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Re-creation options for River Severn/Avon floodplain wetlands

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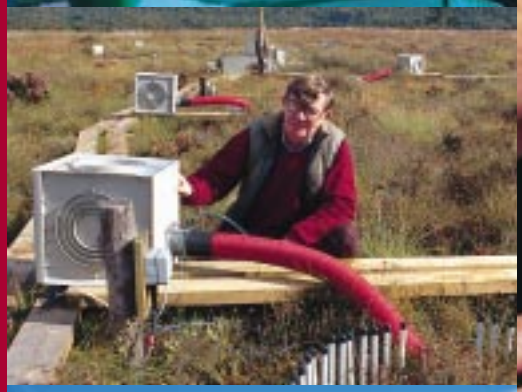

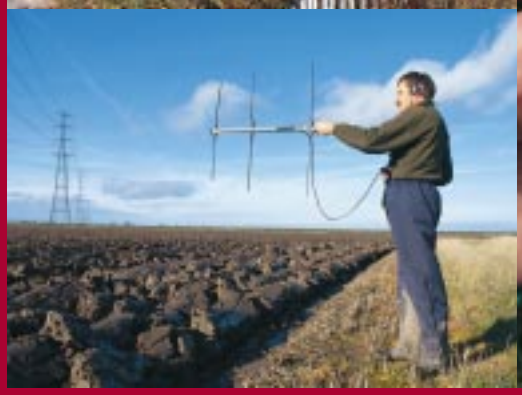

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Re-creation options for River Severn/Avon floodplain wetlands

Ecoscope Applied Ecologists

and

Silsoe College, Cranfield University

with

Aspinwall Clouston Ltd

For:
The Environment Agency (Midlands region, Lower Severn Area)
English Nature (Three Counties Team)
The Royal Society for the Protection of Birds (Central England Region)

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Cover note

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Contributors, consultees and acknowledgements

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The project was managed by Peter Holmes (English Nature), Alan Churchward and Cathy Beeching (Environment Agency) and Ian Barber (RSPB).

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Landowners and Internal Drainage Board representatives
Robin Smith (Longdon and Eldersfield IDB), Noel Baker and Colin Evers (Trustees for Walmore Common), Mr Hyslop (West Gloucestershire IDB) and Larry Howells (South Gloucestershire IDB).

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Dr Colin Studholme (Gloucestershire Wildlife Trust), Andrew Thompson (Warwickshire Wildlife Trust) and Andrew Fraser and Andy Graham (Worcestershire Wildlife Trust).

Executive summary

The aim of this project has been to identify and assess areas that are suitable for the re-creation of floodplain wetland habitats within the Severn and Avon Vale Natural Area, as defined by English Nature.

Although historic data on habitats within the Natural Area are scattered and incomplete, it is clear that a large proportion of the River Severn and Avon floodplains formerly consisted of wetlands. Before widespread human influence, such wetlands would probably have been predominantly natural marshland and wet woodland communities. These natural habitats were then gradually replaced by wet grasslands for hay production and grazing. Such traditionally managed semi-natural grasslands had rich plant communities and often held substantial numbers of breeding and wintering birds.

However, the majority of wetlands within the Natural Area have been lost as a result of centuries of river impoundments and other navigational improvements, flood prevention measures and drainage schemes. Furthermore, in recent years, many of the remaining wet grasslands have been lost or degraded through agricultural improvements including ditching, field drainage, re-seeding and the use of fertilisers. As a result, only small remnants of semi-natural grassland remain and fens, reedbeds and wet woodlands are now relatively rare. In turn, many associated species, including some nationally rare and scare wetland plants and breeding waders, have also declined.

Consequently, an English Nature objective for the Natural Area is to "'Prevent deterioration of wetland habitats and where appropriate reverse past degradation and re-create wetland habitats within areas of high water table or subject to winter flooding". Four formerly widespread habitats of particular biodiversity importance were therefore identified as targets for this project:

- semi-natural wet grasslands, in particular species-rich flood meadows (National Vegetation Classification community MG4) and inundation grasslands (NVC community MG13);
- reedbed (NVC community S4);
- tall herb fen (NVC community S25);
- wet woodland (NVC community W5).

The re-creation of such wetlands could make a significant contribution to the UK Biodiversity Strategy and implementation of its associated Habitat Action Plans, such as for reedbeds and grazing marshes, and Species Action Plans, such as for otters and water voles. The re-creation of these habitats also aims to contribute to biodiversity actions for other associated UK Species of conservation concern, including breeding waders (eg curlew, lapwing, redshank and snipe), wintering waterfowl (eg Bewick's swans), as well as to regional, county and local biodiversity targets.

The study has been carried out in a two-stage process using two levels of criteria. The first stage aimed to identify large areas of the Natural Area that are of general suitability for wetland re-creation in terms of their topography, current land-use, general soil suitability and water availability (eg groundwater sources and flooding frequency).

This initial broad assessment revealed that there is a large area of land that could feasibly be used for wetland re-creation in the Natural Area. However, 18 large candidate areas (with preliminary boundaries) were identified for further detailed investigation and evaluation against a second set of criteria.

Firstly, each candidate area was assessed in terms of potential constraining factors, including land-use (eg housing, commercial use or presence of high grade agricultural land under intensive farming), presence of transport and service infrastructures, presence of important archaeological features and flood defence considerations.

Each area was also evaluated in relation to the requirements of each target habitat type. In particular, assessments were made of the suitability of the soils, potential water regime, quality of water supply and the existing habitat. Finally, each candidate area was assessed in terms of its suitability for target species groups, taking into account land-use and topography, linkage to other suitable habitats and populations, the potential habitat and water regime that may be re-created, available food resources and the potential impacts of disturbance.

For each criterion, the area was ranked according to three levels of suitability for the creation of wetlands: low, medium or high.

The project was primarily carried out as a desk-study of existing data, supplemented with information obtained during brief visits to some of the key candidate areas. Further information was also obtained by consultations with landowners and trustees, IDB representatives, Wildlife Trusts, the Environment Agency, English Nature and RSPB.

The overall conclusion of the study is that there is considerable potential for re-creating a range of different wetland types in the Severn and Avon Vale Natural Area. Most of the candidate areas have the potential for the successful re-creation of one or more target habitat in at least part of their area. Furthermore, some areas are particularly suitable for wetland re-creation and have the potential for meeting multiple objectives.

A subjective ranking of the sites in terms of their overall suitability indicates that two sites are highly suitable overall: Longdon Marsh (Site 8) and the River Severn floodplain from Tewkesbury to Longford (Site 9). Another four sites were ranked as Medium/High: Birch Green (Site 5), Upton-upon-Severn (Site 6), Walmore Common (Site 13) and the River Avon floodplain from Eckington Bridge to Tewkesbury (Site 17).

Due to the broad nature of this study and current hydrological and other data limitations, it is suggested that further detailed investigations are made of the feasibility of re-creating wetlands on the most suitable candidate areas. This should include confirmation of each area's historic, current and potential hydrology and habitats. Consultations with landowners and other interested parties must also be carried out to assess the socio-economic implications of various wetland re-creation options and to measure support or oppositions to potential schemes. This information could then be used to prepare practical costed proposals for phased wetland re-creation.

Contents

1 Background and objectives

The objective of this project has been to identify and assess areas that are suitable for the re-creation of fens, reedbeds, grazing marsh and wet woodlands within the floodplains of the River Severn and River Avon (ie the English Nature Severn and Avon Vale Natural Area). Re-creation of wetlands within the area could make a significant contribution to the UK Biodiversity Strategy and Action Plans for key wetland habitats and associated species such as otter, water vole and bittern, as well as other declining species, such as breeding waders. Re-creation of wetlands with the Severn and Avon Vale is also a conservation objective for the Natural Area (Box 1.1).

Box 1.1. English Nature objectives for wetlands within the Severn and Avon Vale Natural Area (English Nature 1997)

Prevent deterioration of wetland habitats and where appropriate reverse past degradation and re-create wetland habitats within areas of high water table or subject to winter flooding.

Reason for objective

The rivers and streams define the drinage pattern of most of the Natural Area and their flood basins and plains form a significant natural feature. This objective promotes maintenance, restoration and recovery of wetland habitats.

Components

1. Maintain and restore the processes that increase the naturalness of river systems and functioning flood plains.
2. Maintain and restore water quality and quantity (including minimising diffuse pollution from agricultural sources within the catchment).
3. Enhance river bank and floodplain habitats and features particularly for otter and water vole.
4. Minimise the impacts of land use changes on water quality and in-river habitats.
5. Target hydrologically suitable areas for habitat restoration and re-creation schemes (including mineral workings).
6. Promote saltmarsh creation through managed retreat options.

Similarly, the Environment Agency (formerly the National Rivers Authority) River Severn Lower Reaches (1995) local Catchment Management Plan (NRA 1995a) and the Warwickshire Avon (1998) Local Environment Agency Plan (LEAP) (Environment Agency 1998) identify floodplain wetland/landscape restoration and re-creation as key issues requiring action. Also the Royal Society for the Protection of Birds (RSPB) has highlighted the need for a major and challenging programme to restore and create extensive wetland systems in river valleys in *Wet grasslands – what future?* (RSPB 1994).

To meet these broad aims, this jointly funded project by English Nature, the Environment Agency and RSPB had the following specific aims (see Appendix 1 for full specification):

1. To assist English Nature/EA/RSPB with the development and trialing of selection criteria for possible wetland re-creation sites.
2. To define past and present wetland resources, and to assess the hydrological condition of the surviving areas.

3. To identify/evaluate potential target areas/sites for wetland re-creation through the use of existing information and the standardised selection criteria.
4. To assess relevant hydrological determinants, including present regimes and necessary/feasible changes, at candidate sites for wetland re-creation.
5. To assess the flood defence/land drainage constraints (including capital and maintenance works and costs) and technical and financial implications of wetland re-creation at candidate sites.
6. To identify opportunities for achieving wetland re-creation in conjunction with new or upgraded capital flood defence schemes.
7. To predict wetland type(s) and areas likely to be re-created, and their relationship to national and local Biodiversity Action Plan targets.
8. To produce recommendations for the implementation of a wetland recovery strategy in the Severn/Avon floodplain, and to indicate possible future areas of work.

Note. All maps of sites referred to in the text are placed at the back of this report. Other figures (ie river water levels) are placed within the text.

2 The past and current status of wetlands in the Severn and Avon Vale Natural Area

2.1 The past status of wetlands within the Severn and Avon Vale Natural Area

The Severn and Avon Vales Natural Area is centred on the broad flood plain of the Rivers Severn and the Warwickshire Avon (Figure 2.1). The Natural Area covers more than 2000 square km and lies mainly in Worcestershire and Gloucestershire with small areas in Warwickshire and South Gloucestershire (the former County of Avon). The Natural Area crosses the mouth of the Bristol Avon to include the low lying peat wetlands of the Gordano Valley. This area is not included within this study.

Much of the landscape of the Natural Area is a low-lying, undulating plain through which the Rivers Severn and Warwickshire Avon and their many tributaries flow. Historical data on the location and extent of wetlands with the Severn and Avon Vale are incomplete and scattered, and an overall assessment of the past wetland resource within the Natural Area is not available. However, it is likely that the majority of the floodplain of these rivers as depicted in Figure 2.2 was once wetland. Before the widespread influence of human activities there would probably have been a wide diversity of natural wetland habitats. These would have reflected the different hydrological and soil conditions (see Table 4.1 for target habitat requirements) across various stages of vegetation succession, from deep open water habitats to wet woodlands. In addition to the rivers and streams themselves, with their variety of physical features, such as riffles and pools, habitats would have probably included ox-bow lakes, swamp communities with stands of tall emergent vegetation (eg reedbeds), carr woodlands and mature stands of wet woodland. Alder and willow would have been the predominant species of the wet woodlands, which would have probably covered a large proportion of the floodplain.

The clearance of the wet woodlands and the advent of wide-scale pastoral farming in Roman times subsequently led to the creation of semi-natural wet grassland habitats on the Severn and Avon floodplain and the lower reaches of the Teme. By the 6th century the majority of land in the Severn Vale had been turned to agriculture (GWT 1981). Initially most of the land was pastureland for livestock, but after the Anglo-Saxon invasion of 577 AD large areas of land were ploughed for cereal production. Nevertheless, until the 18th century most of the land in the vale was enclosed and, within Gloucestershire, grasslands continued to cover half the landscape (Marshall 1789, cited in GWT 1981). Following the Enclosure Acts, most of the cereal fields were restored to pasture, mainly for dairy farming, and the Severn Vale has been predominantly grassland since.

Many floodplain grasslands within the Severn and Avon Vales were held as common land with complex systems of ownership and hay and grazing rights. These historic grasslands, which to this day are often locally known as hams, were traditionally managed as hay meadows on a lammas(strip) system with aftermath grazing by commoners. Although partly man-made, these semi-natural ham meadows were botanically rich and the pattern of tenure provided an open field landscape that was favourable for breeding waders and wintering waterfowl. The hams were also associated with extensive ditch/rhyne systems. Where these

maintained high spring and summer water levels they provided valuable wildlife habitat, especially for invertebrates.

Successive river engineering, land drainage and reclamation has reduced the extent of wetland within the Natural Area. Information on such events is incomplete but it is likely that many wetlands have been lost as a direct result of land drainage and flood prevention schemes in the 18th and 19th centuries. For example, Pitt (cited in Green and Westwood 1991) stated in 1813 that the Earl of Coventry at Croome was an especially skilful drainer: "his part of the country was a morass not half a century back, and is, at the present time (though formerly on morrish soil) perfectly dry, sound for sheep and cattle".

One of the last great wetlands to be lost was that of Longdon Marsh. This was formerly referred to as "The Great Marsh of Worcestershire" and was of considerable ecological importance. Some plants that occurred, which are now scarce or absent in Worcestershire, included sea club-rush *Scirpus maritimus*, marsh pea *Lathyrus palustris*, brown sedge *Carex disticha*, meadow thistle *Cirsium dissectum*, yellow loostrife *Lysimachia vulgaris*, narrow-leaved water-dropwort *Oenanthe silaifolia*, parsely water-dropwort *Oenanthe lachenalii*, great burnet *Sanguisorba officinalis*, golden dock *Rumex maritimus*, flowering rush *Butomus umbellatus*, water-violet *Hottonia palustris* and bladderwort *Utricularia* sp. (Lees 1867, Green and Westwood 1991). The marsh was also of considerable importance for its birds and was said by Harthan (1947, cited in Green and Westwood 1991) to be rich in waterfowl and to contain extensive reedbeds with bearded tit, bittern and marsh harrier.

In the 17th century the marsh extended over 10,000 acres and was the remains of the great tidal estuary of the Severn above Gloucester (Green and Westwood 1991). The area was difficult to drain and although surveyed in 1763 and 1788, the first major drainage scheme was not started until 1861 and 1866 when operations were carried out under the Land Drainage Act. This partially failed but by 1872 the marsh had been enclosed and drained. Over the subsequent 100 years the drainage has been improved by various schemes, including the recent deepening of Longdon Brook in 1986. The area still regularly floods in winter (see Chapter 12) but the period of inundation has declined substantially and the land is now sufficiently dry in spring for the cultivation of cereals on some parts of the marsh.

Drainage improvement schemes throughout the Severn and Avon Vales have continued up to the present day and some important wetlands have only been lost in recent decades. For example, Elmore Marsh was drained in the 1960's (GWT 1981).

Previously winter floods were an important component of the annual farming cycle as these deposited nutrient-rich silt that fertilised the land. However, the use of modern fertilisers is more efficient and winter flooding is no longer beneficial as it prevents the use of the land by stock in winter and can delay farming operations in spring. Consequently, many of the original flood meadows have now been protected to some degree by flood embankments. Although most of these do not provide complete protection, they have reduced the frequency of flooding and encouraged within-field drainage with consequent loss and deleterious changes to the hydrology and ecology of the floodplain wetlands.

Wetland habitats have also been significantly affected by navigational improvements to the River Severn and Avon. The Severn has been an important transport route from Tudor times and was regularly travelled by shallow-draught boats from Bristol to Welshpool in the mid-18th century (Green and Westwood 1991). Despite this, early navigational improvement

schemes, such as an attempt to obtain a Navigation Act in 1786 were blocked by local boat-owners who feared for their livelihoods and landowners who were concerned about potential flooding. During these times the effects of the tides were considerable, with high spring tides reaching up to Upton-upon Severn. This backed-up the freshwater, leading to a river level increase of 18 inches at Worcester. Consequently, brackish water reached far inland and plants associated with coastal conditions, such as the sea club-rush *Scripus maritimus* occurred along the Severn and surrounding wetlands (eg parts of Longdon Marsh). However, the Severn was slowly improved for navigation in the 19th century, and tidal influences were substantially reduced with the building of locks and weirs. This resulted in a permanent loss of brackish wetland habitats and maritime plant species above Gloucester.

Unlike the Severn, the Avon has a long history of navigable improvement, starting in 1636 and now has a large number of locks and weirs. It has also been repeatedly dredged over the last three centuries.

The construction of reservoirs higher up the Severn catchment also affected the river through changes in its flooding and flow regime. In particular, the construction of Lake Vyrnwy and other reservoirs in central Wales reduced spring and summer floods, which were previously common and probably contributed to high floodplain groundwater levels.

As a result of these navigational improvements and impoundments the hydrological and ecological character of the Severn and Avon floodplain habitats are likely to have been further changed and many wetlands lost. Changes in river flows and the reduced tidal influence also led to a decline in migratory fish populations such as salmon, trout, lamprey, eels (elvers), allis shad and twaite shad.

In addition to the effects of historic and large-scale river engineering and drainage schemes, many wet grassland have been degraded or lost as a result of recent agricultural improvements (GWT 1981). Such improvements include the simple clearance and deepening of ditches, installation of field drains, fertilisation, re-seeding, use of herbicides and a switch from hay cropping and grazing systems to silage production. Thus, although such areas may continue to flood in winter, their characteristic wet grassland communities have been lost. Furthermore, many of the areas with the best flood protection have been converted to arable farmland or market gardening.

Some increases in wetland habitats have occurred as a result of human activities in recent centuries. These have mostly been the result of the excavation of clay or gravel pits that have subsequently been flooded. These formed new marshland, open water and wet woodland habitats of some ecological importance. In Gloucestershire and along the Severn, some pits excavated to provide clay for bricks and tiles were also planted with osier willows.

In general, although poorly documented, it is clear that human activities over the last few centuries have profoundly changed the majority of wetlands within the Severn and Avon Vale Natural Area. Many wetlands have been entirely lost, whilst the majority of the remaining areas have been degraded and are consequently now of low ecological value. Although many important wetlands remain within the area, these constitute a small remnant of their former extent.

2.2 The current status of wetlands within the Severn and Avon Vale Natural Area

2.2.1 Rivers and streams

The main remaining wetland habitats within the Natural Area consist of rivers and streams: principally the Severn, Avon and Teme, as well as several canals, all of which are important wildlife corridors. Of these, the Severn has been altered considerably by man (as described above), with water levels highly influenced by impoundments in the upper catchment and, below Stourport-on-Severn, the river is largely controlled by a series of locks and weirs, so that it runs broad and deep between fairly high banks. The water is too deep and turbid for aquatic plants to grow, except near the bank. A narrow fringe of emergent vegetation, such as branched bur-reed *Sparganium erectum* and purple-loosetrife *Lythrum salicaria* is common, but the banks are prone to erosion from floods and boat wash and bare areas are often dominated by ruderal weeds. A narrow band of willow, alder and hawthorn scrub is often present, though below Worcester the river is much more open and bordered by extensive flood meadows (see below).

Although nutrient levels are fairly high, water quality corresponds to River Ecosystem Class 2 (ie water of good quality – suitable for all fish species). The Severn is important for migratory fish, including salmon, eel, river and sea lamprey and twaite and allis shad as well as resident game fish such as brown trout and a variety of coarse fish.

The River Avon also meandered over a wide flood plain and its channel has been similarly modified by locks, watergates, dredging and improvements to the banksides. Consequently, within the Natural Area, the river is fairly broad, slow-flowing, deep and bordered by steep banks of variable height, depending on the distance and fall to the nearest weir. The river runs over Lower Lias Clays that are naturally fairly rich in nutrients, but it also suffers some eutrophication from sewage discharges. Below Leamington Spa the river had a Chemical General Quality Assessment grade of C (Fair) in 1996, whilst most of the tributaries within the Severn and Avon Vale were of grade B (Good) (Environment Agency 1998). Biological General Quality Assessments were mostly grade B (Good) below Stratford-upon-Avon, but some stretches and tributaries were only of grade C (Fair).

The eutrophic conditions together with dredging and disturbance from boat traffic creates turbid waters that are largely unsuitable for aquatic plants. However, floating and emergent plants of eutrophic conditions, such as yellow water-lily *Nuphar lutea*, common club-rush *Schoenoplectus lacustris*, great yellow-cress *Rorippa amphibia*, arrowhead *Sagittaria sagitifolia* and branched bur-reed *Sparganium erectum* are common on the muddy margins. Reeds also occur in thin bands along the shallows. Scrub vegetation along the river bank includes scattered hawthorn, blackberry, dog rose and willow. Pollarded willows are abundant and grow along the riverbanks and elsewhere. English alder also grow in some places and form mature trees.

In contrast to the Severn and Avon, the River Teme, has remained relatively natural. It is fairly free from pollution and complies with River Ecosystem Classification Class 2 over the majority of its catchment (NRA 1995b). Consequently, it has been designated, throughout its length, as an SSSI as it is one of the best examples of a Type VI river – a large river over sandstones, mudstones and hard limestones (NCC 1989). It supports a rich aquatic flora and fauna and is important for salmon, twaite shad, bullhead and sea lamprey (English Nature

1997). The otter population, which survived on this river during the decline of the 1970s-80s, has acted as a source for recolonisation of the Severn and Avon.

2.2.2 Non-riverine wetlands

Remnants of non-river remnant wetland habitats occur across the Natural Area and include a wide range of vegetation types, including - neutral grassland, swamp, mire and saltmarsh (Table 2.1).

Table 2.1. Wet grassland, swamp, mire and saltmarsh habitats that occur within the Severn and Avon Vale Natural Area (English Nature 1997)

Community	National Vegetation Classification (NVC) communities (Rodwell 1991 *et seq.*)
Wet grassland	
Flood meadows	MG4 Meadow fox-tail – great burnet
Dairy and fattening pastures*	MG6 Rye grass – crested dog's-tail
Water meadows	MG8 Crested dog's-tail – marsh marigold
Tussocky wet meadows*	MG9 Yorkshire fog – tufted hair-grass
Ordinary damp meadows*	MG10 Yorkshire fog – soft rush
Inundation grassland	MG11 Red fescue – creeping bent - silverweed
Inundation grassland	MG13 Creeping bent – marsh fox-tail
Swamp	
Reedbed	S4 Common reed
Tall sedge meadows	S7 Lesser pond sedge
Reedmace swamp	S12 Reedmace
Common spike-rush swamp	S19 Common spike-rush
Other	S23 Other water margin vegetation
Mire	
Western-fen meadows	M23 Soft rush – common marsh bedstraw
Litter and wet Culm grassland	M24 Purple moor-grass – meadow thistle
Saltmarsh	
	SM6 Small cord-grass
	SM10 Common saltmarsh grass
	SM13 Common sea-lavender – thrift
	SM23 Reflexed saltmarsh grass
	SM24 Halberd-leaved orache – common couch

Note: * agriculturally improved grassland.

There has not been a comprehensive survey of the extent of these habitats according to the Severn and Avon Natural Area profiles. Most existing habitat data have been collected on a county basis and habitat definitions and survey methods differ between these. It is therefore difficult to assess the current extent of wetland habitats on a Natural Area basis.

However, a review of habitats in Worcestershire according to Natural Areas has recently been prepared as part of the development of a county Red Data Book (Fraser in prep.). This has utilised data from a number of surveys, including a Phase I survey completed in 1978, which, although out of date, is considered to be accurate in general terms. This has been augmented by a number of specific habitat surveys, some of which have been based on the NVC (Rodwell 1991 *et seq*.).

In Gloucestershire a habitat survey was carried out in 1981 (GWT 1981). However, this is now rather out-of date and was carried out before the NVC and Severn and Avon Vale Natural Areas were devised. A more recent account of habitat extent is given in Cordrey (1996) and GBWG (1998) as part of an audit of biodiversity in the south-west. However, again these habitat accounts are based on counties rather than Natural Area boundaries and do not follow the NVC or provide detailed definitions of habitat types. The results of these surveys are summarised in Table 2.2 for wetland habitats.

Table 2.2. The extent of wetland habitats in the Severn and Avon Vale Natural Area within Worcestershire and Gloucestershire

Habitat	**Extent (hectares)**	
	Severn and Avon Vale Natural Area within Worcestershire (Fraser in prep.)	**Gloucestershire** (Cordrey 1996)
Rivers and streams	?	5306 km
Lowland still water	?	950
Neutral wet grasslands	?	10,250*
• MG4	77	?
• MG5	49	?
• MG8	0	?
• MG9/10	34	?
• Other grasslands of conservation interest	70	?
Reedbed	25	9
Marshes and fens	115	?
Wet woodland	127	Local patches on stream-sides and river banks (GWT 1981)
Saltmarsh	Small areas of inland marsh at Upton pools	264

Note: * 441 ha in GWT (1981) which includes lowland meadows and hams that predominantly occur within the Severn and Avon Vale Natural Area.

Due to the lack of available data it is not possible to map the location of all the currently existing wetlands within the Severn and Avon Vale Natural Area. However, data have been collated from English Nature, the Gloucestershire Wildlife Trust and Worcestershire Wildlife Trust to compile a map of existing wetlands that have been designated as SSSIs or County Wildlife Sites (Figure 2.2). Summary details of these sites are provided in Appendix 2. These

wetlands are likely to represent the majority of wetlands currently within the Natural Area that are of particular ecological importance.

It is clear from Figure 2.2 that, although the remaining non-river wetland habitats are widely distributed across the Natural Area, the majority lie on the floodplain of the Severn and Avon rivers. This is because, despite river engineering and the creation of floodbanks, the Severn, Avon and lower parts of the Teme still regularly flood large areas most winters. Some areas also receive groundwater baseflows where these overlie permeable gravels that are in hydraulic continuity with the river.

Also, these river valleys are still mainly used for pastoral or mixed farming enterprises. Therefore wet grassland habitats are relatively widespread within the Natural Area. Some of these are remnants of the traditional ham meadows (described above) and are of considerable botanical importance. These are typically species rich flood meadow communities characterised by the presence of meadow foxtail *Alopecurus pratensis* and great burnet *Sanguisorba officinalis* (NVC MG4) and often hold the nationally scarce narrow-leaved water-dropwort *Oenanthe siliafolia*. Some also hold important populations of breeding waders, such as redshank, curlew and lapwing, or wintering waterfowl. Six of these have been designated as SSSIs: Upham Meadow and Summer Leasow, Rectory Farm Meadows, Upton Ham, Chaceley Meadow, Ashleworth Ham, and Severn Ham.

Some small patches of other semi-improved grasslands or neglected grasslands also remain. of these, tussocky grasslands, with tufted hair-grass *Deschampsia cespitosa* (MG9) or soft-rush *Juncus effusus* (MG10), are favoured breeding sites for waders. However, the majority of the remaining wet grasslands in the Natural Area have been agriculturally improved and are of little botanical interest. Nevertheless, some of these improved grasslands still regularly flood in winter and these are often favoured feeding areas by grazing wildfowl, especially at sites, such as Walmore Common (see chapter 13), that are close to the Severn Estuary.

Although detailed information is lacking, it is clear that the extent of marsh and fen habitats within the Severn and Avon Vale Natural Area is very limited. Overall it is considered that there are no more that 34 hectares of reedbed within the whole Natural Area (Table 2.2) and this mostly consists of small and fragmented marginal stands that are likely to be of low conservation value. Similarly, the apparently large area (115 hectares) of other marshland and fens habitats in the Worcestershire part of the Natural Area consists of a large number of very small sites, many of which are little more than narrow margins to rivers and streams (Fraser in prep.).

Some areas of saltmarsh and regularly inundated upper saltmarsh grasslands occur on the lower reaches of the Severn and the Severn estuary. These habitats straddle the transition between the Severn and Avon Vales and the adjoining Severn Estuary Maritime Natural Area and can be considered common to both.

Several standing water bodies are found in the Natural Area, most of which are man-made. Of those within the Severn and Avon floodplain, most were formed as a result of past sand, clay or gravel extraction and several have been designated as SSSIs (ie Frampton Pools, Northwick Marsh and Grimley Brick Pits). Many of these are particularly valuable for breeding/wintering wildfowl and waders. Others are of botanical importance, for a number of nationally scarce plants or their associated wet woodland habitats. Many of the pits were planted and managed as osier beds or have become overgrown with willow carr and alder

woodland as a result of natural succession. Consequently the majority of wet woodland habitats within the Natural Area are now found in such former pits.

Other man-made wetlands include the freshwater and brackish pools and scrapes created by the Wildfowl and Wetlands Trust at Slimbridge in Gloucestershire. This site also has important grazing marshes and lies within the Upper Severn Estuary SSSI and is of particular importance for its wintering waterfowl (including Bewick's swans and white-fronted geese). The pools also hold a significant population of the nationally rare plant, grass poly *Lythrum hyssopifolia* whilst the surrounding ditches are important for invertebrates and water vole.

2.3 The status of target species within the Severn and Avon Vale Natural Area

2.3.1 Breeding waders

Wet floodplain grasslands provide suitable breeding habitats for a number of waders, including curlew, lapwing, redshank and snipe. Such species were probably once numerous in the Severn and Avon Vale before the widespread drainage and agricultural improvements of grasslands over the last couple of centuries. Nevertheless, small numbers of breeding waders have remained at some sites. In 1982 a national survey of waders breeding on lowland wet grasslands found 125 pairs within the Severn Vale (Smith 1983).

However, the 1982 survey was incomplete and a repeat survey with better coverage was carried out by the RSPB in 1995 (Quinn 1995). This survey covered 7,014 hectares over 84 sites within the NRA River Severn Lower Reaches catchment boundary and along the River Avon to Evesham. This survey found 227 pairs of breeding waders (excluding oystercatchers) consisting of 115 pairs of lapwing, 69 pairs of redshank, 42 pairs of curlew and one pair of snipe. It is considered that this is probably close to the true population size for the Severn Vale.

Despite the higher number of birds found in the 1995 survey, it is apparent that breeding wader populations are relatively low for the size of the area. Mean density estimates on suitable habitat were only 1.9 pairs per km^2 for lapwing, 0.9 per km^2 for curlew and 1.4 pairs per km^2 for redshank. Snipe densities were negligible. According to Quinn (1995), these densities are much lower than those found in the best sites in England, though close to those found on the Somerset levels in 1982 (Smith 1983). Only one site, the Wildfowl and Wetlands Trust reserve at Slimbridge, had breeding densities close to those of the best sites in England, such as the Ouse Washes and Nene Washes.

On the basis of current criteria no sites qualified for national importance (these criteria were set in 1982 and may now be too stringent). Four sites qualified for regional (Severn Trent) importance for their breeding redshank in 1995: New Grounds, Slimbridge, Upham Meadow and Summer Leasow, Bredon's Hardwick (East) and Aylburton Warth. Four other sites were of divisional (River Severn Lower Reaches) importance: Bredon's Hardwick (west) for lapwing, and Saul Warth, Upton Ham and Severn Ham for redshank.

It is also apparent from a comparison of 28 sites that were covered by both the 1982 and 1995 surveys that waders numbers are declining on most sites (Table 2.3). Although there is little difference in the total numbers, a more general decline is obscured by a contrasting increase at Slimbridge as a result of active management for breeding waders. With the exclusion of

Slimbridge, it is apparent that numbers fell on the remaining 27 sites from 117 in 1982 to 78 in 1995, a decline of 33%. For each species, this consisted of declines of –80% for snipe (from 5 pairs to 1 pair), -30% for redshank, -36% for lapwing and -13% for curlew.

Although, these declines may have been partly exaggerated by the particularly dry spring in 1995, it is clear that wader numbers are continuing to decline in the Severn Vale, and probably over the entire Natural Area. This long-term decline is typical of wader populations over much of southern England and is mainly due to continued habitat loss and degradation. This is primarily the result of agricultural improvements, including the drainage and re-seeding of fields, use of fertilisers and conversion of hay fields and pastures to silage or cereal production. In particular, such improvements result in the loss of rough, wet and tussocky grassland, which is the favoured breeding habitat for waders, especially snipe.

Table 2.3. Numbers of pairs of waders surveyed in 1982 and 1995 in the Severn Vale (Source: Smith 1983, Quinn 1995)

Site	Grid reference	Lapwing		Snipe		Curlew		Redshank	
		1982	1995	1982	1995	1982	1995	1982	1995
Kempsey Upper Ham	SO849501	0	0	0	0	0	0	0	0
Ashmoor Common	SO853467	2	5	0	0	1	0	3	0
Kempsey Lower Ham	SO845485	0	0	0	0	0	0	0	1
Rhydd Meadows	SQ843452	8	0	0	0	1	1	3	0
Clifton Meadows	SO840465	8	0	0	1	9	2	7	0
Ryall's Court Farm	SO850420	0	0	0	0	3	0	0	0
Severn Stoke Ham (Northfield)	SO850435	4	0	0	0	0	1	0	1
MythePool	SO878355	3	2	0	0	1	1	1	0
Bow Farm	SO873364	0	6	0	0	0	1	0	2
Longden Brook	SO860365	6	5	0	0	0	3	0	0
Upham & Summer Leasow	SO915375	6	4	1	0	1	3	10	9
Eckington Marshes	SO913417	0	3	0	0	0	2	0	0
Gooseham &Aysham	SO925425	0	0	0	0	0	1	1	2
Falfield Area, Lower Stone	ST681940	0	0	0	0	0	0	0	0
New Grounds, Slimbridge	ST685970	4	23	0	0	0	0	1	15
Elmore Back	SO770160	2	0	0	0	0	0	0	0
Saul Warth	SO741075	4	5	0	0	0	0	3	5
Walmore Common	SO745150	3	2	2	0	0[1]	0	1[1]	0
Minsterworth & Corn Ham	SO800170	0	0	0	0	1	0	0	0
Port Ham	SO820190	0	0	0	0	0	0	0	0
Maisemore Ham	SO820205	0	0	0	0	0	0	0	0
Sandhurst – Maisemore Park	SO820225	0	0	0	0	1	0	0	0
Ashleworth & Hasfield Ham	SO833264	7	4	2	0	2	1	3	0
Chaceley	SO856293	0	0	0	0	1	1	0	0
Severn Ham	SO885325	0	0	0	0	1	1	1	3
Carrant Brook	SO903337	0	0	0	0	0	0	0	0
Coombe Hill Canal	SO870270	2	0	0	0	1	2	0	0
Canal, parkened bridge to ….	SO782116	1	0	0	0	0	0	0	0
TOTAL		**60**	**59**	**5**	**1**	**23**	**20**	**34**	**38**
Total excluding Slimbridge		**56**	**36**	**5**	**1**	**23**	**20**	**33**	**23**

Note: [1] Data provided by RSPB (Barber pers comm.) as data included in Quinn (1995) are incorrect.

2.3.2 Wintering waterfowl

The Severn and Avon Vale Natural Area holds large populations of wildfowl during the winter. In particular, flooded grasslands in winter are the main habitat of grazing wildfowl (eg swans, geese and wigeon) and are also used by dabbling species (eg mallard, teal, shoveler and pintail). The populations of several of these species are fairly dispersed and winter counts from the floodplain are incomplete. However, several sites that are of particular importance and probably hold a high proportion of the population in the Natural Area are routinely monitored by the national Wetland Bird Survey (WeBS). Mean peak numbers for these sites and the Severn vale as a whole from 1989-90 – 1993-94 are provided in Table 2.4.

On the basis of these sites alone the Severn Vale support internationally important populations (ie >1% of the NW European winter population) of Bewick's swan and gadwall and nationally important populations (ie >1% of the national winter population) of white-fronted goose, wigeon, teal, pintail, shoveler and pochard.

Of these sites the Wildfowl and Wetlands Trust Reserve at Slimbridge is by far the most important. It is internationally important for Bewick's swan and gadwall, and of national importance for white-fronted goose, wigeon, teal and pochard. The reserve forms part of the Upper Severn SSSI, SPA and Ramsar site. Walmore Common is also of international importance for Bewick's swans and is designated as a Ramsar site for this reason (See chapter 17). These birds are part of the same population that occurs at Slimbridge as birds move between sites to feed and roost. Although this population appears to have fluctuated in recent years, no clear trend in wintering numbers is apparent (Cranswick and others 1995). However, numbers of Bewick's Swans have declined since peaks in 1990-91 in the Avon Valley. Data on population trends on other species on floodplain sites with the Vale are not currently readily available.

Deeper permanent standing water bodies, such as flooded gravel and brick pits are also used by dabbling species as well as diving ducks such as pochard and tufted duck. Some grazing species, such as wigeon also use these as roost sites. Although none of these are of international or national importance, some have been designated as SSSIs at least partly on the basis of their winter wildfowl populations (Appendix 2). Data on population sizes and trends are not currently readily available for these sites.

Table 2.4. Mean peak numbers of wildfowl counted by WeBS in the Severn Vale from 1989-90 to 1993-94 and their significance with respect to national and international populations (Source: Quinn 1995)
Populations of national importance (ie >1% of population) are indicated in italics and populations of international importance are underlined.

Species	Walmore Common (SO7415)	Wylmer Common (SO7411)	Coombe Hill Canal (SO8626)	Ashleworth & Hasfield Ham (SO8326)	WWT Slimbridge (SO7105)	Upham Meadow, Twyning (SO9035)	Mean Peak for the Severn Vale	% of GB population	% of NW Europe population
Little grebe					1	9	3	0.1	0
Cormorant					20	13	21	0.2	0
Mute swan	12	9		11	119	11	137	0.5	0
Bewick's swan	*134*	28	9	6	*286*		328	*4.7*	1.9
Whooper swan				2			2	0	0
Greylag goose	1			39	292		293	0.3	0.3
White-fronted goose					*2,950*		2,950	*49.2*	0.7
Canada goose	2		16		346	176	393	0	0
Shelduck	24	31		6	210		214	0.3	0
Wigeon	500		213	1,470	*2,867*	78	4,043	*1.4*	0.5
Gadwall	26			12	*320*	7	336	*4.2*	1.3
Teal	123		134	677	*1,745*	14	2,119	*1.5*	0.5
Mallard	35	4	64	339	2,150	97	2,417	0.5	0
Pintail	110		9	93	266		369	*1.3*	0.5
Shoveler	12		2	44	58	5	92	1	0.2
Pochard	38			2	*1,168*	42	1,208	*2.7*	0.3
Tufted duck				2	344	29	349	0.6	0
Coot	1	1		33	115		121	0.1	0

2.3.3 Otter

The otter was relatively numerous and widely distributed over Britain until at least the mid-18th century, but subsequently declined considerably as a result of hunting pressure combined, since the 1950s, with the effects of organochlorine pollution of rivers (Harris and others 1995). As a result, by the early 1970s the otter was absent from most of lowland England, including the lower reaches of the Severn and Avon, but survived in the Teme catchment (Strachan and Jefferies 1996). However, a slow recovery has commenced since the early 1980s and there is recent evidence that otters are present on the Severn and Avon in Warwickshire and Worcestershire (unpublished Worcestershire Wildlife Trust data) and Gloucestershire (unpublished Gloucestershire Wildlife Trust data), albeit probably in small numbers.

It is believed that the core population on the River Teme has been the source population for this recovery. Furthermore, the Severn and its tributaries has been recognised as a key recovery 'gateway' linking the otter populations of mid-Wales to the currently unoccupied waterways of southern and eastern England (GBWG 1998).

Various actions have been carried out to support the recolonisation of the Rivers Severn and Avon catchments, including the Vincent Wildlife Trust's Otter Haven Project and, since 1990, the Otter and Rivers Project, run by the Royal Society for Nature Conservation, and locally in conjunction with the Worcestershire Wildlife Trust, Environment Agency, Severn Trent Water plc and Fuji Hunt Ltd (The River Severn Otter Project).

2.3.4 Water voles

At the turn of the century the water vole was an abundant and widespread species in suitable habitats in England. However subsequently the species has undergone a long-term decline. Since 1900, at least 69% of occupied water vole sites in Britain have been lost (Strachan and Jefferies 1993). Furthermore, the decline is continuing and Strachan and Jefferies have calculated that by the end of the century 94% of formerly occupied sites may be lost.

The national water vole survey in 1989-90 reported that, although suitable water vole habitats occur along the Severn, Avon and Teme, populations appear to be small and fragmented. More recently, a 1997 survey of water voles in Gloucestershire revealed that the species is now absent from 75% of sites previously occupied in 1984 (Gloucestershire Wildlife Trust in prep.).

There is currently inconclusive proof of the cause of this species' national decline, but predation by mink, habitat destruction and disturbance, organochlorine pollution, increased cattle grazing on river banks and climate change have been proposed as causal factors (Harris and others 1995).

3 Stage 1 identification of candidate sites for wetland re-creation

3.1 Factors governing the suitability of areas for wetland re-creation

The evaluation has been carried out by a two-stage process using two levels of criteria. The first stage aimed to identify large areas of the Severn and Avon Vales study area that are of general suitability for wetland re-creation as judged against the following factors:

- Topography
- Current land-use
- General geology and hydrogeology (including potential ground-water sources)
- General soil suitability
- Flooding regime
- Size

For each factor (other than size) maps were produced of areas that were considered to be suitable or unsuitable for wetland re-creation according to the criteria outlined below.

3.2 Topography

The main aim of this project has been to identify large areas of lowland floodplain habitats that may be suitable for wetland re-creation. Therefore, land within the current floodplain was firstly identified. The maximum extent of the floodplains of the River Severn, River Avon and their tributaries are indicated in Figure 2.2 according to the Land Drainage Survey Section 24 (5) maps. It should, however, be pointed out that these maps were produced in the 1980s and are now considered to be out of date, especially following the flood events of 1998. More detailed and accurate maps are currently available for some sections of the study area and these were consulted for evaluation of the Stage 2 criteria. Nevertheless, for the purpose of this stage of the project the Section 24 maps were considered to be sufficiently accurate to indicate approximate extent of floodplains.

3.3 Land-use

Areas were considered to be unsuitable for wetland re-creation if they contained significant areas of forest or urban development.

3.4 General geology and hydrogeology

The geology of the Severn and Avon valleys essentially comprises Triassic Mercia Mudstones and Jurassic Lower Lias Clays overlain by patchy Quaternary Alluvium and Gravels. Triassic Sandstone outcrops in the very north of the Study Area.

The Triassic Mercia Mudstones comprises mainly reddish brown mudstones and silty mudstones, with occasional bands of sandstone and siltstone. They are present beneath much of the area west of the River Severn, and are regarded by the Environment Agency as a Non-

Aquifer, generally exhibiting negligible permeability and containing insignificant quantities of groundwater flow. Springs are rare but locally significant. However, where the sandstones bands ('skerries') are sufficiently thick, groundwater supplies for local use may be frequent, although yields are not high. The Arden Sandstone is about twelve metres thick and is the most prominent sandstone in the Mercia Mudstones. This sandstone has a relatively high permeability, and is important for both local supplies and in supplying baseflow to rivers. For these reasons the Arden Sandstone is classified as a Minor Aquifer.

The Triassic Sherwood Sandstones are a Major Aquifer, but are only present in the very north of the Study Area. They comprise poorly cemented, locally pebbly sandstones with thin beds and lenses of mudstone. Permeabilities are high and the aquifer is able to support large public water supply abstractions and river baseflows.

The Jurassic Lower Lias strata comprise a thick sequence of low permeability mudstones which are occasionally separated by limestone bands of variable thickness. It is present beneath much of the area east of the River Severn, and is regarded by the Environment Agency as a Non-Aquifer. The limestone bands may be utilised for small local supplies.

The Quaternary Alluvium and Gravels are generally thin and variable in nature but exhibit moderate permeabilities and are in hydraulic continuity with the surface watercourses. They are therefore regarded by the Environment Agency as a Minor Aquifer, and are locally important in the small supplies they can yield to individual abstractors.

Baseflow from groundwater can be an important contributor to a wetland's water-balance. For the purposes of the Stage 1 Assessment, it has been assumed that wetland re-creation is likely to be most feasible in areas classified by the Environment Agency as Major or Minor Aquifers. These strata and deposits contain significant volumes of groundwater and exhibit moderate or high permeabilities.

In the Severn and Avon valleys the Major and Minor Aquifers include the Triassic Arden and Sherwood Sandstones and the Quaternary Alluvium and Gravels. The approximate extent of these strata and deposits are shown in Figure 3.1. This map is based on the published 1:100000 scale Groundwater Vulnerability Maps published by the Environment Agency (Sheets 29, 30 and 37). However, it is important to be aware that local conditions occasionally permit the development of wetland conditions in areas underlain by Non-Aquifers.

Also shown in Figure 3.1 are the locations of 35 Sites of Special Scientific Interest and three other sites that were included in two recent studies let by the Environment Agency (Aspinwall & Co 1995; Water Management Consultants 1998). These sites are regarded by the Environment Agency as important wetland sites which potentially have significant groundwater inputs. Their distribution indicates that on hydrogeological grounds efforts to re-create wetlands should be concentrated on areas of Quaternary drift deposits alongside the major watercourses.

3.5 General soil suitability

The soil series maps drawn by the Soil Survey of England and Wales (1984, scale 1:250000, sheets 3 &5) were inspected in order to identify those soil series which occur within the Natural Area and which would be inappropriate for wetland creation purposes. It was

considered that all categories of pelosol, brown earth, gley and peat soils would be suitable for some form of wetland creation, if a range of target habitats including wet grassland, reedbed, fen and wet woodland were all to be included.

The soil types which were considered less amenable for wetland creation were those comprising undeveloped soils lying over rock, such as the rankers and rendzinas and also the podzols. These latter soil types do not occur to any great extent within the Natural Area. There are some local patches of rankers alongside the Bristol Channel, and rendzinas on the margins of the Cotswolds and on Bredon Hill, which could be excluded at this stage, but these are also classed as unsuitable due to local topography. The one significant zone of podzol in the area which occurs on the edge of the Malverns has already been excluded as it is a block of woodland.

It was not considered useful therefore to map in detail the unsuitable soils at this stage. Soil suitability is considered in more detail in Stage 2 of investigation where higher resolution soil maps have been used.

3.6 Flooding regime

Information provided by Jim Crabbe of the Environment Agency on flood prevention measures and flooding frequency was used to supplement the Land Drainage Survey maps (see 3.3 above) to identify those areas of the floodplain that flood in most years. Areas that may have the potential for increased flooding because they are suitable sites for managed retreat were also identified.

3.7 Size

It is well established that a single large area of habitat is generally of higher overall ecological value than numerous smaller sites of equal total area. This is principally because large sites are less susceptible to external influences (eg pollution or disturbance) and can hold larger and therefore potentially more viable populations of species. Potential sites for wetland re-creation were, therefore, ranked according to their size. Sites less than 20 ha were considered to be unsuitable, although in practice such sites were not identified by this wide-scale study.

3.8 Selection of candidate sites

Wetlands may **potentially** be re-created on areas with high water tables (ie overlying shallow aquifers) or surface water inputs in areas of the floodplain that are not forested or under residential or industrial development. The application of the Stage 1 criteria has, therefore, indicated that there is a large extent of suitable land that may be potentially used for wetland re-creation in the Severn and Avon Vale Natural Area (Figure 3.2).

From this large area a manageable number of candidate sites were identified for further investigation in Stage 2 of the project. These were selected by visually examining the overlay map indicating aquifers, areas prone to flooding and areas of unsuitable land-use (Figure 3.2). Large rural and primarily agricultural areas that are prone to frequent flooding and overly aquifers were identified. Ordnance Survey 1:50,000 maps were then examined to establish provisional boundaries for each area. On this basis 18 candidate sites for wetland re-creation

within the Severn and Avon floodplains were identified. These are indicated in Figure 3.3 and summarised in Table 3.1, with indicative assessments of their overall suitability.

It should be pointed out that the list of candidate sites is not comprehensive and that wetlands could feasibly be re-created within many other areas within the floodplain. Furthermore, outside the floodplain, areas on tributaries to the Severn and Avon that are prone to flooding or poorly drained may be highly suitable for wetland re-creation. Although these have not been considered by this floodplain study a number of sites may merit future consideration. According to Andrew Fraser of the Worcestershire Wildlife Trust these could include the recently drained Bick Marsh (SP110485) and Moor End (SO910575) as well as Huntingdrop Common (SO930620), Mere Hall (SO955920), Baughton / Smithmoor Common (SO874410), Mucknell (SO900515) and Feckenham Bog (SP020605). Spring fed wetlands could also be re-created on many areas of sloping ground above the floodplain but no information on the location of spring lines was available for this study and therefore such areas could not be identified.

Table 3.1. Preliminary assessment of the suitability of candidate sites for wetland re-creation on the Severn and Avon floodplain

Site	Landuse	Hydrogeology	Water availability (flooding regime)	Approximate area (ha)	Comments	Overall suitability
1. R. Severn: Worcester to Holt (SO836575 - SO827632)	Mostly agricultural, with scattered woodlands & urban fringe in south	Underlying aquifer with 2 groundwater fed SSSIs	Unprotected floodplain in lower section, floods regularly	90	Existing wetland SSSIs: Grimley Brick Pits & Northwick Marsh	Moderate
2. R. Teme & R. Severn confluence (SO8451)	Agricultural and rural, but with urban fringes, major A road and powerlines	Underlying aquifer	Unprotected and floods regularly	270		Moderate / High
3. R. Severn: Upper Ham & Lower Ham near Kempsey (SO849 498 & SO845485)	Agricultural, although bounded by Kempsey village	Underlying aquifer	Unprotected and floods regularly	40	Potential flood risk to village	Moderate
4. R. Severn: Clifton to Upton on Severn (SO846502 – SO855410)	Rural and agricultural, but gravel extraction near Clifton	Underlying aquifer	Embanked floodplain, floods 1 in 4/5 years	190		Low (unless embankment is removed)
5. Birch Green (SO854455)	Agricultural and rural	Underlying aquifer (adjacent SSSI is groundwater fed)	Protected floodplain which only floods in exceptional events, but poor drainage	20	Existing adjacent SSSI: Ashmoor Common	Moderate
6. R. Severn: Upper & Lower Hams at Upton on Severn (SO8539)	Agricultural, but adjacent to small town	Underlying aquifer and SSSI (Upton Ham) is groundwater fed	Unprotected floodplain, floods regularly	180	Existing SSSI: Upton Ham	Moderate
7. R. Severn, Ukinghall to Tewkesbury (SO8638 – SO8833)	Rural agriculture	Underlying aquifer	Protected floodplain, but part of area floods 1 in 1-2 years	320	Existing open water bodies	High / Moderate

Site	Landuse	Hydrogeology	Water availability (flooding regime)	Approximate area (ha)	Comments	Overall suitability
8. Longdon Marsh (SO8235)	Rural agriculture	Underlying aquifer	Floodplain floods 1 in 1-2 years	500	IDB area. Burley Dene Meadows SSSI nearby higher in catchment	High
9. R. Severn: Tewkesbury to Longford (SO8731 – SO8321)	Rural agriculture	Underlying aquifer	Mostly embanked floodplain but floods annually	1140	Brick pit SSSIs at Sandhurst and large wetland SSSI at Ashworth Ham. IDB area	High
10. R. Severn: Coombe Hill (SO8727)	Rural agriculture and disused canal	Part underlying aquifer	Mostly embanked floodplain but floods annually	480	Existing SSSI at Coombe Hill, potential for expansion?	High / Moderate
11. R. Severn: Minsterworth Ham (SO8016)	Agriculture and close to Gloucester, but no developments	No underlying aquifer	Protected tidal / fluvial floodplain, but floods 1 in 2+ years	320		Moderate
12. R. Severn: Elmore Back to Longney (SO7716 – SO7513)	Rural agriculture, but some roads, villages and powerlines	No underlying aquifer	Floodplain embanked and rarely floods, but pumped drainage	610		Moderate/Low
13. R. Severn: Walmore Common (SO7415)	Rural	No underlying aquifer	River floodplain embanked against tidal floods	210	Existing SSSI & Ramsar Site; WLMP being prepared by IDB. Potential for enlargement ?	Moderate
14. R. Severn: Awre (SO7108)	Agriculture, no developments	No underlying aquifer	Protected floodplain (but embankment under review and potential site for retreat)	130	Opposite Slimbridge tidal marshes	High (but value may be low)

Site	Landuse	Hydrogeology	Water availability (flooding regime)	Approximate area (ha)	Comments	Overall suitability
15. Wicksters Brook and the Moors, Slimbridge (SO7405 & SO7203)	Agricultural, scattered housing and some roads	No underlying aquifer on the majority of the site	Mostly outside floodplain, but poor drainage	540	Adjacent to Slimbridge SSSI	Moderate
16. Evesham to Birlingham (SP032448 – SP940437)	Mostly rural agriculture, but also villages and town of Pershore	Underlying aquifer	Mainly unprotected floodplain, floods every 1-2 years	400		Moderate / low
17. Eckington Bridge to Tewkesbury (SP923424 – SO8933)	Agriculture, but several roads (motorway) and villages and railway. Existing open water bodies	Underlying aquifer	Unprotected floodplain, floods every 1-2 years	580	Existing SSSIs at Rectory Farm Meadows, Upham Meadows and Summer Leasow	Moderate
18. R. Avon: Bidford on Avon to Offenham (SP0951 – SP0546)	Several roads. Villages and small towns nearby. Existing open water bodies	Underlying aquifer	Unprotected floodplain, floods every 1-2 years	450		

4 Stage 2 assessment of candidate sites for wetland re-creation

4.1 Stage 2 criteria

Candidate sites identified as suitable according to the Stage 1 criteria (3.1) were assessed in more detail according to the following criteria.

- Constraining factors
  - land-use (detailed assessment);
  - presence of transport and service infrastructures (ie sewers, water mains, electricity lines, gas mains and oil pipelines);
  - presence of important archaeological features;
  - flood defence / drainage requirements or opportunities from potential new flood defence schemes.
- Requirements for each target habitat type (ie wet grasslands, reedbed, wet woodland and fen)
  - detailed soil suitability assessment (eg porosity, hydraulic capacity, pH and nutrient status);
  - predicted water regime (ie assessment of annual summer and winter water requirements, availability and storage capacity);
  - quality of water supply (nutrient status, pH & salinity);
  - suitability of existing habitat (including available food resources) / land-use for wetland habitat re-creation and linkage to or complementarity to existing habitat / ecological linkages.
- Requirements for target species (breeding waders, wintering wildfowl, otters and water voles)
  - land-use topography;
  - linkage to other suitable habitats and populations;
  - potential habitat;
  - water regime;
  - food resources;
  - lack of disturbance.

For each criterion, the area was ranked according to three levels of suitability for the creation of wetlands: low, medium or high. Further information on the methods used to assess these criteria are provided below.

4.2 General methods and data sources

Due to the available resources and time-scale this project was primarily carried out as a desk-study of existing data. Descriptions of the data used and their sources are provided below for each criterion. It was not within the scope of this study to collect new data or carry out new detailed analyses of existing primary data sets.

However, the collated data were supplemented with information obtained during brief visits to the following candidate sites.

- Site 2. R. Teme & R. Severn confluence
- Site 3. R. Severn: Upper Ham & Lower Ham near Kempsey
- Site 6. R. Severn: Upper & Lower Hams at Upton on Severn)
- Site 7. R. Severn, Ukinghall to Tewkesbury
- Site 8. Longdon Marsh
- Site 9. R. Severn: Tewkesbury to Longford
- Site 10. R. Severn: Coombe Hill
- Site 11. R. Severn: Minsterworth Ham
- Site 12. R. Severn: Elmore Back to Longney
- Site 13. R. Severn: Walmore Common
- Site 15. Wicksters Brook and the Moors, Slimbridge
- Site 17. Eckington Bridge to Tewkesbury

Although it was not possible with this study to visit each site, or examine them comprehensively, these visits were particularly useful in obtaining information on general land-use (3.3) and existing habitats. Some information on habitats, soils, water-courses and hydrology characteristics were also obtained from field visits.

Further information was also obtained by consultations with landowners and trustees, IDB representatives, Wildlife Trusts, the Environment Agency, English Nature and RSPB.

4.3 Constraining factors

4.3.1 Land uses

Broad land-uses were included as a Stage 1 criterion (as described in the preceding section). Therefore, the main aim of this Stage 2 evaluation was to assess land-uses within and adjacent to the candidate sites in more detail. Thus each area was assessed in terms of the presence of current land-uses that are not compatible with wetland re-creation, including housing, industrial, commercial and recreational uses. Forested areas that are inappropriate for conversion to wet woodland habitats were also taken into account. Similarly agricultural areas that are unsuitable for wetland re-creation, such as orchards, glass-houses and horticultural areas were ascertained. The suitability of other agricultural habitats (eg arable and grassland type) for the re-creation of target habitats is taken into account in the assessments of each habitat type, as described below.

Information on land-uses was primarily taken from Ordnance Survey maps, supplemented with other information, such as the Worcestershire Wildlife Trust Phase 1 habitat maps and Worcestershire Wildlife Trust Grassland Inventory, Water Level Management Plans, SSSI documents and observations during site visits.

4.3.2 Presence of transport and service infrastructures

The presence of roads, railways and service / utility structures such as water, gas and oil mains, sewerage pipes and electricity lines (under and over-ground) could be a potential constraint on wetland re-creation. In particular the submergence of roads and railways during flood events would clearly be unacceptable, and probably, on economic grounds, the realignment or other modification of such structures to overcome higher water levels. Even the raising of water levels without increased flooding of roads and railways may cause problems as strengthening or other modifications may be required. Similarly the bases of electricity pylons may require strengthening if flooding regimes are altered such that the period or depth of water in which the pylons stand is increased. A means of access to pylons, water, sewerage, gas and oil pipelines is also required for maintenance and dealing with emergencies. Increased flooding or the creation of certain habitats such as reedbeds, fens or woodland may therefore be difficult where such structures occur.

The presence of roads and railways was mainly taken into account in Stage 1 of the study. However, they were re-assessed for this stage and other service utility structures were identified and mapped to indicate potential constraints on wetland re-creation.

The presence of roads and railways was obtained from Ordinance Survey maps. Information on service infrastructures were obtained from Transco (gas), Severn Trent Water (water and sewerage), Midlands Electricity (MEB) (electricity and oil), Malvern Hills District Council, Forest of Dean District Council, Tewkesbury District Council and Wychavon District Council (sewerage). Data were received as maps from their records based either on GIS or paper copies, except Wychavon District Council who reported verbally.

4.3.3 Presence of archaeological features

The presence of Scheduled Monuments or other important archaeological features at each site could be a potential constraint for wetland re-creation. In general terms, actions that require excavations could be damaging to archaeological features where present. However, any change that restores arable habitats to permanent grassland or preserves artefacts in constantly saturated organic soils and sediments would assist the preservation of archaeological features, but increased variability in environmental conditions (such as repeated flooding and drying out) could be damaging. The presence of archaeological features were therefore identified and mapped (where data were available) and general subjective assessments made of the resulting constraints on wetland re-creation. Data were obtained from Gloucestershire County Council (maps and database outputs) and Worcestershire County Council (summaries of features on each candidate site) based on searches of their Sites and Monuments Records (SMR) databases.

These assessments should, however, be treated as provisional as actual impacts would depend on the proposed wetland re-creation scheme and primarily:

- the degree of ground disturbance;
- the nature of alteration to the present environment;
- frequency and significance of any environmental change.

The assessment of such impacts should be made by an appropriately qualified archaeologist.

4.3.4 Flood defence issues

Flood defence issues have been highlighted where it is believed that there are properties potentially at risk. Account has not been taken of the standard of service of drainage to agricultural land since it is assumed that it will be reduced in the areas where wetland is created. In some of the site descriptions the possibility of altering the height of the flood banks has been considered as an option for increasing flood frequency and duration. This could lead to an increase of flood risk. A more detailed study of the potentially affected area would need to be made if alterations to flood banks were to be pursued.

4.4 Habitat requirements

A wide variety grazing marsh, fen, reedbed and wet woodlands habitats (see Chapter 1 Objectives) could be feasibly created in the Severn and Avon Vales. However, it was considered appropriate to focus on the following National Vegetation Classification communities (Rodwell, 1991 *et seq*.) as these are of botanical conservation importance, or valuable for other target species, and would probably have been formerly widespread and typical of the Natural Area:

- species-rich flood meadow (NVC community MG4);
- inundation grassland (NVC community MG13);
- reedbed (NVC community S4);
- wet woodland (NVC community W5);
- tall herb fen (NVC community S25).

The habitat requirements for each of these communities are summarised in Table 4.1. This information was based on a distillation of the results of previous research by Silsoe College into the environmental tolerances of plant communities (eg Gilbert and others 1996; Gowing and others 1997.)

Broad environmental tolerances were assigned to each community and compared with data available from each of the candidate sites for wetland re-creation. A matrix of the soil and hydrological parameters for each site was then constructed using the same parameters as the habitat requirements table. This was used as a tool, in combination with information gained during site visits, to assign a level of suitability to each of the sites for creating a range of wetland habitats. The complete matrix is shown in Appendix 3, with summaries provided in the accounts of each candidate site below.

Table 4.1: Target habitat soil and hydrological requirements

Parameter	Habitat type (NVC type)				
	Wet grassland (MG4)	Wet grassland (MG13)	Reedbed (S4)	Wet woodland (W5)	Tall herb fen (S25)
Hydraulic conductivity	High	Low-Med	Low-Med	-	High
Drainable porosity	High	Low	Low	Med	Med
pH	5.5-7.5	5.5-7.5	5.5-7.5	5.5-7.5	5.5-7.5
Organic Carbon	-	-	-	-	Med-High
Presence of winter surface water	Yes	Yes	Yes	Yes	Yes
Tolerance of spring/summer surface water	No	Yes	Yes	No	No
Surface water source	-	Yes	Yes	-	-
Groundwater (or gravel present)	Yes	-	-	Yes	Yes
Water quality tolerated	Mod	Poor	Poor	Mod	Good
Soil nutrient status tolerated	Mod	High	High	Mod	Mod
Tolerance of summer drying	Yes	Yes	Some	Some	Some
Ploughed	No	-	-	-	-
Sloping land	-	No	No	-	No

Notes: Med = Medium; Mod = Moderate; - = No preference.

4.4.1 Soils

Soil information was extracted from 1:50 000 scale maps of the area (Soil survey of England and Wales, 1983 and 1986) and from the soil descriptions in Beard and others (1986) and Finlay and others (1984). The dominant soil series at each site was used for analysis of soil properties. Maps showing the approximate extent of each soil series are included with the site descriptions.

4.4.2 Hydrogeological assessment

A hydrogeological assessment of each candidate site was carried out as part of the assessment of the potential hydrological regime. This aimed to establish the potential for maintaining wetlands through ground-water inputs. This was principally carried out by the inspection of published 1:25000 Ordnance Survey Pathfinder and Explorer topographic maps, 1:50000 British Geological Survey geology maps and Environment Agency licensed abstraction records and SSSI hydrogeological assessment reports.

Groundwater hydrographs were not available for any of the candidate sites. Therefore, groundwater levels and flows were inferred from a consideration of the following surrogate parameters:

- **nature of site geology**. The presence of a Major or Minor Aquifer provides an opportunity for water to infiltrate to ground and become available to wetlands during low rainfall periods;
- **presence of significant surface water features**. Springs, ponds and marsh areas with no obvious surface inflows can be indicative of high groundwater levels. In Major and Minor Aquifer areas, high hydraulic conductivities mean that major watercourses such as the Rivers Severn and Avon are also often associated with high

groundwater levels. The presence of ditches and small streams is of less significance, because such features are often man-made and/or receive only surface water inputs;

- **nature of surrounding topography and geology**. A relatively high, steeply sloping area comprising a Major or Minor Aquifer may be associated with significant groundwater inflows to a candidate site. If such an area comprises a Non-Aquifer, then the groundwater resources of the candidate site may still benefit, due to increased runoff and infiltration;
- **presence of licensed surface and groundwater abstractions**. The latter in particular will lower groundwater levels and therefore make an area less suitable for wetland re-creation. The location of licensed abstractions are indicated in the soil map provided for each candidate site account. Further details of the abstractions are given in Appendix 6.

The characteristics of each candidate site were considered and their hydrogeological suitability qualitatively assessed as Low, Moderate or High (Appendix 4). This information was then incorporated into the overall assessment of the site's potential hydrological regime (see Appendix 3).

4.4.3 Water quality

Water quality information was provided by A. Horsman and N. Wason at the Environment Agency Tewkesbury Office. This showed that the River Severn contains medium levels of phosphate ([1]less than 1.0 mgl^{-1}). This water would be suitable for occasional winter flooding but would not be suitable for additional water supply in the spring and summer. Phosphate levels were not available for the River Teme, but it is assumed that on the basis of other water quality parameters, these are similar to those of the Severn. The Rivers Avon and Chelt have very high levels of phosphate (2.0-4.0 mgl^{-1}) and could cause an increase in soil available phosphorus if this water regularly floods onto the sites. Bushley Brook, which takes the outflow from Longdon Marsh, contains the lowest levels of phosphate of the sampled rivers in the area (0.4 mgl^{-1}).

The pH of the Rivers Severn, Avon, Chelt and Bushey Brook are all close to 8.0. This would not cause any detrimental effect to wet grassland, reedbed, wet woodland or fen since all of these can occur in high pH conditions.

All the water courses sampled in the area of study contain high levels of total oxidised nitrogen (5.4-14.8 mgl^{-1}). This is unlikely to have a detrimental effect on created wetlands since nitrate released by the mineralisation of organic matter and nitrate in rainfall would provide a much larger input of nitrogen than could be supplied by flood water.

A number of sites within the study area currently retain water into the spring. These sites often contain diverse flora. The supply of water to these areas is mostly from ground water transmitted via gravel layers. The quality of this water has not been recorded but is likely to be of high standard.

Ditches currently drain many of the sites under study. During the winter when river levels are high, these ditches are occasionally unable to drain and overtop onto the surrounding

[1] All values refer to three year means.

land. There are no water quality data collected from these water courses so a judgement as to the possible enriching effect of allowing these water courses to overtop more often cannot be made.

4.5 Suitability for target species

In addition to the creation of target habitats described above, the re-creation of wetlands within the Severn and Avon Vale Natural Area aims to contribute to meeting biodiversity targets for certain target species and species groups. These include breeding waders, wintering wildfowl, otters and water voles. Their requirements were therefore identified and the suitability of each candidate site was subjectively assessed, on the basis of the predicted habitats and water regime that could be potentially re-created, together with information on existing and surrounding habitats, landscape and topography, proximity to habitation and footpaths etc, collected from Ordnance Survey maps, site visits and consultations.

4.5.1 Breeding waders

Wet grasslands within the Severn and Avon Vale Natural Area provide suitable breeding habitats for a number of waders, primarily lapwing, redshank and curlew, although populations are presently far below potential numbers (see Chapter 2). Within such habitats, the occurrence and successful breeding of waders is primarily affected by:

- water regime;
- food availability;
- vegetation structure and composition;
- predation levels (which is often acerbated by disturbance by people);
- loss of nests or young from trampling by livestock or farming operations;
- disturbance by people and dogs.

Of these, the presence of a high water table during the breeding season (mid-March to end of June) is probably the single most important factor (RSPB, English Nature and ITE 1997). High soil water tables ensure that soil invertebrates are close to the surface and that the soil is sufficiently soft for species such as redshank and snipe to probe. However, the exact requirements, differ between species and depend on the soil type present (Green 1986, Spoor and Chapman 1992, Self and others 1994).

Ideally high water levels should be maintained without extensive surface flooding. Flooded grasslands, compared to those that do not flood, contain significantly lower densities of important soil invertebrate food resources, but this may be offset by their increased availability because vegetation is shorter and the soils are soft and penetrable (Ausden and Sutherland 2001).

On sites that regularly flood the soil invertebrate fauna is normally adapted to fluctuations in water levels, with, for example, populations of semi-aquatic earthworm species. However, on sites that do not flood, the soil invertebrate populations are dominated by terrestrial species. Sudden flooding of such sites thus results in massive declines of soil invertebrate food resources to levels below those of regularly flooded grasslands; after temporary increases as invertebrates are flushed out of the soil. Although soil invertebrate communities will

eventually adjust and increase, as semi-aquatic species are normally present to some degree in dry habitats, this process is likely to be slow. Therefore, where wet conditions are to be re-created for waders, it is best to raise water levels, but to avoid complete flooding of areas, especially were these have not been regularly flooded in recent years (RSPB, English Nature and ITE 1997). Similarly, newly flooded areas should be extensions to areas that currently flood to facilitate the spread of source populations of appropriate invertebrate species.

Another constraint on the availability of food resources for waders is the degree of agricultural improvement. Temporary grass leys and cultivated arable fields hold substantially lower numbers of earthworms and other important invertebrate food resources for birds than permanent grasslands (Edwards and Lofty 1977; Tucker 1992). Thus, re-creation of wet grasslands on such sites by re-seeding and flooding or raising water levels, is unlikely to provide suitable wader feeding areas in the short-term.

Feeding opportunities for waders can be enhanced by providing alternative foraging habitats, such as pools or ditches within the site as invertebrates associated with these features, such as aquatic diptera larvae, are important food sources for redshank and lapwing.

Of the target vegetation communities considered here most waders will breed on flood meadows (NVC MG4) and inundation grasslands (NVC MG13), but also readily occur on other wet grasslands, including ordinary damp meadows (NVC MG10) and tussock wet meadows (NVC MG9). In fact, sward height and structure are probably the overriding factors that influence the use of wet grasslands by breeding waders. Preferred vegetation structure varies between species, from long vegetation that attracts snipe, to short, intensively grazed swards suitable for lapwing (Table 4.2). Some grazing of vegetation is normally required to maintain suitable conditions (as for the maintenance of botanical importance and suitable swards for grazing by wintering wildfowl). However, trampling of nests and young by livestock is a significant risk for breeding waders and therefore requires careful management.

Table 4.2. Vegetation requirements of some breeding waders on wet grasslands (adapted from Green 1986, Self and others 1994, Tucker 1994, Ausden and Treweek 1995 and RSPB, English Nature and ITE 1997)

Habitat component	Lapwing	Redshank	Curlew	Snipe
Vegetation height	Short (<15 cm)	5 – 50 cm	Mosaic of short and tall (>25 cm)	Mosaic of short and tall (>25 cm)
Species-rich vegetation	Not preferred	Not preferred	Preferred	Preferred
Tussocks	No clear preference	Essential	Preferred	Essential
Rushes	Not required	Not required	Required	Required
Grazing / mowing	Heavy grazing by sheep or cattle from mid-May	Moderate cattle grazing June – October	Light cattle grazing required after breeding	Light cattle grazing required after late May
Large fields	Required	Required	Required	Required
Trees / hedges	Avoided	Avoided	Avoided	Avoided

Breeding waders are also susceptible to high rates of nest predation by foxes, mink, crows and magpies etc. They therefore normally avoid nesting in areas with, or alongside, extensive cover or mature trees that harbour predators. Also, like wildfowl, they prefer open and flat landscapes that enable them to see and evade approaching predators. In addition to natural

predators, breeding waders are also vulnerable to predation by dogs and disturbance by walkers and picnickers etc.

4.5.2 Wintering wildfowl

Wintering wildfowl have three broad habitat requirements (RSPB, English Nature and ITE 1997):

- suitable feeding conditions;
- suitable roost sites;
- lack of disturbance.

The availability of large areas of shallow (<50 cm depth) open water on wet grasslands is probably the most important habitat characteristic. This provides food for dabbling species by releasing seeds from vegetation and flushing out of invertebrates as well as secure feeding areas. Relatively frequent and permanent winter floods also favour more inundation-tolerant species such as docks *Rumex* spp., buttercups *Ranunculus* spp. and persicarias *Persicaria* spp. whose seeds are an important food resource for teal, mallard and pintail. It also provides security from ground predators for these species as well as secure roost sites for grazing species that feed on open grassland.

Grazing species (ie geese, swans and wigeon) generally prefer a short (5 – 15cm) young sward composed of softer grass species such as creeping bent *Agrostis stolonifera* and marsh foxtail *Alopecurus geniculatus* which are dominant species of inundation grasslands (NVC MG13). White clover *Trifolium repens* is also favoured by geese and wigeon. Some grazing by livestock is normally required to provide suitable swards for wildfowl to feed on.

The young nutritious grass of fertilised perennial rye-grass *Lolium perenne* leys are also often using by grazing wildfowl, particularly in locations adjacent to or on the former sites of wetlands. For example, at Walmore Common (Site 13) where such fields are the favoured feeding habitat of Bewick's swans.

Wildfowl species, such as pochard and tufted duck, that feed by diving require water that is typically over 2 m deep. Such species are therefore unlikely to directly benefit from the re-creation of the target habitats being considered here.

All wintering waterfowl are sensitive to disturbance (Hockin and others 1992; Madsen and Fox 1995) and will, therefore, avoid otherwise suitable habitats where this occurs frequently. Sites with large expanses of open water in flat and open rural countryside are preferred, particularly by the larger species, such as geese and swans. Thus, hilly areas, or areas with high densities of tall trees or buildings etc are avoided as these reduce visibility (of potential predators) and may impair take-off. In contrast, some smaller species, such as teal and mallard, prefer some emergent vegetation cover, such as reeds. Such emergent vegetation also provides seed sources and invertebrates for dabbling species.

Specific requirements vary between species, and therefore mosaics of flooded and unflooded grasslands with differing depths and associated vegetation communities increase the diversity of wintering wildfowl populations.

4.5.3 Otter

Initial studies suggested that otter distribution along lowland rivers was related to the availability of possible resting sites, the density of bankside vegetation and the density of mature ash and sycamore trees (Mason and Macdonald 1986). However, more recent work has shown that in freshwater habitats, no single vegetation or habitat component has been identified as playing a "key role" in otter populations, apart from the fact that the animals need to be in or near water (Durbin 1993, Kruuk 1995, Kruuk and others 1995). Also it is concluded that the distribution of trees along banks did not affect habitat use by otters and it is disputed that holts are of great importance in freshwater areas as couches are used more frequently. Favoured rest sites appear to be riverine islands and reedbeds where present.

It has also been widely considered that otters are susceptible to disturbance and avoid areas close to human habitation. Durbin (1993), however, also found that otters readily used streams and rivers near houses and in towns and villages.

In freshwater, utilisation of foraging habitat is correlated with fish biomass and it is considered that otter populations are often food limited. Indeed, it has been argued that habitat characteristics which do not affect food availability are relatively unimportant and that riverine otter populations are best conserved by the conservation of relevant fish stocks over wide areas (Kruuk and others 1995). However, the otter's diet varies in different areas and more studies are required on habitat preferences in non-salmonid areas (eg cyprinid fish feature heavily in eutrophic lakes and eels appear to be important in all habitats). Nevertheless, Kruuk (1995) established that the width of stream or river is an important factor for otters. Narrow streams are favoured and exploited more intensely, probably because of the high fish density and the otters habit of foraging close to or under banks.

In conclusion the most important requirements for ensuring that wetland habitats are suitable for otters is the presence of adequate water of good quality, abundant food and adequate cover, especially for giving birth and rearing cubs (NRA 1993; RSPB , NRA and RSNC 1994). However, to utilise such re-created wetlands there must be a successfully reproducing population nearby which are linked by suitable habitat.

4.5.4 Water vole

Water voles are principally associated with slow-flowing rivers, streams and canals 1-3 m wide and up to 2 m deep (Strachan and Jefferies 1993). However, they may also occur along ditches and could benefit from the reinstatement or creation of these as part of the creation of wet grasslands. They will also readily use wet reedbeds or fens with permanently water filled ditches. However, scrubby or wooded habitats are avoided as the shade from trees reduces food plant species.

Watercourses with shallow sloping (less than 35^0) banks of over 1 m height are preferred. A dense 2 m band of vegetation that extends to the water's edge is also required to provide cover, but patches of open areas are also important (Strachan 1997). The species mainly feeds on vegetative plant material, preferring reeds *Phragmites*, rushes, bur-reed *Sparganium*, reedmace *Typha* and reed sweet-grass *Glyceria maxima*.

Like the otter and other species that utilise linear riverine habitats, water voles may be prone to habitat fragmentation. Small populations may be vulnerable to extinction from chance events if suitable habitats are isolated. Suitable re-created wetland sites will also need to be linked by suitable habitat to existing populations if colonisation is to take place without reintroduction programmes. Habitat re-creation priorities for water voles may, therefore, be to extend existing suitable habitats to increase existing small vulnerable populations. However, the benefits of creating or maintaining suitable habitat may be limited if mink populations are high. Indeed, in some areas, with apparently suitable habitat, it is suspected that water voles are absent due to high predation levels by mink.

A summary of the general habitat and other ecological requirements for the target species groups is provided in Table 4.3.

Table 4.3. Habitat requirements for restoration of target species populations

Parameter	Breeding waders	Winter wildfowl	Otters	Water vole
Land-use / topography	Prefer large areas of open relatively flat countryside	Prefer large areas of open relatively flat countryside	Preference for low intensity land-uses that avoid water pollution	No strong preferences
Habitat / ecological linkage	Habitat linkage not required	Habitat linkage not required	Requires large expanses of interconnected suitable habitat to allow population interchange	Linkage to suitable habitat with existing water vole populations required
Potential habitats	Winter flooded wet grasslands, or fens and mires on organic soils are preferred according to species requirements (see Table 4.2)	Most species prefer winter flooded wet grasslands (MG4 and MG13), grass leys also used for feeding and reedbeds (with open water) by smaller species	In freshwater lakes, and along river catchments reedbeds important. Presence of cover on river's edge useful for couch areas	Ditches and streams (1-3 m wide and <2 m deep) with shallow sloping banks (> 1m high). Requires patches of cover and will use reedbeds and fens but avoids trees
Water regime	High water tables are essential during the breeding season for most species and surface water features are beneficial	Shallow (<50 cm depth) open water required. Large expanses favoured by most species. Fluctuating water levels preferred by dabbling species	Open permanent waterbodies required, with small narrow streams preferred with riffles, large boulders, and/or gravel in salmonoid areas.	Permanent deep open water in ditches and streams. Stable water levels required during breeding season.
Food resources	Soil invertebrates (eg earthworms) and terrestrial insects	Young swards dominated by soft grasses or white clover preferred by grazing species. Abundant seeds and invertebrates required by dabbling species	High fish densities essential	A variety of emergent vegetation (eg reeds, *Typha* and *Glyceria*)

Parameter	Breeding waders	Winter wildfowl	Otters	Water vole
Lack of disturbance	Susceptible to disturbance	All wildfowl are sensitive to disturbance. Larger species require particularly large, open and flat disturbance-free sites	Susceptible to disturbance particularly during breeding, but will occur close to human habitations	Not susceptible, provided adequate vegetation cover is present

These requirements form the basis for the candidate site suitability assessment criteria against which each area was scored.

4.5 Interpretation of site assessments

A summary of the assessments of each suitability criterion for wetland re-creation is provided for each candidate site in the subsequent 18 chapters. Descriptions of the site with respect to each criterion (except water quality and existing habitat – which are provided in tables) are firstly given. Accompanying figures are provided where necessary to illustrate the location of utility infrastructures. Soil maps together with the locations of abstractions are also provided for all candidate site. All figures and generic keys for their interpretation are provided at the back of this document.

A summary table of the assessments in terms of low, medium or high suitability *for wetland re-creation* is then provided for each criterion and for overall constraining factors and potential for target habitats and species. These assessments take into account the factors described above for each criterion, but it should be remembered that these are largely subjective. This is considered to be appropriate and sufficiently robust to provide a broad ranking of site suitability as required by this study. However, due to the broad nature of this study, these assessments should be regarded as preliminary, particularly where data are lacking.

The assessments of soil, water regime, water quality and existing habitat suitability for each target habitat are based on semi-quantitative data and these are provided in Appendices 3 and 4.

5 Site 1: River Severn, Worcester to Holt

5.1 General wetland constraints

5.1.1 Land uses

Principally agricultural grasslands with some old clay workings and willow and alder carr woodlands within Grimley Brick Pits SSSI.

5.1.2 Presence of service infrastructures

No metalled roads or railway lines occur within the site, and it is mostly free of service infrastructures, although some do cross the site (Figure 5.1).

5.1.3 Presence of archaeological features

There is extensive evidence of prehistoric and Roman occupation within this area. Any change of use to permanent pasture would aid the preservation of the archaeology as long as this does not involve repeated changes to the environment (ie repeated episodes of flooding and drying out).

5.1.4 Flood risk and defence requirements

There are no properties known to be at risk in this area.

5.2 Potential for target habitats

5.2.1 Soils

The soils mainly comprise the Clwyd series (Figure 5.2). These silt clay loams are of high hydraulic conductivity and drainable porosity. They have low organic carbon content and a typical pH of 5.6.

5.2.2 Topography and water regime

The site is gently sloping towards the River Severn. There are no flood banks on this stretch of the river. A number of streams and drainage ditches cross the site. Gravel is believed to underlie some parts of the site. Grimley Brick Pits SSSI (see Appendix 2) lies within the site boundary. These are topographic lows, which retain surface water.

The current water regime is one of occasional winter flood. It is difficult to increase the retention of surface water at this site since there are no flood banks and the site is gently sloping. It might be possible to modify the existing drainage infrastructure to hold higher water levels. The soil in this area has a high hydraulic conductivity and the presence of gravel in some parts could enable water tables to be raised by managing ditch water levels.

5.3 Potential for target species

5.3.1 Landscape and topography

The site is gently sloping but surrounded by higher ground, with a steep scarp slope to east (across the river). Some patches of woodland and a marginal strip of scrub and woodland occur along the western bank of the river in the southern half of the site. The site was not visited and no further information can be provided on the presence of hedgerows and trees etc. However, the site may be too enclosed to support large populations of breeding waders or larger species of wintering waterfowl.

5.3.2 Habitat / ecological linkages

The area is on the main River Severn corridor and already contains existing alder and willow carr woodlands and permanent open water pools at Grimley Brick Pits SSSI. Otters are known to occur on the river above Worcester, but there is currently no information available on the presence of water voles in the area. However, current information on the habitats present and surroundings suggest that conditions are favourable for both species.

5.3.3 Potential habitats

Breeding waders such as lapwing, redshank and curlew could benefit from the re-creation of MG4 grasslands. Snipe could also potentially occur on suitable fen habitat. The creation of further wet woodlands and tall fen could provide cover for otters and suitable habitats for other wetland species. However, this may reduce the suitability of the area for breeding waders, and there may already be sufficient cover otters.

5.3.4 Water regime

The occasional winter flooding could provide suitable feeding and roosting conditions for wintering waterfowl. However, as it is difficult to retain surface water on the site then such benefits are likely to be short-lived.

Breeding waders would benefit from the maintenance of higher water tables into the spring period, but this may be difficult on this site. Further investigation of the site's hydrology is necessary to assess this with certainty.

5.3.5 Potential food resources

As the site is currently known to flood regularly, it is likely that semi-aquatic soil invertebrates already dominate the site. It is therefore likely that adequate food resources would be available for breeding waders given suitable hydrological conditions.

No information is available on food resources for wildfowl, otters or water voles.

5.3.6 Lack of disturbance

The area is rural and relatively isolated, with no roads passing through it. Some footpaths occur in the southern part of the area, including the major long-distance footpath (Severn Way) along the west bank. Nevertheless, overall the area is likely to be relatively little disturbed, particularly in winter.

5.4 Conclusions

This site is potentially of high suitability for species-rich flood meadow or wet woodland on the areas of the site where gravel is present (Table 5.1). Since it would be difficult to increase the frequency and duration of flooding the area would be less suitable for inundation grassland or reedbed. It would also be of low suitability for tall herb fen since the organic content of the soil is very low.

The overall area and existing habitats are probably already highly suitable for otters and water voles if water quality and food supplies are adequate. There may be some potential for improving conditions for breeding waders, but this may be limited by the site's enclosed landscape and potential for hydrological management.

Table 5.1. Summary of suitability assessments for Site 1: River Severn, Worcester to Holt

Criteria	**All habitats**				
Land uses	High (no constraining land-uses)				
Service infrastructures	High (no roads or railways)				
Archaeological features	Medium ? (present and possibly susceptible to flooding)				
Flood risks	High (no properties at risk)				
OVERALL SUITABILITY	HIGH?				
Potential for habitats	**Wet grassland MG4**	**Wet grassland MG13**	**Reedbeds (S4)**	**Wet woodland (W5)**	**Tall herb fen (S25)**
Soils	High	Low	Low	Medium	Low
Water regime	High	Low	Low	High	High
Water quality	High	High	High	High	Low
Existing habitat	?	?	?	?	?
OVERALL SUITABILITY	HIGH?	LOW?	LOW?	MEDIUM?	MEDIUM?
Potential for species	**Breeding waders**	**Wintering wildfowl**	**Otters**	**Water vole**	**Other species**
Land-use / topography	Medium ?	Low ?	High	High	
Habitat / ecological linkage	-	-	High	?	
Potential habitats	High	Medium	Medium	Medium	wet woodland species
Water regime	Medium	Low	Medium	Medium	
Food resources	High	Medium	?	?	
Lack of disturbance	High	High	High	High	
OVERALL SUITABILITY	MEDIUM	LOW	HIGH	?	

Note: ? = No data available or uncertain; - = Not applicable.

6 Site 2: River Teme and River Severn Confluence

6.1 General wetland constraints

6.1.1 Land uses

The area is almost entirely agricultural with some small patches of woodland plantation. Most of the land is improved grasslands, with some arable crops grown on the higher land within the area.

6.1.2 Presence of service infrastructures

The site is crossed by two major A roads and a railway line (Figure 6.1). A new bypass link road (that is not marked on Figure 6.1), also crosses the site between the Powick Hams roundabout on the A422 and the A4103 to the north of Upper Wick. A number of over- and underground service lines cross the site at Powick Hams, and an overhead high voltage electricity line crosses the southern part of the site.

6.1.3 Presence of archaeological features

Part of the site is the location of the Battle of Worcester and is a Registered Battlefield Site. The site has been subject to subsequent alluvial deposition but still remains much of the character of the 17th century landscape. This would be improved by reversion of the arable areas to grassland. However, there should be no further additions to the landscape (eg ponds, reedbeds or woodland) other than those that might be documented for the 17th century.

6.1.4 Flood risk and defence requirements

A house and two shops in Powick are at risk from flooding.

6.2 Potential for target habitats

6.2.1 Soils

The dominant soil series at this site is Lugwardine (Figure 6.2). These are silty soils of high hydraulic conductivity and medium drainable porosity. They have a low organic carbon content and a typical pH of 6.2.

6.2.2 Topography and potential water regime

The site has very little topographic variation. It rises gently away from the Teme towards the Severn. There is a shallow embankment along the edge of the Teme near Powick Bridge. A number of ditches cross the site carrying water to the Severn.

The site is currently subject to frequent winter flooding from the rivers Teme and Severn. Although the rivers are not embanked sufficiently in this area to be able to increase the frequency of flooding by altering them, it would be possible to install sluices in the drainage ditches to retain winter flood waters on the site for a longer period. The soils in this area have high hydraulic conductivity hence if ditch water levels could be increased, the water table in the vicinity of the ditch could also be raised. However, there is currently insufficient

information available to quantitatively assess the potential for maintaining raised water levels.

6.3 Potential for target species

6.3.1 Landscape and topography

The site is a fairly large flat area. However, there are numerous mature trees (mostly willows), particular, along the River Teme, that reduce visibility and create a relatively enclosed landscape. High ground to the west of Powick also further encloses part of the area. Much of the site is therefore unlikely to be suitable for breeding waders or wintering waterfowl.

6.3.2 Habitat / ecological linkages

Otters are thought to be present in the area and have been recorded nearby on the Severn during the 1997 survey, although not at the actual confluence. The abundant bankside trees and other vegetation would enable movements of otters into and through the site. No information on the presence of water voles in the area is available.

6.3.3 Potential habitats

The site is of medium suitability for the creation of inundation grasslands and reedbeds. The re-creation of such grasslands could provide suitable habitats for waders and wintering waterfowl, but the benefit may be limited by the enclosed nature of the site. Although the RSPB reported that two pairs of waders (curlew and redshank) were holding territories in 1995, these were not thought to have bred successfully (Quinn 1995). This is may have been due the dry conditions of the land and a lack of tussocky grassland.

The creation of reedbeds could provide increased cover and foraging areas for otters, smaller dabbling ducks and other reedbed birds.

6.3.4 Water regime

Raising water levels could benefit waders, but the site is only moderately suitable for this. There is no capacity for increasing the frequency of winter flooding but an increase in retention time could benefit wildfowl.

6.3.5 Potential food resources

The site regularly floods in winter and therefore suitable soil invertebrate communities probably exist. Further flooding or increased water levels would therefore be unlikely to reduce soil invertebrates availability for birds.

The area is currently dominated by improved grasslands with few areas of semi-natural habitat or stands of emergent vegetation in water courses etc. Food availability for surface-feeding wintering waterfowl (that rely on seeds to a large extent) or water voles (if present) may therefore be limited under current conditions.

6.3.6 Lack of disturbance

The area is crossed by two major roads and is close to a number of villages and urban areas. Also a number of footpaths cross the site. However, human dispersal from these is likely to be limited by water courses and ditches and a large part of the north of the site is undisturbed. Overall it is therefore likely that disturbance levels are relatively moderate.

6.4 Conclusions

There is no information on the amount of water that could be supplied by the drainage ditches in this site. If there were sufficient volume it could be possible to create inundation grassland or reedbed in the eastern part of the site (Table 6.1). There are no gravels known in this area making a more species-rich flood meadow or tall herb fen less suitable.

Table 6.1. Summary of suitability assessments for Site 2: River Teme and Severn confluence

Criteria	**All habitats**				
Land uses	High (with the exception of some small plantations and arable fields)				
Service infrastructures	Low (two major roads, railway, electricity pylons)				
Archaeological features	Medium (some restrictions at the Registered Battle Field Site)				
Flood risks	Medium (High risk to a couple of properties)				
OVERALL SUITABILITY	MEDIUM				
Potential for habitats	**Wet grassland MG4**	**Wet grassland MG13**	**Reedbeds (S4)**	**Wet woodland (W5)**	**Tall herb fen (S25)**
Soils	Medium	Medium	Medium	Medium	Low
Water regime	Low	Medium	Medium	Low	Low
Water quality	High	High	High	High	Low
Existing habitat	Low	High	High	Medium	Medium
OVERALL SUITABILITY	LOW	MEDIUM	MEDIUM	MEDIUM	LOW
Potential for species	**Breeding waders**	**Wintering wildfowl**	**Otters**	**Water vole**	**Other species**
Land-use / topography	Medium	Low	High	Medium	
Habitat / ecological linkage	-	-	High	?	
Potential habitats	Medium	Medium	Medium	Medium	
Water regime	Low	Medium	Medium	Low	
Food resources	High	Medium	?	Medium ?	
Lack of disturbance	Medium	Medium	High	High	
OVERALL SUITABILITY	MEDIUM	MEDIUM	MEDIUM	MEDIUM	

Note: ? = No data available or uncertain; - = Not applicable.

7 Site 3: River Severn, Kempsey Upper Ham and Lower Ham

7.1 General wetland constraints

7.1.1 Land uses

The site consists of two areas of low-lying flat land on the Severn floodplain. The area is agricultural and, according to the Worcestershire Wildlife Trust Grassland Inventory, are predominantly improved former MG4 grasslands. According to Quinn (1995) the Upper Ham is mostly semi-improved pasture, with about 18% root crops, whilst the Lower Ham is about half semi-improved grassland and the rest arable autumn-sown crops or bare ground. Kempsey village is nearby and lies between the two parts of the site.

The sites were not visited and no information on the extent of trees or other habitat features is available.

7.1.2 Presence of service infrastructures

No roads pass through or close to the site. An underground high pressure government oil pipeline runs through the north part of the site, and a sewerage pipe crosses the south part (Figure 6.1).

7.1.3 Presence of archaeological features

The site consists of traditional flood meadows and there would be no known archaeological impact from wetland re-creation.

7.1.4 Flood risk and defence requirements

There are no properties known to be at risk in this area.

7.2 Potential for target habitats

7.2.1 Soils

The Upper Ham comprises mainly of soils in the Hollington series (Figure 6.2). These are fine silty and clayey soils of medium hydraulic conductivity and drainable porosity. They are generally low in organic carbon and have a typical pH of 5.6. The Lower Ham comprises mainly of soils in the Teme series. These are silty soils of high hydraulic conductivity and drainable porosity. They generally contain moderate levels of organic matter and have a typical pH of 5.2.

7.2.2 Topography and potential water regime

Upper Ham

The Upper Ham is an elongated bowl, bounded by the River Severn on the west and higher ground on the east. Ground levels slope gradually from the flood bank towards the back drain about 250m from the River. Flooding from the River Severn occurs approximately once a year during the winter (Figure 7.1). Much of the area is drained by ditches.

Lower Ham

The Lower Ham is a topographic bowl on the left bank of the River Severn. It is bound on three sides by the River Severn and to the East by higher ground. The base of the bowl is up to 500m wide and generally flat. Flooding from the River Severn occurs approximately once a year during the winter (Figure 7.1). There is no obvious back drain. The Hatfield Brook at the North of the site is at a lower elevation than the lowest ground level in the bowl.

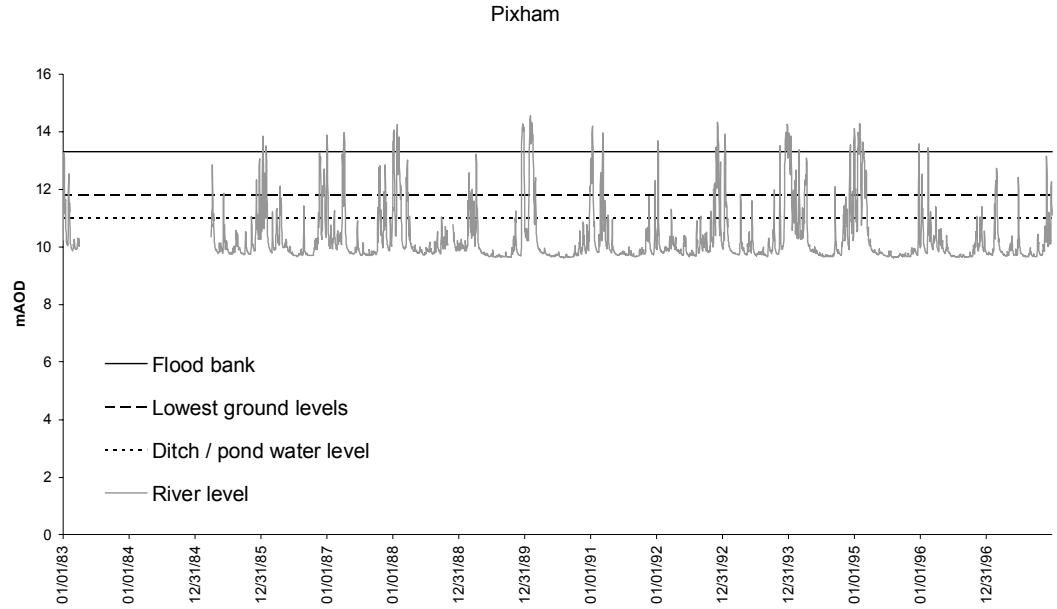

Figure 7. 1. River levels in the Severn[2] compared with ground level and flood bank height at Pixham

Retaining the current water regime would provide winter flooding followed by drier springs and summers. If the flood bank were lowered, flood duration would be increased and occasional spring floods would occur. The Hams lie in topographic bowls giving the potential to retain surface water for prolonged periods. In the Upper Ham there is also potential to exploit the current ditch system to provide additional water by preventing drainage in the winter and early spring.

[2] River levels for sites upstream of Tewkesbury have been estimated by linear interpolation between recorded levels at Diglis Lock, Saxon's Lode and Mythe Bridge by Environment Agency continuous water level recorders (EACWLR). They serve as guide levels only.

7.3 Potential for target species

7.3.1 Landscape and topography

The sites are open and flat and probably potentially suitable for breeding waders and wintering wildfowl.

7.3.2 Habitat / ecological linkages

Otters have been recorded nearby on the Severn and are known to occur within the Teme catchment. No information is available on the presence of water voles.

7.3.3 Potential habitats

Wintering waterfowl could benefit from the re-creation of MG13 inundation grasslands.

No waders were recorded on either Ham in 1982, but one pair of redshank was found breeding on the Lower Ham in 1995 (Quinn 1995). This and other potentially breeding waders could benefit from the re-creation of semi-natural MG4 or MG13 grasslands. However, further grazing management to encourage tussocky grassland and late cutting of hay crops would also be required.

7.3.4 Water regime

Wintering wildfowl could benefit from increased winter flooding, but spring flooding could be detrimental to breeding waders (if present). However, the maintenance of high water levels on the Upper Ham could provide benefits for breeding waders.

7.3.5 Potential food resources

As the areas predominately consists of grasslands that already flood regularly then invertebrate food resources for waders should be available.

7.3.6 Lack of disturbance

Both Hams are close to Kempsey village and have footpaths running alongside or through them. Quinn (1995) notes that the Upper Ham is particularly popular for people walking dogs and is probably too heavily disturbed to be attractive to waders.

7.4 Conclusions

The Hams are of moderate suitability for inundation grassland (Table 7.1). The length of time for which this habitat could be utilised by wildfowl would depend on the water regime implemented. Alterations to flood banks and exploitation of ditch infrastructure would increase the duration of the flood.

The soil conditions are suitable for reedbed but data are not available on the volume of water that could be supplied via the drainage ditches. Salmon (1998) suggests that there is little inflow of water from surrounding areas implying that reedbed would be of low suitability.

Flood meadow, wet woodland and fen would be of low suitability since there is no information to suggest that gravel lies under the site which could provide the necessary sub-irrigation.

Table 7.1. Summary of suitability assessments for Site 3: River Severn, Kempsey Upper Ham and Lower Ham

Criteria	**All habitats**				
Land uses	High				
Service infrastructures	High				
Archaeological features	High				
Flood risks	Medium (Moderate risk to a property)				
OVERALL SUITABILITY	HIGH				
Potential for habitats	**Wet grassland MG4**	**Wet grassland MG13**	**Reedbeds (S4)**	**Wet woodland (W5)**	**Tall herb fen (S25)**
Soils	Medium	Low	Low	Medium	Medium
Water regime	Low	Medium	Medium	Low	Low
Water quality	High	High	High	High	Low
Existing habitat	High	High	High	High	High
OVERALL SUITABILITY	MEDIUM	MEDIUM	MEDIUM	MEDIUM	LOW
Potential for species	**Breeding waders**	**Wintering wildfowl**	**Otters**	**Water vole**	**Other species**
Land-use / topography	High	High	High	?	
Habitat / ecological linkage	-	-	High	?	
Potential habitats	Medium	Medium	Medium	Medium	Reedbed passerines ?
Water regime	Medium	Medium	Medium	Medium	
Food resources	High	Medium	?	?	
Lack of disturbance	Low	Low	Medium	Medium ?	
OVERALL SUITABILITY	MEDIUM	MEDIUM	MEDIUM	MEDIUM ?	

Note: ? = No data available or uncertain; - = Not applicable.

8 Site 4: River Severn, Clifton to Upton on Severn

8.1 General wetland constraints

8.1.1 Land uses

The area is large and entirely agricultural land. According to Quinn (1995), the north section at Clifton Meadows consists of about 58% grassland (mostly improved), 13% set-aside and 41% arable (mostly autumn sown); the middle section at Northfield Meadows is mostly semi-improved grassland, with some root crops, and the southern section at Ryall's Court Farm is all pasture, of which the majority is improved.

The landscape is flat and predominantly open, although there are some small scattered patches of woodland and pollarded willows along the bank of the Severn on the northern part of the site.

There are new gravel workings at Clifton, which could provide substantial opportunities for wetland re-creation in the future.

8.1.2 Presence of service infrastructures

No roads pass through or alongside the site, and there are few service pipes or cables crossing the site (Figure 8.1).

8.1.3 Presence of archaeological features

There is extensive evidence of prehistoric and Roman occupation within this area. Any change of use to permanent pasture would aid the preservation of the archaeology as long as this does not involve repeated changes to the environment (ie repeated episodes of flooding and drying out).

8.1.4 Flood risk and defence requirements

Properties in Severn Stoke, Rhydd, Clevelode, the A4104 and a caravan park are known to flood.

8.2 Potential for target habitats

8.2.1 Soils

The soils comprise mainly of the Clwyd series (Figure 8.2). These silt clay loams are of high hydraulic conductivity and drainable porosity. They have low organic carbon content and a typical pH of 5.6.

8.2.2 Topography and potential water regime

Left bank: Clifton – Rhydd

The land slopes gently towards the east to a back drain at about 800m from the main River. Flooding from the Severn occurs every few years (Figure 8.3).

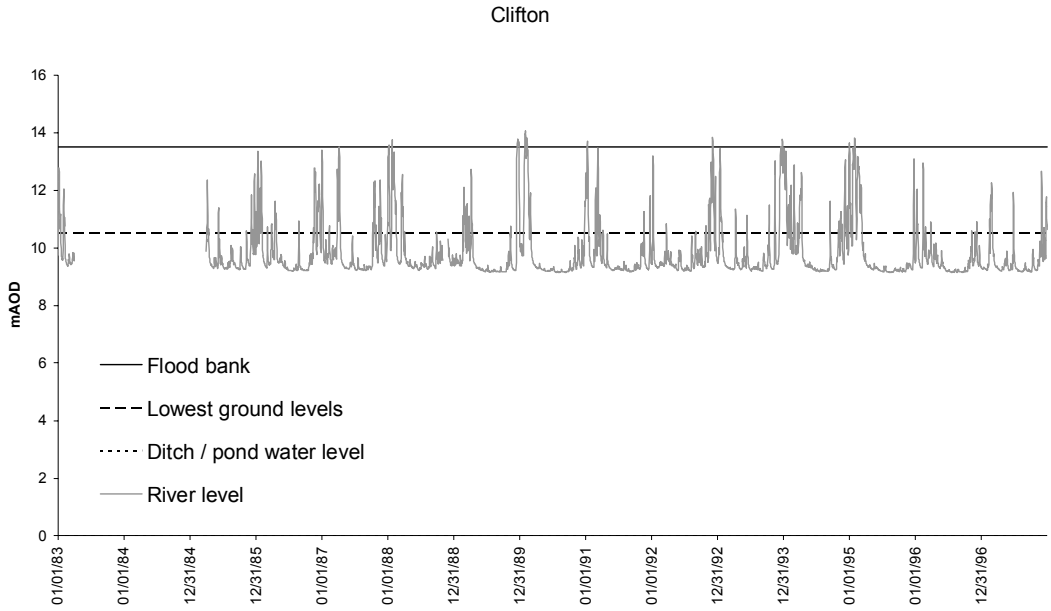

Figure 8.3. River levels in the Severn[3] compared with ground level and flood bank height at Clifton

8.2.3 Right bank: Cliffey Wood – Church End

A flat area behind the right flood bank sloping slightly towards the west. There are drains and ponds with water levels 0.5 – 1.0m below ground level. Flooding from the Severn occurs every few years (Figure 8.4).

8.2.4 Left bank: Severn Bank – Ryall

The land slopes gently to east. There are many drains and springs (*issues*) marked on the map. An area of marsh is marked at 10.4mAOD. The topography is irregular with 'islands' up to 12.5 mAOD. Flooding from the Severn occurs every few years (Figure 8.4).

[3] River levels for sites upstream of Tewkesbury have been estimated by linear interpolation between recorded levels at Diglis Lock, Saxon's Lode and Mythe Bridge by EACWLRs. They serve as guide levels only.

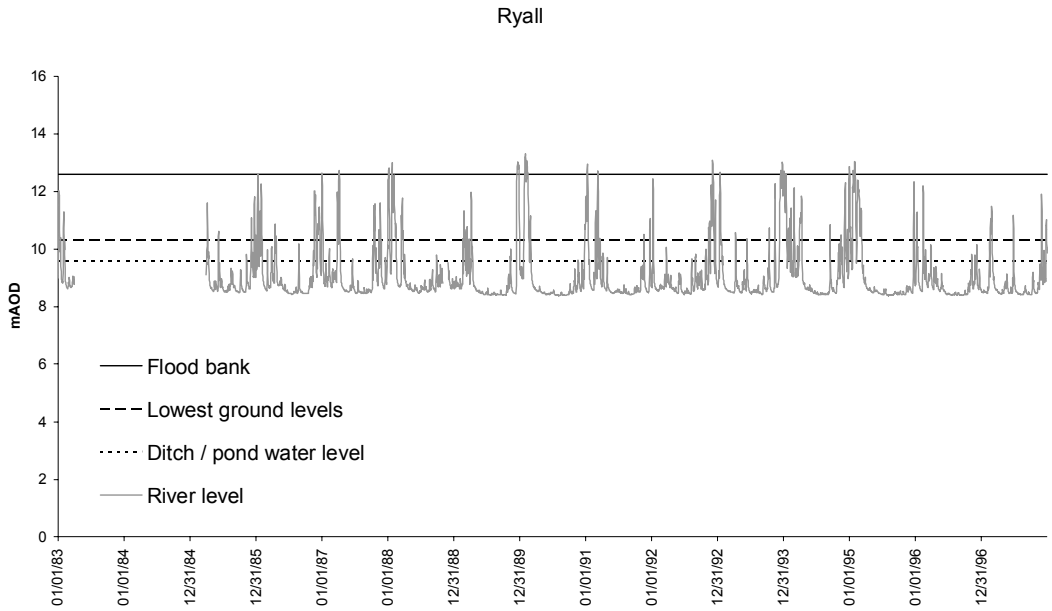

Figure 8.4. River levels in the Severn[4] compared with ground level and flood bank height at Ryall.

The springs in the south of the area currently provide water conditions suitable for wetland habitat. The flood embankment is relatively high compared with the ground level at this site and if more extensive winter flooding is required then alterations to the flood bank could be considered. The gentle slope of the land makes retention of surface water over large areas difficult but water could be retained in topographic lows. There are a number of drainage ditches that cross the site and the water level in these could be managed to increase the water retention time of the area and provide water by sub-irrigation in the summer. It is not known whether a gravel minor aquifer underlies the site.

8.3 Potential for target species

8.3.1 Landscape and topography

Being a relatively large, open and flat area, the site is probably potentially suitable in most parts for breeding waders and wintering waterfowl.

8.3.2 Habitat / ecological linkages

Otters have been recorded within the site and nearby. No information is currently avaliable on the presence of water voles.

8.3.3 Potential habitats

Improvement of the site could be particularly beneficial for breeding waders. The northern section at Clifton Meadows held two pairs of curlew and one pair of snipe in 1995 (Quinn 1995). This is the only site out of 84 surveyed in the Severn Vale that holds breeding snipe and is therefore of considerable value. However, wader numbers have declined at the site, as

[4] River levels for sites upstream of Tewkesbury have been estimated by linear interpolation between recorded levels at Diglis Lock, Saxon's Lode and Mythe Bridge by EACWLRs. They serve as guide levels only.

in 1982 there were 8 pairs of lapwing, 9 of curlew and 7 of redshank. Only 1 pair of curlew were found in Northfield Meadows section and no waders occurred in the southern part of the site by Ryall's Court Farm. These parts of the site were generally regarded as too dry and intensively managed for breeding waders.

The creation of MG4 flood meadows or other more marshy grassland (eg MG9 or MG10) habitats would, therefore, be particularly beneficial, particularly if combined with management measures to increase tussocks and reduce mortality of nesting birds from livestock trampling or hay cutting.

According to Worcestershire Wildlife Trust, gravel extraction is being carried out in the northern section. This could provide future potential for the creation of other wetland habitats including open water with associated reedbeds.

8.3.4 Water regime

Wintering wildfowl could benefit from increased winter flooding, but spring flooding could be detrimental to breeding waders (if present). However, the maintenance of high water levels on the site could provide benefits for breeding waders.

8.3.5 Potential food resources

As the area predominately consists of grasslands that already flood regularly then invertebrate food resources for waders should be available.

8.3.6 Lack of disturbance

The site is rural and entirely agricultural with relatively few footpaths and nearby villages. Disturbance levels are therefore likely to be low.

8.4 Conclusions

If gravel underlies the site and the ditch water levels were managed appropriately then it would be of high suitability for flood meadow (Table 8.1). Inundation grassland would be of moderate suitability in the lowest areas if the flooding frequency were increased either by altering the flood embankments or managing the drainage ditches. Reedbed and wet woodland would be of moderate suitability in the spring-fed areas.

It is important to maintain the existing waders on Clifton Meadows and there is considerable scope for improving habitat conditions for them in other parts of the site.

Table 8.1. Summary of suitability assessments for Site 4: River Severn, Clifton to Upton on Severn

Criteria	All habitats				
Land uses	High				
Service infrastructures	High				
Archaeological features	Medium? (present and possibly susceptible to flooding)				
Flood risks	Medium (high risk to some properties on part of the site)				
OVERALL SUITABILITY	MEDIUM				
Potential for habitats	**Wet grassland MG4**	**Wet grassland MG13**	**Reedbeds (S4)**	**Wet woodland (W5)**	**Tall herb fen (S25)**
Soils	High	Low	Low	Medium	Low
Water regime	Medium	High	High	Medium	Medium
Water quality	High	High	High	High	Low
Existing habitat	High	High	High	High	High
OVERALL SUITABILITY	HIGH	MEDIUM	MEDIUM	MEDIUM	LOW
Potential for species	**Breeding waders**	**Wintering wildfowl**	**Otters**	**Water vole**	**Other species**
Land-use / topography	High	High	High	Medium?	
Habitat / ecological linkage	-	-	High	?	
Potential habitats	High	Medium	Medium	Medium	
Water regime	Medium?	Medium?	Medium	Medium	
Food resources	High	Medium ?	?	?	
Lack of disturbance	High	High	High	High	
OVERALL SUITABILITY	HIGH	MEDIUM	MEDIUM	MEDIUM?	

Note: ? = No data available or uncertain; - = Not applicable.

9 Site 5: Birch Green

9.1 General wetland c onstraints

9.1.1 Land uses

The area is in an old peat-filled oxbow lake of the River Severn. It is therefore low lying and surrounded by gently rising land. The landscape is rural and currently predominantly used for market gardening. Part of the site falls within Ashmoor Common SSSI.

9.1.2 Presence of service infrastructures

No roads or service infrastructures are present on the site. Some service infrastructure is present (Figure 8.1).

9.1.3 Presence of archaeological features

There is potential for buried archaeological features of importance on this area. An archaeological evaluation should therefore be undertaken if any alterations to the present landscape are proposed.

9.1.4 Flood risk and defence requirements

There are no properties known to be at risk in this area.

9.2 Potential for target habitats

9.2.1 Soils

The soil at this site comprises mainly of Adventurer's peat (Figure 8.2). There are no data on the hydraulic conductivity or drainable porosity of this peat but it is likely that both are high. It has a typical pH of 6.9.

9.2.2 Topography and potential water regime

The site lies in a flat bottomed valley 100-200 m wide at about 12 mAOD. It is drained by a central drain with a water level 0.5–1 m below ground levels.

There is potential to install a sluice in the central channel. This would provide a greater control over water levels in the vicinity of the ditch but a more extensive infrastructure would be necessary to affect the full width of the valley. Details are not available on the existence of land drains in this area but if they are present then they could possibly be used to provide sub-irrigation if the central ditch water level were raised.

9.3 Potential for target species

9.3.1 Landscape and topography

Suitable for breeding waders, but the site is too small to support substantial numbers of wintering waterfowl.

9.3.2 Habitat / ecological linkages

Otters are known to occur nearby on the Severn, but it is uncertain whether they occur at Ashmoor Common or whether the habitat between the sites is suitable for them. Similarly, the status of water voles and the suitability of habitat for the species is unknown.

9.3.3 Potential habitats

The re-creation of flood meadows (MG4) or marshy grassland could benefit breeding waders.

9.3.4 Water regime

The maintenance of higher water levels into the spring would benefit breeding waders, but flooding would be detrimental due to impacts on food resources (see below).

9.3.5 Potential food resources

The site has been mostly converted to market gardening and probably has reduced soil invertebrate populations. As the site does not flood regularly, then new flooding could further reduce food resources for breeding waders.

9.3.6 Lack of disturbance

The area is predominately rural and there is no direct road access. However, the site is crossed by a number of paths and the current predominant land-use of market gardening is likely to be a source of disturbance.

9.4 Conclusions

Of the target habitats considered here, this area is of moderate suitability for flood meadow or tall herb fen providing that the water supplied by the central ditch is sufficient to meet the requirements of these habitats (Table 9.1). No information on the quantity of water supplied by this ditch is currently available.

Part of the site falls within Ashmoor Common SSSI, which is predominately marshy grassland supporting plants communities that are associated with neutral to acidic soils. This represents one of the few remaining examples of this type of habitat in Worcestershire. According to the Worcestershire Wildlife Trust Grassland Inventory the site contains MG5c/MG10 However, the natural habitat and biological interest of the southern half of the site has been lost and the area is now mainly used for market gardening. The re-creation of marshy grassland to extend the biological interest over the whole of the SSSI would therefore be appropriate for this site.

Table 9.1. Summary of suitability assessments for Site 5: Birch Green

Criteria	All habitats				
Land uses	Medium (much of the site has been converted to market gardening)				
Service infrastructures	High				
Archaeological features	Uncertain (evaluation required if landscape to be changed)				
Flood risks	High (low risk)				
OVERALL SUITABILITY	MEDIUM				
Potential for habitats	**Wet grassland MG4**	**Wet grassland MG13**	**Reedbeds (S4)**	**Wet woodland (W5)**	**Tall herb fen (S25)**
Soils	High	Low	Low	Medium	High
Water regime	Medium	Medium	Medium	Medium	Medium
Water quality	?	?	?	?	?
Existing habitat	High	High	High	High	High
OVERALL SUITABILITY	HIGH ?	MEDIUM ?	MEDIUM ?	MEDIUM ?	HIGH ?
Potential for species	**Breeding waders**	**Wintering wildfowl**	**Otters**	**Water vole**	**Other species**
Land-use / topography	Medium	Medium	Medium	Medium ?	
Habitat / ecological linkage	-	-	Medium	Medium ?	
Potential habitats	High	Low	Low	Medium	
Water regime	High	Low	Medium	High ?	
Food resources	Low ?	Low	?	?	
Lack of disturbance	Medium	Medium	Medium	Medium ?	
OVERALL SUITABILITY	MEDIUM	LOW	MEDIUM	MEDIUM	

Note: ? = No data available or uncertain; - = Not applicable.

10 Site 6: River Severn, Upper and Lower Hams at Upton on Severn

10.1 General wetland constraints

10.1.1 Land uses

The area is flat and open agricultural grasslands, but adjacent to the town of Upton upon Severn. The northern part of the site (Upper Ham) consists of the Upton Ham SSSI.

10.1.2 Presence of service infrastructures

There are no metalled roads across or alongside the site. The site is crossed by some service infrastructure (Figure 10.1).

10.1.3 Presence of archaeological features

There is potential for buried archaeological features of importance on this area. An archaeological evaluation should therefore be undertaken if any alterations to the present landscape are proposed.

10.1.4 Flood risk and defence requirements

Cottages at Saxon's Lode and Uckinghall and properties at Upton-on-Severn suffer from flooding.

10.2 Potential for target habitats

10.2.1 Soils

The soils comprise mainly of the Clwyd series (Figure 10.2). These silt clay loams are of high hydraulic conductivity and drainable porosity. They have low organic carbon content and a typical pH of 5.6.

10.2.2 Topography and potential water regime

The eastern part of this site is designated as a SSSI for its species-rich wet grassland flora. The area is generally flat with a small area shallowly sloping into the central drain. Inundation grassland occurs in the vicinity of the drain where water is held back in the drain by a small rise in the ground level. A levee separates the SSSI from the River Severn. The site floods approximately once a year (Figure 10.3).

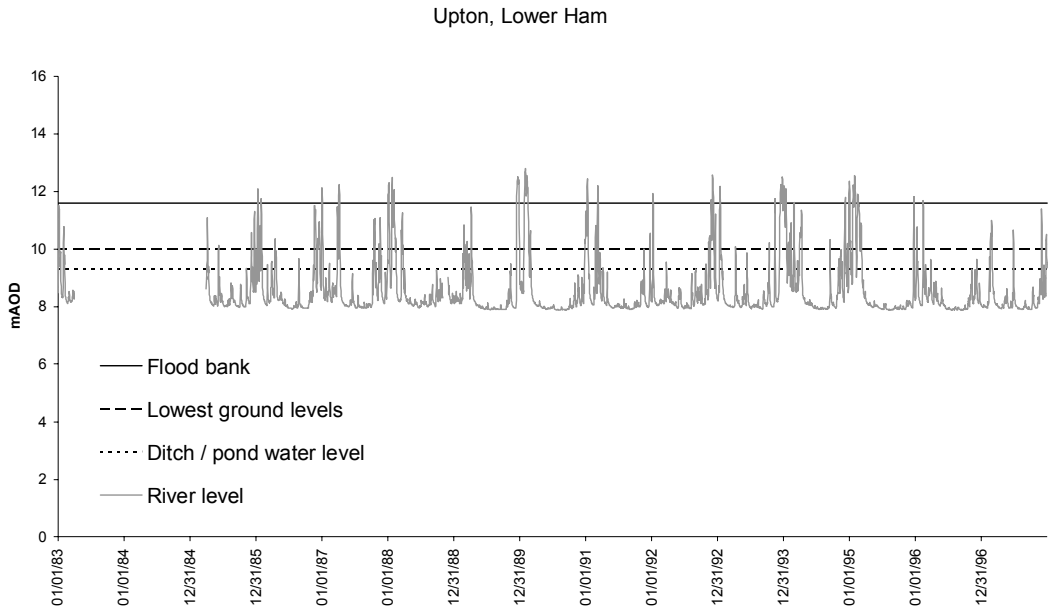

Figure 10.3. River levels in the Severn[5] compared with ground level and flood bank height at Upton

The current water regime is one of frequent winter flood. The flood waters are able to leave the site via the drainage ditches which evacuate through a tidal flap. It is probable that the site is underlain by gravel which provides water in the summer by sub-irrigation. The water regime could potentially be altered by reducing the level of the natural levee or preventing flood waters from leaving the site by installing sluices in the ditches. This would cause longer duration of inundation.

10.3 Potential for target species

10.3.1 Landscape and topography

The site is predominantly open and suitable for breeding waders and wintering waterfowl.

10.3.2 Habitat / ecological linkages

Otters are known to occur in the area, but no information is available on the presence of water voles or the suitability of the surrounding habitats for them.

10.3.3 Potential habitats

Quinn (1995) noted that although 3 pairs of redshank and 1 pair of curlew bred on the Upton Ham in 1995, the habitat did not appear to be in optimal condition for the species. The general habitat type in Upper Ham (SSSI) is suitable for breeding waders, but the management could be improved by the careful management of grazing to provide a shorter and less dense but more tussocky sward. Care should, however, be taken to avoid damaging the botanical interest of the site.

[5] River levels for sites upstream of Tewkesbury have been estimated by linear interpolation between recorded levels at Diglis Lock, Saxon's Lode and Mythe Bridge by EACWLRs. They serve as guide levels only.

In the remaining parts of the site, breeding waders could potentially benefit from the re-creation of more semi-natural flood meadows.

10.3.4 Water regime

Breeding waders could benefit from the maintenance of high water tables into the spring, particularly on the western part of the site. A reduction in the height of the levee could provide benefits for wintering waterfowl by providing more frequents floods. However, this could be highly detrimental to breeding waders if floods occur in spring.

10.3.5 Potential food resources

The site regularly floods and probably supports adequate soil invertebrate food resources for breedings waders. The site is fairly open and an increase in stands of emergent vegetation, such as reeds, along ditches could provide increased food resources for wintering waterfowl as well as suitable cover for water voles and otters.

10.3.6 Lack of disturbance

There are a couple of footpaths across and around the site and the area is used as an amenity resource by people from the town of Upton upon Severn. Disturbance of breeding waders and wintering waterfowl is, therefore, likely to be significant. However, the presence of breeding waders in 1995 suggests that it may be at sustainable levels, at least on parts of the site. Measures to reduce disturbance away from footpaths would be beneficial.

10.4 Conclusions

The vegetation community extant in the SSSI is dependent on the current water regime of winter flooding and sub-irrigation by groundwater during the late spring and summer. It is recommended that no alteration to this regime is made, other than carefully improving management for waders.

The vegetation in the western part of the site is not of SSSI standard and would possibly be of high suitability for flood meadow habitat if appropriate management were implemented (Table 10.1). This could provide significant benefits for breeding waders. Current flooding risks to some properties is, however, a potentially major constraint.

Table 10.1. Summary of suitability assessments for Site 6: River Severn, Upper and Lower Hams at Upton on Severn

Criteria	All habitats				
Land uses	High				
Service infrastructures	High				
Archaeological features	Uncertain (evaluation required if landscape to be changed)				
Flood risks	Low (several properties are at high risk of flooding)				
OVERALL SUITABILITY	MEDIUM ?				
Potential for habitats	**Wet grassland MG4**	**Wet grassland MG13**	**Reedbeds (S4)**	**Wet woodland (W5)**	**Tall herb fen (S25)**
Soils	High	Low	Low	Medium	Low
Water regime	High	High	High	High	High
Water quality	High	High	High	High	Low
Existing habitat	High	High	High	High	High
OVERALL SUITABILITY	HIGH	MEDIUM	MEDIUM	MEDIUM	MEDIUM
Potential for species	**Breeding waders**	**Wintering wildfowl**	**Otters**	**Water vole**	**Other species**
Land-use / topography	High	High	Medium	Medium ?	
Habitat / ecological linkage	-	-	Medium	?	
Potential habitats	High	Medium	Medium	Medium	
Water regime	High	Medium	Medium	Medium	
Food resources	High	Medium	?	?	
Lack of disturbance	Medium	Medium	Medium	High?	
OVERALL SUITABILITY	HIGH	MEDIUM	MEDIUM	MEDIUM?	

Note: ? = No data available or uncertain; - = Not applicable.

11 Site 7: River Severn, Uckinghall to Tewkesbury

11.1 General wetland constraints

11.1.1 Land uses

The area is rural and predominantly agricultural, mostly improved grasslands with some arable crops (eg potatoes and linseed). There are also some fishing lakes. The village of Ukinghall bounds the northern part of the site.

11.1.2 Presence of service infrastructures

The M50 crosses the site on a viaduct but there are no other roads within the area. The site is generally free of service infrastructures, although some underground pipes cross the north of the site (Figure 10.1).

11.1.3 Presence of archaeological features

There is extensive evidence of prehistoric and Roman occupation within this area. Any change of use to permanent pasture would aid the preservation of the archaeology as long as this does not involve repeated changes to the environment (ie repeated episodes of flooding and drying out).

11.1.4 Flood risk and defence requirements

It is believed that two properties and a caravan park are at risk of flooding in this area.

11.2 Potential for target habitats

11.2.1 Soils

The soils comprise mainly of the Clwyd series (Figure 10.2). These silt clay loams are of high hydraulic conductivity and drainable porosity. They have low organic carbon content and a typical pH of 5.6.

11.2.2 Topography and potential water regime

Land slopes east from the flood bank to a low lying area of drains, ponds and osiers. These drain into the Mythe Brook and then the Severn via two flapped outfalls. The site floods occasionally at the northern end (Figure 11.1) and more regularly at the southern end. The main part of this site is embanked to a 1 in 4/5 year standard with the southern part of the site protected to a 1 in 1/2 year standard.

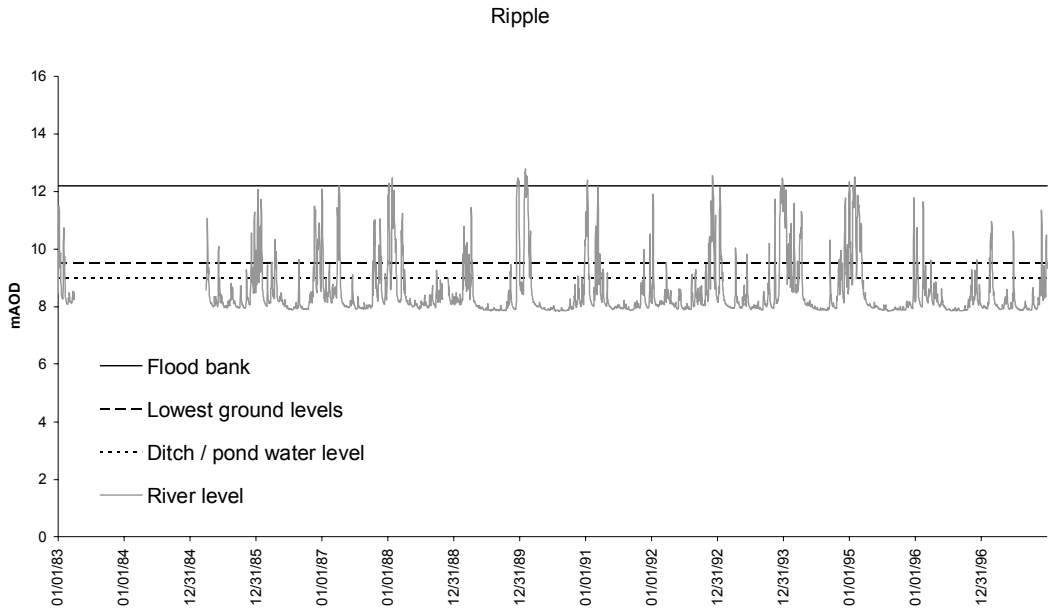

Figure 11.1. River levels in the Severn[6] compared with ground level and flood bank height at Ripple.

The current water regime is one of occasional winter flooding. The frequency and duration of the winter floods could be increased by making alterations to the flood banks. The flood banks are made of the permeable soils excavated from the site. They are designed so as not to increase the retention time of flood waters on the site by more than 24-36 hours over the unembanked situation on the occasions when the bank is overtopped. They could therefore not be used to hold back surface water on the site for long periods. There are a number of ditches which cross the site. It is possible that sluices could be installed in these to raise the water levels and impede drainage from the site.

There are several brick pits in the north and south of the site that retain water throughout the year.

11.3 Potential for target species

11.3.1 Landscape and topography

The area is open and suitable for breeding waders and wintering waterfowl.

11.3.2 Habitat / ecological linkages

Otters were not found on the nearby Ripple Brook or within the site during the 1997 survey. However, otters are present upstream and habitat conditions are probably suitable for them to reach this site.

No information is available on the presence of water voles or the suitability of the habitat for this species.

[6] River levels for sites upstream of Tewkesbury have been estimated by linear interpolation between recorded levels at Diglis Lock, Saxon's Lode and Mythe Bridge by EACWLRs. They serve as guide levels only.

11.3.3 Potential habitats

The site is already one of the best for breeding waders in the Severn Vale, holding 6 pairs of lapwing, 2 of redshank and 1 of curlew in 1995 on meadows near Bow Farm (Quinn 1995). This is because the land is currently farmed at a fairly low intensity and there are suitable areas of wet ground with tussocky vegetation. The re-creation of wet grasslands may, therefore, not be necessary at this site, but according to Quinn, management could be improved.

The creation of reed beds could provide cover on the site for otters and water voles as well as a variety of reedbed passerines (eg reed buntings and reed warblers). However, the potential size of any reedbeds would be too small for species of particular high conservation value, such as bittern or marsh harrier.

11.3.4 Water regime

The maintenance of high soil water tables into the spring would benefit breeding waders, but an increased likelihood of flooding in spring would be damaging. Wintering waterfowl, however, would benefit from an increase in flooding frequency.

11.3.5 Potential food resources

Wintering waterfowl could benefit from the re-creation of MG13 inundation grasslands as palatable species that are preferred by grazing species are typically dominant in such communities. Seed bearing species favoured by dabbling ducks, such as mallard, teal and pintail, are also common in such habitats.

The site occasionally floods and soil invertebrate food resources for waders would probably be adequate if the frequency of flooding increased, particularly in the southern part of the site. No information is available for food resources for other target species.

11.3.6 Lack of disturbance

The area is relatively remote and disturbance levels are likely to be mostly very low, except in the vicinity of footpaths close to the village of Uckinghall and along the river bank.

11.4 Conclusions

Inundation grassland and small areas of reedbed would be of moderate suitability at this site if the flood banks were lowered and flood duration were increased (Table 11.1). The BGS drift map of the area shows that this site is not underlain by gravels so flood meadow and wet woodland probably would not be suitable.

There is some scope for improving the site for wintering waterfowl and reedbed species. However, care should be taken to avoid degrading the suitability of the site for the existing breeding waders population.

Table 11.1. Summary of suitability assessments for Site 7: River Severn, Ukinghall to Tewkesbury

Criteria	All habitats				
Land uses	High				
Service infrastructures	High				
Archaeological features	Medium (but possible low for excavating reed beds)				
Flood risks	Low (several properties are at high risk)				
OVERALL SUITABILITY	MEDIUM				
Potential for habitats	**Wet grassland MG4**	**Wet grassland MG13**	**Reedbeds (S4)**	**Wet woodland (W5)**	**Tall herb fen (S25)**
Soils	Medium	Low	Low	Low	Low
Water regime	Low	Medium	Medium	Low	Low
Water quality	High	High	High	High	Low
Existing habitat	Low	High	High	Medium	Medium
OVERALL SUITABILITY	MEDIUM	MEDIUM	MEDIUM	LOW	LOW
Potential for species	**Breeding waders**	**Wintering wildfowl**	**Otters**	**Water vole**	**Other species**
Land-use / topography	High	High	High	Medium	
Habitat / ecological linkage	-	-	Medium	?	
Potential habitats	Medium	High	Medium	Medium	
Water regime	Medium	Medium	-	-	
Food resources	High	High	?	?	
Lack of disturbance	High	Medium	Medium	High	
OVERALL SUITABILITY	MEDIUM	HIGH	MEDIUM	MEDIUM?	

Note: ? = No data available or uncertain; - = Not applicable.

12 Site 8: Longdon Marsh

12.1 General wetland constraints

12.1.1 Land uses

Longdon Marsh is a large rural area entirely under agricultural production. Most of the land is arable farmland (spring and autumn sown) or improved grassland, although there are still some areas of semi-improved grassland.

12.1.2 Presence of service infrastructures

Only one minor road crosses the site and there are no constraining service or utility structures (Figure 12.1)

12.1.3 Presence of archaeological features

There is a high potential for features of archaeological interest within the site. These should be sampled and assessed before any alteration is made to the present environment.

12.1.4 Flood risk and defence requirements

There are no properties known to be at risk in this area.

12.2 Potential for target habitats

12.2.1 Soils

The soils at this site comprise mainly of Fladbury series (Figure 12.2). These are clay soils of medium hydraulic conductivity and high drainable porosity. They contain moderate levels of organic carbon and typically have a pH of 5.6.

12.2.2 Topography and potential water regime

Over 400 ha of lowland west of Longdon are subject to annual flooding for periods usually longer than 12 hours and 1,500 ha of agricultural land suffer from inadequate arterial drainage (Environment Agency 1997). The site lies in a topographic bowl with hills rising from all sides. The marsh itself has very little topographic variation. Longdon Brook is a statutory Main River and flows through the site providing the only outflow for the drainage water. Longdon Brook evacuates into the Severn. Many smaller ditches drain into Longdon Brook. The whole area is under the management of the Longdon and Eldersfield IDB. Most of the fields have land drains that are up to six feet below the ground surface, some dating back to the 1800's.

The current water regime is one of winter and occasionally spring flooding. The drainage of the site allows the soils to dry out in the late spring and summer. Exploitation of the ditch infrastructure could allow the retention of flood waters for a longer duration and an increased frequency of flood. It would also be possible to install sluices in the ditches to increase the water level held in them in the spring and summer to increase percolation of water from the

ditches into the fields. Water tables can only be raised in this way if the distance between the ditches is small or land drains can be used as sub-irrigation pipes.

12.3 Potential for target species

12.3.1 Landscape and topography

Longdon Marsh is an extensive area of low lying land, drained by Longdon Brook which has a very shallow fall. However, the landscape is only moderately open, as there are numerous hedges, pollarded willows and tall mature trees across the site. This may limit the suitability of large parts of the site for breeding waders and larger species of wintering waterfowl, such as geese and Bewick's swans. Appropriate carefully planned management could, however, overcome this.

12.3.2 Habitat / ecological linkages

Otters are known to occur nearby, but were not found on Longdon Brook on the 1995 or 1997 surveys. However, it is likely that given appropriate habitat management they could repopulate the area. According to the Worcestershire Wildlife Trust, water voles are present within Longdon Marsh.

The upstream area around Eldersfield that is below the 50 m contour is also prone to poor drainage and could be an additional area for wetland re-creation. This could provide a corridor of wetland habitat linking re-created wetland in the currently defined candidate site with the existing wetland at Burley Dene SSSI (see Appendix 2).

12.3.3 Potential habitats

In the past, Longdon Marsh has been of considerable ecological interest, especially for waterbirds (see Chapter 2) and there is substantial potential for the re-creation of a large area of wetland habitat of high biodiversity value. In particular, there is considerable potential for the improvement of the habitat for breeding waders. In 1995, the site only held 5 pairs of lapwing, which were on spring-sown cereal or set-aside fields, and 2 pairs of curlew. Breeding waders could therefore benefit from the re-creation of semi-natural wet grasslands, particularly if combined with appropriate grazing management and controls on agricultural operations.

Wintering waterfowl could also benefit from the conversion of arable crops to grasslands, although for grazing species improved perennial rye-grass leys may be as beneficial as semi-natural grasslands.

Dependent on further investigations, there may be the potential for the creation of large reedbeds within the site. These could provide habitat for a range of reedbed passerines birds, as well as possibly bittern and marsh harrier. Reedbeds are also favoured resting sites for otters and marginal reeds along ditches provide food and cover for water voles. Many of the ditches on the site are overgrown and probably highly suitable for water voles in their present condition. However, the creation of further ditches on the site to help raise soil water levels would also provide further habitat for water voles and otters.

12.3.4 Water regime

The maintenance of high soil water tables into the spring would benefit waders. Wintering waterfowl would also benefit from increased flooding frequency and long inundation periods. However, careful water level management would be required to avoid spring floods that could destroy wader nests.

12.3.5 Potential food resources

Wintering waterfowl food resources could be provided by the existing improved grass leys (for grazing species such as Bewick's swans and wigeon) and the re-creation of MG13 inundation grasslands.

Wader food resources on the existing regularly flooded grasslands would probably also be adequate as they are probably dominated by a semi-aquatic soil invertebrate fauna. However, arable fields are likely to hold depleted soil invertebrate populations that are not adapted to semi-aquatic conditions. The reversion of these to regularly flooded permanent grasslands would probably only provide long-term benefits in terms of food resources. This could, however, be offset by increasing other foraging habitats, such as shallow ephemeral pools and shallow sloping ditches with poached muddy margins.

The currently overgrown ditches on the site are likely to provide adequate food resource for water voles.

12.3.6 Lack of disturbance

The site is a sparsely populated rural area and although it is crossed by a number of paths, is likely to be relatively undisturbed. In particular, access to large areas of the site during winter floods would be especially difficult. The site, therefore, has the potential for providing a large expanse of open water and grassland that could support substantial populations of wintering waterfowl.

12.4 Conclusions

If suitable land management were employed at this site then inundation grassland habitat would be suitable without altering the water regime. However, the area covered by this habitat and the duration of the flood waters could be increased by altering the drainage management. The surrounding topography suggests that there might be sufficient water to make part of the area suitable for reedbed. Information on the volume of water entering the site may be available in a report on the feasibility of creating a reservoir at Longdon Marsh (Binnie and Partners 1976). However, this report was not available for consultation during this study.

Habitat re-creation and the appropriate hydrological management at this site could provide substantial benefits for breeding waders, wintering waterfowl, water voles and possibly otters and a wide range of reedbed species.

Table 12.1. Summary of suitability assessments for Site 8: Longdon Marsh

Criteria	All habitats				
Land uses	Medium (mostly improved agricultural land including arable crops)				
Service infrastructures	High (none present)				
Archaeological features	Uncertain (a survey would be required before major habitat changes)				
Flood risks	High (low risk)				
OVERALL SUITABILITY	MEDIUM				
Potential for habitats	**Wet grassland MG4**	**Wet grassland MG13**	**Reedbeds (S4)**	**Wet woodland (W5)**	**Tall herb fen (S25)**
Soils	Low	Medium	Medium	Medium	Low
Water regime	Low	High	High	Low	Low
Water quality	High	High	High	High	Low
Existing habitat	Low	High	High	Medium	Medium
OVERALL SUITABILITY	MEDIUM	HIGH	HIGH	MEDIUM	LOW
Potential for species	**Breeding waders**	**Wintering wildfowl**	**Otters**	**Water vole**	**Other species**
Land-use / topography	Medium	Medium	Medium	Medium	
Habitat / ecological linkage	-	-	Medium?	High	
Potential habitats	High	High	Medium	High	Reedbed spp
Water regime	High	High	Medium	Medium	
Food resources	Medium	High	?	High	
Lack of disturbance	High	High	High	High	
OVERALL SUITABILITY	HIGH	HIGH	HIGH	HIGH	

Note: ? = No data available or uncertain; - = Not applicable.

13 Site 9: River Severn, Tewkesbury to Longford

13.1 General wetland constraints

13.1.1 Land uses

The area consists of a large expanse of rural agricultural land along the Severn floodplain. Most of the land is semi-improved or improved grassland, with some arable crops, such as potatoes and maize.

Two SSSIs occur within the candidate site: Chaceley Meadow (SO 857306) an unimproved herb-rich neutral grassland and Ashleworth Ham (SO 833263) an area of neutral and wet marshy grassland with open water ditches that is important for wintering waterfowl and breeding waders. Gloucestershire Wildlife Trust manages part of Ashleworth Ham as a Nature Reserve.

13.1.2 Presence of service infrastructures

The area is crossed by 1 B road (B4213), which is raised above flood levels, and has a number of minor roads running along the uppermost edge of the floodplain (Figures 13.1 and 13.2). A minor road that is prone to flooding also serves the Yew Tree Inn at Chaceley Stock (SO 846298). There are a number of utility / service structures crossing the site, particularly in the southern section (Figure 13.2) that may restrict the potential for wetland re-creation in some areas.

13.1.3 Presence of archaeological features

There are a number of features of archaeological interest within the area, mainly west of Thirley (Figures 13.3 and 13.4). The potential constraints from these on wetland re-creation require further investigation.

13.1.4 Flood risk and defence requirements

Several properties in Chaceley, Haw Bridge, Tirley, Ashleworth Quay, Longford and Lower Lode and the caravan park at Lower Lode Hotel are subject to flooding. Minor roads between Ashleworth and Tirley are known to flood. Cottages in Sandhurst and some minor roads are at risk from flood but lie just outside the area of study.

13.2 Potential for target habitats

13.2.1 Soils

This dominant soil at this site is the Compton series (Figures 13.5 and 13.6). These are clays of low hydraulic conductivity and medium drainable porosity. They contain moderate levels of organic carbon and have a typical pH of 5.5.

13.2.2 Topography and potential water regime

The site lies in a broad floodplain (up to 2 km wide) drained by the ditches of the North Gloucestershire IDB. The drainage of this area is described in detail by Arthur Amos

Associates (1998). A flood bank runs along the east of the site. It is designed to be overtopped on average once per year (Figure 13.7). Additional water is supplied to the area from an upland catchment which lies to the west of the site. The site is an elongate bowl shape with the lowest area at 8.5 m AOD. There are a number of outfalls allowing drainage water from the catchment to flow into the Severn via tidal flaps. The flaps remain closed during high river level episodes in the Severn causing drainage waters to build up and flood areas of the site for approximately 15 days per year. Parts of the site are underlain by gravel and springs are reputed to arise from the area south-west of Chaceley.

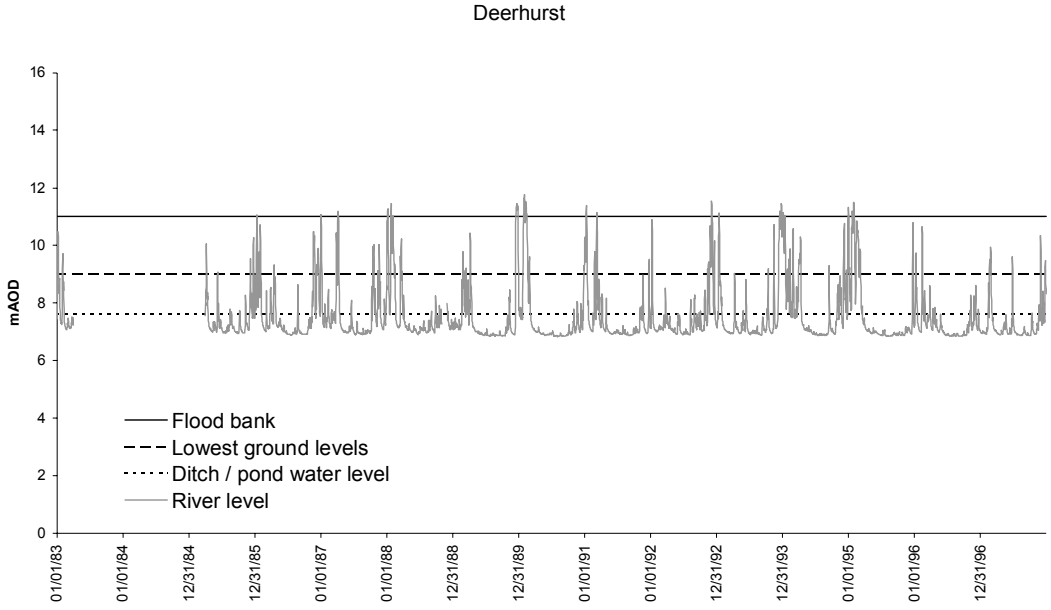

Figure 13.7. River levels in the Severn[7] compared with ground level and flood bank height at Deerhurst.

The current water regime is one of prolonged winter floods in some areas. Ditch water levels are maintained high in some areas. This, in combination with sub-irrigation water provided by the gravel, allows water tables to remain high through the spring and early summer in parts of the site. If alterations to the flood bank were made then the frequency of winter flooding from the Severn would be increased. However, the main cause of flooding in the site is impeded drainage during periods when the tidal flaps are closed on the outflows. This period of inundation could be increased by holding the flood flaps closed artificially, after the Severn flow has subsided. There are many ditches which cross the site. Additional sluices could be installed in these to provide higher ditch water levels during the late spring and early summer. The hydraulic conductivity of the soils in this area is generally low so in areas where there is no gravel, ditches would need to be close together or sub-irrigation pipes would be needed to facilitate the movement of water from the ditches into the fields.

13.3 Potential for target species

13.3.1 Landscape and topography

The landscape is flat and mostly open. However, there are numerous hedges and some areas with tall trees that may reduce the area's suitability for breeding waders and wintering

[7] Water levels at Deerhurst gauging station have only been available since December 1995. The figures presented above have been extrapolated based on correlation with records at Saxon's Lode EACWLR.

waterfowl, particularly, in the north of the site near Chaceley. The floodplain on the southern section of the site, downstream of Ashleworth is relatively narrow and unlikely to be of potential importance for breeding waders or wintering waterfowl.

13.3.2 Habitat / ecological linkages

Otters are known to occur in the area (eg at Ashleworth Meadows) and are likely to use the Severn for moving between sites. No information is available on Water Voles within the candidate site or nearby areas.

13.3.3 Potential habitats

The northern area of the site (upstream of Ashleworth) is currently of importance for breeding waders (Table 13.1). Sandhurst Hill (SO 820248) and Gardiner's Farm(SO 825215) in the southern section of the site were also surveyed by the RSPB in 1995. However, no waders were found at either site, probably due to the intensity of land-use in these areas.

Table 13.1. Breeding wader pairs at Site 9 in 1995 (Source: Quinn 1995)

Site	Lapwing	Redshank	Curlew
Chaceley meadows (SO 865305)	0	0	3
Chaceley stock (SO 855294)	6	1	2
Ashleworth Ham & Hasfield Ham (SO 833264)	4	0	1
TOTAL	10	1	6

There is clearly considerable potential for improving wader numbers within the northern section of the site through the re-creation of semi-natural wet grasslands, particularly if combined with appropriate grazing management and controls on farming operations etc. Similar benefits could be obtained in the southern part of the site, but the area is relatively narrow and more intensively farmed, and therefore probably of lower priority for restoration measures.

The creation of reedbeds or wet woodland within the area would increase overall habitat diversity and provide additional cover and feeding opportunities otters, water vole and a wide range of other species of conservation importance.

13.3.4 Water regime

Wintering waterfowl could also benefit from increased flooding frequency during the winter.

Increasing spring water levels would benefit breeding waders, but spring flooding would be highly damaging. In fact Gloucestershire Wildlife Trust have reported some problems in recent years from spring flooding at Ashleworth Meadows.

13.3.5 Potential food resources

Soil invertebrate populations are probably adapted to a flooding regime and therefore an increase in flooding would not be detrimental to wader food resources.

13.3.6 Lack of disturbance

The area is rural and relatively sparsely populated. However, there are a number of footpaths across the site and disturbance may be a problem close to these, particularly in the vicinity of villages

13.4 Conclusions

The patchiness of the gravel across the site makes a number of habitats possible. Species-rich flood meadows would be of moderate suitability in areas over gravel, especially in the areas that have not been ploughed or improved near Chaceley (Table 13.2). Inundation grassland would be of high suitability in the areas where sub-irrigation is not possible but winter floods stand for prolonged periods. Reedbed or wet woodland would be of moderate to high suitability in the area where springs arise. No data are available on the water quality of the drainage ditches although their appearance in August 1998 suggested that they may contain high levels of nutrients. This would make the site unsuitable for the creation of tall herb fen unless management measures were taken to alleviate the nutrient levels.

Parts of the site are already of conservation importance for target species. However, there is considerable potential for the improvement of the site for a number of these, including breeding waders and wintering waterfowl.

Table 13.2. Summary of suitability assessments for Site 9: River Severn, Tewkesbury to Longford

Criteria	**All habitats**				
Land uses	Medium (mostly grassland)				
Service infrastructures	Medium in the north section, low in the south				
Archaeological features	Medium				
Flood risks	Medium (some properties are at high risk)				
OVERALL SUITABILITY	MEDIUM				
Potential for habitats	**Wet grassland MG4**	**Wet grassland MG13**	**Reedbeds (S4)**	**Wet woodland (W5)**	**Tall herb fen (S25)**
Soils	Low	High	High	High	Low
Water regime	Medium	Medium	Medium	Medium	Medium
Water quality	High	High	High	High	Low
Existing habitat	Low	High	High	Medium	Medium
OVERALL SUITABILITY	MEDIUM	HIGH	HIGH	MEDIUM	MEDIUM
Potential for species	**Breeding waders**	**Wintering wildfowl**	**Otters**	**Water vole**	**Other species**
Land-use / topography	Medium	Medium	High	High	
Habitat / ecological linkage	-	-	Medium?	?	
Potential habitats	High	High	Medium	Medium?	
Water regime	High	High	Medium	Medium	
Food resources	High	High	?	High ?	
Lack of disturbance	High	High	High	High	
OVERALL SUITABILITY	HIGH	HIGH	MEDIUM?	HIGH?	

Note: ? = No data available or uncertain; - = Not applicable.

14 Site 10: Coombe Hill

14.1 General wetland constraints

14.1.1 Land uses

The site is entirely agricultural, being dominated by mostly improved grasslands and some arable crops, including spring-sown cereals and maize, although some remnants of semi-natural / unimproved grassland remain. The site also contains the disused Coombe Hill Canal (which holds water all year). The whole canal is still an SSSI, but much surrounding land has been denotified. Gloucestershire Wildlife Trust manages the whole of Coombe Hill Canal as a Nature Reserve.

14.1.2 Presence of service infrastructures

Only a small section of an A-road (A38) passes through the site (Figure 14.1). However, a number of service / utility structures affect the site, including a high pressure oil pipeline and high voltage electricity lines.

14.1.3 Presence of archaeological features

Coombe Hill Canal and a number of other features are some archaeological interest (Figure 14.2). The potential impacts of these on the feasibility of wetland re-creation require further investigation.

14.1.4 Flood risk and defence requirements

There are properties in this area which may be subject to flooding. Two gardens in Norton flooded in February 1993.

14.2 Potential for target habitats

14.2.1 Soils

The dominant soil at this site is the Compton series (Figure 14.3). These are clays of low hydraulic conductivity and medium drainable porosity. They contain moderate levels of organic carbon and have a typical pH of 5.5.

14.2.2 Topography and potential water regime

This site is essentially a floodplain and is subject to annual flooding. Many ditches cross the site and flow into the Chelt (including the Leigh Parish Drain and the Leigh Drain with flapped outfalls), which then evacuates into the Severn through a tidal flap. The topography is generally flat, rising gently at the edges of the site. The Deerhurst Parish Drain is a Main River, which crosses the northern part of the site and runs parallel to a disused canal. Smaller ditches drain into the brook and the drainage network either side of the canal is connected by culverts.

North of the canal is a flat, low lying area at about 8.2 mAOD drained by ditches with <1m freeboard. This area is included in the Coombe Hill SSSI. Between the Leigh Brook and the canal is a low lying area (Cobney Meadows) lying between 8.25 – 8.4 mAOD which is only a little above the canal (≈7.9 mAOD) and the River Chelt (≈7.3 mAOD).

The current water regime is one of winter flooding. Flooding occurs when the flow in the Severn is high and the tidal flaps remains closed causing water to back up in the Chelt. The frequency and duration of the flood could be increased if the tidal flap were held closed artificially. Modification of the ditch infrastructure could also enable winter waters to be retained on the site for longer. The soils at this site have a low hydraulic conductivity and there are no gravels present so provision of water by sub-irrigation would not be a possibility.

The River Chelt contains very high levels of phosphate and oxidised nitrogen from sewage treatment works. Increasing the flooding frequency from this river could potentially enrich the soil and prevent an increase in plant diversity even after soil improvement from agriculture has ceased.

14.3 Potential for target species

14.3.1 Landscape and topography

The landscape is predominantly open and suitable for breeding waders and wintering waterfowl. Indeed, large numbers of waterfowl regularly occur during winter floods on the site.

14.3.2 Habitat / ecological linkages

Otters are known to occur in the area and are likely to use the Severn for moving between sites. No information is available on Water Voles within the candidate site or nearby areas.

14.3.3 Potential habitats

Wintering waterfowl would benefit from the re-creation of semi-natural inundation grasslands on the site. However, the sowing of grass leys would probably also be beneficial for grazing species. Breeding waders would also benefit from the conversion of arable crops to inundation grassland, particularly if combined with appropriate grazing management and control of agricultural operations.

The creation of reedbeds on the site would benefit a range of birds and potentially bittern and marsh harriers if sufficiently large. Otters may also benefit from the additional secure resting habitat that reedbeds would offer in the relatively open landscape of the area.

14.3.4 Water regime

Quinn (1995) reports that most of the sites surveyed for waders within the candidate site appeared to be dry, and that only 3 pairs of curlew were present. Breeding wader populations could be potentially increased substantially if spring water tables could be increased. Wintering waterfowl could potentially benefit from increased flooding frequency and periods of inundation. However, as with other sites, wader nests would be at risk from any increase in flooding during spring and early summer.

14.3.5 Potential food resources

Wintering waterfowl would benefit from an increase in MG13 inundation grasslands or perennial rye-grass leys (for some grazing species). Remaining grasslands that are regularly flooded could probably provide adequate food resources for wader populations if soil water

levels and flooding frequency were increased. In contrast, areas that have been converted to arable crops would contain substantially reduced soil invertebrate numbers. Re-flooding of these habitats would therefore not provide improved feeding conditions for breeding waders in the short term.

14.3.6 Lack of disturbance

Although a rural area, disturbance levels in the spring and summer are likely to be moderate due to the presence of a number of footpaths (including the Nature Reserve) and the proximity of the site to a number of villages and a caravan and camping site. Winter disturbance levels are likely to be low.

14.4 Conclusions

Some remnants of semi-improved / unimproved grasslands remain and are prime targets for restoration of appropriate management and high water levels. The existing invertebrate conservation interest features of the site are probably also declining due to a lack of water level management and the remaining osier beds and reed areas could be additional targets for restoration and expansion. In fact, the site would be of high suitability for inundation grassland or reedbed if sufficient water was available in summer (Table 14.1). Amending the outfall to the Severn or altering the ditch infrastructure could increase the period of the year for which this area is inundated.

Table 14.1. Summary of suitability assessments for Site 10: Coombe Hill

Criteria	**All habitats**				
Land uses	Medium (some areas of arable crops)				
Service infrastructures	Medium				
Archaeological features	Medium				
Flood risks	Medium (moderate risk)				
OVERALL SUITABILITY	MEDIUM				
Potential for habitats	**Wet grassland MG4**	**Wet grassland MG13**	**Reedbeds (S4)**	**Wet woodland (W5)**	**Tall herb fen (S25)**
Soils	Low	High	High	High	Low
Water regime	Low	High	High	Low	Low
Water quality	Low	High	High	Low	Low
Existing habitat	High	High	High	High	High
OVERALL SUITABILITY	LOW	HIGH	HIGH	MEDIUM	LOW
Potential for species	**Breeding waders**	**Wintering wildfowl**	**Otters**	**Water vole**	**Other species**
Land-use / topography	High	High	Medium	Medium?	
Habitat / ecological linkage	-	-	High	?	
Potential habitats	Medium	High	Medium	High	Reedbed spp
Water regime	Medium	High	Medium	Medium	
Food resources	Medium	High	?	High ?	
Lack of disturbance	Medium	High	Medium	High	
OVERALL SUITABILITY	MEDIUM	HIGH	MEDIUM	HIGH ?	

Note: ? = No data available or uncertain; - = Not applicable.

15 Site 11: River Severn, Minsterworth Ham

15.1 General wetland constraints

15.1.1 Land uses

Predominantly grassland, grazed by sheep and cattle. Information on the conservation value of the grasslands is not available, but they are most likely or be improved or semi-improved. Some small areas of maize also occur.

15.1.2 Presence of service infrastructures

No roads are within the site, other than one small section of an access road (Figure 15.1). Wetland re-creation options may, however, be limited by the presence of a number of electricity lines and a gas pipeline.

15.1.3 Presence of archaeological features

Several features of archaeological importance occur within the site (Figure 15.2). The potential impacts of these on the feasibility of wetland re-creation require further investigation.

15.1.4 Flood risk and defence requirements

Properties at the western end of this area are vulnerable to flooding during major floods when the Severn overtops its flood banks.

15.2 Potential for target habitats

15.2.1 Soils

This dominant soil at this site is the Compton series (Figure 15.3). These are clays of low hydraulic conductivity and medium drainable porosity. They contain moderate levels of organic carbon and have a typical pH of 5.5.

15.2.2 Topography and potential water regime

The site consists of two flat areas between the River Severn and upland on the right bank of the river. Both areas are protected by flood banks. Land levels are higher in the northern part, (downstream of Lower Parting) than in the southern part (Minsterworth Ham). 30 ha of agricultural land suffer from flooding from the Naight Ditch and / or inadequate arterial drainage (Figures 15.4 and 15.5). Discharge of the Naight Ditch is governed by River Severn levels. A number of drainage ditches cross the site. At least one farmer has a pumping scheme.

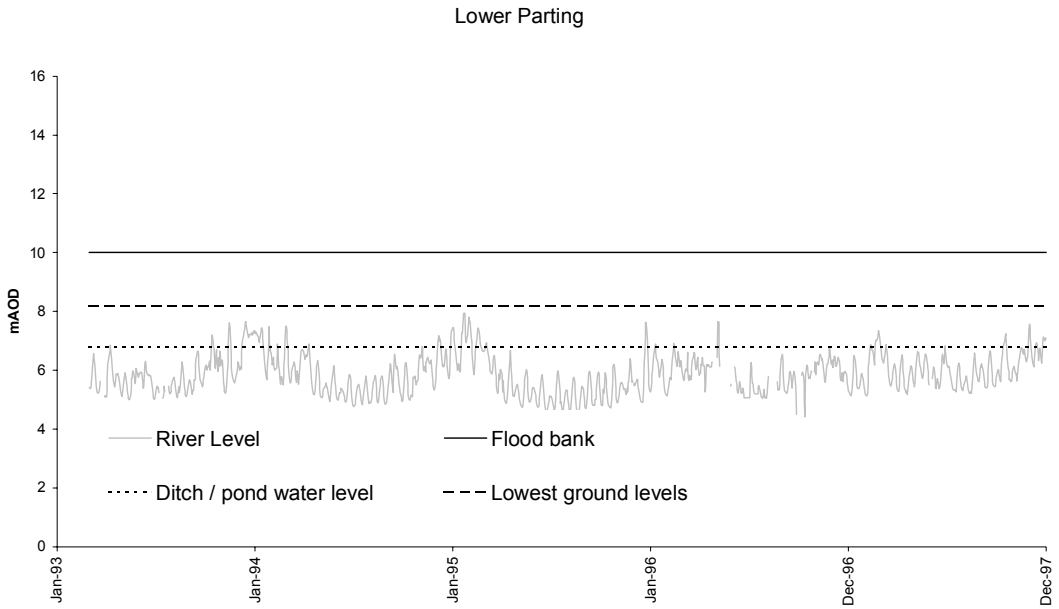

Figure 15.4. River levels in the Severn[8] compared with ground level and flood bank height at Lower Parting.

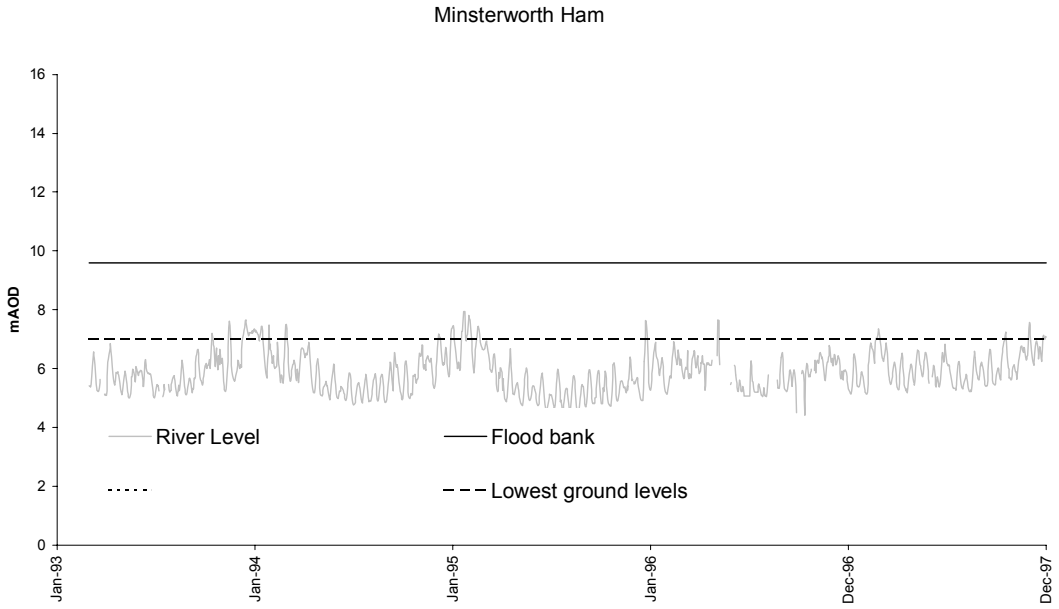

Figure 15.5. River levels in the Severn[9] compared with ground level and flood bank height at Minsterworth Ham.

This site is currently protected from flooding by embankments. An annual flooding regime could be created by making alterations to the flood banks that border the site. Surface water could also be retained by the installation of sluices in the drains thus impeding drainage from the site. The soil is of low hydraulic conductivity so the provision of water by sub-irrigation from ditches is unlikely to be successful.

[8] River levels at Minsterworth EACWLR
[9] River levels at Minsterworth EACWLR

15.3 Potential for target species

15.3.1 Landscape and topography

The landscape is flat and fairly open over most parts. However, there are some plantations, scattered pollarded willows and tall trees and hedges that could limit its suitability for waders and waterfowl.

15.3.2 Habitat / ecological linkages

There is currently no information available on the occurrence of otter or water voles in the area.

15.3.3 Potential habitats

There could be considerable benefits for wintering waterfowl from the re-creation of inundation grasslands. The creation of pockets of reedbed would also increase habitat diversity in the area and could provide shelter for some species of wildfowl, otters, water voles and other reedbed species.

15.3.4 Water regime

The potential water regime would be advantageous for wintering waterfowl, but an increase in spring flooding would be detrimental for breeding waders.

15.3.5 Potential food resources

An increase in the extent of MG13 inundation grassland on the site would increase food resources for waterfowl in winter. The creation of reedbeds would provide additional feeding opportunities for some wildfowl as well as other reedbed species.

15.3.6 Lack of disturbance

Due to the inaccessibility of the site, disturbance levels are likely to be very low.

15.4 Conclusions

Inundation grassland would be of high suitability at this site if flooding were increased or drainage impeded (Table 15.1). There is no information on the volumes of water available but it is possible that a small area of reedbed would also be suitable here. However, the major constraint on wetland re-creation at this site is that an increase in flooding would probably be unacceptable because of the high risk to properties.

Table 15.1. Summary of suitability assessments for Site 11: River Severn, Minsterworth Ham

Criteria	All habitats				
Land uses	High				
Service infrastructures	Medium				
Archaeological features	Medium ? (further assessments required)				
Flood risks	Low (high risk to properties)				
OVERALL SUITABILITY	LOW				
Potential for habitats	**Wet grassland MG4**	**Wet grassland MG13**	**Reedbeds (S4)**	**Wet woodland (W5)**	**Tall herb fen (S25)**
Soils	Low	High	High	High	Low
Water regime	Low	High	High	Low	Low
Water quality	High	High	High	High	Low
Existing habitat	High	High	High	High	High
OVERALL SUITABILITY	LOW	HIGH	HIGH	MEDIUM	LOW
Potential for species	**Breeding waders**	**Wintering wildfowl**	**Otters**	**Water vole**	**Other species**
Land-use / topography	Medium	Medium	High	High	
Habitat / ecological linkage	-	-	High	?	
Potential habitats	High	High	Medium	Medium	
Water regime	Medium	High	Medium	Medium	
Food resources	High	High	?	?	
Lack of disturbance	High	High	High	High	
OVERALL SUITABILITY	MEDIUM	HIGH	MEDIUM	MEDIUM	

Note: ? = No data available or uncertain; - = Not applicable.

16 Site 12: River Severn, Elmore Back to LongNey

16.1 General wetland constraints

16.1.1 Land uses

The area is mixed grassland and arable farmland. Most of the grassland is likely to be improved grassland for silage and hay. Some cattle grazing also occurs. In the area around Elmore Back Quinn (1995) reported that about 4% was improved pasture, 3% hay, 37% silage, 9% spring-sown crops and 47% autumn-sown crops.

16.1.2 Presence of service infrastructures

A road which is liable to flooding crosses the area and provides the only means of access to the village of Elmore Back (Figure 16.1). The area is crossed by a high voltage power line and a number of smaller electricity lines and a gas main.

16.1.3 Presence of archaeological features

There are a number of archaeological features of interest on the site, particularly in the area close to Elmore Back (Figure 16.2). The effects of this on the feasibility of wetland re-creation require further investigation.

16.1.4 Flood risk and defence requirements

There are no properties known to be at risk in this area. However, raising water levels in the Elmore Back area could restrict access to the village.

16.2 Potential for target habitats

16.2.1 Soils

This site contains soils of the Blacktoft series (Figure 16.3). These are calcareous silty soils of high hydraulic conductivity and drainable porosity. The have a low organic carbon content and a typical pH of 7.4.

16.2.2 Topography and potential water regime

An area of ditch drained land from which water is either released under gravity or pumped into the River Severn, under the auspices of the South Gloucestershire IDB. A number of houses and farms at Elmore Back are situated just behind the flood embankment along the R. Severn and the flood protection of this settlement has recently been enhanced. In the northern part (Elmore Back to Waterend) land levels drop to 5.6 mAOD (Figure 16.4) and all drainage is pumped. In the southern part land levels are higher (6.6 mAOD) and drainage is via a rhine (Figure 16.5).

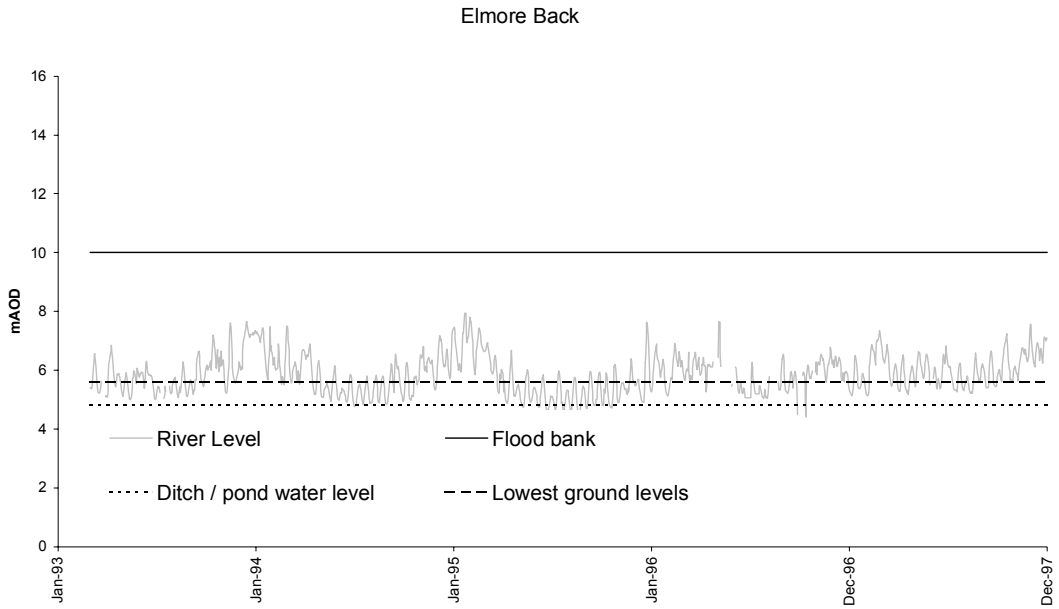

Figure 16.4. River levels in the Severn[10] compared with ground level and flood bank height at Elmore Back.

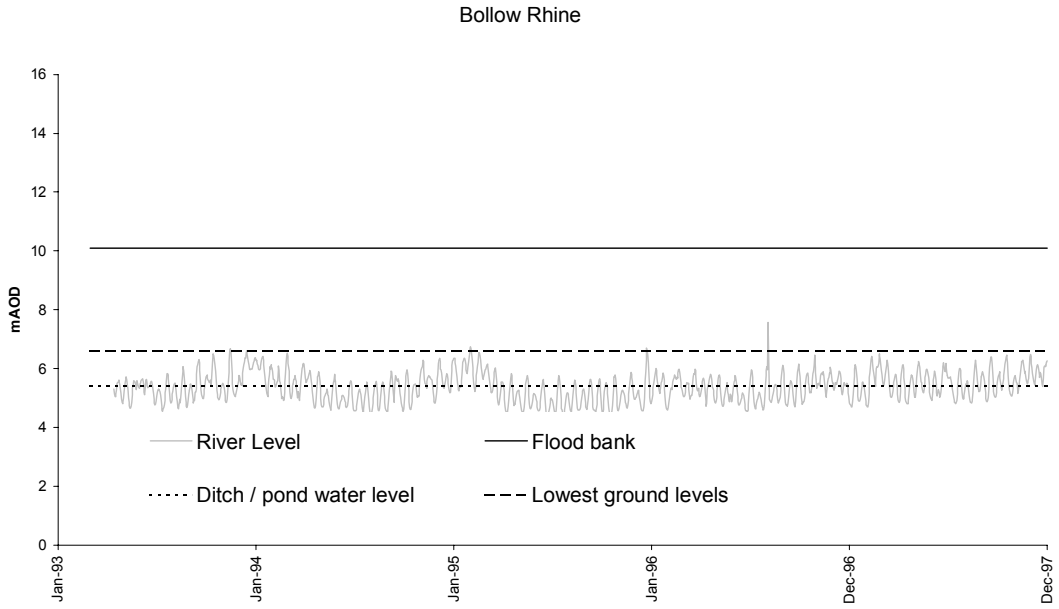

Figure 16.5. River levels in the Severn[11] compared with ground level and flood bank height in the southern part of Site 12.

A discrete area known as Wick's Green lies at 5.8 – 6.2 mAOD and has an intensive ditch network and is surrounded by higher land. Water is pumped to the River Severn near Wick's Green Farm providing up to 2 m freeboard.

[10] River levels at Minsterworth EACWLR.
[11] River levels at Epney EACWLR.

This area is currently protected from flooding by the Severn. It is pump drained and the easiest method of increasing the wetness of the site would be to alter the pumping regime. Surface water in the winter could be retained under an altered regime. Also, sluices could be installed in the ditches to give more water table control to specific areas.

16.3 Potential for target species

16.3.1 Landscape and topography

The landscape is flat in the northern section of the site. But there are some scattered trees, hedgerows and plantations that may restrict the suitability of the habitat for breeding waders and wintering waterfowl. The area around Wick's Green Farm is probably too small and enclosed to be suitable for breeding waders or wintering waterfowl.

16.3.2 Habitat / ecological linkages

No information on the occurrence of otters or water voles, or the suitability of habitats for these species is currently available for the site or its immediate surroundings.

16.3.3 Potential habitat

There could be benefits for wintering waterfowl and breeding waders from the re-creation of inundation grasslands. However, as the potential for these species groups are likely to be limited for other reasons (ie landscape and disturbance) the creation of redbeds may be more appropraite at this site. The creation of reedbed would increase habitat diversity in the area and could provide shelter for otters, water voles and other reedbed species.

16.3.4 Water regime

The potential water regime could be advantageous for wintering waterfowl if flooding frequency is increased and breeding waders if water tables are kept high in the spring. The maintenance of water in ditches and reedbeds during the spring and summer would also benefit otters, water voles (if present) and potentially bitterns.

16.3.5 Potential food resources

An increase in the extent of MG13 inundation grassland on the site would increase food resources for waterfowl in winter. Food resources for waders may however be low as some of the land has been cultivated and no longer floods regularly. The creation of reedbeds would provide additional feeding opportunities for some wildfowl as well as specific reedbed species.

16.3.6 Lack of disturbance

The area is close to a number of villages and roads and is crossed by a number of footpaths. It would, therefore, probably be subject to significant levels of disturbance.

16.4 Conclusions

This site could be suitable for inundation grassland if either sluices were installed or the pumping regime were altered. There is no information on the quantities of water available at this site but reedbed could be suitable if there is a large enough source.

Due to limitations on the site's suitability for waders and waterfowl, the re-creation of reedbeds may be the best option for this site.

Table 16.1. Summary of suitability assessments for Site 12: Elmore Back to Longney

Criteria	**All habitats**				
Land uses	Low				
Service infrastructures	Medium (one important access road)				
Archaeological features	Medium ? (further assessment required)				
Flood risks	Medium (low risk to properties, but potential risk to access road)				
OVERALL SUITABILITY	LOW				
Potential for habitats	**Wet grassland MG4**	**Wet grassland MG13**	**Reedbeds (S4)**	**Wet woodland (W5)**	**Tall herb fen (S25)**
Soils	Medium	Low	Low	Low	Low
Water regime	Low	High	High	Low	Low
Water quality	Tidal	Tidal	Tidal	Tidal	Tidal
Existing habitat	Low	High	High	Medium	Medium
OVERALL SUITABILITY	LOW	MEDIUM	MEDIUM	LOW	LOW
Potential for species	**Breeding waders**	**Wintering wildfowl**	**Otters**	**Water vole**	**Other species**
Land-use / topography	Medium	Medium	High	Medium ?	
Habitat / ecological linkage	-	-	High	?	
Potential habitats	Medium	Medium	Medium	Medium ?	
Water regime	Medium	Medium	Medium	Medium	
Food resources	Low	Medium	?	?	
Lack of disturbance	Medium	Low	Low	Medium?	
OVERALL SUITABILITY	MEDIUM	MEDIUM	MEDIUM	MEDIUM	

Note: ? = No data available or uncertain; - = Not applicable.

17 Site 13: Walmore Common

17.1 General wetland constraints

17.1.1 Land uses

The site consists of an area of improved perennial rye-grass leys and two commons consisting of unimproved marshy grassland. The two commons have been designated as an SSSI. The north common has been designated solely for its botanical interest. The southern common and adjoining improved grassland has been designated for its wintering wildfowl with the eastern section also being designated for its MG13/9 marshy grassland habitat and ditches. The south common and the adjoining private land (47.7.ha) is also designated as an SPA and Ramsar site for its wintering population of Bewick's swans.

17.1.2 Presence of service infrastructures

No roads or service infrastructures occur on the main part of the site (Figure 16.1).

17.1.3 Presence of archaeological features

There is only one feature of archaeological interest on the site (Figure 16.2). However, information on the importance of this feature and the implications for potential wetland re-creation are not currently available.

17.1.4 Flood risk and defence requirements

There are no properties known to be at risk in the area.

17.2 Potential for target habitats

17.2.1 Soils

This site contains soils of the Midelney series (Figure 16.3). These soils comprise clay over peat but some of Walmore Common appears to have a very humic alluvial topsoil grading to peat.

17.2.2 Topography and potential water regime

Walmore Common is a flat area (6.2 – 6.8 mAOD) at the foot of a bowl formed by the surrounding hills which drain into the common. A high level carrier runs around the north side of the common intercepting runoff and evacuating via a tidal flap into the Severn. A low level carrier passes through the site taking all the drainage water and evacuating via a tidal flap into the Severn. There is a sluice in the low level carrier which is used to raise water levels on the common from May to October. When the water level of the Severn is high, the tidal flaps are held closed causing water to be held back in both the high and low level carriers. This then causes extensive flooding on the common. The area experiences annual flooding, with waters often standing for several weeks and on rare occasions, several months.

Drainage is the responsibility of the West Gloucestershire IDB.

The current water regime of periodic winter flooding very occasionally continuing until spring is suitable for inundation grassland. This habitat already exists on the registered common and small numbers of waders are known to breed there. The private area of common is managed intensively for rye-grass. It is reseeded regularly since if left it reverts to creeping bent (*Agrotis stolonifera*) and would become an inundation grassland. It would be possible to change the timing of the management of the sluice to hold more water on the site in the late spring and summer or so that the retention height is altered to suit the seasonal conditions.

17.3 Potential for target species

17.3.1 Landscape and topography

The majority of the site is very open and provides excellent landscape conditions for wintering waterfowl and breeding waders.

17.3.2 Habitat / ecological linkages

Part of the site is a botanical and ornithological SSSI and Ramsar / SPA for wintering waterfowl. There is currently no information on the occurrence of otters or water voles at the site or its vicinity.

17.3.3 Potential habitats

The current habitats on the site are already of high conservation importance for wintering waterfowl, in particular the winter population of Bewick's swans. According to research by the Wildfowl and Wetlands Trust (WWT) in 1986/87 (cited in CPM 1998) the swans principally feed on the rye-grass leys to the west of the common land. However, recent advice to English Nature from WWT, based on research at Slimbridge, suggests that annual re-seeding of the rye-grass leys is not required to attract the swans to the site to feed and more infrequent re-seeding (once every 3-5 years) would be sufficient. It is, therefore, possible that the frequency of re-seeding could be reduced without detriment to the wintering swan population. This should be included as part of the development of an overall SPA / Ramsar site management plan.

17.3.4 Water regime

Maintaining high spring water levels in the Southern Common would provide benefits for breeding waders. Dipwell data collected by the Trustees of Walmore Common, English Nature and RSPB indicates that the current management of the site leads to a fall of the water table such that it is typically 0.6 m below the ground surface by June. A water table at this depth is unlikely to provide suitable conditions for breeding waders.

Requirements for water level management in the spring must be balanced, however, with ensuring that the habitats on the site continue to be suitable to support the internationally important population of Bewick's Swans. Any changes must therefore make the need to retain some productive swards on the site a priority since it is these areas which are favoured by the swans.

These issues are currently being addressed by the development of a Water Level Management Plan for the site.

17.3.5 Potential food resources

Due to the current periodic flooding of the site and existing habitats it is likely that semi-aquatic soil invertebrates are present and that food resources for waders are potentially available. As described under 17.4.3 above, rye-grass leys and inundation grasslands provide favoured food resources for grazing wildfowl such as Bewick's swans.

17.3.6 Lack of disturbance

Disturbance levels are likely to be low over most of the site, particularly during winter flood periods. However, some disturbance of breeding waders is likely to occur on the southern common from livestock. The success of breeding waders may be affected by livestock numbers resulting in losses of eggs and nests. Effective management of livestock would be required to address this issue.

17.4 Conclusions

If the intensive management of the private common ceased then the water regime would already be suitable for inundation grassland (Table 17.5). However, it should be noted that the wintering Bewick's swans, for which the site is currently designated an SSSI, SPA and a Ramsar site, prefer to graze on enriched grassland swards of the private common to the more nutrient poor and tussocky habitat of the registered common. Retention of some improved swards is therefore required.

Table 17.5. Summary of suitability assessments for Site 13: Walmore Common

Criteria	**All habitats**				
Land uses	High				
Service infrastructures	High				
Archaeological features	High				
Flood risks	High (low risk)				
OVERALL SUITABILITY	HIGH				
Potential for habitats	**Wet grassland MG4**	**Wet grassland MG13**	**Reedbeds (S4)**	**Wet woodland (W5)**	**Tall herb fen (S25)**
Soils	High	Low	Low	Medium	High
Water regime	Low	High	High	Low	Low
Water quality	Tidal	Tidal	Tidal	Tidal	Tidal
Existing habitat	High	High	High	High	High
OVERALL SUITABILITY	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM
Potential for species	**Breeding waders**	**Wintering wildfowl**	**Otters**	**Water vole**	**Other species**
Land-use / topography	High	High	Low	Low	
Habitat / ecological linkage	-	-	?	?	
Potential habitats	High	High	Medium	Medium	
Water regime	High	High	-	-	
Food resources	High	High	?	?	
Lack of disturbance	High	High	High	High	
OVERALL SUITABILITY	HIGH	HIGH	MEDIUM?	MEDIUM?	

Note: ? = No data available or uncertain; - = Not applicable.

18 Site 14: River Severn, Awre

18.1 General wetland constraints

18.1.1 Land uses

The site is agricultural, but no information is readily available on current land-uses.

18.1.2 Presence of service infrastructures

There are no roads or service infrastructures within the site (Figure 18.1).

18.1.3 Presence of archaeological features

There are no features of archaeological importance within the main part of the site, other than the existing floodbank (Figure 18.2). The effects of this on the feasibility of wetland re-creation requires further investigation.

18.1.4 Flood risk and defence requirements

There are no properties known to be at risk in this area.

18.2 Potential for target habitats

18.2.1 Soils

This site contains soils of the Blacktoft series (Figure 18.3). These are calcareous silty soils of high hydraulic conductivity and drainable porosity. The have a low organic carbon content and a typical pH of 7.4.

18.2.2 Topography and potential water regime

The site consists of a small flat area in a bend of the River Severn protected by a flood bank at 9.6 mAOD which is 3.6 m above mean high water mark (6.0 mAOD). Land levels drop to 7.6 mAOD. This site is not flooded by the Severn, which is tidal at this point, but could be if the existing flood banks are moved, removed, lowered or breached. In fact the benefits compared to the cost of maintaining the flood banks are relatively low and there may be future opportunities for increasing flooding frequency.

Drainage is the responsibility of the West Gloucestershire IDB.

The site contains a number of drainage ditches which could also be modified to increase the wetness of the site. Sluices could be installed to raise the ditch water level. The soil is of high hydraulic conductivity and raised ditch water levels should allow higher water tables to be obtained.

18.3 Potential for target species

18.3.1 Landscape and topography

The landscape is flat and mostly open although some small woodlots towards the inland edge of the site. The landscape and topography is, therefore, likely to be generally suitable for waders and wildfowl, although the site was not visited and detailed information on the landscape is not available.

18.3.2 Habitat / ecological linkages

No information is available on the presence of otter and water voles on the site. However, available information on the habitats and landscape suggests that there may be insufficient cover for otters on the site and in surrounding areas.

18.3.3 Potential habitats

The site is of medium suitability for the re-creation of flood meadows (MG4) or inundation grasslands (MG13), both of which could be beneficial for waders if managed appropriately. Grazing species of wildfowl, such as Bewick's swans, which occur on the otherside of the river at Slimbridge, could benefit from the re-creation of inundation grasslands. The re-creation of patches of reedbed could also provide cover and food sources for smaller species of wildfowl and other reedbed birds. Otters could also benefir from such cover, although as described above, the site may be too isolated from existing populations and surrounded by unsuitable habitat.

18.3.4 Water regime

The potential water regime could be advantageous for wintering waterfowl if flooding frequency is increased and breeding waders if water tables are kept high in the spring. An increase in flooding frequency in spring may, however, be detrimental to breeding waders.

18.3.5 Potential food resources

An increase in the extent of MG13 inundation grassland on the site would increase food resources for waterfowl in winter. Potential food resources for waders may however be low the land does not flood regularly. The creation of reedbeds would provide additional feeding opportunities for some wildfowl as well as specific reedbed species.

18.3.6 Lack of disturbance

The site is in a rural location and is not crossed by any roads. Although a number of footpaths occur, including one close to the bank of the estuary, it is unlikely that these are subject to high usage due to the relatively remote location of the site. Access to, and therefore, disturbance of other parts of the site by walkers and dogs etc may also be limited by the presence of ditches. Overall, therefore, disturbance impacts are likely to be low.

18.4 Conclusions

Under current conditions, if drainage from this site were impeded by installation of sluices then it is possible that inundation grassland or reedbed would be of moderate suitability. The

quantity of water available at this site is not known but would need to be significant to maintain a reedbed throughout the summer.

Some future opportunities may exist for altering the water regime and re-creating wetland habitats as a result of abandonment or removal of existing flood protection, but this is dependent on further studies by the Environment Agency.

Table 18.1. Summary of suitability assessments for Site 14, River Severn, Awre

Criteria	**All habitats**				
Land uses	High?				
Service infrastructures	High				
Archaeological features	High (except for existing floodbank)				
Flood risks	High (low risk and potential site for managed retreat)				
OVERALL SUITABILITY	HIGH				
Potential for habitats	**Wet grassland MG4**	**Wet grassland MG13**	**Reedbeds (S4)**	**Wet woodland (W5)**	**Tall herb fen (S25)**
Soils	High	Low	Low	Medium	Low
Water regime	Low	High	High	Low	Low
Water quality	Tidal	Tidal	Tidal	Tidal	Tidal
Existing habitat	?	?	?	?	?
OVERALL SUITABILITY	MEDIUM?	MEDIUM?	MEDIUM?	LOW?	LOW
Potential for species	**Breeding waders**	**Wintering wildfowl**	**Otters**	**Water vole**	**Other species**
Land-use / topography	High	High	Low?	?	
Habitat / ecological linkage	-	-	?	?	
Potential habitats	Medium	Medium	Medium	Low	
Water regime	Medium?	Medium?	-	Low	
Food resources	?	Medium	?	?	
Lack of disturbance	High	High	Medium?	High	
OVERALL SUITABILITY	MEDIUM?	MEDIUM?	?	?	

Note: ? = No data available or uncertain; - = Not applicable.

19 Site 15: Wicksters Brook and the Moors, Slimbridge

19.1.1 General wetland constraints

19.1.2 Land uses

The area is mainly small fields of semi-improved grassland with old established hedges and some arable land.

19.1.3 Presence of service infrastructures

Several roads pass through the site and there are a number of utility / service structures that may limit the potential for increased flooding and wetland re-creation (Figure 18.1).

19.1.4 Presence of archaeological features

There are several features of archaeological interest on the site, in particular in the western section (Figure 19.1). The effects of this on the feasibility of wetland re-creation requires further investigation.

19.1.5 Flood risk and defence requirements

There are no properties known to be at risk in this area.

19.2 Potential for target habitats

19.2.1 Soils

The soils at this site comprise mainly the Fladbury series (Figure 18.3). These are clay soils of medium hydraulic conductivity and high drainable porosity. They contain moderate levels of organic carbon and typically have a pH of 5.6.

19.2.2 Topography and potential water regime

The arterial channels, River Cam and Wicksters Brook are maintained at a high level to feed the Gloucester and Sharpness canal. The area to the north of Wickster's Brook known as 'The Marshes' lies between 7.7 – 8.4 mAOD which is well below the water level of the brook (≈ 9.9 mAOD). Land between the Wickster's Brook and the River Cam (10.1 mAOD) lies at about 9.8 – 10.4 mAOD. As part of a flood alleviation scheme a flood storage area was created, from which stored flood water is pumped back into the Cam via two large pumps. One small pump maintains land drainage. An outfall from the canal is used to supplement water levels in the summer and to supply water to the 'New Grounds' west of the canal. South of Hope House Farm the area is drained by gravity to the Royal Drift outfall.

Drainage is managed by the South Gloucester IDB.

Water levels on this site are managed by a ditch and mainly gravity (with some pump) drainage infrastructure. Alterations could be made to this system to increase the wetness of the area. The existing infrastructure in combination with soils of moderate hydraulic

conductivity enables good control of water tables in the area. The site could possibly be managed for winter inundation and high spring and summer water tables if required.

19.3 Potential for target species

19.3.1 Landscape and topography

The site has an extensive large, flat and generally open landscape that is highly suitable for breeding waders and wintering waterfowl.

19.3.2 Habitat / ecological linkages

The site could provide an extension to the adjoining grasslands of Slimbridge, thereby providing suitable overspill habitats. According to Quinn (1995) wader populations at the New Grounds at Slimbridge have increased dramatically since 1982 and now hold 23 pairs of lapwing and 15 pairs of redshank. In addition 5 pairs of lapwing and 5 pairs of redshank also breed nearby at Saul Warth (SO 7410750). Further expansion of these populations may require new breeding habitats.

19.3.3 Potential habitats

The site is of medium suitability for the re-creation of inundation grasslands, reedbeds and wet woodland. This could benefit breeding waders and wintering wildfowl, as well as otters and water voles if present. However, care would need to be taken to ensure that the creation of reedbeds or wet woodlands does not lead to enclosure of the landscape as this would limit the potential of the site for waders and wildfowl.

19.3.4 Water regime

The potential water regime of winter flooding with high soil water levels maintained into spring and summer would be suitable for both wintering wildfowl and breeding waders.

19.3.5 Potential food resource

The creation of MG13 inundation grassland on the site would increase food resources for waterfowl in winter. The creation of small reedbeds would also provide additional feeding opportunities for some wildfowl as well as specific reedbed species. Food resources for waders may, however, be harmed if new winter flooding is carried out as the land does not currently flood regularly and therefore semi-aquatic soil invertebrates may not present.

19.3.6 Lack of disturbance

The site is crossed by a number of roads and footpaths and is close to a number of villages. Disturbance levels may therefore be moderate, particularly in the northern section of the site.

19.4 Conclusions

If the water regime were managed appropriately, this site would be of moderate suitability for inundation grassland and possibly reedbed. The suitability of reedbed would depend on the quantities of water available. Flood meadow, wet woodland and tall herb fen are less suitable for this site since there are no gravels present to provide sub-irrigation in the summer

although if the ditches are close enough together it is possible that they could supply the necessary water.

Table 19.1. Summary of suitability assessments for Site 15: Wicksters Brook and the Moors, Slimbridge

Criteria	**All habitats**				
Land uses	High				
Service infrastructures	Medium				
Archaeological features	Medium ? (further assessments necessary)				
Flood risks	High				
OVERALL SUITABILITY	MEDIUM				
Potential for habitats	**Wet grassland MG4**	**Wet grassland MG13**	**Reedbeds (S4)**	**Wet woodland (W5)**	**Tall herb fen (S25)**
Soils	Low	Medium	Medium	Medium	Low
Water regime	Low	High	High	Low	Low
Water quality	?	?	?	?	?
Existing habitat	Low	High	High	Medium	Medium
OVERALL SUITABILITY	LOW	MEDIUM	MEDIUM	MEDIUM	LOW
Potential for species	**Breeding waders**	**Wintering wildfowl**	**Otters**	**Water vole**	**Other species**
Land-use / topography	High	High	Medium	Medium	
Habitat / ecological linkage	(see text)	-	?	?	
Potential habitats	Medium	Medium	Medium	Medium	Reedbed spp
Water regime	High	High	Medium	Medium	
Food resources	High	High	?	?	
Lack of disturbance	Medium	Medium	Medium	High	
OVERALL SUITABILITY	HIGH	HIGH	?	?	

Note: ? = No data available or uncertain; - = Not applicable.

20 Site 16: River Avon, Evesham to Birlingham

20.1 General wetland constraints

20.1.1 Land uses

This large site contains a mix of agricultural land, including semi-improved and improved grasslands, arable crops and market gardening. According to Quinn (1995) land at Lench Ditch (SO 977466) consisted of 19% unimproved pasture, 15% semi-improved pasture, 16% hay and 50% silage. However, land west of Pensham (SO 940437) consisted of mostly arable crops, the majority of which were spring-sown.

20.1.2 Presence of service infrastructures

There are a number of utility / service structures within the candidate site (Figures 20.1 and 20.2)

20.1.3 Presence of archaeological features

The area has an unknown potential for archaeological features, but there is an increasing amount of evidence for prehistoric activity in this area. A field survey and evaluation would need to be carried out before any final recommendations can be made concerning archaeological issues.

20.1.4 Flood risk and defence requirements

There are no properties known to be at risk in this area.

20.2 Potential for target habitats

20.2.1 Soils

The dominant soil type at this site is Fladbury series (Figures 20.3 and 20.4). These are clay soils of medium hydraulic conductivity and high drainable porosity. They contain moderate levels of organic carbon and typically have a pH of 5.6.

20.2.2 Topography and potential water regime

This is a series of floodplain areas on the left and right banks of the River Avon from Pensham to Evesham. Along much of the river there are old flood banks which are breached in many places. Some of these banks are private and some are the result of river dredging. The water level is partly controlled by a series of weirs and navigation locks, such that it changes in a series of ‘steps’. Table 20.1 shows the relationship between land levels and river levels for sub-reaches.

Table 20.1. The relationship between land levels and river levels

Site No.	Bank	Reach		Mean[12] water level mAOD		Land Level mAOD		Freeboard m		Embankment height mAOD
16a	L	Pensham		12.5	12.6	14.8	14.9	2.2	2.3	15.7
	R		Pershore	12.9	13.0	14.6	14.8	1.7	1.8	>15
	L	Wyre Mill	Pershore	15.3	15.3	15.6	15.6	0.3	0.3	16.0
	R	Piddle Br.	Wyre Mill	15.3	15.3	16.2	16.6	0.9	1.3	
	L	upstream of	Wyre Mill	16.2	16.3	16.8	17.2	0.6	0.9	17.4
	R	Wyre Mill	Fladbury	16.5	17.4	17.0	18.0	0.5	0.6	
16b	L	Fladbury	Chadbury	18.3	18.8	19.2	20.0	0.9	1.2	19.8
	R	Fladbury	Chadbury	18.3	18.6	19.8	19.8	1.4	1.1	20.5
	L	Chadbury	Evesham	19.5	19.7	20.5	21.0	1.0	1.3	21.0

Where the freeboard is low, ditch water levels are high and the sites are subject to frequent inundation.

[12] Mean water level was taken as mean level at Evesham gauging station (1983-97) scaled according to the relative levels for each reach shown on the February / March 1977 aerial survey. The two figures relate to the average land levels at the upper and lower end of the reach respectively.

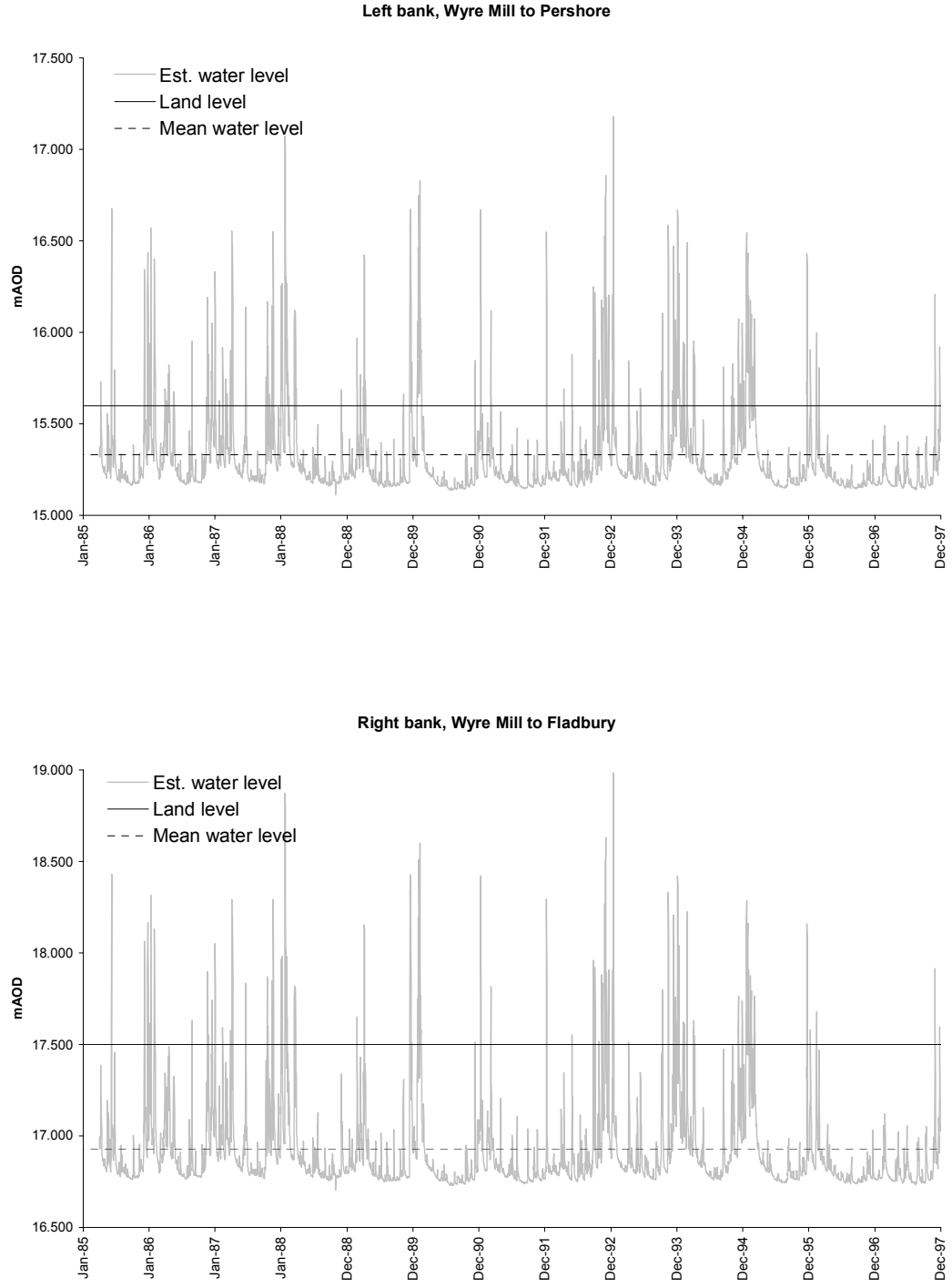

Figure 20.5. Relationship between river level[13] and land level for two reaches on the River Avon.

[13] River levels are those recorded at Evesham EACWLR scaled according to the relative levels for the reach shown on the February / March 1977 aerial survey. These should be taken as a guide only.

This is a very large site and the influence of the river is variable along it. In some parts, the river water level is within 0.3 m of the ground surface. The river floods regularly onto the floodplain in areas where it is not embanked, or the embankments have not been maintained at their original height (Figure 20.5). In the areas where flood banks are still functioning, alterations could be made to their height to increase the frequency and duration of flood events. Some stretches of this site have an existing drainage infrastructure. This could be exploited to impede drainage, thus retaining water on site for a longer period, or to provide additional water during the spring and summer by sub-irrigation.

20.3 Potential for target species

20.3.1 Landscape and topography

The floodplain at this candidate site is narrow and adjoined in places by some relatively high and steeply rising land. Also, although generally open, scattered pollarded willows are typical of the Avon valley. Therefore, although the site was not visited as part of this study, it is likely that the narrowness and partly enclosed nature of the landscape may limit is suitability for wintering wildfowl and breeding waders in some areas. The scattered willows and other vegetation, may however, provide suitable cover for otters.

20.3.2 Habitat / ecological linkages

Detailed information on the status of otters and water voles at the site are not available. However, apparently suitable habitats for both species occur along the river corridor and there are recent scattered records of otters in the Avon valley. It is therefore possible that colonisation of the site by water voles and otters may occur given suitable wetland re-creation on the site.

20.3.3 Potential habitats

The re-creation of inundation grasslands could provide suitable feeding habitats for grazing species of wintering waterfowl. Also, if appropriately managed, eg by cattle grazing to encourage tussocky grassland suitable breeding habitats for waders may be possible. However, the benefits of such habitat for waders and wildfowl may be limited by the small size, narrowness and relative enclosure of the site and high levels of disturbance. The re-creation of reedbeds may therefore be more appropriate for such a site as these could provide further cover and feeding areas for otters as well as a range of reedbed birds.

20.3.4 Water regime

An increase in flooding frequency could benefit wintering wildfowl, but as described above, this benefit may be limited by the site's size, topography and landscape. Also, an increase in flooding frequency may result in increased spring flooding, which would be damaging to breeding waders. However, the retention of high ditch water levels into the spring and summer could provide benefits for breeding waders, otters and water voles if present.

20.3.5 Potential food resources

An increase in the extent of MG13 inundation grassland on the site would increase food resources for waterfowl in winter and invertebrate food resources for waders are likely to be

adequate in areas that flood regularly. The creation of reedbeds would provide additional feeding opportunities for some wildfowl as well as specific reedbed species.

20.3.6 Lack of disturbance

The site is close to the towns of Evesham and Pershore as well as several villages and is crossed by several footpaths. Also, like many other areas of the Avon valley, the area is popular for tourism and recreation, with the waterway particularly heavily used by pleasure craft. It is therefore likely that the area is subject to fairly high levels of disturbance, particularly in spring and summer, which may limit is suitability for some species, especially breeding waders.

20.4 Conclusions

The most suitable habitat for the site as a whole would be inundation grassland (Table 21.2), although the site is large and some parts of it may be more suitable than others. It may be suitable for small areas of reedbed where there is an additional source of water. It is less suitable for flood meadow, wet woodland and tall herb fen because the site is not thought to be underlain by gravel and hence there may not be enough water to provide the sub-irrigation necessary to support these habitats. It should be noted that the river water on this stretch contains high levels of phosphates and oxidised nitrogen from sewage treatment works and an increase of flooding frequency could cause enrichment of the soil.

Table 21.2. Summary of suitability assessments for Site 16: Evesham to Birlingham

Criteria	**All habitats**				
Land uses	Medium				
Service infrastructures	Medium				
Archaeological features	Medium				
Flood risks	High (Low risk to properties)				
OVERALL SUITABILITY	MEDIUM				
Potential for habitats	**Wet grassland MG4**	**Wet grassland MG13**	**Reedbeds (S4)**	**Wet woodland (W5)**	**Tall herb fen (S25)**
Soils	Low	Medium	Medium	Medium	Low
Water regime	Low	High	High	Low	Low
Water quality	Low	High	High	Low	Low
Existing habitat	?	?	?	?	?
OVERALL SUITABILITY	LOW	HIGH?	HIGH?	LOW	LOW
Potential for species	**Breeding waders**	**Wintering wildfowl**	**Otters**	**Water vole**	**Other species**
Land-use / topography	Medium	Low ?	Medium	Medium ?	
Habitat / ecological linkage	-	-	Medium ?	?	
Potential habitats	Medium	Medium	Medium	Medium	
Water regime	Medium	High	Medium	Medium	
Food resources	Medium	High	?	?	
Lack of disturbance	Low	Medium	Medium	Medium	
OVERALL SUITABILITY	MEDIUM	MEDIUM	MEDIUM?	MEDIUM?	

Note: ? = No data available or uncertain; - = Not applicable.

21 Site 17: River Avon, Eckington Bridge to Tewkesbury

21.1 General wetland constraints

21.1.1 Land uses

The area is predominantly grassland, of which most is semi-improved or improved pasture or silage or hay meadows. Some small areas of unimproved pasture also remain, for example at Eckington Marshes (SO 913417). Arable crops are also grown, for example at the south of the site near Twyning and Bredon's Hardwicke (Quinn 1995).

Two SSSIs occur within the site. Upham Meadow and Summer Leasow (SO 917375) is an area of semi-natural neutral grassland that is subject to annual winter flooding and is notified primarily for its breeding waders and over-wintering populations of waders and wildfowl. Rectory Farm Meadows SSSI (SO 922382) is an area of flood meadows which are of special interest for their overall botanical diversity and comparatively large size.

21.1.2 Presence of service infrastructures

The area is crossed by the M5 motorway, but this is raised on a tall viaduct and embankment and not affected by flooding in the valley. Only one other small and disused access road is within the site (Figure 21.1). The area is generally unaffected by utility / service structures.

21.1.3 Presence of archaeological features

The area has an unknown potential for archaeological features. Therefore, a field survey would need to be carried out before any final recommendations can be made concerning archaeological issues. A field evaluation may also be necessary in selected areas if excavations are proposed.

21.1.4 Flood risk and defence requirements

There are no properties known to be at risk in this area.

21.2 Potential for target habitats

21.2.1 Soils

The soils at this site comprise mainly of Fladbury series (Figure 21.2). These are clay soils of medium hydraulic conductivity and high drainable porosity. They contain moderate levels of organic carbon and typically have a pH of 5.6.

21.2.2 Topography and potential water regime

Land north of Twyning Green is old grassland with an intermittent spoil bank alongside the Avon. Gravel was detected at about 1.0 m depth in some areas. A back-ditch crossing the grassland is in open connection with the River. On the opposite side of the river the grassland is behind higher flood embankments left from gravel workings and some areas appeared to have been abandoned by agriculture.

The current water regime at this site is one of winter flooding. The site is crossed by a number of ditches and these, in combination with the gravel may enable high water tables to be retained into spring. The frequency and duration of winter flooding could possibly be increased by making alterations to the spoil banks in some parts of this site, although the spoil banks are only shallow in some areas

Table 21.2. Water levels and freeboard at Site 17

Site No.	Bank	Reach		Mean water level[14] mAOD		Land Level mAOD		Freeboard m		Embankment height mAOD
17	L	Tewkesbury	Bredon	9.6	9.6	10.3	10.6	0.6	1.0	11.7
	R	Twyning Green		9.7	9.9	10.7	10.9	1.0	1.0	11.7
	L	Bredon	Eckington Br.	9.9	11.1	11.5	11.4	1.6	0.3	12.0

21.3 Potential for target species

21.3.1 Landscape and topography

The site is predominantly an open landscape which is generally suitable for breeding waders and wintering waterfowl. However, there are some areas with numerous scattered pollarded willows, taller mature trees and hedgerows that would limit the suitability of the habitat for waders and wildfowl.

21.3.2 Habitat / ecological linkages

As described above, the site contains two SSSIs. There are recent scattered records of otters in the valley. As with the other sites in the Avon valley, information on the status of water voles is not available although apparently suitable habitats for the species occurs along the river corridor. It is therefore possible that colonisation of the site by water voles and otters may occur given suitable wetland re-creation on the site.

21.3.3 Potential habitats

Re-creation of more semi-natural and particularly tussocky grasslands would provide considerable benefits for waders in the area. The site is also highly suitable for the creation of reedbed, small patches of which could provide cover for otters and smaller species of wildfowl, without reducing the suitability of the site for other wildfowl and breeding waders.

21.3.4 Water regime

The maintenance of spring and summer water levels would provide considerable benefits for breeding waders, particularly at Upham Meadow and Summer Leasow SSSI. In 1995 this site held 4 pairs of lapwing, 9 pairs of redshank and 3 pairs of curlew (Quinn 1995) but was reported to be dry during the breeding season. It was recommended that both water levels and grazing regimes could be better managed for waders at this site.

An increase in winter flooding could benefit wintering waterfowl, but if this was not controllable, spring flooding could be a significant problem for breeding waders at some sites.

[14] Mean water level was taken as mean water level at Evesham gauging station (1983 – 97) scaled according to the relative levels for each reach shown on the February / March 1977 aerial survey. The two figures relate to the average land levels at the upper and lower end of the reach respectively.

21.3.5 Potential food resources

The site probably already contains sufficient grassland food resources for wildfowl and as it regularly floods semi-aquatic soil invertebrates are probably available for waders. The creation of reedbeds would provide additional feeding opportunities for some wildfowl as well as specific reedbed species.

21.3.6 Lack of disturbance

Although the area is fairly sparsely populated and holds few footpaths or roads, it is likely that the area is subject to fairly high levels of disturbance. This is primarily due to its popularity for tourism and recreation. In particular the waterway is heavily used by pleasure craft and there are several caravan sites and a water park in the area.

21.4 Conclusions

Species-rich flood meadows already occur in parts of this site. These are probably sustained by high spring water tables maintained by sub-irrigation through the gravel layer. It may be possible to extend the range of this habitat within the site by making alterations to the current land management. Wet woodland would also be of moderate suitability at this site. An increase of flooding frequency and duration would extend the area suitable for inundation grassland and reedbed although this could be detrimental to the flood meadows especially since the river in this location is high in phosphates and oxidised nitrogen.

Table 21.2. Summary of suitability assessments for Site 17: Eckington Bridge to Tewkesbury

Criteria	**All habitats**				
Land uses	Medium (mixed grassland and arable)				
Service infrastructures	Medium				
Archaeological features	Uncertain (survey required)				
Flood risks	High (low risk to properties)				
OVERALL SUITABILITY	MEDIUM				
Potential for habitats	**Wet grassland MG4**	**Wet grassland MG13**	**Reedbeds (S4)**	**Wet woodland (W5)**	**Tall herb fen (S25)**
Soils	Low	Medium	Medium	Medium	Low
Water regime	High	High	High	High	High
Water quality	Low	High	High	Low	Low
Existing habitat	High	High	High	High	High
OVERALL SUITABILITY	MEDIUM	HIGH	HIGH	MEDIUM	LOW
Potential for species	**Breeding waders**	**Wintering wildfowl**	**Otters**	**Water vole**	**Other species**
Land-use / topography	High	High	Medium	Medium	
Habitat / ecological linkage	-	-	Medium ?	?	
Potential habitats	High	High	Medium	Medium	
Water regime	High	High	Medium	High	
Food resources	Medium	High	?	?	
Lack of disturbance	Medium	Medium	Low	Medium	
OVERALL SUITABILITY	HIGH	HIGH	MEDIUM ?	?	

Note: ? = No data available or uncertain; - = Not applicable.

22 Site 18: River Avon, Bidford on Avon to Offenham

22.1 General wetland constraints

22.1.1 Land uses

The area consists of mostly semi-improved and improved grasslands, but with some areas of arable and market gardening. There is also a number of caravan sites and a recreation ground.

22.1.2 Presence of service infrastructures

There are no roads through the site. However, the new A345 T has recently been completed (marked as under construction on Figure 22.1) and this runs alongside part of the site. There are also a number of utility / service structures within the site.

22.1.3 Presence of archaeological features

The area has an unknown potential for archaeological features. Therefore, a field survey would need to be carried out before any final recommendations can be made concerning archaeological issues. A field evaluation may also be necessary in selected areas if excavations are proposed.

22.1.4 Flood risk and defence requirements

Two shops, a cafe, two public houses four terrace houses and a caravan site were affected by a 1 in 25 year flood in this area in 1968. Any wetland creation in this area should avoid causing water to back up upstream of the B4085 road bridge at Bidford to prevent increased flood risk to these properties. During the same event an agricultural and industrial machine manufacturing company was flooded (SP 081 514). Flood protection for this establishment may have been constructed since then.

22.2 Potential for target habitats

22.2.1 Soils

The soils at this site comprise mainly of Fladbury series (Figure 22.2). These are clay soils of medium hydraulic conductivity and high drainable porosity. They contain moderate levels of organic carbon and typically have a pH of 5.6.

22.2.2 Topography and potential water regime

This site consists of a series of floodplains on either bank of the River Avon between Offenham and Bidford-on-Avon. There are very few ditches within the area and no gravel is known to underlie the site.

Table 22.1. River levels at site 18

Site No.	Bank	Reach		Land Level mAOD		Embankment height mAOD
18	L	Offenham	Billington	23.5		24.4
	R			24.5	25.0	
	L	Billington		25.3		26.0
	R	Harvington	R. Arrow	25.6		26.4

The current water regime is one of frequent winter flood. The levees of the river are low but it would be possible to slightly increase the frequency and duration of flooding by lowering them further. The lack of ditches makes other alteration to the water regime difficult. The River Arrow could possibly be used as a source of additional water but information has not been collated on this river.

22.3 Potential for target species

22.3.1 Landscape and topography

The site is predominantly an open landscape, which is generally suitable for breeding waders and wintering waterfowl. However, there are some areas with numerous scattered pollarded willows, taller mature trees and hedgerows that would limit the suitability of the habitat for these species. Some areas on the eastern edge of the site are also close to steeply rising ground.

22.3.2 Habitat / ecological linkages

As with the other sites in the Avon valley, detailed information on the status of otters and water voles are not available. However, otters have been recorded in the valley and apparently suitable habitats for otters and water voles occur along the river corridor. It is therefore possible that colonisation of the site by water voles and otters may occur given suitable wetland re-creation on the site.

22.3.3 Potential habitats

The existing habitats are probably already suitable for some wintering wildfowl, in particular grazing species that utilise improved grasslands. However, further benefits would be gained by the conversion of arable and market gardening to grassland. The creation of reedbeds would also provide additional cover and feeding habitats for smaller wildfowl, reedbed birds and possibly otters.

22.3.4 Water regime

An increase in winter flooding could benefit wintering waterfowl, but if this was not controllable, spring flooding could be a significant problem for breeding waders at some sites.

22.3.5 Potential food resources

An increase in the extent of MG13 inundation grassland on the site would increase food resources for wildfowl, particularly dabbling species that feed on seeds. The creation of

reedbeds would also provide additional feeding opportunities for such wildfowl as well as specific reedbed species.

22.3.6 Lack of disturbance

It is likely that the area is subject to fairly high levels of disturbance as it is close to several villages and towns and has several footpaths within it. The area is also used for tourism and recreation. In particular the waterway is heavily used by pleasure craft and there are several caravan sites and a recreation ground in the area.

22.4 Conclusions

If flooding frequency and duration were increased then the site could be moderately suitable for inundation grassland (Table 22.2). The river water on this stretch contains high levels of phosphate and oxidised nitrogen which could cause enrichment of the soil if flooding was increased markedly. Other habitats are of low suitability due to the lack of appropriate water supply.

Table 22.2. Summary of suitability assessments for Site 18: Bidford on Avon to Offenham

Criteria	**All habitats**				
Land uses	Medium				
Service infrastructures	Low				
Archaeological features	Uncertain				
Flood risks	Low (high risk to properties)				
OVERALL SUITABILITY	LOW ?				
Potential for habitats	**Wet grassland MG4**	**Wet grassland MG13**	**Reedbeds (S4)**	**Wet woodland (W5)**	**Tall herb fen (S25)**
Soils	Low	Medium	Medium	Medium	Low
Water regime	Low	Medium	Low	Low	Low
Water quality	Low	High	High	Low	Low
Existing habitat	?	?	?	?	?
OVERALL SUITABILITY	LOW	MEDIUM	MEDIUM	LOW	LOW
Potential for species	**Breeding waders**	**Wintering wildfowl**	**Otters**	**Water vole**	**Other species**
Land-use / topography	Medium	Medium	Medium	?	
Habitat / ecological linkage	-	-	Medium ?	?	
Potential habitats	Medium	Medium	Medium	Low	
Water regime	Low	Medium	Medium	Medium	
Food resources	Medium	High	?	?	
Lack of disturbance	Medium	Low	Medium	Medium	
OVERALL SUITABILITY	MEDIUM	MEDIUM	MEDIUM ?	?	

Note: ? = No data available or uncertain; - = Not applicable.

23 Conclusions

23.1 Overall assessment and ranking of candidate sites

This study has found that there is considerable potential for re-creating a range of different wetland types and restoring target wetland species in, at least part of, most of the candidate sites considered. This, however, is to some extent not surprising, as wetlands were formerly widespread in the Severn and Avon Vale (see Chapter 2). Whilst some of the larger wetlands have been destroyed by large-scale drainage schemes and river regulation projects, many wetland habitats have been lost or degraded recently (ie post 1960's) by simple agricultural improvements such as ditching, field drainage, re-seeding, fertilisation or conversion to arable crops. In theory, many of these changes could be reversed to re-create habitats. Indeed, it is widely recognised that it is usually much easier to re-create wetlands, where previous wetlands existed (Treweek and Sheail 1991; Lewis 1995) than create completely new habitats. This is because the suitable hydrological conditions are more often likely to be present, seedstock for wetland plants are often available and fauna may re-establish themselves from remnant populations.

However, the successful re-creation of a former wetland will be dependent on a number of key factors that affect its ecology. In particular, a wetland's value is influenced by subtle relationships between hydrology, soils, vegetation, animal life, and nutrients, which may have developed over thousands of years. Consequently, although many wetland restoration and re-creation schemes have been carried out worldwide, problems have commonly arisen from a lack of basic ecological knowledge and a consequent over-emphasis on civil engineering aspects of wetland design (Lewis 1995).

Hydrology is fundamental to the ecology of any wetland, its re-creation and subsequent management. This study has, therefore, assessed the hydrological conditions of the candidate sites in some detail (data permitting) and compared these to the requirement of the target habitats for re-creation (see Table 4.4 and Appendix 3).

An initial assessment of the hydrogeological conditions of the candidate sites (see Appendix 4) revealed that on these grounds alone, six sites are highly suitable for wetland re-creation and a further seven are moderately suitable. Of the highly suitable sites (Sites 1, 8, 9, 10, 13 and 15), all are characterised by the presence of significant surface water features and inflows (runoff and occasionally groundwater inflow) from adjacent areas.

However, this hydrogeological evaluation only formed part of the overall hydrological suitability assessment. Hydrogeological considerations are important in that groundwater can help maintain water levels and saturated soil conditions during low rainfall periods, but flooding regime and soil type etc. are of equal or greater importance. Water availability from flooding events was, therefore, also considered. Both the Severn and Avon rivers have been substantially regulated and engineered such that water levels are well below field levels in most areas over most of the year. Nevertheless, both rivers flood regularly over extensive areas and it was found that there was some scope for increasing the frequency and period of inundation on several sites. Overall it was found that the potential water regime was highly suitable for at least one target habitat on 13 sites.

In addition to the hydrological assessment a number of other constraining factors were evaluated for each site, including land-use, presence of transport and service infrastructures, presence of archaeological features of interest and the potential flood risk to properties. This provides a general suitability assessment for wetland re-creation. In addition the suitability of the soils, existing habitat and water quality were assessed with respect to each target habitat. Finally, the suitability of the candidate site for target species was evaluated in terms of its topography and landscape, linkage to other habitats and populations, potential habitats, water regime, food resources and levels of disturbance. The results of all these assessments are summarised in Tables 23.1 and 24.1.

Table 23.1. Summary of the wetland re-creation suitability assessments for each candidate site

Site	Suitability with respect to general constraints	Target habitats					Target species				
		Flood meadows (MG4)	Inundation grassland (MG13)	Reedbeds	Wet woodland	Tall herb fen	Breeding waders	Wintering waterfowl	Otters	Water voles	Combined overall suitability
1. R. Severn: Worcester to Holt	High?	High?	Low?	Low?	Medium?	Medium?	Medium	Low	High	?	**Medium**
2. R. Teme & R. Severn confluence	Medium	Low	Medium	Medium	Medium	Low	Medium	Medium	Medium	Medium	**Medium**
3. R. Severn: Upper Ham & Lower Ham near Kempsey	High	Medium	Medium	Medium	Medium	Low	Medium	Medium	Medium	Medium	**Medium**
4. R. Severn: Clifton to Upton on Severn	Medium	High	Medium	Medium	Medium	Low	High	Medium	Medium	?	**Medium**
5. Birch Green	Medium	High?	Medium?	Medium?	Medium?	High?	Medium	Low	Medium	Medium	**Medium/High**
6. R. Severn: Upper & Lower Hams at Upton on Severn	Medium?	High	Medium	Medium	Medium	Medium	High	Medium	Medium	?	**Medium/High**
7. R. Severn, Ukinghall to Tewkesbury	Medium	Medium	Medium	Medium	Low	Low	Medium	High	Medium	?	**Medium/Low**
8. Longdon Marsh	Medium	Medium	High	High	Medium	Low	High	High	High	High	**High**
9. R. Severn: Tewkesbury to Longford	Medium	Medium	High	High	Medium	Medium	High	High	Medium?	High?	**High**
10. R. Severn: Coombe Hill	Medium	Low	High	High	Medium	Low	Medium	High	Medium	High?	**Medium**

Site	Suitability with respect to general constraints	Target habitats					Target species				
		Flood meadows (MG4)	Inundation grassland (MG13)	Reedbeds	Wet woodland	Tall herb fen	Breeding waders	Wintering waterfowl	Otters	Water voles	Combined overall suitability
11. R. Severn: Minsterworth Ham	Low	Low	High	High	Medium	Low	Medium	High	Medium	Medium	**Medium**
12. R. Severn: Elmore Back to Longney	Low	Low (Med*)	Medium (High*)	Medium (High*)	Low (Med*)	Low (Med*)	Medium	Medium	Medium	Medium	**Medium/Low (*Medium/High) * = Wick's Green**
13. R. Severn: Walmore Common	High	Medium	Medium	Medium	Medium	Medium	High	High	Medium?	Medium?	**Medium/High**
14. R. Severn: Awre	High	Medium	Medium?	Medium?	Low?	Low	Medium ?	Medium?	?	?	**Medium**
15. Wicksters Brook and the Moors, Slimbridge	Medium	Low	Medium	Medium	Medium	Low	High	High	?	?	**Medium**
16. Evesham to Birlingham	Medium	Low	High?	High?	Low	Low	Medium	Medium	Medium?	Medium?	**Medium/Low**
17. Eckington Bridge to Tewkesbury	Medium	Medium	High	High	Medium	Low	High	High	Medium?	?	**Medium/High**
18. R. Avon: Bidford on Avon to Offenham	Low?	Low	Medium	Medium	Low	Low	Medium	Medium	Medium?	?	**Medium/Low**

Table 24.1. A summary of the suitability of sites for the re-creation of target habitats and species

Target habitat	Overall suitability of site			
	High	**Medium**	**Low**	**Unknown**
Flood meadows (MG4)	1?,4,5?,6	3,7,8,9,13,14,17	2,10,11,12*M,15,16 18	
Inundation grassland (MG13)	8,9,10,11,16?,17	2,3,4,5?,6,7,12*H,13 14?,15,18	1?	
Reedbed	8,9,10,11,16?,17	2,3,4,5?,6,7,12*H13, 14?,15,18	1?	
Wet woodland		1?,2,3,4,5?,6,8,9,10 11,13,15,17	7,12*M,14?,16,18	
Tall herb fen	5?	1?,6,9,13	2,3,4,7,8,10,11,12* M14,15,16,17,18	
Target species				
Breeding waders	4,6,8,9,13,15,17	1,2,3,5,7,10,11,12 14?,16,18		
Wintering wildfowl	7,8,9,10,11,13,15,1 7	2,3,4,6,12,14?,16,1 8	1,5	
Otter	1,8	2,3,4,5,6,7,9?,10,11 12,13?,16?,17?,18?		14,15
Water vole	8,9?,10?	2,3,5,11,12 13?,16?		1,4,6,7,14, 15,17,18

Note: ? = suitability is uncertain; *M partly medium; *H partly High.

The summary provided in Table 23.1 should be interpreted with care, because, as described in the site accounts and indicated in Table 24.1, most of the sites have the potential for the successful re-creation of some habitats in at least part of their area. Furthermore, because habitats have different requirements, many sites differed significantly in their suitability for re-creating the various targets habitats or restoring populations of the various target species. Thus the selection of candidate sites for wetland-recreation depends on habitat and species objectives.

Nevertheless, some sites are particularly suitable for wetland re-creation and have the potential for meeting multiple objectives. A subjective ranking of the sites in terms of their overall suitability is therefore included in Table 23.1. This indicates that two sites are highly suitable overall: Longdon Marsh (Site 8) and the River Severn floodplain from Tewkesbury to Longford (Site 9). Another four sites were ranked as Medium/High: Birch Green (Site 5), Upton-upon-Severn (Site 6), Walmore Common (Site 13) and the River Avon floodplain from Eckington Bridge to Tewkesbury (Site 17), and also show considerable potential for the re-creation of wetlands of considerable ecological value.

23.2 Constraints and limitations on the study

Although this report has been compiled using the best available hydrological data, it is inevitable that assumptions need to be made, especially when assessing site hydrology. To

have confidence in the conclusions, however, validation of assumptions against observed data is necessary. There are detailed observations relating to river levels for most of the 18 sites under consideration, allowing for the frequency and extent of inundation events to be estimated and permitting assumptions to be tested. Equivalent information with respect to groundwater in superficial aquifers or to water-table depths in the soil profile is not available, as this aspect of site hydrology has been neglected in the Natural Area as a whole. This situation compares poorly with other areas such as the Upper Thames Valley or with many of the East Anglian river valleys, where there is comprehensive hydrological data relating to many sites over many years. As a consequence of this dearth of information, many of the conclusions made within this report, which relate to site hydrology are tentative, and should be treated as such. The original intention within the study was to estimate quantitative water balances for each site, but with such a key piece of information absent, this was not feasible.

On the majority of sites considered in Stage 2, there is an indication from geological maps that river gravel terraces are present. Where this is in fact the case, their presence could well dominate the local hydrology and largely determine the site's suitability for wetland restoration as a whole, particularly in terms of which vegetation types would be best suited to the hydrological regime. It was not possible, within the scope of the present study, to physically determine the presence and depth of such features at more than a couple of sites. The existence of hydrological data from observation wells would have allowed firm conclusions to be drawn regarding the presence and functionality of local gravel aquifers and assumptions could have been made on a much more reliable basis. It is just such data that are lacking, and their collection should be a priority within any subsequent phase of this investigation to alleviate the current constraint.

23.3 Recommendations for future study

Due to the broad nature of this study it is suggested that further investigations are made of the feasibility of re-creating wetlands on the most suitable candidate sites before detailed project proposals are made. Such investigations should comprehensively assess the historic and current wetland habitats of each area and describe their hydrological characteristics. As detailed hydrological data are necessary for these evaluations, it is recommended that baseline surveys and hydrological monitoring is initiated as soon as possible. Such data would permit a more refined characterisation of each site's current hydrology and should allow the effect of future scenarios to be predicted with confidence.

The physical instrumentation of the sites need not be an expensive undertaking. Recurrent monitoring costs would need to be addressed, but may be defrayed if a local volunteer could be found to take periodic readings. A modest number of simple tubewells in the soil profile would be the primary priority. These would require careful location in order to demonstrate the range of variation and direction of seepage within a site. They may need supplementation (perhaps at a later date) by deeper piezometers into underlying semi-confined aquifers, but only if initial investigations and interpretation of water-table data suggest the need.

Installation at other sites of existing or potential interest should also be considered, as a baseline dataset is an invaluable resource, if a threat to the site arises in the future.

The socio-economic implications of wetland re-creation options on local inhabitants and landowners should also be assessed. This would need to address possible impacts on farm-businesses, but should also take into account potential benefits to other components of the

rural economy, eg increased trade from visitors for village shops, pubs and hotels. Wide consultations with interested parties should, therefore, be carried out to evaluate these financial implications and to gauge local support or opposition to potential schemes. Lastly, potential funding sources for land purchase, financial compensation to landowners, capital works and ongoing management requirements must be identified.

This information could then be used to prepare practical costed proposals for phased wetland re-creation. These proposals should define the proposed wetland re-creation area and identify and cost the required hydrological and other land management changes, provide technical specifications for necessary works and quantify the predicted habitat and other biodiversity benefits.

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Appendices

Appendix 1. Project specification

Re-creation options for River Severn/Avon flood plain wetlands

Scope of the project

The project seeks to establish the contribution to the UK Biodiversity Action Plan targets for wetland habitats and species that can be made from wetland re-creation in the Severn and Avon Vales Natural Area.

The Environment Agency (Midlands Region, Lower Severn Area), English Nature (Three Counties Team) and The Royal Society for the Protection of Birds (Central England Region) are jointly looking to identify areas suitable for targeting wetland re-creation within the floodplains of the Rivers Severn and Avon. The area in question is the Severn and Avon Vales Natural Area (see attached map), including all land up to the sea defence line. The habitats proposed for re-creation are coastal and floodplain grazing marsh, wet woodland, reedbed and fen.

Rationale/context

Corporate Plan (1998/99) and Environmental Strategy (1997) underline its lead role in promoting the conservation of water-based habitats and species. English Nature's profile for the Severn and Avon Vales Natural Area identifies flood plain/basin wetland habitats as a key resource and sets objectives for their conservation and re-creation. Re-creation of wetland within this area could make a significant contribution towards the UK Biodiversity Steering Group report (1995) costed targets for fens, reedbed and coastal and floodplain grazing marsh, and possibly subsequent habitat action plan (HAP) targets for wet woodland, marsh and swamp; English Nature's Three Counties Team has currently indicated a provisional target for the re-creation of 100+ hectares of wet reedbed in the Severn & Avon Vales Natural Area. There would also be an indirect contribution to BAP targets for otter, water vole and possibly bittern through creation of suitable habitat.

The Environment Agency Midlands Region has proposed 'Regional Action Plans' for Agency-led contributions towards the wetland costed HAPs (July 1996) relevant to Lower Severn Area. Re-creation of the once regionally significant breeding wader populations in the Severn and Avon Vales is an associated objective.

English Nature's national *Wildlife and Freshwater Agenda* (1996) sets broad re-creation and creation objectives for fens and lowland wet grasslands, whilst the Environment Agency (National Rivers Authority) Warwickshire Avon (1994) and River Severn Lower Reaches (1995) local Catchment Management Plans identify floodplain wetland/landscape restoration and re-creation as key issues with indicative actions.

The RSPB's *Wet Grasslands - What Future?* (1993) highlighted the need for a major and challenging programme to restore and create extensive wetland systems in river valleys. At a regional level the RSPB, with funding from the Environment Agency, commissioned a

breeding wader survey of the Severn Vale (1995) and as a consequence of the poor results is seeking to maintain and enhance sites in the Severn Valley for breeding waders.

Research is necessary to demonstrate firstly where, why and how wetland habitats (and associated species) can be re-created on farmland, and secondly to examine the consequential socio-economic factors. The present uptake of wetland management and restoration options locally under existing agri-environment schemes has been disappointing.

A two phase approach is proposed, but this tender document is for the first phase only.

Aims and objectives

English Nature/EA/RSPB are developing strategic criteria for evaluating candidate wetland re-creation options, incorporating the counties' BAP targets, and the Contractor will be expected to input to this process. These will be fundamental to the Contractor's work in the assessment of site choices and mechanisms.

1 To trial and use selection criteria set by English Nature/EA/RSPB to evaluate possible wetland re-creation sites.
2 To define past and present wetland resource, and hydrological condition of the surviving areas.
3 To identify/evaluate potential target areas/sites for wetland re-creation through the use of existing information and standardised selection criteria.
4 To assess the hydrological determinants relevant to the re-creation candidates: present regimes and necessary/feasible changes.
5 To assess the flood defence/land drainage constraints (capital and maintenance) and technical and financial implications of re-creation in practice.
6 To identify opportunities for achieving wetland re-creation in conjunction with new or upgraded capital flood defence schemes.
7 To predict wetland type(s) and areas likely to be re-created, and the relationship to national and local BAP targets.
8 To produce recommendations for the implementation of a wetland recovery strategy in the Severn/Avon floodplain, and to indicate possible future areas of work.

Outputs/products and timetable/milestones

The project should start in April 1998. The initial stage will involve discussions with English Nature/EA/RSPB staff to develop selection criteria as described in 1 above. Payment will be in three stages: one following the production of a draft report (in mid August), one following the satisfactory completion of the final report (by 30 September) and the third following a workshop and presentation (points 6-7 below, mid September). The report should cover points 1-5 below.

1 An assessment of the historical and present wetland resource and definition of candidate re-creation areas (maps, site descriptions, selection criteria and summary report).
2 An assessment of hydrological determinants/re-wetting options of re-creation candidates (site reports and overview).
3 An assessment of anticipated nature conservation gains from candidates (site reports and overview against agreed objectives).

4 An appraisal of feasibility/viability of candidate options in relation to flood defence parameters.
5 A ranked appraisal of candidates on ecological, technical and direct cost criteria, leading to selection of front-runners for attention in a second phase to be the subject of a further tendering exercise.
6 To run a English Nature/EA workshop preceding English Nature Team/EA Area business planning in August 1998.
7 To make a presentation to EA/English Nature key partners in September 1998 to assist the influencing of delivery mechanisms.

The report should lay out the methods used and clearly identify a ranked list of sites with potential for wetland re-creation. It should include clear colour-coded maps (similar to for example those published in English Nature's *Heathland Re-creation Plan for Worcestershire*, available for inspection at this office) of the historic extent of wetland within the natural area at 1:25,000 scale, and identify current land use of former wetland. Coupled with the above, a map-based plan at 1:25,000 scale should be provided which identifies and evaluates land in the Natural Area which would be of the greatest potential for wetland re-creation, using the agreed criteria.

Ten bound copies and three disk copies of the report should be produced. The report is to be produced by 30 September 1998. The nominated project officer is Dr Peter Holmes based at English Nature's Three Counties Team office, Bronsil House, Eastnor, Ledbury, Herefordshire HR8 1EP, tel 01531 638500.

Information needs (including IT/IS etc)

Data sources would include maps and aerial photos, river corridor aerial videos, Section 24(5) land drainage surveys, existing habitat and species survey information and old records, flood defence/land drainage systems/ hydrological unit functional descriptions and records of capital schemes and maintenance regimes, soils and agricultural land capability, current and proposed Water Level Management Plans for SSSIs.

Environment Agency Lower Severn Area / English Nature Three Counties Team /RSPB Central England Region 9 March 1998

Appendix 2. Current wetlands within the Severn and Avon Vale Natural Area that are designated as Sites of Special Scientific Interest (SSSIs) or County Wildlife Sites

Information presented is based on SSSI Notification Statements and information provided by Worcestershire Wildlife Trust, Gloucestershire Wildlife Trust and Warwickshire Wildlife Trust. Sites that are within Candidate Sites for wetland re-creation identified by this study are indicated in the comments column.

Key to habitat types: O = open water, G = wet grassland, F = fen, R = reedbed, W = wet woodland.

Site no.	Site	Area (ha)	Habitats present	Features of particular conservation importance	Comments
Sites of Special Scientific Interest (SSSIs)					
A	Frampton Pools (SO 753073)	59.84	O	Developing fauna and flora of the disused pits. Local importance for wintering waterfowl.	Disused gravel pits
B	Walmore Common (SO 740162 & SO 745150)	57.78	G	Marshy grassland and ditches in northern part of the site with a wide variety of plants. Southern part important for wintering waterfowl (Ramsar site and SPA for Bewick's swans) with breeding waders on adjoining area of grassland	Part of Candidate Site 13.
C	Badgeworth (SO 911206)	3.08	G	One of only two British sites for adder's-tongue spearwort *Ranunculus ophioglossifolius*.	
D	Coombe Hill Canal (SO 870269)	20.16	G, F, W, O	Nationally rare and scarce invertebrates (particularly beetles) and nationally scarce plants, including golden dock *Rumex maritimus*, corky-fruited water-dropwort *Oenanthe pimpinelloides*, great dodder *Cuscata europaea* and true fox sedge *Carex vulpina*.	Part of Candidate Site 10
E	Ashleworth Ham (SO 833263)	104.7	G	A large area of neutral grassland and ditches of botanical interest with a range of typical wetland plants. Particular importance for wintering waterfowl, including wigeon, teal, mallard and shoveler and occasionally Bewick's swans. Redshank and curlew breed.	Part of Candidate Site 9a.
F	Poolhay Meadows (SO 829308)	2.75	G	Two ancient hay meadows with green-winged orchid *Orchis morio*, great burnet *Sanguisorba officinalis* and meadow thistle *Cirsium dissectum*	
G	Chaceley Meadow (SO 857306)	1.98	G	Unimproved herb-rich neutral grassland with a range of herb species typical of this formerly widespread habitat. Of particular interest is the large population of slender spiked-rush *Eleocharis uniglumis*.	Part of Candidate Site 9a. Traditionally managed.
H	Severn Ham, Tewkesbury (SO 885325)	70.82	G	Traditionally managed ham meadow with rich grassland, the rare narrow-leaved water-dropwort *Oenanthe silaifolia*and breeding lapwing, redshank and curlew.	Subject to annual winter flooding.

Site no.	Site	Area (ha)	Habitats present	Features of particular conservation importance	Comments
I	Old River Severn, Upper Lode (SO 880331)	3.72	O, W, F, G	Holds six nationally rare plants: swamp meadow grass *Poa palustris*, great dodder *Cuscuta europaea*, tasteless water-pepper *Polygonum mite*, small water pepper *P. minus*, mudwort *Limosella aquatica* and needle spiked rush *Eleocharis acicularis*	
J	Rye Street Meadows (SO 785356)	5.5	G	Herb rich pastures characterised by species such as pepper saxifrage *Silaum silaus* and dyer's greenweed *Genista tinctoria*. Also large population of southern marsh orchid *Dactylorhiza praetermissa*.	
K	Upham Meadow and Summer Leasow (SO 917375)	104	G	Semi-improved neutral hay meadow and pastures with one of the largest populations in Britain of narrow-leaved water-dropwort *Oenanthe silaifolia*. Of primary importance for breeding waders (redshank and curlew) and wintering waterfowl (lapwing, dunlin, golden plover and occasionally Bewick's swans). Also has mousetail *Myosurus minimus*.	Part of Candidate Site 17
L	Malthouse Farm Meadows (SO 806390)	4.77	G	Species rich hay meadow, with one of the largest colonies of southern marsh orchid *Dactylorhiza praetermissa* in the county and a particularly important sedge community	
M	Rectory Farm Meadows (SO 922382)	16.17	G	Botanically diverse flood meadows (NVC MG4) with the nationally scarce narrow-leaved water-dropwort *Oenanthe silaifolia*.	Part of Candidate Site 17
N	Upton Ham (SO 860400)	56.6	G	An unimproved flood meadow with a rich and characteristic flora (MG4), including narrow-leaved water-dropwort *Oenanthe silaifolia* and mousetail *Myosurus minimus*. Also has breeding curlew and redshank.	Traditionally managed for hay with aftermath grazing. Part of Candidate Site 6
O	Ashmoor Common (SO 854464)	30.4	G	The site is of geological interest as a palaeochannel (old oxbow) representing an earlier course of the River Severn. It also holds one of the few areas of marshy grassland on neutral to acidic soils, with ditches holding the nationally scarce orange foxtail *Alopecurus aequalis*.	Part of Candidate Site 5
P	Cookshole Meadows (S0 889505)	8.2	G	Unimproved grassland, including two traditionally managed hay meadows and a damp pasture with botanically rich vegetation holding some locally scarce species. Abundant Lepidoptera.	
Q	Northwick Marsh (SO 835579)	5.1	F, G	Open marsh community which is now very scarce in Worcestershire and holds some uncommon plants and a variety of sedges. In winter holds concentrations of teal, snipe and occasionally jack snipe.	Disused clay pits that are grazed by cattle in the summer.

Site no.	Site	Area (ha)	Habitats present	Features of particular conservation importance	Comments
R	Wylde Moor, Freckenham (SP 011603)	11.3	F, G, O	A remnant of the once extensive Feckenham Moor wetland with a variety of marsh and fen vegetation. The site contains a number of pools and peripheral parts of the marsh have been grazed by cattle and support species-rich damp neutral grassland. The site is also one of the most important in the county for dragonflies.	
S	Oakley Pool (SO 893606)	5.9	O, R, F, G	The site contains a pool surrounded by reedswamp, fen and grassland and has a large colony of reed warblers as well as breeding little grebe, tufted duck and pochard.	
T	Grimley Brick Pits (SO 840605)	18.69	W, F, R, O, G	Wide range of wetland habitats present, holding rare county plants, including golden dock *Rumex maritimus* and marsh cinquefoil *Potentilla palustris*. Rich dragonfly fauna and breeding bird community and locally important for wintering waterfowl	Disused clay workings
U	Monkwood Green (SO 800603)	7.5	G	Damp acidic species-rich grassland	
V	Westwood Great Pool (SO 880633)	29.13	O	One of the largest areas of open water in Worcestershire. The lake and its margin supports a wide variety of plants, including two national rarities: eight-stamened waterwort *Elatine hydropiper* and ribbon-leaved water plantain *Alisma gramineum*. One of the most important sites for wintering waterfowl in the county.	Man-made lake
W	Upton Warren Pools (SO 935672)	42.57	O, F, G	A series of shallow pools surrounded by pasture, fen and neglected grassland of principal importance for its breeding birds, including mute swan, tufted duck, great crested grebe and little grebe. The site is also of botanical interest, especially its saline vegetation.	
X	Burley Dene Meadows (SO 814325)	17.13	G,O	Unimproved grassland maintained by hay cutting and light grazing with high naturalness and floristic diversity, including MG4 and MG5 grassland. Corky-fruited water-dropwort *Oenanthe pimpinelloides* is frequent.	
Y	Severn Valley Grasslands 11. Dean Brook Valley Meadows (SO 942605)	4.31	G	Poorly drained pastures with a diverse semi-natural grassland sward, with locally uncommon species including dropwort *Filipendula vulgaris*, saw-wort *Serratula tinctoria*, common meadow-rue *Thalictrum flavum* and common restharrow *Ononis repens*.	

Site no.	Site	Area (ha)	Habitats present	Features of particular conservation importance	Comments
Z	Severn Valley Grasslands 16. Stockwood Meadows (SO 998586)	1.75	G	Traditionally managed hay meadows with a diverse damp semi-natural neutral mesotrophic grassland sward, characterised by crested dog's-tail *Cynosurus cristatus* and common knapweed *Centaurea nigra*. The vegetation is typical of the lady's bedstraw *Galium verum* sub-community. Locally uncommon species include green-winged orchid *Orchis morio* and adder's tongue fern *Ophioglossum vulgatum*.	
AA	Upper Severn Estuary (SO 720060)	1,436		Extensive areas of mud and sandflats bordered by saltmarsh which grades through saltmarsh pasture into neutral grassland, which of outstanding ornithological importance. The site holds internationally important numbers of Bewick's swans, European white-fronted geese and wigeon and nationally important numbers of gadwall, shoveller and pochard.	Adjacent to Candidate Site 15
Worcestershire Special Wildlife Sites					
1	Ley Farm Lake & Wood		O	Fringe of willow scrub / reedbed, with reed warblers and other wetland birds. Oak woodland with rich flora.	
2	Pirton Pool		O, R	Large pool with reedbed. Good for birds including reed warblers.	
3	Norton Brickpits		O	Base-rich pool with calcicolous plants and a couple of black poplars.	Degraded by creation of fishing pools.
4	Hindlip Lake		O	Shallow lake with reedbed, willow scrub and aquatic birds.	
5	Bourne's Dingle and Turnmill Pond Complex (SO 841618)	22.0	O, R, F	A mosiac of semi-natural ancient woodland, open water, marsh and grassland, including one of Worcestershire's largest reedbeds.	
6	Salwarpe Valley		G	Woodland with halophytic plants.	Interest decreased.
7	Nunnery Wood Pools		O, W	Marsh / reedbed.	Possibly denotified
8	Bredon Hardwick Gravel Pits (SO 907355)	16.0	G, O	Complex of flood meadows and a series of old gravel pits. Holds breeding waders (e.g. redshank and lapwing) and is important for wintering waterfowl, including Bewick's swans.	
9	Lower Avon Valley (S0 921389)	70.0	G	The most important flood meadows in Worcestershire for breeding and over-wintering waders and wildfowl. Most meadows are semi-improved, but one on eastbank has marsh-marigold *Caltha palustris*, pepper-saxifrage *Silaum silaus* and great burnet *Sanguisorba officinalis*.	Part of the Avon Valley SSSI (see notes). Part of Candidate Site 17.
11	Lower Moor Pits (SO 980465)	22.0	O, F, W	A complex of pools, marsh, wet woodland and rough grassland. One of the last breeding sites for marsh warbler.	Disused gravel pit.

Site no.	Site	Area (ha)	Habitats present	Features of particular conservation importance	Comments
13	Ford Farm Marsh		G, F	Marsh and sedge bed	
14	Body Brook Marsh		R	Marsh and sedge bed and halophytic plants	
16	Harvington Carr (SP 066491)	4.4	W, F	Mosiac of willow carr, scrub, sedge marsh, pond and rank grassland.	
17	Fladbury Osier Bed (SP 000463)	1.2	W, F	An old osier bed with some marsh vegetation and a rich flora.	
18	Stakumford Marsh		G	Reedbed, fen with marsh with some plants of conservation interest	Part of Candidate Site 18
19	Margate Farm Meadows		G	Old grazed hay meadow (MG5) grassland and a range of damp grasslands	Recently destroyed
20	Osiers (SO 840506)	1.0	W	Managed osier beds with a rich wetland ground flora.	Managed osiers are rare in Worcestershire
21	Severn Stoke Meadow		G	Flood meadows (MG4 grassland)	
22	Kempsey Lower Ham (SO 845484)	27.0	G	Alluvial hay meadow; one of the best examples left in Worcestershire.	Part of Candidate Site 3
23	Clifton Arles Complex		W, F, G	Alder wood and wet marshy grassland with transitions from wet grasslands to mire communities	
24	Uckinghall Meadows (SO 862379)	29.5	G	One of the best examples of an alluvial flood meadow in Worcestershire, with a rich flora, including pepper-saxifrage *Silaum silaus*, great burnet *Sanguisorba officinalis*, narrow-leaved water-dropwort *Oenanthe silaifolia* and mousetail *Myosurus minimus.*	Part of Candidate Site 7. Recently severely damaged or possibly destroyed by applications of chicken faeces
25	Queenhill Brickpit & Uckingham Pool (SO 863374)	2.9	O	Rich wetland flora and a number of dragonflies and damselflies.	Part of Candidate Site 7
26	Ripple Meadow (SO 869362)	3.7	G	Unimproved flood meadow with a rich flora.	Part of Candidate Site 7
27	Ripple Lake & The Napps (SO 874364)	9.0	W, O	One of the largest wet woodlands in Worcestershire, with open water and ditches. Mostly crack willow and osier. Important for wintering teal, wigeon and short-eared owl.	Part of Candidate Site 7
Gloucestershire Key Wildlife Sites (excluding sites that are entirely SSSIs)					
28	Coombe Hill Canal (SO 887272)	13.0	G,F,W	See SSSI description	Part SSSI (4) and GWT Reserve
29	The Small Reserve (SO 855286)	0.8	W	Small osier bed	GWT Reserve

Site no.	Site	Area (ha)	Habitats present	Features of particular conservation importance	Comments
30	Ashleworth Ham and Meerend Thicket (SO 830265)	40.9	G	See SSSI description	GWT Reserve; Part SSSI (5) and part of Candidate Site 9a.
31	Walham Ponds (SO 826206)		O, R, W	Two disused brick pits with open water, emergent vegetation, reedbeds and Osiers, with a rich flora. Important for invertebrates.	
32	Sandhurst Lane Meadows (SO82/19)		G	Damp neutral grassland with a rich flora	Part of Candidate Site 9b
33	Sandhurst Brick Pits (SO 817233)		O, W	Disused brick pits with a variety of wet woodland, open water and water-fringe vegetation. Many uncommon plants occur and rare invertebrates.	GWT Reserve & part of Candidate Site 9b
34	Gloucester and Sharpness Canal (SO 739052 – 744084) & (SO 763098 – 778107)		O	Canal still in use, of particular importance for a number of scarce molluscs. Also used by otters.	
35	Saul Gravel Pits (SO 751091)		O	An area of flooded sand and gravel workings with varied habitats of botanical and ornithological interest.	
36	Newnham Hai Bog (SO 764106)		-	A small marsh with several uncommon species, including marsh helleborine *Epipactis palustris*.	
37	Cambridge Old Canal		F/R?	A small section of old canal, overgrown with emergent vegetation and with an interesting invertebrate fauna.	Part of Candidate Site 15
38	River Frome and Stroudwater Canal		O	Important as an ecological corridor for otters	
39	Mythe Lake and Osier Bed (SO 883345)		O,W,F	Range of wetland habitats, including open water, osier beds and deep ditches. Exceptionally rich in birds, insects and plants.	
Warwickshire					
40	Alderham Pastures (SP 277626)		G	Wet meadow	
41	Warwick Castle Park (SP 285634)		O,R	Parkland including lakes and reedbed	
42	Alderham Osier Bed (SP278620)		W,F	Willow scrub and sedge beds	
43	Longbridge Sewage Works (SP 276632)		W	Willow scrub and tall herbs	
44	Longbridge Brook Meadows (SP 266619)		G	Wet meadow	

Site no.	Site	Area (ha)	Habitats present	Features of particular conservation importance	Comments
45	Riverside Meadows (SP 211558)		G	Marshy grassland	
46	Clopton Bridge Water Meadow (SP 208551)		G	Flood meadow	
47	Ingon Grange Lake (SP 214582)		O	Large pond	
48	Charlecote Park (SP 263564)		O,R	Parkland including a lake and reedbeds	
49	Charlecote Gravel Pits (SP 263575)		O	Ponds	
50	Hampton Wood and Meadow (SP 255559)		G	Ancient woodland and flood meadow	
51	Abbots Salford Scrub (SP 072502)		W	Willow scrub	
52	Exhall Court Wet Meadow (SP 099547)		G,R	Reedbed and scrub	
53	Welford Road Meadow (SP 114513)		G	Wet grassland	
54	Four Alls Meadow (SP 148532)		G	Wet grassland	
55	Binton Riverside Meadow (SP 142531)		G	Wet grassland	

Notes:

Grassland sites were only included if a significant part of the site was a wet grassland type (eg MG5 hay meadows are not included). Most of the small sites that make up the Avon Valley SSSI are not mapped or included as these are designated solely for their breeding marsh warblers (which no longer breed). Wildlife Sites that consist solely of a water course, listed for potential value as a wildlife corridor, have not been included. Several Wildlife Sites are very small in size (ie less than 5 hectares).

The Severn Estuary and Upper Severn Estuary in the adjoining Severn Estuary Maritime Natural Area, are also proposed as Special Areas of Conservation under the EC Habitats and Species Directive.

Wildlife Site numbers are not continuous.

Appendix 3. Current site soil and hydrological parameters

Parameter / Sites	**1**	**2**	**3 Upper Ham**	**3 Lower Ham**	**4**	**5**	**6**
Hydraulic conductivity	High	High	Med	High	High	High	High
Drainable porosity	High	Med	Med	High	High	High	High
pH	5.6	6.2	5.6	5.2	5.6	6.9	5.6
Organic Carbon	Low	Low	Low	Med	Low	High	Low
Soil nutrient status	No data	Improved	No data	No data	No data	part SSSI	SSSI
Soil suitability							
MG4	**High**	**Medium**	**Low**	**High**	**High**	**High**	**High**
MG13	**Low**	**Medium**	**Medium**	**Low**	**Low**	**Low**	**Low**
S4	**Low**	**Medium**	**Medium**	**Low**	**Low**	**Low**	**Low**
W5	**Medium**	**Medium**	**Medium**	**Medium**	**Medium**	**Medium**	**Medium**
S25	**Low**	**Low**	**Low**	**High**	**Low**	**High**	**Low**
Water source (tributaries)	Yes	Yes - in east part	Yes	No	Yes	Yes	Yes
Groundwater (or gravel present)	Some (gravel)	No	No	No	Yes (springs in S)	Yes (springs)	Yes?
Presence/potential of winter surface water	Yes/Yes	Yes/Yes	Yes/Yes	Yes/Yes	Yes/Yes	?	Yes/Yes
Presence/potential of spring or summer surface water	No/No	No/Yes in part	No/Yes	No/Yes	No (some yes in S)/Yes	?	?/Yes
Summer drying	Yes	Yes	Yes	Yes	?	?	Yes?
Sloping land	Gently sloping	No	No	No	Gently sloping	No	No
Water regime suitability							
MG4	**High**	**Low**	**Low**	**Low**	**Medium**	**Medium**	**High**
MG13	**Low**	**Medium**	**High**	**Low**	**High**	**Medium**	**High**
S4*	**Low**	**Medium**	**High**	**Low**	**High**	**Medium**	**High**
W5	**High**	**Low**	**Low**	**Low**	**Medium**	**Medium**	**High**
S25	**High**	**Low**	**Low**	**Low**	**Medium**	**Medium**	**High**
River water quality	Medium phosphate levels	Medium phosphate levels	Medium phosphate levels	Medium phosphate levels	Medium phosphate levels	No data	Medium phosphate levels
Water quality suitability rating							
MG4	**H**	**H**	**High**	**High**	**High**	**?**	**High**
MG13	**H**	**H**	**High**	**High**	**High**	**?**	**High**
S4	**H**	**H**	**High**	**High**	**High**	**?**	**High**
W5	**H**	**H**	**High**	**High**	**High**	**?**	**High**
S25	**L**	**L**	**Low**	**Low**	**Low**	**?**	**Low**
Is site ploughed?	?	Some	?	No	?	No	No
Habitat suitability rating							
MG4	**?**	**Low**	**?**	**High**	**?**	**High**	**High**
MG13	**?**	**High**	**?**	**High**	**?**	**High**	**High**
S4	**?**	**High**	**?**	**High**	**?**	**High**	**High**
W5	**?**	**Medium**	**?**	**High**	**?**	**High**	**High**
S25	**?**	**Medium**	**?**	**High**	**?**	**High**	**High**

* Depends on quantity of water

Parameter / Sites	**7**	**8**	**9**	**10**	**11**	**12**
Hydraulic conductivity	High	Med	Low	Low	Low	High
Drainable porosity	High	High	Med	Med	Med	High
pH	5.6	5.6	5.5	5.5	5.5	7.4
Organic Carbon	Low	Med	Med	Med	Med	Low
Soil nutrient status	Improved	Improved	Improved & umimproved (SSSI)	Improved	No data	Improved
Soil suitability						
MG4	**Medium**	**Low**	**Low**	**Low**	**Low**	**Medium**
MG13	**Low**	**Medium**	**High**	**High**	**High**	**Low**
S4	**Low**	**Medium**	**High**	**High**	**High**	**Low**
W5	**Low**	**Medium**	**High**	**High**	**High**	**Low**
S25	**Low**	**Low**	**Low**	**Low**	**Low**	**Low**
Water source (tributaries)	Yes	Yes	Yes	Yes	Yes	Yes
Groundwater (or gravel present)	No	No	Yes (gravel in NE part)	No	No	No
Presence/potential of winter surface water	Yes/Yes	Yes/Yes	Yes/Yes	Yes/Yes	Yes/Yes	No/Yes
Presence/potential of spring or summer surface water	Some- in osier beds/ Yes in parts?	No/Yes	Yes in parts (Ashleworth Ham)	No / Yes?	No / Yes?	No / Yes
Summer drying	Yes	Yes	Yes	Yes	Yes	Yes
Sloping land	No	No	Some	No	No	Some
Water regime suitability						
MG4	**Low**	**Low**	**Medium**	**Low**	**Low**	**Low**
MG13	**Medium**	**High**	**Medium**	**High**	**High**	**High**
S4*	**Medium**	**High**	**Medium**	**High**	**High**	**High**
W5	**Low**	**Low**	**Medium**	**Low**	**Low**	**Low**
S25	**Low**	**Low**	**Medium**	**Low**	**Low**	**Low**
River water quality	Medium phosphate levels	Medium phosphate levels	Medium phosphate levels	High phosphate levels	Medium phosphate levels	Tidal
Water quality suitability rating						
MG4	**High**	**High**	**High**	**Low**	**High**	**-**
MG13	**High**	**High**	**High**	**High**	**High**	**-**
S4	**High**	**High**	**High**	**High**	**High**	**-**
W5	**High**	**High**	**High**	**Low**	**High**	**-**
S25	**Low**	**Low**	**Low**	**Low**	**Low**	**-**
Is site ploughed?	Some - in north	Some	Some	No	No	Some
Habitat suitability rating						
MG4	**Low**	**Low**	**Low**	**High**	**High**	**Low**
MG13	**High**	**High**	**High**	**High**	**High**	**High**
S4	**High**	**High**	**High**	**High**	**High**	**High**
W5	**Medium**	**Medium**	**Medium**	**High**	**High**	**Medium**
S25	**Medium**	**Medium**	**Medium**	**High**	**High**	**Medium**

* Depends on quantity of water

Parameter / Sites	**13**	**14**	**15**	**16**	**17**	**18**
Hydraulic conductivity	High	High	Med	Med	Med	Med
Drainable porosity	High	High	High	High	High	High
pH	5.6	7.4	5.6	5.6	5.6	5.6
Organic Carbon	High	Low	Med	Med	Med	Med
Soil nutrient status	Half highly improved, half unimproved	No data	Semi-improved to improved	No data	Semi-improved	No data
Soil suitability						
MG4	**High**	**High**	**Low**	**Low**	**Low**	**Low**
MG13	**Low**	**Low**	**Medium**	**Medium**	**Medium**	**Medium**
S4	**Low**	**Low**	**Medium**	**Medium**	**Medium**	**Medium**
W5	**Medium**	**Medium**	**Medium**	**Medium**	**Medium**	**Medium**
S25	**High**	**Low**	**Low**	**Low**	**Low**	**Low**
Water source (tributaries)	Yes	Yes	Yes	Yes	Yes	Small
Groundwater (or gravel present)	No	No	No	No	Yes (gravel)	No
Presence/potential of winter surface water	Yes/Yes	No/Yes	Yes/Yes	Yes in part/Yes	Yes/Yes	Yes/Yes
Presence/potential of spring or summer surface water	Some - reverts to Ag sto if unmanaged / Yes	No/?	No/ Yes	No/?	No / Yes?	No/No
Summer drying	Yes	Yes	No	Yes	Yes	Yes
Sloping land	No	No	No	No	No	No
Water regime suitability						
MG4	**Low**	**Low**	**Low**	**Low**	**High**	**Low**
MG13	**High**	**High**	**High**	**High**	**High**	**Medium**
S4*	**High**	**High**	**High**	**High**	**High**	**Low**
W5	**Low**	**Low**	**Low**	**Low**	**High**	**Low**
S25	**Low**	**Low**	**Low**	**Low**	**High**	**Low**
River water quality	?	Tidal	?	High phosphate levels	High phosphate levels	High phosphate levels
Water quality suitability rating						
MG4	**?**	**-**	**?**	**Low**	**Low**	**Low**
MG13	**?**	**-**	**?**	**High**	**High**	**High**
S4	**?**	**-**	**?**	**High**	**High**	**High**
W5	**?**	**-**	**?**	**Low**	**Low**	**Low**
S25	**?**	**-**	**?**	**Low**	**Low**	**Low**
Is site ploughed?	No	Some	Some	No	No	?
Habitat suitability rating						
MG4	**High**	**Low**	**Low**	**High**	**High**	**?**
MG13	**High**	**High**	**High**	**High**	**High**	**?**
S4	**High**	**High**	**High**	**High**	**High**	**?**
W5	**High**	**Medium**	**Medium**	**High**	**High**	**?**
S25	**High**	**Medium**	**Medium**	**High**	**High**	**?**

* Depends on quantity of water

Appendix 4. Hydrogeological assessment

Site	Geology	Surface water features	Surrounding geology and topography	Nearby Abstractions	Hydrogeological suitability
1. R. Severn - Worcester to Holt	Alluvium and patchy River Terrace deposits overlying Sherwood Sandstone in the north and Mercia Mudstone in the south	River Severn on eastern edge of site, number of springs, ponds and marsh, Grimley Brick Pits SSSI, Grimley Brook	Steep western slope comprising Sherwood Sandstone outcrop in north, River Terrace deposits over Mercia Mudstone in the south	No abstractions	High. High groundwater levels result from sandstone seepage flows and from hydraulic continuity with adjacent River Severn, also number of significant surface water features and no abstractions
2. R. Teme and Severn confluence	Alluvium underlain by Mercia Mudstone	River Teme, marsh and some ditches, but no springs or SSSI's	Higher ground to north and south, comprising patchy River Terrace deposits underlain by Mercia Mudstone	Three surface water and two groundwater abstractions, little significance	Moderate. Alluvium in hydraulic continuity with River Teme, some inflow from adjacent areas and no significant abstractions, but few significant surface water features
3. R. Severn - Kempsey	Alluvium underlain by Mercia Mudstone	River Severn on western edge of site and numerous ditches and ponds, but no springs, marsh or SSSIs	Slightly higher ground to east, comprising patchy River Terrace deposits underlain by Mercia Mudstone	Two River Severn abstractions, little significance	Low. Alluvium in hydraulic continuity with River Severn and no abstractions of significance, but little inflow from adjacent areas and few significant surface water features
4. R. Severn - Baynhall to Upton on Severn	Alluvium underlain by Mercia Mudstone	River Severn and numerous ditches and ponds, but no springs, marsh or SSSIs	Reasonably flat ground, comprising River Terrace deposits underlain by Mercia Mudstone	Six River Severn and one groundwater abstraction, only latter of significance	Low. Alluvium in hydraulic continuity with River Severn, but little inflow from adjacent areas, few significant surface water features and one small groundwater abstraction
5. Birch Green	Peat and Alluvium over Mercia Mudstone	Spring, marsh and Ashmoor Common SSSI, unnamed Severn tributary running entire length of site	Shallow valley slopes comprising River Terrace deposits and Mercia Mudstone	Three surface and one groundwater abstraction, together of some significance	Moderate. Extensive Peat cover and also a number of significant surface water features, but little inflow from adjacent areas and some significant abstractions
6. R. Severn - Upton on Severn	Alluvium underlain by Mercia Mudstone	River Severn on eastern edge of site and some marsh and numerous ditches, but no springs or SSSIs	Flat ground comprising River Terrace deposits underlain by Mercia Mudstone	Two major River Severn abstractions	Low. Alluvium in hydraulic continuity with River Severn, but little inflow from adjacent areas, no springflows and two major River Severn abstractions
7. R. Severn - Ukinghall to Tewkesbury	Alluvium underlain by Mercia Mudstone	River Severn and some marsh and numerous ditches, Ripple Lake and Mythe Brook, but no springs or SSSIs	Gently sloping ground comprising patchy River Terrace deposits underlain by Mercia Mudstone	One River Severn and one groundwater abstraction, little significance	Moderate. Alluvium in hydraulic continuity with River Severn, also a number of surface water features and no significant abstractions, but little inflow from adjacent areas

Site	Geology	Surface water features	Surrounding geology and topography	Nearby Abstractions	Hydrogeological suitability
8. Longdon Marsh	Alluvium underlain by Mercia Mudstone	No springs, marsh or SSSI's, but headwaters of Longdon Brook	Higher ground on all sides, comprising patchy head and fan gravel over Mercia Mudstone	One surface water and one groundwater abstraction, the former possibly of significance	High. Enclosed headwaters of Longdon Brook, significant runoff from surrounding higher ground, but one possibly significant surface water abstraction
9. R. Severn - Tewkesbury to Longford	Alluvium and patchy River Terrace deposits underlain by Mercia Mudstone (site 9a) or Blue Lias limestone (area 9b)	River Severn and two SSSI's (Asleworth Ham and Chaceley Meadow), some marsh and numerous ditches, ponds and streams, including Newhall Brook, Horn's Ditch and Broadboard Brook, but no springs	Steeply sloping ground in places, comprising patchy River Terrace deposits underlain by Mercia Mudstone and Lias Group limestones and clays	Four River Severn abstractions, little significance	High. Alluvium in hydraulic continuity with River Severn, also a number of significant surface water features, runoff and groundwater inflows from adjacent areas and no significant abstractions
10. R. Severn - Coombe Hill	Alluvium underlain by Mercia Mudstone	No springs, but some marsh, one SSSI and numerous watercourses, including the lower River Chelt, Coombe Hill Canal, Leigh Brook and Collier's Brook	Steeply sloping ground in places, comprising Mercia Mudstone and Lias Group limestones and clays	No abstractions	High. Alluvium in hydraulic continuity with River Chelt, also a number of significant surface water features, runoff from adjacent areas and no abstractions.
11. R. Severn - Minsterworth Ham	Alluvium underlain by Lower Lias clays	River Severn on eastern edge of site and numerous ditches and ponds, but no springs, SSSIs or marsh	Gently sloping ground, comprising patchy River Terrace deposits underlain mainly by Lower Lias clays	One River Severn abstraction, little significance	Low. Alluvium in hydraulic continuity with River Severn and no significant abstraction, but limited runoff from adjacent areas and no significant surface water features
12. R. Severn - Elmore Back to Longney	Alluvium underlain by Mercia Mudstone in the north and by Lower Lias clays in the south. Small areas where Lower Lias clays exposed at outcrop	River Severn on northern and western edges of site and numerous ditches and ponds, including Groundless Pool, but no springs, SSSIs or marsh	Steeply sloping ground, comprising patchy River Terrace deposits underlain by Mercia Mudstone and Lower Lias clays	No abstractions	Moderate. Alluvium in hydraulic continuity with River Severn, some runoff from adjacent areas and no abstraction, but few significant surface water features
13. R. Severn - Walmore Common	Alluvium, River Terrace deposits and peat underlain by Mercia Mudstone	No springs, but numerous ditches and ponds, extensive heath cover and existing Walmore Common SSSI and RAMSAR site	Almost entirely surrounded by fairly steeply sloping ground, comprising Lower Lias clays and limestone and Tea Green Marl	One surface water abstraction, little significance	High. Existing SSSI and RAMSAR site, with extensive peat cover, some runoff from adjacent areas and no significant abstraction.
14. R. Severn – Awre	Alluvium underlain by Lower Lias clays	Alongside the River Severn. No springs, SSSIs or marsh, but a few ditchesand opposite Slimbridge tidal marshes	Gently sloping ground to the west, comprising patchy River Terrace deposits underlain by Lower Lias clays	No abstractions	Low. Alluvium in hydraulic continuity with River Severn and no abstractions, but little inflow from adjacent areas and few other significant surface water features

Site	Geology	Surface water features	Surrounding geology and topography	Nearby Abstractions	Hydrogeological suitability
15. Wicksters Brook and the Moors, Slimbridge	Alluvium underlain by Lower Lias clays	One spring and numerous watercourses, including the River Cam, Wickster's Brook, Lighten Brook, Gilgal Brook and Billow Brook. Adjacent to Slimbridge SSSI	Gently sloping ground to the south, comprising patchy River Terrace deposits underlain by Lower Lias clays	Unknown	High. Alluvium in hydraulic continuity with River Cam and several other watercourses and adjacent to a major wetland SSSI, but little inflow from adjacent areas and no abstraction data
16. Evesham to Birlingham	Alluvium underlain by Lower Lias clays	The River Avon, one spring, several ditches and discrete areas belonging to the Avon Valley SSSI.	Generally gently sloping ground, comprising River Terrace deposits underlain by Lower Lias clays	15 surface water and 2 groundwater abstractions, some of significance	Moderate. Alluvium in hydraulic continuity with River Avon, and one spring and some inflow from adjacent areas, but some significant abstractions and few significant surface water features
17. Eckington Bridge to Tewkesbury	Alluvium underlain by Lower Lias clays over most of the area, but by Blue Lias limestone in the extreme south	The River Avon, one spring, numerous ditches and Upham Meadow and Summer Leasow SSSI	Generally gently sloping ground, comprising River Terrace deposits underlain by Lower Lias clays and Lue Lias limestone	6 surface water and 1 groundwater abstractions, little significance	Moderate. Alluvium in hydraulic continuity with River Avon, one spring, some inflow from adjacent areas and no significant abstractions, but few significant surface water features
18. R. Avon - Bidford on Avon to Offenham	Alluvium underlain by Mercia Mudstone over most of the area, but by Lower Lias clays in the extreme south	The River Avon and numerous ditches and ponds, but no marsh or SSSI	Occasionally steeply sloping ground, comprising River Terrace deposits underlain by Mercia Mudstone and Lower Lias clays	10 River Severn abstractions, little significance	Moderate. Alluvium in hydraulic continuity with River Avon, some inflow from adjacent areas and no significant abstractions , but few surface water features

Appendix 5. Gloucestershire County Council Sites and Monuments Record

See corresponding figures for locations within each candidate area.

SMR number	Description	Grid reference	
Area 9a			
475	Ashleworth tithe barn	381790	225210
4342	Possible enclosures - Ashleworth Quay	382000	225200
5504	Forthampton Court	387000	231780
5543	The Naight	386700	229700
5548	Coombe Hill Canal	385000	226530
5561	St Andrew & St Bartholomew Church Ashleworth	381850	225180
5562	Cross in Churchyard	381850	225180
5564	Ashleworth Court	381860	225210
5569	St Michael's Church Tirley	384010	228550
5570	Haw Bridge-Bronze Bowl Find	384500	227800
5575	Bronze Palstave	384500	225800
7443	Roman Pottery	384400	227700
7662	Cropmarks	384430	228150
7666	Malthouse	384400	227700
8530	Mill House Fieldname	386200	230900
8578	The Nap Fieldname	384800	226400
8579	Ripples Fieldnames	386800	229400
8583	The Grove Fieldname	386700	231400
8670	Grove Ground Fieldname	384800	228800
8672	Gallows Leasow Fieldnames	384250	227750
8674	Broadlains Fieldname	384050	227450
8728	The Grove Fieldname	385500	228200
9732	Roman Pottery recovered from River Severn	381900	225100
11139	The Old Ferry Inn, Chaceley Stock	386500	229700
11147	Quay	381800	225100
11152	Coal Wharf at Apperley	385400	228300
11153	Old wharf and Inn at The Haw	384500	227800
15680	Chaceley Stock Brickworks.	386420	229800
17026	Flow gauging station and associated works, Priory Farm	387030	229970
Area 9b			
4660	Abloads Court DMV-Earthworks	382550	221900
5582	Abloads Court DMV	382800	221300
7678	Cropmark	382000	224700
8517	Hill Close & Long Ridge Hill Fieldname	380800	224700
8590	Old Mill Fieldname	383500	221500
8592	Brick Kiln Acre Fieldname	382100	224700
8599	The Grove Fieldname	382200	222800
9616	Queens Dyke Roman Occupation	383000	220500
11855	Roman pottery from trench observation	382770	220970
17582	Ridge and furrow	383300	220600
Area 10			
4459	Moat-Leigh Court	386480	225660
4466	Earthworks-Elvington House	388350	226840
5548	Coombe Hill Canal	385000	226530
5553	Canal Cottages	388600	227300
5571	Medieval Bridge	384900	226200
5601	Nortonbrigge	386870	224930
7158	Cropmark	385800	226100
7159	Lime Slaking Pit	386400	225600

SMR number	Description	Grid reference	
7283	Little Brick Mill	386600	224800
7284	Remains of Moat	386900	224700
7285	Site of Windmill	385800	224400
7286	Cropmark	386000	224600
7287	Cropmark	386200	224800
8566	Stanway Piece Fieldname	386150	224250
8578	The Nap Fieldname	384800	226400
8730	Tumpy Milkland Fieldname	388300	227700
8732	Notberrry Butts Fieldname	388400	226500
13836	Mound On Low Hill	386810	224670
15007	Brawn Farm	387110	227160
Area 11			
4427	Earthworks-Upper Ham Green	379750	217800
5274	Alleged course of Roman Road	379800	217900
8555	The Dark Orchard Fieldname	379600	217800
8560	Pucks Fieldname or "Poolmead" and "Poolend" or "Poolend House and Orchard".	377900	216800
8561	Black Woman Ground Fieldname	378400	216700
8564	Rudgey Ground Fieldname	379400	217100
8565	Knowles of "The Knolls" fieldname	379300	216500
14982	Upper Moorcroft Farm, Minsterworth	379700	218400
14983	Middle Moorcroft Farm, Minsterworth	379600	218200
15018	Kacott's Green fieldname, Minsterworth	378100	216960
15019	Netland's Tump fieldname, Minsterworth	378300	216900
15072	Cornham Green, Minsterworth	379200	216800
15073	Ham Green, Minsterworth	379200	217330
15074	Ham Orchard, Minsterworth	379940	217700
15085	Site of buildings, Minsterworth	377880	216720
16693	Roman land reclamation	370000	210000
17955	Fishing hut along the Severn at Minsterworth	377740	216780
19875	Finds from Linton Farm Highnam	379900	218900
Areas 12 & 13			
4650	Dubious enclosure Walmore Common	373900	215200
5281	Elmore Court	478280	215330
7576	Windmill Hill	378900	215800
9451	Cropmarks south of Lake Street Farm	376970	216040
11125	Romano-British Building Material at Windmill Hill	378700	216300
11127	Roman finds at Bridgemacote	376200	215400
11128	Medieval finds at Bridgemacote	376200	215400
12717	Early medieval finds at Bridgemacote	376200	215400
13065	C12-3 pottery near Lake Street Farm	376970	216040
13066	Fragments of C17 clay pipes - Lake Street Farm	376900	216000
14519	Romano-British settlement	376000	213000
14978	NRA Priding to Bush Crib scheme: stage 1 archaeological assessment	374200	210500
16689	Undetermined ridge and furrow, Elmore Parish	378300	216100
16690	Undetermined ridge and furrow	375900	215600
16692	Undetermined ridge and furrow south-east of Lake Street Farm	376900	216150
16693	Roman land reclamation	370000	210000
16695	Great Wall, Roman sea defences	370000	210000
16702	Post Medieval ridge and furrow	376100	214900
Site 14			
4352	Earthwork SE of Awre Church	371050	208000
9502	Awre Fishtrap.	372000	208000
9503	Fish trap - Frampton	371900	207600

SMR number	Description	Grid reference	
9507	Fish trap, SOOm E of Whitescourt	371320	207630
9537	Exposures of Wentlooge Peats	371500	207000
4098	Earthworks S of Prices Court Farm - Shepherd's Patch	372950	203950
4109	DMV type earthworks NW of Newhouse Farm	74400	4350
4639	Cropmark complex - Lighten Brook/Lane	373100	203500
4641	Enclosure & Linear features	375150	205280
5218	Doubtful moat & cropmarks	375700	204300
5221	RB pottery Elmcote Farm	375700	203200
5222	Pottery finds Elmcote Farm	375600	202700
5257	Canal at Cambridge	373900	205100
5692	Wickster's Bridge	375610	204780
5954	Romano-British Pottery Finds at Elmcote Farm	376000	202900
7025	Possible Moat	376420	204900
11157	The Gloucester and Sharpness Canal	366800	202200
12495	OS parcel SO2257	375300	205500
12496	OS parcel SO2444	375200	205400
12497	OS parcel SO1500	375130	205350
12498	OS parcel SO0006	375050	205300
12499	OS parcel SO8732	374980	205150
12500	OS parcel SO7800	374900	205100
15604	Watching Brief at Slimbridge sewerage system.	373032	204140
19833	Slimbridge Munitions Depot	372200	202400

Appendix 6. Licensed abstractions within the vicinity of candidate sites

See Soil maps for locations of abstractions.

Candidate site	Licence number	Source	National Grid Reference	Use	Annual Quantity (m^3)
2 & 3	18/54/8/100	Surface	SO 8485 5035	Spray irrigation	27,276
2	18/54/8/414	Surface	SO 8505 5225	Spray irrigation	9,092
2	18/54/8/310	Surface	SO 8395 5095	Spray irrigation	7,062
3	18/54/8/401	Ground	SO 8495 4945	Spray irrigation	4,318
4	18/54/8/205	Surface	SO 8475 4755	Spray irrigation	13,638
4	18/54/8/209	Ground	SO 8440 4530	Agriculture other than spray irrigation	1,659
4	18/54/8/371	Surface	SO 8460 4470	Transfer to stream	100,012
4	18/54/8/465	Surface	SO 8465 4745	Spray irrigation	72,736
4	18/54/8/466	Surface	SO 8475 4455	Spray irrigation	31,822
4	18/54/8/494	Surface	SO 8377 4521	Spray irrigation	18,000
4	18/54/8/497	Surface	SO 8423 4488	Spray irrigation	27,272
5	18/54/8/204	Surface	SO 8535 4635	Spray irrigation	1,031
5	18/54/8/372	Surface	SO 8545 4565	Spray irrigation	54,552
5	18/54/8/397	Ground	SO 8555 4585	?	72,736
5	18/54/8/416	Surface	SO 8525 4515	Spray irrigation Agriculture other than spray irrigation	30,940 45,460
6	18/54/8/101	Surface	SO 8645 3985	Public Water Supply	60,225,000
6	18/54/8/486	Surface	SO 8641 3960	Mineral washing	100,000
7	18/54/8/272	Ground	SO 8675 3815	Spray irrigation	909
7	18/54/8/439	Surface	SO 8635 3765	Water level maintenance	5,455
8	18/54/8/341	Surface	SO 8250 3590 - SO 8360 3710	Spray irrigation	22,730
8	18/54/8/309	Ground	SO 8176 3620	Agriculture other than spray irrigation	68
9	18/54/8/165	Surface	SO 8895 3365	Public Water Supply Circulated cooling water	43,920,000 5,856,000
9	18/54/20/265	Surface	SO 8775 3195	Spray irrigation	19,120
9	18/54/26/310	Surface	SO 6815 2945	Spray irrigation	4,546
9	18/54/20/75	Surface	SO 8215 2165	Circulated cooling water	32,731
9	18/54/20/231	Surface	SO 8265 2495	Spray irrigation	20,693
9	18/54/20/312	Surface	SO 8195 2255	Spray irrigation	2,097
11	1854/20/323	Surface	SO 8055 1815	Spray irrigation	40,915 13,630
13	18/54/20/344	Surface	SO 7415 1495	Spray irrigation	25,000
16	18/54/17/104	Surface	SP 0035 4735	Spray irrigation	10,229
16	18/54/17/130	Surface	SO 9835 4515	Spray irrigation	15,911
16	18/54/17/151	Surface	SO 9545 4545	Spray irrigation	11,365

Candidate site	Licence number	Source	National Grid Reference	Use	Annual Quantity (m^3)
16	18/54/17/207	Surface	SO 9525 4505	Spray irrigation	41,369
16	18/54/17/278	Surface	SO 9565 4605	Spray irrigation	41,096
16	18/54/17/292	Surface	SP 0235 4635	Spray irrigation	4,210
16	18/54/17/232	Ground	SO 9495 4545	Spray irrigation	318
16	18/54/17/305	Ground	SO 9450 4510	Agriculture other than spray irrigation	455
16	18/54/17/306	Surface	SO 9735 4635	Spray irrigation	54,552
16	18/54/17/372	Surface	SP 0015 4715	Spray irrigation	182
16	18/54/17/361	Surface	SO 9635 4725	Spray irrigation	25,700
16	18/54/17/381	Surface	SO 9995 4615	Spray irrigation	159,110
16	18/54/17/279	Surface	SO 9815 4525	Spray irrigation	19,939
16	18/54/17/477	Surface	SO 9565 4725	Spray irrigation	182
16	18/54/17/524	Surface	SO 6675 4515	Spray irrigation	172,800
16	18/54/47/648	Surface	SO 9555 4715	Spray irrigation	2,727
16	18/54/17/678	Surface	SO 9522 4612	Spray irrigation	1,542
17	18/54/17/9	Ground	SO 9179 3871	Agriculture other than spray irrigation	1,637
17	18/54/17/178	Surface	SO 9115 4225	Spray irrigation	110,000
17	18/54/17/608	Surface	SO 9095 3705	Spray irrigation	2,232
17	18/54/17/635	Surface	SO 9195 3955	Spray irrigation	10,000
17	18/54/17/63	Surface	SO 9215 3775	Spray irrigation	10,000
17	18/54/17/656	Surface	SO 9024 3535	Spray irrigation	4,546
17	18/54/17/657	Surface	SO 9175 3574	Spray irrigation	4,546
17	18/54/17/683	Surface	SO 9088 4174	Spray irrigation	5,238
18	18/54/17/195	Surface	SP 0665 4715	Spray irrigation	2,273
18	18/54/17/105	Surface	SP 0625 4715	Spray irrigation	3,346
18	18/54/17/270	Surface	SP 0595 4725	Spray irrigation	1,137
18	18/54/17/288	Surface	SP 0635 4615	Spray irrigation	3,182
18	18/54/17/289	Surface	SP 0605 4725	Spray irrigation	1,364
18	18/54/17/317	Surface	SP 0665 4815	Spray irrigation	25,003
18	18/54/17/324	Surface	SP 0655 4715	Spray irrigation	4,546
18	18/54/17/462	Surface	SP 0505 4745	Spray irrigation	18,502
18	18/54/17/567	Surface	SP 0755 4915	Spray irrigation	68,190
18	18/54/17/675	Surface	SP 0600 4720	Spray irrigation	9,092
18	18/54/17/701	Surface	SP 0825 5075 - SP 0795 4990	Spray irrigation	27,272

Notes: No information was supplied for Candidate Site licences 18/54/9/48, 18/54/9/49 & 18/54/9/53. No licensed abstractions occur at Candidate Sites, 1, 10, 12, and 14. No information was supplied for Candidate Site 15.

ENGLISH NATURE

Research Information Note

English Nature Research Reports, No 692

Re-creation options for River Severn / Avon floodplain wetlands

Report Authors: Ecoscope Applied Ecologists, Silsoe College & Aspinwall Clouston Ltd, January 1999

Keywords: wetland, habitat restoration, re-creation, River Severn, River Avon, breeding waders

Introduction

The aim of this project has been to identify and assess areas that are suitable for the re-creation of floodplain wetland habitats within the Severn and Avon Vale Natural Area, as defined by English Nature.

Although historic data on habitats within the Natural Area are scattered and incomplete, it is clear that a large proportion of the River Severn and Avon floodplains formerly consisted of wetlands, predominantly natural marshland and wet woodland communities. These natural habitats were then gradually replaced by wet grasslands for hay production and grazing. Such traditionally managed semi-natural grasslands had rich plant communities and often held substantial numbers of breeding and wintering birds.

However, the majority of wetlands within the Natural Area have been lost as a result of centuries of river impoundments and other navigational improvements, flood prevention measures and drainage schemes. Furthermore, in recent years, many of the remaining wet grasslands have been lost or degraded through agricultural improvements including ditching, field drainage, re-seeding and the use of fertilisers. As a result, only small remnants of semi-natural grassland remain and fens, reedbeds and wet woodlands are now relatively rare. In turn, many associated species, including some nationally rare and scare wetland plants and breeding waders, have also declined.

What was done

Four formerly widespread habitats of particular biodiversity importance were identified as targets for this project:

- semi-natural wet grasslands, in particular species-rich flood meadows (National Vegetation Classification community MG4) and inundation grasslands (NVC community MG13);
- reedbed (NVC community S4);
- tall herb fen (NVC community S25);
- wet woodland (NVC community W5).

The re-creation of such wetlands could make a significant contribution to the UK Biodiversity Strategy and implementation of its associated Habitat Action Plans, such as for reedbeds and grazing marshes, and Species Action Plans, such as for otters and water voles. The re-creation of these habitats also aims to contribute to biodiversity actions for other associated UK Species of conservation concern, including breeding waders (eg curlew, lapwing, redshank and snipe), wintering waterfowl (eg Bewick's swans), as well as to regional, county and local biodiversity targets.

The study was carried out in a two-stage process using two levels of criteria. The first stage aimed to identify large areas of the Natural Area that are of general suitability for wetland re-creation in terms of their topography, current land-use, general soil suitability and water availability (eg groundwater sources and flooding frequency). This initial broad assessment revealed that there is a large area of land that could feasibly be used for wetland re-creation in the Natural Area. However, 18 large candidate areas (with preliminary boundaries) were identified for further detailed investigation and evaluation against a second set of criteria.

In the second stage each of these 18 candidate areas was assessed in terms of potential constraining factors, including land-use (eg housing, commercial use or presence of high grade agricultural land under intensive farming), presence of transport and service infrastructures, presence of important archaeological features and flood defence considerations. Each area was also evaluated in relation to the requirements of each of the above target habitat types. In particular, assessments were made of the suitability of the soils, potential water regime, quality of water supply and the existing habitat. Finally, each candidate area was assessed in terms of its suitability for target species groups, taking into account land-use and topography, linkage to other suitable habitats and populations, the potential habitat and water regime that may be re-created, available food resources and the potential impacts of disturbance.

Continued……..

For each criterion, the area was ranked according to three levels of suitability for the creation of wetlands: low, medium or high.

The project was primarily carried out as a desk-study of existing data, supplemented with information obtained during brief visits to some of the key candidate areas. Further information was also obtained by consultations with landowners and trustees, IDB representatives, Wildlife Trusts, the Environment Agency, English Nature and RSPB.

Results and conclusions

The overall conclusion of the study is that there is considerable potential for re-creating a range of different wetland types in the Severn and Avon Vale Natural Area. Most of the candidate areas have the potential for the successful re-creation of one or more target habitat in at least part of their area. Furthermore, some areas are particularly suitable for wetland re-creation and have the potential for meeting multiple objectives.

English Nature's viewpoint

Due to the broad nature of this study and current hydrological and other data limitations, it is suggested that further detailed investigations are made of the feasibility of re-creating wetlands on the most suitable candidate areas. This should include confirmation of each area's historic, current and potential hydrology and habitats. Consultations with landowners and other interested parties must also be carried out to assess the socio-economic implications of various wetland re-creation options and to measure support or oppositions to potential schemes. This information should then be used to prepare practical costed proposals for phased wetland re-creation.

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