which new staff will need to be trained are:-

i) **Identification**
A basic macrophyte identification course is needed before any surveys are undertaken. This course should cover all the common macrophytes of the region. The new staff member should look through the reference collection and identification guides.

ii) **Method**
New staff members should read the standard methods 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 control exercise as described in the On-going training section below.

iii) **Database input**
In house training by an experienced member of staff.

13.2 On-going Training

Macrophyte surveyors should read the standard methods manual at the start of each macrophyte survey season.

i) **Annual "refresher" course**
As described in the quality control section 12.1.

ii) **Advanced macrophyte identification course**
More experienced staff from each area office should attend an advanced macrophyte identification course. This course should cover macrophytes which are "difficult" to identify to species level, such as some *Ranunculus*, fine-leaved *Potamogeton*, *Callitriche* and Bryophyte species. These biologists will then be able to help with identification confirmation.

APPENDICES

Appendix 1: Information regarding Leptospirosis (Weils disease) and Tetanus
(Southern NRA Safety Code of Practice - Field Sampling activities)

Leptospirosis letero is a listed Industrial Disease under the R.I.D.D.O.R. Regulations 1985.

This strain of the disease can be contracted through contact with material/water which has been contaminated with urine from infected rats.
The infection commences with high temperature and general muscle and joint pains.

You **must** seek medical advice immediately because the disease shows itself similar to influenza, pneumonia, tonsillitis, rheumatic fever or nephritis and later catarrhal, jaundice, or gall stones, etc. Show the doctor your white card. It is advisable that next of kin are also aware of its whereabouts.
Pictured overleaf are a card, which should be completed, and a letter to hand to your doctor to be kept with your medical records. A photocopy of the white card issued to all employees at risk from *Leptospirosis* is also included. Contact your Safety Advisor if you have not received these.

Precautions against infection with *Leptospirosis*

After contact with sewage, water from a watercourse or cattle, wash your hands and forearms with soap and water - even if gloves have been worn. It is particularly important to do this before eating any food, taking a drink or smoking. If clothing or footwear become contaminated it should be thoroughly washed.

DO NOT WORK IN WATER OR SEWAGE WITH OPEN WOUNDS ON HANDS OR ARMS

Take care to wash thoroughly and cleanse with antiseptic any cut, scratch or abrasion as soon as possible, whether the injury was caused at work or not. Keep any wound covered even when wearing gloves.

NRA

National Rivers Authority

LEPTOSPIROSIS
(WEIL'S DISEASE)

Instructions to persons working in contact with rivers or other water sources.

THIS CARD IS FOR
YOUR PROTECTION

Whenever you go to your Doctor or to a Hospital on account of illness show this card and make sure that those attending you know of your occupation.

INSTRUCTIONS TO CARD HOLDERS

1. As infection may enter through breaks in the skin ensure that any cut, scratch or abrasion is thoroughly cleansed and covered with a waterproof plaster.
2. Avoid rubbing your eyes, nose and mouth during work.
3. Clean protective clothing, footwear and equipment etc. after use.
4. After work and particularly before taking food or drink wash hands thoroughly.
5. Report all accidents and/or injuries however slight.
6. Keep this card with you at all times.

MEDICAL INFORMATION

The holder of this card is engaged in work which may bring them into contact with water which may contain Leptospira.
Some of the symptoms of early Leptospirosis or Weil's disease are non-progressive and diagnosis is based on laboratory investigations. Should you suspect the holder may have been infected please arrange for the appropriate tests. The infection may resemble influenza in the early stages

NRA

National Rivers Authority
Anglian Region

To: THE GENERAL MEDICAL PRACTIONER FOR

of

Our Ref:

Your Ref:

Dear Doctor

This letter is to inform you that the above named person is engaged by the Anglian Region of the National Rivers Authority to carry out work which may bring him/her into contact with polluted water, so that there is a remote risk of contracting leptospiral jaundice (Weil's disease).

I understand that early diagnosis and treatment are important in cases of infection with this disease. The disease in its early stages may closely resemble influenza, with fever, rigors, headache and myalgia. Jaundice is often absent at this stage. Therefore, if the disease is suspected, you may wish to arrange admission to hospital. I shall be grateful if you will inform me if this person should suffer from an attack or suspected attack of Weil's disease.

You may wish to file this letter with the appropriate medical record for future reference.

Yours faithfully

Grainger Davies
Regional General Manager

WP-1/JOHH2

GRAINGER DAVIES
Regional General Manager
B.Sc. C.Eng. FICE FIWEM

Kingfisher House
Goldhay Way
Orton Goldhay
Peterborough
PE2 5ZR
Tel: 0733 371811
Fax: 0733 231840
TEL: 781640

PRECAUTIONS AGAINST RISK OF LEPTOSPIRAL JAUNDICE

1. Always thoroughly wash your hands before eating or drinking whether or not your hands will be coming into contact with food.
2. Wet protective clothing should be thoroughly dried as soon as possible after use; it should be remembered that handling dirty footwear and clothing can be as much a source of infection as direct contact with polluted water or sewage.
3. Do not touch your nose or mouth with your hand during work.
4. If you should incur any cut, scratch or abrasion of the skin, wash it thoroughly at once, and protect the wound. A covering should be retained until the wound has healed. This procedure should apply whether the wound is sustained at work or elsewhere.
5. Visit your doctor as soon as possible after sustaining any injury liable to expose you to infection.
6. Every accident at work, however trivial, must be recorded in the accident book.

NATIONAL RIVERS AUTHORITY ANGLIAN REGION

INSTRUCTIONS TO STAFF WHOSE WORK MAY BRING THEM INTO CONTACT WITH POLLUTED WATER

This card is for YOUR protection

keep it in a safe place

When you get this card you should

1. Complete the details inside the front cover as soon as possible.
2. Hand the accompanying letter to your doctor at the earliest opportunity, after filling in your name and address.
3. Complete and detach the tear-off portion of the card and return it to the District or Area Office.

Whenever you go to a Doctor or to a Hospital on account of illness or injury, always show this card and make sure those attending you know your occupation.

Employee's Name .....

Address .....

.....

.....

Occupation .....

Employed at .....

Doctor's Name .....
(Block Capitals please)

Address .....

.....

Telephone No.....

If any change occurs in the details given above you should notify your District or Area Office.

LEPTOSPIROSIS

People working in contact with sewage or other polluted water may very occasionally contract a form of jaundice known as leptospirosis. It is emphasised that the incidence of this disease is extremely rare.

The infection can enter the body through breaks in the skin, so any wounds, however slight, should be given thorough first aid treatment. The early stages of this disease may be rather like influenza, so whenever you go to a doctor you should produce this card so that he can, if necessary, arrange for further examination in hospital and notify the Area Medical Adviser.

Tear off this portion when completed and pass it in to District or Area Office. The relevant District Engineer/Office Manager should pass it on to the Personnel Section.

I have handed the accompanying letter to my doctor, who is

Doctor's Name .....
(BLOCK capitals please)

Address .....

.....

Tel. No. .....

Employee's Name .....

Emp.....

Date .....

Appendix 1A: Procedure for handling formaldehyde (under review).

Principle

Formaldehyde, in the form of a solution of Formalin is used as a fixative agent prior to the preservation of biological material, or to prevent subsequent microbial growth. Formalin is a hazardous material and requires careful handling, reference must be made to the COSHH assessment 0106. Formalin should only be used where absolutely necessary.

The stock solution normally purchased is a 37-41% solution of the gas formaldehyde in water. This may be known as "100% formalin", "40% formaldehyde solution" or "concentrated formalin". The working dilution for charophyte fixation/preservation is usually a 1 in 10 dilution of this, giving 4% formaldehyde or 10% formalin.

Toxicity

Formalin is acutely toxic. There have been 13 deaths due to the ingestion of amounts estimated to be 100 ml (or a few drops in the case of a child).

Inhalation is the most likely hazard in the biology laboratory. The threshold for detecting an effect on the eyes has been claimed to be as low as 0.01 ppm, symptoms of mild throat irritation occur at about 0.5 ppm and it is intensely irritating to the eyes at about 4 ppm. Brief exposure to 50 ppm would cause very serious injury. There is some evidence that continued exposure can result in desensitisation to the irritant effect.

Splashes to the eye of 40% solution have resulted in permanent eye damage. Splashes of a 4% solution produce a strong irritant effect and visual disturbance for one day, after which the eye returned to normal.

Contact with the skin at concentrations greater than 2.5% may cause dermatitis. Skin sensitisation and allergic contact dermatitis can occur.

Carcinogenicity

There is no evidence to suggest that exposure to formaldehyde has produced cancer in humans, nor is there acceptable evidence for any adverse effects on the reproductive system. However, formalin has been shown to be carcinogenic in laboratory animals and so a possible risk of cancer caused by chronic inhalation exists. Precautions are required when using formaldehyde solution.

First Aid.
Standard Treatment:

Eyes	Irrigate thoroughly with water for at least 10 minutes. **OBTAIN MEDICAL ATTENTION.**
Lungs	Remove casualty from exposure, rest and keep warm. In severe case or if exposure has been great **OBTAIN MEDICAL ATTENTION.**
Skin	Drench the skin with plenty of water. Remove contaminated clothing and wash before re-use. Unless contact has been slight **OBTAIN MEDICAL ATTENTION.**
Mouth	Wash out mouth thoroughly and give water to drink. **OBTAIN MEDICAL ATTENTION. DO NOT INDUCE VOMITING.**

Exposure limits

Long and short term exposure limit is 2 ppm or 2.5 mg m^a. This is well below the threshold of mild irritation and it is safe to assume that if Formalin cannot be detected in the laboratory it is below the MEL. Routine checks for Formaldehyde should be carried out using a Drager gas detecting kit.

General precautions (see COSHH assessment 0106)

Clothing.

When dealing with >500 ml of formaldehyde (COSHH regulation) and also formalin a PVC apron, Grade 2C plastic goggles/visor and appropriate gloves *e.g.* black chemical resistant heavyweight Marigold gloves, not disposable vinyl gloves, must be worn.

In situations of high formaldehyde vapour the use of an appropriate respirator is recommended, *e.g.* 3M formaldehyde respirators which protect up to the OEL. In addition, goggles which seal around the face, rather than eye shields should be used in such situations.

Spillage.

In the event of a spill of more than 500 ml of 40% formalin the laboratory should be evacuated and assistance from the fire brigade requested. Use formalin neutraliser Chroma FNC for significant spillages. Smaller or more dilute spills can be handled.

All sources of ignition should be shut off and the area evacuated - do **not** re-enter until ventilation has been achieved. Wearing a face-shield or goggles and gloves the formalin can be mopped up with plenty of water and run to waste, diluting greatly with water. The area should be well ventilated to evaporate remaining liquid and to dispel vapour.

Under no circumstances should formalin be disposed of down general laboratory sinks not designated for the purpose.

Formalin must not come into contact with hydrochloric acid to avoid the formation of Bis-chloromethyl ether (BCME) a known carcinogen.

For handling of formaldehyde/formalin and storage/handling of preserved samples refer to the COSHH assessment.

Appendix 2 Identification Guides/Preservation

Macrophyte Preservation:

Moore J A, (1986). Charophytes of Great Britain and Ireland. BSBI Handbook No 5.

Bridson D and Forman L. The Herbarium Handbook

These can be borrowed from the Biology Section at RHQ.

Books specific to Water Plants

Haslam S M, Sinker C S and Wolsey P A, (1982) British Water Plants, Field Studies Council, Nettlecombe, Taunton, Somerset.

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

***Ranunculus* sp:**

Holmes N T H, (1979). A Guide to Identification of Batrachium Ranunculus Species of Britain, Chief Scientist's Team Notes No 14. Nature Conservancy Council, Shrewsbury.

***Potamogeton* sp:**

Potamogeton species: Botanical Society of the Britsh Isles (BSBI) handbook soon to be published.

Course guides:

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

General books/keys:

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

Clapham A R, Tutin T G and Moore D M, (1989). Flora of the British Isles. CUP 3rd ed. (key)

Clapham A R, Tutin T G and Warburgh E F, (1981). Excursion Flora of the British Isles (3rd ed), CUP. (key)

Garrard I and 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.

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

Stace, C E, (1992) A New Flora of the British Isles, CUP. (key)

Sedges:

Jermy A C and Tutin T G, (1968). British Sedges: A Handbook to the Species of Carex found growing in the British Isles. (Botanical Society of the British Isles).

Grasses:

Hubbard C E, (1968). Grasses (2nd ed), Penguin.

Bryophytes:

Watson E V, (1968). British Mosses and Liverworts. 495pp. CUP.

Smith A J E, (1978). The Moss Flora of Britain and Ireland. CUP.

Smith A J E, (1990). The Liverworts of Britain and Ireland. CUP.

Charophytes:

Allen G O, (1950). British Stoneworts (Charophyta). Haslemere Natural History Society.

Moore J A, (1986). Charophytes of Great Britain and Ireland. BSBI Handbook No 5.

Algae:

Belcher H and Swale E, (1976). A Beginner's Guide to Freshwater Algae, 47pp, HMSO, London.

Bellinger E G, (1980). A Key to Common British Algae 94pp Institution of Water Engineers and Scientists, London.

BSBI handbooks are available for various macrophyte groups eg Umbellifers, Willows and Docks.

Appendix 3 **Rank Class Percentage Cover Scale recommendations**

The alternative rank class scales are:-

Scale A		Scale B		Scale C	
A1	<0.1%	B1	<0.1%	C1	<0.1%
A2	0.1-1%	B2	0.1-5%	C2	0.1-1%
A3	1-5%	B3	>5%	C3	1-2.5%
A4	5-10%			C4	2.5-5%
A5	>10%			C5	5-10%
				C6	10-25%
				C7	25-50%
				C8	50-75%
				C9	>75%

Recommendations:-

Segment length	Scale
100 m	Detailed comparisons use 9 pt, Scale C For less detailed comparisons use 5 pt, Scale A Less detailed information required about abundance use 3 pt, Scale B
500 m	Most detailed scale suitable is 5 pt, Scale A Less information required about abundance use 3 pt, Scale B

Appendix 4

i) **Comparison of percentage of species recorded for different survey lengths**

From Nigel Holmes:

500 m lengths contain approximately 37% more spp. than 100 m*

1 km lengths contain approximately 56% more spp. than 100 m*

1 km lengths contain approximately 13.5% more spp. than 500 m*

2 km lengths contain approximately 2.5% more spp. than 1.5 km+

97% of river species and 94% of bank species which occur in more than 2% of 500 m reaches surveyed in whole rivers are found in 1 km sites located approximately 7 km apart.+

1 km sites surveyed every 7 km enables the majority of species to be recorded in 14% of the time would take to survey a whole river+

* Results based on over 50 km sites surveyed on more than 10 river systems in England and Wales in 1978.

+ Results based on analysis of data gathered for a source to mouth survey in N E England.

ii) **Summary of Survey information.**

Reason for Survey	Segment length	Rank class % cover scale	Number of segment lengths - ideal	Minimum number of segment lengths
Monitoring a discharge - impact	100 m	9pt	1 u/s 2 d/s	1 u/s 1 d/s
Monitoring a discharge - impact and recovery	100 m	9pt	1 u/s 5 d/s	1 u/s 3 d/s
Broad overview	500 m	5pt or 3pt	1 every 5/10km*	
Conservation - species richness	500 m	5pt or 3pt		
Conservation or typing (Holmes,1983)	500 m	5pt or 3pt	2 x 500 m consecutive every 5/7km*	2 x 500 m consecutive

* This depends on size of the river - 5km for smaller rivers, 10 km for larger rivers.

If detailed information on abundance is required as well as a more complete species list a combination of segment lengths can be used. The first 100 m within a 500 m segment could be recorded separately with a detailed abundance category and macrophyte species noted for the next 400 m, with a less detailed scale of abundance if required.

Appendix 5 Standard Record Sheets

MACROPHYTE FIELD RECORD SHEET

River _____ Site _____ Surveyor(s) _____

Segment no. _____

Date __/__/__ Start time __:__ NGR top (segment) _____ NGR bottom (segment) _____

Survey details

Percentage cover scale 9 point, C ☐ 5 point, A ☐

Segment length 100 m ☐ 500 m ☐

Wadeable ☐ Non-wadeable ☐ Boat ☐

Overall percentage cover |_____|

Scale	%
C1	< 0.1
C2	0.1 - 1
C3	1 - 2.5
C4	2.5 - 5
C5	5 - 10
C6	10 - 25
C7	25 - 50
C8	50 - 75
C9	> 75

MACROPHYTE SPECIES CHECKLIST

	Rel	Cov		Rel	Cov		Rel	Cov
ALGAE:			*Littorella uniflora*			*Elodea canadensis*		
Blue-Green Mats			*Mentha aquatica*			*Elodea nuttallii*		
Batrachospermum sp(p)			*Menyanthes trifollata*			*Glyceria maxima*		
Hildenbrandia rivularis			*Montia fontana*			*Glyceria other sp(p)*		
Lemanea fluviatilis			*Myosotis sp(p)*			*Groenlandia densa*		
Vaucheria sp(p)			*Myosoton aquaticum*			*Iris pseudacorus*		
Enteromorphia sp(p)			*Myriophyllum alterniflorum*			*Juncus acutiflorus*		
Stigeclonium sp(p)			*Myriophyllum spicatum*			*Juncus articulatus*		
Cladophora sp(p)			*Nasturtium officinale agg.*			*Juncus bulbosus*		
Other filamentous Greens			*Nuphar lutea*			*Juncus effusus*		
Chara sp(p)			*Nymphaea alba*			*Juncus inflexus*		
Nitella sp(p)			*Oenanthe crocata*			*Juncus sp(p)*		
LIVERWORTS:			*Oenanthe fluviatilis*			*Lemna gibba (gibbous)*		
Chiloscyphus polyanthos			*Polygonum amphibium*			*Lemna minor agg*		
Marsupella emarginata			*Potentilla palustris*			*Lemna trisulca*		
Nardia compressa			*Ranunculus aquatilis*			*Phalaris arundinacea*		
Pella endiviifolia			*Ranunculus calcareus*			*Phragmites australis*		
Pellia epiphylla			*Ranunculus circinatus*			*Potamogeton alpinus*		
Scapania undulata			*Ranunculus flammula*			*Potamogeton berchtoldii*		
Solenostoma sp(p)			*Ranunculus fluitans*			*Potamogeton crispus*		
Foliose Liverworts indet			*Ranunculus hederaceus*			*Potamogeton friesii*		
Thalloid Liverworts Indet			*Ranunculus omiophyllus*			*Potamogeton gramineus*		
MOSSES:			*Ranunculus peltatus*			*Potamogeton lucens*		
Amblystegium fluviatile			*Ranunculus penicillatus*			*Potamogeton natans*		
Amblystegium riparium			*Ranunculus trichophyllus*			*Potamogeton pectinatus*		
Cinclidotus fontinaloides			*Ranunculus sceleratus*			*Potamogeton perfoliatus*		
Fontinalis antipyretica			*Ranunculus indet*			*Potamogeton polygonifol*		
Fontinalis squamosa			*Rorippa amphibia*			*Potamogeton praelongus*		
Hygrohypnum luridum			*Rumex hydrolapathum*			*Potamogeton pusillus*		
Hygrohypnum ochraceum			*Solanum dulcamara*			*Potamogeton indet*		
Racomitrium aciculare			*Veronica anagalis-aquatica*			*Potamogeton other sp(p)*		
Rhynchostegium riparioides			*Veronica beccabunga*			*Sagittaria sagittifolia*		
Sphagnum sp(p)			*Veronica catenata*			*Scirpus fluitans*		
Mosses indet			MONOCOTYLEDONS:			*S. lacustris/tabernaemon*		
VASCULAR CRYPTOGAMS:			*Acorus calamus*			*Scirpus maritimus*		
Azolla filiculoides			*Agrostis stolonifera*			*Sparganium angustifolim*		
Equisetum fluviatile			*Alisma lanceolatum*			*Sparganium emersum*		
Equisetum palustre			*Alisma plantago-aquatica*			*Sparganium erectum*		
DICOTYLEDONS:			*Alopecurus geniculatus*			*Spirodela polyrrhiza*		
Apium inundatum			*Butomus umbellatus*			*Typha latifolia*		
Apium nodiflorum			*Carex acuta*			*Zannichellia palustris*		
Berula erecta			*Carex acutiformis*			ADDITIONS:		
Callitriche hamulata			*Carex aquatilis*			1.		
C. hermaphroditica			*Carex elata*			2.		
Callitriche obtusangula			*Carex paniculata*			3.		
Callitriche platycarpa			*Carex riparia*			4.		
Callitriche stagnalis			*Carex rostrata*			5.		
Callitriche indet			*Carex vesicaria*			6.		
Caltha palustris			*Carex indet*			7.		
Ceratophyllum demersum			*Carex other sp(p)*			8.		
Epilobium hirsutum			*Catabrosa aquatica*			9.		
Hippurus vulgaris			*Eleocharis sp(p)*			10.		

PHYSICAL RECORDS

Record 1, 2 or 3 in the boxes below.
1 = <5%, 2 = 5 - 25% and 3 = >25%

Width (m)	<1 ☐	1 - 5 ☐	>5 - 10 ☐	10 - 20 ☐	>20 ☐
Depth (m)	<0.25 ☐	0.25 - 0.5 ☐	>0.5 - 1.0 ☐	>1.0 ☐	
Substrates	Bedrock ☐	Boulders ☐	Cobbles ☐	Pebbles ☐	Gravel ☐
	Sand ☐	Silt/mud ☐	Clay ☐	Peat ☐	
Shading Left bank	None ☐	Broken ☐	Dense ☐		
Right bank	None ☐	Broken ☐	Dense ☐		
Habitats	Pool ☐	Run ☐	Riffle ☐	Slack ☐	
Water clarity	Clear ☐	Cloudy ☐	Turbid ☐		
Bed stability	Firm ☐	Stable ☐	Unstable ☐	Soft ☐	

Photograph identification facing downstream ☐ facing upstream ☐

_____

_____

_____

Sketch map ☐

Comments

_____

_____

_____

_____

_____

_____

_____

STANDARD SKETCH MAP SHEET (MACROPHYTE SURVEY, 100 m)

River _____ Site _____ Surveyor(s) _____

Date __/__/__ Segment no. _____ NGR top _____ NGR 'bottom _____

100 m

LEFT BANK RIGHT BANK

DIRECTION

OF FLOW ↑

90 m

80 m

70 m

60 m

50 m

40 m

30 m

20 m

10 m

0 m

Main features to mark on sketch map:-

River channel
Width of channel
Relocation features
Shading position and type
Grid north (found from OS map)
Dominant macrophyte stands
Extent of riverbanks and adjacent landuse
Depth of water

Label clearly.

STANDARD SKETCH MAP SHEET (MACROPHYTE SURVEY, 500 m)

River _____ Site _____ Surveyor(s) _____

Date __/__/__ Segment no. _____ NGR top _____ NGR 'bottom _____

500 m

LEFT BANK RIGHT BANK

DIRECTION

OF FLOW ↑

450 m

400 m

350 m

300 m

250 m

200 m

150 m

100 m

50m

0 m

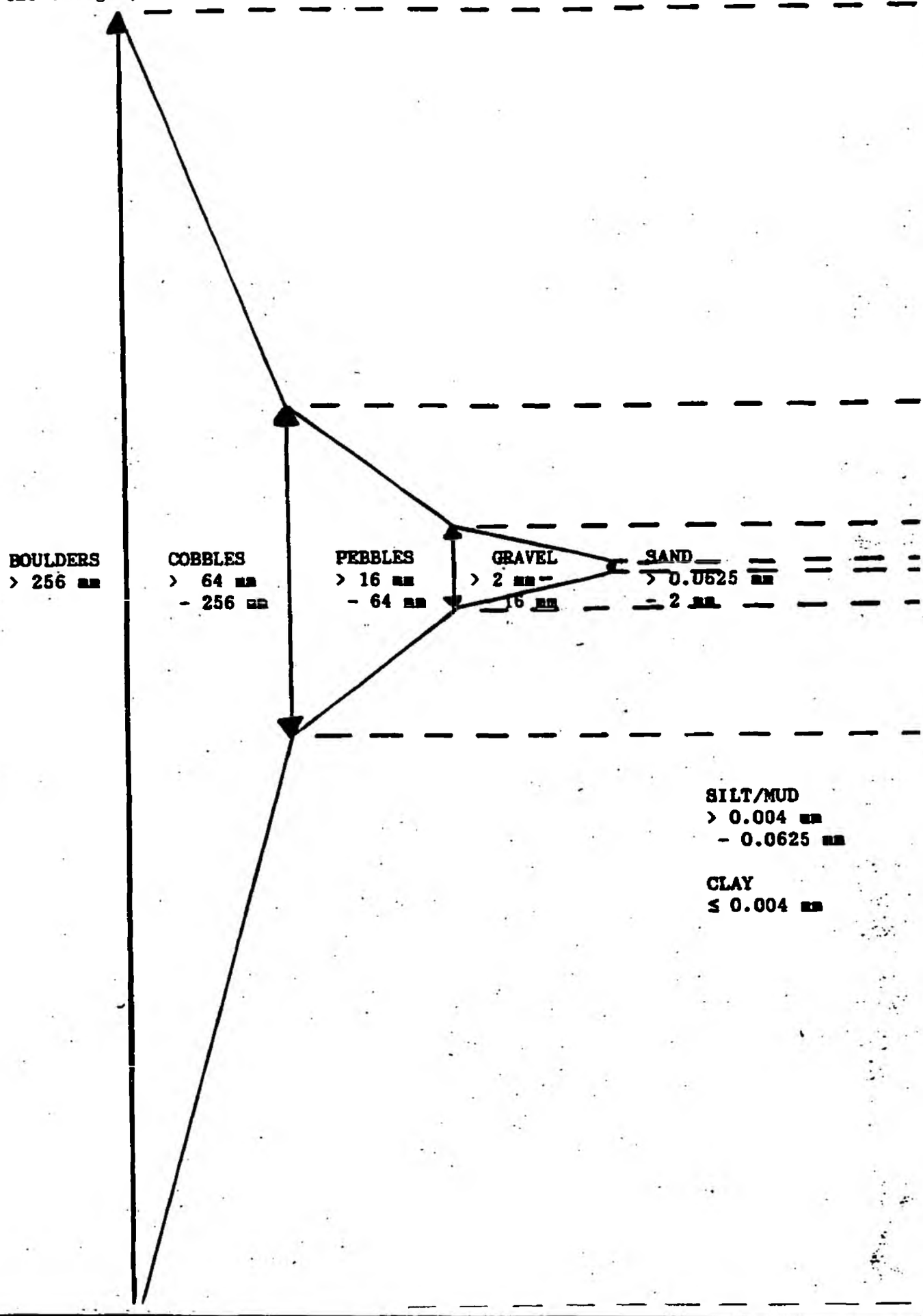
Main features to mark on sketch map:-

River channel
Width of channel
Relocation features
Shading position and type
Grid north (found from OS map)
Dominant macrophyte stands
Extent of riverbanks and adjacent landuse
Depth of water

Label clearly.

SUBSTRATE REFERENCE SHEET

Substrate categories and size ranges are marked. Use this sheet to determine the category of substrates in the field.



MACROPHYTE SURVEY REPORT SHEET

River _____ Site _____ Surveyor(s) _____

Date __/__/__ NGR _____

Management works

Type of work _____

Proposed date for commencement __/__/__

Actual date of work start __/__/__ end __/__/__

Pollution incidents (since last report) no ☐ yes ☐

Incident 1 Date __/__/__

Pollutant _____

Severity _____

Location and area affected _____

Comments _____

_____

Incident 2 Date __/__/__

Pollutant _____

Severity _____

Location and area affected _____

Comments _____

_____

Incident 3 Date __/__/__

Pollutant _____

Severity _____

Location and area affected _____

Comments _____

_____

SURVEY RECORD SHEET

Site _____ NGR _____

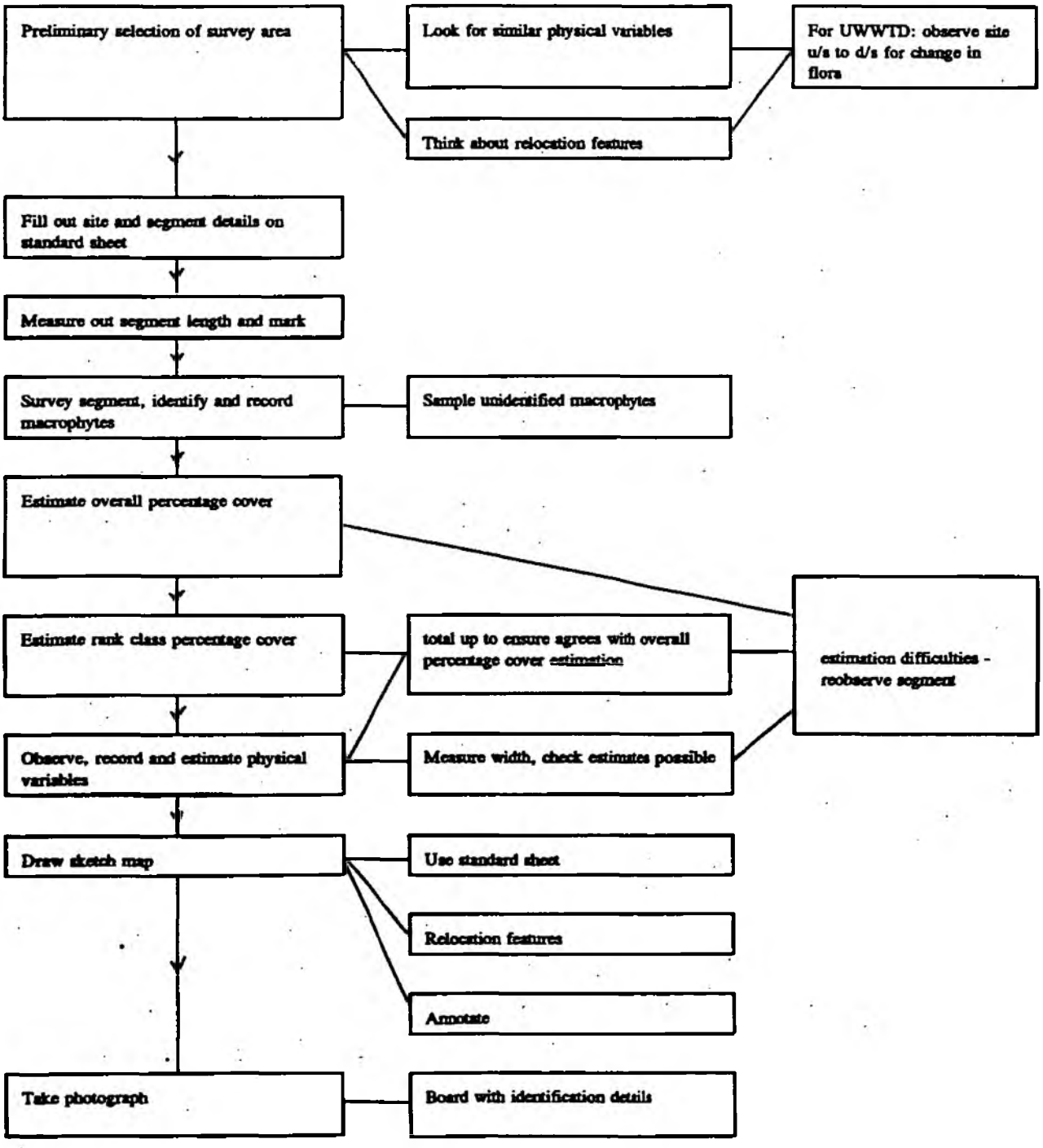
River _____ Site code _____

Survey date __/__/__ Number of segments _____

Reason for survey _____

Segment Number	Length/m
1	
2	
3	
4	

Appendix 6 MACROPHYTE SURVEY FLOW CHART



Take a copy of this chart into the field as a memory aid.

Appendix 7 Rare plants

There are two species of river plants which are nationally rare, Sharp-leaved and Loddon pondweeds, which are on the Red Data list of higher plants.

(from Nigel Holmes chapter in RSPB book.)

Further details of rarities can be found in the NCC Focus No 1 and new distribution maps are being produced, part funded by the NRA and JNCC.

Appendix 8 Foreign invaders

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:

Bank species:

Indian Balsam, *Impatiens glandulifera*
Orange Balsam, *Impatiens capensis*
Giant Hogweed, *Heracleum mantegazzianum*
Japanese knotweed, *Polygonum cuspidatum*
Monkey flower, *Mimulus guttatus*

River species:

Nuttall's pondweed

Crassula helmsii, Australian swamp stone-crop: found in shallow water.

Appendix 9 Identification confirmation

The following is a list of BSBI county recorders who have agreed to undertake identification confirmation for species found within their areas. The BSBI is a voluntary organisation. Any expenses including postage should be paid. Before sending a sample contact the relevant BSBI recorder to ensure they are available to identify the specimen and that they are confident in the macrophyte group which needs identification to species level.
BSBI = Botanical Society of the British Isles
VC = vice county

BUCKS VC 024	Mr R Maycock
ESSEX VC 018 & 019	Dr K J Adams
HERTS VC 020	Mr T James
LINCS VC 053 & 054	Mrs I Weston
(EAST) NORFOLK VC 027	Mr A L Bull
(WEST) NORFOLK VC028	Mr and Mrs K A Beckett
RUTLAND VC 055b	Mr K G Messenger

Contact the Biology Section at RHQ for the address of the BSBI recorder you would like to contact.

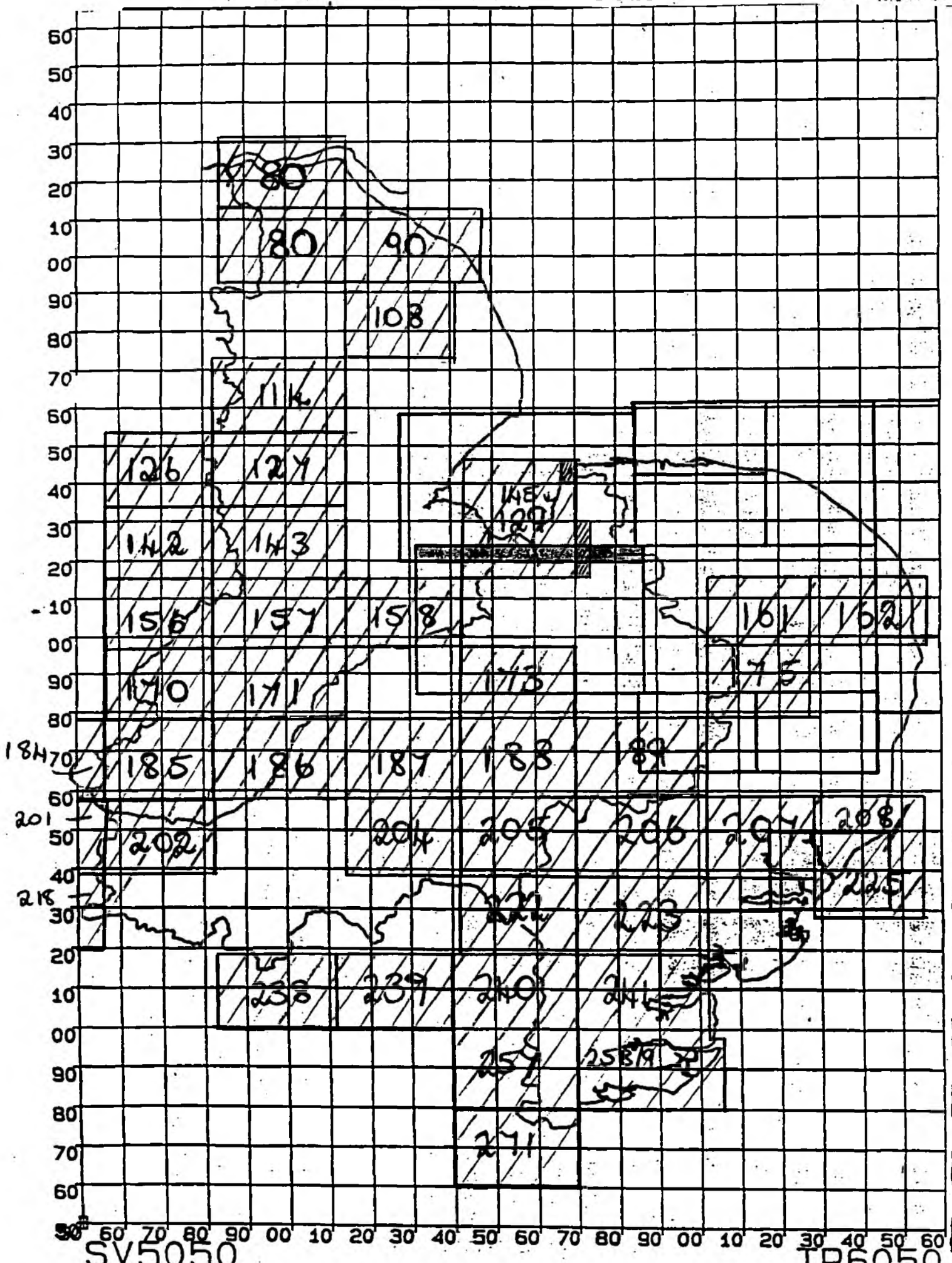
Appendix 10 Contacts for Training Courses

A list of suitable contacts for provision of training courses should be completed by each Region.

Appendix 11 Charts showing areas of the Anglian region covered by geological maps.

BRITISH GEOLOGICAL MAPS, SCALE 1:50 000 OR 1 INCH 1:63

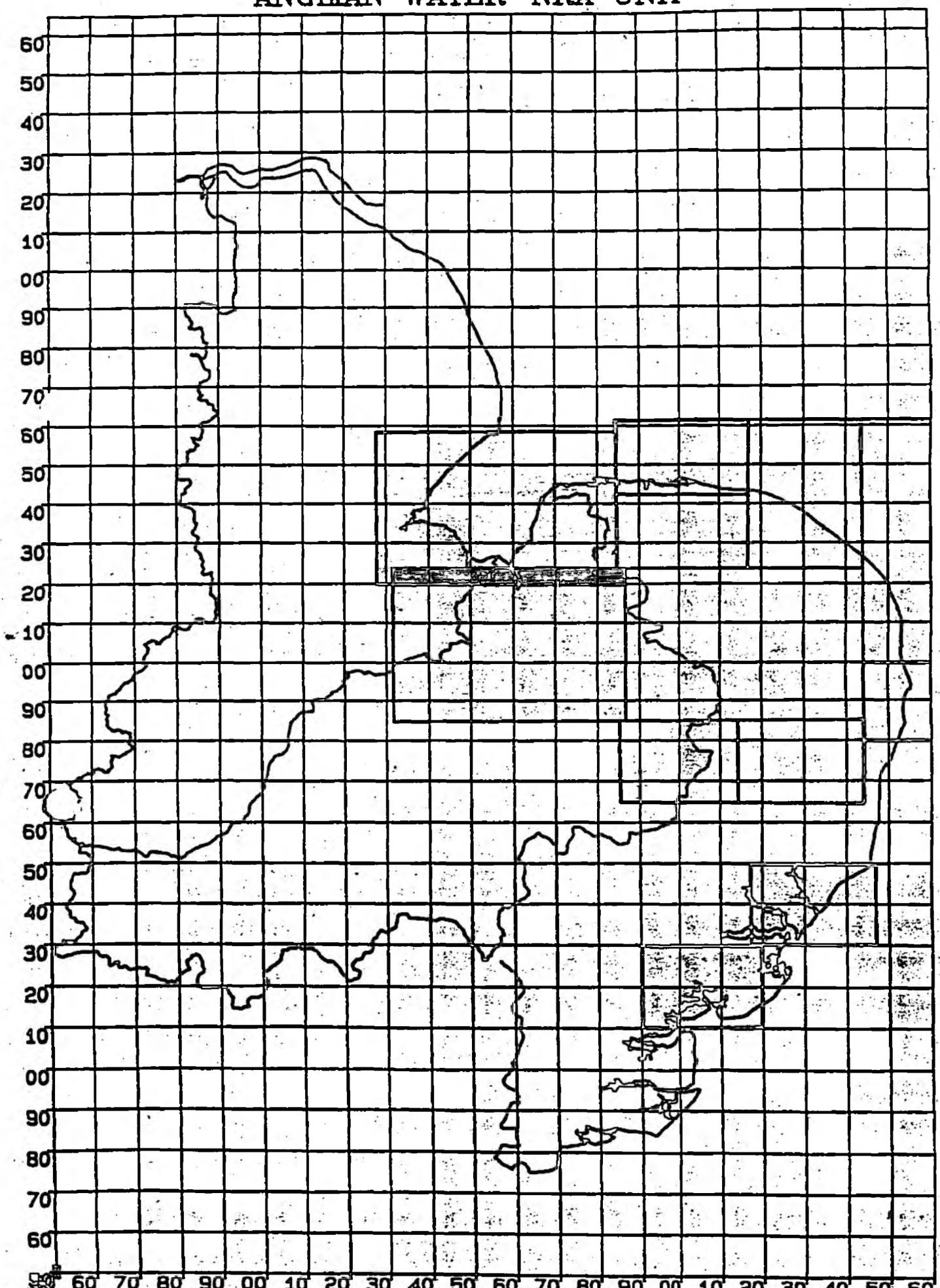
ANGLIAN WATER–NRA UNIT



OLD SERIES

"VICTORIAN" 1:63360 GEOLOGICAL MAPS

ANGLIAN WATER–NRA UNIT



Appendix 12 Equipment suppliers

This list may NOT include all suppliers of the equipment

1. Underwater TV camera Model FM-1000

See included photocopy of brochure for details. 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 Jan 1994 £2,058-38 + VAT
Available from SWIFTECH marine electronics, Fareham (0329) 823300.

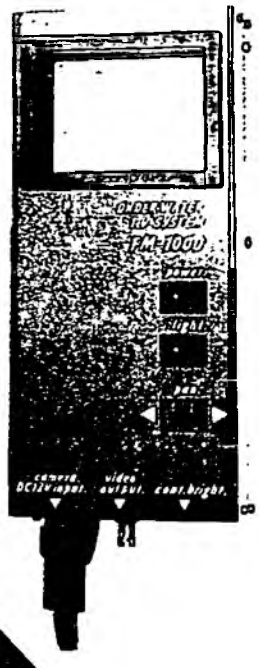
A 12 volt battery will be required.

2. Optical Range Finder

RANGING 120 - this has a range of 3 to 30 m which would be suitable for most river widths in Anglian Region. Cost Jan 1994 £57.20
Available from York Survey Supply Centre TEL: (0904) 692723

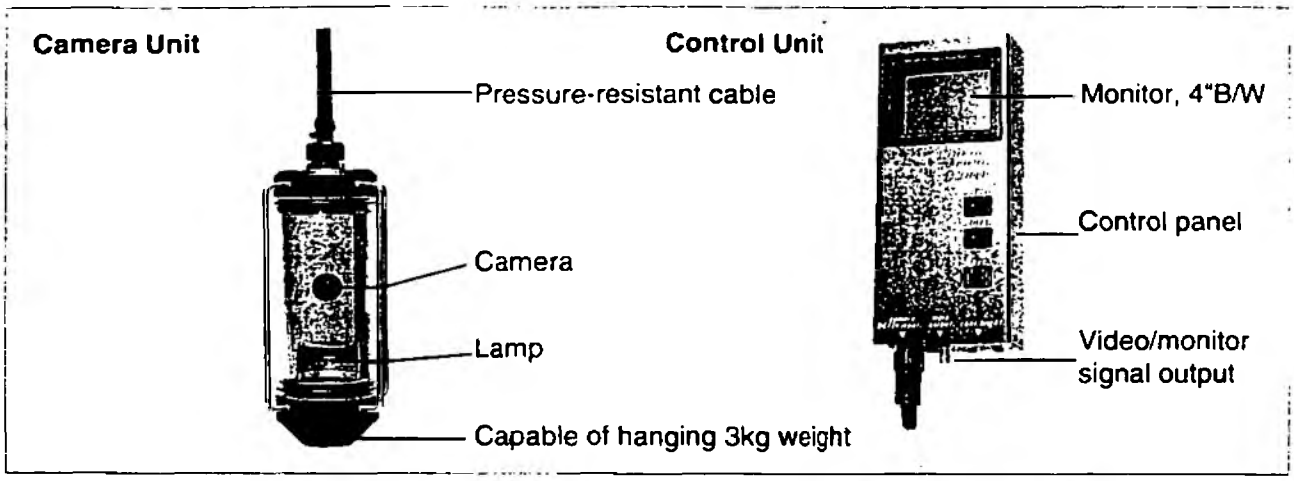
SUPER-MINI UNDERWATER TV CAMERA,

MODEL FM-1000



SWIFTECH
MARINE ELECTRONICS

DESCRIPTION



FEATURES

- High sensitivity monochrome solid state CCD camera, withstands direct sunlight. Very robust. Visible light and partial infra red spectrum coverage.
- Battery or car lighter operated — low power consumption.
- Motorised revolving camera, 360° visibility.
- Quartz halogen 20 watt lamp.
- Corrosion-free aluminium and plastic camera housing — light weight — no maintenance.
- Slim and robust hand held monitor ergonomically designed for single handed use. Warm up time 3 seconds.
- Bright CRT in monitor.
- Standard European video output BNC connector for video recording or additional larger monitor.
- Comes complete with small visor and weather proof bag.
- Power consumption 10 watts max — 30 watts with lamp on.

SPECIFICATIONS

Camera Unit

- Image Sensor : CCD $^1/_2$" monochromatic sensor
- Lens : f=5.3mm F1.5 auto iris
- Minimum Illumination : 5 Lux
- Revolving motor : 336° revolving (over 360° visibility)
- Light : halogen lamp 20W
- Weight : mid-air hanging, approximately 1.5kg underwater, approximately 0.5kg
- Dimensions : ø 80 x 220mm (excluding lower hanging section)
- Lens viewing angles : 41° horizontal, 32° vertical } approx

Control Unit

- Monitor : 4" B/W fat CRT
- Resolution : 450 lines on CRT screen (horizontal centre)
- Weight : 1.3kg
- Dimensions : 108(W) x 245(L) x 59(H) mm
- Power Supply : DC11-13V 2.3A maximum

Cable

- Structure : composite cable ø 8mm x 50 m

Accessories

Water-proof vinyl case : 1 set
Sun visor : 1 set
} Included in price
Reeling drum : optional extra

SWIFTECH MARINE ELECTRONICS

REGISTERED OFFICE
218-228 Edmiston Drive
GLASGOW G51 2YT
Tel: 041-427 5331/8
Fax: 041-427 5419
Telex: 778312

BRANCHES
Unit G
Fort Wallington
FAREHAM
Hants PO16 8TT

Station Road
Lawford
MANNINGTREE
Essex CO11 2LL

Unit 8
Tamar View Industrial Estate
SALTASH
Cornwall PL12 6LD

Dealer :

Appendix 13 REFERENCES

Introduction references:

Royal Commission on Environmental Pollution, Sixteenth Report. Freshwater Quality. June 1992.

Consultation paper on criteria and procedures for identifying sensitive and less sensitive areas (UWWTD) and 'polluted water' (nitrate directive) in England and Wales.

Water Quality 2000 A Strategy for the Water Quality Function NRA April, 1992 Version 8.

Seeger, J - Head of Environmental Quality. For EQC use only, Proposed special ecosystem classification for rivers.

Methods manual:

Ecosurveys Ltd. Methodology for Linear Plant Survey. Version 1, April 1992.
English Nature. Standard macrophyte survey method.
Holmes, N. 1983

Furse, M T, Moss, D, Wright, J F, Armitage, P D, Gunn, R J M - preliminary version. RIVPACS A practical manual for the classification and prediction of macro-invertebrate communities in running water in Great Britain. 1986.

Haslam, S M and Wolsey, P A. River Vegetation. Its Identification, Assessment and Management. 154, CUP, 1981.

Harding, J P C. Macrophytes as Monitors of River Quality in the Southern NWWA area. NWW, 1981.

Harding, J P C. Macrophytes of the River Weaver Summer 1978. NWWA, Rivers division, Scientist Dept. Technical Support Group, 1980.

Hobsley, C. Conservation value of rivers Teith and Forth, UCL, 1981.

Holmes, N T H, Macrophyte Surveys of Rivers, Approaches used previously to survey Macrophytes in rivers. Planned surveys of rivers in England and Wales. NCC CST Notes, No 7, 1978

Holmes, N and Newbold, C. River Plant Communities - reflectors of Water and Substrate Chemistry. NCC Focus on nature conservation, No 9, 1984.

Holmes, N and Whitton, B A. The macrophyte vegetation of the River Tees in 1975: observed and predicted changes. Freshwater Biology, 7, 43-60, 1977.

Holmes, H and Whitton, B A. Macrophyte vegetation of the River Swale, Yorkshire. Freshwater Biology, 7, 545-558, 1977.

Kelly, M. Monitoring water pollution:the role of plants. Plants Today, 1989, 96-100.

Methods for the Use of Macrophytes for assessing Water Quality 1985-86. Methods for the examination of Waters and Associated Materials. Standing Committee of Analysts. HMSO.

Newbold, W and Holmes, N. Nature conservation: Water Quality Crisis and Plants as Water Quality Monitors. NCC, 1986. The Institute of Water Pollution Control: Annual Conference.

Watson, G. Comparison of water quality using aquatic macrophytes in three rivers in Northern Ireland. M.Sc research project, Napier Polytechnic of Edinburgh, 1992.

Whitton, B A and Buckmaster, R C. Macrophytes of the River Wear. Naturalist (Hull). 1970. 97-116.

Preservation of aquatic macrophyte material:

Moore J A, (1986). Charophytes of Great Britain and Ireland. BSBI Handbook No 5.

Bridson D and Forman L. The Herbarium Handbook

These can be borrowed from the Biology Section at RHQ.

Actual biomass:

Standing Committee of Analysts. The Direct Determination of Biomass of Aquatic Macrophytes and Measurement of Underwater Light. Methods for the Examination of Waters and Associated Materials, HMSO, 1985.

Background/General information:

Briefing Note for meeting with DoE and AWS - SA[E]'s. 18 June 1993, Dave Foster (Directives Scientist).

Council Directive of 21 May 1991 concerning urban waste water treatment (91/271/EEC). Official Journal of the European Communities.

Draft: The UWWT (England and Wales) Regulations 1993: A guidance note issued by the Department of the Environment and the Welsh Office.

Holmes, N and NRA SW. Macrophyte Identification Guide. 1992, amended 3/1993.

Macrophyte Surveying Methods. NRA Thames Region. Biology (Fobney Mead), 1993

Mesotrophic Rivers of the Anglian Region of the NRA. Ecology Unit, University of Leicester. Operational investigation: draft report (version 1) March 1993

Murray-Bligh, J A D, c/o NRA SW Region. Freshwater Biology Technical Handbook No 1. Macro-invertebrate surveys, Standard Sampling Methods and Procedures. 3rd preliminary draft v3.3. Nov 1993.

NRA Conservation Technical Handbook 1, River Corridor Surveys, 1992.

UWWTD Sensitive Areas Working Group meeting at NRA London Office, Eastbury House, Albert Embankment. 15 June 1992.

Consultation Paper. Methodology for identifying sensitive areas (UWWTD) and methodology for designating vunerable zones (nitrates directive) in England and Wales. DoE, MAFF, Welsh Office. March 1993.

Wildlife and Countryside Act 1981, Schedule 8.

Anderson, M R and Kalff, J. Nutrient limitation of Myriophyllum spicatum growth in situ. Freshwater Biology, 16, 735-743, 1986.

Brierley, S J, Harper, D M and Barham, P J. Factors effecting the distribution and abundance of aquatic plants in a navigable lowland river:the River Nene, England. Regulated rivers: Research and Management, 4, 263-274, 1989.

Butcher, R W. Studies on the Biology of Rivers. I. On the Distribution of Macrophyte Vegetation in the rivers of Britain. J of Ecology, 21, 59-91, 1933.

Chambers, P E and Prepas, E E. Competition and coexistence in aquatic plant communities: the effects of species interactions versus abiotic factors. Freshwater Biology 23 541-550, 1990.

Dawson, F H, Castellano, E and Ladde, M. Concept of species succession in relation to river management. Verti-Internat. Verein. Limnol. 20 1429-1434
Stuttgart, Oct 1978

Freeman, M C. The role of nitrogen and phosphorus in the development of Cladophora glomerata(L) Kutzing in the Manawatu River, New Zealand. Hydrobiologia 131, 23-30 (1986).

Haslam, S M. Keep those river weeds - they are useful. University of Aston. The 39th annual meeting of the British Association for the Advancement of Science, 1977.

Haslam, S M. Physical factors and some river weeds. Proc. Eur. Weed Res. Coun. 3rd Int. Symp. Aquatic Weeds, 1971.

Haslam, S M. Macrophytes in Relation to Stream Quality. Paper taken from information compiled for 'River Plants'.

Hellawell, J. Biological Indicators of Freshwater Pollution and Environmental Management, 1986.

Hellawell, J M. Biological Surveillance of Rivers. NERC, WRc, Regional Water Authorities, 1978.

Holmes, N T H, Whitton, B A and Hargreaves, J W. A coded list of Freshwater Macrophytes of the British Isles. Lichens - Bryophytes - Vascular Plants. Water Archive Manual Series No 4. DoE Water Data Unit, 1978.

Laddle, M J and Scorgie, H R A. The effects of recreation on freshwater plants and animals: a review. Biological Conservation 17, 183-206, 1980.

Lewis, G and Williams, G. Rivers and Wildlife Handbook: A guide to the practices which further the conservation of wildlife on rivers. RSPB, 1984.

Madsen, J D and Adams, M S. The seasonal biomass and productivity of the submerged macrophytes in a polluted Wisconsin Stream. FWB, 20, 41-50, 1988.

Marshall, E P J and Westlake, D F. Recent studies on the role of aquatic macrophytes in their ecosystem. Proc. EWRS 5th Symp. on Aquatic Weeds, 1978.

Moss, B. Conservation problems in the Norfolk Broads and Rivers of E. Anglia, England - phytoplankton, boats and the causes of turbidity. Biol. Cons. 12 1977.

Murphy, K J, Eaton, J W and Hyde, T M. The management of Aquatic Plants in a navigable canal system used for amenity and recreation. Proc. EWRS 6th Symposium on Aquatic Weeds, 1982.

Murphy, K J and Eaton, J W. Effects of pleasure boat traffic on macrophyte growth in canals. J. of applied Ecology 21 713-729, 1983

NCC Nature conservation and pollution from farm wastes, 1991.

Niols, S A and Shaw, B H. Ecological life histories of 3 aquatic nuisance plants: Myriophyllum spicatum, Potamogeton crispis and Elodea canadensis. Hydrobiologia 131 3-21, 1986.

Phillips, G L, Eminson, D and Moss, B. A mechanism to account for macrophyte decline in progressively eutrophicated freshwaters. Aquatic Botany, 4, 103-126, 1978.

Pieterse, A H and Murphy, K J. Aquatic weeds: The ecology and management of nuisance vegetation. Oxford Scientific Press, 1990

Roa, S V R and Mall, L P. Effect of Sewage and Industrial Wastes on the Floristic composition and distribution of macrophyte vegetation in the River Khan. Water Research, 15, 287-288, 1981. Technical note.

Sand-Jensen, k, Jeppesen, E, Nielsen, K; Vander Bijl, L; Hjermind, L, Neilsen, L W and Iversen, T M. Growth of macrophytes and ecosystem consequences in a lowland Danish Stream. Freshwater Biology, 22, 15-32, 1989.

Sand-Jensen, K and Sondergaard, M. Distribution and quantitative development of aquatic macrophytes in relation to sediment characteristics in oligotrophic Lake Kalgaard, Denmark. Freshwater Biology, 1-11, 1978

Symoens, J J ed. Handbook of vegetation science. Vegetation of Inland Waters. Kluwer academic publishers, 1988

Westlake, D F. Temporal changes in aquatic macrophytes and their environments. Dynamique de populations et qualite de l'eau. 1981 Cons. proceedings.

Westlake, D F and Dawson, F H. The management of *Ranunculus calcareous* by pre-emptive cutting in Southern England. Proc. EWRS\AAB 7th Symposium on Aquatic Weeds. 1986

Whitton, B A. Plants as indicators of river water quality.

Health and Safety References:

Freshwater Biology Technical Handbook No.1 Macro-invertebrate Surveys, Standard Sampling Methods and Procedures 2nd preliminary draft, March 1993.

Measurement of liquid flow in open channels, Part 3. Stream flow measurement Part 3Q. Code of practice for safe practice in stream gauging BS 3680: Part 3Q: 1993, BSi

NRA Code of Practice - Marine Activities, Part II, Boats - Type II - V

NRA Policy Implementation Note Lone Worker Code of Practice Version 1, FEB 1993.

NRA River Corridor Surveys Conservation Technical Handbook 1, 1992.

NRA Southern Region, Field safety document

Quality control:

NRA Anglian Region. Standard methodologies: Assessment of estuarine/marine water quality using benthic macro-invertebrates.

NRA Anglian Region. Phytoplankton standard methodologies. 1993.

NRA FW Subgroup. A proposed internal statistical quality control scheme for macro-invertebrate sample analysis together with an external audit.

NRA Thames Region/WRc. The application of statistical quality control methods to macro-invertebrate sampling. Report No L02905, Oct 1991.