Final Report **Project WFD42**

LAKE HABITAT SURVEY IN THE UNITED KINGDOM

FIELD SURVEY GUIDANCE MANUAL

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SNIFFER
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LAKE HABITAT SURVEY IN THE UNITED KINGDOM

PART ONE: INTRODUCTION AND GENERAL GUIDANCE

A. Preamble

The Lake Habitat Survey (LHS) is a method designed to assess and characterise the physical habitats of lakes, ponds and reservoirs (collectively known as standing waters). It is applicable to all types of permanent standing waters in the UK (including brackish lakes and those with tidal influence). The method may require adaptation for use at non-permanent lakes such as turloughs and meres.

LHS has been developed to fulfil the requirements of the Water Framework Directive, along with those of 'Common Standards Monitoring' and 'Condition Monitoring' for designated sites in the UK. It can also play a pivotal role in systematising habitat assessment for environmental impact assessment and prioritising programmes of measures aimed at restoring degraded lake ecosystems.

The first stage of LHS development was undertaken in Phase 1 of the SNIFFER project WFD40 "Development of a technique for Lake Habitat Survey (LHS)" from March-November 2004. The project was contracted to and carried out by the Environmental Systems Research Group, University of Dundee.

During the 2004 field testing phase two survey schemes with differing levels of comprehensiveness were investigated. The first, LHS_{core}, was designed for rapid deployment, featuring a sub-set of 'essential' or 'core' data that should be recorded any time a lake is subject to inspection. The complete or full version of LHS was more intensive and was tested over fewer lakes. Field testing was carried out by the contractors as well as by teams from the environment and conservation agencies in Great Britain and Northern Ireland.

At the culmination of Phase 1 a workshop was held to review the protocol, with expertise drawn from participants from the United Kingdom (UK), Europe and the United States of America (USA). At the beginning of Phase 2 a second workshop was held to consider the relevance of LHS to ecological issues. This manual describes LHS Version 3.1 which is the protocol developed from the Phase 2 project (SNIFFER Project WFD42). This version advances only the full version of LHS, and LHS_{core} is discontinued forthwith. Version 3.1 is the product of the extensive testing programme carried out in 2005, with this manual providing the necessary instructions.

B. Scope of the manual

This manual was produced for Phase 2 of the LHS development programme.

The manual covers guidance for completing the survey form only. It does not attempt to deal with preparatory work prior to the survey, or details of how to link LHS with other survey requirements. Preparations, including organising permissions for access to survey areas, must be planned by the commissioning organisation and surveyors prior to any fieldwork.

The manual does not include health and safety guidelines as these vary between agencies. Surveyors are expected to follow the health and safety guidelines of the agency or organisation under whose auspices they are undertaking fieldwork. This applies also to the use of boats, for which a full set of safety equipment should be carried. However, one piece of boat safety equipment - the anchor - will often be useful for positioning the boat at the various points within the lake from which LHS observations are made.

Surveyors should take all care to minimise disturbance to species and habitats at the lake. The manual and field guidance sheets give information to assist in the identification of notable introduced (nuisance and invasive) plant species for the UK. If these are problematic at a site, surveyors should be especially vigilant to avoid spreading them to other sites, and should follow any guidelines on this subject that are issued by their own organisations.

A summary of the survey approach and important survey details, techniques and recording instructions are provided in the remainder of Part One of this manual. Part Two provides instructions and recommendations for timing and sequencing of operations for the survey. Full definitions and instructions for undertaking LHS are provided in Part Three. A detailed photo gallery is provided in Part Four to assist surveyors in identifying features in the field. The survey form and field guidance sheets are provided in Appendices 1 and 2.

C. Summary of the survey approach

LHS is carried out using a combination of field survey and a minimal amount of desk-based information gathering. The field survey component is preferably carried out by boat, but a foot-based option is also provided.

In most cases, the survey is applied to an entire lake as a unit. Some large lakes have more than one basin, and where these are distinctly different with little interconnection, individual basins have been designated as separate water bodies for WFD purposes (there are only a few examples in the UK). In such cases, it may be appropriate to carry out a separate LHS survey for each basin.

The LHS survey form is used to record a set of standard observations, which can later be compared between different surveyed lakes.

Essential background information is preferably recorded prior to arrival in the field, using the UKLakes[1] database and a recent OS 1:25,000 topographic map (or a higher resolution map if available). It can be helpful to obtain additional background information from other desk sources (if available) and from stakeholders for the individual lake. **Experience indicates access to a colour base map (and/or an appropriately scaled aerial photography) is especially valuable**.

A sketch map of the lake is made by tracing from an original OS 1:25,000 (or higher resolution) map onto the survey form. This is used to record the locations at which specific elements of the survey are carried out. Alternatively, a direct photocopy (enlarged if necessary) of the OS map can be attached to the survey form and used for this purpose.

Photographs should be taken throughout the survey, to illustrate the lake's general character as well as specific features and recording problems.

Upon arrival at the site, survey details such as weather conditions are recorded.

Detailed habitat characteristics are recorded (and photographs taken) at 10 habitat observation plots (Hab-Plots A-J). The first Hab-Plot is positioned randomly, and the remainder are distributed evenly around the perimeter of the lake.

Additional Hab-Plots may be placed (non-randomly if required) and recorded for specific purposes, for example to provide habitat information to accompany biological data such as vegetation transects or macro-invertebrate samples.

[1] GBLakes is a database of lakes in Britain (see http://www.uklakes.net/). If completing LHS in another region, use a relevant database applicable to the area, if available.

More general observations of the lake's perimeter and the proximal parts of its catchment are made whilst cruising between Hab-Plots. These observations cover both habitats for biota and human activities within and near the lake. During foot-based surveys, this part of the survey is carried out by viewing sections of the opposite shore through binoculars.

During boat-based surveys only, the deepest point of the lake (the Index Site) is located and the maximum depth, water clarity and some other features are recorded. If the survey is conducted in mid to late summer (July to September), temperature and dissolved oxygen profiling is also carried out at the Index Site.

D. Equipment

Essential items of equipment required by surveyors for each survey method are listed in Table 1.

Table 1. Equipment required to complete LHS.

Equipment	Details	Boat based	Foot based
Field survey forms, guidance sheet, pencils	If available, coloured pencils are ideal for sketching onto diagram	✔	✔
Access to UKLakes database	Or have relevant information supplied	✔	✔
OS 1:25,000 topographic base map	Most recent edition. Obtain a larger scale/ higher resolution map if possible	✔	✔
GPS	For recording locations of various sites, e.g. Hab-Plots	✔	✔
Binoculars	For identifying habitats and pressures from a distance	✔	✔
Camera	For taking photographs of the site	✔	✔
Tape measure (or rangefinder)	For measuring distance to shore	✔	✔
2 m ranging pole	For identifying underwater substrates by probing, especially when water is turbid; also useful for measuring shallow water depths	✔	✔
Bathyscope	For examining underwater substrates and vegetation; especially useful when estimating vegetation structure and Percent Volume Inhabited	✔	✔
Rake and grapnel	For collecting samples of underwater vegetation when water depth and/or turbidity make it impossible to view the lake bed	✔	✔
Boat	Use a boat for the survey if possible	✔	×
Fathometer and weighted cord	For measuring water depth in different situations	✔	×
Secchi disc	For measuring water clarity and light transmission	✔	×
Dissolved oxygen/ temperature meter	For measuring profiles of dissolved oxygen and temperature at the Index Site (useful only in July, August and September when the thermocline will have developed in stratifying lakes)	✔	×

E. The habitat observation plots (Hab-Plots)

The Hab-Plots are designed to record predominant lake-shore habitat characteristics over 15 m wide plots that extend from within the riparian zone to within the littoral zone. Ten plots (A-J) are required for a standard LHS survey, and these must be evenly distributed around the lake but positioned randomly.

Figure 1.1 shows the layout of zones and important locations within a Hab-Plot, and Figure 1.2 shows the profile of a Hab-Plot to aid interpretation of Figure 1.1. Zones within the Hab-Plot are defined for the purposes of LHS, and do not necessarily reflect ecological boundaries. The zones are described as follows:

The **riparian zone** extends 15 m landwards from the **bank edge**. The bank edge is generally defined by a convex break in slope, but this can also be defined as the line along which riparian (terrestrial or land) conditions change to in-lake conditions. The **bank top** itself is defined as the area 1m landwards from the edge of the bank, and is therefore included in the riparian zone.

The **shore zone** is the region from the current waterline and to the bank edge, and may be visible only when the water level is in the lower part of its annual range, or when it is artificially drawn down in a reservoir. Thus, a shore zone may or may not intervene between the riparian and littoral parts of the Hab-Plot at the time of survey, but if there is a shore zone it may be many metres wide in some cases. If it is exposed, it offers opportunities to examine sediments more closely than may be possible when it is covered with water. Its condition may also give insights into the condition of the lake; for example if the shore zone has been colonised by terrestrial vegetation, the last significant storm or drawdown probably occurred at least some months before the survey.

If a shore zone is present, it may comprise one or two different sub-zones, termed the **bank face** and the **beach**. The junction between these sub-zones may be defined by a distinct concave break in slope, change in material, a wave-cut notch, or a trash line. A bank is formed by the action of water or waves cutting into the shore, so the bottom of the bank is often at the high waterline or at the height reached by storm wave action. The beach can form either as a consequence of water level regression or may be an erosional/depositional landform resulting from local bank erosion and shoreline sediment transport, and usually has a gentler gradient. Note that in many natural lakes and in lakes where the water level has been raised, the high waterline will form the junction between the riparian zone and the littoral zone; i.e. the beach and bank face sub-zones may not be present. The boundary between riparian and in-lake conditions can be well defined, or may be indistinct, especially where an emergent reed bed is present.

The **littoral zone** is the area from the waterline to 10 m offshore, over the entire 15 m wide plot. The **offshore station** should routinely be 10 m from the waterline, and is the position where the boat is moored, anchored or held stationary whilst the Hab-Plot data are being recorded. A depth measurement is taken here. If a boat is not available, surveyors should walk out to 10 m, or maximum wading depth (usually 0.75 m) if this is a shorter distance. In all cases the depth and the distance to the shore are recorded here at this offshore station.

The locations of the Hab-Plots should be determined prior to or upon arrival in the field. A randomised sampling design is used to ensure that Hab-Plots A-J are evenly spaced but in unbiased locations. A coin is tossed onto the sketch map and the first Hab-plot is located at the point on the lake edge closest to the coin. From this location, the other nine plots are spaced as evenly as possible around the lake perimeter.

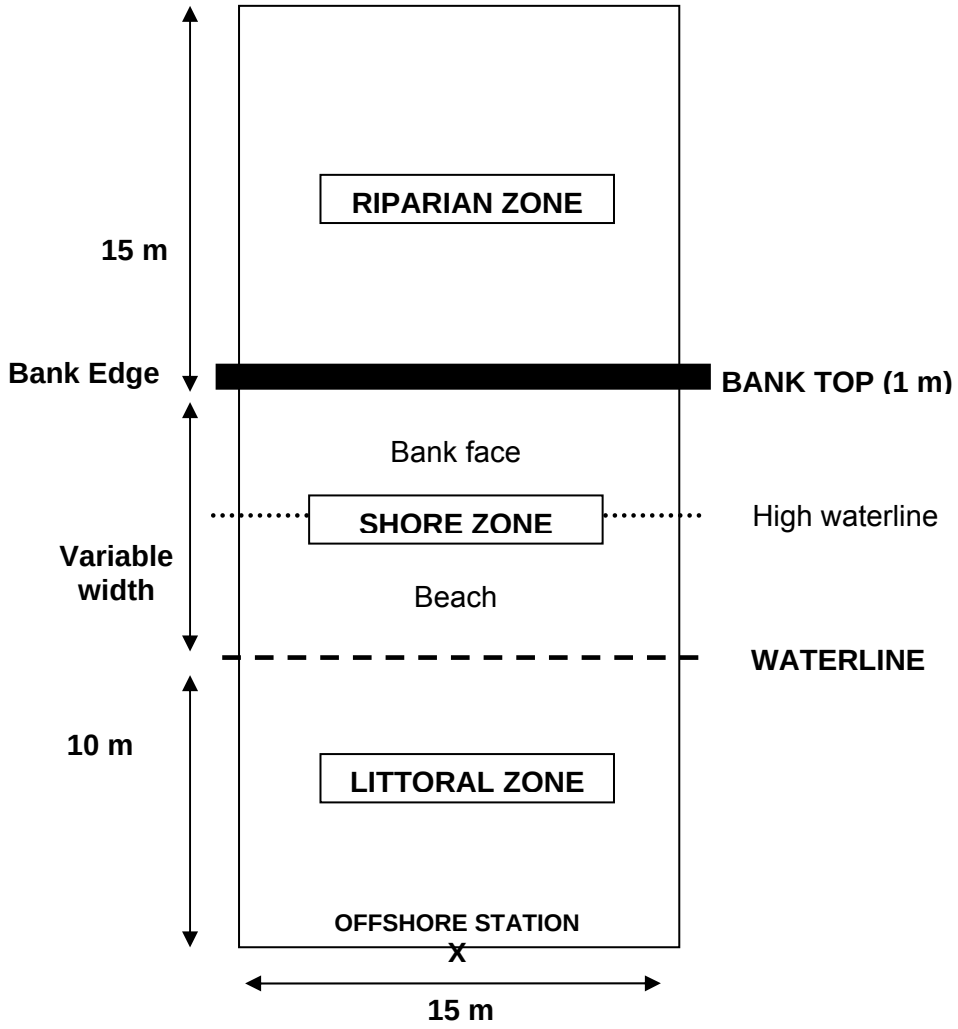


Figure 1.1 Diagram of a Hab-Plot showing zones

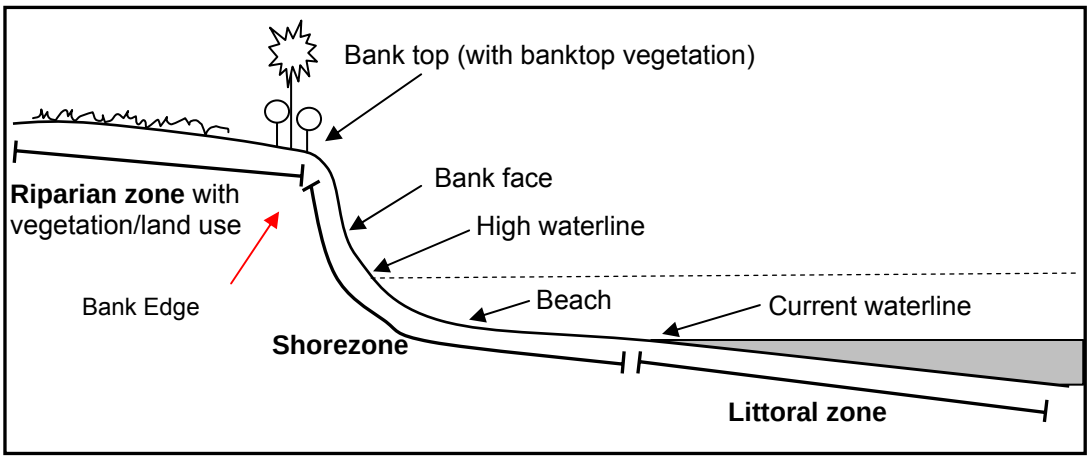


Figure 1.2 Cross-section of a Hab-Plot

Inaccessible areas may be obvious from the map, and it is acceptable for surveyors to take account of these by adjusting the position of the first Hab-Plot (or re-tossing the coin) so that Hab-Plots B-J do not fall within such areas. Once the survey begins, however, surveyors may find that some of the Hab-Plot locations selected beforehand are not accessible in practice. In this case, new plots can be found as close as possible to the original sites. These should be named BX, CX, etc. to indicate the original plot they are replacing, and marked on the survey base map.

Additional Hab-Plots may be required for individual surveys, for example to support vegetation transect surveys or invertebrate sampling. In such circumstances use another form and re-label (e.g. K-T) as appropriate, and include these sheets with the basic form. If a standard survey only is being carried out, these extra pages will not be required.

The locations of the Hab-Plots are marked on the sketch map, and the latitude and longitude of the offshore station as indicated by the GPS are recorded (in whole degrees, minutes and seconds) upon arrival at each plot.

The Hab-Plots should be observed from the offshore station, whether surveys are boat- or foot-based, as shown in Figure 1.1. Testing has shown that it is almost always possible to view the whole plot, including the riparian zone, from this point. Underwater features are viewed using a bathyscope if necessary. If there is insufficient light for this, the characteristics of bottom sediments can be assessed by probing with a ranging pole, and samples of vegetation collected using a rake and/or grapnel.

If any features cannot be seen clearly from the offshore station, both boat-based and foot-based surveyors may walk about onshore in order to resolve any uncertainties. Surveyors may also move about in the littoral zone to make recordings of macrophytes and other features. However, this and any other extra measures that are taken must be noted in Section 7 of the form. Such extra measures may increase the overall survey time, particularly if boat-based surveyors choose to moor the boat and land in order to examine the shore and/or riparian zones.

Habitat features are observed within each zone progressively from the landward end or the ‘back’ of the plot (riparian zone), down to the waterline (shore zone), and then into the littoral zone. Pressures and impacts over the entire plot and within 50 m of it are also recorded.

F. The lake perimeter survey

This part of the survey aims to build up a comprehensive picture of the range of habitats present; and of the range, extent and intensity of human activities that may be affecting the lake. The intention is to capture and separate influences that encroach directly on the lakeshore from those that are present in the wider catchment but whose effects may be buffered by any intervening areas.

To this end, information relating to land use, human pressures and natural habitats is recorded simultaneously for two belts of different widths. The first belt includes the entire lake shore; it covers any structures and pressures (such as boat moorings) within the lake that are associated with specific parts of the shore, and a belt extending 15 m landwards from the bank edge. The second belt extends 50 m from the bank edge but excludes the whole of the first belt, so it actually commences 15 m landward of the bank edge.

Ideally, the whole perimeter of the lake should be recorded from a single location in order to minimise uncertainty with regard to the total extent of each characteristic recorded. In most cases, however, the whole shore will not be visible at any one time

during the survey, so that the belts will be observed in sections. Note always seek to check observations – often being some distance (hundreds of metres) from the shore sector being observed permits a useful integrated view of all constituent habitats.

The approach for carrying out the lake perimeter survey in sections differs between boat-based and foot-based surveys. The two approaches are described separately below.

Boat-based version: observe the lake shore and in-lake and surrounding pressures while cruising between Hab-Plots.

- Begin the perimeter survey after completing the first Hab-Plot (plot A in Figure 1.3), while cruising to the next Hab-Plot (B). This will be Perimeter Section 1.
- Estimate the percentage of the shoreline made up by Perimeter Section 1. Enter the extents of features observed in the two belts for that perimeter section in the spaces provided on the form.
- Upon completing Hab-Plot B, observe the shore while cruising between plots B and C, (which will be Perimeter Section 2). Repeat the process after completing each Hab-Plot.
- Ensure there is no overlap between perimeter sections. Indicate any areas that cannot be seen, but at least 75 % of the perimeter must be observed.

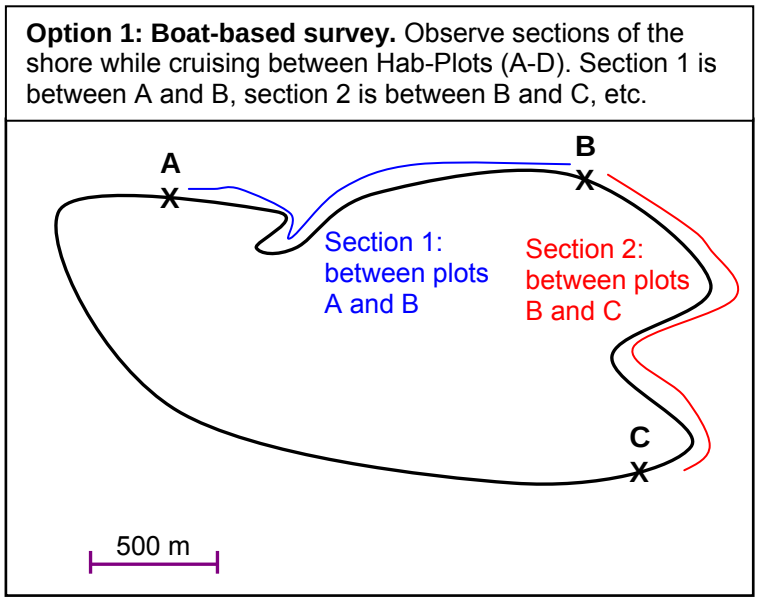


Figure 1.3 Boat-based lake perimeter survey

Foot-based version: from each of the offshore stations of the 10 Hab-Plots (plus extra viewing points if necessary), observe visible sections of the opposite shore using binoculars. Observe lake shore, in-lake and surrounding pressures over these sections.

- Begin the perimeter survey after completing the first Hab-Plot (plot A in Figure 1.4). From the offshore station of Hab-Plot A, observe the stretch of the opposite shore that is visible. If you can see only a very limited section of the opposite shore and could substantially improve your view by moving to an alternative viewing location nearby, do this and mark the position of the alternative viewing location on the sketch map.
- Mark the stretch of the opposite shore that you can see from your chosen viewing location on the sketch map and label it as Perimeter Section 1. If you have chosen a viewing location other than the offshore station of Hab-Plot A,

record the GPS reference of the new viewing point in the row provided for "new viewing stations if required" on page 4 of the survey form.

- Estimate the percentage[2] of the perimeter that is made up by Perimeter Section 1. Enter the extents of features observed in the two (15 m and 50 m) belts for that perimeter section in the spaces provided on the form.
- Move to Hab-Plot B, and after completing the plot survey, observe the new perimeter section visible on the opposite side of the lake from the offshore station or an alternative viewing location if necessary. Do not include any of Perimeter Section 1 in this section, even if you can still see it. This will be Perimeter Section 2. Record details as for Perimeter Section 1.
- Repeat the procedure at the remaining Hab-Plots. Ideally, the entire perimeter of the lake will have been observed when all ten Hab-Plots have been visited.
- If less than 75% of the shore has been observed at this stage, the surveyor is obliged to seek further viewing locations. Mark these on the sketch map and record their GPS locations. Mark the sectors seen from each viewing location on the map and fill in details on the form as before, until at least 75% of the lake shore has been surveyed. If you need extra columns, write in the margins of page 4; if you run out of space completely, record the information in Section 7 of the form.

Option 2: Foot-based survey. Observe sections of the opposite shore from the offshore stations of Hab-Plots A to D. Dotted lines show field of view from each station.

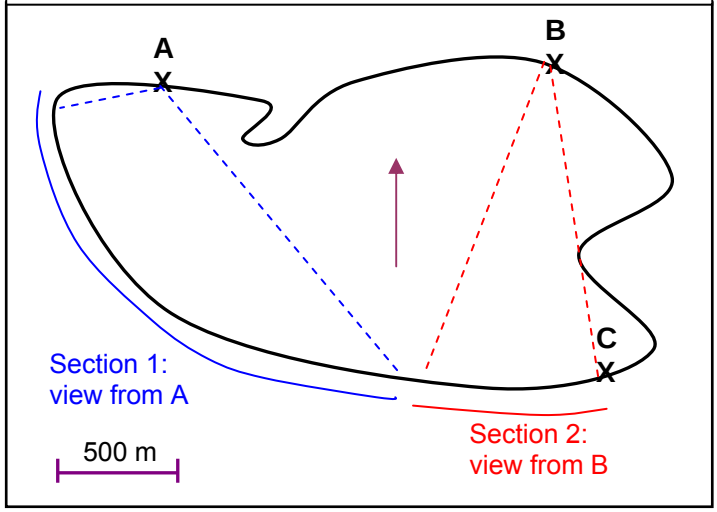


Figure 1.4 Foot-based lake perimeter survey

G. Recording information on the survey forms

The LHS form consists of seven sections over seven pages, and is accompanied by a field guidance key of two pages. Surveyors must also complete any health and safety paperwork required by the agency or organisation under which they are working.

It is recommended that the survey form is filled out in pencil so that amendments can be made, particularly at this draft stage of the methodology. Coloured pencils are ideal for annotating the sketch map. A clipboard or 'Weather-writer' may be used, and a waterproof laminated copy of the field guidance key should be taken into the field at all times.

[2] If the calculation is too difficult to carry out in the field, it can be completed using desk-based resources once back in the office.

Surveyors are required to record the presence, absence, size, extent or number of specific features. Different types of information are recorded on the form by:

- **circling** an option from a list;
- entering a **two-letter abbreviation** or code for features such as land cover type or bank modification type;
- counting the **number** of certain features (e.g. number of dams or islands);
- taking or estimating **measurements** (e.g. heights, angles, distances), or assigning a category of measurement (e.g. GE = Gentle slope of 5-30°);
- **ticking boxes** ✓ to indicate the presence of a feature;
- **estimating areal extent** of features using the standard categories: 0 (0%), ✓ (>0-1%), 1 (>1-10%), 2 (10-40%), 3 (>40-75%), 4 (>75%) [except for sediments where slightly different categories are used for classification reasons]- note that a ✓ is used to indicate a feature that is present but to less than 1% areal coverage, which is a recent change to the protocol; or
- **ringing** or circling various types of **entries** (such as an abbreviation or a percentage estimate) can also be used to indicate further information (e.g. ringing the entry indicating the presence of wetland if it is reedbed, or the entry indicating the type of sediment if it is compacted).

The option of using 'other' (abbreviation 'OT') is often offered. This is because it is difficult for every possible type of feature to be allocated an abbreviation or a space on the survey form. In particular, since this version of LHS is still a prototype, you may observe important new features that have not yet been allocated an abbreviation code. If you do use 'other', always record details of what was observed, either within the current section if space is provided, or in Section 7 at the end of the survey form. Surveyors are encouraged to use 'OT' even in cases where it may not be offered as an option (since some features may not have been anticipated so far), and to record any extra information in Section 7 to aid in the development of the methodology.

The option of using 'not visible' (abbreviation 'NV') is also offered. This can be used when the surveyor is unable to see the feature in question. Again, surveyors are encouraged to use 'NV' even in cases where the option is not provided, and to record any extra information in Section 7 to aid in the revision of the methodology.

PART TWO: TIMING OF SURVEYS AND SEQUENCING OF OPERATIONS

A. Timing considerations

LHS should be carried out in the summer months of the year. It is recommended to undertake full LHS surveys during the months of July, August and September because during this period the data collected from the Index Site measurements are likely to be most representative (see below). However, the remainder of the survey can be carried out from late May through to September, since the condition of the vegetation over this period is such that its form and extent, and thus its influence on habitats, can be seen. There are a few important (introduced) plant species that must be recognised by surveyors if they are present; these may be in flower or fruit, and at least the deciduous species will be in leaf, and thus easier to identify, during the summer months. Finally, the water level is less likely to be high at this time of year, and it may well be in the lower part of its range so that the bank and beach sub-zones are exposed and can be examined easily.

Profile measurements are carried out at the Index Site in July, August and September only, because this is the time when almost all stratifying lakes will have a detectable thermocline. The absence of a thermocline at other times of year does not mean that the lake never stratifies.

Postponing the survey until another day should be considered (be pragmatic!) if, on arrival at the lake, one of the following is found:

- It is too foggy to see the opposite shore.
- flood conditions are occurring e.g. the water level is so high that it is impossible to see the banktop.

For non-permanent lakes such as Breckland meres and turloughs, pragmatism will again required if there is no water in the lake on the day of the survey. It may be possible to complete a meaningful foot-based survey if a shoreline can be unambiguously defined, but this may not be possible in some cases.

Other timing constraints may be laid down by the health and safety rules of individual organisations, and these should be followed.

B. Sequencing

Be familiar with the survey form and requirements. Movement between sections of the form when completing the survey is minimised, but may still be necessary. Figure 2.1 gives guidance for completing each section of the survey in a logical sequence, but flexibility is generally required.

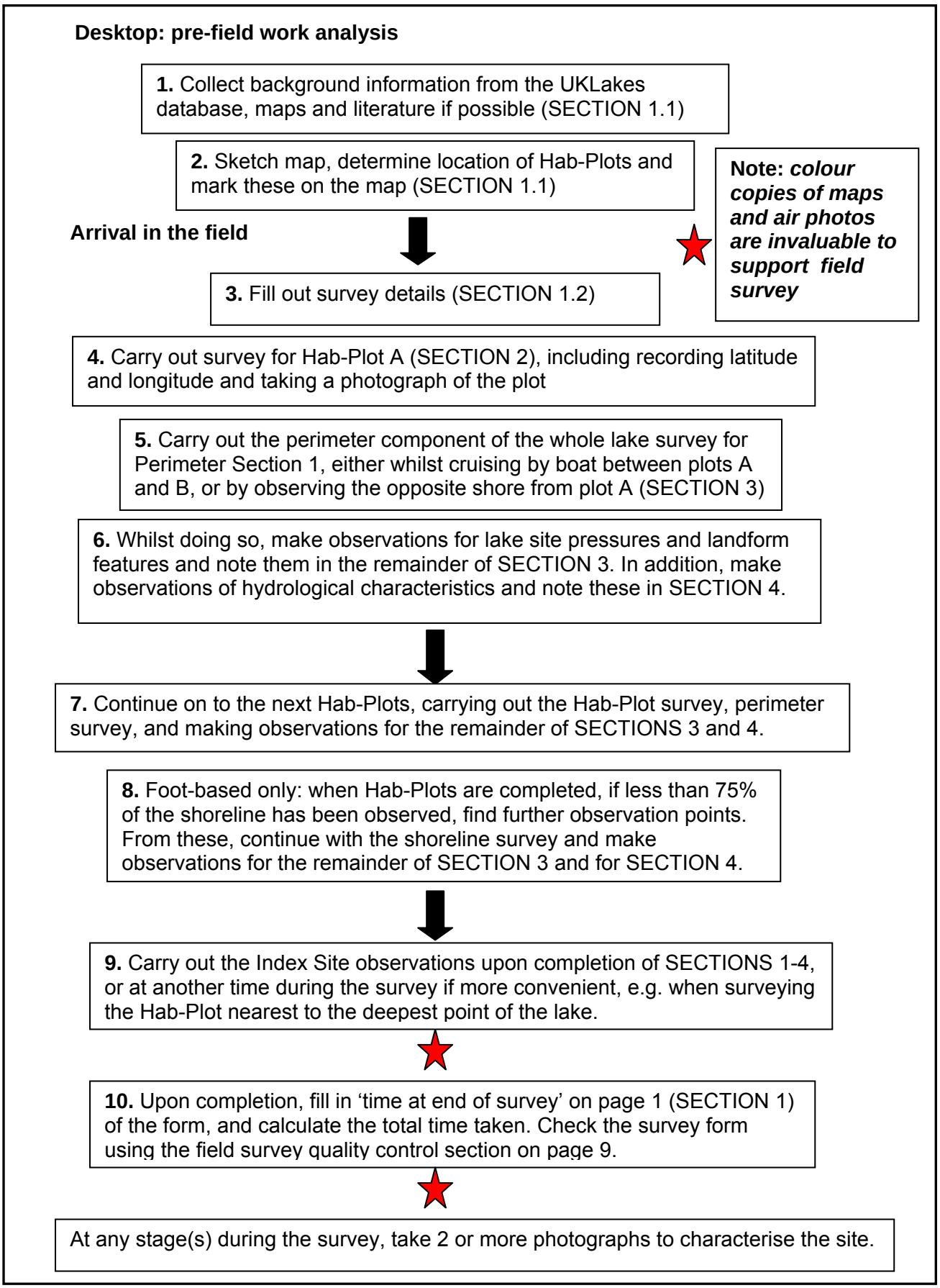


Figure 2.1 Overview of the steps required to complete LHS

PART THREE: DEFINITIONS AND DETAILED GUIDANCE

At the top of each page of the LHS field form, enter the lake name, UKLakes (or other code), the date, and the visit number (i.e. if this is the first visit to the lake for LHS purposes this will be "1").

SECTION 1: LAKE INFORMATION AND SURVEY DETAILS

SECTION 1.1 BACKGROUND INFORMATION

Fill in as much as possible in Section 1.1 using UKLakes database (or an alternative database if applicable) and the most recent available edition of an OS 1:25,000 map, prior to arrival at the lake. This will allow you to access desk-based resources while completing the details in this section. UKLakes is accessible by most staff of the statutory environment and conservation agencies. A user name and password is required for full access, but valuable data can be obtained without these *via* the website http://www.uklakes.net/ contains background information for many lakes that will be surveyed. However, it is known to contain mistakes, and LHS surveys provide an opportunity to formally identify and correct some of these; therefore you are requested to record any anomalies that you notice in Section 7 of the LHS form. Agencies have differing access to OS map sources, but you should use the most recent edition from the best source available. Hard copies of other maps, and programs such as Mastermap, Getmapping and LCM2000 should be very helpful for this section. You may also find that you have desk-based resources that can be used to complete some of Section 4 (Hydrology) before the survey.

Maximum depth
Fill in if known. For some lakes, maximum depth is recorded in UKLakes database. Indicate whether the depth measurement recorded in UKLakes was measured or obtained by modelling. To the right of this entry, circle the method by which depth was determined, .i.e. either 'modelled' or 'measured'. Note that, whether or not a maximum depth is available in UKLakes, a maximum depth measurement should be taken if a boat-based LHS survey is carried out.

Lake perimeter
Fill in from UKLakes if possible. Otherwise, use GIS or determine using a map wheel. Note if islands are present lake perimeter includes the island shoreline length also.

Lake surface area
Fill in from UKLakes if possible. Otherwise, use GIS or determine surface area by overlaying a grid and counting grid cells.

Lake altitude
Fill in from UKLakes if possible. Otherwise, determine using the map and/or record using the GPS when at the site (but remember that altitudes given by hand-held GPS equipment are generally quite inaccurate).

Catchment area
Fill in from UKLakes if possible. Otherwise, use GIS or determine entire upstream catchment area by overlaying a grid and counting grid cells.

Lake type
Type according to the UK WFD reporting typology, available from UKLakes.

Catchment geology
Fill in from UKLakes if possible. Otherwise determine using general knowledge of the area with the aid of a geological map and/or GIS-based data. Catchment geology categories are: Siliceous, Calcareous, Organic, or Mixed. Use Mixed if two or more categories are equally dominant (circle those included in mixed category).

Dominant catchment land cover
Determine the most common use of land from the categories shown in Table 3.1. Use UKLakes, a 1:25,000 map or GIS- based data (e.g. LCM2000) to provide answer. Try to record only the dominant type, but make notes in Section 7 of the form if necessary.

Table 3.1 Land cover types

Code	Land cover type	Description
NV	Not visible	Unable to be determined.
BL	Broadleaf/mixed woodland (semi-natural)	Woodland predominantly deciduous. Excludes mixed plantations.
BP	Broadleaf/mixed plantation	Plantation woodland of deciduous trees (e.g. poplars). Includes sapling plantations.
CW	Coniferous woodland (semi-natural)	Native conifers, typically Caledonian forest in Scotland. Excludes plantations.
CP	Coniferous plantation	Coniferous woodland (e.g. Sitka spruce, lodgepole pine), usually in commercial plantation; also shelter belts.
SH	Scrub and shrubs	Scrub (e.g. brambles, gorse, rhododendron) and woody shrubs (e.g. blackthorn and hawthorn).
WL	Wetland (e.g. bog, marsh, fen)	Includes marshes (wet ground without peat), fens (peat-forming wetlands in depressions), and bogs (rain-fed peat systems). Circle/ring entry WL if the wetland is a fringing reedbed.
MH	Moorland/heath	Presence of heather, sometimes acid tolerant grasses, cotton grass.
RP	Rough/unimproved grassland/pasture	Unimproved, usually herb-rich and tussocky and may not be enclosed for grazing.
IG	Improved/semi-improved grassland/pasture	All other agricultural grassland, i.e. all improved grassland, usually enclosed for grazing.
TH	Tall herb/rank vegetation	Vegetation of at least waist height, dominated by herbs (not grasses or reeds), includes bracken.
TL	Tilled land	Agricultural land where crops are grown on regularly ploughed soil.
IL	Irrigated land	Agricultural land dependent upon irrigation for crop yield, includes cress beds.
PG	Park, lawn or gardens	Includes parks, golf courses, public amenity areas, sports fields etc., where grass is mown. Does not include lawns in gardens around individual houses or other buildings.
SU	Suburban/urban	Any artificial or built environment. Includes suburban and urban developments and their gardens, buildings, roads, car parks, railways, etc.

Mode of lake formation
If possible, assign lake to one of the lake formation categories shown below. Use the tips given to help you in assigning the correct code to the lake.

Table 3.2 Mode of lake formation

Lake formation types		Tips for assigning lakes to formation modes
Natural glaciated		
RV	Ice-scoured rock basin (valley floor)	Long, narrow and straight sided, reflecting the form of a valley glacier.
RC	Ice-scoured rock basin (corrie)	Typically small, circular and located at higher altitudes.
KL	Knock and lochan (glacial scour)	Low-lying, occupying rock basins of irregular form.
KH	Kettlehole basin (detached ice block)	Generally circular depressions left on level surfaces when ice, formally covered by drift, melts.
GD	Glacial drift (moraine or outwash dam)	Formed by cross-valley moraine or drift deposits reworked by rivers draining from melting ice.
Natural non-glaciated		
DP	Depression in blanket bog	Often irregular plan shape, and often dry during summer months.
FV	Fluvial processes on valley floor	Created by natural fluvial processes e.g. valley-floor ox-bow lakes.
WW	Wind/wave driven sand-blocked valley	Lake created by natural dam built up by aeolian processes.
BS	Depression in coastal windblown sand	Depression in sand in coastal areas.
CW	Chemical weathering	Formed in limestone terrain by solution.
Artificial		
IW	Impounded watercourse (reservoir)	Reservoir.
EH	Flooded excavation in hardrock	Flooded quarry.
ED	Flooded excavation in drift	Flooded sand, gravel or peat-cut excavation.
BP	Bunded (completely artificial concrete bowl)	Artificial concrete bowl.
OT	**Others** (specify in comments section at end of survey form e.g. beaver dams recorded in Poland)	

Designation Status
Indicate any designation status associated with the area in which the lake occurs. These are recorded in the UKLakes database and are likely to be known by surveyors. Categories include:

- **SAC** (Special Area of Conservation)
- **SPA** (Special Protection Area for birds),
- **SSSI** (Site of Special Scientific Interest) in England, Wales and Scotland, equivalent to ASSI (Area of Special Scientific Interest) in Northern Ireland
- **NNR** (National Nature Reserve)
- **LNR** (Local Nature Reserve)
- **Ramsar** site (Wetland of International Importance).

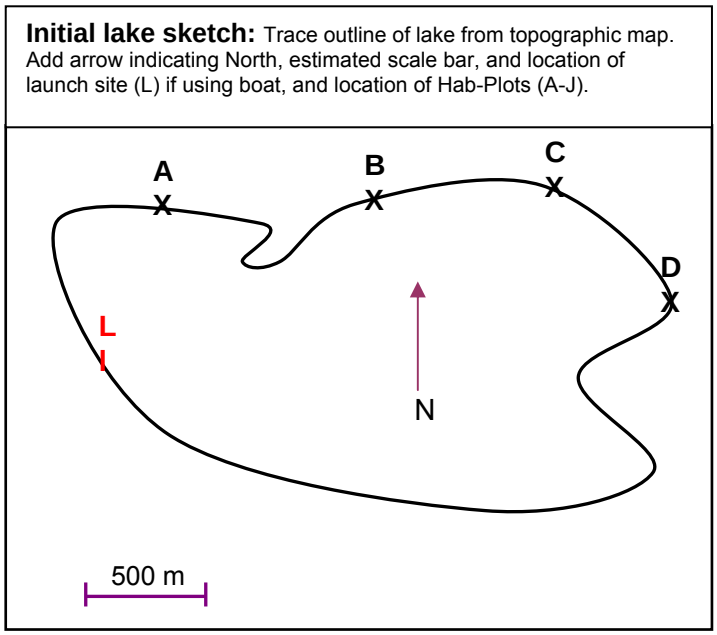
Specify others in section 7.

Trace lake outline into space provided
In the space provided in Section 1.1, page 1, trace the outline of the lake from a 1:25,000 OS map (or smaller scale if appropriate) to represent the entire system on the sketchmap (e.g. Figure 3.1). Add an arrow indicating north and an estimated scale bar. Indicate scale, source and age of map, including details of enlarged photocopies if used. *Experience indicates that best results are obtained by*

annotating directly onto a colour topographic base map (supplemented where available with recent aerial photographs).

The lake sketch or photocopy will be used as a simple sketch map to aid the collection and interpretation of information. If known at this stage, mark the location of the Hab-Plots and the boat launch site (if using a boat) onto the lake outline. Additionally, mark on the location of the Index site when that is known.

Figure 3.1 Outline map of lake



SECTION 1.2 SURVEY DETAILS

At the bottom of page 1, fill in most of the survey details when you begin the field survey. These include:

- **Surveyor name(s).**
- **Organisation**.
- **Survey method**, i.e. boat or foot.
- **Time at start** of the survey (record time at start and end of survey even if LHS is being carried out in conjunction with other survey work, as it may still be useful to know the times between which LHS details were recorded).
- **Time at end** of survey should be left blank at this stage and filled in when LHS is completed.
- **Estimated time** to complete LHS survey work. If other survey work was being carried out in conjunction with the lake habitat survey, estimate the amount of time that was occupied for LHS.
- **Adverse conditions affecting survey** (e.g. fog) should be recorded. Do not continue the survey under dangerous conditions or if the opposite shore cannot be seen.
- **Lake verification** (ensure that you are at the correct lake, and tick (✓) the relevant sources of verification).

Recording GPS (National Grid Reference) of Launch site and each Hab-Plot

The 12 figure National Grid Reference is recorded for the launch site (if using a boat) and the Hab-Plots using a GPS. This consists of two letters, and five digits for each of the eastings and northings (e.g. NO 14729 34834). These sites should already be annotated onto the sketch map, which is used to guide the surveyor to the correct

location. Note alternative position systems (e.g. latitude/longitude) can readily be obtained through conversion programs.

SECTION 1.3 PHOTOGRAPHS

Take two photographs that illustrate the lake's general characteristics, and one photograph of each Hab-Plot. Add photographs of interesting or unusual features and difficult situations encountered. Attach photographs to the survey form. Use a digital camera if available, and provide photographs in digital form.

SECTION 2: PHYSICAL ATTRIBUTES

The physical attributes of the lake are to be assessed in detail at ten Hab-Plots, plus any additional (optional) Hab-Plots required for the individual survey (see PART ONE (E) and the accompanying Figures). Remember to record the GPS location upon arrival at the plot.

PLACING OF HAB-PLOTS

Each Hab-Plot is placed with reference to the edge of the bank, and its length is determined by the position of the waterline relative to this (see Figures 1.1 and 1.2). The bank top is the line that marks the junction between riparian and in-lake conditions, or between the land and the lake. The waterline moves relative to the edge of the bank as the lake's water level fluctuates through time, and the conditions on any day are a 'snapshot' of this movement. Therefore, on the day of the survey, the waterline may be:

- at the bank top so that the bank face and/or the beach are not exposed;
- drawn down into the shore zone, so that part or all of the bank face and/or the beach are visible;
- occasionally, above the bank top so that the riparian zone is flooded; or
- severely drawn down so that a shore zone many metres wide is exposed (in reservoirs); or drawn down completely below the floor of the lake (in natural intermittent lakes and in reservoirs that have been emptied for maintenance).

The riparian, shore and littoral zones are recorded as defined by the relative positions of the bank top and the waterline at the time of the survey.

In mineral lake basins, the position of the bank edge will often be obvious as a convex break in slope where seldom-flooded terrestrial vegetation (e.g. grass and trees on dry land) gives way to much sparser or different (e.g. reeds) vegetation. If the shoreline has been re-profiled or reinforced with hard materials such as gabion baskets or a wall, the bank edge as designed should be used.

Where there is wetland adjacent to the lake, the waterline is less likely to be drawn down, but it should still be possible to identify the bank top as the line where there is a transition from wetland to lake conditions; e.g. from bog/fen to emergent reeds/sedges or open water. If the effective bank top is the edge of a floating raft of non-rooted vegetation, this should be noted.

When the water level is high, and especially where there is adjacent wetland, it may be difficult to work out the position of the bank top. If in doubt, one of the following definitions may be used (note which one in Section 7 of the form):

- the outer boundary of the open water area where the boat can move easily (e.g. the lakeward edge of dense terrestrial, wetland, or emergent vegetation;
- the transition from open water to swamp or marsh conditions); or
- the boundary between open water and extensive very shallow water.

If the water level is above the bank top, but it is still possible to define its position and describe the features of the riparian zone, the Hab-Plot should be surveyed as if the waterline was coincident with the bank top and the fact that the riparian zone is flooded should be noted in Section 7 of the form. If it is impossible to see enough of the riparian zone to describe its vegetation, or if the bank top cannot be identified at all, the survey should be postponed until drier weather.

If there is no water in the lake, pragmatism should be applied. For drawn-down reservoirs, it should be possible to describe the riparian and (extensive) shore zones in a foot-based survey. The method has yet to be tested on natural intermittent lakes.

SECTION 2.1 RIPARIAN ZONE

The riparian zone is assessed within the 15 m wide plot, over an area extending 15 m landwards from the top of the bank. It includes the bank top, for which extra information is recorded, as this is the part of the riparian zone that is most susceptible to erosion.

Areal cover

Assess areal cover of vegetation over the 15 x 15 m area (i.e. including the bank top). Visually divide the vegetation into the following three height categories:

> ***> 5 m (Tall).*** Any vegetation greater than 5 m in height. Estimate the extent of trees with diameters of ≥ 0.3 m and < 0.3 m. Also estimate the extent of this layer that is damaged or diseased (note this is the percentage of the plot occupied by diseased trees with height > 0.5 m, not the percentage of trees that are diseased).
>
> ***0.5 m – 5 m (Medium).*** Any vegetation between 0.5 and 5 m in height. Differentiate between 'woody shrubs and saplings' and 'tall herbs and grasses'.
>
> ***< 0.5 m (Short).*** Any vegetation less than 0.5 m in height. Differentiate between 'woody shrubs and seedlings' and 'herbs, grasses and bryophytes'.

The extent of each type is recorded on the form as one of the following: 0 (0%), ✓(>0-1%), 1 (>1-10%), 2 (>10-40%), 3 (>40-75%), 4 (>75%). Note that the vegetation categories are not mutually exclusive so that total cover can exceed 100%, even within a single height category.

Options are given for 'other' vegetation and ground cover features. Record here the extent of any of the following:

> ***Standing water or inundated vegetation*** (standing water above bank top, e.g. artificial pond or swampy wetland, which may have growing vegetation)
>
> ***Bare ground*** (indicating bare but natural ground)
>
> ***Artificial*** (indicating any man-made ground cover, e.g. cement slab or wooden platforms)

Dominant land cover within riparian zone

Fill in by allocating one of the categories shown below. These categories are mostly the same as those used for 'dominant catchment land cover', but there are some additional categories that are unlikely to dominate a whole catchment but may be dominant within the riparian zone. Try to choose one dominant type, but if this isn't possible make notes in Section 7 of the form.

Table 3.3 Land cover types

Code	Land cover type	Description
NV	Not visible	Self explanatory.
BL	Broadleaf/mixed woodland (semi-natural)	Woodland predominantly deciduous. Excludes mixed plantations.
BP	Broadleaf/mixed plantation	Plantation woodland of deciduous trees (e.g. poplars). Includes sapling plantations.
CW	Coniferous woodland (semi-natural)	Native conifers, typically Caledonian forest in Scotland. Excludes plantations.
CP	Coniferous plantation	Coniferous woodland (e.g. Sitka spruce, lodgepole pine), usually in commercial plantation; also shelter belts.
SH	Scrub and shrubs	Scrub (e.g. brambles, gorse, rhododendron) and woody shrubs (e.g. blackthorn and hawthorn).
OR	Orchard	Horticultural crop of fruit trees planted in rows and used for commercial fruit production.
WL	Wetland (e.g. bog, marsh, fen)	Includes marshes (wet ground without peat), fens (peat-forming wetlands in depressions), and bogs (rain-fed peat systems). Circle/ring entry WL if the wetland is a fringing reedbed.
MH	Moorland/heath	Presence of heather, sometimes acid tolerant grasses, cotton grass.
AW	Artificial open water	Artificial lakes reservoirs, filled gravel pits, canals, farm ponds, etc.
OW	Open water	Natural lakes, ponds, bog pools, etc.
RP	Rough/unimproved grassland/pasture	Unimproved, usually herb-rich and tussocky and may not be enclosed for grazing.
IG	Improved/semi-improved grassland/pasture	All other agricultural grassland, i.e. all improved grassland, usually enclosed for grazing.
TH	Tall herb/rank vegetation	Vegetation of at least waist height, dominated by herbs (not grasses or reeds), includes bracken.
RD	Rock, scree or sand dunes	Rocky outcrops, mountain scree, sand dunes.
TL	Tilled land	Agricultural land where crops are grown on regularly ploughed soil.
IL	Irrigated land	Agricultural land dependent upon irrigation for crop yield, includes cress beds.
PG	Park, lawn or gardens	Includes parks, golf courses, public amenity areas, sport fields etc., where grass is mown.
SU	Suburban/Urban	Any artificial or built environment. Includes suburban/urban developments, buildings, roads, car parks, railways, etc.

Notable introduced (nuisance / non-native) plant species

Record here any occurrences of introduced terrestrial species, whether they are growing in the riparian zone or on the shore or bank area. In the UK, the most common introduced species associated with lake shores are:

- Giant Hogweed (GH) – *Heracleum mantegazzianum*
- Rhododendron (RH) – *Rhododendron ponticum*
- Himalayan Balsam (HB) – *Impatiens glandulifera*
- Japanese Knotweed (JK) – *Fallopia japponica*

These species are shown on the species identification sheet (Appendix 1), and there is more information in Part Five of this manual. If other nuisance species are present, note them in Section 7 of the form.

Bank top features
Record prominent features of the bank top. These are important for characterising the bank and its stability. Options include:

- **NO** - None (this indicates that none of the below features occur on the bank top, not that no bank top is present)
- **Bedrock** - underlying rock, *in situ*
- **Boulders** - large rocks ≥ 256 mm, not *in situ*
- **Beach ridges** - successive upper-shoreface deposits deposited on an advancing shoreline, usually separated by narrow depressions
- **Dunes** - Ridges or mounds of loose, wind-blown material, usually sand
- **Quaking bank** - distinct floating ledge or shelf of vegetation only, equivalent to a quaking bog or 'schwingmoor' which extends into the lake, forming a floating mat that is attached to the shore along one side

Streams / flushes
Record the presence of streams and/or flushes within 50 m of Hab-plot. This indicates the importance of direct surface-water inputs and groundwater exchange in the immediate vicinity of the shorezone. Stream inflows are also important for spawning/connectivity issues and any engineering should be noted in Section 4.

SECTION 2.2 SHORE ZONE

The shore zone extends from the current waterline to the bank edge, so that its width varies with the fluctuations of the water level. It includes two sub-zones - the bank face and the beach - either or both of which may be absent. The bank (vertical or steep slope) gives way to the beach (shallower slope) at the first significant concave break in slope below the bank top (see Part 1 (D) and Figure 1.1 for more detailed explanation).

Boulder aprons are common features of lake shores. These are large (typically > 1 m and generally vegetation-free) boulders fringing the shorezone. Boulder aprons are naturally emplaced and different from engineered rip-rap (though morphologically similar). For LHS purposes they are viewed as bank face rather than beach features.

Bank face (if present)
Indicate whether a bank face is present. It will not be visible (record 'absent') when the current waterline is at the bank top. If the water level is drawn down, it may be visible as anything from a 'notch' a few centimetres deep at the lakeward limit of terrestrial vegetation to a substantial bank or boulder apron. If the edge of the lake is formed by a cliff, the bank face may be tens of metres high. If the bank face is not visible, the following questions referring to it (indicated by *) need not be answered.

Bank face height*

Estimate the vertical height of the bank face to the nearest metre, or to the nearest 0.1 m if less than 1 m. This refers to the distance in m from the bank edge to the concave beak in slope where the base of the bank joins the beach.

Bank face angle*

Estimate the average slope or angle of the bank face into one of the following categories: **GE** = Gentle (5 -30^{o}), **SL** = Sloped (>30-75^{o}), **VE** = near Vertical (>75^{o}), **UN** = Undercut.

Table 3.4 Substrates and grain size grades occurring within shorezone (bank face and beach) and littoral zones

Code	Material/substrate	Description
NV	Not visible	Self explanatory
BE	Bedrock	Underlying solid rock, *in situ*
BO	Boulder (Gravel)	Large rocks ≥ 256 mm in diameter (larger than head sized)
CO	Cobble (Gravel)	Loose medium gravels ≥ 64, < 256 mm i(half-fist to head sized)
GP	Pebble (Gravel)e	Loose small gravels ≥ 2, < 64 mm (ladybird to half-fist sized)
SA	Sand	Fine grained particles ≥ 0.06, <2 mm in diameter (gritty when rubbed)
SI	Silt	Very fine, smooth material <0.06 mm in diameter
EA	Earth	Crumbly soil, rare as a predominant in lake substrate, may occur on poached banks
PE	Peat	Lake bed formed of organic matter derived from decayed vegetation. Rare. Usually dark brown or black.
CL	Clay	Sticky cohesive clay material (can be rolled without crumbling)
MA	Marl	Fine calcareous material deposited in Marl lakes (crumbles when rolled)
OT	Other	Self explanatory
Artificial materials; when recorded as bank/beach materials, reinforcement will also be noted in bank/beach modifications		
Code	**Material/substrate**	**Description**
CC	Concrete	Cemented revetment, possible on bank face for reinforcement
SP	Sheet piling	Vertical, interlocking steel sheets (e.g. corrugated iron), possible on bank face for reinforcement
WP	Wood piling	Wooden poles, or vertical or horizontal planks, usually protecting bank face
GA	Gabion	Stones in wire baskets, to protect banks from erosion
BR	Brick/laid stone	Bank protection that includes cemented walls (e.g. brick walls) or uncemented laid stones (e.g. in lakes in the Lake District)
RR	Rip-rap	Boulders (normally quarried, square and of similar size) purposely tipped or laid along bank face for erosion protection. Includes uncemented block stone/boulders compacted into soil banks.
TD	Tipped debris	Discarded material, e.g. rubble, metal, wood, old cars and excavated soils and other minerals. May be intentional or un-intentional.
FA	Fabric	Synthetic (usually permeable geotextile) bank protection fabric, often used in conjunction with soil back fill. Always non-biodegradable, e.g. plastic
BI	Bio-engineering materials	Live or dead plants or non-synthetic materials used to protect banks from erosion and/or to restore bankside habitat (e.g. willow stakes and spiles, biodegradable matting, planted reeds)

Predominant bank material*

Record the predominant material of the bank face. The same categories shown in Table 3.4 are used for the bank material, as well as for the shore material and for the littoral zone substrate. Some of the artificial substrates are less likely to occur on the beach and especially in the littoral zone, but common categories are used to avoid confusion.

Bank face modifications*

Record any bank face modifications (Table 3.5). If any artificial bank materials were recorded, 'reinforced' should be indicated here. The categories shown in this table are also used in the 'shore modifications' section to avoid confusion. Structures such as fishing platforms should be recorded in Section 2.4 (human pressures).

Table 3.5 Modifications for bank face and beach

Code	Modification type	Description
NV	Not visible	Self explanatory.
NO	None	No evidence of modification.
RS	Resectioned	Profile modified but not reinforced, often to accommodate flood flows, for flood defence or other maintenance using machinery. Evidenced by a smooth, uniformly angled bank slope, no trees/uniformly spaced trees, or intensive use.
RI	Reinforced	Whole or part of bank strengthened for protection purposes. Includes types listed in the 'artificial materials' table above.
PC	Poached	Significantly trampled by livestock or people (e.g. as a result of picnicking, fishing etc.). May be predominantly bare earth.
EM	Embankment	Artificial raising of the bank using materials such as earth and natural stone, or walls of concrete or brick.
DM	Dam	A barrier constructed to contain the flow of water into or out of the lake.

Bank face vegetation cover*

Estimate the cover of vegetation on the bank face in the following categories: 0 (0%), ✓(>0-1%), 1 (>1-10%), 2 (>10-40%), 3 (>40-75%), 4 (>75%). This includes all vegetation types from large trees to fringing reeds. It does not include debris or 'washed-up' macrophytes.

Bank face vegetation structure*

Record the dominant vegetation structure on the bank face using the following vegetation height categories (as for bank top vegetation):

- **TA** – Tall vegetation greater than 5 m in height;
- **ME** – Medium vegetation from 0.5 to 5 m in height;
- **SH** – Short vegetation less than 0.5 m in height; and
- **MI** – Mixed (use if two or more of the above categories are prominent).

Evidence of bank face erosion*

Indicate whether there is any evidence of erosion. Enter 'NO' (none) or 'ER' (eroding). An eroding cliff is generally composed of sandy soil, sand and/or gravel. Vegetated banks are usually stable. Circle if erosion biogenic e.g. muskrats in France.

Beach (if present)

Indicate whether there is a beach within the shore zone. It will be absent in cases where the current waterline sits at the top or bottom of the bank. If none of the beach is visible, the following questions referring to it (indicated by *) need not be answered. NB: If both the bankface and beach are absent, a record of the predominant shore material should still be recorded.

Beach width*

Estimate the width of the beach to the nearest metre by estimating from the boat, pacing, or using a tape measure if possible. Note that this is not the horizontal distance, but the paced distance from the waterline to the base of the bank face (do not include the bank face or any area of the riparian zone within this measurement).

Beach slope*

Estimate the average slope of the beach. If the beach is undulating, imagine placing a plank of wood along it to estimate the average slope. Estimate to one of the following categories: HO = near Horizontal (<5^{o}), GE = Gentle (5 -30^{o}), SL = Sloping (>30-75^{o}), VE = near Vertical (>75^{o}).

Predominant shore (beach) material

When recording, the same categories are used as for the bank face material. **Circle the entry** if the shore material is compacted (or indurated). Some of the artificial substrates are less likely to be present on the beach, but the same categories are used to avoid confusion. ***NB. IF BOTH BANK FACE AND BEACH ARE ABSENT, AN ENTRY FOR SHORE FORMING MATERIAL IS STLL REQUIRED –*** make observations of materials forming lake shore (typically earth, peat etc.)

Components of beach substrates* (particle size distribution)

Assess the relative cover of the following particle size grades of unconsolidated sediment: boulders, cobbles, pebbles, sand and silt-clay (amalgamating cover for silt and clay fractions). Estimate the cover of each size grade provided into the standard categories: 0 (0%), ✓(>0-1%), 1 (>1-10%), 2 (>10-40%), 3 (>40-75%), 4 (>75%).

NB. where beaches are dominated by gravels (of various sizes) estimating the cover of sand and silt-clay fractions can be challenging. Remember the objective is capture the full range of substrate sizes across the beach (each offering different habitat potential). Beach sediments also frequently display evidence of particle size sorting by wave action e.g reasonably uniform sized sandy deposits at top of the beach often give way to progressively coarser (and more mixed sizes) of gravel-sized sediment (pebbles, cobbles or boulders) towards the water's edge.

Beach modifications*

Record beach modifications, if any. The categories used are the same as for bank face modifications, and shown under 'Bank face modifications' above. Some of the modifications are less likely to be present on the beach, but the same categories are used to avoid confusion.

Beach vegetation cover*

Estimate the cover of vegetation on the beach in the following categories: 0 (0%), ✓(>0-1%), 1 (>1-10%), 2 (>10-40%), 3 (>40-75%), 4 (>75%). This includes all vegetation types from large trees to fringing reeds. It does not include debris or 'washed-up' macrophytes.

Beach vegetation structure*

Record the dominant vegetation structure on the beach using the same vegetation height categories as for bank top vegetation.

Signs of erosional or depositional imbalance*

Record any evidence of geomorphological imbalance over the beach e.g. clear and uncharacteristic signs of erosion (scour) or sediment accumulation (build up of sediment). Enter: AL = Active Loss ('eroding') or AG = Active Gain ('depositional'). Active loss is indicated by the presence of bare sandy soil, or sands and/or gravels that appear to be undergoing removal. Active gain is evidenced by apparent overlaying of eroded material onto the natural substrate of the beach.

Height from waterline to upper trash-line (RECORD EVEN IF IN RIPARIAN ZONE)
Organic and other debris on may have been formed into a trash-line along a former high-water mark, so that the position of any trash-line relative to the current waterline gives useful information about water level fluctuations. If there is a trash-line, it will often be on the beach, but debris deposited in the riparian zone during a flood episode is also of interest here. Enter 'NO' if there is no obvious trash-line; or estimate the distance in metres from the waterline to the highest trash-line, whether it is in the shore zone, on the bank, or in the riparian zone.

SECTION 2.3 LITTORAL ZONE

The littoral zone is assessed over a 15 m wide plot, and extends lakewards for 10 m from the current waterline.

Distance of offshore station from waterline
Ideally this will be 10 m, but in practice this target will not always be achievable. For foot-based surveys, the distance from the water's edge to the maximum safe wading depth may be less than 10 m; whilst for boat-based surveys the water may prove to be too shallow to reach 10 m offshore. In these cases, the offshore station will be more than, but as close as possible to, 10 m offshore. Estimate this distance by eye, or using a range-finder or tape measure if possible.

Depth at offshore station
Record the depth in metres at the offshore station (which is 10 m offshore OR at the closest point of approach for the boat [if further] OR at the maximum wading depth). Use a fathometer if available; or a 2 m surveyor's ranging pole; or, if the water is deeper than 2 m, use a length of weighted cord/rope.

Predominant littoral substrate
The littoral substrate should be described from the offshore station, but if the substrate is highly heterogenous observations should seek to capture the entire plot. Use a bathyscope to view the substrate. If you cannot see the bottom, use a 2 m ranging pole as a probe. Clay-rich substrates will stick to the ranging pole. Hard sediments can be 'felt' with the ranging pole, and sandy substrates can be 'felt' or 'heard' by twisting the pole and detecting grittiness. If this is not possible (e.g. deep water over hard rocky substrate), enter 'NV' for Not Visible. Assign the substrate to a category from the materials and substrates table shown under 'Bank material' in Section 2.2 above. The same categories are used to avoid confusion, although many are unlikely to occur in the littoral zone. **Circle the entry** if the substrate is compacted. If more than one category is dominant, make notes in Section 7.

Components of littoral substrate (Particle size distribution)
Assess the relative cover of bedrock: boulders, cobbles, pebbles, sand and silt-clay (for practical purposes again amalgamating the silt and clay fractions). Estimate the cover of each size grade provided into the standard categories: 0 (0%), ✓(>0-1%), 1 (>1-10%), 2 (>10-40%), 3 (>40-75%), 4 (>75%).

Note depending on site conditions (sediment type, shore form, fetch and exposure) wave action can be highly effective at sorting littoral zone sediments into distinctive size patterns. Attempt to express the relative cover of different particle size classes across the entire littoral zone plot (effectively a large quadrat of 15 x 10 m = 150 m^2). If there is a significant organic sediment component ring (circle) the silt/clay entry.

Water depth of coarse to fine sediment boundary
Record depth where distinct sediment boundary appears within littoral zone (e.g. where 'fines' (here taken to represent sand+silt+clay) becomes the predominant substrate. This depth corresponds closely to the wave-base (a product of lake fetch)

and is also frequently associated with increased macrophyte cover. If a distinct coarse-fine boundary is not evident record NO.

Any sedimentation over natural substrate?
Record any evidence of sedimentation over the natural substrate, by entering the sediment type using the categories shown under 'Bank material' in Section 2.2 above. This may not always be obvious, but does occur where some form of 'geomorphological imbalance' is occurring e.g. enhanced catchment sediment supply or localised bank/beach erosion. It should be recorded in situations where it can be detected, most obviously where a clear distinction in the texture (particle size) of the accreting sediment is recognised, for example where sandy sediment overlies gravel.

Littoral habitat features
Features within the littoral zone that may provide habitat for fish in particular are recorded in this section. This is important for informing biological surveys, and for linking biological information to hydromorphology. For each feature, assess areal cover within the classes: 0 (0%), ✓(>0-1%), 1 (>1-10%), 2 (>10-40%), 3 (>40-75%), 4 (>75%), then enter '0', '1', '2', '3' or '4' in the appropriate box. Note that features are not mutually exclusive so that overall percentages can add up to more than 100.

Underwater tree roots
Inundated roots of trees growing within or beside the littoral plot.

Woody debris
Non-living woody material. Ring the entry if the material is predominantly ≥ 0.3 m in diameter.

Inundated live trees
Living trees, including trunks and branches. Ring the entry if the material is predominantly ≥ 0.3 m diameter.

Overhanging vegetation
Any branches etc. that overhang the water, and are less than 1 m above the water surface.

Rock ledges or sharp drop-offs
Includes overhanging banks, submerged rock shelves and steep, sloping rock walls that could provide cover for fish.

Vegetation structure
The structure of the vegetation (macrophytes) within the littoral zone is assessed by viewing as much as possible from the offshore station, using the bathyscope if practical. For each type, enter: 0 (0%), ✓(>0-1%), 1 (>1-10%), 2 (>10-40%), 3 (>40-75%), 4 (>75%). Note that the vegetation categories are not mutually exclusive and overall percentages within categories can add up to more than 100.

The variety of vegetation that you may observe is introduced in Part Five of this manual. However, vegetation types are recorded in categories that describe the habitat structure they provide at the time of survey, **not** on their species-specific morphological characteristics as described in textbooks. The purpose is to provide information on the range of functional habitats that vegetation may be providing for other organisms. ***In some cases a single species may occur in more than one form – for example, the yellow water lily has both submerged and floating leaves when mature.*** Be as consistent as possible in assessing cover in growth form categories, not species categories.

Liverworts/mosses/lichens
Aquatic liverworts (e.g. *Scapania*), mosses (e.g. *Fontinalis*) and lichens (e.g. *Collema*). Includes vegetation that is submerged or in the splash zone.

Emergent broad-leaved herbs
Broad-leaved plants rooted on the lake bed. Leaves and flowers grow above water level (e.g. fools water-cress).

Emergent reeds/sedges/rushes
Narrow leaved monocotyledons (includes grasses and horsetails), rooted below water level or along water's edge.

Floating-leaved (rooted)
Plants rooted on the lake bed, with floating leaves. Leaves may be either broad floating leaves (e.g. broad-leaved pondweed), or linear floating leaves (e.g. unbranched bur-reed).

Free-floating
Plants floating on or just under the water surface, but not rooted to the lake bed (e.g. duckweeds, hornwort).

Submerged broad-leaved
Rooted submerged plants with underwater leaves which are no more than four times longer than broad. Some parts of plants may reach the surface, but they are primarily submerged. Examples include some broad-leaved pondweeds, e.g. perfoliate pondweed and Canadian pondweed.

Submerged short, stiff-leaved
Rooted plants, submerged or in the drawdown zone, with short, stiff, narrow tapering leaves (possibly also fleshy and/or dark green) forming a rosette. Characteristic of sandy to stony substrates in nutrient-poor lakes with soft water but little silt or peat. Examples: *Littorella*, *Lobelia* and *Isoetes*.

Submerged linear-leaved
Rooted submerged plants with narrow, unbranched, laminar leaves (blade, strap, belt-shaped), that are predominantly submerged, but may have tips floating on the surface. Examples include unbranched bur-reed, bulrush and flowering rush.

Submerged fine- and dissected-leaved
Rooted submerged plants with fine branched leaves (e.g. fennel pondweed, water milfoil, *Myriophyllum* and stoneworts). Ring your entry if the vegetation observed is an extensive lawn of stoneworts.

Filamentous algae
Blanketweed, green algae (chlorophyceae), or any other obvious filamentous growths. Do not record diatom films that occur alone, or coat plants or stones. In eutrophic sites can contribute to high cover and PVI scores.

Phytobenthos
Diatom and algal growths living on or attached to substrate or other organisms in the littoral zone (inclusive of biofilms).

Seaweeds
Brown macro-algae, e.g. *Fucus* species (wracks), typical of salty environments. Found in brackish lakes.

Total macrophyte PVI (percent volume inhabited)
Estimate the volume of the littoral zone that is inhabited by all types of macrophytes (including filamentous algae). It can be useful to use a bathyscope for this estimate. Enter: 0 (0%), ✓(>0-1%), 1 (>1-10%), 2 (>10-40%), 3 (>40-75%), 4 (>75%). Take care not to overestimate PVI; a PVI of 4 would indicate a completely choked lake.

Do macrophytes extend lakewards?
Record whether macrophyte cover extends lakewards from the littoral zone. Count as 'Yes' only if they extend more than 10 m lakewards from the offshore station. Enter: NV=Not Visible, NO=None, YE=Yes.

Notable introduced species
Record here any incidences of aquatic nuisance species in the littoral zone, shore or bank areas. The main introduced nuisance species associated with standing waters in the UK are:

- Nuttalls pondweed (NP) – *Elodea nuttallii*
- water fern (WF) – *Azolla filiculoides*
- Australian swamp stonecrop (AS) – *Crassula helmsii*
- parrots feather (PF) – *Myriophyllum aquaticum*
- floating pennywort (FP) – *Hydrocotyle ranunculoides*

These species are shown on the species identification sheet in Appendix 1, and there is more information in Part Five of this manual. Canadian pondweed - *Elodea canadensis*- is common, but in recent years it has become less problematic and is considered preferable to the more invasive *Elodea nuttallii* and curly waterweed *Lagarosiphon major*. Record occurrences of Canadian pondweed and curly waterweed as 'Other' if identified (make notes in section 7). Also record evidence of introduced fish or animal species (e.g. zebra mussel if identified) as 'OT' and note in section 7.

SECTION 2.4 HUMAN PRESSURES

Human pressures are to be assessed over the entire plot, including the littoral zone, as well as behind or adjacent to the plot. The area defined as behind or adjacent to the plot is within 50 m of the edge of the plot (i.e. a 50 m buffer around the whole perimeter of the plot, including an area extending into the lake from the lakeward edge of the littoral zone). Record the presence of any of the human pressures described below if observed. Enter: NO= NO (not present), ✓(tick) if present, or use B = present behind or adjacent to the plot.

Commercial activities
Any activities or evidence of activities such as shopping centres, cafes, factories, car parks, barns or other farming constructions. Does not include quarrying or mining.

Residential areas
Suburban housing, schools etc. Even a single house counts!

Roads or railways
Sealed (metalled or tarred) roads and railway lines.

Tracks and footpaths
Unsealed tracks and footpaths.

Parks and gardens
Mowed grass, tended gardens and areas enhanced to encourage visitor use (e.g. parks and playgrounds). Does not include residential lawns or recreational beaches.

Camping and caravaning
Comprises both readily recognised official campsites (with roads and infrastructure) to obvious concentrations of unofficial road- and lake-side camping activities.

Docks, marinas, boats, moorings and platforms
Boats, any construction built for boating use, moorings, jetties and fishing platforms.

Walls, dykes or revetments
Constructions used to control water movement within or out of the lake.

Recreational beaches
Sandy or pebbly beaches that are accessible and suitable for human recreation. Record even if the beach is not being used at the time of survey.

Educational recreation
Outward Bound activities etc.

Litter, dump or landfill
Areas currently or previously used for rubbish disposal.

Quarrying or mining
Large areas of exposed material on land due to mineral or peat extraction, or current extraction occurring.

Improved grassland
Fields that are enclosed for grazing, including improved grassland (regularly replanted) and even relatively rough grassland used for grazing. There may be other evidence of grazing (e.g. poached banks). Ring the entry If grazing observed.

Other grazed land
Land where there is evidence of grazing even though there are no enclosed fields specifically intended for this, e.g. upland rough pasture or moorland. If grazing is actually observed, ring the entry.

Coniferous plantation
Coniferous trees (e.g. sitka spruce, lodgepole pine) planted for commercial forestry. If there is evidence of recent felling, ring the entry.

Tilled land
Regularly ploughed soil either in preparation for, or supporting, crops.

Orchard
Plantation of trees for fruit growing.

Pipes, outfalls
Any pipe intended to direct discharge into the lake, e.g. sewage, stormwater.

Dredging
Extraction of littoral zone substrates, usually to facilitate navigation.

Riparian vegetation control
Evidence of clearing weedy scrub along the shoreline.

Aquatic macrophyte cutting
Evidence of in-lake macrophyte management, usually removal of leafy growths to clear water for recreational activities such as sailing, swimming and fishing.

SECTION 3: WHOLE LAKE ASSESSMENT

The whole lake assessment involves the completion of three sections of the form covering lake perimeter characteristics, lake site activities/pressures, and landform features. While viewing the shoreline, take note of features that will be recorded in all of these survey sections, as well as anything that is relevant to Section 4, which deals with hydrology.

SECTION 3.1 LAKE PERIMETER CHARACTERISTICS

Circle the contents of one of the two boxes at top left of the page to indicate the whether 'Boat' or foot-based surveys were carried out. As you view each shoreline section, trace it on the sketch map as shown for each method in Part 1 (E) of this manual ***(this is most effectively done by annotating directly on a topographic map, large-scale colour versions e.g. 1:25,000 are most valuable).*** Estimate the fraction (%) of the perimeter that each shoreline section represents and write it in the space provided on the form. Attempt to survey the entire shore, but if this is not possible always observe at least 75% of the total perimeter.

For each shore section defined, estimate what fraction of this length contains the various features listed in section 3.1. Do this first for belt between 10 m from the water's edge to 15 m landwards of the bank edge, which equates to the 'Littoral + Shore + Riparian Zones of Hab-Plots. Then repeat the observation for the same perimeter section, extending the landward limit to 50 m from the bank edge i.e. this belt is from >15 to 50 m. In the spaces provided on the form, enter: 0 (0%), ✓(>0-1%), 1 (>1-10%), 2 (>10-40%), 3 (>40-75%), 4 (>75%). **NB** these entries are length estimates, and multiple feature entries (exceeding 100 % are common), e.g. for a shore section containing continuous reed-beds and fringing wet woodland both would be entered as 4's in their respective boxes within the first belt.

Comparison of the two estimates should indicate which pressures are operating immediately adjacent to the lake, and which are possibly buffered; e.g. bank erosion vs. loss of soil from ploughed fields separated by a vegetated riparian buffer strip. The features to be recorded are described below. Ring any entry that you consider indicates a pressure which is affecting a critical area, such as spawning grounds.

Bank construction

Impoundments
Human-engineered structures acting to control water, e.g. dams, walls, etc.

Hard engineering
The use of resilient materials such as concrete breakwaters and steel sheet piling to stabilise shorelines (do not include water control structures, but do include docks and marinas composed of hard engineering materials). Two sub-types of engineering can be distinguished:

- **Closed**-type: Any sealed material, such as sheet piling (metal, wood); concrete and brick-laid stone walls/embankments
- Open-type: Any unsealed material, such as rip-rap, boulder placements and gabion baskets

Soft engineering
Stabilisation of the shoreline using 'soft' materials including basket-work, live vegetation e.g. planted saplings and woven live willow, dumped natural debris (to re-nourish sediment supply) and soft synthetic materials. Also earthmoving, such as re-

sectioning and re-profiling of the shore, but without the use of hard engineering materials.

Docks and marinas
Includes docks, marinas, jetties, boats and any construction built for boating use.

Pressures and land use

Commercial activities
Any activities or evidence of activities such as hotels, shopping centres, cafes, factories, car parks, barns or other farming constructions. Does not include quarrying, mining or residential areas.

Residential areas
Residential buildings, such as suburban housing, schools etc. (includes a single house and areas of residential lawn).

Roads, railways, paths
Tarred roads and railway lines.

Parks and gardens
Mowed grass, tended gardens and areas enhanced to encourage visitor use (e.g. parks and playgrounds). Does not include residential lawns or recreational beaches.

Camping and caravaning
Comprises both readily recognised official campsites (with roads and infrastructure) to obvious concentrations of unofficial road- and lake-side camping activities.

Recreational beaches
Sandy or pebbly beaches that are accessible and suitable for human recreation. Record even if the beach is not being used at the time of survey.

Educational recreation
Indicate whether the lake is used for field courses, nature walks etc. if known.

Litter, dump or landfill
Areas currently or previously used for rubbish disposal.

Quarrying or mining
Large areas of exposed material on land due to extraction of minerals or peat, or current extraction occurring.

Coniferous plantation
Coniferous trees (e.g. Sitka spruce, lodgepole pine) planted for commercial forestry. If there is evidence of recent felling, enter an estimate of extent in the next row.

Improved grassland
Fields that are enclosed for grazing, including improved or unimproved grassland. There may be other evidence of grazing (e.g. poached banks).

Observed grazing
Record if grazing is actually observed.

Tilled land
Regularly ploughed soil either in preparation for, or supporting, crops.

Orchard
Plantation of trees for fruit growing.

Erosion
Areas of bank or beaches showing signs of sediment removal or deposition. Also record soil or peat erosion on land within 15 or 50 metres of the bank top as appropriate.

Wetland habitats

Reedbed
Fringing reeds such as common/Norfolk reed which extend at least halfway up the bank. Do not record if it extends for less than 10 m along the bank.

Wet woodland (carr)
Comprises trees such as willow and alder, with an understorey of wetland herbs, reeds and mosses. Often occurs at the edges of other wetland types.

Bog
Vegetation growing on permanently wet peat where the water table is at, or below, the general ground surface (although there may be numerous open water pools). The bog surface is domed so that its only water source is rainfall. *Sphagnum* moss almost always present, often with bog cotton.

Fen or marsh
Wetlands sustained by surface water or groundwater, with flat or concave surfaces. Fen is usually peat-forming and the water table is always at or just below the ground surface. Fen vegetation may include *Sphagnum* moss, but is often dominated by tall reeds, wetland herbs, sedges and rushes. Marsh vegetation is quite similar (tall grasses, rushes, wetland herbs) but it grows on periodically (not permanently) wet ground and does not form peat.

Floating vegetation mats
Floating rafts of non-rooted emergents such as bogbean (*Menyanthes*) or reed (*Phragmites*). Also floating ('quaking') mats of *Sphagnum* moss with or without other plants rooted in them, known as schwingmoor. Usually occur as floating 'ledges' or 'shelves' of vegetation attached to the shore as lakeward extensions of riparian wetlands (reedbeds, bogs or fens).

Other wetlands
Other wetland habitats include:

- **Flushes**: a collective term for wet areas near springs where water emerges from the ground or seeps from fissures in valleys or rock faces. Fed by groundwater.
- **Water meadows**: floodplain meadows, which often feature remnant channels and floodplain grasslands.

Other habitats

Broadleaf/mixed woodland
Natural or semi-natural woodland with predominantly deciduous trees. Excludes mixed plantations.

Broadleaf/mixed plantation
Plantation woodland of deciduous trees (e.g. poplars). Includes sapling plantations.

Coniferous woodland
Natural or semi-natural native conifers, typically Caledonian forest in Scotland. Excludes plantations.

Scrub and shrubs
Scrub (e.g. brambles, gorse, rhododendron) and woody shrubs (e.g. blackthorn and hawthorn).

Moorland/heath
Heather, sometimes with acid tolerant grasses, cotton grass.

Open water
Natural lakes, ponds, bog pools etc.

Rough grassland
Unimproved grassland, usually herb rich and tussocky, and not enclosed for grazing.

Tall herb/rank vegetation
Vegetation of at least waist height, dominated by herbs (not grasses or reeds), includes bracken.

Rock, scree or dunes
Rocky outcrops, mountain scree, sand dunes.

SECTION 3.2 LAKE SITE ACTIVITIES / PRESSURES

Whilst carrying out the survey, observe evidence that any of the lake site activities listed below occurs within the lake or up to 50 m from the shore. If any of these activities is known to occur, tick the box 'P', and circle the tick if the activity is actually observed on the day of the survey.

For some activities, you are asked to estimate the areal cover of the pressure or construction to the nearest 5%. For others, you are requested to indicate whether the activity is extensive (tick box 'E') if more than 30% of the lake area or shoreline length is affected; and/or intensive (tick box 'I') if it is at high density over the area affected (relevant definitions are given for each activity below). Specify any other activities/pressures observed in the space provided.

Table 3.6 Lake site activities and pressures

Activity/pressure	Description	Threshold for extensive	Threshold for intensive
Bridges	Bridge over the lake for roads, railways or for supporting pipes or other infrastructure.	NA	NA
Causeways	Routeway, road, or railway constructed across the lake forming physical barrier extending to the lake bed where gaps in the foundings represent < 20% of the total length	NA	NA
Fish cages (aquaculture)	Cages used for commercial fish farming	NA	NA

Activity/pressure	Description	Threshold for extensive	Threshold for intensive
Commercial fishing	Commercial scale operations with nets or traps	NA	NA
Dredging	Any evidence of sediment removal, usually for navigation or recreational purposes	NA	NA
Dumping	Dumping of sediment or land reclamation	NA	NA
Commercial fishing	Commercial scale operations with nets or traps	NA	NA
Macrophyte control	Clearing and management of macrophytes, usually for recreational purposes such as sailing and swimming	NA	NA
Motorboat activities	Any sport activity involving a boat with a motor (e.g. jetski, waterskiing)	> 30% of lake area	> 1 boat ha^{-1}
Non-motor boat activities	Any boating activity not involving a motor (e.g. sailing, windsurfing, rowing)		
Angling from boat	Any form of fishing taking place from a boat		
Angling from shore	Any form of fishing taking place from the shore	> 30 % of shoreline	Visible disturbance caused by baiting, trampling, etc OR Unrestricted access to breeding sites and nursery grounds
Non-boat recreation / swimming	Non-boat recreational activities usually associated with the lake shore (includes swimming, paddling, wading)	> 30 % of lake area or shoreline	High levels of activity along the shore and/or extending into the lake
Wildfowling and hunting	Shooting and hunting of wild birds and animals		Large amounts of litter at any one site
Introduced species	Any aquatic or riparian non-native and nuisance species		A high density of nuisance species at any one site
Fish stocking	Supplementing fish populations with added stocks, usually for commercial fisheries.	NA	NA
Navigation lanes	Areas of the lake are used for boat traffic	NA	NA
Military activities	Any evidence of military vehicles, shelling, jets, etc	NA	NA
Powerlines	Any powerlines in the vicinity of the lake area	NA	NA
Chemical applications	The addition of chemicals e.g. lime to counteract high acidity levels in lakes	NA	NA
Surface films	Scums, slicks, algal mats, etc, observed at any time during the survey	NA	NA

SECTION 3.3 LANDFORM FEATURES

Indicate the extent of any of the following landform features that are observed during the survey. Enter: 0 (0%), ✓(>0-1%), 1 (>1-10%), 2 (>10-40%), 3 (>40-75%), 4 (>75%).

Many of these are deltaic features, where a ***delta*** can be defined as: a typically fan-shaped deposit of alluvial sediment located at the mouth of a stream where it enters a body of standing water. Specify any others observed in the space provided or in Section 7.

Vegetated islands (non deltaic)
Vegetated islands not formed by deltaic deposits. These are generally comprised of bedrock or other stable material and are usually remnants which glaciers have scoured around.

Unvegetated islands (non deltaic)
Unvegetated islands not formed by deltaic deposits. These are generally comprised of bedrock or other stable material and are usually remnants which glaciers have scoured around.

Aggrading vegetated deltaic deposit
A vegetated bar that has large areas of deposition, indicating that it is still forming (includes all substrate types).

Stable vegetated islands (deltaic)
Islands that have permanent vegetation and appear to be in a stable condition, i.e. not aggrading or degrading.

Deltaic unvegetated gravel deposit
Unvegetated deposit made up of gravel.

Deltaic unvegetated sand/silt/clay deposit
Deposit of sandy, silt or clay substrate without vegetation, indicating instability.

SECTION 3.4 OUTLET GEOMETRY

Assess the cross-sectional shape of the lake's outlet channel at the control section – the point where the change from lake to river conditions occurs. If this is not obvious, do this at the narrowest point of the outlet channel. Tick the box below the sketch that shows the most similar channel cross-section, and estimate the width of the water surface at the control section. Channel form choices are illustrated below.

Trapezoidal Vee-shaped Rectangular Parabolic

SECTION 4: HYDROLOGY

Little is known about the hydrological regimes of lakes in the UK, so that any information that can be gathered in conjunction with LHS survey is highly valuable. Whilst it is probably impossible to obtain a definitive indication of e.g. the annual range of water level fluctuations from a single site visit, any opportunities to record

information on the water level regime and any modifications to it associated with water use should be exploited.

The survey generally takes the approach that the water level conditions on the day of survey are simply recorded – for example, there may or may not be a visible beach. If there is a beach, its width gives one measurement for drawdown of the water level. If there is a trashline, this gives a second indication of the range of water level fluctuations. If no beach is visible, the water level may be close to its annual maximum, or the water level may have been artificially raised.

Observations of impoundments and other structures designed to change the water level give further insights, as do observations of hydro-power plants, discharges, and diversion channels. It may be difficult to assess some of this type of evidence from observation alone; for example it may not be clear which species can successfully pass a hydro-power dam even if it incorporates a salmon ladder, and Borland lifts are not always obvious and may not be effective in any case. Thus, if data from desk-based sources are available (as within some of the UK agencies), or if information on water level fluctuations can be obtained from a stakeholder before the survey, this should be done at the same time as Section 1 of the form is completed. Otherwise on-site estimates can be made, in order to fill out as much of this section as possible.

Whilst features associated with large-scale uses like hydro-power and water supply can usually be obtained from other sources, the smaller-scale 'unofficial' modifications e.g. associated with local use of lakes for fisheries, are not; and special care shoud be taken to record these during the survey.

Some characteristics of the hydrological regime will need to be recorded as features are observed during other parts of the survey (e.g. hydrological features should be observed when conducting the shoreline survey).

Principal use
Circle the principal use of the water body, if any. More than one use may be circled if applicable.

Hydropower
Water body is used for generating electricity

Water Supply
Water body is used for water supply (may not always be an artificial reservoir)

Flood Control
Water body is used to store or divert flows for flood management

Navigation
Water body is used for boat traffic moving from place to place. This is often associated with lakes that are joined by a series of canals.

Amenity
The water body is used for recreation activities, such as water-sports, tourism and fishing.

Water body type
Circle the appropriate water body type for the lake in relation to naturalness of formation.

Natural$_{(unmodified)}$
The lake was formed naturally and has not been raised or lowered.

Natural$_{(raised)}$
The lake was formed naturally but has since been raised, often in lakes that have been dammed for hydropower or water supply.

Natural$_{(lowered)}$
The lake was formed naturally but has since been lowered, often to gain fertile farmland in the previous submerged zone.

Impoundment
The lake was formed from by damming a watercourse, i.e. before human intervention a standing water body was not present.

Flooded pit
The lake was formed by digging and filling a pit with water, i.e. before human intervention a standing water body (or running watercourse) was not present.

Hydrology questions:
If the lake has been raised or lowered, **state height difference of water level** relative to natural condition (m). Fill in this if known.

If the lake has been raised or lowered, **state when raising or lowering occurred**. Fill in to nearest year if known, however less certain and/or accurate entries are still useful.

State the maximum **height from lake bed of principal retaining structure** (m). The map may help to locate the principal retaining structure.

State the **number of significant influent streams.** Significant streams can be defined as those with a catchment area >10% of the total catchment.

Are there **any upstream impoundments**? Observe this at the site or use the map to find the answer to this if possible.

Is there any evidence of significant **flow diversion** into/out of the catchment? Observe this at the site.

Does the water level experience **tidal influence**? Tides are likely if the lake is coastal. Otherwise, use local knowledge and observe evidence of twice daily fluctuations in water level.

Tick a box to indicate the maximum **vertical range of water level fluctuation** for both annual and daily cycles. Indicate whether the measurement was estimated on-site or was obtained from data records.

Hydrological structures observed
As you traverse the lake and view the lake shore, make a tally of the number of each type of hydrological control structure in the boxes provided. This means that when the percentage of shore length taken up by an impoundment is recorded in Table 3.1, the details will need to be recorded here. As shown on the form, separate structures according to whether they are at an inflow or an outflow.

On completing the survey, add up the numbers. Add any other hydrological control structures in the space provided.

Dam without fish pass
Dam with no opening or ladder to allow the movement of fish.

Dam with fish pass
Dam with opening or ladder to allow the movement of fish. Some dams have enclosed arrangements for fish passage (e.g. Borland lift), which may not be so obvious as open fish ladders (series of connected pools at different levels). This is important mostly for fish spawning migrations. Not all fish species can successfully negotiate fish ladders, and Borland lifts do not always work properly.

Channelised channel
A stream flowing into or out of the lake that has been straightened and/or deepened.

Barrage
A structure comprising a series of gates which, when fully open, allow floods to pass without appreciably increasing the flood level upstream, at the inflow or outflow of the lake

Sluice
A structure containing a gate to control the flow of water from one area to another, at the inflow or outflow of the lake

Lock
An enclosure in a canal at the inflow or outflow of the lake with gates at each end, used in raising or lowering boats as they pass from one level to another.

Weir
A barrier placed across a stream, river, or canal at the inflow or outflow of the lake, to catch or hold fish, or to raise or divert the water in order to regulate its flow.

Outfall
A point of discharge into the lake, e.g. sewer discharges.

Intake
Point of abstraction from the lake.

SECTION 5: LAKE PROFILE INFORMATION AT INDEX SITE

SECTION 5.1 INDEX SITE AND WATER CONDITIONS

The Index Site is used to provide a single measure representative of the physical characteristics of the water body. It is located at the deepest point of the lake, which if not already known, can be found using a brief sonar survey.

Upon arrival at the Index Site, record the grid reference in the space provided, using the same co-ordinate system as for the Hab-Plots. Additionally, mark the location on the sketch map.

Record the **surface water conditions**, which may be:

- Flat
- Ripple
- Choppy
- Breaking waves

Record any **surface films**, such as:

- Scum
- Algal mat
- Oily films
- Other (note in Section 6)

Record any **odours**, such as:

- Sulphurous
- Sewage
- Oily
- Chemical
- Other (note in Section 6)

Using a fathometer or weighted cord, take a **depth** measurement in metres at the exact location of the Index Site and record this in the space provided. Indicate whether or not you can see the bottom vertically below you by circling 'yes' or 'no'.

Measure the water clarity as the **Secchi disc transparency**. Lower the Secchi disc into the water, and record the (shallowest) depth (m) at which you can no longer see it. Then raise the disc and record the depth at which it re-appears. The water clarity is given by the average of these two values.

SECTION 5.2 DISSOLVED OXYGEN AND TEMPERATURE PROFILE

If the survey is being conducted in July, August or September, take the dissolved oxygen and temperature measurements of the water profile using a dissolved oxygen and temperature probe. Measure at the surface, and then at depths (m) of 0.5, 1, 1.5, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 20, 25, 30, 35, 40 and 50 m. Include readings at 1 m above the lake bottom. If depth ≤ 3 m, take readings at the surface, every 0.5 m, and 0.5 m above the bottom.

Locate the position of the metalimnion (also known as the thermocline), i.e. region of the water temperature profile where the temperature changes at a rate of 1^{o}C or more per metre of depth. Indicate the depth of the top of the metalimnion with a "T", and the bottom of the metalimnion (when the rate of change becomes less than 1^{o}C per metre) with a "B". After the metalimnion is encountered, take readings every 1 m until bottom of the metalimnion is reached.

When bringing up the probe, take a repeat dissolved oxygen reading at the surface, and confirm whether this reading is within ± 0.5 mg L^{-1} of the initial surface reading.

SECTION 6: FIELD SURVEY QUALITY CONTROL

Check the list of questions given in this section, and tick boxes to confirm completion of each part of the survey. If any remains incomplete, give reasons. The quality assurance questions are as follows:

- Have you taken two or more photographs of the site and one of each Hab-Plot?
- Have you filled in the lake's name, UKLakes WBID, date and visit number on each page?
- Have you sketched the lake on page 1 (or provided photocopy of OS map), and annotated it?
- Have you completed the background data (from UKLakes) on page 1?
- Have you filled in 'time at end of survey' and 'estimated LHS time' (Section 1.2) on page 1?
- Have you completed 10 Hab-Plots, including GPS locations (Section 2) on pages 2 and 3?
- Have you surveyed at least 75% of the lake shoreline (Section 3) on page 4?
- Have you completed the whole lake survey (Section 3), activities, special habitats, and animals on page 5?
- Have you completed the hydrology section (Section 4) on page 5 answering all questions possible?
- If a boat is available, have you completed the Index Site (Section 5)?

SECTION 7: FURTHER COMMENTS

You should use this section at any time during the survey to record:

- Any other survey work that was carried out in conjunction with LHS
- details of any situation that arose during the survey when you recorded 'other' instead of one of the options offered, if there was insufficient space for a full account in the relevant section of the form;
- information about any other problems you encountered whilst carrying out the survey;
- any other comments on the survey protocol; and
- any mistakes that you found in UKLakes.

Also make a note here of any animals observed that may directly or indirectly have an impact on, or provide some indication of the condition of, the lake; for example:

- animals that are of special interest for conservation, such as rare species, red list species, and species listed in Annex 2 of the European Habitats Directive;
- animals that depend on a resource provided by the lake, e.g. fish or for food (indicating a healthy fish population);
- animals from which there is a risk of over-exploitation of the resource, which may affect the ecological status of the lake; especially
- birds that congregate in large flocks, which might be responsible for raising nutrient levels if they move between the lake and other feeding grounds (indicate if you know this is the case); and
- non-native species.

Some examples of animal species for which sightings should be noted are listed in Table 3.7.

Table 3.7 Some animals that might indicate/affect the condition of lakes; record species if possible, and numbers, if sighted.

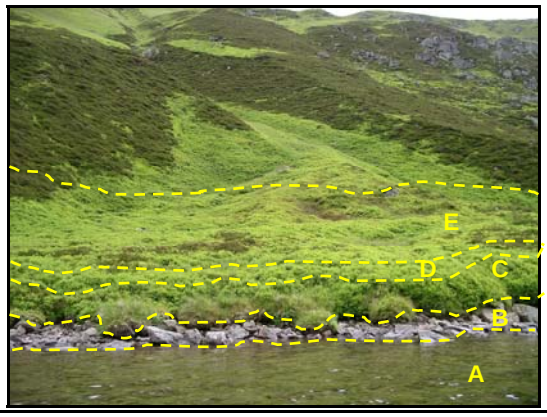
Group	Species	Background information
Insects	dragonflies	Conservation interest
Birds	black-headed gull	Colonies may introduce nutrients, especially if they feed elsewhere
	Canada goose	Large flocks may bring nutrients to the lake if they feed elsewhere
	coot	Macrophyte dependent – indicates an abundant and healthy macrophyte population
	swan	
	cormorant	Piscivore – primarily dependent upon a diet of fish, indicates an abundant and healthy fish population
	grebe	
	kingfisher	
	osprey	Piscivore, high conservation interest
Mammals	mink	Non-native, invasive introduced pest
	otter	Conservation interest

PART FOUR: PHOTOGRAPH GALLERY

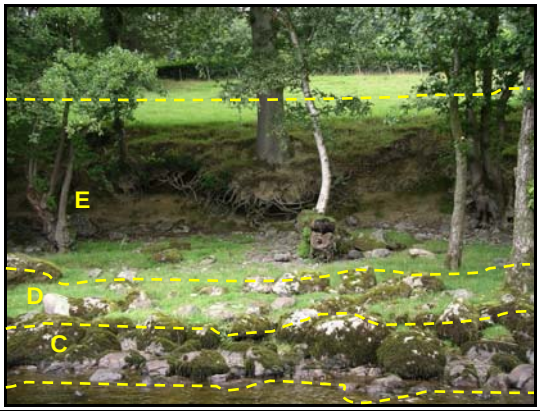
Three examples of Hab-plots are given below to illustrate the accepted boundaries between Hab-plot zones, where:

A = Littoral Zone (extends 10 m lakewards from waterline)
B = Beach (Variable width; May not be present)
C = Bankface (Variable height; May not be present)
D = Banktop (Extends 1 m shorewards from back of bank)
E = Riparian Zone (Extends 15 m shorewards from back of bank)

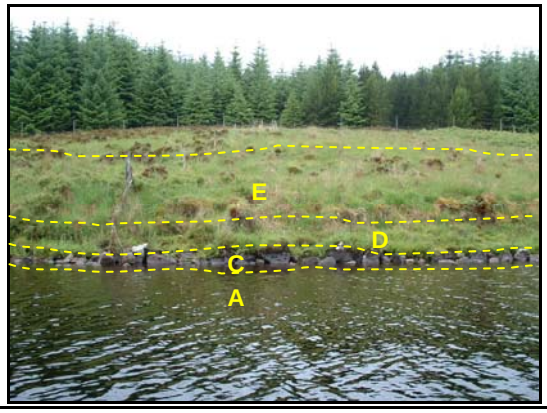
Loch Brandy: LA, deep



Llyn Tegid: LA, deep



Loch Ailsh: LA, shallow



PART FIVE: ESSENTIALS OF PLANT IDENTIFICATION

INTRODUCED (NUISANCE) PLANT SPECIES

These are non-native plant species that have become established in the wild and can vigorously out-compete native species in certain situations. It is important that all LHS surveyors should be able to recognise these species, and to take precautions to avoid spreading them to other lakes. The species identification sheet illustrates the most important nuisance species, which all surveyors **must** be able to recognise. Some surveyors may have additional 'pet' nuisance species, and are encouraged to record these in Section 7 of the form.

When these species reach 'nuisance' level, you are bound to see them because they form dense stands that tend to eliminate all other plants. If your record of a nuisance species is based on a chance sighting of just a few specimens, make a note of this in Section 7 of the form. Odd plants need not cause nuisance, but their presence may indicate that they are just beginning to invade!

Nuisance species fall into two groups, terrestrial and aquatic species, which are recorded in different parts of the LHS form.

Terrestrial species

You will usually find these in the riparian zone, but they may also be present in the shore zone if there is one. If they occur anywhere within the Hab-Plot, record them under 'riparian zone' (Section 2.1 of the form).

English name and *Latin name*	Notes
Giant hogweed *Heracleum mantegazzianum*	You can't really miss this, because it is an enormous herb with large umbels of white flowers well above head height. Avoid touching or brushing against the plants because they can severely irritate the skin.
Rhododendron *Rhododendron ponticum*	Familiar as a garden shrub with large, brightly coloured flowers in early summer. Unfortunately, escaped plants are now vigorously invading much semi-natural and natural land.
Himalayan balsam *Impatiens glandulifera*	An alternative name for this herb is 'policeman's helmet' because of the shape of the pink flowers.
Japanese knotweed *Fallopia japponica*	A woody shrub that forms dense, impenetrable thickets once it gets established.

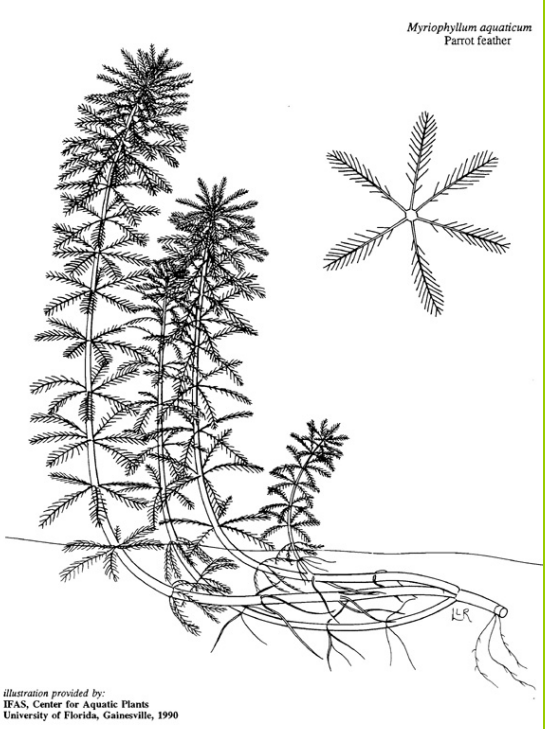
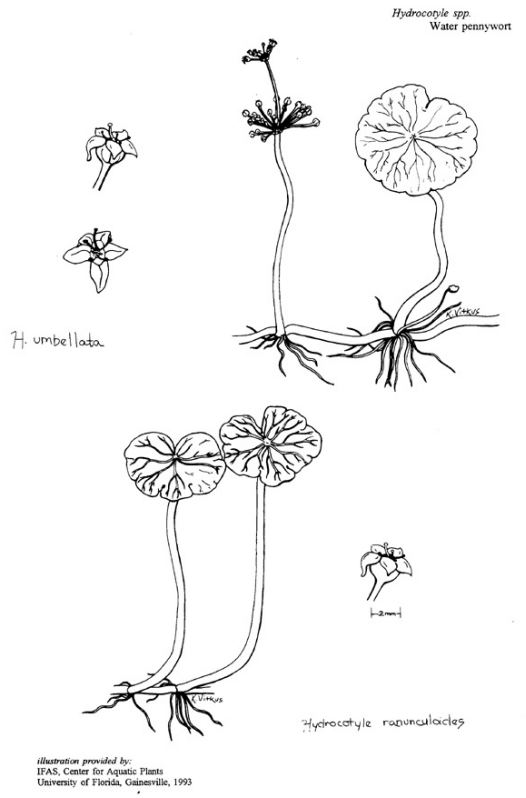
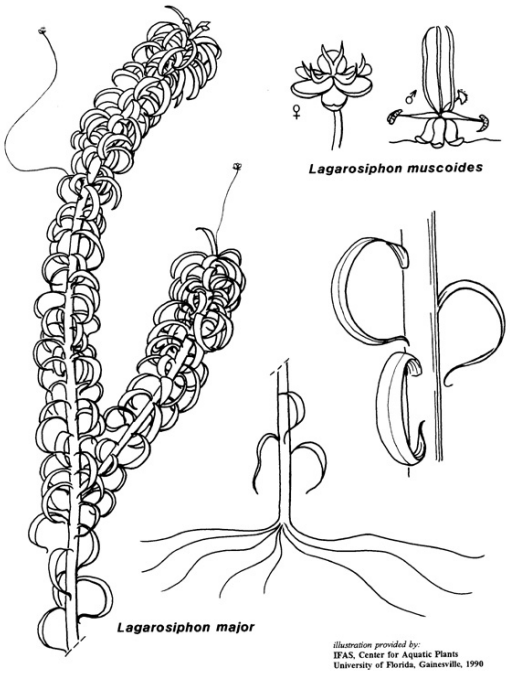
Aquatic species

You will find these in the littoral zone, but they may also be present on the beach, especially if the shore zone is relatively temporary; they are recorded under 'littoral zone' (Section 2.3 of the form).

The most common nuisance species associated with lake shores are illustrated on the species identification sheet, but there are a few additional ones that can be invasive. Record occurrences of any species you find, if necessary as 'Other' in Section 7 of the form. As these species may be less familiar to non-botanists, some additional illustrations are provided here; as line drawings. For a couple of species that may not be adequately covered by the field sheet, there are also additional colour illustrations showing the plants in close-up and the way that they grow.

water fern : *Azolla filiculoides*

Australian swamp stonecrop : *Crassula helmsii*

parrots feather *Myriophyllum aquaticum*	floating pennywort *Hydrocotyle ranunculoides*
	
curly waterweed *Lagarosiphon major*	Nuttalls pondweed *Elodea nuttallii*
	
Canadian pondweed *Elodea canadensis*	A relative of Nuttalls pondweed, this is also regarded as a nuisance species but in recent years it has become less problematic and is now considered preferable to other more invasive species

HABITAT SURVEYOR'S GUIDE TO LAKE VEGETATION

Shore zone vegetation can consist of:

- **TA** – Tall vegetation greater than 5 m in height;
- **ME** – Medium vegetation from 0.5 to 5 m in height;
- **SH** – Short vegetation less than 0.5 m in height;
- **MI** – Mixed: use if two or more of the above are present; and

TA (tall) mature deciduous trees	
SH (short) mown grass	
SH (short) farmland	
SH (short) grazed upland vegetation	

ME (medium) reeds >0.5 m tall	
MI (MIXED) ME (medium) small trees and shrubs + SH (short) mown grass and un-mown grass/herbs	
MI (mixed) TA (tall) mature trees + ME (medium) smaller trees + SH (short) heather and other scrub	

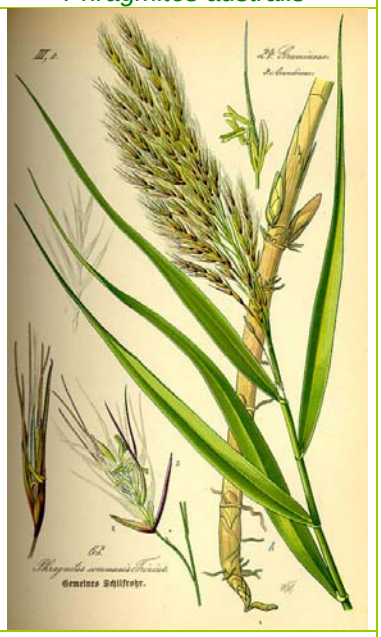
Some examples of aquatic vegetation for LHS surveyors

'Quaking' bank

Floating rafts of normally emergent vegetation such as bogbean or reed. Instead of growing into a substrate, the roots have woven together to form a floating mattress extending into the lake from the banktop. Also floating ('quaking') mats of bog moss (*Sphagnum* which never has roots), usually with higher (vascular) plants rooted in them, known as schwingmoor. Usually occur as floating 'ledges' or 'shelves' of vegetation attached to the shore as lakeward extensions of riparian wetlands (reedbeds, bogs or fens).

Bogbean
Menyanthes trifoliata

Common reed
Phragmites australis



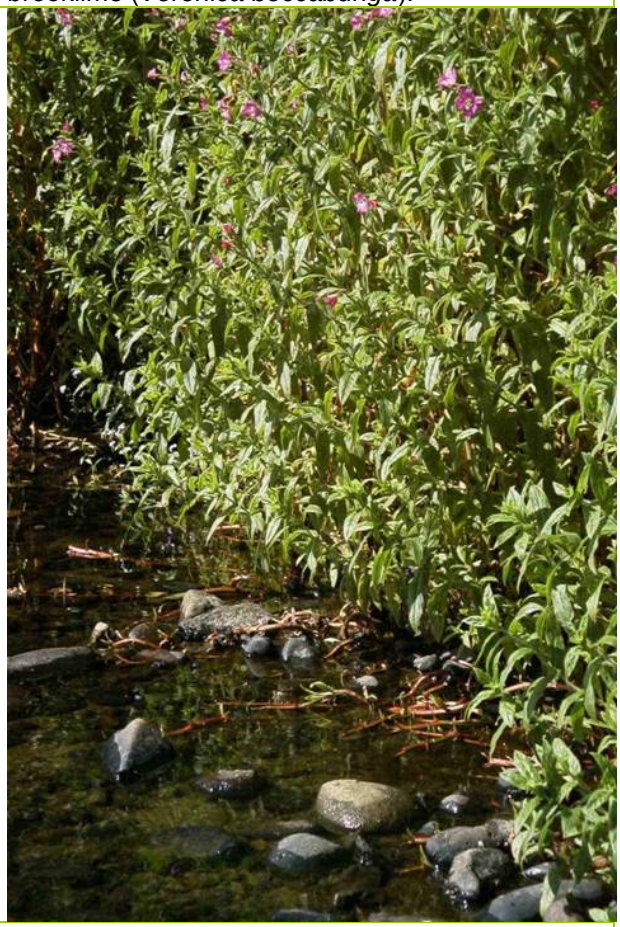
Liverworts/mosses/lichens

Submerged or emergent aquatic mosses (e.g. *Fontinalis, Sphagnum*) liverworts (e.g. *Scapania*), and lichens (e.g. *Collema*). Includes attached plants only, which may be submerged or in the splash zone.

Common water moss
Fontinalis antipyretica

Emergent broad-leaved herbs

Broad-leaved plants rooted on the lake bed. Leaves and flowers grow above water level e.g. fool's water-cress (*Apium nodiflorum*) and brooklime (*Veronica beccabunga*).



(Photo N. Willby)

Emergent reeds/sedges/rushes

Emergent plants with narrow leaves or green 'leafless' stems, rooted below water level or along the water's edge. Includes grasses, sedges and horsetails.

Bottle sedge
Carex rostrata

Water horsetail
Equisetum fluviatile

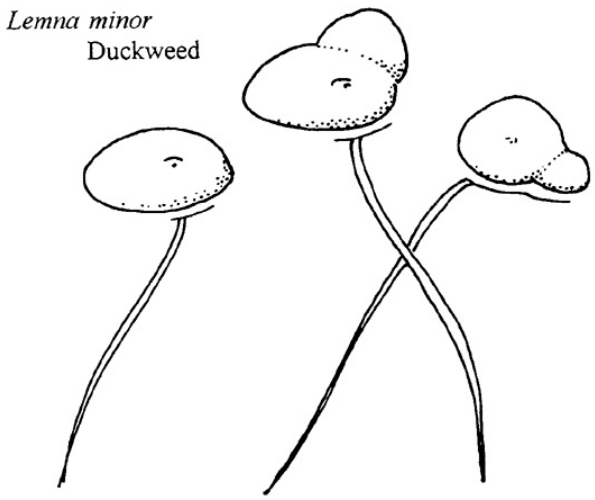
Common spike-rush
Eleocharis palustris

Emergent reeds (photo N. Willby)

Free-floating

Plants floating on or just under the water surface, but not rooted to the lake bed (e.g. duckweeds, hornwort).

Duckweed
Lemna minor



Floating-leaved (rooted)

Plants rooted on the lake bed, with floating leaves. Leaves may be either broad floating leaves (e.g. broad-leaved pondweed and water lilies), or linear floating leaves (e.g. unbranched bur-reed).

Floating pondweed (foreground) with emergent vegetation at the lake edge beyond.

Common / floating pondweed
Potamogeton natans (Loch Leven, Scotland)

Yellow water lily; *Nuphar lutea*
(Loch of Lindores, Scotland)

Submerged broad-leaved

Rooted submerged plants with underwater leaves which are no more than four times longer than broad. Some parts of plants may reach the surface, but they are primarily submerged. Examples include yellow water lily (which has both submerged and floating leaves), some broad-leaved pondweeds, e.g. perfoliate pondweed and Canadian pondweed.

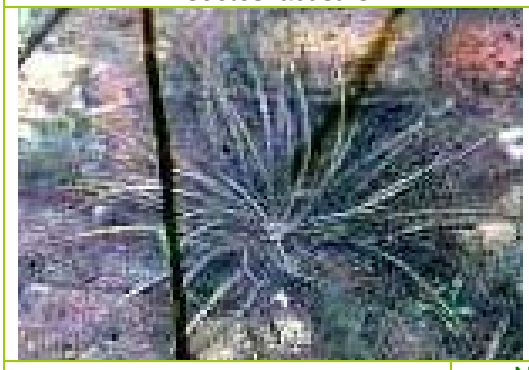
Narrow water starwort
Callitriche hermaphroditica

Marshwort
Apium inundatum

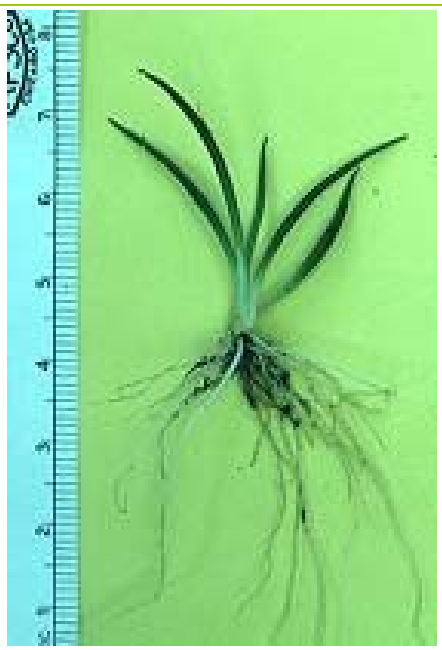
Submerged short, stiff-leaved

Rooted plants, submerged or in the drawdown zone, with short, stiff, narrow tapering leaves (possibly also fleshy and/or dark green) forming a rosette. Characteristic of sandy to stony substrates in nutrient-poor lakes with soft water but little silt or peat.

Lake quillwort
Isoetes lacustris



Shoreweed
Littorella uniflora



Water lobelia
Lobelia dortmanna

Submerged linear-leaved

Rooted submerged plants with narrow, unbranched, laminar leaves (blade, strap, belt-shaped), that are predominantly submerged, but may have tips floating on the surface. Examples include unbranched bur-reed, bulrush and flowering rush.

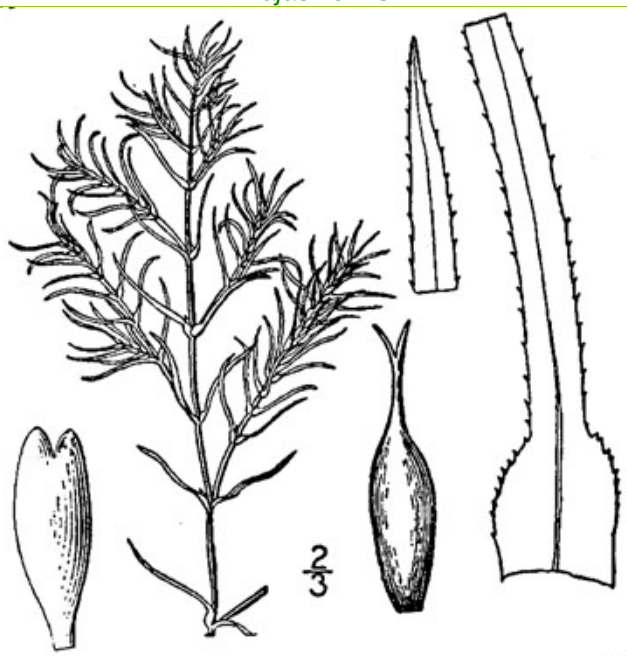
Narrow-leaved bur-reed
Sparganium angustifolium

(photo N. Willby)

Submerged fine-leaved

slender naiad
Najas flexilis

Rooted submerged plants with fine branched leaves, e.g. fennel pondweed (*Potamogeton pectinatus*) and stoneworts.

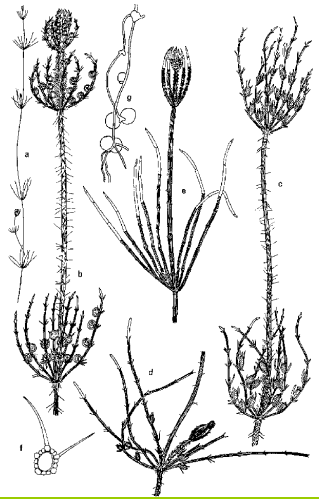


Submerged fine-leaved (stoneworts)

Nitella opaca

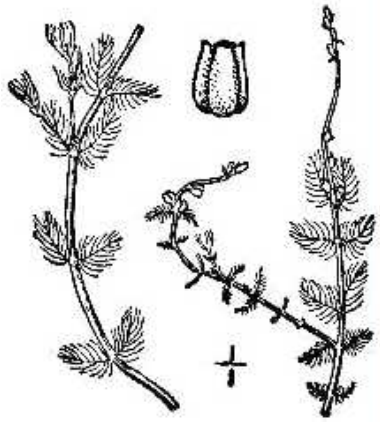
Stonewort
Chara aspera

Rooted submerged algae with fine ‘leaves’, may form extensive lawns on the lake bed.



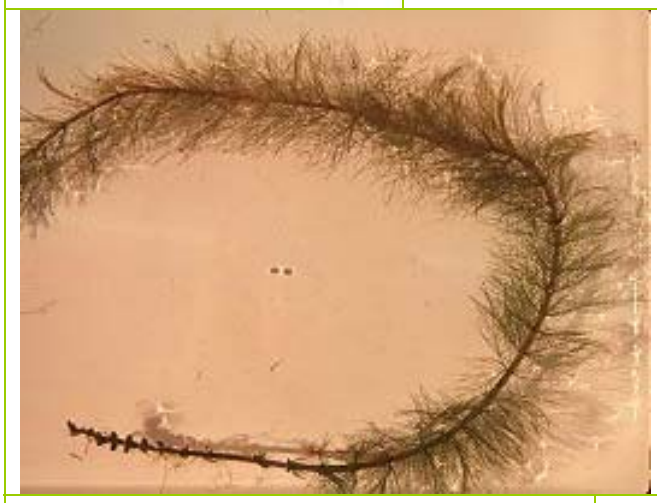
Submerged dissected-leaved

alternate-flowered water milfoil
Myriophyllum alterniflorum

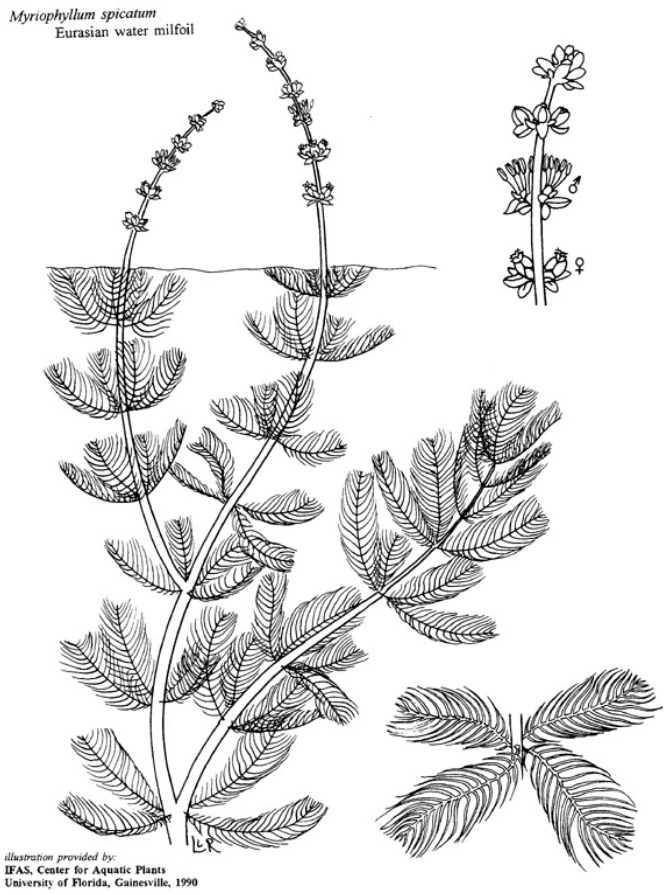


e..g. *Myriophyllum* species

whorled water milfoil
Myriophyllum verticillatum



spiked water milfoil
Myriophyllum spicatum



Filamentous algae

Enteromorpha intestinalis

Blanketweed, green algae (chlorophyceae) such as *Enteromorpha*, or any other obvious filamentous growths. Do not record diatom films that occur alone, or coat plants or stones.

APPENDIX I: LHS FIELD SURVEY FORM VERSION 3.1

LAKE HABITAT SURVEY (LHS)

Name of Lake:	UKLakes code (or other- specify): WBID	Date:	Visit #

1. LAKE INFORMATION AND SURVEY DETAILS

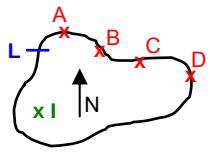
1.1 BACKGROUND INFORMATION (use UKLakes database and recent OS 1:50,000 topographic map)

IF YOU FIND ANY ERRORS IN UKLAKES, PLEASE RECORD THESE IN SECTION 7 OF THE FORM

Maximum depth (m) *[if known]*		*Circle method by which depth was determined*	Modelled / Measured
Lake perimeter (inc. islands) (m)		Lake altitude (m)	
Lake Surface area (km^2)		Catchment area (km^2)	

Lake type [circle]:	Peat, Low Alkalinity, Medium Alkalinity, High Alkalinity, Marl, Brackish
Catchment geology [circle]:	Siliceous / Calcareous / Organic / Mixed (also circle components)
Dominant catchment land cover [circle]:	NV, BL, BP, CW, CP, SH, WL, MH, RP, IG, TH, TL, IL, PG, SU
Mode of lake formation *[if known]* [circle]:	RV, RC, KL, KH, GD, DP, FV, WW, BS, CW, IW, EH, ED, BP, OT
Designation status [circle]:	SAC, SPA, NNR, SSSI/ASSI, LNR , Ramsar Site, or OTHER (specify in Section 7)

MARK ON MAP
Arrow indicating North and scale bar
L = Launch site (if using boat)
A,B,C,D…etc = location each Hab-Plot
I = Index site



Trace lake outline into space provided below or annotate directly on an appropriately-scaled colour base-map. Attach with your survey form (colour maps e.g. 1:25,000 are most useful)

Trace from topographic base map (circle scale) [1:10,000, 1:25,000, 1:50,000, other specify]:
Indicate source of map (e.g. Mastermap, OS Map, Other):
Indicate age of map:

1.2 SURVEY DETAILS (fill in when commencing and finishing field survey)

Surveyor name(s):		Time at start of survey:	
Organisation:		Time at end of survey:	
Survey method (circle):	Boat/ Foot	Estimated time to complete LHS components:	

Adverse conditions affecting survey? (☐ ✓ tick if none, otherwise specify):

LAKE IDENTITY VERIFIED BY (✓ all that apply) GPS ☐ Local contact ☐ Signs ☐ Topo. Map ☐

1.3 PHOTOGRAPHS (Take <u>two</u> to illustrate the lake's characteristics and <u>one</u> of each Hab-Plot)

LAKE HABITAT SURVEY (LHS)

Name of Lake:	UKLakes code (or other- specify): WBID	Date:	Visit #

Record 12 digit OS grid reference for Hab-Plots and launch site (2 letters, and 10 digit eastings & northings)

Launch (L)		**F**		
A		**G**		
B		**H**		
C		**I**		
D		**J**		
E				

2. PHYSICAL ATTRIBUTES *(to be assessed across at least TEN EVENLY SPACED 15 m wide observation plots)*

	A	B	C	D	E	F	G	H	I	J
New Hab-Plot ID (if needed):										
Hab-Plot ID:										

2.1 RIPARIAN ZONE (15 m x 15 m plot landwards from bank top)

Estimate areal cover over plot *(0 (0%), ✓(>0-1%), 1 (>1-10%), 2 (>10-40%), 3 (>40-75%), 4 (>75%))*

VEGETATION LAYERS	HEIGHT	> 5 m	Trees ≥ 0.3 m diameter (ring if diseased/ damaged)
			Trees < 0.3 m diameter (ring if diseased/ damaged)
		0.5 – 5 m	Woody shrubs & saplings (ring if diseased/ damaged)
			Tall herbs & grasses
		< 0.5 m	Woody shrubs & seedlings
			Herbs, grasses, bryophytes
OTHER			Standing water or inundated vegetation
			Bare ground
			Artificial

	A	B	C	D	E	F	G	H	I	J
Dominant land cover within riparian zone (NV, BL, BP, CW, CP, SH, OR, WL, MH, AW, OW, RP, IG, TH, RD, TL, IL, PG, SU, WL - *circle if reedbed*)										
Notable introduced plant species (NO=No, GH=Giant hogweed, RH= Rhododendron, HB=Himalayan balsam, JK=Japanese knotweed, OT=Other)										
Bank top features (No=None, NV=Not Visible, BE=Bedrock, BO=Boulders, BC=Beach ridges, DU=Dunes, QB=Quaking bank, OT=Other)										
Any streams/flushes within 50 m of Hab-Plot? (No=No, NV=Not Visible, S=Stream, F=Flush, SF=Both)										

2.2 SHORE ZONE (15 m wide plot of variable length between bank top and waterline)

	A	B	C	D	E	F	G	H	I	J
BANK FACE (if present- includes boulder aprons) Bank face present (NO=No, YE=Yes)										
Bank face height (m) (estimate to nearest metre, or 0.1 m if bank < 1 m)										
Angle (GE=Gentle (5-30°), SL=Sloped (>30-75°), VE=near Vertical (>75°), UN=Undercut)										
Predominant bank material (NV, BE, BO, CO, GP, GS, SA, SI, EA, PE, CL, CC, SP, WP, GA, BR, RR, TD, FA, BI, OT) circle if compacted or cemented										
Bank face modification(s) (NO, NV, RS, RI, PC, EM, DM, OT -circle RI if also Resectioned)										
Bank face vegetation cover (*0 (0%), ✓(>0-1%), 1 (>1-10%), 2 (>10-40%), 3 (>40-75%), 4 (>75%)*)										
Bank face vegetation structure (NO=No, TA=Tall (>5 m), ME=Med (0.5-5 m), SH=Short (<0.5 m), or MI=Mixed (circle MI entry if trees > 5 m are present)										
Evidence of bank face erosion (NO=No, ER=Eroding) – (circle if erosion biogenic in origin)										
BEACH (if not present complete beach material and trash line) Beach present (NO=No, YE=Yes)										
Beach width (m) (estimate to nearest metre)										
Slope (HO=near Horizontal, GE=Gentle (5-30°), SL=Sloping (>30-75°), VE=near Vertical (>75°)										
Predominant shore material (NV, BE, BO, CO, GP, GS, SA, SI, EA, PE, CL, CC, SP, WP, GA, BR, RR, TD, FA, BI, OT) circle if compacted or cemented *complete if bank face and beach absent										
Components of beach substrate (complete only if visible- otherwise leave blank). Estimate cover of each size grade into the percentage bands: *0 (0%), ✓(>0-1%), 1 (>1-10%), 2 (>10-40%), 3 (>40-75%), 4 (>75%)* — Bedrock										
Boulders (> 256 mm)										
Cobbles (> 64 mm - 256 mm)										
Pebbles (> 2 mm - 64 mm)										
Sand (≥ 0.063 mm - 2 mm)										
Silt/clay (< 0.063 mm)										
Beach modification(s) (NO, NV, RS, RI, PC, EM, DM, OT -circle RI if also Resectioned (RS))										
Beach vegetation cover (*0 (0%), ✓(>0-1%), 1 (>1-10%), 2 (>10-40%), 3 (>40-75%), 4 (>75%)*)										
Beach vegetation structure (NO=No, TA=Tall(>5 m), ME=Medium(0.5-5 m), SH=Short(<0.5 m), or MI=Mixed (circle MI entry if trees > 5 m are present)										
Signs of erosional or depositional imbalance (NO=No, AL=Active Loss, AG=Active Gain)										
Height from waterline to upper limit of trash-line* (to nearest 0.1 m, NO=None, NV=Not Visible)										

Name of Lake:	UKLakes code (or other- specify): WBID	Date:	Visit #

	New Hab-Plot ID (if needed):									
	Hab-Plot ID:	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
2.3 LITTORAL ZONE (15 m x 10 m plot extending from waterline to offshore station)											
Distance (m) of offshore station from waterline (10 m or max. wading / min. approach point)											
Depth (m) at offshore station (10 m offshore or maximum wading point)											
Predominant littoral substrate (NV,BE,BO,CO,GP,GS,SA,SI,EA,PE,CL,CC,SP,WP,GA,BR,RR,TD,FA,BI,OT) circle if compacted											
Components of littoral substrate (complete if possible to observe- otherwise leave blank). Estimate cover of each grain size grade into the percentage bands: *0 (0%), ✓(>0-1%), 1 (>1-10%), 2 (>10-40%), 3 (>40-75%), 4 (>75%)* ***Ring the silt/clay entry if there is a significant presence of organic matter***	Bedrock										
	Boulders (> 256 mm)										
	Cobbles (> 64 mm - 256 mm)										
	Pebbles (> 2 mm - 64 mm)										
	Sand (≥ 0.063 mm - 2 mm)										
	Silt/clay (< 0.063 mm)										
Water depth of coarse to fine sediment boundary (if distinct change not evident enter NO)											
Recent sedimentation over natural substrate? (NV, NO, BO, CO, GP, SA, SI, EA, PE, CL, MA)											
LITTORAL HABITAT FEATURES *Estimate areal cover (0 (0%), ✓(>0-1%), 1 (>1-10%), 2 (>10-40%), 3 (>40-75%), 4 (>75%))*											
Underwater tree roots											
Woody debris (ring if predominantly > 0.3 m diameter)											
Overhanging vegetation close to water surface (< 1 m above)											
Rock ledges or sharp drop-offs											
VEGETATION STRUCTURE *Estimate areal cover (0 (0%), ✓(>0-1%), 1 (>1-10%), 2 (>10-40%), 3 (>40-75%), 4 (>75%))*											
Liverworts/mosses/lichens											
Emergent broad-leaved herbs											
Emergent reeds/sedges/rushes											
Floating-leaved (rooted)											
Free-floating											
Submerged broad-leaved											
Submerged short, stiff-leaved											
Submerged linear-leaved											
Submerged fine- and dissected-leaved (ring if stonewort lawn)											
Filamentous algae											
Phytobenthos											
Seaweeds											
Total macrophyte Percent Volume Inhabited (PVI) ***Estimate volume of macrophytes within littoral plot*** *(0 (0%), ✓(>0-1%), 1 (>1-10%), 2 (>10-40%), 3 (>40-75%), 4 (>75%))*											
Do macrophytes extend lakewards? (NV=Not Visible, NO=No, YE=Yes)											
Notable introduced species (NO=No, NP=Nuttalls pondweed, AS=Australian swamp stonecrop, PF=Parrots feather, FP=Floating pennywort, OT=Other) * If animals or fish use OT & explain in section 7											
Surface film (NO=None, SC=Scum, AM=Algal Mat, OL=Oily, OT=Other)											
2.4 HUMAN PRESSURES (to be assessed over entire plot) NO=No, *✓(tick) if present, B = behind or adjacent to plot (within 50m radius)*											
Any other pressures or comments for this section (indicate which Hab-Plots affected):	Commercial activities										
	Residential developments										
	Roads or railways										
	Unsealed tracks and footpaths										
	Parks and gardens (includes golf courses)										
	Camping and caravans										
	Docks, marinas, boats, moorings or platforms										
	Walls, dykes or revetments										
	Recreational beaches										
	Educational recreation										
	Litter, dump or landfill										
	Quarrying or mining										
	Improved grassland (ring if grazing observed)										
	Other grazed land (ring if grazing observed)										
	Coniferous plantation (ring if evidence of logging)										
	Tilled land										
	Orchard										
	Pipes, outfalls										
	Dredging										
	Riparian vegetation control										
	Aquatic macrophyte cutting										

Name of Lake:	UKLakes code (or other- specify): WBID	Date:	Visit #

3. WHOLE LAKE ASSESSMENT (carry out in consultation with large scale e.g. colour 1:25,000 topographic map)

3.1 LAKE PERIMETER CHARACTERISTICS Complete in two belts, the first extends from 10 m into the littoral zone to 15 m landwards of the bank edge (e.g. Hab-Plot length), the second > 15 - 50 m landwards of the bank edge (extra-riparian)

Complete table from either a boat-based survey (cruising and observing between Hab-Plots) ***OR*** *by viewing visible perimeter sections from each Hab-Plot (these must be shown on sketch map). Observe progressively from Hab-Plots A, B, C, etc. Observe 100% if possible, but always observe at least 75%.* ***Observe the whole lake perimeter from one location if possible.***

EXTENT OF LAKE PERIMETER SECTION AFFECTED BY (OR COMPRISED OF) EACH PRESSURE OR LAND COVER TYPE

Estimate extent (0 (0%), ✓(>0-1%), 1 (>1-10%), 2 (>10-40%), 3 (>40-75%), 4 (>75%)). Ring entry if known to affect 'critical' area.

Perimeter section number		1		2		3		4		5		6		7		8		9		10	
Circle option used	Boat: viewed between Hab-Plots	A-B		B-C		C-D		D-E		E-F		F-G		G-H		H-I		I-J		J-A	
	Shore: viewed from Hab-Plots	A		B		C		D		E		F		G		H		I		J	
New viewing locations (if req.)																					
Section as % of total shore																					
% shoreline (0-15 and 15-50 m)		15	50	15	50	15	50	15	50	15	50	15	50	15	50	15	50	15	50	15	50
Bank construction	Impoundments																				
	Hard engineering: Closed-type																				
	Hard engineering: Open-type																				
	Soft engineering																				
	Docks and marinas																				
Pressures and land use	Commercial activities																				
	Residential areas																				
	Roads, railways, paths																				
	Parks and gardens (golf)																				
	Camping and caravans																				
	Recreational beaches																				
	Educational recreation																				
	Litter, dump, landfill																				
	Quarrying or mining																				
	Coniferous plantation																				
	Evidence recent logging																				
	Improved grassland																				
	Soil poaching (trampling)																				
	Tilled land																				
	Orchard																				
Erosion																					
Wetland habitats	Reed-bed																				
	Wet woodland (carr)																				
	Bog																				
	Fen or marsh																				
	Floating vegetation mats																				
	Other																				
Other habitats	Broadleaf/mixed woodland																				
	Broadleaf/mixed plantation																				
	Coniferous woodland																				
	Scrub and shrubs																				
	Moorland/heath																				
	Open water																				
	Rough grassland																				
	Tall herb/rank vegetation																				
	Rock, scree or dunes																				

LAKE HABITAT SURVEY (LHS)

Name of Lake:	UKLakes code (or other- specify): WBID	Date:	Visit #

3.2 LAKE SITE ACTIVITIES/PRESSURES

Where indicated:

P: ✓*(tick) if the pressure known to be present, and ring entry if actually observed*

%: *Estimate the areal cover of the pressure/construction to the nearest 5%*

E: ✓*(tick) if the pressure appears to be Extensive (>30% lake area or shoreline length where applicable)*

I: ✓*(tick) if the pressure appears to be Intensive (high density of the activity over the area in which it occurs)- refer to manual for more details*

	P	%		P	E	I		P
Bridges			Motorboat activities				Fish stocking	
Causeways			Non-motor boat activities				Navigation channels	
Fish cages (aquaculture)			Angling from boat				Military activities	
Commercial fishing (nets/traps)			Angling from shore				Powerlines	
Dredging			Non-boat recreation/swimming				Chemical applications	
Dumping			Wildfowling and hunting				Surface films	
Macrophyte control			Introduced species (specify below)				Litter	

Other

3.3 LANDFORM FEATURES

Estimate extent as % lake surface area (0 (0%), ✓(>0-1%), 1 (>1-10%), 2 (>10-40%), 3 (>40-75%), 4 (>75%))

Vegetated islands (non deltaic)		Aggrading vegetated deltaic deposit		Deltaic unvegetated gravel deposit	
Unvegetated islands (non deltaic)		Stable vegetated islands (deltaic)		Deltaic unvegetated sand/silt/clay deposit	

Other

3.4 OUTLET GEOMETRY (record details of outlet dimensions)

Outlet form *(✓tick appropriate box)*

☐ ☐ ☐ ☐

Width of water in outflow channel at its narrowest section (estimate to the nearest metre) _____ (m)

Record any further details on outlet (optional)

4. HYDROLOGY (to be assessed over entire lake)

Principal use(s) *(circle)*	None / Hydro-power / Water supply / Flood control / Navigation / Amenity / Other (specify)
Water body type *(circle)*	Natural(unmodified) / Natural(raised) /Natural(lowered) / Impoundment / Flooded pit

If raised or lowered, state height difference of water level relative to natural condition (m) *[if known]*	(m)
If raised or lowered, state when this occurred *[if known]*	
Estimate maximum height from bed of outflow channel to top of principal retaining structure (m)	(m)

Number of significant influent streams (stream catchment >10% total catchment)	
Are there any upstream impoundments? (circle)	No / Yes / Unsure
Evidence of significant flow diversion (i.e. may affect residence time) into/out of catchment? (circle)	No / Into / Out of / Unsure
Does water level experience tidal influence? (circle)	No / Yes / Unsure

Vertical range of water level fluctuation (m) *(✓tick appropriate box)*

Daily$_{max}$	< 0.5 ☐	> 0.5 – 2 ☐	>2 – 5 ☐	> 5 – 20 ☐	> 20 ☐	Unsure ☐	**This question answered by:**
Annual$_{max}$	< 0.5 ☐	> 0.5 – 2 ☐	>2 – 5 ☐	> 5 – 20 ☐	> 20 ☐	Unsure ☐	On-site estimation ☐ Data ☐

Water management structures observed (total each type in boxes provided). Where possible, indicate if critical areas are affected. Mark the location of any structures on the sketch map or photocopy of OS map.

Inflow	Dam without fish pass		Barrage		Weir	
	Dam with fish pass		Sluice		Outfall	
	Channelised channel		Lock		Intake	
Outflow	Dam without fish pass		Barrage		Weir	
	Dam with fish pass		Sluice		Outfall	
	Channelised channel		Lock		Intake	

Other

Name of Lake:	UKLakes code (or other- specify): WBID	Date:	Visit #

5. LAKE PROFILE INFORMATION AT INDEX SITE (to be measured at deepest point of lake)

Record 12 figure Ordnance Survey Grid Reference of the Index Site and mark this site on the map

5.1 INDEX SITE AND WATER CONDITIONS

Surface conditions (circle):	Flat / Ripple / Choppy / Breaking waves
Surface films (circle):	None / Scum / Algal mat / Oil / Other (specify)
Odour (circle):	None / Sulphurous / Sewage / Oil / Chemical / Other (specify)

MEASUREMENTS AT INDEX SITE		SECCHI DISC TRANSPARENCY	
Index Site water depth (m)		Depth disc disappears (m)	
Clear to bottom (circle):	Yes / No	Depth disc reappears (m)	

5.2 DISSOLVED OXYGEN AND TEMPERATURE PROFILE (July-September ONLY)

Measure at depths of (m) surface, 0.5, 1, 1.5, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 20, 25, 30, 35, 40 and 50 m. Include readings at 1 m above lake bottom). If depth ≤ 3 m, take readings at the surface, every 0.5 m, and 0.5 m above the bottom.

Calibration check confirmed (circle) Yes / No

Comments	Depth (m)	O_2 (mg l^{-1})	Temp (^oC)	Metalimnion (T,B)
	Surface			
	Surface (duplicate)			

Confirm that duplicate O_2 reading is within ± 0.5 mg l^{-1} of initial surface reading (Yes / No)

Metalimnion (T, B): locate the position of the metalimnion, i.e. region of the water temperature profile where the temperature changes at a rate of 1°C or greater per metre of depth. Indicate the depth of the top of the metalimnion with a "T", and the bottom of the metalimnion (when the rate of change becomes less than 1°C per metre) with a "B". After the metalimnion is encountered, take readings every 1 m until bottom of the metalimnion is reached.

Name of Lake:	UKLakes code (or other- specify): WBID	Date:	Visit #

6. FIELD SURVEY QUALITY CONTROL (*✓tick boxes to confirm checks, explain in Section 7 if necessary)*

- ★ Have you taken two or more photographs of the site and one of each Hab-Plot? ☐
- ★ Have you filled in the lake's name, UKLakes WBID, date and visit number on each page? ☐
- ★ Have you sketched the lake on page 1 (or provided photocopy of OS map), and annotated it? ☐
- ★ Have you completed the background data (from GBLakes) on page 1? ☐
- ★ Have you filled in 'time at end of survey' and 'estimated LHS time' (Section 1.2) on page 1? ☐
- ★ Have you completed 10 Hab-Plots, including GPS locations (Section 2) on pages 2 and 3? ☐
- ★ Have you surveyed at least 75% of the lake shoreline (Section 3) on page 4? ☐
- ★ Have you completed the whole lake survey (Section 3), activities, landform features, outlets, on page 5? ☐
- ★ Have you completed the hydrology section (Section 4) on page 5 answering all questions possible? ☐
- ★ If a boat is available, have you completed the index site information (Section 5) on page 6? ☐

7. FURTHER COMMENTS

Use this section to describe any incidences of 'OT= Other', where insufficient room was provided within the section. Indicate any additional factors that may directly or indirectly influence lake morphology or habitat quality (e.g. pressure of large numbers of animals). Also include general comments on, and problems encountered during, the survey; as well as details of any mistakes you have identified in GBLakes.

Indicate any other survey work that was carried out in conjunction with LHS- add others in the spaces provided and record details where indicated):

Survey	✓ tick if carried out	Details
Macrophytes	☐	
Invertebrates	☐	
Site Condition Monitoring	☐	
Water chemistry	☐	
Bathymetry	☐	
Others:	☐	
	☐	
	☐	
	☐	

APPENDIX II: FIELD SURVEY GUIDANCE SHEETS

LAKE HABITAT SURVEY (LHS) : FIELD GUIDANCE SHEET

CODES FOR ABBREVIATIONS (SECTIONS 1 AND 2)

LAND COVER TYPES
SECTION 1.1 & SECTION 2.1

NV	Not visible
BL	Broadleaf/mixed woodland (semi-natural)
BP	Broadleaf/mixed plantation
CW	Coniferous woodland (semi-natural)
CP	Coniferous plantation
SH	Scrub and shrubs
OR	Orchard
WL	Wetland (e.g. bog, marsh, fen)
MH	Moorland/heath
AW	Artificial open water
OW	Natural open water
RP	Rough/unimproved grassland/pasture
IG	Improved grassland/pasture
TH	Tall herb/rank vegetation
RD	Rock, scree or sand dunes
TL	Tilled land
IL	Irrigated land
PG	Park, lawn or gardens
SU	Suburban/urban

MODE OF LAKE FORMATION
SECTION 1.1: LAKE FORMATION

Natural glaciated	
RV	Ice-scoured rock basin (valley floor)
RC	Ice-scoured rock basin (corrie)
KL	Knock and lochan (glacial scour)
KH	Kettlehole basin (detached ice block)
GD	Glacial drift (moraine or outwash dam)
Natural non-glaciated	
DP	Depression in blanket bog
FV	Fluvial processes on valley floor
WW	Wind/wave driven sand-blocked valley
BS	Depression in coastal windblown sand
CW	Chemical weathering
Artificial	
IW	Impounded watercourse (reservoir)
EH	Flooded excavation in hardrock
ED	Flooded excavation in drift
BP	Bunded completely artificial concrete bowl
OT	Others (specify in comments)

PHYSICAL ATTRIBUTES SECTION 2

Materials and substrates 2.2 SHORE ZONE & 2.3 LITTORAL ZONE

NV	Not visible	
BE	Bedrock	Underlying, *in situ*
BO	Boulder	≥ 256 mm
CO	Cobble	≥ 64, < 256 mm
GP	Gravel/pebble	≥ 2, < 64 mm
GS	Gravel/sand mix	≥ 0.06, < 64 mm
SA	Sand	≥ 0.06, < 2 mm
SI	Silt	< 0.06 mm
EA	Earth	Crumbly
PE	Peat	Organic
CL	Clay	Sticky
MA	Marl	Like clay but crumbly
OT	Other	

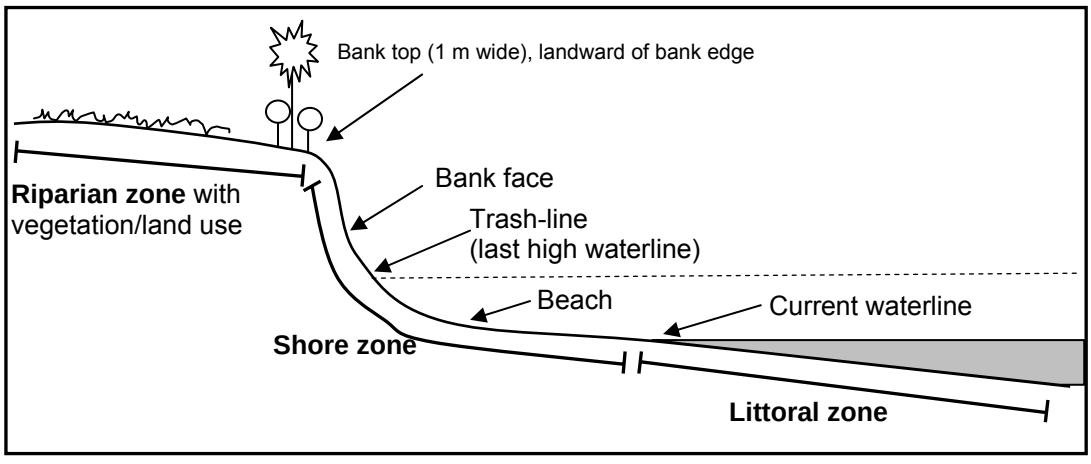
Artificial types

CC	Concrete
SP	Sheet piling
WP	Wood piling
GA	Gabion
BR	Brick/laid stone
RR	Rip-rap
TD	Tipped debris
FA	Fabric
BI	Bio-engineering materials

Modifications 2.2 SHORE ZONE

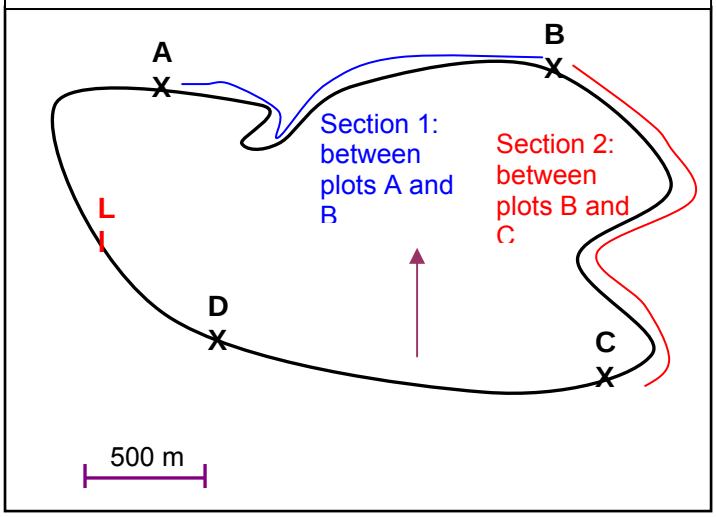
NV	Not visible
NO	None
RS	Resectioned
RI	Reinforced
PC	Poached
EM	Embankment
DM	Dam
OT	Other

LAKE SHORE PROFILE (CROSS SECTION OF HAB-PLOT)

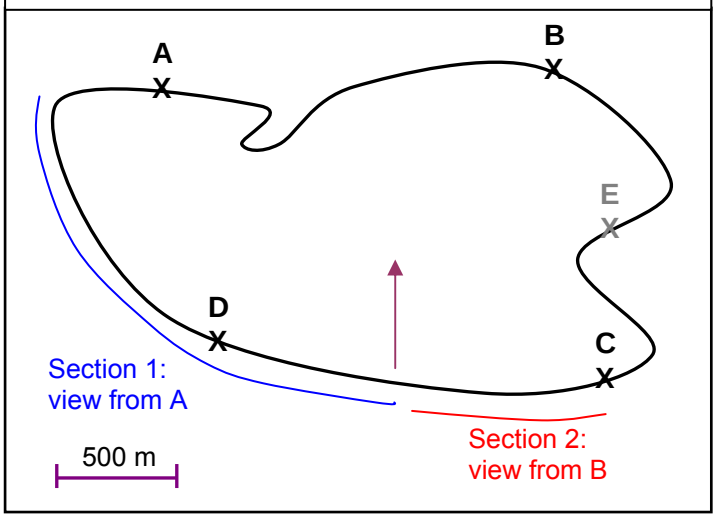


SKETCH MAP (FOR SECTION 1)

Option 1: Boat-based survey (sketch arrow indicating North, estimated scale bar, and location of launch site (L) and Hab-Plots (A-D). Observe and sketch sections of shore between each pair of Hab-Plots for section 3.1 (as shown for 1.2)



Option 2: Foot-based survey (sketch arrow indicating North, estimated scale bar, the location of Hab-Plots (A-D) and extra viewing points if required (e.g. E, F). Observe and sketch sections of shoreline observed for section 3.1 (as shown for 1.2)



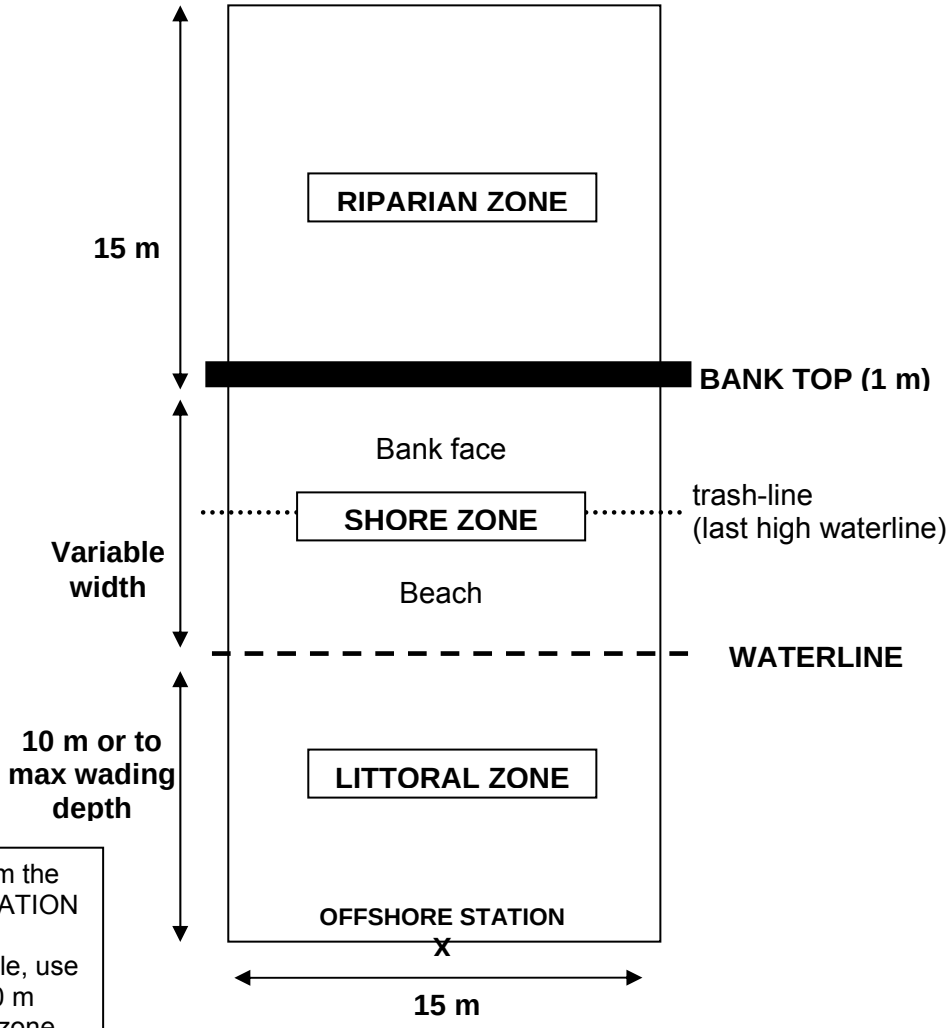
IN SECTION 2, USE **10 15 m WIDE HAB-PLOTS** TO CHARACTERISE LAKE HABITAT

HABITAT PLOT OBSERVATION STATION (HAB-PLOT)

The **riparian zone** (section 2.1) begins at the top of the bank face, indicated by change in slope. It includes the **'bank top'**, which is an area 1m from the edge of the bank.

The **shore zone** is of variable width, and is the region between the edge of the bank and the current waterline. The **edge of the bank** is defined by a distinct change in slope and/or the junction between inlake and riparian conditions.
The shore zone includes the **bank face** and the **beach**, which are separated by the high waterline. Both the bank face and the beach may or may not be present.

The **littoral zone** is the area from the waterline to the OFFSHORE STATION which is ideally 10 m from the waterline. If a boat is not available, use maximum wading depth up to 10 m from the waterline to define this zone.



SPECIES TO IDENTIFY IN THE RIPARIAN ZONE – NUISANCE SPECIES AND ALDERS

Giant hogweed (GH) – *Heracleum mantegazzianum*

Large growth (right) and close view of flowers (far right)

Rhododendron (RH) – *Rhododendron ponticum*

Large growth (below) and close view of flowers (right)

Himalayan balsam (HB) – *Impatiens glandulifera*

Large growth (right) and close view of flowers (below)

Japanese knotweed (JK) – *Fallopia japponica*

Large growth (left) and close view of distinctive seed pods (right)

Alders -*Alnus glutinosa*

Close view of healthy leaves

Dead trees as a result of *phytopthora* disease lining a river bank with live trees visible behind

Close view of diseased alder trunk showing legions

SPECIES TO IDENTIFY IN THE LITTORAL ZONE – NUISANCE MACROPHYTES

Nuttall's pondweed (NP) - *Elodea nuttallii*
Close view of plant growths and leaves. Left shows size of leaves.

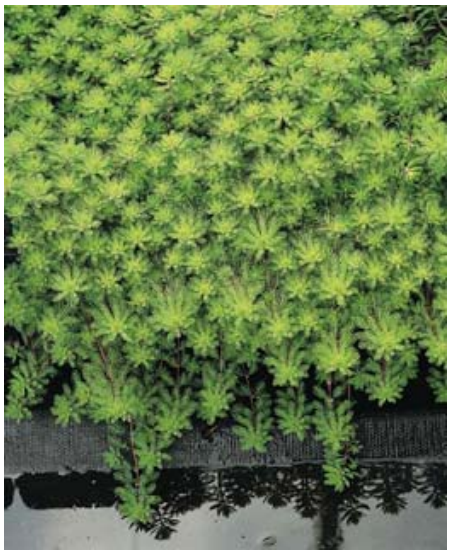
Water fern (WF) – *Azolla filiculoides*

Close view of floating leaves

Australian swamp stonecrop (AS) – *Crassula helmsii*
Close view of plants in flower (above) and yellowing well - established mat (below)

Parrot's feather (PF) – *Myriophyllum aquaticum*

Large growth (left) and close view of featherlike leaves (below)



Floating pennywort (FP) – *Hydrocotyle ranunculoides*

Large growth (right) and close view of leaves (left)