TOOLKIT FOR RAPID ASSESSMENT OF SMALL WETLAND SITES

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Status:	Version 2 (Final)
Date:	3rd March 2014
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WAAS Project ref:	P3783
EH ref:	PNUM 6244MAIN
Report reference:	1982

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Toolkit for rapid assessment of small wetland sites

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Part 1 Project summary

This project has further developed and widely implemented a toolkit for the rapid identification, mapping and assessment of small wetland sites within areas of Worcestershire identified as being most under threat from development and other pressures.

Such small and discrete sites are often at far more threat than the generally better documented and protected large expanses of blanket peats in England, yet contain unique and important evidence potential. The toolkit provides a rapid approach for the mapping and assessment of such assets within an Historic Environment Record (HER), thereby making the information readily accessible, and ensuring that such significant deposits are better identified, better recognised, and thus more effectively protected in the future.

It involves both mapping and rapid desk-based assessment of the wetland sites, tested by the validation or ground-truthing of a selection of these assets. A total of 1,652 new sites have been mapped and their potential assessed through the project and, in addition to data from previous projects, there are now 4,911 records of this type mapped within the Worcestershire HER.

Only a small percentage of these sites had been previously recorded on the HER with for example only 2.7% of identified marshes and 7.6% of ponds having been previously recorded. This demonstrates that the mapping tool greatly improves the recording of such features in the HER, flagging up their potential to contribute towards archaeological knowledge, and improving the management and protection of such sites. The majority of the 272 sites that had previously been recorded on the HER were features with a cultural association, for example, fishponds and moats, site types for which only a few newly recorded examples were identified in strong contrast to the numerous examples of newly mapped natural features.

Validation of a selection of the mapped sites through walk-over survey undertaken by local volunteers has proved invaluable, with photographic records proving particularly invaluable. The assessment of potential after validation was in agreement with the initial desk-based assessment for many of the validated sites. Exceptions to this were wooded sites where there was no obvious marshy ground, and hence potential seemed lower.

The project has demonstrated that the toolkit is highly effective in providing a rapid overview of the potential of small wetlands in Worcestershire, and is a method that could be replicated elsewhere. Many new sites with potential for palaeoenvironmental study can be added to the HER, covering large areas at a relatively low cost. It is recognised that such a broad-brush and desk-based approach will not comprehensively map or accurately assess all small wetland sites, however, the low cost, rapid and extensive HER enhancement that can be provided by using the toolkit within a county (or defined project area), is invaluable, providing a platform from which further knowledge can subsequently be added. Areas where the toolkit could be refined or enhanced have also been identified to address limitations in the current approach and these warrant testing. Recommendations include use of the 2nd Edition OS in addition to the 1st Edition for base-mapping in order to provide more comprehensive coverage without significantly increasingly resources required. The use of British Geological Survey data on geology and drift deposits and of Environment Agency LiDAR mapping held by the HER have also been identified as particularly useful potential additional sources for examination and/or more detailed consideration to both improve the range of features identified and provide more accurate desk-based assessment of their potential where this is required.

The toolkit, though currently focussing on a well-defined geographical area, is considered suitable to have the potential for application more widely, although minor adaptations may be required to reflect the different conditions and type sites which may be present in other regions.

Part 2 Detailed report

1. Background

Worcestershire, like many areas of the country, is not associated with extensive wetland landscapes that are generally considered to produce large bodies of valuable archaeological and palaeoecological information such as those recovered from the well known and well surveyed Cambridgeshire/Lincolnshire fenlands or Somerset Levels. Nevertheless, small wetland sites or deposits are widely dispersed across the county and have high significance for palaeoenvironmental work. These include, for example, marshes, natural ponds, fishponds and millponds, palaeochannels, mill leats and mill races, moats and organic deposits within cut-off river/stream meanders or pronounced meander loops.

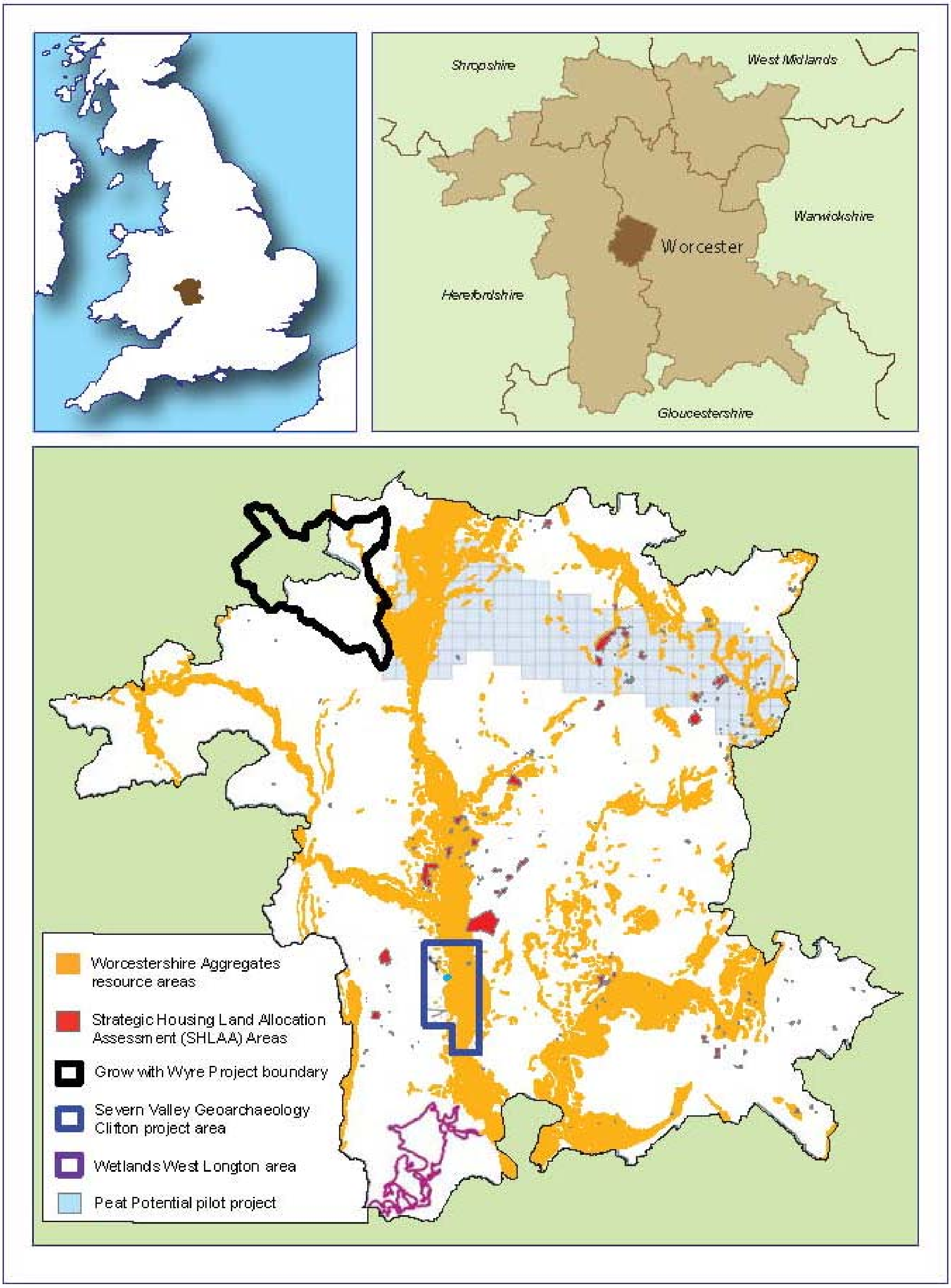
Palaeoenvironmental data from such organic deposits (organic and inorganic) is essential to interpret long-term environmental change, much of which relates to human activity, and to provide a landscape context for archaeological data. These wetland areas are localised and increasingly highly vulnerable to destruction by housing and business development, quarrying, water extraction, flood mitigation measures, climate change and even wetland restoration, yet they are an important resource as they often provide high quality data on past environment from small catchment areas in the immediate vicinity of significant archaeology. Although not a focus of this project, other material such as worked wood, leather, and timber structures (for example relating to mill and fishpond dams or weirs) which are of archaeological value, may also survive in these features. For example, numerous wooden items survived in waterlogged deposits relating to a mill race and bypass channel at Bordesley Abbey near Redditch (Astill 1993) which included cogs, pegs, wedges and weaving apparatus (a heddle horse, winding peg and warping paddle). Hence this toolkit can be used to highlight potential survival of cultural and structural remains as well as palaeoenvironmental data.

Palaeoenvironmental data from such small catchment areas is valuable because it records local environmental change thus providing greater prospect of linking changes in environment seen in the data to specific events (for example, human activity on a known archaeological site in the vicinity) where precise chronology exists (Geary *et al* 2009).

The distribution and potential of such palaeoenvironmental assets in areas such as the West Midlands (with the exception of the North-West wetlands) is poorly understood. This largely arises from the fact that historically palaeoenvironmental deposits have not been formally recognised as an element of the historic environment resulting in poor understanding and notably in poor representation on HERs; the primary tool used by archaeological curators and other practitioners in identifying and scoping sites in the first instance.

The problem of under-representation on HERs can be threefold and cyclical. Firstly, during the planning process potential for good preservation of organic deposits may not be recognised by all archaeological curators. Some may have limited knowledge of palaeoenvironmental work as this is a specialised area of study. Secondly, in such circumstances it is likely that no specifications will be made in the brief for assessment or analysis of organic deposits and opportunities for gaining palaeoenvironmental data from these deposits will be missed. Thirdly, missed opportunities for gathering palaeoenvironmental data will further result in data from small wetland sites not being represented in county HERs. Even where good palaeoenvironmental data has been recovered, the manner in which HER data is recorded usually results in the data not being readily accessed and visible.

The toolkit developed and resultant presentation of the information gathered as a GIS layer on an HER, enables rapid mapping and assessment of many of these small wetland sites and makes them 'visible' to the curator at an early stage in the planning process, thus enabling the inclusion of their study as part of archaeological projects. Effective incorporation of the palaeoenvironmental data into the HER (and updating of the small wetland assessment) closes the loop. The toolkit, if widely disseminated and accepted, may also encourage researchers (for example, from universities) to consider carrying out palaeoenvironmental work in the area mapped.



Project scope: mapping areas *Figure 1*

As a result of the problems discussed above, to date, in both Worcestershire and the wider region, investigations have largely taken place only on a limited number of discrete sites. Most of these have been unexpected during the development control process at either evaluation or mitigation and consequently have been investigated in circumstances where neither project strategies nor resources have been adequately designed to address them. Most are palaeochannels buried under alluvium and hence are difficult to map using this toolkit, although as they generally fall within the floodplain zone, other more detailed mapping methods (See Baker 2006 and 2007, Jackson *et al* 2011, 2012), applicable mainly to palaeochannels and buried peat deposits, can be used. However, many sites with potential for gathering palaeoenvironmental data exist as wetland today (such as marshes and a variety of cultural features), or are potentially relict wetland sites visible on OS maps (such as meander loops and meander movements). These sites can be overlooked during the early stages of the development control process or may be unknown to, for example, university researchers prospecting over a large area. Sites of this type where investigations have taken place show their potential value. Examples include early Holocene sequences from Hartlebury Common (Brown 1984), Wilden Marsh (Shotton and Coope 1983 Brown 1988, Rackham 2006) and later sequences of historic date at Kyre Pool (Pittam *et al* 2006), Bordesley Abbey (Carruthers 1993) and Abbot Chyryton's Wall, Evesham WRW (Cook *et al* 1996).

It is important, therefore, that the presence and potential of such features is identified as early as possible in the development control process, and is made available to various researchers, in order that assessment and subsequent mitigation strategies can ensure that they may be properly protected or their high potential effectively realised. Since many of these features are visible on OS mapping and other sources (though not all, See Section 3.1), they can potentially be identified, mapped and made available for use within an HER as a tool for predicting potentially vulnerable deposits.

The Project covers the development and implementation of a toolkit for the rapid mapping and assessment of such assets within the HER for those areas of Worcestershire identified as being most under threat from development and other pressures (Fig. 1); thereby providing a readily accessible means of ensuring that such significant deposits are better identified and better recognised, and thus more effectively protected in the future.

2. Aims

The overall aims and objectives of this project were as follows:

- To identify and map (by creating spatial and attribute data) all small wetland/waterlogged (or potentially so) sites or deposits in a defined project study area which covers areas of potential threat to such assets within Worcestershire (Fig. 1) and delivers the results through the HER so they can be readily used and accessed by various user groups;
- To provide a basic indication of the potential of the mapped sites for palaeoenvironmental study (indicated as high, medium or low potential); and
- To further develop and test the mapping tool for use elsewhere in Worcestershire and beyond.

The Project aims help meet EH Corporate Objectives through the Natural Heritage Protection Plan (English Heritage 2011) and SHAPE (English Heritage 2008) as follows:

A1 *Measure 3. Understanding: Recognition and Identification of the Resource (Topic 3 A: Survey and identification, Activity 3A5 Identification of wetland/waterlogged sites)*

Small wetland sites are numerous in Worcestershire, and although some are considered as historic assets (such as moats and fishponds) and are listed on the HER, many features such as marshes, reed swamps and cut-off river/stream meanders are not generally considered as part of the archaeological resource and are unknown to many in the historic environment sphere. Many of the features are mapped (some are not, See Section 3.1)) but not on the HER or in a form that is readily usable to identify those of potential for palaeoenvironmental study. Mapping and assessing potential of such small wetland sites will enhance the Worcestershire HER and considerably raise the profile of a variety of small wetland/waterlogged sites as historic assets.

A2 *Objective 1D: Develop new approaches which improve understanding and management of the historic environment (sub-programme 14111.110, multi-disciplinary research approaches to the historic environment; challenges and benefits)*

Combining various sources such as historic and present day mapping and Historic Landscape Character assessments with aerial photographs and LiDAR will help to identify a broad range of small wetland/waterlogged assets which have potential for palaeoenvironmental study. These may still be readily visible in the landscape or may remain buried under modern development or 'masking' deposits such as alluvium. The combination of a range of appropriate sources within a GIS will provide a means of mapping many of these assets and help to better understand 'what's out there'.

A3 *Objective 3B; Ensure that the condition of the most significant parts of the Historic environment is recorded and monitored to enable their better protection.*

Systematic recording and comprehensive mapping of small wetland sites is needed to provide an audit. Assessing their potential (high, medium or low) and focussing first on areas where these features are most at threat will ensure that the most significant parts of this aspect of historic environment are protected. Other areas can be covered as and when funding becomes available.

The objectives were to:

- Working within a GIS environment to create a GIS layer (.mxd file) of mapped features of potential significance for palaeoenvironmental research within identified areas of high threat (aggregate resource areas, preferred option areas for housing and development, areas subject to significant water abstraction, etc).
- As part of the mapping, rapidly assess and review for each mapped feature

  i) the potential for organic deposits to survive,

  ii) the accessibility (for example, for sampling) and completeness of the site, and

  iii) any visible change in the presence of standing water from First Edition OS to modern day mapping.

  A score will be given for each site/deposit which indicates the overall potential for palaeoenvironmental research expressed as low, medium or high.
- Further assess and potentially refine the GIS mapping and scoring of potential through carefully targeted 'ground truthing' to validate results.
- Integrate the mapped data into the Worcestershire HER, add the data to the HER Environmental Index and provide supporting documentation (guidance for use), thereby providing a readily accessible tool for archaeologists and other stakeholders to use in planning, project design and research.
- Provide a case study for the effective integration of such mapping into HERs and thus raise awareness for archaeologists and other interested parties of the potential value and approaches to such mapping.
- Provide a mapping and assessment toolkit which can be used in other areas and regions where such deposits are present and under threat.
- Submit the project archive and results to support dissemination and make project outputs accessible.

Through provision of mapping and assessment of areas of palaeoenvironmental potential, this project has:

- Enhanced the Worcestershire Historic Environment Record (HER), thereby providing better recognition and understanding of these valuable assets;
- Provided a readily accessible HER resource, thereby supporting the effective management and protection of such archaeological assets;
- Provided a useful and readily accessible resource for various organisations or groups who have a research interest in small wetland sites; these may include university researchers, archaeological contractors and potentially community or volunteer groups. Outside of

archaeological interest groups, this may be of interest to wildlife or nature conservation organisations (eg Wildlife trusts, Natural England etc) and farmers. Enhanced understanding of the nature and variety of archaeological assets in the region highlighting the potential for such wetland resources to be present within areas with which they are not traditionally associated; and

- Provided a simple and effective toolkit which can be used in other similar areas and regions to enable these benefits to be more widely realised.

3. Methods

3.1 Project scope

Mapping was undertaken within a defined study area (Fig. 1) as follows:

Study area

Areas within Worcestershire which are most likely to be impacted on by development, mineral extraction or water extraction were selected for mapping and assessment.

These comprise:

- Aggregates resource areas as defined by the Worcestershire Aggregates Resource Assessment (PNUM 3966; Jackson and Dalwood 2007);
- Areas identified within Strategic Housing Land Allocation Assessments (SHLAAS);
- Areas liable to be affected by water extraction (especially the Severn and Avon Valleys)
- Potential wetland restoration areas identified by Wetlands West (formerly Severn Avon Vales Wetland partnership) which fall outside of the aggregate resource areas and SHLAAs (above). This comprises one area: Longdon and Eldersfield (as shown on Figure 1).
- Areas of current and former wetland as mapped by the Worcestershire Historic Landscape Characterisation Project (comprising WVF3 Watermeadow, WVF3 Artificial lake or pond, WVF 5 Marsh, WVF6 Natural Open Water, WVF7 Miscellaneous Floodplain Soils and WVF34 Bog).

There are inevitably considerable overlaps between these areas and in total an area of approximately 318 km² was studied as shown on Figure 1.

Re-mapping was not undertaken of any areas which had already been completed within the pilot schemes already undertaken by WHEAS (now Worcestershire Archives and Archaeology Service or WAAS). The original intention was to re-score features where a method had been revised and update the attribute tables so that they were consistent with the current project mapping. However, during this project it became apparent that there was a greater degree of inconsistency in the earliest project (Mills 2009, Pearson 2010) than previously thought, hence it was only possible within budget constraints of the current project to update the scores and HER records for features scored as of high potential along with a selection of other records where possible. A method has been applied to flag these records in the HER so that it is clear that only a selection of features within that project area have been included. As considerable modification of the landscape will have taken place in urban areas, only towns previously mapped within the pilot schemes were considered (as test cases). These included Redditch, Bromsgrove, Kidderminster, Stourport and parts of Bewdley.

The main project (Stages 2, 3 and 4) further developed and highlighted a methodology for mapping and assessing non-extensive wetland (or potentially wetland) sites or deposits with palaeoenvironmental potential which had already been developed by WHEAS and piloted within the county (see for example Jackson *et al* 2011 http://archaeologydataservice.ac.uk/archives/view/geosevern_eh_2011/).

These projects have already demonstrated that the method identifies many sites with potential for palaeoenvironmental work. However, it is recognised that it is not possible to capture all sites with potential for the following reasons:

- Some will be too deeply buried beneath sediment to have been visible on the ground and mapped by the 1st Edition Ordnance Survey (the baseline for mapping at this stage).
- Some sites (a small number) exist today as wet grassland, or are slightly marshy, and are known for peat survival, but were not marked as such on 1st Edition mapping, for example Impney Farm near Droitwich (Williams *et al* 2005) for unknown reasons.
- Sites within urban areas can be mapped as they will often show on historical mapping, but it is difficult to check sources such as LiDAR and aerial photographs over the entire area as they will mostly be obscured by modern development and this affects the assessment of potential.

These factors have been emphasised in an introduction to the toolkit which will be supplied with any data provided.

3.2 GIS, LiDAR processing, mapping and desk-based assessment

For the project study area (Fig. 1) a GIS (ArcMap Version 10) was established incorporating OS 1:10,560 1st edition historical mapping on which the mapping of features was based. Once a feature had been identified on the 1st edition map, other data sources consulted included the Worcestershire Historic Environment Record (HER), later historic maps, modern OS mapping (1:10,000 colour), aerial photographs, Google earth, Historic Landscape Character mapping, WCC habitat mapping, and Environment Agency LiDAR data in the form of geo-referenced images (held within the HER as .JPEG images). A list of sources used is presented in Appendix 1.

3.2.1 Mapping of small wetland sites

The potential for mapping of geomorphological features (as opposed to 'cultural' features such as moats and fishponds) with palaeoenvironmental potential from OS, other historic maps and aerial photographs has been recognised elsewhere (Baker 2006): project methodology was therefore based upon map-based approaches developed within the Trent Valley (Baker 2006; Baker 2007) and also by the WAAS environmental team on three local study areas (Jackson *et al* 2011 and 2012, Pearson *et al* 2011 and Pearson and Daffern 2012).

Features were mapped as a separate layer within the GIS according to an established methodology (Appendix 1) using polygons, following the shape of features seen on the 1st edition OS. First edition OS maps were identified for use as the primary map source since these show features which are at least 100 years old, and because it is a form of historic mapping which is comprehensive, hence providing consistent information across Worcestershire (and other counties or areas, should this tool be used elsewhere). Information for each of the features mapped from the 1st Edition OS was supplemented by examination of modern maps, aerial photographs, LiDAR, Appendix 1). Where feature boundaries were not clearly defined (such as for areas of reed swamp or marsh), the judgment rested upon the person carrying out the GIS mapping. As these are small areas of wetland this is considered sufficient for a broad-brush assessment tool.

The focus of the mapping lay in using the information collated in the GIS to identify and examine visible features which may contain organic or waterlain mineral sediments and which have potential for palaeoenvironmental reconstruction (eg ponds, marshes, meander loops, meander movements, palaeochannels, fishponds, moats, and osier beds). These categories were chosen as they appeared to be the most relevant within the Worcestershire landscape, but for other areas of the country the number and types of categories could be adjusted as appropriate. Natural features and those with a cultural association were kept separate as the type of information recovered could potentially be different. Hence, fishponds being a common type of artificial pond (with potential for waterlogged structures and cultural debris) was categorised separately from other ponds of no known use. Moats and osier beds were two other categories with certain cultural associations, while 'other' covered less common cultural features such as water meadows, mill ponds and leats. Natural features relating to water courses were separated into palaeochannels, meander movements and meander loops, an arrangement which takes into account that deposits may have formed slightly differently.

Particular attention was paid to those features identifiable on 1st edition OS maps since these have been demonstrated in the pilot studies to be the most important sources of information. Other sources were primarily used for cross-checking and verifying information. An example is shown in Figures 2, 3 and 4. For copyright reason, it is not possible to publish Environment Agency LiDAR images.

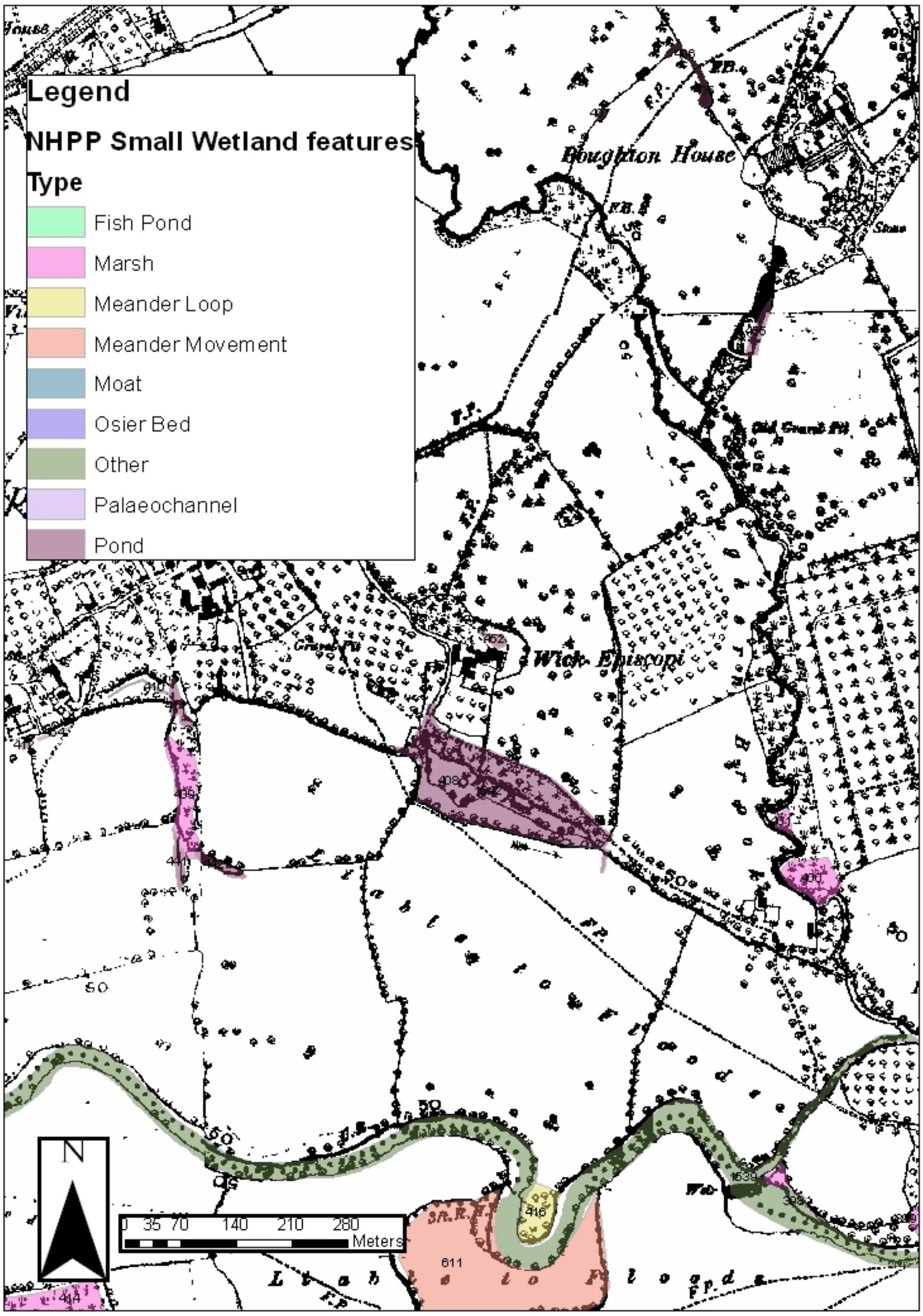


Figure 2: Powick and Wick near Worcester, 1st Edition OS map (baseline data)

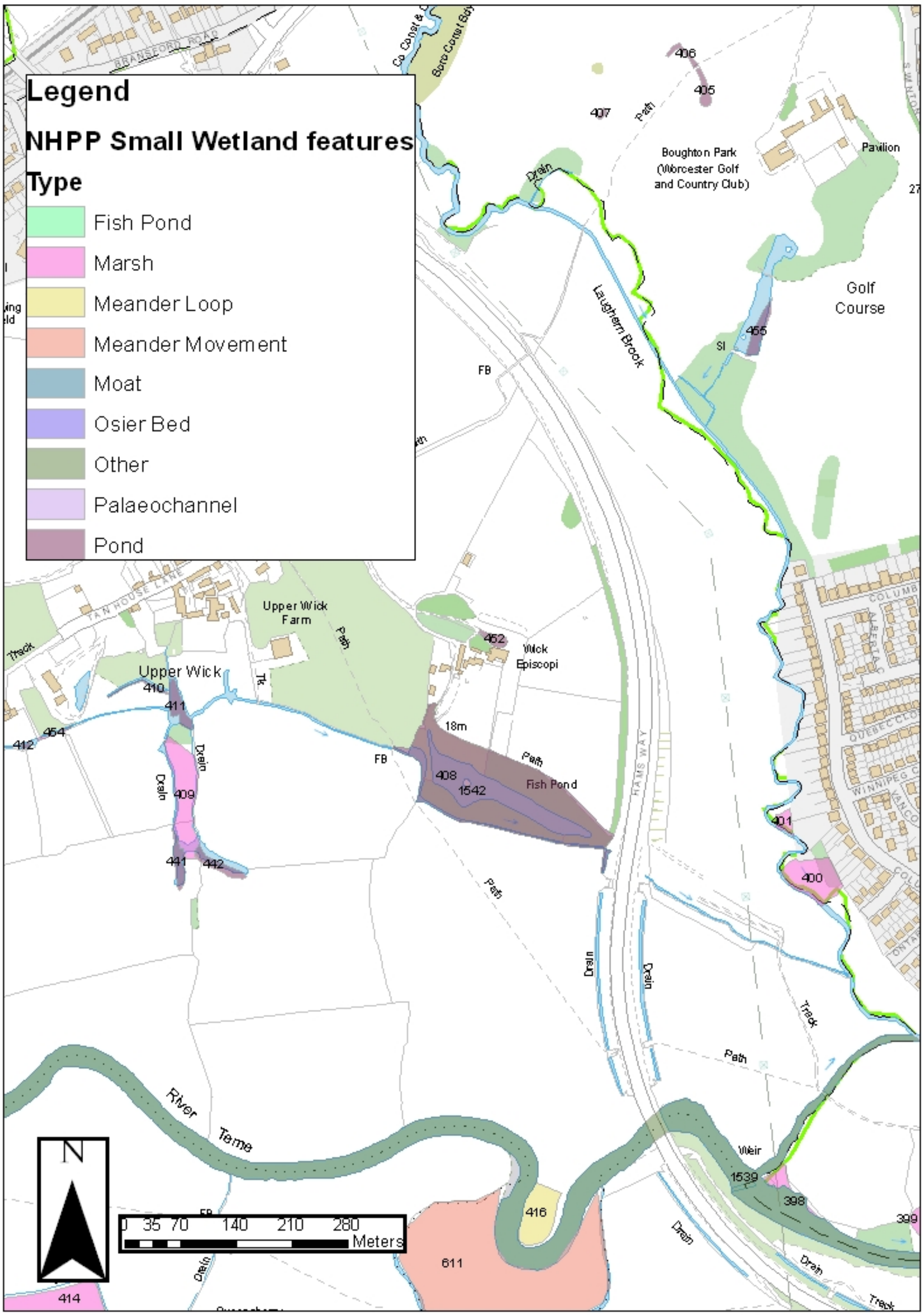


Figure 3: Powick and Wick near Worcester, modern OS map

Figure 4: Powick and Wick near Worcester, aerial photograph (2005)

Green line = Civil administration boundary

3.2.2 Desk-based assessment of mapped sites

Once the mapping for each feature was completed as described above, a rapid desk-based assessment was made of the potential for organic deposits to survive within each mapped site. Much of the interest is in organic deposits where there is a greater potential for a wide range of biological material to survive, including remains useful for radiocarbon dating. Pollen, for example, can provide broad scale information on landscape change, such as woodland clearance or renewal, while macrofossil remains (such as plant, wood and insect remains) provide complementary detail on vegetation and climate. Other significant archaeological evidence such as the remains of timber structures (such as might be associated with dams, weirs, timber or wattle lining, revetments etc) or wooden, leather or organic artefacts may also survive. It is also recognised that inorganic sediments have the potential for palaeoenvironmental study, for example, in providing information on fluvial regime. Wetland deposits also have potential for recording a geochemical, magnetic susceptibility, micro-charcoal or micro-pollutant record of human activity such as metalworking.

Assessment was based on size of the feature or deposit (measured by surface area) as this is the most readily accessible information which greatly affects survival of a good sequence of deposits. Through fieldwork over many years, it has been apparent that organic deposits are more likely to survive in larger features (ie over 2000 m^2) as there is a smaller surface area to volume and therefore less exposure to wetting and drying. Microstratigraphy is also more likely to survive where there has been less exposure to wetting and drying. Moreover, deeper sequences are more likely to be found in larger features. A longer sequence covering a greater time span provides valuable data for environmental reconstruction, and potentially artefactual material. The type of substrate (gravel, clay, etc) will also affect the extent to which small features (ie less than 500 m^2) are exposed to wetting and drying and movement of the water table (being more likely to be affected on gravel than clayey substrates) so the method has its limitations. Nevertheless, it is an aspect that can be rapidly assessed, and in Worcestershire many features are cut into gravel. Where features were subsequently subject to ground truthing, this work was used to update the score for this aspect of potential.

The accessibility of all the features for validation and analysis (based on coverage by trees, hard surface or buildings), seen on OS mapping or aerial photographs, was assessed through a desk-based assessment (Appendix 1), and for selected cases by subsequent ground-truthing (Section 4.2).

Any change in apparent waterlogged state from first edition OS to modern mapping was also taken account of in the assessment.

Scores were applied and the results presented as ‘low, ‘medium’ or ‘high’ potential (Table 1; for detail see Appendix 1: Methodology). The accent was on rapid assessment: to flag up areas of potential and provide a 'broadbush' indication of whether an informative sequence of waterlain deposits is likely to survive, the degree to which such deposits may have been truncated or disturbed by modern surfaces or tree growth, and how accessible the feature may be for fieldwork. It cannot determine the antiquity of the deposits, other than that the feature has been in existence for at least 100 years. It is acknowledged that other sources of information could be added at a later stage to refine the assessment (such as substrate type from BGS maps, or visual inspection of the deposits by augering), but were not included within the scope of this project.

Features were ‘flagged' where there is already archaeological or historical information available through the HER, which is of direct relevance. This did not, however, affect the scoring as this is intended to be a first stage of assessment, and irrespective of the likely date of the features. For example, a large fishpond, known from documentary evidence to have been created as part of a medieval estate would be considered as being of high potential for anyone researching medieval landscape but of no value to anyone researching prehistoric landscape. Hence, it is difficult to score potential using the date of the feature, if known. As noted above, more detailed and targeted assessment is seen as a function of any further investigations resulting from HER searches within the development control process or as part of a research project.

Data from the GIS attribute table was imported into an Access data table to facilitate presentation of the report and also for use in conjunction with validation data. Mapping and assessment results were reviewed by the WAAS Senior Environmental Officer in order to support selection of sites to be validated during the 'ground truthing' stage of the project (Section 4.2).

	Questions	**LOW TO HIGH SCORING**		
A	To what level is the feature accessible/covered? (Assessed from modern map)	Fully Covered **1**	Semi/Partially Covered **3**	Open **5**
B	What scale/size is the feature? (Info taken from attribute table)	Small (<500m^2) **1**	Medium (501-1999m^2) **3**	Large (2000> m^2) **6**
C	Has there been any change in the extent of waterlogging? (1^{st} Ed OS, modern maps and AP's compared)	Major Change (No longer mapped) **1**	Minor Change (A decrease but still there) **2**	No Change or a ‘Positive’ Change **3**
	Is there any associated information with or related to the feature? (Take from HER layer)	No **Leave blank**		Yes **Add comment**

Table 1: Scoring potential and accessibility

3.2.3 Validation by walk-over survey

The importance of validation (or 'ground truthing') of such features and the limitations of any unverified desk-based survey and assessment has been highlighted in the Severn Geoarchaeology Project report (Jackson *et al* 2011, 2012) and has been demonstrated elsewhere (in the case of palaeochannels) as in the Suffolk Rivers Project (Hill *et al* 2008a and b). As a result, upon completion of the desk-based mapping and assessment described above, a number of sites were selected for validation.

Following selection of sites and checking for ease of access, validation or 'ground truthing' was largely carried out by volunteers supported by WAAS staff and targeted on a sub-set of the mapped features. As the area covered was relatively large, for ease of access it was possible to select sites that were located on public land (such as Kempsey Common), or on or adjacent to public footpaths and bridleways. An attempt was made to secure access to farmland under farm stewardship, but this proved too time consuming.

The proposal aimed to collect validation data from approximately 2% of the total number of features mapped during this project (excludes features mapped previously). A total of 1,652 sites were mapped and therefore validation of 33 sites would be anticipated. By mid-February 2013 it was possible to validate 31 sites, but flooding prevented access to a number of sites for which information for volunteers was prepared. The results of two of the validated sites (small ponds) were also discounted as it is thought that more recent ponds in the vicinity were mistaken for the historic mapped sites. The sites chosen included a range of feature types and sizes (small, medium and large). The target of 2% for walk-over survey was based on experience gained within the Grow with Wyre project and aimed to offer volunteers clusters of sites within a small area wherever possible (say 3 to 6 sites), close to where they live.

A training day in the field and a house meeting were held with groups of volunteers to demonstrate the process for validating the selected mapped features, and this was followed up by telephone or email support from the project specialist. This method has worked well on a recent project, for example, Grow with Wyre in 2010/2011 (Pearson and Daffern 2012). Fieldwork included walk-over survey to note aspects such as the ground conditions, the extent of any standing water, accessibility issues, for example. Observations made during the walk-over were noted on a recording sheet (AS47, Appendix 2) and accompanied by photographs of the features and surrounding context. Photographs in this case were particularly useful in amplifying the comments made on the recording form; prompts having been given during training on what aspects of the features to photograph. Volunteers who helped with this type of work for the Grow with Wyre project were recruited for areas bordering the Forest. Other volunteers were recruited from local interest groups (South Worcestershire Archaeology Group and Redditch Local History Society).

Lastly, the resultant data was collated and reviewed with assessment scores adjusted where appropriate. To carry out the collation and review, validation data from the volunteer's recording sheets was entered into an Access database table and any digital photographs supplied also linked into the Access database. This data was queried against data imported into an Access table from the GIS.

Should funds become available for any follow-on project it is recommended that a selection of the validated sites could be further tested by augering in order to make a record of the sediment sequence, assess the potential of these deposits and carry out radiocarbon dating.

3.2.4 Ground truthing by cross-referencing with previously acquired field data

Where mapped features have been sampled previously as part of an archaeological project, the data was used to validate the mapping, thus supplementing the sub-sample examined through walk-over survey and increasing confidence in the effectiveness of the methodology.

Examples include sites which have been mapped using this toolkit and also those which fall outside of the mapped area to date, but would theoretically be mapped using this tool. A couple of sites would be mapped with a small adjustment to the methods (Section 4.3 and 5). Finally, a number of sites investigated can be identified which would not be mapped using this tool, mainly those buried under alluvium. A basic assessment of these has been made of which additional sources would be needed to identify these sites.

3.2.5 Dissemination

GIS data and supporting documentation has been submitted to the Worcestershire HER and to ADS along with this report. The report also identifies areas considered to be appropriate for further validation work (*eg.* augering and assessment of selected deposits/sequences).

The principal project output is in the form of GIS data which has been deposited with the WCC HER along with supporting documentation and guidance on use. The Toolkit methods are summarised below and described in greater detail in Appendix 1. All of the GIS data generated has been archived and is accompanied by descriptive metadata following the format proposed in the Archaeological Data Service guidelines (Gillings and Wise 1998). For each archive directory an ASCII text file has been created as an index for the directory contents using the following format: Directoryname_Contents.txt comprising a list of the files in the directory by name with brief description including the following information:

1. Filename
2. Computer software used
3. Date of data capture/purchase
4. Who created the file
5. Data source
6. Scale and resolution of data capture
7. Scale and resolution of data storage
8. Purpose of data set creation
9. Method of original data capture

An article has been produced for inclusion in the journal *The Historic Environment: Policy and Practice* to highlight the approaches used and potential of such mapping to the archaeological profession including archaeological advisors to other stakeholder groups (eg Natural England, Forestry commission, Environment Agency, etc).

Copies of accompanying reports and articles have been deposited with the ADS and an OASIS entry has been completed.

4. Results

4.1 Stage 1 Mapping and assessment of site potential

4.1.1 GIS mapping

A total of 1,652 new sites were mapped (Appendix 3) covering approximately 28 km^2, and in addition to data from previous projects, there are now 4,911 sites of this type mapped. Based upon comparable mapping undertaken within the pilot projects for Severn Valley Geoarchaeology and Grow with Wyre (which covered a total of *c.* 90km² and provided *c.* 6.5 sites/km² respectively), it was estimated that approximately 2,050 sites would be mapped within the 318km² study area for this project.

	Potential					
Type	**High**		**Medium**		**Low**	
	Number	%	Number	%	Number	%
Fish Pond	29	6.3	13	5.1	15	1.6
Marsh	80	17.3	34	13.4	105	11.3
Meander Loop	16	3.5	7	2.8	8	0.9
Meander Movement	17	3.7	6	2.4	12	1.3
Moat	15	3.2	6	2.4	12	1.3
Osier Bed	71	15.3	17	6.7	33	3.5
Other	100	21.6	14	5.5	34	3.7
Palaeochannel	17	3.7	29	11.4	52	5.6
Pond	120	25.9	131	51.4	662	71
TOTAL	**465**		**255**		**933**	

Table 2: Sites recorded in the Worcestershire HER prior to the mapping programme

Type	HER	No of features in HER	% of mapped sites
Fish Pond	Y	54	95%
Marsh	Y	6	2.7%
Meander Loop	Y	4	12.9%
Meander Movement	Y	5	14.3%
Moat	Y	33	100%
Osier Bed	Y	8	6.6%
Other	Y	71	48%
Palaeochannel	Y	22	25.5%
Pond	Y	69	7.6%
TOTAL		**272**	

Table 3: Summary of mapped features by potential

A total of 275 of the newly mapped sites were also on the county HER prior to this mapping project (approximately 16% of the sites mapped through this project). The type of site identified, the number per category and % of newly mapped sites are shown in Table 2 with Table 3 providing a summary of the potential of each mapped site type.

The types of site (as grouped by current wetland mapping project) most commonly included in the HER previously were 'other', 'ponds', 'fishponds' and 'moats'. Those in the category 'other' are mostly water meadows, pools, mill leats, with occasional marshes and osier beds. These results might be expected as the features recorded are mostly artificial and therefore, having a cultural association, had previously been identified within the archaeological record. As shown in Table 3, 100% of moats and 95% of fishponds were already recorded on the HER, but the percentage for other was much lower (for example only 7.6% of ponds and only 2.7% of marshes were recorded on the HER) and thus the level of enhancement achieved for these is considerable. Osier beds, drainage or other ditches and water channels, which are also artificial, occasionally appear on the HER. Natural features such as marshes, palaeochannels, meander movements and meander loops, which make up a large number of mapped records, rarely appear on the HER, because there is no obvious cultural element. Examples of high potential natural features are shown in Figures 5 and 6.

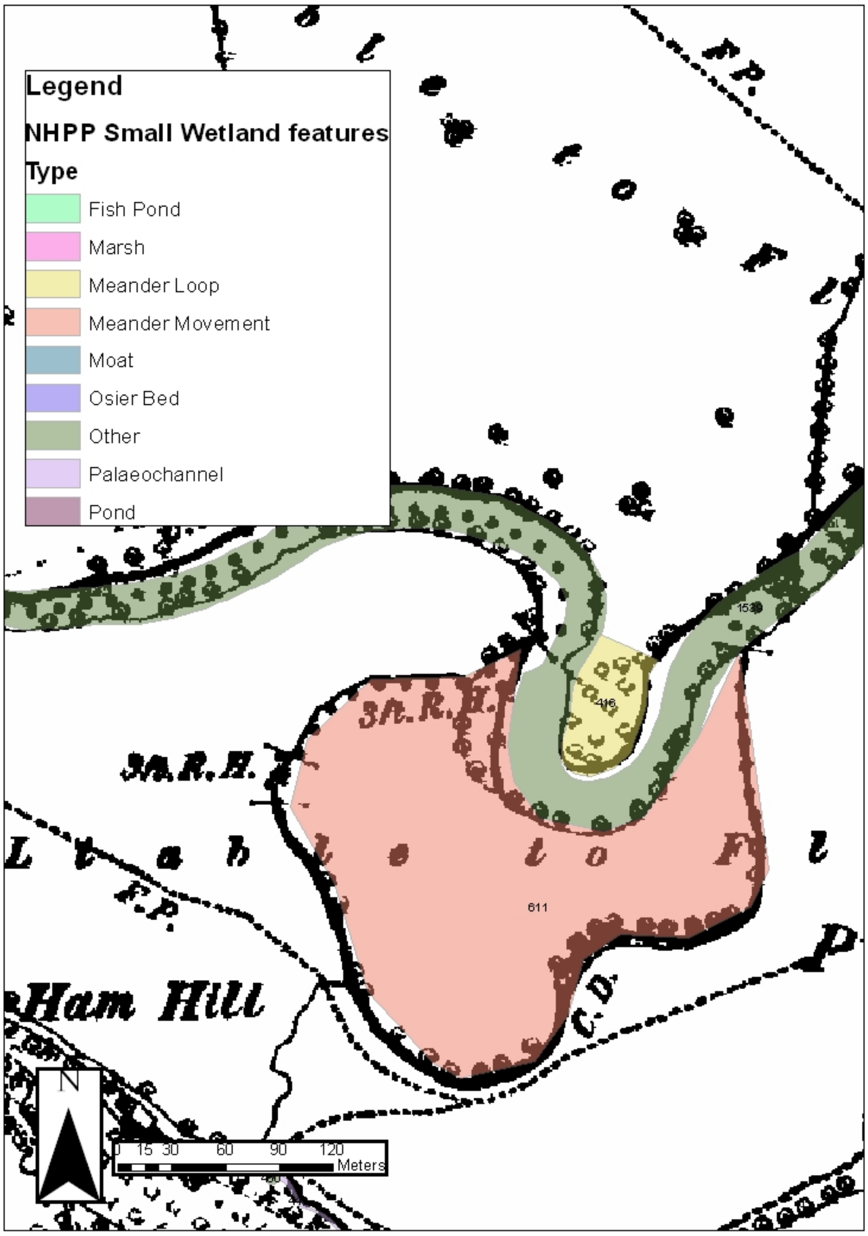


Figure 5: High potential Meander Movement North of Ham Hill, Powick (#611)

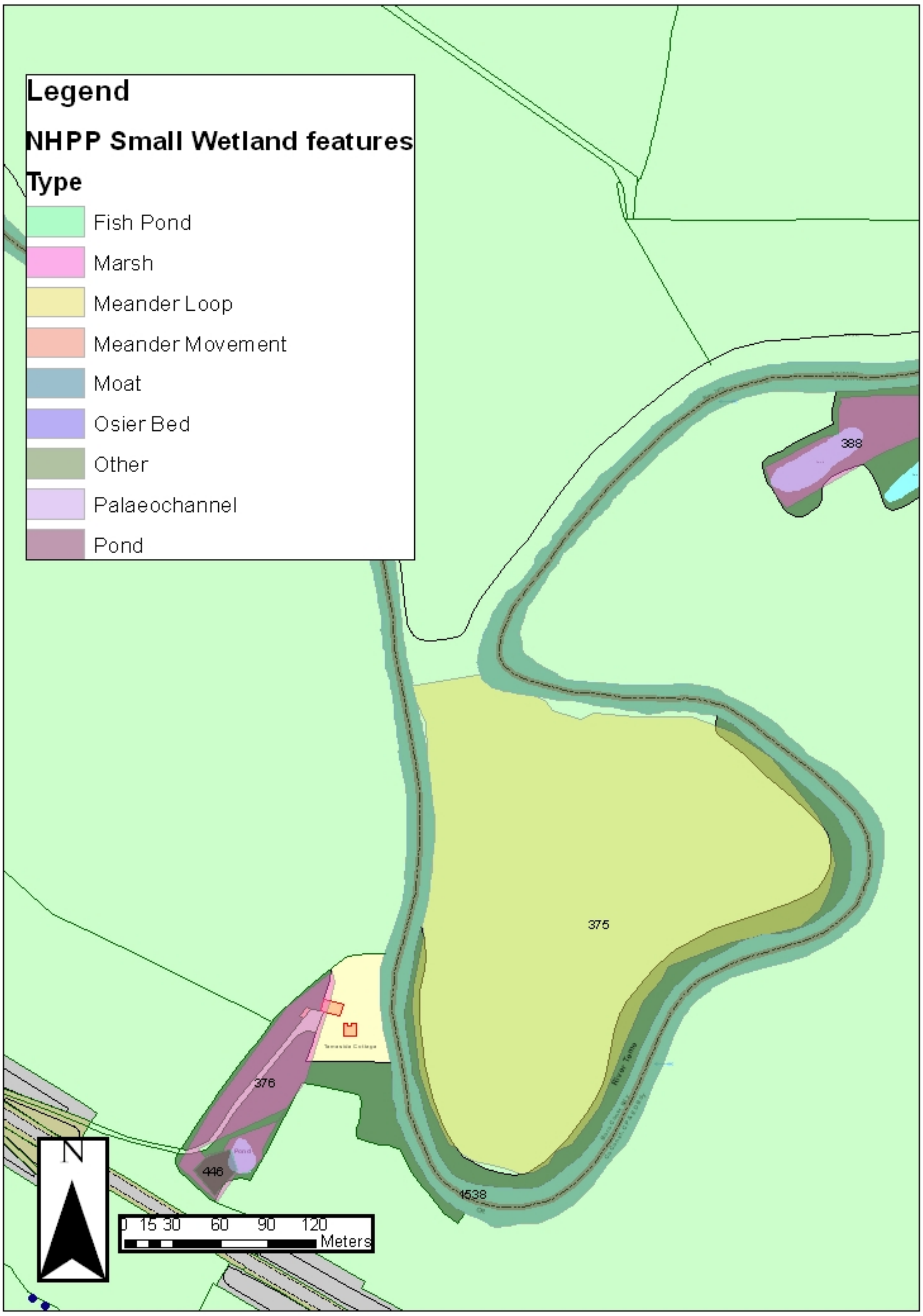


Figure 6: High potential Meander Loop at Temeside Cottage near Worcester (#375)

For features such as moats and fishponds, despite these generally being recorded on the HER, recording through the small wetlands mapping tool is still useful as an assessment of potential can be applied (high, medium or low) and statistics on size and coverage can be viewed: aspects which may not be recorded on an HER record.

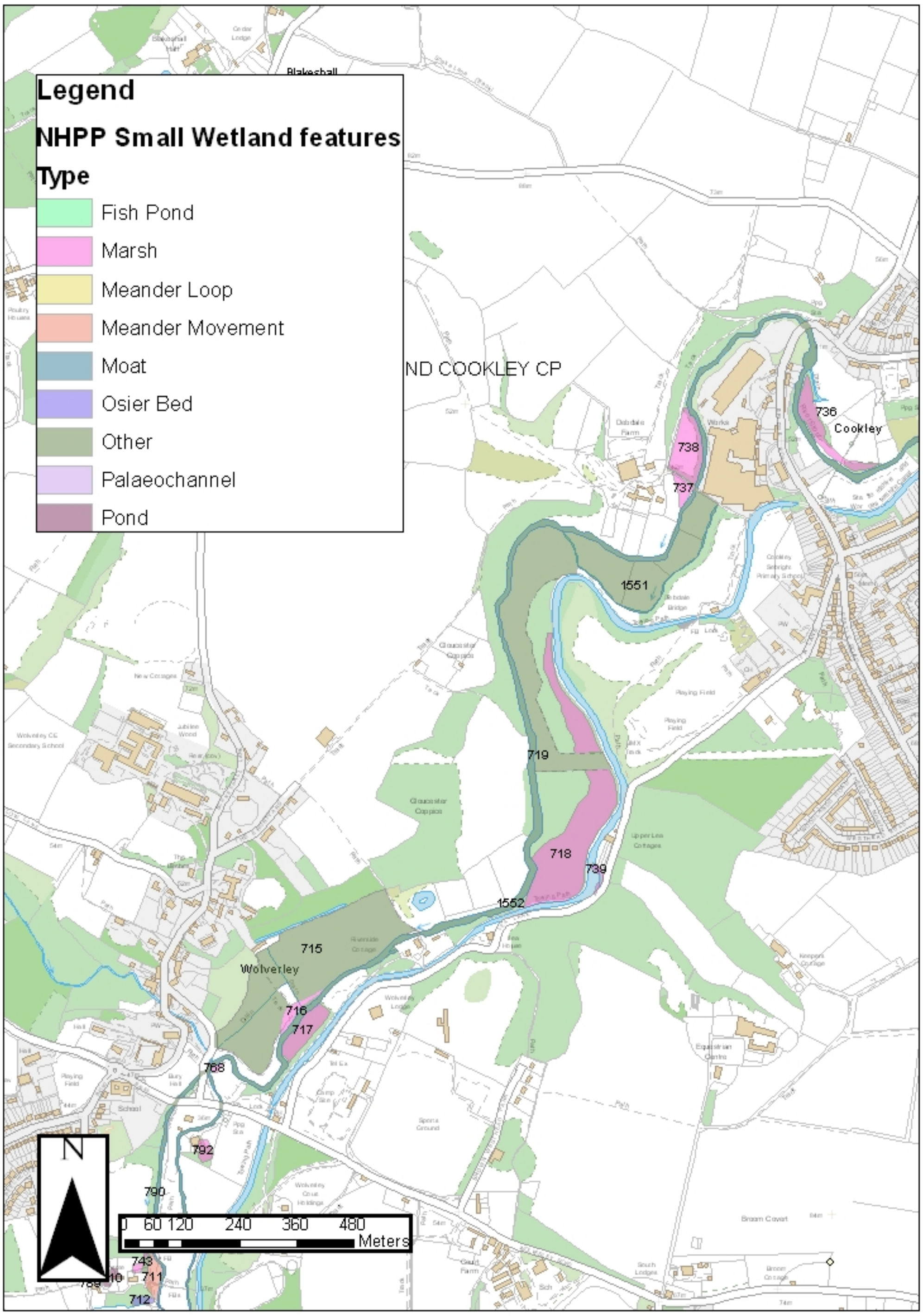


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Figure 7: Area of high potential at Wolverley and Cookley, north Worcestershire

There are areas which stand out as being of particular interest for palaeoenvironmental study, where recorded features are particularly densely clustered. For example at Wolverley and Cookley, there are large areas of marsh, palaeochannels and meander movements (Fig. 7), in an area previously unstudied. Similarly, along the Arrow Valley Country Park running through Redditch (Figs. 8 and 9) there are some extensive features recorded, and during development of the new town in the 1960s deep deposits of peat were revealed, along with a large timber which was radiocarbon dated to the Bronze Age (WSM 45434). This area has remained relatively undisturbed since the new town development as a country park but is largely uninvestigated. Large numbers of borehole records exist for Redditch from the late 1960s (over 200 borehole investigations) which would provide invaluable data for deposit modelling.

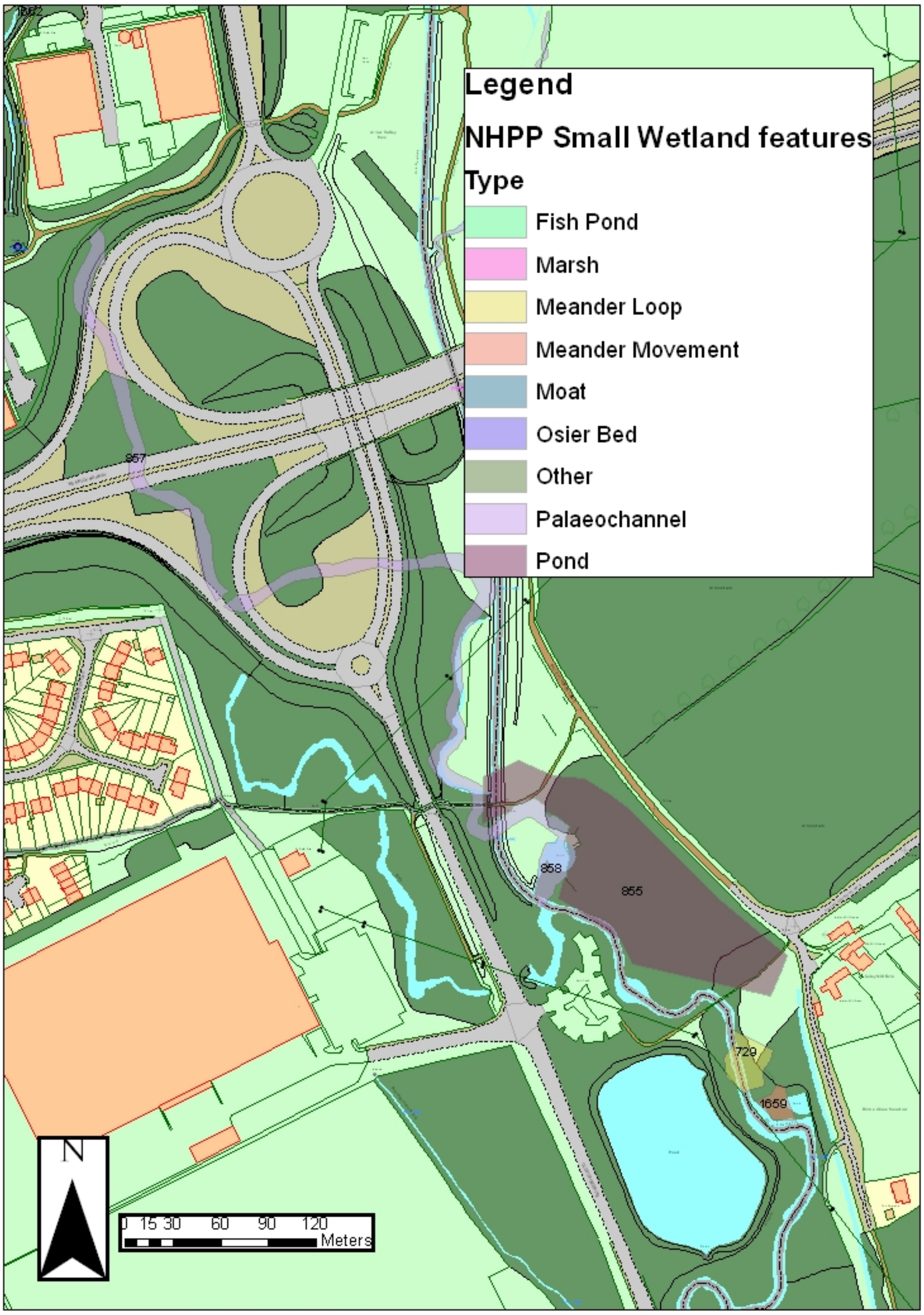

Figure 8: Area of high potential at Arrow Valley Country Park, Redditch (middle section)

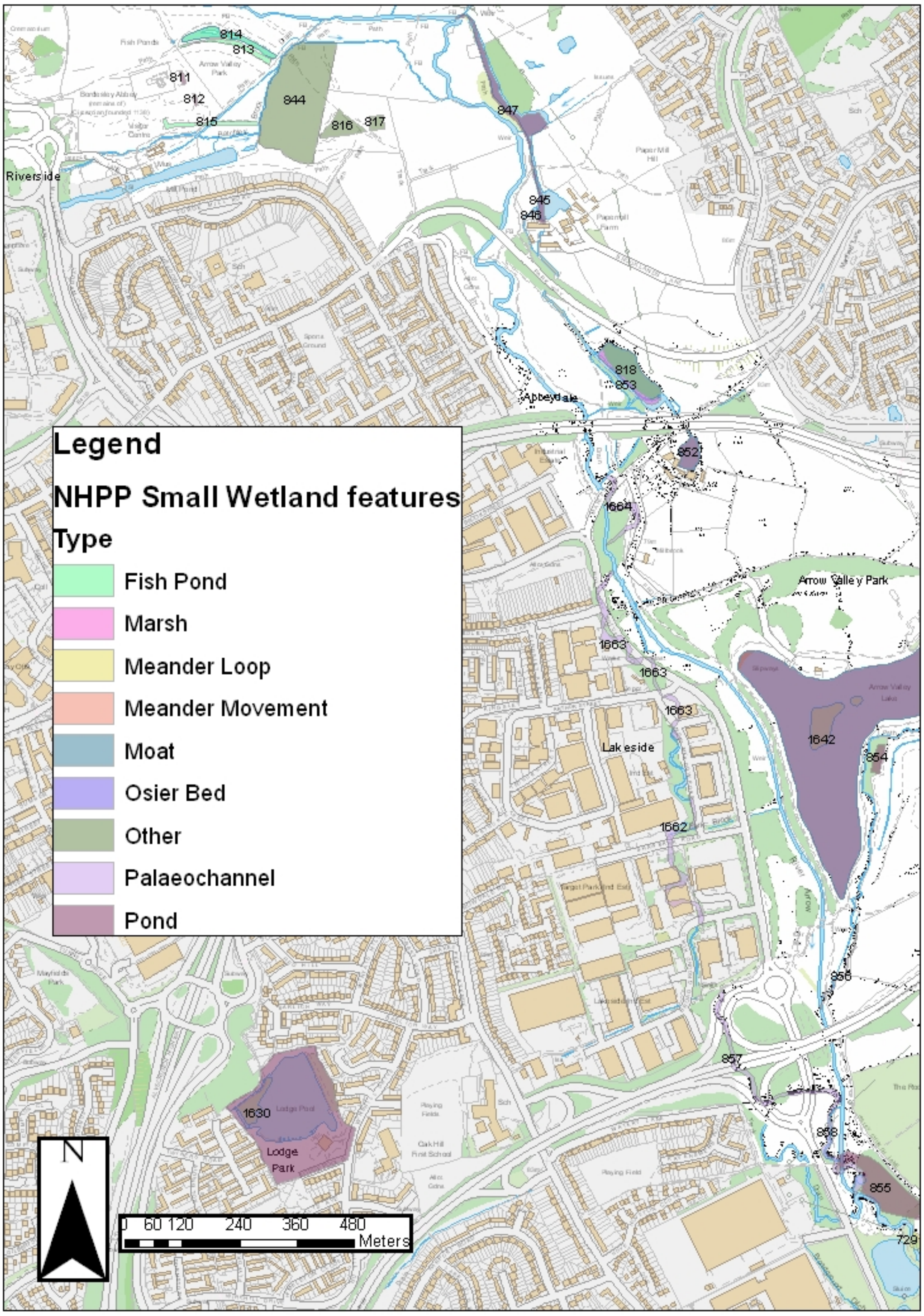

Figure 9: Area of high potential at Arrow Valley Park, Redditch (northern part)

A map of all ponds was also made just before development in the late 1960s, which exists in the County archives (Brian Stallard pers comm). To the south of Wolverley and Cookley, between Stourport and Kidderminster is an area called Wilden Pool (Fig. 10), where studies have previously been carried out demonstrating the potential of peat deposits (Shotton and Coope 1983, Brown 1988, Rackham 2006 and Daffern 2010, Section 4.3). A significant number of sites are also recorded along the River Stour north and south of the area previously investigated.

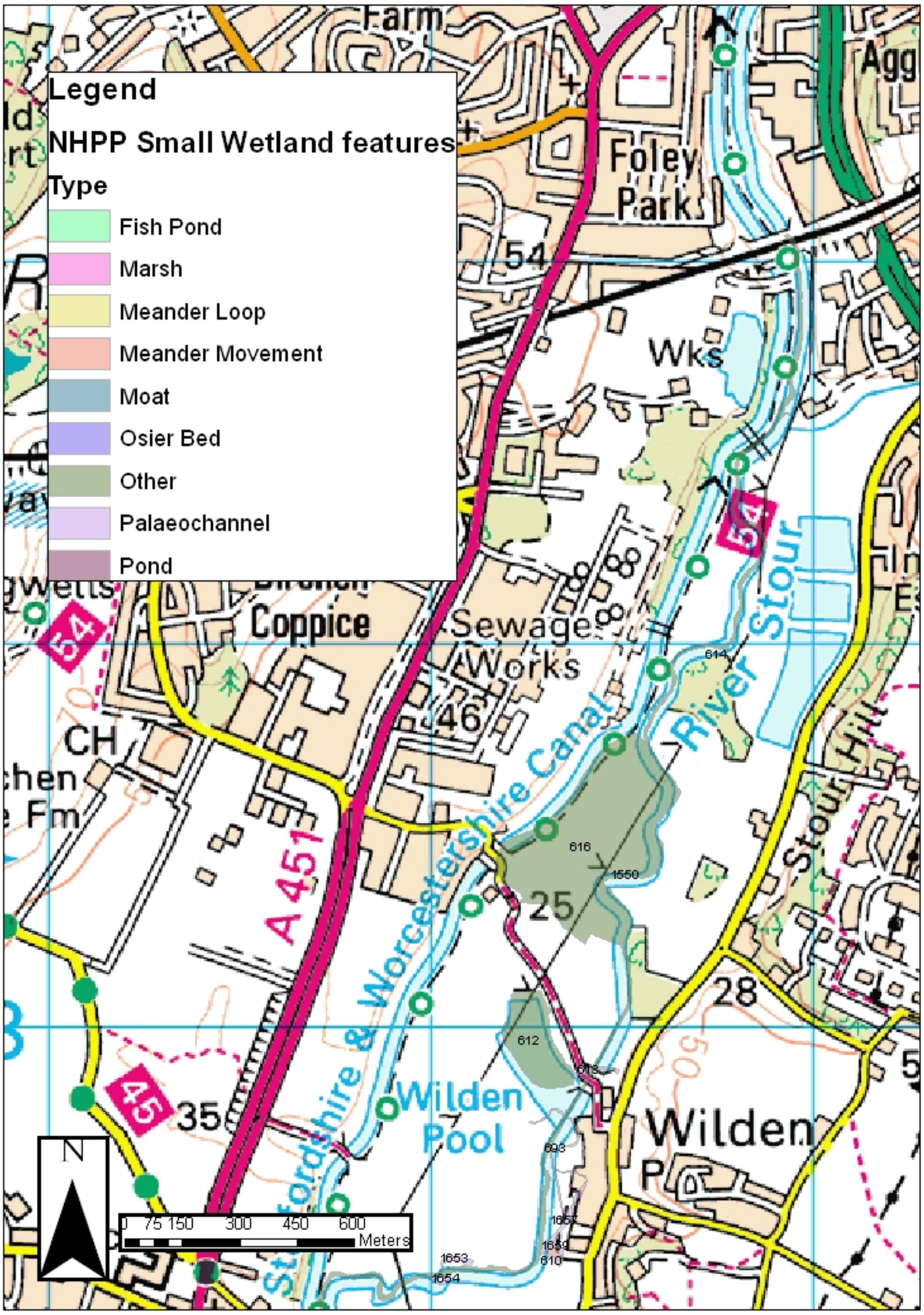

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Figure 10: Area of high potential at Wilden Pool, Stourport

Some pattern in the distribution of mapped features is also evident. Osier beds are common along the River Severn, and have been included as a mapping category as they are frequently marshy, and although a small number are known to be of 19th century date, some could be much older. In the case of the more recently planted osiers, they are likely to have been planted on unprofitable, and potentially marshy or floodable land, so upon sampling may reveal older peaty or waterlain deposits. Many osiers may prove to lie within palaeochannels; some have already been noted occupying such locations, such as #1154 at Naunton, Severn Stoke and #1301 West of Mill Croft, Birlingham. Comparing these sites against LiDAR data could indicate whether this is the case and this is considered further below (Section 8). Some are situated on islands within the River Severn. A total of 121 osiers were identified as a result of the recent mapping, and 153 as a result of previous project work. Some of these sites are particularly large (over 30,000 sq metres, and in one case over 40,000 sq metres). Their potential for palaeoenvironmental sampling could be high but are an untested site type in Worcestershire at present. Possible problems may be the abundance of woody root growth which could impede sampling (depending on density of rooting), and that root material would need to be excluded from analysis in case it is not contemporary with the surrounding sediment.

Water-meadow systems are most common in the south of the county. They tend to be scored as being of high potential (Table 1) as they are often large (over 2000 m^2) and are usually open (not affected by buildings, hard surfaces or tree cover). These are largely untested, but in many cases could be of low potential for palaeoenvironmental deposits as their management results in the land being only seasonally wet, and despite their large size they mostly comprise systems of narrow water channels. However, because of their location in flood-prone areas, they may overlie earlier palaeochannels or buried marsh deposits, and hence could be an indicator of earlier deposits of potential (as could be osier features described above). These of course remain important heritage assets in their own right and their scoring for palaeoenvironmental potential using the method described for this project could remain valid, but the results do need to interpreted with caution bearing the above points in mind.

4.1.2 Assessment of potential

A total of 1,655 features (Appendix 3) of potential for palaeoenvironmental study were mapped based on criteria described in Appendix 1, and the records of a further 443 features previously mapped through earlier projects updated so that attribute data is consistent with mapping carried out through the current project programme (Table 4).

High potential features

A total of 465 features were considered to be of high potential at this stage (approximately 28% of the total new mapped sites). These included the full range of feature types recorded, but were mostly areas of water meadow, osier beds, ponds (including fish ponds) and marsh.

Medium potential features

A total of 255 features were assessed as being of medium potential (approximately 15% of mapped features). These were predominantly ponds and marshes.

Low potential features

The majority of the mapped features were classed as being of low potential, and these were mostly small (933 features; approximately 57% of mapped features). Many of these were small ponds, areas of marsh and narrow palaeochannels. Osier beds scored as being of low potential, were also common despite being of medium size, because of the dense tree canopy visible of aerial photographs. However, ground truthing has frequently demonstrated that the tree cover is more open than would appear on aerial photographs, and hence the potential is likely to be higher.

4.1.3 Urban areas

Urban areas present some problems for mapping potential of small wetland sites using this toolkit as features visible on the 1st Edition OS can be obscured by modern development on aerial photographs and LiDAR, and hence it is not always possible to undertake assessment of the features and use the toolkit consistently in these areas. However, development is often minimal in the floodplain zone (a key area for mapping wetland deposits), so features here may be visible on all mapped, AP and LiDAR sources. It is also clear from features mapped in Redditch, Kidderminster and Stourport that some important cultural wetland features such as fishponds, moats and mill ponds have been built around and become incorporated into the urban landscape. These will tend to have been recorded on the HER, so may not be newly mapped sites, but in these cases it will often be possible to view all digital sources to complete the desk-based assessment to determine whether they are of high, medium or low potential.

On a positive note, there tends to be a greater availability of borehole and test pit data from development-led ground investigation in urban areas which can enable assessment of risk to waterlogged deposits to be carried out using deposit modelling. Currently this method is being tested on the Droitwich area through an NHPP funded project (EH PNUM 6513; WAAS 2012).

4.2 Stage 2 Validation of mapped features

The validation data recorded on forms by volunteers has been transferred to a Microsoft Access database, the results of which are presented in Appendix 4.

A total of 31 features were validated. The validation results, where overall potential was concerned, were in agreement with the GIS mapping for 21 out of the 31 features validated.

Aspects to note are as follows:

a) Sites which show dense tree coverage on aerial photographs have been given a medium score for coverage based on previous validation work because, although it is assumed that this may result in some restrictions to access and suitability for fieldwork and sampling, on validation, tree cover appears to be either not as dense as when seen on the ground. Generally, for large sites this does not reduce the overall potential. This was borne out by the recent validation work. Potential was only judged to be lower where the ground did not appear marshy. Examples validated include an osier bed (#586) and marsh (#588) west of Winnall Coppice, an osier (#625) at Astley and Dunley and marsh (#356) at Powick Hams (Table 3; Plates 2-5 and 7)

b) Some marshes or ponds appear to have disappeared since the 1st edition mapping took place and are now open pasture or arable land. Validation may suggest a lower score as no obviously organic deposits are present (although waterlain sediments may survive). Previous fieldwork, however, has shown that often well-preserved sequences of organic and waterlain sediments survive beneath the surface on pasture land. This may because of limited disturbance on this type of land and the frequent location on damper soils closer to rivers and watercourses. Examples validated include #384, #385 and #396 on Powick Hams (Plate 6). On validation the scoring of these features was, therefore, considered to be sufficient, particularly on open pasture (the high score for 'open' land being balanced by the low score for the loss of the feature on modern mapping). For those features on arable land, comments have generally been added to the record in the attribute table

c) For a couple of sites volunteers had local knowledge about recent disturbance to feature, such as ploughing for cereals (#385) and dumping and use of area for stock control (#384) which may have damaged any surviving deposits

Comments on volunteer contributions:

- Photographs combined with the recording form (AS47, Appendix 2) have proved invaluable, as has been found during previous projects which have trialled this approach. This is particularly so for showing extent of tree cover (Plates 2 to 6), ground conditions (Plate 7) and aspects of access to the site
- Local knowledge has also proved useful (see comments in Appendix 4). For example volunteers were sometimes able to provide information on recent disturbance to sites, or in one or two cases knowledge of the extent of re-landscaping decades previously during development (ie Redditch new town development)

Ways of minimising inaccuracies in the scoring of potential are described below (Section 5).

Site name	NHPP feature	Grid reference	NHPP potential	Sampled potential	Date deposits	1st ED OS	2nd Ed OS	3rd Ed OS	7th ED OS	HER	LiDAR	Bibliography	Comments
Ashmoor Common	#1094	SO 851 466	medium	high	5930 bp to ?present	Y	Y	Y	Y	Y	N	Brown 1982	
Bordesley Abbey, fish ponds	#813, 814	SP 047 688	medium - high	high	medieval	Y	Y	Y	Y	Y	Y	Carruthers 1993	
Bordesley Abbey, mill pond, leat & race	#816, 817, 844	centred on SP 049 686	medium - high	high	medieval	N	N	N	N	Y	Y	Carruthers 1993	
Bordesley Abbey, fishpond	#815	SP 047 686	medium	high	medieval	N	N	N	N	Y	Y	Carruthers 1993	
Bordesley Abbey, ponds	#811, 812	SP 046 687	low	high	medieval	N	N	N	N	Y	Y	Carruthers 1993	
Evesham WRW	within #1068	SP 037 441	high	high	post-medieval	N	N	N	N	N	N	Cook *et al* 1996	relict marsh under orchards on historical mapping, but falls within large mapped meander loop
Hartlebury Common	#600	SO 818 705	high	high	Late Glacial to present	Y	Y	Y	Y	Y	Y	Brown 1984	
Inkberrow Millennium Green	outside project area	SP 017 573	low	medium/ high	post-medieval	Y	Y	Y	Y	Y	Y	Hurst and Pearson 1999	
Kyre Pool	#1496	SO 633 644	high	high	1584 to present	Y	Y	Y	Y	N	Y	Pittam, Mighall and Foster 2006	
Wilden Marsh & Meadows SSSI	#616	SO 827 737	high	high	Mesolithic to ?	N	Y	Y	Y	Y		Rackham 2006, Daffern 2010	

Site name	NHPP feature	Grid reference	NHPP potential	Sampled potential	Date deposits	1st ED OS	2nd Ed OS	3rd Ed OS	7th ED OS	HER	LiDAR	Bibliography	Comments
Wilden Marsh	close to #614	SO 826 738	N/A	high	Mesolithic to ?	N	Y	Y	Y	?		Shotton & Coope 1983; Brown 1988	
Redditch, Moons Moat	outside project area	SP 069 681	high	high	mean calibrated date 1790 AD (above basal deposits)	Y	Y	Y	Y	Y	Y	Head *et al* 2006	
Bewdley, Snuffmill Dingle	Grow with Wyre #19	SO 782 744	medium	medium	post-medieval to pond relict pond deposits	Y	Y	Y	Y	Y	Y	Pearson and Daffern 2012	augering suggests medium potential based on good preservation of organic but uncertain earliest date of deposits

Table 4: Sites previously sampled which are mapped, or could potentially be mapped, using the small wetlands mapping toolkit

Site name	NGR Grid reference	Deposits known	OS mapped field boundary/contour evidence	LiDAR	APs	Digital terrain modelling	BGS mapping	Bibliography	Comments
Birlingham, Gwen Finch Nature Reserve	SO 939 418	peat layer Cal BC 3520 to 3355 to present?	Y?	Y	N	Y	N	Bretherton and Pearson 2000	Buried under alluvium
Clifton Quarry, Severn Stoke	SO 845 472 to 85	Mesolithic to Early Bronze Age palaeochannel	Y	Y	Y*	Y	N	Jackson *et al* 2009; Jackson *et al* 2009	Buried under alluvium *AP faint at large scale
Cookley, Lightmarsh Farm	SO 787 767?*		N	N	N	Y?	Y	Jackson *et al* 1994, Jackson *et al* 1996	*Exact location not known - 1km from Lightmarsh Farm
Droitwich, Pulley Lane	SO 8955 6156	peat identified by ground stability assessment. Likely to be 1) Upton Warren Interstadial c 40,000 BP 2) c10,000BP 3) Post-Roman 5th - 8th century alluviation	Y	Y	N	Y	Y	WSM 12586	
Impney Farm, Droitwich	SO 911 635	8740 - 8410 cal BC; 8600 - 8320 cal BC to present	N	Y	Y	Y	N	Williams *et al* 2005	Marshy deposits present today but do not show on historical mapping
Pershore Lane, Tibberton	SO 893 562	Late Bronze Age to Early Iron Age palaeochannel; Middle Iron Age timber trackway	Y	Y?	Y?	Y	N	Keith-Lucas 2010	Buried under alluvium
Ribbesford Nr Bewdley/Stourport	SO 7930 7220	palaeochannel dated 2688BC to 2695 BC by dendrochronology on timbers	N	Y?	N	Y	N	Dinn and Hemmingway 1992	Buried under alluvium
Ripple Brook	SO 38786 23734	early prehistoric sequence	N	Y?	N	Y	Y	Brown 1982, WSM 39803	
Stouport-on-Severn,	SO 818	Roman peat deposit, approx	N	Y	N	Y	N	Osborne, P,	Probably detectable from LiDAR

Site name	NGR Grid reference	Deposits known	OS mapped field boundary/contour evidence	LiDAR	APs	Digital terrain modelling	BGS mapping	Bibliography	Comments
Marina	698	200 AD, rich insect assemblage						1996 (for 1995)	and digital terrain modelling - at a confluence with R Severn and R Stour
Washford, Redditch	SP 0726 6543	worked timber 760 BC (+/- 90 years); peat 3125 BC (+/-125 years)	N	N	N	Y?	N	WSM 37587	Urban area
Redditch, Ipsley Marsh	SP 0784 6755	peat layer from auger core. Dates 6350 - 4400 +/-115 BC at 1.2 to 1.5m BGS and 5430 - 3480 +/-155 BC0.5 50 0.7 BGS	N	N	N	N	N	Welin *et al* 1975	Known and mapped as marsh today, but not on historical mapping.
Callow End	SO 38421 25058	early prehistoric sequence from post-glacial cut-off	Y	Y	Y	Y	N	Brown 1982, WSM 39804	Post-glacial cut-off not mapped but falls within mapped watermeadow #326
Beckford, Carrant Brook	SO 9843 3611	Early Bronze Age to post-Roman organic and alluvial sequence	N	N	N	N	N	Greig and Colledge 1988	Buried under alluvium

Table 5: Sites previously sampled which would not be mapped using the small wetlands toolkit

* exact location unknown

4.3 **Review of data from previous field work**

A selection of sites where previous fieldwork has taken place is summarised in Tables 4 and 5. The information from these sites complements information recovered from volunteer validation, and also provides an opportunity to archaeological data recovered.

Few sites have been sampled in Worcestershire which exist today as wetland (or could be mapped as potential relict wetland sites), the majority being palaeochannels or buried peat deposits encountered during excavation. This aspect was one of the reasons for prompting the use of this type of mapping (in addition to those stated in Section 1), so that knowledge could be improved on the location of sites which have the potential for producing palaeoenvironmental data independent of intrusive excavation. Sampling resulting from excavation will be mostly governed by the need for development, whereas sampling of existing wetland sites can be carried out independent of this, assuming access can be arranged and any restrictions (such as SSSI or SAM status) mitigated for.

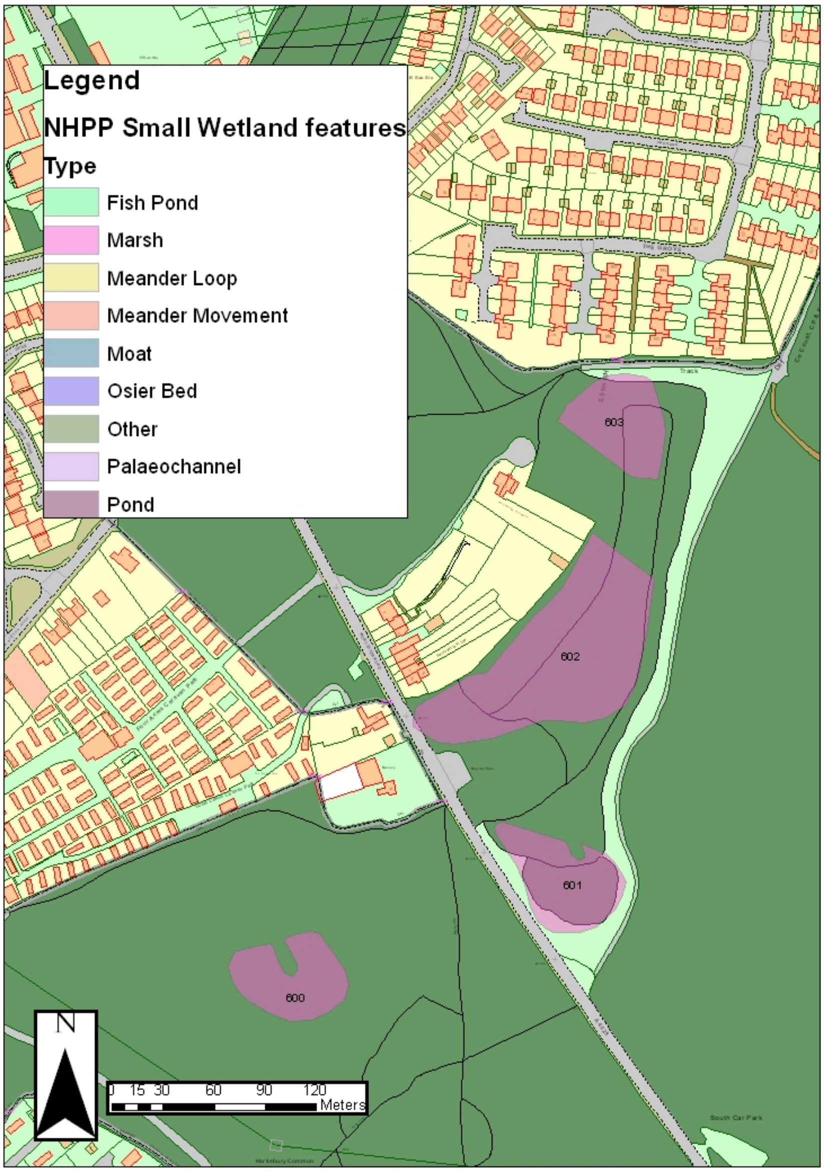

Fig 11: Areas of marsh at Hartlebury Common near Stourport. A sequence dating from the Post-Glacial to present is known from #600 (highlighted)

It is recognised that many of the existing sites may be historic in date, most likely medieval or later, but few palaeoenvironmental sequences of this date have been analysed, and they are therefore of interest. Suitable sequences of waterlain deposits of prehistoric date, however, often lie buried beneath alluvium, and hence may not be mapped using this mapping tool. Nevertheless, some significant early Holocene deposits are known to exist as wetland today, or can be mapped as potentially relict wetland

One example includes the remnants of a Late Glacial to Holocene palaeochannel of the River Stour at Hartlebury Common, now marshland (#600). The project assessed this as being as of high potential and the evidence from previous work bears this assessment out. The sequence dates from the Late Glacial period to the present day (Fig. 11; Plate 1). The pollen diagram has unusual features such as a mid-Holocene gap or hiatus in the sequence which may reflect the decomposition and destruction of organic material due to high rates of biological activity during the sub-Boreal. Evidence also indicates intensive use of the Common for arable agriculture during the last 2,600 years (Brown 1984). Brown states that 'The site shows how terrace depressions can provide a detailed picture of Flandrian vegetation changes in the lowland zone, a zone otherwise poorly represented by existing palaeoecological sites'. The Common is protected by SSSI status but drying out of the marshy areas as a result of local dewatering is a concern which affects both the nature conservation and the historic environment (Mindykowski and Bretherton 2003). Other important sequences of early Holocene date include a palaeochannel at Ashmoor Common, Kempsey (#1094) and a post-glacial cut-off at Callow End (Brown 1982). The former was mapped as being of medium potential because of its size, and because it is now unmapped and showing no standing water. The latter was not mapped as such but as a watermeadow (#326) and is visible on aerial photographs and LiDAR.

Previous work at Wilden Marsh (Shotton and Coope 1983: Brown 1988) has revealed a sequence of peat deposits dated at their base to a Mesolithic date potentially lying between 9140 +/- 70 and 8010 +/- 50 years BP (uncalibrated). The landscape during this period is likely to have been a dynamic one with frequent fluctuations in the water table through channel migration and variation in seasonal climate as shown by the formation of peat, the variability in organic preservation and the types of remains encountered, particularly the plant macrofossil remains (Daffern 2010). Peat deposits were encountered during augering at Wilden Marsh and Meadows SSSI in 2010 (Daffern 2010), and by cross-referencing to earlier work these have been shown to be a continuation of the sequence discussed by Shotten and Coope (1983) and Brown (1988). The site at Wilden Marsh and Meadows SSSI (NGR SO 827 737) had been recorded on the HER because of the work carried out in 2006 and 2010, and hence is mapped as #616. On the 1st edition OS map the area is not shown as marsh or any of the small wetland indicators used for the project (Fig. 12), although it is noted as 'liable to floods'. In contrast, the 2nd Edition OS and later OS maps (Fig. 13), both have narrow bands of marsh marked on the western boundary along the river. This site would therefore not have been located and thus this would not have been located solely using the 1st Edition OS, although the assessment methodology once applied would have scored the site as of high potential. The area falls between Wilden Pool (#612) and the location of boreholes reported on by Shotton and Coope (1983). Here also, the area is blank on 1st Edition OS mapping but is recorded as an osier on 2nd Edition mapping. The lack of marshy ground on 1st Edition OS maps seems anomalous, but it is possible that the mapping for this area at the time was carried out during a long dry spell when marshy ground was less evident than normal and this suggests that consultation of later OS editions would be of benefit.

Other sites mapped through this project which have been sampled during previous fieldwork are later in date. They include a medieval fishpond at Bordesley Abbey (#813 and 814; Carruthers 1993), a post-medieval sequence from Kyre Pool (#1496) near Tenbury Wells, and a post-medieval peat deposit at Abbot Chyryton's Wall, Evesham WRW (within #1068). Kyre Pool (#1496) was formed by the damming of a tributary of the Kyre Brook in 1584 AD. The lake has 4.16m of sediment and preserved a 419-year archive of landscape change (Pittam *et al* 2006). The site was recorded as being of high potential through the current mapping, an assessment which is borne out by the previous field work. At Abbot Chyryton's Wall, (Cook *et al* 1996), a peat deposit dated to the 17th century by shoe leather was encountered during work on the Evesham WRW. The peat deposit was not visible on OS maps as the area was under orchards, but it was located within a large mapped meander loop of the River Avon

(#1068), in which the town of Evesham is located. This area has previously been identified as being of high potential for recovery of organic deposits useful for palaeoenvironmental analysis (Pearson 1996). The deposits sampled contained rich assemblages of pollen, plant macrofossil and insect remains. Substantial pollen records of cereal, hemp or hop and flax are discussed, while insect remains (for example the beet leaf weevil) are suggestive of market gardening, a local industry during the 17th century. A rare species *Stenelmis canaliculata* (Red Data Book Class 2, Hymen 1992) was also recorded. The large meander loop (#1068) was judged to be of high potential through the small wetland mapping toolkit, and also as a result of the previous sampling.

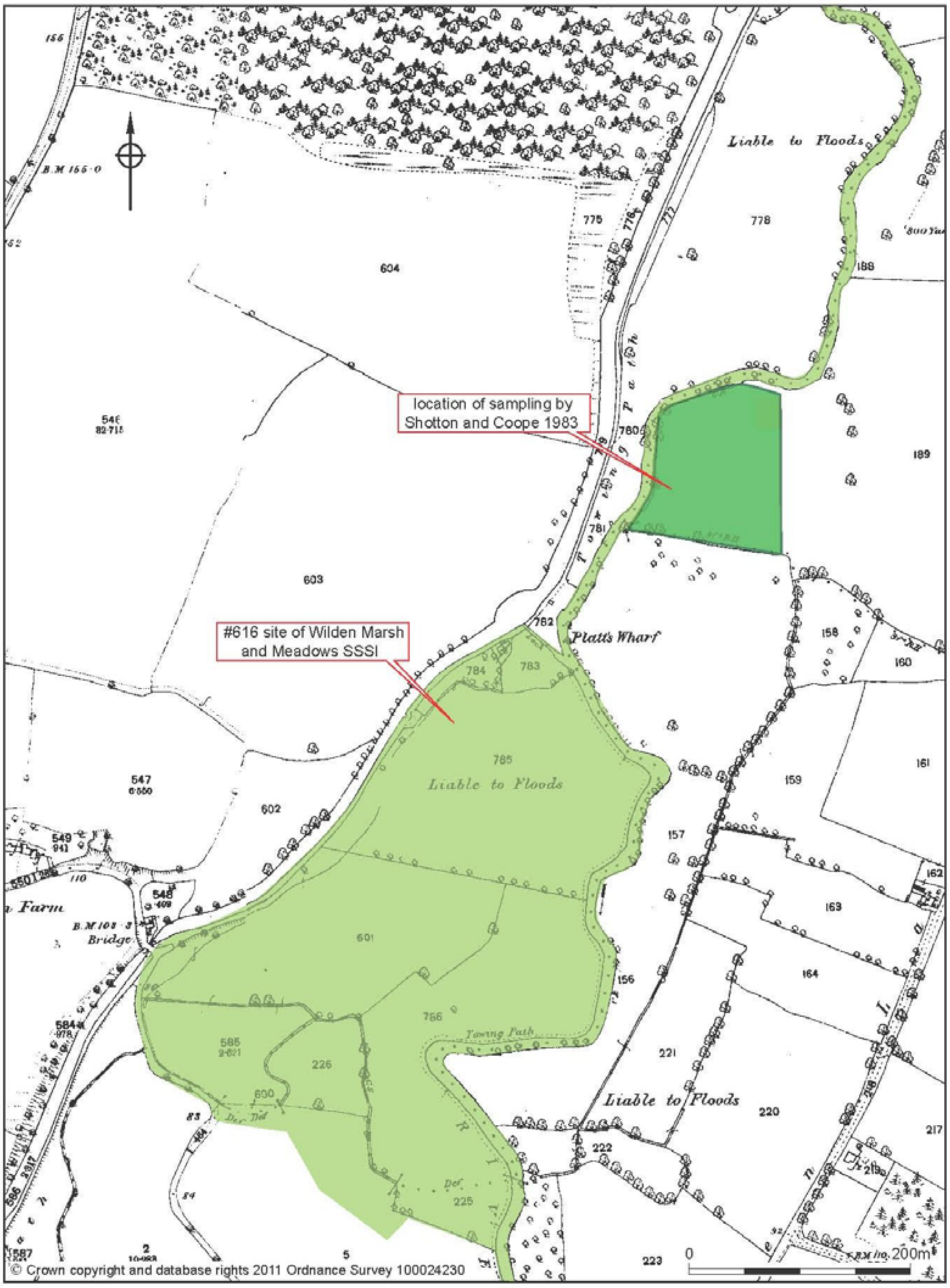

Figure 12: Wilden Marsh 1st edition OS map

Two fish ponds were investigated at Inkberrow Millennium Green (Hurst and Pearson 1999) in which rich organic silts were sampled by augering. These produced rich pollen and plant macrofossil assemblages. Although the deposits were not dated by radiocarbon dating, basal deposits may potentially be of late medieval to post-medieval in date. The site does not lie within the scope of the project, but would have been mapped as the ponds (along with a moat which was not sampled) show on 1st edition and later OS maps. Both ponds would have been scored as low potential because of their small size and tree coverage, but sampling indicates medium to high potential.

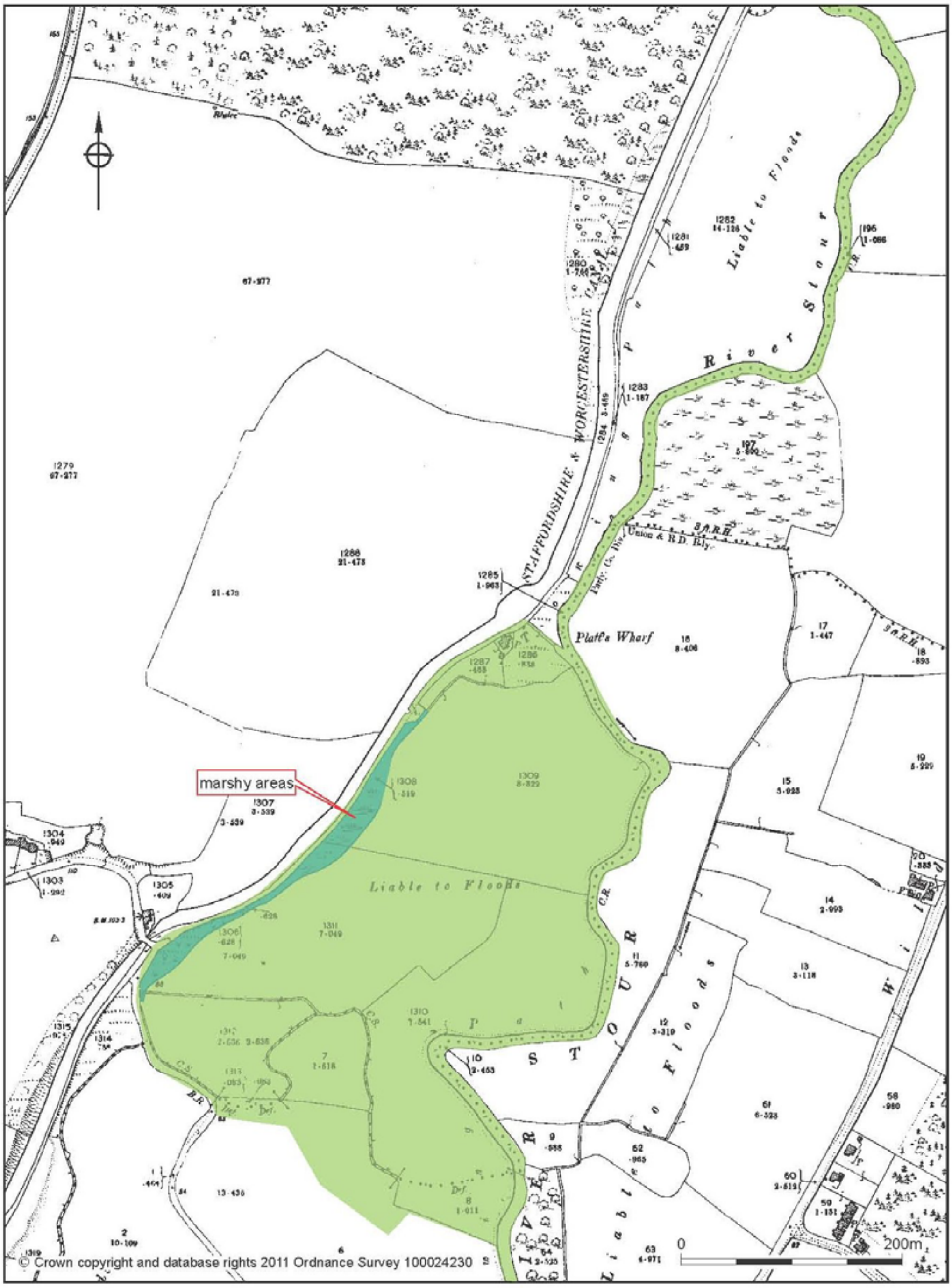

Figure 13: Wilden Marsh 2nd edition OS map

Several examples of significant early prehistoric sequences are known from fieldwork which would either not be mapped using this toolkit, or would only show as small features using this mapping tool as they generally lie buried beneath alluvium (Table 4). These sites may be evident from field boundary patterns, contours on OS maps, or ground terrain modelling using LiDAR images, aerial photographs and BGS geological mapping. These techniques have been tested through the ALSF funded Severn Valley Geoarchaeology project (Jackson *et al* 2011, 2012).

5. Discussion

5.1 GIS mapping

This project has clearly demonstrated and further developed the potential suggested by previous projects for the use of this 'toolkit' as a broad-brush approach for mapping and assessing the potential of small wetland sites over relatively large areas with 1,652 new sites added to the HER through the project. The method is quick to apply with an estimated 30 to 40 new sites being mapped per day once the archaeologist undertaking the GIS work was familiar with the tool. The overall score for potential is generated automatically within the GIS and mapping and assessment was found to have the potential to cover approximately 7.5km^2 of study area per day.

As part of ongoing refinement of the toolkit by WAAS, experience from the pilot projects was used to inform several adjustments to the mapping of small palaeochannel features and to the recording of tree cover (Appendix 1). Following validation, this adjustment appears to have improved scoring, but there are still some concerns over the scoring of tree cover for smaller features (see Section 5.2 for recommendations).

As stated previously (Section 3.1), there are some instances where small wetland sites with potential may not be picked up by this mapping tool. Former wetland sites buried under alluvium are not liable to be recorded as they will not show on the 1st Edition OS maps, but the focus of this project has been on wetland sites that were in existence and visible at least as late as the 1st Edition OS mapping, and in many cases are still wetland sites today. Using LiDAR images and/or aerial photographs as baseline data (rather than for comparison with OS mapping only) may pick up some buried sites, but this would add considerably to the time taken to carry out the mapping, and therefore this is suitable more for a higher level of survey. Also, some known marsh sites (for example Ipsley Alders marsh at Redditch; SP 0784 6755)) were not mapped on 1st Edition maps possibly because mapping was either not as detailed as later editions or a dry season during mapping has affected the visibility of marsh. For this reason it is worth considering that 2nd Edition OS maps could be used instead of, or as an addition to, 1st Edition maps as the baseline survey. In Worcestershire, this mapping edition was as undertaken over 100 years ago. Some marsh areas may show on British Geological Survey drift mapping (British Geological Survey 2013). The areas in Worcestershire where peat shows on BGS mapping have now been added to the HER.

The toolkit, in combination with some ground truthing or validation survey, provides a suitable broad-brush method to use as a first phase of mapping and assessment to cover large areas of land for relatively low cost. The results can be a good guide to the potential of areas and are a starting point from which more detailed investigations can be planned, where needed. It is a method which covers categories of small wetland not emphasised by other techniques (Baker 2006 and 2007, Hill *et al* 2008a, Hill *et al* 2008b). In order to predict sites buried under alluvium, techniques demonstrated as part of a previous WAAS project (and Jackson *et al* 2011, 2012) could be used, as part of a more intensive level of survey, particularly for the floodplain zone. Hence the mapping tool tested here can be used in combination with other techniques (where additional/enhanced information is required or resources allow) as follows:

- Use of other sources, such as 2nd Edition OS mapping, LiDAR images, BGS solid geology, drift and soil series mapping (depending on the degree of detail required), in addition to the 1st edition OS mapping would provide more comprehensive mapping as well as enabling more refined assessment.
- Validation by auger survey of selected sites would provide invaluable further information and further ground-truth the results thus testing the accuracy of the 'toolkit', potentially identifying additional refinements or limitations of the approach. This can be carried out to various levels of complexity from simple visual recording of deposits to analysis of micro-organics (such as pollen), macro-organics (such as plant macrofossils) and micro-stratigraphy of sediments, combined with radiocarbon dating.

- Validation using volunteers with botanical knowledge (for example, Wildlife Trust volunteers) who could use this knowledge to assess the extent of marshy ground and the degree of wetness (both independent of recent weather).
- Use of deposit modelling relating existing borehole and test pit data to known archaeology, currently being used by WAAS on Droitwich as a test area as part of an NHPP funded project (WAAS 2012; EH PNUM 6513)

5.2 Validation work and working with volunteer groups

Access

Securing access for sites on private land can be time consuming, as firstly the name of the owner and contact details can be difficult to establish and secondly, telephone contact with the landowner is preferable in order to fully explain the project and be approachable but on previous experience, owners have often been unavailable by phone during daytime hours. It may be possible that some farmland comes under countryside stewardship schemes, for which contact names are often available.

For this project, selecting sites on public land or accessible by public footpaths and byeways has been the most time efficient method of finding suitable sites for validation or ground truthing.

Working with volunteer groups

In general, guidance through a field meeting is preferable, but depending on the experience of the volunteer group, an off-site meeting with provision of guidance notes on filling in record forms and taking photographs may be sufficient. The latter may be the case, for example, for groups who are familiar with various types of archaeological survey. Phone or email support is generally also needed, or some volunteers may be happy to visit the project leader in the office. Where this has been possible, viewing the mapping in progress has proved useful for volunteers.

Validation results

Generally, validation has shown the mapping and assessment tool used to be an efficient method of mapping many small wetland sites over large areas of landscape, with a good broad-brush assessment of potential.

As discussed in Section 4.2 above, however, validation has shown that there are a couple of aspects that can be difficult to assess at the desk-based assessment stage. Tree cover can often be over estimated from aerial photographs, an aspect that was determined from previous projects (Pearson *et al* 2011; Pearson and Daffern 2012). In order to minimise this effect recommendations were made as a result of work on the previous Grow With Wyre project (Pearson and Daffern 2012) to reduce the weighting that was applied during the scoring of potential (Appendix 1). Tree cover would only be scored as providing *partial* cover even when appearing as dense coverage on aerial photographs. The maximum score applied for 'coverage' would therefore be '3'.

Validation of tree-covered features was generally in agreement with pre-validation scoring, except where marshy ground was not evident. These were all large sized features. Validation of smaller tree covered features by augering may, therefore, further inform the process.

Other aspects apparent from validation carried out through this and previous projects are:

- Geo-referencing can be slightly inaccurate and where this has affected the shape of features mapped, it is often possible to detect when comparing with aerial photographs and LiDAR, or might be confirmed by validation
- Small watercourses seen on 1st edition OS maps but not on modern OS maps (therefore identified as palaeochannels) can often still be at least seasonally active channels. Only those not visible as watercourses on aerial photographs but appearing on LiDAR as a definite channel (at least 2m wide) have been recorded. Specifying limits such as these is recommended as the best way of limiting the number of active channels wrongly identified as palaeochannels. The minimum

width of channel could be debated and adapted depending on environment, or goals of the mapping in any one area. Features recorded in this category may have only recently become palaeochannels, but could have been gradually infilling with sediments for some time before the 1st Ed OS mapping.

These issues could be flagged up on information provided with searches of the HER using this toolkit.

Other aspects that can affect the potential of the sites include modern ground disturbance of a type that is difficult to detect at the mapping stage. Some landscaping such as ground levelling, or the presence of service pipelines may not always be noticeable on maps and aerial photographs. Information from volunteers who know their local area can be invaluable here and in some cases there may be relevant information on the HER.

Many features assessed as being of low potential are small ponds `where organic deposits could have built up, but because of their small size this is uncertain. Nevertheless, at this stage they are still seen as worth identifying as having some potential.

6. Conclusions

Potential for palaeoenvironmental study of Worcestershire has been assessed by mapping of small wetland or waterlogged sites where organic deposits and waterlain sediments are likely to survive. The sites mapped using the small wetland mapping toolkit indicate features which could be used to reconstruct the nature of the past landscape of discreet areas within Worcestershire from the waterlogged organic remains and sedimentary sequences liable to survive within them. It is uncertain how many of these contain deposits that are contemporary with known archaeological sites, but from previous fieldwork it is clear that when contemporary wetland deposits are found they are of significant value for aiding interpretation of the archaeological evidence.

Over 4,900 small wetland sites have now been mapped on a GIS for the project area as a result of new mapping through this project and records generated from three previous projects which piloted this approach. This is not an area of the country associated with extensive wetland landscapes of the kind that are generally considered to produce large bodies of valuable archaeological and palaeoecological information, such as those recovered from the well known and well surveyed Cambridgeshire/Lincolnshire fenlands or Somerset Levels. Nevertheless, this mapping provides an indication of the high potential of this resource having identified numerous new small wetland sites or deposits widely dispersed across Worcestershire which could be of significance for palaeoenvironmental work. Many of these new sites would not normally have been recorded on an HER, and hence may be overlooked during the development control process, or may be at risk from modern farming methods or dewatering. The areas selected for study during the project were those identified as being most at risk development. One of these areas, the sand and gravel aggregates, forms one of the most likely environments for small wetland sites to survive, as this includes large tracts of valley floodplain. However, over 400 new sites have been added to the HER for the Wyre Forest (previously mapped through the Grow With Wyre Project) despite the fact that in a largely wooded landscape with many narrow steep valleys, this did not seem a promising area for such features.

Over 40% of the features mapped (pre-validation) are of medium potential or higher with many (approximately 57%) of low potential, largely on account of their small size. Organic material within most of the feature types mapped (except palaeochannels) tends to derive from sediment influx small catchment areas. Where the catchment area is small, palaeoenvironmental data is invaluable because there is greater prospect of linking changes in environment seen in the data to specific events (for example, human activity on a known archaeological site in the vicinity).

The date of many of the features is unknown, so it is not always possible to determine whether the features identified by the mapping are contemporary with any nearby known archaeological sites, monuments or historic landscapes. As this is a desk-based approach the nature and depth of the waterlain deposits and any organics present are not taken into account. However, using this approach is an efficient method of covering large areas of the county without requiring significant resources, but providing a starting point for any research into past historic environment using the types of features identified by this mapping. The method can be readily applied to lowland valley landscapes over much of the Midlands and south or eastern England. With some adaption of the categories of wetland and the scoring thresholds for assessment, this method could potentially be used to assess other landscape types such upland, areas where wetland is more extensive, or where the significance of cultural features is different (for example where moats or osiers are less common).

Although the tool was designed to predict sites with potential for palaeoenvironmental sampling, it may also prove to be useful for research into more general aspects of historic landscape use and may be useful for archaeological countryside officers in managing the rural archaeological resource. Combining this data with data acquired through the Worcestershire Historic Landscape Assessment (HLC) may also further inform the assessment of some individual features.

Assessment of the GIS mapping

Validation has shown the tool be generally efficient, although some aspects can limit the accuracy of assessment of potential at the mapping stage. These are:

- that tree cover can be over-estimated using aerial photographs, although an adjustment to the scoring appears to correct for this (at least for large sized features)
- that geo-referencing is sometimes slightly inaccurate, and
- that features identified as small palaeochannels can sometimes still be active watercourses (at least seasonally active).

These problems have largely been minimised (see above).

The toolkit developed and refined here lends itself to being used in conjunction with other survey techniques discussed above.

7. Research frameworks

A number of areas of research are identified as being of importance to Worcestershire which relate to those discussed in national, local and regional research frameworks. These include the English Heritage water and wetland strategy (Heathcote 2012), English Heritage aggregate resource assessments (Jackson and Dalwood 2007, Jackson *et al* 2011, 2012), and assessments of potential for environmental archaeology for the *West Midlands Regional Research Framework for Archaeology* (Hodder 2011, Pearson 2002, 2003 and forthcoming).

- The project as a whole contributes towards a stated need for predictive modelling for areas of potential for palaeoenvironmental analysis (of current wetland or buried peat deposits), as identified by national strategy (Heathcote 2012), and more locally, the aggregate resource assessments (Jackson and Dalwood 2007; Jackson *et al* 2011, 2012) and the West Midlands Regional Research Framework for Archaeology sessions for the late prehistoric and early post-medieval seminars (Pearson 2002, 2003 and forthcoming);
- The assessment of wetland sites as ‘high’, ‘medium’ or ‘low’ potential contributes towards a recommendation to ‘produce better mechanisms for flagging important wetland and waterlogged archaeology to raise awareness of its value to ourselves and others outside the sector’ (Heathcote 2012);
- The project will improve accessibility of models which identify wetland/waterlogged potential by integrating information into a County HER in a relatively straightforward format (Objective 2.2, Heathcote 2012);
- The project will help to enable more use of off-site environmental profiles (ie from wetland sites) to aid interpretation of archaeological sites, as recommended in Jackson and Dalwood 2007, Pearson 2002, 2003, Jackson *et al* 2011, 2012;
- The desk-based assessment of sites and ground-truthing will contribute towards knowledge needed to ‘enhance understanding of management options and promote

or enable changes to land management to reduce risk where possible' (Objective 1.5, Heathcote 2012). The desk-based assessment identifies broadly whether there has been a reduction in area of wetland sites and, where relevant, amount of standing water. Ground truthing may identify degradation of deposits or disturbance to the site as well as further refine understanding of potential;

- The importance of studying palaeoenvironmental sequences from sites to investigate the effects of industry should also be highlighted (Pearson 2002, 2003). Potential areas to develop include the use of geochemical signatures to identify the development of metalworking industries, and more use of palaeoenvironmental sequences of historic date to recover evidence of, for example, craft and textile industries and market gardening;
- Use of small wetland sites associated with post-medieval landscaped gardens to improve knowledge and aid garden reconstruction projects (Pearson 2003).

8. Recommendations

The following recommendations are made for further work to further investigate these small wetland sites and refine the mapping tool should funds become available:

- Completion of updating the mapping carried out through previous projects, and integration into the HER, as it was not possible to complete this within the budget constraints of the project. This would ensure a consistent level of information was available for all sites within areas which have been mapped using this toolkit;
- The possibility that many osier beds might overlie features containing older organic deposits has been identified. Such older features (and thus deposits and associated remains of potential high palaeoenvironmental importance) may not always be indicated by the mapping toolkit as currently applied, due to either being masked by the osier beds themselves or through not being identifiable in their own right on the Ist Edition OS basemapping used. In particular it has been identified that osier beds may have been established along the routes of palaeochannels. A rapid check of one example against the Environment Agency LiDAR images held by the HER confirmed this as a potential area for further investigation. Since palaeochannels have a high potential for good preservation of organic remains (including those of early Holocene date), it is proposed that the project GIS could be used to map the osier beds (of which there are 274 examples) against the LiDAR images to rapidly assess how many of these features lie within palaeochannels. Where this was the case, the osier beds would then be re-scored to reflect the higher potential that these areas have, whilst the work would also highlight the potential that osier beds have to be used as indicators of earlier organic deposits.
- Further validation of features by walk-over survey is recommended to include more low potential sites;
- Validation by augering of selected features to visually assess and date deposits. Of particular interest would be:

  i) Osier beds (especially any which are indicated as surviving along the lines of palaeochannels - as discussed above);

  ii) Small to medium sized features showing dense tree cover on aerial photographs to assess the affect of tree cover; and

  iii) Small, low potential features (for example small palaeochannels, meander loops and ponds).
- Development and testing of the 'added value' provided by using other sources, such as:

  i) Use of later OS mapping editions, especially the 2nd Edition to provide more comprehensive and reliable baseline mapping;

  ii) Use of Environment Agency LiDAR JPG images, now widely held within most HERs to improve identification of palaeochannels; and

iii) The incorporation of additional weighting in the assessment based on BGS geology, drift and soil series mapping as wetlands will be more prevalent on some geologies.

- Consideration of whether geochemical, magnetic susceptibility and microcharcoal/micro-pollutant analysis of wetland deposits may be suitable to study the development and impact of metalworking industries (Gilbertson *et al* 1997; Mighall *et al* 2009) in Worcestershire; in particular the Iron Age and Romano-British iron working industry around Worcester, medieval and later iron working in the Wyre Forest and (steel) needle making in the Arrow Valley around Redditch since the 1700s are potential industries for testing. In Kidderminster some tin working is also known.
- Consideration of whether the ground-truthing method could benefit from adopting elements of the methods used for Heritage at Risk Monitoring (specifically those used for the Worcestershire HER HARM Project). Elements to include would need to be those that are suitable for volunteers to assess, rather than archaeology or heritage professionals; such as overall condition of the site.

9. Acknowledgements

The Service would like to thank the following for their kind assistance in the successful conclusion of this project:

Jen Heathcote, Helen Keeley and Jacqui Huntley of English Heritage were all involved in the design and delivery of this project.

Gill Campbell, Zoe Hazell, Michelle Farrell and Ruth Pelling, also of English Heritage, provided invaluable input during discussions of an early draft of this report.

Above all, Carole Gammond, Jacqui Bradley, Lynda Evans, Helen Kirkup, Redditch Local History Group, Steve Southwick and Pete Wolfe, the volunteers who put their time into validating the mapped features are thanked for their help in making this project a success.

10. Personnel

The fieldwork and report preparation was led by Elizabeth Pearson. The project manager responsible for the quality of the project was Robin Jackson. GIS mapping and integration of data in to the HER was undertaken by Tegan Cole.

11. Bibliography

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Plates

Plate 1: Marsh at Hartlebury Common

Plate 2: Osier #586 West of Winnal Coppice, Ombersley, looking south at northern end of feature

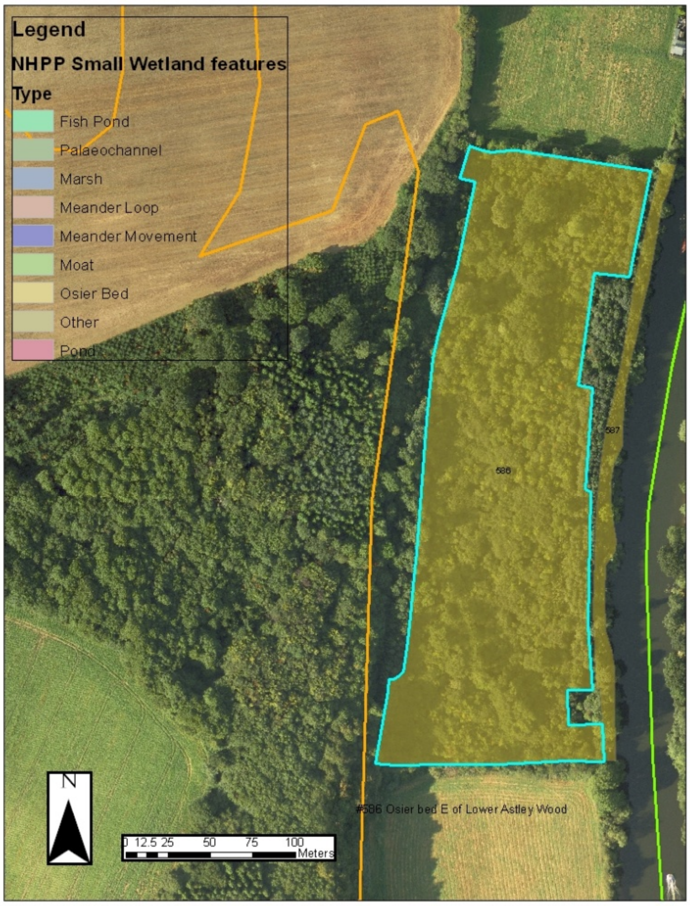

Plate 3: Osier #west of Winnall Coppice, Ombersley (aerial photograph)

Plate 4: #Marsh 356, East of Powick Church, Powick. Looking SW into marsh (drier part)

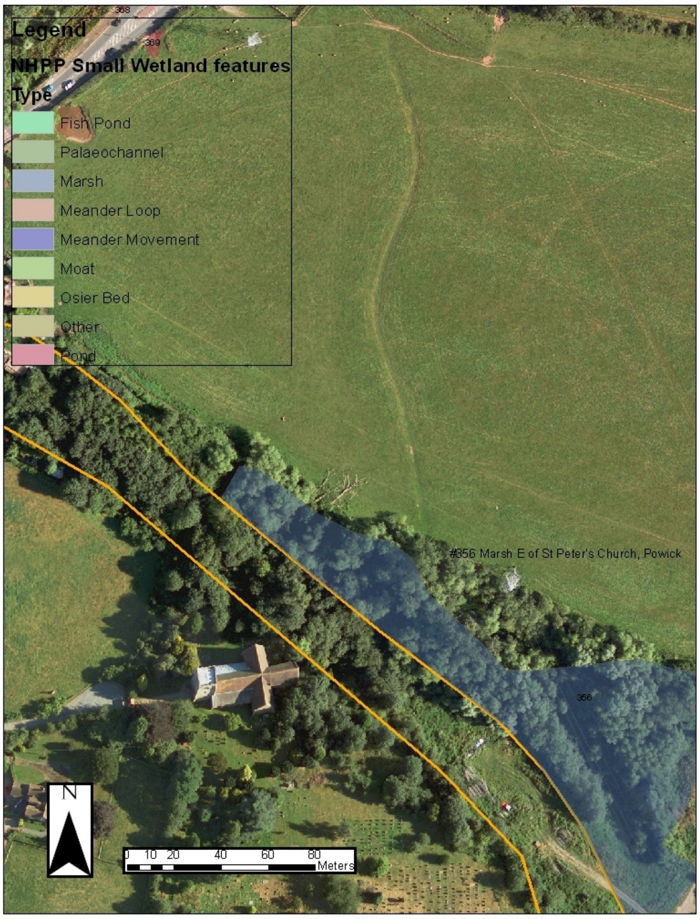

Plate 5: Marsh #356, east of Powick Church, Powick (aerial photograph)

Plate 6: Pond #396 North-west of Cromwell's Tavern, Powick

Plate 7: Marsh #588, West of Winnall Coppice, Winnall, Lineholt