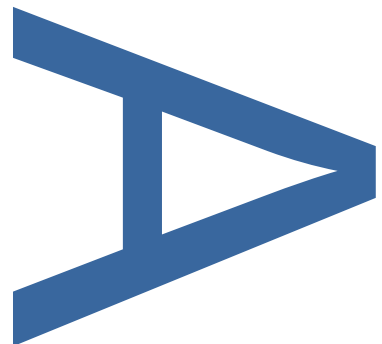
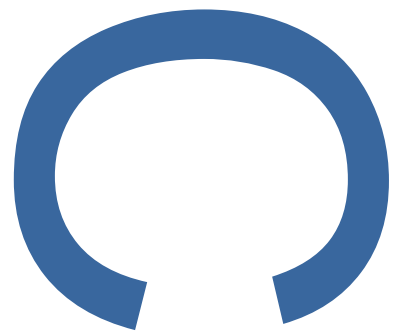


**ASSESSMENT REPORT ON THE  
HISTORIC BUILDING RECORDING  
OF THE WARDROBE TOWER,  
HM TOWER OF LONDON,  
LONDON BOROUGH OF TOWER  
HAMLETS**



**SITE CODE: TOL 164**

**PCA REPORT NO: R13071**

**NOVEMBER 2017**

**PRE-CONSTRUCT ARCHAEOLOGY**

# **Assessment Report on the Historic Building Recording of the Wardrobe Tower, HM Tower of London, London Borough of Tower Hamlets**

**Site Code:** ToL 164

**Central Ordnance Survey NGR:** TQ 33648 80517

**Commissioning Client:** Historic Royal Palaces

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## DOCUMENT VERIFICATION

### Site Name

Wardrobe Tower,  
HM Tower of London,  
London Borough of Tower Hamlets

### Type of project

Assessment Report on the Historic Building Recording

#### Quality Control

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## 1 NON-TECHNICAL SUMMARY

- 1.1.1 Pre-Construct Archaeology was commissioned by Historic Royal Palaces to undertake building recording of the Wardrobe Tower, HM Tower of London. The Tower of London is a Scheduled Monument, a UNESCO World Heritage Site and lies in a Conservation Area. The Wardrobe Tower is of exceptional significance as a surviving fragment of a D-shaped medieval tower, incorporating the base of a Roman bastion and an adjacent section of the Roman City Wall. The upper part of the tower was demolished in the late 19th century. The recording before and during conservation was carried out in 2017 as a condition of Scheduled Monument Consent.
- 1.1.2 Fabric analysis of the Roman City Wall identified it as a single build consisting of hard Kentish Ragstone in an *opus caementatum* black pebble mortar. Tile bonding courses were arranged in groups of three, consisting of Lydian sized bricks of two fabrics: common 2<sup>nd</sup> century red Roman sandy fabric and distinctive yellow Eccles fabric manufactured in East Kent (AD50-80). As well as squared Kentish Ragstone facing blocks, Carrstone, Barnack Stone and Weldon Stone were identified in the plinth. The recording established that much more of the Roman bastion fabric survives within the Wardrobe Tower than had previously been thought. It was identified at the base of the outer and inner elevations of the Wardrobe Tower.
- 1.1.3 The medieval Wardrobe Tower was built on top of the foundations of the Roman bastion in the 1190s. The outer south-east elevation has two distinct medieval elements: an area of small *Petit Appareil* blocks of Kentish Ragstone and two ashlar piers of Reigate Stone, Caen Stone, Quarr Stone, all common medieval stone types supplemented by larger monumental blocks of Calcaire Grossier. The latter is a French Ditropan Limestone and was possibly reused from a monumental Roman building or structure. Large blocks in Calcaire Grossier are extremely rare in the British Isles.
- 1.1.4 Tudor/Stuart bricks in the inner elevations of the Wardrobe Tower show that it underwent change and repair in the early post-medieval period. A Tudor/Stuart red brick curved feature at the base of these elevations is thought to have formed part of a flue for a fireplace given that so much of the brick is vitrified, with the upper sections perhaps consisting of sections of chimney.
- 1.1.5 In 1879 John Taylor demolished most of the 12<sup>th</sup> century Wardrobe Tower. Work was stopped in time to salvage the fragment of the structure that survives today. Following the demolition, the newly exposed remains of the Wardrobe Tower underwent wholesale stone repair and re-pointing using hard fragments of Kentish Ragstone and hard gravel flint cement.
- 1.1.6 A proposal to publish this work is recommended as an article in *LAMAS* (London and Middlesex Archaeological Society's journal) or *Britannia* including the results of unpublished excavations from this area of the Tower of London incorporated by George Roberts (formerly HRP).

## 2 INTRODUCTION

### 2.1 Background

2.1.1 Pre-Construct Archaeology Limited (PCA) was commissioned by Historic Royal Palaces (HRP) to undertake historic building recording (including petrographic survey) and historic building recording watching brief at the Wardrobe Tower and adjacent section of the Roman City Wall, HM Tower of London, London Borough of Tower Hamlets (**Figures 1 and 2**). The building recording was carried out intermittently from 18<sup>th</sup> January 2017 to 15<sup>th</sup> April 2017 before and during conservation works on these structures in accordance with a Brief (Roberts, 2016) and Written Scheme of Investigation (Matthews, 2016).

2.1.2 The Tower of London is a Scheduled Monument (Greater London SM No 10) and a UNESCO World Heritage Site (No 488). The Wardrobe Tower lies within the boundaries of these designations. Designations of this level recognise that the Tower of London and its buildings are of international significance. The Tower of London also lies in the Tower of London Conservation Area. The D-shaped Wardrobe Tower is of exceptional significance because as well as being an important surviving remnant of one of the earliest medieval building programmes associated with the Tower of London (AD 1196), it has at its base a surviving brick and *opus signinum* foundation of Roman Bastion B1 (RCHM 1928). Furthermore, the adjacent wall is a substantial 6m long by 2.1m wide surviving section of the north-south Roman defensive Town wall for *Londinium*.

2.1.3 The Scheduled Monument description of the Tower of London includes the Wardrobe Tower as follows:

‘The open areas of the Tower of London, between the fortifications, are known as the Inmost Ward, Inner Ward and Outer Ward. The Inmost Ward relates to William I’s primary castle and was originally a bailey surrounding the keep. The walls of this bailey were partly altered or replaced in the 12th century. It includes the Wardrobe Tower, Main Guard Wall and Coldharbour Gate. The area is defined by the line of the Roman city wall on the east side, inner curtain on the south, Main Guard Wall on the west and previously would have extended north of the White Tower to a ditched defence. The Wardrobe Tower is to the east of the White Tower. It is the remains of a 12th century tower that was later surrounded by buildings of the Royal Wardrobe; hence its name. The tower was built in about the 1190’s under Richard I. The lower part incorporates the base of a Roman bastion and a section of London Wall with an external face of ragstone rubble and tile bonding courses. The tower is D-shaped in plan and built of ragstone rubble with Caen and Reigate ashlar and with additional repairs in 18th century red brick. The upper part of the tower was demolished in the late 19th century.’

2.1.4 Historic Royal Palaces, as custodian of the Tower, seek the agreement of Historic England regarding any repairs, improvements or alterations that may impact upon historic fabric. Scheduled Monument Consent has been granted by Historic England for the conservation work. The recording was carried out before and during conservation as

a condition of this consent.

## **2.2 Site Location**

2.2.1 The Wardrobe Tower is located at Ordnance Survey National Grid Reference TQ 33648 80517 (**Figures 1 and 2**). It lies just 50m east from the south-east corner of the White Tower in the Inner Precinct of the Tower (**Figure 2**).

### **3 METHODOLOGY**

#### **3.1 Aims and Objectives**

3.1.1 The aim of the project as set out in the Brief for historic building recording and watching brief (Roberts 2016) was to record the areas of the external fabric before and during the conservation project.

3.1.2 The objectives of the project as set out in the Brief were as follows:

- To record all areas of the external fabric of the Wardrobe Tower before and during conservation work
- To augment Historic Royal Palace's photogrammetric elevations record of the Wardrobe Tower with the results of the petrographic and mortar analysis, correcting any inaccurate or missing details in the survey
- To mark up and record on the photogrammetry any significant features and building phase changes.
- To carry out a full stone-by-stone petrographic survey of all external elevations and mark up results on the photogrammetry.
- To record changes in mortar-type, and to identify the need for, and location of, suitable areas for mortar analysis to assist with understanding the sequence of building material.
- To digitise the results for the recording and petrographic analysis, and provide a phased, context-based, interpretation of the results, which will help inform the conservation works.
- To carry out the above tasks to the standard of a Level 3 survey (Historic England 2016)
- As necessary, to provide a well-informed watching brief service during the conservation works.

3.1.3 The research questions of the project as set out in the Brief were as follows:

- What evidence, if any, is there for the surviving Roman bastion remains?
- Was Wheeler correct that the Wardrobe Tower is on the site of a Roman Bastion?
- How much, if any of the original city wall survives in the lower courses of the Wardrobe Tower?
- Is there any evidence for how the Wardrobe Tower was connected to the now lost buildings which it used to adjoin – the eastern annex of the White Tower, the Horse Armoury and the Tudor-era Wardrobe building?

#### **3.2 Documentary Research**

3.2.1 The historical background detailed in the statement of significance (Ateeq & Roberts



2017) has been repeated in this report with some additional research using material provided by HRP.

### **3.3 On-Site Recording**

#### ***Photographic Survey***

3.3.1 Prior to the erection of the scaffolding for the conservation work, digital photographs were taken by the Pre-Construct Archaeology photographer as an aid to later interpretations and to record the condition of the wall prior to conservation work.

3.3.2 During conservation work, close up digital photographs of the stone-types, areas of mortar and stone were taken by the Pre-Construct Archaeology building material specialist.

#### ***Petrographic Survey***

3.3.3 An initial assessment of the walls prior to the erection of scaffolding provided a wider understanding and appreciation of patterns within the stonework.

3.3.4 A more detailed and comprehensive stone-by-stone petrographic survey and historical analysis of the structure was undertaken from the scaffold platform. Full photogrammetric elevations of the masonry supplied by HRP were annotated, with missing or inaccurate detail filled in or corrected. Identifiable building phases or significant features were recorded. Emphasis was placed on the identification of the Roman, medieval and early post-medieval elements. Areas identified as 19<sup>th</sup> or 20<sup>th</sup> century rebuilding were also recorded including identifiable building phases but not at the same level of detail. All stone types, ceramic building materials and mortar present in the external elevations of the Wardrobe Tower were recorded. Identification of the *in-situ* fabric was conducted using a Gowlland x10 magnification hand lens by Dr Kevin Hayward, PCA's petrologist.

3.3.5 The analytical and petrographic survey of the fabric was in accordance with the standards of a Level 3 survey (Historic England 2016) and of the same nature as that commissioned by the Devereux Tower project (2009), the Bowyer Tower and Inner Curtin Wall Project (2013), the Develin Tower (2014), the Bell Tower (2015) and the Well Tower (2016).

#### ***Ceramic Building Material Analysis***

3.3.6 Bricks were analysed using the system of ceramic building material classification used in archaeological work in Greater London. Each fabric number (e.g. fabric 3031) specifies the composition, form, approximate method of manufacture and date range of the material. Examples of the brick fabrics can be found in the archives of the Museum of London and PCA. The ceramic building material types are described in Appendix 1.

#### ***Stone Identification***

3.3.7 Detailed stone-by-stone geological identification of the stone was undertaken. During the conservation work, two samples of stone were removed from the medieval fabric for hand specimen comparative analysis under the binocular microscope. It has been shown from previous conservation projects that detailed visual analysis of stone type and geological

source can support phased analysis, particularly as certain rock types were used in certain archaeological and historical periods. **Figures 11, 13 to 17** show the identification of stone types within the elevations of the Wardrobe Tower. The stone types are described in Appendix 1.

#### *Mortar Analysis*

3.3.8 Different types of facing and bedding mortars were identified from the scaffolding and marked on the photogrammetric elevations (**Figures 12 to 17**). During conservation work, three samples of bedding mortar were removed from the medieval and early post-medieval fabric for hand specimen comparative analysis under the binocular microscope (**Figures 12 and 15; Plates 24 and 25**; mortar samples 1 to 3). It has been shown from previous conservation projects that detailed visual analysis of mortar colour, fabric and inclusions support analysis of phases of development. Mortar types are described in Appendix 2.

### **3.4 Project Archive**

3.4.1 The project archive is currently held at the offices of Pre-Construct Archaeology Limited in Brockley, London, under the site code ToL 164. It is anticipated that the archive (copies of the report, drawings and photographs) will be lodged in the Historic Royal Palaces permanent archaeological stores at Hampton Court Palace in due course.

### **3.5 Guidance**

3.5.1 All works were undertaken in accordance with standards set out in:

- Historic England (2016) *Understanding Historic Buildings: A Guide to Good Recording Practice*
- ClfA (2014) *Standard and guidance for the archaeological investigation and recording of standing buildings or structures*
- Historic England (2015) *Greater London Archaeology Advisory Service: Guidelines for Archaeological Projects in Greater London.*

## **4 HISTORICAL AND ARCHAEOLOGICAL BACKGROUND**

### **4.1 Introduction**

4.1.1 The following introduction to the Tower of London is taken from the Brief (Roberts, 2016).

4.1.2 The building of the Tower of London was begun shortly after the Conquest by William the Conqueror, whose great keep, the 'White Tower', sits at its heart. The fortress was first constructed within the south-eastern corner of the ancient Roman city walls, along the riverbank of the Thames. Extended beyond the boundaries of the Roman city walls by Henry III, and developed as a concentric castle by Edward I in the 13th century, the Tower – the monarch's stronghold amidst an often hostile city – became the home of major State Institutions such as the Royal Mint, as well as the setting for nationally significant historical events. The Tower is the home of the Coronation Regalia and Crown Jewels, and the birthplace of the Royal Armouries Museum, which still displays part of its collection within the White Tower. The fortress is most strongly associated in the popular imagination with the Tudors, and the turbulent events of the 16th century, particularly with the many prisoners kept within its walls. The 19th century Romantic perception of the Tower, and the castle's emerging identity as a tourist attraction, led to the demolition of many institutional structures and the addition of new 'medieval' style neo-gothic buildings.

### **4.2 Historical Summary**

4.2.1 The following historical background to the Wardrobe Tower is taken from the Statement of Significance (Ateeq & Roberts 2017).

#### ***Roman***

4.2.2 The Wardrobe Tower is believed to have been built on the surviving foundations of one of the Roman bastions of the city wall and was connected to the south-east corner of the White Tower with a contemporary pilaster buttressed wall (Parnell, 1993; 23). This long-standing theory has been based on remnants of a Roman bastion along with existing fabric that shows the medieval building was erected on top of its Roman forbear (Keay, 2001; 42).

4.2.3 Wheeler designated the Wardrobe Tower as the location of Bastion 1 of the Roman city wall (**Figure 9**; RCHM 1928, 83). However, as Maloney (1980; 70) noted, it is a rare example of an eastern bastion, which is not solid above its foundations (Bastion 11 is the other exception).

#### ***Anglo-Saxon***

4.2.4 Renn's (2015; 228-229) claim that the Wardrobe Tower may have been an Anglo-Saxon chapel is unlikely due to the close proximity, and accepted pre-Norman origins of the Chapel of St Peter ad Vincula (Haslam, 1988).

#### ***Medieval***

4.2.5 Tatton-Brown (1991) has suggested that the Wardrobe Tower was constructed around the same time as Longchamp's Bell Tower, which is located south-west of the White

Tower circa 1190.

4.2.6 The function of the Wardrobe Tower to a certain extent is unclear. Though evidence is limited on this issue, the generally accepted and most feasible theory is that the Wardrobe Tower was used by the Royal Wardrobe as a store to house wardrobe goods. The constant movement of monarchs from palace to palace around the country is an old custom that meant that when monarchs travelled their advisors and servants along with all their belongings travelled with them. This included: 'jewels, ornaments, coined money, books, accounts, arms and armour, furniture' and food (Parnell, 1993). These extravagant and precious belongings were known as the wardrobe. To allow for more ease, efficiency and safety officials responsible for the wardrobe began to store these goods in buildings. As a result this led to the construction of purpose-built buildings with the specific objective to house wardrobe goods.

4.2.7 The Great Wardrobe was responsible for the 'bulk storage of durable goods' (*ibid.* 53). In 1253 the Great Wardrobe became independent in its own right when it gained independence from its parent organisation. In the mid fourteenth century the Great Wardrobe started to relocate from the Tower of London to grounds near Baynard's Castle to create more room at the Tower for 'military stores and records' (Ashbee, 2008; 153). A further divide in the organisation resulted in the establishment of the privy wardrobe at the Tower of London in July 1323, which became known as the arsenal branch (*ibid.* 153). In 1360 the Tower establishment broke all connections with privy wardrobe, including financial and administrative ties (Parnell, 1993; 53).

#### **Post-medieval**

4.2.8 In autumn 1523, carpenters provided a new roof for the Wardrobe Tower and brick layers restored the battlement (Keay, 2001; 42). In 1532-33 Henry VIII constructed a new timber-framed wardrobe building in preparation for Anne Boleyn's coronation. It measured 31 by 7m (101 by 24ft) and ran eastward from the Wardrobe Tower to the Broad Arrow Tower on the inner curtain wall (Parnell, 1993; 56). Also known as the Wardrobe Gallery, it may have replaced an earlier wardrobe storehouse in the same location (Clark, 1884; 220).

4.2.9 The construction of the Wardrobe building seems to have helped name the tower, as prior to this date the Wardrobe Tower appears not to have had a permanent name and was only identified in connection to other buildings in its immediate vicinity (Keay, 2001; 42). Its name as the 'Warderoap Tower' on Haiward and Gascoyne's plan of the Tower in 1597 (**Figure 3**) seems to have been the earliest reference to its name. The Wardrobe Tower labelled "Y" on the plan connected to the Broad Arrow Tower (labelled "L") with the Wardrobe building running between the two. The Haiward and Gascoyne's plan labels the Jewel House in front of the White Tower and the east annex to the White Tower with the Queen's Lodging's to the south.

4.2.10 In 1642 the Tower of London came under the control of Parliament and as a result the Great Wardrobe's status started to significantly decline (Impey, 2008; 180). In 1649, the

House of Commons passed an Act which stated that all the goods and assets of the king, queen and Prince of Wales were forfeit. This led to many of the Wardrobe buildings being left vacant (Impey, 2008; 180). In the 1650s, the eastern annexe of the White Tower was altered from a Wardrobe storehouse to provide gunpowder storage and proofing (Impey, 2008; 166). In spring 1670 the long building between the Wardrobe and Broad Arrow Tower was demolished (Impey, 2008; 184).

4.2.11 A clock turret was constructed between 1673-4 on top of the Wardrobe Tower at the south-east corner of the White Tower. The structure was faced with free-stone ashlar, was battlemented and capped with a cupola. It contained an extraordinary clock supplied by Thomas Tompion for £45 and was also furnished with sundials that were painted and gilded (Parnell, 1993; 67). The turret was demolished in 1715 after the Board declared that it was too narrow to carry cupola and therefore in danger of falling (*ibid.* 67).

4.2.12 Holcroft Blood's 1688 'birds-eye' view of the Tower of London (**Figure 4**) shows the Wardrobe Tower and clock turret at the south-east corner of the eastern annexe to the White Tower. This view shows that the western part of the Wardrobe buildings had been demolished and no longer joined the Wardrobe Tower. William Maitland's 1756 History and Survey of London (**Figure 5**) again appears to show the Wardrobe Tower and clock turret at the south-east corner of the eastern annexe to the White Tower.

#### ***Nineteenth Century***

4.2.13 In 1825 a new horse armoury was constructed against the south side of the White Tower (Parnell 1993). Part of the south end of the eastern annexe was transformed in 1851 to store armoury items (Impey, 2008; 213). The 1872-73 First Edition Ordnance Survey map (**Figure 6**) shows the White Tower with 'The Spanish Armoury' and 'Site of the Jewel House' to the south. The Wardrobe Tower is shown at the south-east corner of the eastern annexe with three flights of steps, one to the south and two to the north. The map has a label 'Site of Wardrobe Tower' just to the east with a further label 'Site of Wardrobe' to the east and immediately to the west of the Broad Arrow Tower.

4.2.14 A photograph of the White Tower taken in the 1870s (**Plate 1**) shows the Wardrobe Tower at the south-east corner of the three story eastern annexe. The Wardrobe Tower has a castellated parapet and the windows show that it had at least three storeys. The single storey horse armoury is shown to the south of the White Tower and also had a castellated parapet.

4.2.15 In 1876 expenditure of £1000 was approved to extend the displays of the historic armour over all floors of the eastern annexe. The work however was not undertaken. In preparation for the proposed renovation, the terrible structural condition of the annexe was recognised. The western wall was discovered to be in "a very dangerous state" and it was deemed essential that this be taken down, for health and safety reasons (Impey, 2008; 213).

4.2.16 In the 1870s there was an aggressive campaign at the Tower of London to demolish all the 'useless' contemporary annexes, which 'obscured' the older buildings (Compton,

1881, 279). The work was overseen by the Board of Works architect, John Taylor who in 1878 recommended that the entire eastern annexe of the White Tower should be removed in order to return the White Tower to 'its original condition' (**Plate 1**; Key and Harris, 2008; 213). Partial demolition of this annexe took place in 1879, which included the buttressed wall, storehouse and much of the annexe itself (*ibid.* 213). During the course of the demolition the remains of the medieval Wardrobe Tower were exposed, along with traces of the Roman city wall onto which it had been built.

4.2.17 On inspection by the Society of Antiquaries the base of the Wardrobe Tower was identified as Roman. It was semi-circular in shape, and hollow, containing rubble masonry 5ft high made of stone and broken Roman brick along with brown and red mortar (**Figure 7**; Loftus Brock, 1882; 130). The remaining twelfth-century buttressed wall was eventually demolished in 1883 (Key and Harris, 2008; 214). Lastly in 1885 the New Horse Armoury was entirely demolished, thus removing the last of the White Towers appendages (Key and Harris, 2008; 215).

4.2.18 The 1896 Second Edition Ordnance Survey map (**Figure 8**) shows the White Tower without its annexes. The New Horse Armoury to the south has been removed and the area is labelled 'Site of the Spanish Armoury' and 'Site of the Jewel House'. The eastern annexe to the White Tower has also gone and the curve of the Wardrobe Tower is labelled 'Wardrobe Tower (Remains of)'. The map labels the 'Site of Wardrobe' to the east and immediately to the west of the Broad Arrow Tower.

#### ***Twentieth Century***

4.2.19 In 1904 the Society of Antiquaries conducted further excavations to the south end of the remaining fragment of wall with the purpose of finding traces of the continuation of the wall towards the Thames, or where the angle of the wall was located but failed to find any further Roman remains (Norman and Reader, 1907; 239). Photographs taken in 1909 show the remains of the Wardrobe Tower covered in vegetation and surrounded by fencing (**Plates 2 to 5**).

4.2.20 In the mid-1950s, three sites were excavated at the Tower of London to present evidence on the defences of Roman London. The 1954 excavation took place at the north-east corner of the White Tower, where the foundation of the Roman City Wall was discovered 21ft 4in east of the White Tower (TOL 24). The 1955 excavations near the Lanthorn Tower revealed a length of 46ft of the wall, taking its line to a point 120ft south of the Wardrobe Tower (TOL 24). The 1956-7 excavation, which took place on the east side of the White Tower to the north of the Wardrobe Tower, revealed the foundations of the city wall and an internal turret (TOL 25; Butcher, c.1957/58b). Photographs of the Wardrobe Tower taken in 1954 and 1957 show the remains cleared of vegetation and eventually railings (**Plates 6 to 9**).

4.2.21 According to Parnell (1985; 33) the Wardrobe Tower was examined again in 1962 when a double course of broken tiles set in a hard pink coloured mortar was found, similar to that found in 1879.

## 5 DESCRIPTION

### 5.1 Introduction

5.1.1 Stone-by-stone photogrammetric drawings of the Wardrobe Tower and Roman city wall have been provided for the following sections and elevations (**Figures 11 to 17**):

Figure No.	Plate No.	Elevation
<b>Figures 11 and 12</b>	<b>Plates 10 to 18</b>	South section through the Roman city wall and south-east elevation of the Wardrobe Tower
<b>Figure 13</b>	<b>Plates 19 to 25</b>	North section through the Wardrobe Tower
<b>Figure 14</b>	<b>Plates 21 to 24 and 29</b>	Inner east elevation of the Wardrobe Tower
<b>Figure 15</b>	<b>Plates 19 to 25</b>	Inner south elevation of the Wardrobe Tower
<b>Figure 16</b>	<b>Plates 19, 20, and 26</b>	East elevation of the Roman City Wall
<b>Figure 17</b>	<b>Plates 10, 21, 27 to 29</b>	West elevation of the Roman city wall and west section through the Wardrobe Tower

### 5.2 Outer South-East Elevation of the Wardrobe Tower

5.2.1 The large (8m-long x 4.75m-high) curved external south-east elevation of the remains of the Wardrobe Tower (**Figures 11 and 12; Plates 11 to 18**) has elements of the Roman, medieval, Tudor-Stuart and post-1879 (Taylor) builds and repairs. This elevation includes a section through the north-south Roman City Wall at its west end.

#### ***South section through the Roman City Wall***

5.2.2 The section through the north-south Roman defensive city wall is preserved flush against the western end of the taller remains of the Wardrobe Tower (**Figure 11 and 12; Plates 11 and 12**). It had been incorporated into the Wardrobe Tower at the corner of the eastern annexe to the White Tower (**Plate 1**). Its width (2.15m – 7ft) is the same as many other sections of the perimeter Town Wall (Merrifield 1965). In height, only the basal 0.75m survives consisting of a rubble core of angular and flaggy fragments of very hard, sometimes cherty Kentish Ragstone in a distinctive extremely hard *opus caementatum* black pebble mortar (M2) with broken shelly fragments. This was the only mortar type that was found in this stretch of the Roman City Wall and was also found in both its east and west elevations (**Figures 12, 16 and 17**). This mortar type also survives in places in the basal sections of the Wardrobe Tower including its east and south inner elevations (**Figures 14 and 15**). This shows that parts of the medieval Wardrobe Tower were built on top of the relict foundation and base of the Roman bastion.

5.2.3 Three facing courses of complete Roman Lydian sized (1½ft x 1ft x 1½ inches – 400x290x36mm thick) rectangular brick in both the red sandy brick fabric 2452 (AD55-160) and yellow Eccles fabric 2454 (AD50-80) define the uppermost level of the surviving Roman City Wall (**Figures 11 and 17; Plates 11, 12, 27 to 29**). A further facing course is just visible at the base of the wall (**Figure 17; Plate 27**). At least six groups of three

lacing courses of in both Eccles and red sandy brick have been observed in the surviving 6m section of Roman City Wall by Tower Hill Station (Hayward pers. obs.).

#### **Roman Bastion**

5.2.4 A narrow (25cm) irregularly shaped linear (2m) section of broken red sandy Roman brick in fabric 2452 (AD55-160) is bonded in pink Roman concrete or *opus signinum* (M4) along the base and towards the eastern end of the south-east elevation (**Figures 11 and 12; Plates 17 and 18**). The size of some of the surviving brick fragments indicates that they were once rectangular Lydian bricks, similar to those used in the adjacent section of Roman City Wall. The presence of *in-situ* Roman brick and *opus signinum* corroborates Wheeler's observations (RHCM 1928, 99) that this is a surviving basal section of Roman bastion B1 (**Figure 9**).

5.2.5 Immediately above the brick and *opus signinum* section was a small (1m-long by 0.5m-high) area of surviving Roman "herring-bone" Kentish Ragstone walling that appears to have been truncated by medieval rubblestone and *Petit Appareil* walling above.

#### **Medieval Petit Appareil Wall**

5.2.6 Along the curved 4m-long external eastern half of the south-east elevation (**Figure 11**), the upper 3.5m consisted of tightly wedged micro-blocks of hard Kentish Ragstone, typically 5 inches long by 3 ½ inches deep in the *Petit Appareil* style of wall construction (**Plates 15a to 15c**; Allen 2010). This medieval construction style has been identified elsewhere in the Tower of London especially the late 13<sup>th</sup> century Outer Curtain Wall between the Develin Tower and the Well Tower (Hayward & Garwood 2015).

5.2.7 Other rock types are limited to occasional small rubble blocks of cemented London Clay or Septarian Nodule, Reigate Stone and Tufa. This combination of materials has only been identified together in the White Tower (Worssam & Sanderson 1998).

5.2.8 Relict *opus signinum* (M4) coating some of the Kentish Ragstone suggests that this material was recycled from Roman Bastion 1 (**Figure 12**).

5.2.9 A relict hard white gritty Render (R1) was noted on the face of about 20% of the Kentish Ragstone micro-blocks in the basal 1m of the *Petit Appareil* walling. This is likely to be a surviving whitewash. It has been found on the adjacent White Tower, on parts of the north-south medieval wall running north from the Well Tower (Hayward 2017), on the c.1190 Bell Tower (Hayward 2016) and on *Petit Appareil* blocks in the Outer Curtain Wall next to the Develin Tower (Hayward & Garwood 2015).

5.2.10 The bedding mortar consisted of soft white lime mortar (M3) associated with Tudor/Stuart bricks elsewhere in the Wardrobe Tower, whilst the face of the medieval wall was entirely repointed in grey flint gravel facing mortar (M1) of late 19<sup>th</sup> or early 20<sup>th</sup> century date.

#### **Medieval Ashlar**

5.2.11 Two surviving 4m high sections of medieval ashlar at the western end of the south-east elevation (**Figure 11; Plates 12 to 14**) are situated above an area at the base of the wall, some 1m high, of 19<sup>th</sup> century repaired Kentish Ragstone in a late 19<sup>th</sup> or early 20<sup>th</sup> century pebble mortar (M1).



- 5.2.12 Large (60x45x40cm) monumental blocks of Calcaire Grossier dominate the base of the projecting ashlar pier. This is a distinctive earthy brown limestone pitted with white Ditrupa worm casts from the Middle Eocene (Lutetian) of the Paris Basin. This rock had only previously been identified in Britain in large monumental blocks in the late 1st/early 2nd century Richborough Archway (Strong 1968; Hayward 2009), the Saxon Shore Fort at Reculver, Corinthian capital fragments and religious sculpture in the Neronian proto-palace at Fishbourne (Cunliffe 1971; Hayward 2009) and in Roman sculpture along the West Sussex coast (Black *et al.* 2012). It appears to represent Roman blocks from the 4th century Bastion that have been reused in the medieval Wardrobe Tower.
- 5.2.13 Above three metres, the pier is constructed of smaller ashlar blocks of green Reigate Stone and yellow Caen Stone, which are typical of 11<sup>th</sup> and 12<sup>th</sup> century construction at the Tower of London. The presence of a large Quarr Stone block from the Isle of Wight at a height of 3.5m above ground level is also indicative of 11<sup>th</sup> and 12<sup>th</sup> century construction, since its quarry ran out of suitable stone after the 12<sup>th</sup> century. This material is associated with construction of the c.1080-1090 building of the White Tower (Harris 2008). An ashlar block of Coombe Down Oolite, a banded shelly limestone from the South Cotswolds, is a rock type that is associated with Roman monumental architecture, sculpture and funerary monuments in London (Hayward 2009; 2015a). It may represent recycled funerary material from the adjacent eastern cemeteries, as is the case with monumental blocks found in the Tower Hill Roman Bastion (*ibid.*).
- 5.2.14 The ashlar section to the west of the pier is almost entirely built from smaller ashlar blocks of medieval Reigate Stone, with only the occasional Caen Stone and much smaller blocks of Calcaire Grossier.
- 5.2.15 A vertical pink–white brick at the base of the western ashlar section is of the same type as bricks found in the late 13<sup>th</sup> century Beauchamp Tower. This appears to represent a later medieval/early post-medieval repair using salvageable medieval material.
- 5.2.16 The little mortar that could be identified between the tightly wedged ashlar blocks of both sections resembled the Tudor/Stuart lime mortar with red brick fragments (M3) but samples were too small to confirm this with any certainty (**Figure 12**).
- 5.2.17 The presence of Portland Stone in both ashlar sections as well as post-medieval peg tile is indicative of later repairs. Portland Stone only became widely available from the late 17<sup>th</sup> and 18<sup>th</sup> century to the present day, whilst the common red sandy peg tile (fabric 2276) with fine moulding sand (1700-1900) could easily date to the Victorian period shortly after the time when the Wardrobe Tower was part demolished in 1879 and 1883.
- Remnant Tudor/Stuart Brickwork**
- 5.2.18 Red 50mm (2 inch) Henrician sized Tudor/Stuart bricks in a white lime mortar (M3) are visible at the base of the central section of south-east elevation (**Figures 11 and 12**). This mortar type with Tudor/Stuart brickwork is visible elsewhere in the Wardrobe Tower such as the inner east and south elevations (**Figures 14 and 15**).

### **Late 19th century/Early 20th century Kentish Ragstone repair**

5.2.19 The south-east elevation shows evidence of repair, repointing and stone replacement in the late 19<sup>th</sup> and early 20<sup>th</sup> centuries following the partial demolition of the Wardrobe Tower in 1879. Sections of the medieval *Petit Appareil* walling were repointed in late 19<sup>th</sup> and early 20<sup>th</sup> century grey flint gravel facing mortar (M1; **Figure 12**). Angular hard Kentish Ragstone has been used as replacement stone in the very hard brown flint mortar (M1) along the basal metre of the south-east elevation as well as the rubble crown (**Plate 16**) and its far eastern and western extremities (**Figures 11 and 12**). This stone type is visible throughout the Tower of London (Hayward & Garwood 2015; Hayward 2016; Hayward 2017). These repairs ensured that the ashlar facing and exposed core of the remains of the Wardrobe Tower remained intact, safe to passers by and somewhat resistant to freeze-thaw action and pollution.

### **5.3 North section through the Wardrobe Tower**

5.3.1 The narrow, 2m wide x 4.5m high, section through the Wardrobe Tower, incorporates elements of Roman, medieval and post-medieval builds and repairs (**Figure 13**).

#### **Roman Bastion**

5.3.2 The remains of the Roman Bastion were visible in this section as a very small area of angular fragments of Kentish Ragstone in the distinctive extremely hard *opus caementatum* black pebble mortar (Type M2) at the base of the western side of this elevation (**Figure 13**). This area of Roman fabric was the same as that visible in the east inner elevation flush against the arched Tudor/Stuart brick wall or culvert (**Figures 14 and 15**).

#### **Medieval Ashlar**

5.3.3 The sides of a number of small (10cm x 10cm) Reigate Stone ashlar blocks were visible between 2.5m and 4m above ground level along the western side of this section (**Figure 13**). The ashlar formed part of the facing of the inner east elevation (**Figure 14**). The little mortar that could be identified between the tightly wedged ashlar blocks in both the north section and the inner east elevation resembled the Tudor lime mortar with red brick fragments (M3) visible in other parts of the Wardrobe Tower however samples were too small to confirm this with any certainty. It is possible that a projecting large (40x40cm) Kentish Ragstone block on the east side of the section at about 1m above ground level (**Plate 18**), repointed in late 19<sup>th</sup>/early 20<sup>th</sup> century mortar (M1), represents a surviving element of one the former medieval Wardrobe buildings that connected the Wardrobe Tower with the Broad Arrow Tower as depicted on the 1597 plan (**Figure 3**).

#### **Tudor/Stuart Brickwork**

5.3.4 Five courses of red Tudor/Stuart brickwork survive along the west side at the top of this section through the Wardrobe Tower at about 4.5m above ground level (**Figure 13**). This forms the uppermost brickwork courses in the inner east elevation (**Figure 14**). A second

area of Tudor/Stuart brickwork is visible as 5 courses at the base on the west side of this section. This brickwork forms the side of the culvert visible in the inner east elevation (**Figure 14**). These consist of red 50mm (2 inch) Henrician sized bricks bonded in the early post-medieval white lime mortar (M3).

#### **Late 19th/Early 20th century Kentish Ragstone repair**

- 5.3.5 The exposed Kentish Ragstone core of the north section (**Figure 13**) had been protected in the late 19<sup>th</sup> or early 20<sup>th</sup> century with very hard brown flint mortar (M1), which has been observed in other repairs of this date in other parts of the Tower of London (Hayward & Garwood 2015; Hayward 2016; Hayward 2017). One or two fragments of Reigate Stone and a small example of Calcaire Grossier in the section represent recycling of medieval and Roman materials respectively.

### **5.4 Inner East and South Elevations of the Wardrobe Tower**

- 5.4.1 The inner east and south curved elevations of the Wardrobe Tower (**Figures 14 and 15; Plates 19 to 24**) are each some 5.5m high x 2.5m wide. Both elevations contain elements of Roman, medieval, Tudor/Stuart and late 19<sup>th</sup>/early 20<sup>th</sup> century build and repair. The inner east elevation tapers at its north end where all that remains of the circular Wardrobe Tower is a rubble Kentish Ragstone core, just 0.5m high.

#### **Roman bastion**

- 5.4.2 An area of Kentish Ragstone in extremely hard *opus caementatum* black pebble mortar (M2) (some 1m high x 1.5m wide) survives towards the base of the inner east elevation at its south end and another (some 2m high x 1.5m wide) towards the base of the inner south elevation at its west end (**Figures 14 and 15**). These remains of the Roman Bastion appear to have been truncated by the construction of a Tudor/Stuart brick arch/flue. The same Kentish Ragstone in extremely hard *opus caementatum* black pebble mortar (M2) is visible in the adjoining Roman City Wall (**Figure 16**). The mortar in both the Bastion and City Wall merges suggesting both were built together at the same time.

- 5.4.3 Further evidence for a Roman construction date is provided by the presence of sizeable blocks of Tufa and a part worked banded shelly Oolitic Limestone typical of the South Cotswolds. Both are common Roman construction stone in London (Hayward in prep; Hayward, 2009; 2015a). The latter may represent salvaged Roman tombstone material perhaps from the adjacent Eastern Cemetery.

#### **Medieval Rubble Core**

- 5.4.4 A section of the medieval rubble core of the Wardrobe Tower survives to a height of 2m to the side of and above the Roman Bastion rubble core and Tudor/Stuart arch. This rubble core had been repointed in the very hard brown flint late 19<sup>th</sup>/early 20<sup>th</sup> century mortar (M1), although on the inner south elevation it retained some relict, hard white gritty Render (R1), which was noted on the face of about 5% of the Kentish Ragstone fragments (**Figure 15**). This render has also been observed on the medieval *Petit*

*Appareil* blocks in the external south-east elevation (**Figure 12**). It is likely to be a surviving whitewash similar to that identified on the adjacent White Tower and also sections of the later medieval wall close to the Well Tower (Hayward 2017) and the c.1190 Bell Tower (Hayward 2016).

#### **Medieval Ashlar**

- 5.4.5 Immediately above the medieval rubble base of the Wardrobe Tower and surviving from a height of between 2 and 5m above ground level are reused Roman and medieval ashlar blocks of Reigate Stone, Caen Stone; Calcaire Grossier, banded shelly Oolitic Limestone (South Cotswolds) and Kentish Ragstone (**Figures 14 and 15**). The same stone types are visible in the outer external south-east elevation of the Wardrobe Tower (**Figure 11**). The blocks are much smaller and more variable in size than in the external south-east elevation, suggesting perhaps use of left-over seconds in the hidden inner elevation. Green Reigate Stone is particularly dominant forming about 80% of the ashlar, followed by Kentish Ragstone (10-15%), and remnants of Roman pale grey-cream Calcaire Grossier (<5%). Very locally in places, such as at 3m above ground level at the juncture of the inner south and east elevations, are yellow and pink medieval bricks of the same type as those found in the late 13<sup>th</sup> century Beauchamp Tower (**Figures 14 and 15**). One example was also seen in the external south-east elevation (**Figure 11**) and may indicate that this part of the medieval Wardrobe Tower was repaired at this time.

#### **Tudor/Stuart Brickwork**

- 5.4.6 Tudor/Stuart red brickwork (fabric 3046) has been used extensively above 2m above ground level in the inner east and south elevations of the Wardrobe Tower (**Figures 14 and 15**). It forms the walling between 4 and 5m above ground level (7 courses) and more intermittently between 3 and 4m above ground level. The brickwork consists of red 50mm (2 inch), sometimes vitrified (burnt) Henrician sized bricks bonded in the early post-medieval white lime mortar (M3; mortar sample 3 taken; **Figure 15; Plates 24 and 25**), supplemented very occasionally by brown sandy (fabric 3030) bricks (1400-1660). The coursing of the bricks displayed no obvious pattern and can best be described as English Garden Wall bond.
- 5.4.7 A second area of Tudor/Stuart brickwork is visible in the lowest 75cm of the inner east and south elevations. Here the bricks are slightly offset and form the edge of an arch, flue or culvert. The majority of this arch is visible in the adjacent inner south elevation (**Figure 15**). There is also a substantial brick base adjacent to the arch consisting of 6 courses with the brickwork randomly arranged in English Garden Wall bond. The arch has an estimated diameter of 2m. Given that many of these bricks are vitrified this would suggest that the arch formed part of a flue for a fireplace, with perhaps the brickwork higher up forming part of an extremely large Tudor/Stuart fireplace or even a chimney. Similar sized bricks have been observed in Tudor chimneys elsewhere in the Tower of London, for example the Bell Tower (Hayward 2016).

### **Late 19<sup>th</sup> century/early 20<sup>th</sup> century Kentish Ragstone repair**

5.4.8 East: The lowest 2m of rubble in the southern and eastern halves of the inner east and south elevations, respectively, including the infill of the Tudor/Stuart arch/flue had been repaired and repointed in hard angular Kentish Ragstone bonded in the very hard brown flint mortar (M1) visible in other late 19th repairs to the Wardrobe Tower and throughout the Tower of London (Hayward & Garwood 2015; Hayward 2016; Hayward 2017). The infill of the Tudor/Stuart arch flue contained examples of vitrified Tudor/Stuart brick that had been re-incorporated into the fabric, presumably following late 19<sup>th</sup> century demolition. Only a 50cm high tapering and curving rubble foundation is present at the north end of the inner east elevation. This too was strengthened with mortar M1. The damaged crown and exposed western rubble core fringe of the inner south elevation had been rebuilt using hard angular Kentish Ragstone fragments and repointed in mortar M1. Occasional narrow (100mm) post-Great Fire bricks have been used to repair the Tudor/Stuart brickwork. The dimensions of these bricks are in accordance with the 1776 Brick Tax, which continued through to the very end of the 19<sup>th</sup> century.

## **5.5 East elevation of the Roman City Wall**

5.5.1 The remaining east elevation of the Roman City Wall is 3m long and 0.75m high (**Figure 16**). It mainly comprises five hard Kentish Ragstone facing courses, each block measuring 30x20x20cm, topped with one yellow Eccles brick, the remains of a lacing course, bonded in extremely hard *opus caementatum* black pebble mortar (M2) with broken-up shelly fragments. This mortar type is also visible in the south section through, and west elevation of, the Roman city wall (**Figures 12 and 17**).

5.5.2 Forming the lowest course, and largely hidden, are six curved chamfered plinth stones, representing the base of the visible wall as it appeared in Roman times approaching the bastion. Each is about 15-20kg in weight and measures 500x200x200mm. Three of the blocks are dark brown ironstone (Loftus Brock 1882), which is the same lithology (Carrstone–Folkestone Beds Lower Greensand from the Sevenoaks area of the Weald; **Figure 16; Plate 26**) that has been identified from other sections of the chamfered Roman City Wall at Cripplegate and at Aldgate (Potter & Hayward 2006).

5.5.3 The remaining three chamfered plinth blocks were of two different Lincolnshire Limestone stone types. The southernmost two plinth blocks are Barnack Stone, a very hard sparry oolitic shelly limestone containing high-spired nerineid gastropods from the Middle Jurassic (Bajocian) of Cambridgeshire. The other block is Weldon Stone, a softer more open textured shelly oolitic grainstone from the Middle Jurassic (Bajocian) (**Figure 16; Plate 26**).

5.5.4 Until now these limestones had only turned up in the Roman defences as reused sculptural material as at the Riverside Wall (Dimes 1980). This is the first time that these purpose-made chamfered elements have been identified as incorporated within the

Roman City Wall.

- 5.5.5 The upper exposed surface of the town wall rubble core is of angular and flaggy fragments of very hard, sometimes cherty Kentish Ragstone, bonded in Type M2 mortar. The occasional Eccles brick fragment and flint nodule are present.

## **5.6 West elevation of the Roman City Wall and west section through the Wardrobe Tower**

- 5.6.1 The west elevation of the Roman City Wall is 4m long x 0.9m high and tapering, while the section through the medieval rubble core and ashlar facing of the Wardrobe Tower is 4m high and 1m wide (**Figure 17**). The rubble core has been extensively replaced and re-pointed during the late 19th century using the dark-grey gravel mortar with brown angular flint pebbles (Type M1).

### ***Roman City Wall***

- 5.6.2 The west elevation of the Roman City Wall, which continues north up slope, is bonded in the same extremely hard *opus caementatum* black pebble mortar (Type M2), with broken-up shelly fragments, seen in section and its east elevation (**Figures 11 and 16**).
- 5.6.3 Three courses of large facing Kentish Ragstone blocks (40x30x30cm) at the southern end of the Roman City Wall separate two groups of facing courses of Lydian sized Roman brick. The upper level, consists of 3 facing courses of very early (AD50-80) yellow Eccles bricks, with a lower facing course just visible at the base of the wall of both red sandy (fabric 2452) bricks and yellow (fabric 2454) Eccles bricks.
- 5.6.4 Only the rubble core is preserved in the northern 2.5m of the elevation comprising Kentish Ragstone and hard *opus caementatum* black pebble mortar (Type M2).

### ***Roman Bastion***

- 5.6.5 A very small area of the rubble core of the Roman bastion is preserved in the lower part of the west section through the Wardrobe Tower (**Figure 17**). This is also bonded in the hard *opus caementatum* black pebble mortar (Type M2) and has a fragment of Tufa as well as a fragment of Lodsworth Greensand. Both are common Roman stone types. Lodsworth Greensand was widely used in the southern half of the province as a quern material (Peacock 1987; Shaffrey & Roe 2011; Green 2017). The hard chert inclusions were not only suitable for grinding grain into coarse flour but also as a source of building stone as at Silchester (Hayward 2011).

### ***Medieval Ashlar***

- 5.6.6 Side on views of the medieval ashlar in the external curved south-east elevation are visible from the west (**Figure 17**). Reigate Stone, Caen Stone, Calcaire Grossier and Quarr Stone are present in between 1m to 4.5m above ground level. Smaller ashlar blocks of Reigate Stone and Calcaire Grossier are visible in the inner (north) side of the section between 2.5 and 4.5m above ground level. Both stone types are pointed in the white lime mortar with brick inclusions (Type M3).

***Early post-medieval brickwork***

- 5.6.7 Side on views of the small 50mm (2 Inch) Henrician sized brick associated with early post-medieval rebuilds are visible in the section from 3 to 5m above ground level in the west section through the wall of the Wardrobe Tower (**Figure 17; Plate 29**). These are also pointed in the white lime mortar with brick inclusions (M3).

***Late 19<sup>th</sup>/early 20<sup>th</sup> century Kentish Ragstone repair***

- 5.6.8 Side on views of the damaged rubble core and capping of the west section through the wall of the Wardrobe Tower between 1.5 and 4.5m show it had been strengthened and re-pointed with angular hard Kentish Ragstone bonded in the very hard brown flint late 19<sup>th</sup>/early 20<sup>th</sup> century mortar (M1; **Figure 17**).

## 6 CONCLUSION

- 6.1.1 Conservation works on the Wardrobe Tower permitted detailed analysis of its historic fabric. A total of 18 stone types and 7 types of (Roman, medieval and post-medieval) ceramic building material were identified. Five types of mortar and render were also identified.
- 6.1.2 The Wardrobe Tower consists of a surviving fragment of a former D-shaped (in plan) tower, built c.1190 on the line of the Roman City Wall (Figure 10). It incorporates the base of a Roman bastion and a section of the Roman City Wall. Wheeler labelled the former as Bastion B1 on his plan of Roman defences of London (Figure 9; RCHM, 1928, 99).
- 6.1.3 The Roman City Wall is nearly 2.4m wide with a projecting limestone and sandstone plinth. The external elevation of this wall is faced with neat rows of large squared Kentish Ragstone facing stone and rubble with tile bonding rows set at regular intervals. Hand specimen fabric analysis of the wall identified it as a single build consisting of angular stone fragments of hard cherty Kentish Ragstone bonded in an extremely hard *opus caementatum* black pebble mortar. Each tile bonding row comprises three courses of Lydian sized bricks of two fabrics. As well as the common second century red Roman sandy fabric, there are large quantities of the distinctive yellow Eccles fabric, manufactured in East Kent very early in the province's development (AD50-80). As well as the squared Kentish Ragstone facing blocks, petrological analysis of the projecting basal sandstone plinth, not only identified the ubiquitous iron rich Carrstone but for the first time purpose cut blocks of Lincolnshire Limestone in both Barnack Stone and Weldon Stone.
- 6.1.4 The recording established that much more of the Roman bastion fabric survives within the Wardrobe Tower than had previously been thought. In accordance with earlier accounts (RCHM, 1928, 99), Roman Bastion (B1) was identified at the base of the Wardrobe Tower as areas of brick and *opus signinum* up to 1.5m above ground level in the outer south-east elevations of the Wardrobe Tower. Further basal sections of the Roman bastion were visible in the inner south and east elevations of the Wardrobe Tower. These were identified by the use of the same hard *opus caementatum* black pebble mortar and the reuse of fragments of stone types associated with Roman London, such as Tufa, Lodsworth Greensand and large fragments of Bath Stone. The latter representing possible tombstone reuse from the East Roman Cemetery, which is a feature of many bastions along the eastern margin of the Roman City Wall (Coombe et al. 2015).
- 6.1.5 It is very likely that the large blocks of the French Ditropan Limestone or Calcaire Grossier identified at between 1-2m above ground level in the ashlar facing of the outer south-east elevation of the Wardrobe Tower are Roman and have been reused in this ashlar pier. This Roman stone type is also occasionally reused in the sections through



the medieval Wardrobe Tower and in the inner south and east elevations. Although, this rock type has been identified in reused rubble fragments elsewhere in the Tower of London such as the Develin Tower (Hayward & Garwood 2015) examples of monumental ashlar blocks in Calcaire Grossier are extremely rare in the British Isles.

- 6.1.6 The D-shaped medieval Wardrobe Tower, which was built on top of the foundations of the Roman bastion, is thought to have been constructed in the 1190s as part of Longchamp's work during the reign of Richard I. The outer south-east elevation had two distinct medieval elements. First, a 4m square area along the outer east elevation of small *Petit Appareil* blocks of Kentish Ragstone between a height of 0.75m up towards 4.75m above ground level. Second, two projecting ashlar piers along the outer south elevation from a height of 1 to 5m above ground level. This ashlar facing is likely to represent part of the medieval royal Wardrobe Buildings as shown on the 1597 plan. The freestone ashlar was fashioned out of Reigate Stone, Caen Stone, Quarr Stone, all common medieval stone types supplemented by larger monumental blocks of Calcaire Grossier. The latter, a limestone with distinctive *Ditrupa* worm tubes, and quarried from the Tertiary (Lutetian) of the Paris Basin had only previously been identified at sites along the coast of Roman Britain at Richborough, Reculver and Fishbourne. Its identification, at the Tower in such large quantities would indicate either recycling from one of these sites, the Roman London town wall or Riverside defensive wall or even a large monumental structure sited within this south-east corner of Londinium.
- 6.1.7 Surviving medieval ashlar is also present in the inner south-east elevation of the Wardrobe Tower from a height of 2 to 4.5m above ground level.
- 6.1.8 During its history the tower became the focus of the royal Wardrobe buildings. It is shown in Hayward and Gascoyne's plan of 1597 (Figure 3) as a cylindrical tower with the Wardrobe building running east from it to the Broad Arrow Tower. This plan also shows an eastern annexe to the White Tower thought to be associated with the fourteenth-century wardrobe running northwards from the Wardrobe Tower.
- 6.1.9 That the Wardrobe Tower, underwent change and repair in the early post-medieval period, is shown by the widespread use of red 2 inch thick "Henrician" Tudor bricks. Most of the surviving early post-medieval (Tudor-Stuart) brick fabric of the Wardrobe Tower is found within the inner east and south elevations replacing the occasional Reigate ashlar block from above 2m above ground level progressing to wholesale replacement above 4m above ground level. A Tudor/Stuart red brick curved feature, 1.5m wide and 0.75m high, is present at the base of the inner south and east elevations. This feature is most likely to have formed part of a flue for a fireplace given that so much of the brick here is vitrified, with the upper sections perhaps consisting of sections of chimney. Its construction probably relates to the 1532-33 new roof of the Wardrobe Tower. Similar Tudor/Stuart chimney flues have been observed in other parts of the Tower e.g. Bell Tower (Hayward 2016).
- 6.1.10 In 1879 John Taylor demolished the eastern annexe to the White Tower including the

majority of the surviving twelfth-century Wardrobe Tower. Work was stopped in time to salvage the fragment of the structure that survives today (Loftus Brock, 1882). The twelfth-century pilaster-buttressed wall linking the Wardrobe Tower to the south-east corner of the White Tower was demolished in 1883 (Plate 1). After Loftus Brock's assessment in 1882, the Wardrobe Tower was assessed again in 1962, when it was identified as containing a double course of broken Roman tiles set in a pink coloured mortar (Parnell 1985, 33).

- 6.1.11 Following the demolition, the newly exposed Roman and medieval stone as well as Tudor/Stuart brickwork in the surviving remains of the Wardrobe Tower were vulnerable to external weathering and pollution. These underwent an intensive programme of repair during the late 19<sup>th</sup> to early-mid 20<sup>th</sup> century. The newly exposed edges, surfaces and crown of the tower, were shown during recording to have undergone wholesale stone repair and re-pointing by the use of very hard angular fragments of Kentish Ragstone and hard brown gravel flint cement typically associated with late 19<sup>th</sup> - 20<sup>th</sup> century works seen elsewhere in the Tower of London.

## 7 PUBLICATION PROPOSAL

### 7.1 Introduction

7.1.1 The historic building recording of the fabric at the Wardrobe Tower has identified a number of new and unusual Roman stone and ceramic building materials surviving within the fabric of the Roman Bastion (B1; Merrifield 1965) and the connecting section of the Roman City Wall. This surviving south-east part of the Roman defences was revealed only after 1879 (Loftus Brock 1882, 127-135) following the demolition of the eastern annexe to the White Tower. It has received scant detailed attention since initial findings were first published 136 years ago (Loftus Brock 1882, 127-135) and none since 1905 (Jones, 239). Adjacent sections of wall excavated during the 1950s to the north (Butcher 1957/58a) as well as to the south of the Wardrobe Tower and at the juncture with the Lanthorn Tower including a section of the Riverside Wall (Butcher 1957/58b) have also gone largely unreported.

### 7.2 Potential for Post-Excavation Analysis and Publication

#### *Roman City Wall*

7.2.1 The stone-by-stone petrological survey identified a number of interesting stone, ceramic building material and mortar in the Roman City Wall adjacent to and immediately to the west of the Wardrobe Tower:

- a) Complete, and fragmentary *Lydian* bricks made from the distinctive yellow Eccles fabric 2454, were present in upper three levelling courses of the Roman City Wall. This fabric was manufactured in Kent very early on in the province's development (AD50-80) (Pringle 2009). Their appearance in what is widely believed to be a late 2<sup>nd</sup> century wall raises questions as to what they are doing in such quantity in a structure built 120 years later.
- b) Largely hidden, curved chamfered plinth stones were identified flush against the sides of the wall, representing the base of the visible wall as it appeared in Roman times approaching the Wardrobe Tower bastion. One rock type that had previously been identified was dark brown ironstone (Loftus Brock 1882) which is the same lithology (Carrstone – Folkestone Beds Lower Greensand, Sevenoaks area of the Weald) identified in thin-sectioned chamfered and ashlar elements from a tower at Cripplegate and at a section of the wall at Aldgate (Potter & Hayward 2006). Two different Lincolnshire Limestone stone types were also identified in the adjoining chamfered plinth stones that had not originally been identified. This stone has provisionally been identified in hand specimen as Barnack Stone, Weldon Stone. Until now, it has only been found in the defences as reused sculptural material as in the Riverside Wall (Dimes 1980). The appearance of fresh consignments of this limestone indicates purpose made elements were quarried not just from the Weald but from sources much further afield than had previously been thought. The second

and third century represents a time when London was incorporated into a Province that includes part of the Lincolnshire Limestone outcrop.

A hard-pebbly Roman mortar was found in both the Roman City Wall and in Bastion B1 (lower parts of the inner elevations of the Wardrobe Tower) suggesting that the bastion was bonded into the wall. This is atypical of the Roman defensive structures in London where most bastions were built against the wall (Merrifield 1965) and deserves further comment.

### **Roman Bastion B1**

7.2.2 As well as *opus signinum* and associated *Lydian* brick in the base of the east external elevation of the bastion (Wardrobe Tower) which has already been commented upon (Loftus Brock 1882), there are two other areas in the Wardrobe Tower that contain Roman Bastion building materials not mentioned previously. These contain either primary rubble stone or Roman ashlar re-incorporated in the medieval fabric of the Wardrobe Tower.

- c) One is a section of lower inner bastion wall that has the same pebble mortar as the Roman City Wall. This has examples of Bath Stone – banded shelly oolitic limestone (Hayward 2009; 2015), Tufa and part of a quern made from Lodsworth Greensand; all stone materials associated with Roman London and south-east England.
- d) Second and of greatest importance are a group of large ashlar blocks of Calcaire Grossier or Ditrupa Limestone (Tatton-Brown & Worssam 1990) in the external south elevation of the Wardrobe Tower as well as other examples from the inner south elevation, and north section through, the Wardrobe Tower. These blocks are from the Lutetian Middle Eocene, Oise Valley, Paris. The presence of numerous worm tubes, *Ditrupa* is the characteristic petrological feature of these rocks. These distinctive rocks had been identified from the Tower of London only in small quantity as rubble from the White Tower (Sanderson & Worssam 1998) and reuse in the late 19<sup>th</sup> century Salvin Works of the Develin Tower (Hayward & Garwood 2015). Elsewhere in the British Isles, they have only been found in Roman sites along the south-east coast. These include their use in Corinthian capitals from the Neronian proto-palace at Fishbourne (Cunliffe 1971; Hayward 2009), elsewhere in Sussex (Hayward 2012) and as large ashlar blocks associated with the Richborough Arch (Hayward 2009), reuse at Canterbury (Tatton Brown 1990) and in the Reculver Cross (Worssam & Tatton Brown 1990). The importance of this discovery cannot be underestimated. The use of fresh continental limestone within Roman structures such as the City Wall, bastion or the Riverside Wall is a new concept. This shows what a draw on resources the defensive project had to transport large ashlar blocks (probably as ballast) 200km up the Seine to the French coast, along the Channel and down the Thames Estuary to London.

### 7.3 Research Aims

#### ***Geological materials***

7.3.1 The variety of high quality freestone materials used in the Roman City Wall and Bastion B1 (Wardrobe Tower), part of the defensive structures of Roman London, are significant and contribute to the research framework objectives for London (Nixon et al 2002). They assist in our understanding of the early ‘interplay between road and river transport ...’ part of the key R4 framework objective for Infrastructure ‘studying the procurement and supply of building materials’ (Nixon et al. 2002, 34). Also on the theme of economy, in the R13 framework for ‘Economy – Production, distribution and consumption’ (Nixon et al. 2002, 42) it mentions the benefits of ‘Artefacts that can be securely provenanced’ and their ‘special role to play in evaluating the flow of goods in and out of London’ citing ‘Building material supply’ (Nixon et. al. 2002, 42) as an area that would benefit from a characterisation study.

7.3.2 Geological studies of early Roman worked stone in London and Colchester, have in themselves already been successful in providing an insight into the variety of material types and their geological source (Hayward 2009; 2015). This is in a province that has no pre-existing history of working or carving fine limestone materials (freestone). Certain limestone types also appear to have been used only in Roman Britain such as Calcaire Grossier and banded shelly oolitic limestone, both of which appear within the fabric of the Wardrobe Tower and adjoining Roman City Wall. Applying this methodology to the Roman stone types used in the Wardrobe Tower and the Roman City Wall would help to establish and enhance our understanding on the draw on resources that just one part of this major defensive project had. Petrological comparison with the stone types used in the *in-situ* south-east section of the Roman Riverside Wall between the Lanthorn Tower and Wakefield Tower (Butcher 1957/58b) would further enhance our understanding of material origin and reuse in this stretch of the defensive wall. As would material recovered from Roman masonry buildings adjacent to this section of the Roman Wall (Butcher 1957/58a).

#### ***Roman buildings in the south-east quadrant of the Tower of London***

7.3.3 Specific questions relating to the construction of the Wardrobe Tower and the earlier Roman masonry buildings adjacent to the White Tower follow (dependent upon whether or not there is an archive of finds from the 1950s excavations).

7.3.4 If an archive of building materials (mortar; Roman tile; stone) from the 1950s excavation of the substantial tessellated and embellished stone masonry buildings (Butcher 1957/8a) exists then it would be possible to relate these to the current stone-by-stone study of the Wardrobe Tower (Roberts 2017). For example if both the yellow Eccles brick and Calcaire Grossier stone (both mid to late 1<sup>st</sup> century materials) are present in the archive then this may provide evidence for a substantial first century Thames facing masonry building on the eastern edge of the Roman Town. Furthermore, as ashlar blocks,

architectural elements and religious sculpture (Black et al. 2012) made from Calcaire Grossier were used in high status public buildings (Richborough Arch) and private villas (Fishbourne Roman Palace) in the south-eastern coastal part of the province (Hayward 2009), then does their presence here indicate a prestigious building.

#### 7.4 Recommendations

7.4.1 Preliminary examination and sampling of some of the more unusual worked stone types and ceramic building materials recorded during the current stone-by-stone analysis of the Wardrobe Tower and adjacent section of the Roman Town Wall (Roberts 2016) have raised a number of questions as to their origin and geological source.

7.4.2 For publication, the following tasks are proposed:

- Production of text on the geological character and source of some of the more unusual materials that turn up only in this south-eastern corner of the Roman defensive wall of *Londinium* and nowhere else. For this, three thin sections would be prepared and analysed (one of the probable Calcaire Grossier; one of the Bath Stone and one of the Carrstone)<sup>1</sup> each example would be photomicrographed.
- Understand whether or not any of the material from the Wardrobe Tower, derived from the Roman Riverside Wall. This would include a petrological examination of the *in-situ* south-east stone section of the Roman Riverside Wall between the Lanthorn Tower and Wakefield Tower (Butcher 1957/58b). Even at distance, there is a considerable variety of materials in use.
- Identify whether or not there is an archive of building material kept from the unpublished 1950s excavations of the Riverside Wall and the masonry structure next to the White Tower. If so, examine their petrological character to determine whether there are links with the Wardrobe Tower

Task	Estimated number of days
<i>In-situ</i> recording of the nearby section of Riverside Wall between Lanthorn Tower and Wakefield Tower, using stone-by-stone photogrammetry	1
Provision (should there be an archive) for one day review of any archived building material from the 1950s excavations of the masonry buildings (Butcher 1957/8a); and Riverside Wall (Butcher 1957/8b).	1
Thin-section preparation of 3 samples of Roman dimension stone from the Wardrobe Tower.	6 days preparation time
Provision for the thin-section preparation of a further 2-3 stone samples from the Riverside Wall or archived material from the 1950s excavations should a) permission be given b) there are comparable	As above (in one batch of 6)

<sup>1</sup> Already sampled from the Wardrobe Tower and adjacent section of the Roman City Wall

or unusual dimension stone materials.	
Hand specimen and thin-section comparative analysis of all building materials (mortar; ceramic building material; stone) using a reference collection of outcrop and monument material slides prepared from earlier research (Hayward 2009; 2015) including production of photomicrographs of each lithotype for publication	2
Research and comparanda	2
Report writing. Preparation of a petrological report for publication on the wider use of the more unusual building materials in the south-east corner of the Roman Defensive Wall (in the Tower) to be included in a joint paper with George Roberts (formerly HRP) on the Roman masonry structures in the south-east corner of the Tower for <i>LAMAS</i> (London and Middlesex Archaeology Society journal) or <i>Britannia</i>	6
Revisions	1

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- 8.1.2 The historic building recording was managed for Pre-Construct Archaeology by Charlotte Matthews. The on-site recording and photographic survey were carried out by Kevin Hayward and Armando Ribeiro, respectively. Kevin Hayward wrote this report and Mark Roughley prepared the illustrations.



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## APPENDIX 1: Stone, brick and tile types

The twenty five building material fabrics from the Wardrobe Tower and adjacent section of the Roman City Wall can be divided further into eighteen rock types and seven ceramic building material fabrics. These are all described, sourced and discussed below. They are presented in approximate order of frequency.

### **Kentish Ragstone (2 Types)**

The most common material type in the wall facing not only of the Wardrobe Tower but also the Develin Tower (Hayward & Garwood 2015); Devereux Tower (Palmer & Shaffrey 2011), Bell Tower (Hayward 2016), Well Tower (Hayward 2017) and the White Tower (Worssam & Sanderson 2008) is this hard medium-grained calcareous sandstone quarried from the Lower Greensand (Hythe Beds) of Kent.

#### ***Kentish Ragstone sensu strict***

This especially hard compact light-grey variant containing no visible fossils is the type used extensively by the Romans for the construction of the city wall as well as the rubble-stone and rough-facing ashlar of the medieval Tower of London from the earliest masonry White Tower (Worssam & Sanderson 2008). At the Wardrobe Tower, it is used extensively as rubble core infill and facing stone of the Roman City Wall (**Figures 11, 16 and 17**), in the smaller *Petit Appareil* blocks on the medieval external east elevation (**Figure 11**) and in late 19<sup>th</sup> century Kentish Ragstone repairs throughout the Wardrobe Tower (**Figures 11, 13 to 15, and 17**). This lithotype also has no glauconite or coarse quartz but often contains black chert, enhancing further still the robustness of this building stone. Chert rich Kentish Ragstone was quarried from the uppermost part of the Hythe Formation from the Maidstone area, above a bed termed by quarryman as the Flint Lane (Worssam & Sanderson 1998). The material is comparable to a Kentish Ragstone sample thin sectioned from the Outer Curtain Wall, Develin Tower (Hayward & Garwood 2015) showing the rock to contain bolivinid foraminifera microfossils.

It is the characteristic and dominant (99%) rubble stone core material-type in the Roman City Wall, forming 15cm x 10 cm angular blocks bonded by the hard *opus caementatum* brown pebble mortar (type M2) (see **Appendix 2**). It is also present as larger 30x20x15cm facing stone blocks on the west face of the Roman City Wall.

It was also present, bonded with Type M3 bedding mortar and repointing Type M1 facing mortar as small sub-rectangular blocks (*Petit Appareil* Masonry style) (Allen 2010) for a significant part of the outer east elevation. This form of masonry was also typical of the outer 14<sup>th</sup> century defences of the Well Tower (Hayward 2017) and Develin Tower (Hayward & Garwood 2015) where the blocks were tightly wedged together, with little or no mortar, forming a near impenetrable barrier to external weathering.

Finally, its wholesale use, this time in the late 19<sup>th</sup> century repairs throughout the Wardrobe Tower,

bonded by the angular flint gravel facing mortar (Type M1) is testament to the durability of this material.

Examples of relict render/whitewash (Render 1) are very common, especially at a height of between 1 and 2m above ground level on the medieval *Petit Appareil* blocks in the external east elevation of the Wardrobe Tower, suggesting recycling from earlier painted walls. One obvious candidate would be the nearby White Tower, although it is possible that the adjacent Wardrobe Tower was also similarly coated.

Material type	Proportion	Use in Wardrobe Tower and Roman City Wall	Whereabouts
Kentish Ragstone (hard sometimes cherty)	75-100%	Primary Roman City Wall – rubble core and facing material 13 ½ x 8 x 6 inches bonded in Type M2 mortar East and west elevations and south section through the Roman City Wall ( <b>Figures 11, 16 and 17</b> ). Lowest 2m of bastion visible in inner south elevation of the Wardrobe Tower ( <b>Figure 15</b> ) Primary medieval – <i>Petit Appareil</i> microblocks (5x3 ½ inches in size) in the east external elevation of the Wardrobe Tower ( <b>Figure 11</b> ) Reuse late Victorian rubble core repairs ( <b>Figures 11, 13 to 15, and 17</b> )	Dominates (95% - 100%) the Roman City Wall rubble core, facing stone and <i>Petit Appareil</i> microblocks, also late 19 <sup>th</sup> century repairs throughout.

#### ***Kentish Ragstone – poorer quality***

The second sub-type a softer green-brown-grey Kentish Ragstone, containing visible grains of the green mineral glauconite and very occasional marine bivalve shells of *Exogyra*, is very rare in the Wardrobe Tower. This rock was far more prone to weathering than the cherty Kentish Ragstone, due to the presence of the unstable iron-clay mineral glauconite making it more liable to fragment, spall and flake as fragments when exposed to the cold and the wet.

Unlike other towers at the Tower of London, its use in the Wardrobe Tower is restricted to the occasional ashlar block inserted as localised 19<sup>th</sup> century repair along one course of the medieval *Petit Appareil* wall in the external east elevation at 4m above ground level (**Figure 11**).

Superficially at least it resembles Reigate Stone, the difference being that Reigate Stone has no visible fossils, is finer, micaceous and lacks a harder granular core and occasional chert in this rock. The rock somewhat resembles Hassock Stone, which inter-beds with Kentish Ragstone at outcrop however it is far more likely this is an inferior version of Maidstone Kentish Ragstone, quarried from another part of the Lower Greensand (Hythe Beds) of the North Weald of Kent.

Material type	Proportion	Use in Wardrobe Tower	Whereabouts
Kentish Ragstone (poor quality Victorian Type)	<1%	Ashlar - Later 19 <sup>th</sup> century repairs	Localised in the <i>Petit Appareil</i> section of the external east elevation Wardrobe Tower ( <b>Figure 11</b> ).

### Hassock Stone

Interbedded at outcrop with the Kentish Ragstone are softer glauconitic medium grained sandstones, speckled with black iron oxide, termed locally as Hassock Stone. This rock turns up in the Wardrobe Tower only as the occasional 19<sup>th</sup> century rubblestone repair material associated from the basal 2m of the north section through, and the inner south elevation of, the Wardrobe Tower (**Figures 13 and 15**, respectively).

Material type	Proportion	Use in Wardrobe Tower and Roman City Wall	Whereabouts
Hassock stone	<1%	Restricted to a small number of rubblestone blocks associated with 19 <sup>th</sup> century repair.	Basal 2 metres of the north section through, and the inner south elevation of, the Wardrobe Tower ( <b>Figures 13 and 15</b> , respectively).

### Portland Whit Bed (grain prominent white oolite)

This Upper Jurassic open-textured, durable fine white-grey oolitic limestone from the Isle of Portland (Portland Whit Bed) is present as the occasional post-medieval ashlar replacement stone in the medieval ashlar facing of the south external elevation of the Wardrobe Tower (**Figure 11**). Unlike other Victorian repairs in the Tower (Hayward & Garwood 2015; Hayward 2017), it is only used sparingly in the Wardrobe Tower. Other occurrences are limited to rare Victorian rubble replacement stone bonded in Type M1 mortar in the inner south and external south and east elevations of the Wardrobe Tower (**Figures 11 and 15**).

Material type	Proportion	Use in Wardrobe Tower	Whereabouts
Portland Stone (Whit Bed)	1%	Late 19 <sup>th</sup> century. Post-medieval ashlar and rare	Localised Victorian ashlar replacement external south and east elevations of the Wardrobe Tower ( <b>Figure 11</b> ). Rubble replacement in the inner south and external south and east elevations of the Wardrobe Tower ( <b>Figures 11 and 15</b> )

### Purbeck Limestone

As elsewhere in the Tower of London (Palmer & Shaffrey 2011, 14; Hayward & Garwood 2015; Hayward 2016; 2017), these slabby shell-rich calcareous mudstones are associated with later post-medieval building phases. These robust materials were quarried on a very large scale from different horizons of the Lower Cretaceous of the Isle of Purbeck for paving slabs, rubble stone, lintels and roofing slates etc. for use in London especially from the late 17<sup>th</sup> century onwards.

However, like other 19<sup>th</sup> century replacement stone materials in the Wardrobe Tower (Portland Stone; Poor Quality Kentish Ragstone) it is used sparingly with one example from the inner east elevation of the Wardrobe Tower (**Figure 14**) and capping the relict medieval ashlar on the external south elevation of the Wardrobe Tower (**Figure 11**).

Material type	Proportion	Use in Wardrobe Tower	Whereabouts
Purbeck Limestone (standard Corbula type)	<1%	19 <sup>th</sup> century replacement stone	Very infrequent - late 19 <sup>th</sup> century filler material in the inner east and external south elevations of the Wardrobe Tower ( <b>Figures 11 and 14</b> ).

### Caen Stone (yellow packstone)

This condensed, pale-yellow to pale-orange fine-grained pelletal packstone (Dunham 1962) identified as Calcaires de Caen limestone from the Middle Jurassic (Bathonian) of Normandy is a rock type that forms part of the package of freestone types (Purbeck Marble, Reigate Stone, Taynton Stone) used in major medieval ecclesiastical (Hayward in prep; Samuel 2011; Blows & Worssam 2011) and defensive (Worssam & Sanderson 1998; Harris 2008) construction in London.

It is the second most common medieval freestone material in the Wardrobe Tower (after Reigate Stone) being used in large ashlar blocks in the pier on the external south elevation (**Figures 11 and 17**), with smaller chopped up examples evident within the inner south and east elevations of the Wardrobe Tower above 2m above ground level (**Figures 14 and 15**).

Material type	Proportion	Use in Wardrobe Tower	Whereabouts
Caen Stone	5%	Medieval primary material - ashlar	Common - Projecting pier on the external south elevation ( <b>Figures 11 and 17</b> ) and to a lesser extent in the inner south and east elevations of the Wardrobe Tower above 2m above ground level ( <b>Figures 14 and 15</b> ).

### Reigate Stone (fine glauconitic calcareous siltstone)

This low-density, poorly cemented micaceous greensand exploited from the Upper Greensand quarries of Reigate-Mertsham has survived in a very good state of preservation in parts of the medieval ashlar fabric. It is easily the most common freestone ashlar material in the inner (above 2m above ground level) and external south and east elevations (**Figures 11, 13 to 15 and 17**), so much so that it often forms entire sections of wall. Normally, because of its susceptibility to weathering and pollution many examples of ashlar elsewhere in the Tower have decayed and been replaced by post-medieval freestone materials. Protection from the prevailing westerly wind by the much larger White Tower and later on by Inner and Outer Curtain Wall sections has ensured preservation. However, there are also examples where it cracks, splits and breaks due to the following properties

- It has a high overall porosity 30% (Sowan 2000, 145) which enhances water infiltration and subsequent freeze-thaw damage. South facing walls with greater diurnal temperature variation which are more prone to freeze-thaw action merely accelerate the process. Within 20 to 30 years of use the rock can degrade rapidly (de Domingo 1994, 241)

- Chemistry – The green mineral glauconite, a common constituent of Reigate is unstable iron-rich clay. It rapidly breaks down and oxidises red-brown when exposed to water, enhancing the rocks already high porosity thus accelerating chemical and physical weathering still further.
- Unlike the harder Lower Greensands, the silica in the Reigate is chemically precipitated and much finer. Because of this the rock lacks the robust siliceous framework of coarser grained sandstones making it physical and chemical weathering.
- Its low density can also make it structurally unsound under a heavy loading. Subsequent chemical and physical weathering can accelerate failure over time.

Material type	Proportion	Use in Wardrobe Tower	Whereabouts
Reigate Stone	7%	Primary Medieval ashlar material	Very common – entire sections of the external and inner (above 2m above ground level) south and east elevations ( <b>Figures 11, 13 to 15 and 17</b> )

#### **Purbeck Marble (gastropod rich packstone)**

Although Purbeck Marble comes from the same geological formation as Purbeck Limestone, it needs to be considered separately. This is because this hard, light-grey condensed fossil rich limestone dominated by the small 10mm freshwater gastropod *Paludina carinifera* was extensively used in Roman and medieval London (Hayward in prep; Samuel 2011) especially in tombstones and monumental architecture. Its use within the Wardrobe Tower is restricted to one relict weathered block near the base of the ashlar facing the external south elevation of the Wardrobe Tower (**Figure 11**). Given the widespread use and reuse of Roman materials in the Wardrobe Tower and adjacent wall, it is possible that this block could be Roman rather than medieval.

Material type	Proportion	Use in Wardrobe Tower	Whereabouts
Purbeck Marble	<1%	Medieval Rare	1 degraded example base of ashlar blocks in the external south elevation of the Wardrobe Tower ( <b>Figure 11</b> )

#### **Weldon Stone (open-grained, pale cream yellow oolitic shelly grainstone)**

This open textured, pale yellow shelly oolitic grainstone (Dunham 1962) is lithologically comparable to Weldon Stone from the Middle Jurassic (Bajocian) of Northamptonshire. Its use is restricted to one plinth element at the base of the east elevation of the Roman City Wall (**Figure 16**). This rock is usually associated with late Roman sarcophagi and monumental fragments in London (Hayward 2015a). One example being its presence in frieze elements originally for the Roman monumental arch in the temple precinct in the south-west corner of Roman London only to be subsequently incorporated into the 4<sup>th</sup> century Roman Riverside Wall (Hill *et al.* 1980). This is the first time that it



has been found in a plinth.

Material type	Proportion	Use in Wardrobe Tower	Whereabouts
Weldon Stone	<1%	Roman Rare basal plinth element 17 x 9 x 5 ½ inches	Base of the east elevation of the Roman City Wall ( <b>Figure 16</b> ).

#### **Barnack Stone (sparry hard, oolitic shelly grainstone)**

Two examples of this sparry, very hard shelly oolitic grainstone (Dunham 1962) were identified in the plinth at the base of the east elevation of the Roman City Wall (**Figure 16**). This was comparable to Barnack Stone of Middle Jurassic (Bajocian) of Cambridgeshire. These hard limestones are usually associated with late Roman sarcophagi and monumental fragments in London, an example being its presence in frieze elements, along with Weldon Stone originally for the Roman monumental arch as well as the Screen of Gods in the temple precinct in the south-west corner of Roman London only to be subsequently incorporated into the 4<sup>th</sup> century Roman Riverside Wall (Hill *et al.* 1980). This is the first time that it has been found in a plinth.

Material type	Proportion	Use in Wardrobe Tower	Whereabouts
Barnack Stone	<1%	Roman Rare Basal plinth element 17 x 9 x 5 ½ inches	Base of the east elevation of the Roman City Wall ( <b>Figure 16</b> ).

#### **Carrstone (Dark-red, loosely compact brown ferruginous sandstone)**

Three examples of this distinctive friable iron rich medium-grained sandstone were identified in the plinth at the base of the east elevation of the Roman City Wall (**Figure 16; Plate 26**). This rock has been sourced to the Carrstone – Folkestone Beds from the Lower Greensand, Sevenoaks area of the Weald) (Potter & Hayward 2006) and is a feature of the curved basal plinth elements along many sections of the Landward Wall as well as ashlar blocks at Cripplegate Fort (Potter & Hayward 2006). This rock had not been identified from this south-east corner of the Roman City Town until now.

Material type	Proportion	Use in Wardrobe Tower	Whereabouts
Carrstone	<1%	Roman Rare Basal plinth elements 17 x 9 x 5 ½ inches	Base of the east elevation of the Roman City Wall ( <b>Figure 16; Plate 26</b> ).

#### **Calcaire Grossier (pale grey-brown shelly grainstone with *Ditrupa* worm tubes)**

This distinctive open textured yellow brown shelly grainstone (Dunham 1962) pitted with white *Ditrupa* worm tubes is comparable to Calcaire Grossier from the Middle Eocene (Lutetian) of the Paris Basin. It is present as ashlar in entire sections of the east medieval pier of the external south elevation of the Wardrobe Tower (**Figures 11 and 17**). Some of the blocks are very large exceeding 60x45x40cm in places. Smaller, reused examples are occasionally present in the west medieval ashlar pier of the external south elevation of the Wardrobe Tower (**Figure 11**) as well as in the inner east and south elevations of the Wardrobe Tower above 2m above ground level (**Figures 14 and 15**).

This rock had only been identified in London, at the Tower as reused 19<sup>th</sup> century replacement

material in the Devereux (Palmer & Shaffrey 2011) and Develin Tower (Hayward & Garwood 2015). Outside of London, the rock is restricted specifically to mid-late first century Roman monumental builds at Richborough (where it is also found in very large monumental blocks) (Hayward 2009), Fishbourne in Neronian Corinthian Capitals (Cunliffe 1971) villas along the South Coast (Black *et al.* 2012), the Reculver Cross (Worssam & Tatton-Brown 1990) and Roman Winchester (Tweddle *et al.* 1995). Its occurrence then as very large ashlar blocks in such large quantities is of considerable interest both in relation to the Roman Defensive Wall of London and wider implications in relation to the supply of high quality freestone from Gaul during Roman occupation, possibly in this case by the *Classis Britannica*.

Material type	Proportion	Use in Wardrobe Tower	Whereabouts
Calcaire Grossier	5%	Roman Common	Numerous very large ashlar elements in the south elevation of the Wardrobe Tower ( <b>Figure 11</b> ) and as smaller reused fragments in the inner south and east elevations ( <b>Figures 14 and 15</b> )

**Bibury Stone (banded shelly oolitic grainstone with calcite veinlets or watermarks)**

It has been shown elsewhere in the Tower (e.g. Hayward 2016; 2017; Worssam & Sanderson 2008) that the use of different types of Bath-stone from the Cotswolds was important in the construction of the medieval Tower of London (Taynton Stone) and late 19<sup>th</sup> century repairs and rebuilds (Box Groundstone; Burford Stone).

At the Wardrobe Tower, there is evidence for the reuse of weathered Roman Bath freestones, typified by Bibury Stone (banded shelly oolitic grainstone) Middle Jurassic (Bathonian) Cirencester within the Roman bastion identified in the lower parts of the inner south elevation of the Wardrobe Tower (**Figure 15**) (pointed in pebbly Type M2 *opus caementatum* mortar) and another example in the upper part of the external south elevation of the Wardrobe Tower (**Figure 11**) associated with Calcaire Grossier. This material probably came from broken up funerary monuments that lay immediately to the east of the Tower. Numerous examples of Roman tombstones, monumental architecture, and sculpture from the provincial capital are carved in this stone (Hayward 2015a), many of which are incorporated into the later 4<sup>th</sup> century bastions on the eastern side of the London Wall.

Material type	Proportion	Use in Wardrobe Tower	Whereabouts
Bibury Stone	<1%	Roman Rare	Two examples, one reused in the Roman rubble core in the lower parts of the inner south elevation of the Wardrobe Tower ( <b>Figure 15</b> ) and another in the external south elevation of the Wardrobe Tower ( <b>Figure 11</b> )

### Quarr-stone (white skeletal grainstone)

A good indicator of early medieval quarrying, this hard skeletal limestone or “featherbed” quarried from the Bembridge Limestone Formation Tertiary (Oligocene) of the Isle of Wight coast does not continue to have been used after the 12<sup>th</sup> century as the quarries on the Isle of Wight had by then had most of the quality stone extracted. Its presence, then as a single ashlar block in association with reused Roman Calcaire Grossier in the east pier of the external south elevation of the Wardrobe Tower (**Figure 11**) would support this early date. It may, however, have originated from the adjacent White Tower where it was used extensively in the first construction phase (1067-83) (Harris, 2008, 42; Sanderson 1998; Worssam & Sanderson 1998).

Material type	Proportion	Use in Wardrobe Tower	Whereabouts
Quarr stone	<1%	Medieval ashlar block 13 x 10 x 8 inches	Projecting east pier of the external south elevation of the Wardrobe Tower ( <b>Figure 11</b> )

### Tufa (calcareous spring water deposit)

A second rock type associated with the earlier 11<sup>th</sup> and 12<sup>th</sup> century development of the Tower, especially the White Tower having been effectively worked out by the 13<sup>th</sup> century (Worssam & Sanderson 1998, 2) is the hard low-density white chemically precipitated tufa. Its presence, as large fragments, particularly in the Roman fabric of the bastion in the basal one metre of the inner south elevation of the Wardrobe Tower (**Figure 15**), but also sporadically within the medieval *Petit Appareil* blocks of Kentish Ragstone in the east external elevation of the Wardrobe Tower (**Figure 11**) provides some indication of the great age of the Wardrobe Tower. The Tufa would have been chemically precipitated at the interface of a spring line and river. There is evidence for thick Tufa deposits along the Medway, particularly where the calcareous Kentish ragstone crops out.

Material type	Proportion	Use in Wardrobe Tower	Whereabouts
Tufa	<1%	Rubble core in basal Roman sections of bastion (later Wardrobe Tower) and <i>Petit Appareil</i> blocks	Present –basal 1 metre of the inner south elevation of the Wardrobe Tower ( <b>Figure 15</b> ) and within 12 <sup>th</sup> century Kentish Ragstone <i>Petit Appareil</i> blocks in the east external elevation of the Wardrobe Tower ( <b>Figure 11</b> ).

### Flint

Small flint nodules, of uncertain provenance (possibly local Tertiary Gravels or Upper Cretaceous chalk) are inserted within the core fabric of the Kentish Ragstone Roman City Wall (south section through, and the external east elevation of, the Roman City Wall (**Figures 11** and **16**)). However, there are also scattered examples in the later medieval *Petit Appareil* Kentish Ragstone of the external east elevation of the Wardrobe Tower (**Figure 11**). Some of the latter probably relate to minor Victorian repairs and could be galleting.

Material type	Proportion	Use in Wardrobe Tower	Whereabouts
Flint	<1%	As small fractured flint nodule Roman wall in walling core And Victorian galleting	Dispersed – Roman City Wall (south section through, and the external east elevation of, the Roman City Wall ( <b>Figures 11 and 16</b> ). 12 <sup>th</sup> century <i>Petit Appareil</i> fabric (external east elevation of the Wardrobe Tower ( <b>Figure 11</b> ).

### Chalk

Two fragments of this soft white calcareous rock, probably from the local Upper Chalk were recorded at the base of the *Petit Appareil* wall in the external east elevation of the Wardrobe Tower (**Figure 11**).

Material type	Proportion	Use in Wardrobe Tower	Whereabouts
Chalk	<1%	Rubble core	Rare in base of <i>Petit Appareil</i> wall in the external east elevation of the Wardrobe Tower ( <b>Figure 11</b> ).

### Septarian Nodule

Another rubble walling material is the soft cream yellow concretionary clay, “Septarian Nodule”. This chemically precipitated clay derives from the London Clay from the underlying bedrock. Just two fragments were identified, both located towards the base of the medieval *Petit Appareil* walling in the external east elevation of the Wardrobe Tower (**Figure 11**). They are usually a Roman construction material, so its presence close to a section of extant Roman City Wall should not be seen as surprising.

Material type	Proportion	Use in Wardrobe Tower	Whereabouts
Septarian Nodule	<1%	Rubble core of <i>Petit Appareil</i> Kentish Ragstone	Rare – Towards base of <i>Petit Appareil</i> Walling in the external east elevation of the Wardrobe Tower ( <b>Figure 11</b> ).

### Lodsworth Greensand

One example of a medium grained glauconitic sandstone (greensand) with black cherty wisps (relict fossil burrows), located in the rubble core of the west section through the Wardrobe Tower (**Figure 17**) may well be part of a discarded Roman quern, made from Lodsworth Greensand. The stone used in enormous quantity during the Late Iron Age and Roman occupation, in saddle and rotary querns (Peacock 1987)

Material type	Proportion	Use in Wardrobe Tower	Whereabouts
Lodsworth Greensand	<1%	Rubble core of the	Rare – One example rubble core of the west section

		west section through the Wardrobe Tower (Figure 17)	through the Wardrobe Tower (Figure 17), probably repointed in 19 <sup>th</sup> century mortar
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### Ceramic Building Materials

The date, fabrics and distribution of types of ceramic building material (brick, roofing tile, and floor tile) are described chronologically.

#### Roman Brick

It is a feature of the Wardrobe Tower and the adjacent section of the Roman City Wall that so much Roman brick has survived. This consists of complete or broken up rectangular *Lydian* sized brick mostly in the fine red sandy brick-earth fabric<sup>2452</sup> (AD55-160) but also the yellow gault Eccles brick fabric 2454 (AD50-80).

Material type	Proportion	Use in Wardrobe Tower	Whereabouts
Roman brick; red fabric 2452	5%	Complete and broken up <i>Lydian</i> bricks as groupings of 3 lacing courses in the Roman City Wall and reused as rubble core sometimes with <i>opus signinum</i> .	Common - lacing courses in the Roman City Wall (Figures 11 and 17; Plates 27 to 29). Present reused and fragmentary with <i>opus signinum</i> in relict basal 0.5 metres of Bastion in the external east elevation of the Wardrobe Tower (Figure 11). Occasional reuse within Tudor/Stuart bricks in the inner south elevation above 2m above ground level (Figure 15).
Roman brick Yellow fabric 2454	3%	Complete and broken up <i>Lydian</i> bricks as groupings of 3 lacing courses in Roman City Wall	Common - lacing courses in the Roman City Wall: (Figures 11, 16 and 17; Plates 27 and 28)

#### Fabric 2452

The very fine red sandy Roman brick (fabric 2452 AD55-160) is common in the upper three lacing courses of the Roman City Wall (Figures 11 and 17; Plates 27 to 29) both in the core and facing of the wall. Beneath this and barely visible at the base of wall in both elevations the red bricks are present at the start of a second grouping of lacing courses. Complete examples conform in size and shape (1 ½ x 1 foot x 1 1/2 inches – 400x290x36mm) to rectangular *Lydian* bricks, common throughout Roman Britain as lacing courses (Brodrigg 1987). These are bonded in the Type M2 *opus caementatum* pebble cement.

Towards the base of the Wardrobe Tower in the external east elevation of the Wardrobe Tower (Figure 11), the red Roman brick survives in an irregularly tapering, narrow (10-25cm) longitudinal (2

<sup>2</sup> Museum of London Fabric Series

metre long) band coated in thick red *opus signinum*. There is complete *Lydian* sized brick in this surviving section of the Roman bastion, roughly arranged as two facing courses, between 35 and 40mm thick and up to 300mm across. In addition, to this there is fragmentary brick which suggesting some at least was reused and probably derived from the adjoining section of the Roman defensive wall.

**Fabric 2454**

The earliest dated tile fabric for London, the very distinctive very fine yellow-pink Eccles fabric 2454 (AD50-80) with scattered fine rose quartz is present in about one third of the facing courses within this section of the Roman City Wall. It is not present at all within surviving sections of the Bastion, where only the red fabric 2452 is present. The brick was produced from Gault clay very close to the River Medway at Eccles, close to where both the Carrstone and Kentish Ragstone outcrops are that produced the plinth, rubble core and facing sections of the Roman City Wall.

Once again the bricks conform in shape and size (1 ½ x 1 foot x ½ inch - 400x290x36mm) to rectangular *Lydian* bricks, common throughout Roman Britain as facing courses (Brodrigg 1987). These bricks which appear more in the core of the top 3 facing courses rather than the face of the Roman City Wall have degraded more rapidly than the red brick, come off in small sheets (**Plate 27**). Again they are bonded in the Type M2 *opus caementatum* pebble cement.

**Medieval yellow brick**

Medieval pink and yellow irregular bricks in fabric 3031nr3042 comparable with the large bricks used in the Beauchamp Tower from 1281 onwards was identified in two areas at the Wardrobe Tower. One small group lies 2.5m up in the inner east and south elevations (**Figures 14 and 15**), whilst an isolated example is located at the base of the outer west projecting medieval ashlar pier in the external south elevation of the Wardrobe Tower (**Figure 11**). These brick types which date from 1280-1450 have been identified in the extant medieval fabric from 14<sup>th</sup> century Outer Curtain Wall adjoining the Develin Tower (Hayward & Garwood 2015) and from the Bell Tower (Hayward 2016). This fabric is identical to the large brick used in the adjoining Beauchamp Tower from 1281 and also present in the adjacent Causeway (Hayward 2015c), both of which are large Edward I building programmes. Their presence here within surviving ashlar and rubble core sections of the Wardrobe Tower indicate a 13<sup>th</sup>-14<sup>th</sup> century building programme.

Material type	Proportion	Use in Wardrobe Tower	Whereabouts
Medieval brick 3031nr3042	<1%	Relict medieval brickwork with medieval stone ashlar and rubblestone	Rare –at 2.5 metres above ground level within the medieval ashlar and rubblestone fabric of the inner east and south elevations of the Wardrobe Tower ( <b>Figures 14 and 15</b> ).  One example - at 1 metre above ground level at the base of the medieval ashlar in the external south elevation of the Wardrobe Tower ( <b>Figure 11</b> ).

**Late medieval – Early post-medieval brick**

Very occasional, poorly made, dark brown sandy brick, in a fabric 3030 comparable with the late medieval to early post-medieval brick fabric 3030 (1400-1660) were identified in the inner east and south elevations of the Wardrobe Tower above 2.5metres usually along with Tudor/Stuart brick (Figures 14 and 15). This would suggest that they formed a minor role in the period of Tudor/Stuart brick building in the Wardrobe Tower.

Material type	Proportion	Use in Wardrobe Tower	Whereabouts
Late medieval early post-medieval brick fabric 3030	<1%	Brickwork	Rare – inner east and south elevations of the Wardrobe Tower above 2.5 metres within the Tudor/Stuart brickwork and occasional Reigate Stone.

**Tudor/Stuart brick**

Parts of the uppermost 3 metres of the inner south and east elevations of the Wardrobe Tower (Figures 14 and 15) are defined by the widespread use of sandy red bricks, made from London brick-earth fabric 3046 (AD1450-1700). The bricks here and in a small arched feature at the base of these elevations are of roughly the same dimensions. They are quite small, shallow, wide bricks conforming in size (8 7/8 x 4 1/4 x 2 inches – 225x110x51mm) to Henrician bricks (Hampton Court reference collection Type D), manufactured between 1515 and 1550. These only have small variations in width (105-110mm) and thickness (43-51mm) suggesting large scale centralised brick production.

A small, slightly arched section mid-way along the base of the external south and east elevations of the Wardrobe Tower (Figure 11) may represent the continuation of the Tudor/Stuart arch visible on the other side of the wall (Figures 14 and 15).

Material type	Proportion	Use in Wardrobe Tower	Whereabouts
Tudor/Stuart red sandy brick fabric 3046	10%	Widespread Tudor/Stuart brickwork	Common – Upper 3 metres of the inner south and east elevations of the Wardrobe Tower (Figures 14 and 15), also a small arched feature at the base of these elevations. Also small surviving section mid-way along the base of external south and east elevations of the Wardrobe Tower (Figure 11) and in the west (uppermost 1 metre) and north sections through the Wardrobe Tower (Figures 13 and 17).

**Post-medieval Post-Great Fire Brick**

Only occasionally are 18<sup>th</sup> and 19<sup>th</sup> century post-Great Fire bricks used in the Wardrobe Tower. Most of this purple-red clinker rich brick, fabric 3032 (1664-1900), is narrow and quite thick (4 x 2 1/2 inches – 100x63mm), conforming in size with the brick tax regulations brought in after 1776. These bricks were identified very sporadically in areas associated with Victorian repairs that is mixed rubble, Tudor/Stuart red brick and ashlar core in the inner south and east elevations of the Wardrobe Tower

above 3 metres above ground surface (**Figures 14 and 15**). They may have been inserted to replace the odd degraded Tudor/Stuart bricks when the surviving wall was repaired in the 19<sup>th</sup> century.

Material type	Proportion	Use in Wardrobe Tower	Whereabouts
Purple clinker rich post great fire brick fabric 3032	<1%	Very rare – Victorian replacement for degraded Tudor Brick,	Mixed, Tudor Brick rubble and ashlar sections in the inner south and east elevations of the Wardrobe Tower above 3 metres ( <b>Figures 14 and 15</b> ).

### ***Post-medieval Peg tile***

Examples of unglazed post-medieval red sandy fabric 2276 peg tiles (1480-1900) were present locally as Victorian levelling repairs to a small section of medieval ashlar mid-way along the external south-east elevation of the Wardrobe Tower at 3.5 metres (**Figure 11**) as well as levelling repairs to the mixed Tudor/Stuart red brick, rubble core and ashlar core of the inner south and east elevations (**Figures 14 and 15**), above 3 metres above ground level.

Material type	Proportion	Use in Wardrobe Tower	Whereabouts
Fine red sandy unglazed peg tile 2276	<1%	Rare – Victorian levelling replacement material for degraded medieval and Tudor stone	Repairs to a small section of medieval ashlar mid-way along the external south-east elevation of the Wardrobe Tower at 3.5 metres ( <b>Figure 11</b> ) as well as levelling repairs to the mixed Tudor/Stuart red brick, rubble core and ashlar core of the inner south and east elevations above 3 metres above ground level ( <b>Figures 14 and 15</b> ).



## APPENDIX 2: Mortar types

Mortar Type	Description	Use at the Wardrobe Tower
M1	<p><b>Very hard pale grey (10YR 7/2) to dark grey gravel mortar.</b> Variable inclusions of large angular brown flint up to 30mm across</p>	<p>Widespread - Early 20<sup>th</sup> century Board of Works facing mortar. Used, along with fresh consignments of hard angular Kentish Ragstone, occasional flecks of Portland Stone in areas of the Wardrobe Tower that have undergone wholesale repairs and restoration. Facing mortar to the entire <i>Petit Appareil</i> Kentish Ragstone section of the east external elevation (<b>Figure 12</b>), covers rubble core (including the rubble top) of the west and north sections through the Wardrobe Tower (<b>Figures 13, 14 and 17</b>), inner east and south elevations of the Wardrobe Tower up to a height of 2m above ground level (<b>Figures 14 and 15</b>).</p>
M2	<p><b>Very hard Brown black pebble mortar <i>opus caementatum</i></b></p>	<p>Localised - Roman facing and bedding mortar used throughout the Roman City Wall bonding the Kentish Ragstone rubble, facing, and brick lacing courses together (<b>Figures 12</b> (mortar sample 4), <b>16 and 17</b>) 1m height. Also localised surviving sections of the Roman bastion (later Wardrobe Tower) at its base – inner south and east elevations and north section through the Wardrobe Tower (<b>Figures 13 to 15</b>)</p>
M3	<p><b>White soft lime mortar.</b> Fine mortar occasional red brick flecks</p>	<p>Widespread bedding Tudor/early post-medieval mortar associated with Tudor/Stuart bricks in the upper 3 metres of the inner south and east elevations (<b>Figures 14 and 15</b>; mortar sample 3; <b>Plates 24 and 25</b>), bedding mortar of the <i>Petit Appareil</i> Kentish Ragstone blocks in the east external elevation of the Wardrobe Tower (<b>Figure 12</b>; mortar sample 2), also identified as bedding mortar of the arched brick feature at the base of the external south and east elevations of the Wardrobe Tower (<b>Figure 11</b>)</p>
M4	<p><b><i>Opus signinum</i> - Very hard light pink concretionary mortar with flecks of red brick</b></p>	<p>Localised – Facing and bedding mortar at base of east external elevation of the Wardrobe Tower in a section 2 metres long by 25cm thick associated with Roman courses of <i>Lydian</i> bricks (<b>Figure 12</b>). Relict surviving <i>in-situ</i> fabric of the Roman bastion. One of two Kentish Ragstone blocks identified with <i>opus signinum</i> above this Roman bastion base, reused in the <i>Petit Appareil</i> Kentish Ragstone facing.</p>
R1	<p><b>Hard white (5Y 8/1) gritty lime render</b> Thin veneer consisting of regular small (&lt;0.3mm) angular quartz set within softer white lime matrix</p>	<p>Medieval render present on the external face of small medieval Kentish Ragstone <i>Petit Appareil</i> blocks in the east external elevation of the Wardrobe Tower in a defined area: roughly 1.5m to 2m high, along a 4m section (<b>Figure 12</b>). Seen in reused blocks from the 1190 Bell Tower (Hayward 2016) and in sections of the outer curtain wall adjacent to the Develin Tower (Hayward &amp; Garwood 2015). Originally from the White Tower or another Norman structure.</p>

## APPENDIX 2: Mortar types used in the Wardrobe Tower (cont.)

There was found to be a rather limited suite of mortar types (4) (M1-M4) used in the Wardrobe Tower as well as render (R1). The hard Roman *opus signinum* (M4) and *opus caementatum* (M2) facing/bedding mortars have survived extremely well, helping to pick out discrete pockets of surviving Roman bastion fabric at the base of the Wardrobe Tower as well as in the Roman City Wall. By contrast any surviving medieval bedding mortars used to point the ashlar and *Petit Appareil* Kentish Ragstone bedding have been entirely replaced by softer white Tudor mortar (M3) with red brick flecks. There was only one post 1880 very hard grey angular brown flint mortar (M1) used to strengthen the surviving fabric of the demolished Wardrobe Tower. This was used extensively as a facing mortar on all sections of the Wardrobe Tower but not used at all in the Roman City Wall and is of a similar recipe to that associated with 20<sup>th</sup> century repairs at the Well Tower (Hayward 2017), Bell Tower (Hayward 2016) and Develin Tower (Hayward & Garwood 2015).

### **Roman *opus caementatum***

By far the hardest mortar was found to be the very hard distinctive round black flint pebbly recipe with occasional lime shell fragments (M2), bonding the Roman City Wall. It held together the facing courses of Roman brick, the Kentish Ragstone rubble and facing stone as well as the basal coping stone blocks.

Its use can be traced to discrete basal sections of the adjacent Wardrobe Tower (once Bastion 1 or B1 (Merrifield 1965)). The core material contains reused fragments of Tufa and banded shelly Oolitic Limestone, both very common Roman materials for London (Hayward 2009; 2015a).

### **Roman *opus signinum***

Pink, hard Roman cement (*opus signinum*) (M4) made from very small fragments of red fabric 2452 Roman tile and brick was used in a discrete pocket (2 metres long x 25 cm high) at the base of the external east elevation of the Wardrobe Tower (**Figure 11**), once Bastion or B1 (Merrifield 1965). Its presence, along with the associated Roman *Lydian* bricks provides evidence for the Roman bastion.

### **Medieval Render**

Traces of a remnant hard white (5Y 8/1) gritty lime render were (R1) was identified in pockets in the *Petit Appareil* Kentish Ragstone blocks along the external east elevation of the Wardrobe Tower (**Figure 12**). This render was located in a defined area; roughly 1.5 m to 2 m in height, by 4 metres across and may have originated from the adjacent White Tower given their identification from the White Tower Batter (Hayward 2015b). Alternatively, it is an early attempt to whitewash the Wardrobe Tower as well. Other examples of this render were found reused in the 1190 Bell Tower (Hayward 2016) and outer curtain wall between the Develin Tower and Well Tower (Hayward & Garwood 2015) and sections of the medieval fabric of the Well Tower itself.

### **Early Post Medieval mortar**

Soft white bedding mortar (M3) with red brick flecks (fabric 3046; 1450-1700) (mortar sample 3; **Plates 24 and 25**) were identified holding together the Tudor/Stuart brickwork of the upper 3 metres of the inner south and east elevations of the Wardrobe Tower (**Figures 14 and 15**) and a small section, mid-way along the base of the south and east external elevations of the Wardrobe Tower (**Figure 12**). It also formed the bedding mortar for the *Petit Appareil* Kentish Ragstone blocks along the east external elevation of the Wardrobe Tower (**Figure 12**; mortar sample 2), which may itself have replaced an earlier relict medieval mortar.

### **Victorian and 20<sup>th</sup> century mortars**

Both the discovery of previously hidden sections of the Wardrobe Tower's medieval masonry (and associated friable mortar), and its partial demolition in the late 19<sup>th</sup> century mortar, instigated a programme of works that targeted wholesale repairs and repointing of much of the bastions fabric in the 20<sup>th</sup> century

A single mortar fabric, a hard, dark-grey recipe with small angular brown flint inclusions (M1) was used to repoint the *petit appareil* ragstone blocks, strengthen the medieval rubble core (including introducing fresh ragstone blocks) along most of the elevations, including the surviving exposed rubble core at the top of the bastion, This is comparable to the gravel facing mortar seen elsewhere in the Tower where it is used in conjunction with fresh Kentish Ragstone in the turreted areas of the Well Tower (Hayward 2017), Bell Tower (Hayward 2016) and Develin Tower (Hayward & Garwood 2015).

## APPENDIX 3: OASIS FORM

### 9.1 OASIS ID: preconst1-295079

#### Project details

Project name	Wardrobe Tower, Tower of London Historic Building Recording
Short description of the project	Pre-Construct Archaeology was commissioned by Historic Royal Palaces to undertake building recording of the Wardrobe Tower, HM Tower of London. The Tower of London is a Scheduled Monument and a World Heritage Site. The Wardrobe Tower is of exceptional significance as a surviving fragment of a D-shaped medieval tower, incorporating the base of a Roman bastion and an adjacent section of the Roman City Wall. The upper part of the tower was demolished in the late 19th century. The recording before and during conservation was carried out in 2017 as a condition of Scheduled Monument Consent. Fabric analysis established that the Roman City Wall was a single build comprising Kentish Ragstone in <i>opus caementatum</i> , tile bonding courses and a plinth of Carrstone, Barnack Stone and Weldon Stone. The recording established that much more of the Roman bastion fabric survives than had previously been thought. The bastion contained Kentish Ragstone in <i>opus signinum</i> . The medieval Wardrobe Tower was built on top of the foundations of the Roman bastion. Medieval facing included Petit Appareil blocks of Kentish Ragstone and two ashlar piers of Reigate Stone, Caen Stone, Quarr Stone with larger blocks of French Calcaire Grossier. The latter are thought to have been reused from a monumental Roman building or structure. A Tudor/Stuart red brick curved feature at the base of the inner elevations is thought to have been a fireplace. In 1879 most of the Wardrobe Tower was demolished. Work was stopped in time to salvage the remains that survives today.
Project dates	Start: 18-01-2017 End: 15-04-2017
Previous/future work	No / Yes
Any associated project reference codes	ToL 164 - Sitecode
Type of project	Building Recording
Site status	Conservation Area
Site status	World Heritage Site
Site status (other)	Scheduled Monument, Listed Building, World Heritage Site
Current Land use	Other 8 - Land dedicated to the display of a monument
Monument type	DEFENSIVE WALL Roman
Monument type	TOWER Medieval
Monument type	BASTION Roman
Methods & techniques	"Photographic Survey", "Survey/Recording Of Fabric/Structure"
Prompt	Scheduled Monument Consent

#### Project location

Country	England
Site location	GREATER LONDON TOWER HAMLETS STEPNEY Wardrobe Tower, Tower of London

Postcode E1W 1LE  
Site coordinates TQ 53356 18040 50.940805249784 0.183048391733 50 56 26 N 000 10 58 E  
Point  
Lat/Long Datum  
(other)

---

#### Project creators

Name of Organisation Pre-Construct Archaeology Limited  
Project brief originator George Roberts  
Project design originator Charlotte Matthews  
Project director/manager Charlotte Matthews  
Project supervisor Kevin Hayward  
Type of sponsor/funding body Historic Royal Palaces  
Name of sponsor/funding body Historic Royal Palaces

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#### Project archives

Physical Archive Exists? No  
Digital Archive recipient Hampton Court  
Digital Archive ID ToL 164  
Digital Contents "Survey"  
Digital Media available "Survey","Text","Images raster / digital photography"  
Paper Archive recipient Hampton Court  
Paper Archive ID ToL 164  
Paper Contents "Survey"  
Paper Media available "Survey "

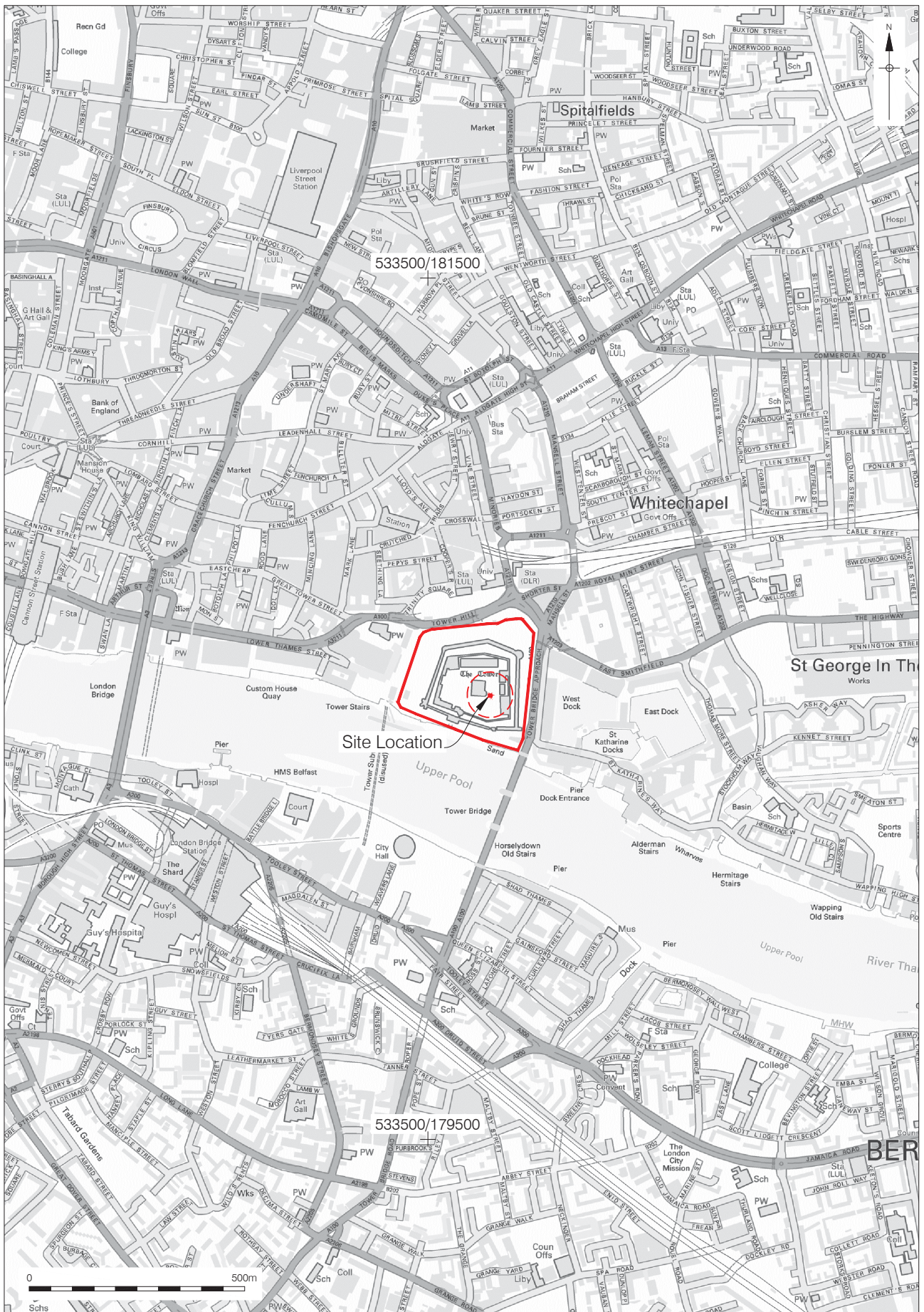
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#### Project bibliography 1

Publication type Grey literature (unpublished document/manuscript)  
Title Assessment Report on the Historic Building Recording of the Wardrobe Tower, HM Tower of London, London Borough of Tower Hamlets  
Author(s)/Editor(s) Hayward, K.  
Other bibliographic details PCA Report No. R13071

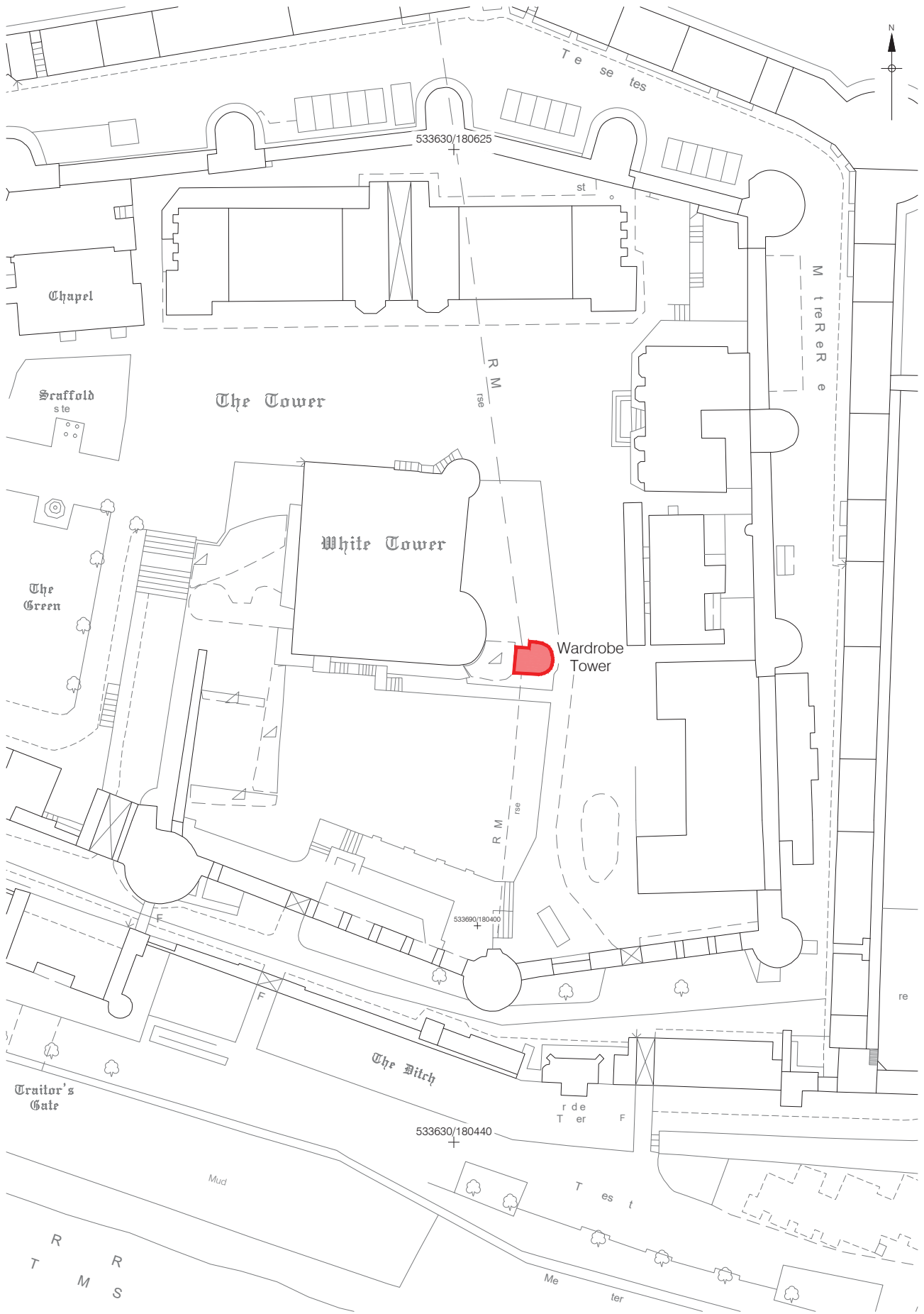
Date	2017
Issuer or publisher	Pre-Construct Archaeology Limited
Place of issue or publication	Brockley, London
Description	A4 report
Entered by	Charlotte Matthews (cmatthews@pre-construct.com)
Entered on	27 October 2017

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 30/10/17 MR

Figure 1  
 Site Location  
 1:12,500 at A4



0 40m

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30/10/17 MR

Figure 2  
Detailed Site Location  
1:1,000 at A4



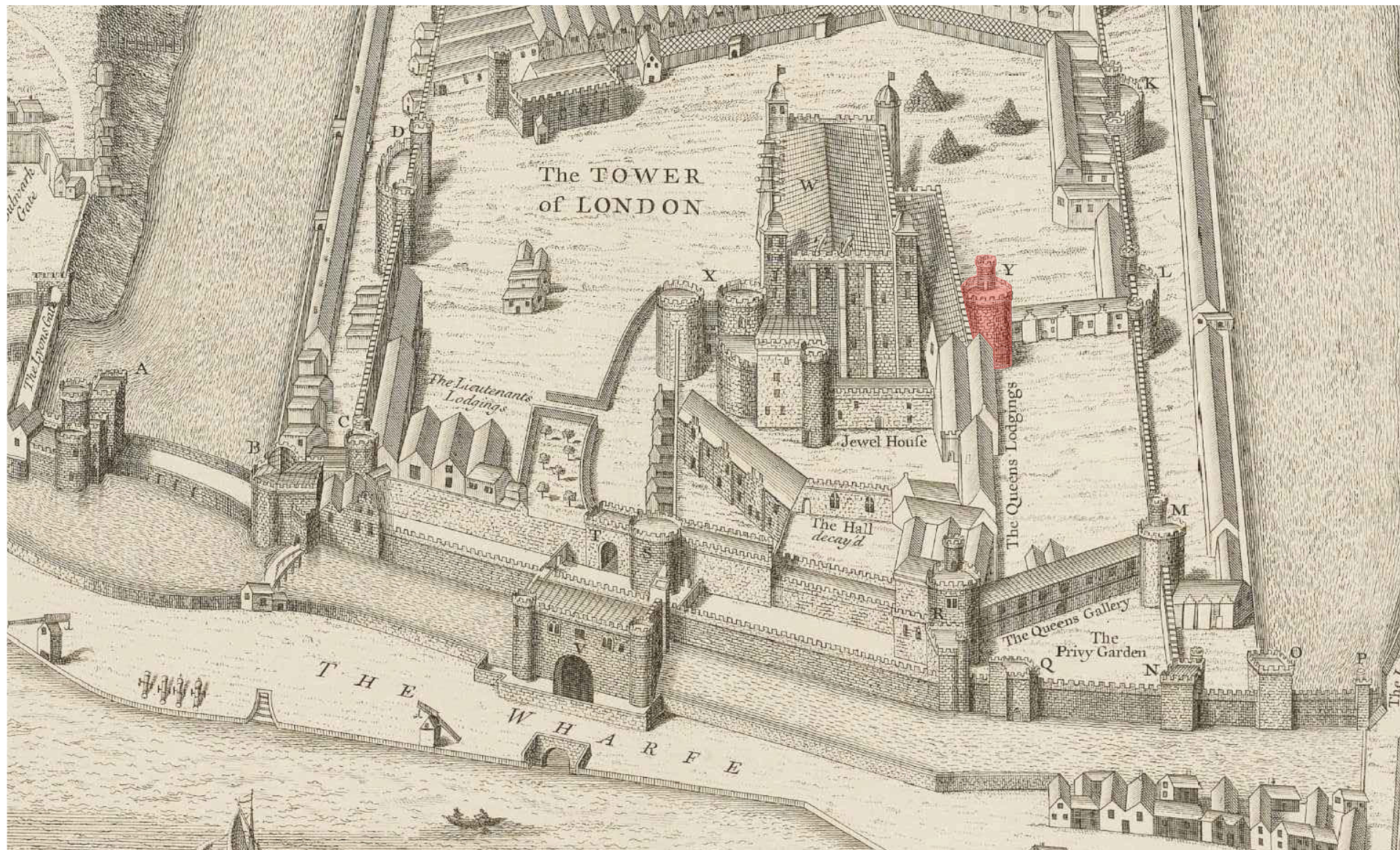
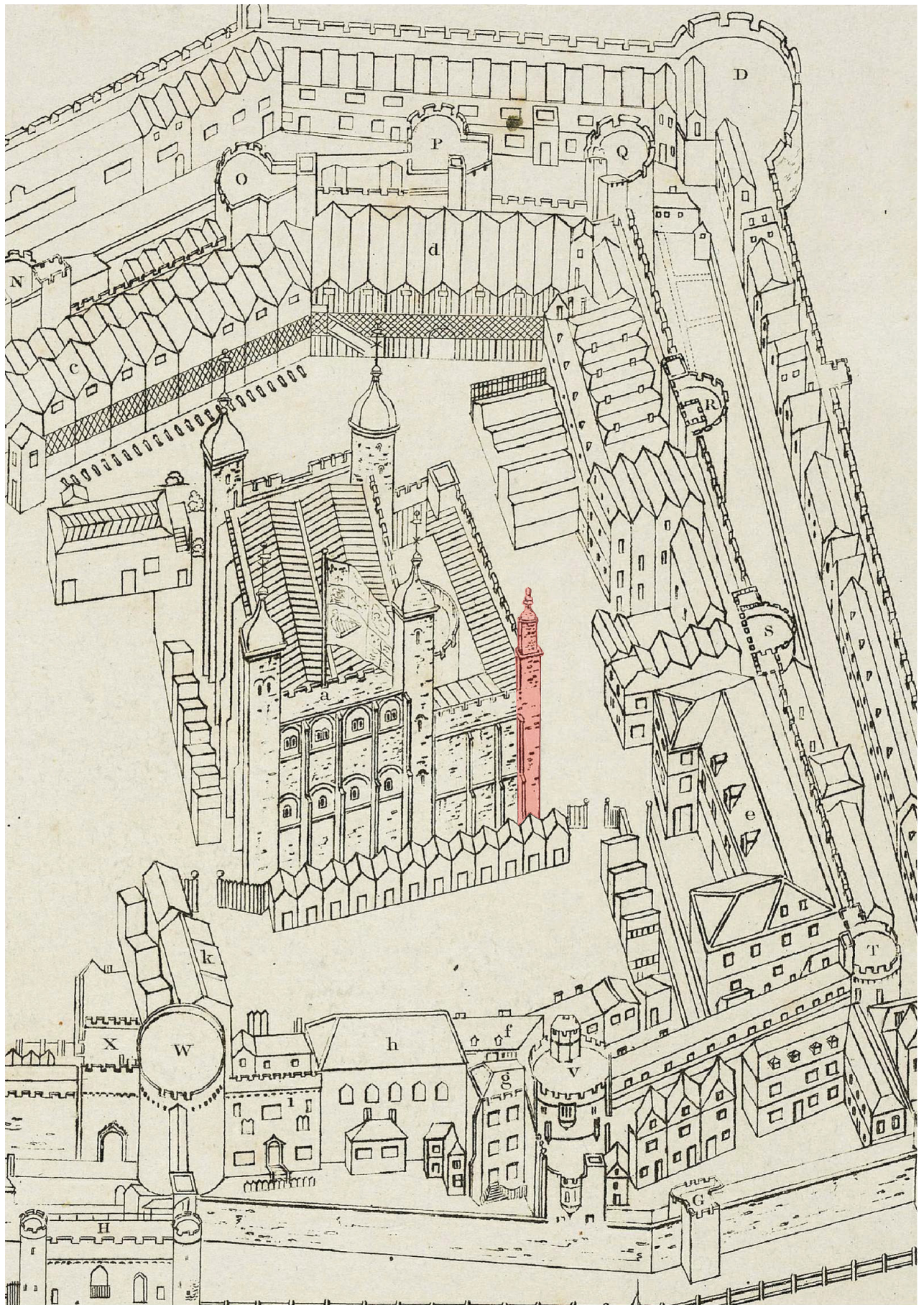
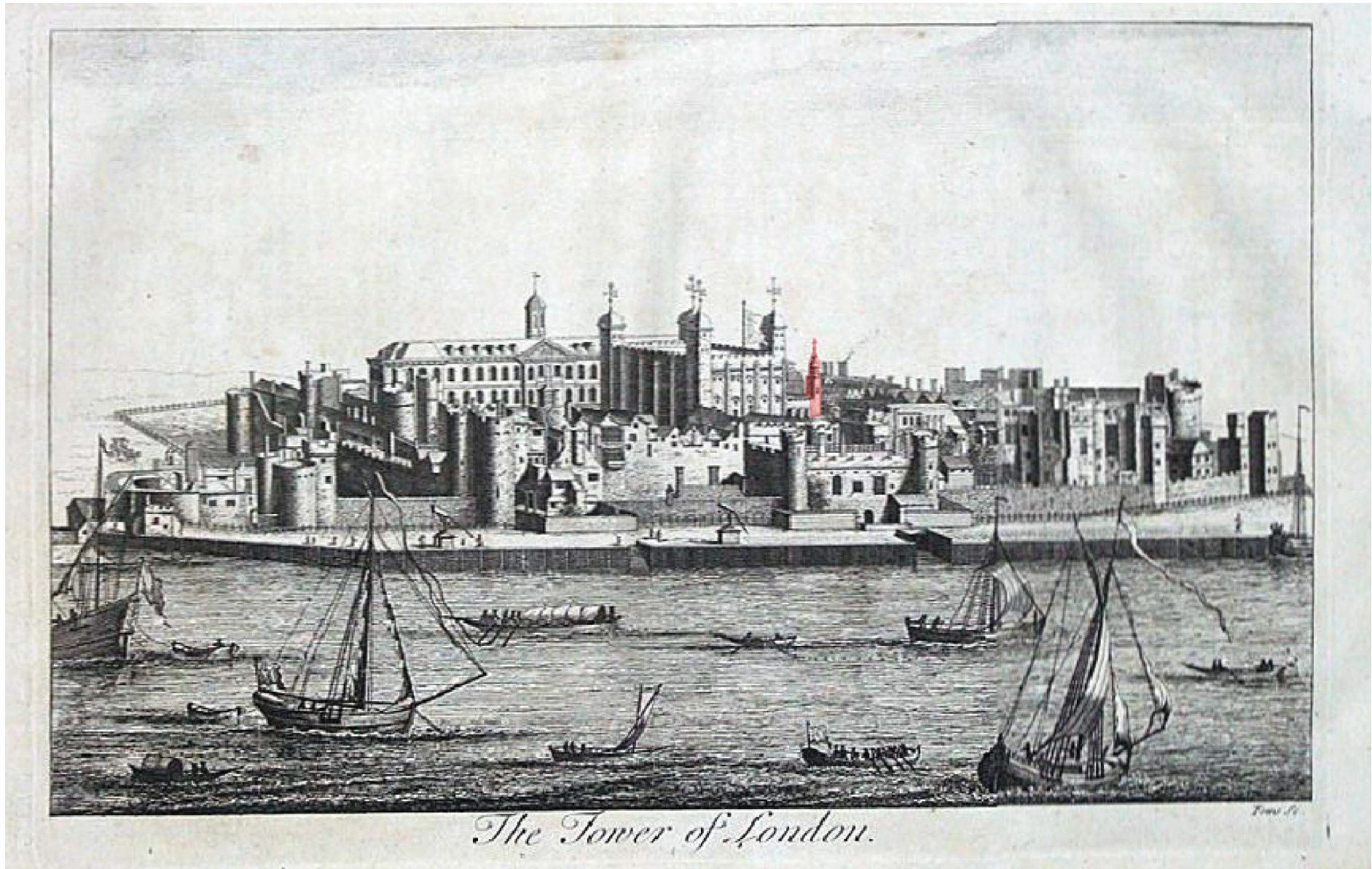
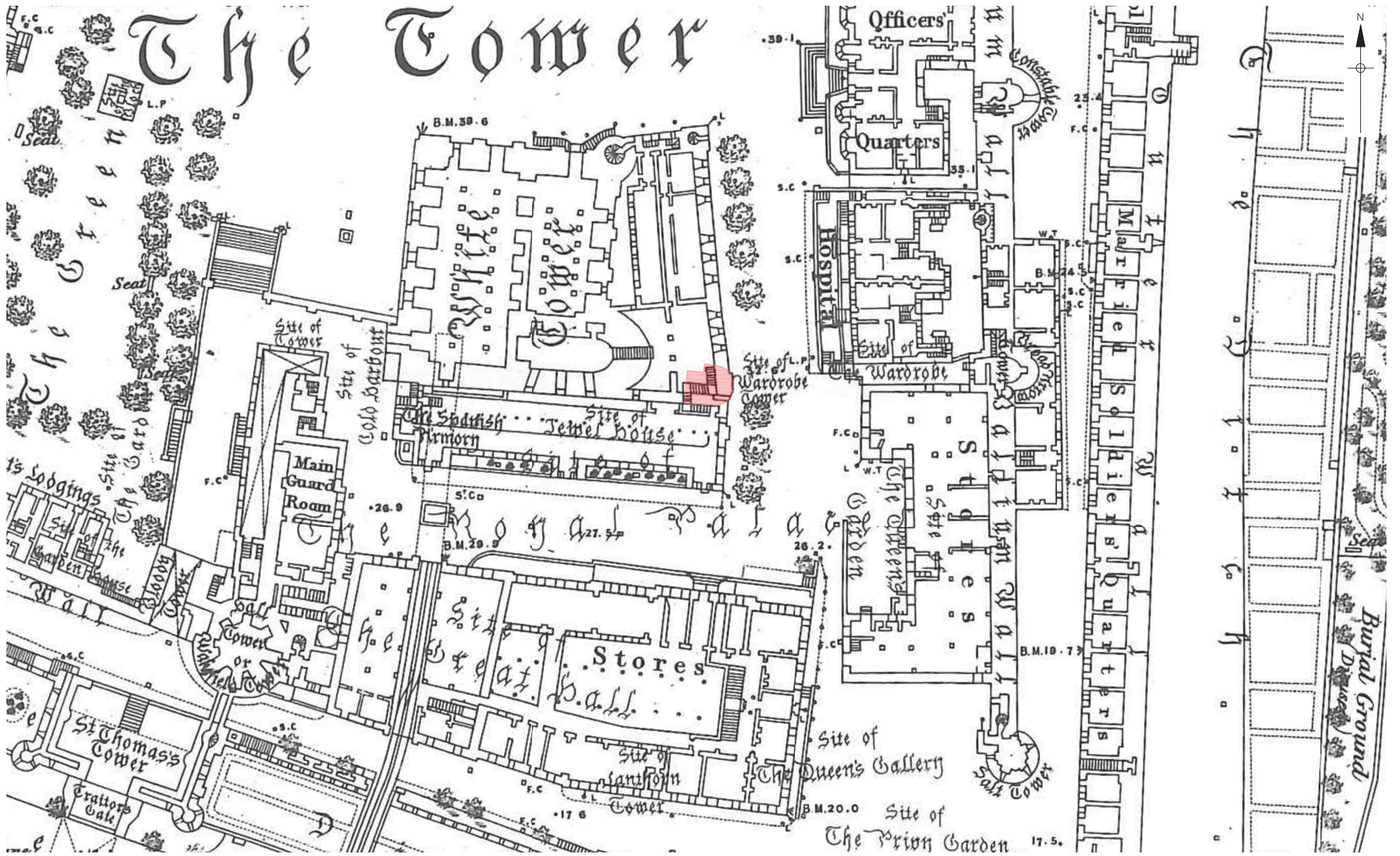


Figure 3  
Copy of Haiward and Gascoyne's Survey of 1597 made for the Society of Antiquaries in 1741  
(The Society of Antiquaries of London)  
(no scale)

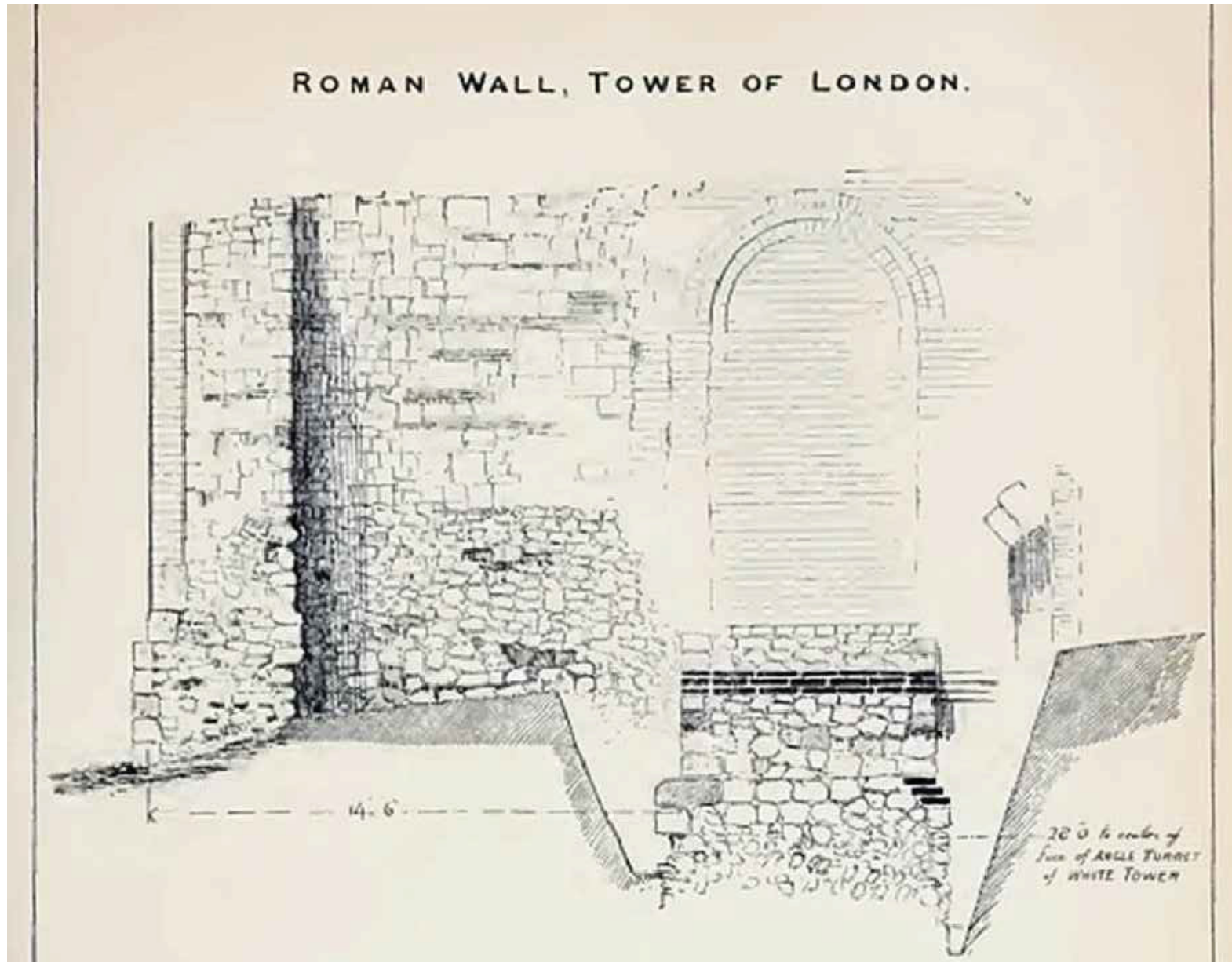






0 40m

Figure 6  
First Edition Ordnance Survey map, 1872-73  
1:800 at A4





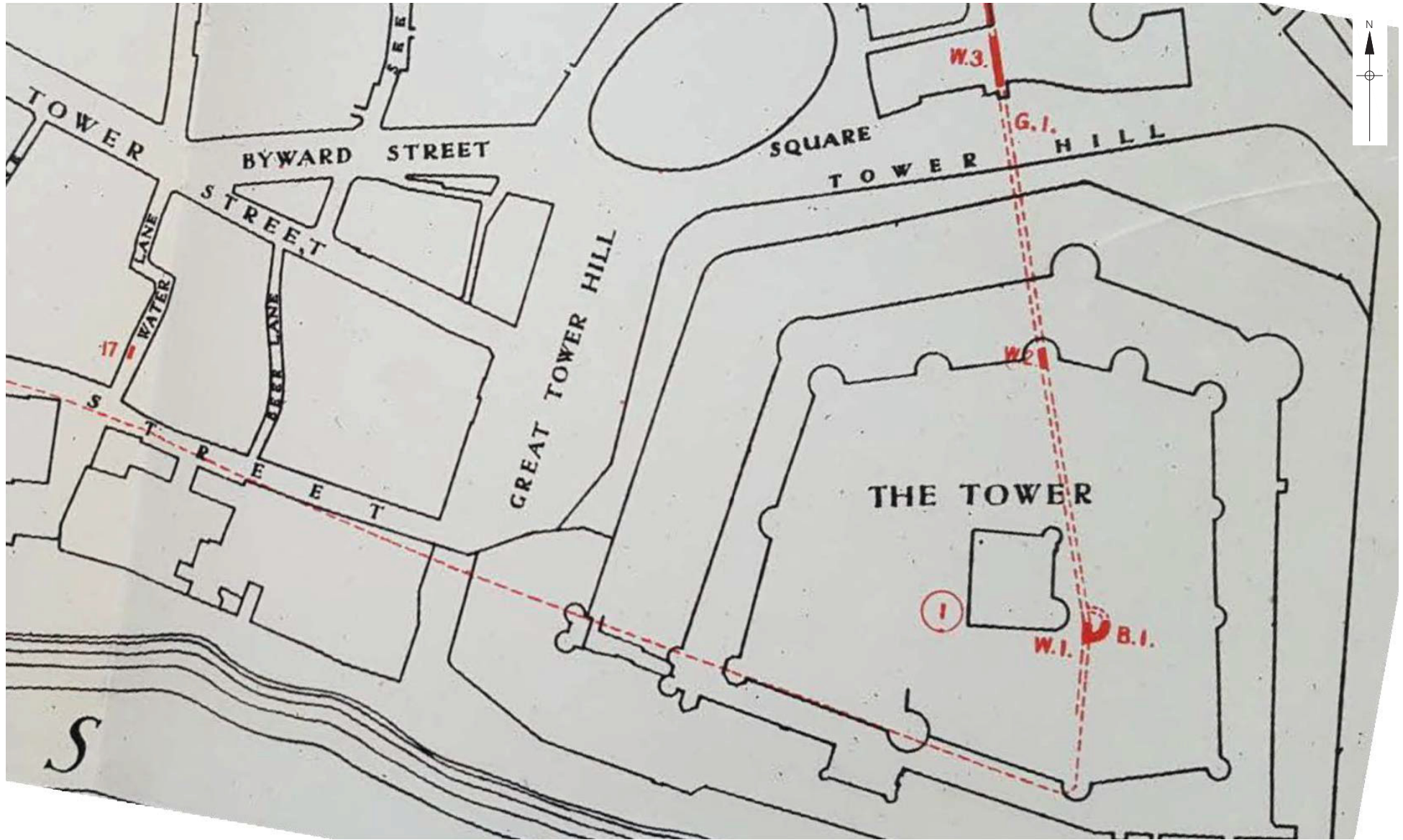


Figure 9  
 Plan showing the Roman City Wall with the Wardrobe Tower labelled as Bastion 1 (B.1.)  
 (RCHM, London; Volume 1 (1928))  
 (no scale)

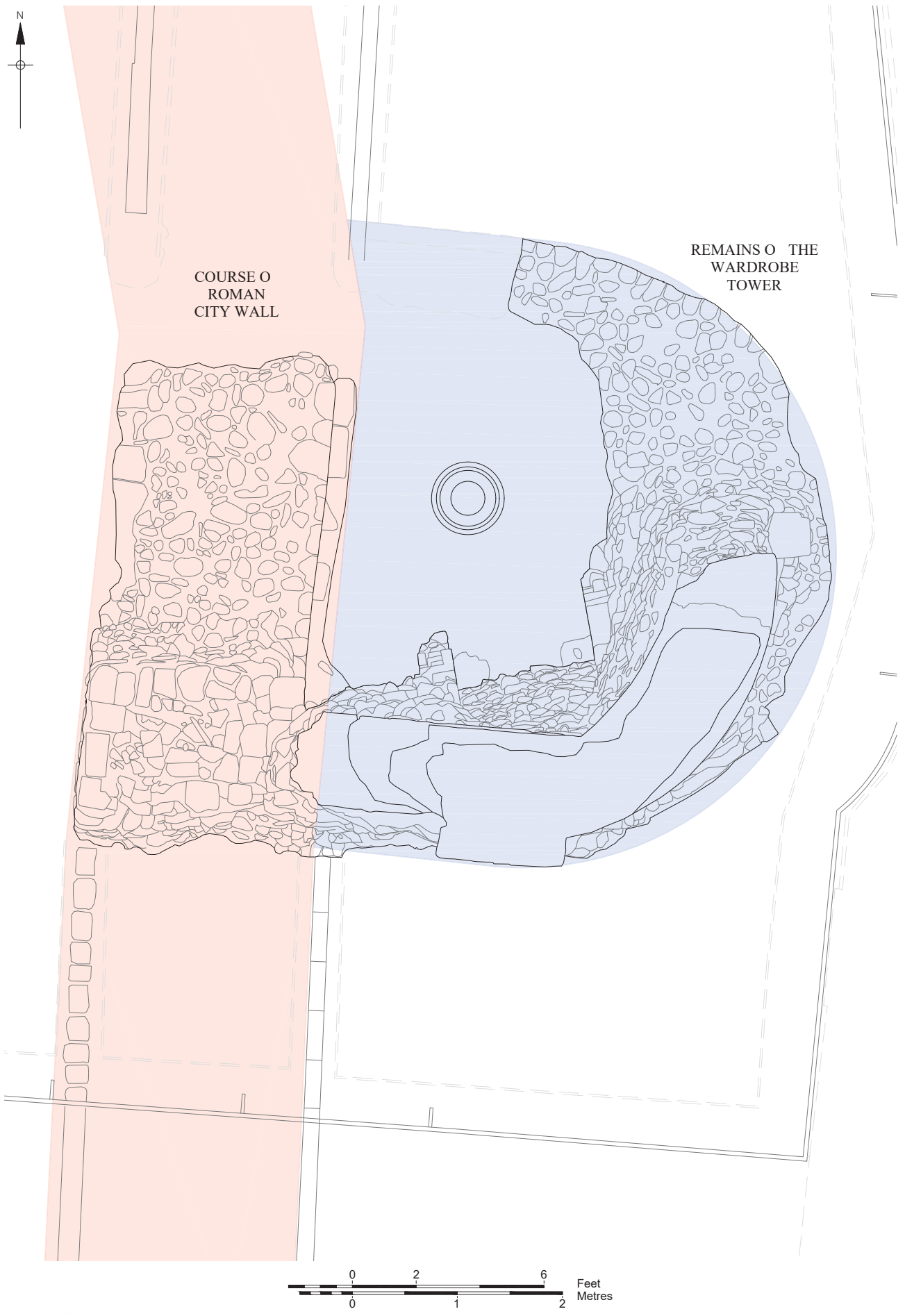
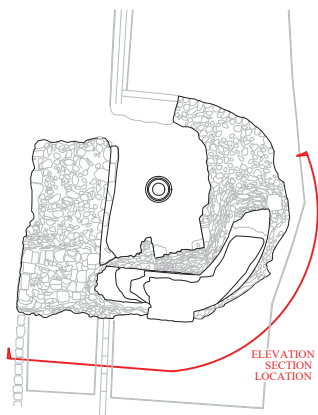
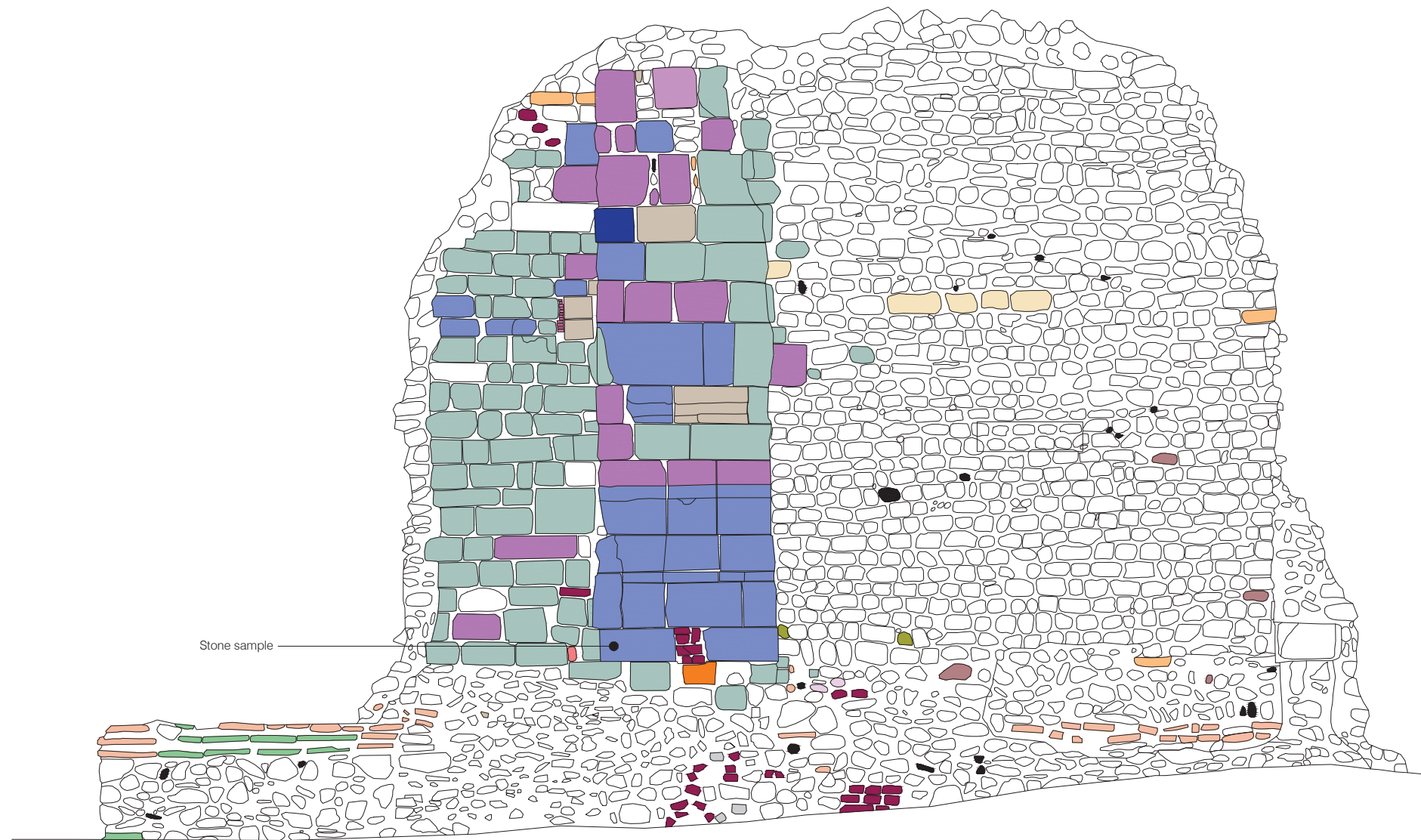


Figure 10  
Plan of the remains of the Roman City Wall and Wardrobe Tower  
1:50 at A4





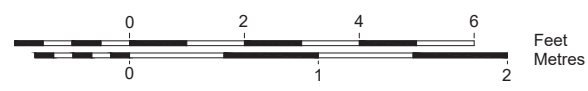
- Caen stone
- Calcaire Grossier
- Chalk
- Coombe Down Oolite
- Flint
- Kentish Ragstone
- Poor quality Kentish Ragstone
- Portland stone
- Purbeck Limestone
- Purbeck Marble
- Quarrstone
- Reigate stone
- Tufa
- Septarian Nodule
- Roman Brick
- Eccles Yellow Roman Brick
- Medieval brick
- Tudor brick
- Post-Great Fire Brick
- Post-medieval Peg Tile
- Stone sample

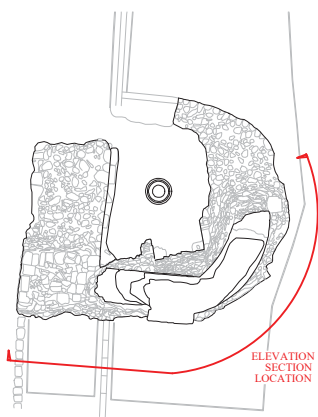


SECTION THROUGH THE ROMAN CITY WALL      WARDROBE TOWER

8.00m Above Newlyn Datum

CURVED ELEVATION IS UNWRAPPED





- Type M1: Late C19/early C20th flint gravel facing mortar
- Type M2: Roman *opus caementatum* black pebble mortar
- Type M3: Tudor/Stuart lime bedding mortar
- Type M1 facing mortar over Type M3 bedding mortar
- Type M4: Roman *opus signinum*
- Relict Roman *opus signinum*
- Type R1: Remnant hard white medieval render
- Mortar sample

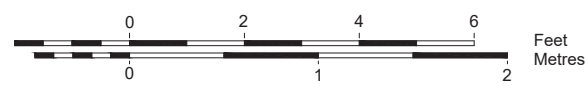
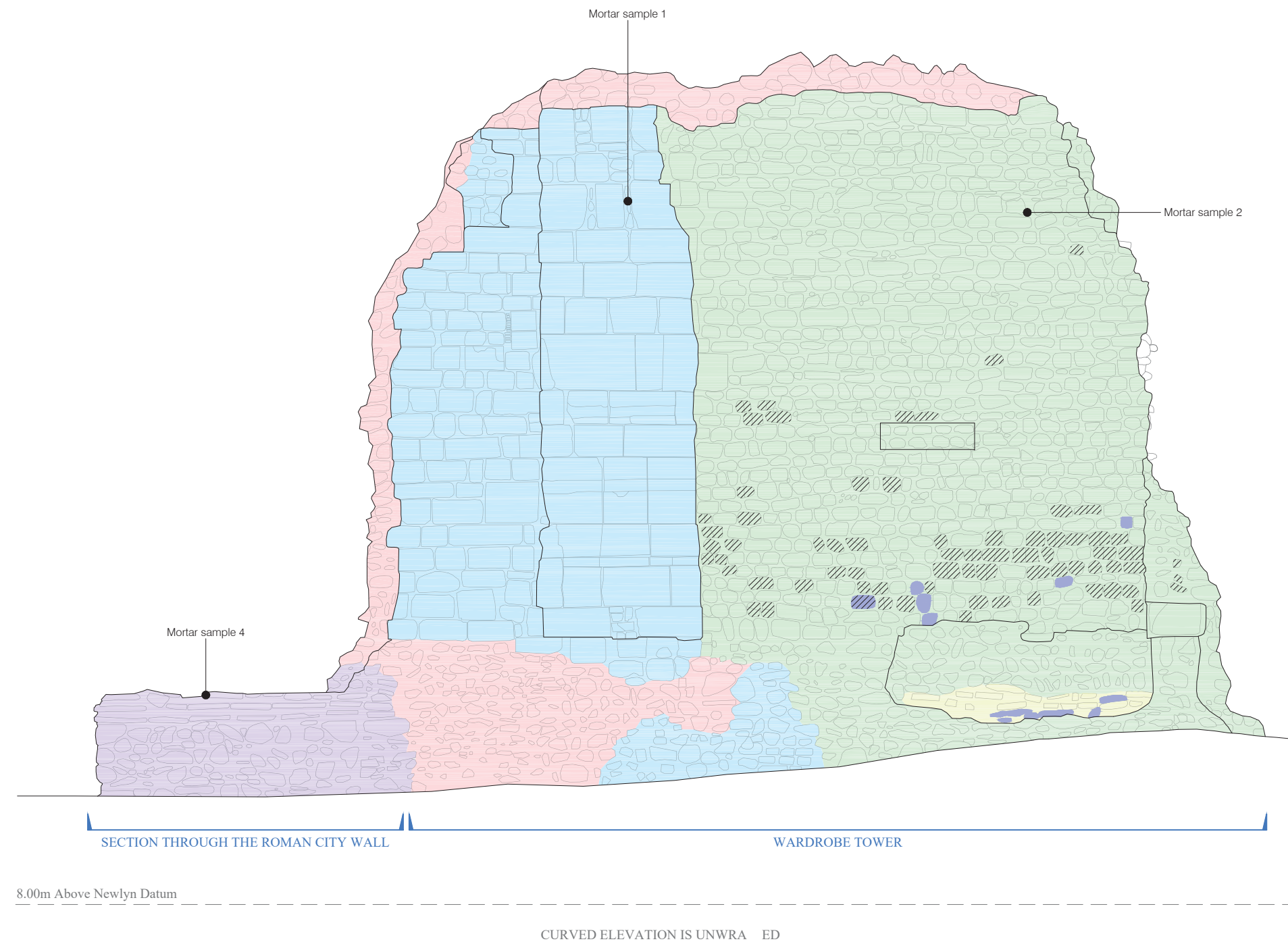
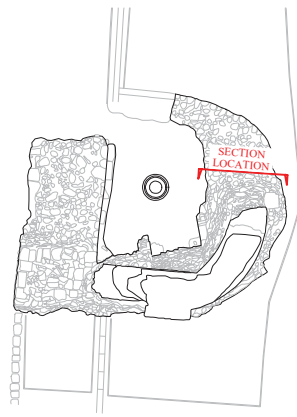
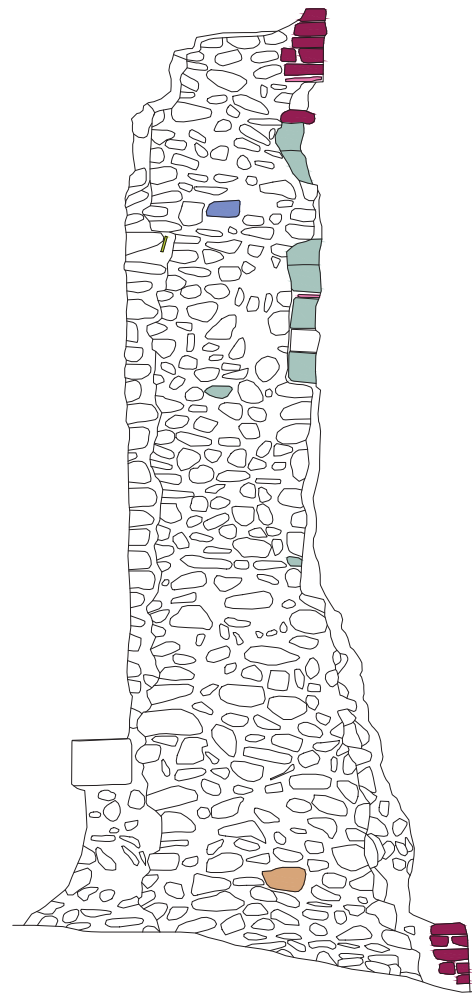


Figure 12  
Mortar types in the section of the Roman City Wall and in the South and East External Elevations of the Wardrobe Tower  
1:40 at A3

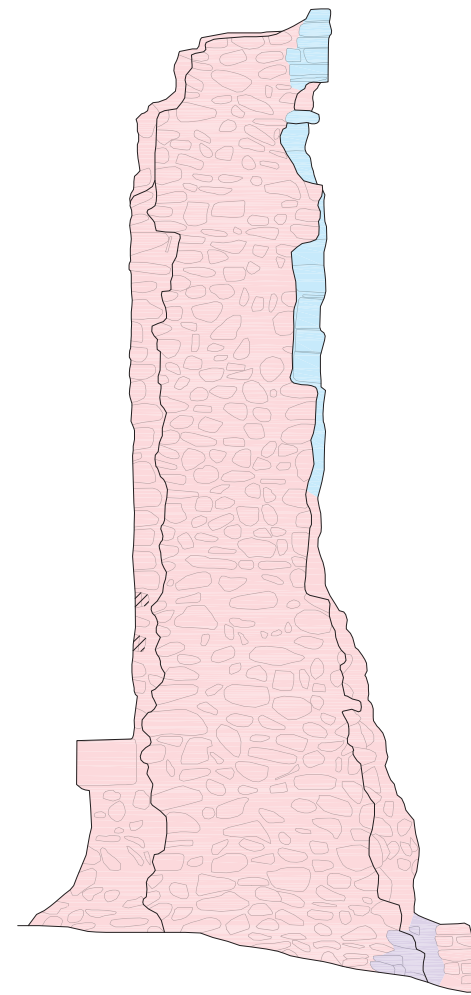


- Calcaire Grossier ■
- Hassock Greensand ■
- Kentish Ragstone ■
- Reigate stone ■
- Tudor brick ■
- Post-medieval Peg Tile ■

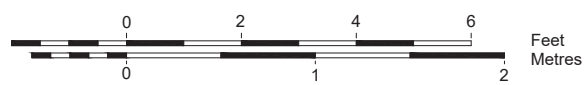
- Type M1: Late C19/early C20th flint gravel facing mortar ■
- Type M2: Roman *opus caementatum* black pebble mortar ■
- Type M3: Tudor/Stuart lime bedding mortar ■
- Type R1: Remnant hard white medieval render ▨

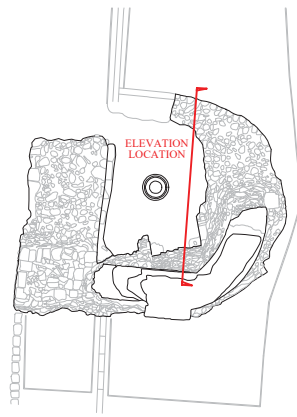


8.00m Above Newlyn Datum

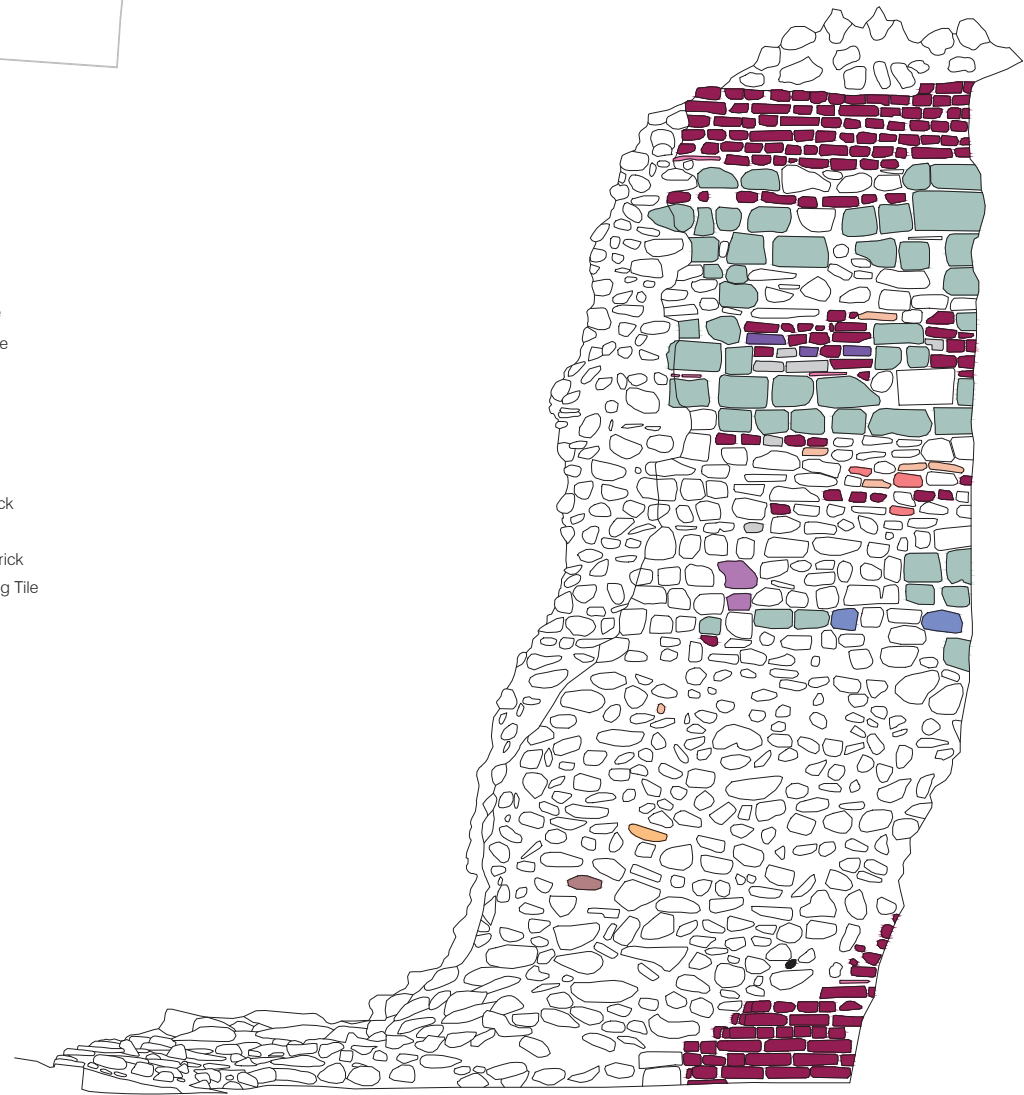


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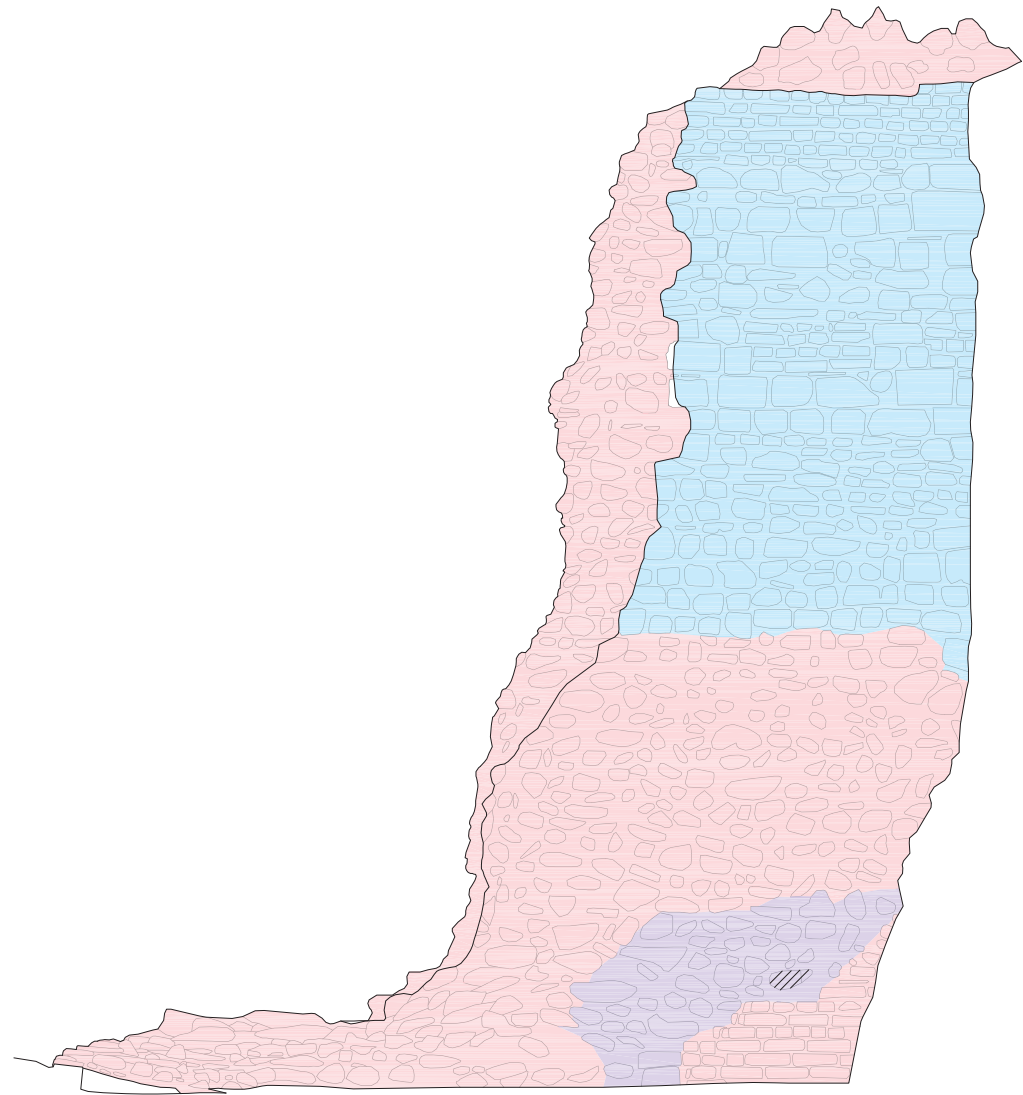


- Caen stone
- Calcaire Grossier
- Flint
- Kentish Ragstone
- Purbeck Limestone
- Reigate stone
- Tufa
- Roman Brick
- Medieval brick
- Late Medieval Brick
- Tudor brick
- Post-Great Fire Brick
- Post-medieval Peg Tile

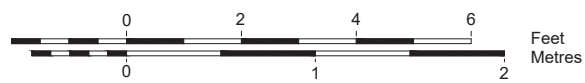


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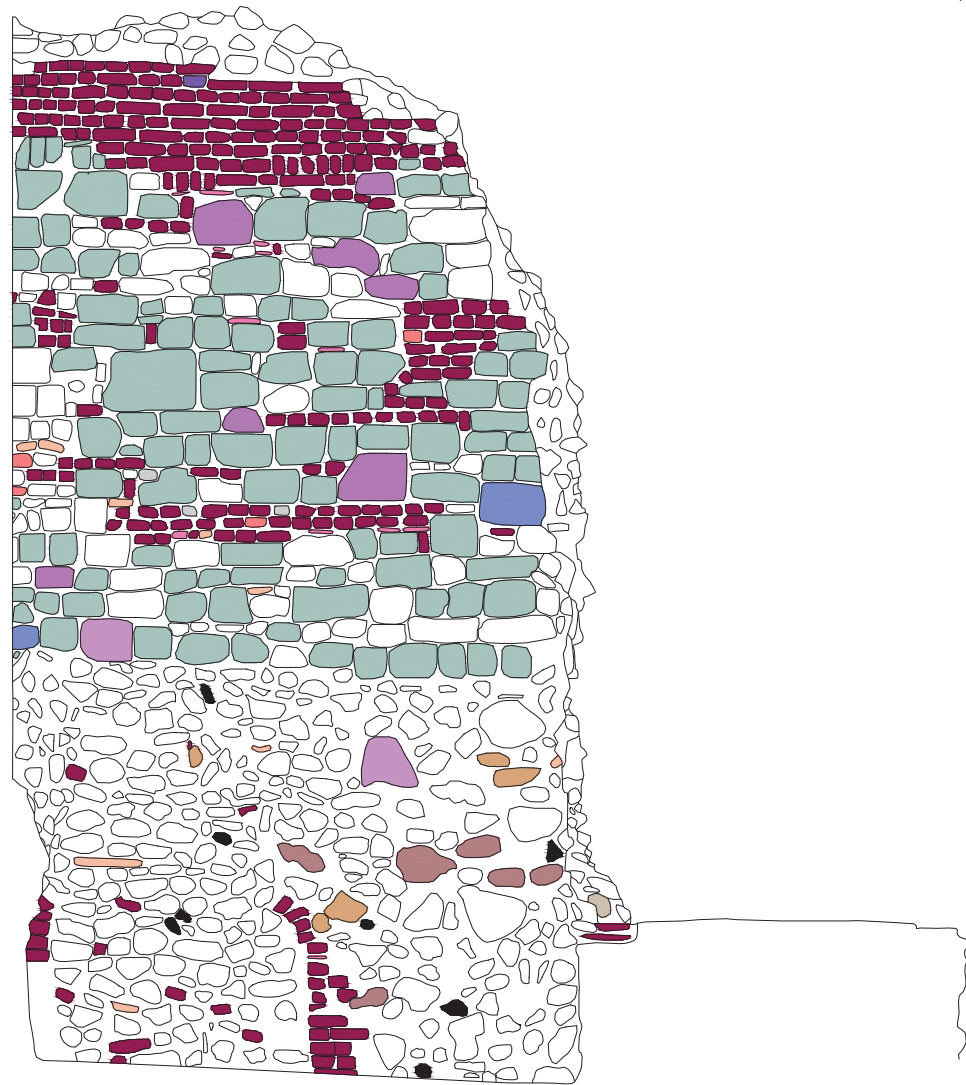
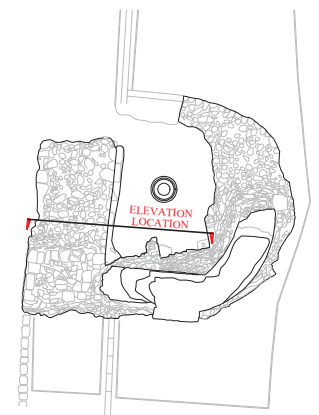
- Type M1: Late C19/early C20th flint gravel facing mortar
- Type M2: Roman *opus caementatum* black pebble mortar
- Type M3: Tudor/Stuart lime bedding mortar
- Type R1: Remnant hard white medieval render



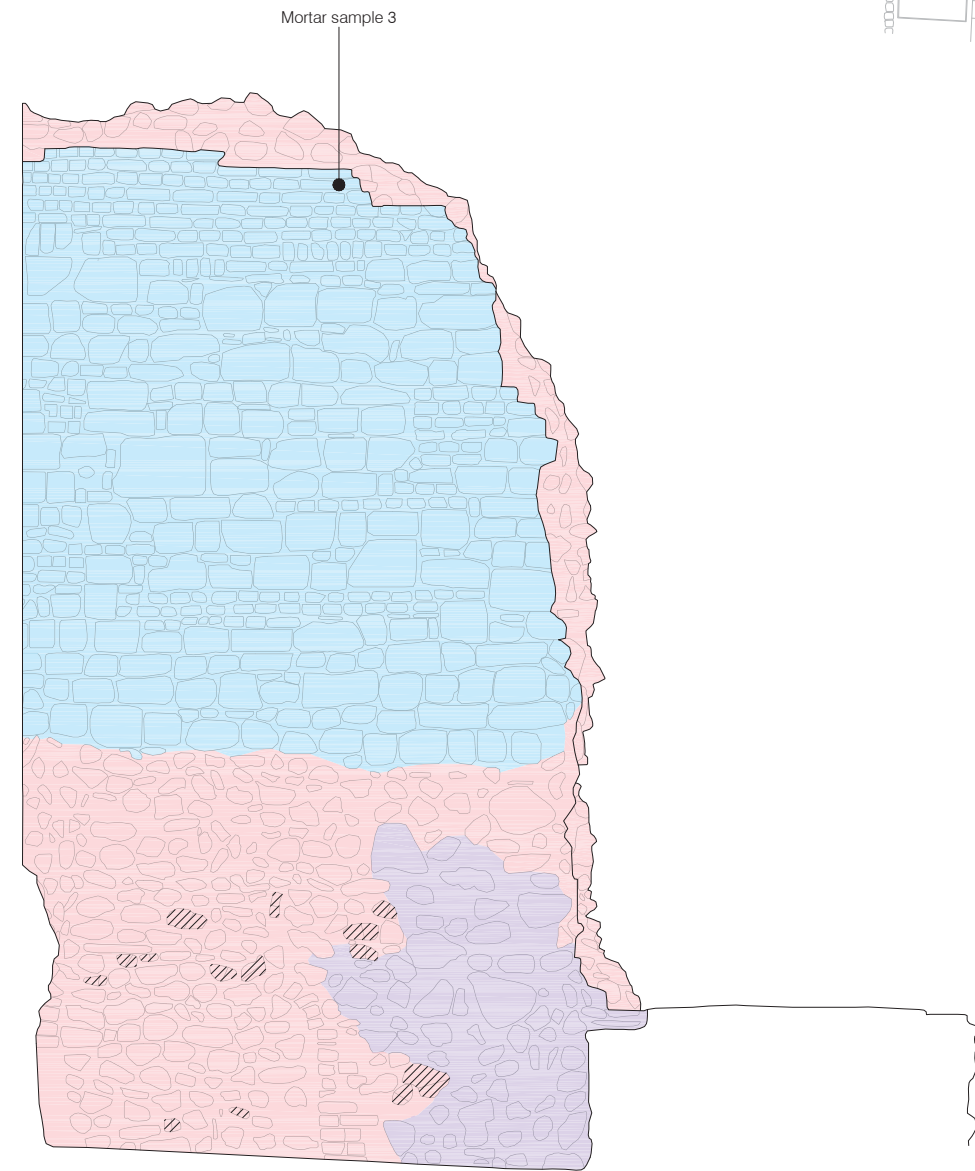
8.00m Above Newlyn Datum



- |                        |   |  |   |
|------------------------|---|--|---|
| Caen stone             | ■ | Type M1: Late C19/early C20th flint gravel facing mortar   | ■ |
| Calcaire Grossier      | ■ | Type M2: Roman <i>opus caementatum</i> black pebble mortar | ■ |
| Coombe Down Oolite     | ■ | Type M3: Tudor/Stuart lime bedding mortar                  | ■ |
| Flint                  | ■ | Type R1: Remnant hard white medieval render                | ▨ |
| Hassock Greensand      | ■ | Mortar sample  | ● |
| Kentish Ragstone       | ■ |  |   |
| Portland stone         | ■ |  |   |
| Reigate stone          | ■ |  |   |
| Tufa                   | ■ |  |   |
| Roman Brick            | ■ |  |   |
| Medieval brick         | ■ |  |   |
| Late Medieval Brick    | ■ |  |   |
| Tudor brick            | ■ |  |   |
| Post-Great Fire Brick  | ■ |  |   |
| Post-medieval Peg Tile | ■ |  |   |



8.00m Above Newlyn Datum



8.00m Above Newlyn Datum

