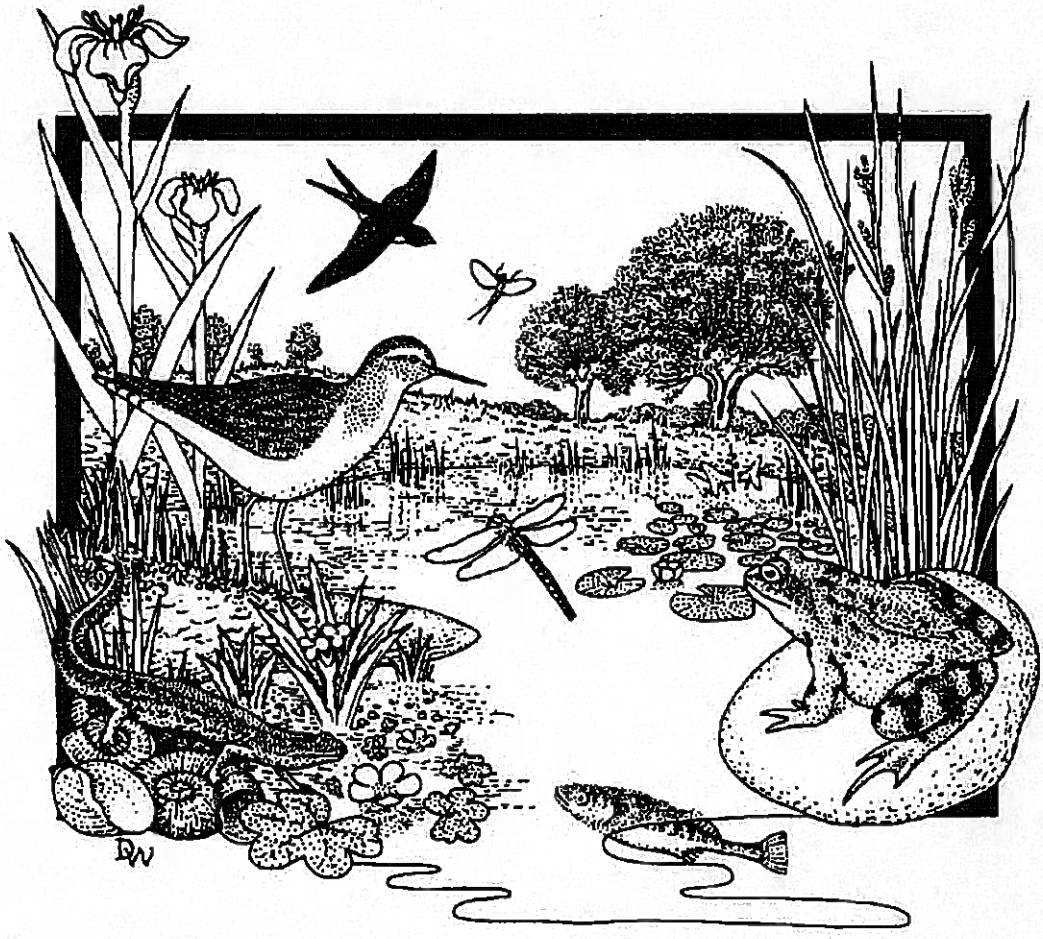
4810

AN ASSESSMENT OF THE ECOLOGICAL VALUE OF SUSTAINABLE URBAN DRAINAGE SYSTEM PONDS IN SCOTLAND



May 2000

Pond Action
Oxford Brookes University
Gipsy Lane
Headington
Oxford OX3 0BP
Tel: 01865 483249

Acknowledgements

Many thanks to David Basset (Watershed Systems Ltd.), Derek Carter (Carter McGlynn), Jock Maxwell (Meedhurst Project management) for supplying information about the SUDS sites and, particularly, their planting schemes. Thanks too to Gaye McKissock from Abertay University for providing information and maps for the DEX site.

Summary of findings

An ecological survey of Sustainable Urban Drainage System (SUDS) ponds was undertaken in the Edinburgh and Dunfermline areas of Scotland in order to assess the biodiversity value of SUDS ponds and provide information which will inform the future design of SUDS schemes.

A total of thirteen ponds from four SUDS schemes were investigated. All ponds were surveyed for wetland macrophytes and five of the thirteen were also surveyed for aquatic macroinvertebrates. For these groups biodiversity value was assessed in terms of numbers of species and occurrence of uncommon species, using the minimally impaired National Pond Survey (NPS) sites as a baseline for comparison. Evidence of amphibians and small mammals was also noted at all survey ponds.

The results of the work showed that the SUDS ponds varied considerably in quality. The best SUDS ponds had colonised naturally with rich plant and animal communities, and supported a range of uncommon plant species. The Freeport scheme was particularly notable for supporting a highly diverse aquatic invertebrate and plant community. In addition, evidence of water vole occupancy was recorded at two ponds on the Motorola site. Since water vole is a Biodiversity Action Plan species which is at increasing threat in the UK, this was a particularly welcome finding.

Set against these positive results, however, was evidence that some of the SUDS ponds had relatively species-poor plant and invertebrate communities. In addition all ponds had far fewer uncommon invertebrate species than would be expected, compared to minimally impaired sites. Overall, the factors which appeared to positively influence plant and invertebrate species richness, and favour the occurrence of uncommon species, included the presence of (i) semi-natural areas in the near surrounds (ii) good water quality (iii) variation in waterbody shape and management regime.

Investigation of the SUDS schemes also highlighted a range of issues associated with the introduction of inappropriate planting schemes at many ponds. This included the widespread introduction of aliens species, ornamental cultivars, very rare species outside their natural range and native species which were not of local provenance. The most worrying finding was the widespread occurrence of the alien plant New Zealand pigmyweed (*Crassula helmsii*). Almost certainly this species was introduced accidentally to ponds – most probably as seeds or vegetative fragments present in the soil of other plants supplied by contractors. The frequent occurrence of *Crassula* is a problem because the species is highly invasive and poses a serious threat to freshwater ecosystems. The danger is that, through accidental transfer, SUDS ponds could become a vector that helps to move *Crassula* around the country and encourage its spread into other semi-natural ponds and wetlands.

Overall, the main conclusion from survey is that there appears to be considerable potential for SUDS ponds to deliver ecological benefits in addition to their functional and aesthetic benefits. In particular, it seems likely that with general improvements in site design and location, and greater care with planting regimes it should be possible for SUDS schemes to make a positive contribution to the protection of freshwater biodiversity in Scotland.

Contents

AN ASSESSMENT OF THE ECOLOGICAL VALUE OF SUSTAINABLE URBAN DRAINAGE SYSTEM PONDS IN SCOTLAND

1. AIMS AND OBJECTIVES

This report describes the results of an ecological survey of permanent and temporary waterbodies created as part of Sustainable Urban Drainage Systems (SUDS) in the Edinburgh and Dunfermline areas of Scotland.

The surveys were undertaken for the Scottish Environment Protection Agency (SEPA) in order to assess the ecological value of SUDS ponds, and to provide information which could inform the future design and creation of sustainable urban drainage schemes.

1.1 Background

Sustainable urban drainage systems are increasingly being used for the management of urban wastewater in the UK. Such schemes have a range of proven benefits over conventional drainage schemes particularly in their ability to ameliorate runoff volumes and reduce the export of pollutants from urban areas.

Proponents frequently suggest that SUDS schemes also have additional environmental benefits in that they create new wetland habitats for wildlife. In practice, however, there have been few investigations of the biodiversity value of SUDS schemes.

The aim of the current study was to obtain a preliminary indication of the value of SUDS ponds in Scotland and, in particular, to begin to identify areas where scheme designs could be modified in order to increase their wildlife value.

The work was partly carried out in order to provide supporting information for the SEPA handbook "Ponds, Pools and Lochans: Guidance on good practice in the management and creation of small waterbodies in Scotland". In addition, work at one of the SUDS sites (the Dunfermline East Expansion Area), will provide information which is complementary to a longer term SUDS assessment project being undertaken by Abertay University.

2. OUTLINE OF THE SITES SURVEYED

Ecological surveys were undertaken at four sites where SUDS schemes had been implemented in the last seven years. These were:

1. Motorola, Easter Inch, Bathgate (NS99476782).
2. Freeport Leisure, Westwood, West Calder (NT00716337).
3. Houston Industrial Estate (NT0055699).
4. Dunfermline East Expansion Area, Duloch Park (NT1287).

Each of these sites is described briefly below.

1. Motorola, Easter Inch, Bathgate (NS99476782)

The Motorola site includes four SUDS ponds. Three of these are linked as a series that runs around the northern side of the site. The Motorola ponds become progressively more informal, from the Upper

Pond which has reinforced concrete banks and gardened beds around it, to the Lower Pond which has earth banks and rank grassland surrounds. This three-pond series drains water from the built areas of the Motorola site including car parking and loading yard. The fourth pond is a semi-natural grazed waterbody which is located adjacent to the M8 on Motorola's south-east boundary and which drains road runoff from the motorway. All the ponds were created in 1993, so at the time of the current survey they were six years old. The location and general characteristics of the ponds are briefly summarised below.

Upper pond (NS992676): The top pond in the triple series. Located next to the Motorola car park with planted bed and lawn surrounds. Approximately 500 m^2 in area with concrete banks dropping vertically to shallow water. The pond had no marginal plant stands. Submerged plant cover was good (50%), but was dominated by the alien species Canadian pondweed (*Elodea canadensis*). Approximately 50% of the pond was covered in filamentous algae.

Middle pond (NS993676): Located immediately below and to the north-east of Upper Pond and linked by a short cascade. Approximately 1000 m^2 in area. Largely surrounded by amenity grassland and planted beds. The margins were mainly gravel or cobble overlying clay. At the time of the survey most of the pond margins were bare, the main exception being a marshland area along the south-eastern edge which had been planted with a wetland wildflower mix. Approximately 30% of central areas of the pond supported submerged plants, dominated by Canadian pondweed. Approximately 25% of the pond was covered in filamentous algae.

Lower pond (NSNS995677): The lowest pond in the triple series. Approximately 1750 m^2 in area. Located on the north-east margin of the Motorola site and surrounded by unimproved rank grassland. Linked to Middle Pond via a partly culverted ditch. The pond had a 6 m planted band of common reed (*Phragmites australis*) around its edge. It also had a good cover of submerged plants (c. 60%) dominated by the alien Canadian pondweed (*Elodea canadensis*), but also the native species blunt-fruited water-starwort (*Callitriche obtusangula*) and spiked water-milfoil (*Myriophyllum spicatum*).

Motorway pond (NS995674): Located in short improved grassland adjacent to the M8 on the south-east edge of the Motorola site. Approximately 500 m^2 in area, long, narrow and sinuous in shape with clay/earth banks. The only SUDS pond of the 13 surveyed to have margins that were grazed by livestock (sheep). The pond supported a marginal fringe of mixed tall emergent plants (c.40% cover of pond) and good cover of native submerged and floating-leaved plant species (c.50% cover).

2. Freeport Leisure, Westwood, West Calder (NT00716337)

The Freeport Leisure shopping centre scheme includes two closely linked SUDS ponds. These lie in an area of semi-natural acid grassland about 250 m south-east of the Freeport shopping centre complex. The ponds receive surface runoff water from the shopping centre including the car parking areas. This water is collected into a semi-vegetated swale that runs through the grassland area to the top SUDS pond. The two ponds are linked via a short ditch connection. The ponds were approximately three years old at the time of the survey.

Freeport Upper (NT005635): This is a small pond, approximately 500 m^2 in area, with a broadly circular outline and clay lined banks. At the time of the survey the pond supported a thin but diverse fringe of semi-natural wetland vegetation in the upper drawdown zone (occupying c.10% of pond area) and, in the water, a good cover of native submerged and floating-leaved plants (c.35% cover).

Freeport Lower (NT005635): The lower pond was similar in size and shape to the upper site. It also had a thin fringe of wetland herbs and grasses at its edge (c.8% cover of pond) and good cover of native submerged plant species (c.30%).

3. Houston Industrial Estate, Caw Burn (NT070698)

The Houston SUDS scheme lies next to Caw Burn in an area largely surrounded by rank vegetation and scrub. The scheme includes an open waterbody of c.800 m^2 in area with an extensive marsh area behind. The system was created to take hard-surface runoff from the industrial estate. In practice, however, it also receives a polluted (non-consented) discharge from unknown source(s) in the industrial estate. The pond's water quality is, therefore, unusually poor. The waterbody and wetland were created in 1996 and planted in 1997. Only the SUDS pond was included in our survey, not the wetland area,

since this proved impossible to access. The pond had a thin marginal fringe of marginal herbs and an extensive (80%) cover of the alien submerged species Nuttall's pondweed (*Elodea nuttallii*).

4. Dunfermline East Expansion Area (DEX), Duloch Park (NT1287)

The Dunfermline East Expansion Area (DEX) is a 370 hectare site under development for housing and commercial purposes. The site has a range of SUDS waterbodies including both permanent ponds and seasonal retention basins for attenuating runoff. The waterbodies ranged in age from 1 to 3 years. Six ponds were investigated:

Linburn Pond (NT119874): A large waterbody, c.4800 m^2 in area, surrounded by amenity grassland and beds of perennials herbs and shrubs. The margins of the pond were planted-up with common reed (*Phragmites australis*). A range of lower-growing wetland herbs and aquatics had also been introduced at the water's edge. The water was relatively turbid and supported little submerged plant growth.

Halbeath Pond (NT128883): A large waterbody (c.3200 m^2), similar to Linburn Pond with steep grassland banks. The pond margins were planted-up with a range of low growing and aquatic and wetland plants and with a broad band of common reed. Unlike Linburn Pond, the water was relatively clear and locally supported good stands of mare's-tail (*Hippuris vulgaris*).

Calais Wood 'Marsh' (NT125868): This was the largest of the SUDS ponds surveyed (c.13500 m^2 in area). It was also the most complex in shape and the only waterbody to incorporate islands. Except for Calais Wood to the east, the pond was surrounded by amenity grassland. The north-eastern edge of the pond was unusual in that it supported a relatively acid flora, whilst other areas of the pond were more circum-neutral. This reflected the fact that, prior to the creation of the pond, this part of the site had supported a small area of bog (largely destroyed when the SUDS pond was excavated), small areas of which were retained following the construction of the pond. The pond supported locally extensive stands of wetland grasses (15%) and submerged plants (12%).

Pond 5 (NT127862): This pond is approximately 3100 m^2 in area. Its banks are sown with grass mix. The pond currently receives no urban runoff, and is being used as a "control" waterbody in the Abertay study. The pond margins were planted up with a range of lower-growing wetland herbs and aquatics and with a broad band of common reed.

Retention Basins 1 and 2 (NT130878, NT125863 respectively): These seasonal retention basins were dry at the time of the survey. Both were small (c.50 m^2 in area), and only retained a wetland flora at their base.

3. ECOLOGICAL SURVEYS

3.1 Survey methods

The SUDS ponds were surveyed on 6th and 7th of October 1999. In total, 13 sites were surveyed for plants and 5 for invertebrates (see Table 1).

The methods used for the surveys were based on the standard techniques used for the National Pond Survey and are described in Appendix 1. In brief, however, invertebrates were sampled using a standard hand-net with material collected from all the main pond habitats. The habitat samples were then sorted in the laboratory to remove invertebrates for identification to species level. Wetland plants were surveyed by walking and wading the perimeter and, where possible, the open water areas of the ponds. Deeper areas were surveyed using a grapnel thrown from the bank. The margins of all ponds were searched for evidence of small mammals and amphibians. Amphibians were also noted where they were caught during the invertebrate hand net samples.

The ponds' conservation value was assessed in terms of (i) the number of species recorded at the site and (ii) the number of uncommon species found. Data from the site were compared with information from other sites in the UK surveyed using the same methodology (see Appendix 4).

Table 1. Number of ponds surveyed from the four SUDS schemes

Site	*Number of ponds surveyed for plants*	*Number of ponds surveyed for invertebrates*
Motorola	4	2
Freeport Leisure	2	1
Houston Industrial Estate	1	1
Dunfermline East Expansion Area	6 (including 2 seasonal sites)	1

3.2 Results of invertebrate surveys

3.2.1 Number of species

Five SUDS ponds were surveyed for macroinvertebrates: Motorola Lower and Motorway, Freeport Upper, Houston Caw Burn and DEX Calais Wood Marsh. In total, 91 aquatic macroinvertebrate species were recorded from these waterbodies. This represents approximately 12% of aquatic macroinvertebrate species found in the UK in the groups investigated.

The number of invertebrate species recorded from individual ponds ranged from 24 to 58 (see Table 2). The richest pond was Freeport Upper pond, which supported 58 species. This was a very high total, particularly considering that this was a small pond – about 25 times smaller than the DEX Calais Wood Marsh for example.

Three of the remaining four ponds (Motorola Lower, Motorola Motorway and DEX Calais Marsh Wood pond) supported in the order of 40 invertebrate species per pond. These are good, but not exceptional totals, which are similar to the average values for permanent ponds recorded in the National Pond Survey.

The pond that supported fewest species was Caw Burn pond which drains the Houston Industrial estate. A total of 24 invertebrate species were recorded from this site. The site was also unusual in that many dead invertebrates were netted from the pond, presumably these were individuals that were unable to survive the pond's polluted water.

3.2.2 Rarity

Only one uncommon invertebrate species was recorded in the survey, the cased caddis-fly *Limnephilus binotatus* which is a regionally notable species typical of fen and reed swamp. The caddis was recorded in two ponds (Freeport Upper and Motorola Lower).

The very low number of uncommon invertebrate species recorded from the five SUDS ponds is unusual. Ponds in semi-natural landscapes would normally be expected to support an average of four local or Nationally Scarce species per pond. The average for the SUDS ponds was an order of magnitude less at only 0.4 species per pond.

Table 2. Number of invertebrate species recorded from the SUDS ponds

	Motorola Motorway	*Motorola Lower*	*Freeport Upper*	*Houston Caw Burn*	*DEX Calais Wood Marsh*
Number of species	40	37	58	24	40
Number of uncommon species	0	1	1	0	0
Conservation value*	High	High	Very high	Moderate	High

* see Appendix Table 4.2

3.2.3 Overall assessment of conservation value of macroinvertebrate assemblages

The conservation value of invertebrate assemblages was assessed using the system developed by Pond Action which compares sites to the National Pond Survey (NPS) database (see Appendix Tables 4.4 and 4.5). NPS ponds are located in semi-natural landscapes throughout England, Wales and Scotland where damaging impacts (e.g. agricultural and road runoff, intensive land management, fish stocking) are largely absent. They therefore provide a baseline against which the quality of ponds can be judged. Thus sites of Low value support species measures which are well below the average for NPS sites. Moderate value sites are those which are close to the NPS average whereas High and Very High value sites are those slightly or considerably above NPS average values. Sites are judged *either* in terms of numbers of species *or* in terms of numbers of uncommon species (e.g. where species numbers are low, but uncommon species occur).

Using this assessment system, one of the five SUDS ponds supported a macroinvertebrate assemblage of Very High conservation value, three ponds had High conservation value assemblages and one a moderate value assemblage.

3.3 Results of plant surveys

3.3.1 Issues associated with plant assessments

There are a number of issues associated with SUDS schemes that can make it difficult to assess the conservation value of their plant assemblages. In particular, plant species are often specifically added to SUDS ponds either to aid pond functioning or to enhance their visual appeal.

In order to assesses the long term value of SUDS schemes for wetland plant conservation, it is preferable that all artificially planted species are omitted from estimates of pond species richness and rarity. This is because evidence suggests that ponds have a naturally high turnover of plants, recent studies indicating that in the order of 50% of species may be lost, and similar numbers of species gained, over a 25 year period (Nicolet 1998). This means that measures of the richness of a SUDS pond's *naturally colonised* plant community are likely to be better predictors of the *long-term* potential of the site, than estimates which include *deliberately planted species*, because if the latter become extinct they are not likely to be replenished from the local surrounds.

In order to identify the 'natural' plant community of SUDS ponds, an attempt has been made in this study to differentiate between native plant species that colonised the SUDS ponds through natural agents (wind, animals etc), and species which are either non-native, or which have been introduced during planting schemes. To help compile this list, planting records were obtained from the contractors involved in planting up the original schemes. This was not the perfect solution since, in general, only partial records of the original planting schemes were available for the ponds. In addition, in at least two ponds (Motorola Motorway pond and DEX Calais Marsh), local plants were introduced from nearby sites but no record of the species added was kept. Overall, therefore, the native species lists for each site are only likely to be in the order of 80%-90% accurate. Fortunately, however, the general plant community trends are sufficiently clear for explicable conclusions to be draw.

Table 3. Number of plant species and uncommon species recorded from the SUDS ponds

	M'rola Upper	*M'rola Middle*	*M'rola Lower*	*M'rola M'way*	*Freeport Upper*	*Freeport Lower*	*Houston Caw Burn*	*DEX Calais Marsh*	*DEX Halbeath*	*DEX Linburn*	*DEX Pond 5*	*DEX Retention 1*	*DEX Retention 2*
Number of native species	2	12	12	17	24	21	13	25	11	13	11	3	6
Number of alien or planted species	2	8	14	4	10	9	3	6	12	11	5	1	0
Number of uncommon species	1	1	2	3	1	1	0	4	4	1	3	0	0
Plant Conservation value*	Mod	Mod	Mod	Mod	High	Mod	Mod	High	High	Mod	Mod	Low	low

* see Appendix Table 4.2, Mod = moderate.

3.3.2 Number of plant species

Appendix 2 lists the plant species recorded from each of the 13 ponds surveyed for wetland macrophytes. Table 3 summarises these data in terms of the number of (i) native self-colonised species, and (ii) non-native and/or artificially introduced species.

In total, 54 native self-colonised plant species were recorded from the 13 ponds. This represents about 14% of the UK's total wetland flora. In addition, 31 non-native species, cultivated varieties or other planted species were recorded. A number of plants, such as Brooklime (*Veronica beccabunga*), were present in some ponds as species that had colonised naturally, and in others as planted stock.

The number of native self-colonised plant species recorded in individual SUDS ponds ranged from 2 to 25 per pond. The three richest ponds each supported over 20 wetland plant species. These were the two Freeport ponds and the large Calais Wood Marsh pond on the DEX site.

The ponds with fewest native self-colonised species were the concrete-sided Upper Pond at Motorola (2 plant species), and the two highly seasonal retention basins 1 and 2 at the DEX site (3 and 6 plant species respectively).

These results can be compared with data from other UK pond surveys (see Appendix Table 4.5). Comparison with the DETR Lowland Pond Survey (Williams *et al.* 1998), for example, shows that all of the SUDS ponds, except for the two DEX Retention ponds and concrete-sided Motorola Upper pond, had above average numbers of plant species for ponds in lowland Britain. Note, however, that the DETR survey contained a high proportion of countryside ponds which were, themselves, highly degraded. A more stringent and appropriate comparison can be made using data from the National Pond Survey (NPS) – a survey that included only high quality ponds in semi-natural landscapes. In this comparison only the Freeport ponds and DEX Calais Marsh pond were close to the NPS average of 23 plant species per pond.

It is possible that some of the SUDS ponds were below the NPS average richness because they are new sites which are still colonising. This may, in particular, have affected some of the DEX ponds since these waterbodies were only 1 - 3 years old. Age is, however, not likely to be a major factor at the other SUDS sites since new ponds are renowned for their rapidity of colonisation. New ponds typically support similar or greater numbers of plant species to mature ponds within 3 – 5 years of their creation (Williams *et al.* 1998).

3.3.2 Uncommon Plants

Table 3 summarises the number of uncommon plant species recorded from the 13 SUDS ponds, excluding deliberately planted species. All ponds except for the polluted Houston Caw Burn pond and the two seasonal DEX Retention Basins supported at least one locally uncommon plant species[1]. Three of the DEX ponds (Calais Wood Marsh, Halbeath, Pond 5) and Motorola Motorway pond supported over three or more locally uncommon species. In all cases, the relatively high number of uncommon species was mainly due to the richness of the pond's *submerged* plant community. Many submerged plants are becoming increasingly uncommon in the UK, largely through water pollution damage. New ponds often support high numbers of submerged aquatic plants, presumably because these waterbodies have not yet built up a pollutant burden in their water and sediments. Unfortunately, however, submerged plant richness and rarity often decline rapidly as the ponds increase in age. The new DEX ponds in particular, therefore, may not retain their high quality communities in the long term.

3.3.4 Introduced and alien plant species

A considerable number of alien plant species were recorded from the SUDS ponds. There are a number of possible sources for these plants including:

- Deliberately planted species, introduced as part of the SUDS schemes (e.g. exotic bulrush and water-lilies).
- Plants introduced accidentally as seeds or plants in the soil of other introduced stock: e.g. New Zealand Pigmyweed (*Crassula helmsii*) in the DEX ponds and the American bulrush *Typha minima* as a mistake for the native *Typha latifolia* at Freeport.
- Plants introduced by local people after formal planting schemes had been completed (no certain examples, but possible at the Motorola site).
- Alien species that are now naturalised in many parts of the UK and have probably colonised naturally: e.g. Canadian pondweed (*Elodea nuttallii*), curly water-thyme (*Lagarosiphon major*)etc.

Overall, the proportion of alien species recorded from the SUDS ponds was very high. Results from the DETR survey of ponds in lowland Britain, suggest that, on average only 2% of the species recorded in country side ponds are usually alien species or cultivars. Amongst the SUDS ponds the average was 13% - and in two of the DEX ponds (Halbeath and Linburn) the proportion of alien species was 36% and 46% respectively. In most cases the exceptionally high numbers of aliens was clearly due to their deliberate introduction as part of the planting schemes.

The most worrying finding was the widespread occurrence of the alien plant New Zealand Pigmyweed (*Crassula helmsii*) in three of the DEX and one of the Motorola ponds. This plant is currently spreading rapidly in the Britain, causing very severe damage to natural vegetation communities in many areas and threatening a range of rare plant species. It is estimated that £3 million is needed to control the species in the UK and many organisations have argued that the sale of this plant should be banned (Plantlife 2000). *Crassula* is unfortunately commonly transported to sites as seeds or small plants in the contaminated soil of other pot plants from aquatic plant suppliers. It is likely that this was the source in the SUDS ponds.

In addition to the occurrence of alien species, a range of other plants that might be considered inappropriate were recorded from the SUDS ponds. This includes:

1. Variegated cultivated varieties of native species including Reed Sweet-grass (*Glyceria maxima*).
2. Nationally uncommon or rare species (e.g. Hampshire Purslane, *Ludwigia palustris*).
3. Species which were 'out of place' e.g. arrowhead (*Sagittaria sagittifolia*) IS THAT SPELT CORRECTLY which is a common wetland plant in England species but not native to Scotland and largely confined to rivers (Preston and Croft 1997).

[1] A 'locally uncommon' plant is defined here as a plant species which has been recorded from less than one quarter of the 10 x 10 km squares in the UK. It does not include Nationally Scarce or Red Data Book plant species which are much rarer.

Table 4. Other species of interest recorded from the SUDS ponds				
Site	*Motorola Motorway*	*Motorola Lower*	*Freeport Upper*	*Houston Caw Burn*
Species recorded	Water vole	Water vole	1 Common Frog metamorph 1 Smooth/Palmate Newt larva	50 Smooth/Palmate Newt larvae

Of these, the most unusual was the occurrence of the submerged aquatic Hampshire Purslane (*Ludwigia palustris*). This is a Red Data Book species which, in Britain, is limited to the grazed, base-rich soils of the New Forest in Hampshire and one site in Dorset. Planting lists from Beaver Aquatics Ltd who supplied this species to the DEX sites, confirm that its origin is "Hampshire". There are clearly issues here about how appropriate it is to introduce an exceptionally rare British species (a) outside it's natural and historic range, and (ii) without discussion with appropriate authorities such as English Nature and JNCC.

Finally, there are issues of local provenance. It is generally agreed that, in principle, planting schemes should use native species of local provenance. This was often an aim within the SUDS planting schemes. For example Meedhurst Management Ltd, who managed development of the DEX site, specified that the common reed (*Phragmites australis*) should be of northern provenance (in fact it came from Castle Kennedy in Dumfries and Galloway). However, similar specifications were not made for other imported plants. Hence in practice, the 'Pond Edge Mix' supplied by Emorsgate Seeds for the DEX site contained seeds derived largely from central and Southern England and Wales. Additional planting, which was "instructed later in the contract and was left largely up to the contractor" (*in lit.* Adrian Watkins 1999). The survey showed that, in practice, the contractor (Beaver Aquatics Ltd) largely introduced a mixture of inappropriate natives, aliens and cultivars.

3.4. Amphibians and mammals

The results of searches for amphibians and small mammals are summarised in Table 4.

Of the five ponds that were netted for invertebrates, amphibians were recorded at two: Freeport Upper and Houston Caw Burn. In both cases, newt larvae were caught. These were too young to distinguish their species but were either smooth or palmate (*Trituris vulgaris* or *T. helveticus*). Newts were particularly common at the Houston Caw Burn site, where approximately 50 individuals were netted. This was surprising given the pollutant loading that the pond clearly receives. However, it is worth noting that smooth newts are sometimes found in highly polluted ponds, although their ultimate breeding success in these locations is largely unknown. In addition, at Freeport Upper pond a single newly metamorposed common frog (*Rana temporaria*) was seen at the edge of the pond.

Evidence of water voles (*Arvicola terrestris*) was seen at two of the Motorola sites (Lower pond and Motorway pond). In both cases the evidence took the form of the vole's characteristic piles of droppings and/or cut vegetation. In the Motorway pond, this evidence was only seen at a single point on the north-west bank, 20 m from the stream exit. In Lower pond, however, 8 - 10 piles of droppings and some cut vegetation were seen concentrated into a 30 m^2 area in the southern corner of the pond. Water vole use was particularly associated with the mouth of the inflow near to the *inner* water edge of the common reed belt. This area may have been favoured because of the presence of vegetation tussocks which had developed in the inflow area, created by locally dense growth of introduced greater spearwort (*Ranunculus lingua*) and other broad-leaved wetland plants.

The occurrence of water voles associated with SUDS schemes is particularly interesting because this is a Biodiversity Action Plan (BAP) species, which is now much threatened through habitat loss and mink predation, particularly along river systems. It is believed that, currently, about 94% of the water vole's former sites have now been lost (Environment Agency 1997). The use of SUDS ponds by this species is therefore a welcome finding, which could be encouraged in future SUDS scheme designs.

4. OVERALL CONSERVATION VALUE

In terms of comparisons with semi-natural ponds none of the SUDS ponds surveyed appeared to have biotic communities which were top quality in all respects i.e. with similar numbers of plant and invertebrate species and uncommon species to undegraded sites. Despite this, many individual ponds were valuable for specific aspects of their fauna or flora.

The Freeport Scheme was particularly notable for its plant richness and the exceptional number of invertebrate species recorded although, as at other sites, the number of uncommon invertebrate species was low. Calais Wood Marsh was also rich in common and locally uncommon plants. The Motorola Lower pond and Motorway ponds were particularly valuable in supporting the BAP species water vole.

Amongst the ponds of lower quality, Houston Caw Burn had generally poor invertebrate and plant community. However, though polluted it still managed to support a newt population.

The concrete-sided Upper pond at Motorola, not surprisingly, supported few wetland plants, however its value for invertebrates was not assessed. The seasonal ponds also had few plants and, in practice, it is likely that water in the retention basins drains away too rapidly to allow these sites to develop a significant wetland interest.

5. FACTORS AFFECTING THE ECOLOGICAL VALUE OF THE PONDS

This section discusses the range of factors that are likely to have influenced the biodiversity value of the SUDS ponds. The discussion is inevitably provisional, because (i) the results are based on a small sample size and (ii) there are few environmental data, such as water chemistry, which can be used to confirm or refute the findings.

5.1 Location and surrounds

One of the most interesting findings of the survey was that the Freeport SUDS Scheme was markedly richer in invertebrate species than other sites and also had a rich plant community. This is despite the fact that these ponds were amongst the smallest ponds, and were very simply shaped.

It is likely that three factors contributed to their unusual richness:

1. The ponds were located in the most semi-natural landscape of all the SUDS schemes. The waterbodies were created in an extensive are of unimproved acid grassland - a relatively natural Scottish landscape type, whereas most other ponds were located in more formally landscaped or improved grassland surrounds.
2. The water quality may have been better than in other sites, particularly in terms of nutrient and micro-organic loading, because the water was culverted down a long drain (c.200 m long), with some reed filtering, before reaching the pond.
3. The ponds were located relatively near to Breich Water, a small river about 200m away, a factor that probably facilitated colonisation of the SUDS ponds.

5.2 Water quality

Water quality clearly affected the quality of some of the SUDS ponds. Houston Caw Burn, in particular, was clearly polluted, with dead invertebrates found in the water and a low diversity invertebrate community dominated by a small number of tolerant species. Linburn Pond on the DEX

site was unusually turbid for a new pond, suggesting either a high fish population, or more probably excessive algal growth due to high nutrient inputs. In the case of the latter this appeared to affect plant species richness and cover which was very low.

5.3 Management

One of the sites at Motorola (Motorway pond) was unusual in that its margins were grazed. This site and the nearby Motorola Lower pond were both surveyed for plants and macroinvertebrates in order to get an idea of the relative effect of grazing on the ponds. The results show that than the grazed Motorway pond supported similar species to Lower pond even though the latter was much larger (3-4 times the area).

More significantly, however, grazing appeared to encourage the development of rather different floral communities. Thus at Motorola, the adjacent Motorway and Lower ponds had only 30% of their plant species in common. In contrast, the two adjacent Freeport ponds, which had identical management regimes (both were ungrazed), had very similar floral communities with approximately 70% of their plant species in common. The implication is that varying the management regime at Motorola, to include both grazed and ungrazed ponds, appeared to increase the plant biodiversity across the site as a whole.

5.4 Design

Most of the SUDS ponds included in the survey were simply shaped. Typically the ponds had a broadly oval outline, with few spits of bars. In profile, most SUDS ponds had (i) a very limited area of shallow water (i.e. water in the 0 cm - 5 cm depth zone), (ii) a shelf 0.1 m - 0.3 m deep which was planted with *Phragmites*, and (iii) a deep water area (1.5 m - 2.5 m).

The main exception to this was Calais Wood Marsh on the DEX site. This pond had a more complex design including a range of spits, bars and islands. Perhaps partly because of the greater extent of edge habitat, this pond had the richest flora of the DEX sites. Its invertebrate fauna was also good, although not exceptional. On-site evidence suggests the richest areas of the Calais Wood site were the grassy edges and, in particular, the more acid areas adjacent to the area that was once a small bog.

It is likely that most of the sites, including Calais Wood Marsh, could be improved by extending the shallow water edge area, and where possible, by creating complexes of pools which mix critical factors such as depth, permanence, substrate types and hydrological regime.

5.5 Issues of non-native and other introduced plants

5.5.1 Why SUDS ponds are planted – and should they be?

There is a widespread acceptance that the water quality function of SUDS ponds is enhanced if common reed (*Phragmites australis*) or other tall emergent wetland plants are incorporated into these systems. In practice, however, most schemes are planted with additional marginal emergent herbs and sometimes also with submerged and floating-leaved species. In many cases these species are introduced for aesthetic purposes, particularly where the waterbodies are located in urban areas. However, as the current survey shows, plants are also often introduced to new ponds SUDS sites which are far from public view - possibly to help the new pond colonise quickly, or perhaps because planting-up new sites is simply standard practice.

In practice, current evidence suggests that it is usually both unnecessary and undesirable to plant ponds up beyond the requirements of functionality and visual amenity. New ponds are not empty habitats: they quickly colonise with plants and animals. Bugs and beetles will begin to arrive within hours, especially in the summer months. Most other insect families (e.g. mayflies, caddis flies, dragonflies) and some annual water plants usually become established within the first summer, and a good new pond can often be as rich as a pond over 50 years old in 2 or 3 years (Williams *et al.* 1999).

In addition, surveys show that new ponds provide a very different and distinctive habitat type, used by a specific range of plant and animal species which either (a) prefer bare inorganic sediments or (b) do not compete well with other species. These species often disappear after a few years as ponds become more mature. Adding plants in order to "mature" sites artificially hastens the end of this distinctive and important 'new pond' stage.

A more worrying aspect of planting up is the common introduction of non-native species as part of planting schemes. There is now a widespread agreement that planting schemes for new SUDS ponds should use only native plants of local provenance. This is helps to maintain the distinctiveness, biodiversity and gene pool of the area. It will also prevent the increasingly worrying spread of "garden centre" aliens around the countryside. This includes cultivars, stock imported from the continent, and species such as New Zealand Pigmyweed (*Crassula helmsii*), which is very frequently present as seeds or small plants in the soil of pots.

5.5.2 Planting up of ponds in the current study

In the SUDS sites investigated for this project all the ponds had been planted up, to a greater or lesser extent. In many cases the planting went beyond what might be considered necessary of functional for aesthetic purposes and in some cases the planting was potentially ecologically damaging.

The most unfortunate planting was associated with the DEX site, where many marginal emergent and aquatic species were aliens or cultivars, and where the (probably accidental) introduction of *Crassula helmsii* was widespread. In addition, most of the DEX SUDS planting appeared to be an unnecessary extra. Ponds such as Halbeath, for example, were located far away from areas where the planted species could be appreciated. Similarly much of the planting in marginal areas of Linburn Pond (the most urban site) was hidden by shrubs on the bank-side and by *Phragmites* in the water.

Of the 13 sites surveyed, the most natural planting was recorded at the Motorola Motorway site. This site, it subsequently transpired, had been largely planted up with species in consultation with the Wildlife Trust (Derek Carter pers. comm.), and its planting scheme was more or less indistinguishable from what would be expected for its type and location. At most other sites, it was usually possible to distinguish a range of species which were out of place for the pond, either because they were non-natives, or because they were not appropriate to the pond or its location.

7.CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Overall the findings from the study are mixed. The 13 SUDS ponds included sites with a range of valuable features. In particular:

- Two of the Scottish SUDS ponds had colonies of water voles (a BAP species). This is a important finding, and with additional design it would be probably be possible to increase the area of habitat attractive to water voles in the ponds still further.
- The best SUDS ponds had rich plant and animal communities, and supported a range of uncommon plant species.

To balance this, however, some of the SUDS ponds were relatively poor in either plant and/or invertebrate species and the number of uncommon invertebrate taxa was generally below what normally be expected. There was also a range of problems associated with unnecessary or inappropriate planting schemes at many sites.

Taken together, the results suggest that there is much potential for future SUDS schemes to contribute significantly to freshwater biodiversity in urban areas. With improved designs, for example, it should be possible to at least double the wildlife value of many schemes - increasing both their diversity and the number of uncommon species they support. With greater care in planting it will also be possible to minimise the adverse affects of introducing alien and invasive species to areas through SUDS schemes.

7.2 Recommendations

As a result of the study findings a number of recommendations can be made which should increase the future value of ponds incorporated within SUDS schemes.

Location

The study clearly illustrates that the biodiversity of SUDS ponds is likely to be maximised by locating ponds in relatively semi-natural landscapes and, in particular, near to other wetland areas. If there are opportunities in the design process to locate SUDS pond in such areas (without compromising the ecology or water quality of the existing area) it is recommended that these opportunities are taken.

Water quality

SUDS schemes are designed to reduce or eliminate the export of pollutants from urbanised landscapes and ponds within those schemes are likely to be exposed to a variety of pollutants. From a conservation perspective, however, the ecological quality of ponds increases when water quality is kept relatively clean and natural. Two approaches could be used to improve the quality of water standing in SUDS ponds, whilst not compromising their function:

1. Ensure that the water which enters SUDS ponds is as clean as possible by, for example, implementing the full range of SUDS interception features to maximise water quality. This might include filtering run-off through porous surfaces or, as at Freeport, draining water through long, well-vegetated swales before water reaches the pond.

2. Ensure that maximum use is made of any clean water that is available on the site – particularly by locally retaining surface runoff from uncontaminated grass or other semi-natural areas to create mosaics of small clean-water ponds and seasonal pools.

Design

Most of the SUDS ponds were simply shaped and only a very small proportion of their area was given over to the very shallowest water zones, less than 10 cm deep, which are usually the most biodiverse areas for wildlife. The design of the SUDS ponds would undoubtedly have been improved for wildlife by including more extensive areas of shallow water and by undulating the marginal topography to give greater hydrological variation at the pond edge. The inclusion of such features into SUDS schemes would be a simple and effective way increasing the biodiversity of SUDS ponds without compromising their functional efficiency. The addition of features such as spits, islands and marginal sub-basins might extend the value of SUDS ponds further, but their hydrological implications would need to be carefully considered in terms of pond functioning.

A further increase in biodiversity could also be achieved at some sites by varying the management regime of some SUDS ponds. As the Motorola scheme showed, the presence of grazing around some but not all ponds can create a greater variety of physical habitats on the site as a whole, leading to an increased species pool.

Planting up issues

There are a number of recommendations that arise from investigating the planting schemes in the study ponds.

Don't plant unless necessary

Much planting of marginal, floating leaved and aquatic plant species in the SUDS ponds appeared to be unnecessary in terms of either functioning or visual affect, and appeared to have been introduced merely to help the ponds colonise rapidly. In practice it would be better to omit such planting, since ponds will colonise naturally, and the new pond stage is ecologically valuable in its own right in that it supports species which are not seen at later stages of colonisation. Planting up also fills up space in ponds that could otherwise be exploited by self-colonising local species, and in doing so reduces the potential ecological value of the pond.

In general it would be better to focus effort into developing a good design and location which will encourage natural colonisation of an appropriate range of plants at an appropriate rate.

Provenance

The provenance of plants used when planting up SUDS schemes is particularly problematic. Bearing in mind the many issues of provenance raised by the present study the following recommendations are made:

- Ensure that the contract for *all* planting up of SUDS schemes specifies the requirement for 'native species of local provenance'. For example, the poor planting at the DEX scheme appears to have occurred because any planting additional to the *Phragmites* was left to the contractor's choice.
- Ensure that an experienced botanist checks planting schemes before projects are signed-off to check what has actually been planted (as opposed to specified). For example, the Bulrush (*Typha latifolia*) used in the Freeport scheme also included a much smaller bulrush, which is probably the American species *Typha minima*. Contractors should be responsible for removing any unwanted material.
- Where possible work with local plant suppliers to develop appropriate ranges of native plant species of local provenance.

Invasive alien species

One of the most worrying findings in the study was the occurrence of *Crassula helmsii* in about one third of all the SUDS ponds. This is a serious problem because the species is so highly invasive. The danger is that through accidental transfer, SUDS ponds become a vector that helps to transfer *Crassula* around the country and encourage its spread into other semi-natural ponds and wetlands. In order to combat such problems it is recommended that:

- Visits are made to check aquatic suppliers premises in order to ensure that highly invasive species are not rampant and "growing wild" in their propagating areas (as has be observed at some sites!). Species of particular concern in this respect are: New Zealand pigmyweed (*Crassula helmsii*), parrot's feather (*Myriophyllum aquaticum*), floating water-pennywort (*Hydrocotlye ranunculoides*) and water fern (*Azolla filiculoides*).
- Check closely for the presence of invasive species after one year.
- Consider including a clause in the contract with the plant supplier to agree that if specified invasive species are found at the site within in 1 year of the planting, then it is the contractor's responsibility to eradicate the species and make good any damage incurred to other plants.

8. REFERENCES

Biggs, J., Williams, P.J., Whitfield, M., Thorne, A., Bryant, S., Fox, G. and Nicolet, P. (2000) *Biological techniques of still water quality assessment 3. Method development.* R&D Technical report E110. Environment Agency, Bristol.

Environment Agency (1998) *Water Vole Conservation Handbook.* Wildlife Conservation Research Unit, Oxford.

Nicolet, P. (1998) *25 years of change in the plant community and the conservation value of some Cheshire ponds.* MSc thesis.

Plantlife (2000). *At war with aliens: changes needed to protect native plants from invasive species.* Plantlife, London.

Preston, C.D. and Croft, J.M. (1997). *Aquatic plants in Britain and Ireland.* Harley Bookes, Colchester, Essex.

Williams, P.J., Biggs, J., Barr, C.J., Cummins, C.P., Gillespie, M.K., Rich, T.C.G., Baker, A., Baker, J., Beesley, J., Corfield, A., Dobson, D., Culling, A.S., Fox, G., Howard, D.C., Luursema, K., Rich, M., Samson, D., Scott, W.A., White, R. and Whitfield, M. (1998). *Lowland Pond Survey 1996.* Department of the Environment, Transport and the Regions, London.

Williams, P.J., Biggs, J., Whitfield, M., Thorne, A., Bryant, S., Fox, G. and Nicolet, P. (1999). *The Pond Book.* Pond Conservation Trust, Oxford.

APPENDICES

APPENDIX 1. SURVEY METHODS

The methods used to survey the ponds followed the methods developed for the National Pond Survey, initiated by Pond Action in 1989. National Pond Survey methods have subsequently been used as the basis for many other regional and national surveys including DETR's Lowland Pond Survey 1996 (Williams *et al.*, 1998) and Pond Action's national survey of degraded ponds. A full copy of the methodology is given in Pond Action (1998). Modified extracts which describe the field sampling protocol are given below.

Summary of pond survey procedure

The following list gives a broad outline of the information gathered at each pond.

- A description of the main physical features of the pond and its surroundings together with notes about the age, history and management of the pond.
- A list of the wetland plant species found within the outer boundary of the pond, together with estimates of the abundance of species or major vegetation stands which occupy more than 5% of the pond.
- A list of the species of macroinvertebrates recorded from the pond with estimates of their abundance.
- Notes on the presence of amphibians, small mammals and fish where seen.

The methods used for collecting biological data are outlined in more detail below.

Recording wetland plants

The main aim of plant recording is to make a complete list of the *wetland plant species*[2] present within the *outer edge* of the pond[3]. Wetland plants are recorded by walking and wading around the margin and shallow water areas of the pond. In deep water aquatic plants are surveyed using a grapnel thrown from the bank and/or boat.

Sampling aquatic macroinvertebrates

The main aim of invertebrate sampling is to obtain, within the sampling time, as complete a species list as possible for the pond,

The pond is sampled, using a hand net, for a total of three minutes (net in the water time). During this time all of the major habitats in the pond are sampled. Examples of typical habitats are: stands of sedge; gravel- or muddy-bottomed shallows; areas overhung by willows, including water-bound tree-roots; stands of submerged aquatics; flooded marginal grasses and inflow areas. The average pond contains 4-10 habitats. Habitats are identified by an initial walk around the pond examining vegetation stands and other relevant features.

Invertebrate sampling is based on the following protocol:

(i) The three minute sampling time is divided equally between the number of habitats recorded: e.g. with six habitats, each is sampled for 30 seconds. Where a habitat is extensive or covers several widely-separated areas of the pond, the sampling time allotted to that habitat is further divided in order to represent it adequately (e.g. into 6 x 5 second sub-samples).

(ii) Each habitat is netted vigorously to dislodge and collect animals. In stony or sandy ponds the substrates are kicked-up to disturb and capture inhabitants.

The three-minute sampling time refers only to 'net-in-the-water' time and does not include time moving between adjacent habitats.

[2] The term 'wetland plant species' refers to species defined as wetland plants on the National Pond Survey field recording sheet list. Terrestial plant species are not recorded.

[3] The 'outer edge' of the pond is defined as the 'upper level at which water stands in winter'. In practice this line is usually readily distinguishable from the distribution of wetland plants or as a 'water mark' on surrounding trees or walls.

(iii) A one-minute search (total time, not net-in-the-water time) is undertaken for animals that may otherwise be missed in the main 3-minute sample. Areas which might be searched include the water surface (for whirligig beetles and pond skaters), hard substrates (for firmly-attached animals), the silty or sandy bottom sediments (for dragonflies and mayflies) and under stones and logs (for limpets, leeches, flatworms and caddis).

(iv) Amphibians or fish caught whilst sampling are noted on the field recording sheet and returned to the pond.

Sorting and identifying macroinvertebrate samples

The hand-net samples are sorted in the laboratory to remove invertebrates collected in the net. Samples are sorted 'live' and not frozen or preserved prior to sorting. Samples are sorted as soon as possible after collection, usually within three days of collection.

In general the aim of sorting the sample is to remove and identify all individual invertebrates. In samples where one or two species are present in large numbers (e.g. thousands of specimens), specimens of these species are counted in a sub-sample and numbers then extrapolated to the whole sample. All specimens of species which cannot be reliably identified in the sorting tray are removed and preserved in alcohol, with the exception of flatworms which are identified immediately. On average, sorting a pond sample to remove invertebrates takes approximately 6-8 hours. Samples containing a considerable amount of algae or duckweed may take considerably longer.

Species which are not immediately identifiable whilst sorting are identified using biological keys and a microscope with a magnification of at least x30. A list of guides is given in Pond Action (1994). Many species (especially the larval stages of insects) cannot be identified below certain sizes. Appropriate sizes are given in identification keys. After identification, invertebrates are returned to a labelled bottle and archived.

Appendix Table 1.1. Macroinvertebrate taxa included in pond surveys

Taxon	*Identification level*	*Notes*
Tricladida	Species	Identified live
Gastropoda	Species	As adults
Bivalvia	Species	Inc. *Sphaerium* spp., but not *Pisidium* spp.
Crustacea (Malacostraca)	Species	As adults
Hirudinea	Species	Identified live
Ephemeroptera	Species	As larvae
Odonata	Species	As larvae
Megaloptera (inc. spongeflies)	Species	As larvae
Hemiptera	Species	As adults
Coleoptera	Species	As adults
Plecoptera	Species	As larvae
Lepidoptera	Species	As larvae
Trichoptera	Species	As larvae
Oligochaeta	Class	As adults
Diptera	Family	As larvae

Note: water mites, zooplankton and other microarthropods are not included in the survey.

Appendix 2: Macroinvertebrate species recorded

	Motorola motorway	*Motorola Lower*	*Freeport Upper*	*Houston Caw Burn*	*DEX Calais Wood Marsh*
Flatworms					
Polycelis nigra					2
Polycelis tenuis		1	31	52	1
Dugesia polychroa			2	2	
Dugesia tigrina			2		
Leeches					
Erpobdella octoculata	3		26	2	
Glossiphonia complanata	4	1			
Helobdella stagnalis	45	5	1		1
Theromyzon tessulatum	1	5	10	1	2
Snails					
Anisus vortex		124			
Armiger crista		170			
Bithynia leachi			30		
Bithynia tentaculata		1	85		
Gyraulus albus			5		
Lymnaea palustris		1			19
Lymnaea peregra	500	136	72	500	300
Lymnaea stagnalis		24		1	
Lymnaea truncatula			1		12
Physa sp. (acuta type)				500	
Physa fontinalis		5			
Planorbarius corneus		1		1	
Potamopyrgus antipodarum				38	
Bivalves					
Musculium lacustre			54	3	
Sphaerium corneum				2	
Shrimps and slaters					
Asellus aquaticus	500		234	10	
Asellus meridianus			391		
Crangonyx pseudogracilis			500		
Gammarus pulex	1				
Damselflies & dragonflies					
Coenagrion puella/pulchellum		2			
Enallagma cyathigerum			1		5
Ischnura elegans	8	7	2	29	21
Pyrrhosoma nymphula	41	30	1	1	
Water beetles					
Agabus bipustulatus	1	2	17	3	1
Agabus nebulosus	2	1	2		10
Agabus paludosus	1				
Agabus sturmii	10	23	5		1
Anacaena globulus			1		
Coelambus confluens					3
Coelambus impressopunctatus	1	1			3
Colymbetes fuscus		1	1		6
Dytiscus semisulcatus			1		
Gyrinus substriatus			11		

Appendix 2: Macroinvertebrate species recorded (continued)

	Motorola Motorway	*Motorola Lower*	*Freeport Upper*	*Houston Caw Burn*	*DEX Calais Wood Marsh*
Haliplus immaculatus	2				
Haliplus lineatocollis	2		1		
Haliplus ruficollis	4	1	4		
Haliplus wehnckei	2	4	11		
Helophorus aequalis	1	1	2		
Helophorus brevipalpis			1		1
Helophorus grandis	2				
Helophorus obscurus			2		1
Hydraena riparia					1
Hydrobius fuscipes	4	2		1	2
Hydroporus angustatus	1				
Hydroporus incognitus			2		1
Hydroporus memnonius					1
Hydroporus palustris	11	2	7	1	13
Hydroporus planus	10	2	2	1	3
Hydroporus pubescens	3	1	1	3	1
Hydroporus striola	1		1		
Hygrotus inaequalis	15		2	1	26
Ilybius fuliginosus	7	3	7		1
Laccobius bipustulatus	3				
Laccobius biguttatus		1	2	1	
Laccobius minutus			4		
Rhantus exsoletus		4	2		
Caddis flies					
Agrypnia varia	2		3		1
Athripsodes aterrimus	200	8	12		1
Limnephilus binotatus*		1	1		
Limnephilus extricatus	3	2	6		
Limnephilus marmoratus			1		
Limnephilus rhombicus			1		
Phryganea bipunctata			55		
Alderflies					
Sialis lutaria		31	7		
Bugs					
Callicorixa praeusta	1		1		1
Corixa punctata	1				35
Gerris lacustris	1		2		
Gerris odontogaster		1			
Hesperocorixa castanea	1				
Hesperocorixa linnei	1				
Hesperocorixa sahlbergi	20	2	7	1	3
Notonecta glauca	1		12	3	18
Notonecta obliqua					1
Sigara concinna			1		3
Sigara distincta			1		7
Sigara dorsalis		1			1
Sigara falleni					12
Sigara lateralis					14
Sigara nigrolineata				1	

Appendix 2: Macroinvertebrate species recorded (continued)

	Motorola Motorway	*Motorola Lower*	*Freeport Upper*	*Houston Caw Burn*	*DEX Calais Wood Marsh*
Sigara scotti			3		
Sigara semistriata	1		1		
Velia caprai					1
Mayflies					
Cloeon dipterum			5		80
Flies (identified at family level only)					
Ceratopogonidae	+				
Chaoboridae			+	+	+
Chironomidae	+	+	+	+	+
Culicidae					+
Dixidae			+		+
Psychodidae	+				+
Ptychopteridae	+				
Sciomyzidae		+	+	+	+
Tipulidae	+	+			
No Species (Excludes flies which were recorded at family level)	40	37	58	24	40

* Regionally Scarce species

Appendix 3a. Plant species recorded

Submerged aquatics	*M'rola M'way*	*M'rola Lower*	*M'rola Middle*	*M'rola Upper*	*Freeport (1)*	*Freeport (2)*	*Houston Caw Burn*	*DEX Calais Wood Marsh*	*DEX Halbeath*	*DEX Linburn*	*DEX Pond 5*	*DEX Retention basin 1*	*DEX Retention basin 2*
Callitriche hamulata[x]								+		+	+		
Callitriche obtusangula*[4]		+											
Callitriche stagnalis[x]	+												
Callitriche stagnalis/ platycarpa agg[y]								+	+		+		
Ceratophyllum demersum[1]				+									
Chara virgata[1]								+					
Chara vulgaris[1]								+	+	+	+		
Hippuris vulgaris[1]	+							+	+				
Potamogeton berchtoldii[1]	+				+	+		+					
Sparganium emersum	+									+	+		
Zannichellia palustris[1]											+		
Floating-Leaved													
Lemna minor	+				+	+	+	+		+			
Potamogeton natans					+	+		+		+			
Potamogeton polygonifolius								+					
Emergents													
Achillea ptarmica					+	+	+	+					
Agrostis stolonifera	+	+	+		+	+	+		+	+	+	+	+
Alisma plantago-aquatica		+			+	+		+		+	+		
Alopecurus aequalis[1]									+		+		+
Alopecurus geniculatus								+	+	+	+	+	
Cardamine pratensis	+	+	+		+	+		+					
Carex disticha					+								
Carex nigra					+	+		+					
Cirsium palustre	+												
Deschampsia cespitosa	+	+			+	+							
Eleocharis palustris		+	+		+								
Epilobium hirsutum		+	+	+	+	+		+	+	+	+	+	+
Epilobium palustre		+											
Filipendula ulmaria							+						
Galium palustre					+	+							
Glyceria declinata[1]	+		+						+				
Glyceria fluitans	+		+		+	+							
Iris pseudacorus													
Juncus acutiflorus								+					
Juncus articulatus	+	+	+		+	+	+	+	+	+	+		
Juncus bufonius agg.								+	+	+			
Juncus bulbosus						+		+					
Juncus conglomeratus					+	+	+	+					+
Juncus effusus	+	+	+		+	+	+	+		+			+
Juncus inflexus							+						
Lotus pedunculatus		+	+				+	+					

[4]Nationally 'local' species are defined here as species which occur in less than about a quarter of all 10 x 10 km squares in the UK (i.e. less than 700 10 x 10 km squares).

Appendix 3a: Plant species recorded (continued)

	M'rola M'way	*M'rola Lower*	*M'rola Middle*	*M'rola Upper*	*Freeport (1)*	*Freeport (2)*	*Houston Caw Burn*	*DEX Calais Wood Marsh*	*DEX Halbeath*	*DEX Linburn*	*DEX Pond 5*	*DEX Retention basin 1*	*DEX Retention basin 2*
Lycopus europaeus							+						
Myosotis laxa	+				+				+				
Myosotis secunda			+										
Phalaris arundinacea													+
Potentilla erecta					+	+							
Ranunculus flammula	+		+		+	+		+					
Ranunculus sceleratus							+						
Rorippa nasturtium-aquaticum agg.							+	+					
Rorippa palustris			+							+			
Stachys palustris							+						
Stellaria uliginosa	+	+			+	+		+					
Trichophorum cespitosum					+	+							
Veronica beccabunga	+				+								
Veronica scutellata					+	+							
Submerged plants total	4	1	0	1	1	1	0	6	3	3	5	0	0
Floating leaved plants total	1	0	0	0	2	2	1	3	0	2	0	0	0
Emergent plants total	12	11	12	1	21	18	12	16	8	8	6	3	6
All plants total	**17**	**12**	**12**	**2**	**24**	**21**	**13**	**25**	**11**	**13**	**11**	**3**	**6**

Non-native or clearly planted species

Deschampsia cespitosa									+				
Elodea canadensis		+			+	+							
Elodea nuttallii							+		+				
Glyceria fluitans								+	+			+	
Lagarosiphon major	+					+				+			
Ludwigia palustris[2]									+	+	+		
Myriophyllum spicatum[1]		+											
Sagittaria sagittifolia[1]			+										
Nymphaea alba[1]				+					+	+			
Nymphaea sp. (cultivar)										+			
Potamogeton natans	+	+	+	+		+	+						
Alisma sp. (exotic)			+							+	+		
Butomus umbellatus[1]		+											
Caltha palustris		+	+						+	+	+		
Carex riparia (cultivar)					+	+							
Crassula helmsii		+						+	+	+			
Epilobium ciliatum					+	+		+					
Filipendula ulmaria		+											
Glyceria maxima (varigated)									+	+			
Juncus sp. (exotic)									+	+	+		
Iris pseudacorus	+	+	+		+	+		+	+	+			
Lychnis flos-cuculi			+										
Lythrum salicaria		+	+		+	+							
Menyanthes trifoliata		+											

Appendix 3a: Plant species recorded (continued)

	M'rola M'way	*M'rola Lower*	*M'rola Middle*	*M'rola Upper*	*Freeport (1)*	*Freeport (2)*	*Houston Caw Burn*	*DEX Calais Wood Marsh*	*DEX Halbeath*	*DEX Linburn*	*DEX Pond 5*	*DEX Retention basin 1*	*DEX Retention basin 2*
Mimulus guttatus					+								
Phragmites australis		+	+					+	+	+	+		
Ranunculus lingua[1]		+											
Sparganium erectum	+	+			+	+		+	+				
Typha latifolia					+	+	+						
Typha minima					+								
Veronica beccabunga		+			+								
Total introduced plants	**4**	**14**	**8**	**2**	**10**	**9**	**3**	**6**	**12**	**11**	**5**	**1**	**0**
Exotics and cultivars	1	2	1	0	3	3	1	2	4	6	2	0	0

[1] Locally uncommon species [2] Red Data Book species [x] Checked in fruit [Y] No fruiting material present

Appendix 3a: Plant species recorded (continued)

Achillea ptarmica	Sneezewort
Agrostis stolonifera	Creeping Bent
Alisma plantago-aquatica	Water- plantain
Alisma sp. (exotic)*	Exotic species
Alopecurus aequalis	Orange Foxtail
Alopecurus geniculatus	Marsh Foxtail
Butomus umbellatus	Flowering-rush
Callitriche hamulata	Intermediate Water-starwort
Callitriche obtusangula	Blunt-fruited Water-starwort
Callitriche stagnalis	Common Water-starwort
Callitriche stagnalis/platycarpa agg	Water-starwort species
Caltha palustris	Marsh-marigold
Cardamine pratensis	Cuckooflower
Carex disticha	Brown Sedge
Carex nigra	Common Sedge
Carex riparia (cultivar)	Greater Pond-sedge
Ceratophyllum demersum	Rigid Hornwort
Chara virgata	Delicate Stonewort
Chara vulgaris	Common Stonewort
Cirsium palustre	Marsh Thistle
Crassula helmsii*	New Zealand Pigmyweed
Deschampsia cespitosa	Tufted Hair-grass
Eleocharis palustris	Common Spike-rush
Elodea canadensis*	Canadian Waterweed
Elodea nuttallii*	Nuttall's Waterweed
Epilobium ciliatum*	American Willowherb
Epilobium hirsutum	Great Willowherb
Epilobium palustre	Marsh Willowherb
Filipendula ulmaria	Meadowsweet
Galium palustre	Common Marsh-bedstraw
Glyceria declinata	Small Sweet-grass
Glyceria fluitans	Floating Sweet-grass
Glyceria maxima (varigated)	Reed Sweet-grass (Cultivar)
Hippuris vulgaris	Mare's-tail
Iris pseudacorus	Yellow Iris
Juncus acutiflorus	Sharp-flowered Rush
Juncus articulatus	Jointed Rush
Juncus bufonius agg.	Toad Rush
Juncus bulbosus	Bulbous Rush
Juncus conglomeratus	Compact Rush
Juncus effusus	Soft Rush
Juncus inflexus	Hard Rush
Juncus sp. (exotic)*	Exotic species
Lagarosiphon major*	Curly Waterweed
Lemna minor	Common Duckweed
Lotus pedunculatus	Greater Bird's-foot-trefoil
Ludwigia palustris	Hampshire-purslane
Lychnis flos-cuculi	Ragged-Robin
Lycopus europaeus	Gipsywort
Lythrum salicaria	Purple-loosestrife
Menyanthes trifoliata	Bogbean
Mimulus guttatus*	Monkeyflower
Myosotis laxa	Tufted Forget-me-not
Myosotis secunda	Creeping Forget-me-not
Myriophyllum spicatum	Spiked Water-milfoil
Nymphaea alba	White Water-lily
Nymphaea sp. (cultivar)*	Waterlily cultivar
Phalaris arundinacea	Reed Canary-grass
Phragmites australis	Common Reed
Potamogeton berchtoldii	Small Pondweed
Potamogeton natans	Broad-leaved Pondweed
Potamogeton polygonifolius	Bog Pondweed
Potentilla erecta	Tormentil
Ranunculus flammula	Lesser Spearwort
Ranunculus lingua	Greater Spearwort
Ranunculus sceleratus	Celery-leaved Buttercup
Rorippa nasturtium-aquaticum agg.	Water-cress
Rorippa palustris	Marsh Yellow-cress
Sagittaria sagittifolia	Arrowhead
Sparganium emersum	Unbranched Bur-weed
Sparganium erectum	Branched Bur-reed
Stachys palustris	Marsh Woundwort
Stellaria uliginosa	Bog Stitchwort
Trichophorum cespitosum	Deergrass
Typha latifolia	Bulrush
Typha minima*	Slender Bulrush
Veronica beccabunga	Brooklime
Veronica scutellata	Marsh Speedwell
Zannichellia palustris	Horned Pondweed

* non-native species

Appendix 4. Methods for assessing pond conservation value

1. Assessment of conservation value

The conservation value of plant and invertebrate communities can be assessed on the basis of:

(i) the number of plant and invertebrate species recorded from the site (the number of marginal and aquatic plants may be recorded separately).

(ii) the presence of uncommon species.

2. Method for assessing species rarity

Species rarity can be quantified for a site by allocating a numerical rarity score to each plant and invertebrate species. The scores used and their definition is given Table 1 below.

Appendix Table 4.1 Species rarity terms and scores

Status	*Definition*
Common	Species generally regarded as common. For wetland plants, these are species recorded from >700 10x10 km grid squares in Britain.
Local	Species either (a) confined to limited geographical areas, or (b) of widespread distribution but relatively low population levels. For wetland plants, local species are those recorded from between 101 and 700 10x10 km grid squares in Britain.
Notable	Nationally Scarce. Recorded from 16-100 10x10 km grid squares in Britain.
RDB3	Red Data Book: Category 3 (rare).
RDB2	Red Data Book: Category 2 (vulnerable).
RDB1	Red Data Book: Category 1 (endangered).

Appendix Table 4.2 Wetland plants: provisional categories for assessing the conservation value of ponds

Low	Few wetland plants (≤8 species) and no local species.
Moderate	Below average number of wetland plant species (9-22 species) or 1-3 local plant species.
High	Above average number of wetland plant species (23- 39 species), or four or more local plant species. No Nationally Scarce or Red Data Book (RDB).
Very High	Supports at least one Nationally Scarce or RDB species or an exceptionally rich plant assemblage (≥40 species).

Appendix Table 4.3 Aquatic macroinvertebrates: provisional categories for assessing conservation value of lowland ponds (single season 3 minute sample).

Low	Few invertebrate species (0-10 species) and/or no local species.
Moderate	Below average number of invertebrate species (11-30 species) or 1 – 4 local species but no Nationally Scarce species.
High	Above average number of invertebrate species (31-50 species), or more than 4 local species or 1 -2 Nationally Scarce species. No Red Data Book (RDB) species.
Very High	Supports more than two Nationally Scarce or one RDB species or an exceptionally rich invertebrate assemblage (≥50 species).

The following information gives range of data about the conservation value of *other* ponds in Britain. This information indicates the *typical* species richness of ponds in Britain. The data are based on standard National Pond Survey samples of both plant and invertebrate communities in ponds.

Plant data

Appendix Table 4.4 Number of plant species recorded from UK ponds

		Number of species:		
		Marginal plants	*Aquatic plants*	*Total plants*
National Pond Survey (high quality ponds mostly located in nature reserves*)	Average	18	5	23
	Range	(1-42)	(0-14)	(1-46)
Wider countryside ponds (DETR Lowland Pond Survey, Williams *et al.*)	Average	8.0	2	10
	Range	(0-30)	(0-10)	(0-35)
Wider countryside ponds (ROPA Survey*)	Average	11	3	14
	Range	(1-32)	(0-11)	(1-38)

*The ROPA survey was undertaken by Pond Action with funding from the Natural Environment Research Council.

Appendix Table 4.5 Number of aquatic macroinvertebrate species recorded from other UK ponds

		*Number of invertebrate species**
National Pond Survey (All ponds were high quality i.e. located in semi-natural areas).	Average	**32**
	Range	(6-98)
Wider countryside ponds (ROPA Survey)	Average	**26**
	Range	(2-64)

* All results are from a single season 3 minute hand-net sample surveys undertaken by Pond Action.