north western international river basin district

North South Shared Aquatic Resource (NS SHARE)

neagh bann international river basin district

North South Shared Aquatic Resource (NS SHARE)

north eastern river basin district

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North South Shared Aquatic Resource (NS Share)

Methods Manual
I River Macrophytes

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DEPARTMENT OF THE ENVIRONMENT, HERITAGE AND LOCAL GOVERNMENT

INTERREG IIIA

North South Shared Aquatic Resource (NS Share)

Water Framework Directive

A Directive establishing a new framework for Community action in the field of water policy (2000/60/EC) came into force in December 2000. This Water Framework Directive (WFD) rationalises and updates existing legislation and provides for water management on the basis of River Basin Districts (RBDs). The WFD was transposed into national law in Northern Ireland by the Water Environment (Water Framework Directive) Regulations (Northern Ireland) 2003 and in the Republic of Ireland by the European Communities (Water Policy) Regulations 2003. The primary objective of the WFD is to maintain the "high status" of waters where it exists, prevent deterioration in existing status of waters and to achieve at least *"good status"* in relation to all waters by 2015.

NS Share Study Area

NS Share is a cross border project and incorporates three River Basin Districts as set out in the joint North/South Consultation paper *Managing our Shared Waters*:

1. North Western International River Basin District (NWIRBD);
2. Neagh Bann International river Basin District (NBIRBD);
3. North Eastern River Basin District (NERBD).

The NW and NB are International River Basin Districts as they share their waters between Northern Ireland (NI) and Republic of Ireland (ROI). The NERBD is contained wholly within NI.

NS Share Project

The overall objective of the project is to strengthen inter-regional capacity for environmental monitoring and management at the river basin district level, to improve public awareness and participation in water management issues, and to protect and enhance the aquatic environment and dependent ecosystems.

The NS Share project aims to facilitate delivery of the objectives of the WFD within the project area between August 2004 and March 2008.

The NS Share project is funded by the EU INTERREG IIIA Programme for Ireland / Northern Ireland. The Department of the Environment (NI) and the Department of the Environment, Heritage and Local Government (ROI) are implementing agents for the project. Donegal County Council is the project promoter. Technical support is proivded by the Environment and Heritage Service an agency within the Department of the Environment (NI), and the Environmental Protection Agency (ROI). RPS Consulting Engineers in association with Jennings O'Donovan are the principal consultants.

Assistance was also provided by the Marine Institute, Central Fisheries Board, Geological survey Ireland, Geological survey Northern Ireland, Loughs Agency, North West Regional Fisheries Board, and Cavan, Leitrim, Longford, Louth, Meath, Monaghan, and Sligo County Councils.

Project publications are available at www.nsshare.com/publications

PREFACE

The work presented in this paper was carried out as part of the NS SHARE project, which is funded by the European Union INTERREG IIIA programme for Ireland/Northern Ireland. The implementing agents for the NS SHARE project are the Department of Environment (DOE), Northern Ireland, and the Department of Environment Heritage and Local Government (DEHLG), Republic of Ireland. Donegal County Council (DCC) is the project promoter.

All data, drawings, reports, documents, databases, software and coding, website and digital media and publicity material produced as part of this project shall be the property of the DOE/DEHLG who will use, reproduce and distribute same as they see fit.

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NORTH SOUTH SHARED AQUATIC RESOURCE (NS Share)

Methods Manual

I River Macrophytes

Introduction

Macrophyte communities in rivers respond directly to physical and chemical conditions, but are subject to variation because of differences in composition of substrata, shading and flow regimes. Species can be distinguished broadly as submergents or emergents, with some typically associated with the riparian ecotone. A variety of methods have been developed for assessment of macrophyte and riparian communities for nature conservation (Palmer, 1989; Palmer, Bell & Butterfield, 1992; Raven *et al.*, 1997). There have been recent developments in survey and analysis methods to fulfil obligations under the Water Framework Directive (WFD) (Council of the European Communities, 2000) in Ecoregions 17 and 18: for rivers, CBAS (Canonical Correspondent Analysis (CCA)-Based Assessment System) (Dodkins, Rippey & Hale, 2005) and LEAFPACS (currently unpublished, Nigel Willby), and for lakes: Pilot Study 2002-FS-1-M1 for the EPA (Free et al., 2005), CBAS and LIMPACS (currently unpublished, Nigel Willby).

The survey and analysis method for macrophytes in rivers presented here uses the CBAS method, specifically designed for Ecoregion 17, although it should have applicability for Ecoregion 18 and the underlying principles are applicable throughout the EU.

The development of methods for ecological classification has been undertaken by the NS SHARE project and supporting documentation is available on the project website (http://www.nsshare.com/publications).

While sampling procedures in rivers and lakes differ, analysis of macrophyte data for both use CBAS. Sampling and analysis methods for lakes are provided in Module II of the methods handbook (http://www.nsshare.com/publications).

Safety Statement

Sampling water bodies involves some inherent dangers that fieldworkers must be familiar with. This field manual cannot identify particular hazards and it is the responsibility of those sampling, and their managers, to appraise, and act upon, those risks, and to establish compliance with national, and other regulatory issues identified by their employers. Useful general guidance is provided in the UK Environment Agency's *Generic Risk Assessment for Fieldwork* and *Generic Risk Assessment Water Framework Directive Ecological Sampling of Still Water.* Specific guidance may also exist for the processing of samples for individual biological elements. For all surveys that require access over private, or otherwise protected, land appropriate authorisation should be obtained prior to embarking on reconnaissance or survey work.

Scope:

The method has been developed for the assessment of ecological status of macrophytes (including macro-algae) in non-tidal reaches of rivers within the NS SHARE region. The methods are specifically designed for Ecoregion 17, although it should have applicability for Ecoregion 18 and the underlying principles are applicable throughout the EU, although species complement may change. Assessment of ecological status is based on the normative definitions given in Annex V of the EU Water Framework Directive (Council of the European Communities, 2000), and reproduced below. The determination of class boundaries is subject to further refinement as part of the EU inter-calibration exercise. The method can, however, be adapted to accommodate agreement among EU Member States and national agencies on those boundaries, and on the composition of macrophyte communities associated with reference conditions ratified by the North-South Technical Advisory Group (NS-TAG). Further testing and validation of the method is expected and the uncertainty of class estimates requires further development and agreement at national level.

Definitions within the WFD (Council of the European Communities, 2000)

Ecological status

“Ecological status is an expression of the quality of the structure and functioning of aquatic ecosystems associated with surface waters, classified in accordance with Annex V [of the WFD].”

High status (for macrophytes)

“The taxonomic composition corresponds totally or nearly totally to undisturbed conditions. There are no detectable changes in the average macrophytic ... abundance.”

Reference condition

To determine ecological status of a site, reference conditions are used as an unimpacted base-line such that: For each surface water body type, type-specific hydromorphological conditions, physicochemical conditions and biological quality elements, shall be established representing the values of the hydromorphological, physicochemical and biological quality elements for that surface water body type at high ecological status.

Ecological Quality Ratio (EQR)

“In order to ensure comparability of such monitoring systems, the results of the systems operated by each Member State shall be expressed as ecological quality ratios for the purposes of classification of ecological status. These ratios shall represent the relationship between the values of the biological parameters observed for a given body of surface water and the values for these parameters in the reference conditions applicable to that body. The ratio shall be expressed as a numerical value between zero and one, with high ecological status represented by values close to one and bad ecological status by values close to zero.”

Other terms and definitions

CBAS

Canonical correspondence analysis-Based Assessment System. A statistical model that utilises existing survey data to calculate optima of species along different impact gradients. These optima are then used to determine diagnostic metrics that indicate the likely impacts occurring at a survey site (RepS). These metrics can then be combined to produce an Ecological Quality Ratio.

Mean Trophic Rank

A method of measuring eutrophication using species optima which were chosen using expert opinion. The optima are weighted by species abundance and then averaged to produce the eutrophication score.

RepS (Representative Site)

"A length of river reach representative of the ecological quality that characterises that reach" (European Committee For Standardisation, 2003).

Hydrophyte

"An aquatic plant that is normally rooted under water with floating or submerged leaves, or totally free floating at the water surface." (European Committee For Standardisation, 2003)

Helophyte

"A plant that is normally rooted under water with emergent shoots, typically growing in marginal or marshy areas." (European Committee For Standardisation, 2003)

Site score

A score calculated from the mean species scores at a RepS, representing the chemical and physical characteristics of this RepS which enable these species to occur.

Reference Score

The expected score if a RepS was at reference (unimpacted) condition.

Metric score

A score representing the change in macrophyte ecology relative to reference condition at a RepS owing to (a particular type of) anthropogenic impact (e.g. increases in soluble reactive phosphate, increase in nitrate, siltation).

Principle

Data collection should be guided by information needs (Bartram & Ballance, 1996). It is important for field surveyors to understand how the data they collect will be used, so as to ensure compatability of any judgements made in the field with model outputs. The method describes the sampling of macrophyte communities from rivers and the determination of ecological status using CBAS (Dodkins et al., 2005). This includes the estimation of key physical and chemical properties. The macrophyte sampling method in rivers follows that of Holmes et al. (1999) and is compatible with CEN/BSi standard BS EN 14184:2003 on *Water quality-Guidance standard for the surveying of aquatic macrophytes in running water* (European Committee For Standardisation, 2003). Analyses of species composition within 100 m lengths of river is used in conjunction with the physical and chemical data to estimate departure from reference conditions i.e. a comparison of the optima of species occurring at the monitoring location with that at reference condition. This provides an Ecological Quality Ratio (EQR), as a metric of departure from reference condition, for each river section sampled.

Equipment

Safety and navigation equipment:

1. Self-inflating life-jacket (per person)
2. Chest waders or thigh boots
3. 1:50,000 maps of river reach and surrounding area, preferably laminated
4. Hand-held Geographical Positioning System
5. First-aid kit
6. Sanitised wipes (for cleaning hands following survey)
7. Binoculars
8. Mobile phone

For surveying:

1. Grapnel with sufficient string or rope
2. Measuring tape
3. Record sheets (Appendix 1)
4. Sharp pencils and an eraser
5. Hand lens
6. Copy of this survey procedure
7. Polarising sunglasses
8. Records from any previous macrophyte surveys
9. Camera with polarising lens
10. Underwater viewing aid/aqua-scope
11. Two survey poles (for depth estimation and to assist with walking in the river)

For sample collection and examination:

1. Large white tray
2. Dry newspaper
3. 30 ml sample bottles (for algae)
4. Large plastic bags for samples
5. Macrophyte identification books and keys, including that provided in Appendix 2
6. Marker pen or waterproof labels for bags

For deeper waters additional equipment may be necessary:

1. Boat and necessary safety equipment (including engine if necessary)
2 Grapnel with depth marking in meters on the rope
3. Wet-suit/diving equipment

Survey Planning

Macrophyte sampling should only be done between 1st May and 30 September inclusive. Comparative surveys in subsequent years should be undertaken at the same time as in previous years.

Prior to visiting, the following information should be compiled for each site.

1. Upstream location of the RepS (minimum 6 figure Irish Grid Reference (IGR))
2. Accessibility (permission of land-owners, potential risks and easiest access method)
3. Reference conditions (see below)

Reference conditions

Representative reference conditions are used as a base-line for comparison with the survey data, allowing estimation of the EQR. With the CBAS method, site-specific reference conditions are generated for each RepS.

The following parameters should be compiled for each RepS within the monitoring network:

- Alkalinity (mean of a minimum of 4 representative samples) (mg/l $CaCO_3$)
- Slope over the 100 m section (m/km)
- Width, as a mean of a minimum of 4 representative samples measured over the 100m section (m)

The values should be characteristic of the RepS at an unimpacted state. If alkalinity, slope and width values measured in the field are judged not to be representative of values expected at reference condition, an estimate of the values expected at reference condition must be made. Once the characteristic alkalinity, slope and width of the RepS are determined, these stay the same regardless of change to these parameters in the field. This is to ensure that, for example, if the width of the river is altered due to channel engineering, the reference condition is not also altered.

The $\log_{10}$ of these parameters is calculated, and these values are used in the equations from Table 1 to produce the metric values expected at reference condition. Thus, for each RepS within the monitoring network, 7 reference metrics values are calculated. This only needs to be done once for the whole monitoring network, and these values can then be stored in a database.

Table 1. Equations to predict metric values expected at reference condition, using $\log_{10}$ alkalinity (a), $\log_{10}$ slope (s) and $\log_{10}$ width (w). See 'Data Analysis – Field Method' Step 2, for an example.

Metric	Impact	Equation
SRP	Soluble Reactive Phosphate	3.9a - 0.5s - 11.7
NO_3	Nitrate	0.9a - 0.3s + 0.9w - 5.4
NH_4	Ammonia	3.3a - 0.4s - 0.8w - 8.9
SUBS	Siltation	1.2a - 1s + 1.8w - 6.3
DO	Reduced dissoloved oxygen	2.4a - 0.7s - 7.4
$_PH$	Acidification	-8.1a + 15.7

Site-specific alteration of reference metric predictions

Particular conditions at a survey site may suggest reference metric values to be different to those predicted, owing to the site's unique ecology or environmental situation. Site-specific expert opinion can be used to alter the reference metric values predicted for the RepS. If this is the case, the alteration should be justified in writing and the new metric values recorded in the database.

Selection of survey sites

Selecting river reaches

River reaches are selected for survey with sufficient coverage to ensure changes in macrophyte assemblages owing to anthropogenic factors can be distinguished from changes owing to natural factors, such as geology, slope or stream order. Collation of ancillary information such as aerial photographs, water chemical results and catchment pressures (e.g. as collated by WFD Article V reporting) is highly desirable. A sketch map of the river should be prepared marking: (i) any known point sources of pollution; (ii) physical structures (such as reservoirs, weirs, navigation channels, ditches, and drains) that may affect the hydromorphology or otherwise influence the macrophyte community; (iii) where changes in catchment usage and differences in nutrient loadings may occur, and (iv) solid and drift geology. Physical features such as bridges and weirs should be avoided where possible.

Selecting RepS

Following selection and documentation of the river reaches, the location and number of representative sites (RepS) within each reach should be determined such that they are representative of: (i) the flora within the reach; (ii) the human impact in the reach; and (iii) exposed and shaded stretches along the reach. In certain cases it may be determined that the RepS surveyed should be longer or shorter than the standard 100 m. (e.g. to adequately reflect the macrophyte diversity of the river). The CBAS method should be robust to changes in survey length since it is not based on species number, and indeed is likely to be more accurate with more species. However, it is usually better to keep to 100 m lengths since CBAS was developed from data recorded over this distance.

The criteria for RepS selection should be documented. Criteria for selection will also relate to the objectives of the work and type of monitoring (surveillance, operational or investigative as defined in L327/53 of the WFD).

Species Lists

For quality control, surveyors should be competent, prior to survey, in identifying ALL the species on the field survey sheet (Appendix 1), to the level of identification indicated. This prevents the absence of a species being recorded, where in fact it was just an inability to spot or identify it. Any aquatic macrophytes found additional to Appendix 1 should also be noted on the field sheet. Although they will not contribute to the estimation of EQR they may be used in subsequent method development.

Channel vs. Bank species

The field sheet separates the recording of bank species from channel species. Adopting the Mean Trophic Rank (MTR) protocol (Holmes *et al.*, 1999); **channel species** are macrophytes attached to a substrate that are likely to be submerged for more than 85% of the year; and **bank species** are macrophytes submerged for more than 50% but less than 85% of the time.

In practice these hydrological values are not evaluated at survey sites. However, during the survey period the water level is likely to be below the mean level unless there has been heavy rainfall. Therefore helophytes or hydrophytes that are submerged, have their roots in the water, or are floating, are usually considered to be within the channel. Helophytes on the bank and without their roots in the water (during the survey period), are bank species. Bank species will also include those found on rocks or islands emerging from the channel i.e. the definition of channel is not delineated by its edges, but by the location relative to the water surface.

It is often necessary for an experienced ecologist to recognise when water levels are exceptionally high; in which case bank species may be partly or fully submerged, or more rarely, exceptionally low; when channel species may be found above the water level.

Bank and channel species need to be recorded separately since channel species are strongly associated with the river water and, therefore, used to determine water quality metrics, whereas bank species usually reflect soil or rock geology.

Survey Procedure

Survey Preparation

For deeper rivers establish whether or not a boat is needed and consider alternative techniques such as the use of grapnel, rake, underwater viewing aid, scuba or direct observation from both river banks.

- Assemble the necessary equipment
- Print field survey sheets: one single, double sided, sheet for each RepS
- Prepare survey sheets including:
    - river name
    - unique identification number for the RepS
    - upstream IGR for the RepS
    - metric values expected at reference condition (point 2 on the survey sheet)
- Obtain access permission and identify where to access the site
- Determine whether chemical and hydromorphological data will be collected at the survey location independently of this survey to ensure that replication of effort is avoided (see Field Survey)

A field guide for macrophytes is provided in Appendix 2. It is recommended that this is laminated (double-sided) in the order provided, producing three water-proof field guide sheets which can be carried on the clip-board.

Field Survey

A 100m belt transect representative of the ecology and impacts (RepS) should have been selected previously. Physical features such as bridges and weirs should be avoided where possible. Find the location of the upstream grid reference in the field using GPS and maps and also determine the lower end of the transect 100m downstream. Be aware that tree shading can interfere with the accuracy of a GPS reading. Supporting chemical and hydromorphological data should be collected at the survey location (Table 2) if they have not been collected in a separate survey.

In shallow sites, wade in a zigzag manner across the channel in order to observe the macrophyte species present. Wade upstream so that disturbed sediments do not interfere with macrophyte observation and identification. Where it is not safe to wade (e.g. owing to fast currents or the nature of the substratum) observations should be made from the bank, using the aid of binoculars and grapnel. Record channel and bank macrophyte species separately within the RepS on the survey sheet (Appendix 1). Where hydrophytes or helophytes are identified that are not present on the checklist, record these separately. Re-wade the survey stretch, checking for species not recorded in the primary assessment.

Table 2. Supporting chemical and hydromorphological data

A. Physical habitat

1	Mean river width
2	Mean river depth
3	Estimate of percentage of channel shaded
4	Substrate type as % cover of channel with: Bedrock Boulders Cobbles Pebble/Gravel Sand Silt/Mud Clay Artificial
5	Bank profiles recorded as: Vertical/undercut Vertical and toe Steep (>45 degrees) Gentle Composite
6	Flow types recorded as: glide boil run chaotic riffle rapid chute waterfall

B. Neighbouring land-use

6	Proximate land-use (at 5 and 50m from bank-top) recorded as: Broadleaved/mixed woodland Coniferous plantation Moorland/Heath Scrub Rough pasture Wetland Open water Improved/semi-improved grassland Tiled land Urban/semi-urban development

C. Water chemistry
(Preferably these water quality parameters are monitored monthly over two years and a mean value is used)

7	Alkalinity
8	pH
9	Soluble Reactive Phosphate
10	Nitrate
11	Dissolved Oxygen concentration
12	Hazen value

D. A characteristic photo

N.B. Hazen value was not previously taken in surveillance monitoring, but is recommended wherever macrophyte sampling is done to estimate peatiness/light transparency

Estimate the cover of each species recorded using Table 3. An easy method of determining the area of species cover to fit into each category is to multiply the river width by 100m (the survey length) and determine the number of m^2 cover required for 0.1, 1, 5 and 10 % cover.

Bank species cover is determined as a percentage of the channel area. This is because bank area can be difficult to estimate and can be affected by re-sectioning.

Table 3. Macrophyte cover scale. Cover is as percentage of the channel area.

Scale	Percentage cover
1	< 0.1
2	0.1 - 1
3	1 - 5
4	5 - 10
5	> 10

Where a boat is used, adopt the same strategy for observation and recording as for wading a shallow reach. The use of fixed reference points on the banks and GPS is recommended to ensure the channel is covered in a zigzag manner.

NOTE: The current version of CBAS does not require abundance estimates, or records for species not listed on the survey sheet, however both of these are useful for further method development.

In addition to species records, two additional metrics need to be determined.

Complementary Metrics

In addition to the 100m transect surveys two general metrics complement the CBAS method of EQR calculation. These are abundance (Box 1) and invasive alien (Box 2) metrics.

High macrophyte biomass in a river is not necessarily indicative of eutrophication e.g. in *Ranunculus* rivers. However, a tick box on the survey sheet is used to indicate high cover of species associated with eutrophication.

Box 1. Abundance metric
If the RepS has **> 50 %** in total of *Cladophora*, *Vaucheria*, other filamentous algae, *Azolla* or *Lemna* spp. the site is automatically deferred to (at most) **moderate status**. However, if the abundance (especially for filamentous algae) is believed to be unrelated to nutrient enrichment, this deferment should be ignored.

Box 2. Invasive alien metric
If the total percentage cover of invasive alien species on the bank OR channel exceeds that shown in Table 4, then the site is classified, at most, the status indicated. Invasive species include any nuisance species, but not those that have become naturalised and are not generally considered a threat to the ecology of the water-body.

Table 4. Highest achievable status with different % cover of invasive alien species.

Total % cover of alien invaders	Highest achievable status
> 5 - 10	Good
>10-50	Moderate
> 50	Poor

Invasive alien species list

These are the suggested alien invaders species list. *Elodea* spp. are considered naturalised and should not be considered in this invasive alien metric assessment.

Acorus calamus
Aponogeton distachyos
Azolla filiculoides
Crassula helmsii
Crocosmia spp.
Egeria densa
Fallopia japonica
Heracleum mantagazzianum
Hydrocotyle ranunculoides
Impatiens capensis
Impatiens glandulifera
Lagarosiphon major
Lemna minuta
Mimulus spp.
Montia sibirica
Myrophyllum aquaticum
Petasites fragrans
Petasites japonicus
Vallisneria spiralis

Many of these species are not on the survey sheet, and therefore may not be readily identified by field workers. Surveyors should be able to identify those in bold. It is also suggested that field workers stay aware of the threats of invasive aliens and report any unusual plants that are colonising rapidly or are dominating the banks or channel.

Sample collection, transport and preservation

Collect samples of plant for later verification for *Bryophyta*, algae, *Ranunculus* species, *Callitriche* species, narrow leaved *Potamogeton* species and *Charales*. Photographic records are also recommended. Samples should be kept in voucher collections. Where necessary, specimens should be retained in national collections following verification of species that are rare or difficult to identify. If necessary there should be confirmation of the species by a regional/national expert.

Plants can be transported in pre-labeled plastic bags. Algae can be collected in 30 ml sample bottles. Collect only sufficient material to allow positive identification. Be aware of rare or endangered species protected by Regional & National legislation.

Bryophytes should be dried in paper and stored in small paper bags. Broad leaved higher plants should be dried in a flower press (regularly changing the drying paper). Fine leaved species should be stored in 70% ethyl alcohol or industrial methylated spirit (although this will not keep them indefinitely, and colour may be lost from flowers and foliage). In certain cases it may be preferable to press fine leaved species or store broad leaved species in alcohol.

Data Recording

Macrophyte cover is recorded on the field survey sheets as detailed in the field survey section.

Data should be input into the computer as soon as possible after returning from the field to ensure data is not lost and to enable errors to be corrected whilst the memory of the field survey site is still fresh. Data input sheets should have a similar format to the field survey sheet to ensure input is quick and simple and to reduce the chance of errors.

Data Analysis

Ecological status can be calculated on the field survey sheet or preferably within a spreadsheet in the office.

Data Analysis – Field Method

A calculator is useful for establishing ecological status in the field. Either metric values expected at reference condition or $\log_{10}$ alkalinity, $\log_{10}$ slope and $\log_{10}$ width values are required for the RepS (see 'Reference Conditions').

Only channel species that have optima indicated on the field sheet are used in this calculation. The optima represent where along an environmental gradient of soluble reactive phosphate (SRP), nitrate (NO_3), ammonia (NH_4), percent siltation (SUBS), percent dissolved oxygen (DO) and pH ($_PH$) the species are expected to occur.

The steps below relate to the steps indicated on the field sheet.

Step 1 – Site score

Add up all the SRP optima values for the species found at the site and divide by this number of species (i.e. take the mean value). This is the site score for SRP. Insert this value in the first box. Repeat for NO_3, NH_4, SUBS, DO and $_PH$ site scores.

For example, for the SRP metric, if *Chiloscyphus* (-7), *Alisma lanceolatum* (-1) and *Thamnobryum* (-8) are found, the site score is (- 7 - 1 - 8)/3 = -5.3. Recording to zero decimal places would be -5.

The site scores represent the predicted location of the site along each environmental gradient. A zero value is average for sites within Ireland (regardless of river type).

Step 2 – Reference score

Values expected at reference condition may have already been entered prior to field survey. If not, $\log_{10}$ alkalinity, $\log_{10}$ slope and $\log_{10}$ width (to two decimal places) should have been entered on the field survey sheet. These values allow reference scores to be calculated using the equations shown on the field sheet. In the equations 'a' represents $\log_{10}$ alkalinity, 's' represents $\log_{10}$ slope and 'w' represents $\log_{10}$ width. Calculate the scores expected at

reference condition for SRP, NO_3, NH_4, SUBS, DO and $_PH$ and insert the values into the second row of boxes.

For example, if log alkalinity = 0.91, log slope = 0.65 and log width = 0.85, the SRP reference metric score is:

3.9a - 0.5s - 11.7 = (3.9 x 0.91) - (0.5 x 0.65) -11.7 = - 7.8

Recording without decimal places = - 8

The reference score represents the expected site score if there were no anthropogenic impacts.

Step 3 – Metric score
The following equation is used to determine the metric score:

$$metric\_score = 2 - \left(\frac{site\_score + 15}{reference\_score + 15} \right)$$

Using the same examples as above, for SRP:

2 – (-5+15)/(-8+15) = 0.57

The metric score converts the site score (which may be a negative value) to a value between 1 (unimpacted) and zero (severely impacted), taking reference conditions into account. Some metric scores may exceed one or be less than zero in exceptional circumstances. The metric score represents the level of anthropogenic impact (beyond reference condition) that the site is exhibiting for each metric variable (SRP, NO_3, NH_4, SUBS, DO and $_PH$).

Step 4 – Ecological Quality Ratio (EQR)
The ecological quality ratio is calculated as the mean of the six metric scores (for SRP, NO_3, NH_4, SUBS, DO and $_PH$).

For example, if the metric scores from Step 3 were calculated as SRP (0.57), NO_3 (0.60), NH_4,(0.80) SUBS (-0.10), DO (0.7) and $_PH$ (1.1), the mean score would be 0.64.

N.B. the metric score may be higher than one or lower than zero, and these will still be used in the calculation of the EQR.

The EQR represents the ecological change at the site due to the combined anthropogenic stresses, relative to reference condition.

Following the calculation of EQR a preliminary ecological status is determined using Table 4 (also supplied on the field sheet). Circle the preliminary ecological status on the field sheet. This preliminary ecological status may further be modified due to the presence of alien species or species indicating eutrophication.

Table 4. Preliminary status classes for an EQR value.

EQR	Status
≥ 0.9	High
≥ 0.8	Good
≥ 0.7	Moderate
≥ 0.5	Poor
< 0.5	Bad

Step 5 – Eutrophic

Using the abundance metric (described previously) it should be determined whether there is > 50 % total cover of species associated with eutrophication. Such species are marked with an asterisk (*) within the field survey sheet to aid this interpretation, although it is likely to be easier to judge directly in the field. If the site is judged to be eutrophic, circle 'Y' on the field sheet, otherwise circle 'N'. A site which is judged to be eutrophic cannot achieve more than moderate status.

Step 6 - % aliens on channel or bank

Circle either 0 (less than 5 % invasive aliens), >5, 10-50 or >50 on the field survey sheet to indicate the cover of invasive aliens on the channel or bank. Alien species are marked with a (§) within the field survey sheet to aid interpretation, although it is likely to be easier to judge directly in the field The highest ecological status achievable with >5 % invasive aliens is either good (>5-10 %), moderate (10-50 %) or poor (>50 %). Both the channel and the bank are assessed for invasive aliens, and the worst status of either is applied.

Step 7 – Status

Based on the preliminary ecological status assessment (Step 4) and using the amendments from the two additional metrics (Step 5 and 6) the final ecological status is entered in box 7.

Data Analysis – Using a Spreadsheet

To determine ecological status the following data must be input into a spreadsheet:

- Channel species which have associated optima value
- Either the log alkalinity, log slope and log width values or the metric values expected at reference condition
- The eutrophication and alien invaders metric results

It is not necessary to input bank species or channel species without associated optima in order to calculate ecological status, however these species should be recorded in a spreadsheet for future records and investigations.

Reporting

The output from the CBAS system produces diagnostic metrics. For example, a low SRP metric score indicates that there is likely to be nutrient pollution within the RepS. Only the EQR value and ecological status are required for reporting in the Water Framework Directive.

Error for the EQR can be estimated from the variance in EQR at reference condition. 95% of reference sites do not have an EQR lower than 0.84 (only one reference site is below 0.82). Therefore it is estimated that an EQR value is accurate within ± 0.16 units.

It is important to remember that the EQR value can never fully represent the impacts occurring at a site since this single score is an amalgam of scores from a multi-metric (or multivariate) response. Therefore catchment managers should examine individual metric scores for catchment management.

For EQR and ecological status reporting within the WFD, rivers need to be classified into types. This can be determined from Table 5 using the same alkalinity and slope parameters described in the ‘Reference Condition’ section.

Table 5. The Ecoregion 17 river typology. The type codes have two-digits with the first indicating the alkalinity, and the second the river slope at the RepS at reference condition (Environmental Protection Agency, 2004). For example, a site with an alkalinity of 20 mg/l and a slope of 18 m/km will have a river type of 1,2.

Code:	Hardness/Alkalinity	Description
1	<35 mg $CaCO_3$/l	Soft water
2	35-100 mg $CaCO_3$/l	Medium hardness
3	>100 mg $CaCO_3$/l	Hard water

Code:	Slope (drop in m/km)	Description
1	<=5	Low Slope
2	5 - 20	Medium Slope
3	20 - 40	High Slope
4	> 40	Very High Slope

It is recommended that the following data-bases are maintained:

- Expected reference condition metric values and river type for RepS within the monitoring network, together with any justifications for site-specific changes to the predicted reference metrics.
- Macrophyte data, including bank and channel species for each RepS
- Physical and chemical data associated with each RepS
- The ecological status, EQR and associated metric outputs for each RepS

It is important to ensure that each RepS has a unique site code, and that a survey date is associated with each field survey.

Data collection (field survey), data input, information output and consequent management decisions form part of a water management cycle. It is important to understand that each part of the process shapes and is dependent on the previous parts, and that problems or redundancy with any aspect should be reported. Data collection should always be driven by information needs such that environmental protection can be achieved effectively and efficiently.

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Appendix 1

Field Survey Sheets

Print double-sided such that only one sheet is required for each RepS

MACROPHYTE SURVEY

Date:			
	day	month	yr

BANK SPECIES

Site No:		Surveyors:	
River:		upstream grid ref:	

cover scale: 1 (< 0.1%), 2 (0.1 - 1%), 3 (1 - 5%), 4 (5 - 10), 5 (>10%)

cover	**invasive**
	§ Acorus calamus
	§ Crocosmia spp.
	§ Fallopia japonica
	§ Heracleum mantagazzianum
	§ Impatiens capensis
	§ Impatiens glandulifera
	§ Mimulus guttatus
	Bryophytes/liverworts
	Amblystegium fluviatile
	Bracythecium plumosum
	Bracythecium rivulare
	Bracythecium rutabulum
	Bryum pallens
	Bryum pseudotriquetrum
	Calliergon cuspidatum
	Chiloscyphus
	Cinclidotis
	Conocephalum
	Dichodontium
	Dichranella
	Fissidens spp
	Hyocomium
	Lunilaria
	Marchantia
	Marsupella
	Mnium hornum
	Mnium puntatum
	Pellia endiviifolia
	Pellia epiphylla
	Philinotis fontana
	Plagiomnium rostratum
	Plagiomnium undulatum
	Polytrichum commune
	Racometrium
	Rhizomnium punctatum
	Rhytidiadelphus
	Riccardia
	Riccia
	Scapania
	Solenestoma
	Sphagnum spp.
	Thamnobryum

cover	**Vascular plants**
	Angelica sylvestris
	Caltha palustris
	Carex acutiformis
	Carex riparia
	Carex rostrata
	Carex versicaria
	Catabrosa aquatica
	Cicuta virosa
	Eleocharis
	Epilobium hirsutum
	Equisetum arvense
	Equisetum fluviatile
	Equisetum palustre
	Eupatorium cannabinum
	Filipendula ulmaria
	Geum rivulare
	Glyceria fluitans
	Hydrocotyle vulgaris
	Iris psudocorus
	Juncus acutiflorus
	Juncus articulatus
	Juncus bulbosus
	Juncus effusus
	Juncus inflexus
	Lychnis
	Lycopus europaeus
	Lysimachia vulgaris (yellow)
	Lythrum salicaria (purple)
	Mentha aquatica
	Montia fontana
	Myosotis scorpioides
	Oenanthe crocata
	Persicaria hydropiper
	Petasites hybridus
	Phalaris arundinacea
	Phragmites australis
	Potentilla palustris
	Pulicaria dysenterica
	Rannunculus flammula
	Ranunculus scleratus
	Rorripa amphibia
	Rorripa nasturtium-aquatica

cover	
	Rumex hydrolapathum
	Scrophularia
	Sium latifolia
	Solanum dulcamara
	Sparganium emersum
	Stachys palustris
	Symphytum spp.
	Valeriana
	Veronica anagallis-aquatica
	Veronica beccabunga
	Additional

Notes

CBAS 2007

CHANNEL SPECIES

cover scale: 1 (< 0.1%), 2 (0.1 - 1%), 3 (1 - 5%), 4 (5 - 10), 5 (>10%)

cover	Species	SRP	NO3	NH4	SUBS	DO	PH
	Amblystegium fluviatile	0	-2	3	-3	1	-2
	Amblystegium riparium	3	2	4	-2	2	-3
	Batrachospermum (jelly)	17	12	12	-8	5	-6
	Blindia acuta	-19	3	-18	-7	-17	20
	Brachythecium plumosum	-5	-8	-2	-6	-3	3
	Brachythecium rivulare	-6	-7	-2	-5	-1	2
	Brachythecium rutabulum	-18	-2	-16	-9	-12	13
	Calliergon cuspidatus	-8	-14	-1	-6	-2	4
	Chara spp.	-18	7	-15	-11	-20	-18
	Chiloscyphus polyanthos	-7	-5	-6	-4	-5	3
	Cinclidotis fontinaloides	-4	-3	-3	-2	-5	-6
	* Cladophora spp.	5	3	3	-1	1	-3
	* Diatomaceous algae	0	3	-3	-1	-1	-3
	Dichodontium	-5	-8	-1	-5	-3	1
	Dicranella pallustris	-1	-3	0	-4	-2	-7
	* Filamentous greens	-9	-1	-17	-5	-6	2
	Fontinalis antipyretica	0	0	-1	-2	0	1
	Fontinalis squamosa	-11	-2	-8	-5	-7	13
	Hildenbrandia	7	2	4	-3	0	-7
	Hygrohypnum spp	-11	-7	-8	-6	-8	7
	Lemanea	10	7	6	-4	-2	-1
	Lyngbia (blue-green filamnt)	-12	-20	-4	-5	-6	-4
	Marsupella emarginata	-13	7	-16	-8	-15	39
	Nardia compressa	2	1	0	-6	-5	6
	Orthotrichum	-5	-12	0	-7	-1	1
	Pellia endiviifolia	-3	-4	0	-5	-2	-5
	Pellia epiphylla	-6	-11	0	-5	-1	4
	Philonotis fontana	-14	-4	-10	-10	-15	-11
	Racometrium spp	-12	-9	-8	-6	-8	14
	Rhynchostegium ripariodes	-5	-2	-5	-4	-4	-1
	Scapania undulata	-14	-4	-12	-7	-9	20
	Schistidium alpicola	-8	-13	1	-7	-3	4
	Solenestoma (Jungermannia)	-13	-7	-9	-7	-11	1
	Sphagnum	-11	-32	-2	-9	-6	25
	Thamnobryum	-8	-6	-6	-5	-6	-4
	* Vaucheria	8	4	7	-1	3	-3
	Alisma lanceolatum	-1	4	-11	5	-9	-8
	Alisma plantago-aquatica	3	3	2	15	10	3
	Apium nodiflorum	-2	7	-5	9	-5	-4
	* § Azolla filiformis	32	14	10	20	17	-4
	Berula erecta	5	3	6	20	11	-3
	Butomus umbellatus	-5	5	-6	6	-5	-4
	Callitriche hamulata	-11	-1	-10	2	-2	17
	Callitriche obtusangula	2	2	3	4	4	0
	Callitriche platycarpa	-18	12	-18	5	-13	-5
	Callitriche stagnalis	-15	2	-18	3	-12	7

cover	Species	SRP	NO3	NH4	SUBS	DO	PH
	Carex rostrata	-20	9	-20	10	-16	12
	Eleocharis palustre	-5	-4	-6	0	-7	-5
	Elodea canadensis	6	4	5	9	7	-3
	Elodea nuttallii	14	8	12	22	14	0
	Equisetum fluviatile	-3	-4	-1	7	-1	-2
	Equisetum palustris	0	-1	3	-1	3	1
	Glyceria maxima	-1	-6	1	21	2	-5
	Hydrocharis morsus-ranae	-2	-13	3	25	7	-6
	Iris pseudacorus	-6	-7	-4	-3	-4	0
	Juncus bulbosus	-10	-3	-6	-6	-2	12
	* Lemna gibba	9	7	8	32	5	-7
	* Lemna minor	5	5	3	13	7	-1
	* Lemna polyrhiza	16	9	12	30	26	5
	* Lemna trisulca	-6	8	-4	12	-6	-9
	Littorella uniflora	-16	-3	-14	-2	-5	20
	Menyanthes trifoliata	-4	-10	0	1	0	-5
	Myriophyllum alternifolium	-10	1	-13	0	-7	1
	Myriophyllum spicatum	0	-3	-2	2	5	4
	Nuphar lutea	12	6	8	23	15	1
	Oenanthe fluviatilis	1	-3	1	-9	-4	17
	Phragmites australis	-3	-12	-1	2	-1	-5
	Polygonum amphibia	-2	-1	2	8	0	-7
	Potamogeton alpinus	-20	4	-25	9	-13	17
	Potamogeton crispus	5	4	4	2	3	-4
	Potamogeton filiformis	-18	2	-27	17	-6	39
	Potamogeton gramineus	9	7	7	17	1	0
	Potamogeton lucens	10	8	8	19	2	-3
	Potamogeton natans	6	4	6	11	13	4
	Potamogeton pectinatus	10	11	2	3	2	-11
	Potamogeton perfoliatus	-1	-1	-1	18	-1	-11
	Potamogeton pusillus	-9	7	-6	8	-8	-13
	Potamogeton salicifolius	1	-11	3	25	5	-4
	Ranunculus flammula	-13	-8	-10	-9	-8	11
	Ranunculus peltatus	-14	7	-22	4	-12	15
	Ranunculus penicillatus	5	4	3	0	1	0
	Ranunculus trichophyllus	6	4	6	8	12	-2
	Rorippa nasturtium-aquaticum	-7	-3	-3	1	-5	-3
	Rumex hydropiper	1	-13	-1	-9	1	0
	Sagittaria sagittifolia	12	11	9	18	11	7
	Schoenoplectus	-4	0	-1	9	2	-8
	Sparganium emersum	9	5	7	9	11	2
	Sparganium erectum	7	4	6	11	7	-1
	Typha latifolia	-12	-20	-4	-5	-6	-4
	Veronica anagallis-aquatica	0	-3	2	5	0	-3
	Veronica beccabunga	-5	-1	-3	2	-5	-4

cover	Additional Species	cover	Additional Species
	Apium inundatum		Potamogeton friesii
	Caltha palustris		Potamogeton obtusifolius
	Ceratophyllum		Potamogeton polygonyfolius
	Didymosphenia (Sponge)		Potamogeton praelongus
	Eleogiton fluitans		Ranunculus circinatus
	Glyceria fluitans		Ranunculus fluitans
	Glyceria plicata		Ranunculus heraceous
	Hyocomium armoricum		Ranunculus omiophyllus
	Lobellia		Riccardia
	Mentha aquatica		Riccia
	Hippuris vulgaris		Rorippa amphibia
	Hydrocotyle vulgaris		Spirogyra (globular algae)
	Isoetes lacustris		Veronica catenata
	§ Lagarosiphon major		Verrucaria spp. (black lichen)
	Lunularia cruciata		Zannichellia palustris
	Marchantia polymorpha		
	§ Myriophyllum aquaticum		
	Nitella		
	Nymphaea alba		
	Nymphoides peltata		
	Oenanthe aquatica		
	Oenanthe crocata		
	Persicaria amphibia		
	Phormidium (globular)		
	Potamogeton berchtoldii		

	SRP	NO3	NH4	SUBS	DO	PH
1. Site score						
2 d.p. a — $\log_{10}$ alk (mg/l CaCO3)	3.9a - 0.5s - 11.7	0.9a - 0.3s + 0.9w - 5.4	3.3a - 0.4s - 0.8w - 8.9	1.2a - 1s + 1.8w - 6.3	2.4a - 0.7s - 7.4	-8.1a + 15.7
s — $\log_{10}$ slope (m/km)						
w — $\log_{10}$ width (m)						
2. Reference score						

$$metric\ \_score = 2 - \left(\frac{site\ \_score + 15}{reference\ \_score + 15} \right)$$

3. Metric score						

4. EQR (Mean metric score) — 2 d.p.

EQR	Status
≥ 0.9	High
≥ 0.8	Good
≥ 0.7	Moderate
≥ 0.5	Poor
< 0.5	Bad

5. Eutrophic? >50% of spp. marked (*) — Y / N

mod - (max)

6. % aliens (§) on chan. or bank — 0-5 / > 5 / 10-50 / > 50

\- good mod poor

7. STATUS

Appendix 2

Macrophyte Identification
Field Guide

Print double-sided and laminate (in the order provided) to produce three water-proof field guide sheets.

Bryophytes

Submerged mosses

Rhyncostegium riparioides
No beaks, but sometimes little flower like tip
No wavy hair point (cf Bracythecium)
Midrib not to tip
Usually submerged

Amblestegium riparium
Flat shoots
Wavy hair point
Midrib not to tip
Submerged

Hygrohypnum
Robust hooded shoots
Leaves point in one direction (like a caterpillar)
No hairs or points to leaf tip
Midrib not to point
Spray zone

Fontinalis antipyretica
Leaves in groups of 3
V-shaped leaf cross-section

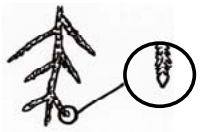
Fontinalis squamosa
Leaves in groups of 3
Rounded leaf cross-section

Wet rock mosses

Amblestegium fluviatile
Hangs down damp rocks
Small narrow rigid leaves with stiff point
Midrib to tip (cf Ambelstegium, Rhyncostegium)
Often dark shoots with long green growing tips
(but bigger leaves than hyocomium)
Near water level

Thamnobryum
Like upside-down fir tree, hangs down damp rocks
Dark at base
Leaf has a mid-rib but no hair point
(cf. Hyocomium)

Hyocomium
Hangs down damp rocks
Very tiny leaves
Bright green tip to shoots
Leaf has a hair-point but no mid-rib
(cf. Thamnobyum)



Dark green/black rock/bank/spray zone mosses

Racometrium
Fruiting body on long stalks
Rounded tip to leaf
Midrib not to tip
No border (cf. cinclidotis)

Cinclidotis
Bordered leaf
Midrib extends beyond tip
Fruiting body at bottom

Schistidium
Pointed tip and midrib to tip (cf. Racometrium)
Looks similar to Cinclidotis but no border

Orthotrichum
No border
Midrib not to tip (barely)
Fruiting body at top of plant (cf. Racometrium)

Green rock/bank/spray zone mosses

Bracythecium rivulare
Hard 'beak'
Leaves bend to one side
Fine point on leaf (cf hygrohypnum)
Midrib not to tip
Above water level

Bracythecium plumosum
Hard 'beak'
Leaves bend to one side
Forms cushions (cf B. rivulare)
Fine point on leaf (cf hygrohypnum)
Midrib not to tip

Calliergon
Spiky spear like plant
No mid-rib
Rounded leaf

Dichranella
Star shaped cushions
Leaves recursive (bend back)
Light green
Slightly smaller than Dichodontium

Dichodontium
Star shaped cushions
Leaves NOT recursive
Light green
Slightly larger than Dichranella

Fissidens
Large long thin leaves
Midrib extends beyond tip
Whole plant often flattened

Bryum psudotriquetrum
Large leaves
Thickened border and midrib
No teeth (cf. Mnium hornum)

Philinotis
Woolly socks (hairy at base of stem)
Upright, tightly packed stems

Liverworts

Chiloscyphus
One flat layer of leaves

Scapania
Big leaf with accompanying little leaf

Solenostoma
3-dimensional
Often with rose-bud tip

Marsupella
3-dimensional
Notch in 'leaf'

Nardia
Leaves together as if in prayer
Only very acidic waters

Conocephalum
On rock or clay bank
Thallus ≈ 8mm wide
Pores visible to naked eye

Riccia
Highly branched
Slow flows
Thallus ≈ 1.2 mm wide

Riccardia
Highly branched, often central stem
Thallus ≈ 0.5 mm wide
Fast flows

Marchantia
Gemma cups complete

Lunilaria
Gemma cups half-moon shape

Pellia epiphylla
Thalli with no surface pattern
When held to light, wide black 'mid-rib'
Associated with acid rivers

Pellia endiviifolia
As P. epiphylla but:
Smaller
Dark midrib not always present
Associated with calcareous rivers

Fine leaves Submergents

Myriophylum spicatum
Bigger than alterniflorum
Often pink stalk
Stiff leaves

Myriophylum alterniflorum
Cats tail (leaves cling together
when removed from water)

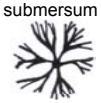
Myriophylum verticillatum (rare)
Feather-like leaves in a whorl (like M. Spicatum) but:
stalk PALE (green/white) not pink
leaves do not hold themselves errect

Myriophylum aquaticum (rare invasive alien)
Unlike other Myriophylum:
Whorls be 4-6 leaves
Often emergent shoots
Bright green

Ceratophylum
Dichotomous branching

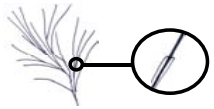
demursum

submersum

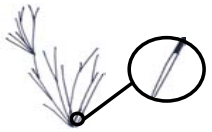


Zanichellia palustris
Leaves usually <1mm wide
No mid-rib (like 2 solid tubes)
No obvious stipules
Clumped leaves

Eleogiton (Scirpus) fluitans
Translucent fine leaves
No mid-rib
Leaves leaf-like
Translucent 'wings' at leaf base



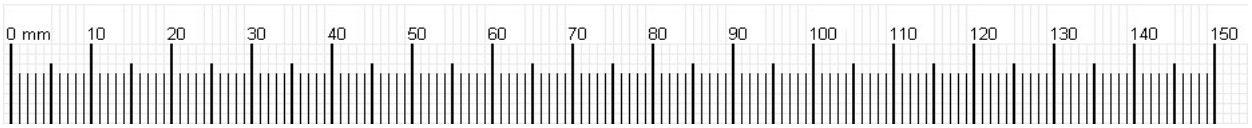
Juncus bulbosus
Leaf is 2 hollow tubes
Characteristic juncus leaf sheath at base
Clumped leaves from base,
or branching like spider plant



Hottonia palustris
Flat (unlike myriophylum) feather leaves
Leaves branch off main stem
Pretty white flowers

Oenanthe aquatica
Very fine non-flattened compound leaves
Very obvious branching of main leaflets

Ireland v1 © I. Dodkins

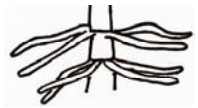


Oenanthe fluviatilis
Ragged, flattened compound leaves (carrot like)
No obvious parallel branching of 2° leaflets
Base-rich rivers

Apium inundatum
UNragged, flattened compound leaves
Off-set' thrice pinnate leaves
Upland (base-poor) rivers and bogs
(emerged and sumerged leaves similar form)

(emerged and sumberged)

Hippuris (Mare's tail)
Strap-like non-branching leaves
Leaves at regular intervals
Single tubular shoot



Utricularia
Characteristic air bladders
Ragged wiry dividing shoots

Elodea canadensis
Leaves in whorls of 3 (or 2) and:
rarely recurved
tips rounded
parellel sided

Elodea nutalii
Leaves in whorls of 3 (or 2) and:
recurved
tips pointed
triangular

Groenlandia densa
Paired opposite leaves 6-42 mm long
Cannot be confused!

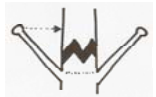
Lagarosyphon (invasive alien)
Larger than elodea with more dense leaves
Traingular leaves strongly recurved
Leaves not in whorls on close inspection
Sometimes leaves have 'crunchy' texture

Equisetum

E. fluviatile
Wide, hollow tube
Usually no leaves (esp. in water)

(to distinguish from arvense from palustre, pluck off joints to leaf)

E. arvense
Last joint of leaf longer than coronet
Dark edge to coronet



E. palustre
Last joint of leaf shorter than coronet
Translucent white edge to coronet

Fine Leaved Aquatic Ranunculus

Trichotomous division in leaves, white flowers, 5 petals

R. circinatus
NO leaf stalks
Leaves radiate in a single plane (fan)
SMALL short leaves

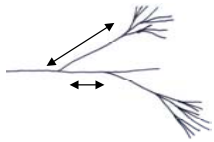
NO FLOATING LEAVES

R. trichophyllus
As R. circinatus BUT
Leaves not in a single plane
(more dishevelled than circinatus)

NO FLOATING LEAVES

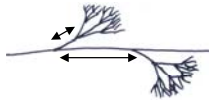
R. fluitans
Leaf shoots LONGER than internodes
Sparesly branched
Long leaves

NO FLOATING LEAVES

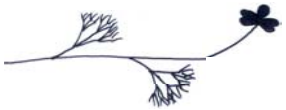


R. penicillatus var. psuedofluitans
Leaf shoots SHORTER than internodes or absent

NO FLOATING LEAVES



R. penicillatus var. penicillatus
Identical to var. psuedofluitans but:
Floating leaves when flowering
5 sections of leaf



R. peltatus
3-5 Lobes on each section of leaf
Petal > 10mm length

R. aquatilis
Often identical to peltatus except:
Leaf lobes sometimes sharply toothed
Petal < 10mm length

(see also Ranunculus without fine-leaves)

Callitriche

all have notch at top of leaf and paired leaves

stagnalis
Never has thin and narrow leaves
<10 leaves in rosette
(Rounded leaves only)
Ubiquitous species

hamulata
Spanner shaped leaves

obtusangula
Dark stiff rosette protruding from surface
> 12 leaves in rosette
(leaves have three 'corrugations')
May have thin and round leaves

platycarpa
Not stiff rosette
May have thin and round leaves

hermaphroditica
Never round leaves (cf. platycarpa)
Parallel sided, though wider at bottom
Notch in tip, but never expanded (cf. hamulata)

Broad leaved Potamogetons

Alternate leaves, stipules

Natans
Stipule > 5 cm
broad opaque floating leaves (petiole jointed)
only linear, opaque, submerged leaves (if any)


Lucens
Double keeled stipule
Pointed tip to leaf
Leaf joins directly to stem
No floating leaves



Perfoliatus
Leaf wraps around stem (at least 2/3 rds)
Tiny stipule (1-3 cm)

Praelongus
50 obvious stripes on rolled stipule
Leaf wraps half way round
No floating leaves
Hooded leaf tip (like glyceria)
No obvious veins on leaf

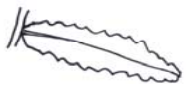

Alpinus
Leaf joins directly to stem
Often pinkish in colour (in exposed areas)
Sometimes opaque floating leaves
7-11 prominent veins on open stipule (cf. praelongus)


Gramineus
Leaves like crispus (parallel sided)
But larger and NO teeth at margin
Prominent rolled stipule (but no lines of keel)
Leaves recurved (band backwards)
May have pointed leaf tip
Leaves on stalks as it gets older


Polygonifolius
Like natans, broad opaque floating leaves
BUT may have broad submerged leaves (translucent)
No hint of keel on stipule (natans may have)
Shorter stipule than natans
Long petioles

Coloratus
Broad almost translucent leaves
Floating leaves and submerged leaves the same
(floating leaves often just under the surface)
Rounded translucent stipule (2-4 cm)
Petiole aprox 1/4 blade length

Crispus
Small wavy leaves
No petiole
Visible teeth

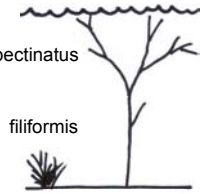
Be aware of hybrids, particularly P. zizii (gramineus x lucens) and P. nitens (gramineus x perfoliatus)

Fine leaved Potamogetons

Alternate leaves, stipules

Tubular Leaves (Lacking obvious midrib):

Pectinatus *leaf width (mm)*
Fennel (tubular) leaved pondweed
Blades not translucent
'pull test' - stipule fused to base of leaf (long tube)
(when you pull leaf away stipule rips)
lacks obvious midrib


5.0 (1-9)

Filiformis
Leaves tubular
Lacks obvious midrib
Grass like growth (from bottom area)
Also has stipule fused to base of leaf!
Often forms carpets on substrate

2.0 (1-3)

Round Stem (rolls bet. fingers)

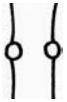
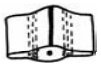
Trichoides
Midrib half width of blade
Shake water off, leaf stands upright
(very stiff and obvious in water)
Translucent fine leaves


0.7 (0.3-1)

Pusillus
Prominent but thin midrib
Translucent blade (limp in water)
When twirled in water leaves move like ribbons
(more strap like than trichoides)


1.1 (0.8-1.4)

Berchtoldii
Midrib not proud of blade
Line of air sacks each side of midrib
Often distinctive nodal glands (2 lumps)
When twirled in water leaves move like ribbons

1.3 (0.8-1.8)

Compressed Stem (flips when rolled)

Obtusifolius
Broad flat midrib with air cells either side
1 vein either side
Characteristic dense clumps of 'broad' blunt leaves

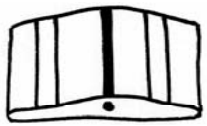
3.0 (2.5-3.5)

Friesii
Pronounced midrib with no air cells
2 veins either side of midrib

2.5 (1.5-3.5)

Flat Stem (can't turn in fingers - 'leaf like')

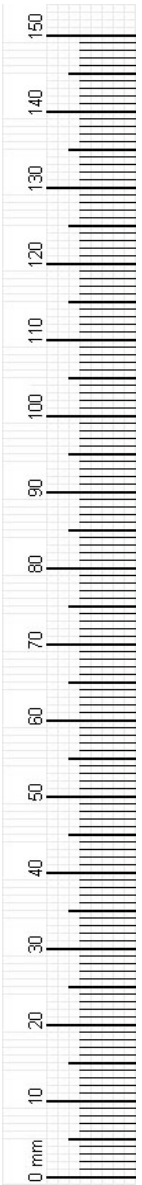
Compressus
2 veins either side of midrib



4.5 (3-6)

Acutifolius
Very broad leaves
Broad band of air cells along midrib
(air cells occupy almost full leaf at base)
1 vein either side of midrib (cf. compressus)

3.5 (1.5-5.5)



Narrow floating leaves and Emergents

Typha latifolia
Charactersitic large brown flower
No midrib to leaf
Spongy stalk
Single spongy tube at bottom
Leaf 'D' shaped with wings near top

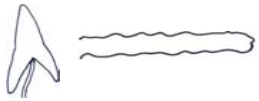
Typha angustifolia
as above but leaf more U-shape

Butomus
Spongy triangular leaves
Stringy when broken

Sparganium erectum (branched bur-reed)
Spongy triangular leaves
MIDRIB present
Rounded tip to leaf
Brick like structure on sheath
Flowers like pompoms, fruit spiky balls
Branched inflorescence

Sparganium emersum (unbranched bur-reed)
Identical to S. erectum but:
> 50% of leaves will flop over
Inflorescence unbranched
NB both erectum and emersum may be submerged

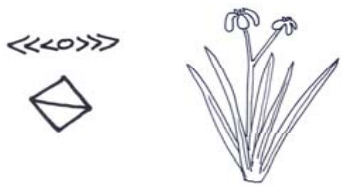
Sagittaria sagittifolia
Submerged leaves wavy in 2 directions
,with no mid-rib
Arrow shaped emergent leaves



Schoenoplectus lacustris
Tubular stems upto 3m (like giant Juncus)
Submerged strap like leaves (5mm width)
Flecks on leaf sheath
NO midrib
Leaf gradually tapers to point

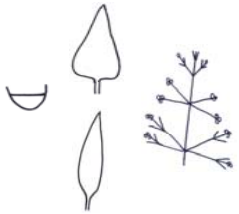
Eleocharis
Spongy cylindrical upright shoots (10-60 cm)
Single spike flower at tip
Sheath at base forms enclosed collar

Iris psuedocorus
Compressed (flat) base to plant
Some leaves tend to flop
Leaves 2 triangles together
Pen-knife shaped tips
Characteristic yellow iris flower



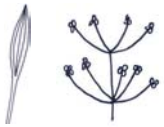
Acorus
Identical to Iris but:
Leaves more crinkly
Smells strongly of tangerines

Alisma plantago-aquaticum
D-shaped stem
Leaf broadens quickly beyond petiole
3 petal pinky white flowers (many whorls)



Alisma lanceolatum
As A. plantago-aquatica but:
'Lance' like leaf

Baldellia ranunculoides
Mostly errect emergent lanceolate leaves
Leaves like small A.lanceolatum but:
3 distinctive leaf veins,
and numerous cross-veins
Inflorescence only 1-2 whorls in an umbel



Broad Floating Leaves

Water-lilies

Nuphar lutea
Rounded triangular leaf stem
Yellow flowers
Oval/elongated leaves

Nymphaea alba
Round stem with hollow tubes
White flowers
Round leaves

Nymphoides peltata
Thin (1-3mm) leaf stem
Yellow flowers
Wavy margin of leaf
'Nappy rash' discolouration on underside

Crowfoots

Ranunculus hederaceus
Ivy-like 3-5 lobed leaves
Leaves float on surface
No fine leaves
Petals less than 2 x size of sepals

Ranunculus omiophyllus (southern region of Ireland)
Rounded 3 (sometimes 5) lobed leaves
Leaves float on surface
No fine leaves
Petals 3 x size of sepals

Hydrocotyle vulgaris
Small round leaves with gentle indentations
Petiole arises from centre of leaf

Persicaria amphibia
Opaque floating leaves (amphibious)
'Bandage' effect on stem
Cross-veins on leaves (cf. potamogetons)
Pink persecaria flowers

Free-floating

Lemna trisulca
ivy-shaped connected leaflets

Lemna minor
Single flat platelet
1 rootlet

Lemna polyrhiza
Single flat platelet
Many rootlets

Lemna gibba
Fat platelet
1 rootlet

Azolla filiculoides (Water Fern)
Compound, red/grean thalli
Branching 'stem'

Hydrocharis morsu-ranae
Small rounded floating leaves
2 horse-shoe shape veins on underside

Stratiotes aloides
Free-floating dense rosettes
Fleshy, spiky leaves
Serrated edge to leaf

Submerged rosette

Isoetes
Leaves cylindrical and reflexed
Cross-section shows 4 tubes
DISTINCT white flecks
I.lacustris stiff & curved leaves (8-25 cm)
I. echinospera, flaccid leaves <12 cm

Littorella
Leaves chunky and solid (rush-like)
Stiff, pointed, parralllel sided
No white flecks
Stoloniferous

Lobellia
Characteristic BLUNT TIP
2 tubes in cross-section
White 5 petalled flowers on tall stem

Subularia aquatica
Thick pointy leaves, looks spikey from above
Leaves flat at top and v-shape near base
Indistinct white flecks at leaf base
Stiff and straight (not reflexed)
White 4 petal flowers

Eriocaulon aquaticum (rare - Ireland west coast)
Tranlucent triangular thin leaves with spongy base
White, jointed roots (like worms)
Characteristic white flower cluster on stem
(see also Alisma and Juncus bulbosus)

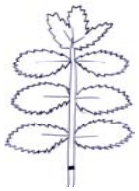
round stems OPPOSITE leaves

Umbelliferers

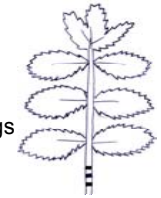
all have: flowers in umbels
round stems
opposite paired leaves

Apium
Round toothed leaves
No ring at base

Berula
As Apium but:
larger and 1 ring



Sium
As Berula but:
larger and 2-4 rings



Angelica
red joints on leafs
finely toothed margin

Cicuta
Hollow celery like stem
Hollow petiole
Deeply toothed leaves

Veronica anagallis aquatica
Broad, pointed leaves
Gentle serrations
No leaf stalks
blue flowers

Veronica catenata
As V. anagallis aquatica but:
pink flowers
(hybrid between both has
purple flowers)

Veronica scutellata
Small thin pointed leaves
No leaf stalks
Pale pink flower

Veronica beccabunga
Rounded leaves
Pink juicy stem
Leaves on short stalks

Mimulus guttatus
Prominent veins down leaf
Roundish leaves
No leaf stalks
Bright yellow flowers
Distinctive leaf seration

Montia fontana
fleshy paired leaves
leaves broader in top half
small white flowers
pink stems

Eupatorium cannibinum (Hemp agrimony)
tall downy plant with woody stem
leaves in 3 lobes, short stalks
yellow, pink or purple flowers
flowers hang down in a bunch

Bidens cernua
Coarsely toothed leanceolate leaves
drooping button like flower
heads (10-25mm diameter)

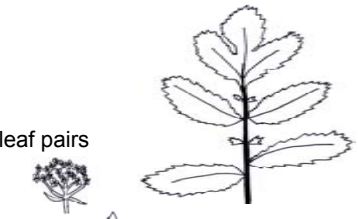
Oenanthe crocata
Cats paw leaf
Smells strongly of parsley

Also see Oenanthe fluviatilis and Oenanthe aquatica (fine leaved submerged)

Leaves not perfect pairs

Rorippa nasturtium aquaticum
Small white crucifer flowers
Leaves more rounded than Apium
Leaves not exact pairs!

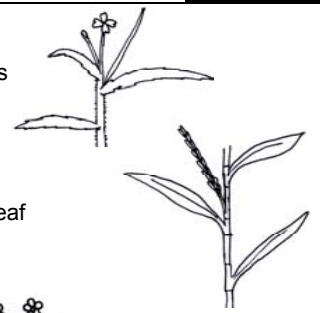
Filipendula
Coarsly serrated leaves
Deep pink stem
Smells of germaline
Ragged leaflets between leaf pairs



Valeriana
Veins in leaf indented
Umbel like flowers (5 petals)
Hollow stem
leaflets not perfect pairs
Toothed leaf

round stems ALTERNATE leaves

Epilobium hirsutum
Round hairy stems
Toothed margins to floppy hairy leaves
No leaf stalks
Pink 4 petalled flowers



Persicaria hydropiper
Pink at joint between main stem and leaf
Bandage at nodes
Characterisitc string of pink flowers

Myosotis scorpioides
Narrowly ovate leaves
5 petal pale blue flower
Slightly reflexed leaves

Rorippa amphibia
Very variable
Typical crucifer like flower
Alternate leaves
Hairless
Blade joins leaf stalk (slightly)
Tiny 4 petal yellow flowers

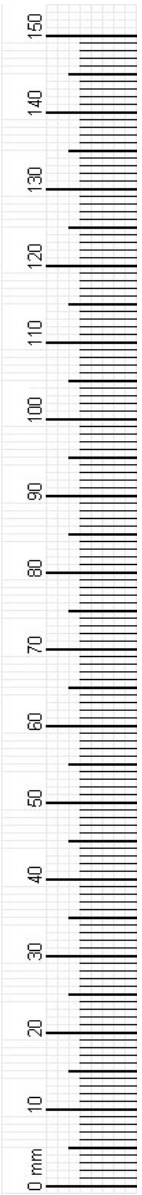
Pulicaria dysenterica
White downy stem and leaves
Wings of leaf join stem

Ranunculus flammula
Leaves variable but:
Petiole near leaf is flat laterally

Ranunculus scleratus (Celery leaved buttercup)
3 (often sub-divided) lobes to leaf
hollow 'celery' stem

Solanum dolcamara
Characteristic lobed leave
Woody stem
5 petal purple flowers

Ireland v1



Lobed leaves

Potentilla palustris
Five lobed serrated leaflets

Menyanthes trifoliata
3 large round lobes

Whorled leaves (may appear paired/alternate)

Lysimachia vulgaris (yellow loose strife)
5 petal yellow flower
perfectly rounded stem (inc. branch stems)
Gentle serrations on leaf
Leaves opposite, usually in 3's
Not hairy

Lythrum salicaria (purple Loose-strife)
Ridges on stem giving 4-6 sided appearanc
Leaves opposite, usually in 3's
Branch stems square
Gentle serrations on leaf

Impatiens glandulifera
Large broad toothed leaves
Stems and leaf teeth pink
Distinctive pink flower

Large leaves

Rumex hydrolapthum
Large 'dock' leaves (>50cm)

Symphytum officinale
Long, toothless, pointed leave
Winged (but round) stem
Leaves and stems hairy

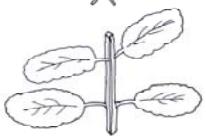
Caltha palustris
Distinctive shiny, kidney shaped leaves
5 petal yellow flower

SQUARE STEMS (all have opposite leaves)

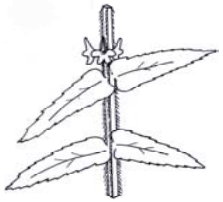
Mentha aquatica
Rounded leaves (on stalks)
Minty smell

Lycopus europaeus
Very deeply toothed leaves
Occasionally stalks on leaves

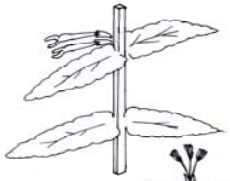
Scrophularia
ribbed stem
rounded leaves, sometimes with 'ear
rounded serations on leaves



Stachy palustris
No stalk to leaf
Pungent smell
Pale pink flowers
Hairy, toothed, leaves
Stem has downward pointing hairs
Serated leaf



Scutelleria galericulata
Like Stachys but:
rounded serations
purple flowers
no smell or hairs



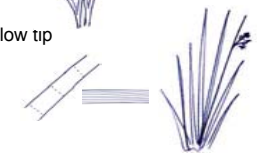
Hypericum elodes
Stems and leaves downy
Round leaves
No petiole

Juncus (rushes)

J. Effusus (soft rush)
Single stems with flower just below tip
Spongy tube - no septa

J. articulatus (jointed rush)
Branched stems
no ridges or septa

J. inflexsus (hard rush)
Single stems with flower just below tip
Septa along stem (can be felt)
Single stems
Fine ridges along stem



See also Juncus Bulbosus (fine leaved submerged) and Eleocharis (emergents)

Grasses

Large reeds

Phragmites
Upto 3.5m tall


parallel sided leaves


hairy ligule

Phalaris
Upto 2m tall


pointed leaves


papery ligule

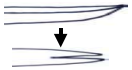
Glyceria maxima
Upto 2m tall


rounded lemma


strange point on ligule

Glyceria

- pointed, boat-shaped leaf tips that split if you flatten the tip with your finger




- flattened upper shoots (oval-shaped)

	Glyceria fluitans	Glyceria plicata	Glyceria declinata
ligule	 sharp V-shape	 U-shape	 V-shape
lemma	 pointed	 rounded	 teeth

Catabrosa aquatica (rare)
Rounded leaf-tip
creeping growth habit
Broad, parellel sided leaves
Inflated leaf base

Carex

	leaf shape	ligule	stem shape	inflorescence	other
C. riparia pointed male flowers 3 stigmas thickening in leaf			△		
C. acutiformis blunt male flowers 2 stigmas fine net like filaments at base			△		
C. acuta papery sheath at base (cf. acutiformis) bracts exceed top of flower 2 stigmas			△		
C. elata 2 stigmas papery sheath at base (cf. acutiformis) forms more distinct clumps than acuta short bracts, not exceeding top of flower			△		
C. vesicaria yellow/pale green colour no spongy leaves bottle shaped fruits 3 stigmas			△		
C. pseudocyprus yellow-green like vesicaria bottle-shaped fruits			△		
C. rostrata obvious blue/grey colour spongy leaves			○		