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Fig 1 Watching Brief Trench Location

Fig 2 Plan of EIP/TBM trench, showing archaeological timbers

Fig 3 Evaluation section 1

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1 Introduction

This Interim Report covers the archaeological excavation and watching briefs carried out at the location of the future Crossrail Pudding Mill Portal by the C261 Museum of London Archaeology (MOLA).

All fieldwork was conducted between January 2011 and April 2012 directed by MOLA Senior Archaeologists David Sankey and Sam Pfizenmaier and included:

- **Targeted Watching Brief and Archaeological detailed excavation, EIP/TBM Chamber**
- **Targeted Watching Brief, Cut and Cover Tunnel Section 1**
- **General Watching Brief, Sewer Diversion**
- **General Watching Brief, 11Kv electric cable diversion**

It was recorded under event code (sitecode) XSK10.

This report incorporates the results of an Archaeological Test Pit Evaluation, on which an earlier Interim Statement has been written (MOLA for Crossrail, 2012, C261 Archaeology Early East, Interim Statement, Archaeological Evaluation, EIP/TBM Chamber, Pudding Mill Lane, XSK10, doc no. C261-MLA-X-RGN-CR140-50057 v2 20.3.12).

This document is an enhanced interim statement of the results of the fieldwork, and contains more extensive background, results, and figures that are usually reserved for a Fieldwork Report (which will not be required until other fieldwork at Pudding Mill Lane has been completed).

All levels in this document are quoted in metres Above Tunnel Datum (m ATD). To convert Tunnel Datum to Ordnance Datum subtract 100m, ie 101m ATD = 1m OD.

The fieldwork was carried out in accordance with:

- A Crossrail **Site-specific Written Scheme of Investigation (SS-WSI): Package C152 Pudding Mill Lane Portal, Archaeology Site-specific Written Scheme of Investigation, Doc. No. C152-SWN-C2-RSI-CR094_PT002-0001 Version 10, 12.05.10 (Crossrail 2010a)**
- An **Addendum to the WSI: C152 – Pudding Mill Lane Portal, Addendum to WSI: Test pit Evaluation, Watching Brief & Detailed Excavation [sic] (XSK10), Doc. No. C152-SWN-C2-RSP-CR094_PT002-50001 Revision 2.0, 12.08.11 (Crossrail 2010b)**
- **MOLA, C261 Archaeology Early East, Method Statement Archaeological Watching Briefs Pudding Mill Lane Portal: Doc. No. C261-MLA-T1-GMS-CR094-50002, Version 3, 03.02.11**
- **MOLA, C261 Archaeology Early East, Method Statement Archaeological Targeted Watching Briefs Pudding Mill Lane Portal: Doc. No. C261-MLA-X-RGN-CR140-500036, Version 3, 22.09.11**

- *MOLA, C261 Archaeology Early East, **Method Statement for Archaeological Test Pit Evaluation** at Pudding Mill Lane: Addendum to document C261-MLA-X-RGN-CR140-500036, Doc. No. C261-MLA-X-RGN-CR140-50044 Version 3, 21.10.11*

2 Aims and Objectives

2.1 Research Aims

The original aims and objectives were listed in the WSI (Crossrail 2010a) and stated that ‘data collected from archaeological investigation and mitigation may contribute to the following research themes’:

- Understanding London’s hydrology, river systems and tributaries and the relationship between rivers and floodplains;
- Understanding the relationship between landscape, river and settlement;
- Using the understating that comes from reconstructing London’s past to contribute to wider environmental studies about contemporary concerns such as: climate change; sea level fluctuations; flood defence initiatives; links between pollution, health and quality of life;
- Understanding the reasons for evolution of the road systems, street layouts, river crossings and ferries, and their importance as engines of development and change;
- Understanding the nature and meaning of the deposition of metalwork in the Thames and at the headwaters of river tributaries;
- Understanding how water supply and drainage provision were installed and managed;
- Studying the correlation between sites associated with watercourses and meander bends, so as to understand the origin of settlements; and
- Understanding the evolving character of development in central London, in comparison to other riverine settlements.

Furthermore, the potential at Pudding Mill Lane for geo-archaeological and palaeoenvironmental deposits to be recovered will contribute to the following themes:

- The development of models for understanding the significance of geomorphology, ecology, ecosystems and climate, hydrology, and vegetational and faunal development, on human lives;
- Characterising changing climatic conditions, and air and water quality and pollution, throughout the archaeological record, towards understanding its implications for how people behaved;
- The Mesolithic/Neolithic transition: understanding the significance of horticultural experimentation at this time, and the transition from hunter-gatherers into farmers; and
- Understanding what London’s past environments meant to different groups and individuals.

Any evidence for Post-medieval industrial activity will contribute to the following themes:

- Charting how and why different parts of London developed as specialist producers, and understanding the implications of this for London as a world city;
- Establishing how daily work and life in London reflected and contributed to the rise of London as the commercial centre of the British Empire, and to its continued eminence as a world city thereafter; and
- Examining the success with which small towns in the London region adapted to the capital's growth.

2.2 Fieldwork Objectives

The Addendum to the WSI (Crossrail 2010b) states that the objective of the watching briefs is to:

- Excavate and record archaeological deposits for analysis and dissemination.

The original WSI (Crossrail 2010a) also states that the archaeological investigations have the potential to recover:

- Prehistoric land surfaces and occupation evidence formed in alluvial deposits, sealed by alluvial deposition from the marshy meadowland environment of the Medieval period onward;
- Organic artefacts and structures associated with wetland exploitation from late prehistory onwards;
- Palaeo-environmental and geo-archaeological deposits providing information about the course of ancient rivers; environmental remains; and riverside/wetland remains from the Late Glacial to the present;
- Evidence of Post-medieval pastoral and industrial activity and for the ground raising and landscaping of the area;
- Evidence for Medieval settlement and industry; and
- There is also low potential for Saxon activity.

Additionally, Site Specific Fieldwork Objectives were set out in the Addendum to the WSI (Crossrail 2010b, section 2.2, p5).

1. To record evidence for post-medieval industrial buildings and structures noted in the DDBA and in particular their remains of a large building with landscaped grounds recorded in the 1867 OS edition (within section 1 of the cut and cover tunnel).
2. To inspect, record and sample profiles in the geo-archaeological sequence of deposits present within the site to understand the topography and date to its phased development.
3. To analyse the palaeo-environmental evidence recovered from the works and contribute evidence to inform the Lea Valley Pleistocene and Holocene archaeological resource.
4. To inspect the sequence of post Pleistocene alluvial organic deposits and clay silt units for prehistoric, Roman, and medieval archaeological remains at channel edge and areas of higher ground (land and channel management, settlement and industry).
5. To identify, record and, if appropriate, recover any archaeological artefacts (vessels, structural remains and small finds) preserved in the deeper channel areas.

3 Provisional Results

See Fig 1 for trench locations

3.1 Emergency Insertion Point – Tunnel Boring Machine Chamber (EIP/TBM)



Photo 1 Structures [31] (near) and [32] being hand cleaned, 20th January, looking north

EIP/TBM Chamber Trench (Fig 1, Fig 2, Fig 3, Fig 4)	
Location	Pudding Mill Lane, Emergency insertion Point – Tunnel Boring Machine Chamber
Dimensions	35.4m north-east–south-west, 20.8m north-west–south-east, >6m deep
Modern ground level/top of the slab	104.58m ATD
Modern subsurface deposits	In much of the trench, deep modern concrete intrusions were more than 4m deep. However, in discrete areas, horizontal truncation by modern reinforced concrete intrusions was at 1.13m below ground level, with concrete driven piles through archaeologically significant layers below this level
Level of base of archaeological	Base of observations: 98m ATD

deposits observed and/or base of trench																																																																																																							
Natural observed (truncated/not truncated ?)	Archaeologically sterile substrata include: River Terrace Gravels at 100.43m ATD and London Clay at 98m ATD (approx.) Not truncated – (Note, alluvium above Terrace Gravel is a natural deposit but is of archaeological interest)																																																																																																						
Extent of modern truncation	1.13m→4.5m bGL (below ground level)																																																																																																						
Archaeological remains	Dating Evidence, Finds, and Samples																																																																																																						
Periglacial terrace gravels [29] were exposed first in a machine cut section, and later during bulk excavation, at 100.43m ATD, overlaid by an organic peaty mud [13], 100mm thick, which survived at 100.53m ATD. These were directly overlain by grey organic alluvial clay [12], from 101.3m ATD (south), 101.05m ATD (north).	Samples: Monoliths M7 and M8, and bulk samples <7> (part), <8> [12] and <9> [13]																																																																																																						
Parallel lines of upright timber stakes and piles: structures [28] [31] [32] [64] [65] with oak posts <400mm diameter and <2.0m long. The channel bed they were driven into was at 101.35m ATD and the larger posts were driven <500mm into natural terrace gravel. They were driven into the earlier part of [11] (see below) and [12], and the later part of [11] had accumulated around them. Structure [28] had been recorded in an earlier evaluation trench, and the tops of its posts were worn smooth by water action at 101.65m ATD. Parallel to, and 3.3m north of, structure [28] were two lines of posts, 5.7m long and half a metre apart (structures [31], south, and [32], north). They survived to 102.04m ATD [31] and 101.92m ATD [32]. The southern line of posts had robust rods woven as wattle through the structure [31]. The northern line of posts [32] had a more fragile panel of wattle fixed to	<table border="1"> <thead> <tr> <th>Str28</th> <th>Str31</th> <th>Str32</th> <th>Str64</th> <th>Str65</th> <th>Str98</th> </tr> <tr> <th>sample</th> <th>sample</th> <th>sample</th> <th>sample</th> <th>sample</th> <th>sample</th> </tr> </thead> <tbody> <tr> <td>13</td> <td>27</td> <td>26</td> <td>20</td> <td>28</td> <td>29</td> </tr> <tr> <td>12</td> <td>54</td> <td>45</td> <td>22</td> <td>32</td> <td>50</td> </tr> <tr> <td>11</td> <td>34</td> <td>41</td> <td></td> <td>40</td> <td>39</td> </tr> <tr> <td>10</td> <td>27</td> <td>56</td> <td></td> <td>42</td> <td>33</td> </tr> <tr> <td>14</td> <td>27</td> <td>57</td> <td></td> <td>38</td> <td>39</td> </tr> <tr> <td>15</td> <td>27</td> <td>35</td> <td></td> <td>37</td> <td></td> </tr> <tr> <td>16</td> <td>27</td> <td>58</td> <td></td> <td>36</td> <td></td> </tr> <tr> <td>17</td> <td>47</td> <td>55</td> <td></td> <td>47</td> <td></td> </tr> <tr> <td>18</td> <td>27</td> <td>26</td> <td></td> <td>47</td> <td></td> </tr> <tr> <td>19</td> <td></td> <td></td> <td></td> <td>31</td> <td></td> </tr> <tr> <td>23</td> <td></td> <td></td> <td></td> <td>28</td> <td></td> </tr> <tr> <td>24</td> <td></td> <td></td> <td></td> <td>28</td> <td></td> </tr> <tr> <td>25</td> <td></td> <td></td> <td></td> <td>28</td> <td></td> </tr> <tr> <td>44</td> <td></td> <td></td> <td></td> <td>28</td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td>52</td> <td></td> </tr> </tbody> </table>	Str28	Str31	Str32	Str64	Str65	Str98	sample	sample	sample	sample	sample	sample	13	27	26	20	28	29	12	54	45	22	32	50	11	34	41		40	39	10	27	56		42	33	14	27	57		38	39	15	27	35		37		16	27	58		36		17	47	55		47		18	27	26		47		19				31		23				28		24				28		25				28		44				28						52	
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<p>its northern side. The base of wattle of these two lines of posts (and the presumed level of riverbed) was at 101.2m ATD. Rough hewn chalk blocks <200mm had been rammed into the base of Structures [31] and [32]. They may have also been used in post-pits, which were otherwise undetectable as they would have been immediately backfilled with the same alluvium through which they had been dug. If so, it might imply that the river bed here was exposed at low tide. A small group of driven posts with a horizontal elm plank (Structure [64]) may have been part of [32] but later buildings truncated the area between them.</p> <p>Parallel to, and 3.3m south of [28] was a further two lines of posts. Structure [65] has a shallow s-bend 5.5m long, and either had a tree growing through it, or reused an old tree stump. Structure [98] was just 2.5m long and was set at an angle to structure [65]. Both [65] and [98] had horizontal timbers incorporated within the structure. The base of the wattle in Structure [65] was at 101.3m ATD, but the wattle in Structure [95] extended to 100.8m ATD.</p>	
<p>The upper deposits were investigated in an earlier evaluation trench and reported in an Interim Statement (MOLA for Crossrail, 2012, C261 Archaeology Early East, Interim Statement, Archaeological Evaluation, EIP/TBM Chamber, Pudding Mill Lane, XSK10, doc no. C261-MLA-X-RGN-CR140-50057 v2 20.3.12). That information is repeated below to place the finds of wooden structures in context, together with additional information from the targeted watching brief.</p>	
<p>A bedload deposit of grey sandy organic clay [11] with frequent small molluscs and small pebbles. 140–700mm thick, exposed at 101.65m ATD (north) and 101.49m ATD (south). It had accrued around the tops of timber posts, and the sand fraction was responsible for the abrasive action that had worn timbers away. The targeted watching brief exposed more of this [60], and it was clear that there was variation and in some areas accumulations of animal bone, consistent with water-</p>	<p>[60] Brick possibly dated 1500–1666, roof tile 1480–1800, cheam redware pottery dated 1480–1550 Samples: Monolith M6 and bulk samples <6> part <7></p>

<p>sorting of sedimentary particles. Overlain by ...</p>	
<p>Up to 1.0m of grey organic alluvial clay [10]. Where alluvial clay accumulated around Structure [65] it was numbered separately [30]. Overlain by ...</p>	<p>[10] cheam redware pottery dated 1480–1550. [30] Saxo-Norman pottery (residual) Samples: Monoliths M4 and M5 and bulk samples <4> and <5> Samples: Monoliths M4 and M5 and bulk samples <4> and <5>, Monolith M9 bulk sample <30>.</p>
<p>Dark grey organic sticky alluvial clay [8] exposed at 103.45m ATD (the level to which it had been truncated by modern construction), overlay a bedload deposit 80mm-thick [9], of rougher sandy organic alluvium with frequent molluscs and with brick fragments with added coal dust (discarded), at 102.53m ATD.</p>	<p>Ceramic building material: 17th to early 19th-century bricks (site identification) Samples: Monoliths M1, M2, and M3, bulk samples <1>, <2> and <3></p>
<p>Interpretation and summary</p>	
<p>The complete alluvial sequence has been examined at this location. The earliest deposit was periglacial Terrace Gravel overlain by a peaty deposit (stabilisation), and alluvium overlaying it remains undated. A machine-dug slot across the width of the EIP chamber allowed for a much larger exposure of these deposits than was available in the earlier evaluation trench. They remain consistent and the same sequence applies north and south of the timber structures (see below). Coarser-grained bedload deposit [11] [60] contains brick possibly dated 1500–1666, roof tile 1480–1800, Cheam redware pottery dated 1480–1550. Wooden posts and stakes were driven through this deposit, but it continued to accumulate after they had been driven, so later dated material may be stratigraphically later than – or before – wooden structures described below.</p> <p>A series of driven post structures aligned from north-east to south-west, were found on the east side of the EIP trench [28][31][32][64][65] and [95]. The west ends of these structures were truncated by later buildings. They were made mainly from driven oak roundwood posts, most with bark (indicating they had been cut for this purpose) but exhibiting variation in technique (square pointed ends / ad hoc trimmed ends). They also incorporated some reused elm. The driven posts varied in size from small stakes to large piles, and the assembly was somewhat haphazard. In places, chalk blocks had been used to firm the ground into which they had been driven. This might imply that the river bed was exposed here at low tide.</p> <p>The structures incorporated horizontal elements and woven wicker work, which could be added as panels (eg [32]) or integral to the driven posts (eg [31]). That such wicker panels faced both north and south tends to imply that they were not revetments (successive revetments would be facing in the same direction).</p> <p>Historically, it was known that there was confrontation on the River Lea, between those that wanted a navigable river and the traditional use of fish weirs. Following an Act of Parliament, sponsored by the City of London in 1571, Commissioners of Sewers were given the power to remove fish weirs (Fairclough, K.R. 1987, <i>The River Lea 1571–1767: A River Navigation prior to canalisation</i>, 38). It is possible that these wooden structures are the remains of fishing weirs, although it should also be noted that the same source indicates that there was a tidal lock at Bow.</p>	

Evidence that the structures stood in flowing water is provided by the water-worn tops of Structure [28] posts, and individual posts in the other structures. This interpretation requires testing against alternatives, if it is to remain a robust characterisation of the remains.

As indicated by the evaluation, the Targeted Watching Brief confirmed that approximately 2.5m of alluvium accumulated within a relatively short period, with clay [10] overlying the top of the rotted posts [28] and [30] accumulating around Structure [65]. A later channel bed lay at 102.5m ATD [9], which included late 17th-century, or more probably, 18th-century brick fragments. It is impossible to determine whether this is from a man-made or a natural channel. The channel fill [8] continued to 103.45m ATD, the level at which it had been truncated. Original water level was considerably higher, and is thought to have been tidal.



Photo 2 Wattle on north side of structure [32], 20th January 2012, looking south

Crucially, the wattle on the north side of this structure, with wattle also in structure [31] indicated that there was wattle facing both north and south of these two lines of timber uprights, indicating it was unlikely to have been a channel-bank revetment.



Photo 3 Structure [95] (fore) and [65] (rear), truncated by a modern driven pile (bottom right), 17th January 2012, looking south



Photo 4 Structure [31] with Structure [32] behind, 20th January 2012, looking north

3.1.1 Radio carbon and Dendrochronology dating of timber samples

The following samples were taken for radio carbon dating (see 6.2):

Structure number	Sample number	Stake/rod number (where applicable)	Species	Other information	MOLA ref for QUB Chrono lab
28	14		oak	mouldy	XSK10_28_14
31	27	stake 1	willow/poplar	external 3-5 rings sampled	XSK10_31_27
32	26	rod 5	willow/poplar		XSK10_32_26
64	20	-	ash		XSK10_64_20
65	28	rod 7	willow/poplar		XSK10_65_28
98	29	rod 2	willow/poplar	external 4 rings sampled	XSK10_98_29

The following samples were taken for dendrochronology dating (see 6.3):

Structure number	Context number	Species	Estimated rings	Sapwood
32	33	Oak	c 45	Yes
32	111	Oak	c 45	Yes
64	63	Oak	c 45	Yes
98	101	Oak	c 45	Yes
98	105	Oak	c 45	Yes

3.2 Cut an Cover Section 1



Photo 5 Cut and Cover Section 1 excavating through alluvium and into natural terrace gravels (last of concrete intrusions removed), looking east, 1st Feb 2011

Cut and Cover Section 1 (Fig 1)	
Location	Pudding Mill Lane, Cut and Cover Section 1
Dimensions	53m north-east–south-west 15m north-west–south-east >6m deep
Modern ground level/top of the slab	104.58m ATD
Modern subsurface deposits	In much of the trench, deep modern concrete intrusions were more than 4m deep. However, in discrete areas, horizontal truncation by modern reinforced concrete intrusions was at 1.13m below ground level,
Level of base of archaeological deposits observed and/or base of trench	Base of observations: 98m ATD

Natural observed (truncated/not truncated ?)	Archaeologically sterile substrata include: River Terrace Gravels at 100.9m ATD and London Clay at 98m ATD (approx.) Not truncated – (Note, alluvium above Terrace Gravel is a natural deposit but is of archaeological interest)
Extent of modern truncation	1.13m→4.5m bGL
Archaeological remains	Dating Evidence, Finds, and Samples
Brick foundation [114], a rather formless patch of bricks, truncated on all sides with a modern concrete stanchion to the east. The patch of bricks measured 2.1m east-west, 1.8m north–south, it was truncated at 1.5m north of the south diaphragm wall and 3.8m east of the 11kv-cable crossing. It had been truncated at 103.7m OD by modern building foundations and was about 1m thick. The red bricks were all broken and may have been re-used, they were set in dark grey mortar with coal ash used as a pozzolanic additive.	The use of coal ash in mortar indicates an 18th- or 19th-century date
Alluvial organic clay [115], 103.2m–100.9m ATD with a band of increased organics at 101.9m – 101.2m ATD.	No dating evidence
Interpretation and summary	
<p>Brick foundation [114] is probably a fragment of the large building with ornamental gardens represented on the 1869 OS map, east of the soap works (managers house?), or a fragment of the soap works itself.</p> <p>The band of increased organics, observed in section – part of [115], corresponds to the bedload deposit observed in the EIP/TBM chamber (see above).</p> <p>Observations were made of the periglacial river terrace gravel. It was broadly horizontally bedded but there were marked features within this sequence, as shown by the cutting dug beneath a box made for the crossing of the 11kv electric cable.</p>	



Photo 6 Fragment of masonry foundation [114], looking north-west, 6th October 2011



Photo 7 Terrace Gravel beneath the 11kv electric cable chamber, sedimentary structures indicate (potentially) a moving ice-age river channel. This contrasts with horizontal bedding observed elsewhere

3.3 Sewer Diversion



Photo 8 New sewer trench, sediments exposed below far trench box, 6th December 2012, looking northwest

Sewer Diversion (Fig 1)	
Location	Pudding mill Lane: Barbers Road Realignment
Dimensions	240m east-west, 1.8m wide, 3.7m deep
Modern Ground Level/top of the slab	104.5m ATD
Modern subsurface deposits	2.1m – 3.7m deep modern levelling deposits. For part of the length this was through an area of asbestos contamination (not a common material until the 20th century), also coal ashy reworked 19th-century fill
Level of base of archaeological deposits observed and/or base of trench	Base of trench: 100.8m OD

Natural observed (truncated/not truncated ?)	Alluvium and peat are discussed under archaeological remains (below) as they are of archaeological interest. Terrace gravel was not exposed
Extent of modern truncation	2.1m bGL
Archaeological remains	Dating Evidence, Finds, and Samples
A 600mm wide brick wall made of red and blue frogged brick [1], constructed later than 1840 and quite possibly in the early 20th century	Site identification of frogged bricks indicates it was constructed later than 1840
Below modern coal ashy fills were grey alluvial clay and organic deposits [116], observed in isolated exposures from 102.4m ATD. A substantial peaty-mud deposit [117] was exposed near the east end of the trench, from approximately 103m ATD	Undated (assumed pre-19th century)
Interpretation and summary	
<p>The alluvial sequence was deposited by the movement of the river Lea, which was an active meandering stream, given extra energy when it became tidal. Historic maps indicate that there were several channels, and it is quite possible that it recut meanders across the floodplain during the historic period leaving little of earlier river deposits. Shallow water and cut-off meanders are likely to have become choked with reeds, resulting in the peaty mud found near Pudding Mill Lane.</p> <p>The alluvial floodplain was covered with 19th-century coal-ashy landfill dumps, but these have been substantially reworked in the 20th century. Building remains [1] may be from the 19th century, but may be later (first half of the 20th century).</p>	

3.4 11kv Electric Cable Diversion



Photo 9 11kv electric cable route, where it crossed the main cut-and-cover tunnel

11kv Electric Cable Diversion (Fig 1)	
Location	Pudding Mill Lane: Barbers Road Realignment
Dimensions	331m east-west (310m in direct line), width varies between 2m and 4m, with a 24m x 16m chamber where it crossed the cut-and-cover tunnel.
Modern Ground Level/top of the slab	104.5m ATD
Modern subsurface deposits	2.40m deep modern levelling deposits
Level of base of archaeological deposits observed and/or base of trench	102.5m – 100.5m ATD, base of trench
Natural observed (truncated/not truncated ?)	Alluvium is a natural deposit of archaeological interest and is discussed below
Extent of modern truncation	1.13m->4m bGL



Archaeological remains	Dating Evidence, Finds, and Samples
Beneath reworked coal-ashy landfill deposits waterlogged alluvial organic clay was exposed from 103m ATD	undated.
Interpretation and summary	
The 11kv electric cable trench – together with the sewer diversion – indicate that the general sequence observed in the EIP/TBM chamber is applicable throughout the site	

4 Significance of Results (*provisional*)

4.1 Summary of Fieldwork Results

The fieldwork at Pudding Mill Lane, to date, has shown that a consistent stratigraphic sequence may be found across the site. Terrace Gravels are found above London Clay, and at approximately 100.4m ATD they are succeeded by geological deposits of the historic past, a series of alluvial organic clays with at least two river bed deposits, up to 103.5m ATD (approximately). Within this sequence there is potential for archaeological remains. A series of timber structures were exposed formed of parallel lines of driven posts, incorporating horizontal elements and wattle, driven into a river bed that accumulated around them at around 101.2m ATD. Further research may indicate their purpose, but wattle facing in both directions on parallel lines of posts would indicate that they were not revetments. Also, two parallel lines of timbers with water-worn tops lay between other parallel lines of uprights with wattle, and may indicate that the structures succeeded one after the other. Above alluvium was a layer of coal ash dumps, 19th-century landfill deposits. These had been reworked in modern times, and part of the site was contaminated with asbestos.

Concrete foundations had been dug into these remains with mass concrete varying between 1.13m and 4m bGL with occasional blocks truncating deposits at 4.5m bGL. Also both driven and rotary piles had penetrated through the alluvial sequence.

4.2 Importance of Resources

The archaeological remains identified in the fieldwork are provisionally assessed as being of moderate importance, as they provide a crucial insight into the local economy. Whilst fish *traps* of earlier dates have been recorded all along the Thames, the size of the River Lea precluded the use of what may be described as fishing weirs. On the Lea, one might speculate that such weirs restricted the flow to a narrow point, increasing its velocity and allowing the capture of fish in nets or basket traps. If that is what the structures at Pudding Mill Lane were, it is the first time that they have been recognised in London.

4.3 *Provisional* Assessment of Results against Aims and Objectives

The results of investigations to date at Pudding Mill Lane indicate that the sedimentary sequence will aid an understanding of London's hydrology and may aid the comprehension of the impact of settlement in central London on the sedimentary regime in the Thames basin (subject to analysis of sample, see aims section 2 above). Thus far, sandy islands within the floodplain have not been encountered and no evidence of **medieval, Roman or prehistoric** remains has been recovered, although the lowest level of alluvium is undated and has the potential for such remains. The comparative levels of alluvium have the potential to illuminate **rising sea levels**.

The most significant remains are those of structures which were set into a tidal river bed which continued to accumulate around the base of wooden posts. Successive lines of driven posts with wattle and horizontal elements may indicate the use of fishing weirs. Artefactual dating is insecure precisely because the river bed accumulated around them, but broadly **Tudor** remains were found in the river bed, and Radiocarbon determinations indicate a date range from the mid 15th to the early 17th centuries (see 6.2).

It should be noted that the Act that led to the removal of fishing weirs was passed in 1571, but the actual removal took place some time later. The change of use of the river, with the idea of a river-navigation, is a crucial insight to the step-change in trade. It also contributes to understanding the change in relationship between local people and the river, the growth of **regional transport infrastructure** and the relationship between that and settlement.

A brick foundation is potentially part of the **19th-century building** observed on the 1867 OS map (Objective 1 in the Addendum to the WSI).

4.4 Provisional conclusions for future work

Future fieldwork includes cut-and-cover tunnel sections 2 and 3 and a grout shaft. Continued surveillance on the level of Pleistocene deposits is required, as there is still the possibility of remains of medieval or earlier date on sandy islands that have survived subsequent erosion. If the base of alluvium remains constant at about the same level, it may imply that the major periods of archaeological remains on site are from the late medieval and Tudor period onwards.

The environmental samples, monoliths and bulk samples are key to interpreting the wider significance of the site and answering broader research aims concerning the river system and settlement. They should be related to the dated timber structures.

5 Future Deliverables

The remaining deliverables for the site, and their delivery dates as specified by *Crossrail, Archaeology, Specification for Evaluation & Mitigation (including Watching Brief, Doc. No. CR-PN-LWS-EN-SP-00001, v. 0.3, 26.06.09*, are:

- **Survey Report** to include all the fieldwork detailed in Section 1
- **Summary Report** to include all the fieldwork detailed in Section 1
- **No Fieldwork Report** (including HER Summary Sheet) is required until after all fieldwork has been completed at Pudding Mill Lane

6 Specialist Reports

6.1 Notes on worked roundwood structures seen in situ and lifted samples seen off-site

DM Goodburn

6.1.1 Background

The site lies a few metres east of the current canalised course of the River Lea, in deep alluvial deposits surmounted by reclamation dumps. The deposits and structures were clearly built where and when the river was still strongly tidal. This writer visited the Targeted Watching Brief of the EIP/TBM Chamber. This followed an earlier phase of watching brief, which revealed an east-west pile line, mainly made of small whole log piles (Str. [28]). That pile alignment, which appeared to be of more than one build, was initially thought to have been possibly one side of a jetty of late-medieval to 16th-century date. The initial dating was based on the use of elm logs mixed with oak, elm being very rarely used in the London region before that period. The clearly truncated level of preservation, and presence of occasional pieces of abraded medieval or later roof tile, also indicated that broad dating. Another tentative suggestion, influenced by the presence of a local 'wick' (= local trading place) road name was that if it proved to be a truncated jetty, it might have been a later manifestation of such structures dating back to Saxon times.

That simplified initial interpretation of jetty elements, has been revised from further archaeological excavation. Several more log pile and wattle structures have been revealed, with a small number of more elaborately worked timbers incorporated in them (see section 3). The woodworking features of these structures are summarised below. The summary comment is derived from notes and sketches made on site, first hand examination and recording of some lifted material, and a review of timber records made on site (plans, elevations and sections). This report is a selective brief summary for more individual details; the individual site records will be available for consultation in the site archive in due course.

6.1.2 Methodology of recording and sampling

All the substantial stakes and piles were numbered and located on scale plans at 1:20, and the majority lifted for more detailed recording. The level of detail included the compilation of pro-forma 'timber sheets' with sketches, and selected scale drawings on gridded film as is described in the MoL Archaeological Site Manual 2nd edition and the English Heritage Guidelines on Waterlogged Wood. All the converted timber elements were drawn. A high proportion of the woody elements attributed, a number were also slice sampled on-site for possible tree-ring study and species identification (see 6.3). The larger slice samples with visually distinct features were reviewed off-site, and the distinctive oak samples identified (by reference to distinctive features such as strong ring porous structure, black stained heart wood and very large compound rays). It was also possible to isolate samples from piles of the elm family in a similar manner (species identification check samples of a selection of these were also retained). A selection of oak samples were retained for possible tree ring study, and those oak and elm samples which had been selected by the site supervisor for possible radiocarbon dating (see 6.2). A selection of small bagged samples of small wattlework rods were also taken, for microscopic species determination.

Over 100 piles and stakes were individually numbered on plan, with four blocks of wattle rods.

A total of 87 slice samples were taken of the larger stakes and piles. 52 were finally lifted and examined by this writer, and retained material rebagged.

A total of 4 bags of small wattle rods were taken, with 10 examples from each bag being a sufficient number for species and age study.

A total of 5 tree-ring samples proved to have 45 annual rings, or a few more, which indicated a potential for absolute dating, and broad sourcing of the parent timbers. However, none of the samples had very much over the bare minimum required, and it was not possible to date the samples, see 6.3.2. The five samples were timbers [33] and [111] from Str [32], [63] from Str [64], [101] and [105] from Str [95].

6.1.3 Key features of the wooden structures found during the excavation

As the sequence of building of these structures is not yet clear, and they also appear to have been built in a relatively short time period, this summary discussion is laid out geographically for cross reference to site plans working from the south to the north. It must also be noted here that some pile and wattle groups given single Structure or group numbers are likely to have had several building and or repair phases within them, as indicated by the location and variation in piles. What follows must inevitably be a considerable simplification.

6.1.3.1 Disturbed wattle and later roots in the extreme south-eastern corner

In the extreme south-eastern corner of the trench a small group of disturbed roundwood stakes were uncovered together with some later roots. The function of this stake group is uncertain.

6.1.3.2 Structure [65] a substantial NE–SW pile and wattle alignment

Just 1.5m or so to the north a substantial east–west line of whole log piles or large stakes, set between 0.2- 0.4 m apart. had been revealed. Around the piles very small (most were smaller than 10mm dia) decayed rods had been woven but were largely lost. Str [65] stood c 0.7m high and extended c 5.5m from the east trench edge to the west where it seems to have originally stopped. The exposed length had been cut in half by the growth of a slightly later tree, the stump of which was still in situ . The growth of the tree indicates that by that period Str [65] had been embedded in a wet earthy bank The line of up rights also had some interlaced horizontal log elements of oak and elm, clearly shown on Elevation 1. The piles and stakes were nearly all oak and were made from whole logs between c 100mm to 170mm maximum dia eg pile [77] and [79] respectively. In the east a small number of elm logs were used eg pile [80]. They survived c 1.2 to nearly 2m long and had been given, axe cut ‘pencil’ form points.

Towards the west end a nearly horizontal log of elm was included below the wattle, whilst at the east end a very decayed, old oak beam set higher up behind the wattle hurdle noted below (Section 1). Most of the uprights were log piles but at least two oak examples were cleft to form half log piles eg pile [63]. Right at the west end of this alignment a strange upright ([83]) could be seen, with a ‘U’-shaped cross section 210mm wide. It is important to note that this was identical to another elm timber [61] found reused in Str [64]. It may imply that Strs, [65] and [63] are broadly contemporary? Both timbers appear to have been a reused elm gutter, or just possibly a split polygonal pump pipe with a large bore.

At the east end of the structure several phases of work could be seen starting with a lightly made east–west wattle hurdle <28> supported by oak roundwood piles that were water eroded at the top, below the level or the bulk of the east–west structure. This was punctured by light

pole stakes of a non-oak species, probably before the main east–west structure [65] was built. This amounts to three or four phases of work in Str [65].

Structure [98] east–west pile and wattle

Attached to the east end of Structure [65], where it had been truncated by the 11kv cable box was short structure [98]. Unlike the other wattle and pile structures found this short structure was orientated on a more east–west alignment. It comprised seven uprights varying from roundwood stakes of c 50mm dia and larger oak log piles up to c 160mm dia. The uprights appear to be retaining a log laid horizontally as was seen in Str [65]. The purpose of these anchored logs is currently uncertain. The other timbers resembled those of the structures already described. To one side of the larger uprights lay a fragment of wattle hurdle.

Structure [28] the north-east–south-west pile alignment found in the evaluation

Approximately 3m to the north lay the north-east–south-west pile alignment Str [28] This again comprised a line of 15 log piles extending from the east trench edge and slightly smaller stakes without surviving wattle weavers. The uprights had been rotted and water eroded to a point on their tops or been machine damaged. They were thought to have survived to a level c 0.6m lower than the similar pile Strs [65] to the south and [32] to the north. Perhaps this can be seen as evidence of a slightly earlier date? The vast majority of the piles were of oak with a scattering of elm. The piles and large stakes were all whole logs and survived up to c 1.7m long and 160mm in dia eg [22]. Smaller examples such as oak upright [20] 130mm in dia and c 1.15m long. The points of the piles were hewn to quite elongated pencil form points and the most complete axe stop mark found was 90mm wide, probably cut with an axe with a blade of c 100mm width.

Extension of Structure [28]

This ‘Structure’ shown on plan 92 was labelled as an ‘extension of Structure [28]’ however the pile uprights are very different in character as all those seen by this writer are of whole elm stems rather than nearly all oak. In addition one of the uprights [93] was a broken rectangular section elm timber 160mm wide, 90mm thick and surviving 0.6m long. It had a relict lap joint showing some form of previous use.

Structure [31] a more lightly built stake and wattle north-east–south-west feature

Three and a half metres north of Str [28] the truncated remains of another east–west wattle structure was exposed. It was altogether more lightly made than Strs [65], [28] and [32]. It survived as the basal four courses of plain woven wattle work with rods c 50mm diameter wound round stakes c 70mm diameter on c 0.4m centres. The roundwood was of a pale non-oak species (poss willow??). The comparatively light wattlerwork was later pierced by two larger log piles [57] and [58]. Species samples were taken and will be examined shortly microscopically. Clearly tidal access was required to weave the lower wattle rods.

Structure [32] an east–west pile and wattle alignment with piles up to 180mm diameter

Half a metre north of Str. [31], another east–west pile and wattle alignment Str [32] was located. It also was a major east–west line of log piles and had a small scrap of light wattle hurdle surviving to the north of the pile line at the east end (Sect 33). The piles were all machine truncated whole log oak piles between c 100 and c 180mm diameter, except for stake [43] which was a stake made from a fragment of oak planking (plan 32). This structure also ran about 5 m west from the east edge of the site and appeared to stop at about the same point east–west. In some places apparent repair resulted in piles set edge to edge. The piles of this structure were a little larger than those of all the others for example pile [42] survived nearly 2.m long with a diameter of 150mm.

6.1.4 A general window on local woodland character and management

In due course the samples and records can be used to shed light on the woodland close to the site. For now we can note that the prevalence of young fast grown oak probably implies the use of old oak coppice stems or young fast growing woodland standards on good soil. Such woodland is still known in south London today and may have been a feature of the managed woodland of what is now north-east London at the time of the building of the pile and wattle structures under discussion.

6.1.5 Initial speculations on possible functions of these east–west wattle features

Initially the east–west structures appeared to be the remains of several phases of possible fish weirs. If they were fish weirs, the period of use may well have been as much as 50 years or more judging from the water erosion of some of the pile heads and rebuilding. However, with more time on site and remembering similar features found during archaeological work ahead of the Olympics development nearby, an alternative interpretation emerged. It was suggested that perhaps the three most substantial east–west wattle and pile Structures [28], [65], and [32] were different phases of dock inlet or channel walls. Here the weight of the structure might reflect its usage so light wattle work such as Str 31 might be associated with lower banks. Indeed wattle revetments to the main Lea bank itself were still being made at the turn of the 21st century at the north end of the Pudding Mill river.

However, the stratigraphy associated with the structures was the same both sides which would not fit a revetment use, unless the land-fill behind was rapidly shovelled in alluvium from the channel itself. Thus we are forced back to an interpretation as short fish weirs built out from the banks at roughly 90 degrees, and perhaps extended with nets at certain times. It is well known from historical accounts that there were conflicts between interests building fish weirs and mill dams and barge operators carrying such essential cargoes as malt from Ware to London on the Lea. In the 1570s when the barge traffic was building rapidly, they typically required a minimum draft of 0.5m of water. Prior to the drawing together of all the various strands of evidence, particularly the geoarchaeological study, it is probably premature to ascribe a definite function to these structures. Parallels will have to be sought. The form of a simple wall running out at 90 degrees from the shore is known in the lower Severn estuary but on the Thames the fish weirs appear to be more commonly laid out as elongated 'V's.

It must also be reiterated that no clear trace of the suggested Saxon trading shore facility has yet been found.

6.1.6 Current evidence for an overall date bracket for the east–west wattle structures

The condition of the timber, sporadic use of elm and fragments of roof tile and chalk suggests a late medieval to 16th-century date bracket is likely for the spread of structures, though a slightly earlier or later date can not be ruled out. A date prior to the late 17th century might also explain why the possible dock inlet revetments or fish weirs are not marked on the later historic maps. Clearly when the trees were growing through and around Str [65] they must have been in a wet bankside or silted inlet situation, where there was water enough for them to be preserved but enough dryness for the tree to grow.

Unfortunately all of the oak piles and stakes were relatively small, and of fast to moderate growth rate, such that only five had the required c 45 or more annual rings for dendrochronology, and these proved undateable (see 6.3). However, radiocarbon dating was

also undertaken, and provided a broad date range which corresponds with that in the preceding paragraph (see 6.2.2).

6.2 Radiocarbon dates

Mary Ruddy

6.2.1 Introduction and method

The six wooden structures (28, 31, 32, 64, 65 and 98) were sampled and one sample from each structure sent to Queens University Belfast Chrono laboratory for radiocarbon dating as dendrochronology samples were assessed and deemed unfeasible (6.3 below). The results were calibrated using OxCal 4.1 and IntCal09 (Bronk Ramsey 2010, Bronk Ramsey 2009a, Reimer et al 2009).

6.2.2 Results and discussion

Results are tabulated and illustrated in a multiple plot (see below) and show a range from AD 1262 (structure 64) to 1633 (structure 31). In the absence of stratigraphic information on the relationship between the structures the results were calibrated as a 'phase': a coherent group of events which there is no information on the internal ordering.

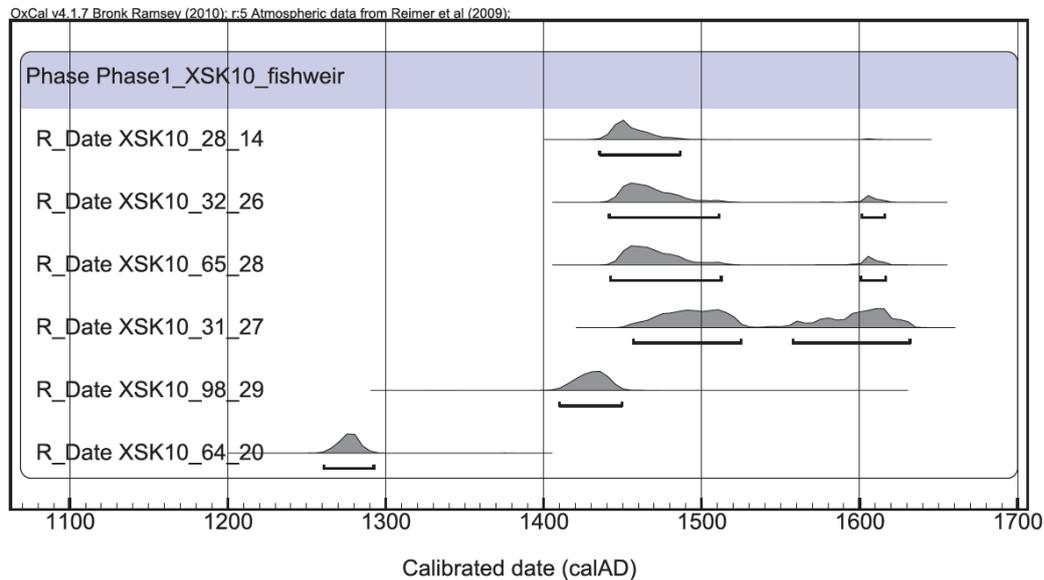
The group of structures with similar probability densities (28, 32, 65 and 31) shows two ranges: the first from the 1430s to the 1520s and the second from AD 1601 to 1616. Structures 64 and 98 appear to predate this cluster, although there is some overlap between structure 98 with the first range of three of the structures (28, 32 and 65). Structure 64 precedes the others by more than 100 years.

In summary, there is clearly a tight cluster in the calibrated dates of structures 28, 32, 65 and 31 suggesting these are likely to be contemporary. Structures 64 and 98 appear to be earlier with structure 64 a definite outlier (dating to the late 13th century).

The following samples were sent for radiocarbon dating and results of analysis

Structure number	28	32	31	65	98	64
Sample number	14	26	27	28	29	20
QUB Chrono lab ref	200149	200151	200150	200153	200154	200152
MOLA ref	XSK10_28_14	XSK10_32_26	XSK10_31_27	XSK10_65_2	XSK10_98_29	XSK10_64_20
Stake/rod number (where applicable)		rod 5	stake 1	rod 7	rod 2	
Species	oak	willow/poplar	willow/poplar	willow/poplar	willow/poplar	ash
other information			external 3-5 rings sampled		external 4 rings sampled	
pretreatment	AAA	AAA	AAA	AAA	AAA	AAA
Radiocarbon determination	421±19 BP	401±20 BP	359±19 BP	397±20 BP	483±27 BP	726±20 BP
Calendar date 2 sigma (98.4% probability) (cal AD)	1436-1483	1441-1502 and 1507-1510 and 1602-1615	1461-1527 and 1555-1633	1443-1512 and 1601-1616	1411-1448	1262-1290

OxCal Multiple plot of the six radiocarbon dates



6.2.3 References

Bronk Ramsey, C 2009a Bayesian analysis of radiocarbon dates. *Radiocarbon*, 51(1), 337-360

Bronk Ramsey, C 2010 OxCal programme v4

Reimer, PJ, Baillie, MGL, Bard, E, Bayliss, A, Beck, JW, Blackwell, PG, Bronk Ramsey, C, Buck, CE, Burr, GS, Edwards, RL, Friedrich, M, Grootes, PM, Guilderson, TP, Hajdas, I, Heaton, TJ, Hogg, AG, Hughen, KA, Kaiser, B, Kromer, B, McCormac, G, Manning, S, Reimer, RW, Richards, DA, Southon, JR, Talamo, S, Turney, CSM, van der Plicht, J and Weyhenmeyer, CE 2009. IntCal09 and Marine09 radiocarbon age calibration curves, 0 - 50,000 years cal BP *Radiocarbon* 51, 1111-1150

6.3 Dendrochronology

Ian Tyers

Five samples from timbers excavated from the Crossrail Pudding Mill Lane excavations (sitecode XSK10, NGR c TQ 3770 8345) were submitted for dendrochronological assessment and analysis. None of these timbers were successfully dated.

6.3.1 Methodology

The timbers were supplied as cross-sections. They were assessed for the wood type, the number of rings they contained, and whether their sequences of ring widths could be reliably resolved. For dendrochronological analysis samples usually need to be oak (*Quercus* spp.), to contain 50 or more annual rings, and the sequence needs to be free of aberrant anatomical features such as those caused by physical damage to the tree whilst it was still alive. Standard dendrochronological analysis methods (see eg English Heritage, 1998 *Dendrochronology: guidelines on producing and interpreting dendrochronological dates*) were applied to both samples. The sequence of ring widths in these samples were revealed by preparing a surface equivalent to the original horizontal plane of the parent tree with a variety of bladed tools. The width of each successive annual growth ring was revealed by this preparation method. The complete sequence of the annual growth rings in the suitable samples were then measured to an accuracy of 0.01mm using a micro-computer based travelling stage. The sequences of ring widths were then plotted onto semi-log graph paper to enable visual comparisons to be made between the sequences and reference data. In addition cross-correlation algorithms (eg Baillie, M G L & Pilcher, J R, 1973 *A simple crossdating program for tree-ring research*, *Tree Ring Bulletin*, 33, 7-14) were employed to search for positions where the ring sequences were highly correlated. Highly correlated positions were checked using the graphs and where these were satisfactory, these locations were used to identify the calendar dates of the measured series.

Computer searches for cross-matching use the original CROS algorithm (Baillie & Pilcher 1973). A t-value of 3.5 or over is usually indicative of a good match, although this is with the proviso that high t-values at the same relative or absolute position needs to have been obtained from a range of independent sequences, and that these positions were supported by satisfactory visual matching.

The tree-ring analysis initially dates the rings present in the timber. The interpretation of these dates relies upon the nature of the final rings in the sequence. Oak timber contains 2 types of wood, heartwood and sapwood, the latter is on the outside of the tree and thus contains the most recent growth rings, this material is softer and is not always preserved under archaeological conditions. If the sample ends in the heartwood of the original tree, a terminus post quem (tpq) date for the felling of the tree is indicated by the date of the last ring plus the addition of the minimum expected number of sapwood rings which are missing. This tpq may be many decades prior to the actual date that a tree was felled, particularly where poor preservation or other loss of outer heartwood has occurred. Where some of the outer sapwood or the heartwood/sapwood boundary survives on the sample, a date range for the felling of a tree can be calculated by using the maximum and minimum number of sapwood rings likely to have been present. For this material the sapwood estimates used are a minimum of 10 and maximum of 46 annual rings, where these figures indicate the 95% confidence limits of the range.

6.3.2 Results

The submitted material comprised 5 oak (*Quercus* spp.) dendrochronological samples. 3 of these contained measurable tree-ring sequences, and were measured successfully (Table 1).

Sequences from these did not cross-match each other, nor with Roman or post-Roman tree-ring data from London, elsewhere in England, or elsewhere in northern Europe.

6.4 Plant Remains

Anne Davis

Nine environmental bulk samples, each of approximately 10 litres, were taken alongside geoarchaeological monoliths, from a section through alluvial deposits (Fig 3). Eight litres from each sample were processed by flotation, and the wet flots assessed to determine the presence and nature of any plant remains and other biological material present. A further two litres from each sample was retained for any future work on invertebrates. The majority of samples produced moderate to large assemblages of waterlogged plant remains, including many roots or wood in some, and a variety of seeds and fruits.

Despite a relatively large volume of fragmentary roots and rootlets, sample [13]{9} from organic peaty mud at the base of the sequence produced only a small number of seeds, which are unlikely to allow any sort of environmental reconstruction. A very small number of mollusc shells were also seen.

The overlying deposit of grey, organic alluvial clay [12]{8} contained a larger amount of organic remains consisting mostly of wood and root fragments, but with rather more seeds than the previous sample. These were again quite mixed however, and included several from dry-ground plants as well as examples of marsh marigold (*Caltha palustris*), water pepper (*Persicaria hydropiper*) and sedge (*Carex* sp.) which may have grown in shallow water or wet marginal land as the alluvium built up.

Sample {7} was taken from the transition between the clay deposit [12] and the overlying, coarser-grained deposit [11]. Small wood and root fragments were again common, and a much larger seed assemblage was present. A wider range of aquatic and wetland plants was represented than in the previous sample, and dry-ground taxa such as self-heal (*Prunella vulgaris*), dandelion (*Taraxacum* sp.) and buttercups (*Ranunculus acris/bulbosus/repens*) suggested the presence of grassy places nearby.

Wood fragments, several large enough for species identification if required, dominated sample [11]{6} from the coarse, bedload deposit. Buds and seed capsules of willow (*Salix* sp.), leaf fragments and occasional thorns also indicate that trees and scrub grew on the river banks during the late medieval or post-medieval periods. A large and diverse seed assemblage included similar environmental indicators to that from sample {7}, with the majority of taxa from aquatic/wetland plants and grassy places. Very many mollusc shells were also present in this sample.

A much smaller plant assemblage from the overlying alluvial clay layer [10]{5} again suggested shallow water and wet conditions, with grassland, although the amount of wood was very much reduced and no other evidence was seen for trees or shrubs. While this might suggest clearance of the river banks, the small assemblage may result from partial drying of the deposit at some time, leading to partial decomposition of organic remains. This may be supported by the lack of any plant remains in sample {4} from the same deposit.

The overlying sandy alluvium [9]{3}, thought to represent a further channel bed, again produced a relatively small, though quite diverse plant assemblage. While taxa such as water-plantain (*Alisma* sp.), fool's watercress (*Apium nodiflorum*) and water pepper (*Persicaria hydropiper*) represent plants from the banks and river's edge, seeds from plants of disturbed ground and grassy places close to the river were also present. Some wood fragments and occasional seeds

of bramble (*Rubus cf. fruticosus*) and elder (*Sambucus nigra*) suggest that at least some woody plants survived in the vicinity.

No plant remains survived in samples {1} and {2} from channel fill [8], presumably due to drying of the deposits.

Invertebrate remains, in the form of insect exoskeleton fragments, were moderately abundant in sample {7}, and also noted in {8}, {6}, {5} and {3}. Shells of freshwater and/or terrestrial molluscs were seen in all samples except {1}, but in {2} and {4} were simply in the form of small fragments. Quite large numbers of shells were present in {7}, {6} and {3}, and several in {8} and {5}. Some ostracods were seen in {7} and {3}.

Samples {3}, {5} and {9} produced only very small assemblages, the majority of which will have been recorded at the evaluation stage. The remaining three samples ({6}, {7} and {8}) from [11] and [12] contained relatively large plant assemblages whose further study would contribute to the reconstruction of the environment at the time of deposition, and assist in the interpretation of the site. Study of the insects from the same samples would add additional information about the environment of the site and its surroundings.

6.5 The Molluscs

Alan Pipe

6.5.1 Introduction and methodology

Wet-sieving and flotation of bulk samples from XSK10 produced diverse assemblages of terrestrial and freshwater mollusc species from the 'flot' fractions of five samples; [9] {3}, [10] {5}, [11] {6}, [11/12] {7} and [12] {8} (Fig 3). Preliminary identifications were made in an attempt to establish general faunal composition of each of these sample groups and to determine the potential for further identification to species level in order to provide ecological information on local habitats and conditions. Preliminary identification followed Cameron & Redfern 1976; and Macan 1977. Preliminary interpretation followed Kerney 1999. This short report summarises the molluscan faunas for each sample in terms of the number of identifiable species present, although identification to species or genus level was only done when the remains were particularly visually distinctive. Table 1 shows all identified and potentially identifiable species for each sample.

6.5.2 The fauna

Samples [9] {3}, [10] {5}, [11] {6}, [11]/[12] {7} and [12] {8} produced a diverse invertebrate fauna composed entirely of molluscs, particularly freshwater bivalves and snails; with a much smaller and somewhat less diverse assemblage of terrestrial snails.

Terrestrial molluscs provided less than 10% of the shell count and derived from two main snail groups; wetland (including amphibious) snails and true terrestrial species of moist, sheltered conditions; all the identified species are widely-distributed in suitable habitats throughout S E England. Marsh whorl snail *Vertigo antivertigo* is a terrestrial mollusc abundant and widespread in moist, sheltered habitats throughout southern Britain (Kerney 1990, 143-6); it is a lowland wetland species mainly avoiding places with marked fluctuations in water level (Kerney 1990, 92). Amber snails in the family Succineidae are widespread wetland species found in damp, sheltered conditions throughout lowland Britain; they are virtually amphibious and able to tolerate long periods of submersion (Kerney 1990, 75-9). Shiny glass snail *Zonitoides nitidus* is a characteristic wetland species typically found on emergent vegetation at the edges of rivers. It is virtually amphibious and can survive long periods of flooding (Kerney 1990, 148). Herald or sedge snail *Carychium minimum* occurs in wet places generally; it is virtually amphibious and

can survive prolonged winter flooding (Kerney 1990, 44). The 'true' terrestrial snail fauna includes glass snail *Oxychilus sp*, slender herald *Carychium tridentatum*, moss snail *Cochlicopa sp* and rounded or radiated snail *Discus rotundatus* all of which are widely-distributed species abundant in moist, sheltered situations throughout SE England.

Freshwater species provided the bulk, at least 90%, of the, of the mollusc shell count. The assemblage included at least two species of bivalve, probably pea shell *Pisidium sp*, common valve snail *Valvata piscinalis*, flat valve snail *Valvata cristata*; at least five species of ram's-horn snail Planorbidae including keeled ram's-horn *Planorbis carinatus*, twisted ram's-horn *Bathyomphalos contortus*, button or white-lipped ram's-horn *Anisus leucostoma* and whirlpool ram's-horn *Anisus vortex*, at least two species of pond snails Lymnaeidae including common or wandering pond snail *Lymnaea peregra*; common bithynia *Bithynia tentaculata*, Leach's bithynia *Bithynia leachii* and river nerite *Theodoxus fluviatilis*. All the identified freshwater snail species are common in still and slow-flowing, calcium-rich waters throughout SE England, although both the Planorbidae and Lymnaeidae show considerable *inter*-specific differences in terms of their ecological requirements, particularly vegetation, water quality and substrate. In contrast, common/wandering pond snail is ubiquitous in freshwater habitats of all kinds (Kerney 1990, 56).

The continued zoological sampling of deposits during further works at Pudding Mill Lane will help to interpret the local environmental conditions and how they have changed through time.

6.5.3 Recommendations

The good preservation of organic remains, both flora and fauna, in many of the samples indicates that further sampling of natural and anthropogenic deposits should be undertaken in any further excavations on the site. Analysis of these will enable a picture to be built up of the changing environment on the site, and possibly also of human activities taking place in the neighbourhood.

6.5.4 Bibliography

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6.5.5 Table

Table 1 Wet-sieved/floated mollusc shell from XSK10/preliminary identifications

CONTEXT	COMMON NAME	[9]	[10]	[11]	[11]/[12]	[12]	HABITAT
SAMPLE		{3}	{5}	{6}	{7}	{8}	
TERRESTRIAL							
<i>Discus rotundatus</i>	rounded/radiated snail	x		x	x	x	moist/sheltered



<i>Zonitoides nitidus</i>	shiny glass snail	x		x			wetland/amphibious
<i>Carychium minimum</i>	herald/sedge snail		x				wetland/amphibious
<i>Carychium tridentatum</i>	slender herald snail			x	x		moist/sheltered
<i>Oxychilus sp.</i>	glass snail		x	x	x		moist/sheltered
<i>Vertigo antivertigo</i>	marsh whorl snail		x				wetland
<i>Cochlicopa sp.</i>	moss snail			x			moist/sheltered
Succineidae	amber snail				x		wetland/amphibious
FRESHWATER							
bivalve species 1		x	x	x	x		freshwater
bivalve species 2				x	x		freshwater
Lymnaeidae	pond snails	x			x		freshwater
<i>Lymnaea peregra</i>	common/wandering pond snail			x			freshwater/ubiquitous
<i>Valvata piscinalis</i>	common valve snail	x		x	x		slow-flowing/still/muddy
<i>Valvata cristata</i>	flat valve snail		x		x		slow-flowing/still/muddy/oxygenated
Planorbidae	ram's-horn snails	x	x	x	x	x	freshwater
<i>Planorbis carinatus</i>	keeled ram's-horn	x		x	x	x	slow-flowing/still/vegetated
<i>Bathyomphalos contortus</i>	twisted ram's-horn	x		x			slow-flowing/still
<i>Anisus leucostoma</i>	button/white-lipped ram's-horn	x		x	x		slow-flowing/still
<i>Anisus vortex</i>	whirlpool ram's-horn			x			slow-flowing/oxygenated
<i>Bithynia tentaculata</i>	common bithynia	x	x	x	x	x	slow-flowing/oxygenated
<i>Bithynia leachii</i>	Leach's bithynia			x			slow-flowing/oxygenated
<i>Theodoxus fluviatilis</i>	river nerite	x		x			flowing/oxygenated

x PRESENT IN SAMPLE

6.6 Animal Bone

Alan Pipe

6.6.1 Introduction and methodology

This report quantifies, identifies and interprets the animal bone recovered from hand-collected context [60] at XSK10. All recovered animal bones were washed, air-dried and then bagged and labelled as a context group.

Each animal bone fragment from context [60] was then described and recorded directly onto the MOLA animal bone post-assessment Oracle database in terms of species, skeletal element, body side, age, epiphysial fusion, dental eruption and wear, sex, fragmentation, modification and measurement of fully-fused bones. Species and skeletal element were determined using the MOLA animal bone reference collection together with Schmid 1972. Evidence for age at death was derived from epiphysial fusion (Schmid 1972) and dental eruption and wear (Amorosi 1989). Fully-fused limb long bones were measured following Driesch, von den 1976. Estimated statures as withers ('shoulder') heights were calculated from measurements of complete fully fused limb long bones following von den Driesch and Boessneck 1974. The complete sitecode assemblage record is held on the Oracle post-assessment database for reference and possible future analysis with respect to available stratigraphic data.

6.6.2 Preservation and quantification (Table 2)

A total of 31 hand-collected fragments, two archive boxes, approximately 7.500 kg, of well-preserved animal bone were recorded from context [60]. Maximum fragment size exceeded 75 mm with most of the bones in very good surface condition and all surface detail easily visible.

6.6.3 The fauna (Table 2)

This small but very well-preserved assemblage indicates waste from two sources; butchery or post-consumption waste from a single right-side tibia (lower hind-leg/shin) of adult ox (cattle) *Bos taurus* and 30 bones, probably a partially-complete skeleton, of an adult horse *Equus caballus*. There was no recovery of poultry, sheep/goat, pig or any other domesticates; there was no recovery of fish, amphibians, poultry, scavengers, commensal species or 'game'. There was no recovery of foetal, neonate, infant or juvenile animals.

The horse group derived from elements of the head (mandibles), upper (scapula and humerus) and lower (radius/ulna) fore-leg, fore-foot (metacarpal), upper (innominate and femur) and lower (tibia) hind-leg and hind-foot (metatarsal); measurement and body side of each element suggest that all may derive from the same animal. Stature estimates range from 1.330 metres (right metacarpal) to 1.367 metres (left metatarsal) with a mean value from nine measured bones of 1.353 metres, very closely comparable to the median value for medieval horses calculated from London archaeological sites (Rackham 1995, 170) and equivalent to a modern riding pony.

There was no evidence for *ante-* or *post-mortem* modification with complete absence of tool marks, burning, gnawing or pathological change and therefore no potential for interpretation of cause of death.

6.6.4 Bibliography

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Table 2 Hand-collected animal bone

CONTEXT	SPECIES	BONE	AGE	BODY SIDE	FUSION (P/A)	FUSION (D/P)	AGE (years)	ESTIMATED STATURE (m)	NO
60	cattle	tibia		right		fused	>2.0		1
60	horse	femur	adult	right	fused	fused	>3.5	1.355	1
60	horse	humerus	adult	left	fused	fused	>3.5	1.363	1
60	horse	humerus	adult	right	fused		>3.5		1
60	horse	innominate	adult	both	fused	fused			2
60	horse	mandible	adult	left					1
60	horse	mandible	adult	right					1
60	horse	metacarpal	adult	left	fused	fused	>1.0	1.333	1
60	horse	metacarpal	adult	right	fused	fused	>1.0	1.33	1
60	horse	metatarsal	adult	left	fused	fused	>1.0	1.367	1
60	horse	metatarsal	adult	right	fused	fused	>1.0	1.364	1
60	horse	radius/ulna	adult	right	fused	fused	>3.5	1.343	1
60	horse	rib	adult						14
60	horse	sacrum	adult		fused	unfused			1
60	horse	scapula	adult	left	fused	fused			1
60	horse	tibia	adult	left	fused	fused	>3.5	1.36	1
60	horse	tibia	adult	right	fused	fused	>3.5	1.36	1
TOTAL									31

6.7 Building Materials

Ian M. Betts

Six fragments of building material were recovered from XSK10 (context [60]). These comprise five peg roofing tiles and a brick. The building material from XSK10 has been fully recorded and the information added to the Oracle database.

6.7.1 Discussion

One thin fragment of abraded peg roofing tile may be of medieval date (fabric 2586). The other four fragments of peg tile, one of which has a round peg/nail hole, are of 1480–1800 date. The brick is overfired and dark brown in colour which makes identification of the fabric slightly difficult, although it is probably type 3046. Its size (? X 100 x 52–57mm) suggests it is of 1500–1666 date.

All the building material from XSK10 was probably made at production sites in or close to London. All the form and fabric types are common on other London urban sites.

6.8 Pottery

Lyn Blackmore

The medieval and later pottery from this targeted intervention yielded seven sherds of pottery from up to four vessels in contexts [10], [30] and [60], with the large joining fragments in [10] representing the better preserved material. Both [10] and [60] yielded cheam redware pottery dated 1480–1550 with [30] containing Saxo-Norman material which therefore provides the earliest dated recorded landuse.

6.9 Metal finds

Michael Marshall

6.9.1 Introduction and discussion

A small assemblage of finds was recovered and examined and recorded in accordance with standard MOLA procedures. All are made of iron and they comprise 1 accession <1>, [60] and three bulk nails from the same context. The finds are all essentially undiagnostic and require no further work and merit no publication. The dating is of insufficient precision to contribute in any major way to our understanding of the site providing only an Iron Age *terminus post quem* and a likely *terminus ante quem* of the mid 1800s based on the form of the nails.

<1>, [60] is badly corroded and flaking. It superficially appears to be a horseshoe but the accidental flaking away of large fragments of corrosion during examination suggests that it is unperforated. Firm identification without x-ray to show any perforations for mounting is impossible but it is most likely a U or oval shaped washer or piece of bracing, probably a structural fitting. Similar fittings are quite common in the medieval and post medieval period but this example is insufficiently well preserved for further identification.

Three iron nails also came from context [60]. All are square sectioned. One is a robust example with a domed head with hammer facets, broken across the shaft. The others are finer. One retains a sub square head and has a probable extraction curve to the shaft. These are all

wrought nails which may imply a date preceding the widespread adoption of drawn nails in the mid 19th century (Hume 1969, 253-4; Adams 2002) but this cannot be regarded as precise form of dating with such a small assemblage.

6.9.2 References

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Hume, I.N. 1969, *A guide to the artefacts of Colonial America* Penn

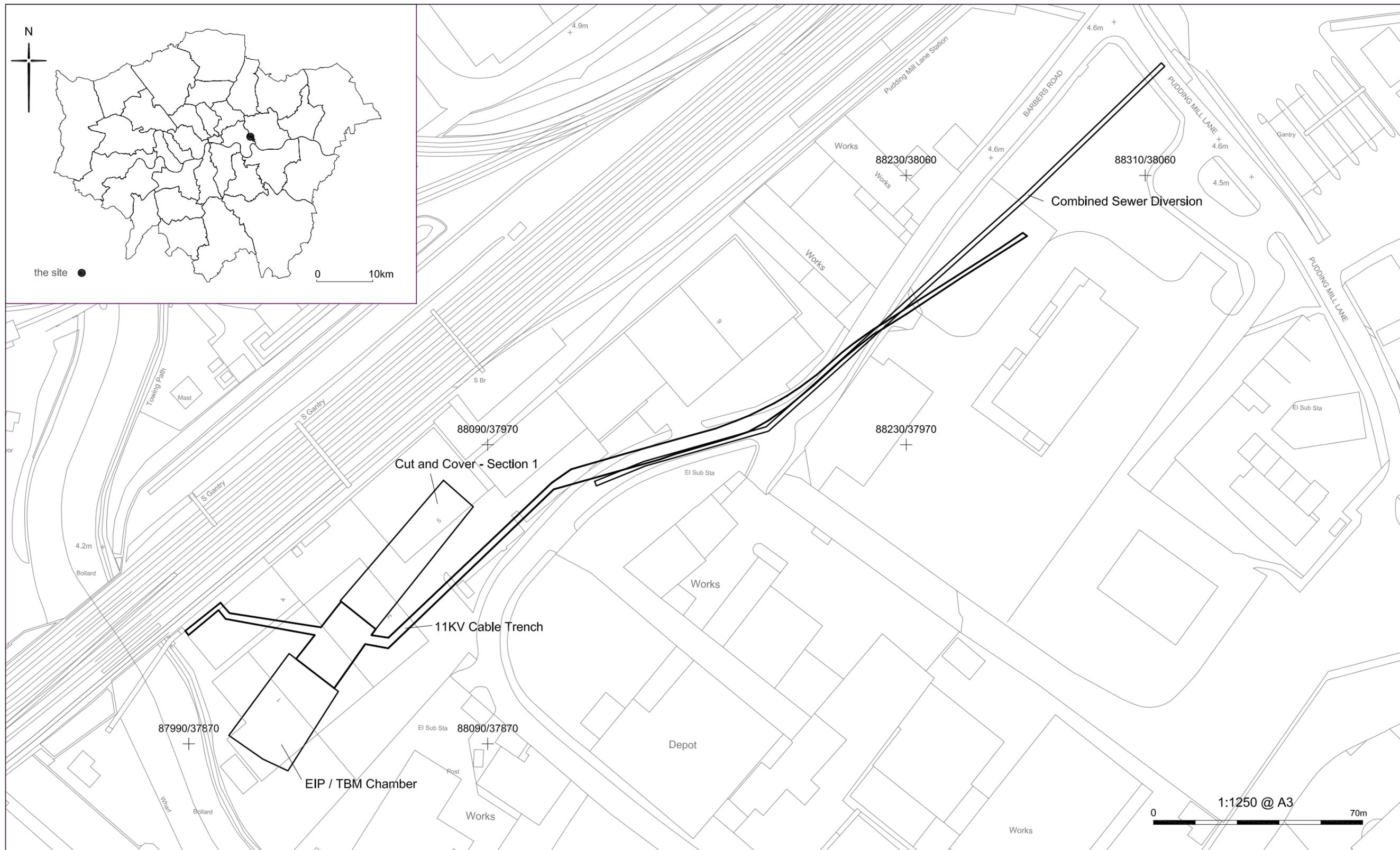


Fig 1: Watching Brief Trench Location

Site code: XSK10

Figure type: Interim report

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Type of fieldwork:

Excavation and Targeted Watching Brief

Site Address:

Crossrail: EIP/TBM Chamber, Cut and Cover Section 1, 11KV Cable Trench and Combined Sewer Diversion, Crossrail Pudding Mill Lane Site, Barbers Road, London E15 2PE

 Trench edge / Watching brief areas

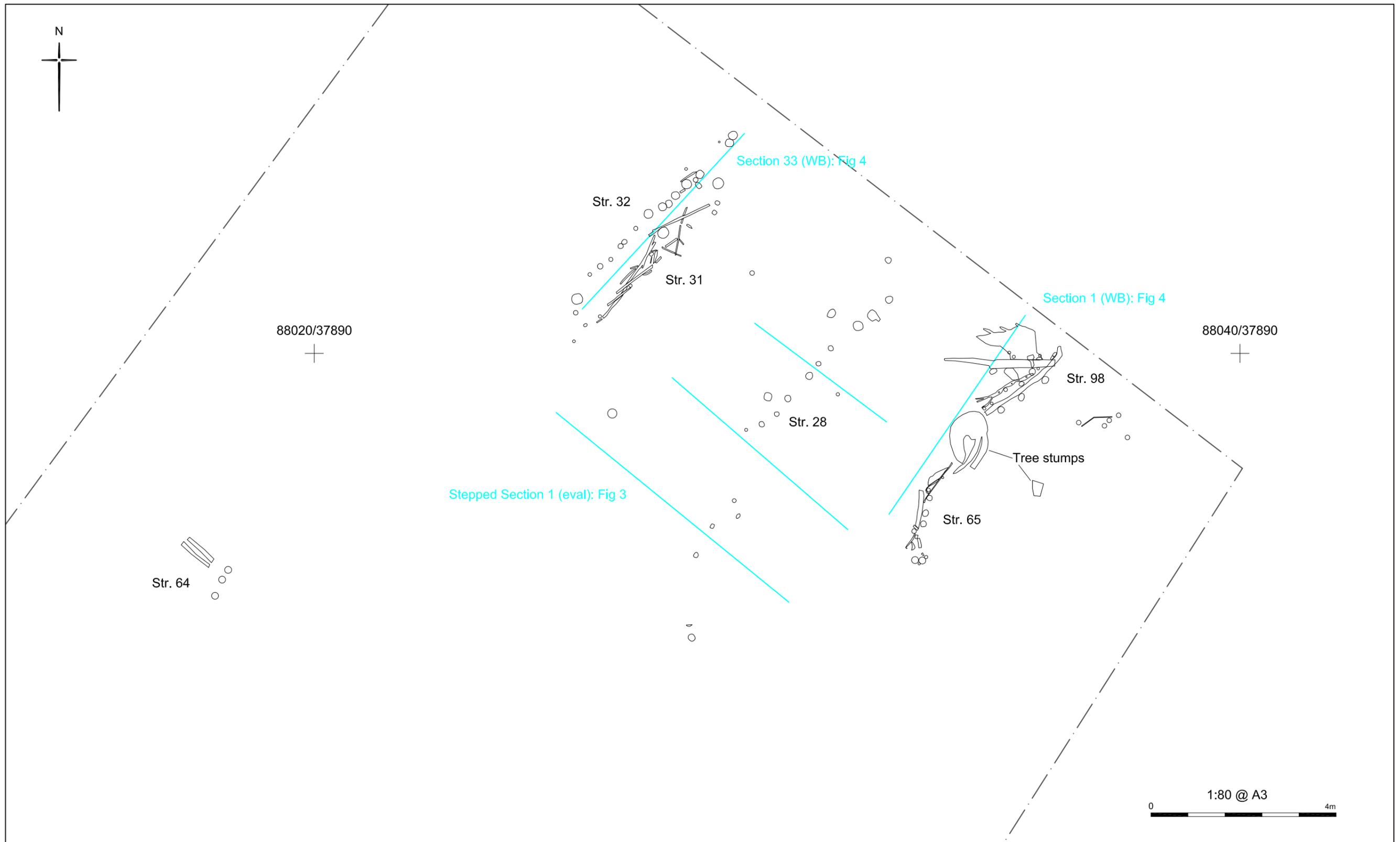


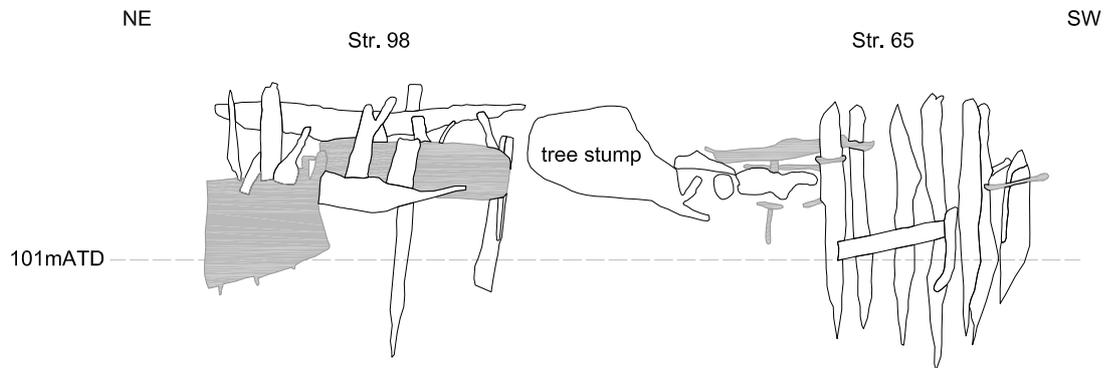
Fig 2: Plan of EIP/TBM trench, showing archaeological timbers
 Site code: XSK10
 Figure type: Interim report

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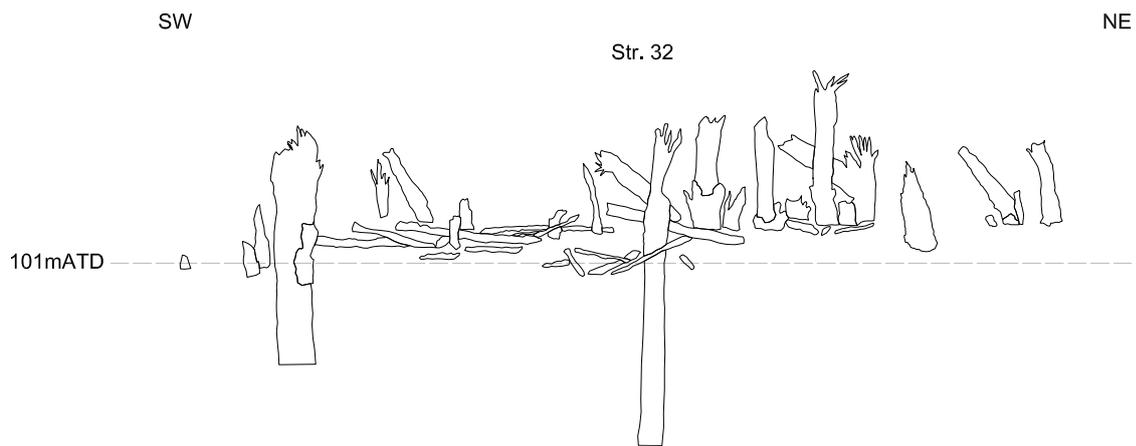
Type of fieldwork:
 Excavation and Targeted Watching Brief

Site Address:
 Crossrail: EIP/TBM Chamber, Cut and Cover Section 1, 11KV Cable Trench and Combined Sewer Diversion, Crossrail Pudding Mill Lane Site, Barbers Road, London E15 2PE

-  Trench edge / watching brief area
-  Archaeological features showing structure number
-  Section / elevation location



Section 1 (Watching Brief)



Section 33 (Watching Brief)

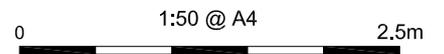


Fig 4: WB sections 1 and 33
Site code: XSK10
Figure type: Interim report

Type of fieldwork:
Excavation and Targeted Watching Brief
Site Address:
Crossrail: EIP/TBM Chamber, Cut and Cover Section 1,
11KV Cable Trench and Combined Sewer Diversion
Pudding Mill Lane, London

-  Archaeological timbers
-  Archaeological wattle
-  102mATD — Level of elevation (for heights in mOD, subtract 100m)

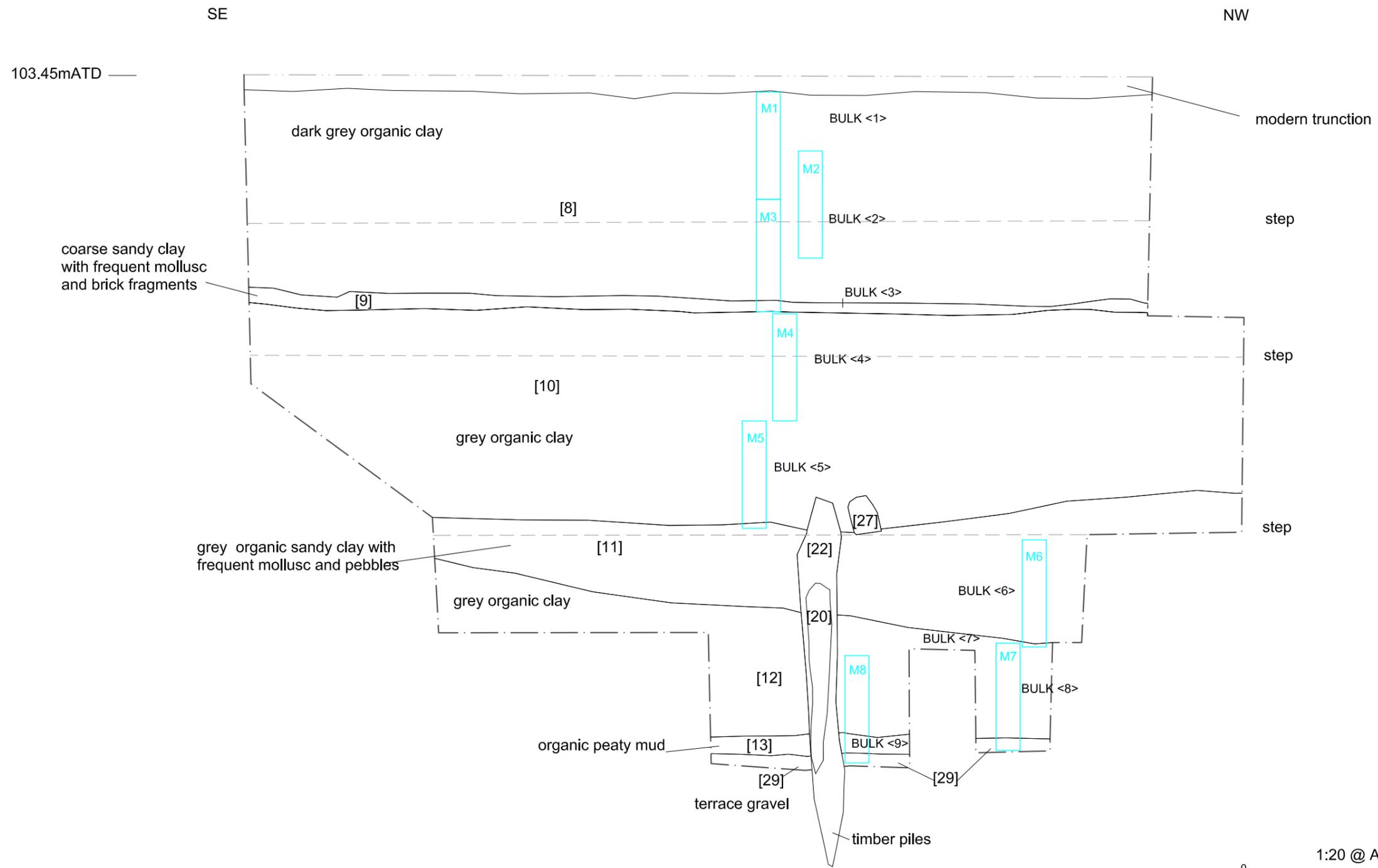


Fig 3: Evaluation section 1
 Site code: XSK10
 Figure type: Interim report

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Type of fieldwork:
 Excavation and Targeted Watching Brief

Site Address:
 Crossrail: EIP/TBM Chamber, Cut and Cover Section 1, 11KV Cable Trench and Combined Sewer Diversion, Crossrail Pudding Mill Lane Site, Barbers Road, London E15 2PE

-  Limit of excavation
-  Step of trench edge
-  Monolith tin sample
-  Archaeological features
-  Bulk sample
-  Level of elevation (for heights in mOD, subtract 100m)