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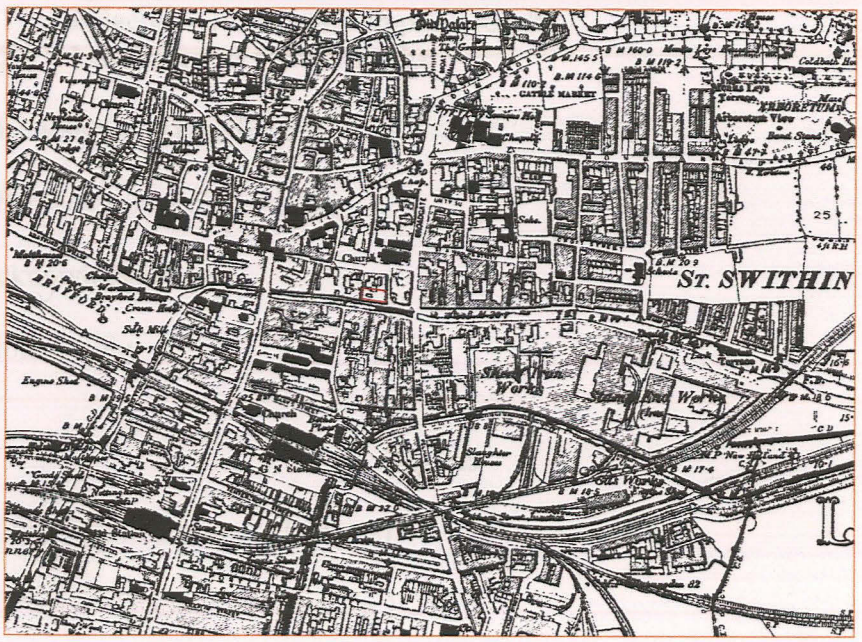
ARCHAEOLOGICAL WATCHING BRIEF AND PALAEOENVIRONMENTAL SAMPLING REPORT

FORMER SLIPPER BATHS SITE, WATERSIDE NORTH, LINCOLN

(Site Code: LISB 05)
NGR: SK 97726 71148
Planning Ref: 2004/0446/F



Report prepared for
Warrant Developments Limited

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Summary

- *An archaeological watching brief with additional palaeoenvironmental sampling was undertaken for Warrant Developments Ltd during the groundworks for two new restaurants at the Former Slipper Baths site, Waterside North, Lincoln*

- *The watching brief identified several limestone walls of likely post-medieval date that ran parallel with walls associated with the former Slipper Baths. A small collection of 17th to 19th century pottery was recovered from a demolition deposit that butted against several of the walls*

- *Palaeoenvironmental sampling indicated that the site was damp or wet throughout the Roman and medieval periods, and that it lay beyond the north bank of the contemporary river, in an area of marginal ground used for the disposal of refuse*

- *Tests to assess the effects of concrete leaching from piling proved inconclusive*

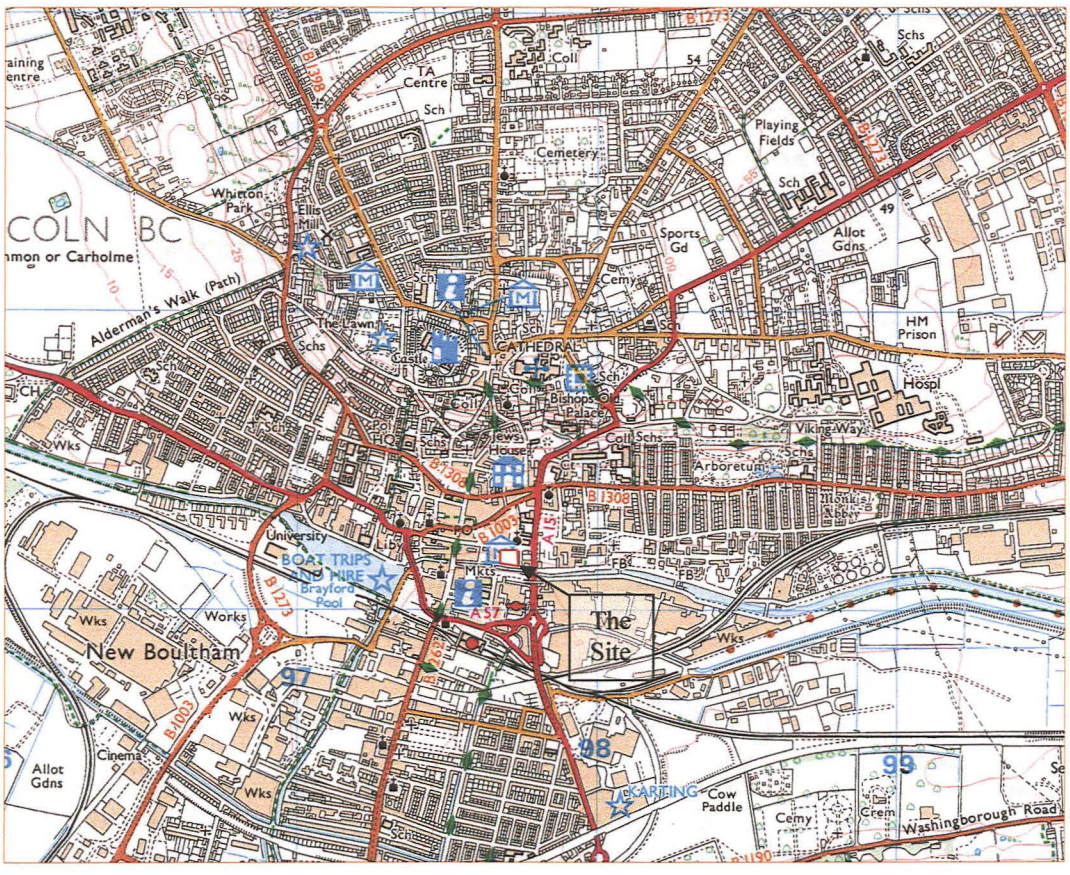

Figure 1: Site location (outlined in red) at scale 1:25,000

1.0 Introduction

Allen Archaeological Associates was commissioned by Warrant Developments Ltd to carry out an archaeological watching brief with additional palaeoenvironmental sampling at the former Slipper Baths site, Waterside North, in Lincoln (figure 1). The work was commissioned to fulfil a planning requirement associated with the construction of two new restaurants (figure 2).

The programme of works was conducted in accordance with a brief provided by the Heritage Team, Directorate of Development and Environmental Services, City of Lincoln Council (2005); procedures that are set out in the Lincolnshire County Council publication *Lincolnshire Archaeological Handbook: A Manual of Archaeological Practice* (LCC 1998); national guidelines produced by the Institute of Field Archaeologists were also observed (IFA 2001), and a specification for the works was prepared by Allen Archaeological Associates.

The archive for this report will be held at the Lincoln City and County Museum (The Collection).

2.0 Site location and description

Lincoln lies c.50.5km northeast of the city of Nottingham and approximately 59.5km west of the modern coastline. The site is located on Waterside North, on the west side of Thorngate, immediately to the east of the Witch and Wardrobe Public House and west of the Green Dragon Public House, at a height of approximately 6m OD.

The geology of the area is predominantly river terrace sands and gravels, with alluvium to the west (Jarvis 2000).

Central National Grid Reference: SK 97726 71148.

3.0 Planning background

The client was granted planning permission in 2004 (planning permission ref. 2004/0446/F) by Lincoln City Council to construct a two storey structure for Class A3 use (food and drink) with associated pedestrian and service access at the former Slipper Baths site at Waterside North, Lincoln. Condition 4 of the planning permission states that "No development, geotechnical investigation, site clearance or other enabling work shall take place on the site until details of the measures to be taken to evaluate, preserve and/or record the archaeological content of the site, which shall include a timescale for the investigation, have been submitted to and approved by the Local Planning Authority. All archaeological work shall thereafter proceed in accordance with the approved programme". Allen Archaeological Associates was commissioned by the client to undertake these archaeological works.

The works comprised an archaeological watching brief on all groundworks, a programme of environmental sampling to provide information on past environmental conditions and changing river line, and a further programme of sampling to assess the potential leaching of cement material from piling into archaeological deposits.

4.0 Archaeological and historical setting

There is relatively little evidence for prehistoric activity in the Lincoln area beyond a number of chance finds of Neolithic and Bronze Age flint implements from around the city, mainly from the east side of Lincoln, in or close to the valley (Jones and Stocker 2003). The site is

classified by the Lincoln Archaeological Research Assessment as comprising valley floor deposits during the prehistoric periods.

By the Roman military era (60 – 90 AD) waterside installations were being built adjacent to the river. These were effectively consolidating the riverbank, with later expansion southwards narrowing the river. The Waterside excavations of 1986 – 1991 (on the site of the Waterside Centre to the west of the site) showed the early Roman riverfront lay close to the line of Saltergate, and that by the mid to late 4th century AD dumps of material and metalling overlay the river there (Jarvis 2000). The excavations showed that the 10th century waterfront lay to the south of the earlier Roman foreshore, with several wattle fences uncovered between which were dumps of sand, stone and peat, evidence of reclamation of the sloping river shore during the early medieval period and later.

From the later medieval period onwards domestic and commercial structures emerged along the river edge, with their frontages mirroring that of the Witch and Wardrobe public house, some 4m further south of the former Slipper Baths frontage.

The Slipper Baths were built in 1931 and operated until c.1999 as public conveniences. Prior to their construction the site was occupied by a number of properties, including number 27 Waterside North, a public house named the Newark Arms Beershop (c.1857 – 1863). The public house was renamed the George in 1867, becoming a lodging house from c. 1899 to 1913, then a grocer's during the 1920's. The building was demolished to make way for the baths building.

Two archaeological investigations have taken place on the site prior to the watching brief that is the subject of this report.

An archaeological evaluation comprising two trial pits and two boreholes was carried out in July 2000 (Jarvis 2000). The results of the investigation suggested that the upper 2.5m of deposits comprised modern archaeology, although it was recognised that due to the limited evaluation of the site, earlier deposits may exist at a higher level on other parts of the site.

During the demolition of the Slipper Baths in 2001, an archaeological watching brief identified a sequence of deposits (within the site of the former boiler house) that dated to the later 12th or early 13th centuries AD (Trimble 2001). The works also revealed evidence for timber and stone buildings, and identified that pre-modern horizons were in evidence between 1.0 and 1.4m below the modern ground surface.

5.0 Watching brief methodology

Initially the site was cleared of vegetation and surface matter, covered with a geotextile membrane and then raised approximately 0.25m with limestone rubble. This was monitored by an experienced archaeologist on 1st November 2005 (Julian Sleep).

The piling excavations were undertaken using a 360^0 excavator fitted with a 0.4m wide toothed bucket. These were monitored constantly between the 7th and 8th November 2005 by archaeologist Sean Jackson, to ensure that any archaeological features exposed by the excavations were identified and recorded.

The piling excavations were excavated to a depth of between 2.0 and 3.0 metres, below reasonable health and safety limits for working in trenches. Therefore it was not possible to hand clean all exposed surfaces during the works. All archaeological deposits identified during the groundworks were allocated a unique reference number (context number) with an individual written description on standard watching brief context record sheets. Sections were

drawn at scale 1:20 and located on the site plan. These records will form the basis of a long-term project archive.

6.0 Watching brief results (figures 2 – 4)

The initial site strip involved the removal of the overlying vegetation and 0.25m of surface deposits. The overlying deposit, (001), comprised brick rubble in dark grey/brown sandy silty clay that was ubiquitous to the site. This sealed a similar deposit that was firmer and with a higher clay content (002). A number of pottery sherds were recovered from (002) that suggested the deposits formed from the 17th to the 19th century.

Two walls were observed beneath (002), recorded as (003) and (004). Wall foundation (003) was approximately 0.8m wide and was built using limestone blocks that were c.0.35m in length by 0.34m in width. Two courses survived for approximately 5m, and the stones were bonded with a blue/grey mortar. Wall (004) was of similar construct although was narrower (some 0.6m in width). Both walls appeared to mirror the former Slipper Baths layout and therefore may have been associated with it.

Following the top strip the site was built up with a layer of limestone hardcore some 0.5m in depth. The location of each pile that was to be driven was then subjected to machine excavation to remove any possible below-ground obstruction such as walls and cellars that would hinder the piling process. Due to their depth only rudimentary recording was possible on health and safety grounds.

The pile excavations were relatively uniform in their results, with several exceptions.

In the main (002) was found to extend to between 0.8m and 1m in depth, sealing dark grey/black waterlogged silt (008).

At the west end of site, in the location of pile number 11, a possible wall of limestone blocks with yellow mortar was noted below (001) but butted by (002), approximately 0.4m below the existing ground level.

The pile to the east of 11 (no. 12) also contained the remains of a wall. Wall (006) ran east – west and survived to a depth of 1.4m, some 0.4m below the existing ground level. The wall comprised a series of limestone blocks varying in size from 1m x 0.6m x 0.2m to 0.7m x 0.6m x 0.6m, with a dark yellow mortar.

The two piles towards the northwest end of the site (pile nos. 9 and 10) contained dark grey clay silt with very frequent brick fragments with cement bonding (007) that was c.0.7m deep, sealing (008) below.

6.1 Palaeoenvironmental sampling results (Appendix 4)

Two palaeoenvironmental cores were taken from the site on the 4th August 2005 using a small hydraulic drilling rig mounted on a Mercedes Unimog truck (see figure 2 for auger locations). These were processed and examined at the offices of the Environmental Archaeology Consultancy.

Auger 1 was taken to a depth of 4.15m below modern ground level, and at its base (1.76m OD) a series of deposits were recognised as probably representing the natural glacial sand sequence, comprising sands inwashed over thin organic sediments that were deposited along the river margin. Overlying this was nearly 2m of dark grey and brown sandy silts and silty

sands containing waterlogged wood and other organics, along with limestone fragments, marine mussel shells, and occasional brick or tile fragments. It is likely that these deposits are of Roman or post-Roman date. These deposits are likely to reflect a mix of waterlain and inwash deposits. At approximately 2.2m OD there is evidence for a possible Roman soil horizon. This horizon would have initially been dry; however the rising river levels to the south must have created a dam or wet environment during the Roman period. The abundance of cultural material in these levels indicates some dumping of refuse along the river margin, perhaps in to raise the ground level in an attempt to combat the rising river levels. The core from Auger 1 suggests that c.1m of Roman deposits survive at that location, with perhaps 0.5 – 0.6m of medieval build-up, with the top 2.3m comprising modern deposits.

The core from Auger 2 produced similar results to Auger 1, although Auger 2 was taken to a depth of 5.2m below existing ground level. The base of the sequence suggested that the boundary between the glacial deposits and archaeological horizons lay at c.0.9m – 1.0m OD, indicating a fall in the original ground surface of approximately 1.2m between the two boreholes (some 15m apart).

6.2 **Leaching assessment results** (Appendix 5)

The boreholes taken to assess the potential for leaching of cement material from piling into the surrounding archaeological deposits were undertaken by Langdale-Smith and Company Limited in November 2005.

Initial samples were taken (Borehole 1) on the position of Pile Number 16, prior to the installation of the pile on the 11th November. The day after Pile 16 was driven Borehole 3 was taken 0.8m to the south of Borehole 1 and then Borehole 2 was taken halfway between the two.

Although there was no visible trace of leached cement material within the boreholes, there was some variation within the chemical tests between the control sample (Borehole 1) and those taken following piling (Boreholes 2 and 3).

7.0 Discussion and conclusions

The watching brief identified a number of former limestone walls across the site. The majority of these either mirrored the former Slipper Baths building or followed a similar orientation to it, suggesting the Slipper Baths respected previous building layouts on the site. The piling excavations also demonstrated that there was up to 2m of modern (19th and 20th century) deposits across the site.

The palaeoenvironmental sampling has suggested that this part of the north bank of the River Witham was damp or wet throughout the Roman and medieval periods, although there is no evidence to suggest that the river encroached upon the site at any time, instead it would appear the site was marginal or on the river edge, and that throughout this time domestic refuse was dumped here. The core from Auger 1 also indicated that there were two episodes when the ground was wetter or more likely had flooded. The top 1m – 2m of deposits in both cores was largely composed of 19th and 20th century levelling, make-up and building debris, although a soil horizon was noted in Auger 1 that may reflect the ground surface immediately prior to the construction of the Slipper Baths in 1921. The augering has demonstrated that the main river channel lay south of the site in both the Roman and medieval periods.

The leaching tests did show some chemical variation within the samples however it was not clear whether this was attributable to leaching of cement from the piling process.

8.0 Effectiveness of methodology

The methodology employed was effective in that the watching brief allowed a record of the archaeological deposits during the groundworks. The palaeoenvironmental sampling also allowed a model of the environmental history of the site to be obtained. The leaching sampling, although seemingly inconclusive on this occasion, has provided previously unknown information regarding the effects of piling on archaeological deposits. As the leaching tests were a development trade-off so that sleeved piles would not be required, their inclusion in this scheme was acceptable. It is therefore concluded that the methodology was appropriate to the development.

9.0 Acknowledgements

Allen Archaeological Associates would like to thank Warrant Developments Limited, especially Mr Jeremy Stevens, for this commission. Mr Vincent Teo of Goyne Adams is also thanked for his support throughout the scheme.

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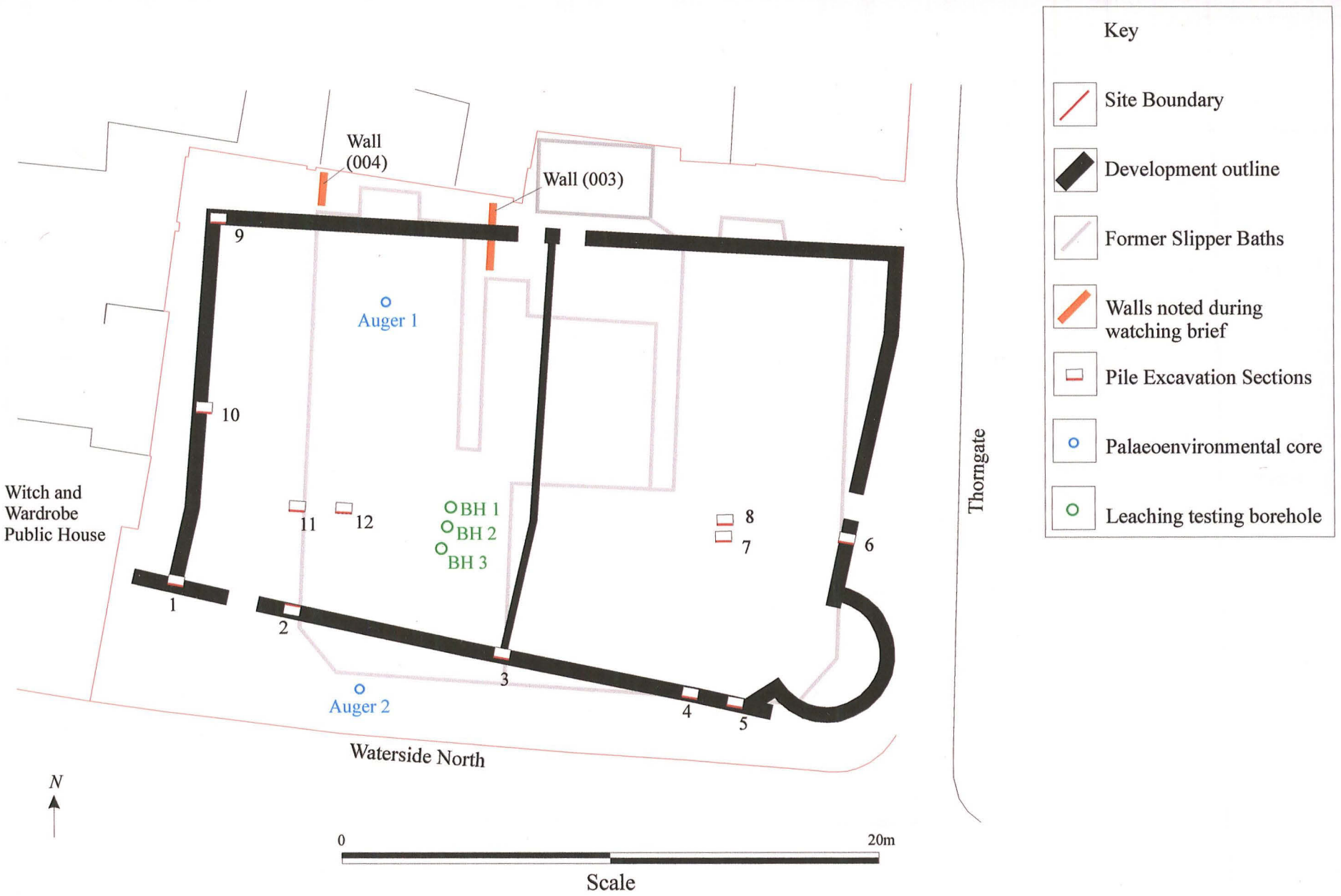

Figure 2: Plan of development at scale 1:200. Red numbered sections relate to numbered Pile Excavation Sections (See figures 3 and 4).

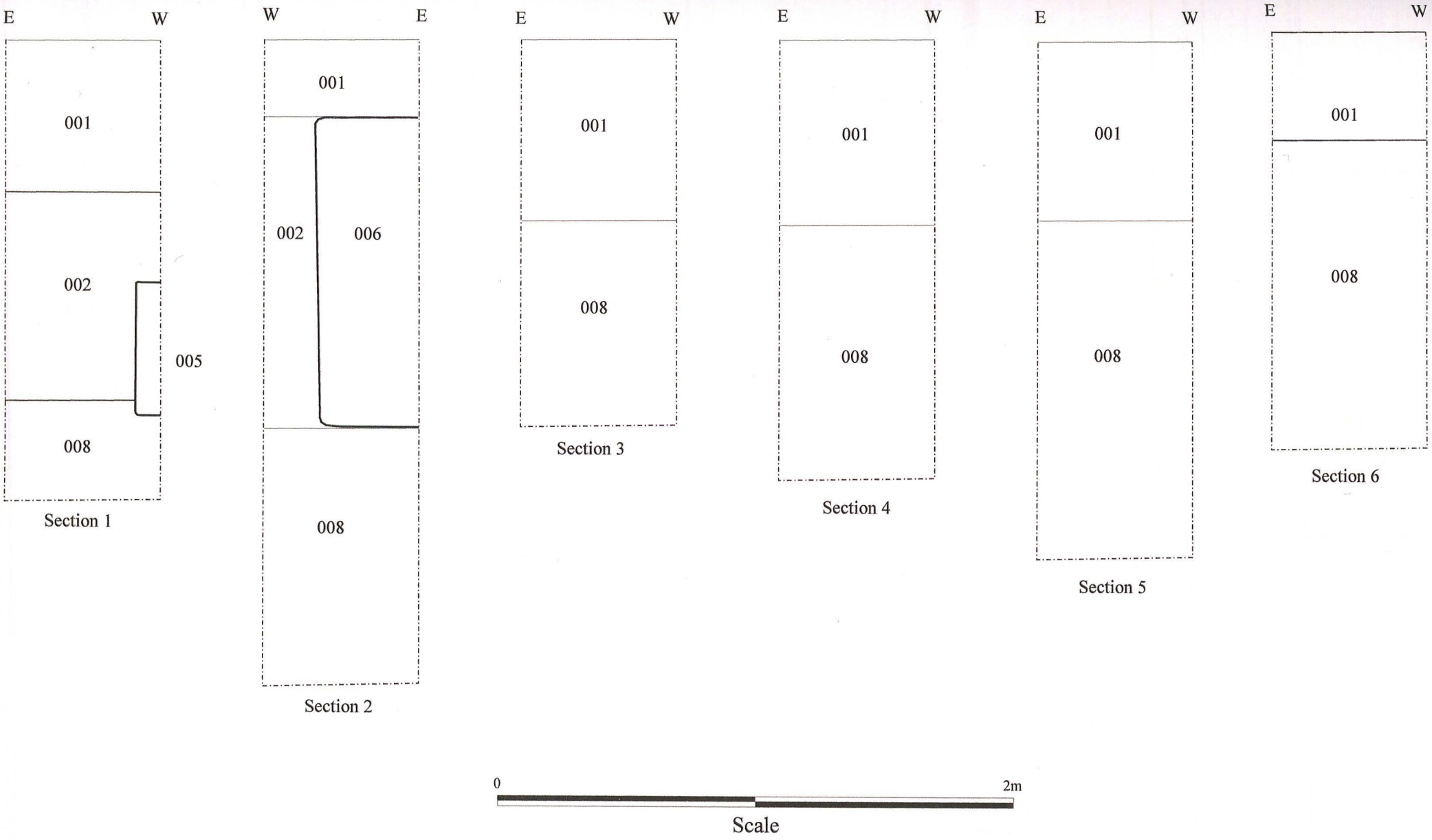

Figure 3: Pile Excavation Sections 1 - 6 at scale 1:20

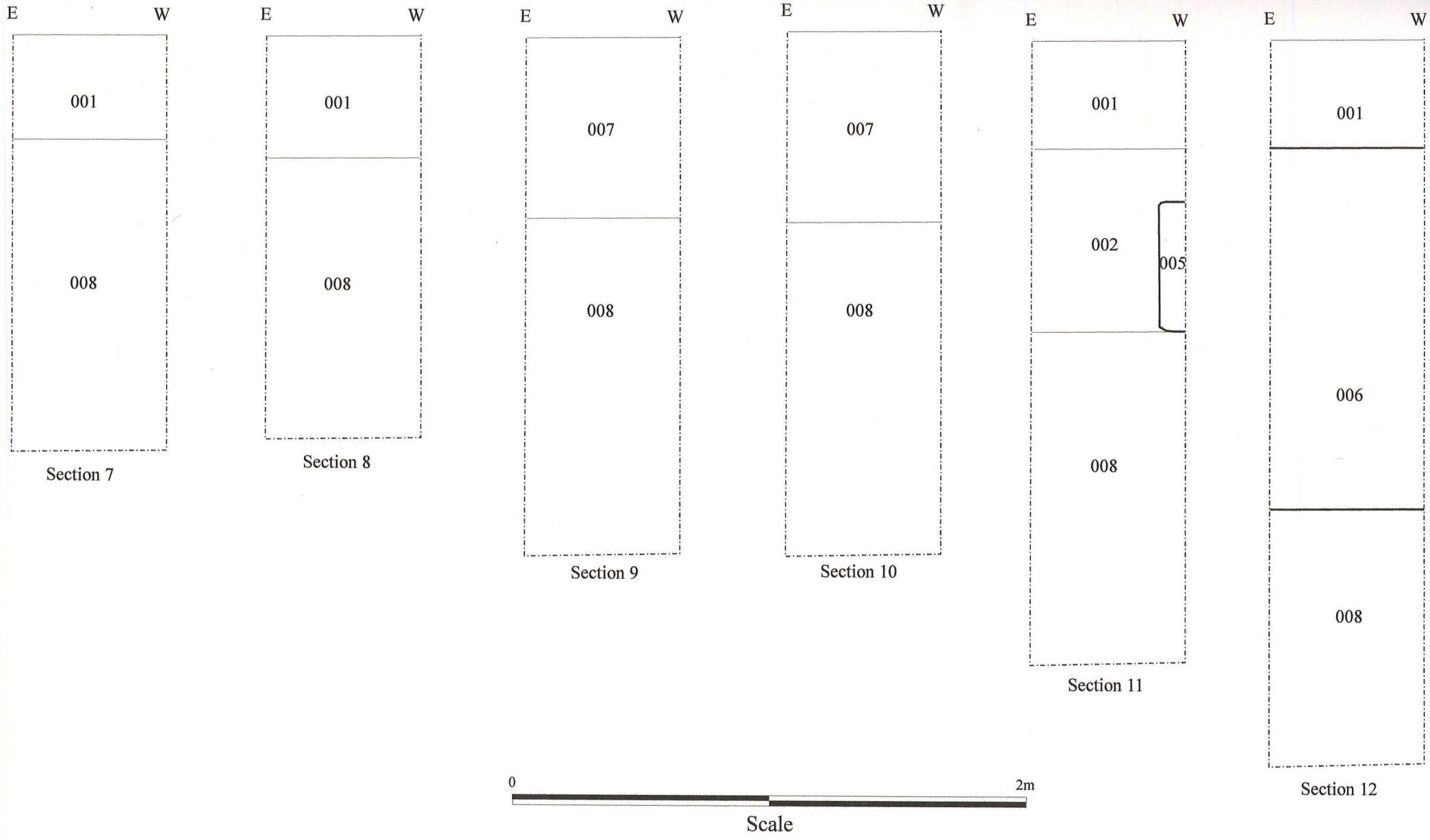

Figure 4: Pile Excavation Sections 7 - 12 at scale 1:20

APPENDIX 1

APPENDIX 1: Colour Plates

Plate 1. Overall site shot, looking west during initial site strip. The Witch and Wardrobe Public House is the white building in the background

Plate 2. Limestone wall (003) exposed during initial site strip. Looking east

Plate 3. Limestone wall (004) exposed during initial site strip. Looking north

Plate 4. Piling Excavation Section Number 6, looking south

Plate 5. Piling Excavation Section Number 10, looking south

Plate 6. Dressed limestone block from the piling excavations

Plate 7. Dressed limestone blocks from the piling excavations

Plate 8. Leaching test augering using hydraulic drilling rig (in foreground), with drilling rig to the rear (in orange)

APPENDIX 2

APPENDIX 2: Pottery Archive LISB05

Jane Young

context	cname	full name	form type	sherds	weight	decoration	part	description	date
002	BL	Black-glazed wares	jar	1	39		BS	fresh condition	late 17th to 18th
002	STSL	Staffordshire/Bristol slipware	cup	1	13	brown trailed & combed dec on yellow	BS	fresh condition;cream fabric	late 17th to 18th
002	STSL	Staffordshire/Bristol slipware	thrown dish	1	53	brown & tan wavy trailed dec on	rim to base	fresh condition;pale orange fabric	late 17th to 18th
002	TPW	Transfer printed ware	jar	1	50		shoulder	fresh condition;angled shoulder	19th probably early to mid
002	TPW	Transfer printed ware	small bowl	1	42	moulded rim edge	rim	fresh condition	19th probably early to mid
002	TPW	Transfer printed ware	saucer	1	61		rim to base	fresh condition	19th probably early to mid
002	WHITE	Modern whiteware	cup	1	47		base	fresh condition	19th probably early to mid
002	WHITE	Modern whiteware	jar	1	14		BS	fresh condition	19th probably early to mid

APPENDIX 3

APPENDIX 3: Context Summary List

Context No.	Type	Description	Interpretation	OD height (approx)
001	Layer	Stone rubble, brick and tile in a grey/brown sandy silty clay	Rubble/demolition layer	4.85-5.35m
002	Layer	Stone rubble, brick and tile in a firm grey/brown sandy silty clay	Rubble/demolition layer	5.25-4.95m
003	Wall	2 courses of limestone (c.0.35m x 0.34m blocks), 5m length and 0.8m wide with blue/grey mortar	Limestone wall running north - south	5.2-5.3m
004	Wall	Limestone blocks, 5m visible length and 0.6m wide with pale buff/white mortar	Limestone wall running north - south	5.2-5.3m
005	Wall	Limestone wall with yellow mortar	?Limestone wall	4.95-4.59m
006	Wall	Limestone wall (1m x 0.2m x 0.6m – 0.7m x 0.6m x 0.6m sized blocks) with dark yellow mortar.	Limestone wall running east - west	5.25-5.15m
007	Layer	Dark grey clay silt, frequent modern brick fragments and cement	Demolition layer	5.55m
008	Layer	Dark grey black waterlogged silt	Urban build-up horizon	5.15-3.95m

APPENDIX 4

APPENDIX 4: Palaeoenvironmental report

Slipper Baths, Waterside North, Lincoln – LISB05

Two boreholes were sunk on the northern side and the southern (river) side of the Slipper Baths site (Fig. 1) as part of the City Archaeological Officer's requirements for archaeological work on the site. The work was supervised by Mark Allen of Allen Archaeological Associates. The coring was undertaken using a hydraulic rig mounted on a Mercedes Unimog truck. The northern core was taken to a depth of 4.15m below modern ground level (bgl) and the southern core 5.2m bgl. The core samples were submitted to the Environmental Archaeology Consultancy for description and interpretation.

The two cores have been opened, cleaned and described (Appendix). Coring is inconsistent and owing to compression and other factors not all the 1m cores were complete. While the base and top of each core sample (a 1m length of core) is precisely known the actual level of intervening sediment boundaries may not be precisely indicated owing to the compression and incomplete nature of some of the cores, particularly where material may have fallen out of the bottom during coring.

Neither of the boreholes recovered undisturbed glacial sands, which underlie the site because the wet sands would not stay in the bores. A borehole conducted on the south side of the site in 1998 (CLAU report 424) showed that the glacial sands and gravels occurred at 5.5m depth and overlay Liass clays at 13.3m bgl.

Auger 1

The basal sequence of sands, with interleaved organic silt lenses suggests that the base of this borehole at 1.76m OD probably represents the top of the natural glacial sand sequence, with sands inwashing over thin organic sediments being deposited along the river margin. The top 0.16m of the core is empty which suggests that it may have failed to pick up the bottom 16cm, which would not be surprising if this was sands (the core can slip down inside the sample tube if the base falls out). Above this are nearly two metres of very dark grey and brown sandy silts and silty sands with preserved wood and other organics, and inclusions of marine mussel shell, limestone fragments and occasional brick or tile fragments. The mussel shells are fairly abundant throughout these deposits, and these with other inclusions indicate that the whole of this sequence has been deposited in the historic period, almost certainly no earlier than the Roman period. The mix of sandy silt layers and silty sand layers, rich in organics and archaeological debris suggests a mix of waterlain and inwash deposits probably forming along the margins of the river channel. In the upper part of this sequence occasional lumps of limestone testify to building debris entering the deposits. The second core is only half full (see Appendix). This may be because the limestone lumps were stuck in the sample tube which was driven through the lower sediments without taking a core or material fell out and the core dropped inside the tube. This gap of just over 0.5m could not be accounted for by compression in these deposits because they contain too much sand and coarse silts. It is probable that the sediments recorded in Core 2 represent the top 0.47m of the core rather than the bottom. The top half of core 2 and the whole of core 1 represent relatively recent ground make-up, levelling and building debris. Apart from the topsoil there is also a probable soil layer at the base of core 1 indicating an episode of soil buildup before further dumping and levelling.

In order to obtain a clearer picture on these sediments and gain some dating evidence cores 1 and 2 were broken up in units and searched for datable archaeological finds, while the deposits in cores 3 and 4 were sampled in 0.1m units and washed on a 2mm and 0.25mm mesh sieve and checked for dating and environmental evidence. The results of this exercise are presented below.

Borehole/Auger 1

Depth above base of core	**inclusions/description**	**date**
Core 1		
60-78cm	brick and red quarry tile	19/20th C
40-60	brick with frog, concrete, mussel shell, plaster with red hair	20th C
2-40	tile	19/20th C
Core 2		
35-53	concrete, brick, blue painted brick, burnt bone	20th C
20-35	cattle size rib	
0-20	marine mussel shell, sheep sized rib	
Core 3		
90-98	concrete, red and yellow brick, modern glass, animal bone, oat grain, mussel shell, tile, medieval pot, mortar, lots small brick fragments in fine residue, small organic component (probably included debris fallen down borehole)	20th C
80-90	brick, mortar, sheep humerus, sheep sized rib, mussel and cockle shell, medieval pot, hammerscale, fish bone, modern glass, coal, lots small brick and occasional concrete fragments	19/20th C
70-80	concrete, brick and tile, glass, mussel shell, hazelnut, lots small brick in fine residues, occasional hammerscale, *Bithynia tentaculata*, *Valvata piscinalis,* flot = comminuted and degraded organic with occasional twigs, stems and charcoal	19/20th C
60-70	occasional small brick fragments, mussel shell, cattle size rib, wood, twigs, coal, *B. tentaculata*, *Valvata* sp., barnacle, flot = degraded organic with occasional beetle fragments, seeds and small twigs, stems and charcoal	
50-60	wood, mussel shell, frog/toad, bone, *Planorbis vortex*, *B. tentaculata*, concreted organic debris (possible cess), charcoal, fish bone, occasional tiny brick/tile fragments, flot – degraded organics with occasional seeds, beetle fragments and charcoal	
40-50	sheep/goat rib, brick/tile, mussel shell, frog/toad,	

	shell tempered pot (medieval), *Lymnaea peregra*, *Pisidium* sp., *Planorbis albus*, *B. tentaculata*, moss, wood, twigs, occasional fish bone, rare tiny brick fragments in fine residue, flot = degraded organics with occasional beetle, pupa, seed, twig and charcoal fragments Medieval
30-40	mussel shell, cockle, barnacle, wood shavings, hazelnut, bone, small brick fragments, leather, wood, twigs, limestone, fishbone, eggshell, *P. vortex*, flot = degraded organic flot with beetle and seed fragments, elder, and better preserved vegetable matter.
20-30	limestone, mussel shell, cockle, hazelnut, occasional small brick fragments, wood shavings, wood, twigs, moss, buds, bone, samian fragment?, fish bone, barnacle, eggshell, flot = organic debris with occasional seeds, beetles, moss, stems, charcoal, etc (preservation average to poor) Roman/post-Rom.
10-20	mortar, pebbles, limestone, mussel shell, cockle shell, oyster, barnacle, *Sphaerium* sp., occasional brick/tile fragments, pot, Roman pot, bone, wood, twigs, tiny brick/tile fragments frequent in fine fraction, fish scale, flot = vegetable matter, charcoal, occasional seeds, beetles, moss and stems. Roman/post-Rom.
0-10	sheep, cattle, pig, mussel, cockle, periwinkle, barnacle, sloe stones, leather fragments, nut/fruit stone?, wood, twigs, rare tiny brick/tile fragments in fine residue, eggshell, *Rubus* seeds, flot = comminuted vegetable matter with occasional seeds, pupa, beetles – weevil
Core 4	
80-88	limestone, brick fragments, bone, mussel shell, fish bone, flot = small flot of degraded organics, charcoal and elder (live worm – material that has fallen down borehole)
70-80	little limestone, small brick fragments, bone, mussel shell, charcoal, eggshell, fish bone, flot = degraded comminuted vegetable matter, rootlets, charcoal. (probably contaminated)
60-70	wood, twigs, charcoal, bone, mussel shell, periwinkle, cockle, barnacle, *B. tentaculata*, occasional small brick/tile fragments, eggshell, hazelnut, flot = comminuted degraded vegetable matter, charcoal, occasional seeds and beetle fragments, small twigs and stems.
50-60	small limestone, occasional brick/tile fragments,

	leather, mussel shell, wood, twigs, occasional pebbles, hazelnut, eel, *Planorbis leucostoma*, *B. tentaculata,* moss, charcoal, seeds, bone, eggshell, flot = comminuted vegetable matter, with seeds, beetle fragments, small twigs and stems, moss, charcoal
40-50	small limestone, brick/tile fragments, mussel shell, hazelnut, plum stone, sloe stone, wood, twigs, stems, rodent, cockle shell, bone, pupa, fish bone, charcoal, barnacle, *Pisidium* sp., *Hydrobia* sp., worm granules, eggshell, seeds, lots limestone crumb in fine residue, flot = well preserved comminuted vegetable matter, with seeds, beetle fragments, pupa, charcoal – fairly large organic fraction
30-40	occasional limestone and brick/tile fragments, bone, hazelnut, wood, twigs, charcoal, mussel shell, moss, sloe stone, bud, fish bone, *Pisidium* sp., *B. tentaculata*, eggshell, a little limestone crumb and brick/tile fragments in fine residue, flot = comminuted vegetable matter with seeds, beetle fragments, small stems, charcoal, moss – fairly large organic fraction
20-30	frequent limestone (including large fragments), brick/tile, charcoal, wood, Roman pot, mortar, mussel shell, *Valvata* sp., eggshell, worm granules, a little limestone crumb and brick/tile fragments in fine residue, flot = comminuted organic fraction with frequent rootlets, and seeds, beetle fragments and occasional charcoal (small organic flot) Roman
10-20	coarse residue almost all limestone with occasional brick/tile fragments, fine residue with some limestone crumb and occasional small brick/tile fragments, flot = small with fibrous rootlets, occasional seeds , charcoal, moss and worm eggs
0-10	no coarse residue, one small fragment mussel shell, fine residue clean fine to medium sand, flot = silt crumb with rootlets

The basal sediments of core 4 have almost no inclusions and were composed of fine sandy silts. The two units above included Roman pottery, lots of limestone fragments with brick/tile, several other inclusions, worm granules, and a flot composed largely of rootlets with little preserved organic material. This evidence suggests that we may be looking at the Roman soil horizon. Allowing for a possible slump of the core sample within its sleeve, this soil layer lies just above 2.2m OD. Although this horizon was initially dry a rising water table (river level) must have created a damp or wet environment during the Roman period. The deposits continue to receive archaeological debris in the form of marine shell, animal bone, eggshell and other food waste, limestone and brick/tile fragments, wood, and occasional freshwater snails and bivalves, but also a high silt component. The latter indicate that the core lies on the margins of the river during this time but the organic component and archaeological finds indicate a fairly high density of human rubbish suggesting perhaps some level of

dumping, perhaps to raise the ground level as the water table continues to rise. All these samples include a fine residue composed of fine to medium sands. The top of core 4 is almost certainly contaminated by material that fell down the borehole. The basal half of core 3 suggests a period of some drying out. Aquatic molluscs are largely absent, archaeological debris including leather fragments and wood shavings, is abundant and Roman pottery occurs at 10-20 and 20-30cm. These sherds may date the deposits but could be redeposited since much of the sand component in these deposits is probably washing down from the river terrace to the north. Above 40cm in core 3 the deposits again produced freshwater molluscs, along with the archaeological debris, perhaps suggesting an increasing freshwater component, either from rising river levels or flood events. This sequence of deposits is presumed to be medieval in date because of the inclusions of a small sherd of shell tempered pottery but at 70cm in this core the deposits include 19/20th century material including floor tiles, concrete and glass, with subsequent deposits representing make-up, leveling and building debris. One probable soil layer occurs in the upper sequence at the base of Core 1 which may equate to the ground before the construction of the Slipper Baths in 1920.

The cores from this borehole suggest approximately 1m of Roman period build up and perhaps 0.5-0.6m of medieval build up, with the top 2.3m of deposits being of relatively recent date. It should be noted however that these conclusions are based upon cores only 8cm in diameter. The deposits suggest that this area on the north bank of the Witham was damp or wet throughout the Roman and medieval periods but was probably not actually in the river at any time but was marginal or river edge, receiving domestic rubbish throughout this period, with two episodes when it may have been wetter or more likely to flood.

Auger 2

The sequence in Auger two is similar. The whole of the first metre below ground level and the top third of the second indicate make-up, leveling and building debris mostly of 19th and 20th century date. Below this a similar sequence of dark grey silty sands and sandy silts with numerous inclusions occurs as those in Auger 1, but because the deposits from this borehole have not been washed and studied we do not have comparable detail to borehole 1. The presence of tiny brick/tile fragments in the deposits in core 5 indicates that this whole sequence is also of Roman and post-Roman date. The base of core 5 is composed of sands, with much less archaeological debris and organics than the deposits above and we can presume that since the subsequent deposits failed to stay in the sample sleeves during coring that these were probably wet sands. This probably represents the top of the glacial sands. Core 5 was only 34% full and although the described sediments sit in the bottom half of the sleeve these probably slipped down the sleeve when underlying wet sands fell out of the sampler. This would make the base of the described sequence (see Appendix) at 1.01m OD, suggesting that the boundary between the archaeological deposits and the underlying glacial sands lies at approximately 0.9-1.0m OD. This would indicate a fall in level of the original ground surface over the eighteen metres between boreholes 1 and 2 of approximately 1.2m.

Although both boreholes include clear evidence for riverine sediments and Auger 1, has aquatic molluscs, none of the deposits in either core sequence are solely riverine sediments. There is an appreciable inwash of sands and the inclusion of building debris and domestic rubbish, even in the lowest deposits, suggesting that much of the silt and aquatic component may derive from flood events and high river levels.

Both core sequences have been sampled for pollen throughout the dark grey silt/sand sediments and the lower three cores of borehole 2 have been retained against a need for any further work on them.

Conclusions

Both core sequences from Boreholes 1 and 2 have cored sediments spanning the Romano-British to modern period. The basal metre or more of each recorded core probably dates to the Roman period with the sediments in the northern core suggesting that this area was dry at the beginning of the Roman period. A rising water table in the river seems to have been responsible for the onset of damp and wet conditions at the site with a sequence of partially waterlogged deposits building up during the Roman and medieval periods, with a probable episode of dryer conditions half way up the sequence. The top 1-2 metres of both boreholes is largely composed of 19th and 20th century levelling, make-up and building debris, although a soil horizon occurs in Borehole 1.

The preservational environment is poor for the top 2.5 to 3 metres, but below this preservation of organics, including leather, wood, seeds, beetles, etc is fairly good and pollen can be expected to be well preserved.

The main river lay south of the site in both the medieval and Romano-British periods.

Recommendations

The core samples taken from Borehole 2 have been kept against a need for further study and a series of pollen samples have been taken through the deposits of both boreholes. A single sample has been taken from the basal 8cm of core 5 of Borehole 2 for possible radiocarbon dating.

The following further work could be undertaken on these cores:

1. The retained cores from Borehole 2 could be sampled and processed in the same manner as Borehole 1 to extract dating evidence and define in greater detail the characteristics of the sediments.
2. The pollen analysis of one of the two sequences (preferably Borehole 2 if the sediments are processed) can be undertaken.
3. The organic component, seeds and beetles, extracted from the sediments of borehole 1 and any extracted from borehole 2 can be studied, identified and used to further refine the interpretation of the sediment sequence.
4. One or more samples from the cores in Borehole 2 can be radiocarbon dated to supplement any ceramic dating evidence and identify the deposits that formed during the post-Roman and pre-medieval periods. This may be necessary to establish an adequate chronology for the pollen diagram.

Although these are possible works it is probably not appropriate to undertake them all. The cores have been subject to some slippage/loss or compression and the sequence may not be complete. Also the precise assessment of the OD height of a particular sediment unit is an essential requirement if the deposits are to be interpreted in terms of a water level at a particular period, and not all the cores can be reliably estimated for reasons of slippage or loss. Analysis of boreholes 1 and 2 would include considerable duplication. The analysis of pollen from deposits of this type, a mix of anthropogenic, riverine, flood and slopewash sediments may prove difficult to reliably interpret in terms of vegetational history and local

changes. Lastly the actual size of the samples is small so the frequency of identifiable macrofossils in some of the sediments may not be sufficient for reliable interpretations.

It is therefore suggested:
1.That the processing of the sediments from borehole 2 is undertaken (in the same manner as borehole 1), to establish the chronology of these sediments.
2. That radiocarbon samples are only taken to fulfill the need for a chronology of this sequence if insufficient ceramic evidence is present. No radiocarbon dates are needed if no further work on the cores is required.
3. That the organic fractions from the samples from borehole 2 are scanned by an archaeobotanist and an archae-entomologist to identify the taxa present in the sediments and clarify the character of the sedimentary environment.
4. That these results are drawn together with those from this study to produce an indication of the changing environment beneath the site during the historic period.

It should be noted that the borehole evidence indicates that the site is likely to have both Roman and medieval archaeology preserved on it, and that any timber structures are likely to be fairly well preserved. This should be taken into account in any engineering works that penetrate more than 2.5 metres below the present ground surface.

Acknowledgements
I should like to thank Gemma Martin and Trude Maynard for assistance with the sampling, washing and sorting of material from these cores.

Bibliography
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Slipper Baths, Lincoln
(all measurements taken from the base of each 1m core sample)

Auger 1.	Ground level at 5.91m OD
Core 1	0-100cm below ground level (bgl)
76-100cm	empty
71-76	dark grey brown friable topsoil with brick and stone fragments
42-71	brown silty sand with numerous brick fragments, concrete, mussel shell, painted brick, stone fragments, etc.
34-42	brown sandy silt loam with stone fragments, charcoal and brick
31-34	tile fragment in a brown silty sand matrix
22-34	brown sandy silt with crushed stone and brick fragments (hardcore?)
18-22	brown slightly layered silty clay
14-18	limestone
9-14	dark brown silty sand with charcoal flecks and limestone crumb, soil layer?
0-9	fine brown sand with occasional pebbles.
Core 2	105-205cm bgl
47-100	empty
35-47	loose friable slightly silty sand with lots fine brick fragments, occasional larger fragments, and limestone
22-35	very dark grey silty sands with occasional limestone fragments
18-22	limestone in very dark grey silty sand matrix
15-18	very dark grey silty sand, with visible plant rootlets
14-15	thin brown and red brown sand lens
9-14	black silty sand with occasional stone fragments
5-9	limestone
0-5	black silty sand with occasional limestone fragments.
Core 3	210-310cm bgl
98-100	empty
75-98	very dark grey silty sand with occasional small brick fragments, animal bone and mussel shell fragments
74-75	thin brown clay lens
38-74	very dark grey and grey brown organic sandy silts, becoming silty sands at top, with wood, mussel shell fragments, etc
0-38	very dark grey organic sandy silts with frequent mussel shell fragments and occasional wood. Sandy pebbly and mussel shell layer at 9-10cm, and leather fragment at 4cm
Core 4	315-415cm bgl
84-100	empty
79-84	disturbed very dark grey sandy silt with brick, stone and mussel shell fragments – some probably taken down during coring.
39-79	very dark grey organic sandy silt with wood fragments, mussel shell, occasional stones and tiny brick/tile fragments
37-39	bone fragments with grey sand deposited around it.
32-37	very dark grey organic sandy silt with wood, shell, occ. stone and tiny brick/tile fragments
31-32	wood

28-31	dark grey organic silty sand
26-28	limestone
19-26	grey brown medium sand
11-19	banded – dark grey fine and fine-medium sands with fine buff sand lens
10-11	very dark brown sandy organic silt
3-10	grey and grey brown banded fine sands
2-3	thin organic brown silt with sharp boundary beneath
0-2	brown fine-medium sand

Auger 2.	Ground level at 5.55m OD
Core 1	0-100cm bgl
91-100	empty
74-91	friable dark grey silty sand with grits, brick fragments, limestone and plant rootlets
61-74	brown silty sand with lots small crushed limestone and brick fragments –hard core?
56-61	yellow brown sand with occasional limestone and brick fragments –levelling?
48-56	dark brown and yellow brown silty sand with coal, brick and limestone fragments
35-48	crushed limestone – hardcore?
20-35	banded dark brown and grey brown silty sand, with charcoal/coal and occasional siltier bands
13-20	limestone in a brown sandy matrix
4-13	brown silty sand with limestone fragments
0-3	brown silty sand with small limestone fragments and occasional brick

Core 2	105-205cm bgl
78-100	empty
73-78	loose brown silty sand with stone fragments – probably fallen in!
68-73	very dark brown sandy silt with brick and limestone fragments
62-68	light brown slightly sandy silt with occasional pebbles, sharp boundary at 62cm
52-62	very dark brown slightly organic silt with limestone and brick fragments and mussel shell.
41-52	very dark grey sandy silt with mussel shell and occasional limestone fragments
36-41	very dark brown slightly sandy organic layer with small grits
24-36	grey brown slightly silty, slightly organic fine to medium sand with occasional wood fragments
0-24	very dark brown organic slightly sandy silt with frequent small wood fragments and occasional mussel shell

Core 3	210-310m bgl
89-100	empty
84-89	very dark grey brown sandy organic silt with mussel shell fragments
77-84	brown and very dark grey-brown silty sand with stone and brick fragments
66-77	very dark grey/black sandy organic silt with small grits and occasional mussel shell fragments
58-66	very dark grey silty fine-medium sand with small grits and occasional mussel shell fragments

22-58	very dark grey/black sandy silt with organics, wood fragments, mussel shell, grits and occasional pebbles
21-22	grey sand lens
8-21	very dark grey brown oxidising organic silt with wood fragments and mussel shell
6-8	dark grey silty sand lens
1-6	very dark grey sandy silt/silty sand with mussel shell fragments
0-1	grey fine sand
Core 4	315-415cm bgl
95-100	empty
65-95	very dark grey brown sandy organic silt with wood fragments, mussel shell and grits
59-65	dark grey silty sand with mussel shell
58-59	grey sticky clay/silt lens
54-58	very dark grey silty sand/sandy silt with leather fragment
48-54	grey and brown sands with limestone and mussel shell fragments
41-48	very dark brown sandy organic silt, with organics and wood fragments
36-41	grey medium sands and sandy organic silts with mussel shell
29-36	very dark brown silty sand with mussel shell and wood fragments
27-29	grey sand, with organics and wood
5-27	very dark brown sandy silt with sand patches, wood fragments, occasional pebbles and mussel shell
4-5	grey sand band
3-4	very dark grey brown sandy organic silt
0-2	gravelly organic sand with tiny brick/tile fragments
Core 5	420-520cm bgl
34-100	empty
27-34	limestone, in a very dark grey sandy silt matrix
22-27	grey fine and medium sands with tiny brick/tile fragments
15-22	dark grey medium silty sand, with mussel shell and tiny brick/tile fragments
10-15	dark grey silty organic sand
0-10	black organic silty sand, with mussel shell and wood fragments

APPENDIX 5

An Assessment of the Potential Leaching of Cement Material from CFA Piles into Archaeological Deposits

at

The Slipper Baths, Waterside North, Lincoln

for

Allen Archaeological Associates,
221 Wragby Road,
Lincoln
LN2 4PY

on behalf of

English Heritage,
44 Derngate,
Northampton
NN1 1UH

Project Number:	**51 021**
Status of Report:	**FINAL**
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Distribution:	**Mr. M. Allen, AA (1 by Email)**
	File (1)

LANGDALE-SMITH and Company Limited
Consulting Engineering & Environmental Geologists

Contents

1. INTRODUCTION

1.1 Objectives

The site of the former Slipper Baths on Waterside North, Lincoln is to be redeveloped with 'a contemporary two-storey building to house high quality restaurants'.

The ground is likely to contain well preserved organic remains and other elements of material culture possibly dating from the Roman period onwards in the unconsolidated ground extending to over six meters below ground level.

The proposed development will be founded on piles set into the bedrock Lias clay and cast *in situ*. The ground is not suitable for the use of sleeved piles and there is concern that the cement used in the construction of the piles would spread or leach laterally, particularly if groundwater is encountered, and damage any archaeological relics.

This report describes the work undertaken to investigate whether the laterally leaching from the pile cement has taken place and has the potential to harm buried archaeology, based on a Methodological Outline (MO) prepared by Dr. Jim Williams of English Heritage.

1.2 Scope of Report

This report gives the borehole logs and analytical results from this investigation.

This report is limited to the data provided and obtained and responsibility cannot be accepted for conditions not revealed by the investigation. Any diagram or opinion of the possible configuration of the strata around the bore or extension of the findings to greater depths is conjectural and given for guidance only.

The groundwater conditions recorded are those observed at the time of the investigation. Changes in groundwater conditions may occur, particularly from summer to winter, after periods of heavy rainfall or drought, from changes in drainage conditions and so on.

2. FIELDWORK

2.1 Strategy

The MO, presented in full in appendix i/, described the data required and a procedure, using bores, to acquire that data.

The data required comprised:
- groundwater level and direction of flow
- soil section from a bore to 6 m bgl before piling on position of a pile
- soil section from bores to 6 m bgl after piling at 0.3 m and 0.8 m from the pile in the direction of the groundwater flow
- chemical analysis of samples from the soil sections and groundwater

At the scale of the site the groundwater head would not be discernibly different to allow measurement of the flow direction from any boreholes. The River Witham flows eastwards less than 20 m south of the site. Although the river is sheet piled along Waterside North the natural groundwater flow direction would be 'remembered' by the strata and would be towards the river.

Soil sections could be taken using a sleeved core barrel and samples could then be taken immediately for chemical analysis.

2.2 Work Undertaken

Fieldwork was undertaken during November 2005 in cool clear weather.

3 No. bores (BH1-3) were made using the percussion-driven sleeved window-sampler, the Archway 110, to 6 m bgl.

BH1 was made on November 11, exactly on the position of pile 16 prior to any pile installation.

BH2 and BH3 were made on November 16, the day after the piles had been installed. The piles were nominally 450 mm diameter but, considering the installation method and the low strength of the unconsolidated ground, an increase 'in places' to over 650 mm were anticipated. BH2 and BH3 were made 0.3 m and 0.8 m from the side of the pile, assuming it was had a 450 mm diameter, southwards and towards the river.

The core from each bore was recovered in 110 mm diameter 1 m long plastic tubes and were opened, logged and sampled immediately. Representative samples were taken from the natural strata encountered, generally at 1 m intervals.

The ground encountered was recorded to BS5930 and the logs are given in Appendix iii/. The depths are given as below ground level (bgl). The levels are taken from the pile cap elevation.

2.3 Description of Results

The ground encountered in the bores is in general agreement with the published geological maps and comprised up to 3 m of a sandy clay Fill overlying Alluvial deposits from the nearby River Witham. The Alluvium was made up from soft sandy Peat overlying a dark brown Sand, with the Peat thinning from BH1 towards BH3.

Groundwater was encouneterd in BH1 and BH3 at 3.7 m bgl.

Fragments of wood and some stones were recovered from BH1 at 3.7 m and 4.5 m bgl respectively. A fragment of leather was recovered from BH3 at 4.5 m bgl.
There was no visible evidence of any cement leachate in the cores recovered.

3.0 LABORATORY TESTING

3.1 Strategy

By taking ground samples before and after the piling operation and analyzing for a suitable suite of chemicals, any changes could be interpreted as having been caused by cement leachate.

The procedure for sampling described in the MO is embedded in normal SI practice and was followed in principle.

The analytical suite given in the MO should be adequate to detect any cement leachate.

3.2 Work Undertaken

9 No. 500 g samples of the natural ground encountered and 2 No. 1 litre samples of the groundwater encountered were taken, placed in sealed plastic pots and kept at $<5^{0}C$.

Sample weights were not taken.

The sample condition and size was unsuitable for particle size analysis although the BS5930 embodies a grain size description.

Samples were sent overnight to Environmental Laboratories, a UKAS-accredited laboratory with MCERTS for some of the analytical methods used.

3.3 Description of Results

The samples were analysed for:

Metals:	Ca, Mg, K, Al, Fe, Pb
Anions:	CO_3, SO_4, PO_4, NO_3 and Cl.
Other:	pH and EC

The results are fully listed in Appendix iii).

Analysis of any trends are beyond the scope of this report.

T.S. Langdale-Smith MSc C.Geol.
February 25th, 2005

Appendix (i)

Methodological Outline

Project specification to assess the potential leaching of cement material from CFA piles into archaeological deposits.
Slipper Baths, Lincoln

Context
The site of the Slipper Baths is likely to contain well preserved organic remains, and other elements of material culture possibly dating from the Roman period onwards. Initial discussion about options for piling on this site sought to find a mitigation solution that would minimise damage to the archaeological deposits from foundation construction. To date, this mitigation has involved the reduction in the number of piles used, which will have a significant positive benefit to long term preservation of the archaeology on this site. However, the other issue raised in these discussions was that without the use of permanent (or even temporary) sleeves or casing, there was a potential that cement from the construction of the piles may leach through the water in the sediments into archaeological deposits adjacent to the pile. As it was not felt by the engineers that sleeving could be used on this site, it was agreed that no sleeves would be necessary, so long as, as a trade off, some analysis on site to investigate whether damage from piling had occurred was carried out. This specification provides a detailed methodological guide for how the work should be carried out.

Methodological outline
The principal work of the project will be two take three core samples, one before piling and two after. Sub-samples from these cores will be subject to laboratory analysis to determine whether piling operations produced changes in the burial environment. There are a number of stages that this work needs to be carried out in, highlighted in bold and discussed below. Firstly the direction of **groundwater flow** needs to be established. Secondly, a **core sample needs to be taken before piling**, characterised, sampled and sent for analysis. **Following piling, two further samples** should be taken, sampled and **sent for analysis**. The results of this work will be presented in a **report**.

Measuring groundwater flow
It is essential that the direction of groundwater flow is established for the site as this will dictate the location of the two core samples following piling. This is because it is most likely that if there is a leaching of concrete from the pile, it will travel in the direction of groundwater flow. The two cores therefore need to be taken downstream of this flow, not upstream or to the side of it. It is possible that the direction of groundwater flow has already been assessed for this site as part of the geotechnical or geochemical analysis. This should be checked first. If no such assessment has been made, then it will be necessary to employ a suitably qualified individual or organisation to carry out this work. They will need access to three boreholes to monitor groundwater level and from this calculate direction of flow. Two are proposed as part of the palaeoenvironmental analysis on site. A further one is necessary before piling, as described below. It essential that the configuration of the layout of these boreholes is triangular, and that they are left accessible so that they can be sampled from. The approximate cost of this work could range from £500-

£1000. The work could be carried out by any suitable qualified water sampling organisation. Two that are local to the area are

Delta-Simons environmental consultants
Shaun Rowson – 01522 882573
http://www.deltasimons.com

Tim Langdale-Smith
01673 843000
http://langdalesmith.co.uk

The former of these has been contacted, and the project discussed with them. They have suggested that the work would cost between £500-1000. The latter has not been consulted, but is currently carrying out groundwater monitoring for the County Council at the site of Fiskerton, so may have the necessary experience to carry out this work. However, the developers engineers will also be able to supply a number of other contacts.

The initial core

In order to compare any change in below ground chemistry resulting from the piling, it is essential that a core is taken and analysed before the piling takes place. Once this core has been taken, it needs to be characterised immediately. Sub-samples for analysis (for detail see below) should be taken on the basis of this characterisation. It is envisaged that between 4 and 5 samples will be taken for each core. These will be taken within archaeological horizons, although it my be beneficial to take one from higher up the core, above the water table, which may be mainly post-medieval / modern site in-fill. Notwithstanding, the main samples should come from the lower levels of the core (probably between 3 & 5m depth). A range of different deposits types should be sampled, i.e. peaty, silty, or sandy. The depth of these deposits within the core should be noted so that samples from the same horizons can be taken in the subsequent cores. IT IS ESSENTIAL that the core is sampled either on the same day or the following day, and that if stored overnight, the core is stored horizontally not vertically. If the samples are not taken immediately, then it is likely that the water within the core will migrate, thus invalidating the analysis. The location of this initial core is suggested to be directly in the centre of pile 16, as shown on drawing No 10/2092/003 A. However, see discussion below about location of cores, before taking this initial core sample.

Two cores following piling

To assess the potential of migration of cement from the piles into the surrounding deposits, two cores should be taken following pile construction. It is suggested that the cores are taken an hour after the pile is constructed. Although this will need to be the subject of further discussion, the location of the initial core was suggested as it was felt that if the piling rig was working out of the site, from west to east, that since this pile was constructed, it would be possible to take cores from locations adjacent to it, without disrupting the piling programme. It is obviously important that all of these implications are discussed before the initial core is taken, as it will be important that both

samples adjacent to the chosen pile are taken as soon after the piling as possible, and not for example, on the following day. Some consideration will therefore have to be given to timetabling. To speed up the collection of these two core samples, it would perhaps be possible to remove the upper fill levels from the two core locations prior to the piling, or during the first hour before the samples are taken. Also, depending on the on-site personnel overseeing the coring programme, and taking the samples, it may be possible to use a window sampler to sample material in these two core locations, rather than taking sealed cores. However, this would only be applicable if it was felt, following the characterisation (logging) of the initial core, that comparable samples could be collected by using a window sampler.

The location of these two cores is currently suggested to be 30cm and 80cm from the outer edge of pile 16. It is not possible to suggest in which direction within this specification, as the direction of groundwater flow first needs to be established. The order in which the samples are taken is also important. The core furthest from the pile (80cm) should be taken first, then the closer one. This is important, as otherwise, it is possible that if the closer (30cm) core was taken first, the empty hole would act as a sump which may reduce potential migration of the material to the outer core.

Sample analysis

As suggested above, samples will be taken from all three cores, immediately after they have been acquired, and sent for analysis. This will mean that they are sent in two batches, firstly the initial core, then after piling, the other two. The samples should be taken from a variety of sediment types within the initial core, and then replicate samples taken from the other two. Although these cores will be situated very close to each other, there is a minor potential that sediment types recovered from the initial core are not present in one or both of the subsequent cores. If this is the case, then samples from similar depths to those in the initial core should be taken. Approximately 100-300grams of sediment is needed for each sample. The absolute minimum is 100g.

The same weight of sample should be taken for each sample. It should be put into an individually labelled bag. These need to be sealed tight, preferably double bagged, to prevent leakage, or drying, and then sent to a suitable laboratory. A suitable laboratory might be the Environment Agency's National Laboratory Service in Nottingham, although others are no doubt also capable of carrying out this work.

Environment Agency - National Laboratory Service Group
Nottingham Laboratory, Meadow Lane, Nottingham, NG2 3HN
0115 986 0325

They have been contacted in the preparation of this specification, and will be providing an outline costing by the 8th August. This can be further refined once the full composition of the cement mix is known. This will be by the 9th August. It will then be possible to calculate total costs for the analysis by the end of that week. Once the range of tests required is known, quotes could be sought from different laboratories.

Two types of tests are needed. Firstly, additional samples from the same locations in the initial core are needed for sediment characterisation. The tests will be *particle size analysis (sieved); moisture content; LOI (loss on ignition)*. Hopefully one sample (from each of the five locations in the core) will be sufficient for this analysis, but this needs to be confirmed with the laboratory. As it is hoped that the material from the other cores will be the same, it will not be necessary to carry out these sediment characterisation analyses on the other cores.

The other tests are those that need to be carried out on all samples, of which it is expected there will be about 15 (five from each of the three cores). The test is termed a leach test. The samples will be mixed in the lab with de-ionised water and agitated for 24 hours. Following centrifuging, water samples are taken and a suite of chemicals analysed. The precise chemicals to be tested will depend upon product specification received for the concrete used in the pile. As suggested, this will be known by the 8th August. However, it is likely that tests will include *pH; a suite of metals such as calcium (Ca), magnesium (Mg), potassium (K), aluminium (Al), iron (Fe), and lead (Pb), (the cost is per suite, so it costs about the same to have one metal as it does to have twenty); an electrical conductivity test; and a number of anions to be agreed, but likely to include carbonate (CO_3^{2-}), sulphate (SO_4^{2-}), phosphate (PO_4^{3-}), chloride (Cl^-) and nitrate (NO_3^-)*. The Nottingham Lab would not be drawn on costs without calculating them on their computer, which they could not do immediately, but it is likely that the leach test with the chemicals outlined above would cost approximately £100 per sample. No costs have been provided for the additional tests to characterise the deposits, but they are unlikely to be very costly.

Reporting

It is essential that the results of this work are adequately reported. A report containing the results of the chemical and sediment analysis, and a brief discussion of whether there are differences between the results for before and after piling should be produced and copies submitted to the City Archaeologist and the HER. An electronic copy (CD) should also be sent to the English Heritage Regional Archaeological Science Advisor, Jim Williams.

Liability

It should be recognised that this project is a planning trade-off, on a site where it was not possible to provide certainty, through the use of preventative measure (sleeving) or alternative methods (driven piles), that archaeological deposits may be damaged outside the radius of the pile. It is not the intention that blame be apportioned, nor further work required, should the results indicate that some migration of concrete has occurred.

Specification prepared by Dr Jim Williams, English Heritage
on behalf of the Lincoln City Archaeologist.

Appendix (ii)

Borehole Logs

Project No. 51 029
Project Name: Slipper Baths
Site: Slipper Baths
Location: On Pile 16
Logged By: TSLS
Date Bored: Nov 11, 05

WINDOW SAMPLER AND DCP BOREHOLE: WS1

Machine: Archway 110
Contractor: Botham Environmental
Crew: CB
Bore Diameter: 100 mm

Elevation: 5.975 m AOD
Easting: 97663
Northing: 71188

Depth (m bgl)	Elevation (m AOD)	Soil Symbol	Soil Description	Groundwater	N-value	DCP (20 40)	Sample Number	Sample Type	Sample Symbol	Comments
1	5		Grey/brown fine medium and coarse Sand FILL							Bore through centre of Pile 16
			White cobbles of chalk Type 1 FILL							Position cleaned to 2 m bgl and refilled
2	4		Soft brown sandy Clay FILL							
3	3		Soft dark brown sandy PEAT, reeds at 3.2 m				1	C		
4	2		wood at 3.7 m	▼			2	C		Groundwater rest at 3.8 m bgl
			stones at 4.5 m				3	C		
5	1		Black silty fine SAND (wet)				4	C		
6	0		stones at 6.0 m							
			End of Borehole							
7	-1									
8	-2									
9	-3									

Langdale-Smith and Company Ltd
Consultant Engineering and Environmental Geologists
Tel: 01673 843000

Project No. 51 029
Project Name: Slipper Baths
Site: Slipper Baths
Location: 0.3 m south of WS1
Logged By: TSLS
Date Bored: Nov 16, 05

WINDOW SAMPLER AND DCP BOREHOLE: WS2

Machine: Archway 110
Contractor: Botham Environmental
Crew: CB
Bore Diameter: 100 mm

Elevation: 5.975 m AOD
Easting: 97663
Northing: 71188

Depth (m bgl)	Elevation (m AOD)	Soil Symbol	Soil Description	Groundwater	N-value	DCP (20 40)	Sample Number	Sample Type	Sample Symbol	Comments
0			Grey/brown fine medium and coarse Sand FILL							
0.5			Soft brown sandy Clay FILL							
1	5									Hole collapsed below 1.3 m bgl
1.5			Yellow/brown fine, medium and coarse SAND, damp							
2	4						1	C		
2.5			Soft dark brown clayey PEAT, wood @ 2.9 m							
3	3		Soft dark brown sandy plastic PEAT				2	C		
3.5										
4	2		Black silty fine SAND (wet)							
4.5			Dark brown/grey SAND with cobbles of deep red brick and grey limestone				3	C		stones in sample pot
5	1		Firm clayey plastic PEAT							
5.5			Black fine SAND, very wet				4	C		
6	0		Dark brown clayey PEAT							
			End of Borehole							
7	-1									
8	-2									
9	-3									

Langdale-Smith and Company Ltd
Consultant Engineering and Environmental Geologists
Tel: 01673 843000

Project No. 51 029
Project Name: Slipper Baths
Site: Slipper Baths
Location: 0.8 m south of WS1
Logged By: TSLS
Date Bored: Nov 16, 05

WINDOW SAMPLER AND DCP BOREHOLE: WS3

Machine: Archway 110
Contractor: Botham Environmental
Crew: CB
Bore Diameter: 100 mm

Elevation: 5.975 m AOD
Easting: 97663
Northing: 71188

Depth (m bgl)	Elevation (m AOD)	Soil Symbol	Soil Description	Groundwater	N-value	DCP (20 40)	Sample Number	Sample Type	Sample Symbol	Comments
0			Grey/brown fine medium and coarse Sand FILL							
1	5		Soft brown sandy Clay FILL							
2	4		Yellow/brown fine, medium and coarse SAND, damp							
			Brown fine SAND, uniform grade, damp				1	C		
3	3		Soft dark brown sandy plastic PEAT							
			Black clayey very peaty fine SAND with mussel shell at 3.3 m	▼			2	C		Groundwater rest at 3.7 m bgl
4	2		Dark brown/grey SAND, very wet							
			fragment of leather at 4.5 m				3	C		
5	1									
6	0		End of Borehole							
7	-1									
8	-2									
9	-3									

Langdale-Smith and Company Ltd
Consultant Engineering and Environmental Geologists
Tel: 01673 843000

Appendix (iii)

Laboratory Test Results

THE ENVIRONMENTAL LABORATORY LTD

The Harley Read Building, Unit C, Drury Lane, Ponswood Industrial Estate, St Leonard's on Sea, East Sussex, TN38 9BA
Tel: 01424 718618 Fax: 01424 729911

2683

ANALYTICAL REPORT No. AR2261

Location: Slipper Baths

Your Order No: 51 021

Reporting Date: 06/12/05

F.A.O Tim Langdale-Smith
38-39 Willingham Road
Market Rasen
Lincolnshire LN8 3DX

Soils		TP/BH	WS1	WS1	WS1	WS1	WS2	WS2	WS2	WS2	WS3	WS3
		Depth (m)	3.30	3.80	4.50	5.50	2.50	3.50	4.50	5.50	2.50	3.50
		Our ref	3884	3885	3886	3887	3888	3889	3890	3891	3892	3893
Lead*	(mg/kg)		137	197	215	114	50	150	436	187	5	250
Aluminium	(mg/kg)		210	230	220	217	290	240	162	200	288	353
Iron	(mg/kg)		4200	4493	5513	4912	3639	4710	7442	9277	3359	6313
Calcium*	(mg/kg)		3473	4253	4103	2441	752	3251	3235	3465	217	5165
Magnesium*	(mg/kg)		104	144	120	82	102	126	80	92	83	149
Potassium*	(mg/kg)		122	139	127	104	118	148	89	102	97	239
Electrical Conductivity*	(µS/cm)		318	440	338	204	131	344	150	212	95	327
Water Soluble Sulphate	(g/l as SO_4)		0.19	0.19	0.21	0.11	0.05	0.09	<0.05	0.09	<0.05	0.12
Water Soluble Chloride	(mg/l)		9	12	11	9	<5	10	<5	11	11	9
Phosphate	(mg/kg)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Carbonate	(% $CaCO_3$)		4.9	10.8	8.9	5.8	0.6	4.7	6.3	8.4	<0.5	8.9
Nitrate	(mg/kg)		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Loss on Ignition	(%)		8.9	8.8	7.7	2.2	2.2	9.0	2.6	3.3	1.8	8.9

* = UKAS accredited test

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2683

ANALYTICAL REPORT No. AR2261

Location: Slipper Baths

Your Order No: 51 021

Reporting Date: 06/12/05

F.A.O Tim Langdale-Smith
38-39 Willingham Road
Market Rasen
Lincolnshire LN8 3DX

Soil			TP/BH	WS3
			Depth (m)	4.50
			Our ref	3894
	Lead*	(mg/kg)		163
	Aluminium	(mg/kg)		3
	Iron	(mg/kg)		5430
	Calcium*	(mg/kg)		45.1
	Magnesium*	(mg/kg)		1.4
	Potassium*	(mg/kg)		1.9
	Electrical Conductivity*	(µS/cm)		276
	Water Soluble Sulphate	(g/l as SO_4)		0.09
	Water Soluble Chloride	(mg/l)		11
	Phosphate	(mg/kg)		<5
	Carbonate	(% $CaCO_3$)		12.6
	Nitrate	(mg/kg)		<5
	Loss on Ignition	(%)		13.5

* = UKAS accredited test

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The Harley Reed Building
Unit C, Drury Lane
Ponswood Industrial Estate
St Leonards on Sea
East Sussex
TN38 9BA
Telephone (01424) 718618
Facsimile (01424) 729911

THE ENVIRONMENTAL LABORATORY LTD

SOIL SAMPLE RECEIPT AND TEST DATES

Our Analytical Report Number	AR2261
Your Ref No:	51 021
Sample Receipt Date:	21/11/05
Reporting Date:	06/12/05
Registered:	21/11/05
Prepared:	22/11/05
Analysis complete:	06/12/05

SOIL TEST METHOD SUMMARY

PARAMETER	Method Number	Brief Description
Lead*	118	Aqua regia soluble, followed by ICPMS
Aluminium	118	Aqua regia soluble, followed by ICPMS
Iron	118	Aqua regia soluble, followed by ICPMS
Calcium*	118	Aqua regia soluble, followed by ICPMS
Magnesium*	118	Aqua regia soluble, followed by ICPMS
Potassium*	118	Aqua regia soluble, followed by ICPMS
Electrical Conductivity*	136	Probe
Water Soluble Sulphate	115	Water soluble followed by Ion Chromatography
Water Soluble Chloride	115	Water soluble followed by Ion Chromatography
Phosphate	115	Water soluble followed by Ion Chromatography
Carbonate	100	Titration
Nitrate	115	Water soluble followed by Ion Chromatography
Loss on Ignition	129	Gravimetric

* = UKAS Accredited test

Any comments, opinions, or interpretations expressed herein are outside the scope of UKAS accreditation (Accreditation Number 2683)

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THE ENVIRONMENTAL LABORATORY LTD

The Harley Read Building, Unit C, Drury Lane, Ponswood Industrial Estate, St Leonard's on Sea, East Sussex, TN38 9BA
Tel: 01424 718618 Fax: 01424 729911

ELAB

ANALYTICAL REPORT No. AR2262

Location: Slipper Baths

Your Order No: 51 021

Reporting Date: 05/12/05

F.A.O Tim Langdale-Smith
38-39 Willingham Road
Market Rasen
Lincolnshire LN8 3DX

Waters		TP/BH	WS1	WS2
		Depth	3.80	–
		Our ref	3895	3896
Lead*	(µg/l)		<5	<5
Aluminium*	(µg/l)		13	5
Iron*	(µg/l)		1301	2880
Calcium*	(mg/l)		356.6	384.9
Magnesium*	(mg/l)		47.6	48.2
Potassium*	(mg/l)		170.2	159.3
Electrical Conductivity*	(µS/cm)		2410	2680
Sulphate*	(mg/l)		50	<5
Chloride*	(mg/l)		67	<5
Phosphate*	(mg/l)		<5	<5
Nitrate*	(mg/l)		<5	<5
Carbonate	(mg/l)		<20	<20

* = UKAS Accredited test

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THE ENVIRONMENTAL LABORATORY LTD

WATER SAMPLE RECEIPT AND TEST DATES

Our Analytical Report Number	AR2262
Your Ref No:	51 021
Sample Receipt Date:	21/11/05
Reporting Date:	05/12/05
Registered:	21/11/05
Prepared:	22/11/05
Analysis complete:	05/12/05

WATER TEST METHOD SUMMARY

PARAMETER	Method Number	Brief Description
Lead*	101	ICPMS
Aluminium*	101	ICPMS
Iron*	101	ICPMS
Calcium*	101	ICPMS
Magnesium*	101	ICPMS
Potassium*	101	ICPMS
Electrical Conductivity*	136	Probe
Sulphate*	131	Ion Chromatography
Chloride*	131	Ion Chromatography
Phosphate*	131	Ion Chromatography
Nitrate*	131	Ion Chromatography
Carbonate	100	Titration

* = UKAS Accredited test

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THE ENVIRONMENTAL LABORATORY LTD

F.A.O Tim Langdale-Smith
38-39 Willingham Road
Market Rasen
Lincolnshire LN8 3DX

Reporting Date: 06/12/05

ANALYTICAL REPORT No. AR2261

Samples Received By:-	Laboratory Courier
Samples Received:-	21/11/05
Your Order No:	51 021
Site Location:-	Slipper Baths
No Samples Received:-	11

Report Checked By:-

SK

Steve Knight
Laboratory Manager

Authorised By:-

Cliff P.V. Knight BSc, EurChem, CChem FRSC
Managing Director

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THE ENVIRONMENTAL LABORATORY LTD

F.A.O Tim Langdale-Smith
38-39 Willingham Road
Market Rasen
Lincolnshire LN8 3DX

Reporting Date: 05/12/05

ANALYTICAL REPORT No. AR2262

Samples Received By:-	Laboratory Courier
Samples Received:-	21/11/05
Your Order No:	51 021
Site Location:-	Slipper Baths
No Samples Received:-	2

Report Checked By:-

SK

Steve Knight
Laboratory Manager

Authorised By:-

Cliff P.V. Knight BSc, EurChem, CChem FRSC
Managing Director

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