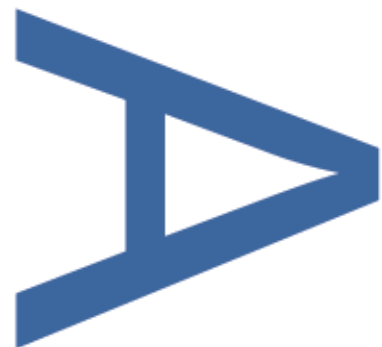


**BUILDING RECORDING
WATCHING BRIEF
DURING LIFTING OF FLOOR
STRUCTURES IN
THE WHITE TOWER,
HM TOWER OF LONDON,
LONDON BOROUGH OF TOWER
HAMLETS**

PCA REPORT NO: R12952

JULY 2017



PRE-CONSTRUCT ARCHAEOLOGY

**Building Recording Watching Brief during lifting of floor structures in the White Tower,
HM Tower of London, London Borough of Tower Hamlets**

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HM Tower of London,
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1 NON-TECHNICAL SUMMARY

- 1.1.1 Pre-Construct Archaeology Limited was commissioned by Historic Royal Palaces to carry out an Historic England Level 1 and 2 building recording watching brief before and during the lifting and reinstatement of historic floor structures in the White Tower, HM Tower of London, Tower Hamlets. The work to the second (upper) floor structures was carried out in connection with improvements to fire protection.
- 1.1.2 The Tower of London is a World Heritage Site, a Scheduled Monument and lies in a Conservation Area. The White Tower is of exceptional significance because it lies at the centre of the Tower of London and 'is the example par excellence of the royal Norman castle in the late 11th century'. The White Tower is Grade I listed and is described as: 'Tower keep. c.1078-1100 for William I and William II, probably to designs of Gundulf, Bishop of Rochester; later repairs and alterations, principally in C18 and C19 and by A Salvin, 1856-7; Rag-stone rubble with Caen stone dressings later replaced by Portland stone; lead roofs. Rectangular plan with apsidal projection at south-east angle housing east end of chapel, and cylindrical north-east stair turret. Anglo-Norman style. 3 storeys and basement, with 5-storey angle turrets'.
- 1.1.3 The recording during the lifting of historic floor structures within the second (upper) floor arcade of arched openings in the spine wall of the White Tower was carried out as a condition of Scheduled Monument consent for improvements to fire protection. The partial removal of the raised modern floor structures within the arched openings through the spine wall (Bays II-V) revealed two characteristically distinct phases of floorboards, with broader, heavier scantling oak boards present within the southernmost two bays (IV and V) and more regular sawn, narrower boards within the two bays (III and II) to the north.
- 1.1.4 In 2007, several second-floor floorboards under the arches in the spine wall, particularly within bays (IV and V), were sampled for dendro-chronological dating. Three of these boards provided evidence for a felling date in the late 15th century. This confirmed that this part of the second floor and present roof structure were contemporary. It also showed that these boards were retained and re-used, when heavier duty floor structures, associated with the tower's subsequent use as a military store, replaced existing floors in the mid-16th/early-17th centuries. The similarities in the character of the floor boards in bays IV and V suggests that all the floorboards in these two bays share a similar felling date. This is not the case for the boards within bays (II and III) which are much more regular in form and dimension and appear to be softwood not oak and are probably 19th century or later in date.
- 1.1.5 Following the removal of the second-floor floorboards from under the arches of the spine wall, it was apparent that the boards across all bays and the underlying floor joists, to which they were secured by nails, had, in recent years, been taken up and subsequently relaid. All floor joists were underlaid by a modern breathable membrane, laid between the joist soffit and the masonry of the spine wall and held in place using a modern cement torching. There was little consistency in the character and form of the floor joists and many were clearly re-used from elsewhere, displaying evidence of dis-used mortices or peg holes. However, four joists, two in bay V, one in bay III and one in bay II displayed similar carpentry features suggesting that they are of a similar date. They were presumably part of the same floor structure, and quite possibly associated with the replacement floor added during the late 16th or early 17th centuries.
- 1.1.6 The boards across all bays were fixed to the underlying joists by nails. There remained a variety of nail types but mainly modern wire nails or more historic hand wrought iron nails. The latter were typically flat section and rose-headed, and were more common within the historic boards of bays IV and V. The rose-headed nails were also observed re-used within the later boards in bays II and III, although they are not likely to be contemporary with the earlier floor boards, hand wrought iron nails were in use from the 17th century onwards.

2 INTRODUCTION

2.1 Background

- 2.1.1 Pre-Construct Archaeology Limited was commissioned by Historic Royal Palaces to carry out an Historic England Level 1 and 2 building recording watching brief before and during the lifting and reinstatement of historic floor structures in the White Tower, HM Tower of London, London Borough of Tower Hamlets (**Figures 1 and 2**). The work to the second (upper) floor structures was carried out in connection with improvements to fire protection. The work was undertaken at the request of Dr Jane Spooner, Historic Royal Palaces Curator (Historic Buildings) Tower of London and Banqueting House, Whitehall and following advice given by the Historic England Advisor, Jane Sidell.
- 2.1.2 The Tower of London is a UNESCO World Heritage Site (No. 488) and a Scheduled Monument (Greater London SM No. 10). The White 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.
- 2.1.3 The Tower of London's Conservation Management Plan lists the White Tower as being of exceptional significance. UNESCO's decision to award World Heritage Site status to the Tower of London, was in recognition of this significance. Gregory (2015) states that 'The White Tower is the example par excellence of the royal Norman castle in the late 11th century'. In addition to World Heritage Status, the White Tower is also designated as a Grade I listed building. It is described in its listing citation as follows:

'Tower keep. c.1078-1100 for William I and William II, probably to designs of Gundulf, Bishop of Rochester; later repairs and alterations, principally in C18 and C19 and by A Salvin, 1856-7; Rag-stone rubble with Caen stone dressings later replaced by Portland stone; lead roofs. Rectangular plan with apsidal projection at south-east angle housing east end of chapel, and cylindrical north-east stair turret. Anglo-Norman style. 3 storeys and basement, with 5-storey angle turrets. Each elevation (4-bay to north and south, 3-bay to east and 5-bay to west) has crenellated parapet, offset flat pilaster buttresses defining each bay and second-floor windows set in round-headed recesses forming bold Romanesque arcading; late C19 windows and early C19 sashes set in early C18 semicircular arched architraves with keyblocks, and impost blocks to large first and second-floor openings. Two early C18 panelled double doors set in similar architraves to first floor of north elevation, late C19 double doors to west and approached by double-flight of steps to east; two late C11 round-arched lights to first floor; apsidal south-eastern projection (to chapel) has mid C19 Norman-style round-arched windows with engaged shafts; south elevation has similar windows to chapel, early C18 architrave to original late C11 entrance to west bay of first floor, and 2 pairs of late C11 round-arched windows set within larger round-arched recesses to third floor. Angle turrets have restored late C11 round-arched lights and weathervanes to cupolas. Interior: each floor divided into two compartments by off-centre spine wall running north to south and by east-west wall defining area of chapel. All floors served by vice in north-east turret; vices from second floor in north-west and south-west turrets; inserted C14 vice in south wall, serving chapel. Basement, former storage and service area, has brick piers and vaulting of c.1730, original well, round-arched doorway to barrel-vaulted sub-crypt, and traces of original splayed recesses for loops in south, west and north walls. First floor: west compartment, former great hall, has C18 timber posts supporting ceiling, 5 round-arched embrasures and remains of late C11 round-arched fireplace along west wall, round-arched doorways flanking 3 tall round-arched recesses later pierced to make entries along east spine wall and round-arched embrasure to south altered into entry to inserted C14 vice; round-arched doorways to two garderobe chambers in north wall; east compartment, also with C18 timber posts supporting ceiling, has restored round-arched doorway to north-east vice, 3 round-arched embrasures and remains of round-arched fireplace along east wall and restored doorway set in wide round-arched recess to south-east crypt, which has had barrel vault restored in C20,

3 embrasures restored in C20, restored east window in niched apse, restored round-arched recess to west wall and restored round-arched doorway to square mural chamber in north wall. Second floor, containing royal hall, chapel and chamber, originally rose two stages (the third floor being an early C17 insertion) with mural gallery and 5-bay round-arched arcade to spine wall at third-floor level. Main western compartment, former great hall with central hearth, has 9 round-arched embrasures, 2 restored round-arched doorways in spine wall, and original round-arched embrasure to south altered into entry for inserted C14 vice; mural passages to other vices.

East compartment or former royal chamber, has 3 tall round-arched recesses later pierced to make entries along west side of spine wall; round-arched entry to garderobe, window embrasure enlarged in C14, and round-arched doorway to garderobe in north wall; late C11 chamfered round-arched fireplace and 3 round-arched embrasures in east wall; round-arched doorway to chapel.

Chapel of St John: aisled plan with eastern apse and ambulatory, of 13 bays; groin vaulting to aisles and ambulatory, with bays defined by responds forming arcade on outer walls and columns to main arcade surrounding barrel-vaulted nave which rises two storeys with barrel-vaulted triforium to upper stage; important series of Anglo-Norman capitals, including eight block-shaped capitals with fluted chamfers, one primitive Corinthian capital, two with primitive volutes, one cushion capital and two double-cushion capitals; all have scribed mouldings to abaci, except geometric carving to two western capitals, and eleven capitals have Germanic-inspired Tau crosses. Round-headed recesses to west wall, including inserted doorway to C14 vice.

Chapel restored by A Salvin in 1864-6, when windows (with C18 stained glass from Strawberry Hill) were replaced.

- 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 improvements to fire protection and the recording during the lifting of historic floor structures was carried out as a condition of this consent.

2.2 Site Description

- 2.2.1 The White Tower is situated within the medieval fortress of the Tower of London, traditionally thought to have been constructed by William the Conqueror at a point where the eastern Roman fortifications abutted the north side of the River Thames. It is the main keep of the fortification and measures 118ft x 106ft, rising to a height of 90ft on the south side with walls up to 15ft thick at its base (Impey and Parnell, 2000).
- 2.2.2 Within the White Tower, the two halves of the building are separated by a north-south spine wall. This original (11th century) Norman wall extends the full height of the building from basement to second floor level and contains primary building fabric. It was more solid at the time of construction than it is now. Originally, the wall on both ground and first floors was blank on its western side, with arched niches opening into the eastern rooms; these were later broken through to create an open arcade. The spine wall was a strong line of defence, behind which the defenders of the castle could retreat if the fortress was attacked. In the White Tower, this defensive role was compromised by doors through the wall at both its south and north ends. Only the doors on the entrance floor were fitted with drawbars and no evidence for these were found at first floor level.
- 2.2.3 At second floor level, the spine wall has five simple round headed openings. The wall at this level was formerly above the roof-line, which was originally much lower than the extant roof and hidden behind a tall parapet. The masonry of the spine wall at this level is of a rougher nature having rubble voussoirs rather than the tooled equivalents on the floors below.
- 2.2.4 It was under the arches of the arcade in the second-floor spine wall that the floor structures were recorded. Each of the spaces below the arches were individually

numbered (bays I to V) from north to south (**Figure 4**). The bay numbering is the same as that previously used when the floorboards were sampled for dendro-chronological dating in 2007.

2.3 Fire Protection Works

- 2.3.1 The building recording watching brief was undertaken in response to the need to address fire protection in the White Tower by providing a fire break along the spine wall between the east and west sides of the building at entrance, first and second floor levels. The following text is mainly taken directly from Spooner (2016).
- 2.3.2 The fire protection required augmenting beneath the modern floor boards of the second floor room. This floor of the White Tower was created in the late fifteenth century, during the reign of Henry VII. At that time, the space within the building required expansion. The Norman (eleventh century) building elevations and the spine wall had been constructed to a much greater height than the original pitched roof level, which facilitated the addition of a shallow-pitched, large span roof in the fifteenth century. At this time, a floor was inserted, forming a new ceiling over the first-floor rooms. Much of the ceiling now extant in the first-floor rooms dates from the seventeenth century.
- 2.3.3 Dendrochronology by Dr Daniel Miles was carried out throughout the White Tower, and has been published in 'The White Tower', a monograph edited by Edward Impey (Yale, 2008). Dendrochronology of the floorboards beneath the spine wall on the second floor of the White Tower has demonstrated that they belong to the fifteenth century and are contemporary with the White Tower roof.
- 2.3.4 The survival of the fifteenth-century floorboards *in-situ* is remarkable. Whilst they cannot be said to have the same significance as Henry VII's magnificent roof structure, they are important evidence of the insertion of a contemporary new floor to complete the impressive expansion of the White Tower. Within the White Tower, they are the oldest surviving floorboards. Presumably the joists beneath them are of a similar date, although they were not sampled. As the oldest floorboards, and as surviving evidence of the fifteenth-century alterations to the White Tower, the spine wall floorboards can be said to be of high significance, despite their rough appearance. Modern joists have been attached to the top of the historic floorboards, and so they are not pristine.
- 2.3.5 Spooner (2016) made the following recommendations: 'The floorboards should be retained *in situ*. It is not particularly desirable that they are disturbed or that fixings are made into them. However, given the gravity of the fire-protection project, small compromises may be considered necessary, and are to be discussed with the Historic England Inspector. If the boards are to be lifted, the operation is to be done with extreme care, working to a detailed method statement, and under the observation of a buildings archaeologist. If the boards are to be de-nailed, again extreme care should be taken. The boards should all be numbered, and replaced in their original positions.
- 2.3.6 The archaeologist should make a level 1 photographic record of the boards *in-situ* prior to lifting. Once the boards have been lifted, a level 2 drawing of the floor structure beneath the boards should be made. A note should be made of the carpentry construction'.

3 METHODOLOGY

3.1 Aims and Objectives

- 3.1.1 The aim of the building recording watching brief at the White Tower was to provide a record of the floor structures below the arches of the second floor (Gallery) spine wall arcade before and during the fire protection works. A Level 1 photographic record as set out in Historic England (2016) *Understanding Historic Buildings: A Guide to Good Recording Practice* was to be made of the 15th century floorboards *in-situ* prior to lifting. Once the floorboards had been lifted, an Historic England Level 2 drawing of the floor structure beneath the floorboards was to be made. A note was also to be made of the carpentry construction. The objective was to provide a better understanding of the floor structures, to analyse the results and compile a lasting archive.
- 3.1.2 At an on site meeting at the start of the work it was also agreed that the floorboards would be drawn *in situ* before lifting and their position would be recorded following their re-instatement.

3.2 Documentary Research

- 3.2.1 No research of primary resources was undertaken.

3.3 On-Site Recording

- 3.3.1 The building recording watching brief was carried out on the floor structures under the arches of the second floor (Gallery) spine wall arcade on 20th, 21st, 24th, 25th October, 3rd and 4th November 2016.
- 3.3.2 The floorboards and joists were hand drawn to scale on permatrace on site using hand tapes and Disto (electronic distance measurer). These drawings were then drawn in AutoCAD in PCA's office (**Figures 6 to 9**).
- 3.3.3 A photographic survey comprising high resolution digital images recorded the floorboards and joists *in situ*, as well as any carpentry and diagnostic features. The end sections of the historic floorboards were also photographed and the floorboards were photographed following the completion of works. A selection of photographs has been included in this report as **Plates 1 to 33** and **Figures 5 to 9** show the location and direction of these photographs.

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 163. It is anticipated that the archive (copies of the report, drawings and photographs) will be lodged with Historic Royal Palaces. The report will be prepared as soon as possible after completion of the on-site work and a copy will be submitted to Historic Royal Palaces and the GLHER (Greater London Historic Environment Record).

3.5 Guidance

- 3.5.1 All works were undertaken in accordance with standards set out in:
- ClfA (2014) *Standard and guidance for the archaeological investigation and recording of standing buildings or structures*
 - English Heritage (now Historic England) (2005) *The presentation of historic building survey in CAD*
 - Historic England (2015) *Greater London Archaeology Advisory Service: Guidelines for Archaeological Projects in Greater London*
 - Historic England (2016) *Understanding Historic Buildings: A Guide to Good Recording Practice*

4 HISTORICAL BACKGROUND

- 4.1.1 The White Tower formed the Keep to the medieval fortress of the Tower of London, traditionally thought to have been constructed by William the Conqueror and his third son William Rufus between 1077-1100, and under the guiding hand of Gundulf, Bishop of Rochester. During the medieval period it was in use as a Royal Hall and Chamber and the Chapel of St John.
- 4.1.2 When originally constructed, the White Tower comprised three basic levels, with a basement, the principal entrance or ground floor and the first floor. The second floor of the White Tower was a later addition added in the late 15th century during the reign of Henry VII. At this time, the earlier medieval roofs were removed and the present nearly flat roofs built one storey higher just below the false (tall parapet) walls and battlements of the Norman Keep. Dendro-chronology has shown that this raising of the roof level and insertion of a new second floor occurred c.1490. The present late medieval roof survives as one of the most outstanding features of the White Tower, covering almost a quarter of an acre in area and built in a late medieval design, typically found in 15th and 16th century church roofs. It incorporates exceptionally large timbers, sourced from the Kings Royal Forests, with tie beams within the western chamber in excess of 43ft in length and at a scale unprecedented in England.
- 4.1.3 During this period, the White Tower was used for the storage of munitions and less for Royal lodgings and formal occasions such as the ceremony of the Knights of Bath. By the 17th century the whole of the top (second) floor was set aside for the storage of gunpowder (Miles, 2007).
- 4.1.4 Plans drawn in 1729 (not illustrated) suggest that the five arched openings within the spine wall had been blocked-in by that date, though the method of in-filling is unclear. Further plans dating to 1736 (not illustrated) suggest a narrow in-fill panel in the west side of the arches and show that the northern-most of the five had a door opening within it. Lemprieres' plan of the second floor dated 1754 (TNA WORK31/102; **Figure 3**) also illustrates the blocking of the arched openings along their western side. This secondary in-filling had been removed by 1815.
- 4.1.5 An extensive programme of dendro-chronology carried out by Dr Daniel Miles in 2007 (published by English Heritage ISSN 1749-8775) also sampled floor boards at second floor level, and pertinently a number of floor boards located 'over the spine wall'. The results recovered from boards (IV47, IV55 and V64) sampled in bays IV and V showed that one particular board produced a felling date of 1488 and two other floorboards, were found to have originated from the same trees as used in the construction of the historic roof above, demonstrating that the top (second) floor and roof structure were contemporary. These boards therefore appear to have survived the later replacement of the floor structures, replaced with heavier duty floor structures associated with the building's later use as a military store, which have been dated (through dendro-chronology) to 1560 and 1602-03.

5 DESCRIPTIONS

5.1 Introduction

- 5.1.1 The numeric system used for the individual floorboards within the five bays during the dendro-chronology works was used for the building recording watching brief. Many of the floorboards were still marked by means of masking tape attached to the surface of the floorboard, with individual numbers, a bay reference and a north arrow. During the building recording watching brief, all were marked again using blackboard chalk and the same reference system.
- 5.1.2 The entire floor area of the second floor had been re-floored using a modern suspended floor built of softwood planks fixed to softwood battens. This modern floor overlay the historic floor in all five of the bays, and, had been removed at the time of the building recording watching brief. The descriptions (below) detail the floor after the removal of the modern suspended floor, prior to and after the removal of the historic floorboards and joists and ultimately their re-instatement.

5.2 Bay I

- 5.2.1 Bay (I) is the northernmost of the five bays (**Figure 4**). The building recording watching brief was carried out across bays II-V and it was understood that bay I was to be completed at a later date (**Figure 5**).

5.3 Bay II

Floorboards

- 5.3.1 Bay (II) is the second northernmost of the five bays (**Figures 4 and 5**). It comprised nine regular sawn softwood floorboards, butted together and laid east-west (**Figure 6; Plates 1 and 2**). The floorboards were numbered (II) 20 to (II) 28, rising in numerical value from north to south. Although the boards were regular sawn, their dimension varied considerably between 0.21m to 0.26m in width, although the scantling or thickness of the boards was consistent at 35mm. The uniformity of the floorboards would suggest that they were machine sawn and planed.
- 5.3.2 The floorboards were cut to fit within and did not extend the full width of the spine wall. They measured 1.52m to 1.58m in length. To the east of bay II and outside the extent of the spine wall, similar softwood boards were present extending below the modern suspended floor. These boards, of similar dimension and also laid east-west did not align with the floorboards within Bay II. To the west of Bay II, the visible boards were laid perpendicular to Bay II boards and on a north-south alignment.
- 5.3.3 Three regular lines of paired nail holes to each board, aligning with the underlying joists, were present to the centre, east and west sides of the boards. Larger diameter holes, formed by a bit, were more randomly located, although an alignment of seven was present to the west side and a more irregular line of five to the east. These larger holes broadly aligned with the path of the joists.
- 5.3.4 The southernmost board (28) showed evidence of four, relatively fresh, equally spaced rectangular mortices cut into the upper face of the board and along the south side. The eastern third of a central board (24) had been removed, just east of a pair of larger diameter (c.60mm) holes. The removal of this section of board exposed part of the underlying floor joist (joist 1).

Joists

- 5.3.5 The removal of the floorboards exposed three floor joists (Joists 1-3), all laid on a north-south axis across the full width of the opening within the spine wall space (**Plates 3 and 4**). All three joists stopped short of the rubble walls to the arch (i.e. not set into sockets in the flank walls) and were flat laid with the largest dimension to the bed. Whilst all three appeared to be oak or elm, the joists were dissimilar in character and in scantling. The joists overlay a modern breathable membrane laid over the masonry of the spine wall and were fixed in place (to an underlying plinth, not seen) using a modern cement torching.

- 5.3.6 **Joist 1** was situated to the eastern side and positioned in-line with the corners of the opening. It measured 253mm (10 inch) in width by 71mm (3 inch) in depth. Three equally spaced peg holes at c.800mm intervals were present along the west edge of the joist while another single peg to the eastern edge. A shallow rebate or trench had been cut into the upper face of the joist at about its mid point. The rebate or the pegging did not align with similar features on the adjacent joists. Given this it appears to be a re-used timber.
- 5.3.7 **Joist 2** was the central of the three joists. It measured 232mm (9¼ inch) in width by 71mm (3 inch) in depth. A large empty mortice (130mm x 130mm) with a central peg-hole was present within the southern half of the joist and along the western edge. It aligned with a corresponding but shallower mortice (un-pegged) to the east side. Two further mortices were also present along the eastern edge of the joist, a smaller mortice c.0.18m to the north and a larger, (130mm width) mortice, 0.66m to the north. None of the mortices on the east side showed evidence of pegging. This joist also appears to be a re-used timber.
- 5.3.8 **Joist 3** was the western of the three joists. It was narrower in width measuring 135mm (5½ inch) but slightly deeper at 0.8m (3¼ inch). Unlike the other two joists it showed no evidence of former uses. The upper face showed nail evidence from the removed boards and the western edge was noticeably impacted by wood worm. This joist was very similar in character to joist 4 in Bay V.

5.4 Bay III

Floorboards

- 5.4.1 Bay III is the central of the five bays (**Figures 4 and 5**). It was covered with eleven regular sawn softwood floorboards, butted together and laid east-west (**Plates 5 and 6**). These floorboards were of the same character and appearance as those present in Bay II, although their layout was dissimilar (**Figures 6 and 7**). The floorboards were numbered (III) 33 to (III) 45, rising in numerical value from north to south (**Figure 7**). As with bay II, the boards were regularly sawn and planed. They varied in their width dimensions (0.18m to 0.22m) and were consistently 35mm in thickness. Half boards were used within the middle of the floor space (37 and 38), and narrow boards or fillets (44 and 45) along the southern edge.
- 5.4.2 The floorboards were cut to extend the full width of the spine wall space (measuring 1.94-1.98m in length). Three regular perpendicular lines of redundant nail holes to most of the boards, aligning with the underlying joists, were present to the centre, east and west sides. These fixings had however been superseded by modern flat headed nails, paired to each board. Older handmade nails with pyramidal heads remained in boards 34, 35, 36 and 38. The western line of these nails (in boards 36 and 38) did not align with an underlying joist, demonstrating that the positioning of the western floor joist is not contemporary with the earlier nailing and is a recent addition.
- 5.4.3 The alignments of larger diameter holes followed the line of the central and western joists. The western line comprised seven holes and the central line five holes, including a slightly larger hole to board (39). A single larger diameter hole was present in the east side of board (35), it aligned with three similar holes to the west in same board. A small group of associated holes were present across boards (40 to 42) to the west.
- 5.4.4 The northern part of the eastern third of central board (39) and the southern part of its adjoining board to the north (37) was missing, presumably through collapse. It in common with Bay II also incorporated a larger diameter hole at the junction of the missing section of board.

Joists

- 5.4.5 The removal of the floorboards exposed three floor joists (Joists 1 to 3), all laid on a north-south axis across the full width of the opening within the spine wall (**Figure 7; Plates 7 and 8**). All three joists stopped short of the rubble walls to the arch (i.e. not set into sockets in the flank walls) and were flat laid with their largest dimension to the bed. Whilst all three appeared to be oak or elm, joists (2) and (3) were dissimilar in

character and in scantling to joist (1). As encountered in all the bays, the joists overlay a modern breathable membrane laid over the masonry of the spine wall and were fixed in place (to an underlying plinth, not seen) using a modern cement torching.

- 5.4.6 **Joist 1** was the easternmost of the three joists, aligned north-south and set back, c.12cm from the eastern wall line of the spine wall. The joist is irregular and no longer in the square, partly fractured along its east side, but generally measures 120-145mm (4¾-5¾ inch) wide and 81mm (3¼ inch) thick. Three regularly spaced shallow rebates (at 80-85mm centres) measuring 130x100mm (c.5x4inch) were cut into the top of the joist along its western edge (**Figure 7; Plate 9**). Each rebate showed evidence of a central peg-hole. The positions of the rebates, cut to receive a floor joist lapped over the top of the joist and pegged into place, suggests this timber was originally carpentered as a floor joist, supporting a structure in the horizontal plane. Whilst this was the only joist of this type in Bay III, there were similarities in character of the rebates and their dimensions to two joists in Bay V. A secondary much deeper trench/rebate (130mm wide) lies slightly off-centre to the upper face. It does not have the same character as those already described and is clearly a single, later feature, which does not align with shallower secondary trenches cut into joists 2 and 3.
- 5.4.7 **Joists 2 and 3** were very similar in appearance and dimension, both regular sawn and re-used timbers taken from the same structure. The central, Joist 2 measured 136-140x96mm, while the western, Joist 3 measured (136x92mm or c.5½ x 4 inch). Both were flat laid, with their widest dimension to bed, and were cut along their upper faces by a shallow rebate, measuring 100mm wide x 5mm deep, which aligned east-west. A series of small random holes, cut by a carpenters bit through the floor boards, were present across the top of both joists, while a regular sequence of 12 peg-holes at 6 inch centres, the majority still retaining their pegs, were observed in both sides of both joists (**Plate 10**). They are indicative of re-use and point toward a former use as a top plate or similar to a close studded wall or partition.

5.5 Bay IV

Floorboards

- 5.5.1 Bay IV is the second southernmost bay within the arcade of five bays (**Figures 4 and 5**). It, along with Bay V, retained a complement of oak floorboards (**Plates 11 and 12**), which have been dated through dendro-chronology to the 15th century. The floorboards were numerically marked IV-47 to IV-55, north to south and cut to fit within the arcade void, protruding slightly beyond the wall line to the east. Unlike those described in Bays II and III, each board varied in its dimension (length and width) and ranged between 35-42mm in thickness, their inconsistency in scantling and absence of saw marks suggesting they were cleaved. The widths of the boards were considerable, measuring a maximum of 345mm or c.12 inches (IV 51 and 52) with many in excess of 300mm and only two (IV53 and 54), falling below that dimension. The board lengths varied to a lesser degree, most measuring between 1.72-1.75m (see **Appendix 2** for individual board dimensions).
- 5.5.2 The boards, laid on an east-west axis and simply butted-up to each other, were fixed in place by nails, mainly modern common wire nails but also examples of hand wrought iron nails. Three perpendicular lines (to the boards) of nailing, typically a mixture of modern, historic or redundant, fixed the boards to the underlying floor joists, at their western, central and eastern ends. The modern nails were mainly concentrated along the line of the central joist, although was also present to the west side. Examples of historic nails, in the form of hand wrought flat section rose headed iron nails, were more prevalent to the western and eastern ends (**Plates 13 and 14**), although they did occur within the central row, while redundant nail holes (formerly used by the larger historic nails) typically in pairs, were present along all three rows. The majority of the boards showed evidence of irregular circular holes, not nailing holes, which had been drilled into the boards from above and measured c.20-25mm in diameter. They were randomly distributed across the boards, with concentrations towards the centre, east and to the very western ends of boards (IV-49, 50 and 53; **Plate 13**). Their function is not certain but they are thought to be associated with the

dendro-chronological sampling strategy.

- 5.5.3 Whilst the boards, given their age, were generally in a fair condition three examples (IV-55, 51-52 and 47) were notably damaged. The easternmost quarter length to IV-55 had been split along both its northern and southern edges, while the central board (IV-51 and 52) had lost almost half its length and two-thirds of its width along the eastern side, a loss mirrored across board (IV-47) to the west of centre. The latter appears to be the result of a distinctive cross cut made to the board at this point (over the joist) which may have weakened the board, while two large ?core samples, drilled through IV-52 and 51) may have compromised its strength, with the same outcome.
- 5.5.4 The western end of the boards stop short (c.30-35mm) of the western wall line to the arcade, the gap between in-filled by a number of shorter boards (IV-58, IV-60 and IV-62) laid perpendicular to but within the arcade.
- 5.5.5 Examination of the ends of the boards would suggest that they have not been cut in recent years.

Joists

- 5.5.6 The removal of the floorboards exposed three floor joists (Joists 1-3), laid on a north-south axis and equally spaced across the full width of the arcade opening (**Plates 15 and 16**).
- 5.5.7 All three joists stopped short of the rubble arch walls to the north but their relationship with the southern wall was not visible, overlain by a modern softwood joist. They were flat laid with their largest dimension to the bed and held in place by modern cement torching. As the latter overlay a permeable membrane laid across the masonry of the spine wall, it is clear that the joists have been relocated/repositioned in recent years. Whilst all three joists appeared to be oak or elm, Joists 2 and 3 were almost identical in both character and dimension.
- 5.5.8 **Joist 1** was the eastern of the three, aligned north-south and set back c.120mm west from the eastern wall line. It is regular sawn 'in the square' and measures 117x140mm (c. 4½ x 5½ inches). A secondary deep rebate (130mm wide), formerly housing a floor joist, lies slightly off-centre to the upper face. The rebate shows no evidence of pegging and has the same character and is in the same location as a rebate in an equivalent joist in Bay III. The rebate is clearly a relatively recent event, which given its present location was cut to house a floor joist projecting a short way into the arcade from the east side.
- 5.5.9 **Joists 2 and 3** were very similar in appearance and dimension, both regular sawn in the square and re-used. The central, Joist 2 measured 140x140mm (5½ inches square), while the western, Joist 3 was identical in its dimension. Joist 2 was notably featureless, lacking any evidence of carpentry, although a very faint, possible fair face mark was observed on the west facing southern end of the joist (**Plate 17**). The most notable feature present on Joist 3 was a series of three semi-circular cuts along the eastern edge of the joist. Spaced at 850mm and 950mm intervals these cuts had no obvious relationship to the present floor structures and indicate the joist was re-used.

5.6 Bay V

Floorboards

- 5.6.1 Bay V is the southernmost bay within the arcade of five bays (**Figures 4 and 5**), which along with the adjacent Bay IV, retained a complement of ancient oak floorboards (**Plates 18 and 19**), dated through dendro-chronology, to the 15th century. The floor boards were numerically marked V-63 to V-68, north to south and cut to fit within the arcade void, protruding very slightly beyond the wall line to the east but c.340mm short of the wall line to the west (**Figure 9**). This 'gap' to the west is filled by a single board (V-69) laid perpendicular to and butting up against the western end of boards V-63 to 68 (**Plate 21**).
- 5.6.2 The boards were very similar in their character and appearance to those in adjacent bay, although they were slightly less regular in shape, boards V-67 and V-68 noticeably lozenge-shaped. Generally, they were also wider, measuring up to 395mm

(V-68), with boards (V-64 and V-66) averaging around c.370mm. They were also slightly heavier scantling than those in Bay IV, ranging between 43mm and 47mm in thickness. The individual board lengths varied to a slight degree, measuring between 1.81m and 1.85m. They were laid on an east-west axis and simply butted-up to each other and were fixed in place by nails. Four equally spaced rows of nails and nail holes, following the underlying joists, extended north-south across the boards. Many of the historic rose-headed hand wrought iron nails remained (**Plate 20**), although some modern common wire nails had been later used to complement the earlier fixings. The former, typically paired for each board, were more prevalent within the central two rows but equally not uncommon in the outer rows. The rows also included empty nail holes demonstrating the removal of some of these historic nails and in some cases the replacement of the same nail close by.

- 5.6.3 As in Bay IV, most of the boards showed evidence of many circular holes, measuring c.20-25mm (1 inch) in diameter which had been drilled into the boards from above. They were less randomly distributed across the boards, (compared to IV) concentrated centrally forming two distinct rows, and to the west. The boards were in a better condition than those in Bay IV, V-64 showed evidence of a longitudinal split (**Plate 21**), while two holes in board V-66 had been stoppered using timber plugs (**Figure 9**).

Joists

- 5.6.4 The removal of the floor boards exposed four floor joists (Joists 1-4), generally laid on a north-south axis, although Joist 3, to the west of centre, was aligned slightly askew on a north-north-east to south-south-west orientation (**Figure 9; Plates 22 and 23**). All extended the full width of the arcade opening, Joists 3 and 4, set (very shallowly) into the masonry to the south, the other two stopping short. They were all flat laid with their largest dimension to the bed and held in place by modern cement torching. Joists 2 and 3 were similar in their character and displayed similar carpentry.
- 5.6.5 **Joist 1** is located to the eastern side was not a joist at all but a re-used softwood floorboard mounted (for height) on top of a plinth.
- 5.6.6 **Joist 2** is located to the east of centre and aligned north-south. It is laid flat section and measures 230mm (9 inch) wide by 75mm (3 inches) thick. Its full length was not recorded as its northern end extended below a softwood board used as a sub-floor spacer, although it likely respected the northern extent of the arch and so measured no more than 2.20m. The most notable features were two paired rebates cut into the upper face of the joist, two along the eastern edge and two corresponding rebates to the west (**Figure 9; Plate 24**). The eastern rebates were smaller in size, 70mm in width and c.20mm in depth, while those to the west, although cut to a similar depth, measured 130mm in width (the same dimension as rebates present in Bay III), was slightly dovetailed in plan and was pegged. This form of carpentry suggests that a common joist lapped over the top of this joist, and was held in place by both the dovetail and peg.
- 5.6.7 **Joist 3** as described was located to the west of centre and aligned slightly askew on a north-north-east to south-south-west orientation. It measured 150mm (6 inch) wide by 75mm (3 inches) thick and was laid flat with its largest dimension to bed. The joist was clearly supported centrally by a modern brick, infilling a void between its soffit and the masonry of the spine wall. Two rebates were cut into the upper face of the joist along its western edge (**Figure 9; Plate 25**). Both, as with Joist 2, measured 130mm (5¼ inch) in width (north-south) and were slightly dovetailed and pegged. The relationship of the rebates between Joists 2 and 3, those in Joist 3 facing away from the rebates in Joist 2, clearly shows that Joist 3 had been either turned or relocated into this bay from elsewhere.
- 5.6.8 **Joist 4:** is the westernmost joist. It is aligned north-south and very regular in form measuring 140mm (or 5½ inch) square. It lacks the carpentry features observed in Joists 2 and 3, and is simply plain oak joist that is badly worm-eaten along its western edge.

5.7 Reinstatement

- 5.7.1 Detailed recording of the reinstatement of previously removed floorboards and joists from within the spine wall arcade, was completed on 3rd and 4th November 2016. Due to the addition of a centrally located north–south firewall with a low concrete foundation within each bay of the four bays (Bays II to V), it was not possible to reinstate the joists and floor boards back into their original locations (**Plate 32**). The initial intention was to place the floorboards and joists back into the original bays from which they were removed but in whatever order was necessary for them all to fit in the available space. It became apparent that the useable space in each bay was inadequate, much of the potential area taken up by the inserted concrete wall and its modern supports, and that three of the bays (Bays II (**Plate 32**), III (**Plates 30 and 31**) and V (**Plates 26 and 27**)) would not accommodate the removed floorboards and joists from those bays. Consequently, a decision was made to store the boards and the joists in any space and in any of the bays that would allow for them to be held, until further works could be undertaken to reinstate them in a more suitable manner.
- 5.7.2 All floorboards and joists (Joists 2 and 4) from Bay IV were placed back in Bay IV (**Plates 28 and 29**). All Bay V boards were placed in Bay III (**Plates 30 and 31**). All Bay II and III boards were dispersed wherever space was available. This includes three placed under the modern floor and above the *in situ* original flooring in Bay I, lying east–west in between the modern joists (**Plate 33**). Ultimately, all floorboards and one of the joists were stored within the bays, with three joists proposed to be stored elsewhere.

The following table records the initial and final locations of each of the removed floorboards and joists.

Board No	Original Bay	Reinstated in Bay
20	II	II
21	II	I
22	II	I
23	II	V
24	II	IV
25	II	V
26	II	II
27	II	IV
28	II	V
29	No board with this No.	
30	No board with this No.	
31	No board with this No.	
32	No board with this No.	
33	III	V
34	III	IV
35	III	III
36	III	V
37	III	IV
38	III	V
39	III	V
40	III	V

41	III	V
42	III	V
43	III	I
44	III	IV
45	III	IV
47	IV	IV
48	IV	IV
49	IV	IV
50	IV	IV
51	IV	IV
52	IV	IV
53	IV	IV
54	IV	IV
55	IV	IV
56	IV	IV
57	IV	IV
58	IV	IV
59	IV	IV
60	IV	IV
61	IV	IV
62	IV	IV
63	V	III
64	V	III
65	V	III
66	V	III
67	V	III
68	V	III
Joist No	Original Bay	Reinstated in Bay
1		
2	IV	IV
3		
4	IV	IV

6 DISCUSSION AND CONCLUSIONS

- 6.1.1 The survey work was carried out to graphically record, through scaled drawings and detailed photography, the extant floor structures present within the second (upper) floor arcade of arched openings in the spine wall of the White Tower. These works were undertaken in response to the need to address the fire compartmentation of the White Tower by providing a fire break along the spine wall and between the east and west divisions of the building, at entrance, first and second floor levels.
- 6.1.2 The partial removal of the raised modern floor structures within the arched openings of the spine wall (Bays II-V) revealed two characteristically distinct phases of floorboards, with broader, heavier scantling oak boards present within the southernmost two bays (IV and V) and more regular sawn, narrower boards within the two bays (II and III) to the north.
- 6.1.3 In 2007, a number of second floor floorboards under the arches of the spine wall, particularly within bays (IV and V), were sampled as part of a wider programme of dendro-chronological analysis of 155 historic timbers within the White Tower. Three of the floor boards (IV-47, IV-55 and V-64) provided evidence for a felling date in the later part of the 15th century. One board had a felling date of 1488 and the two other floorboards, originated from the same trees used in the construction of the historic roof structure above (using timber with felling dates of spring 1489 and spring 1490).
- 6.1.4 This confirmed that the second (top) floor and present roof structure were constructed at the same time. It also showed that these boards, were retained and re-used when heavier duty floor structures, associated with the towers subsequent use as a military store, replaced existing floors in the mid 16th and early 17th centuries. It appears that all of the historic boards in bays IV and V (IV-47 to 55 and V-63 to 68) share a similar felling date based on similarities in their character, appearance and inconsistency in dimension. This is not the case for the boards within bays (II and III) which are much more regular in form and dimension, are sawn and appear to be softwood not oak. As they extend the full width of bays II and III, not respecting those partitions shown on the mid 18th century floor plan by Lempriere, it is likely that they post-date this plan. The use of softwood, their regularity and their 9 inch dimension suggest a 19th century or later date for these boards.
- 6.1.5 Following the removal of the floorboards, it was instantly apparent that the boards across all bays and the underlying floor joists, to which they were secured by nails, had, in recent years, been taken up and subsequently relaid. All of the floor joists were underlaid by a modern breathable membrane, laid between the joist soffit and the masonry of the spine wall and held in place using a modern cement torching. There was little consistency in the character and form of the floor joists and many were clearly re-used from elsewhere, displaying evidence of dis-used mortices or peg holes. However, four joists, two in bay V (joists 2 and 3), one in bay III (joist 1) and one in bay II (joist 2) displayed similar carpentry features suggesting that they were of a similar date and that they had been part of the same floor structure. Joists 2 and 3 in bay V and joist 1 in bay III each had rebates cut into their upper face. These rebates, as standard measured 13cm (7¼ inch) wide and were set at 81-82cm (c. 31½-32inch) centres, housed the ends of a common joist lapped over the top and held by a peg. Joist 2 in bay II however was carpentered with mortices cut into its sides and so more neatly received the tenoned end of the common joist and not one halved over the top. The dimensions of the mortices and their spacing closely matched those in bays III and V. Although no longer in their original locations, given their carpentry they once formed part of a floor structure, and they were quite possibly associated with the replacement floor added during the late 16th or early 17th centuries.
- 6.1.6 The boards across all bays were fixed to the underlying joists by nails. There were a variety of nail types and were mainly modern wire nails (zinc or steel) or more historic hand wrought iron nails. The latter were typically flat section and rose-headed, and

were more visible (or evidence of their former presence in the form of distinct rectangular section holes) within the historic boards of bays IV and V. The rose-headed nails were also re-used within the later boards in bays II and III, although they are not likely to be contemporary with the earlier floor boards, hand wrought nails were in use from the 17th century onward (Nelson, 1968). If this area was used as part of the military store particularly storing ordnance, one may question the use of iron fixings.

7 ACKNOWLEDGEMENTS

- 7.1.1 Pre-Construct Archaeology Limited would like to thank Historic Royal Palaces for commissioning the project.
- 7.1.2 The project was managed by Charlotte Mathews. The building survey was completed by Adam Garwood and Christina Reade and the report was written by Adam Garwood. Hayley Baxter compiled the illustrations

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APPENDIX 1: OASIS FORM

OASIS ID: preconst1-290556

Project details

Project name	Building Recording Watching Brief on floor structures in White Tower, Tower of London,
Short description of the project	Pre-Construct Archaeology Limited was commissioned by Historic Royal Palaces to carry out a building recording watching brief before and during the lifting and reinstatement of second (upper) floor structures within the arches of the spine wall in the White Tower, Tower of London. The work was carried out as a condition of Scheduled Monument consent for improvements to fire protection. The Tower of London is a World Heritage Site, a Scheduled Monument and lies in a Conservation Area. The White Tower is Grade I listed. The partial removal of raised modern floor structures within the arched openings through the spine wall (Bays II-V) revealed two phases of floorboards, with broader, oak boards within the southernmost two bays (IV and V) and sawn, narrower boards within the two northern bays (III and II). In 2007, several floorboards within bays (IV and V) were dendro-chronologically dated to the late 15th century. This confirmed that the second floor and present roof structure were contemporary and that these boards, were retained and re-used when the floors were replaced in the mid 16th/early 17th centuries. All the floor boards in bays IV and V are thought to date to the late 15th century, while the boards within bays (II and III) appear to be 19th century. It was apparent that the boards and joists in all bays had been recently re-laid. Four joists were thought to be late 16th/early 17th century in date. The boards were fixed to the underlying joists by nails.
Project dates	Start: 20-10-2016 End: 04-11-2016
Previous/future work	No / Yes
Any associated project reference codes	ToL 163 - Sitecode
Type of project	Building Recording
Site status	Scheduled Monument (SM)
Current Land use	Other 2 - In use as a building
Monument type	FLOORBOARDS Medieval
Monument type	FLOORBOARDS Post Medieval
Monument type	JOISTS Post Medieval
Methods & techniques	"Measured Survey", "Photographic Survey"
Prompt	Scheduled Monument Consent

Project location

Country	England
Site location	GREATER LONDON TOWER HAMLETS STEPNEY White Tower, HM Tower of London
Postcode	EC3N 4AB
Site coordinates	TQ 33616 80542 51.507491368239 -0.074467710139 51 30 26 N 000 04

28 W Point

Project creators

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

Project archives

Physical Archive Exists?	No
Digital Archive recipient	Historic Royal Palaces
Digital Archive ID	ToL 163
Digital Contents	"Survey"
Digital Media available	"Images raster / digital photography","Survey","Text"
Paper Archive recipient	Historic Royal Palaces
Paper Archive ID	ToL 163
Paper Contents	"Survey"
Paper Media available	"Plan","Report","Survey "

Project bibliography 1

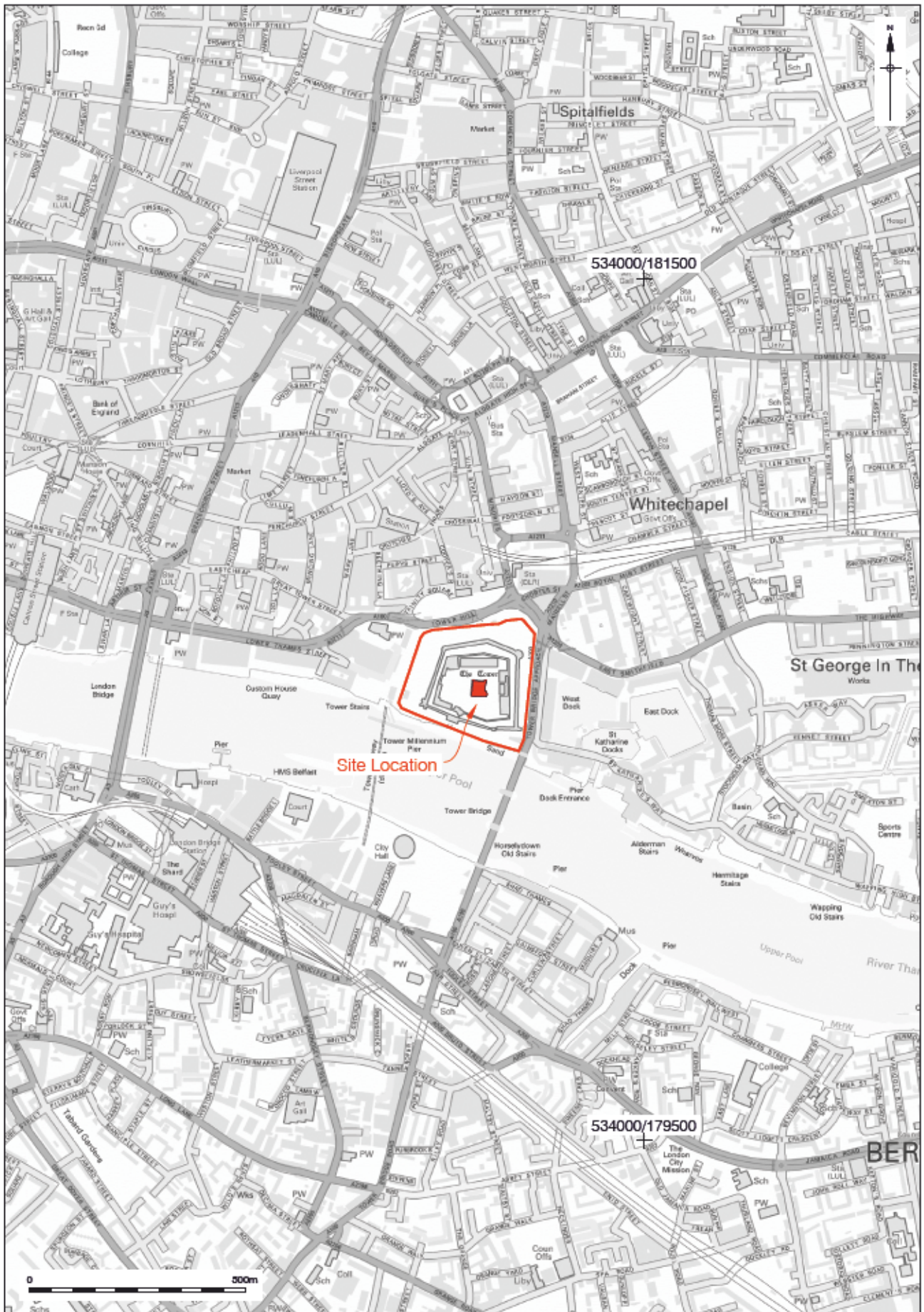
Publication type	Grey literature (unpublished document/manuscript)
Title	Building Recording Watching Brief during lifting of floor structures in the White Tower, HM Tower of London, London Borough of Tower Hamlets
Author(s)/Editor(s)	Garwood, A.
Other bibliographic details	PCA Report Number: R12952
Date	2017
Issuer or publisher	Pre-Construct Archaeology Limited
Place of issue or publication	Brockley, London

Description	A4 pdf report
Entered by	Charlotte Matthews (cmatthews@pre-construct.com)
Entered on	18 July 2017

APPENDIX 2: FLOORBOARD DIMENSIONS

Bay	Board No.	Length (m)	Width (mm)	Thickness (mm)	
V	63	1.85	286-292	45	
	64	1.84	374-377	45 (s)	
	65	1.82	348-332	47	
	66	1.81	377-373	43	
	67	1.81	302-232	47	
	68	1.82	395-259	45	
	69	1.98	200-241	/	
	IV	48 (47)	1.57	317-318	42 (s)
		49	1.75	310-325	41
50		1.73	326-345	41	
51-52		1.73	345	41	
53		1.75	255-260	35	
54		1.73	154-155	41	
55		1.72	302-297	44 (s)	
58		0.64	190	/	
60		0.40	180	/	
62		/	190	/	
III		33	2.00	211-220	32
		34	1.98	207-208	35
		35	1.99	220	34
	36	2.00	220	35	
	37	0.82	160	35	
	38	1.20	222-224	36	
	39		222	35	
	40	2.01	222	36	
	41	2.00	210	35	
	42	2.00	178	35	
	43	1.97	195	35	
	44	0.76	/	/	
	45	1.19	/	/	
	II	20	1.52	215-219	44
		21	1.52	231-232	50
22		1.54	278-280	46	
23		1.54	215-220	53	
24		0.96	235-240	54	
25		1.56	237-240	50	
26		1.58	262-264	48	
27		1.58	262-264	46	
28		1.57	245-269	48	

(s) dendro dated to late 15th century



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Figure 1
 Site Location
 1:12,500 at A4

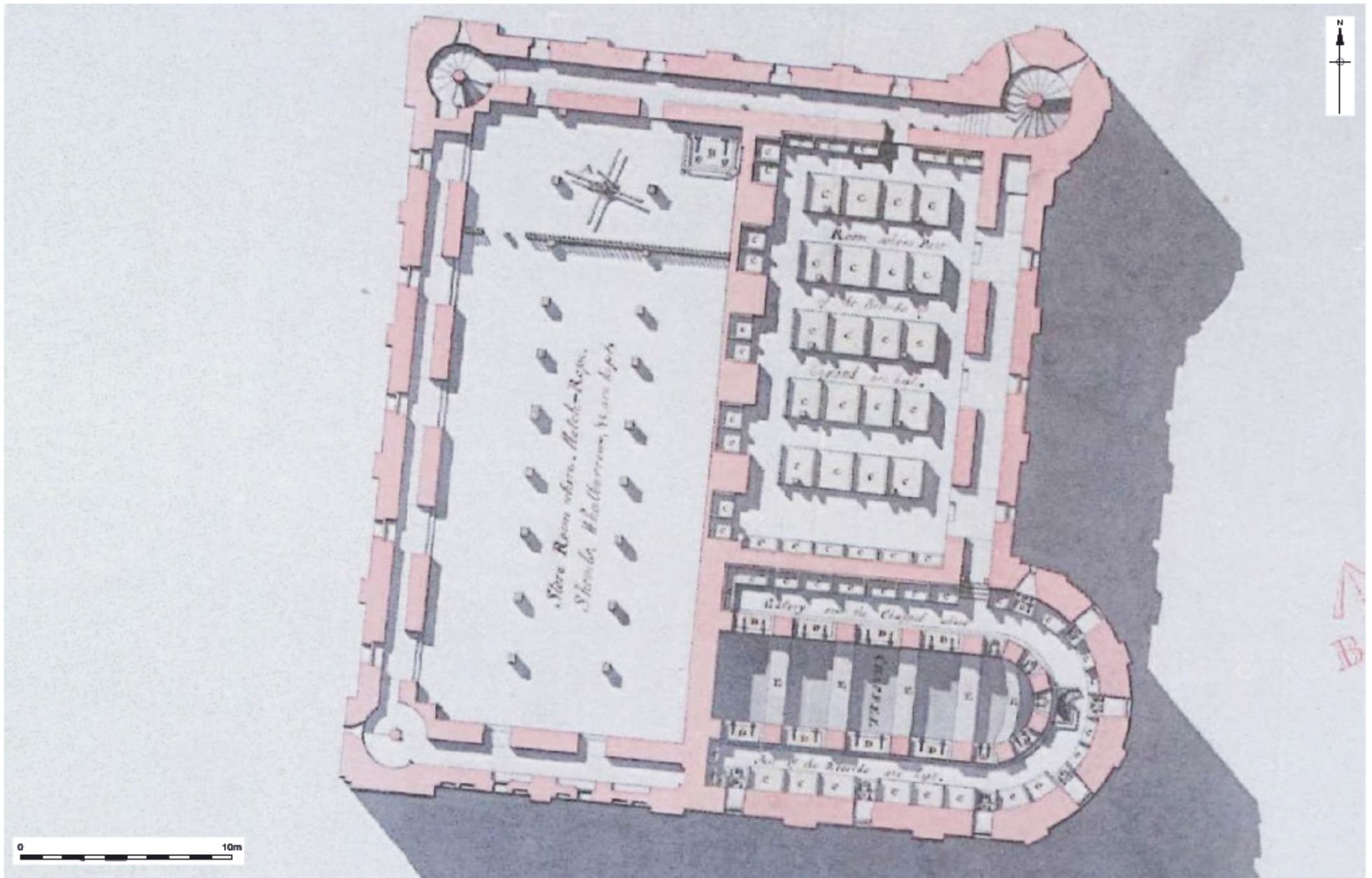
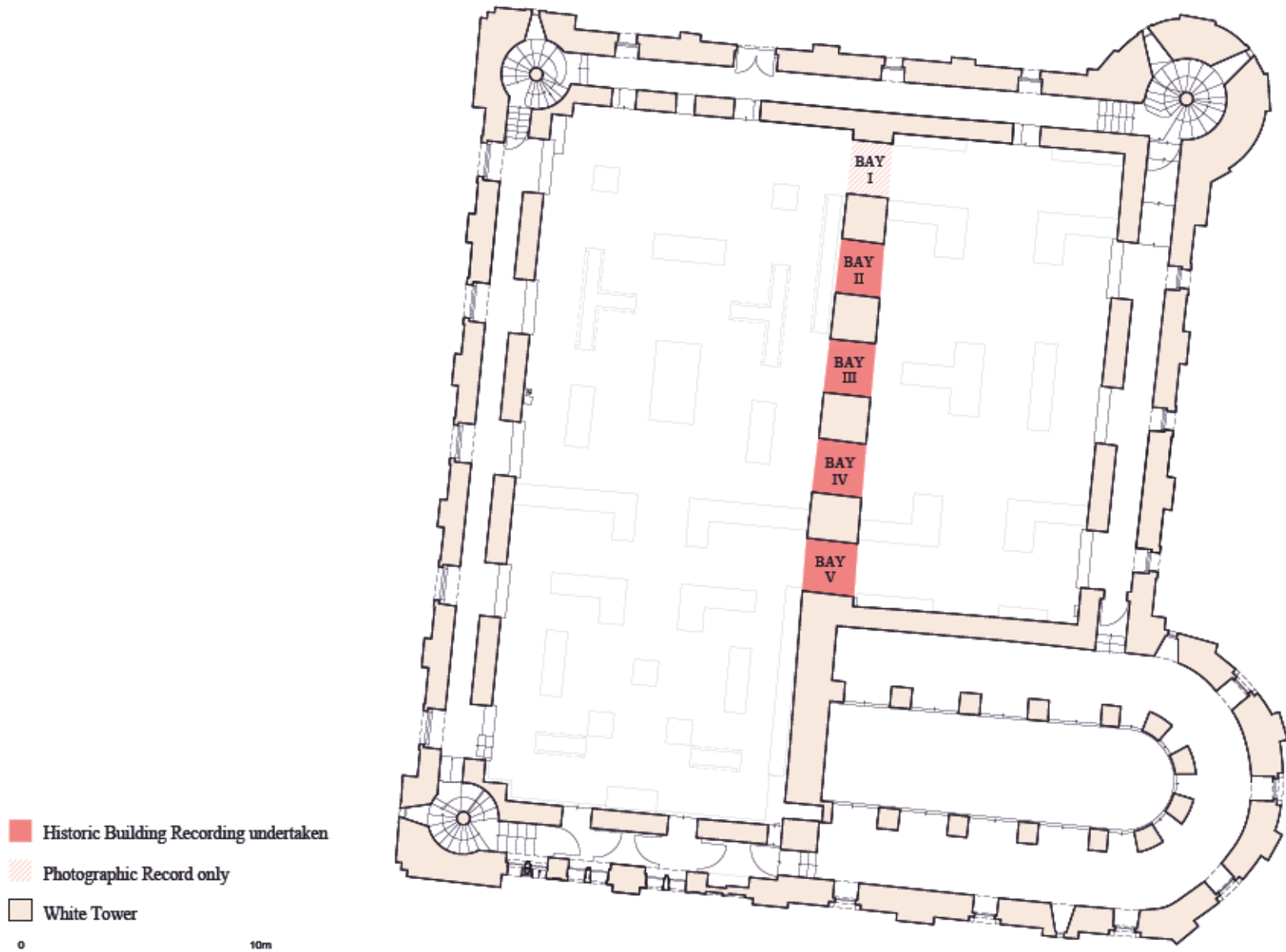


Figure 3
Second Floor Plan by Lempriere dated 1754
1:250 at A4



Historic Building Recording undertaken

Photographic Record only

White Tower

0 10m

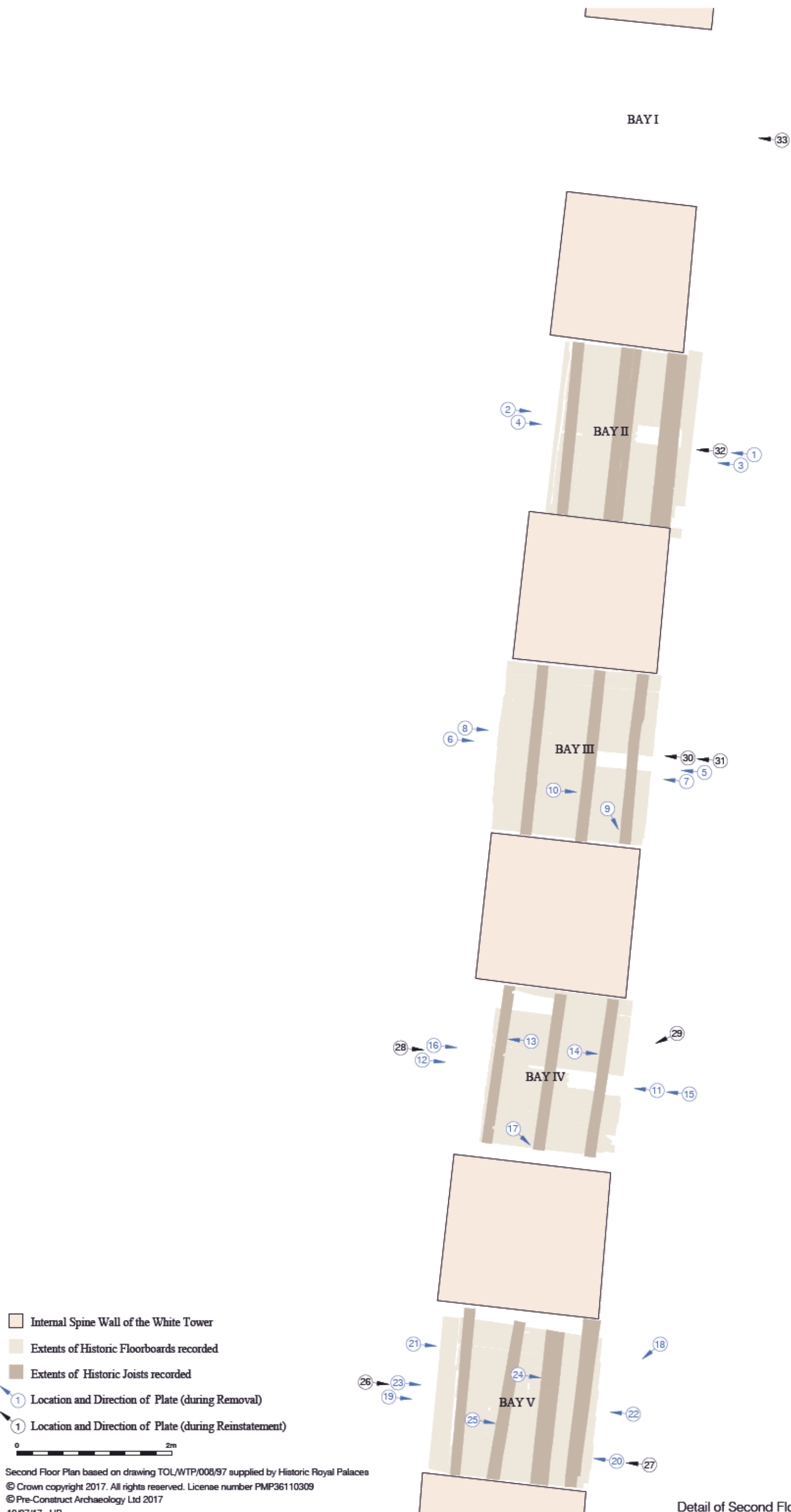
Second Floor Plan based on drawing TOL/WTP/008/97 supplied by Historic Royal Palaces

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Figure 4
 Second Floor (Gallery) Plan
 showing Bay Locations within Internal Spine Wall
 1:250 at A4



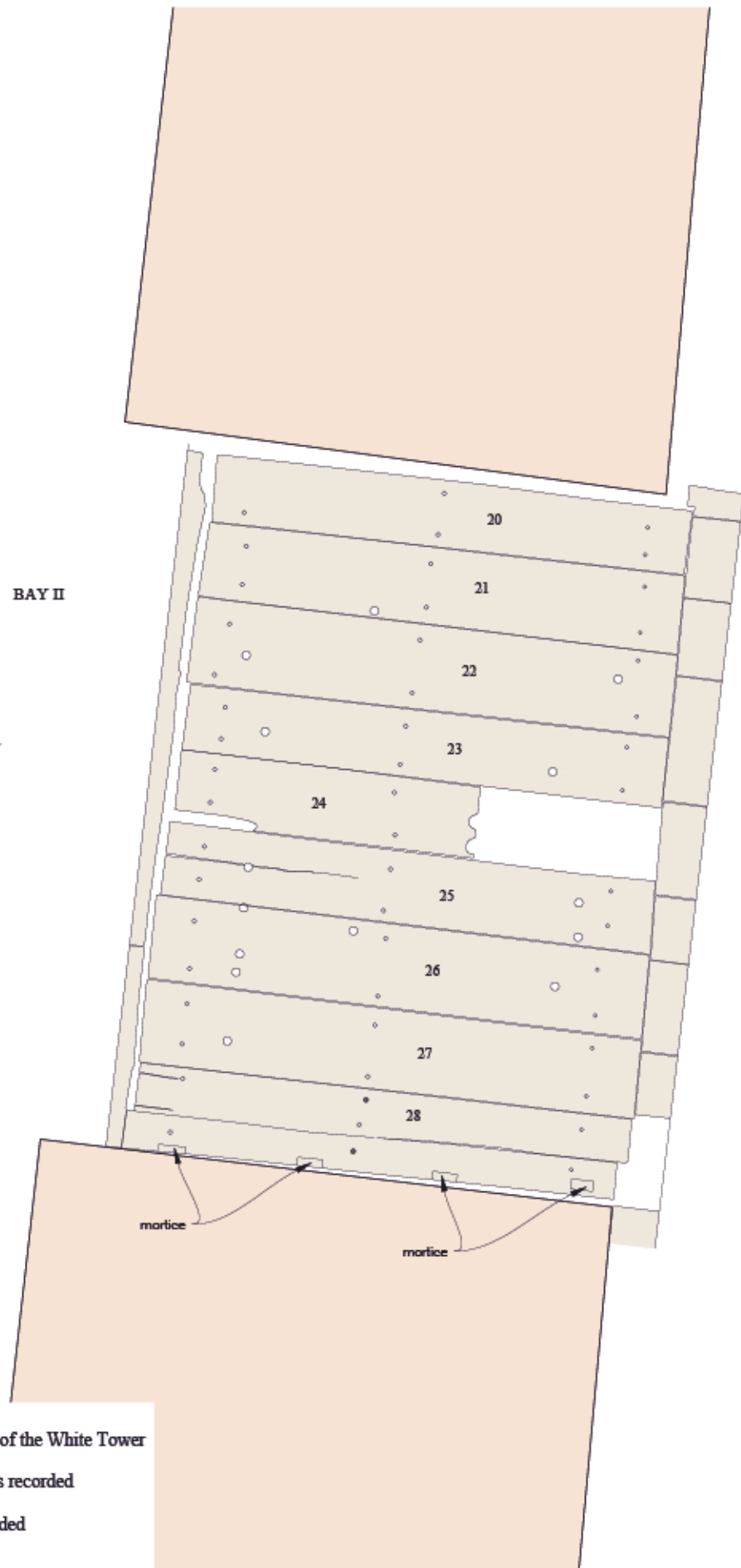
- Internal Spine Wall of the White Tower
- Extents of Historic Floorboards recorded
- Extents of Historic Joists recorded
- ① Location and Direction of Plate (during Removal)
- ① Location and Direction of Plate (during Reinstatement)

0 2m

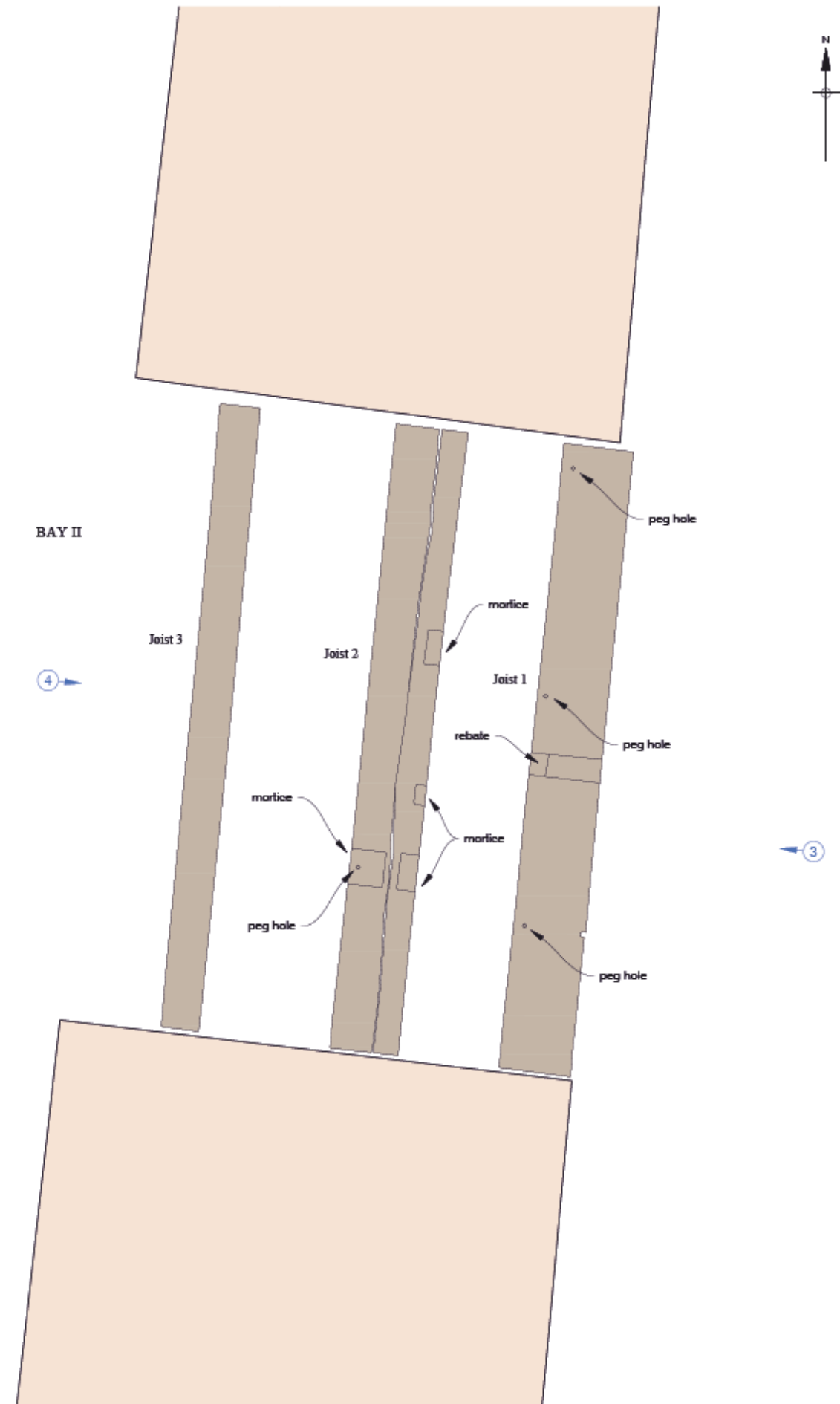
Second Floor Plan based on drawing TOL/WTP/008/97 supplied by Historic Royal Palaces
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Figure 5
 Detail of Second Floor Plan showing Bay & Plate Locations
 1:50 at A3

Plan of Bay II Floorboards



Plan of Bay II Joists



- Internal Spine Wall of the White Tower
- Historic Floorboards recorded
- Historic Joists recorded

- Nail
- ① Location and Direction of Plate

0 1m

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Figure 6
 Detailed Plan of Bay II Floorboards & Joists
 1:20 at A3

Plan of Bay III Floorboards



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Plan of Bay III Joists

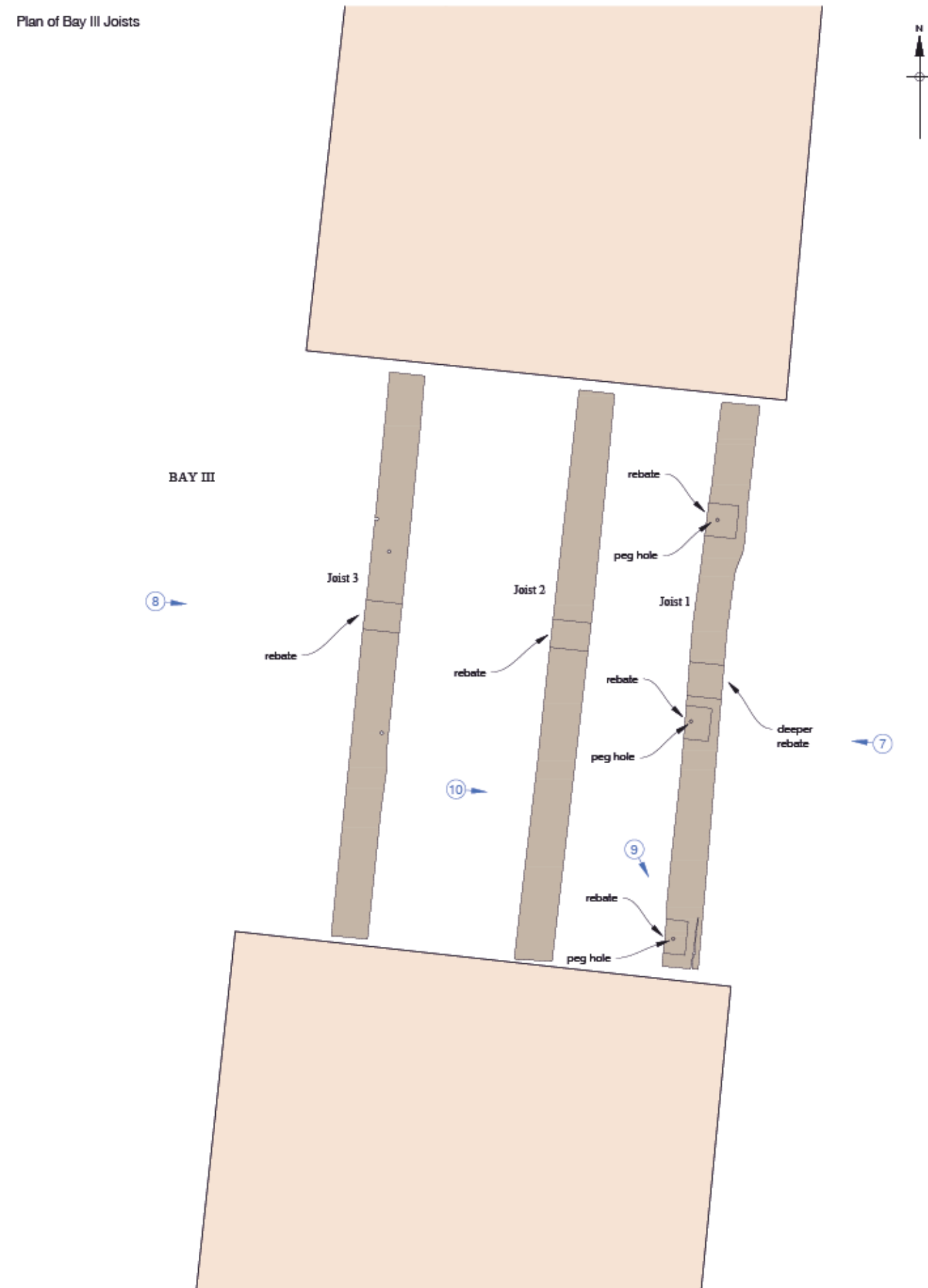
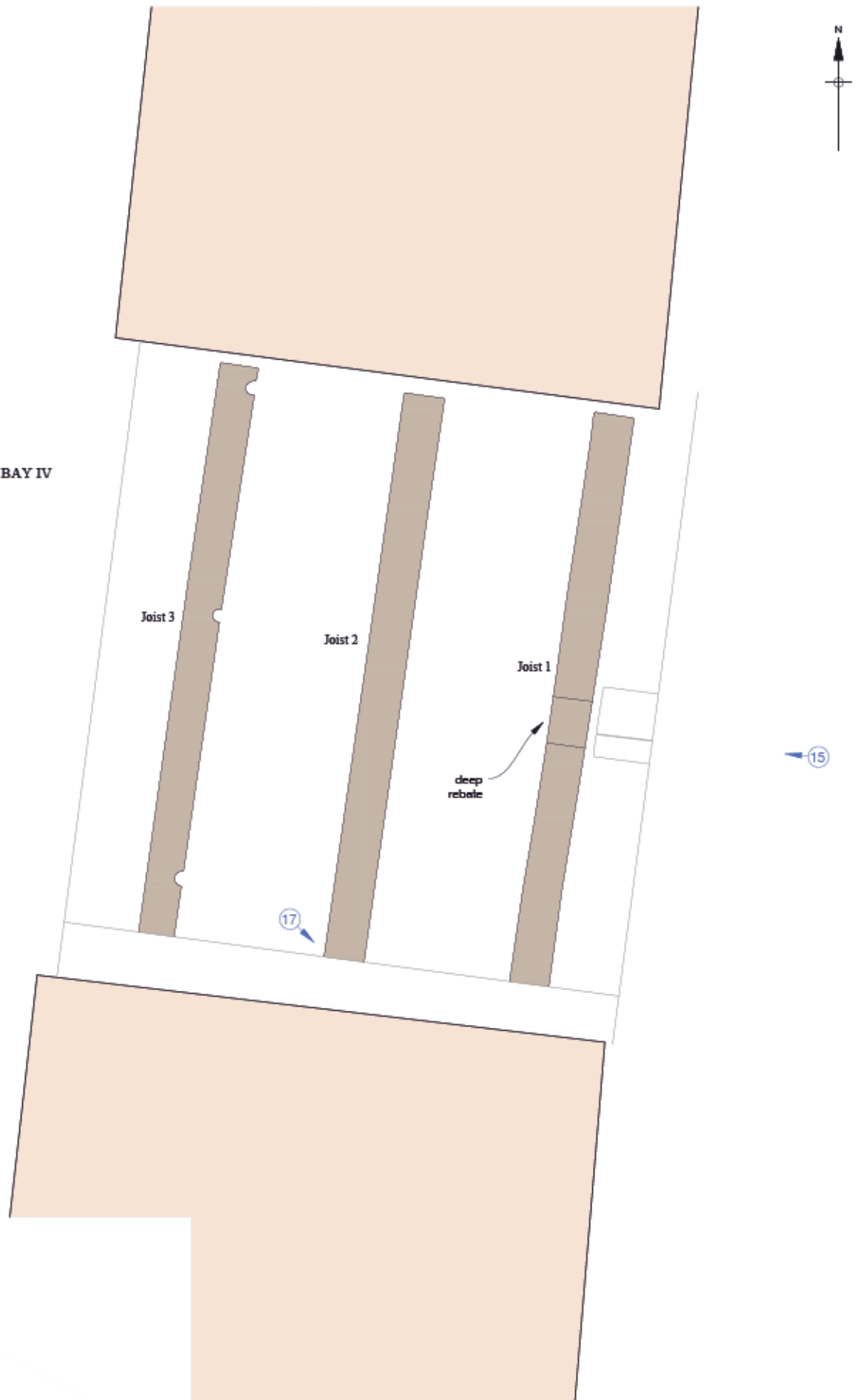


Figure 7
 Detailed Plan of Bay III Floorboards & Joists
 1:20 at A3

Plan of Bay IV Floorboards

Plan of Bay IV Joists



- Internal Spine Wall of the White Tower
- Historic Floorboards recorded
- Historic Joists recorded
- Nail
- Modern Nail
- ① Location and Direction of Plate

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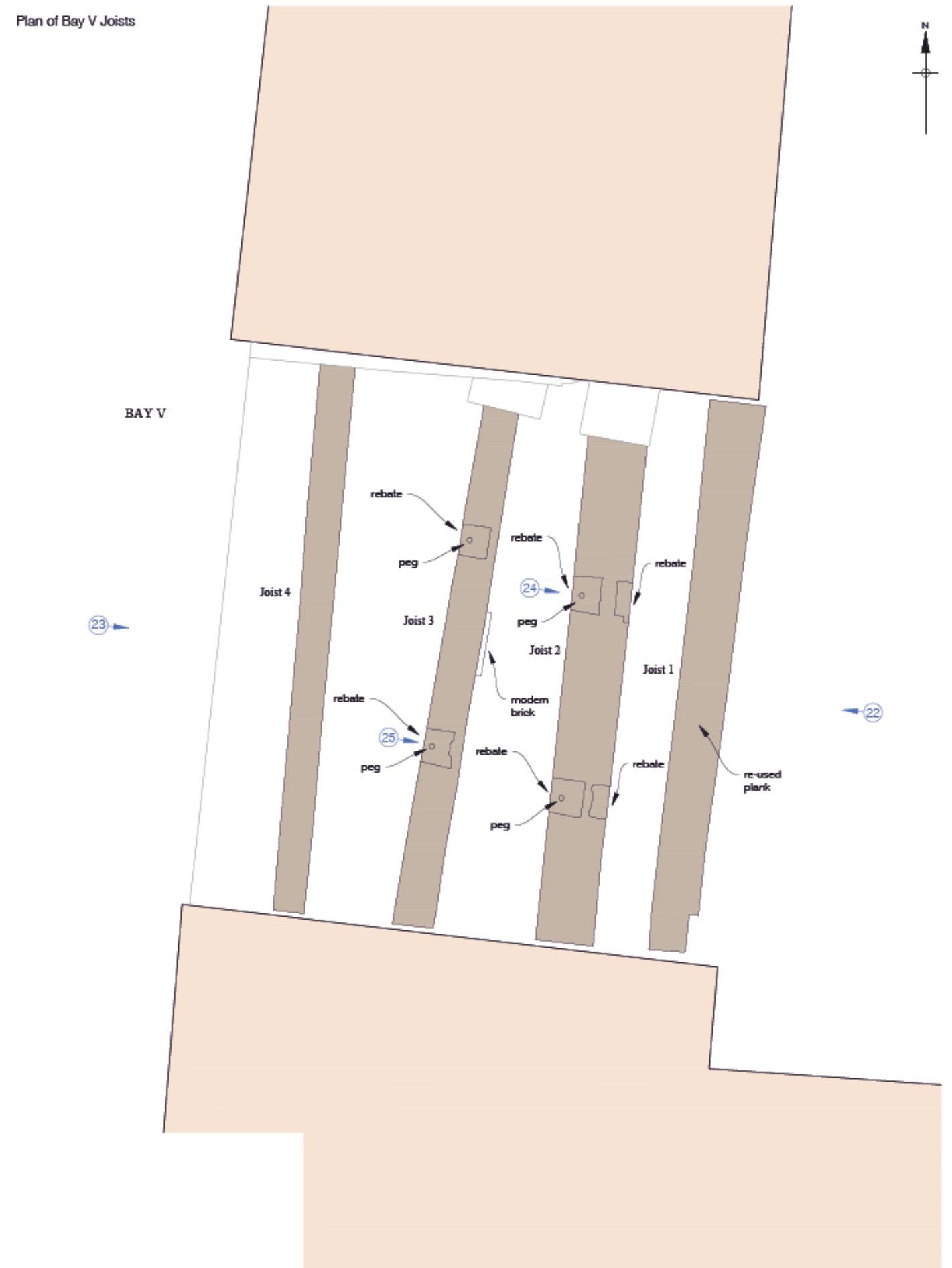


Figure 8
 Detailed Plan of Bay IV Floorboards & Joists
 1:20 at A3

Plan of Bay V Floorboards



Plan of Bay V Joists



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Figure 9
 Detailed Plan of Bay V Floorboards & Joists
 1:20 at A3



Plate 1 Bay II looking west (2m and 0.5m scales)



Plate 2 Bay II looking east (2m and 0.5m scales)



Plate 3 Bay II Joists 1-3 looking west (0.5m scale)



Plate 4 Bay II Joists 1-3 looking east (0.5m scale)



Plate 5 Bay III looking west



Plate 6 Bay III looking east



Plate 7 Bay III Joists 1-3 looking west (0.5m scale)



Plate 8 Bay III Joists 1-3 looking east (0.5m scale)



Plate 9 Bay III Joist 1 detail of rebate (south end)

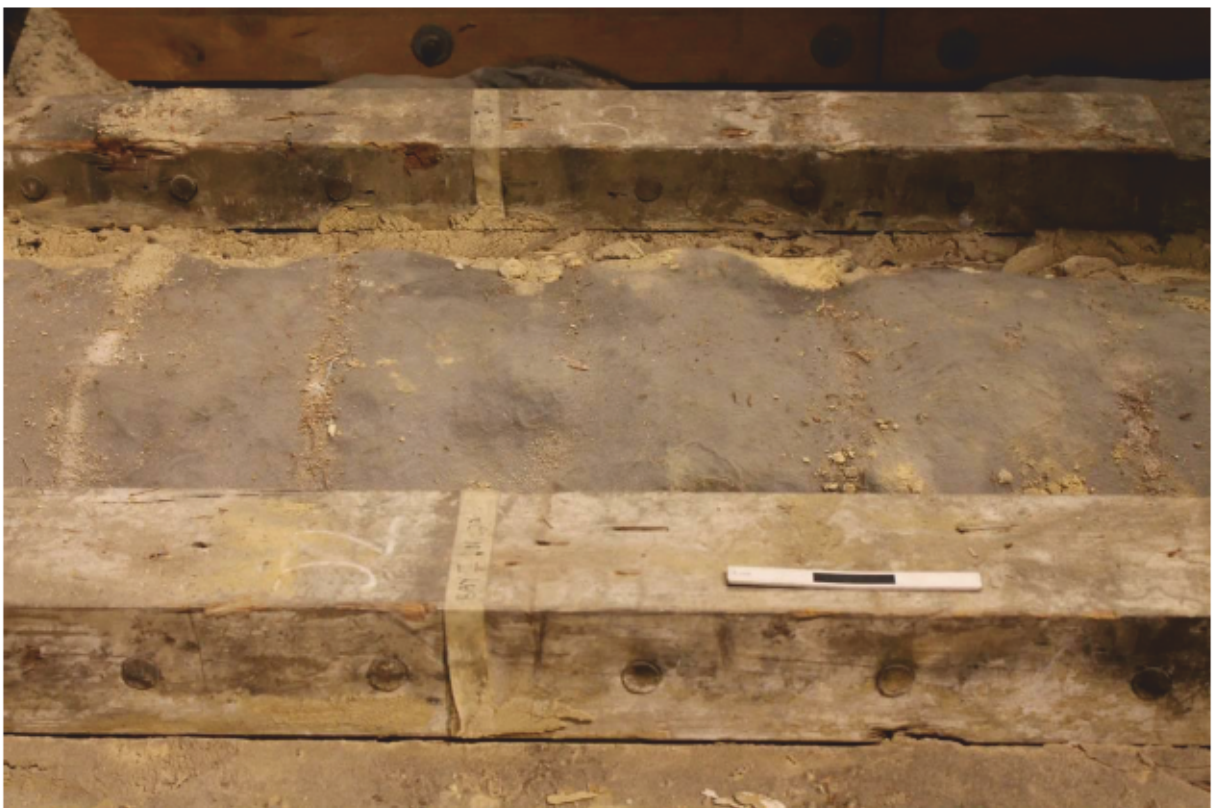


Plate 10 Bay III Joist 2 detail of re-use (0.15m scale)



Plate 11 Bay IV looking west (2m & 0.5m scales)



Plate 12 Bay IV looking east (2m & 0.5m scales)



Plate 13 Bay IV Floorboards (49 and 50) west, detail of historic nails and drilled holes (0.15m scale)

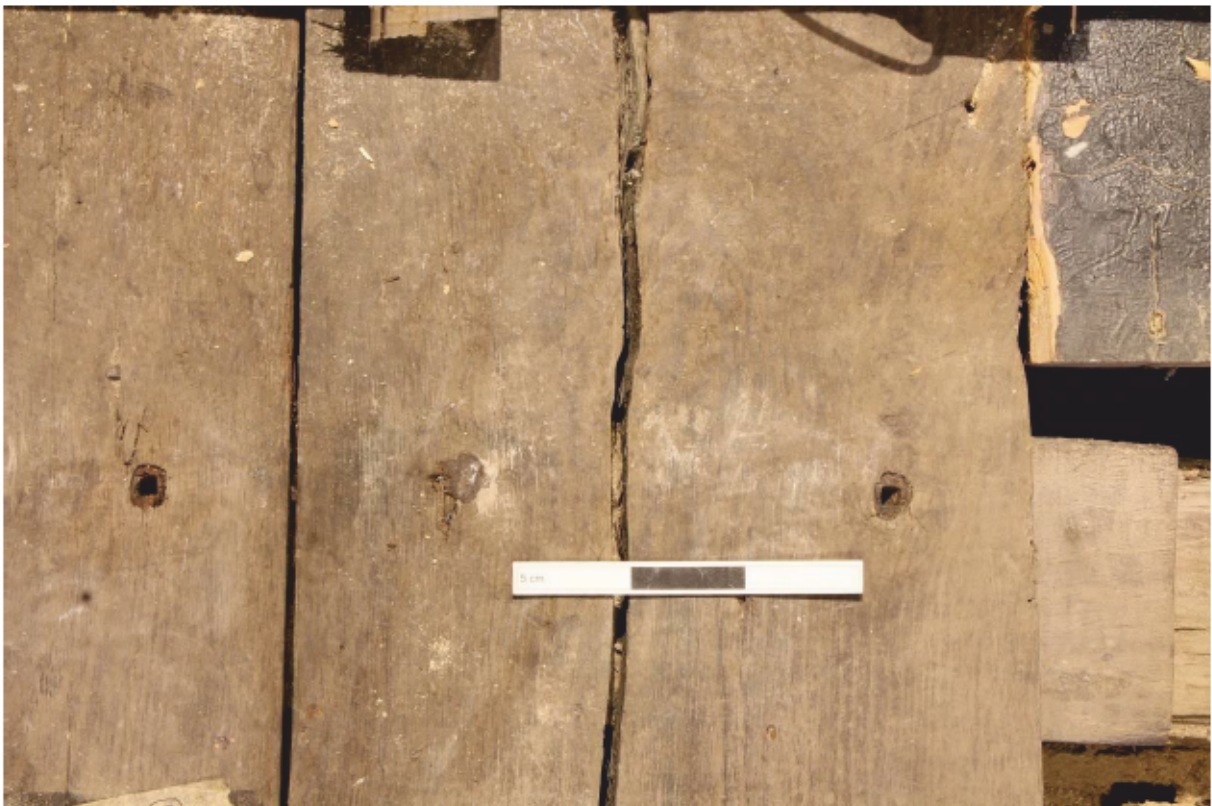


Plate 14 Bay IV Floorboards (49 and 50) east, detail of historic nails (0.15m scale)



Plate 15 Bay IV Joists 1-3 looking west (2m & 0.5m scales)



Plate 16 Bay IV Joists 1-3 looking east (2m & 0.5m scales)



Plate 17 Bay IV Joist 2 fair-face mark



Plate 18 Bay V looking west (2m & 0.5m scales)

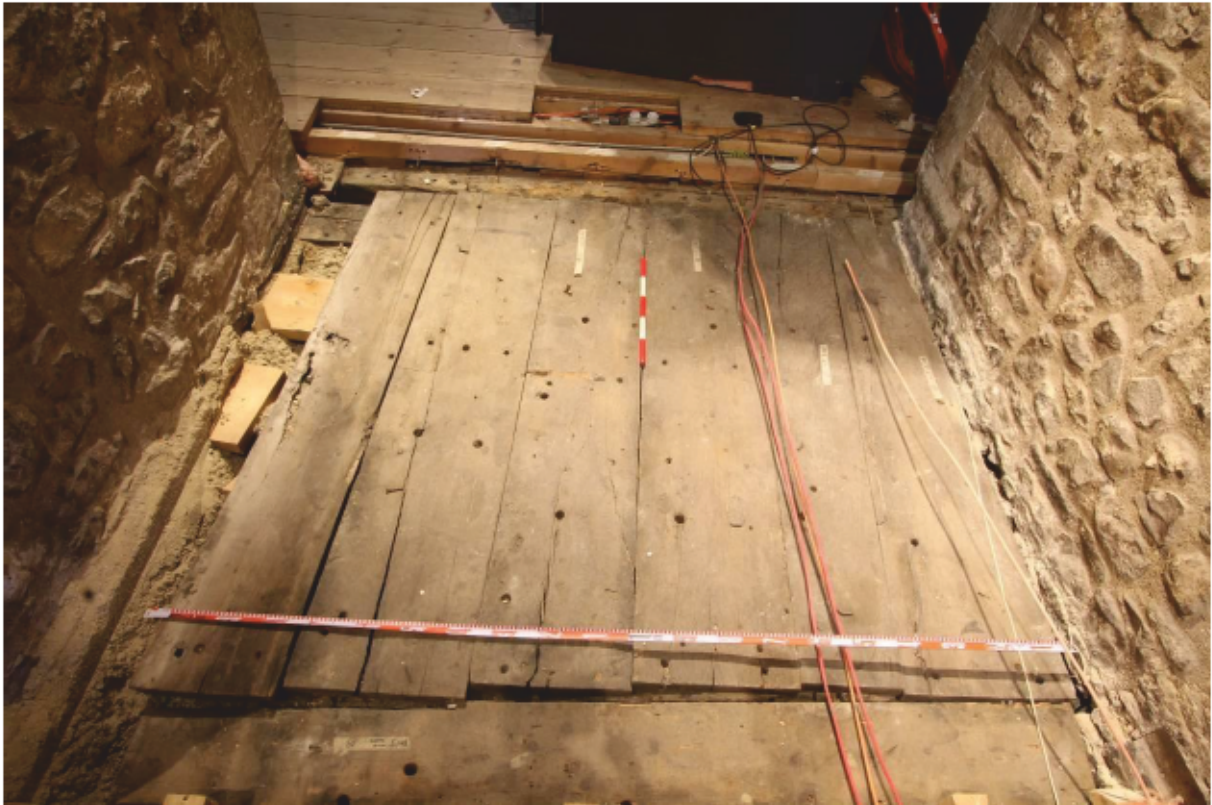


Plate 19 Bay V Looking east (2m & 0.5m scales)



Plate 20 Bay V Floorboard V-67 and 68 (east) detail of nails (0.15m scale)



Plate 21 Bay V Floorboards V-63 to V-66 looking east (0.5m scale)



Plate 22 Bay V Joists 1-4 looking west (2m and 0.5m scales)



Plate 23 Bay V Joists 1-4 looking east (2m and 0.5m scales)



Plate 24 Bay V Joist 2 detail of northern rebate (0.15m)



Plate 25 Bay V Joist 3 detail of southern rebate (0.15m)



Plate 26 Bay V Storage of Floorboards and Joists (intermediate stage)



Plate 27 Bay V Storage of Floorboards and Joists



Plate 28 Bay IV Storage of Floorboards and Joists (intermediate stage)

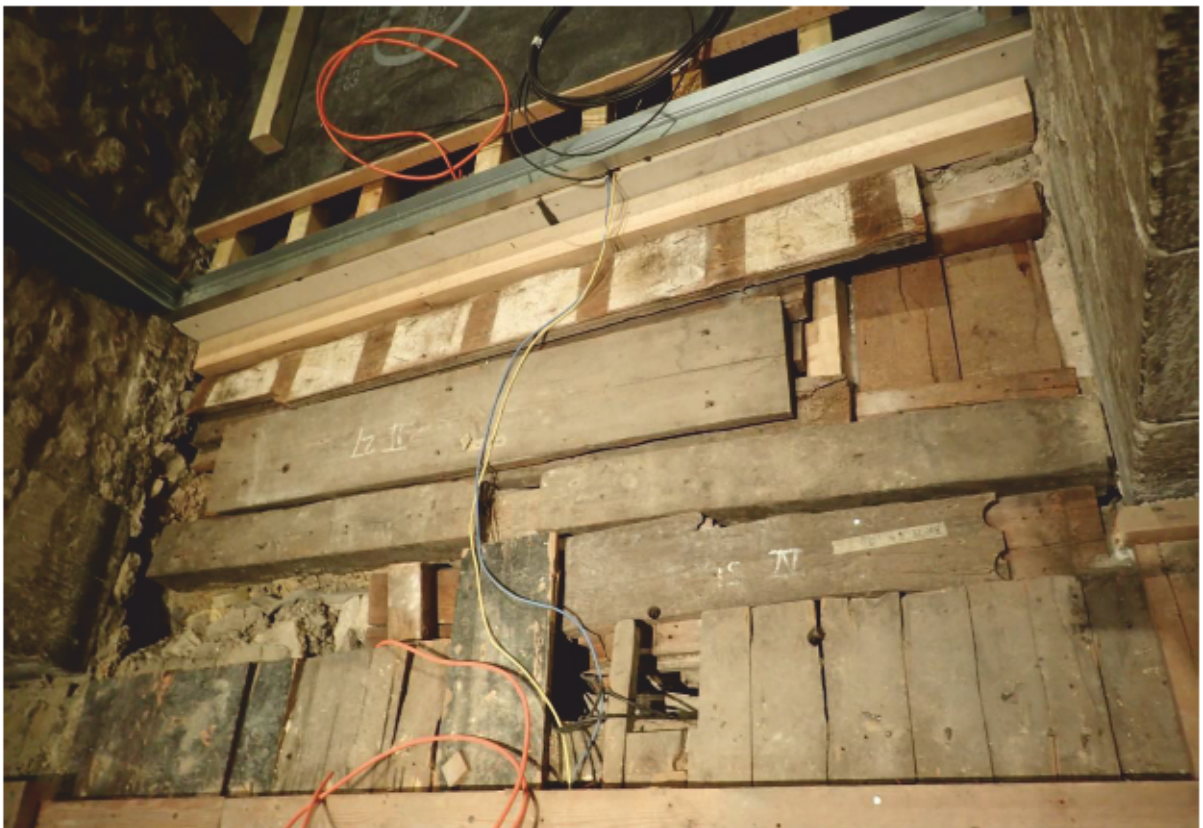


Plate 29 Bay IV Storage of Floorboards and Joists



Plate 30 Bay III Storage of Floorboards and Joists (intermediate stage)



Plate 31 Bay III Storage of Floorboards and Joists



Plate 32 Bay II Storage of Floorboards



Plate 33 Bay I Storage of floorboards below modern floor structure

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