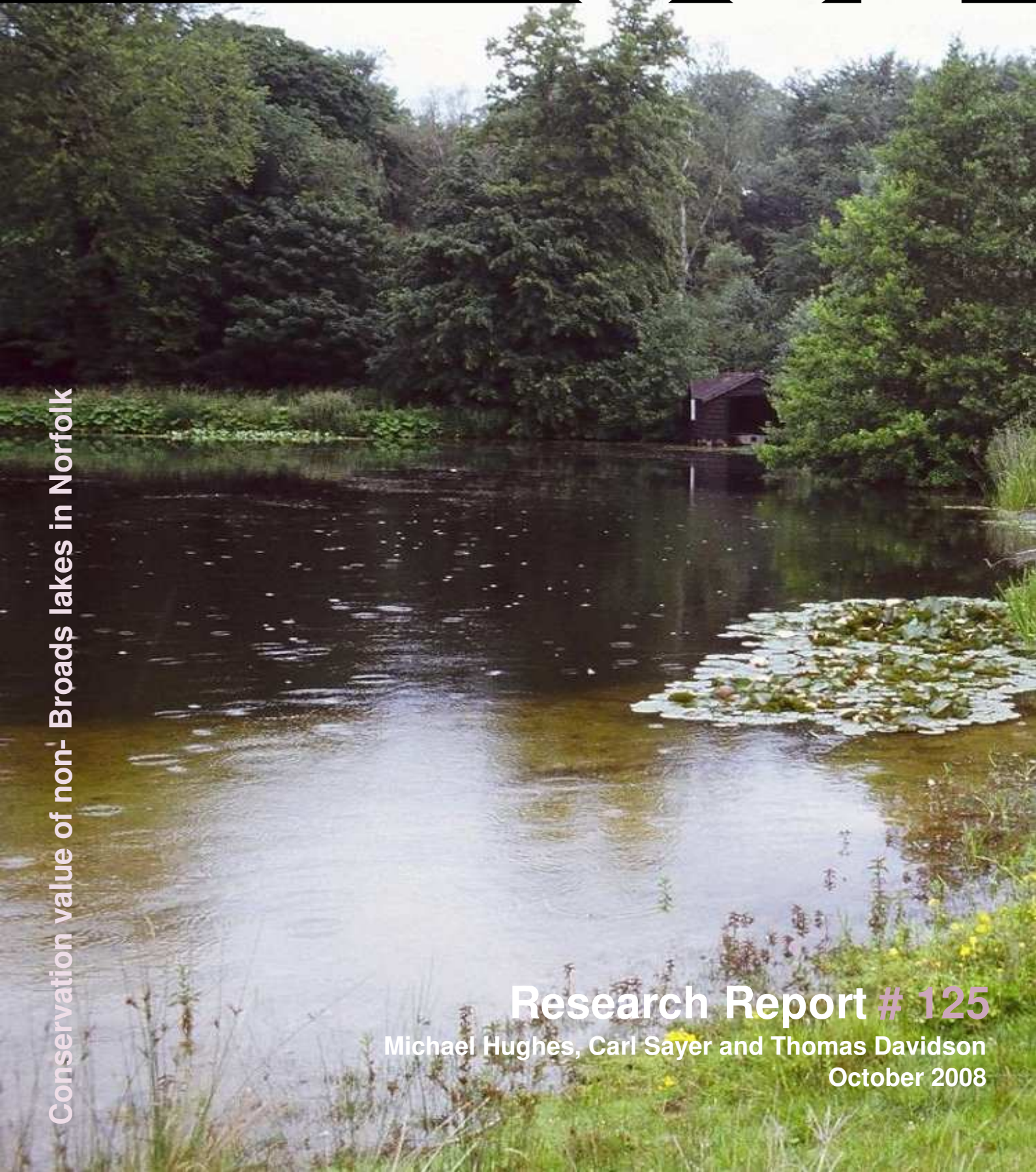




UCL

Conservation value of non- Broads lakes in Norfolk



Research Report # 125

Michael Hughes, Carl Sayer and Thomas Davidson

October 2008

Conservation value of non-Broads lakes in Norfolk: determining what is known

**Final Report
October 2008**

Michael Hughes, Carl Sayer and Tom Davidson

ECRC Research Report 125

Environmental Change Research Centre,
Pearson Building, University College London
Gower St, London, WC1E 6BT.

The authors gratefully acknowledge the support of the Norfolk Biodiversity Partnership, Environment Agency and the Broads Authority. Fieldwork on which the report is based was partly funded by a Natural Environment Research Council (NERC) Fellowship awarded to Dr Carl Sayer.

Cover photo: Brinton Hall Lake (Carl Sayer)

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1. Background

Recent research (e.g. Sayer *et al.*, 2008; Wood *et al.*, 2003) has highlighted an urgent need to consider ornamental and other man-made shallow lakes as potential sites for nature conservation. In Norfolk such lakes have survived the ravages of eutrophication (nutrient enrichment) better than the Norfolk Broads due to their smaller catchments in the upper reaches of river systems. As a consequence many of them (particularly some ornamental lakes, but probably many gravel-pits), still support species-rich communities of aquatic plants (and probably invertebrates), including, in some cases, substantial populations of Characeae. For this reason these lakes are very much worthy of nature conservation.

It is the authors' opinion, based to an extent on recent studies of non-broads lakes in Norfolk, that many ecologically valuable Norfolk lakes have little or no conservation protection (CWS or otherwise), making them vulnerable to future ecological degradation. Yet, it might be argued that at no other time have they been under greater threat, particularly due to the recent fashion for stocking private lakes with common carp. Further, with predicted sea level rises and the massive threats posed by this for the ecology of the freshwater Norfolk Broads, the other water bodies of the county demand further attention from the perspective of nature conservation. Norfolk has one of the highest densities of ponds in the UK (Wood *et al.*, 2003) and it has been found that ponds can support species-rich communities even if relatively small (Oertli *et al.*, 2002).

Against this background this project seeks to; (i) compile existing ecological knowledge for the non-Broads freshwater lakes of Norfolk, with a subjective cut-off size of 0.5 hectares, (ii) identify those sites for which no information exists that would be worthy of surveys to identify their conservation potential.

It is hoped that this project will greatly improve the knowledge base for standing water aquatic conservation in Norfolk. In particular, it is hoped that this and subsequent work may identify good examples of mesotrophic-eutrophic lakes in favourable ecological condition. This work will provide information to the Mesotrophic Lakes Habitat Action Plan for which no non-Broads lakes are currently listed.

2. Methods

2.1 *Non-Broads Survey*

A database was compiled of macrophyte and zooplankton data collected by researchers at UCL-ECRC. A pilot study was carried out during July and August 1998 of 74 sites (of which 35 were non-broads). The pilot study consisted of a 'spot sample' for water chemistry analysis (pH, nutrients, major anions and cations) and a 'rapid assessment' macrophyte survey using the DAFOR (Dominant / Abundant / Frequent / Occasional / Rare) system. In practise, vegetation was recorded for 20-30 randomly selected points across the lake using an underwater viewer (bathyscope), or where necessary (in turbid water), using a double-headed rake pulled approximately 2m along the lake bed. See Sayer *et al.* (2008) for further details.

The following year, with funding from a Natural Environment Research Council (NERC) Fellowship to Dr Carl Sayer, a more detailed study was undertaken at 29 sites (of which 20 were non-broads). This 'main' study consisted of monthly samples for water chemistry (including key nutrients, chlorophyll-a, light and oxygen measurements) between May 1999 and May 2000 (not sampled during October and December 1999 or February 2000), aquatic macrophyte sampling in June and August 1999, zooplankton sampling during May and August and point-abundance fish surveys during September-October 1999. In this study macrophyte densities were determined using the Percentage Volume Infested (PVI) system with plans surveyed from a boat at 30-70 points across the lake using a combination of bathyscope and snorkelling. Zooplankton populations were surveyed by standard tube sampling (5 tubes per lake, tube internal diameter 7.4 cm) along transects from the lake centre to the marginal zone. See Jones & Sayer (2003), Zambrano *et al.* (2006), Davidson *et al.* (2007), Sayer *et al.* (accepted) for further details regarding these sampling methods.

A Microsoft Access database containing raw data from both surveys has been prepared and is available on a CD-Rom as an appendix to this report. For compatibility we have converted PVI scores for plants in the main study to DAFOR scores.

2.2 *GIS Analysis*

An analysis of UKLakes and other spatial data for Norfolk (Ordnance Survey 1:25,000 and MasterMap data) was carried out in order to assess the extent of the standing water resource. The extent to which this resource is currently protected was investigated using the latest data from Natural England and Norfolk Biodiversity Partnership. Analyses were carried out using ESRI ArcGIS 9.2 and Microsoft Access database software.

3. Results

3.1 Non-Broads Survey

This report summarises water chemistry, macrophyte and zooplankton data from these studies and includes some recent data from miscellaneous surveys by Sayer and Davidson (UCL-ECRC). Table 1 shows a summary of the non-broads sites studied by UCL-ECRC which are shown on a map of Norfolk in Figure 1. Species lists for aquatic macrophytes and zooplankton from the UCL-ECRC surveys are given in Appendix 1 and Appendix 2 respectively. Appendix 3 shows pilot study summary water chemistry for the sites and Appendix 4 shows main study summary water chemistry data.

The non-broads lakes studied ranged in size from 0.3 hectares (ha.) to 20.6 ha. and depths were rarely greater than 3 m. Typically, these sites are small, shallow lakes with relatively small catchment areas often in an ornamental setting with adjoining woodland. They range in altitude from 6 to 68 m above sea level. None of the lakes studied here were former gravel pits. Further information on the origins, characteristics and geographical settings of the sites are given in Sayer *et al.* (2008) and Sayer *et al.* (accepted).

Water chemistry analysis of the lakes shows that, with a few exceptions (e.g. Little Perch lake), the lakes are alkaline and many have low phosphorous concentrations compared to the Broads. These factors are largely responsible for the diverse plant communities that they support.

The plant survey data from 1999 (Appendix 1) shows that many of the lakes support diverse assemblages of aquatic macrophytes with four sites having 10 or more species (e.g. BAYF, BRIN, GREP, GUNT). Common plant species include *Ceratophyllum demersum* (rigid hornwort), *Potamogeton pectinatus* (fennel-leaved pondweed), *Potamogeton pusillus* (lesser pondweed), *Potamogeton crispus* (curled pondweed), *Zannichellia palustris* (horned pondweed) and *Characeae* (stoneworts) including *Chara globularis*, *Chara vulgaris*, *Chara contraria*, *Chara virgata*, *Chara hispida* and *Nitella flexilis*. Indeed, the abundant charophyte populations in several estate lakes in the 'Holt - Melton Constable' area has led to this region being recognised as an 'Important Stonewort Area' by Plantlife International (Stewart, 2004). The non-charophyte plant list does not contain any plants currently protected under the 1981 Wildlife and Countryside Act or BAP Priority Species. *Ceratophyllum submersum* (soft hornwort), present at 2 sites (GREP, LOPO), could perhaps be considered uncommon nationally, although it seems to be quite abundant on the Norfolk coast.

Zooplankton populations are similarly diverse with all sites supporting between 20 and 40 species. Common zooplankton species found in these lakes are rotifers, water fleas and

copepods and these commonly include *Asplanchna* spp., *Bosmina* spp., *Brachionus* spp., *Ceriodaphnia* spp., *Daphnia* spp., *Keratella* spp. and *Scapholeberis mucronata*. See Appendix 2 for detailed zooplankton species lists.

Detailed interpretations of the data are given in a number of published papers including: Zambrano *et al.* (2006) for fish data, Davidson *et al.* (2007), Sayer *et al.* (2008) and Sayer *et al.* (accepted).

Table 1. Summary of non-broads sites in the UCL-ECRC studies

Site_Code	Site_Name	WBID	OS100MGR	PILOT	MAIN	S_Area ha	Max_Depth cm	Mean_Depth cm	SSSI/CWS
ANTI	Antingham Lake	35117	TG263326	Yes	No	4.5	85	-	CWS
BARN	Barningham Hall Lake	34976	TG149355	Yes	No	2	68	-	CWS
BAYF	Bayfield Hall Lake	-	TG047405	Yes	Yes	2.7*	143	92	-
BEES	Beeston Hall Lake	35682	TG330213	Yes	Yes	4.4	95	61	-
BIGW	Big Wood Lake	36401	TG317104	Yes	Yes	3.5	118	67	CWS
BLIC	Blickling Hall Lake**	35249	TG176292	Yes	Yes	9.4	258	95	CWS
BLUE	Bluestone Plantation Pond	35458	TG136259	Yes	Yes	3.2	164	120	CWS
BRIN	Brinton Hall Lake	34964	TG039360	No	No	1.1	-	-	-
CAPT	Captain's Pond	35397	TG279271	Yes	No	2.3	100	-	SSSI
CLEY	Cockley Cley Hall Lake	36833	TF785036	Yes	No	2.6	160	-	CWS
FELB	Felbrigg Hall Lake	34827	TG190388	Yes	Yes	2.7	150	90	CWS
GREP	Green Plantation Pond	34696	TG082407	Yes	Yes	1.4	310	147	-
GUNT	Gunthorpe Hall Lake	35030	TG009344	Yes	Yes	1.9	267	113	-
GREA	Gunton Great Water	35023	TG221344	Yes	No	20.6	30	-	-
SAWM	Gunton Sawmill Pond	35023	TG224336	Yes	No	20.6	150	-	-
HAVE	Haveringland Hall Lake	35695	TG157211	Yes	Yes	5.9	90	58	CWS
HING	Hingham Sea Mere	36975	TG037012	Yes	No	8.3	500	-	SSSI
HOKI	Holkham Hall Lake (Isolated)	34551	TF881427	Yes	Yes	14.3	100	82	CWS
HOKM	Holkham Hall Lake (Main)	34551	TF882434	Yes	Yes	14.3	256	146	CWS
HONN	Honingham Hall Lake	36280	TG112120	Yes	No	3	5	-	-
HOVE	Hoveton Hall Lake	-	TG315198	Yes	No	1.2*	100	-	-
KETT	Ketteringham Hall Lower Lake	36896	TG167026	Yes	No	0.9	102	-	CWS
KIMB	Kimberley Hall Lake	36778	TG085045	Yes	No	9.6	15	-	CWS
LETH	Letheringsett Lake	34814	TG063391	Yes	No	1.2	100	-	-
LPER	Little Perch Lake	35404	TG273271	Yes	No	0.3	40	-	SSSI
LOPO	Lowes Pond	34684	TG076408	No	Yes	0.9	150	136	-
MELT	Melton Constable Hall Lake	35195	TG031309	Yes	Yes	6.6	317	124	CWS
NARF	Narford Hall Lake	36160	TF761139	Yes	Yes	20.6	195	105	CWS
PEDH	Pedham Lake	36262	TG336125	Yes	Yes	3.1	95	78	CWS
RACK	Rackheath Springs Lake	36161	TG269141	Yes	No	1.8	156	-	CWS
SAHA	Saham Toney Mere	36929	TF902019	Yes	Yes	3.9	199	156	CWS
SCOT	Scottow Pond	35529	TG263248	Yes	Yes	2.8	115	85	CWS
SELB	Selbrigg Pond	34822	TG108390	Yes	Yes	3.4	137	83	CWS
SENN	Sennowe Park Lake	35506	TF983252	Yes	No	2.4	50	-	-
STRA	Stradsett Hall Lake	36686	TF666061	Yes	Yes	6.5	197	109	-
STST	Stratton Strawless	35761	TG213201	Yes	No	2.4	35	-	-
WOLT	Wolterton Hall Lake	35179	TG163312	Yes	Yes	4.2	197	84	-

Notes: WBID is the UKLakes database water body ID, S_Area is surface area from UKLakes database except where marked * and this is estimated.

** Brinton Hall Lake is an ad hoc addition to this report, there are plant data and some chemistry data but it was not officially in either the pilot or main study.

3.2 GIS Analysis

Analysis of the UKLakes database (Hughes *et al.*, 2006) indicates that there are some 693 water bodies in Norfolk, of which 650 are non-broads (350 are larger than 0.5 ha.). The total area covered by these water bodies is 1611 ha. (of which 849 ha. are non-broads) and sizes range from 0.1 to 160 ha. (maximum area of 20 ha. for non-broads). All but 2 of the pilot study lakes (BAYF, HOVE) are included in the UKLakes database. The UKLakes dataset was derived from Ordnance Survey PANORAMA data at 1:50,000 (created in the early 1980's) and excludes smaller water bodies which were never included in the original survey and many other water bodies, most of which have been created since 1980. As part of this current investigation more detailed and up-to-date Ordnance Survey data (1:25,000 map scans and OS MasterMap) has been assessed.

A visual assessment of the 1:25,000 map scans indicates that, as well as the 693 water bodies identified in the UKLakes database, there are an additional 1541 water bodies in the Norfolk landscape (see Figure 2). These are mainly irrigation ponds, marl pits, moats, duck decoys, ornamental lakes and pits, ponds and pools resulting from recent extractive industries (e.g. sand and gravel pits). Typically, these additional water bodies are small in area (sizes are usually in the range 0.2 to 0.6 ha. hence their omission from the UKLakes dataset) but their large numbers mean that they make a significant contribution to the standing water total (an additional 616 ha. based on a mean size of 0.4 ha.). These figures are estimates and a more detailed map analysis of the county is recommended to verify them. In particular, lake size could be obtained from detailed digital mapping such as OS MasterMap.

OS MasterMap data has been assessed for a few sample areas and this assessment indicates that it would provide the best digital base-mapping for a complete pond and lake survey of Norfolk. Figure 3 shows an example of data for the area north of Thetford and covers an area 10 km by 10 km. There are many more small water bodies in this dataset and more detailed outlines for larger lakes than found in UKLakes or on 1:25,000 maps.

OS MasterMap is based on the best available scale data (as good as 1:1,250 in built-up areas) and as such shows features in great detail. The 'water feature' layer contains outlines for all water bodies including some very small ponds and pools with areas down to 0.01 ha. However, there are considerable difficulties with feature extraction from this dataset meaning that such a task would require a significant amount of time to complete. Initial analysis indicates that there may typically be up to 100 additional very small water bodies (ponds, pools and pits) per 10 km square and these are not shown on the 1:25,000 map scans.

An analysis was also performed on numbers of water bodies (from UKLakes and the 1:25,000 map analysis) currently within areas of conservation interest with a statutory designation

including Sites of Special Scientific Interest (SSSI), Special Areas of Conservation (SAC), National Nature Reserves (NNR), RAMSAR (data from Natural England website June 2007) and County Wildlife Site (CWS) (data from Norfolk Wildlife Trust May 2007). Summary data from this analysis are shown in Table 2.

Table 2. Conservation status of lakes and ponds in Norfolk, numbers (and percentages) of water bodies in designated areas

STATUS	UKLakes	1:25,000 map
SSSI	179 (26%)	181 (12%)
SAC	77 (11%)	135 (9%)
NNR	31 (4%)	62 (4%)
RAMSAR	77 (11%)	122 (8%)
CWS*	184 (27%)	179 (12%)
None	401 (58%)	1181 (77%)

*Analysis was carried out using a 10 m buffer around features to account for the scale of mapping.

It should be noted that CWS and SSSIs are almost always mutually exclusive but that SACs and SSSIs are almost always mutually inclusive. Also note that just because a lake falls within a designated area does not mean that it is the reason for designation. 19 of the 36 study sites are in CWS sites, a further 3 in SSSIs. Of the 184 UKLakes sites in CWS sites, about a third are larger than 0.5 ha. The CWS designation, although not statutory, is particularly suitable for small lakes on privately owned land and offers management advice to help sustain sites with rich wildlife. In Norfolk it is managed by the Norfolk Wildlife Trust (<http://www.norfolkwildlifetrust.org.uk>). Many CWS sites contain habitats and species that are priorities under the UK Biodiversity Action Plan (BAP).

This report presents data for some 37 sites. Just looking at lakes with surface area >0.5 ha. it is estimated that there are approximately a further 500 sites in Norfolk which have never been studied for ecological interest. Furthermore, the greater proportion of these sites will not be protected by any form of conservation designation. Some of these sites will be irrigation ponds and other water bodies of low ecological interest; however, until a systematic survey is carried out we cannot say how many of these sites might contain diverse communities worthy of protection.

3.3 *Summary and Recommendations*

It is clear that Norfolk has an abundant standing water resource other than the well-known broads. However, providing an accurate estimate of the number and total area of these water bodies is problematic. Based on the work carried out here the best estimate of non-broads standing water resource in Norfolk is approximately 2000 water bodies with a total area of 1460 hectares. Of these, it is estimated that about 25% are larger than 0.5 ha. Additionally there are at least another 3000-5000 small ponds, pools and pits. The total area of these smaller water bodies is difficult to estimate but is not likely to exceed 300-500 hectares.

Based on the total population of water bodies in Norfolk (UKLakes and 1:25,000 map combined) about 70% have no statutory nature conservation designation. Of those that remain, half are within SSSIs and half within CWS. Some of these sites are also within areas designated as RAMSAR sites, SACs or NNRs.

It is recommended that a complete freshwater inventory of Norfolk be carried out based on Ordnance Survey MasterMap data. Such an inventory would be invaluable as a baseline resource for studies of change especially as MasterMap data gets updated in the future.

Such an inventory could be used as the basis for a survey of lakes for species of ecological interest. For example, the inventory could be queried to provide a stratified random selection of sites larger than 0.5 ha. currently without any form of conservation designation (e.g. SSSI or CWS) which could then be surveyed. The results would indicate to what extent freshwater sites of conservation interest were currently unprotected and may well reveal new BAP species sites for the county. An initial survey could include 1 site per 10 km grid square (~65 sites). Alternatively, several grid squares could be surveyed in detail. This would give an idea of size distribution and how many sites per 10 km grid square are likely to contain species of conservation interest.

Non-broads lakes in Norfolk can support diverse plant communities, including charophytes, making them sites of potentially high conservation value. However, only a small proportion of these have been studied in detail and few are protected by any kind of conservation designation leaving a large number of potentially wildlife-rich sites at risk from eutrophication and inappropriate management (particularly inappropriate fish-stocking). We are at risk of losing conservation value at these sites before it has even been documented.

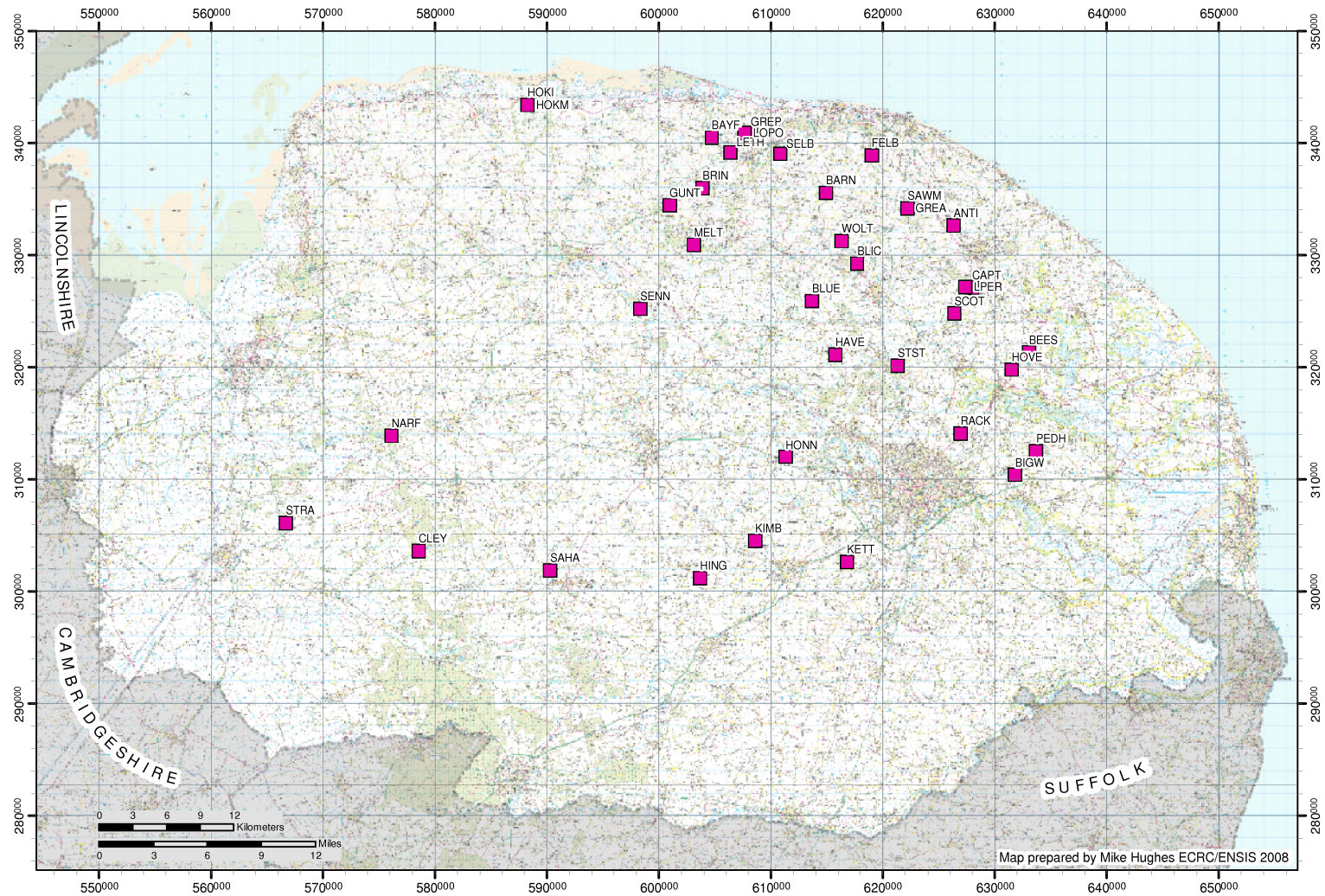


Figure 1. Map of Norfolk showing UCL-ECRC study sites (■). Basemap is OS 1:25,000 raster (Crown Copyright © Ordnance Survey).

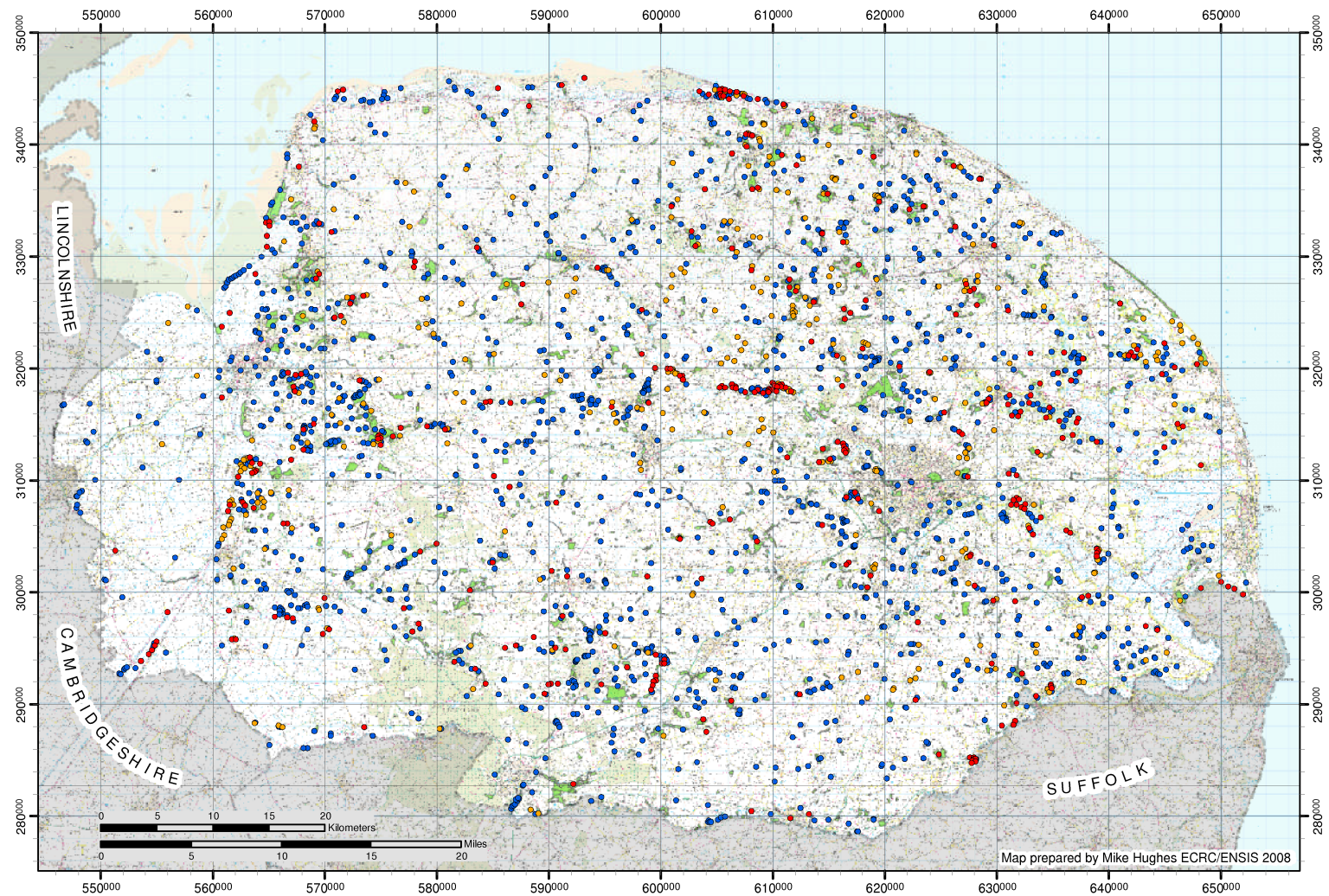


Figure 2. Map of Norfolk showing distribution of water bodies according to UKLakes (● ≤ 0.5 ha, ● > 0.5 ha) with additional sites from 1:25,000 raster map (●). County Wildlife Sites (CWS) are shown as green polygons (■). Basemap is OS 1:25,000 raster (Crown Copyright © Ordnance Survey).

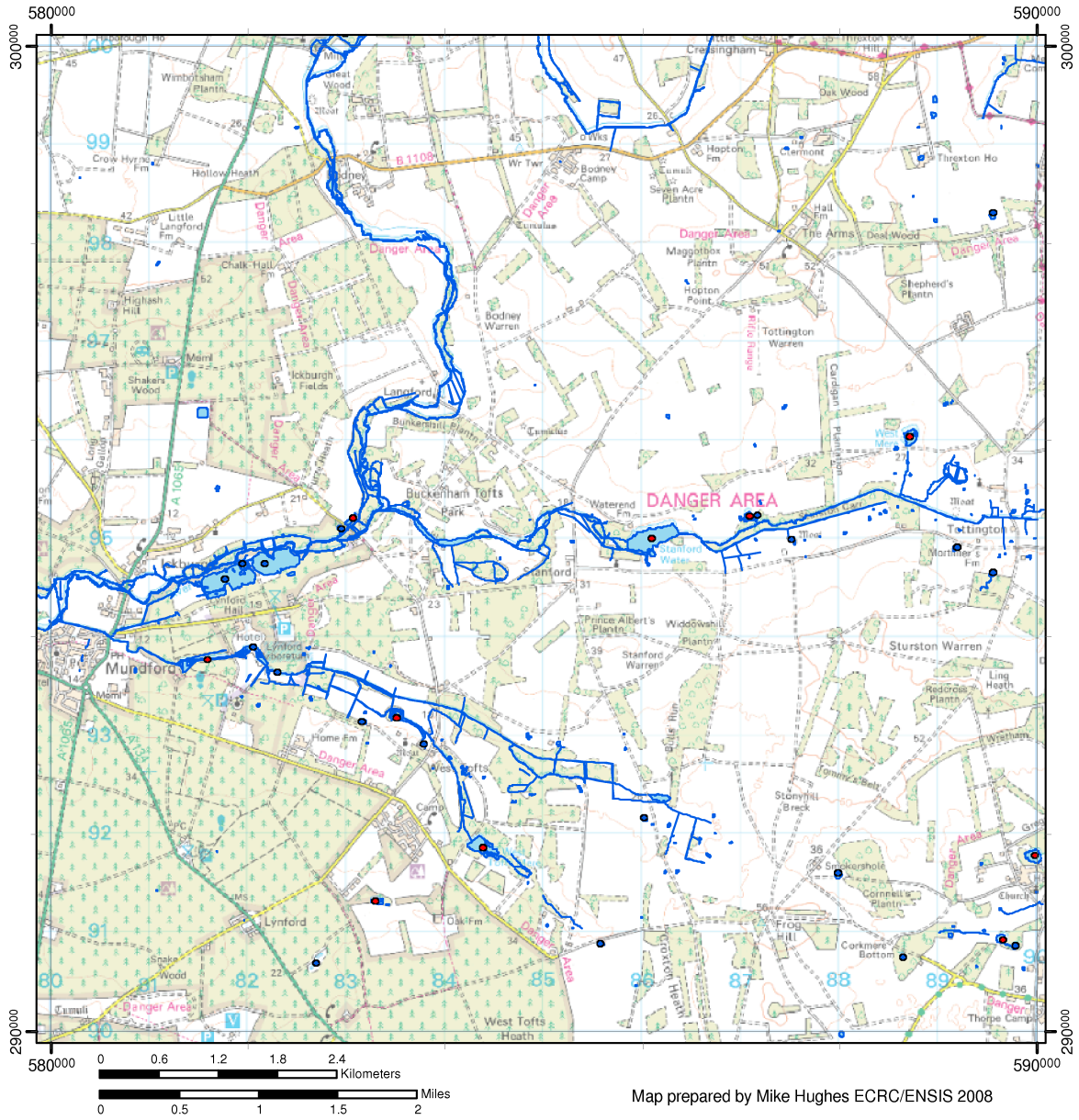


Figure 3. OS MasterMap extract (10 km square TL89) showing water features (blue line) and distribution of water bodies according to UKLakes (●) with additional sites from 1:25,000 raster map (●).
(Crown Copyright © Ordnance Survey).

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Appendix 1. Aquatic macrophyte species list from 1999 UCL-ECRC survey of non-broads lakes

Sites marked ** show some plant species from additional surveys carried out by UCL-ECRC

BAYF Bayfield Hall Lake

Latin Name	Common Name
<i>Ceratophyllum demersum</i>	Rigid hornwort
<i>Chara globularis</i>	Fragile stonewort
<i>Elodea canadensis</i>	Canadian pondweed
<i>Myriophyllum spicatum</i>	Spiked water-milfoil
<i>Potamogeton crispus</i>	Curled pondweed
<i>Potamogeton pectinatus</i>	Fennel-leaved pondweed
<i>Potamogeton pusillus</i>	Lesser pondweed
<i>Ranunculus aquatilis/peltatus</i>	Water-crowfoot
<i>Ranunculus circinatus</i>	Fan leaved water-crowfoot
<i>Zannichellia palustris</i>	Horned pondweed

BEES Beeston Hall Lake

Latin Name	Common Name
<i>Ceratophyllum demersum</i>	Rigid hornwort
<i>Chara vulgaris</i> var <i>longibracteata</i>	Common stonewort
<i>Lemna minor</i>	Common duckweed
<i>Spirodella polyrhiza</i>	Great duckweed
<i>Potamogeton pusillus</i>	Lesser pondweed
<i>Zannichellia palustris</i>	Horned pondweed

BIGW Big Wood Lake

Latin Name	Common Name
<i>Lemna minor</i>	Common duckweed
<i>Potamogeton crispus</i>	Curled pondweed
<i>Potamogeton pectinatus</i>	Fennel-leaved pondweed

BLIC Blickling Hall Lake

Latin Name	Common Name
<i>Chara contraria</i>	Opposite stonewort
<i>Chara contraria</i> var <i>hispidula</i>	Opposite stonewort
<i>Chara hispida</i>	Bristly stonewort
<i>Potamogeton pectinatus</i>	Fennel-leaved pondweed
<i>Potamogeton pusillus</i>	Lesser pondweed
<i>Zannichellia palustris</i>	Horned pondweed

BLUE Bluestone Plantation Pond

Latin Name	Common Name
<i>Ceratophyllum demersum</i>	Rigid hornwort
<i>Potamogeton crispus</i>	Curled pondweed
<i>Potamogeton pusillus</i>	Lesser pondweed

BRIN Brinton Hall Lake**

Latin Name	Common Name
<i>Ceratophyllum demersum</i>	Rigid hornwort
<i>Chara vulgaris</i> var <i>longibracteata</i>	Common stonewort
<i>Chara globularis</i>	Fragile stonewort
<i>Crassula helmsii</i>	Australian swamp stonecrop
<i>Elodea canadensis</i>	Canadian pondweed
<i>Lemna minor</i>	Lesser duckweed
<i>Lemna trisulca</i>	Ivy-leaved duckweed
<i>Myriophyllum spicatum</i>	Spiked water-milfoil
<i>Nuphar lutea</i>	Yellow waterlily
<i>Nymphaea alba</i>	White waterlily
<i>Potamogeton crispus</i>	Curled pondweed
<i>Potamogeton pectinatus</i>	Fennel-leaved pondweed
<i>Potamogeton trichoides</i>	Hair-like pondweed
<i>Ranunculus circinatus</i>	Fan leaved water-crowfoot
<i>Ranunculus aquatilis/peltatus</i>	Water-crowfoot

FELB Felbrigg Hall Lake

Latin Name	Common Name
<i>Chara globularis</i>	Fragile stonewort
<i>Lemna minor</i>	Lesser duckweed
<i>Potamogeton crispus</i>	Curled pondweed
<i>Potamogeton pectinatus</i>	Fennel-leaved pondweed
<i>Potamogeton pusillus</i>	Lesser pondweed
<i>Zannichellia palustris</i>	Horned pondweed

GREP Green Plantation Pond**

Latin Name	Common Name
<i>Alisma plantago-aquatica</i>	Common water-plantain
<i>Ceratophyllum demersum</i>	Rigid hornwort
<i>Ceratophyllum submersum</i>	Soft hornwort
<i>Chara contraria</i> var <i>hispidula</i>	Opposite stonewort
<i>Chara contraria</i>	Opposite stonewort
<i>Chara globularis</i>	Fragile stonewort
<i>Chara vulgaris</i> var <i>papillata</i>	Common stonewort
<i>Elodea canadensis</i>	Canadian pondweed
<i>Lemna minor</i>	Lesser duckweed
<i>Lemna trisulca</i>	Ivy-leaved duckweed
<i>Myriophyllum spicatum</i>	Spiked water-milfoil
<i>Nitella flexilis</i> agg.	Smooth stonewort
<i>Potamogeton crispus</i>	Curled pondweed
<i>Potamogeton pectinatus</i>	Fennel-leaved pondweed
<i>Potamogeton pusillus</i>	Lesser pondweed
<i>Potamogeton natans</i>	Floating pondweed
<i>Ranunculus circinatus</i>	Fan leaved water-crowfoot
<i>Ranunculus aquatilis/peltatus</i>	Water-crowfoot
<i>Zannichellia palustris</i>	Horned pondweed

GUNT Gunthorpe Hall Lake**

Latin Name	Common Name
<i>Alisma plantago-aquatica</i>	Common water-plantain
<i>Ceratophyllum demersum</i>	Rigid hornwort
<i>Chara contraria</i>	Opposite stonewort
<i>Chara contraria var hispidula</i>	Opposite stonewort
<i>Chara vulgaris var longibracteata</i>	Common stonewort
<i>Elodea canadensis</i>	Canadian pondweed
<i>Hippuris vulgaris</i>	Mare's tail
<i>Lemna minor</i>	Lesser duckweed
<i>Nymphaea alba</i>	White waterlily
<i>Potamogeton crispus</i>	Curled pondweed
<i>Potamogeton pectinatus</i>	Fennel-leaved pondweed
<i>Potamogeton pusillus</i>	Lesser pondweed
<i>Zannichellia palustris</i>	Horned pondweed

HAVE Haveringland Hall Lake

Latin Name	Common Name
<i>Lemna minor</i>	Lesser duckweed

HOKI Holkham Hall Lake (Isolated)

Latin Name	Common Name
<i>Chara vulgaris var papillata</i>	Common stonewort
<i>Potamogeton crispus</i>	Curled pondweed
<i>Potamogeton pectinatus</i>	Fennel-leaved pondweed
<i>Potamogeton pusillus</i>	Lesser pondweed
<i>Ranunculus trichophyllus</i>	Thread-leaved water-crowfoot
<i>Zannichellia palustris</i>	Horned pondweed

HOKM Holkham Hall Lake (Main)

Latin Name	Common Name
<i>Ceratophyllum demersum</i>	Rigid hornwort
<i>Potamogeton pectinatus</i>	Fennel-leaved pondweed

LOPO Lowes Pond**

Latin Name	Common Name
<i>Ceratophyllum submersum</i>	Soft hornwort
<i>Chara vulgaris</i>	Common stonewort
<i>Persicaria amphibia</i>	Amphibious bistort

MELT Melton Constable Hall Lake

Latin Name	Common Name
<i>Ceratophyllum demersum</i>	Rigid hornwort
<i>Chara contraria var hispidula</i>	Opposite stonewort
<i>Elodea canadensis</i>	Canadian pondweed
<i>Potamogeton pusillus</i>	Lesser pondweed
<i>Ranunculus aquatilis/peltatus</i>	Water-crowfoot
<i>Zannichellia palustris</i>	Horned pondweed

NARF Narford Hall Lake

Latin Name	Common Name
<i>Chara contraria</i>	Opposite stonewort
<i>Chara contraria</i> var <i>hispidula</i>	Opposite stonewort
<i>Chara vulgaris</i>	Common stonewort
<i>Potamogeton pectinatus</i>	Fennel-leaved pondweed
<i>Potamogeton pusillus</i>	Lesser pondweed
<i>Zannichellia palustris</i>	Horned pondweed

PEDH Pedham Lake

Latin Name	Common Name
<i>Nuphar lutea</i>	Yellow waterlily
<i>Nymphaea alba</i>	White waterlily

SAHA Saham Toney Mere

Latin Name	Common Name
<i>Nuphar lutea</i>	Yellow waterlily
<i>Nymphaea alba</i>	White waterlily

SCOT Scottow Pond

Latin Name	Common Name
<i>Ceratophyllum demersum</i>	Rigid hornwort
<i>Chara globularis</i>	Fragile stonewort
<i>Chara virgata</i>	Stonewort
<i>Chara hispida</i>	Bristly stonewort
<i>Lemna trisulca</i>	Ivy-leaved duckweed

SELB Selbrigg Pond

Latin Name	Common Name
<i>Ceratophyllum demersum</i>	Rigid hornwort
<i>Chara globularis</i>	Fragile stonewort
<i>Chara contraria</i>	Opposite stonewort
<i>Lemna trisulca</i>	Ivy-leaved duckweed
<i>Potamogeton crispus</i>	Curled pondweed
<i>Potamogeton pectinatus</i>	Fennel-leaved pondweed
<i>Potamogeton pusillus</i>	Lesser pondweed
<i>Ranunculus aquatilis/peltatus</i>	Water-crowfoot
<i>Zannichellia palustris</i>	Horned pondweed

STRA Stradsett Hall Lake

Latin Name	Common Name
<i>Ceratophyllum demersum</i>	Rigid hornwort
<i>Chara virgata</i>	Stonewort
<i>Potamogeton pectinatus</i>	Fennel-leaved pondweed
<i>Potamogeton pusillus</i>	Lesser pondweed

WOLT Wolterton Hall Lake

Latin Name

Ceratophyllum demersum
Chara contraria
Chara globularis
Potamogeton crispus
Potamogeton pectinatus
Potamogeton pusillus
Ranunculus circinatus
Ranunculus aquatilis/peltatus
Zannichellia palustris

Common Name

Rigid hornwort
Stonewort
Fragile stonewort
Curled pondweed
Fennel-leaved pondweed
Lesser pondweed
Fan leaved water-crowfoot
Water-crowfoot
Horned pondweed

Appendix 2. Zooplankton species list from 1999 UCL-ECRC survey of non-broads lakes

BAYF Bayfield Hall Lake

Species

Asplanchna sp.
Bosmina longirostris
Bosmina longirostris var. *similis*
Brachionus angularis var. *bidens*
Brachionus calyciflorus var. *dorcus*
Brachionus urceolaris
Ceriodaphnia pulchella
Ceriodaphnia quadrangula
Chydorid naupli
Chydorus sphaericus
Copepodite
Cyclops

Daphnia galeata
Daphnia longispina/hyalina
Daphnia longispina
Daphnia male
Daphnia naupli
Eurycerus lamellatus
Filinia longiseta
Keratella cochlearis
Keratella quadrata
Lecane sp.
Lepadella ovalis
Mytilina ventralis
Notholca labis

Pleuroxus aduncus
Pleuroxus striatus
Pleuroxus trigonellus
Polyarthra sp.
Polyphemus pediculus
Scapholeberis mucronata
Simocephalus expinosus
Simocephalus naupli
Simocephalus vetulus
Testudinella patina
Trichotria pocillum

BEES Beeston Hall Lake

Species

Acroperus harpae
Alona sp.
Bdelloid sp.
Brachionus angularis
Brachionus calyciflorus
Brachionus quadridentatus
Brachionus urceolaris
Ceriodaphnia quadrangula
Chydorus sphaericus
Colourella adriatica
Copepodite
Cyclops

Daphnia galeata
Daphnia longispina/hyalina
Daphnia naupli
Daphnia pulex
Diaptomus
Euchlanis sp.
Eurycerus lamellatus
Filinia longiseta
Keratella cochlearis
Keratella quadrata
Lecane sp.
Lepadella ovalis
Notholca squamula

Pleuroxus aduncus
Pleuroxus uncinatus
Polyarthra vulgaris
Scapholeberis mucronata
Simocephalus expinosus
Simocephalus vetulus
Syncheata sp.
Testudinella patina
Trichocerca porcellus
Trichocerca rousseleti
Trichocerca sp.
Trichotria pocillum

BIGW Big Wood Lake

Species

Alona guttata
Alona rectangula
Anuraeopsis fissa
Asplanchna sp.
Bdelloid sp.
Bosmina longirostris
Bosmina longirostris var. *cornuta*
Bosmina longirostris var. *similis*
Brachionus angularis
Brachionus angularis var. *bidens*

Brachionus calyciflorus
Brachionus calyciflorus var. *dorcus*
Brachionus urceolaris
Chydorus sphaericus
Copepodite
Cyclops
Daphnia longispina/hyalina
Filinia longiseta
Filinia terminalis
Keratella cochlearis
Keratella quadrata

Leydigia leydigii
Notholca labis
Pleuroxus aduncus
Pleuroxus uncinatus
Polyarthra sp.
Pompholyx sulcata
Scapholeberis mucronata
Syncheata sp.
Testudinella patina
Trichocerca sp.

BLIC Blickling Hall Lake

Species

Asplanchna sp.
Bdelloid sp.
Bosmina longirostris
Bosmina longirostris var. *cornuta*
Bosmina longirostris var. *similis*
Brachionus urceolaris
Copepodite
Cyclops
Daphnia galeata

Daphnia hyalina
Daphnia longispina/hyalina
Daphnia magna
Daphnia male
Daphnia naupli
Diaptomus
Epiphanes brachionus
Euchlanis sp.
Filinia longiseta
Keratella cochlearis

Keratella quadrata
Lecane sp.
Polyarthra sp.
Polyarthra vulgaris
Pompholyx sulcata
Scapholeberis mucronata
Trichocerca rousseleti
Trichotria pocillum

BLUE Bluestone Plantation Pond**Species**

Acroperus harpae
Alona affinis
Alona rectangula
Alona weltneri
Alonella nana
Anuraeopsis fissa
Asplanchna sp.
Bdelloid sp.
Bosmina longirostris
Bosmina longirostris var. *cornuta*
Bosmina longirostris var. *similis*
Brachionus angularis var. *bidens*
Brachionus calyciflorus

Brachionus quadridentatus var.
Ceriodaphnia quadrangula
Chydorus sphaericus
Colourella adriatica
Copepodite
Cyclops
Daphnia galeata
Daphnia hyalina
Daphnia longispina
Diaphanosoma brachyurum
Diaptomus
Eurycercus lamellatus
Filinia longiseta
Keratella cochlearis

Keratella quadrata
Lecane sp.
Lepadella ovalis
Pleuroxus aduncus
Pleuroxus denticulatus
Pleuroxus trigonellus
Scapholeberis mucronata
Sida crystalina
Simocephalus expinosus
Simocephalus vetulus
Trichocerca longiseta
Trichotria pocillum

FELB Felbrigg Hall Lake**Species**

Bosmina longirostris
Bosmina longirostris var. *cornuta*
Bosmina longirostris var. *similis*
Brachionus angularis var. *bidens*
Brachionus calyciflorus
Brachionus quadridentatus var.
Chydorus sphaericus
Copepodite

Cyclops
Daphnia cucullata
Daphnia galeata
Daphnia hyalina
Daphnia longispina/hyalina
Daphnia male
Daphnia naupli
Diaphanosoma brachyurum
Diaptomus

Keratella cochlearis
Keratella quadrata
Notholca labis
Pleuroxus aduncus
Pleuroxus sp..
Polyarthra sp.
Scapholeberis mucronata

GREP Green Plantation Pond**Species**

Alona rectangula
Alonella nana
Ascomorpha sp.
Cephalodella gibba
Chydorus sphaericus
Colourella adriatica
Copepodite
Cyclops
Daphnia galeata

Daphnia hyalina
Daphnia longispina/hyalina
Daphnia male
Daphnia naupli
Daphnia pulex
Diaptomus
Eurycercus lamellatus
Keratella cochlearis
Keratella quadrata
Lecane sp.

Lepadella ovalis
Pleuroxus aduncus
Polyphemus pediculus
Scapholeberis mucronata
Simocephalus expinosus
Simocephalus vetulus
Trichocerca similis
Trichocerca sp.

GUNT Gunthorpe Hall Lake**Species**

Acroperus harpae
Alona affinis
Alona sp.
Alonella nana
Anuraeopsis fissa
Ascomorpha sp.
Asplanchna sp.
Bdelloid sp.
Bosmina longirostris
Bosmina longirostris var. *similis*
Brachionus angularis var. *bidens*
Ceriodaphnia quadrangula
Chydorus sphaericus

Colourella adriatica
Copepodite
Cyclops
Daphnia naupli
Diaptomus
Epiphanes brachionus
Eurycercus lamellatus
Filinia longiseta
Filinia terminalis
Hexarthra sp.
Keratella cochlearis
Keratella quadrata
Lecane sp.
Platylas quadricornis

Pleuroxus aduncus
Pleuroxus truncatus
Ploesoma sp.
Polyarthra sp.
Polyarthra vulgaris
Pompholyx sulcata
Scapholeberis mucronata
Simocephalus expinosus
Simocephalus vetulus
Syncheata pectinata
Syncheata sp.
Testudinella patina
Trichocerca sp.

HAVE Haveringland Hall Lake**Species**

Alona affinis
Alona quadrangularis
Anuraeopsis fissa
Asplanchna sp.
Bdelloid sp.
Bosmina longirostris
Bosmina longirostris var. *cornuta*
Bosmina longirostris var. *similis*
Brachionus angularis var. *bidens*

Brachionus calyciflorus var. *dorcus*
Brachionus rubens
Ceriodaphnia quadrangula
Chydorus sphaericus
Copepodite
Cyclops
Daphnia cucullata
Daphnia galeata
Daphnia hyalina

Daphnia longispina/hyalina
Daphnia male
Daphnia naupli
Keratella cochlearis
Keratella quadrata
Polyarthra sp.
Pompholyx sulcata
Trichocerca rousseleti

HOKI Holkham Hall Lake (Isolated)**Species**

Alona affinis
Asplanchna sp.
Bosmina longirostris
Bosmina longirostris var. *cornuta*
Brachionus calyciflorus
Ceriodaphnia quadrangula
Chydorus sphaericus
Copepodite

Cyclops
Daphnia curvirostris
Daphnia galeata
Daphnia hyalina
Daphnia longispina/hyalina
Daphnia longispina
Daphnia magna
Daphnia naupli
Daphnia pulex

Diaptomus
Hexarthra sp.
Keratella cochlearis
Keratella quadrata
Simocephalus expinosus
Simocephalus sp.
Simocephalus vetulus
Trichocerca similis

HOKM Holkham Hall Lake (Main)**Species**

Alona affinis
Alona quadrangularis
Asplanchna sp.
Brachionus angularis
Brachionus rubens
Brachionus urceolaris
Ceriodaphnia quadrangula
Chydorus sphaericus
Copepodite

Cyclops
Daphnia cucullata
Daphnia galeata
Daphnia hyalina
Daphnia longispina/hyalina
Daphnia magna
Daphnia naupli
Daphnia pulex
Diaptomus

Hexarthra mira
Ilyocryptus sordicus
Keratella cochlearis
Keratella quadrata
Lecane sp.
Pleuroxus uncinatus
Polyarthra vulgaris
Scapholeberis mucronata

LOPO Lowes Pond**Species**

Acroperus harpae
Alonella nana
Ascomorpha sp.
Asplanchna sp.
Bosmina longirostris
Bosmina longirostris var. *cornuta*
Bosmina longirostris var. *similis*
Bosmina naupli
Brachionus calyciflorus

Brachionus calyciflorus var. *dorcus*
Ceriodaphnia quadrangula
Chydorus sphaericus
Colourella adriatica
Copepodite
Cyclops
Daphnia hyalina
Keratella cochlearis
Keratella quadrata

Lecane sp.
Lepadella ovalis
Mytilina ventralis
Pleuroxus truncatus
Polyarthra sp.
Polyarthra vulgaris
Scapholeberis mucronata
Trichocerca similis
Trichotria pocillum

MELT Melton Constable Hall Lake**Species**

Asplanchna sp.
Bosmina longirostris
Bosmina longirostris var. *cornuta*
Bosmina longirostris var. *similis*
Bosmina naupli
Ceriodaphnia quadrangula
Chydorid naupli
Chydorus sphaericus
Copepodite

Cyclops
Daphnia atkinsoni
Daphnia cucullata
Daphnia galeata
Daphnia longispina/hyalina
Daphnia male
Daphnia naupli
Daphnia pulex
Diaphanosoma brachyurum

Diaptomus
Filinia longiseta
Keratella cochlearis
Keratella quadrata
Lecane sp.
Pleuroxus aduncus
Pompholyx sulcata
Simocephalus serrulatus

NARF Narford Hall Lake**Species**

Alona affinis
Alona quadrangularis
Bdelloid sp.
Bosmina longirostris
Brachionus calyciflorus
Ceriodaphnia quadrangula
Copepodite
Cyclops

Daphnia atkinsoni
Daphnia cucullata
Daphnia longispina/hyalina
Daphnia magna
Daphnia naupli
Daphnia pulex
Diaphanosoma brachyurum
Diaptomus
Keratella quadrata

Lecane sp.
Mytilina ventralis
Notholca labis
Pleuroxus aduncus
Pleuroxus uncinatus
Scapholeberis mucronata
Simocephalus expinosus
Testudinella patina

PEDH Pedham Lake**Species**

Anuraeopsis fissa
Asplanchna sp.
Bosmina longirostris
Bosmina longirostris var. *cornuta*
Bosmina longirostris var. *similis*
Brachionus calyciflorus
Ceriodaphnia quadrangula

Chydorus sphaericus
Copepodite
Cyclops
Daphnia cucullata
Daphnia longispina/hyalina
Daphnia naupli
Filinia longiseta
Keratella cochlearis

Keratella quadrata
Pleuroxus truncatus
Pleuroxus uncinatus
Polyarthra sp.
Pompholyx sulcata
Scapholeberis mucronata
Trichocerca rousseleti

SAHA Saham Toney Mere**Species**

Bdelloid sp.
Bosmina longirostris
Bosmina longirostris var. *similis*
Brachionus angularis
Brachionus angularis var. *bidens*
Brachionus calyciflorus var. *dorcus*
Brachionus rubens
Ceriodaphnia quadrangula

Chydorus sphaericus
Copepodite
Cyclops
Daphnia atkinsoni
Daphnia cucullata
Daphnia curvirostris
Daphnia galeata
Daphnia longispina/hyalina

Daphnia magna
Daphnia male
Daphnia naupli
Daphnia pulex
Keratella cochlearis
Keratella quadrata
Pompholyx complanata
Pompholyx sulcata

SCOT Scottow Pond**Species**

Alona affinis
Anuraeopsis fissa
Ceriodaphnia quadrangula
Chydorus sphaericus
Colourella adriatica
Copepodite
Cyclops
Daphnia galeata

Daphnia longispina/hyalina
Daphnia male
Daphnia pulex
Diaptomus
Keratella cochlearis
Keratella quadrata
Lecane sp.
Lepadella ovalis
Mytilina ventralis

Pleuroxus aduncus
Pleuroxus laevis
Polyarthra sp.
Scapholeberis mucronata
Simocephalus expinosus
Testudinella patina
Trichotria pocillum

SELB Selbrigg Pond**Species**

Acroperus harpae
Alona affinis
Alona sp.
Alonella exigua
Alonella nana
Anuraeopsis fissa
Asplanchna sp.
Bosmina longirostris
Bosmina longirostris var. *cornuta*
Bosmina longirostris var. *similis*
Brachionus angularis var. *bidens*

Ceriodaphnia quadrangula
Chydorus sphaericus
Copepodite
Cyclops
Daphnia galeata
Daphnia naupli
Diaptomus
Hexarthra sp.
Keratella cochlearis
Keratella quadrata
Lecane sp.

Mytilina ventralis
Pleuroxus aduncus
Pleuroxus uncinatus
Polyarthra sp.
Polyarthra vulgaris
Scapholeberis mucronata
Trichocerca capucina
Trichocerca porcellus
Trichocerca rousseleti
Trichocerca similis

STRA Stradsett Hall Lake

Species

Bosmina longirostris
Bosmina longirostris var. *cornuta*
Bosmina longirostris var. *similis*
Brachionus angularis var. *bidens*
Brachionus calyciflorus
Brachionus calyciflorus var. *dorcus*
Brachionus calyciflorus var. *pala*
Brachionus urceolaris var. *sericus*

Ceriodaphnia quadrangula
Chydorus sphaericus
Copepodite
Cyclops
Daphnia cucullata
Daphnia longispina/hyalina
Daphnia magna
Daphnia male
Daphnia naupli

Daphnia pulex
Diaptomus
Eurycerus lamellatus
Filinia longiseta
Keratella cochlearis
Keratella quadrata
Lepadella ovalis
Testudinella patina

WOLT Wolterton Hall Lake

Species

Alona affinis
Alona quadrangularis
Alona sp.
Asplanchna sp.
Bosmina longirostris
Brachionus angularis
Ceriodaphnia quadrangula
Copepodite
Cyclops

Daphnia cucullata
Daphnia galeata
Daphnia hyalina
Daphnia longispina/hyalina
Daphnia magna
Daphnia naupli
Daphnia pulex
Diaptomus
Eurycerus lamellatus
Hexarthra mira

Keratella cochlearis
Keratella quadrata
Lecane sp.
Polyarthra sp.
Polyarthra vulgaris
Scapholeberis mucronata
Simocephalus expinosus
Simocephalus vetulus
Testudinella patin

Appendix 3. Summary water chemistry data from 1998 UCL-ECRC survey of non-broads lakes

Site	Date	pH	Cond µs cm ⁻¹	DO mg l ⁻¹	Max depth cm	Secchi cm*	SRP µg l ⁻¹	TP µg l ⁻¹	NO ₃ -N mg l ⁻¹	Tot Alk mg l ⁻¹ CaCO ₃	Ca µg l ⁻¹	Na µg l ⁻¹	K µg l ⁻¹	Mg µg l ⁻¹	Fe µg l ⁻¹	B µg l ⁻¹	Ba µg l ⁻¹	Co µg l ⁻¹	Mn µg l ⁻¹	S µg l ⁻¹	Sr µg l ⁻¹	Zn µg l ⁻¹	Cl µg l ⁻¹
ANTI	02/08/1998	9.01	445	10.9	85	vb	13.0	29	1.41	76	77.3	29.7	3.5	8.09	-0.04	0.04	0.1	0.01	0	35.55	0.37	0.07	60.93
BARN	26/07/1998	8.44	508	8.9	68	vb	523.1	810	1.60	218	124.3	27.2	4.2	6.92	-0.03	0.02	0.08	0.02	0.03	23.35	0.39	0.05	45.00
BAYF	26/08/1998	8.42	515	12.2	132	vb	287.7	368	2.00	192	112.8	31.2	3.6	6.13	0.07	0.06	0.12	0.02	0	26.62	0.33	0.08	54.58
BEES	18/08/1998	8.8	450	9.8	95	vb	74.3	101	0.09	134	84.7	38.2	5	15.12	0.04	0.01	0.03	0.01	0.25	35.67	0.36	0.05	72.41
BIGW	21/08/1998	8.96	655	19.4	118	15	27.7	531	0.09	130	74.9	36.1	3.6	14.21	0	0.01	0.12	0.01	0	28.71	0.42	0.05	65.14
BLIC	28/07/1998	8.25	445	9.2	258	nd	20.1	33	0.12	118	87.1	28.2	6	9.04	-0.04	0.03	0.1	0.01	0.02	39.04	0.31	0.06	55.24
BLUE	28/07/1998	8.31	420	7.1	164	83	38.7	63	0.03	162	87.3	30.4	3.9	6.25	-0.04	0.01	0.09	0.01	0.01	14.71	0.24	0.04	55.80
CAPT	13/06/1998	6.71	220	7.95	100	36	0.0	190	0.00	nd	5.9	29.4	1.8	3.7	0.02	0.01	0.05	-0.01	0.12	6.37	0.04	0.11	59.15
CLEY	20/08/1998	7.96	680	16	160	vb	24.3	38	11.48	240	119.9	17.4	2.1	2.44	0.01	0.04	0.16	0.01	0	10.22	0.25	0.09	29.47
FELB	25/08/1998	9.09	390	9.09	150	vb	149.3	203	2.04	112	57.6	33.1	13.8	6.05	0.13	0.13	0.1	0.01	0.03	12.09	0.18	0.04	66.00
GREP	22/07/1998	8.73	610	10.9	310	vb	14.4	21	0.80	256	65.9	33.1	0	8.15	-0.04	0.01	0.07	0	0	20.23	0.22	0.08	64.16
GUNT	01/08/1998	8.76	405	3	245	vb	25.9	35	0.00	142	93.5	18.8	0.3	4.49	0.01	0.01	0.08	0.01	0.15	19.73	0.3	0.04	36.17
GREA	29/07/1998	9.5	400	12.8	30	vb	57.3	292	2.85	114	73.6	35	2.7	9.84	-0.02	0.03	0.06	0.01	0.03	23.96	0.29	0.04	59.73
SAWM	29/07/1998	8.95	380	6.5	150	30	20.1	142	0.71	86	57.7	36.3	2.5	8.85	0.02	0.04	0.17	0.01	0.01	23.41	0.25	0.05	67.76
HAVE	23/07/1998	8.47	460	11.1	80	52	18.7	63	3.37	158	99.8	27.1	5	7.04	0.03	0.03	0.09	0.02	0	25.84	0.35	0.06	48.11
HING	19/08/1998	9.38	330	16.4	500	53	46.0	99	0.04	86	67.3	21.3	2.5	3.62	0	0.02	0.09	0.01	0	23.69	0.24	0.05	56.15
HOKI	06/09/1998	9.59	250	nd	99	vb	118.1	218	0.37	138	32.7	16.9	-1.1	2.73	0.11	-0.01	0.03	0	0	9.58	0.17	0.05	48.10
HOKM	06/09/1998	8.27	460	nd	256	nd	93.9	253	0.56	136	66.6	21.5	0.8	3.52	0.32	0.02	0.09	0.01	0.01	12.02	0.26	0.14	43.38
HONN	23/07/1998	9.78	325	nd	5	vb	38.7	219	4.85	72	66	23.1	3.9	7.66	0.04	0.01	0.08	0.01	0.01	22.67	0.23	0.04	47.84
HOVE	29/07/1998	9.07	515	13.1	100	33	14.4	210	0.61	130	72.9	39.6	5.7	25.24	0.04	0.09	0.11	0.01	0.15	36.29	0.35	0.04	79.59
KETT	23/07/1998	8.16	525	9.2	102	58	33.0	153	0.00	118	134.3	27	6.1	6.49	0.02	0.05	0.11	0.02	0.01	18.48	0.46	0.05	38.19
KIMB	31/07/1998	7.74	420	4.3	15	vb	914.9	950	2.91	172	77.4	25.8	20.8	2.84	0.1	0.13	0.05	0.01	0.04	16.41	0.23	0.05	38.27
LETH	28/07/1998	10.3	840	20+	100	10	75.9	4227	2.09	72	69	90.4	9.4	8.86	-0.05	0.34	0.16	0.01	0	28.72	0.27	0.05	100.49
LPER	13/06/1998	6.01	175	3.65	40	30	34.0	130	0.03	nt	2.5	22.1	2.3	4.44	1.66	0.07	0.17	-0.01	0.2	3.32	0.03	0.23	38.48
MELT	24/07/1998	9.07	265	10.2	317	96	14.4	45	0.03	106	53.6	18.4	1.7	3.69	-0.04	0.01	0.04	0.01	0	9.27	0.17	0.04	38.43
NARF	27/07/1998	9.08	210	12.2	195	vb	13.0	25	1.53	94	35.3	8.6	0.5	1.61	-0.03	0.01	0.05	0	0	6.01	0.14	0.07	25.43
PEDH	30/07/1998	9.09	460	14.8	90	45	30.1	167	1.29	90	68.4	39.9	2.4	14.3	0	0.01	0.06	0.01	0.15	26.22	0.28	0.04	79.70
RACK	30/07/1998	8.3	500	11.9	156	52	18.7	55	3.28	166	103.5	32.9	2.1	10.14	-0.02	0.02	0.05	0.02	0.01	31.26	2.77	0.05	52.57
SAHA	19/08/1998	8.25	670	10.6	190	42	405.3	630	0.04	296	105.5	26.9	6.6	5.74	-0.01	0.04	0.12	0.02	0.01	19.01	0.3	0.07	55.85
SCOT	29/07/1998	7.99	515	8	115	vb	17.3	47	0.00	106	97.5	30.5	3.9	12.33	-0.03	0.02	0.06	0.02	0.07	47.19	0.35	0.05	76.99
SELB	26/07/1998	7.95	412	7.3	128	vb	11.6	22	0.12	146	86.4	30.2	0.4	7.08	-0.04	0.01	0.09	0.02	0.02	18.54	0.26	0.03	58.32
SENN	27/07/1998	8.68	280	8.8	50	vb	53.0	92	0.09	144	63.2	13	3.8	3.36	0.08	0.01	0.03	0.01	0.01	5.25	0.17	0.07	24.13
STRA	19/08/1998	9.74	485	10.9	184	vb	222.7	267	0.06	104	59.7	31.4	2.9	2.77	0.05	0.02	0.07	0	0.01	7.35	0.2	0.07	84.04
STST	10/08/1998	7.76	560	2.2	35	vb	1208.7	1170	0.16	232	83.2	44.7	16.6	15.57	1.43	0.08	0.12	0.02	0.79	5.33	0.36	0.09	88.39
WOLT	22/07/1998	9.72	355	13.6	169	vb	18.7	29	0.03	34	59.2	29.7	2.3	8.07	-0.01	0.01	0.04	0	0.01	43.01	0.3	0.04	54.16

* vb = secchi disk visible on lake bottom

Appendix 4. Summary water chemistry data from the 1999-2000 UCL-ECRC survey of non-broads lakes (mean values from 10 samples throughout the period May 1999 to May 2000)

Site	pH	Cond $\mu\text{s cm}^{-1}$	SRP $\mu\text{g l}^{-1}$	TP $\mu\text{g l}^{-1}$	$\text{NO}_3\text{-N}$ mg l^{-1}	ChIA $\mu\text{g l}^{-1}$	Alk mg l^{-1} CaCO ₃	Si $\mu\text{g l}^{-1}$
BAYF	8.2	651	159	241	2.37	2.9	244.2	8.2
BEES	8.0	616	23	105	0.83	3.7	166.1	10.5
BIGW	8.1	688	16	113	2.63	3.9	234.8	10.5
BLIC	8.7	487	4	102	0.78	5.2	120.0	2.4
BLUE	8.0	515	6	41	0.69	7.1	159.8	2.1
BRIN	7.9	600	6	35	0.14	-	-	-
FELB	8.3	544	31	107	1.26	12.5	158.1	3.3
GREP	7.9	536	19	31	0.90	12.7	141.0	5.2
GUNT	7.9	522	5	65	0.66	14.4	210.3	9.7
HAVE	8.2	574	7	65	2.20	14.9	181.7	4.7
HOKI	8.0	564	18	44	3.64	19.0	180.2	4.4
HOKM	8.2	468	24	58	1.94	21.3	172.8	6.3
LOPO	7.9	623.5	27	40	2.76	22.1	185.6	5.3
MELT	8.4	339	74	154	0.07	32.1	140.3	4.6
NARF	8.2	346	8	34	2.53	33.4	147.4	7.8
PEDH	7.8	529	62	165	1.73	36.3	111.6	13.4
SAHA	8.4	503	247	490	0.03	36.6	174.1	13.8
SCOT	7.6	657	15	72	0.11	44.1	210.4	11.7
SELB	7.9	566	7	35	0.08	45.4	188.4	6.3
STRA	8.5	490	86	166	1.10	45.4	147.7	4.4
WOLT	8.2	526	26	61	0.13	63.9	157.7	9.9