THE DISTRIBUTION OF WATERLOGGED DEPOSITS IN CARLISLE

Final Report

Oxford Archaeology North and Cumbria County Council

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SUMMARY

As part of the National Heritage Protection Plan, English Heritage (EH) defined a project relating to the distribution and significance of waterlogged urban deposits, and the historic city of Carlisle was chosen for such a study because of its very considerable potential for waterlogged deposits. The study area comprised Carlisle's historic core, within the city's medieval defences, and the historic suburb of Stanwix, north of the River Eden, augmented by a 50m-wide buffer zone. Oxford Archaeology North submitted a project design for the work in March 2012 and, following its approval by English Heritage, the study was undertaken throughout 2012.

The aim of the project was to utilise existing information in order to understand better the significance, character and extent of waterlogged archaeological deposits, and their potential vulnerability to future development. A review of palaeoenvironmental evidence was also undertaken. It was envisaged that one of the most significant outcomes would be to enhance the provision of planning advice aimed at the management and preservation of waterlogged archaeological remains, though the data could also serve as an important research tool.

In total, 262 archaeological 'events' were recorded on an Access database, though not all provided positive evidence of waterlogged archaeology. Each event was scored for the quality and significance of its remains. From this information, together with modern contour and lithological data, a predictive GIS model was produced, to map the spatial distribution of deposits and buried topography across the study area, and to generate thickness plots. The data and the predictive model were used as a starting point for an ongoing assessment of possible future threats to Carlisle's buried waterlogged remains, in order to permit informed decisions to be made regarding long-term management and protection.

In Carlisle itself, the very best preservation occurs in the Annetwell Street/Castle Street/Abbey Street area, which is within, and adjacent to, the southern part of the Roman fort and its annexe, and the outer ward of the medieval Castle. Much of this area occupies a shallow valley between the two highest points of the city, occupied by the medieval Castle and Cathedral; there, excavation has demonstrated extensive survival of up to 1.5m of exceptionally well-preserved, waterlogged stratigraphy. However, the study also demonstrated that there is no quarter of the walled city where a lack of waterlogged preservation over an extensive area can be presumed, and limited survival is also attested in the city's historic suburbs. Early Roman timbers have been recorded adjacent to the medieval Cathedral, on what is the highest point within the city walls, indicating that topography is not decisive for waterlogged preservation. Rather, at the few locations where an absence of waterlogging has been proven, or is suggested, it appears to be due to subtle variations in the underlying drift geology, which cannot be extrapolated or predicted.

Across the city, the best preservation occurs in early Roman (late first-early/mid-second-century AD) levels, pertaining to the fort and the adjacent civilian settlement, though deep features of late Roman and medieval date containing waterlogged remains are widespread. For the medieval period, the large ditches associated with the city defences, and the ditch defining the Castle's outer ward, are known to contain exceptionally well-preserved waterlogged stratigraphy. Waterlogged remains of pre-Roman date are mostly limited to small palaeoenvironmental assemblages from buried soils, though a pre-Roman channel of the River Eden on Rickergate is known to contain waterlogged alluvial silts, and it is likely that palaeochannels of Roman and medieval date await discovery in the vicinity. Early

medieval evidence is restricted to one or two deep, cut features, and preserved deposits of post-medieval date are presently known only from the upper part of the medieval ditch fronting the northern city wall. At Stanwix, evidence of waterlogged remains is extremely limited; preservation of organic materials appears to be restricted to a few pre-Roman and Roman deposits in very specific locations, and there is no obvious correlation between these sites and either topography or drift geology.

Wide variability in the quality of the available datasets means that current understanding of the distribution of waterlogged deposits is more likely to reflect, in part, patterns of modern development (and therefore of rescue excavation), rather than providing an accurate model for organic survival. Notwithstanding this, the area of Carlisle with the greatest potential appears to be between the Castle and Cathedral. Whilst this area requires the greatest vigilance in terms of the threat from future developments, the study has demonstrated potential for waterlogged survival over much of the walled city, and the recording of waterlogged deposits should be anticipated in any future archaeological investigations within the walled city.

In Stanwix, there seems to be little potential for waterlogged survival over most of the fort, though why some sites within the study area should have waterlogged remains whilst others should not is unclear. For this reason, the possibility that waterlogged deposits might turn up almost anywhere should also be anticipated in future investigations, particularly for development in the area of the extramural settlement south of the fort, and within the system of pre-Roman fields to the north, where preservation of organic remains has been confirmed by excavation, or for works that impact upon large, deep-cut features where waterlogged fills might exist.

The extent to which new developments might lead to the gradual dewatering of preserved waterlogged archaeology in adjacent areas, even if the development itself does not impact directly upon such remains, is unclear, though concerns have been expressed within the archaeological profession generally. For Carlisle, data on the impact of developments on waterlogging are generally lacking, but archaeological excavation of waterlogged strata immediately adjacent to large, deep modern features suggests that the effects may not always be as damaging as might be expected.

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Rachel Newman, the Project Executive, provided the executive direction for the project and edited the report. The background research into waterlogging in Carlisle was undertaken by John Zant, who was also the lead author. The environmental research was undertaken by Elizabeth Huckerby, who also contributed to the report. The GIS was designed by Anna Hodgkinson, and the GIS modelling was undertaken by Carl Champness and Anna Hodgkinson; additional illustrations were compiled by Anne Stewardson. Jamie Quartermaine managed the project and edited the report.

1. INTRODUCTION

1.1 PROJECT BACKGROUND

1.1.1 ***Introduction***: the National Heritage Protection Plan (English Heritage 2011a) defines how English Heritage (EH) and partners will identify and protect significant heritage assets. One of the foci or objectives defined in the plan is concerned with the *Identification of Wetland/Waterlogged Sites* (Activity 3A5), within which is a specific suite of projects relating to the distribution and significance of waterlogged (anoxic) urban deposits. In order to address this project, EH invited project proposals to collate and synthesise extant data on urban centres with known waterlogged stratigraphy.

1.1.2 As one of the most important urban centres in northern England, where the existence of exceptionally well-preserved waterlogged archaeological deposits has long been known (*Section 1.2*), the historic city of Carlisle, in north-west Cumbria (NY 400 560 (Fig 1)), was an obvious candidate for the proposed study. In both national and regional terms, Carlisle can be regarded as a highly significant historic centre, which, as research has demonstrated (Brennand and Stringer 2011), retains a wealth of archaeological and historical information. This has been recognised, both for the Roman, early medieval and medieval periods, in the *Research Agenda and Strategy* of the *Archaeological Research Framework for North-west England* (Philpott and Brennand 2007, 67, 74-5; Newman and Brennand 2007; Newman and Newman 2007, 104). From the existing archaeological dataset, there was little doubt that extensive buried waterlogged remains represent one of the most significant elements of the city's surviving historic resource.

1.1.3 Consequently, in December 2011, a proposal was submitted by Oxford Archaeology North (OA North 2011) for a project of this type, focusing on the historic centre of Carlisle. Following submission of the proposal, which marked the project's Start-up Stage, as defined in EH's *Management of Research Projects in the Historic Environment (MoRPHE)* (English Heritage 2006, 12), OA North was commissioned to produce a costed project design. This was submitted in February 2012, and a revised version, which addressed comments received from EH, was resubmitted in March (OA North 2012a). Following EH's approval of the revised project design, which marked the project's Initiation Stage (English Heritage 2006, 12), OA North was commissioned to undertake the project, with work commencing in April 2012.

1.1.4 ***Study Area***: the project proposal (OA North 2012a) envisaged that the study area would be confined to Carlisle's historic core, as defined by the city's medieval defensive circuit (Figs 1 and 2; Plate 1). However, at the suggestion of Dr Sue Stallibrass, EH's Regional Scientific Advisor for north-west England, the historic suburb of Stanwix, on the north side of the modern city (and separated from it by the River Eden), was also included in the study (Figs 1 and 3). In both Carlisle and Stanwix, the study areas were further augmented by the provision of a 50m-wide buffer zone. In the case of Carlisle, this was intended to capture, in particular, evidence relating to the survival of waterlogged deposits within the city's medieval defensive ditches, whilst in Stanwix, the buffer zone encompassed such potentially significant features as the defensive ditches of the Hadrian's Wall fort and elements

of a pre-Roman or early Romano-British field system that is known to lie to the north-east of the fort (*Section 4.3.2*).

1.1.5 ***Project Outline***: the aim, during the Execution Stage of the project (English Heritage 2006, 14), was to utilise, in the most efficient and accessible way, the existing topographical, archaeological, and historical dataset, in order to understand better the significance, character and extent of waterlogged archaeological deposits within the study area, and their potential vulnerability to future development. All relevant sources, including the published and unpublished results of modern archaeological investigations, antiquarian observations, and other appropriate records, were interrogated, and the results were entered into a database. Where possible, borehole data were also used, though much of that, formerly held by Carlisle City Council, had been lost to flooding in 2005 (OA North 2012a, 11).

1.1.6 The study was undertaken in conjunction with Cumbria County Council's Historic Environment Service (CCCHES), which provided liaison in the design and implementation of the project. There was also co-operation with Roger Higgins, Carlisle City Council's Heritage/Design Officer, who represented the main point of contact for the City Council.

1.1.7 It was intended that the project should augment the Urban Archaeological Database (UAD) for Carlisle (OA North 2007a). The UAD comprises a database of all available information pertaining to the archaeology of the city, and provides a summary of every known archaeological 'event' that occurred within the study area up to the time of the UAD's compilation in 2007. These included all manner of information sources, from modern archaeological excavations to antiquarian observations, chance discoveries, and cartographic, pictorial and documentary sources. From this data, large numbers of archaeological 'monuments', of all chronological periods, were identified and described within the database. However, it was not the purpose of the UAD to provide a detailed assessment of the character, extent and survival of archaeological deposits across the city, nor to provide detailed information about a particular type of archaeological strata. Consequently, it was not possible to use the data held in the UAD to generate a detailed picture of waterlogged preservation in Carlisle.

1.1.8 Whilst the UAD serves as a stand-alone resource for Carlisle City Council, it has also been incorporated into the Cumbria County Council Historic Environment Record (HER). Although the UAD itself is not currently being updated to incorporate new data generated since 2007, the HER is constantly being enhanced as ongoing investigative work is undertaken in the city. The waterlogged Carlisle study has, therefore, incorporated all archaeological works undertaken within the study area between 2007 and 2012, and these data have been incorporated within the UAD/HER.

1.1.9 ***Outcomes***: the results of the project are considered in detail in *Section 4*. It was envisaged that one of the most significant outcomes would be to raise awareness amongst stakeholders of the character, extent, and importance of waterlogged archaeological remains in Carlisle and Stanwix, the importance of which has been highlighted by earlier studies. It was also intended to enhance the provision of planning advice aimed at the management and preservation of this finite and highly significant heritage resource (Lillie and Smith 2009, 3), although it was also clear that the data gathered could serve as an important research tool.

1.1.10 In terms of products, the principal outcomes have been the creation of an Access database of all available evidence for the presence (or absence) of waterlogged archaeological remains within the study area (and a summary of the character of that evidence), and a predictive GIS model for the survival of waterlogged deposits, extrapolated from topographical, geological, and archaeological excavation data (*Section 3.5*). The format of the data is compatible with the CCCHER, and it is intended that the GIS shapefiles and database should be incorporated as an over-arching layer within the HER. It is envisaged that this will prove to be of considerable significance as a planning tool, facilitating the provision of advice on the likely impact of future development proposals on the city's buried waterlogged archaeological remains (*Section 5.3*). The model will provide an analytical heritage-management tool with which to understand the resource better, and which will allow for the interrogation of heritage datasets and the assessment of future impacts, thus assisting in the future management of these nationally important remains. It is also envisaged that the model could (and ideally should) be refined in the future, as and when new information is forthcoming, either from new archaeological investigations within the historic city, or from other sources, for example, boreholes.

1.2 THE DISCOVERY AND SIGNIFICANCE OF CARLISLE'S WATERLOGGED ARCHAEOLOGY

1.2.1 The existence of widespread waterlogged strata within Carlisle's historic centre has been known since the late nineteenth century, when Richard Ferguson recorded Roman and medieval timber structures exposed during construction works (Ferguson 1878; 1880a; 1893; Ferguson and Hetherington 1880). Some preserved timber features had also been recorded as early as the 1850s, during the construction of Carlisle's Victorian sewers (McKie 1880; Ferguson 1880b). Limited evidence for organic preservation at other sites within the city was also generated by a small number of excavations and observations made during the early/mid-twentieth century (*eg* Bower 1903, 412; Redfern 1921; Shaw 1924, 106; Hogg 1955; 1964). However, it was not until the last quarter of the twentieth century that the full significance of Carlisle's waterlogged archaeological resource became apparent, as a result of a series of large-scale excavations (Fig 2), most notably at Annetwell Street (Charlesworth 1980; Caruana in prep a; in prep b), Blackfriars Street (McCarthy 1990), the Lanes (McCarthy 2000; Zant and Howard-Davis in prep), Castle Street (McCarthy 1991a), and as part of the Millennium Project (Zant 2009; Howard-Davis 2009). Over the past 35 years, the information generated by these major projects has also been supplemented by data gathered from a large number of smaller archaeological interventions, which have recorded the presence (or absence) of waterlogged remains across much of Carlisle's historic core, and beyond, into the city's historic suburbs (*eg* Newman 2011a).

1.2.2 Whilst there remain large areas of Carlisle's historic core where little or no information on the character of the buried archaeological resource is currently available (most notably beneath the medieval Castle, at the north end of the historic city, and over much of the southern part of the medieval walled area, adjacent to English Street (Fig 2)), the existing body of archaeological and antiquarian data is of sufficient size and quality to demonstrate that buried waterlogged strata to some extent exists over much of the historic walled city, and, to a lesser degree, within the historic suburbs. The national significance of this resource has been recognised

in EH's *Strategy for Wetlands* (Van de Noort 2004), and in a more recent EH project, *Identifying top priority vulnerable Wetland / waterlogged Sites: Stage 1*, (English Heritage 2012, 12). In the latter study, Carlisle is included in a list of the top 40 places in the country whose significance needs to be highlighted at a national level. Regionally, Carlisle's waterlogged remains are also highlighted in the *Research Agenda and Strategy* of the *Archaeological Research Framework* for North-west England (Brennand 2007). Specifically, the city's waterlogged medieval heritage is noted (Newman and Newman 2007, 103-4), and the Roman-period *Agenda* also points to the importance of Carlisle's waterlogged strata for dendrochronological dating and studies of Roman woodland management (Philpott and Brennand 2007, 60). Across the city as a whole, however, it is clear that preservation is variable, due both to changes in natural topography and subsoils (*eg* Zant 2009, 43) and the effects of modern developments, which have removed or truncated such deposits in certain areas.

1.2.3 The deep, waterlogged strata within the southern part of the Roman fort (*Section 4.3.3*), known from the excavations undertaken at Annetwell Street (Caruana in prep a; in prep b) and during the Millennium Project (Zant 2009), are of national, or even international, significance, being equalled at only a handful of Roman military sites in northern Europe, such as Vindolanda, in Northumberland (Birley 1994), and Valkenburg, in the Netherlands (Glasbergen 1972). These strata, which attain a maximum recorded thickness of *c* 1.5m in the areas of best survival (*Section 4.4.5*), are exceptionally important, being equalled at only a handful of other British urban centres, for example in the early medieval levels at York (Hall 1984; 2004), and in parts of London, notably on the Roman waterfronts adjacent to the River Thames (Milne 1985). Indeed, for the quality and extent of its early Roman waterlogged deposits, Carlisle is unsurpassed nationally, and has few comparators elsewhere within the boundaries of the Roman Empire (Philpott and Brennand 2007). Furthermore, in Carlisle, the exceptional preservation of structural timbers has facilitated the establishment of the best sequence of first-second-century AD dendrochronological dates for a British site outside of London (*op cit*, 60; I Tyers *pers comm*), and has allowed the early development of the fort to be dated with exceptional precision (Philpott 2006, 64; Zant 2009, 413).

1.2.4 Though generally less deeply stratified, the extensive waterlogged remains recorded elsewhere in the city are also highly significant, since such deposits are rare in urban contexts nationally, especially over large areas. For the Roman period, Carlisle is equalled or surpassed in Britain only by London and York, and, although more common, extensive preservation of waterlogged medieval deposits is also rare at a national level.

1.2.5 In contrast to Carlisle itself, archaeological work at Stanwix has been piecemeal (Zant 1997; 2011, 33), but waterlogged deposits are known from a few sites (Fig 3), notably salvage excavations undertaken within the probable civilian settlement on the south side of the fort (Caruana 2000), and at sites to the north and east of the fort (OA North 2007b (*Section 4.3.5*)). There is, however, currently no evidence for waterlogged remains within the fort itself.

2. AIMS AND OBJECTIVES

2.1 SUMMARY

2.1.1 The aims and objectives of the project were set out in the Project Design (OA North 2012a, 8-9), but are presented again here for convenience. The principal aim of the project was to map the known waterlogged urban deposits in Carlisle and Stanwix, in order to provide a predictive GIS model for assessing the location of waterlogged deposits in Carlisle and Stanwix. Production of the model was intended to aid planners and curators, as well as the wider archaeological community, both in understanding the factors determining the formation and preservation of such deposits within the study area, and in assessing their extent and vulnerability.

2.2 AIM 1

- ***To develop a GIS and database for the project:***
- *Objective 1.1*: to create a GIS, in order to map the extent and character of waterlogged deposits, natural topography, and any other appropriate data, to facilitate the production of a deposit model;
- *Objective 1.2*: to develop an Access database suitable for storing and manipulating data pertaining to the character, extent, and preservation of waterlogged archaeological deposits within the study area, and other relevant information.

2.3 AIM 2

- ***To enhance an understanding of the character, extent, and formation of waterlogged archaeological strata across the study area, and to assess possible threats to the resource:***
- *Objective 2.1*: to locate and map the extent of waterlogged archaeological deposits within the study area;
- *Objective 2.2*: to characterise the nature and preservation of waterlogged deposits, and to elucidate the manner of their formation;
- *Objective 2.3*: to review the evidence for the natural topography and geology, and the extent to which these have influenced the formation of waterlogged deposits;
- *Objective 2.4*: to review existing palaeoenvironmental data from waterlogged deposits within the city;
- *Objective 2.5*: to generate a deposit model, mapping the known location of waterlogged deposits and predicting the likely extent of buried waterlogged strata across the study area;
- *Objective 2.6*: to assess possible future threats to Carlisle's buried waterlogged deposits.

2.4 AIM 3

- ***To integrate the results of the project with Cumbria County Council's HER:***
- *Objective 3.1*: to ensure that the GIS and database formats of the project are wholly compatible with those of the Cumbria HER, thereby ensuring that the data will seamlessly drop into the HER on completion of the project.

2.5 AIM 4

- ***To disseminate the results of the project as widely as possible, to promote and raise awareness of Carlisle's waterlogged heritage, and to highlight the potential vulnerability of the resource:***
- *Objective 4.1*: to prepare a report, presenting the results of the project, integrated with GIS mapping and a deposit model;
- *Objective 4.2*: to produce documentation explaining the use of the database and GIS;
- *Objective 4.3*: to make the results of the project available to appropriate personnel within Carlisle City Council (and also to other relevant organisations and individuals), in order to raise awareness within the Council, and elsewhere, of the national importance of the city's waterlogged remains, and to facilitate the future management of the resource;
- *Objective 4.4*: to present the results of the project at regional and national conferences and forums, as appropriate;
- *Objective 4.5*: to make the project database, and the results of the project, available for consultation online.

3. METHODOLOGY

3.1 INTRODUCTION

3.1.1 In accordance with EH guidelines (English Heritage 2006), fulfilment of the project's aims and objectives (*Section 2*) required the completion, during the Execution Stage of the project (*op cit*, 14), of a series of tasks, which resulted in the creation of a number of products. The tasks required to achieve the waterlogged Carlisle project were presented in the project design's Method Statement (OA North 2012a, 10-17), and in the Task List (*op cit*, 23-4).

3.1.2 Table 1 provides a summary of the main project stages, as identified in the project design. The following section details the methodological results of each of these stages. All the work was undertaken in accordance with the models set out in the second edition of EH's *Management of Archaeological Projects* (English Heritage 1991), and in *MoRPHE* (English Heritage 2006).

1	Design of GIS and database (*Section 3.2*)
2	Data capture (*Section 3.3*)
3	Data analysis and input to database (*Section 3.4*)
4	Production of deposit model (*Section 3.5*)
5	Assessment of threat (*Section 3.6*)
6	Linking results to CCCHER (*Section 3.7*)
7	Reporting and consultation (*Section 3.8*)
8	System documentation and dissemination (*Sections 3.9-10*)

Table 1: Summary of principal project stages

3.2 DESIGN OF GIS AND DATABASE

3.2.1 The flexibility of interface customisation offered by GIS and database packages was demonstrated during the course of other projects undertaken by OA North, including the Carlisle UAD (OA North 2007a). The GIS system was established, designed and maintained to facilitate input and analysis of the data, and has been developed from that used by OA North for the Carlisle UAD. The latter has been updated to take into account the advances in data standards, and new software developments in the five years since the UAD was developed, as well as the creation of new tables and fields that are specific to the requirements of the present project. The design process of GIS and database incorporated input from a geo-archaeologist (Carl Champness) to ensure compatibility with the data for the predictive model. The GIS platform used was Quantum GIS (QGIS), with all data files stored in ESRI shapefile format to ensure backwards compatibility. Occasionally the gvSIG OA Digital Edition was used in order to enhance the functionality of QGIS. The database format is Microsoft Access 97, which is both backward and forward compatible with other Access formats and can be readily imported into other database formats, including the Cumbria HER. This has enabled an analysis of the archaeological and geological resource within the study

area. The GIS was designed to be compatible with EH guidelines (English Heritage 2011b) and, to ensure full compatibility with the HER, the Cumbria HER Officer was involved in trials to test the compatibility of the project GIS with the formats of the HER. Confirmation was provided to English Heritage, as an early performance indicator, that there is compatibility between the dataset and the HER.

3.2.2 Quantum GIS (QGIS) contains extremely powerful tools for the analysis of both vector and raster data, and, together with the implementation of Access 97, facilitated the creation of a fully integrated, custom-built database and GIS package, which was tailored to the needs of the project. One algorithm, namely the interpolation method, Kriging, is not presently supported by QGIS, and therefore the SEXTANTE toolbox in the gvSIG OA Digital Edition was used. The archaeological datasets were standardised to comply with the English Heritage Historic Environment Data Standards (English Heritage 2007a) and the NMR thesauri for monument and event types (English Heritage 2008). The GIS datasets are being transferred into the Cumbria HER, which will take on the long-term maintenance of the dataset.

3.3 DATA CAPTURE

3.3.1 In accordance with the methodology presented in the project design (OA North 2012a, 11-12), information relating to the character, extent, and survival of waterlogged archaeological strata within the study area was obtained, together (where available), with information on the underlying drift geology and bedrock. Three principal sources of information were reviewed: published and unpublished reports/observations and borehole logs.

3.3.2 ***Published Sources***: the most significant source of information for the project proved to be the corpus of published material relating to archaeological investigations and antiquarian observations within the study area. These included published antiquarian records. and modern sources, such as monograph reports and articles in national and regional journals.

3.3.3 The earliest relevant record within the study area dates from 1804, when fragments of wood were found amongst human remains during the digging of cellars on St Alban's Row (Jones 1990). Almost certainly, the workmen had disturbed part of the cemetery associated with the medieval chapel of St Alban (by then long since demolished), and it is therefore possible that the wood fragments were the remains of coffins, although no further details were given. Most antiquarian observations date from the late nineteenth century, a time when Carlisle's historic centre saw a great deal of redevelopment, and most were made by a single individual, Richard Ferguson, who published many reports (including several where preserved waterlogged remains are explicitly mentioned and described) in the First Series of the *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society* (CWAAS) (Caruana 2011, 9). Following Ferguson's death in 1900, relatively few observations appear to have been made, though early volumes of the New Series of the *Transactions* contain a few brief reports, some of which mention waterlogged remains. These mostly date to the period before the First World War, but two records from the 1920s (Redfern 1921; Shaw 1924) also proved to be of relevance to the project.

3.3.4 Comparatively little work on the archaeology of Carlisle was carried out in the 1930s and 1940s, and, with a single exception at Stanwix (*Section 4.3.5*), no

records of waterlogged remains were made during this period within the study area. In Carlisle itself, the first archaeological investigations using recognisably modern techniques were carried out by Robert Hogg, curator at Tullie House Museum, in the 1950s (Hogg 1955; 1964). Hogg encountered well-preserved waterlogged strata at sites on Castle Street and Scotch Street, and in the grounds of Tullie House Museum on Abbey Street, as did FG Simpson in the course of small-scale excavations at the Cathedral in 1953 (Simpson 1988).

3.3.5 At Stanwix, few archaeological observations had been made prior to the early 1930s, when FG Simpson conducted several seasons of work, some of it located within the study area (Simpson 1933; 1934; Simpson and Hogg 1935). Simpson and Sir Ian Richmond also conducted further investigations at Stanwix in 1939-40 (Simpson and Richmond 1941a; 1941b). However, waterlogged organic remains appear to have been encountered only once, when stakes were recorded in the Vallum ditch (Stanwix Event 39; *Section 4.5.4*).

3.3.6 Following Hogg's work in the 1950s, little excavation was carried out in Carlisle until the formation of the Carlisle Archaeological Unit (CAU) in 1977 (Caruana 2011, 11-12). Though some rescue and salvage work was undertaken in the early/mid-1970s (*op cit*, 10), most of the results remain unpublished. From 1977 to 2001, CAU (Carlisle Archaeology Ltd (CAL) from August 1999) carried out a great deal of archaeological work within the study area, including several highly significant, large-scale projects, where extensive waterlogged strata were encountered. Whilst the results of some of these excavations have been published as monographs, for example those undertaken at Blackfriars Street (McCarthy 1990), Castle Street (McCarthy 1991a), the southern Lanes (McCarthy 2000) and as part of the Millennium project (Zant 2009; Howard-Davis 2009), others remain unpublished. A handful of smaller interventions have also been published in the CWAAS *Transactions*, but for the most part, CAU/CAL's work within the study area (including the numerous interventions carried out at Stanwix) remains unpublished. From the late 1990s to 2001, a comparatively small amount of archaeological work was also carried out at Carlisle and Stanwix by other archaeological contractors; however, most of these were either located outside the study area, and/or did not yield data worthy of publication.

3.3.7 The demise of CAL in 2001 coincided with a decline in large-scale redevelopment within Carlisle's historic core, and a concomitant reduction in the amount of archaeological work required. At Stanwix too, relatively few significant interventions have occurred within the study area in the past decade, with work being restricted largely to small-scale watching briefs that have yielded little significant data. One of the few published sites of this period that yielded positive evidence for waterlogged preservation was undertaken at Stanwix in 2004 (Zant and Town in press).

3.3.8 ***Unpublished Sources***: the great majority of unpublished sources reviewed during the course of the project were 'grey literature' reports produced by CAU/CAL, mostly from the early 1990s to 2001, and by other archaeological contractors operating within the study area, principally from the late 1990s to the present. Most of the reports generated by CAU/CAL were obtained from the unit's archive, which is curated by Tullie House Museum Trust at Shaddon Mill, Carlisle. Reports on projects undertaken by OA North are held at their premises in Lancaster, and were

readily accessible, whilst reports generated by other contracting organisations were obtained through the CCCHES.

3.3.9 Additionally, unpublished manuscripts for a number of important excavations were present in the former CAU/CAL archive. These included draft reports on the highly significant CAU excavations at Annetwell Street (Caruana in prep a; in prep b) and the northern Lanes (Zant and Howard-Davis in prep), and on the results of several rescue/salvage operations carried out in the mid-1970s, before CAU was formed. A very few unpublished interventions were also recorded in other sources, including notes compiled by Robert Hogg and held in Tullie House Museum and Art Gallery.

3.3.10 ***Borehole Logs***: although Carlisle City Council's archive of borehole records was lost to flooding in January 2005, the very limited number of records generated after the flooding, or held elsewhere, were consulted and assessed. However, the majority of the records were obtained from historical geotechnical investigations held by British Geological Society.

3.3.11 The borehole records date from various periods from the 1970s to the present-day, and their distribution, for the most part, covers the historic core of Carlisle, where there have also been archaeological excavations, but excludes the area around the Castle and the northern part of the city. Limited numbers of boreholes from beyond the historic core were used to provide a spread of data outside this area, in order to produce a more accurate model near the edges of the study area.

3.3.12 Only paper records were available during the study, with no sample or core data able to be examined to verify any of the observations made from the geotechnical boreholes records. All information comprised paper copies of borehole records; a range of problems is known to exist with this type of dataset, and the limitations and value of borehole data to archaeologists are discussed in detail by Bates and Bates (2000).

3.3.13 In total, 43 data points were collected for Carlisle and 24 datapoints for Stanwix, as part of this exercise, providing the best coverage of the study areas possible, and incorporating various different data-sources. These comprised mainly excavation archives but also eight boreholes for Carlisle (Fig 4), but none for Stanwix. To enable qualitative judgements to be made about the accuracy of the data, a confidence level was ascribed to each point as it was recorded, based on the quality of the source material. While borehole records are often not reliable enough to inform the nature or level of archaeological deposits, they did provide useful data for the top of the natural drift geology and topography.

3.4 PRODUCTION OF LITHO-STRATIGRAPHIC (DEPOSIT) MODEL

3.4.1 A litho-stratigaphic deposit model had been previously constructed as part of the Carlisle UAD, but it was found to be too crude to be usable, and reflected that, with a few exceptions, the absolute heights of waterlogged deposits and finds below the present ground surface have not been routinely recorded in published sources, or in 'grey literature' reports (J Zant *pers comm*), and, for many of the older excavations, only relative heights were captured. In the present study, it was recognised that the availability of the Lidar absolute height data for the surface, coupled with the relative heights from excavation and borehole records, could allow for the production of a new, more accurate, deposit model.

3.4.2 The deposit model was produced to help investigate the relationships between the distribution of waterlogged deposits, with variations in the lithological units, and the palaeotopography. The model correlated the borehole and excavation lithologies into three main interpretive stratigraphic units: modern disturbance/modern deposits; archaeological deposits; and the top of the till deposits (boulder clay). Further distinction of deposits was not thought possible, given the inconsistent recording of the archaeological and borehole evidence, and the incomplete nature of many of the available records. The data for the deposit model were collected from four main sources:

- published excavation reports;
- the CAU/CAL archive at Shaddon Mill, Carlisle;
- borehole records held by Carlisle City Council and the British Geological Society;
- Lidar

3.4.3 The CAU/CAL archives held many of the unpublished excavation archives for the city and these were revisited as appropriate to obtain primary height data for the defined stratigraphic horizons. This included the interface between the natural geology and archaeological deposits, and between archaeological deposits and modern made-ground. A contour survey of the modern surface within the study area was also produced in the new deposit model in order to address the height issues encountered during the previous modelling. The new source of height data was based on 1m-resolution ASCii Lidar data purchased from the Environment Agency.

3.4.4 Height data were collected from a number of sources that included site archives, borehole records and Lidar data. The 43 data points for Carlisle and 24 for Stanwix (*Section 3.3.13*) were used, and were compiled from both archaeological events and boreholes (eight boreholes for Carlisle and none for Stanwix). Of the points pertaining to Carlisle, 33 lay inside the study area and ten were outside, providing a substantial coverage across the historic core and beyond its boundaries. Data from excavations in the city were examined, and recorded in the database, linked to the events from which they derived. Spot heights were recorded, with details of which horizon these related to (for example, the top of archaeological strata), generating six-digit eastings and northings, and absolute heights in metres OD, to give an accurate three-dimensional co-ordinate. This information has been entered into spreadsheets. To enable qualitative judgements to be made about the accuracy of the height data, a confidence level was ascribed to each point as it was recorded, based on the quality of the source material.

3.4.5 Data issues included a preponderance of relative heights, rather than absolute, being recorded in the primary excavation archives. The irregular distribution of points, with outliers having an undue influence over the model, means that areas with poor coverage within the model will be less reliable. As a result of the varied nature of the source material, many points had not been rectified to the OS datum, but were recorded as a height below the current ground surface. To exclude these points would have reduced significantly the amount of data available for analysis, particularly for the modelling of the top of archaeological deposits. Therefore, recorded heights below the ground surface were converted relative to the OS datum, using the height of the current ground surface generated from Lidar data.

3.4.6 In order to verify the accuracy of the models, the data from the excavations were compared back to the heights extracted from the Lidar data. For this purpose, the Lidar raster surfaces were turned into vector points with a resolution of 1m as centroids of the raster grid cells, containing the elevation information with an accuracy of ± 0.15m (Conolly and Lake 2006, 72). From these vector points, several of which could frequently be found within a polygon representing an archaeological site, the average minimum and maximum heights, as well as the standard deviation, were calculated and added to the database. These values allowed the correction of the elevation values of the individual sites, as well as their verification, and the further enhancement of the model. The presence of certain areas that have poor coverage, such as within the Castle and the Cathedral precinct, means that the interpolation algorithm is less accurate within these areas. The thickness of the archaeological deposits was calculated by subtracting the surface of the drift geology from that of the surface of the made-ground. This provided a basic plot of archaeological thickness across the area that is sufficiently accurate to predict the general trend of archaeological survival across the study areas, and the potential for waterlogging.

3.4.7 The geotechnical data often did not record information on historical water-levels, and indicators of waterlogging are not always consistently recorded within geotechnical investigations. Thus the absence, or presence of, for instance, waterlogged wood or plant remains is not routinely noted within non-archaeological investigations. The geotechnical investigations do record current ground water-levels, but these will vary depending on when the work was undertaken. While borehole records cannot be used to inform the nature of archaeological deposits, they do, however, provide useful data for reconstructing the palaeotopography of the area, which is sealed and often obscured by later post-medieval and modern make-up deposits.

3.4.8 An interpolated mesh was produced for each stratigraphic horizon within the deposit model using the geological modelling software, Rockworks 14©. Inverse distance weighting (IDW) was used in order to map the sediments across the study area. The modelled surfaces are sensitive to clustering and the presence of outliers (errors or poor spatial coverage within the dataset) but, in tests, have been shown to produce some of the most accurate models when compared back to the original data source (Hageman and Bennett 2000, 116). IDW assumes that the phenomenon being modelled is driven by local variation, which can be captured (modelled) by defining an adequate search neighbourhood, which, in this case, was the eight points closest to each other with a weighted exponent of two, decreasing with distance. The resulting mesh was produced with a cell spacing of 20m, 0.10m in height.

3.4.9 To create surface models for the top of archaeological deposits and drift geology, levels were extracted from the CAU/CAL site archives, where available, or from published reports. Many of the levels for deposits were already converted to metres OD, and therefore it was still possible to create reliable deposit models for the archaeological and natural surfaces that were not affected by the discrepancies in the modern surface. However, in some cases, only relative heights had been recorded, and it was clear that the surface heights would need to be generated from the Lidar. Each mesh was imported into the GIS, and a raster layer was created from which the contours were generated. This data enabled a comparison of the scored archaeological events within the study area to be made with the influence of

the palaeotopography and the mapped thickness of archaeological deposits across Carlisle. At Stanwix, this approach proved not to be feasible because of the relative paucity of borehole and event data.

3.4.10 The quality of the deposit model relates directly to the density of confirmed data points and these are inevitably concentrated in the areas of greatest development and archaeological investigation, which was generally in the northern part of the historic core of Carlisle. On this basis, it has been possible to determine confidence ratings for the deposit model on the basis of the density of data points (Fig 4). The raster surface was generated using a kernel density algorithm provided by the SEXTANTE toolbox in gvSIG, with a search radius of 100m and a cell size of 1m.

3.5 DATA ANALYSIS AND INPUT

3.5.1 ***Data analysis and input to GIS database:*** in total, 262 archaeological 'events' of relevance to the project were recorded from all available sources (Table 2). Of these, 189 were within the historic core of Carlisle itself, and 73 within Stanwix; however, not all of these provided positive evidence of waterlogged archaeology. The data obtained were reviewed and edited by a single member of the project team, in order to ensure quality and consistency. Wherever possible, brief details of the date, thickness, and character of the waterlogged strata were added to each of the database entries, together with a brief statement on the nature and quality of any palaeoenvironmental remains encountered, and the character of the underlying natural geological subsoil, where this was recorded. Not surprisingly, not all of these data were available for all events; in some cases, for example, the natural subsoil was not reached, whilst other records proved to be insufficiently detailed to allow its description.

Event type	No Events	% of total
Antiquarian (to *c* 1930)	17	6.49
Pre-CAU/CAL (*c* 1930-1977)	26	9.92
CAU/CAL (1977-2001)	148	56.49
Non-CAU/CAL (1977-2001)	5	1.91
Post-CAU/CAL (2001-2012)	58	22.14
Borehole logs	8	3.05
Total	**262**	**100**

Table 2: Quantification of sources of information for archaeological events

3.5.2 Each event was scored, on a scale of 0-6 (Table 3), for the quality and significance of its waterlogged remains. The number of events with each score is given in Table 4, where the data are split between events in Carlisle, and those in Stanwix. To ensure there were no gaps in the dataset, all archaeological events within the study area were included, irrespective of whether or not waterlogged material was recorded, since it was considered important to log negative, as well as positive, evidence. However, a distinction was made between sites where waterlogged remains were definitely absent (*ie* where the full stratigraphic sequence was recorded to the top of the natural geology without encountering waterlogged strata), and those where the full sequence of deposits was not recorded, or where insufficient information was available. Events designated with a score of 0 included antiquarian observations where no mention was made of waterlogged materials.

This is because it was impossible to tell from the records whether such material was definitely not present, or whether it had simply not been recorded.

Score	Criteria
0	Insufficient information available (inadequate records)
1	Definitely no waterlogging (*ie*, natural geology reached, no waterlogged deposits recorded)
2	No waterlogged deposits recorded, but natural geology not reached (*ie* full stratigraphic sequence not recorded), so possibility of waterlogging in lower strata cannot be ruled out
3	Evidence for definite/potential waterlogging from borehole data
4	Waterlogged preservation in deep-cut features only; also all positive antiquarian records of waterlogged deposits
5	Good waterlogged preservation, including shallow waterlogged stratigraphy (up to *c* 0.5-0.6m thick?) and preservation in deep-cut features
6	Extremely good waterlogged preservation (deep waterlogged stratigraphy)

Table 3: Scoring system for quality and significance of waterlogged evidence

Score	No Carlisle events	No Stanwix events	Total	% of Total
0	33	8	41	15.65
1	12	28	40	15.27
2	48	32	80	30.53
3	8	-	8	3.05
4	51	2	53	20.23
5	27	3	30	11.45
6	10	-	10	3.82
Total	**189**	**73**	**262**	**100**

Table 4: Quantification of scoring for Carlisle and Stanwix events

3.5.3 ***Review of Waterlogged Palaeoenvironmental Evidence:*** a rapid review of waterlogged palaeoenvironmental data from sites within the study area was undertaken, in order to assess the character, significance, and preservation of such material across the city. The bulk of the readily available data came from published sources, principally excavation reports, but some *Ancient Monuments Laboratory Reports* and/or draft specialist reports for sites as Annetwell Street (Caruana in prep a) and the northern Lanes (Zant and Howard-Davis in prep) were consulted. EH's regional reviews of invertebrate remains (Kenward 2009), charcoal and wood (Huntley 2010a) and plant macrofossils (Hall and Huntley 2007) from archaeological sites in northern England also proved to be useful sources of information. Online environmental archaeology reports were also consulted, for example those of the former Environmental Archaeology Unit at York University (www.york.ac.uk/inst/chumpal/EAU-reps/eaureps-web.htm).

3.5.4 Archaeological and environmental contractors known to have undertaken work in Carlisle were consulted. These included Headland Archaeology, Wardell-Armstrong Archaeology (formerly Pennines Archaeology/North Pennines Archaeology) and Archaeological Services, Durham University. Jacqui Huntley, the English Heritage Scientific Advisor for North East England and Hadrian's Wall, and Gill Campbell, Head of Environmental Services at English Heritage, provided access and information about unpublished reports.

3.5.5 The information available suggests that the earliest environmental studies from sites in Carlisle and Stanwix date from the late 1970s. The earlier studies included those from the Tullie House Extension Project (part of the Annetwell Street area) (Donaldson 1977a; 1997b; 1980; Huntley 1991), Scotch Street (Donaldson 1977c), Castle Street (van der Veen 1983a; Goodwin and Huntley 1983; Huntley 1993) Blackfriars (van der Veen 1983b; Keeley 1990; Donaldson 1990; Kenward 1990), and Tarraby Lane (Wilkinson 1978; Balaam 1978). All but Tarraby Lane are within the Carlisle study area.

3.5.6 The main criteria used were the presence, and the quality of preservation, of organic artefacts and delicate biological remains, for example structural wood and leather, and ecofacts, including timber, waterlogged macroscopic plant remains, insects, and pollen. The identification of gleying and water-transported deposits in soil micromorphological reports was used as an indicator of possible waterlogged preservation in the area.

3.5.7 The results draw upon all the available sources, most of which are cited. Some, however, have only been used to generate the figures and tables (See *Section 4.8* for details; Goodwin 1989; Keepax 1977; Keepax and Watson 1980; McHugh 1989; Macphail 1980). An assessment of the level of preservation has been made based upon comparisons between published accounts and also personal observations of the palaeoenvironmental remains.

3.6 MAPPING THE DISTRIBUTION OF WATERLOGGED DEPOSITS

3.6.1 A map of waterlogged observations has been produced within GIS for the historic cores of Carlisle and Stanwix, derived from the data captured from the extent of waterlogged preservation recorded from the excavation data (*Section 3.3*). Vector points were created, based on central coordinates for each archaeological site documented in the database, which also contained the waterlogged scores (Table 4).

3.6.2 These data were then used to produce an interpolated raster surface for each study area, which formed the basis of the distribution map. This models the likely location of archaeological waterlogging based on the current patterns recorded in the database from known sites. A confidence rating based on the quality of the data and the spatial coverage, outlining whether, for instance, waterlogging was only encountered at the base of (deep) archaeological features rather than throughout the site, has also been assigned for each dataset. This has helped to identify areas or gaps within the datasets where the model is less reliable (*Section 3.6.5*).

3.6.3 The selected interpolation method for the generation of the distribution map was that of *Ordinary Kriging*, as the event vector points were not gridded, *ie* equally spaced throughout each study area as no direct trend was visible in the data, and there were no extreme peaks or troughs (Conolly and Lake 2006, 99). Any positive autocorrelation of the data, such as is the case in elevation models, could not be predicted (Conolly and Lake 2006, 90, 97). Kriging deals with this type of data distribution better than other interpolation methods, such as Inverse Distance Weighting (IDW) and Triangular Irregular Network (TIN), as it is based on geostatistical methods, which take into account the spatial variation and autocorrelation.

3.6.4 Thus, the results produced through kriging best reflected the waterlogged scores from the archaeological events within the GIS. Kriging is not a function currently supported by Quantum GIS, and therefore the interpolation was done using the SEXTANTE toolbox in the gvSIG OA Digital Edition. Nevertheless, other interpolation methods, IDW and TIN, were also tested and found to produce less relaible results, representing the data from the archaeological sites less accurately in comparison to kriging. The ordinary kriging parameters used were the default settings provided by the gvSIG software: a spherical model, with a minimum number of four, and a maximum of 25 points, and a search radius of 100m. Other parameters were tested, but this was found to produce the best fit with the data from archaeological exavations. Each of the raster files produced through kriging has a spatial resolution of 1m.

3.6.5 ***Testing the accuracy of the distribution mapping:*** the waterlogged distribution map has been verified against the known archaeological sites, which have been scored for waterlogging, and then correlated between an actual score and the interpolated score. The differences have helped to define the reliability of the map across the study area; which has been presented graphically as a confidence score for the process (Fig 5). This was done by interpolating the density of all event points, which could confidently be classified as containing waterlogged remains or lacking these using a kernel density algorithm in gvSIG. Those events with insufficient information (with a score of 0 or 2) were removed from this test. The resulting raster surface demonstrates that there is a sufficiently high correlation between the actual waterlogged scores and those predicted from the interprelation distribution map to have a high-level of confidence in this approach.

3.6.6 In order to test the methodology further, a random subset of events belonging to each scoring category was removed; 10% of each category from both study areas were omitted from a duplicate events dataset and then re-interpolated using the same three interpolation methods (ordinary kriging, IDW and TIN). Ordinary kriging, again, was found to be the most consistent interpolation method, showing the least number of deviations for both Carlisle and Stanwix.

3.6.7 The susceptibility of the model to these limited changes in data was determined by comparing the test models with the full model. A small amount of deviation, represented in a difference raster, between the two models of each type was deemed acceptable, in particular affecting those sites which were relatively isolated (Fig 6). The difference raster image, was produced using the raster calculator tool in QGIS, and by subtracting the raster based on 90% of the data, from the one using the full dataset: the darker the shading on the raster image, the less differences there are between the two interpolations. Overall, the raster image shows very subtle differences, only highlighting isolated sites, but generally proving the feasibility of this approach. After this test was run three times with a different random subset of 10%, it was considered successful, in that the loss of data caused only minor changes to the overall form of the distribution map (*Sections 4.4.3-4*).

3.7 ASSESSMENT OF THREAT

3.7.1 The information gathered and input into the GIS database, in conjunction with the creation of a predictive model for waterlogged strata, has been used as a starting point for an ongoing assessment of possible future threats to Carlisle's and

Stanwix's buried waterlogged deposits. This includes direct threats posed by future development within the study areas, and also indirect impacts, for example, possible changes to the water-table resulting from the extensive refurbishment of the city's flood defences following the flood of January 2005. It was also possible to examine where there is potential for good survival of waterlogged material and what local factors may have relevance to this survival. In addition, it was possible to examine where there is evidence for any recent changes in the level of survival. Such an assessment will permit a greater understanding of the potential threat to Carlisle's buried waterlogged heritage, thus allowing decisions to be made regarding the long-term protection of this nationally significant, non-renewable resource.

3.8 REPORT PREPARATION AND ASSOCIATED GIS MAPPING

3.8.1 One output of the project is this report, which provides details of the methodology, results, and conclusions of the study. In accordance with the project design (OA North 2012a, 15), the report is accompanied by maps indicating the predicted location and extent of significant waterlogged archaeological deposits within the historic cores of Carlisle and Stanwix. It is also supported by layers of GIS data, detailing geology, contours, historical mapping, and the deposit model (*Section 3.4*). Whilst it is not the purpose of the project to provide a synthesis of the history and archaeology of Carlisle, it is important to contextualise the data gathered. A summary of present knowledge is therefore presented in *Section 4.3*, and the significance of waterlogged remains for understanding the development of the settlement in all chronological periods is also discussed. The relationship between the occurrence of waterlogged strata, the natural topography, and the character of the drift geology was also assessed (*Section 4.4*). This report also provides an assessment of threats to the waterlogged resource and guidance for its future management (*Section 5.3*).

3.9 SYSTEM DOCUMENTATION

3.9.1 OA North has provided full documentation on the use of the database and GIS. In accordance with the *Archaeological Data Services Guide to Good Practice for GIS* (Gillings *et al* 1998), this includes full documentation on the derivation and accuracy of the different aspects of the database and GIS. A basic guide to the use of the database has been provided, which includes how to find particular records, how to query the database, and how to generate printed reports from it. Instructions on how to add new data generated by future interventions in Carlisle have also been included, thus allowing the ongoing production of a coherent and user-friendly product. Finally, instructions have been provided on importing the GIS data into common formats for use in other GIS software packages, in order to ensure maximum accessibility across the anticipated varied user groups.

3.10 DISSEMINATION OF RESULTS

3.10.1 The results of the project are being disseminated to as wide an audience as possible, including specialist and non-specialist users, which will entail presentations at public fora within the North West. The project GIS has been designed to be compatible with the Cumbria HER and a dialogue has been maintained with the

HER in the course of the project to ensure this; the database and GIS data have been transferred to the HER for long-term curation. The database and report will also be placed online, to allow a wider understanding of the wealth of remains surviving beneath Carlisle (http://oxfordarchaeology.com/case-studies/31-historic-buildings-and-landscapes/183-distribution-of-waterlogged-deposits-in-carlisle). A process of dialogue with the City Council Planning Department, in particular urban planners, that was initiated during the implementation stage of the project, will be extended to accompany the submission of the present report. The options available to the planners to enable full use of the data to faciliate urban planning include the provision of a GIS, which will allow interactive interrogation of the dataset; the provision of detailed hard and digital copy of the report mapping, and holding a seminar specifically for the members of the planning authority to highlight the wealth of waterlogged remains in Carlisle.

3.10.2 A seminar was convened at Tullie House Museum and Art Gallery, Carlisle, on 24th October 2012, which was attended by an invited audience. The attendees included members of the Carlisle City Council planning department, the archaeological community who have an interest in waterlogged deposits, and also those with a specific interest in the archaeology of Carlisle. It included members of English Heritage, Cumbria County Council, Carlisle City Council, OA North, and the Tullie House Museum and Art Gallery. An attempt was made to invite the Environment Agency archaeological officer for the region, but at that particular time, there was no one in post for the North West. The seminar helped to create a wider awareness of the central archaeological and planning issues and stimulated discussions on the wider implications of the threat to Carlisle's significant buried waterlogged deposits.

4. RESULTS

4.1 TOPOGRAPHICAL BACKGROUND

4.1.1 The historic city of Carlisle occupies a strategically important site (Fig 1), where the principal north / south land route west of the Pennines (represented in the modern road system by the A6 trunk road) crosses the River Eden, and forms a junction with an important trans-Pennine route through the Tyne-Solway gap (represented by the modern A69). The settlement lies on the Cumberland Plain approximately 8km above the tidal limit of the Eden, some 13km upstream of the Solway Firth and 15km south of the Anglo-Scottish border. The historic city centre is situated on the south bank of the Eden close to its confluence with the River Caldew (Fig 1). A third river, the Petteril, flows through the modern eastern suburb and joins the Eden a little over 1.5km east of the Caldew. The historic settlement grew up on a promontory of land extending roughly north to south, bounded by the floodplain of the Eden to the north and north-east, and to the west by the scarp above the Caldew. The prominent bluff at the northern end of the scarp, which was the site of an important military base for much of the Roman period, has been occupied by the existing stone Castle since the twelfth century (Figs 1 and 2; Plate 1). It is probable that the site was previously occupied by a timber Castle during the late eleventh-early twelfth centuries (McCarthy *et al* 1990).

4.1.2 Within the historic walled area of Carlisle, the bluff, which attains a height of *c* 24m AOD at the medieval Castle, forms one of the two highest points. The other, located *c* 350m to the south (*c* 25m AOD), is occupied by the medieval Cathedral (Plate 2). Between these two low eminences is a shallow, roughly east/west-aligned trough or valley, traversed today by Annetwell Street, to the west of Castle Street, and by Finkle Street to the east (Fig 2). At *c* 20m AOD, this area is today only slightly lower than those to north and south, but this modest difference, together with the character of the underlying glacial till, had a significant impact on the preservation of waterlogged archaeological deposits (*Section 4.4*). It seems likely that the valley is less pronounced today that it would have been in antiquity, having been filled to a greater depth with archaeological material than the areas to north and south. It also appears to be the case that the central part of the valley, adjacent to modern Castle Lane, was deeper than elsewhere, since the surface of the natural boulder clay recorded during the Millennium excavations was reached at *c* 17.7m AOD on the south-east (within Trenches 3 and 4 and the south-east corner of Trench 5), but lay at *c* 19.2m AOD in Trench 1, *c* 100m to the west (Zant 2009, 43).

4.1.3 Over the remainder of the walled area, the ground surface is generally fairly level, falling away only very gently to the east and south. The west walls occupy the top of the steep scarp overlooking the River Caldew, but the land inside them, between the walls and the Cathedral precinct, is also fairly level. There is, however, a more pronounced north/south slope in the north-eastern part of the historic core, along Scotch Street. There, the ground slopes slightly more steeply (though still quite gradually) down towards the line of the medieval north wall, which occupied the crest of an ancient terrace formed by the downcutting action of the River Eden. Scotch Street follows the line of a Roman and medieval street that led north to the

river crossing, although today the river itself lies over 300m north of the city defences.

4.1.4 The modern suburb of Stanwix lies on the north bank of the River Eden less than 1km north of Carlisle city centre (Fig 1), and is linked to the city by the nineteenth-century Eden Bridge. It was the site of the largest fort on Hadrian's Wall and existed as a small village in its own right during the medieval and post-medieval periods (Wood 1891; Taylor 1982). Significant expansion beyond the historic core resulted in the creation of this present-day suburb of Carlisle, but this did not commence in earnest until the end of the nineteenth century (Ordnance Survey 1925). Like the fort at Carlisle, the Hadrian's Wall fort at Stanwix occupied a prominent position overlooking the Eden and its floodplain. The fort site itself is fairly level, at approximately 25-30m AOD; to the north and north-east, the ground rises to over 35m AOD at Wall Knowe, whilst on the west it slopes away quite gradually. On the south and east sides, however, the fort site lies more-or-less directly on the crest of Stanwix Bank, which falls away steeply to the river.

4.2 GEOLOGICAL BACKGROUND

4.2.1 The solid geology of the Carlisle area comprises soft, reddish Triassic St Bees sandstone of the Sherwood Sandstone Group, which lies above the Permian St Bees shales and is itself overlain by and intercalated with the less extensive grey Kirklinton sandstone (McCarthy *et al* 1990, 1–2). At Carlisle itself, the sandstone outcrops to form the roughly triangular-shaped bluff, occupied successively by the Roman forts (*Section 4.3.3*) and the medieval Castle (*Section 4.3.11*). Over most of the modern city, and at Stanwix, the sandstone bedrock is overlain to a depth of several metres by drift deposits of glacial till, principally an orange-pink boulder clay (British Geological Survey 1982). Broadly speaking, the surface of the boulder clay within the walled city is overlain by 2-4m of 'made ground', comprising archaeological deposits of (principally) Roman, medieval and post-medieval date, overlain by modern levels. This does not, however, take account of sites where modern groundworks may have truncated overlying deposits, resulting in the clay being significantly closer to the present-day surface than is the case where no disturbance has occurred. Some fluvial deposits are present along the margins of the River Eden.

4.2.2 Modern archaeological investigations in and around Carlisle have shown that the glacial till can change markedly in character over quite short distances, with some deposits being dense and compacted, whilst others contain high proportions of sand and/or gravel. Within the historic core, the clay appears, on present evidence, to be relatively consistent in character, generally containing very little sand or gravel. Some subtle differences have, however, been noted, and it is clear that these can potentially have a major impact on the quality and extent of waterlogged preservation (*Section 4.4.6*).

4.2.3 Towards the north-east corner of the modern city centre, adjacent to Rickergate, the southern edge of an ancient channel of the River Eden was found in 1998 (Fig 7), some 300m south of the present river channel (Zant *et al* 2011a, 10-11). The ancient course of the river was defined by deep alluvial silts, interleaved in places with highly organic peaty deposits of decayed and compacted plant matter. The top of the silts was recorded at *c* 11.7m AOD, but in one trench they were excavated to *c* 10.4m AOD without encountering boulder clay or bedrock (*op cit*, 10-11). A

radiocarbon date of 120 cal BC-cal AD 80 (2015±40 BP; OxA-7155), obtained from decayed plant material within this accumulation (*ibid*), suggested that the channel had become a backwater choked with vegetation by the end of the first millennium BC. The precise course of the Eden in Roman and medieval times is not known, although it probably lay north of the pre-Roman channel in both periods (*Section 4.5.17*), and would therefore be outside the study area.

4.3 ARCHAEOLOGICAL AND HISTORICAL BACKGROUND

4.3.1 ***Prehistory***: whilst a transient human presence during the late Mesolithic period (*c* 6000-4000 BC) is suggested by a small number of flints from the city centre (Zant 2009, 5), settlement at Carlisle appears to have commenced in the late Neolithic or early Bronze Age (*c* 3000-1500 BC), though the evidence for this is largely confined to discoveries of flint artefacts in later deposits (*op cit*, 445). At several sites, evidence for arable farming, in the form of shallow ard-marks scoring the natural subsoil, has been recorded (Stallibrass and Huntley 2011, 27). These features are not closely dated, but have been interpreted by some (*eg* McCarthy 2002, 43) as the remains of cord-rig cultivation, which is usually regarded as being a feature of the later Bronze Age (*c* 1200-700 BC) or the Iron Age (*c* 700 BC-*c* AD 70). Analysis of a buried soil sealed beneath the early Roman fort (Guttmann-Bond 2009) also suggests that the ploughing may have ceased only a short time before the arrival of the Roman army in the early AD 70s (*Section 4.4.3*). However, with the exception of an undated roundhouse of possible late Iron Age date excavated at the southern Lanes (McCarthy 2000, 17), there is currently little other evidence for Iron Age activity in central Carlisle.

4.3.2 At Stanwix, a field system has been identified to the north-east of the fort, comprising ard marks associated with ditched field boundaries and buried soil horizons that pre-date the establishment of the Hadrian's Wall frontier system in the early AD 120s (Zant and Town in press). The presence of an extensive system of prehistoric fields in this area presupposes the existence of a contemporary farming settlement somewhere in the vicinity, although this remains elusive.

4.3.3 ***Roman Period:*** tree-ring dating has demonstrated that the first Roman fort at Carlisle was constructed in the autumn or winter of AD 72–3 (Caruana 1992), and that the interior was rebuilt in the autumn/winter of AD 83–4 (Caruana in prep a; Zant 2009, 413; 2011, 35). This turf and timber fort covered an area of *c* 2.8ha, mostly to the north of modern Annetwell Street, with its remains extending beneath the medieval Castle (Fig 7). A possible defended annexe lay on the south side of the installation, between Castle Street and Abbey Street (McCarthy 1991a; Caruana 1992). The fort was demolished in *c* AD 105 but was rebuilt on the same site, again in timber, after only a short break (Zant 2009, 413; 2011, 41). The second fort continued in use until the beginning of the Antonine period (Zant 2009, 413; 2011, 41-3), but might have been converted into something akin to a military depot following the construction of the Hadrian's Wall frontier system (and the presumed primary Wall fort at Stanwix) in the AD 120s. It may ultimately have been demolished as a consequence of the Roman reoccupation of southern Scotland in the early AD 140s. In the following 60–70 years, the site was probably occupied only intermittently; and may not have been used as a conventional fort (Zant 2009, 441-2; 2011, 47). Intensive occupation began again in the early third century, when a rebuilding in stone occurred, although it is not clear if this was a conventional fort

or some other kind of military establishment (Zant 2009, 414-15; 2011, 48-50). Thereafter, occupation continued until the end of the Roman period, which, on the evidence of coins and pottery, extended into the fifth century (Zant 2009, 460-7).

4.3.4 South of the fort, a settlement adjacent to the main road leading south was in existence by the late AD 70s (McCarthy 1990), and this grew into a sizeable town during the course of the Roman period (Fig 7). A milestone discovered near Penrith demonstrates beyond much doubt that the town had become the tribal capital of the *Carvetii*, the *civitas Carvetiorum*, by AD 223, and it seems likely that *civitas* status had been conferred on the town by the emperor Septimius Severus some years earlier (Edwards and Shotter 2005, 69). As in the fort, the first stone buildings appeared during the late second or early third century AD, and there is good evidence from a number of sites that intensive occupation within the town continued into the late fourth or early fifth century at least (Shotter 2011, 66-8).

4.3.5 ***Stanwix Fort:*** at Stanwix, the study area is crossed by the Hadrian's Wall frontier system (Fig 8), construction of which began in the early AD 120s (Breeze and Dobson 2000, 66). The study area also encompasses the stone cavalry fort, which was the largest fort on Hadrian's Wall and the base for the *ala Petriana*, the largest cavalry regiment in Roman Britain (Breeze 2006, 342). The position of the turf phase of Hadrian's Wall within the study area remains unclear, and the existence of a Turf Wall fort, though virtually certain, has yet to be conclusively proven (Zant 2011, 43-5). However, the alignment of the Stone Wall and the position of the associated stone fort, which may have been constructed in the AD 160s (*op cit*, 45-7), are not in doubt. The alignment of the Vallum, the enigmatic earthwork which runs to the rear of the Wall for its entire length, is also known, except adjacent to the stone fort, where its spatial and stratigraphic relationships with the fort's defences still need to be resolved (Fig 8).

4.3.6 Beyond the fort, limited archaeological evidence points to the existence of a civil settlement to the west (Caruana 2000) and possibly also to the south-east (Zant 2011, 47). Likewise, there is some evidence for the presence of a cemetery north-east of the fort (*ibid*), but its extent is uncertain. If current interpretations are correct, the fort parade ground lay immediately outside the eastern defences (*op cit*, 46).

4.3.7 ***Early Medieval Period***: the nature of early post-Roman settlement at Carlisle is difficult to determine (Newman 2011b, 69). In view of its long history as a Roman administrative centre and its position at the hub of a system of roads, the town is unlikely to have been completely abandoned, though the discovery of 'dark earths' at many sites suggests that the settlement contracted considerably at the end of the Roman period (*op cit*, 75). During the sixth century, Carlisle probably lay within the British kingdom of Rheged (Kirby 1962, 79), but in the first half of the seventh century, the region was absorbed into the Anglian kingdom of Northumbria and from this period onwards, occasional historical references to Carlisle survive. In AD 685, St Cuthbert, Bishop of Lindisfarne, used the grant of a Northumbrian royal estate at Carlisle to establish and endow a nunnery (Summerson 1993, 10), and references to a former abbot of Carlisle suggest that a monastic presence endured until the later ninth century (Tudor 1984, 68-9). The location of these monastic establishments is not known with certainty, but the distribution of early medieval artefacts suggests a focus of activity in the area of the medieval Cathedral and St Cuthbert's church (Fig 9; McCarthy 1993, 34-5). A late ninth- or tenth-

century cemetery is also known from excavations on the west side of the Cathedral (Newman 2011b, 81).

4.3.8 The power of Northumbria collapsed in the political confusion of the later ninth century, and, by the early years of the tenth century, the area seems to have come under the influence of the British kingdom of Strathclyde (Summerson 1993, 1). The Viking incursions seem to have been the catalyst for this political instability, although Scandinavian political influence in the area at this time is debatable. It is clear, however, that the 'Great Army' under Halfdan had made a determined attempt to conquer all of Northumbria in AD 875. Some sources suggest that he sacked Carlisle, although physical evidence for this has not been found (Higham 1986, 308). In the eleventh century, the area came under increasing English control, in the form of the Earls of Northumbria, but was annexed by Malcolm Canmore in the 1060s (Summerson 1993, 14–15), after which it remained technically in Scottish hands until the arrival of the Norman king William II in 1092 (Earle and Plummer 1892).

4.3.9 Occupation of a possible sub-Roman or early medieval date within the Hadrian's Wall fort at Stanwix is suggested by the discovery of a series of large, earth-filled postholes during a programme of limited excavation undertaken in the grounds of Stanwix Primary School in 1999 (Newman 2011b, 71-2). These were seemingly the remains of substantial timber buildings that had evidently been dug through the levelled remains of Roman buildings. The only direct evidence for occupation during the later pre-Norman period is provided by two artefacts: a coin of Cnut (1016-35), unearthed during the construction of the Victorian church of St Michael the Archangel in 1842, and a ninth- or early tenth-century Anglian cross-head, which was found approximately 230m north of the church.

4.3.10 ***Later Medieval Period***: the *Anglo-Saxon Chronicle* records that in the year 1092 William II led an army north to Carlisle (Earle and Plummer 1892) and drove out a certain Dolfin, whose presence in Cumberland has been taken to show that the region was part of the kingdom of the Scots prior to 1092 (Summerson 1993, 47). William, it is said, constructed a Castle and brought settlers from the south to inhabit the re-established town (Earle and Plummer 1892). No trace of this early Castle has been found, but it was almost certainly built of earth and timber and may have occupied the site of the present stone keep (McCarthy *et al* 1990, 11, 28).

4.3.11 The Norman hold on Cumberland was consolidated by Henry I, who visited Carlisle in the autumn of 1122 (Sharpe 2006, 52). During his stay, Henry took measures to strengthen Carlisle's position within his kingdom, providing money for the construction of 'walls and towers', a probable reference to the town defences, and for the foundation of the Augustinian priory of St Mary's (Weston 2011, 104). The priory subsequently became a Cathedral, with the creation of the see of Carlisle in 1133 (Perriam 1987, 127; Weston 2011, 104-5). It was probably also during Henry's reign that construction work began on the stone Castle.

4.3.12 During the comparatively stable period from the mid-twelfth to the late thirteenth century, Carlisle sustained some growth (Fig 10), albeit not spectacular; however, for the English kings, its primary function remained as a border fortress (Summerson 1993). By contrast, the last decade of the thirteenth century heralded the beginning of a disastrous period of unrest for Carlisle and the wider region. Destruction of much of the city by fire in 1292 was followed four years later by the onset of the Anglo-Scottish wars, during which it was attacked or besieged on a

number of occasions (*ibid*). A fragile peace negotiated in the 1320s had broken down a decade later, leading to several centuries of warfare, raiding, and skirmishing in the Border region. The arrival of the Black Death in the late 1340s is also likely to have had a devastating impact, with at least one-third of the population perishing.

4.3.13 Evidence for the development of Stanwix during the medieval period is extremely limited. It is likely that the church there was given to the canons of St Mary's Priory in Carlisle by Walter the Priest, chaplain to Henry I, on whom it had been bestowed by the king (Wood 1891). This demonstrates the existence of a church from at least the first half of the twelfth century, although the discovery of an Anglo-Saxon cross fragment in 1947, *c* 230m to the north (Taylor 1982, 4), suggests that there was a church in the vicinity several hundred years earlier. The extent of the medieval village is unclear but it is likely that the settlement was centred on the Church Street/Kells Place area, around a small two-cell church that stood in the western part of the Roman fort, on the site of the present church of St Michael the Archangel (Plate 3), which was rebuilt in the nineteenth century (*ibid*).

4.3.14 ***Post-medieval Period***: during the sixteenth and seventeenth centuries, Carlisle began the slow process of recovery from the period of warfare and plague that had prevailed during the later Middle Ages. From 1560, a state of peace existed between England and Scotland (McCarthy 1993), although the Border region remained unsettled throughout the sixteenth century, and this is likely to have had a detrimental effect on trade and commercial activity. Within a few years of the accession of James VI of Scotland to the English throne (as James I) in 1603, the era of Border raiding came to an end (MacDonald Fraser 1971) and both Carlisle and the wider region enjoyed a period of peace and comparative prosperity, interrupted only by the English Civil Wars, when the city was besieged by the Scots (McCarthy 1993).

4.3.15 The century following the end of the Civil Wars was a time of slow development for Carlisle (McCarthy 1993). In the second half of the eighteenth century, most of the city's population, estimated at *c* 4-5000 people, continued to live within the medieval defences, where ample space was still available, although the Rickergate, Botchergate, and Caldewgate suburbs continued to develop during this period. By the time of the 1801 Census, however, the population had risen to approximately 10,000 and the city walls were beginning to be viewed as a hindrance to expansion, redevelopment, and the free movement of traffic in and out of the city (*ibid*). Extensive demolition of the curtain wall, along what became West and East Tower Streets on the north and Lowther Street on the east, occurred during the early nineteenth century and was largely complete by 1815 (Perriam 1976).

4.3.16 Census records indicate that Carlisle's population continued to rise sharply during the first half of the nineteenth century, reaching 35,000 by 1841. However, cartographic sources show remarkably little evidence for a significant expansion of the built-up area during this period, and it is clear from historical sources that this led to chronic overcrowding in some parts of the city (McCarthy 1993, 90). By the time that the Ordnance Survey (OS) first edition map of Carlisle was produced in 1865, the city had at last begun to expand significantly beyond its medieval boundaries and this growth continued apace during the second half of the nineteenth century and into the twentieth century, as Carlisle became the leading industrial and commercial centre in the county. North of the river, the construction

of new housing and business premises began the process of transforming Stanwix from a small village into a city suburb.

4.4 ANALYSIS OF SPATIAL DISTRIBUTION OF WATERLOGGED DEPOSITS IN CARLISLE

4.4.1 From the archaeological data captured during the course of the project, and entered into the GIS database, it is clear that waterlogged archaeological remains survive over much of the historic walled city. Of the 189 archaeological 'events' logged within the Carlisle study area (including borehole data), 88 (46.6%) provided some positive evidence of waterlogged preservation (*Section 3.4.1*; Table 4). In a further 48 instances (25.4%), excavation was taken to insufficient depth to demonstrate the presence or absence of organic preservation, though in many cases, the location of these events in areas of clear waterlogged potential (as evidenced by data from other events in the near vicinity) suggests that waterlogged remains would have been found, had the excavations continued to the natural clay. Another 41 events (21.7%) yielded insufficient information on which to base a judgement, leaving only 12 events (6.3%) where an absence of waterlogged remains of any kind was conclusively proven.

4.4.2 It seems clear, from the present study, that there is no quarter of the historic walled city where a lack of waterlogged preservation over an extensive area can be demonstrated, though an absence of waterlogging has been proven or suggested by modern excavation at a few specific locations (*Section 4.4.6-7*). In these cases, the evidence suggests that the absence of waterlogged organic remains is the result of subtle variations in the composition of the underlying drift geology, though this has been proven beyond doubt at only one site in the city (Zant 2009). The relationship between the distribution of waterlogged deposits, natural geology and local topography in the Carlisle study area is discussed in *Section 5.1*.

4.4.3 The data generated by the scoring system used to assess waterlogged survival at each of the recorded archaeological events, when interpolated across the study area (Fig 11), demonstrated that the evidence for waterlogged preservation varies considerably. Such variance can potentially be a reflection of poor data, so a process of testing was undertaken by the random removal of 10% of the events, but the pattern was not significantly affected (Fig 12), which is demonstrated in a raster view of the distribution showing the subtle differences between the interpolations of the full and reduced event datasets (Fig 5). The implication is that the variations reflect genuine differences in waterlogged survival across the study area, but they are also the result of wide variability in the quality of the data available.

4.4.4 It is evident that events scoring 5 and 6 (*ie* those with evidence for good or excellent waterlogged preservation) are mostly in the northern half of the walled area, with hardly any to the south. Whilst this distribution pattern clearly indicates that significant waterlogged archaeological remains survive over much of the northern part of the city, it cannot also be taken as evidence for poor or non-existent preservation further south, since it in part reflects the pattern of modern development (and therefore of modern rescue excavation) within the study area. In fact, despite the paucity of modern fieldwork in the southern part of the city centre, it is clear from positive records of waterlogged remains obtained from antiquarian observations (scored as 4, given the lack of detailed information) that significant waterlogged deposits are also present within this area (Fig 11). Indeed, at Blackfriars Street (Carlisle Event 71), the single site where a major excavation has

taken place within the southern part of the walled area, extensive waterlogging in the lower (Roman) levels was recorded (McCarthy 1990), resulting in a score of 5 for this event. On this evidence, it seems probable that many of the antiquarian records from this part of the city would also have scored more highly had sufficiently detailed information been available on the nature and extent of waterlogged remains at these sites.

4.4.5 Events with a score of 6, indicative of the very highest level of preservation (deep and extensive waterlogged stratigraphy), cluster around Annetwell Street and the north end of Castle Street (Fig 11). This is consistent with the topographical and geological evidence, since this area occupies a shallow valley situated between the two highest points within the city walls (*Section 5.1.3*), and is also underlain by a particularly sticky, impermeable deposit of boulder clay (Zant 2009, 37). However, this area has also seen one of the most extensive programmes of modern archaeological investigation anywhere in the city (McCarthy 1991a; Zant 2009; Caruana 1992; in prep a; in prep b), which has resulted in the generation of a large body of extremely detailed information pertaining to the character and extent of waterlogged strata. Similarly, most of the events awarded a score of 5 (good preservation, including shallow waterlogged stratigraphy and survival in deep-cut features) are modern excavations where good data were readily available. That said, the excavation and borehole evidence do suggest that this trough, which also extends eastwards from the Annetwell Street/Castle Street junction, approximately along the line of modern Finkle Street (where no significant archaeological work has ever been undertaken), does contain the greatest depth of archaeological strata anywhere within the city (Fig 13).

4.4.6 Notwithstanding the possible bias in the data resulting from the pattern of modern excavation, it would be reasonable to conclude, on present evidence, that the very best survival of waterlogged archaeological remains within Carlisle's historic centre is to be found in the shallow valley between the medieval Castle and the Cathedral. In terms of the modern topography of the city, this zone corresponds, broadly speaking, to the area defined by the medieval Castle on the north, Paternoster Row on the south, Abbey Street on the west, and Fisher Street on the east. It is no coincidence that much of this area lies within the boundaries of two Scheduled Monuments (Fig 14), one (SM 547) south of Annetwell Street, the other to the north of Castle Way (SM 27657). Several major excavations in this area, notably those undertaken from 1973 to 1990 on Annetwell Street itself (Caruana in prep a; in prep b (Carlisle Events 7, 8, 67, 413)), the 1981-2 excavation at Castle Street (McCarthy 1991a (Carlisle Event 18)) and the Millennium Project excavations (Zant 2009 (Carlisle Events 134-138)), have demonstrated the survival of extremely significant waterlogged strata, in places up to 1.5m thick. These deposits, as well as containing large assemblages of preserved organic artefacts (*eg* Howard-Davis 2009 (Plate 4)) and a wealth of palaeoenvironmental data (*Section 4.8*), also include the remains of a large number of timber buildings and other features (Plate 5) relating to the Roman forts of the late first-mid-second centuries AD. Important waterlogged deposits within the massive defensive ditch defining the south side of the medieval Castle's outer ward also survive beneath Castle Way, including the remains of late medieval timber buildings, fences and other structures that encroached upon the partly infilled ditch (Zant 2009, 393-410).

4.4.7 Whilst waterlogged preservation rivalling that recorded in previous excavations might be anticipated over the whole of this area, the results of the Millennium

excavations should inject a note of caution. This project comprised the excavation of five separate trenches (MIL 1-5; Zant 2009, 34-7). Four of these (MIL 2-5; Carlisle Events 135-138) were situated in reasonably close proximity to each other, adjacent to the Castle Street/Castle Lane/Annetwell Street junction (Fig 14). In this area, deeply stratified waterlogged strata were encountered in MIL 2-4, and over the eastern part of MIL 5 (Plate 6). However, in the fifth trench (MIL 1; Carlisle Event 134), which was located further west, and at the western end of MIL 5, which lay comparatively close to MIL 1, no waterlogged organic remains were found at all, though a complex sequence of 'dry' archaeological deposits, in excess of 2m thick (Plate 7), was excavated to the surface of the natural clay in these areas. This change, which occurred over a distance of no more than 40m, was gradual, or 'graded', with preservation becoming increasingly poor to the west. It was clear that the change from exceptional waterlogged preservation on the east, to a total absence of waterlogged survival further west, was due in large part to a change in the character of the underlying drift geology, from a sticky, impervious clay on the east, to a sandier (and presumably comparatively free-draining) clay on the west (*op cit*, 43). However, the fact that in MIL 1, and over the western part of MIL 5, the surface of the clay was at a higher absolute level than was the case further east is also likely to have been significant.

4.4.8 Elsewhere in Carlisle, there has not been definitive evidence recorded for the effect of quite abrupt changes in drift geology on the survival of waterlogged archaeological remains. There are several sites, seemingly randomly distributed across the study area, where an absence of waterlogged remains was confirmed by excavation (Score 1; Fig 15). However, many of these interventions, which together make up little more than 6% of the total number of events within the Carlisle study area (Table 4), were very small, so it would be unwise to conclude that the areas adjacent to each site are certainly devoid of organic remains. With the exception of the Millennium site itself, perhaps the strongest evidence came from excavations undertaken in 2002 at 7-9 Fisher Street (Carlisle Event 1190), which seemingly encountered no waterlogged remains at all, even in early Roman cut features (Johnson and Anderson 2008). The reason for this is not clear, for although virtually no archaeological work had previously been carried out in the vicinity of the site, there is no reason to suppose that the Fisher Street area should be significantly poorer in organic preservation than other parts of the historic walled city. In the absence of any direct evidence, it is possible only to speculate that the lack of organic preservation may have been due, as was the case in the western part of the Millennium site, to the character of the underlying drift geology.

4.5 ANALYSIS OF CHRONOLOGICAL DISTRIBUTION OF WATERLOGGED DEPOSITS IN CARLISLE

4.5.1 It is clear, from the evidence gathered during the project, that there is considerable chronological, as well as spatial, variation in the character and extent of waterlogged survival within Carlisle. Broadly speaking, the Roman levels tend to exhibit better, and more extensive, organic preservation than those of the medieval period, for the simple reason that they lie in closer proximity to the water-table and are usually well-sealed by thick accumulations of post-Roman material. The situation is, however, complicated by the presence, in some areas, of extremely large, deep medieval features, most notably the defensive ditches associated with the Castle and the city walls, where exceptional survival of waterlogged remains

has been attested. Such features have been shown to contain deep accumulations of waterlogged deposits, sometimes including the remains of timber buildings, fences and other structures (*Section 4.5.4*), which rival, in depth and complexity, the best-preserved Roman strata found elsewhere in the city.

4.5.2 ***Prehistory:*** with the exception of flints, almost all of which occur residually in Roman and later levels, prehistoric remains are comparatively rare in Carlisle, being restricted almost entirely to shallow ard-marks scoring the surface of the natural boulder clay (*Section 4.3.1*), and buried topsoil/ploughsoil horizons sealed beneath Roman levels (Plate 8). It is therefore unsurprising that no significant waterlogged prehistoric remains have been found within the study area. That said, at a few sites, limited palaeoenvironmental assemblages have been recovered from buried soil horizons lying directly above the natural clay. Small collections of waterlogged seeds and other plant materials were present in such soils at the southern and northern Lanes (Huntley 2010b, 110, 114, 124; 2012), and were also recorded during the Millennium project (Huckerby and Graham 2009a, 931-2; 2009b). At Castle Street, a pre-Roman buried soil contained wood shavings, though these had probably been trampled in at the beginning of the Roman period (McCarthy 1991b, 8). A small assemblage of insect and parasite remains was also collected from a buried soil at the southern Lanes (Kenward *et al* 2010, 132). Whilst the dating of these soil horizons remains unclear, the most recent evidence suggests that they may have formed only a relatively short time before the arrival of the Roman army in the early AD 70s, during the late pre-Roman Iron Age (Guttmann-Bond 2009). What is certain is that, wherever they are encountered, the surface of these deposits formed the old ground surface at the beginning of the Roman period.

4.5.3 ***Roman Period*:** whilst it is clear that waterlogged archaeological remains attributable to the Roman period occur widely across the city's historic core, it is also evident that their preservation is extremely variable. As already noted (*Section 4.1.2*), waterlogged preservation in general, and of Roman deposits in particular, appears, on present evidence, to be best in the shallow natural hollow or valley between the medieval Castle and the Cathedral, along modern Annetwell Street (and, potentially, Finkle Street), and the northern part of Castle Street. In these areas, up to 1.5m of complex waterlogged strata have been recorded in several modern excavations (*Section 4.5.4*).

4.5.4 ***The Fort and Annexe*:** from the south side of Annetwell Street northwards, exceptionally well-preserved deposits (scoring 6) lie within the Roman fort (Fig 5), and have been subject to significant modern excavation on Annetwell Street itself (Caruana in prep a; in prep b), and as part of the Millennium project (Zant 2009). Further south, they may relate principally to activity within a putative defended annexe attached to the south side of the fort, which has been investigated at Castle Street (Hogg 1955; McCarthy 1991a) and on Abbey Street (Hogg 1964; Caruana 1992). In the fort itself, the available evidence demonstrates exceptionally good survival of waterlogged remains in the south-eastern part of the installation, south of the main east/west street (*via principalis*), and in at least a small part of the central range (*latera praetorii*), north of the *via principalis*. In these areas, waterlogged elements of approximately 40 buildings, relating to two superimposed timber forts of the late first-mid-second century AD, have been excavated (Plate 9); in addition there are many other elements of the infrastructures of these forts, including the south gate, part of the south rampart of the primary fort, timber drains

(Plate 10) and water pipes (Plate 11), and wooden walkways. These features, and associated strata, have yielded a wealth of organic artefacts (Plates 12 and 13) and waterlogged palaeoenvironmental remains; the latter included a human lead louse (Plate 14), found between the teeth of a wooden nit comb (Plate 15) during the Millennium project. Metalwork is also generally exceptionally well preserved in such deposits, since the lack of oxygen inhibits corrosion (Plates 16 and 17). Similar results have been obtained from excavations within the putative southern annexe, with several timber buildings and other wooden structures being amongst the remains investigated (Plate 18; McCarthy 1991a).

4.5.5 In both the fort and annexe, outstanding preservation of structural timbers has resulted in the establishment of the best sequence of late first- and early second-century dendrochronological dates for a British site outside of London (Philpott and Brennand 2007, 60; I Tyers *pers comm*), the latest felling date so far obtained being AD 117 (Zant 2009, 413). This has allowed the construction phases within the early Roman forts at Carlisle to be dated with exceptional precision, and has in turn led to significant advances in the understanding of the chronology of the Roman military occupation of northern England (Bidwell and Hodgson 2009, 10).

4.5.6 Further to the north, no significant excavation has occurred over most of the central range, or in the northern part of the fort, so the character of archaeological deposits in these areas is currently unknown. In view of the fact that the northern part of the fort occupied the sandstone bluff on which the medieval Castle now stands, and which represents one of the highest points within the modern city centre, it might be anticipated that waterlogged survival would be comparatively poor, though deep excavation would be needed to test this hypothesis. Given that within the comparatively low-lying southern part of the fort, it is clear that there are areas where no organic waterlogged materials have been preserved (*Section 4.4.6*), it is evident that organic survival is patchy and it would be unwise to make assumptions as to the character of the preservation across the extent of the fort.

4.5.7 It is also important to note that the outstanding survival of waterlogged Roman deposits in this area is largely confined to the lower (*ie* earlier) strata, dating (broadly speaking) to the late first- to mid-second century AD. During this period, the area was occupied by two successive timber forts, the first in use from AD 72/3 to *c* AD 105, and the second from *c* AD 105-*c* AD 140 (*Section 4.3.3*). The putative southern annexe appears to have been in use from the earliest phases of occupation within the fort to around AD 125, when the area may have been given over to other types of activity (McCarthy 1991a). In general, the preservation is better in the lower levels, becoming less good in the stratigraphically (and chronologically) later deposits. In both the fort and (former) annexe, limited waterlogged survival is attested in deposits dating to the second half of the second century AD (Zant 2009, 245-65; McCarthy 1991a, 38-47), when the status of the fort site is uncertain, but thereafter waterlogged deposits of the third/fourth century AD (associated with the later Roman stone fort or, in the area of the former annexe, with probable civilian occupation) occur only in deep-cut features such as pits, wall-construction trenches and pipe trenches (*eg* Zant 2009, 307-8, 316). At the Millennium site, it was noted that the absolute height of the top of waterlogged survival (*ie* the uppermost levels where some degree of waterlogged preservation was evident) lay at approximately 19.3-19.4m AOD (*op cit*, 37).

4.5.8 ***The Civilian Settlement*:** outside the fort and annexe, waterlogged remains relating to the Roman civilian settlement have been subjected to modern excavation over large areas at the southern and northern Lanes (McCarthy 2000; Zant and Howard-Davis in prep), *c* 300m east of the fort, and at Blackfriars Street (McCarthy 1990), *c* 400m to the south. In these areas, waterlogged preservation, whilst good (mostly scoring 5), does not appear to be as outstanding as that in the Annetwell Street/Castle Street area. Elsewhere, a larger number of small-scale modern investigations and antiquarian reports demonstrate that waterlogged Roman remains of some kind are to be found over virtually all of the historic walled city, though these data are inevitably patchy and often imprecise.

4.5.9 At the Lanes and Blackfriars Street, as in the early forts, large numbers of early Roman timber buildings were excavated (Plate 19), together with other associated wooden structures and external deposits containing waterlogged remains. Unlike the situation within the earliest levels within the fort, where deep horizontal stratigraphy had survived in a waterlogged condition, preservation was largely confined to the fills of cut features, such as wall-construction trenches (where the stumps of wall posts commonly survived (Plate 20)), pits/wells and drainage ditches, though shallow waterlogged strata also survived in many areas. Chronologically, the preservation of waterlogged remains was similar to that in the fort and putative annexe, with the bulk of the deposits dating to the late first to mid-second century AD, and the later material being restricted to deep-cut features. Although numerous dendrochronological dates have been obtained from structural timbers recovered from these excavations (Groves 2010; in prep), most are far less precise than those available for the fort and putative annexe, due in part to comparatively poor preservation, but also to differences in the way the timbers had been modified for use (*ibid*).

4.5.10 Beyond these areas of large-scale, modern excavation, evidence for waterlogged Roman deposits is comparatively sparse. In the case of many of the published antiquarian observations, the date of the waterlogged remains recorded is not always clear. Where a Roman date can be established, most of the records appear to relate to discrete, deep-cut features, particularly timber-lined pits and/or wells (*eg* Ferguson 1878, 136; Redfern 1921). For the most part, there is little evidence for waterlogged Roman stratigraphy, though observations during construction works on Bank Street in 1880 recorded 'a layer of black mould containing fragments of Roman pottery, lamps, etc' (Ferguson and Hetherington 1880, 93). The lack of such evidence is unsurprising, since the methods of observation and recording were so rudimentary that such deposits are unlikely to have been recorded, had they been present. However, evidence from several small excavations carried out in the period from the 1950s to the 1970s, notably those undertaken at the Cathedral in 1953 (Simpson 1988), and on Scotch Street in 1953 and 1976 (Hogg 1955; Clare and Richardson in prep), demonstrates that shallow waterlogged stratigraphy, including the well-preserved remains of substantial timber buildings, survive well to the south and east of the fort.

4.5.11 ***Early medieval period*:** evidence for survival of waterlogged early medieval deposits is currently restricted to two cut features, both timber-lined pits, that were recorded during modern rescue excavations on Castle Street (McCarthy 1991a; Plate 21) and at the southern Lanes (McCarthy 2000). There is presently no indication that waterlogged horizontal stratigraphy of this period survives anywhere within the study area, and it is considered unlikely that any will be present, since

later Roman waterlogged remains are similarly absent, except within the fills of deep individual features (*Section 4.5.7*). On Castle Street, a timber from the pit lining yielded a dendrochronological felling date range of AD 770-803 (McCarthy 1991a, 48), and a very similar date range (AD 771-816) came from the lining of the pit excavated at the southern Lanes (McCarthy 2000, 48 (the fills of this feature also yielded a ninth-century strap end (*ibid*))).

4.5.12 ***Later medieval period*:** over the study area as a whole, waterlogged medieval deposits are confined to discrete, deep-cut features, principally pits and/or wells, with no survival of waterlogged horizontal stratigraphy. Most of these features have been discovered during the course of large-scale, modern excavations, for example the southern and northern Lanes, where two timber-lined wells of probable twelfth-century date were excavated (McCarthy 2000, 48-9; 1993, 52-3; Plate 22), together with clusters of medieval pits containing waterlogged organic fills, some of which yielded preserved artefacts of leather and wood (Plate 23) and fragments of textiles. Although many of the waterlogged features mentioned in published antiquarian records cannot be accurately dated, a few timber-lined pits/wells can be attributed to the medieval period in instances where reference was made to the recovery of green-glazed pottery from their fills (*eg* Ferguson 1880a, 342). It is also probable that many of the observations of timber 'tanks' (*ie* pits or wells) and 'palisades' (probably piled wall foundations and/or the remains of timber buildings) made in the late nineteenth century on the south side of Bank Street (Ferguson and Hetherington 1880) relate to structures associated with the medieval Franciscan Friary; this is known to have occupied this area of the city from the early/mid-thirteenth century to the Dissolution in the sixteenth century (Jones 1981). However, few, if any, of these features are independently dated, and it is conceivable that some were of Roman date.

4.5.13 Far and away the best survival of medieval waterlogged deposits, though, is to be found within the massive defensive ditches associated both with the city defences and those of the medieval Castle. Extremely good waterlogged preservation has been demonstrated by modern excavation in two places: on Rickergate, within the ditches fronting the north wall of the medieval city (Zant *et al* 2011a); and during the Millennium project, within the massive ditch which once formed the southern boundary of the Castle's outer ward (Zant 2009, 393-410). These features were so substantial (up to 16m wide and 3.25m deep as it survived, in the case of the Castle ditch) that they contained sequences of waterlogged horizontal stratigraphy equal in complexity and importance to those associated with the early Roman forts (*Section 4.5.4*). On Rickergate, two large ditches contained sequences of waterlogged fills up to 2.8m deep (Plate 24), from which a large assemblage of leather, including an unique water-carrier designed to be slung across a pack animal (Plate 25), and some wooden artefacts (Plate 26), were recovered. The Castle ditch, which now lies beneath Castle Way, yielded similar material, but also contained, exceptionally, the waterlogged remains of medieval timber buildings, plank-boarded fences and associated features within two late medieval tenements that had encroached into the ditch when it had ceased to be maintained (Plates 27 and 28). At both sites, important assemblages of palaeoenvironmental materials were also recovered from the ditch fills (Huckerby 2011a; Huckerby and Bonsall 2011; Huckerby and Graham 2009a, 934-6).

4.5.14 With the exception of the Rickergate and Millennium excavations, the city and Castle ditches have only been investigated in a few very small interventions, the

results of which were not always well recorded. Waterlogged deposits, within one of the northern city ditches were recorded in a very small trench excavated as part of the northern Lanes project (J Zant *pers comm*), and preserved leather artefacts were recovered from the Castle's outer ward ditch during the construction of Castle Way in the early 1970s (Zant 2009, 25). However, no waterlogged deposits appear to have been recorded when part of the ditch fronting the medieval east wall was observed on Lowther Street in 1949 (Hogg 1955, 65), nor when the same ditch was partly excavated, again on Lowther Street, in 1990 (Flynn 1995). None of the other defensive ditches associated with the city walls, or with the Castle, have been subject to investigation, although it seems probable that, in some areas at least, waterlogged preservation similar to that encountered at the Rickergate and Millennium sites will be present.

4.5.15 ***Post-medieval Period*:** within the study area, the only evidence for survival of waterlogged post-medieval deposits comes from the Rickergate site, at the north-east corner of the historic walled city. There, the uppermost fills of the latest of two large defensive ditches fronting the medieval city wall (*Section 4.4.20*) comprised thick deposits of dark, organic soil, some of which yielded some preserved organic plant materials (Zant *et al* 2011a, 26-7). The precise date of these deposits, which were mostly removed mechanically or had been destroyed entirely by late post-medieval cellars, is not certain, although a few sherds of sixteenth- to eighteenth-century pottery were recovered from these levels (*op cit*, 27, 34-7), indicating a likely post-medieval date. This is supported by cartographic evidence, which indicates that sections of the ditch fronting the north wall remained open into the mid-eighteenth century (*op cit*, 66).

4.5.16 During the Millennium project, it was found that the upper 2m of the medieval Castle's outer ward ditch had been destroyed when Castle Way was built in the early 1970s (Zant 2009, 393). No post-medieval deposits had therefore survived within the area investigated, and it is likely that the latest fills of this feature, some of which could potentially have been of post-medieval date and waterlogged, were completely removed during the road construction, since Castle Way appears to coincide more-or-less exactly with the line of the Castle ditch.

4.5.17 ***The Historic Suburbs:*** although outside the scope of the present study, it is worth noting that limited evidence for preservation of waterlogged archaeological deposits has also been recorded along Rickergate and Botchergate (Fig 2), two modern roads leading (respectively) north and south from the city. On Rickergate, where the modern road lies approximately on the line of a Roman and medieval road leading north to a crossing of the River Eden (Zant *et al* 2011a, 2-3), this preservation was confined to the recovery of small assemblages of waterlogged plant and insect remains from an ancient channel of the River Eden, which appears to have gone out of use by the beginning of the Roman period (*op cit*, 60-1). The invertebrate assemblage included many dung beetles, suggesting the possible proximity of riverside pasture, perhaps during the late pre-Roman Iron Age (Kenward 2011, 58-9). The southern edge of this feature, as recorded by excavation in 1998-9, lies immediately outside the northern limit of the present study area (Fig 7). Along Botchergate, where the modern road follows approximately the line of the main Roman and medieval route leading south from the city (*op cit*, 2-3), extensive excavations in the late 1990s, on both sides of the modern road, recorded a considerable body of evidence for intensive activity at certain times during the Roman period, and more limited data pertaining to the medieval suburb (Zant *et al*

2011b). There, although most of the archaeological deposits were 'dry', waterlogged preservation was recorded in a few deep-cut features, including, on the north side of the road, a second-century well, which yielded a rich assemblage of waterlogged plant remains (Huckerby 2011b), and a timber-lined well of twelfth/thirteenth-century date (Giecco *et al* 2001, 26-7).

4.6 ANALYSIS OF SPATIAL DISTRIBUTION OF WATERLOGGED DEPOSITS IN STANWIX

4.6.1 At Stanwix, in marked contrast to Carlisle itself, evidence for waterlogged preservation is very limited. Whilst this may be in part due to the piecemeal nature of the archaeological work undertaken there (Zant 2011, 33; OA North 2007b), preservation of organic materials does appear to be restricted to a few very specific locations. It is, however, possible (perhaps even likely) that waterlogged remains also survive in unexcavated parts of the study area, particularly in deep-cut Roman features, such as the Vallum ditch, the Hadrian's Wall ditch, or the fort's defensive ditches, that have seen little or no archaeological investigation.

4.6.2 Spatially, evidence for preservation of waterlogged archaeological materials has been recovered from four sites to the north and north-east of the stone Hadrian's Wall fort, one within, and a single site to the south (Fig 16; sites scored 4 and 5). There are currently no records of waterlogged organic remains from within the fort itself; indeed, records from many small interventions in and around the fort, where the natural drift geology was reached (scored 1 in Figure 16), make it clear that such remains are unlikely to be found over much of the study area. However, at many other sites (scored 2 in Figure 16), excavation was taken to insufficient depth to demonstrate conclusively the presence or absence of waterlogged remains, whilst no information was available for a number of other interventions in this area (scored 0 in Figure 16). No borehole logs (scored 3) were available within the Stanwix study area.

4.6.3 North of the fort, suites of waterlogged plant remains (*Section 3.4.5*), principally comprising seeds and pollen but also including other preserved plant materials, have been recovered from buried soils and the lower fills of broadly contemporary ditches in an area of modern pasture at Tarraby Lane (Stanwix Event 45; Smith 1978), and within the campus of the Cumbria Institute for the Arts (Stanwix Event 5 (information from CAU archive); Stanwix Event 49 (Zant and Town in press). These remains are thought to have formed part of an extensive system of pre-Roman or early Romano-British arable fields that pre-date the establishment of the Hadrianic frontier system (*Section 4.3.2*). At Tarraby Lane, waterlogged fragments of oak posts were also recovered from a posthole line located just to the north of the study area (Smith 1978).

4.6.4 Also within the present campus of the Institute for the Arts, investigations on the line of Hadrian's Wall by FG Simpson in 1934 (Stanwix Event 39; Simpson and Hogg 1935) revealed preserved stakes in a section of the Vallum ditch. The precise location of this discovery is not known, though it appears to have been south or south-east of the main complex of college buildings (*Section 3.3.5*).

4.6.5 South of the fort, good waterlogged preservation in strata recorded *c* 2.5m below the modern surface was attested during salvage excavations undertaken in 1986 at the Miles MacInnes Hall on Scotland Road (Stanwix Event 7), south of the stone Hadrian's Wall fort (Caruana 2000). This is, however, the only substantive

archaeological intervention to have been carried out in this area, and certainly the only one to penetrate to sufficient depth to record evidence for waterlogging.

4.7 ANALYSIS OF CHRONOLOGICAL DISTRIBUTION OF WATERLOGGED DEPOSITS IN STANWIX

4.7.1 Of the five archaeological interventions undertaken within the Stanwix study area where waterlogged organic preservation has been attested (*Section 4.6.2*), waterlogged deposits of possible pre-Roman (or, conceivably, early Roman) date, have been recorded at three sites (*Section 4.6.8*), all to the north of the known Hadrian's Wall fort. Preserved organic materials of certain or probable Roman date have also being recorded at three sites, one north of the fort and two to the south or south-east (*Section 4.6.3*). No evidence for waterlogged survival of medieval or post-medieval deposits has yet been found at Stanwix.

4.7.2 ***Prehistory*:** small assemblages of waterlogged plant remains and pollen were recovered from dark buried soils overlying ploughmarks, which were recorded during excavations at Tarraby Lane in 1976 (Stanwix Event 45), and in 1994 and 2004 within the campus of the Cumbria Institute of the Arts (Stanwix Events 5 and 49 (Plate 29)). All three sites were to the east of the known Roman fort. In the 1994 excavation, where a considerable area of the buried soil and ploughmarks was exposed, material described as 'brushwood' was recorded within the soil (information from the Carlisle Archaeological Unit Archive). Broadly contemporary field-boundary ditches, with organic lower fills yielding waterlogged plant remains and pollen, were also found at Tarraby Lane (Balaam 1978; Donaldson 1978) and in the 2004 excavation within the college campus (Zant and Town in press). The field system represented by the buried soils, ditches and ploughmarks (the latter scoring the surface of the natural clay) are not closely dated. They certainly pre-dated the establishment of the Hadrianic frontier system in the early AD 120s, since the Wall crossed the area diagonally, on an alignment quite different from that of the putative fields). Immediately north-east of the stone Hadrian's Wall fort, the remains of these fields were also sealed by dumps of clay and earth (Plate 29), which have been interpreted as make-up layers for the stone fort's parade ground (McCarthy 1999, 166). If correct, this may date to the AD 160s, when the stone fort is thought to have been built (Zant 2011, 45). The fields could, therefore, be either of Iron Age or early Roman date, but are still effectively pre-Roman. Although the buried soil, and further ditches, have been excavated at several sites, waterlogged preservation has only been recorded at these three sites.

4.7.3 ***Roman Period*:** the best evidence for the waterlogged preservation of Roman archaeological deposits was recovered during salvage excavations in 1986 on the site of the Miles MacInnes Hall on Scotland Road, south of the stone cavalry fort (Stanwix Event 7; Caruana 2000). There, up to 2m of Roman deposits were recorded, probably within an extramural settlement associated with the stone Hadrian's Wall fort and its presumed Hadrianic predecessor. The thickness of the waterlogged strata in this area is not known, and the remains could not be adequately characterised due to the restricted nature of the explorations, but the lowest levels, up to 2.5m below the modern surface, were certainly waterlogged, with preservation seemingly very good. A large, squared oak post and several lengths of oak timber were recovered, together with an assemblage of leather artefacts and a few other scraps of wood.

4.7.4 Elsewhere, a posthole row of possible Roman date, at Wall Knowe, just to the north of the study area, yielded a few fragments of waterlogged oak posts (Stanwix Event 45; Smith 1978, 26, 31). There is also a record from 1934 (Stanwix Event 39) of preserved stakes being found in the Vallum ditch. No mention of this is made in the short published report on the work (Simpson and Hogg 1935), but the stakes are mentioned by Robert Hogg in a letter written in 1974 (Tullie House Museum Trust archive), when he describes the findspot as 'in a small paddock east of Holmacres, now used as the recreation ground for the College of Art'. No waterlogged deposits are currently known from within the Hadrian's Wall fort itself.

4.7.5 ***Medieval and Post-medieval Periods*:** no evidence for waterlogged preservation in medieval or post-medieval levels at Stanwix has been found; although it is conceivable that large, deep-cut features of these periods could contain some waterlogged organic remains in their lower fills, no such features have yet been recorded. Alternatively, waterlogged medieval or post-medieval strata could survive as fills within large Roman features, such as the Vallum ditch, that could have remained partially open long after the end of the Roman period. Again, however, no evidence for this has yet been recovered from Stanwix.

4.8 PALAEOBOTANICAL ASSESSMENT

4.8.1 A review of the published and unpublished environmental reports for Carlisle and Stanwix has been undertaken (*Sections 4.8.4-9* and *4.8.10-13*). There have, however, been major advances in environmental archaeology in recent years and this is reflected in how much detail the reports contain, many of the earlier reports having very little information about the site or the features from which the samples were taken. Indeed, in some cases, but not all, it is difficult to distinguish whether the plant remains were preserved by waterlogging or by charring. Sampling on-site was also very limited and it is clear that, often, only one or two samples were available for study.

4.8.2 Despite differences in the level of detail in the data, it is clear that a range of ecofacts has been recorded in both the Carlisle and Stanwix study areas. Buried soil profiles and both zoological and botanical remains have been preserved in both areas; macroscopic and microscopic plant remains have also been identified. The former include seeds preserved by waterlogging and charring, waterlogged wood, bran, crop-processing waste, mosses and charcoal. Microscopic remains include pollen, non-pollen palynomorphs (fern spores and algae) and phytoliths (Gilpin 2009, 1527-9). Zoological remains are also varied and include animal bone, a wide range of insects, with, amongst other types, grain pests and mites recorded, as well as human and animal parasites and *Cladocera*. The invertebrate remains are of national interest for the Roman and medieval periods.

4.8.3 The waterlogged conditions have also allowed the preservation of organic finds, such as leather and structural wood. At Annetwell Street and the Millennium site, the excellent preservation of the latter has allowed different phases of the timber forts to be dated tightly by dendrochronology (Groves 1990; Tyers and Tyers 2009). Well-preserved leather objects have also been excavated, such as the armour and tent fragments from the Millennium Project (Winterbottom 2009, 825-31), the exceptionally rich assemblage of leather artefacts in the medieval city's defensive ditch at Rickergate (Mould 2011), and also from Castle Street (Padley and Winterbottom 1991, 3), and a few fragments from Blackfriars Street (Padley 1990,

158). The preservation of all these finds is the result of the waterlogged nature of much of central Carlisle.

4.8.4 ***Carlisle - Pre-Roman Environmental Remains:*** environmental samples from the prehistoric period are comparatively rare in Carlisle (Fig 17) although a few prehistoric features have been identified during excavations at the Millennium site (Huckerby and Graham 2009a; 2009b), the North (Huntley 2012) and South Lanes (Huntley 2010b; Kenward *et al* 2010), Rickergate (Huckerby and Bonsall 2011, 57; Huckerby 2011a, 58; Kenward 2011, 58-62) and Scotch Street (Shaw 2010). Pre-Roman buried soil profiles (Keeley in prep; Guttmann-Bond 2009) exhibit evidence of gleying, indicative of intermittent or permanent waterlogging, and corroborative evidence for areas of wet conditions is also exhibited in the pollen diagrams (Huckerby 2009). Preservation of plant macrofossils from all these sites was by waterlogging, with a little carbonisation. Insect are usually preserved in waterlogged conditions (Kenward 2009), although they are not abundant in pre-Roman contexts.

4.8.5 ***Carlisle - Roman Environmental Remains:*** a much better record of environmental remains is available for the Roman period, reflecting the greater amount of development and corresponding archaeological investigation (Fig 18) undertaken on such sites. The evidence clearly demonstrates the much larger number of sites where Roman environmental remains have been recorded and the wealth of material found on them. Excellent waterlogged preservation occurred at all the sites, notably at Annetwell Street (Caruana in prep a; in prep b) and the Carlisle Millennium site (Zant 2009), although, at Abbey Street and Blackfriars Street (Caruana 1992; McCarthy 1990), it was more mixed, and at Botchergate (Zant *et al* 2011b), waterlogged plant remains were only recorded in a single feature. Leather, structural and non-structural wood, pollen and plant and insect remains were all frequently recorded in Roman contexts. There were, however, variations in the level of preservation between different sites and, at Abbey Street (Caruana 1992), organic finds were well preserved but the preservation of the waterlogged plant remains was more mixed.

4.8.6 Although the preservation of Roman waterlogged remains is exceptional, it does not occur throughout the study area. In some areas only carbonised material is recorded, for example, in parts of the Millennium site (Huckerby and Graham 2009) and at Botchergate (Huckerby 2011b). More recently, a single sample taken during an evaluation at the Fratry of Carlisle Cathedral, from a buried organic silt, contained charred rather than waterlogged material (OA North 2012b). The finds from this material were largely Roman (C Howard-Davis *pers comm*) and the plant remains were more characteristic of the Roman period, although contextually the material seemed to be medieval.

4.8.7 ***Carlisle - Medieval Environmental Remains:*** as in the Roman period, there was excellent waterlogged preservation of environmental material in the Carlisle study area (Fig 19); however, sample selection has been biased historically towards Roman features, as at Castle Street (Goodwin and Huntley 1991; Kenward *et al* 1991), Annetwell Street (Huntley 1989a; 1989b; 1989c; Large and Kenward 1987), the South Lanes (Huntley 2010b; Kenward *et al* 2010) and the North Lanes (Huntley 2012; Kenward 1998). Consequently, the relative proportion of medieval environmental evidence to that from the Roman period is small, but it does suggest

good waterlogged preservation. There may be opportunities in the future to assess/analyse some of the remaining medieval samples from the North Lanes.

4.8.8 More recently, medieval contexts have been targeted for analysis / assessment at three sites: the Millennium Project (Huckerby and Graham 2009; Smith and Tetlow 2009a; 2009b); Rickergate (Huckerby and Bonsall 2011; Huckerby 2011a; Kenward 2011); and Scotch Street (Shaw 2010). Excellent waterlogged preservation was recorded at all of these sites, and at the Millennium and Rickergate sites in particular. Plant and animal remains were recorded together with leather artefacts (*Section 4.5.12*) and both structural and non-structural wood.

4.8.9 Just outside the study area, at Botchergate, medieval pollen and waterlogged and charred plant remains, together with structural wood, were recorded (Giecco *et al* 2001; Huckerby 2011b). The site therefore has been included in this review, as it demonstrates that waterlogged preservation is not confined to the historic walled core of Carlisle.

4.8.10 ***Stanwix - Pre-Roman Environmental Remains:*** there are only three sites with pre-Roman environmental remains (Fig 20) in the Stanwix study area: Tarraby Lane (Wilkinson 1978; Balaam 1978; Donaldson 1978); the Cumbria College of Art (Hall *et al* 1994); and the Ceramics Courtyard (OA North 2006). The environmental remains from Tarraby Lane are perhaps the most significant, with some soil profiles dating to the Late Glacial period and others from turf layers sealed by Hadrian's Wall, both containing well-preserved pollen, and evidence of gleying, suggesting that the area was wetter in the past. Pre-Roman environmental remains were recorded in 'the old ground surface' beneath the parade ground at the Cumbria College of Art (Hall *et al* 1994) and at the Ceramics Courtyard (OA North 2006). Moderate waterlogged preservation of both plant and invertebrate remains had taken place, with the evidence from the former suggesting both grazing land and wet ground.

4.8.11 ***Stanwix - Roman Environmental Remains:*** the number of sites with Roman environmental remains (Fig 20) in the Stanwix study area is also limited to the three with pre-Roman material (*Section 4.8.10*) and another near the Roman fort (Cotton 1999). Two sites, Tarraby Lane (Donaldson 1978) and the Cumbria College of Art (Hall *et al* 1994), had well-preserved waterlogged environmental remains, and at the latter there is possible evidence of hay and dumped stable manure. Preservation of both waterlogged and charred environmental remains was poor at the other two sites.

4.8.12 ***Distribution of Areas where Environmental Remains may have been preserved by Waterlogging:*** the distribution of waterlogged environmental material within the Carlisle and Stanwix study areas suggests that it is widespread. The entire area of both the centre of Carlisle, and beyond, for example, at Botchergate (Zant *et al* 2011b; Huckerby 2011b), and Stanwix, may potentially have waterlogged environmental remains preserved. The existing data suggest that there can be variations, even on a single site, between the preservation of environmental remains and/or organic finds; for example, some areas excavated by the Millennium Project only had charred remains (Huckerby and Graham 2009a; 2009b) and, at Abbey Street (Huntley 1992), organic finds were preserved but there were no environmental remains identified, although this might be a reflection of the number of samples taken. The present distribution of sites where remains have been recorded is not, however, a true reflection of the potential for waterlogged

preservation, as it relates directly to the distribution of archaeological events, and, for the most part, that relates to areas of development.

4.8.13 The pre-Roman wet conditions at Tarraby Lane suggest that there is a considerable potential in some parts of Stanwix to the east of the fort for the preservation of a record of the prehistoric environment in this study area and, as such, is of regional importance. The Regional Archaeological Research Agenda for the period (Hodgson and Brennand 2007, 36) notes that the recovery of prehistoric environmental material from excavations across the North West is of considerable archaeological importance, because there has been very limited recovery of such material in the past. The excavations of Hadrian's Wall at Tarraby Lane (Smith 1978) and the associated environmental research work on both pre-Roman and Roman deposits demonstrated that there was considerable potential for the survival of buried soils (Wilkinson 1978), pollen (Ballam 1978) and plant remains (Donaldson 1978). Additionally, a pollen assessment from beneath the putative parade ground associated with the Hadrian's Wall fort also recorded the survival of pre-Roman pollen (Zant and Town in press).

5. DISCUSSION

5.1 RELATIONSHIP BETWEEN WATERLOGGED DEPOSITS, GEOLOGY AND TOPOGRAPHY

5.1.1 ***Carlisle***: in Carlisle, the data gathered during the course of the project demonstrate that waterlogged archaeological remains survive over much of the study area. Nearly half (49%) of the recorded archaeological interventions provided positive evidence of waterlogged preservation, with an absence of organic remains being conclusively proven in little more than 6% of cases. The latter are scattered across the study area, and show no obvious spatial patterning. The remaining interventions (*c* 45%) yielded insufficient evidence to demonstrate the presence or absence of waterlogged strata. This was mainly due to the fact that the excavations did not penetrate to a sufficient depth, though, in some cases, inadequate record keeping was also a factor. Indeed, wide variability in the quality of the available data was clearly a significant factor, which hindered the establishment of meaningful distribution patterns for the quality and survival of waterlogged archaeology across the study area. However, despite these limitations, it seems clear that there is no quarter of the historic walled city where a lack of waterlogged preservation over an extensive area can be presumed. Some idea of the research potential of such remains can be obtained when it is considered that preserved organic materials, which are totally absent from the majority of archaeological sites in Britain, may account for 75-90% of all material excavated from waterlogged strata (Lillie and Smith 2009, 9).

5.1.2 In the few cases where an absence of waterlogged strata has been demonstrated, the evidence suggests that subtle variations in the composition of the underlying drift geology were responsible, but this has been proven beyond doubt only during the Millennium excavations to the north of Annetwell Street (*Section 4.4.6*). It had been hoped to map the extent of variations in the drift geology, but, on detailed investigation, it became apparent that the available geological and soil mapping was insufficiently detailed to provide this information. Even using data recovered from archaeological excavations, there was insufficient consistency in the recording of the drift geology to be able to generate city-wide mapping, particularly since many of the recorded archaeological interventions did not penetrate to the level of the natural subsoil. It is becoming evident that these geological variations are in fact very localised phenomena, which do not correspond to the palaeotopography, and they do not enable predictions from the current datasets.

5.1.3 Whilst localised geological factors appear to be highly significant in the preservation (or otherwise) of waterlogged archaeological remains, the topography of central Carlisle also appears to exert some influence. On present evidence, obtained from excavation data, borehole logs and Lidar data pertaining to the modern surface topography, the very best waterlogged survival occurs in the Annetwell Street area, and at the north end of Castle Street, which lie in a shallow trough or valley between the two highest points of the historic walled city, the sandstone bluff on which the medieval Castle stands, to the north, and the low eminence occupied by the medieval Cathedral, on the south. This trough is still evident in the modern topography, as the Lidar plot of the modern surface contours demonstrates (Fig 21). However, what is known of the surface contours of the

underlying drift geology, obtained from excavation and borehole data (Fig 22), suggests that it was even more pronounced in antiquity, but has been gradually infilled with anthropogenic material generated by nearly two millennia of human activity. Whilst it seems likely that the exceptional preservation in this part of the city is genuinely the result of topographical factors (enhanced, in places at least, by an underlying deposit of impervious boulder clay), it must be borne in mind that this area has also seen some of the most extensive programmes of modern archaeological investigation undertaken anywhere in Carlisle. Consequently, the data pertaining to waterlogged survival are extremely good, and are (mostly) readily accessible, either in published reports (McCarthy 1991a; Zant 2009; Howard-Davis 2009) or in draft manuscripts (Caruana in prep a; in prep b). In other parts of the study area, information is frequently far less abundant, and/or less readily accessible. This is particularly so over much of the central and southern parts of the walled area, where very few modern excavations have occurred, most of the available information coming from antiquarian observations. It is also an issue elsewhere, for example towards the south end of Fisher Street, in the St Mary's Gate area, where extensive salvage excavations in the late 1970s (Neal and Flynn in prep) found evidence for deep waterlogged preservation, seemingly over large areas. The results of these investigations remain unpublished, and the available evidence is sketchy, reflecting the nature of the fieldwork. On the other hand, extensive modern excavations undertaken at the Lanes, a large and reasonably level site on the east side of the walled area (McCarthy 2000; Zant and Howard-Davis in prep), generated data equal in quality and accessibility to those from Annetwell Street/Castle Street. There, although good preservation of waterlogged deposits was widely attested, survival was not as outstanding as in the lower-lying zone between the Castle and the Cathedral, suggesting that the exceptional preservation of waterlogged strata in the latter area may indeed be due in large part to the local palaeotopography.

5.1.4 That topographical variation is not a decisive factor in the preservation of organic remains in central Carlisle is, however, clear from the limited investigations at the Cathedral. There, a small excavation in 1953 found large and well-preserved Roman structural timbers *c* 4.25m below the modern surface (Simpson 1988, 89), despite the fact that the site was located on the highest point within the medieval city walls. Nearby, small-scale excavations in 1985 (Keevil 2008) and 1988 (Keevil in prep) were not taken to a sufficient depth to reach similarly waterlogged levels, though a few preserved organic artefacts were recovered from the 1988 investigation.

5.1.5 ***Stanwix***: at Stanwix, evidence for waterlogged preservation is very limited (*Section 4.4*), and the resultant predictive model simply shows localised high waterlogged values at the few sites where waterlogging has been identified. Whilst this may be due in part to the piecemeal nature of the archaeological work undertaken (more extensive waterlogged remains may survive, for example, in hitherto largely unexcavated features, such as the Vallum ditch), preservation of organic materials does appear to be restricted to a few very specific locations. However, the factors influencing survival remain unclear, since there appears to be no clear correlation between the local topography and the underlying drift geology (Fig 23), nor is organic preservation restricted only to the bottom of deep-cut features.

5.2 ENVIRONMENTAL REMAINS

5.2.1 ***Carlisle***: the review of waterlogged palaeoenvironmental data from sites within the Carlisle study area (*Section 4.8.11*) demonstrated that the survival of environmental remains, including timber, waterlogged plant remains, pollen and invertebrates, is widespread, although variable. In line with the limited evidence for pre-Roman activity within the modern city centre, environmental data pertaining to prehistoric occupation are scarce, being restricted mainly to small assemblages of preserved plant remains (and occasionally pollen and invertebrates), mostly from buried ploughsoils. Overall, the number of samples dating to the prehistoric period is low, but the data suggest some arable cultivation, which is supported by the identification of buried ploughmarks at several sites. The presence of dung beetles in alluvial silts filling a palaeochannel of the River Eden on Rickergate, just beyond the north-east corner of the study area, also pointed to the possible existence of riverside pasture, perhaps in the pre-Roman Iron Age (*Section 4.8.4*).

5.2.2 By contrast, there is an abundance of environmental remains dated to the Roman and medieval periods, recovered principally from the large-scale excavations undertaken by CAU/CAL from 1977 to 2001, notably the Annetwell Street and Castle Street sites, the southern and northern Lanes, the Rickergate site and the Millennium Project. All these sites yielded abundant and extremely well-preserved environmental evidence, including plant remains, waterlogged structural and non-structural wood, invertebrate remains and soil profiles, and limited suites of pollen were also recovered from the Millennium and Rickergate sites. A similar wealth of palaeoenvironmental evidence can be expected from Roman and medieval levels across much of the walled area of the city, where waterlogged preservation has been attested by antiquarian observations in the nineteenth century, or in limited investigations during the twentieth century. The fact that most of these interventions recorded little or no environmental evidence is irrelevant, since such data were not routinely gathered until the adoption of modern excavation techniques, which in Carlisle did not occur until (at the earliest) the 1950s. Although sampling for pollen was undertaken at several sites in the 1970s, including Dorothy Charlesworth's excavations on Annetwell Street (Caruana in prep a) and at the former Vasey's store on Scotch Street (Clare and Richardson in prep), sampling for pollen was not routinely undertaken in subsequent excavations until the Millennium Project of 1998-2001, and the Rickergate excavations of 1998-9. As a consequence, the sparcity of documented environmental evidence is in part an indication of absence of investigation rather than a reflection of preservation.

5.2.3 ***Stanwix***: at Stanwix, north of the Hadrian's Wall fort, suites of waterlogged plant remains and pollen have been recovered from buried soils and the lower fills of broadly contemporary ditches associated with a system of arable fields pre-dating the construction of the Hadrian's Wall frontier system in the AD 120s (Balaam 1978; Zant and Town in press). Though not closely dated, the fields are considered most likely to be of late pre-Roman Iron Age date. In addition, there is a Late Glacial site (*c* 12,000-8000 BC) at Tarraby Lane, comprising a small kettlehole, left as the ice melted, where pollen and beetle remains indicate much colder conditions (Wilkinson 1978, 52).

5.2.4 Evidence for preservation of Roman environmental remains at Stanwix is extremely limited, being restricted to three discoveries of waterlogged structural timbers, namely fragments of oak posts from a posthole line located north of the fort (Smith 1978, 26, 31), timbers of uncertain provenance recovered from salvage excavations in the probable extramural settlement on the south side of the fort (Caruana 2000), and stakes found in the 1930s within the Vallum ditch (*Section 4.6.10*) east of the fort. However, the mere fact that Roman waterlogged wood has been found at these sites, which are located a considerable distance apart (and on three different sides of the fort), should be an indication of the potential for similar discoveries elsewhere within the study area. No post-Roman organic remains have yet been recovered from within the study area, although their presence in (as yet unrecorded and unexcavated) deep-cut features, such as the Vallum ditch or the upper fills of the fort ditches, cannot be entirely discounted.

5.3 ASSESSMENT OF THREAT

5.3.1 ***Carlisle***: the project has demonstrated that, on present evidence, the areas of Carlisle with the greatest potential for preservation of complex, deeply stratified waterlogged deposits are to be found in the northern part of the walled city, from Annetwell Street in the west to the Lanes on the east, but particularly in the valley or trough between the Castle and Cathedral. These areas require the greatest vigilance in terms of the potential threat from future developments and from other activities that may impact indirectly on this highly significant resource. However, although there is some correspondence between these areas of high potential and the local topography and drift geology (*Section 4.4.6*), to an extent they also reflect the pattern of modern development and rescue excavation within the city. Consequently, the pattern of waterlogged survival developed from available data does not necessarily reflect the true extent of waterlogged archaeology across the study area as a whole. Indeed, antiquarian records and other limited observations suggest that good waterlogged survival, of both Roman and medieval remains, can be anticipated almost anywhere within the walled city and (in the case of medieval remains) within the defensive ditches beyond the city walls, which may also contain preserved post-medieval organic deposits in their upper levels. For this reason, it is extremely important that briefs for all future archaeological investigations within the city should anticipate the recovery of waterlogged deposits.

5.3.2 To a more limited extent, organic preservation can also be expected in the city's historic suburbs (*Section 4.5.13*), especially on Rickergate, in the archaeologically attested pre-Roman river channel south of the Civic Centre (Zant *et al* 2011a) and in the presumed Roman and medieval river channels further north. In addition to waterlogged alluvial silts containing important palaeoenvironmental data, of the kind recorded within the pre-Roman channel during the Rickergate project (*op cit*, 10-11), these channels could potentially contain all manner of preserved timber structures, such as bridge abutments/piers, jetties, and fish traps, ranging in date from prehistory to the eighteenth century. Whilst the precise position of the Eden in the Roman and medieval periods is not clear, it is possible that the river flowed in a series of braided channels at certain times (Caruana and Coulston 1987). The discovery of the south abutment of the medieval bridge during construction of the Civic Centre in the 1960s (Perriam 1997) suggests that the main river channel lay somewhere in this vicinity during the medieval period, but other channels may also

have existed at this time. Certainly, the Eden flowed in two main channels from the late sixteenth century, following the great flood of 1581 (Hogg 1952), to the early nineteenth century, when the southern channel was permanently blocked (MacDonald 1971, 256); the former island between the two channels is known to this day as The Sands.

5.3.3 Although there are a few sites within the walled city where an absence of waterlogged strata has been proven by excavation, this seems to be due to very localised factors (*Section 4.4.6*), so these data cannot be used to define more extensive unwaterlogged areas. Consequently, there needs to be a presumption for at least some organic survival even in areas close to these 'negative' sites, as has been amply demonstrated by the Millennium excavations, where a spatial progression from exceptional waterlogged preservation to completely 'dry' archaeology (with 'graded' preservation between) occurred over a distance of little more than 40m (*Section 4.4.6*).

5.3.4 In reality, the actual threat to waterlogged remains will be dependent upon future patterns of development within the historic city. In some areas of seemingly high potential, for example over much of the Lanes site, most waterlogged strata will have been removed already, either by excavation in advance of previous redevelopment, or by the construction works themselves. However, 'pockets' of survival may still exist in such areas, dependent upon the exact nature of the earlier works. Elsewhere, well-preserved waterlogged strata probably survive over large areas of the walled city, where they have not been removed by cellars or other deep features. A possible extension to Tullie House Museum and Art Gallery, for example, would pose an obvious threat to the exceptionally well-preserved remains associated with the early Roman fort and its putative southern annexe, as attested by previous excavations on Annetwell Street (Caruana in prep a; in prep b), Castle Street (McCarthy 1991a) and Abbey Street (Caruana 1992), and during the Millennium project (Zant 2009; Howard-Davis 2009), but there are many other areas where future development would probably result in destruction or damage to important waterlogged strata. It is vital that all future development sites within the study area are adequately assessed for their potential for waterlogged survival at an early stage in the planning process, by means of desk-based assessment and, if necessary, boreholes and archaeological field evaluation or monitoring.

5.3.5 It is, however, not only in terms of their direct, physical, impact on preserved organic remains that future developments should be considered. Another area of concern is the extent to which development involving deep and extensive groundworks, including piled foundations and complex drainage systems, might lead to the gradual dewatering of preserved waterlogged archaeology in adjacent areas, even if the development itself does not impact directly upon such remains. Evidence for such impacts is limited and often anecdotal (Williams and Corfield 2002, 276; Holden *et al* 2008; Lillie and Smith 2009, 10), but concerns have frequently been expressed within the archaeological profession over the long-term effects of groundworks or drainage on waterlogged strata (Holden *et al* 2008; Williams and Corfield 2002; Williams and Butcher 2007; English Heritage 2007b, 17-18). However, some studies have suggested that the lowering of the water-table below the upper level at which preservation of waterlogged archaeological deposits occurs does not necessarily result in destruction or decay of the affected material (Lillie and Smith 2009, 10).

5.3.6 For Carlisle itself, scientific data are entirely lacking, but evidence from archaeological excavations suggests that the effects of groundworks on waterlogged strata may not always be as damaging as might be supposed. During the Millennium Project, for example, extremely good preservation was evident, even on those parts of the site situated adjacent to, or beneath, the Castle Way ring road and its associated underpass (Zant 2009), which had cut deeply into the exceptionally well-preserved waterlogged strata in the southern part of the Roman fort, and within the massive defensive ditch of the medieval Castle's outer ward. Clearly, dewatering of adjacent deposits had not occurred to any significant degree during the period from the construction of the road in 1972 and the opening of the relevant area of the Millennium site in 1999-2000. Similarly, good waterlogged preservation was noted during excavations at the southern and northern Lanes, adjacent to, and below, several late eighteenth/nineteenth-century cellars (McCarthy 2000, 27-8; Zant and Howard-Davis in prep), there being little indication that deposits located in close proximity to the cellars had suffered more severely than those elsewhere on the site. Although some of the cellars may have been constructed up to 200 years before the beginning of the Lanes excavations in the late 1970s, there was no good evidence that significant deterioration of organic remains had occurred, even over so lengthy a period of time.

5.3.7 In addition to the potential impact of construction and other below-ground works within the study area, the possible effect of processes occurring a considerable distance away from Carlisle's historic core must also be considered. In particular, the possible influence of recent flood-alleviation schemes, undertaken in response to the devastating flood of January 2005, requires consideration, since studies elsewhere have demonstrated that preservation at some sites can be affected by activities such as water abstraction within the wider catchment area (Lillie and Smith 2009, 10). However, a recent study (Holden *et al* 2009) concluded that the quality of hydrological data from urban archaeological sites needed to be considerably improved in order to generate reliable risk models. Furthermore, research in the Netherlands has shown that long-term monitoring of water-level change, and the potential effects of change on organic remains, requires detailed measurements to be taken at frequent intervals over a period of many years (*op cit*, 11). It is also clear that, without catchment-wide hydrological studies, the results of site-specific hydrological research can be difficult to assess (*op cit*, 10). Consequently, in the absence of such research for the catchment area around Carlisle, it is not possible to attempt an assessment of the possible impact on the city's waterlogged archaeology of relatively distant activities, such as flood-alleviation works.

5.3.8 ***Stanwix***: on present evidence (*Section 4.5*), waterlogged preservation is only likely to be encountered at very specific locations, on the south side of the Roman fort and to the north-east. Over most of the Roman fort, it would appear that there is little potential for waterlogged survival (*Section 4.5.9*), though why some sites in Stanwix should have waterlogged remains, whilst others (in some cases quite close by) should not, is currently not clear. For this reason, the possibility that waterlogged deposits might turn up almost anywhere should be borne in mind.

5.3.9 In particular, archaeological briefs relating to future works in the area of the extramural settlement south of the fort (Caruana 2000), and within the system of pre-Roman fields to the north (Smith 1978; Zant and Town in press), where preservation of organic remains has been confirmed by excavation, should stress

the likelihood for the discovery of waterlogged archaeological remains. Similarly, works that impact upon large, deep-cut features, such as the fort ditches, the Vallum ditch, or the ditch fronting Hadrian's Wall, should have considerable potential for the survival of waterlogged fills.

5.4 CONCLUSIONS AND RECOMMENDATIONS

5.4.1 ***Aims and Objectives:*** the study has successfully addressed the project's principal aims and objectives, as set out in the Project Design (OA North 2012a, 8-9) and presented in *Section 2* of this report. The programme of work resulted in the creation of a GIS and an Access database (*Aim 1*), in order to map the extent and character of waterlogged deposits and other appropriate data (*Objective 1.1*), and to store and manipulate all relevant information (*Objective 1.2*). In order to enhance our understanding of the character, extent and formation of waterlogged strata in the study area, and to assess possible future threats to the resource (*Aim 2*), the project has successfully collated, synthesised and plotted the existing evidence for the distribution and character of waterlogged deposits in Carlisle and Stanwix, in relation to what is currently known about the geological and topographical background of the study area, and has established a baseline understanding of the factors that contribute to the formation (or otherwise) of such remains (*Objectives 2.1-2.3*). This report contains an assessment (*Section 4.8*) of existing palaeoenvironmental data (*Objective 2.4*), and a series of maps plotting the known extent of waterlogged strata, together with an interpretative distribution map of the general patterns of waterlogging (*Objective 2.5*). As such, the study represents the starting point for an ongoing assessment of possible future threats to Carlisle's buried waterlogged heritage; in accordance with the project's aims and objectives (*Objective 2.6*), an initial assessment is presented in the present report (*Section 5.3*).

5.4.2 At the outset, care was taken, through consultation with appropriate personnel at the Cumbria HER in Kendal, to ensure that the project's main products, specifically the GIS and the database, were compatible with formats used by the HER, in order that the data could be integrated easily into the HER upon completion of the project (*Aim 3*; *Objective 3.1*). *Aim 4*, which sought to disseminate the results of the project as widely as possible, to promote and raise awareness of Carlisle's waterlogged heritage, and to highlight its potential vulnerability, has been achieved through a variety of initiatives. These include the preparation and circulation of the present report, together with the GIS and database, to appropriate personnel within Carlisle City Council, Cumbria County Council, EH and the Environment Agency, and the production of non-technical documentation explaining the use of the GIS and database (*Objectives 4.1-4.3*). The results have been presented at a seminar, held in Carlisle in November 2012, attended by members of Carlisle City Council, Cumbria County Council, and EH, and the results, together with the project database, have been made available online (*Objective 4.5*), at http://oxfordarchaeology.com/case-studies/31-historic-buildings-and-landscapes/183-distribution-of-waterlogged-deposits-in-carlisle?).

5.4.3 ***General Conclusions:*** on present evidence, the best preservation of waterlogged stratigraphy occurs in the northern part of the city, particularly in the Annetwell Street area, where internationally significant remains of the early Roman forts, in places including complex waterlogged strata up to 1.5m thick, survive over considerable areas. Nationally important waterlogged deposits also survive in this

area within the outer defensive ditch of the medieval Castle and, to the north-east, in the ditches fronting the north wall of the medieval city, adjacent to Rickergate. However, it must be stressed that these areas have also seen some of the most extensive programmes of modern excavation, which has biased the results of the study in favour of this part of the city.

5.4.4 Despite very considerable variability in the quality of the available data, due in large part to the pattern of modern redevelopment and rescue excavation in the city, the study has clearly demonstrated that survival of waterlogged Roman and medieval strata of regional, national and (in some cases at least) international significance can be anticipated almost anywhere within the walled area of Carlisle itself and, to a more limited extent, in the city's historic suburbs, especially in the medieval defensive ditches outside the city walls and in the ancient river channels north of the historic settlement.

5.4.5 In Stanwix, preservation appears to be far more limited, but the discovery of organic remains at several disparate sites across the study area demonstrates the potential for waterlogged survival in certain locations, and possibly also in large, deep-cut features. In both Carlisle and Stanwix, it is vital that archaeological briefs pertaining to future developments stress the possibility/likelihood of encountering buried waterlogged archaeology, and that adequate provision is made for dealing with such deposits, in terms of excavation, recording, conservation, analysis and publication, if they cannot be preserved *in situ*.

5.4.6 ***Recommendations:*** on the whole, opportunities for additional field research to advance our present understanding of the character and extent of Carlisle's buried waterlogged heritage appear limited. For the most part, the study area comprises a densely built-up, urban environment, where test-pitting and/or drilling of boreholes purely for research purposes would be extremely difficult. Research into the possible impact on the city's water-table of the recent flood defence works along the Rivers Eden and Caldew is also unlikely to be worthwhile, since there is little or no information pertaining to the level of the water-table prior to the commencement of the works, with which new data could be compared.

5.4.7 That said, there may well be some potential to enhance our understanding of the position of the buried palaeochannels of the River Eden that are known, or are suspected, to lie well to the south of the river's present course, immediately to the north of the study area (*Section 4.2.3; 4.5.17*). The southern edge of a pre-Roman channel of the Eden was found during excavations on Rickergate, *c* 300m south of the modern channel (Zant *et al* 2011a), and waterlogged organic materials were recovered from its alluvial fills. However, as only a very small intervention was possible, the full potential of these strata has not been determined, nor is the position of the channel known beyond the boundaries of this single archaeological site. Topographically, it would make sense for the palaeochannel to extend westwards or north-westwards, beneath the eastern part of Bitts Park, perhaps turning north in the vicinity of the bluff occupied today by the medieval castle. A carefully targeted programme of borehole drilling with perhaps geophysics (magnetic) survey, and/or test-pitting within the park, much of which is open and readily accessible, might shed important light on the prehistoric course of the river, and the presence or absence of waterlogged remains within its fills. There may also be some potential to target the channel (and, potentially, later channels in the vicinity; *Section 5.4.8*) within the built-up area adjacent to Rickergate, if areas of

open ground (or even roadside verges) suitable for the drilling of boreholes could be located.

5.4.8 A project of this kind might also provide important new information on the position and character of the Roman and medieval river channels, which are presumed to lie between the archaeologically attested prehistoric channel and the river's present course. The discovery of a (stone) medieval bridge abutment during construction of the Civic Centre on Rickergate, during the 1960s (Perriam 1997), gives some idea of the river's course at that time, and is consistent with the idea of a gradual northwards movement of the river from the pre-Roman period to the present day. However, no record was made of the river channel fills when the Civic Centre was built, so it is not known if waterlogged materials were present. Furthermore, the location of the Roman and medieval channels further west, in Bitts Park, is not known, nor is there currently any evidence to indicate whether these channels contain waterlogged archaeological remains.

5.4.9 It is recommended that the process of outreach, that was initiated within the regional and local context at a Carlisle-based seminar, be extended to a national perspective. This could entail a conference or seminar drawing upon the results of the waterlogged studies from other urban contexts elsewhere in the country, and could be an effective outreach vehicle to highlight the remarkable archaeological resource preserved beneath our towns, but would also allow an assessment of the national issues relating to urban waterlogging, leading towards generating a more coordinated strategy for their preservation.

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APPENDIX 1: WATERLOGGED CARLISLE EVENT DATA STRUCTURE

A1.1 The project database is in Microsoft Access 97 format, which is compatible with all later versions. The key headings of the tables in the database are fully described in the database table design view for each table, but, for ease of reference, the descriptions for the monument table are given in Table 5.

Field Name in Events table	**Definition**
Carlisle_Recevent_Number	The numeric string which uniquely identifies each event in Carlisle
Stanwix_Recevent_Number	The numeric string which uniquely identifies each event in Stanwix
County_Code	The numeric string which uniquely identifies each county
District_Code	The codes for each District currently used by the National Buildings Record, the National Archaeological Record (London) and English Heritage, derived originally from the National Census
Civil_Parish	The name of the civil parish. If there is no civil parish, then the District name is entered
Site_Name	Name or names by which a site is known
Recevent_Type	The term or terms by which a site has been classified. This will normally be the interpretation of the site by function or form
Event_Start_Date	Date event commenced
Event_Finish_Date	Date event ended
Event_Date_Precision	Precision of the date range given as defined in table *tlkpMonDatePrecisions*
NGS	NGR 100km square
Easting	The full six-figure Easting of the NGR
Northing	The full six-figure Northing of the NGR
Nat_Grid_Qualifier	A code, defined in lookup table *tlkpNGRQualifier*, indicating whether the given NGR refers to a single site, a group of sites, or an inaccurate locality only
Nat_Grid_Precision	A number, defined in lookup table *tlkpNatGridPrecision*, indicating the precision (in metres) of the given NGR

Field Name in Events table	Definition
Carlisle_Recevent_Number	The numeric string which uniquely identifies each event in Carlisle
NGR	The NGR abbreviated code for the site. Not always completed
Historic_Parish	The name of the civil parish is entered, if it differs from the modern parish
Site_Description	A free text description summarising the event
Associated_Organisation	The organisation undertaking the archaeological work
Compilation_Date	Date the event was entered into the database
SiteCode	Site code, as referenced in the original grey literature / primary resource
Waterlogged_Relevant	Whether or not the event is relevant to this project. Irrelevant events have been filtered out and are now stored in the table *TblEvents_NOT_waterlogged_relevant*
Waterlogged_Description	A free text description summarising the presence, absence and preservation of waterlogged remains for the event
Waterlogged_score	Score (between 1-6) describing the presence, absence and preservation of waterlogged remains for the event *(Section 3.4.2)*
Waterlogged_Depth	The depth that waterlogged deposits were encountered at
Waterlogged_Disturbance	Whether or not the waterlogged deposits were affected by modern disturbance
Waterlogged_not_deep_enough	Whether or not the excavations went deep enough to encounter waterlogged deposits
Waterlogged_local	Whether or not waterlogged deposits only occurred at the base of archaeological features
Modern ground level	The level of the modern ground surface, from Lidar data
Top_of_Archaeology	The top of archaeological strata
Top_of_Natural	The top of natural layers

Table 5: The Event table field definitions

A1.2 All vector and raster data supplied will load into any GIS, using the British National Grid coordinate reference system (EPSG code: 27700). No data are stored in a geodatabase but will be supplied in universally compatible formats. A list of all the general shape files is given (Table 6), as is a list of all the vector and raster data

for the creation of the predictive model (Table 7), and all the vector and raster data for the creation of the deposit model (Table 8).

Data Type	General	
Data Definition	General ESRI shapefiles, such as the boundaries of the study area and event outlines	
Files Supplied		***File description***
Study_Areas.shp		The boundaries of the Carlisle and Stanwix study areas, including a 50m buffer for each
Event_polygons.shp		ESRI polygon-type shapefile, containing the events from both study areas relevant to this project, where the site boundary has been defined by a polygon. Centroids exist in the event points shapefiles
Event_lines_relevant.shp		ESRI line-type shapefile, containing the events from both study areas relevant to this project, where the site boundary has been defined by a line. Centroids exist in the event points shapefiles

Table 6: The general shapefiles

Data Type	Predictive Model	
Data Definition	Models predicting the presence or absence of waterlogged remains throughout the Carlisle and Stanwix study areas, in addition to data sources (events)	
Files Supplied		***File description***
Event_points_Carlisle_1.shp		Carlisle events with negative evidence (waterlogged score of 1) for waterlogging – extract from *Carlisle_centroids_f_interpol_new.shp*. Point type ESRI shapefile
Event_points_Carlisle.shp		Carlisle archaeological events up to 2012. Point type ESRI shapefile
Carlisle_difference.shp		Random subset of 10% of events throughout the Carlisle study area removed for testing the validity of the predictive model. Point type ESRI shapefile
Event_points_Stanwix.shp		Stanwix archaeological events up to 2012. Point type ESRI shapefile
Stanwix_difference.shp		Random subset of 10% of events throughout the Stanwix study area removed for testing the validity of the predictive model. Point type ESRI shapefile

Carlisle_KRIG.asc	Interpolated ASCII raster model based on *Carlisle_centroids_f_interpol_new.shp*. To be styled using a colour map, with values 0-6
Carlisle_KRIG _test.asc	Interpolated ASCII raster model based on *Carlisle_centroids_f_interpol_new.shp*, excluding the 10% random subset *Carlisle_difference.shp*. To be styled using a colour map, with values 0-6
Stanwix_KRIG _TIF.asc	Interpolated ASCII raster model based on *Stanwix_centroids_f_interpol.shp*. To be styled using a colour map, with values 0-5
Stanwix_KRIG _TIF_test.asc	Interpolated ASCII raster model based on *Stanwix_centroids_f_interpol.shp*, excluding the 10% random subset *Carlisle_difference.shp*. To be styled using a colour map, with values 0-5

Table 7: The vector and raster data for the predictive model

Data Type	Deposit Model	
Data Definition	Models of the current ground surface, tops of natural geology and interpreted archaeological horizons, for the purpose of generating deposit models	
Files Supplied		***File description***
Deposit_model_Carlisle.shp		ESRI point-type shapefile generated from archaeological events and geological borehole data, containing information on tops and bases of the modern surface, archaeological strata and boulder clay for Carlisle
Deposit_model_Stanwix.shp		ESRI point-type shapefile generated from archaeological events and geological borehole data, containing information on tops and bases of the modern surface, archaeological strata and boulder clay for Stanwix
Carlisle_Bedrock_Contours_0_5.shp		Contours extracted from *Carlisle_Bedrock_TIN_16102012.asc* at 0.5m intervals. ESRI line-type shapefile
Carlisle_made_ground_Contours_0_5.shp		Contours extracted from *Carlisle_arch_thickness_clip.tif* at 0.5m intervals. ESRI line-type shapefile
Stanwix_Bedrock_Contours_0_5.shp		Contours extracted from *Stanwix_Bedrock_TIN_16102012.asc* at 0.5m intervals. ESRI line-type shapefile

Carlisle_arch_thickness.tif	Interpolated thickness of archaeological strata, based on the attributes of *Deposit_model_Carlisle_final.shp*. GeoTIFF raster file
Carlisle_Bedrock_TIN.asc	Interpolated top of bedrock in Carlisle, based on the attributes of *Deposit_model_Carlisle_final.shp*. ASCII raster file
Stanwix_Bedrock_TIN.asc	Interpolated top of bedrock in Stanwix, based on *the attributes of Deposit_model_Stanwix_final.shp*. ASCII raster file
Dep_mod_density.asc	Interpolated density of event points used for the creation of the Deposit model to check its validity. Based on the distribution of *Deposit_model_Carlisle/Stanwix_final.shp*. ASCII raster file
0_5mcontours_lidar_Carlisle.shp	Contours extracted from the modern Lidar DTM raster data for Carlisle at 0.5m intervals. ESRI line-type shapefile
1mcontours_lidar_Carlisle.shp	Contours extracted from the modern Lidar DTM raster data for Carlisle at 1m intervals. ESRI line-type shapefile
0_5mcontours_lidar_Stanwix.shp	Contours extracted from the modern Lidar DTM raster data for Stanwix at 0.5m intervals. ESRI line-type shapefile
1mcontours_lidar_Stanwix.shp	Contours extracted from the modern Lidar DTM raster data for Stanwix at 1m intervals. ESRI line-type shapefile

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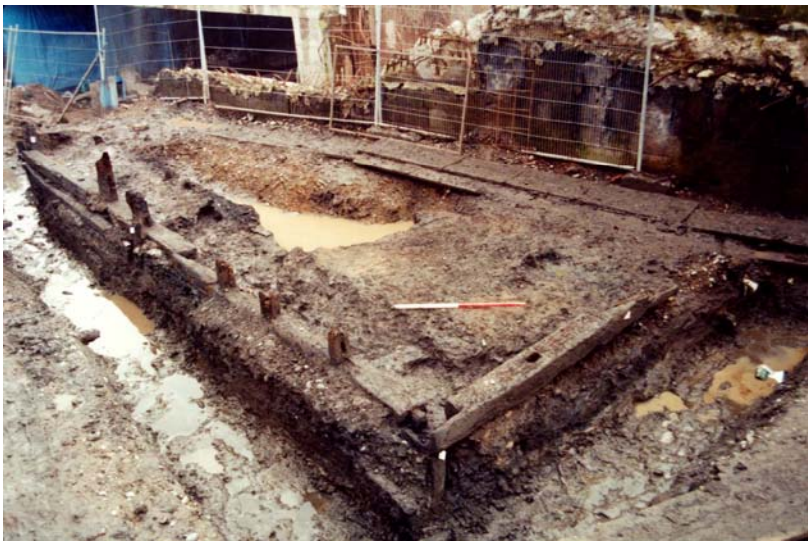

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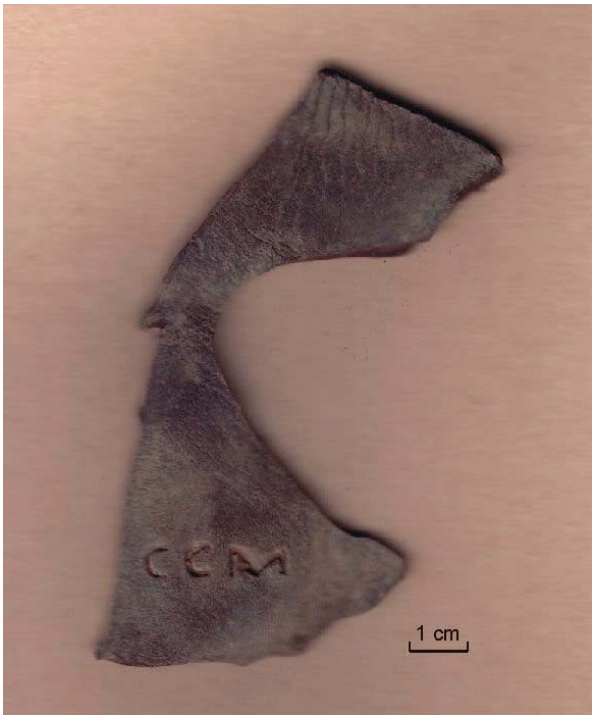

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Plate 22: Late twelfth-century timber-lined well at the northern Lanes

Plate 23: Medieval wooden spade blade from the northern Lanes

Plate 24: Two phases of the defensive ditch fronting the medieval city's north wall, as excavated on Rickergate in 1998

Plate 25: Wood and leather water-carrier from the ditch fronting the north wall of the medieval city

Plate 26: Turned bowl of ash wood from the ditch, probably fourteenth-century, fronting the north wall of the medieval city

Plate 27: A late fourteenth-century building erected over the disused defensive ditch for the medieval Castle's outer ward

Plate 28: Post-and-wattle fence in the medieval Castle's outer ward ditch, late fourteenth century

Plate 29: Pre-Roman ploughmarks and buried soil beneath Roman dumped deposits at Stanwix, north of the Hadrian's Wall fort

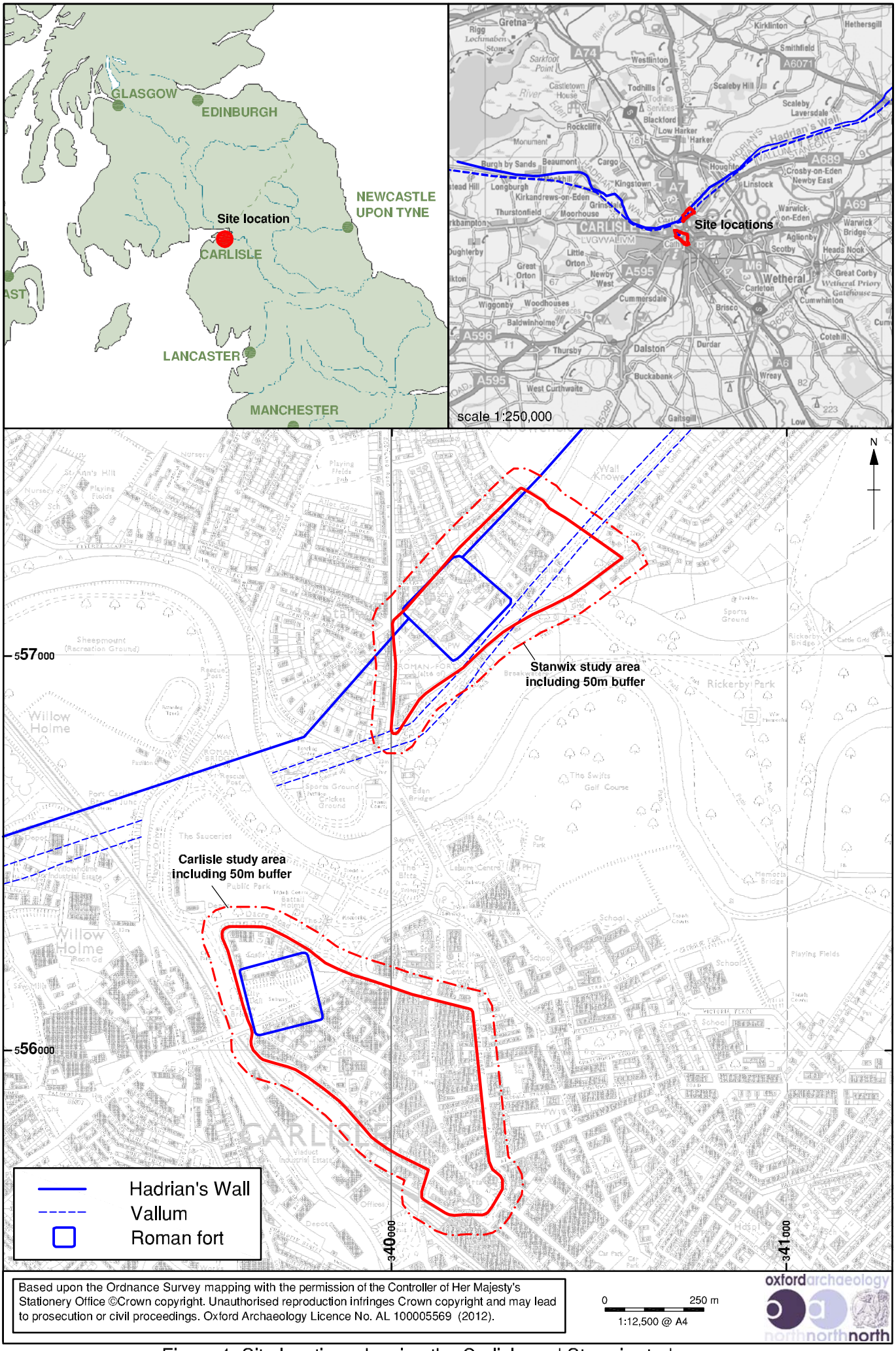

Figure 1: Site location, showing the Carlisle and Stanwix study areas

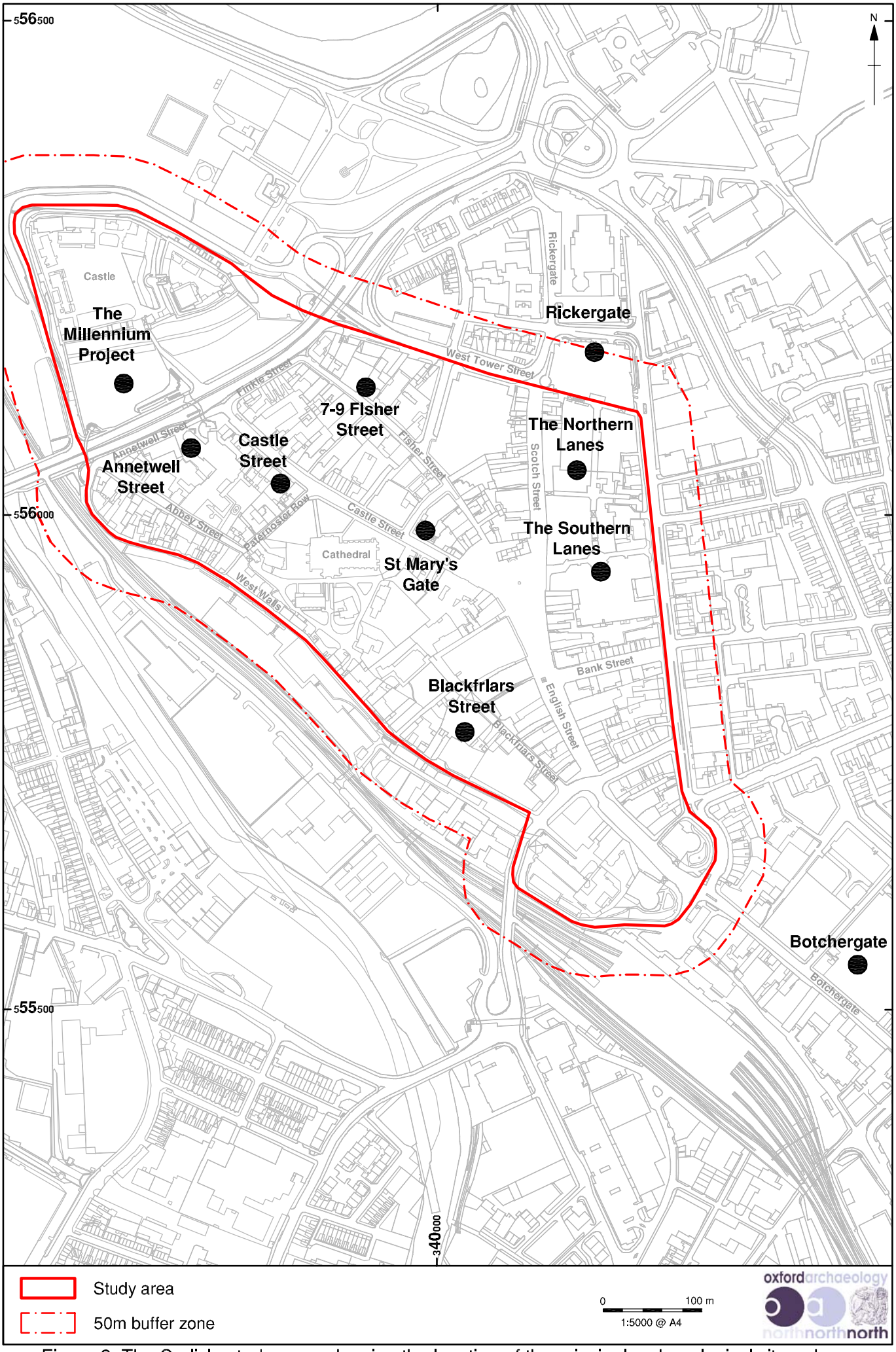

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Figure 2: The Carlisle study area, showing the location of the principal archaeological sites where waterlogged remains have been recorded

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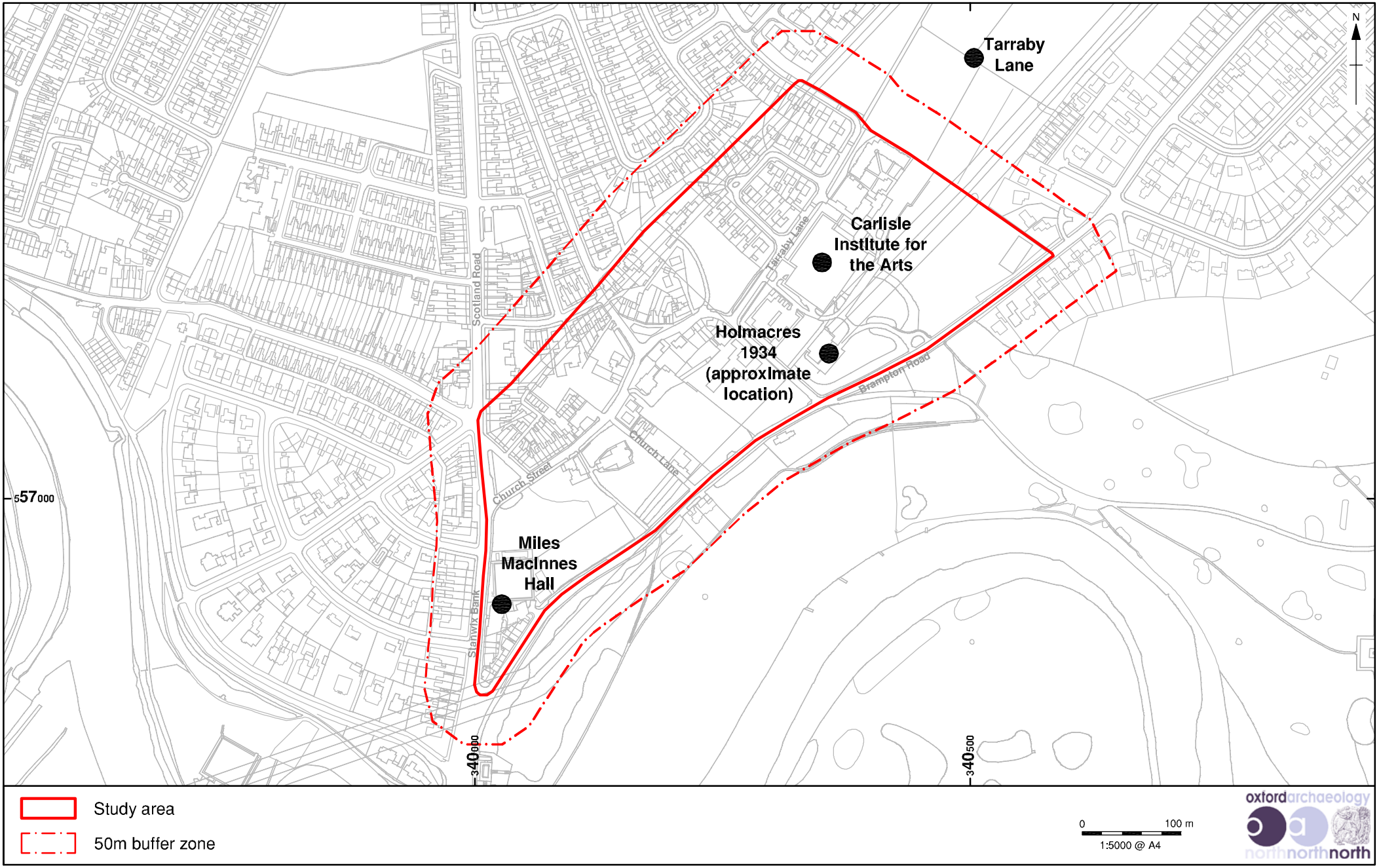


Figure 3: The Stanwix study area, showing the location of archaeological sites where waterlogged remains have been recorded

Figure 4: Confidence rating for the quality of data used for the production of the deposit model

Key

Study area

Red areas on the raster show the highest density, while blue areas show the lowest density of event points with a confident waterlogged score

0 100 200 m

1:5000 at A4

oxfordarchaeology

northnorthnorth

Figure 5: Carlisle: Density of event points with a score indicating confident waterlogging

Figure 6: Carlisle: Raster image showing the subtle differences between interpolations based on the datasets of the full and the reduced events

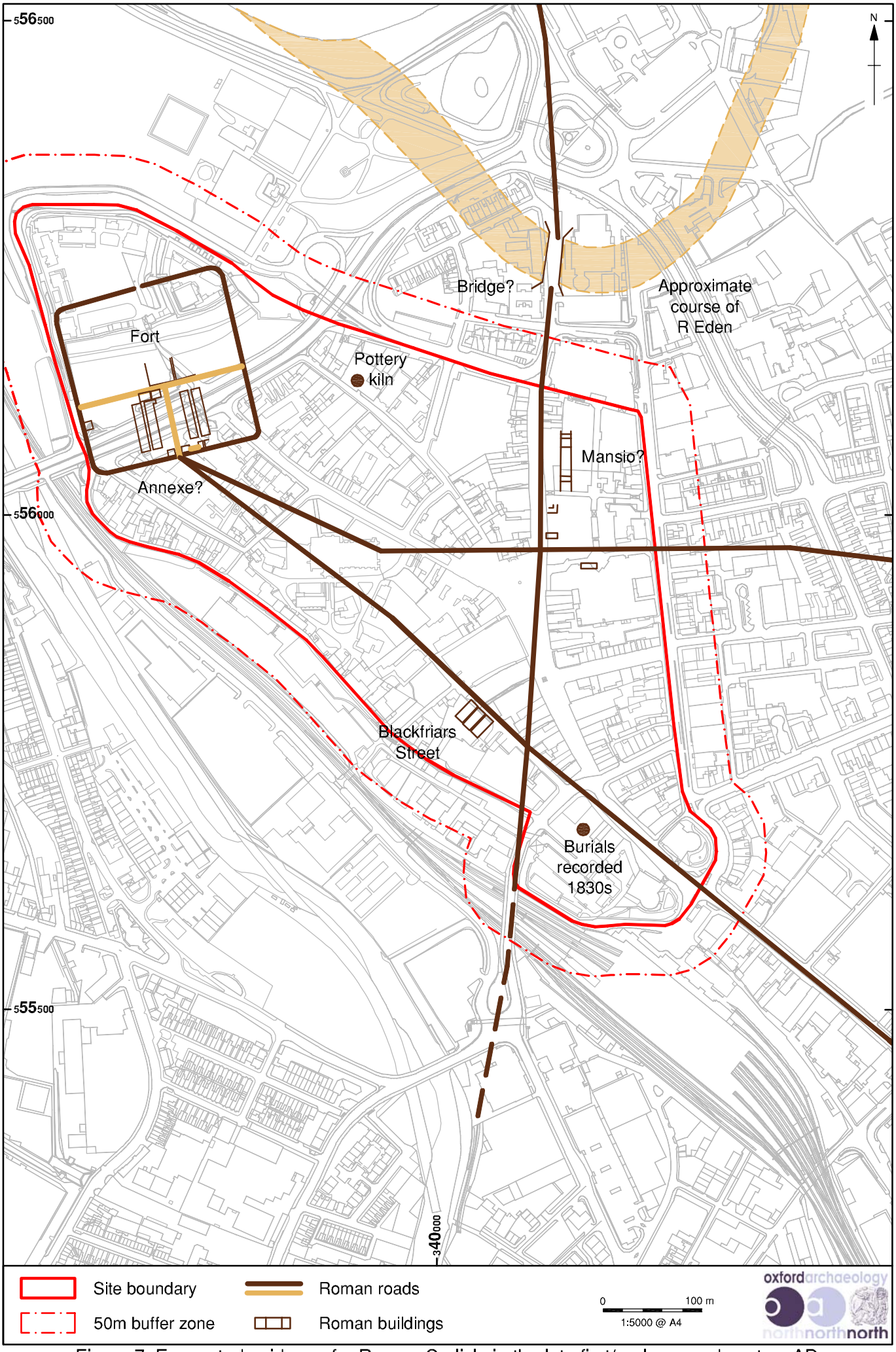


Figure 7: Excavated evidence for Roman Carlisle in the late first/early second century AD

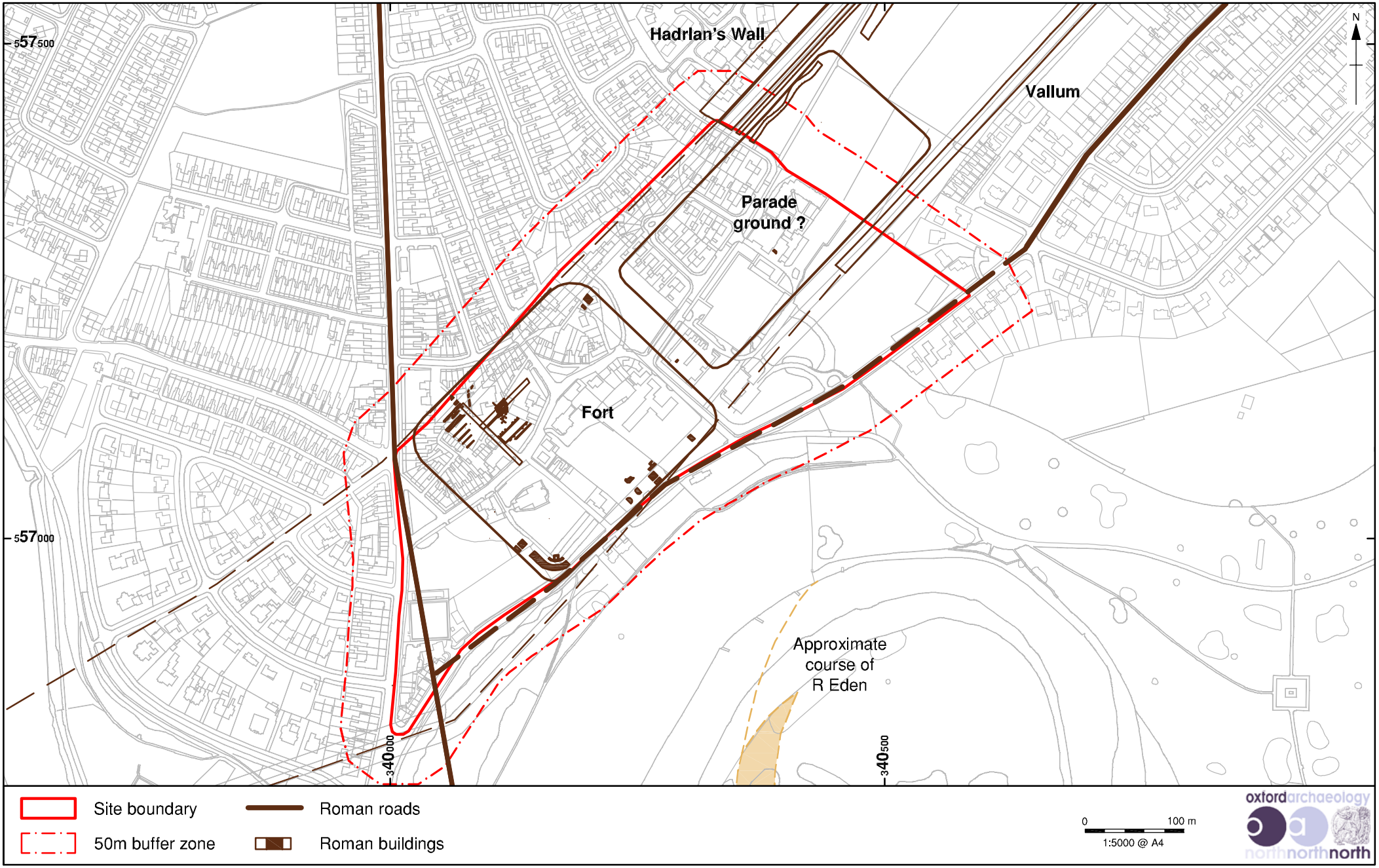


Figure 8: Excavated evidence for Roman Stanwix in the late first/early second century AD

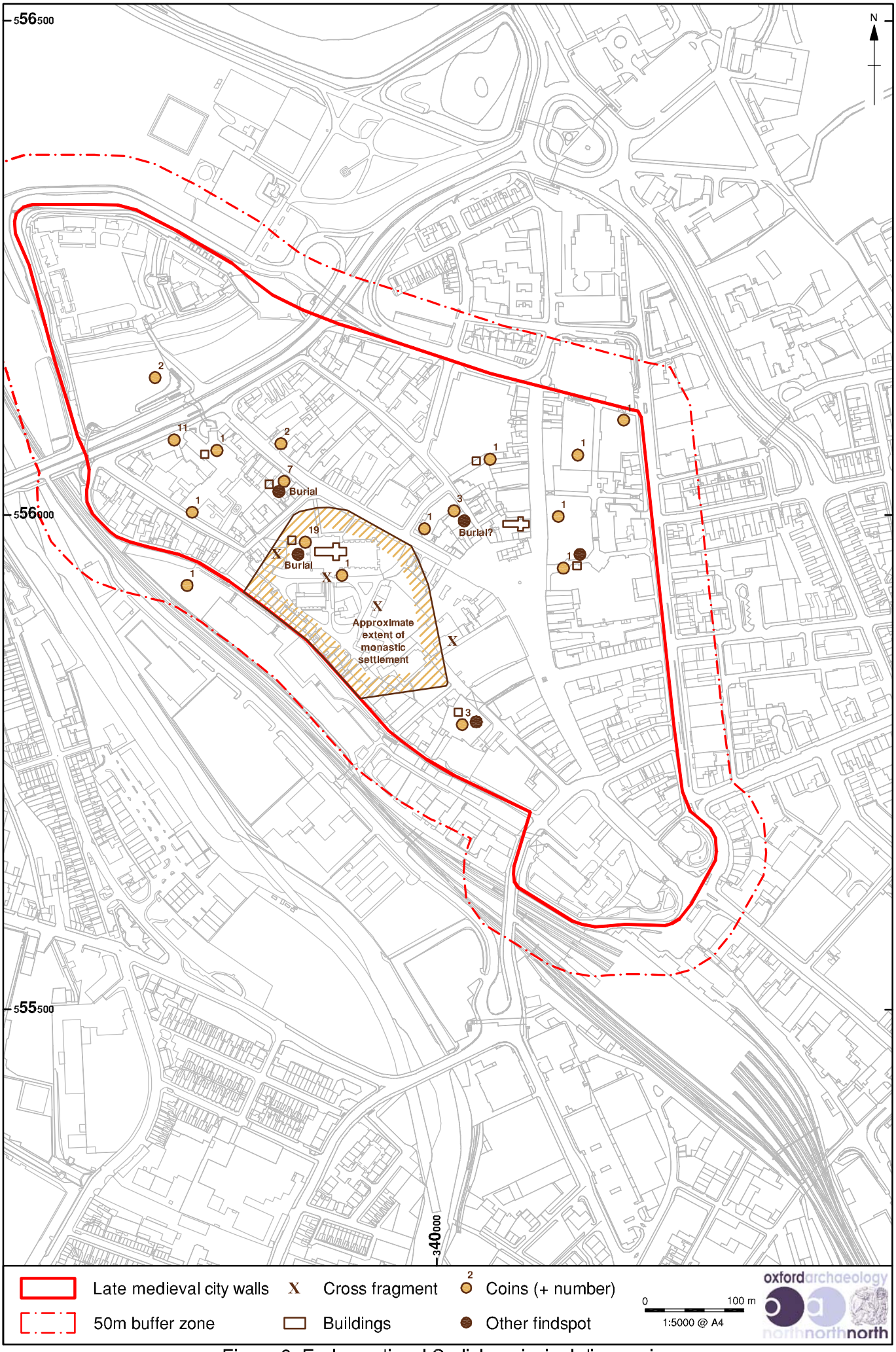


Figure 9: Early medieval Carlisle: principal discoveries

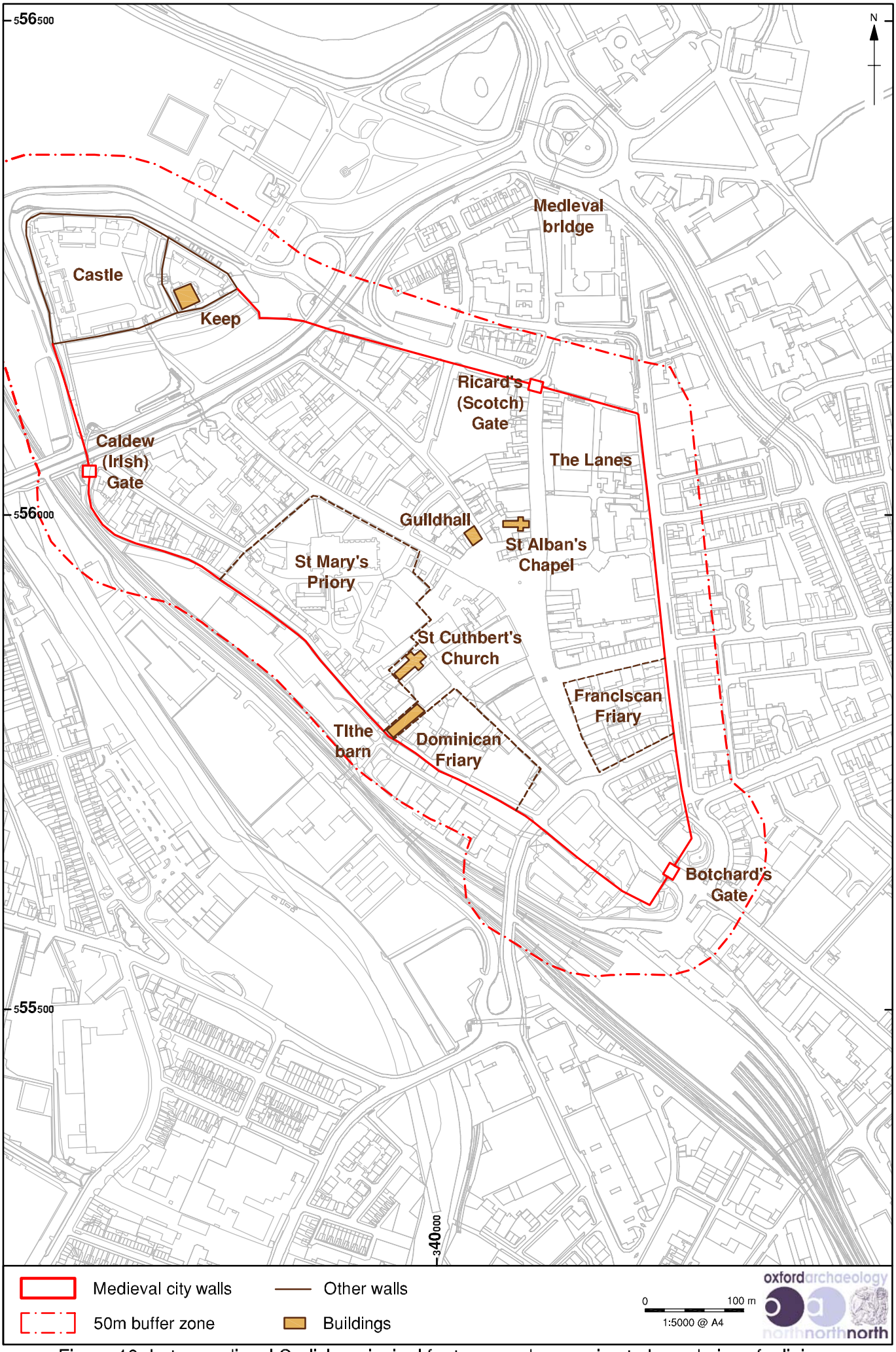


Figure 10: Later medieval Carlisle: principal features and approximate boundaries of religious establishments

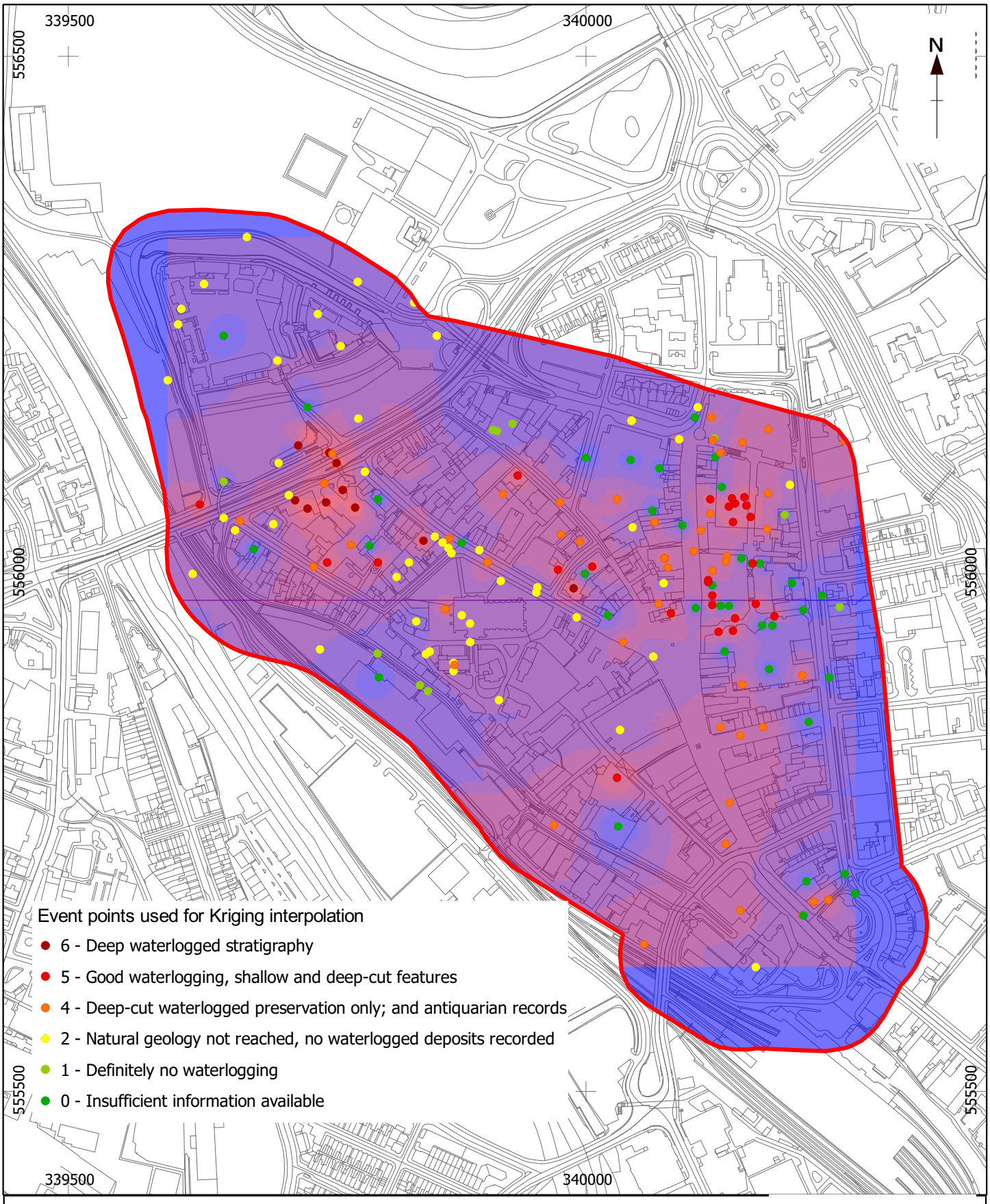
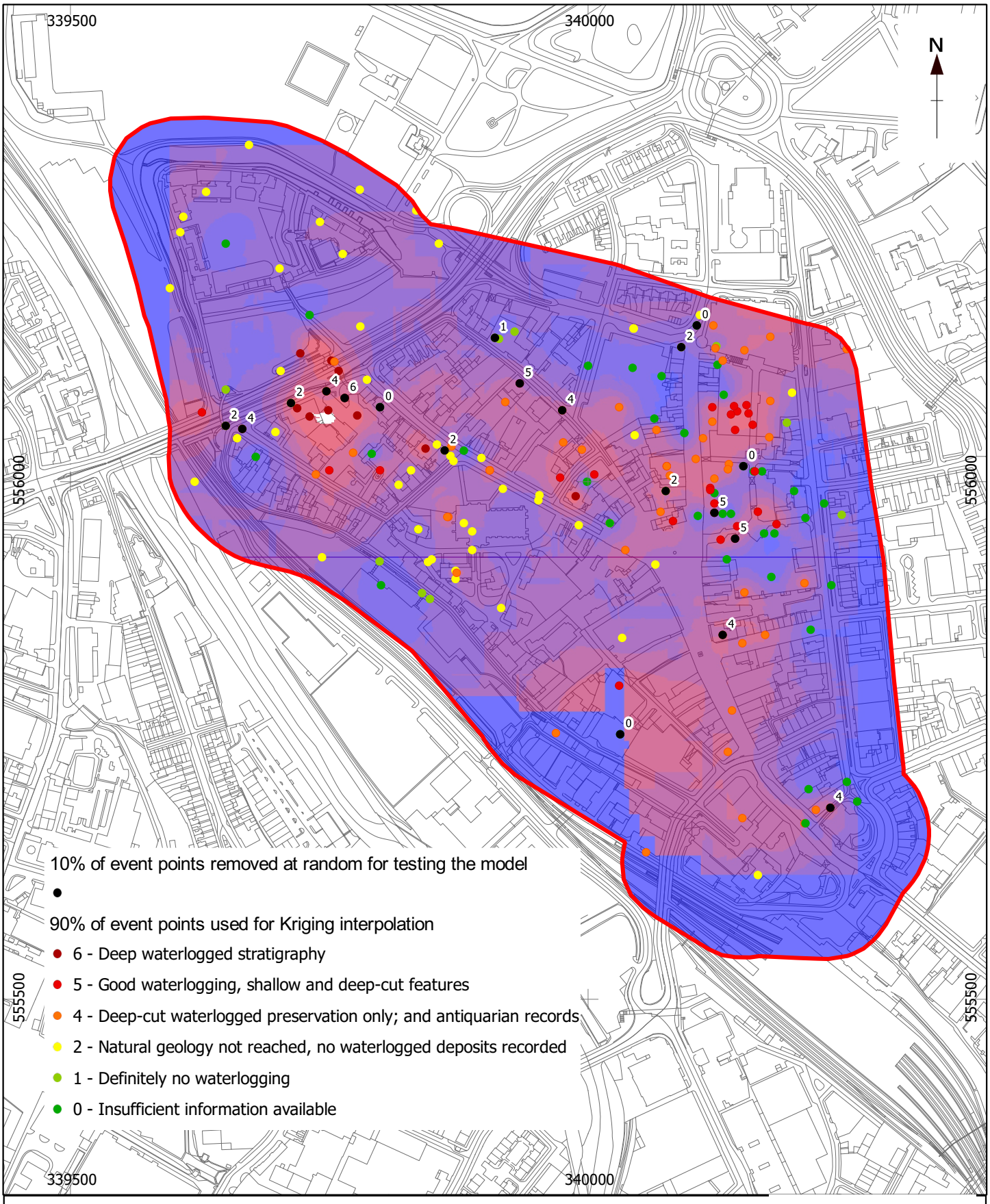


Figure 11: Carlisle: Kriging interpolation of waterlogging, showing scoring of individual event points



Key

0
1
2
3
4
5
6

Kriging interpolation of 90% event points based on their waterlogged scores

Study area

0 100 200 m

1:5000 at A4

Borehole data (event type 3) was not used for the Kriging interpolation

Figure 12: Testing of the Kriging interpolation model (Fig 11) by the random removal of 10% of the recorded events

Figure 13: Carlisle: interpolated thickness of archaeological strata from excavation and borehole evidence

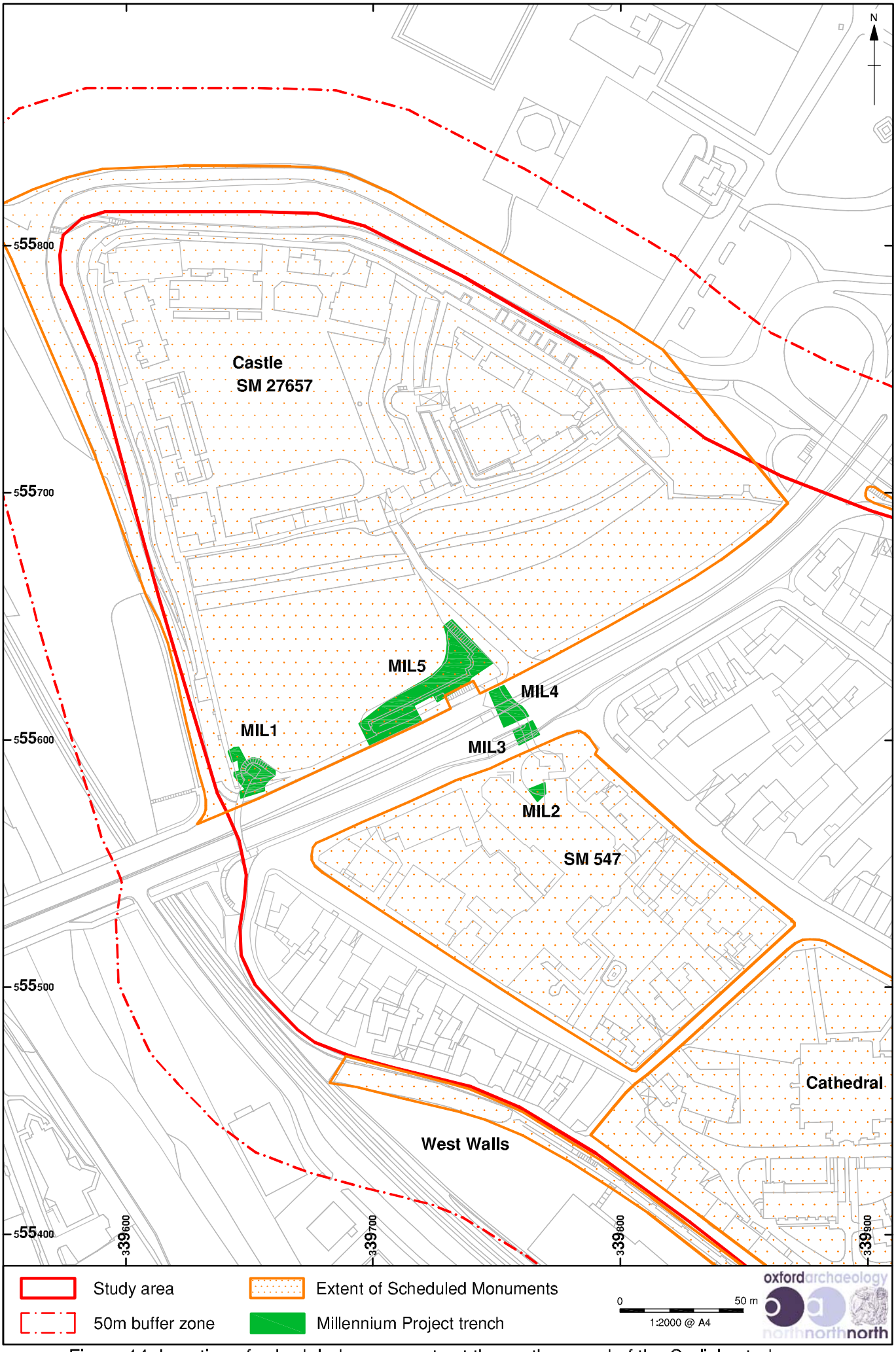


Figure 14: Location of scheduled monuments at the northern end of the Carlisle study area

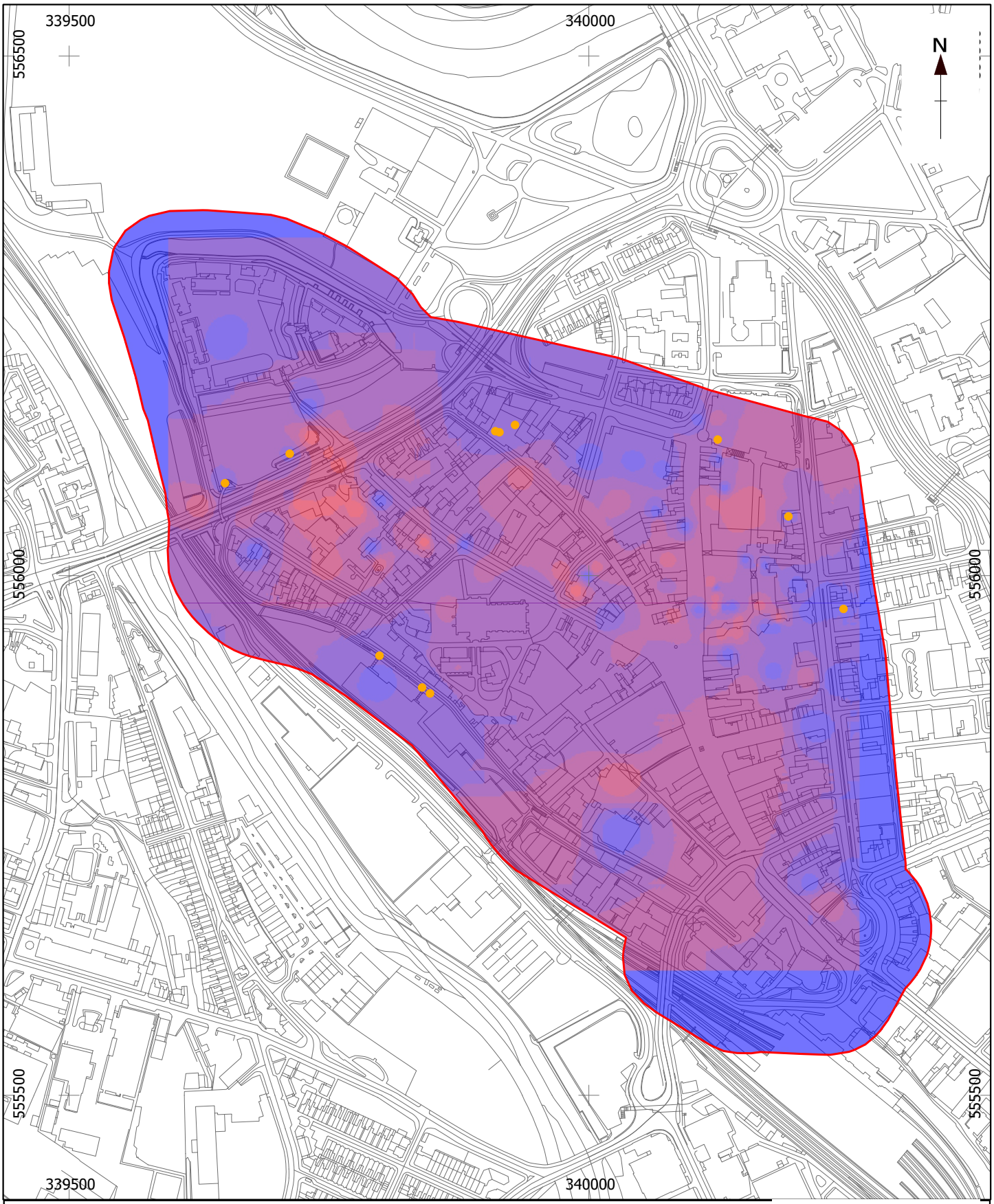


Figure 15: Carlisle: distribution of sites where an absence of waterlogged remains has been confirmed by excavation

Figure 16: Stanwix: Kriging interpolation of waterlogging, showing scoring of individual events

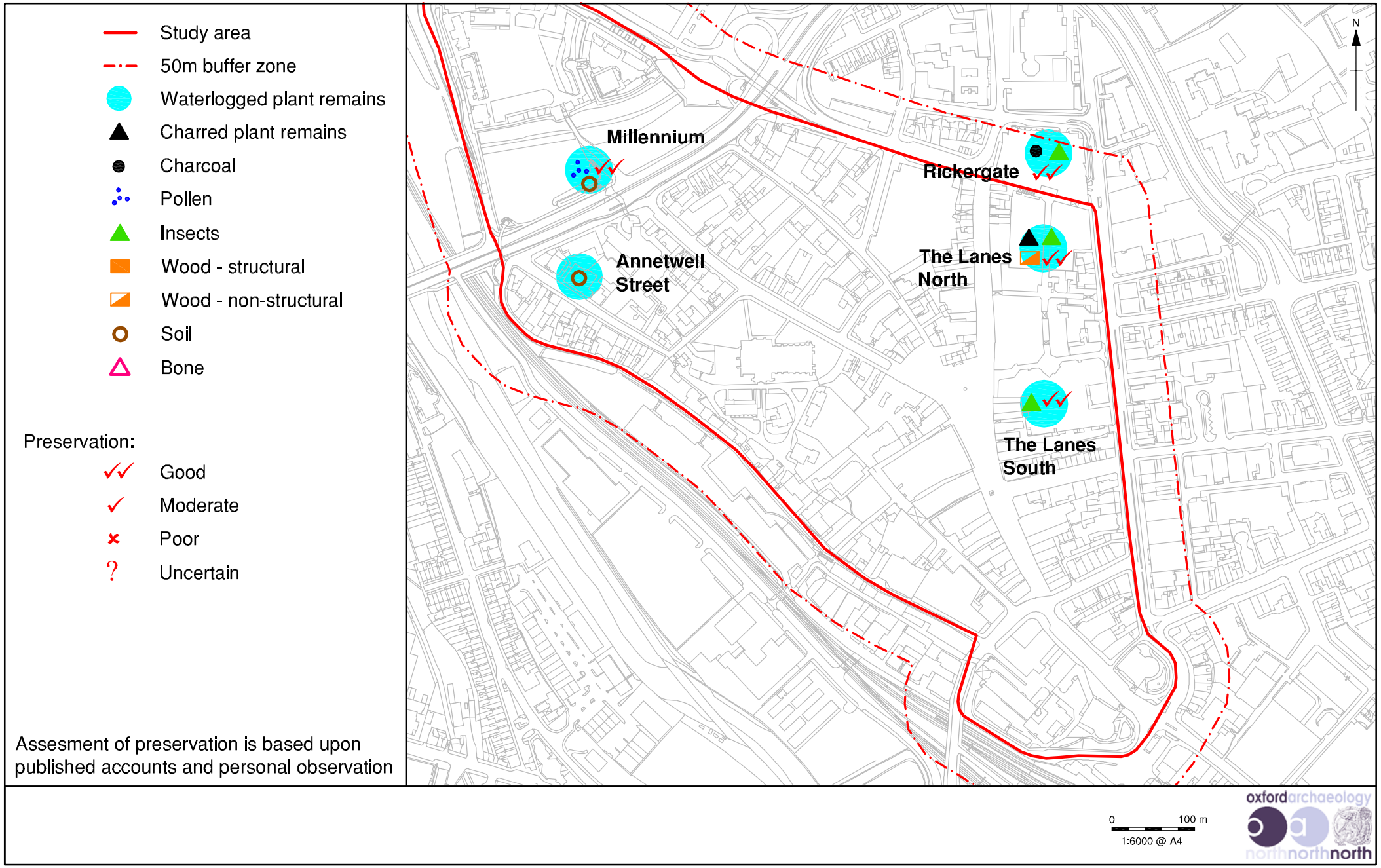


Figure 17: Carlisle: pre-Roman sites with waterlogged palaeoenvironmental remains

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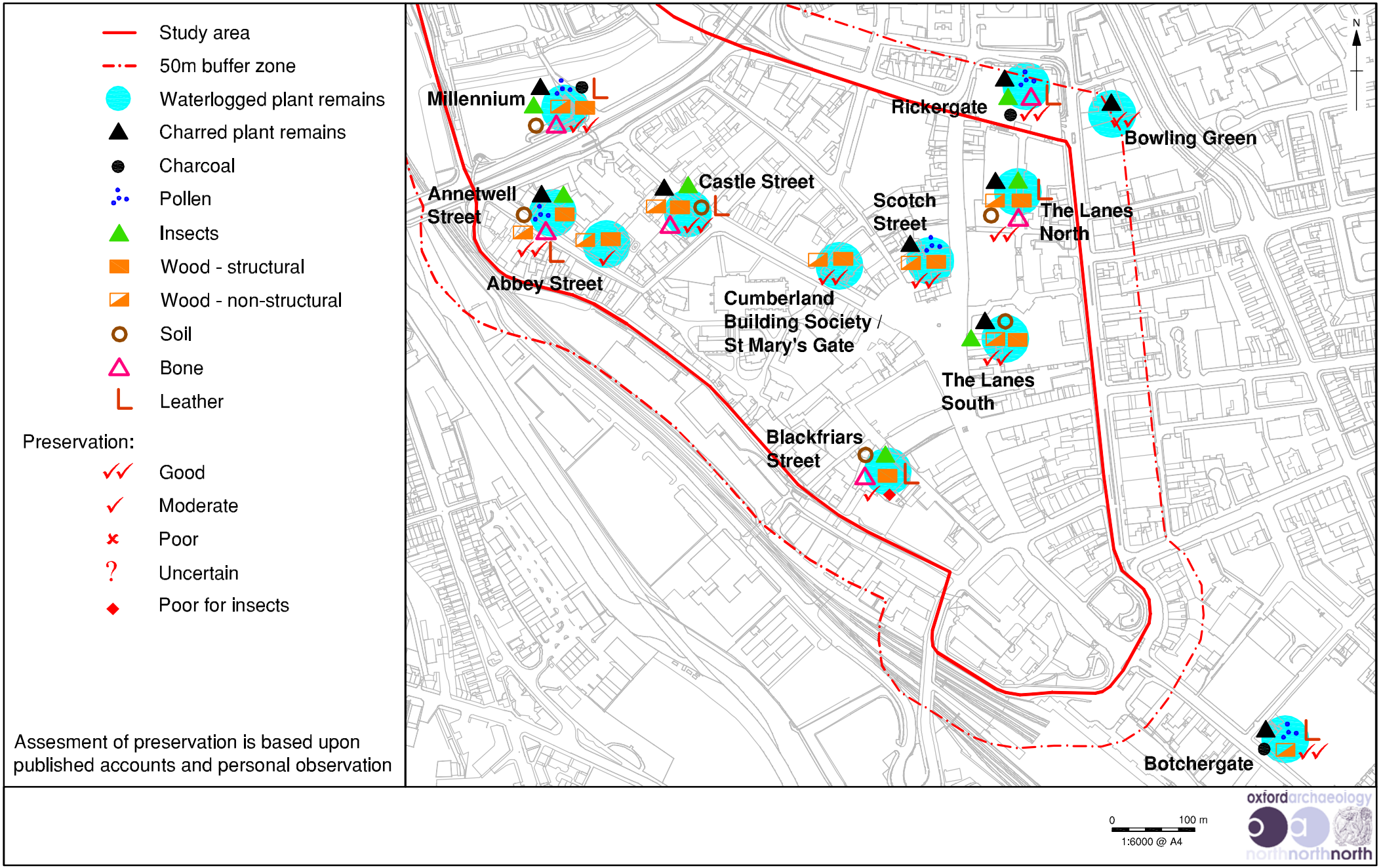

Figure 18: Carlisle: Roman sites with waterlogged palaeoenvironmental remains

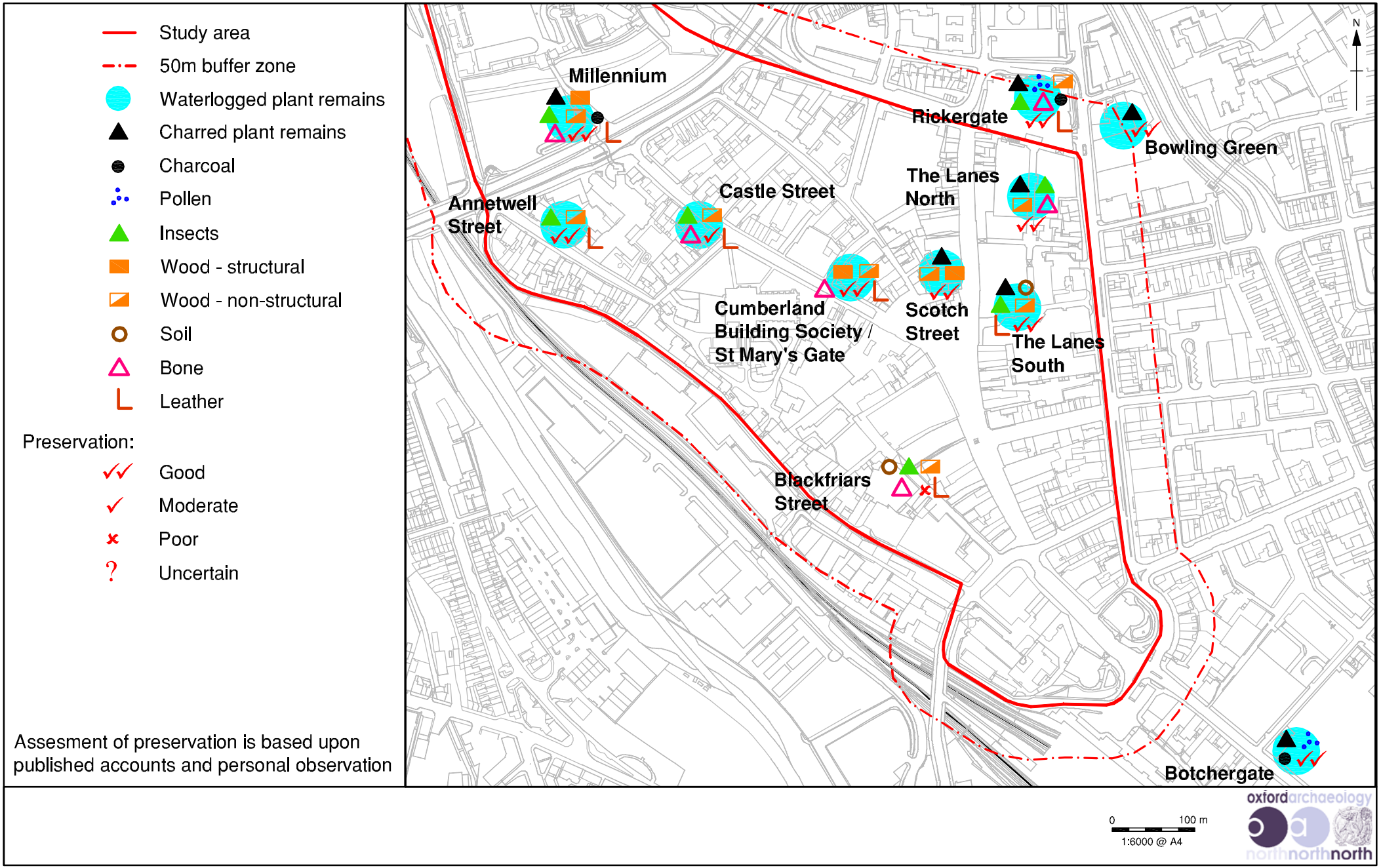

Figure 19: Carlisle: medieval sites with waterlogged palaeoenvironmental remains

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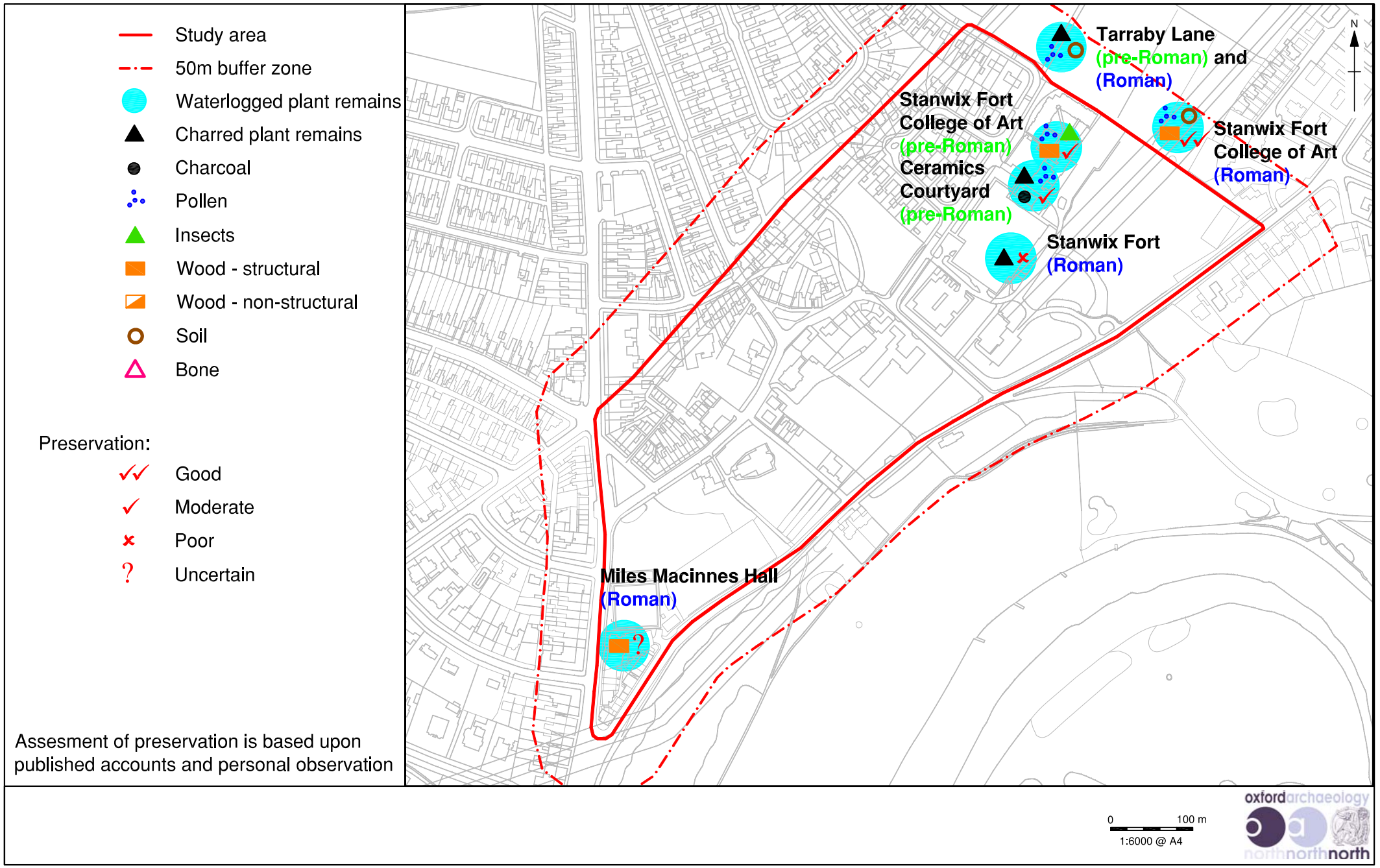

Figure 20: Stanwix: pre-Roman and Roman sites with waterlogged palaeoenvironmental remains

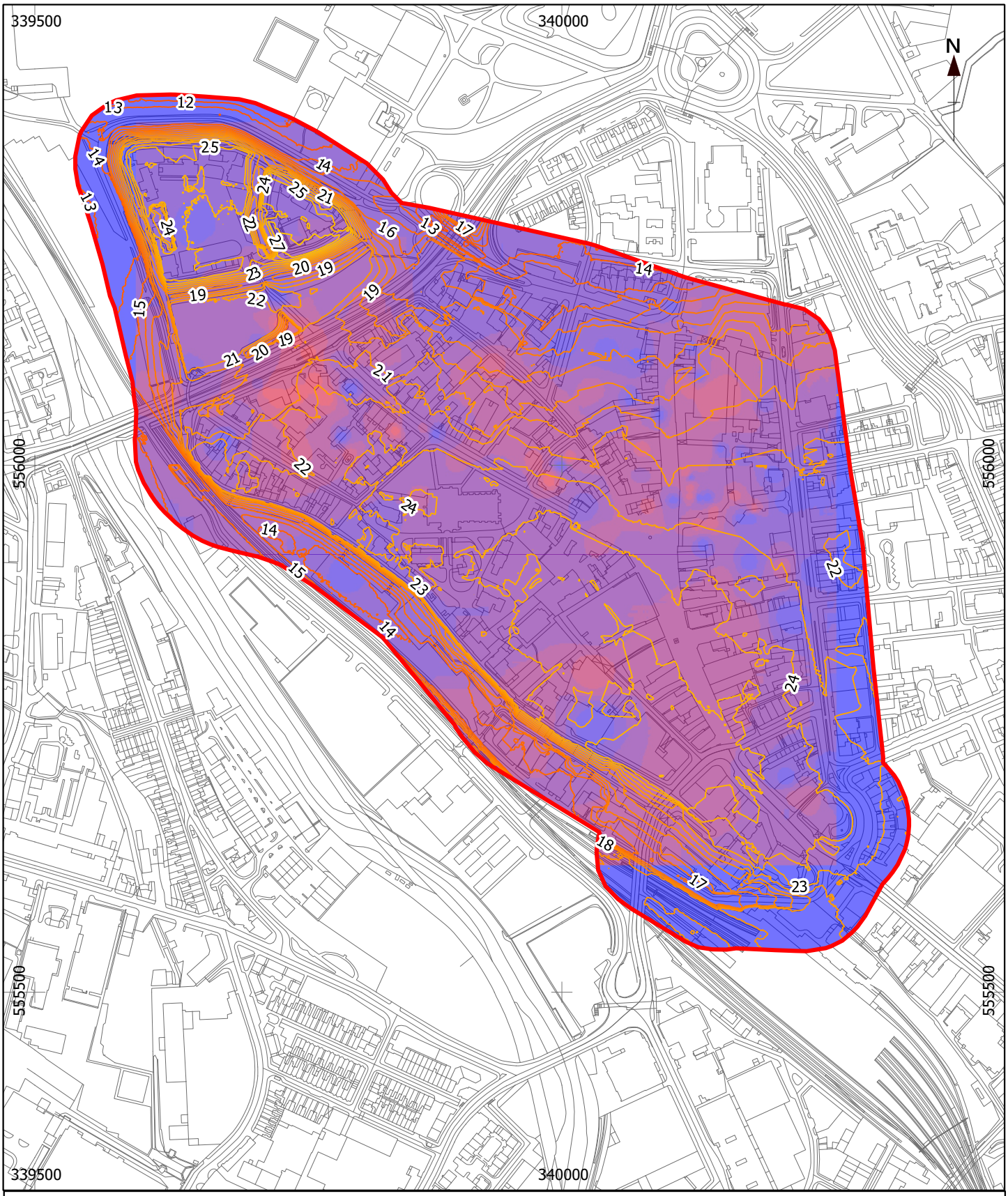

Figure 21: Carlisle: Kriging interpolation of waterlogging overlain on modern surface contours obtained from Lidar data

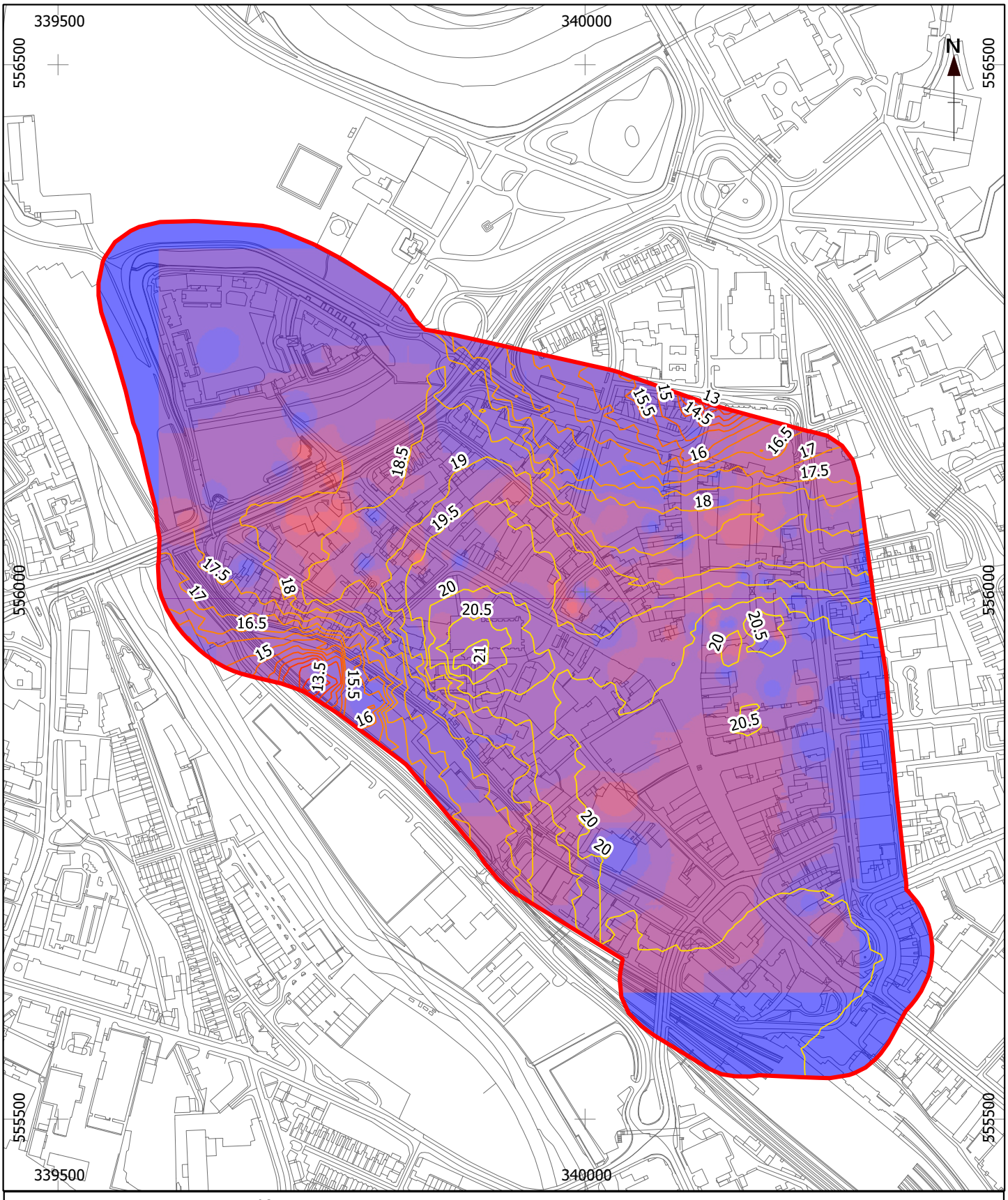

Figure 22: Carlisle: Kriging interpolation of waterlogging, overlain on contours of underlying drift geology, obtained from excavation data and boreholes

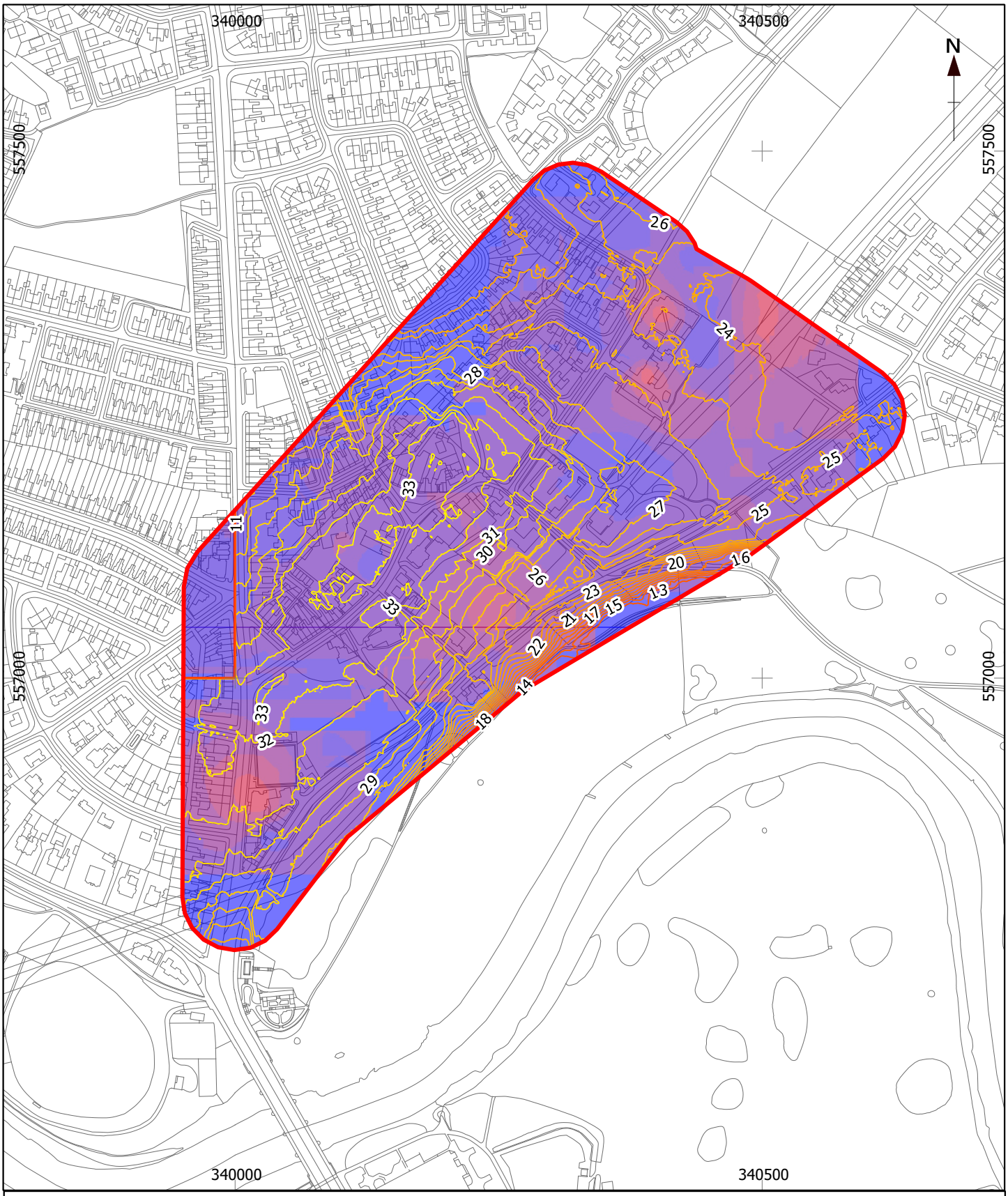

Figure 23: Stanwix: Kriging interpolation of waterlogging, overlain on modern surface contours obtained from Lidar data

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