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1 ABSTRACT

- 1.1 An archaeological watching brief was conducted by Pre-Construct Archaeology Ltd. at two sites within The Royal Arsenal, Woolwich, in advance of their redevelopment for light-industrial units. The sites are part of wide-ranging development by the IO Group incorporating Phase 3a (Zone 17) and Phase 4 (Zones 21 and 23) (see Figure 1). Henceforth in this report the work for Phase 3a in Zone 17 is referred to as Site 1, while the work for Phase 4 in Zones 21 and 23 is referred to as Site 2. The work was commissioned by Fitzpatrick Contractors Limited.
- 1.2 The investigations at Site 1 were undertaken between 14th and 21st December 2004; those at Site 2 were between 18th October and 15th December 2004. The work at Site 1 was a watching brief on the excavation of strip footings, while at Site 2 it comprised a watching brief on the ground reduction within the footprints of three new buildings and the areas external to these.
- 1.3 The investigations have revealed a detailed sequence of natural deposits and made ground layers, which served to consolidate the marshy land for construction. Following the use of part of Site 2 as a timber seasoning field, they were both developed structurally to accommodate elements of the Cartridge Establishment, Boiler House and Rolling Mill. Extensive remains of these were recorded. At Site 2 evidence was found of the late 19th century construction and enlargement of the South Boring Mill and associated features. The development of Site 2 through the 20th century was seen from a variety of remains.
- 1.4 Pre-Construct Archaeology Ltd. have previously conducted a large-scale watching brief to the west of Site 2 during the works of Phase 2 (Zone 22) for the IO Group¹ (henceforth referred to as RYR 03). This revealed evidence of the 19th and 20th century structural development of The Royal Arsenal (henceforth the Arsenal), which by the end of the 19th century incorporated heavy industrial processes. The remains of an early 19th century Royal Laboratory building was found to have been built on a foundation raft of re-used timbers from naval- and land-gun carriages. Other structures included the substantial remains of the South Forge (including the foundations of a 35 ton steam hammer), South Boring Mill, Tender Shop and other buildings.
- 1.5 Prior to the work detailed in this report, Pre-Construct Archaeology Ltd. conducted evaluations of both Sites 1 and 2 in July 2004². These indicated the presence of structural remains relating to the Arsenal, but at a lower concentration than was seen at RYR 03, including elements of the Boiler House, South Boring Mill, Building C47 and the Cartridge Establishment.
- 1.6 This report presents the results of the investigations in both areas, and explores the potential of the results to answer archaeological research objectives specific to the sites.

¹ Mayo 2004a

² Mayo 2004b&c

2 INTRODUCTION

- 2.1 An archaeological watching brief was undertaken by Pre-Construct Archaeology Ltd. at two sites in the Arsenal, Woolwich, London Borough of Greenwich. They are part of an ongoing redevelopment of the Arsenal, a process that has seen the area subdivided for construction purposes: Phase 3a covers part of Zone 17 (Site 1 in this report), while Phase 4 covers all of Zones 21 and 23 (Site 2 in this report). Pre-Construct Archaeology Ltd. were commissioned by Fitzpatrick Contractors Limited. Site 1 is centred at National Grid Reference TQ 4435 7903; Site 2 is centred at TQ 4435 7915.
- 2.2 An archaeological desk-based study of the whole Arsenal complex, including both of the Sites, was undertaken in 1995³. A brief for the project⁴ was prepared, and followed by evaluation projects in July 2004. These revealed the survival of structural remains of the Boiler House, South Boring Mill, Building C47⁵ and the Cartridge Establishment⁶. Targeted trenches of Site 2 to test the survival of the Pilkington Canal showed that its upper levels had been remediated. The investigations reported here followed a Written Scheme of Investigation⁷.
- 2.3 The desk-based assessment, evaluation work and project designs indicated the high likelihood of widespread archaeological remains in a good state of preservation. The initial project brief⁸ outlined a number of areas for potential research; these are listed below (see 3.2.1). The project's Written Scheme of Investigation⁹ included a map regression exercise that revealed the intensive use of the Site since the early 19th century. It also made predictions regarding the nature of obstructions that could be expected during the investigation, including brick, concrete and timber remains.
- 2.4 The watching brief at Site 1 was conducted between 14th and 21st December 2004; the work at Site 2 was undertaken between 18th October and 15th December 2004. Previous to the works by Pre-Construct Archaeology Ltd., Oxford Archaeology (OA) had undertaken a programme of archaeological recording immediately to the west of Site 2 during the construction of Armstrong Road and had excavated an evaluation trench in Zone 21 of Site 2. The same company have also completed watching briefs to the south and east of Site 1¹⁰; these works revealed very similar sequences to those recorded by Pre-Construct Archaeology Ltd. in these investigations and at RYR 03.
- 2.5 Site 1 covered an area of land approximately 400m² in size and centred on National Grid Reference TQ 4435 7903. It is bordered to the south by Seymour Sreet, to the west by Skeffington Street, to the north by Duke of Wellington Avenue, and to the east by the Marshgate Path. Site 2 covered an area of land approximately 17,250m² in size and centred on National Grid Reference TQ 4435 7915. It is bordered to the north by new houses, to the west by Armstrong Road, to the south by Duke of Wellington Avenue, and to the east by a construction site (see Figure 1).
- 2.6 The project manager for Pre-Construct Archaeology Ltd. was Jon Butler, and the works were monitored by Mark Stevenson of the Greater London Archaeological Advisory Service (GLAAS). The work was supervised by Chris Mayo. The archaeological consultant was Duncan Hawkins of CgMs Consulting.

³ Mills Whipp Partnership 1995

⁴ Stevenson 2003

⁵ Mayo 2004b

⁶ Mayo 2004c

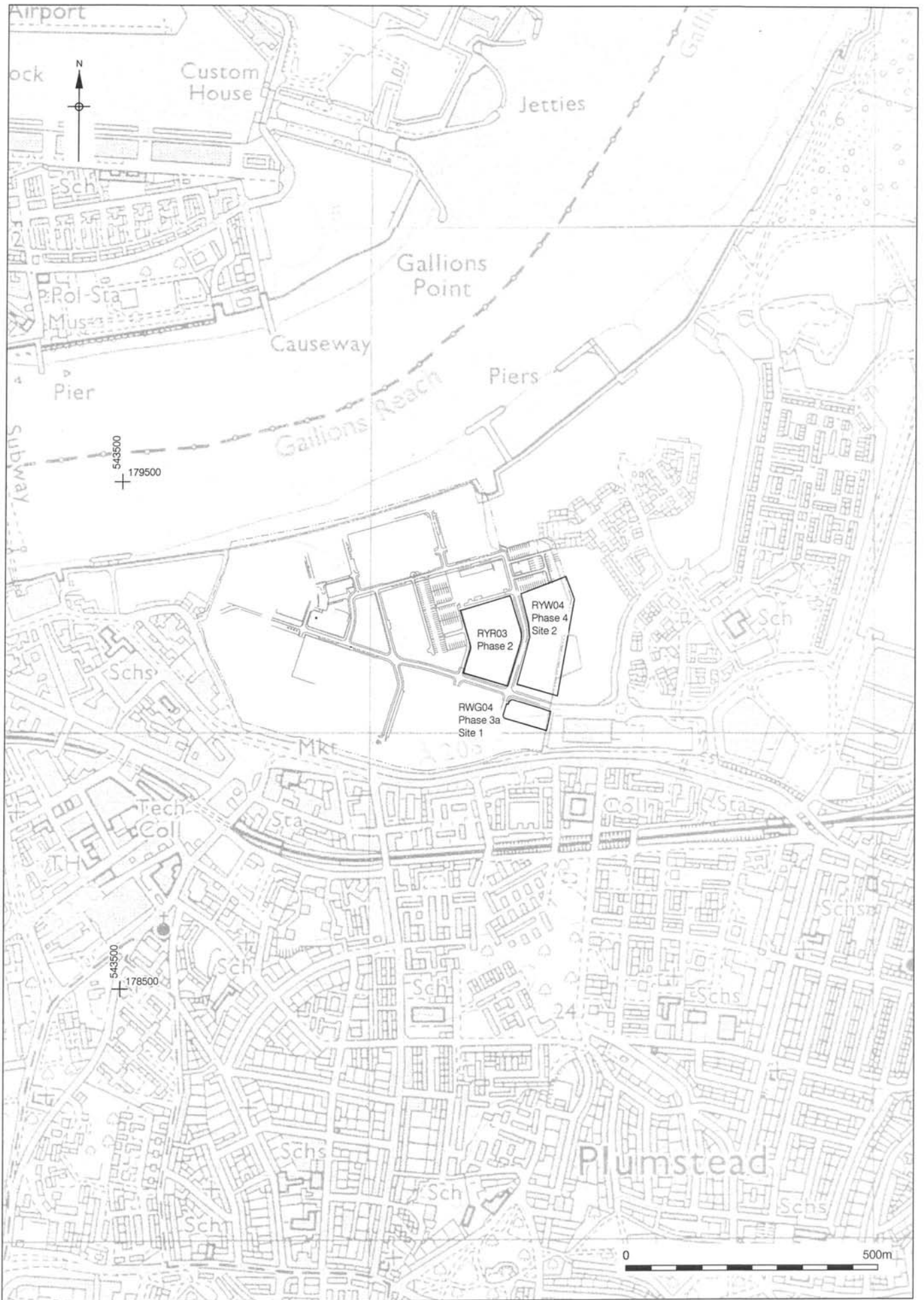
⁷ Butler 2004

⁸ Stevenson 2003

⁹ Butler 2004

¹⁰ Oxford Archaeology 2002. Works to the west of Site 1 covered the Phase 1 development of Zone 16; those to the south covered part of Zone 17 and Zone 18.

- 2.7 The completed archive, including written, drawn and photographic records, as well as artefactual material, will eventually be deposited at either the London Archaeological Archive and Research Centre (LAARC) or at the Greenwich Heritage Centre at the Arsenal, under the site codes RYG 04 (Site 1) and RYW 04 (Site 2).



Reproduced from Ordnance Survey 1:25,000. Crown Copyright 1993.

Figure 1
Site Location
1:10,000

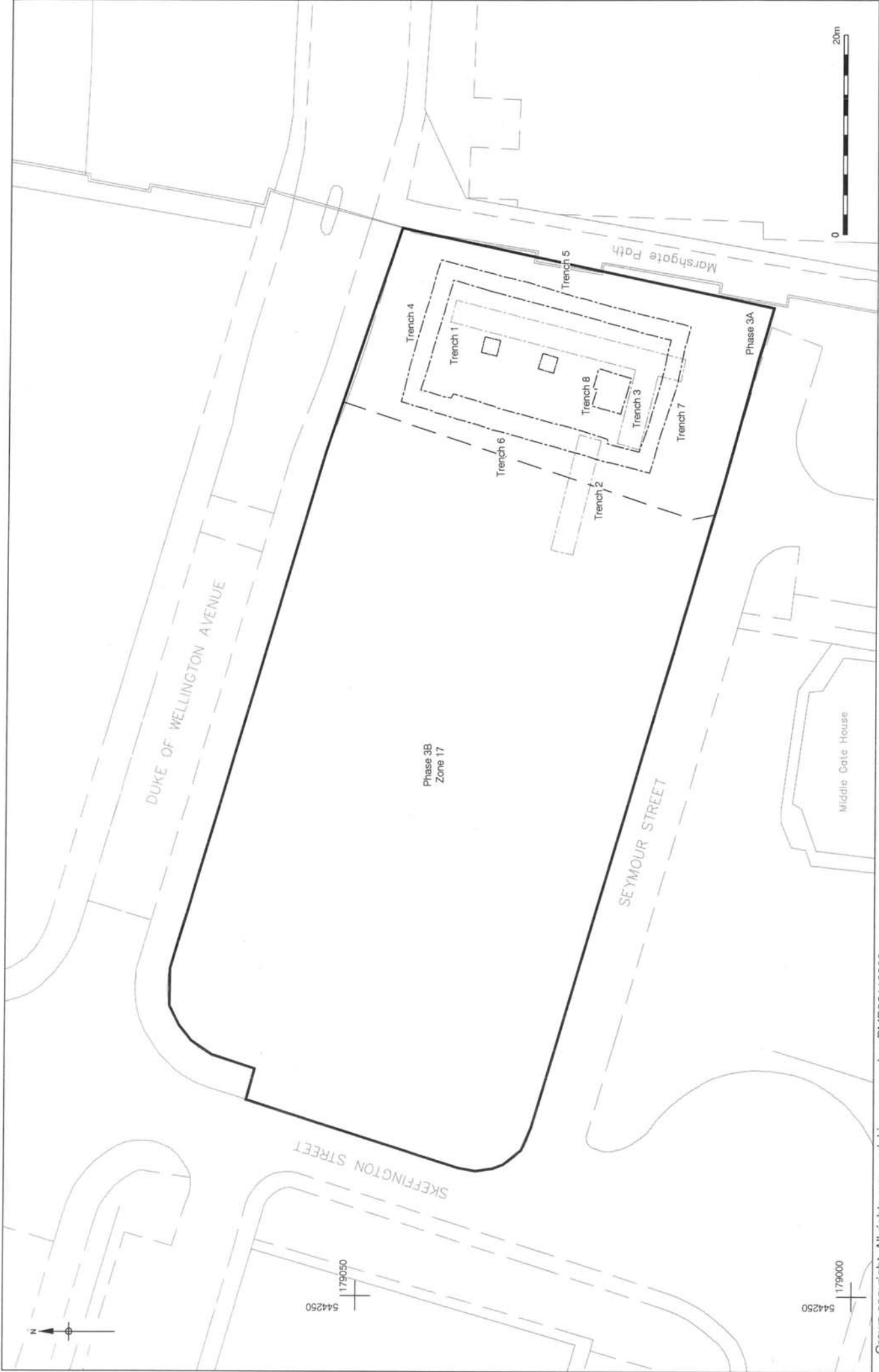
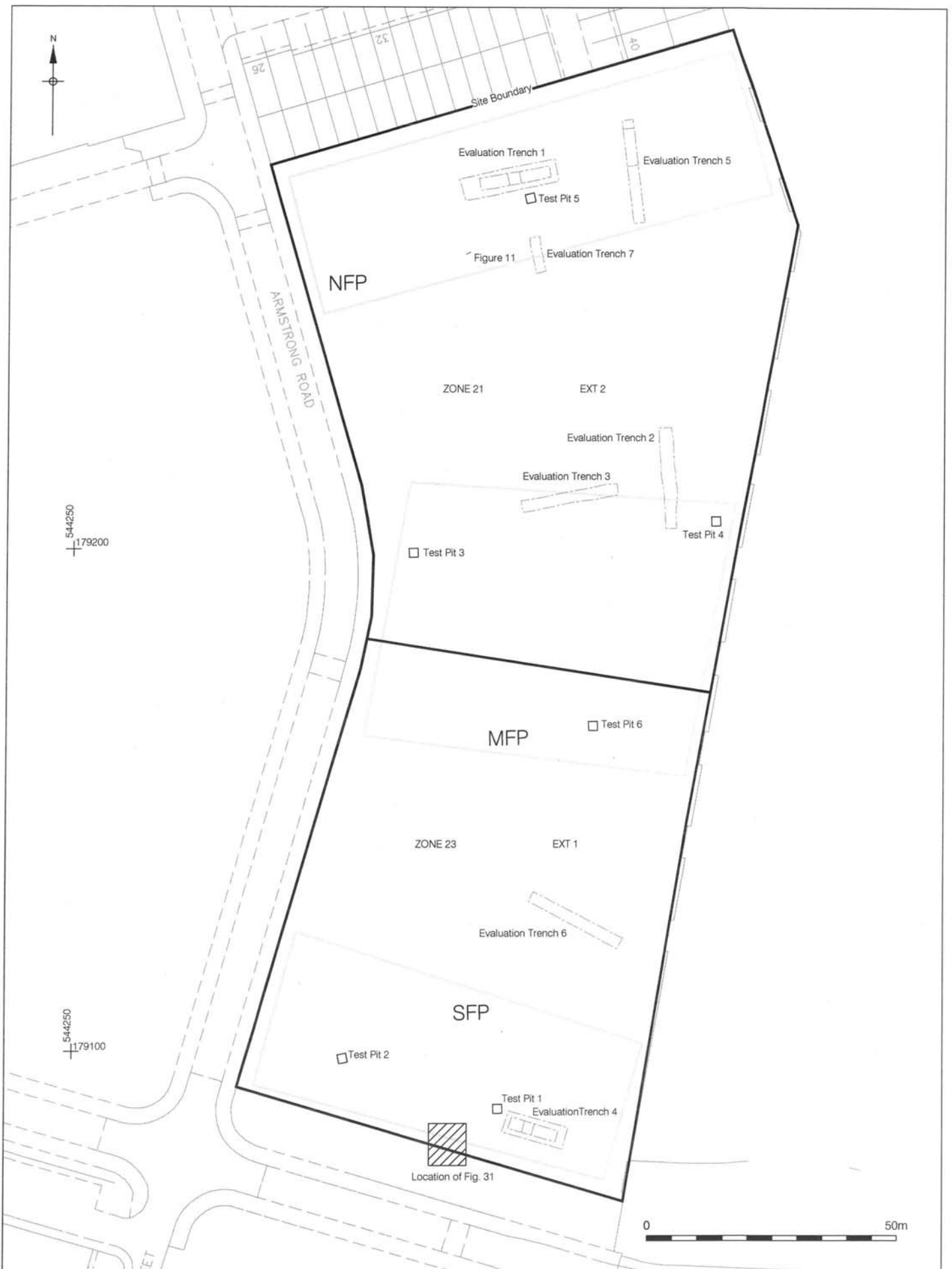


Figure 2
 Site 1 (RWG04) Location of Trenches including Evaluation Trenches
 1:500

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-  Evaluation trenches
-  Excavation trenches



Crown copyright. All rights reserved. License number PMP36110309



-  Evaluation trenches
-  Excavation trenches

Figure 3
 Site 2 (RYW04) Location of Trenches including Test Pits and Evaluation Trenches
 1:1000

3 PLANNING BACKGROUND AND RESEARCH OBJECTIVES

3.1 PLANNING BACKGROUND

- 3.1.1 The design for the investigation fulfils the requirements set out by the Development Plan Framework of the London Borough of Greenwich Unitary Development Plan (UDP), published in 1994 (see below):

ARCHAEOLOGY

POLICY D27A

AT IDENTIFIED SITES OF KNOWN ARCHAEOLOGICAL REMAINS OF NATIONAL IMPORTANCE, INCLUDING SCHEDULED MONUMENTS, THERE WILL BE A PRESUMPTION IN FAVOUR OF THE PHYSICAL PRESERVATION OF THE REMAINS *IN SITU* AND TO ALLOW FOR PUBLIC ACCESS AND DISPLAY. FOR REMAINS *IN SITU*, BUT WHERE THIS IS NOT FEASIBLE, THE REMAINS SHOULD BE EITHER EXCAVATED AND REMOVED FROM THE SITE, OR EXCAVATED AND RECORDED BEFORE DESTRUCTION. APPROPRIATE CONDITIONS / LEGAL AGREEMENTS AMY BE USED TO ENSURE THIS IS SATISFIED.

POLICY D27B

THE COUNCIL WILL EXPECT APPLICANTS TO PROPERLY ASSESS AND PLAN FOR THE IMPACT OF PROPOSED DEVELOPMENTS ON ARCHAEOLOGICAL REMAINS WHERE THEY FALL WITHIN AREAS OF ARCHAEOLOGICAL POTENTIAL AS DEFINED ON THE CONSTRAINTS MAP 10. IN CERTAIN INSTANCES PRELIMINARY ARCHAEOLOGICAL SITE INVESTIGATIONS MAY BE REQUIRED BEFORE PROPOSALS ARE CONSIDERED. THE COUNCIL WILL SEEK TO SECURE THE CO-OPERATION OF DEVELOPERS IN THE EXCAVATION, RECORDING AND PUBLICATION OF ARCHAEOLOGICAL FINDS BEFORE DEVELOPMENT TAKES PLACE BY USE OF PLANNING CONDITIONS / LEGAL AGREEMENTS AS APPROPRIATE.

- 3.1.2 The London Borough of Greenwich produced its UDP First Deposit Draft in February 2002. The plan contains the following policies, which provide a framework for the consideration of development proposals affecting archaeological and cultural heritage features.

ARCHAEOLOGY

POLICY D29A

AT IDENTIFIED SITES OF KNOWN ARCHAEOLOGICAL REMAINS OF NATIONAL IMPORTANCE, INCLUDING SCHEDULES MONUMENTS, THERE WILL BE A PRESUMPTION IN FAVOUR OF THE PHYSICAL PRESERVATION OF THE REMAINS *IN SITU* AND TO ALLOW FOR PUBLIC ACCESS AND DISPLAY. FOR SITES OF LESSER IMPORTANCE THE COUNCIL WILL SEEK TO PRESERVE THE REMAINS *IN SITU*, BUT WHERE THIS IS NOT FEASIBLE THE REMAINS SHOULD BE EITHER INVESTIGATED, EXCAVATED AND REMOVED FROM SITE, OR INVESTIGATED, EXCAVATED AND RECORDED BEFORE DESTRUCTION.

APPROPRIATE CONDITIONS / LEGAL AGREEMENTS MAY BE USED TO ENSURE THAT THIS IS SATISFIED.

POLICY D29B

THE COUNCIL WILL EXPECT APPLICANTS TO PROPERLY ASSESS AND PLAN FOR THE IMPACT OF PROPOSED DEVELOPMENTS ON ARCHAEOLOGICAL REMAINS WHERE THEY FALL WITHIN 'AREAS OF ARCHAEOLOGICAL POTENTIAL' AS DEFINED ON THE CONSTRAINTS MAP 10. IN CERTAIN INSTANCES PRELIMINARY ARCHAEOLOGICAL SITE INVESTIGATIONS MAY BE REQUIRED BEFORE PROPOSALS ARE CONSIDERED. THE COUNCIL WILL

SEEK TO ENSURE THE CO-OPERATION OF DEVELOPERS IN THE EXCAVATION, RECORDING AND PUBLICATION OF ARCHAEOLOGICAL FINDS BEFORE DEVELOPMENT TAKES PLACE BY USE OF PLANNING CONDITIONS / LEGAL AGREEMENTS AS APPROPRIATE.

3.2 RESEARCH OBJECTIVES

3.2.1 The research design for the investigation, as discussed in the English Heritage Brief¹¹, comprised the following areas for investigation:

- Pre-Roman waterlogged deposits in alluvium and / or peat.
- Deposits to raise ground during the period of the Napoleonic wars.
- Construction detail of the canal and opportunities for environmental sampling.
- The phases of changes to the former buildings and how this relates to their changing use and / or level of use.
- Evidence of power generation, supply and transmission.

3.2.2 A series of further research questions have been posed based on the evidence from map regression exercises and previous archaeological work in the vicinity:

- From the borehole logs thick deposits of peat are known to occupy the north of the Site 2. What can be learnt from a study of the peat?
- Is there any evidence of archaeological activity prior to the post-medieval period?
- On the early 19th century maps several buildings appear only for a very short period. What is the nature of these structures and is it possible to assign a function to them?
- What is the precise location of Pilkington's Canal? What material is it backfilled with?
- To what degree do the 19th and 20th century structures survive on Sites 1 and 2?
- Is it possible to record different phases of building with regard to the Rolling and Boring Mills and the Boiler House?
- Can the position of the former Marlborough Road be located?
- Are there any other buildings on Sites 1 and 2 that are not documented on the maps?

¹¹ Stevenson 2003

4 GEOLOGY AND TOPOGRAPHY

4.1 GEOLOGY

- 4.1.1 The underlying geology of the sites is sand and clay with variable gravel¹². Overlying this in the northern majority of Site 2 is a sequence of alluvial sand and silts, capped with thick peat deposits and then sealed with alluvial clay. Such was the sequence found to the west at RYR 03¹³. This phase of fieldwork has shown that the northern edge of the river gravel terrace lies within the southern edge of Site 2.
- 4.1.2 Site 1 was seen during the evaluation to be at the top of the gravel terrace¹⁴.
- 4.1.3 Site 2 is likely to have comprised river marshland prior to the late Medieval period, which was periodically drained and reclaimed. With the development of the Arsenal from the 17th century onwards the local area was built up substantially with made ground deposits. A borehole survey within the area of RYR 03 revealed made ground deposits with thicknesses ranging between 2.9m (borehole 13) to 4.9m (borehole 14)¹⁵.

4.2 TOPOGRAPHY

- 4.2.1 The Sites are located on relatively flat ground at a height of approximately 4.5m OD.
- 4.2.2 The natural topography of Zone 22, recorded at RYR 03¹⁶, suggested the presence of an underlying natural channel, possibly aligned east - west.
- 4.2.3 The River Thames lies approximately 250m to the north of Site 2 and 400m to the north of Site 1 (see Figure 1).

¹² From British Geological Survey, 1:50 000 Series, England and Wales Sheet 271: Dartford (1998)

¹³ Mayo 2004a

¹⁴ Mayo 2004c

¹⁵ Borehole logs from WSP Environmental Ltd

¹⁶ Mayo 2004a

5 ARCHAEOLOGICAL AND HISTORICAL BACKGROUND

5.1 The archaeological and historical backgrounds of Sites 1 and 2 have been detailed in a desk-based assessment¹⁷. This information, and more, is summarised below.

5.2 PREHISTORIC

5.2.1 There have been no finds of early prehistoric date recovered from within the vicinity of the sites.

5.2.2 A small number of Bronze Age artefacts have been found in the vicinity, although as during this time the area of Site 2 was a peat marsh environment and Site 1 was at the very limit of the terrace, the likelihood of concentrated archaeological remains is limited. At a nearby site the study of local peat deposits revealed that it had been formed between c 6150 BP (the Neolithic period) and c 2450 BP (the Bronze Age). The Bronze Age layers of the peat deposit revealed evidence for cereal production¹⁸. Peat deposits at comparable heights were found at RYR 03¹⁹.

5.2.3 There is no evidence for Iron Age activity within the immediate area of the sites, and indeed it is thought that the sites may have been frequently flooded at this time. However, an important Iron Age settlement has been excavated to the west of the Arsenal, approximately 0.8 km from the sites, at the former Woolwich Power Station.

5.3 ROMAN

5.3.1 During the early Roman period it is likely that the area of the sites was pastureland; by the late Roman period it may have once more been flooded. The majority of evidence for Roman activity within the vicinity comprises burials and cremations. The latter, uncovered during works at the Arsenal in the 19th century, are undated, although a burial was found in association with 3rd and 4th century coins to the south.

5.3.2 The recent excavation of an extensive inhumation cemetery beneath Dial Square²⁰ to the west has produced further evidence for Roman burial activity on the gravel terrace.

5.3.3 Roman occupation in the area of the Arsenal may have comprised settlements or farms possibly every 1.5km or so, with the use of isolated pockets of (semi-) permanent dry land for arable, pasture or market gardening²¹.

5.3.4 Other evidence for Roman activity has included artefacts from the higher, drier ground to the south and west of the sites.

5.3.5 An amount of Roman material was excavated from the upper layers of Late Iron Age enclosure ditches at the Power Station site to the west²².

5.4 ANGLO-SAXON / EARLY MEDIEVAL

5.4.1 No evidence exists for activity within this period, when the area of the Arsenal comprised marshland.

5.5 LATE MEDIEVAL

¹⁷ Mills Whipp Partnership 1995 Vol I

¹⁸ MoLAS 1997

¹⁹ Mayo 2004a

²⁰ Oxford Archaeology 2002, 6

²¹ Mills Whipp Partnership 1995 Vol I, 8

²² Mills Whipp Partnership 1995 Vol I, 9

- 5.5.1 Whilst Woolwich itself was established as a town by the late medieval period, the area of the Arsenal was still a regularly inundated marsh. Consequently activity for this period at the sites was probably limited to flood-relief.

5.6 POST-MEDIEVAL

- 5.6.1 In 1671 an area of the Arsenal was purchased by the Crown from Sir William Pritchard, and the Ordnance depot was transferred to this land from upriver near the Woolwich Ferry²³. The Gun Foundry, as it was known, rapidly expanded in size, helped by both its proximity to the Woolwich Naval Dockyards and the constant military engagements / expansion of Britain through the post-medieval period.
- 5.6.2 By the 18th century, the Gun Foundry was known as The Warren, before arriving at its current name, The Royal Arsenal, in 1805. Initial development of the Arsenal was centred to the west of the sites, where buildings were erected to serve the divisions of the Arsenal, all under the control of the Office of Ordnance (until 1855). These main divisions were: the Royal Gun Factory (RGF), which produced the guns themselves; the Royal Laboratory (RL), which produced munitions and developed new weapons; the Royal Carriage Department (RCD), which produced the carriages upon which the guns were mounted.
- 5.6.3 Between the 17th and 19th centuries, as the Arsenal was enlarged, a substantial process of ground consolidation was conducted in order to reclaim the marshland for heavy industry. To this end, the buildings in the area of Site 2 are founded upon massive deposits of made ground. This material was either imported into the Arsenal, dredged up from the River Thames or waste from the Arsenal itself²⁴. Investigations at RYR 03 revealed the made ground to range in thickness between 2.35m to 4.9m²⁵.
- 5.6.4 Historical maps of the Arsenal²⁶ show that until 1802, Site 2 was criss-crossed by ditches. By 1808, a segmented linear feature ran NE-SW across Site 2; the southerly section is labelled as 'Lobby' and may have been a pathway. The northerly section may be a continuation of this.
- 5.6.5 By 1812, the majority of the Pilkington Canal had been dug. This ran SW from the Thames across Site 2 before terminating to the south; it was seen during the evaluation of Site 1 to not reach that far²⁷, although it had a westerly spur that encroached and terminated on Site 2. By 1816²⁸ the canal had been extended so that it looped through the site to join, albeit non-continuously, with the original terminus to the SE. It also had a looping-arm that headed east from the stretch that crossed Site 2 (see figures 4 to 6). The canal was a large construction ranging in width between approximately 10m and 20m. Sizes such as this imply that the canal was strongly revetted with either timber or masonry. A large pond had been dug in site 2 to the north of the canal by 1858. The canal is shown on historical maps in this form until 1884; also until at least this time, both sites were in part of the RCD's Timber Field (see Figure 4). The maps also imply that the earlier pathway, or Lobby, had been conjoined, straightened and presumably strengthened to form the precursor of Street N^o 10, or the Marlborough Road, which was maintained until at least the 1960s.
- 5.6.6 By the time of the Crimean War, part of Site 1 was covered in the buildings of the Cartridge Establishment (although concentrated to the south and west), part of the RL. A range of structures was built, with access to the Pilkington Canal to the north. These buildings were extant, largely unchanged, until at least 1870. Hogg mentions that the Cartridge Establishment was completed in 1857²⁹; it was built after the time

²³ Hogg 1963, xiii

²⁴ Hogg 1963, 594

²⁵ Mayo 2004a

²⁶ Butler 2004

²⁷ Mayo 2004c

²⁸ Mills Whipp Partnership 1995 Vol I, 41

²⁹ Hogg 1963, 814

of a map of 1812. Investigations by OA revealed extensive structural remains at foundation level. By 1884 an historical map suggests that some structural alterations had occurred.

- 5.6.7 A map of 1878 (see Figure 5) shows that the northern area of Site 2 had been structurally developed with the Rolling Mill and Boiler House (part of which was recorded at RYR 03). These buildings were engaged in the production of heavy guns with the South Forge to the west, where the 35-ton steam hammer was found³⁰.
- 5.6.8 A map of 1895 indicates that a section of the Pilkington Canal, towards the southern end of Site 2, had been in-filled (see Figure 6). The space created by this was used to lay small bogie tracks that by now traversed the Arsenal. These features were necessitated by the processes of heavy industry that were being employed, for example, in the South Boring Mill. This structure was centred at this time to the west, on Zone 22, but also infringed on the western side of Site 2. The enlargement eastwards of this structure over the next 30 years meant that by the early 20th century, a large area of Site 2 comprised its' structure and associated services.
- 5.6.9 Through the 20th century the historical maps show that the use of Site 2 was fairly consistent. The Rolling Mill had been altered by 1917 into a range of smaller buildings (see Figure 7) before being reworked again by 1931 to form Buildings D72 and D74. By 1917 Building C47 had been built on the east side of Site 2. Sites 1 and 2 also included a variety of small-scale and largely ephemeral structures, probably serving short-lived purposes.
- 5.6.10 An office building was built after World War II at the southern edge of Site 2, reflecting the decreasing use of the Arsenal for industry. It had become semi-redundant as a centre for military production by the 1960s, and was closed as a factory in 1967. In the area of the Site the upstanding buildings were removed to slab level. The Pilkington Canal and possibly the pond were remediated as well.

³⁰ Mayo 2004, 27



Figure 4
Map of 1860
1:1250



Figure 5
Map 1878
1:1250



Figure 6
1895 map
1:1250



Figure 7
 Map of 1917
 1:1250



Figure 8
Map of 1946
1:1250

6 ARCHAEOLOGICAL METHODOLOGY

6.1 FIELDWORK METHODOLOGY

- 6.1.1 The watching briefs followed a methodology specified in the Written Scheme of Investigation³¹ for the sites and in the English Heritage Brief³².
- 6.1.2 All ground-invasive machining was monitored by an archaeologist. The majority of groundwork was completed by 360° tracked machines fitted with flat grading buckets. However, given the nature of the ground, i.e. with a great deal of concrete and made ground, the machines were occasionally fitted with toothed buckets. Such work was closely monitored, and the machines re-fitted with toothless buckets once the ground conditions permitted it.
- 6.1.3 Once an area had been machined, archaeologists cleaned and recorded all of the exposed features. All were surveyed with an EDM and photographed.
- 6.1.4 The groundworks at Site 2 required the removal of all intrusive remains to a depth at which it could be confidently said that piling for the new structures would not be impeded; this ground reduction was done to a minimum depth of 1.8m in the areas of the three new buildings. The footprints for these were given the trench names Southern, Middle and Northern Footprint (henceforth SFP, MFP and NFP) (see Figure 3). In certain areas where deep obstacles were encountered, to depths of up to 8m, archaeological remains could not be safely recorded by archaeologists; in these situations approximate measurements and photographs were taken.
- 6.1.5 The areas external to the new construction footprints required ground reduction of 0.5m. This work was conducted under archaeological supervision. The area between the SFP and MFP is referred to as EXT 1; between the MFP and NFP is EXT 2.
- 6.1.6 In a number of places, after the ground reduction had been completed, further deep holes had to be dug. This was to investigate metallic anomalies that were found during a process of bomb-probing on site. The excavation of these holes were monitored by archaeologists; their depths allowed records to be made of the underlying natural sequence that might otherwise not have been seen from the original ground reduction. These holes were recorded as Test Pits (TP) 1 to 6.
- 6.1.7 A process of hand-excavation and recording was undertaken by archaeologists in particularly sensitive areas in the NFP.
- 6.1.8 The works at Site 1 required only the excavation of trenches for strip footings, three pads and a lift shaft, to 1.6m deep (Trenches 4 - 8) (see Figure 2).

6.2 POST-EXCAVATION METHODOLOGY

- 6.2.1 Owing to the nature of the majority of features recorded during the watching briefs, i.e. concrete and metal, and the fact that they originated in structures over a small time-scale, the archaeological results have been assessed using a combination of the stratigraphic information obtained from the sites and the historical maps for the Arsenal. This has been done in order to best phase the archaeological sequence.
- 6.2.2 The sequences from Sites 1 and 2 have been phased separately in this report to best present the results.

³¹ Butler 2004

³² Stevenson 2003

7 THE ARCHAEOLOGICAL SEQUENCE - SITE 1

7.1 PHASE 1: NATURAL

- 7.1.1 The natural sequence at Site 1 was seen to be alluvial sand [80] overlain by riverine terrace gravel [65], the latter of which was recorded at 3.39m OD in Trench 8. It was at least 0.6m thick. This sequence reinforces the conclusion drawn from the evaluation that Site 1 lies at the northern edge of the gravel terrace before it declines through Site 2 towards the River Thames to the north.

7.2 PHASE 2: MADE GROUND

- 7.2.1 Given the position of Site 1 on the gravel terrace, it is unsurprising that made ground deposits were found to be of nominal thickness and probably serving for levelling rather than ground raising. Layers [72] and [76] were recorded at 3.03m OD in Trenches 4 and 6.

7.3 PHASE 3: CARTRIDGE ESTABLISHMENT (see Figure 9)

- 7.3.1 Brick walls were observed in Trenches 5, 6 and 7. Wall [60] was aligned east-west, measuring 1.04m wide by at least 1.6m long. At its western end, it returned to the south as wall [61] for at least 13.0m. Both walls were built in a header and stretcher coursing. They were built within construction cuts [69] and [75] dug from a minimum height of 3.26m OD.
- 7.3.2 To the west of these, another wall [78] also ran east-west but offset from the alignment of wall [60]. Wall [78] had a return at its eastern end, extending south for at least 18.0m (the southerly exposed end of the wall survived only as collapsed masonry [83]). The wall was 1.25m wide, and built within construction cut [79], also in a header and stretcher coursing.
- 7.3.3 These two sections of masonry potentially formed the northwestern and northeastern corners of two structures that were part of the Cartridge Establishment. From their corresponding alignments they have been interpreted as being co-existent (structure [84]). Work by OA to the south, over a far wider area than was possible at Site 1, revealed similar arrangements of rectangular groundplans of Cartridge Establishment structures, the northern extents of which are likely to have been those found during this phase of works. Cartographic evidence concurs with this: a map of 1860 indicates the Cartridge Establishment to have been formed of adjacent rectangular structures. Bricks used in wall [78] have a date range between 1666 and 1900 (see Appendix 7).

7.4 UNPHASED FEATURES (see Figure 9)

- 7.4.1 A feature partially exposed in Trench 8 was likely to have been a pit cut [74]. Measuring 1.02m by at least 1.22m, and with a maximum depth of 0.65m from 3.39m OD, its fill [73] contained a piece of grog-tempered pottery dating from AD 0 - 400 and a piece of cbm with a date range of 1180 - 1950. Whilst the Roman pot is clearly residual, it is perhaps of interest when considered against the local evidence for Roman cemetery activity and isolated settlement on the high ground, especially considering the position of Site 1 at the edge of the gravel terrace.
- 7.4.2 In Trench 4 a brick manhole and service cuts were found, possibly associated with a layer of compact crushed chalk [64] at 2.86m OD. The stock bricks used in the manhole imply a 19th to 20th century date.

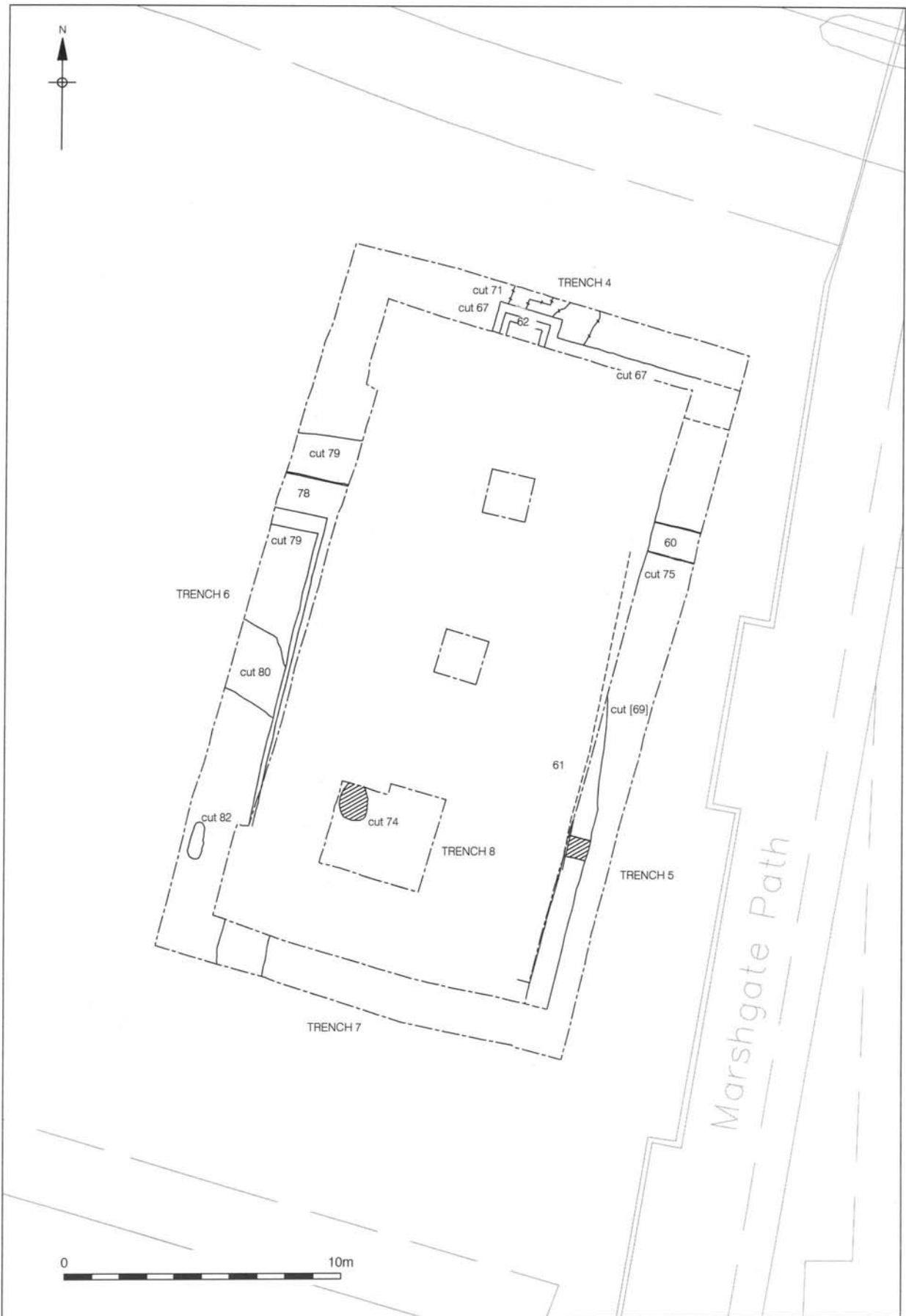


Figure 9
 Site 1 (RYG04) features
 1:200

8 THE ARCHAEOLOGICAL SEQUENCE - SITE 2

8.1 PHASE 1: NATURAL

- 8.1.1 The natural ground sequence (group number [498]) was observed in TPs 1 to 6 (see Figure 3). Towards the north of Site 2 it largely mirrored the sequence seen to the west at RYR 03³³, but to the south it comprised terrace gravel deposits showing that the northern edge of the terrace actually falls within Site 2.
- 8.1.2 Deposits of alluvial sand [484] and [514] were observed at untruncated upper heights between -0.07m OD, [514] in TP 2, and -4.67m OD, [484] in TP 3. This shows a drop in height from south to north of 4.6m over a distance of approximately 100m.
- 8.1.3 The sand was partly overlain by sandy-gravel [513] in TP 2. Further ballast was also found in TPs 1 ([509]), 4 ([485]) and 6 ([516]). The gravel was generally well-rounded, consistent with a riverine terrace. In TP 2 deposit [513] was sealed by a layer of blue-grey alluvial clay [512], in turn sealed below another layer of gravel [511]. The heights of these layers reveal a steady drop seen from southwest to northeast, from 1.63m OD ([511]) to 1.05m OD (TP 4).
- 8.1.4 Also overlying the sand in the north and west of Site 2 were peat deposits with a high wood content, observed in TP 3, [483] at -1.67m OD, and TP 5, [506] at -1.25m OD. It was not possible to safely sample the peat during the monitoring. These heights are substantially higher than those for the peat found at RYR 03³⁴, which were at a maximum level of -2.31m OD.
- 8.1.5 All gravel and peat layers were sealed by deposits of blue-grey alluvial clay [482], [505], [508], [510], [512] and [515] in TPs 1, 2, 3, 5 and 6. The heights of the deposits again reflect a drop from south to north, from 1.83m OD ([510] in TP 1) to -0.15m OD ([505] in TP 5).
- 8.1.6 Analysis of the natural sequence recorded to the west at RYR 03³⁵ suggested the presence of a possible east-west aligned channel at the levels of the peat and alluvial clay. The investigations at Site 2 have not shown a dip in the level of the clay, but have for the peat: it rises slightly from -1.67m OD in TP 3 ([483]) to -1.25m OD in TP 5 ([506]). This maintains the possibility of the presence of a natural feature. However, the discovery of gravel deposits in TPs 1, 2, 4 and 6 suggests that the riverine terrace may be aligned southwest to northeast, before dipping off to the northwest and resulting in the peat deposits revealed on Site 2 and to the west. As such, the possible channel may be aligned southwest to northeast.

8.2 PHASE 2: MADE GROUND

- 8.2.1 Overlying the natural are thick deposits of made ground (group number [497]) that were laid between the 17th and 19th centuries to reclaim the original marshland and level the ground. As such the made ground was also deposited over the higher natural terrace levels at the south and east of Site 2. The made ground revealed very little consistency across Site 2, varying between: well sorted gravels, which had probably been dredged from the river; waste material from industrial processes, for example clinker and slag; demolition rubble; redeposited alluvial clay, presumably excavated during the development of the Arsenal; silts and sands.
- 8.2.2 The made ground deposits were between 2.6m thick in the SFP and 3.95m in the NFP. The varying thicknesses of the made ground reflects the variations in the heights of the underlying natural. However, the measurements are a mirror of those recorded at RYR 03, which showed a greater thickness in the south than the north.

³³ Mayo 2004a

³⁴ Mayo 2004a

³⁵ Mayo 2004a

Given the function of the made ground for levelling as well as ground consolidation, this could be further evidence of an underlying channel aligned southwest to northeast.

- 8.2.3 Excavation of the made ground deposits revealed two cannons that had been discarded. It is thought that both examples had been brought to the Arsenal for proofing, but had failed³⁶. There is evidence that they had been re-used as mooring posts as both had been plugged with chain attachments; one of the pieces (small find 1) had a length of chain (small find 2) still attached and also showed residual concrete scarring around its breech end from its setting (see Plate 1 and Appendix 8). Maker's stamps were visible on both: the first (small find 1) bore a 'G', the mark of Graham & Sons operating from London between 1760 and 1790. The second (small find 8) had a 'T', signifying either Todd, operating from Hull between 1793 and 1828, or Tanner, a Welsh manufacturer between 1788 and 1820 (see Figure 10 and Appendix 8). That the second example had come from either Hull or Wales reaffirms the importance of the Arsenal as a centre for arms control and not just production, as they had likely been brought here for proofing³⁷.
- 8.2.4 Because the cannon were found randomly among made ground deposits, it cannot be said where they would have been used as mooring posts. Whilst they could have been located on the banks of the Thames itself, they were found in the eastern side of the MFP, close to the remediated edge of the Pilkington Canal, and therefore it is also possible that they were placed on the edge of that waterway.
- 8.2.5 Another interesting artefact recovered from the made ground was a rear-axle tree from a naval gun carriage. This piece [223], found from below the South Boring Mill in the MFP, stands out from the assemblage recovered at RYR 03³⁸ because it had a copper alloy star-shaped plate at one end. This may be an unusual example of decoration on a gun carriage³⁹. Excavation of the made ground also revealed eight trucks from naval gun carriages (group number [461]). These were in a good state of preservation, with intact bolts and nails on some examples⁴⁰.
- 8.2.6 Other finds from the made ground deposits included a graphite mould or crucible from the MFP (small find 6) (see Appendix 8). The use of graphite in industrial processes⁴¹ is a common occurrence and therefore its presence at Site 2 is not exceptional. A clay tobacco pipe (small find 3) was decorated with a sphinx and inscribed with the legend "EGYPT", below which was the name "[INNIS]KILLINGS". The piece relates to the Inniskilling Royal Fusiliers who fought 19th century campaigns in Egypt, and is also stamped with a local maker's name from Plumstead (see Appendix 6).

³⁶ M Smith and P Evans, pers comm

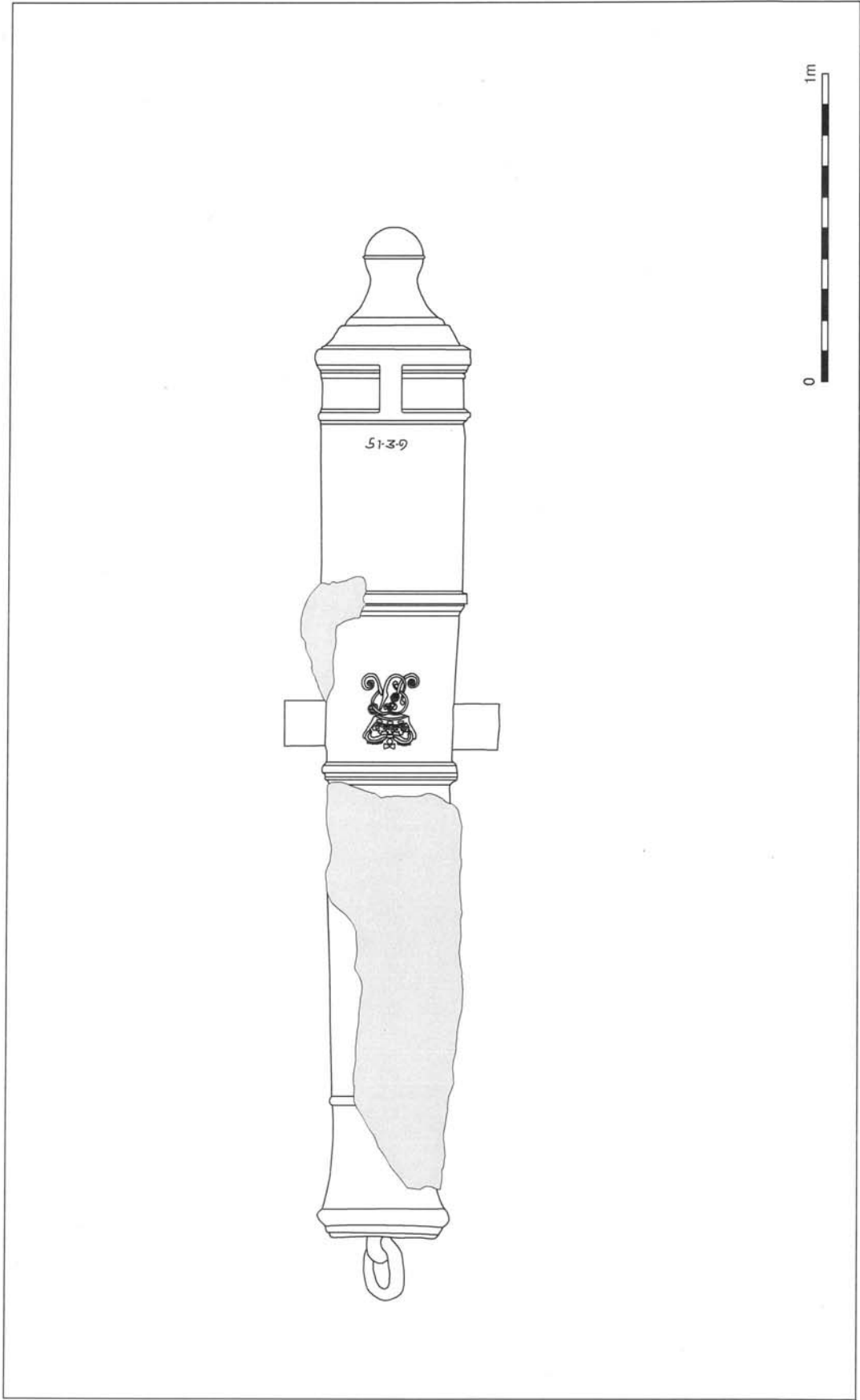
³⁷ P Evans, pers comm.

³⁸ Mayo 2004a, Appendix 5

³⁹ C Henry, pers comm. The rear-axle tree has been transferred to Explosion! The Museum of Naval Firepower in Gosport for conservation and study.

⁴⁰ The trucks have been transferred to Explosion! The Museum of Naval Firepower in Gosport for conservation and study.

⁴¹ <http://www.answers.com/>



concrete

Figure 10
George III period cannon (Site 2, SF8)
1:20



Plate 1: Cannon from made ground deposits (SF 1)

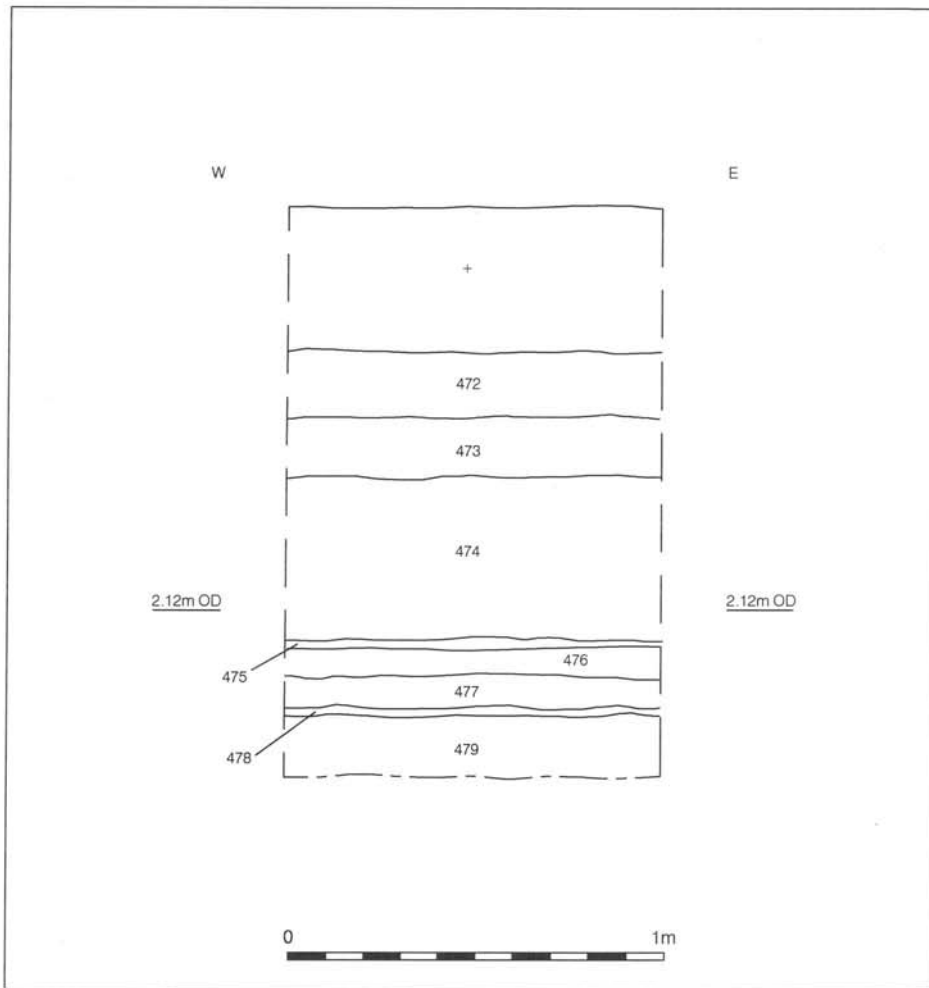


Figure 11
Site 2, Phase 3 Section through timber field deposits
1:20

8.3 PHASE 3: TIMBER FIELD

- 8.3.1 A section recorded through a sequence of made ground in the NFP revealed three layers [475], [477] and [478] that were mulch-like in their appearance, comprising wood cuttings and shavings (see Figure 11). They were found at heights between 1.87m OD ([478]) and 2.05m OD ([475]). They may relate to the use of Site 2 as a seasoning Timber Field for the RCD. Historical maps show that this use began between 1858 and 1860, and continued until before 1890, albeit in a decreasing area as adjacent structures encroached upon it. The area of the NFP had been structurally developed by 1872.
- 8.3.2 The works at RYR 03 to the west revealed structural remains that were interpreted as part of the same Timber Field, yet these were at heights of approximately 3.6m OD⁴². These new results suggest that the previous remains may have been misinterpreted (see 9.3.2.1).

8.4 PHASE 4: BOILER HOUSE AND ROLLING MILL

- 8.4.1 The remains of the Rolling Mill (structure [239]) and part of the Boiler House (structure [238]) were found within the NFP. The interpretation of the archaeological remains of these structures is complicated by their alteration suggested in the cartographic evidence, alterations which are not clearly manifested in the remains. Both structures, and with the South Forge to the west, were built in the early 1870s as three distinct buildings. However, by the time of a map of 1917 the South Forge had been remodelled to form a Tender Shop, while the Boiler House and Rolling Mill had seemingly been combined to form Buildings D71, D72 and D74 (see Figure 7). Of these, Building D71 encompassed the Boiler House but had been sub-divided into three compartments, labelled west to east as Boiler House, Coal Bunker and another Boiler House. The Rolling Mill had been compartmentalised so that its western third, Building D74, was also a Boiler House while the eastern two thirds, Building D72, was labelled Fitting Shop and Engineers Section. By the time of the 1931 map, Building D71 had been demolished but Buildings D72 and D74 remained, presumably with the same function.
- 8.4.2 The cartographic evidence indicates the complicated nature of the structures over a period of less than 60 years. The buildings were remodelled in that time but have maintained largely the same function, and this makes the discernment of elements of the buildings from the archaeological remains difficult. This is especially true within the original Rolling Mill, or the later Buildings D72 and D74, where the remains provide little uniformity or consistency to allow convincing phasing to occur. As such parts of these buildings that show marked differences in terms of construction, perhaps indicating technological advances, have been phased with the later Buildings D72 and D74 (see 8.10).

8.5 PHASE 4: SUB-PHASE 1: BOILER HOUSE (see Figures 12 to 18, Plates 2 to 6)

- 8.5.1 The Boiler House provided the power to the 35-ton steam hammer within the South Forge, the remains of the anvil of which were found at RYR 03⁴³. The western side of the Boiler House was also found at RYR 03⁴⁴ as a series of brick-built pier bases and flues, to evacuate the exhaust into a large north-south flue. Nothing of its superstructure was seen.
- 8.5.2 The elements of the Boiler House found at Site 2 closely resemble those recorded to the west. Nothing of the superstructure was found and therefore it is possible that the roof of the structure may have been founded upon the pier bases described below

⁴² Mayo 2004a, 27

⁴³ Mayo 2004a, 27

⁴⁴ Mayo 2004a, 29

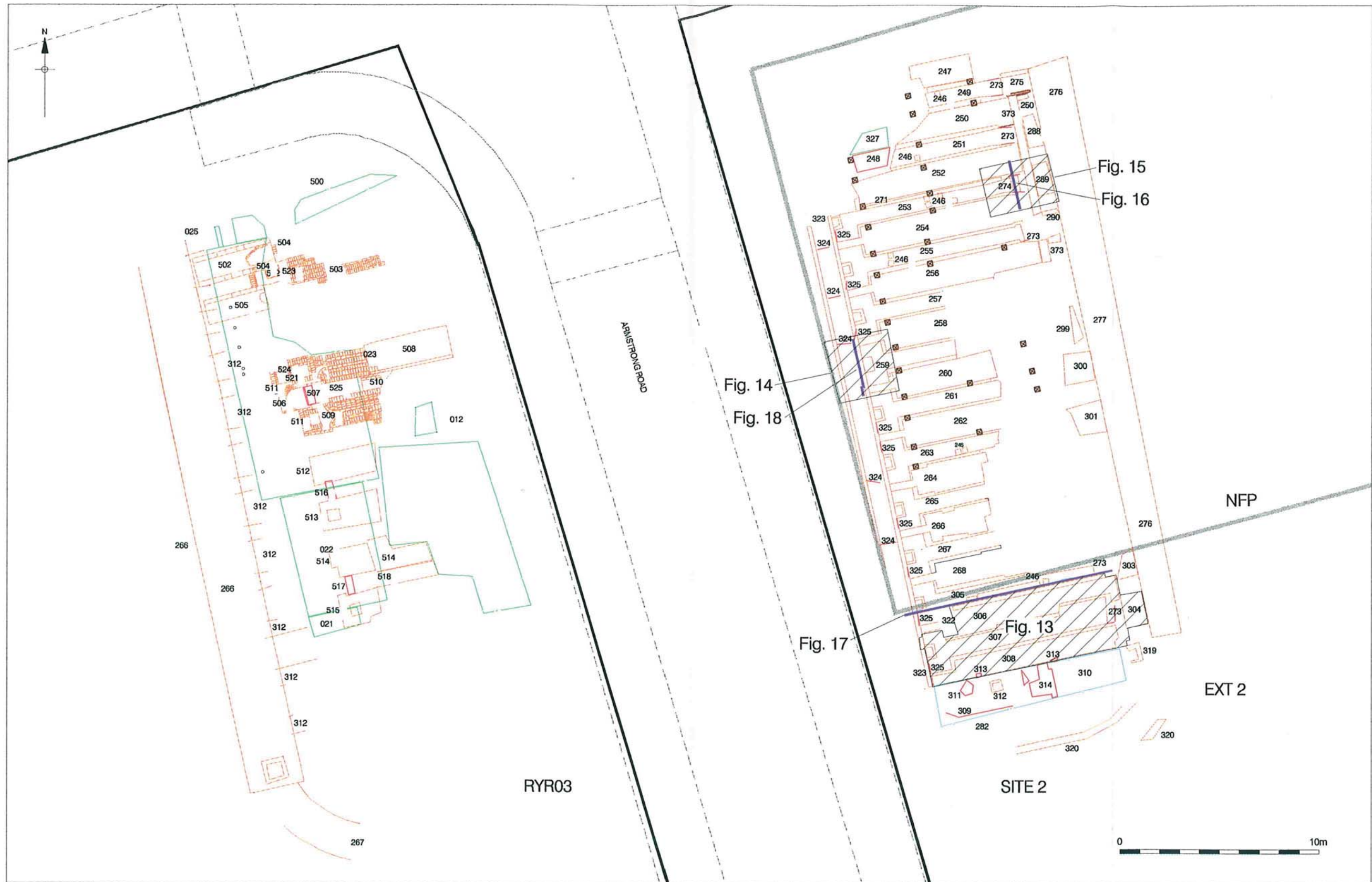
which, with numerous flues, formed the main evidence for the building. Their good state of preservation, and the uniformity of their construction, was particularly striking (see Plate 2).

- 8.5.3 A series of east-west aligned pier bases were recorded with context numbers [247], [250], [252], [254], [256], [258], [260], [262], [264], [266], [268], [306] and [308]. Between these were flues [249], [251], [253], [255], [257], [259], [261], [263], [265], [267], [305] and [307]. Disregarding later truncation, the central pier bases and flues had the same dimensions (see Figure 12 and Plate 2). The best survived examples were at the south of the Boiler House; pier bases [306] and [308] were to the north and south respectively of flue [307] (see Figure 13 and Plate 4)). Pier base [306] had a slightly truncated length of 8.32m east-west, and was 1.7m thick. Pier base [308] was the southernmost within the Boiler House and as such was slightly thinner at 1.30m, the difference being because the heat was only concentrated on one side in flue [307], whereas [306] had flue [307] to the south and flue [305] to the north. Pier base [308] had an untruncated length of 8.9m. All the pier bases had on their flue sides a single brick-thick skin to serve as an easily replaceable heat barrier and not tied to the pier bases. The skins were stretcher-coursed and bonded with a lime-free clayey mortar, to make their dismantlement easy (see Appendix 7).
- 8.5.4 The pier bases were rectangular in shape and brick-built in a regular header-and-stretcher coursing. Masonry [306] and [308] were the least truncated of all the pier bases, surviving at an upper level of 3.56m OD. This fact explains why they were the only bases that had a curvi-linear arrangement of bricks at its upper course on the flue side, essentially forming a void within the masonry. The void contained loose demolition backfill, and it seems that it may have been the base of an access shaft should the flue have needed servicing.
- 8.5.5 The flues were complex in design: essentially linear in shape but splitting two ways at the western end where they connected with a north-south flue [323] to form two spurs (see Figures 12, 13 and 15 and Plate 3). The northern spur was entirely closed, while the southern spur fed into flue [323] by means of metal doors [325] (see Figure 18) with maximum dimensions of 0.525m by 0.505m. A thin iron lintel provided support above the doors. Only at the end of flue [261] was the door at the end of the northern spur. There was no indication that the enclosed spurs were ever built with doors as well, and their function as enclosed spaces is unclear. The east-west flues had floors formed of bricks laid on their bed, which stepped to a lower level before the point at which they split north and south. The upper level of the flue floor was at approximately 2.9m OD, while the lower level was at approximately 2.8m OD (see Figure 15). The step down was marked by a row of bull-nosed bricks in the flue floor. Similarly within the Boiler House the vast majority of open corners, i.e. those at angles of 270° as opposed to 90°, were built with bull-nosed bricks; this was perhaps to lessen the risk of corrosion from acidic exhaust fumes (see Figure 13 and Appendix 7).
- 8.5.6 A further design feature at the western end of the east-west flues was an opening in the space between the two spurs (see Figure 15 and Plate 2). It was open at the side facing north-south flue [323] and vertically too. There were no indications that a louvre to seal the opening was ever present. The openings may have served as observation or testing hatches, overflow 'valves' or some other purpose. Above the openings were iron lintels set into the brickwork.
- 8.5.7 North-south flue [323] was 1.39m wide and at least 26.50m long. It had a terminus at its southern end and may therefore have led to an opening to the north. It was braced every 2.4m with a series of iron struts [324] (see Figures 12 and 16 and Plate 6). These had been inserted into the brickwork at the time of construction rather than being a later repair, and were only present in flue [323], leading to the conclusion that they may have been designed to support inspection covers or perhaps a simple series of duckboards.

- 8.5.8 The eastern ends of the east-west flues led directly into a substantial north-south flue [276]. This was an arched brick structure, extending at least 29.35m north-south beyond the limit of excavation and 2.30m wide (see Figure 12). The internal height was at least 1.7m, with the top of the flue recorded at 3.18m OD. The flue was similar in terms of size and construction to one found to the west of the Boiler House at RYR 03 (context [266])⁴⁵. Both flues would have led northwards to a chimney. At the connections between the east-west flues and this main north-south one, the floors of the former dropped at an angle of approximately 45° into the larger one (see Figure 14 and Plate 5). These sections of flue were roofed with barrel-vaulted brick arching (see Figure 13). Also at these points bull-nosed bricks were used only on the northern corners, showing that the exhaust was being channelled in a northerly direction.
- 8.5.9 Whilst the southern ends of flue [276] and its opposite at RYR 03 had definite southern termini, both were seen to have been extended to the south by a curvi-linear flue that is almost definitely the same structure (see Figure 12). The position and alignments of flue [320] leading south and to the west of flue [276] corresponds exactly with flue [267] (RYR03) leading south and east of flue [266] (RYR03). This implies that the exhaust system for the Boiler House was altered to make it cyclical, perhaps to increase the level of through-draft. Based on this, it is likely that the smaller north-south flue [323] was the route by which air was brought in to the Boiler House, through the east-west flues to heat the Boilers above, before being expelled through flue [276].
- 8.5.10 The materials used in the construction of the Boiler House were primarily specially manufactured fireclay bricks (see Appendix 7). They bore a variety of maker's stamps that can be traced to production centres in Scotland, the North-East of England, Worcestershire, Staffordshire and Devon. One particular type of brick attested within the Boiler House pier bases, stamped with the legend "STARWORKS * GLENBOIG", were manufactured by the Starworks Company in Scotland. This company was formed in 1873, and therefore the Boiler House can be dated to 1873 or after. Given that the Rolling Mill to the east was built by 1876⁴⁶, the Boiler House was likely to have been erect by then.
- 8.5.11 Evidence was found for a change in design or function of the east-west Boiler House flues. In each a series of fireclay braces [246] were present, designed to hold pipes (see Figure 15 and Plate 4). With a construction date range for these bricks between 1870 and 1920 (see Appendix 7), it could not be ascertained precisely when these were installed, and whether they indicate a change in function for the Boiler House or an advance in the technologies used within it.
- 8.5.12 Upon removal of the flues and pier bases described above, it could be seen that they were all founded upon a series of concrete slabs [494]. Each were 0.2m thick with a combined thickness between 0.8m and 1.4m, and were found at the upper height of 2.87m OD. The slab sat upon a series of timber piles [446], 255mm² and at least 1.0m long, which were capped with concrete beams [453] (see Figure 12). The slabs [494] had been reinforced with a series of scrap girders, most likely from an early 19th century building within the Arsenal. The girders were made of wrought iron, were riveted together to form 'T' beams or corners, and often had red, possibly lead, paint.
- 8.5.13 From the exposed remains from Site 2 and RYR 03, it can be seen that the Boiler House measured approximately 44.6m by 30.0m.

⁴⁵ Mayo 2004a, 30

⁴⁶ Hogg 1963, 816

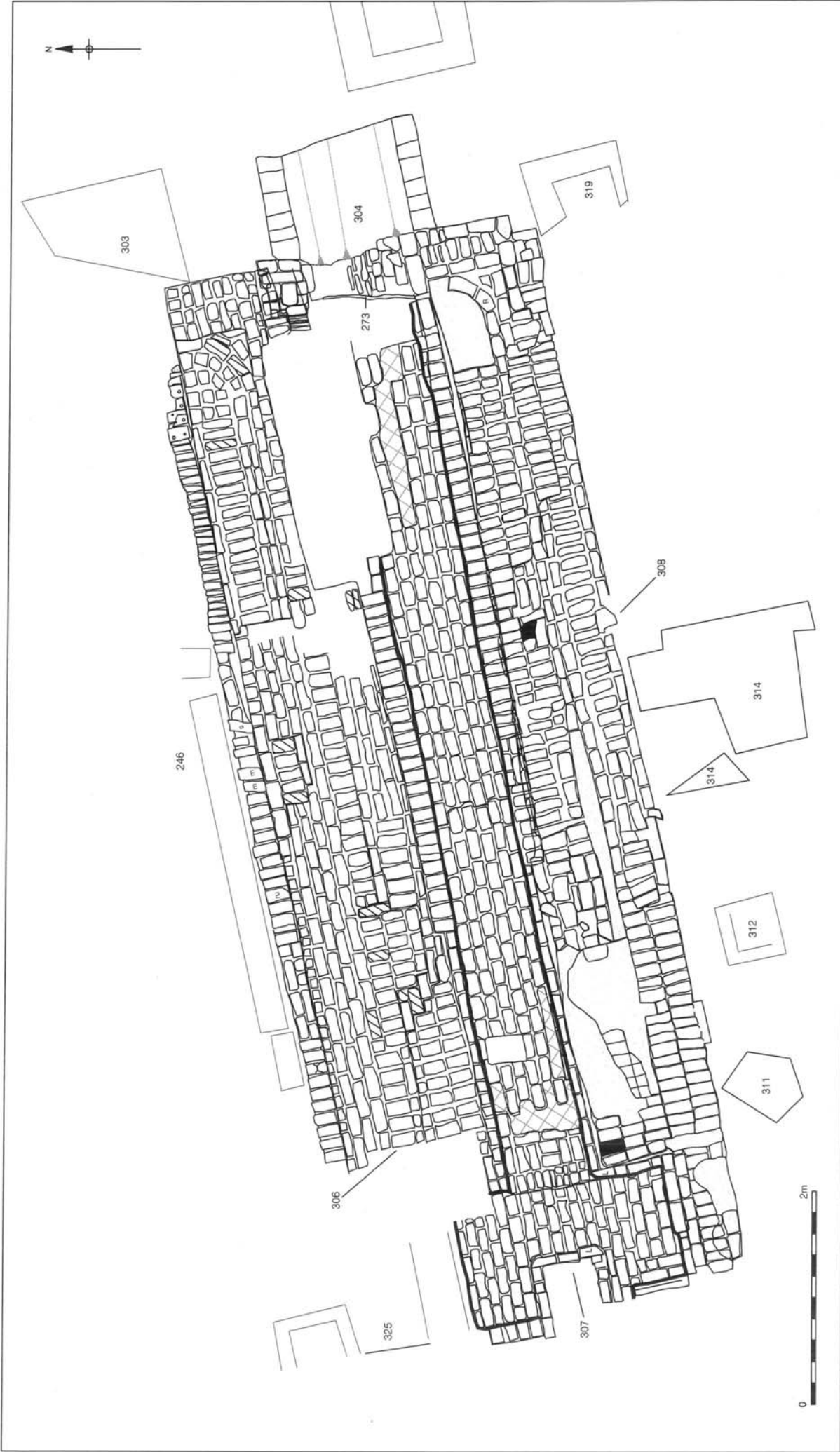


Key

446

- Colour scheme for features:
 Green - Concrete
 Grey (thick line) - Footprint positions
 Red - Metal
 Orange - Brickwork
 Brown - Timber
 Purple - Cobbled surfaces
 Light blue - Concrete surfaces
 Dark blue - Sections
 Black (thick line) - Site boundaries

Figure 12
 Phase 4.1 Boiler House remains
 1:200



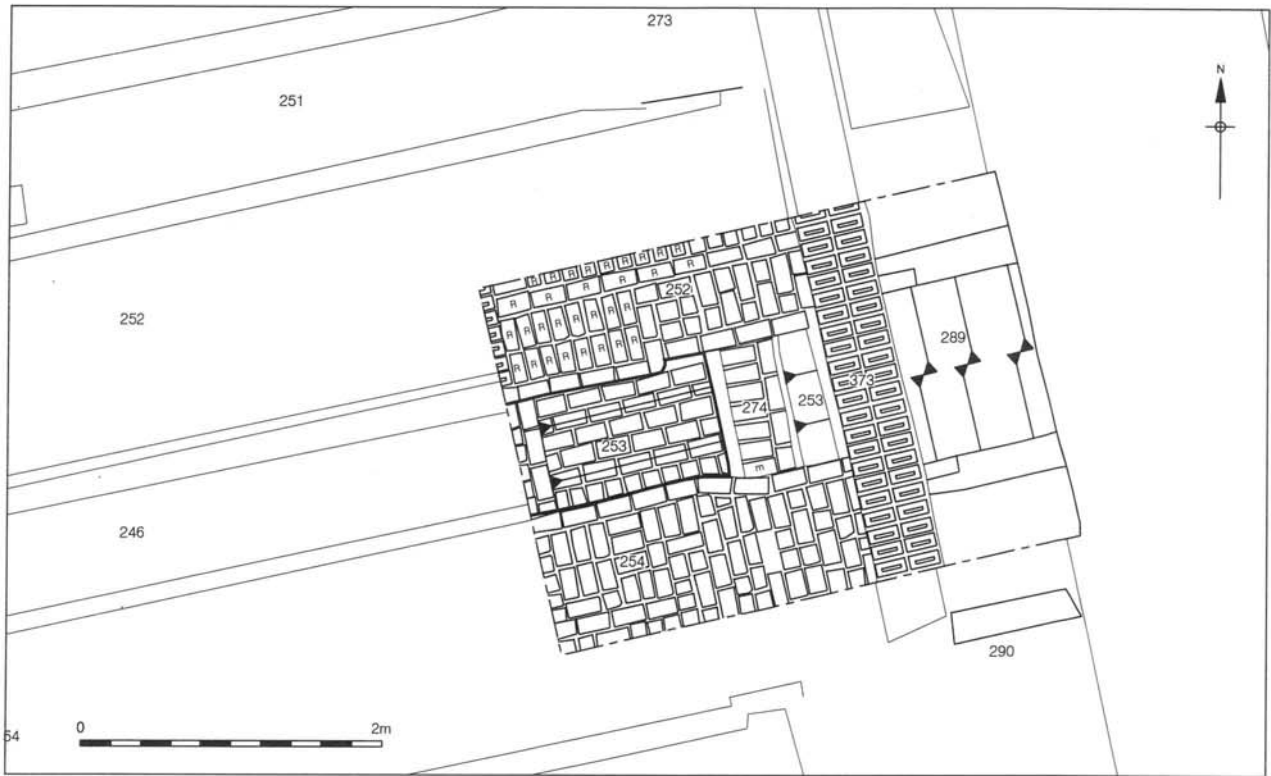
Key:

- Brick Stamps:
- R = Ramsey
- m = Martin Lee Moor
- s = Stourbridge
- ru = Purford
- L = Lucas

- Mortar
- Metal
- Missing brick

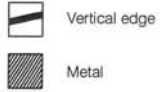
- Bricks degraded by fire
- Vertical edge

Figure 13
Site 2, Phase 4.1 Detail of pier bases and flue
1:50

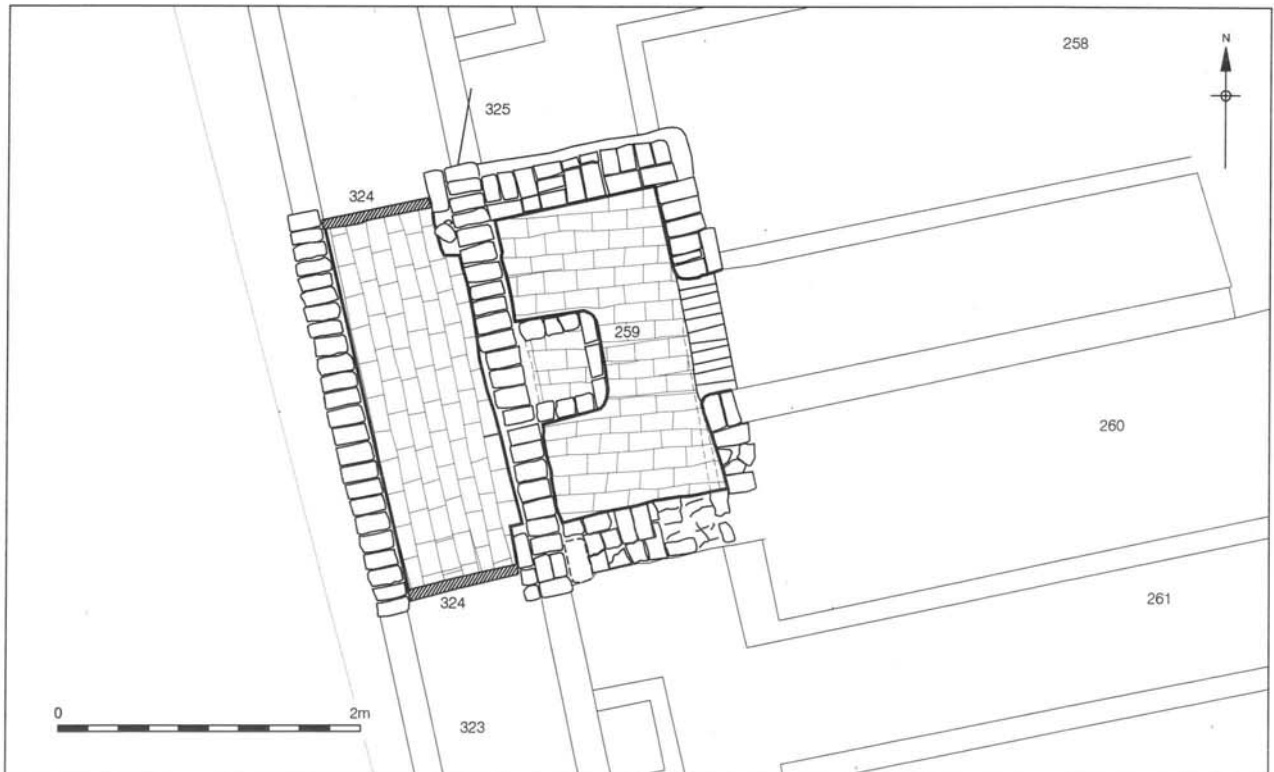


Key:

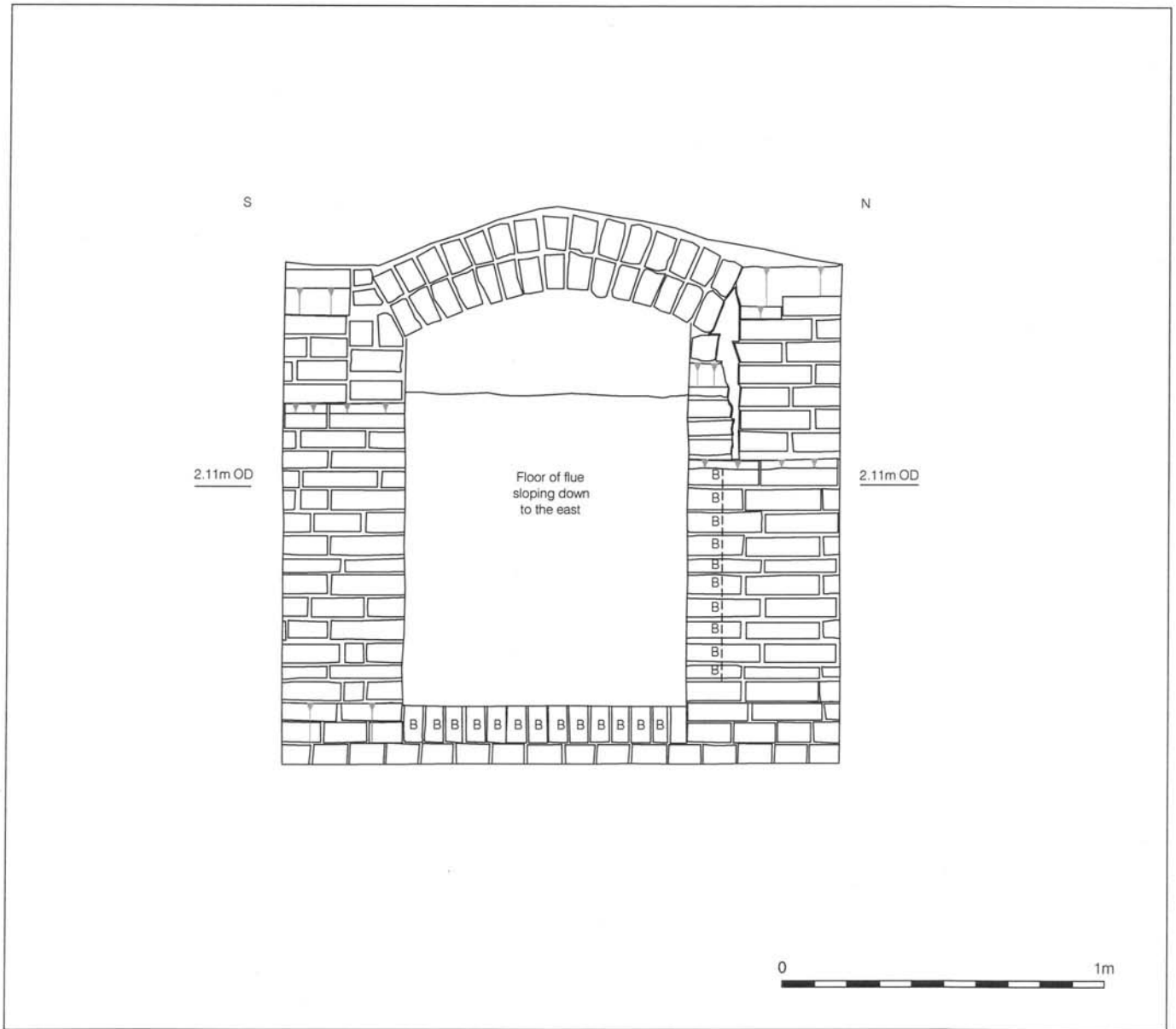
Brick Stamps:
R = Ramsey



Figures 14
Site 2, Phase 4.1, Detail of flue (eastern end)
1:50



Figures 15
Site 2, Phase 4.1, Detail of flue (western end)
1:50



Key:

B = Bull-nosed bricks

Figure 16
 Site 2, Phase 4.1 Elevation of eastern end of flue [289]
 1:20

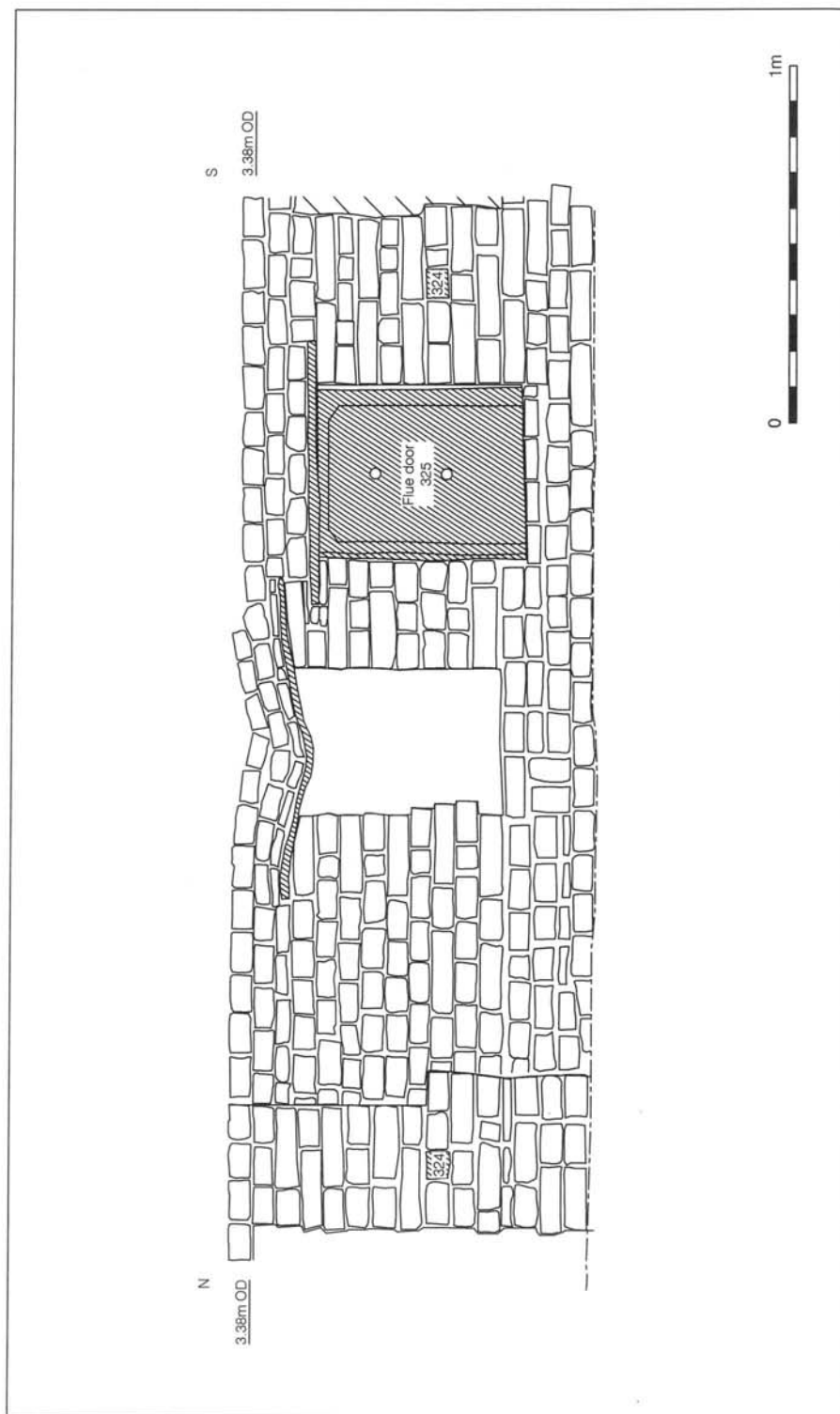


Figure 18
 Site 2, Phase 4.1 Elevation of flue [259] (western end)
 1:20



Plate 2: Boiler House remains (view south, scale = 2.0m)



Plate 3: Detail of western end of flue [259] (view east, scale = 0.5m)



Plate 4: Flue [307] (view east, scale = 1.0m & 0.5m)



Plate 5: East end of flue [289] (view north-west)



Plate 6: Flue [323] (view north)

- 8.6 PHASE 4: SUB-PHASE 2: ROLLING MILL** (see Figures 19 to 22, Plates 7 to 11)
- 8.6.1 The remains of the Rolling Mill included a series of brick-built furnaces, a number of flues and a chimney base. Within the Rolling Mill itself ingots of iron were heated, hammered and coiled to form the bodies of gun barrels before being quenched.
- 8.6.2 The Rolling Mill was distinct from the Boiler House because elements of its superstructure could be identified. A series of cast iron pile caps [281] and [429] along the western edge of the structure, and the timber piles [454] beneath them on the northern edge, delineated those sides of the building (see Figure 19). The pile caps, which also incorporated stanchion bases to seat columns above ground, were found at 3.12m OD. No external walls between the stanchion bases were found, suggesting that the Rolling Mill may have been an open-sided structure. This is also suggested from a map of 1890 that shows the structure with a dotted outline. Anomalously, no similar superstructural remains were found on the southern or eastern edges, yet the size of the mill can be estimated: the piles and stanchion bases along the northern edge, seemingly all present, would suggest that it was approximately 46.5m long, while the cartographic evidence strongly implies that the Rolling Mill was of the same width of the Boiler House, therefore approximately 30.0m. The stanchion bases [281] at the western side of the Rolling Mill respected the position of the large north-south flue [276], associated with the Boiler House, exactly and therefore strongly suggests that the flue marked the gap between the original two structures.
- 8.6.3 The brick furnaces and flues were arranged in two groups. A group of flues [354], [357] and [359] were set between pier bases [346], [355], [358] and [361], and aligned east-west (see Plate 7). To the south of these, a group of furnaces [332], [337] and [338] were set between concrete [334]; these were aligned north-south.
- 8.6.4 The two groups were separated by east-west flue [341]. This brick-built structure was 1.2m wide and 12.8m long (see Figure 19). A series of steps in the floor of the flue ranged from an upper height of 2.47m OD at the western end to below 1.89m OD at the eastern end. The flue contained heavy soot residue implying that it was the route by which smoke was evacuated. It might be that the stepped floor to the flue was designed to act as a soot trap to facilitate maintenance. The original course of this flue could not be seen due to later alteration.
- 8.6.5 Of the group of flues, [357] was perhaps the best surviving example. It was linear but widened at the western end to form an elongated 'T' shape. At this point it was 2.20m wide, with a total length of 9.4m. The pier bases between the flues were built in a consistent header and stretcher coursing with the same free-standing brick skin internal to the flue. At the eastern end of flue [357] an angled opening [365] led into flue [341]. The floor of the flue was built of bricks laid on their bed at 2.70m OD. These features were similar to the flues recorded in the Boiler House to the west, and it is likely that they served a similar purpose.
- 8.6.6 The furnaces were rectangular in shape but had a single brick wide partition along their length (see Figure 20 and Plate 8). Hence each furnace was compartmentalized to fire narrow ingots of iron. A well-surviving example [338] was at least 8.4m long and 1.0m wide; the partition wall created two sub-furnaces each 0.4m wide. They were built between concrete bases [334]; they had the same free-standing brick skin internal to the furnace but in these ones the skin was entirely headers. The use of concrete as surrounds for these furnaces was presumably to increase heat-resistance within the structure. The southern extent of the furnaces had been truncated by later activity.
- 8.6.7 That the flues and furnaces described above were contemporary was proved by their foundation arrangement. Foundation slab [333] at 2.63m OD was seen to extend right under these remains, itself comprising three separate slabs with a total thickness of 0.6m. Curiously no piling arrangement was observed beneath the slab. However, if

the Rolling Mill was indeed an open-sided structure with a roof supported on the external piles discussed above, then this is perhaps plausible.

- 8.6.8 The heavily truncated remains of another furnace were found on the eastern side of the Rolling Mill. Brick furnace [431] was founded upon concrete slab [432]. The brickwork of the furnace was very heavily vitrified.
- 8.6.9 To the east of flue [341], a chimney structure was found (see Figure 21 and Plate 10). Its' position was within the Rolling Mill yet no such chimney is indicated on any of the historical maps, even though others are. However, bricks used within the chimney have the same date ranges and maker's stamps as those in the flues and furnaces to the west, and therefore the chimney was presumably not indicated cartographically because it was not a freestanding structure. It had undergone several phases of rebuilding.
- 8.6.10 Initially a series of concrete pier bases [389], [427] and [447] were aligned east-west through the Rolling Mill covering a distance of approximately 21.0m. They were the foundations for a long furnace [388] and [426], surviving over an east-west distance of 18.0m and brick built (see Figure 19). It was poorly survived, but at its western end it could be seen that the internal faces of the brickwork [388] were heavily vitrified. Any possible relationship between the furnace with flue [341] at its west end had been lost by the alteration of flue [341] with wall [440]. The furnace had been disused and filled with loose rubble to allow the insertion of the chimney.
- 8.6.11 The chimney had a series of foundation levels but none ground penetrating. Perhaps it was thought that the concrete footings for the previous furnace were sufficient. A platform of bricks [397] on their beds and edges lay beneath, at 2.54m OD, a 90mm thick iron plate [395], 2.5m by 2.3m, forming the baseplate for the chimney. Around the edges of the plate the walls [387] of the first chimney were bedded onto concrete [396]. The walls [387] were built to form a square enclosure measuring 3.74m by 3.10m using bricks stamped with the legend "MARTIN LEEMOOR". This can be traced to a Devon based company who were known to be in production by at least 1883 (see Appendix 7). The chimney was fed via a curved brick flue [386] on its eastern side, 1.64m wide and only surviving for 3.50m in length. The base of the flue was at 2.67m OD. No obvious reason could be seen for the curvature of the flue; if it was respecting another feature to the south then later activity had removed any evidence for it. Likewise it could not be ascertained where the flue originated, but it was most likely to have been from any number of further brick furnaces in the eastern side of the Rolling Mill, subsequently destroyed.
- 8.6.12 The chimney was then converted from a square structure to a circular one, presumably to increase the draught-flow by narrowing the flue. Within the square enclosure a circular brick structure [385] was built directly onto the iron plate [395] (see Plate 10). The new chimney had an external diameter of 1.53m and an internal diameter of 0.98m, its' base was at 2.63m OD. The bricks used were again stamped "MARTIN LEEMOOR". Once built, the void around [385] within [387] was backfilled with demolition material [384]. The circular base that was found was completely enclosed and had no access point at that level. Therefore the chimney would have been fed higher up, but it could not be seen if this happened via the same curved flue [386] as for the first chimney, or by a new one (see Figure 21).
- 8.6.13 To the south of the chimney another furnace was found, but of a very different style to those at the western side of the Rolling Mill, being almost square in shape and with an iron fixing at its' centre (see Figure 22 and Plate 11)). The main structure of the furnace was brick built [414] forming an enclosure 5.6m by 4.45m. The walls were, surprisingly, only 0.38m thick which seems very insubstantial considering its purpose. The walls themselves were built around iron plates [433] at 2.45m OD founded upon a concrete slab 0.4m thick. The plates covered an area of 3.72m by 4.8m and were 60mm thick. At the centre of the furnace an iron plate [417] had been set vertically with a wedge-shaped piece cut from the centre. It appeared as if an identical plate

would once have been positioned opposite to [417]. A hole through the plate near ground level suggested that a threaded bar set in, probably a stay to hold the structure firm. Another hole 0.38m in diameter was found in one of the floor plates [433], with an iron sleeve extending underground. The exact purpose of these fittings within the furnace is unclear. At the northwestern corner of the structure there was a break in the wall where a metal pipe [419] entered.

- 8.6.14 At the eastern end of the furnace a brick buttress [415] had been built in each corner. Further strengthening had been added with a wall [416] built diagonally across the southeast corner of the furnace. The space behind this was filled with demolition rubble. Wall [416] was built with bricks with the legend "MARTIN LEEMOOR".
- 8.6.15 The furnace must have been accessed either at a higher level than that at which the remains were found or via a doorway at the western side (although given that there was only a gap of 2.0m between the furnace and flue [341] this is unlikely). This in itself had been altered by the later extension of flue [341] with a northerly return, the new wall [440] of which was built into the west wall of the furnace.
- 8.6.16 Despite its interpretation as a furnace, a number of facts suggest that this structure may have served a different function. Firstly the walls are very thin; secondly there was no sign of substantial heat damage; thirdly there was no apparent entry point for heat or materials at the level at which the remains were found; fourthly the metal pipe is an unlikely object to find a furnace. The exact purpose of this structure is, at present, unclear.
- 8.6.17 Towards the southern edge of the Rolling Mill a hammer base [398] was found, easily datable because it bore the legends "R.G.F." and "1874". The base was built of cast iron and was square, 2.66m², at 2.85m OD (see Figure 19 and Plate 9). The upper level of the base was recessed by 0.19m and within the recess a series of timber planks [399] had been laid, presumably to act as a cushion. Nothing of the hammer's mechanism or machinery was seen. The hammer base was founded upon nine timber piles.
- 8.6.18 The widespread furnace remains and the chimney all indicate the likelihood that originally the Rolling Mill had many more furnaces. The furnace and flue remains that were found were all concentrated in the western third of the building. Given that by the time of the 1917 map the mill had been split into Building D74 (marked as a Boiler House and occupying the western third) and Building D72 (marked as a Fitting Shop and Engineers Section and occupying the eastern two-thirds) it seems highly likely that the original furnaces and flues of the Rolling Mill were retained for Building D74. By the same rationale it seems that the alteration of the Rolling Mill to accommodate Building D72 led to the remodelling of the internal elements of the eastern two-thirds of the structure. The chimney, hammer base and square furnace (see above) appear to have been the only parts of the early structure that were retained in Building D72, where the rest of the features in this area have been phased (see 8.10).
- 8.6.19 A brick wall [368] found less than 1.0m to the north of the Rolling Mill and aligned southwest-northeast may be the southern side of another flue, perhaps a route by which exhaust was removed from either the mill or the Boiler House (see 8.5 and Figure 19). If this was the case then this flue may have intersected with north-south flue [341] (see 8.6.4).



Key:

- Green - Concrete
- Grey (thick line) - Footprint positions
- Red - Metal
- Orange - Brickwork
- Brown - Timber
- Purple - Cobbled surfaces
- Light blue - Concrete surfaces
- Dark blue - Sections

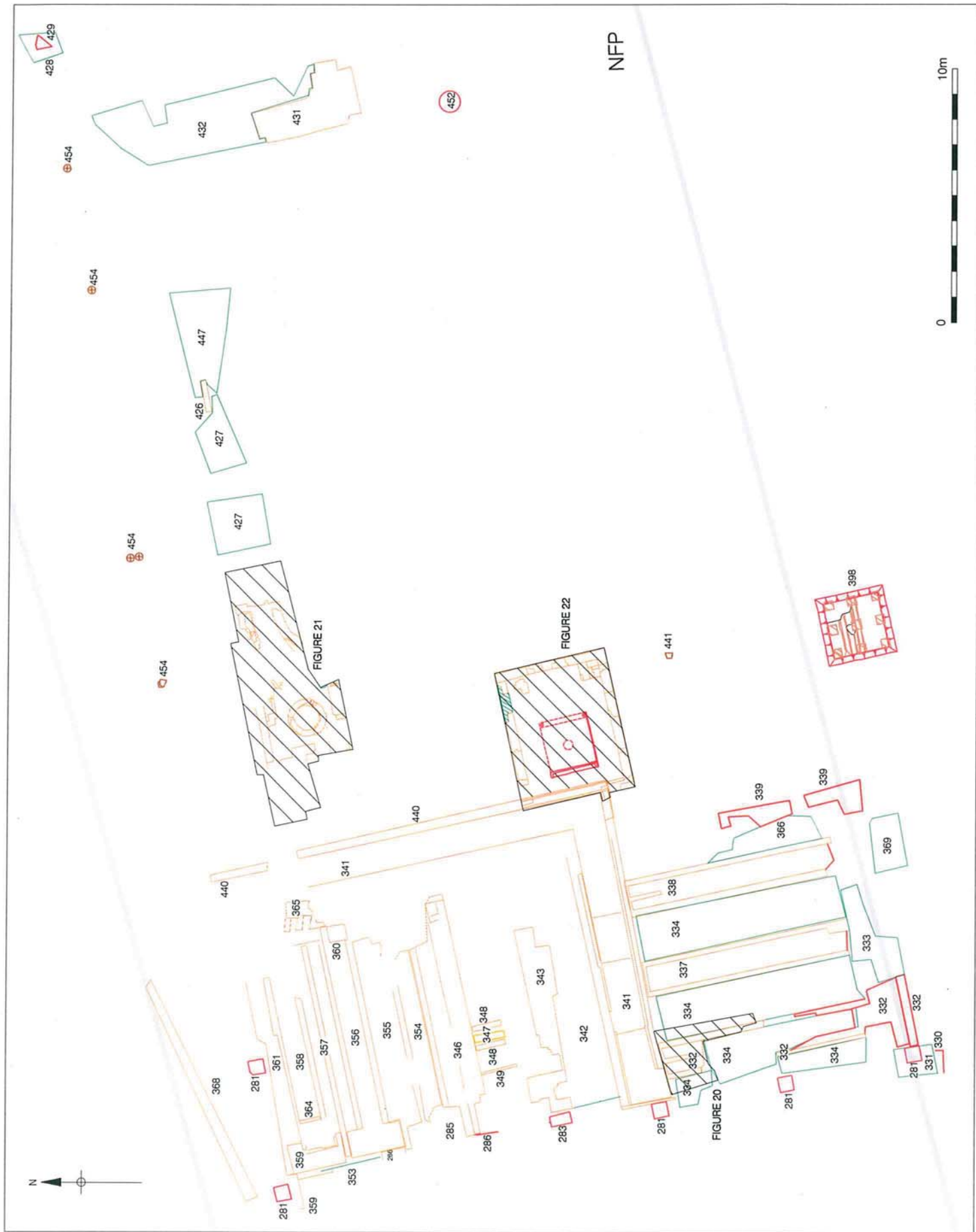


Figure 19
Site 2, Phase 4.2
Rolling Mill
remains
1:200

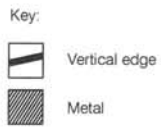


Figure 20
 Site 2, Phase 4.2 Detail of furnace
 1:50



Plate 7: Pier bases and flues in north-west corner of Rolling Mill (view south-east, scale = 2.0m & 1.0m)



Plate 8: Furnaces in Rolling Mill (view south-east)



Plate 9: Hammer base in Rolling Mill (view north-west)

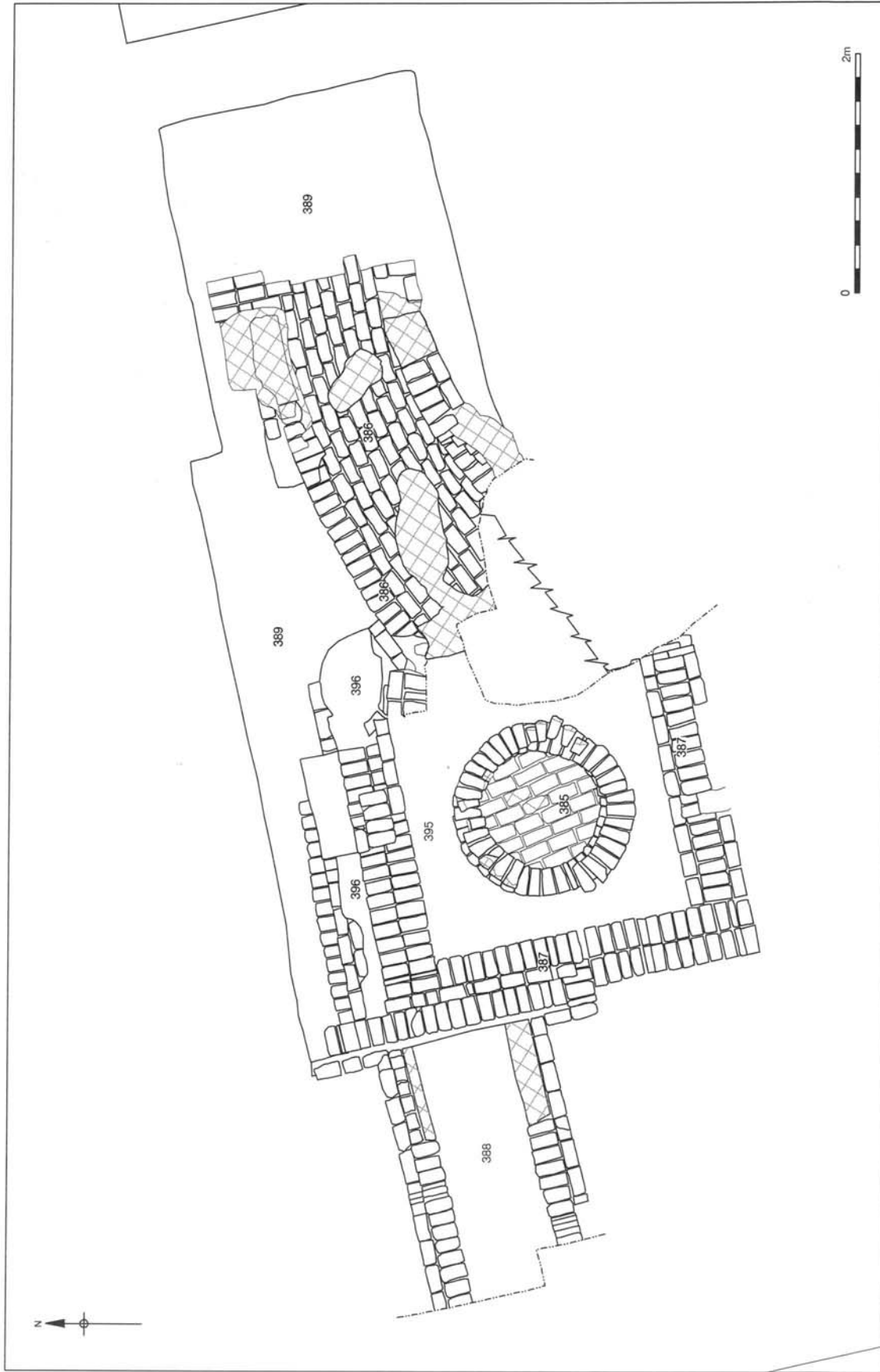


Figure 21
 Site 2, Phase 4.2 Detail of chimney
 1:50



Plate 10: Circular chimney [385] (view east)

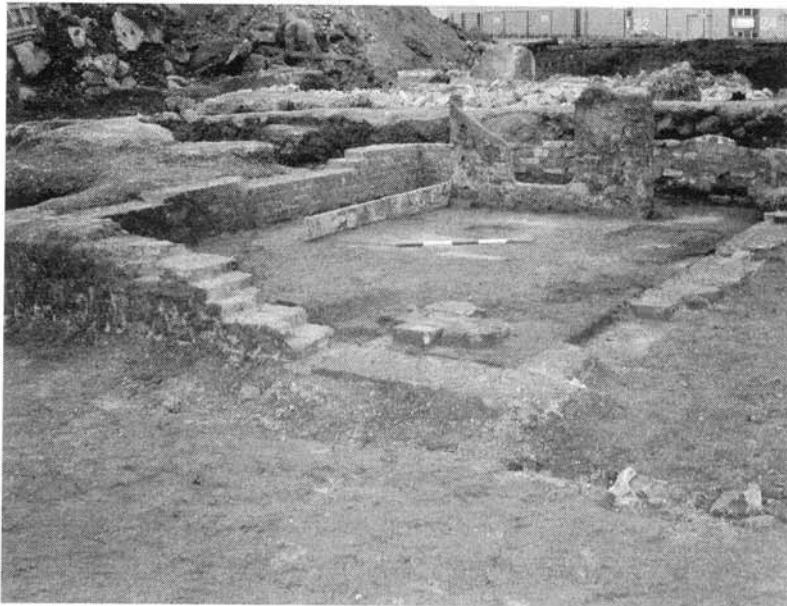


Plate 11: Furnace structure [414] with iron centre-piece [417] (view south-west, scale = 1.0m)

8.7 PHASE 5: SOUTH BORING MILL (see Figures 23 to 25)

- 8.7.1 The development of the South Boring Mill has been well documented by Hogg⁴⁷, who provides dates for the construction of the 'bays' of the 20th century structure. Combined with the archaeological results of RYR 03 to the west⁴⁸, the investigations by Pre-Construct Archaeology (and those by OA) have now revealed the full ground plan of the building. The works at Site 2 have shown elements of Bays 4, 5 and 6 in the SFP, EXT 1, MFP and EXT 2. According to Hogg, the parts of the bays found at Site 2 were built in the years shown in Table 1.

1888	Bay 6	Northern Half
1899	Bay 5	South End (Half)
1902	Bay 6	South End (Half)
1904	Bay 4	South End

Table 1: Years of construction of elements of South Boring Mill found at Site 2^{49, 50}.

- 8.7.2 The usefulness of these dates in the interpretation of the archaeological remains is, however, limited for two reasons. Firstly, the narrow date ranges for the construction leave little room for noticeable differences in the remains. Secondly, due to the extension of the bays of the South Boring Mill, and the subsequent alterations through the first half of the 20th century for, for example, the insertion of large-scale machine bases, the remains have been homogenised so that, again, noticeable differences are difficult to distinguish. As such the elements of the South Boring Mill found at Site 2 have been divided and phased by comparison with historical maps dating from 1895 and 1917 (see Figures 6 and 7). This has convincingly shown that the South Boring Mill was constructed as shown in Figure 23.
- 8.7.3 The components of the South Boring Mill found on Site 2 (structure [235]) are discussed first by their superstructure, and then internally. Due to the fact that the internal machine arrangements would almost certainly have been changed since the initial construction, the difficulty in dating these arrangements and the lack of detailed historical records, it is possible that internal elements of the South Boring Mill are later in date than this phase. They may originate from a post-World War II reworking of the South Boring Mill.
- 8.7.4 The northern half of Bay 6 was the earliest part of the South Boring Mill on Site 2. As identified from cartographic analysis, upon construction in 1888 it measured approximately 48.8m by 15.0m, aligned roughly north-south (see Figure 23). The structure was defined at its northern extent by cast iron stanchion base [135], aligned perfectly with the northern edge of the South Boring Mill as seen at RYR 03⁵¹ (see Figure 25). Its eastern and southern extent had been disfigured by the construction of Building D80 in 1914 (see 8.8) and the southern end of Bay 6 (see 8.7.6) respectively, while its western edge was beyond the limit of excavation. However, one surviving stanchion base [131] may have been at the southeastern corner of the original build; it was cast iron, measuring 0.7m², at 4.27m OD - therefore approximately the internal floor level of the original Bay 6. The base found was of the same construction and shape, but smaller than, the stanchion bases which defined the superstructure of the South Boring Mill at RYR 03⁵² to the west. A consistent piling arrangement was recorded along the eastern edge of this part of Bay 6, despite

⁴⁷ Hogg 1963

⁴⁸ Mayo 2004a

⁴⁹ Hogg 1963, 817

⁵⁰ Confusion arises from Hogg's dates due to his non-specific differentiation between elements of the South Boring Mill. For example, he gives dates for the construction of the south end of Bay 4 in 1899 and again in 1904. It appears that he is talking about the construction of firstly the southern half of Bay 4 and secondly the southern end of Bay 4. Hence the tabulated entries for 1899 and 1902 refer to the southern halves of Bays 5 and 6, not the southern ends as Hogg describes.

⁵¹ Mayo 2004a

⁵² Mayo 2004a

the fact that ground-level stanchion bases or pier bases were not present. This probably arises from the later construction of Building D80 to the east, leading to structural alterations to the adjoining wall between the two buildings. The foundations consisted of four driven concrete piles, each 0.3m², arranged in a square approximately 1.0m apart. In the centre of the 'square' were two further timber piles [437] of the same dimensions. The upper ends of the timber piles were cut to a tenon, to seat a stanchion above. A total of five of these piling arrangements were recorded in the MFP (see Figure 24). Further examples of timber and concrete piles, [437] and [438], were seen in the MFP below the northern half of Bay 6, but their exact purpose at ground level could not be ascertained.

- 8.7.5 The southern half of Bay 5, built in 1899, revealed two stanchion bases [121] on its eastern and western sides, and a small square stanchion base [123] at its southeastern corner.
- 8.7.6 The southern extension of Bay 6 in 1902 increased its north-south length by approximately 30.0m, to 78.8m. This new build was easily distinguishable by more cast iron stanchion bases [121] on concrete pier bases [185]. They were rectangular, measuring 1.84m by 0.43m.
- 8.7.7 Next to be built was the southern end of Bay 4 in 1904. Archaeologically this was seen as concrete strip footing and pier bases [148] and increased the north-south distance of Bay 4 by approximately 12.4m. The remains spanned an east-west distance of approximately 13.0m. At the southwestern corner a return to the footings was seen; this fits well with Hogg's chronology that says the southern ends of Bays 1 to 3, to the west, were not built until 1912⁵³. The footings of [148] were 0.85m wide, while the pier bases were approximately 1.2m². The pier bases supported cast iron stanchion bases [119], surviving on the eastern side of the extension, themselves founded on timber piles such as [149].
- 8.7.8 Within Bay 6 a number of cast iron girders were found, all lying horizontally and aligned east-west to form north-south platforms. Upon these lathe beds would have sat, although in Bay 6 none were present, having been removed during a later remodelling of the South Boring Mill. This foundation arrangement was the same as was found at RYR 03 to the west, below extant lathe beds in Bays 3, 4 and 5⁵⁴. The girders used were of varying types, discussed below:
- 8.7.8.1 Girders [178] and [179]
Six cast iron girders [178] were found on the western side of Bay 6. They ranged between 2.01m and 2.06m in length, and were positioned approximately 1.9m apart. Two different types of girders were found; one had a 'I'-shaped profile and was 0.33m wide, the other a 'Y'-shaped profile which was 0.6m wide at the top. To the east of [178], five girders [179] had exactly the same styles, dimensions and spacing. Given this fact, it is possible that both sets were installed to mount a single wide lathe; the distance between girders [178] and [179] was 1.9m, and therefore such a lathe would have had a minimum width of 1.9m. Both groups of girders were laid upon concrete slabs and were surrounded at floor level, 3.60m OD, by concrete slab [188] - further evidence that the girders founded the same machine. They covered a north-south distance of 12.0m
- 8.7.8.2 Girders [180], [181], [182] and [183]
On the eastern side of Bay 6 a number of girders with group numbers [180], [181], [182] and [183] formed the foundation for another lathe bed with a north-south distance of at least 35.6m. A variety of profile styles were found: [180] were trapezoid and 'I'-shaped; [181] and [183] were rectangular; [182] were rectangular but with concave sides. All were either rectangular or 'H'-shaped in plan. The upper height of these girders was 3.74m OD; inconsistencies in their heights (ranging between 3.54m

⁵³ Hogg 1963, 817

⁵⁴ Mayo 2004a, 42-45

OD and 3.74m OD) can be justified by comparison with the *in situ* lathe beds seen to the west at RYR 03, which were found to have blocks in place between the girders and lathe beds to level them - plus the lathe beds themselves had mechanisms at their joins to allow vertical adjustment. Girders [180] and [181] were bedded on concrete slabs and set at ground level in slab [243]. Girders [182] and [183] were the same, set at ground level in slab [208]. This slab had a rounded profile at its southern edge.

- 8.7.9 Also within Bay 6, numerous metal fixings and plates were found that marked machine positions. A complex cast iron baseplate [209] was almost identical to one found at RYR 03 (context number [132]). A series of cast iron fixing plates [194] occurred in pairs, six in total. These probably date to after 1914, as their position between Bay 6 and Building D80 implies that they were installed after the latter structure. Two examples were found to bear the inscription "LANARKSHIRE STEEL C^O L^D SCOTLAND", and one of these also had the partly legible inscription "H MENS MARIN PROCTER". Another manufacturer's mark was found on a girder from the South Boring mill but unfortunately it could not be ascertained from which lathe foundation or machine fixing it had originated. The incomplete inscription read "EARL OF DUD[LEY]".
- 8.7.10 Concrete slabs [198] and [200] within Bay 6, found at 3.84m OD and 4.00m OD respectively, most likely represent internal floor surfaces.
- 8.7.11 To the west in Bay 5 lathe beds [460] and [470] were found *in situ* (see Figure 24). On the west side [460] was a cast iron bed, 1.80m wide and at least 13.8m long. In profile the lathe bed was similar to one found to the west at RYR 03 (context [127]) in Bay 3. It was semi-rectangular in profile but with a concave upper surface between the rails. These had an inner gauge of 1.25m. The lathe bed was comprised of sections, one of which was seen to be 8.2m long. The sections were joined in the same way as RYR 03 context [127], with a heated ring around projections from the cast iron⁵⁵. Below the lathe bed, perpendicular girders were spaced every 1.47m, themselves set in a concrete slab. The lathe bed was at an upper height of 4.23m OD. Lathe bed [470] was exactly the same as [460] in terms of design, shape and dimensions, although a greater length was exposed in EXT 1, measuring 23.0m north-south. Its' upper height was 4.25m OD. This example also revealed four driven timber piles [471], arranged in a square below its southern end.
- 8.7.12 Externally to the South Boring Mill remains were found on the east side of Bay 6 that may relate to a Pump House marked on a map of 1917 (see Figure 7). Two wrought iron tanks [224] and [225] were 2.25m in diameter and at least 3.0m deep (see Figure 24). The northern tank [225] had a concrete covered ceramic pipe [219] leading north before turning west into the South Boring Mill. Two brick-built inspection hatches [220] and [222] around the pipe were associated with it. The pipe was seen to continue beyond the western limit of excavation in the MFP. Both tanks also had an iron pipe leading west from each. Concrete features [191], [218], [226] and [227] were located around the tanks and presumably either supported associated machinery or the pump house itself.
- 8.7.13 When combined with the results of the investigations at RYR 03, the full ground plan of the South Boring Mill (from Bay 1 to Bay 6) can now said to have measured approximately 93.0m east-west by 104.0m north-south. Works by OA during the construction of Armstrong Road revealed the northern sections of lathe beds [460] and [470].
- 8.7.14 Within the SFP were found the remains of bogie tracks and external surfaces relating to the South Boring Mill (see Figure 24). Iron bogie tracks [100] were aligned roughly north-south and leading directly into the southern end of Bay 4, which was built in

⁵⁵ Mayo 2004a, 43 and figure 22

1904⁵⁶. The tracks had an internal gauge of 1.22m and were found at 4.30m OD. They ran for 27.0m beyond the southern limit of excavation. To the west, an identical set of bogie tracks [107] were aligned to access the southern end of Bay 3, built in 1912. Both [100] and [107] were intersected by identical tracks [101], aligned roughly southwest-northeast across the southern face of the South Boring Mill. These survived for a length of 38.0m, although at their eastern surviving ends, where they had been truncated by the post-1967 incarnation of Street N^o 10 (see 8.18), detail of their foundation arrangement could be seen. This was simply a series of iron girders set perpendicularly to the tracks in a concrete slab [115]. Another set of bogie tracks [114] was identified from this same foundation arrangement. All of these bogie tracks, whilst variously serving the elements of the South Boring Mill in use by 1904, can be identified on a map of 1960.

- 8.7.15 Set around the bogie tracks were a series of cobbled surfaces [102], [103], [104] and [106] recorded at an average height of 4.29m OD. Another expansive cobbled surface [117], at 4.09m OD, was found respecting the South Boring Mill and the Store building (see 8.11), built by 1917.

⁵⁶ Hogg 1963, 817

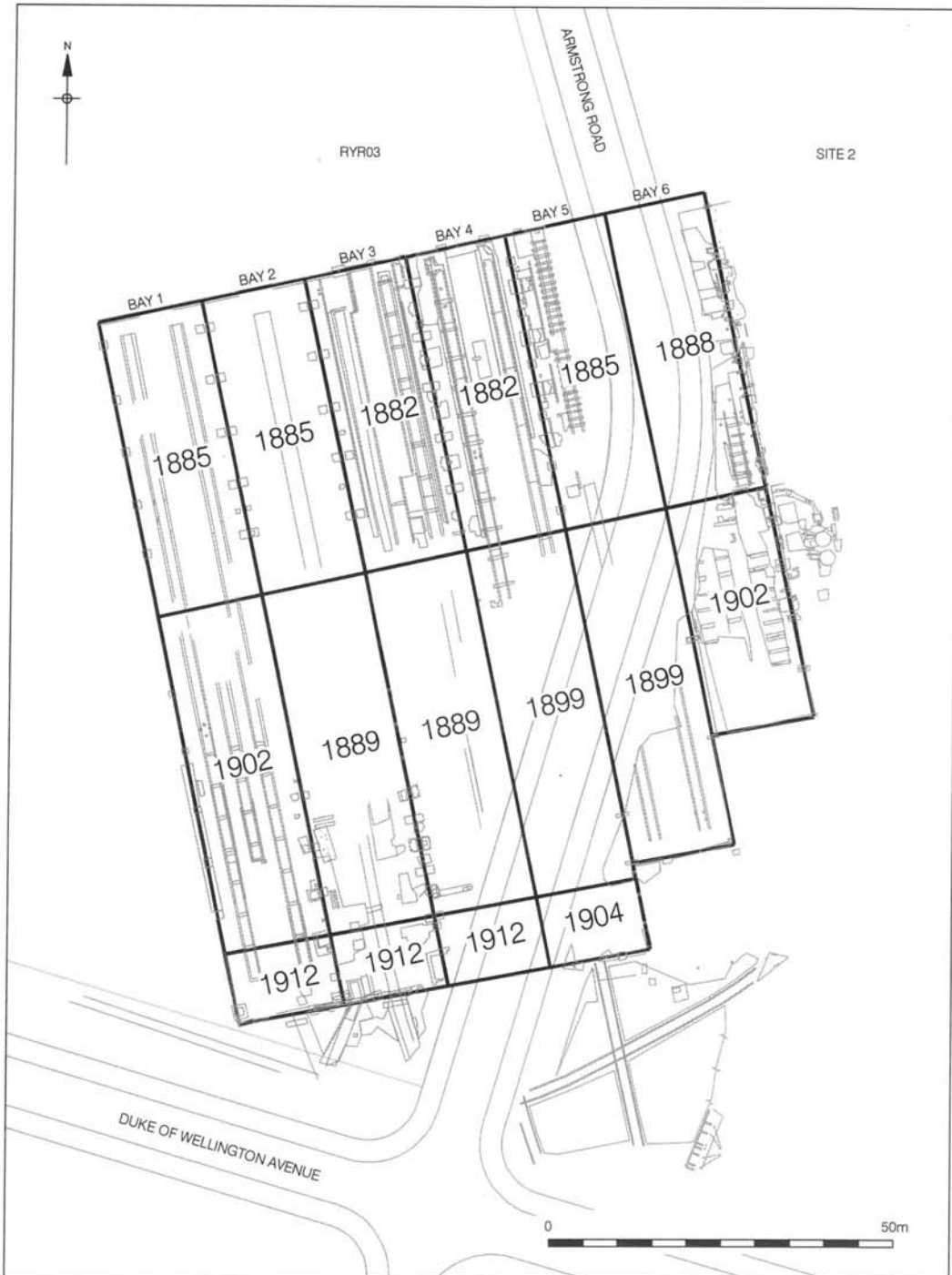


Figure 23
 South Boring Mill by documented construction date
 1:1000

8.8 PHASE 6: BUILDING D80 (see Figure 26)

- 8.8.1 Following the completion of Bay 6 by 1902, the South Boring Mill was again extended in 1914⁵⁷ with the construction of Building D80 (structure [241]). Despite its different name, it seems to have fulfilled a similar function as the main South Boring Mill to the west, for by the time of the 1960 map, Building D80 is labelled as two sub-divided areas, Bays 7 and 8.
- 8.8.2 Building D80 was easily distinguishable from the main South Boring Mill to the west as its edges were denoted by a series of girders [133]. There were forty-nine found, all 260mm by 150mm 'I' beams set vertically into concrete pier bases measuring 1.0m² by 1.3m deep. Compared to the stanchion bases and roof supports seen to the west in the main South Boring Mill, these are much less substantial and suggest that Building D80 had either a lower or lighter roof level, or both. Between the line of [133]'s that defined the division between Bays 7 and 8, a north-south brick wall [141] was found. It had a maximum thickness of 0.52m, and could be seen despite truncation to return along the southern edge of Bay 7 and the northern edge of Bay 8.
- 8.8.3 From these elements, Building D80 can be said to have dimensions of approximately 41.6m north-south by 23.0m east-west. Within that, Bay 7 measured 41.6m north-south by 15m east-west, and Bay 8 measured 36.0m by 8.0m.
- 8.8.4 Internally concrete floor slabs [177] and [193] were at 3.97m OD and 3.68m OD respectively, the lower slab located on the western side. The eastern half of the western side of structure [241], what was later labelled as Bay 7, contained two sets of rails [171], [172] and [174], [175]. They were aligned roughly north-south. At the northern ends of each were iron baseplates [173] and [176], 1.68m by 1.38m and 55mm thick. These were almost identical to a baseplate found at the northern end of lathe [193] during the works at RYR 03 to the west⁵⁸. However, while that baseplate was seen to house the drive mechanism for the lathe, the ones found at Site 2 had no such function, and the tracks themselves were merely rails presumably for small-scale machinery⁵⁹. Each set had an internal gauge of 0.93m, with each rail formed of two oppositely set half-box section girders having a combined width of 160mm. They were only 123mm deep and, surprisingly, had no cross-girders beneath them. This reinforces the conclusion that they were not used for heavy machinery, such as the lathes of the sort seen to the west. The rails were recorded at 3.99m OD.
- 8.8.5 Within the higher western floor slab [193], no tracks or lathe beds were found. Only one probable machine base [196] was found. It was trapezoidal in shape, measuring 1.19m by 1.17m and 0.4m high.
- 8.8.6 To the east of Bay 7, Bay 8 was comparatively poorly survived. Only a small area of floor slab [177] continued into the area. A single rail [134], 8.8m long and 40mm thick, was found at 4.06m OD within Bay 8. Two cast iron plates [140], each 100mm by 130mm, were found set within the floor.
- 8.8.7 To the east of Bay 8 a north-south aligned concrete footing [455] with a truncated westerly return may have been part of the building's eastern edge. Similarly concrete pier base [459] to the south may have marked its southeastern corner.

⁵⁷ Hogg 1963, 817

⁵⁸ Mayo 2004a

⁵⁹ The recorded southern end of the rails was a true end terminating within Bay 7.

8.9 PHASE 7: SUB-PHASE 1: STREET N^o 10

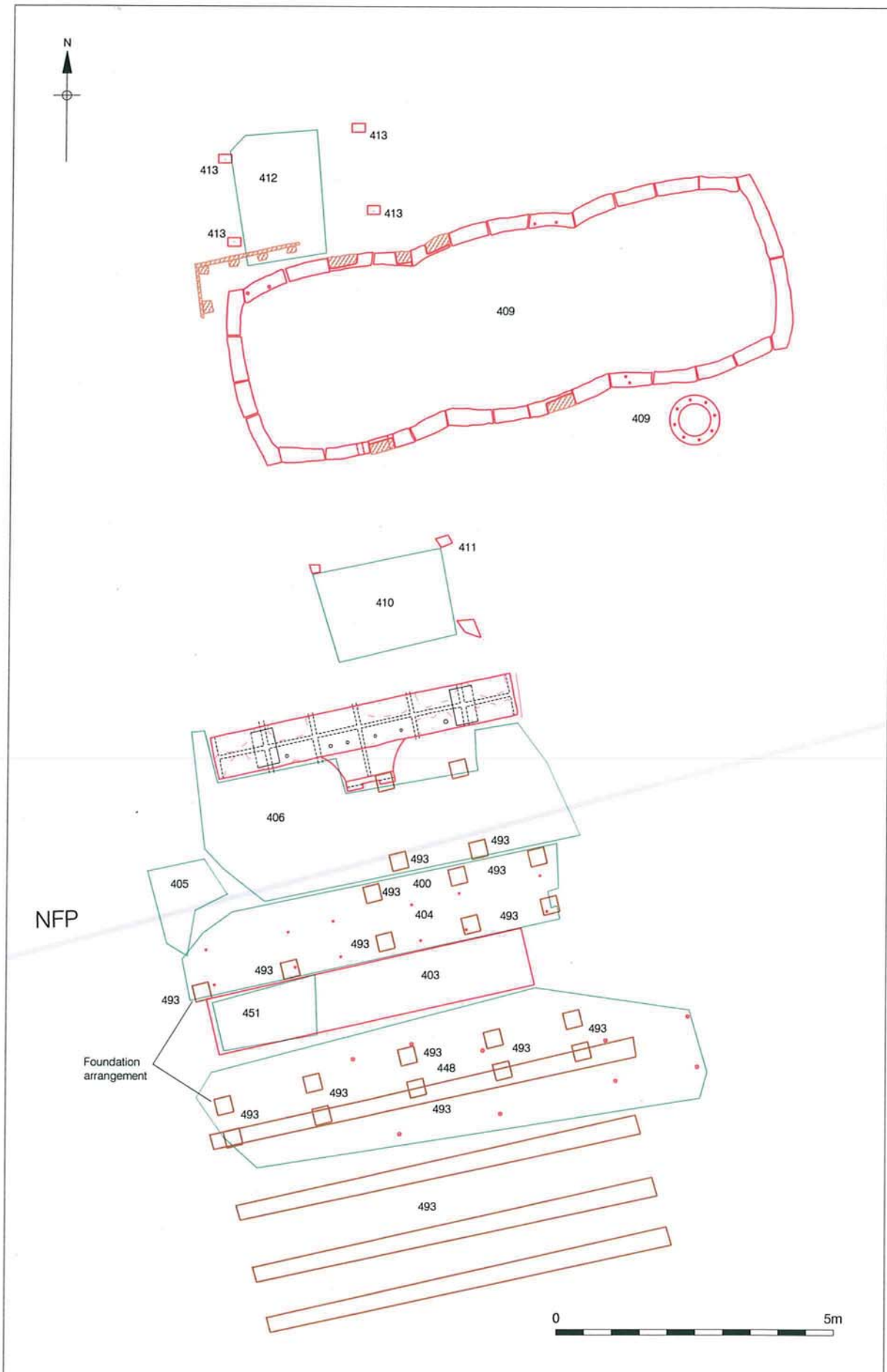
8.9.1 Street N^o 10 can be traced as a thoroughfare through this part of the Arsenal to a map of 1858; it is not shown on a previous map of 1812 and therefore was built between those two dates. However, the substantial structural reworking of the majority of Site 2 from the late 19th century onwards has led to no traces of the earliest road surviving. Beneath the late 20th century Street N^o 10 (see 8.18) areas of cobbling [116], [143] and [458] were recorded at heights between 3.32m OD and 4.06m OD (group number [496]). The inconsistencies in these heights could be because of slumping, topography or more likely that the cobbles relate to undatable stages of the history of Street N^o 10.

8.10 PHASE 7: SUB-PHASE 2: BUILDINGS D71, D72 & D74 (see Figure 27, Plates 12 to 13)

- 8.10.1 The conversion of parts of the Boiler House and Rolling Mill into Buildings D71, D72 and D74 involved varying degrees of alteration. It appears as if Building D71, which was compartmentalised and these labelled on a map of 1917 as Boiler Houses and a Coal Bunker, may have involved very little change from the original Boiler House. With the same function from the 1870s to the early 20th century, the structure may have just changed in name only, for the archaeological remains showed no massive difference. The western third of the Rolling Mill, which became Building D74, is also labelled as a Boiler House and it appears that the remains again show no change (see 8.6.18). However the eastern two-thirds of the Rolling Mill were heavily reworked to become Building D72, labelled as a Fitters Shop and Engineers Section, although some elements from the earlier structure were retained.
- 8.10.2 Flue [341] which separated the furnaces from flues in the Rolling Mill was extended at its eastern end, so that the flue turned northwards for approximately 18.0m and stretched beyond the limit of excavation with new wall [440] (see Figure 19). At its northern visible extent, it could be seen that the flue had a barrel-vaulted arch over the top. That this flue was altered proves that the flues and furnaces of the Rolling Mill were still in use at this time.
- 8.10.3 Within Building D72 evidence for two large-scale installations was found. The first was the timber, concrete and metal remains of a coiling machine upon which heated ingots of iron were rolled to form the crude gun barrels (see Figure 27). The machine was founded upon a complex series of at least 22 timber piles with at least 4 horizontal cross-members [493]. The piles were approximately 0.3m² and at least 2.0m long. The upper ends of the piles had been formed into tenons, upon which the cross-members were seated through mortice holes. The horizontal timbers were also bolted to the vertical piles by a series of iron straps. This was repeated so that a raft of horizontal timbers, aligned east-west, was created. The gaps between the foundation timbers had been filled with a crude concrete, and then another series of horizontal timbers were bolted onto the raft, aligned north-south, to create a platform. During the construction of this platform, a number of cast iron fixing plates were bolted to its underside and then through holes drilled through the platform were inserted iron or steel rods [404]. With flanges at their bottom ends wider than the holes, the rods formed a series of vertical stays to which machinery above ground could be fixed. Above the platform, the rods were formed through another slab of concrete approximately 0.7m thick. This concrete [400], [405], [406] and [448], at an upper height of 2.52m OD, was the base of the coiling machine. The foundation arrangement and slab level covered an area approximately 11.0m by 9.0m in size.
- 8.10.4 Little remained of the above ground machinery apart from a section of the framework [401] and [402] at the northern end and the flywheel housing [403]. The former comprised a complex cast iron structure [401] measuring 5.52m by 0.78m and 1.2m high. It was essentially a non-solid rectangular box shape with internal cross struts all cast in the same mould, and aligned east-west (see Plate 13). On the southern face a

cast iron projection from the box, in the shape of a trapezoid but with curved sides, extended the platform of the box by a further 0.71m. A series of holes in the top of the box would have allowed the fixing of further machine housing above. Also cast into the upper surface of the box were two opposite projections or stubs, in which would have been seated perhaps the end supports for the coiling axis. These were 3.25m apart. Brickwork [402] was a non-supporting encasement for box [401], surviving only on its northern side.

- 8.10.5 The flywheel housing [403] was positioned 3.8m to the south of box [401]. It measured 5.85m by 1.07m and was 0.75m deep at its middle. While the housing had essentially been formed into concrete slabs [400] to the north and [448] to the south, it had been lined with a wrought (?) iron skin. Within the housing no evidence could be seen for power transmission, and therefore this would have happened either to the side of the flywheel or from above. Essentially the remains found were for the foundation of the coiling machine, one of its axle-support bases and the housing for the flywheel by which the machine was turned. No remains were found for the axle support on the southern side of the machine.
- 8.10.6 The second large-scale installation, to the north of the coiling machine, was a massive quenching tank [409]. This structure measured 9.24m east-west by 3.08m north-south (see Figure 27 and Plate 12). It was built using a series of curved cast iron panels which, in plan view, take the form of a minor arc. Each was 1.34m high by 1.54m wide (across the face of the minor arc), and they were bolted together along one long edge in pairs to form another minor arc 3.08m wide. These pairs of panels were then bolted together again so that the length of the quenching tank was formed of three pairs, and the width formed of one. The panels were internally compartmentalised with struts into which were set planks of timber. This may have been to act as a cushion against the gun barrels hitting the sides of the tank. Upon the removal of the quenching tank by machine, it was seen that it had a staged base on three different levels, so that the eastern third was one panel deep, the central third was two panels deep and the western third was three panels deep. Thus the tank was 1.34m deep at its eastern end, with the base at 1.31m OD, and was 4.02m deep at its western end, the base at -1.37m OD.
- 8.10.7 The staged bases of the tank were founded upon concrete slabs, each 0.3m thick, set on three north-south iron girders. No ground-penetrating foundations were seen, although externally to the northwest corner of the tank it could be seen that its construction cut had been revetted with timber planking and piles. At this corner the construction cut was offset from the tank by approximately 0.6m.
- 8.10.8 Within the tank, a 0.3m diameter hole was seen on the western side at 2.0m from the top, by which a pipe would have allowed its' filling and emptying. Another vertical pipe was found outside the tank on the southern edge, approximately 1.0m in diameter and serving a similar function.
- 8.10.9 To the north and south of tank [409] were two large concrete pier bases, [412] and [410] respectively (see Figure 27). Vertical iron rods were set into the concrete below ground level, [413] in [412] and [411] in [410], fixed on the underside by flanges wider than the holes, to attach above ground machinery. It is possible that they supported uprights and, in turn, a jib by which the gun barrels could be lowered into the tank.
- 8.10.10 The remains of the coiling machine and the quenching tank can be seen to complete the sequence of production within Buildings D72 and D74. Long ingots of iron could be heated to a malleable temperature in the furnaces [332], [337] and [338] retained from the Rolling Mill (see 8.6.6), before being hammered on the small anvil base [398] (see 8.6.17), rolled in the coiling machine to form a crude gun barrel and then quenched in the tank [409]. Other elements of Building D72 and D74 that were retained from the Rolling Mill, such as the flues in the northwest corner and the square brick structure [414] must have played a part in this process, although as yet their role is unclear (see Figure 28).



Key:

- Colour scheme for features:
- Green - Concrete
- Grey (thick line) - Footprint positions
- Red - Metal
- Orange - Brickwork
- Brown - Timber
- Purple - Cobbled surfaces
- Light blue - Concrete surfaces
- Dark blue - Sections

Figure 27
 Site 2, Phase 7.2 Remains within Building D72
 1:100



Plate 12: Quench tank [409] to rear of manhole inspection pit (view east)



Plate 13: Coiling machine axle-support base [401] (view north, scale = 1.0m & 0.5m)

8.11 PHASE 7: SUB-PHASE 3: STORE BUILDING (see Figure 29)

8.11.1 A concrete slab [127] found within the external corner formed by the southern ends of Bays 5 and 6 of the South Boring Mill is the floor for a structure shown on the 1960 plan as a store. However, this building can be traced back until the 1917 map (see Figure 7). The slab measured 15.0m by 5.2m and was recorded at an upper height of 4.26m OD. No external wall for the structure was found on its southern or eastern sides (the other two formed by the South Boring Mill), but two 'I' girders [128] were found. It is possible, given the lack of wall, that the store was merely a lean-to structure.

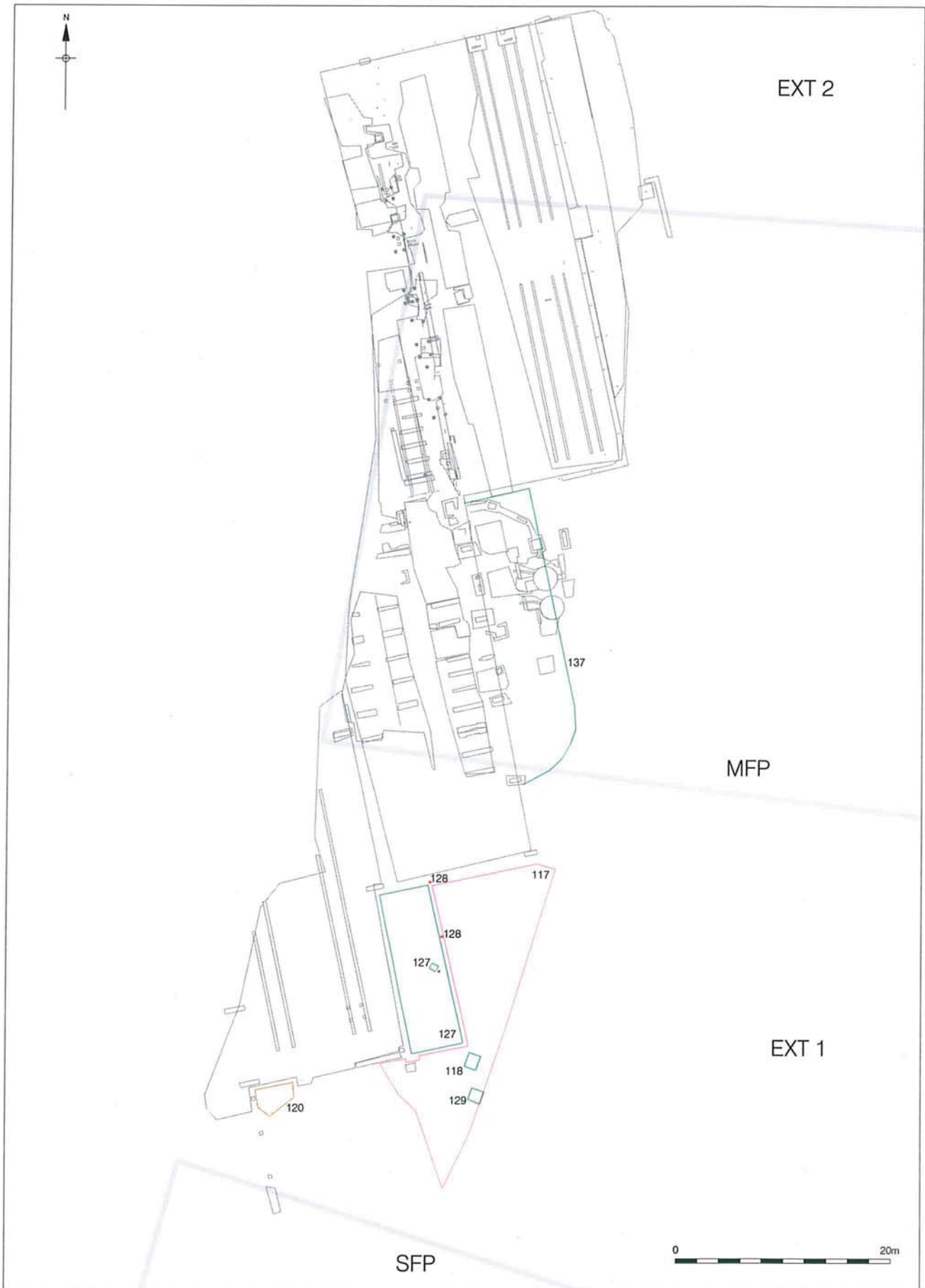
8.12 PHASE 7: SUB-PHASE 4: BUILDING C47 (see Figure 30)

- 8.12.1 Elements of Building C47 (structure [237]) were exposed in the eastern side of the MFP. This structure is first shown on a map of 1917; its purpose at this date is unclear but by 1960 another map labels the western half as 'Sub-Station N° 8'.
- 8.12.2 The southwest corner of the building was delineated by wall [159], brick built on a concrete foundation 1.4m wide. It was seen to run approximately east-west for 11.8m before turning north for at least 15.0m. Within wall [159] two heavily truncated concrete floor slabs were present at different levels. However the upper slab [160] at 2.95m OD did not appear to be a later floor than lower slab [161] at 2.69m OD, as both contained four vertically set girders [162] arranged in a line. The continuation of this slab to the north was exposed in Evaluation Trench 2⁶⁰, increasing the north-south measurement of Building C47 to at least 31.0m.
- 8.12.3 Along the southern east-west section of wall [159] a concrete service duct [164] had been built. Fragments of asbestos within the duct prevented its safe investigation. In the southwest corner of the building cables within this duct may have led into another external service duct [168], aligned southwest-northeast. This was built of brick, concrete and corrugated iron; it incorporated a manhole access in its roof at 3.07m OD, therefore the external ground level of Building C47. Further concrete pipe and cable ducts [165], [166] and [167] were also found externally to the building.
- 8.12.4 Service duct [164] contained a massive concentration of cables, consistent with the use of the western side of Building C47 as a sub-station. Even though this use of the building is not specifically labelled cartographically until 1960, the same east-west divide of Building C47 is shown on the 1917 map. The construction of service duct [164] and wall [159] appeared contemporaneous, and therefore the presence of the sub-station could easily date from the start of the building's use.
- 8.12.5 Beneath the remains of structure [237], four vertical timber piles [278], [279] and [280] were found. Each was 0.33m square and directly underneath slab [160]. Their presence is unusual, because there were no remains at slab level that would seem to require such large piles, and yet they were aligned precisely with wall [159] (see Figure 30). They might indicate that part of the interior of Building C47 was altered, and that previously piles were present internally.

8.13 PHASE 7: SUB-PHASE 5: DINING ROOM BUILDING C33 (see Figure 31)

8.13.1 A heavily truncated brick and concrete wall found at the very southern edge of the SFP may be the remains of Building C33 (structure [501]), first seen on the 1917 map and labelled as a dining room. Only 6.5m of an east-west stretch was found; the western end may mark the southerly return beyond the edge of Site 2, while the eastern end had been truncated by canal remediation cut [156]. The brickwork [155] comprised yellow stock in a very poorly survived condition, on concrete footing [154] at 4.09m OD. The footing was 0.85m wide.

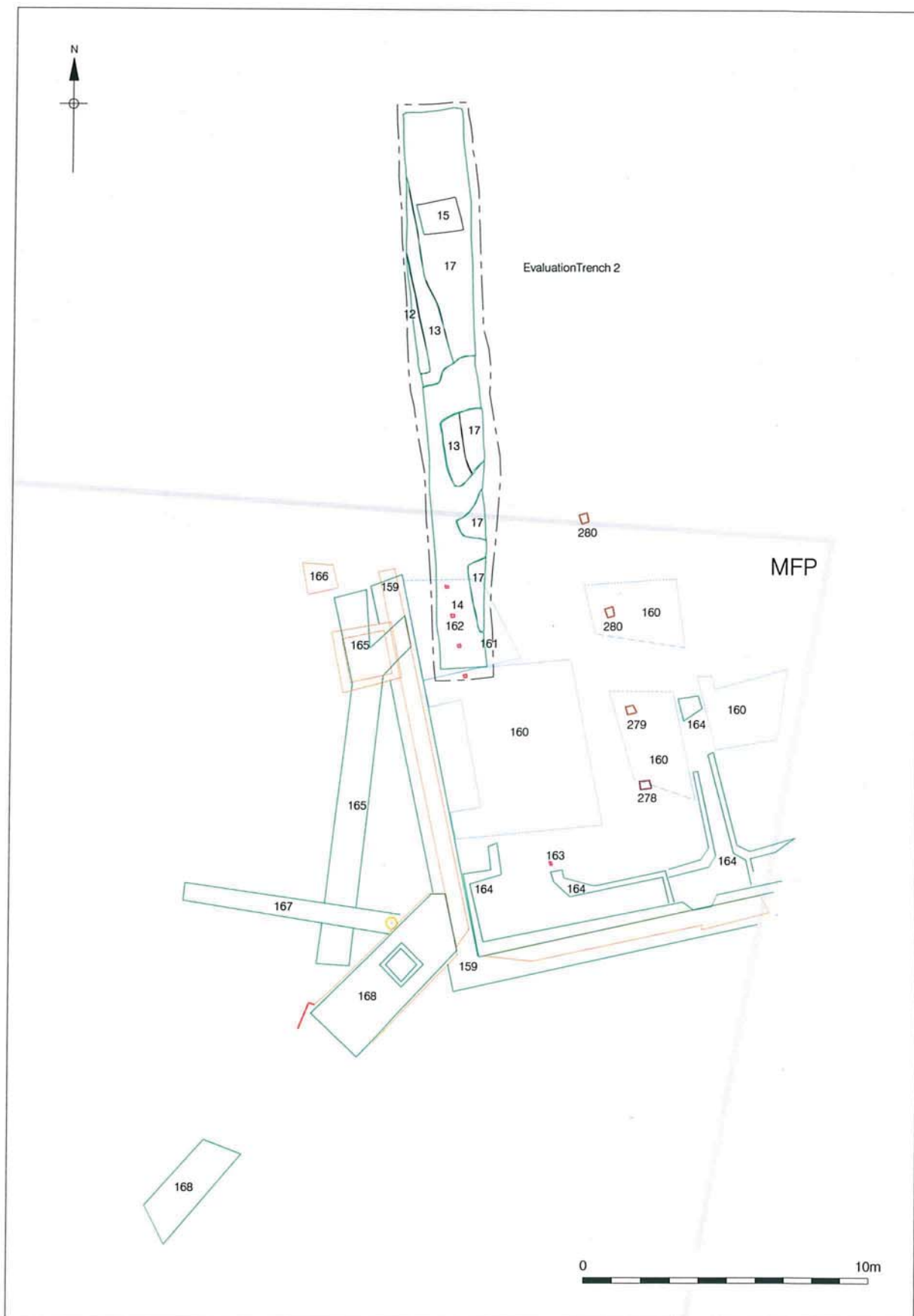
⁶⁰ Mayo 2004b



Key:

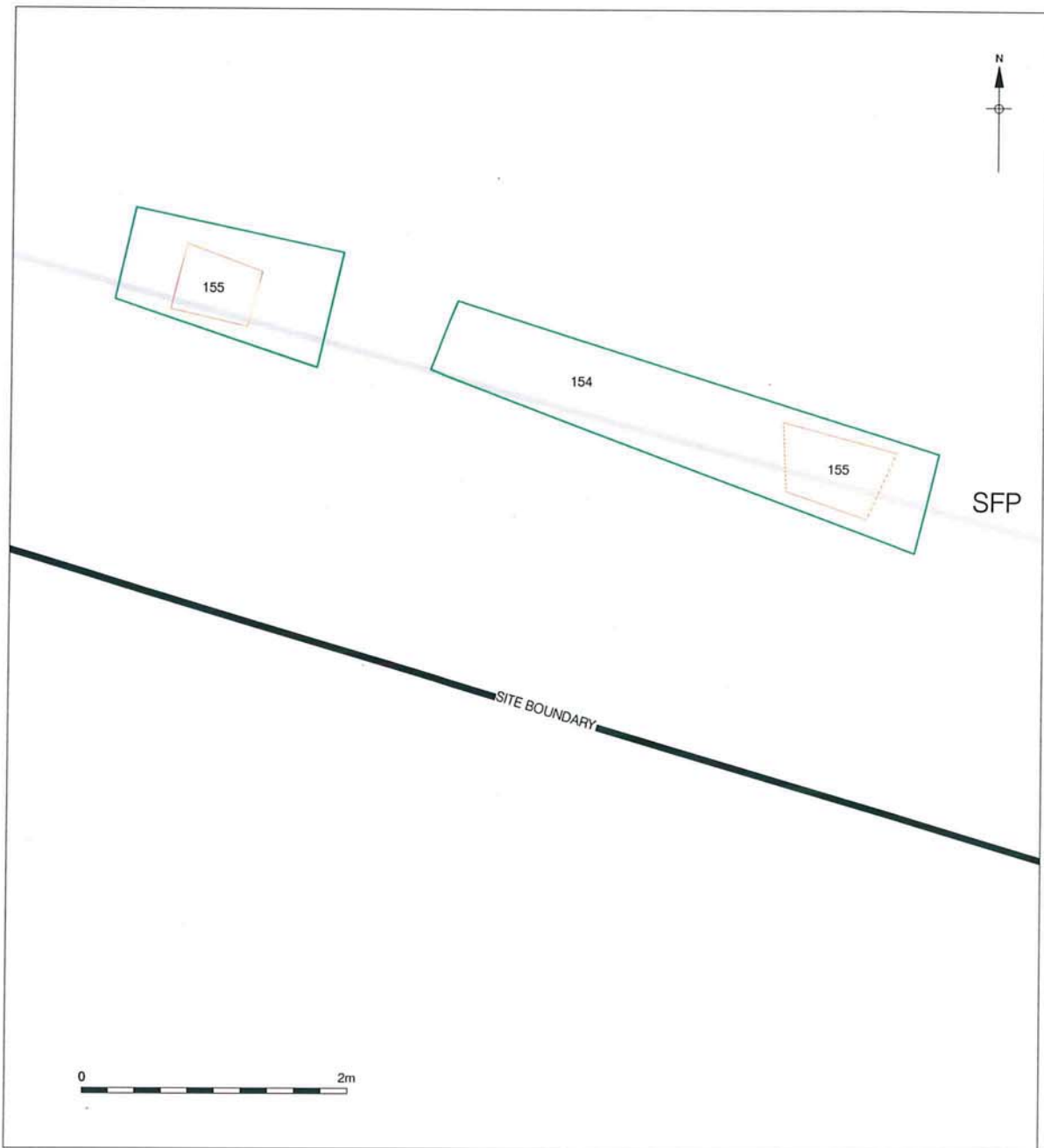
- Colour scheme for features:
- Green - Concrete
- Grey (thin line) - The earlier phase of the South Boring Mill and building D80
- Grey (thick line) - Footprint positions
- Red - Metal
- Orange - Brickwork
- Purple - Cobbled surfaces

Figure 29
 Site 2, Phases 7.3, 9.1 and 9.2 buildings added to South Boring Mill
 1:500



Key:
 Colour scheme for features:
 Green - Concrete
 Grey (thick line) - Footprint positions
 Red - Metal
 Orange - Brickwork
 Light blue - Concrete surfaces

Figure 30
 Site 2, Phase 7.4 Building C47 remains
 1:200



Key:
 Colour scheme for features:
 Green - Concrete
 Grey (thick line) - Footprint positions
 Orange - Brickwork
 Black (thick line) - Site boundaries

Figure 31
 Site 2, Phase 7.5 Building C33 remains
 (See Fig. 3 for location)
 1:50

8.14 PHASE 8: BUILDINGS D72 & D74

- 8.14.1 By the time of an historical map of 1931, the 1870s Boiler House and its successor Building D71 had been demolished. This map shows that the arrangement and, significantly, the labelling of Buildings D72 and D74, as shown from the map of 1917, was maintained. The archaeological remains within the area of Buildings D72 and D74 in the NFP do not indicate a new build or new installations; as such, and combined with the cartographic evidence, it is likely that the internal workings of the structures did not change. However there is no reason why the coiling machine and quenching tank may not have actually been installed at a later date, for instance by 1931.
- 8.14.2 The demolition of the Building D71 and its predecessor the Boiler House involved only the removal of the above ground structure, leaving the subterranean remains described above (see 8.5 and 8.10) *in situ*. The voids within the flues had been backfilled with demolition rubble [244] in which was found a number of artefacts, generally detritus associated with industrial production. They include scrap metal, hand tools and stamped plates that may have been machine identity tags.

8.15 PHASE 9: SUB-PHASE 1: SOUTH BORING MILL OFFICES (see Figure 29)

- 8.15.1 The remains of a rounded concrete slab [137] were found built externally against the eastern edge of Bay 6 of the South Boring Mill and the southern edge of Building D80. Cartographically a structure shown on a map of 1960 has the same rounded southern edge; this structure is labelled as 'Offices'. No external walls on the southern or eastern sides of this structure [495] were found (the opposite sides being formed by the South Boring Mill and Building D80), which is enigmatic unless the 'Offices' were shed-like structures merely sitting on the slab.
- 8.15.2 Slab [137] measured 26.4m by 6.4m, and was recorded at an upper height of 4.25m OD. It had been installed over the remains of the pump house (see 8.7.12), indicating that that structure was disused by at least 1960.

8.16 PHASE 9: SUB-PHASE 2: ABLUTION BUILDING (see Figure 29)

- 8.16.1 In the corner formed by Bays 4 and 5 of the South Boring Mill, historical maps show a structure labelled 'Ablution'. In this corresponding position on the ground the remains of the bedding for a tiled floor [120] were found at an upper height of 4.25m OD. No remains for the eastern or southern sides to the Ablution room were seen (the other two sides having been formed by the South Boring Mill), and so it is possible that this structure was little more than a lean-to.

8.17 PHASE 10: SUB-PHASE 1: REWORKING OF SOUTH BORING MILL AND BUILDING D80 (see Figure 32)

- 8.17.1 Several expansive concrete slabs were found within the South Boring Mill and Building D80 to be sealing the lathe beds, girders and machine fixings below. From this it is obvious that these buildings underwent a change in function (structure 236) - or, more accurately, that only these parts of the buildings were altered, because no such slabs were seen to the west within the mill at RYR 03. Dating these remains is difficult because of their undiagnostic nature, and they have been phased here only because the slabs showed no respect to the internal divisions of the two buildings. For example, slab [136] continuously covered parts of Building D80 and Bay 6. A map of 1960 maintains the internal divisions of the South Boring Mill and Building D80, and therefore the slabs have been tentatively phased after 1960, or perhaps after 1967 when the Arsenal was closed as a factory, and its buildings may have been used for different functions such as storage.

8.17.2 The slabs consisted of contexts [122], [136] and [139]. The former two, covering Bays 4, 5 and 6 and Bay 7 in Building D80, were at a height of 4.30m OD. Slab [139], in Bay 8 of Building D80, was at 4.10m OD and a concrete ramp was found leading from [136] down to [139] along its' western edge. Within slab [136] a formed tank [184] had been constructed in between girders [182] and [183]. A sloping concrete surface on the north and south sides led down into a pit that was found to contain traces of diesel, and therefore may have been a diesel sump.

8.18 PHASE 10: SUB-PHASE 2: REWORKING OF STREET N^o 10 (see Figure 33)

8.18.1 Remains of the post-1960 Street N^o 10 (structure [496]) were found in the SFP, EXT 1, MFP and NFP as Tarmac surfaces [110], [381], [382], [390], [391] and [392] with associated kerblines [380], services [111], [112] and [113], and pavements [108] and [109]. The road surfaces were recorded at heights between 4.19m OD at the south of Site 2 and 3.73m OD at the north. These remains have been phased here because in one place in the SFP the Tarmac was seen to seal parts of a bogie track [114] (see 8.7.14) shown on a map of 1960.

8.19 PHASE 10: SUB-PHASE 3: PETROL STATION

8.19.1 Remains in the NFP in the form of concrete tank holders and pipes relate to a petrol station (structure [492]) that dates to the end of the Arsenal's use as a factory, in the 1960s⁶¹. The concrete tank holders [272] had been built cutting through remains of the Boiler House (see Plate 1). An iron pipe [282] within brick duct [316] and a set of cast iron stanchion bases in concrete pier base [326] probably related to the petrol station.

8.20 PHASE 10: SUB-PHASE 4: OFFICES

8.20.1 Eight reinforced concrete piles [157] were found in the SFP, arranged in pairs and all 0.37m in diameter. The pairs were aligned north-south covering a distance of 22.0m. They are of the same size as concrete pile [11] found in evaluation Trench 4 to the east⁶². The piles are all from a post-1967 office block (structure [495]) shown on modern maps of the Arsenal, which had itself been demolished by the time the canal was remediated. One pile had a surviving pile cap at an upper height of 4.43m OD.

8.21 PHASE 11: CANAL REMEDIATION (see Figure 34)

8.21.1 The Pilkington Canal, which itself had gone out of use and been backfilled between at least 1895 and 1931, was previously remediated. Archaeologically this was manifested as a large cut [156] that had been carefully backfilled with ballast, crush and Geotextile material. The cut was within the outer limits of the canal, but incorporated all the area enclosed by the canal to the east (see Figure 34). From this the canal could be seen to have run north from the southern edge of Site 2, through EXT 1 and into the MFP before turning east beyond the limit of excavation. Hence the canal's exposed dimensions were at least 100m north-south by at least 26m east-west.

8.21.2 The excavation of evaluation Trench 4 revealed that the remediation had removed the upper levels of the canal to a depth of approximately 3.1m⁶³.

8.22 UNPHASED FEATURES

8.22.1 A number of features were found during the works at Site 2 which cannot be convincingly phased. They include external activity that cannot necessarily be

⁶¹ R Fordham, pers comm

⁶² Mayo 2004b

⁶³ Mayo 2004b

identified as confidently from historical maps as structural remains can. Likewise a variety of buried services were found that are regarded here as unphased.

8.22.2 External Activity (Group [499]) (see Figure 33)

- 8.22.2.1 At the northern extent of Street N° 10 in the NFP, two sets of bogie tracks [374] and [375] were revealed at 3.72m OD. Tracks [374] were aligned northeast-southwest, following the exact course of Street N° 10 and were therefore possibly contemporary with the road, running as tramlines. Tracks [375] joined with [374], but curved away to the east in the direction of either the Rolling Mill or Building D72. Central to tracks [374] in the northeast corner of the NFP was a rectangular iron box [376] visible at surface level that had been in-filled with concrete. This may have been an inspection pit or soot trap. Rather than cobbled surfaces as were seen around the bogie tracks in the SFP, these tracks in the NFP had been set in concrete surfaces [381], [382], [390], [391], [392], [393] and [394]. Although expansive concrete surface [390] clearly respected tracks [374], it also respected the western edge of kerblines [377] that curved in a northerly direction. The eastern side of this kerblines however contained no break for the tracks, and therefore it is possible that the earlier straight alignment of Street N° 10 was altered to turn north but that the tracks were left *in situ* when this was done.
- 8.22.2.2 The positions of further bogie tracks could be identified from remains [379] and [439]. The former was three parallel sleeper timbers at 3.53m OD aligned north-south and therefore providing the setting for an east-west bogie track. Concrete surfaces [378] and [383] respected these remains. Two parallel iron beams [439] at 2.74m OD were the foundations for a set of tracks that would have had a gauge of approximately 1.4m. They were also aligned east-west.
- 8.22.2.3 In the SFP, concrete surface [105] at 4.34m OD was above cobbled surface [106] and is therefore a 20th century feature.
- 8.22.2.4 A Tarmac surface and kerblines [132] was exposed in EXT 2 at 4.24m OD and as such is likely to be a late 20th century surface, probably from the post-1967 period.

8.22.3 Services (Group [500])

- 8.22.3.1 A variety of buried services were found during the works at Site 2 (group number [500]). They included a roughly north-south aligned arched brick-built culvert at 2.41m OD in the SFP. This had clearly been altered or extended because a break was seen in the culvert, and in its place the brickwork was connected by a section of iron pipe.
- 8.22.3.2 A substantial iron pipe [150] was found traversing the SFP for at least 34.0m, aligned northeast-southwest with its' top at 1.53m OD. The pipe had a diameter of 0.78m and contained oil residue. A construction cut was visible in only a few places and therefore at least part of the pipe must have been tunnelled.
- 8.22.3.3 Also of note was a cable duct [158] that was built of timber. It was aligned north-south and was seen across the SFP for a distance of at least 26.0m, with an upper height of 3.62m OD. The duct was built using horizontal beams and planks. Due to the poor state of preservation it was not possible to discern any earlier use of the timbers.
- 8.22.3.4 Concrete and ceramic service ducts were particularly concentrated beneath the route of Street N° 10.

8.22.4 Other Features

- 8.22.4.1 To the east of quenching tank [409] in the NFP a vertical wrought iron tank [452] was found. Its' position was within Building D72 but any connection with that

structure or its processes could not be safely discerned (see Figure 27). It was 2.73m high and 0.86m in diameter with an upper height of 3.22m OD. A very similar tank was found to the west at RYR 03⁶⁴ (context number [825]). It was 2.01m high with a diameter of 0.91m OD and was possibly associated with the South Forge, which was built at approximately the same time as the Rolling Mill in the 1870s.

- 8.22.4.2 A number of remains were seen within made ground deposits at the eastern edge of the MFP and it is possible that they were displaced remains of revetments associated with the Pilkington Canal. They comprised an east-west aligned timber beam [170] on concrete [211]. Timber [170] had an upper level of 2.76m OD.
- 8.22.4.3 In the NFP a deposit of iron was found over remains associated with the Rolling Mill. The iron [370] was substantial in size (4.23m by 2.65m and up to 0.8m thick) and irregular in shape; it appeared to be a dump of iron that had been wasted from production elsewhere in the Arsenal⁶⁵. Its position within Building D72 suggests that it had been deposited following the disuse of that structure in the 20th century.
- 8.22.4.4 The base of a brick built structure [457] measuring 4.0m by 2.6m was found in the external corner of Bays 7 and 8 of Building D80. This feature is identifiable on a 1917 map (see Figure 7) but its function is unspecified.

⁶⁴ Mayo 2004a, 29

⁶⁵ Such disposal was common during the production of gun barrels: material rendered useless due to, for example, an accident during the forging process would be dumped in a hole and left to set (R Kinchin-Smith, pers comm).

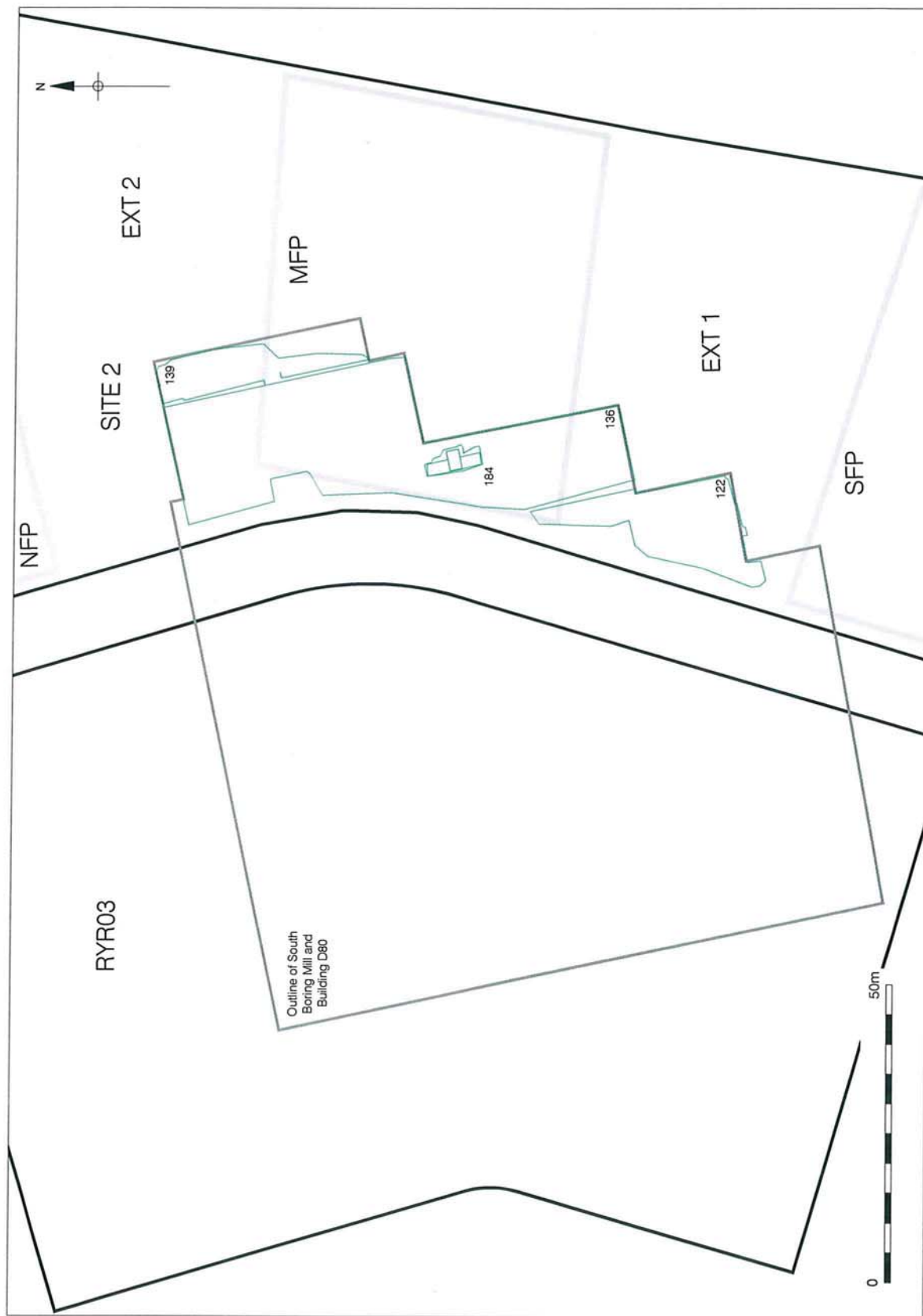
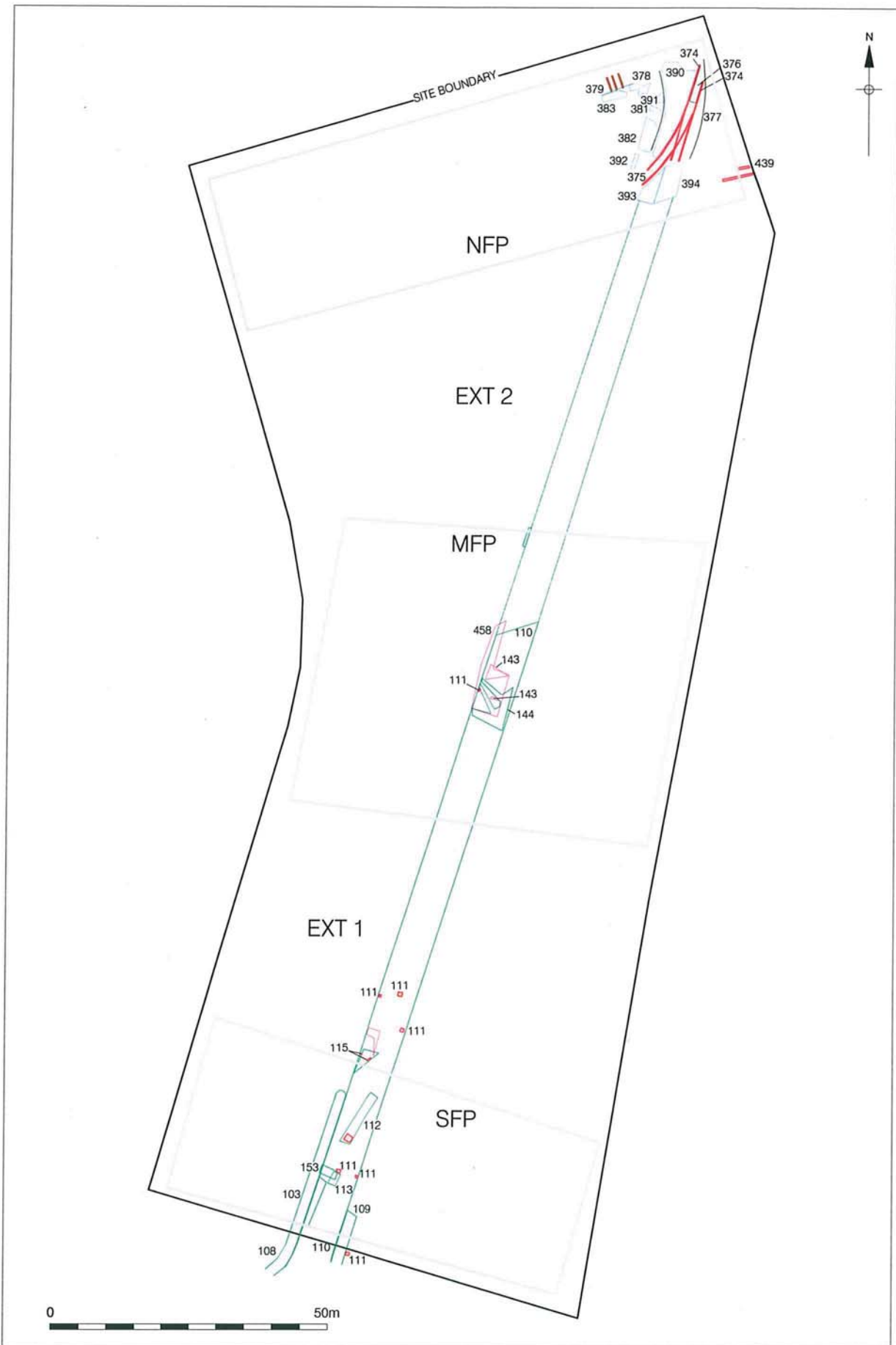


Figure 32
 Site 2, Phase 10.1 Concrete slabs in South Boring Mill and Building D80
 1:1000

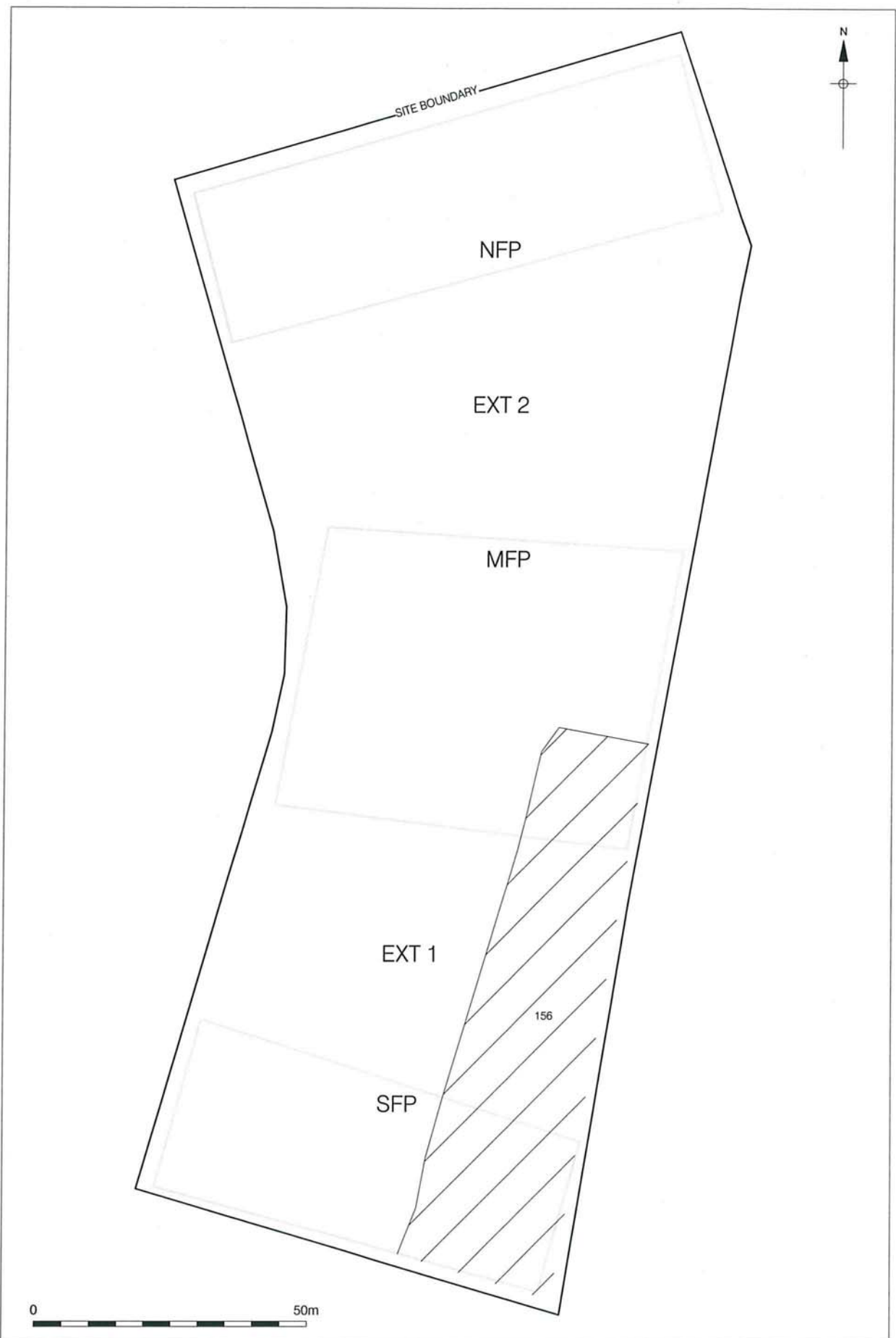


Key:

Colour scheme for features:

- Green - Concrete
- Grey (thick line) - Footprint positions
- Red - Metal
- Brown - Timber
- Purple - Cobbled surfaces
- Light blue - Concrete surfaces
- Black (thick line)- Site boundaries

Figure 33
 Site 2, Phase 10.2 Street No 10 and bogie tracks
 1:1000



Key:
 Colour scheme for features:
 Grey (thick line) - Footprint positions
 Black (thick line)- Site boundaries
 Black (thin line)- Area of remediation

Figure 34
 Site 2, Phase 11 Remediated area of Pilkington Canal
 1:1000

9 ORIGINAL AND REVISED RESEARCH QUESTIONS

9.1 ORIGINAL RESEARCH OBJECTIVES

9.1.1 The areas of interest for investigation, as specified in the English Heritage Brief⁶⁶, can be addressed as follows:

9.1.2 Pre-Roman waterlogged deposits in alluvial and / or peat.

9.1.2.1 Investigations at Sites 1 and 2 revealed a complex natural sequence. Site 1 was situated at the northern edge of the riverine gravel terrace, where the natural ground comprised gravel over alluvial sand. The terrace drops sharply to the north between Sites 1 and 2, where in the latter the natural sequence was largely alluvial sand overlain by peat and alluvial clay. However, deposits of natural gravel were observed in places at the southern and western edges of Site 2, suggesting that the terrace slopes southeast to northwest. This has implications for the conclusions drawn from the works at RYR 03, where investigation implied the presence of a natural channel aligned east-west. The new results suggest that such a channel might actually be aligned southwest to northeast, or that a completely different channel is also present in the natural strata.

9.1.2.2 The sequence of waterlain natural deposits recorded at Site 2 compliments that recorded during the works at RYR 03. As then, close inspection or sampling of the peat deposits was not possible; however the levels of the peat recorded at Site 2 were higher than those at RYR 03.

9.1.3 Deposits to raise ground during the period of the Napoleonic wars.

9.1.3.1 Deposits of made ground were recorded across Site 2 ranging in thickness between 2.6m in the north and 3.95m in the south, comparable to the thicknesses recorded during the works at RYR 03. By comparison, very insubstantial deposits were seen at Site 1 due to the higher natural level below. The made ground comprised dirty sandy-gravel, reworked alluvial clay and industrial waste material. In the MFP two George III cannon were recovered from the made ground; they had been recycled as mooring posts in the Arsenal. One of the guns bore a maker's stamp from either Hull or Wales, and it is likely that it had been brought for proofing⁶⁷, showing the importance of the Arsenal in the production of arms and armaments in the 18th and 19th centuries.

9.1.4 Construction detail of the canal and opportunities for environmental sampling.

9.1.4.1 As was seen in the evaluation⁶⁸, the Pilkington Canal at Site 2 had been previously remediated. The Phase 4 investigations revealed that that process had involved the complete removal of the canal's structure and fill to a depth of approximately 3.0m. Furthermore it was seen that the remediation had also covered all of the area of Site 2 enclosed by the canal. A black canal deposit, sedimentation rather than backfill, was seen during the excavation of TP1. However the nature of the test pit prevented safe inspection of the material. No *in situ* remains of the canal structure were seen; however a displaced timber beam and concrete footing at the eastern edge of the MFP may indicate that the canal was a composite revetted structure. Two cannon found within made ground deposits in the MFP, which had been adapted for use as mooring posts, may have been positioned at the edge of the canal.

9.1.4.2 The investigations at Site 1 found no trace of the canal or modern remediation work and therefore the eastern return of the canal must lie under the present position of Duke of Wellington Avenue.

⁶⁶ Stevenson 2003

⁶⁷ P Evans, pers comm.

⁶⁸ Mayo 2004b

9.1.5 The phases of changes to the former buildings and how this relates to their changing use and / or level of use.

- 9.1.5.1 A number of the structures found at Site 2 revealed evidence for alteration. This is in contrast to the works at RYR 03 to the west, where the majority of structures appeared to be short-lived until the specific processes of production contained within became unnecessary. However, the new work requires a reinterpretation of those results.
- 9.1.5.2 The Boiler House and Rolling Mill in the NFP at Site 2, built in the 1870s, remain archaeologically and cartographically unchanged until the early 20th century. By the time of a map of 1917 both had been converted into one building internally subdivided into six compartments. The western two are shown on the map as Building D71, a Boiler House and Coal Bunker. The central two are Building D74, both Boiler Houses. The eastern two are Building D72, a Fitting Shop and Engineers Section. In terms of function therefore, the Boiler House has changed only in name and correspondingly the archaeological remains are the same from the 1870s. The Rolling Mill was altered internally to accommodate Building D72 with the removal of furnaces and flues (although some original features were retained), but the flues and furnaces at the western end, now a Boiler House within Building D74, were largely untouched. These changes may have been due to advances in technology and a greater need for production at the time of World War I than could be provided by the 19th century installations. However, it was also seen during the works at RYR 03⁶⁹ that the 35-ton steam hammer that was housed in the South Forge, the westernmost of the range of structures of which the Boiler House and Rolling Mill were part, had become badly damaged at anvil level. The disuse of the hammer, by 1914⁷⁰, which was powered by the Boiler House, must have removed its specific purpose. Likewise it is reasonable to assume, given the construction of these three buildings in the same manner, alignment and within the same decade, that the hammer's demise affected production in the Rolling Mill too. The conversion of the Boiler House and Rolling Mill to Buildings D71, D72 and D74 was probably due to a combination of these reasons.
- 9.1.5.3 The South Boring Mill was constructed in the 1880s but was continuously enlarged so that by the 1910s it was a sprawling structure covering large parts of RYR 03 and Site 2. This massive expansion was caused by the enlargement and technological improvements in the military necessitated, for example, by World War I. The development of the South Boring Mill is documented by Hogg⁷¹, who lists dates for the construction of the various bays, yet these expansions are not easily discernible from the archaeological remains. Whilst slightly differing elements of the superstructure are visible the building has been so heavily reworked internally that earlier parts have often been demolished, or are masked. Improvements in technology and increases in the scale of guns and other items being turned in the South Boring Mill explain this. In this sense the South Boring Mill is as difficult to phase archaeologically as it was during the works at RYR 03.
- 9.1.5.4 However, a notable difference was seen in the South Boring Mill at Site 2 relating to its use following the removal of the lathe beds and other machinery. To the west at RYR 03 lathe beds were found to survive intact and *in situ* just below ground level. At Site 2 the majority of the lathe beds had been removed, leaving their positions only visible as foundation girders. The interior of Bays 4, 5 and 6, and Building D80, had been covered in concrete slabs presumably to allow the buildings' use for either small-scale industry or storage, utilising the same superstructure. This alteration probably occurred post-World War II. The presence of the slabs within Site 2 and not to the west may suggest that towards the end of the life of the Arsenal, military production was being scaled down so that Bays 4, 5 and 6 were disused and that Bays 1, 2 and 3 were still operating.

⁶⁹ Mayo 2004a

⁷⁰ Mills Whipp Partnership 1995, Volume I, 48

⁷¹ Hogg 1963, 817

9.1.6 Evidence of power generation, supply and transmission.

- 9.1.6.1 The remains of the Boiler House in the NFP revealed no evidence for the transfer of steam power to the South Forge and therefore, as was concluded from the works at RYR 03⁷², this must have happened at ceiling or roof level. Neither was any evidence found for the origin of the heat that fired the boilers via the flues, and therefore this may have happened to the north of Site 2 in a furnace. It has been presumed that heat was brought south into the Boiler House via flue [323] before being extracted via large flue [276]. This is based on the use of bull-nosed bricks on the northern corners where the Boiler House flues join the main flue, as if the exhaust was directed north. Speculatively, however, it is possible that flue [341] from the Rolling Mill was actually directing recycled heat from that structure into flue [276], before being channelled through the Boiler House flues and exhausted through flue [323]. Such a theory is, however, very difficult to prove conclusively.
- 9.1.6.2 No evidence was seen for the generation or transmission of power (apart from the furnaces) within the Rolling Mill or its successors Buildings D72 and D74. Therefore it is likely that power generation happened elsewhere and that it was transferred to the buildings above ground, maybe at ceiling or roof level, to power the coiling machine for example.
- 9.1.6.3 The same conclusions must be drawn for the South Boring Mill. No evidence for power transmission was found, but the nature of the remains was unlikely to ever provide such evidence because all of the machinery, i.e. lathe beds and their drive mechanisms, had been removed. During the works at RYR 03 to the west, where intact lathe beds and drive mechanisms were found, the remains implied the transmission of power from an external source at ceiling or roof level. No cabling was found within the South Boring Mill in Site 2 to provide evidence for the electrification of the manufacturing processes.
- 9.1.6.4 At the southwest corner of Building C47 in the MFP was a mass of electrical cabling channelled through a concrete and ceramic duct. The duct ran southwest to Street N^o 10 before following the route of that road, but it could not be found in the SFP and therefore it must have turned off site in EXT 1 where the groundworks only involved ground reduction up to 0.5m deep. Crudely by 1917 and specifically by 1946 historical maps label Building C47 as a sub-station and therefore the disappearance of the service duct in EXT 1 is unfortunate.
- 9.1.6.5 The heavy concentration of services seen below Street N^o 10 is typical of the convenient use of thoroughfares for utility routing.

9.2 ORIGINAL RESEARCH QUESTIONS

9.2.1 From the borehole logs thick deposits of peat are known to occupy the north of Site 2. What can be learnt from a study of the peat?

- 9.2.1.1 Deposits of peat were found in test pits in the NFP and MFP in Site 2 only, but the nature of these test pits prevented *in situ* inspection of the material. It was seen *ex situ* to have a high wood content, similar to the peat deposits found at RYR 03. The variation in height between deposits there and at Site 2 is impossible to interpret without a long section across the whole area. It could be caused by an underlying natural channel, possibly aligned northeast to southwest, or simply by the natural topography as it slopes north towards the Thames.

9.2.2 Is there any evidence of archaeological activity prior to the post-medieval period?

⁷² Mayo 2004a, 74

- 9.2.2.1 The only evidence for earlier activity was found within a probable pit in Site 1 as a sherd of grog-tempered Roman pottery. The pit also contained ceramic building material with a date range of 1125 to 1950. As such the pottery is residual, but has implications when considered against the location of Site 1 at the edge of the gravel terrace on higher, drier ground, and also given the discovery of a Roman cemetery to the west in Dial Square⁷³. The presence of further Roman activity on the high gravel terrace in this area of the Arsenal is a possibility.
- 9.2.3 On the early 19th century maps several buildings appear only for a very short period. What is the nature of these structures and is it possible to assign a function to them?**
- 9.2.3.1 A map dating from 1808 shows that an area labelled as 'Rocket Sheds' occupied part of the NFP. The map suggests that this area measures very approximately 31m by 105m, which is clearly too big to have been one structure. Therefore the area denoted on the map was probably fenced and occupied by numerous small-scale sheds. No fencing lines were found to survive in the NFP due to the later ground-invasive structures within Site 2.
- 9.2.3.2 Another map of 1812 suggests the presence of a small structure towards the eastern side of Site 2. No sign of this was found during the investigation but given its small size compared to other structures on maps of which no trace could be found archaeologically, this is unsurprising.
- 9.2.4 What is the precise location of Pilkington's Canal? What material is it backfilled with?**
- 9.2.4.1 The position of the Pilkington Canal was denoted on Site 2 by previous remediation. The canal entered Site 2 on the eastern side in the MFP before turning south through EXT 1 and into the SFP, following the eastern edge of Site 2. The edges of the remediated area closely followed the suggested position of the canal from historical maps but also covered all the area enclosed by the canal, obscuring its eastern edge. The canal measured at least 100m north-south by 26m east-west. It was not found to be present on Site 1 and therefore it must have turned east beneath the position of Duke of Wellington Avenue.
- 9.2.4.2 During the excavation of TP 1 and evaluation Trench 4⁷⁴ a black silt deposit was found at a depth of approximately 3.0m, where the remediation stopped. This material was a result of the natural sedimentation of the canal rather than deliberate backfilling. The remediated areas of the canal had been filled with ballast, sand and crush, layered between Geotextile material.
- 9.2.5 To what degree do the 19th and 20th century structures survive on site?**
- 9.2.5.1 The survival of 19th and 20th century structures on Sites 1 and 2 was generally very good. The concrete remains of Building C47, the South Boring Mill with its associated buildings and Building D80 were largely intact apart from areas of antiquarian truncation. Metal and timber remains associated with all these structures survived well.
- 9.2.5.2 The Boiler House and Rolling Mill were largely built of brick and the good survival of these remains was particularly striking. Their preservation had been assisted by the retention of remains from the original structures into Buildings D71 and D74, although this was not the case in Building D72 where large-scale installations dating from the 1910s and onwards had required the demolition of internal parts of the Rolling Mill. Despite this anomalies were found, for example the superstructure of the Rolling Mill could only be identified on the north and west sides, not the east or south.

⁷³ Oxford Archaeology 2002, 6

⁷⁴ Mayo 2004b

9.2.5.3 Although only seen in small areas, walls of the Cartridge Establishment in Site 1 were in a good condition except for one place where one wall had either collapsed or been damaged.

9.2.5.4 Whilst the latest manifestation of Street N° 10, dating from the end of the Arsenal, survived well, the lack of remains of its predecessor and Marlborough Road was stark. In only a few places in the MFP and EXT 1 could possible traces of earlier road surfaces be identified. This must be attributed to the fact that so many 20th century services had been routed below and along Street N° 10.

9.2.6 Is it possible to record different phases of building with regard to the Rolling and Boring Mills and the Boiler House?

9.2.6.1 Different phases of building activity can be discerned for the Rolling Mill, Boiler House and South Boring Mill although for all three this can only be done confidently by referral to both documentary and cartographic sources. This is because either the internal elements of the structures were retained through different phases, or because the complete overhaul of internal elements but the retention of superstructural remains leaves little trace of earlier phases. For details of the phases within these buildings, see 9.1.5.

9.2.7 Can the position of the former Marlborough Road be located?

9.2.7.1 Street N° 10, or Marlborough Road as it was also known, traversed the area of Site 2 southwest to northeast and served as one of the main thoroughfares through the Arsenal. It is first shown cartographically on a map of 1858; thereafter its position is consistent on historical maps in relation to structures on Site 2. The latest manifestation of Street N° 10 survived well in the SFP, EXT 1, MFP and NFP as a Tarmac road surface with pavements, kerblines and services. It occupied the same position in relation to structures such as the South Boring Mill and Rolling Mill as shown on the historical maps. This road was seen to seal the remains of bogie tracks identifiable on a map of 1960, and therefore it may date to after the closure of the Arsenal in 1967. Beneath the Tarmac road only isolated areas of earlier cobbled road surfaces survived, due to numerous underlying services, the installation of which had removed previous remains. These cobbled surfaces were undatable.

9.2.7.2 Historical maps from 1808 and 1810 indicate the presence of another thoroughfare running through Site 2, labelled 'Lobby' and aligned west-southwest to east-northeast. No traces of this were found during the watching brief.

9.2.7 Are there any other buildings on site that are not documented on the maps?

9.2.7.1 No remains of buildings were found on either Sites 1 or 2 that could not be traced on historical maps. Given that a large-scale industrial complex such as the Arsenal was constantly being enlarged and altered to respond to varying demands, or lack of them, on the military and that a number of unmapped buildings were found at RYR 03, this is perhaps surprising, especially when it is considered that there are often long gaps in the cartographic coverage of the Arsenal.

9.3 REVISED RESEARCH QUESTIONS

9.3.1 What conclusions can be drawn from the various metalwork and brick manufacturer's attested from Site 2?

9.3.1.1 Investigations within Bay 6 of the South Boring Mill revealed two examples of manufacturer's stamps on girders. The first, found on two girders, read "LANARKSHIRE STEEL C^O L^D SCOTLAND", and one of these also had the partly legible inscription "H MENS MARIN PROCTER". The Lanarkshire Steel Company was in operation between 1889 and 1939, producing high quality iron and steel

channels, joists and pile bars⁷⁵. Hogg⁷⁶ documents the construction dates for Bay 6 as 1888 for the northern half and 1902 for the southern half, therefore the dates of operation for the Lanarkshire Steel Company imply that either Hogg refers to the structure only, and that machinery was not installed until at least 1889, or that the plant within Bay 6 was re-fitted after 1889. The second inscription on these girders may relate to a designer, batch label or order commissioner.

9.3.1.2 The second manufacturer's inscription read "EARL OF DUD[LEY]", and most likely relates to the Earl of Dudley family's association with the Black Country⁷⁷. This association was primarily founded on coal mining, for example at the Baggeridge Colliery⁷⁸, but also involved iron and steel production in which the third Earl of Dudley was closely involved at the Round Oak Steelworks particularly in the 1920s and 1930s⁷⁹. Again, these dates imply that machine fixings within Bay 6 and probably the South Boring Mill as a whole were refitted.

9.3.1.3 These two metal producers must be considered with the works at RYR 03, which revealed girders made by Craven Bros in Manchester. As such, works by Pre-Construct Archaeology Ltd. to date have found at least three different manufacturer's supplying the Arsenal from three different iron and steel production centres. This may have implications on a number of things: the quality of work required; the urgency of supply required, perhaps affected by the military requirements of Britain in the 20th century; the varying tasks of the metalwork perhaps relating to various specialisms of the production centres; or perhaps just simply a matter of price.

9.3.1.4 The remains of the Boiler House and Rolling Mill revealed a variety of brick manufacturer's from locations ranging from Scotland to the North-East, to Worcestershire, Staffordshire and Devon. The same reasons for the variety in metalwork sources could be attributed to the bricks as well; however it was striking to see very little specific distribution of the brickwork in elements of the Boiler House, which negates the idea that the bricks were used based on quality, purpose or price. It appears as if the masons used whichever fireclay bricks were to hand, which might suggest that the buildings were constructed as a matter of urgency rather than specialism. Again, given the nature of production at the Arsenal, combined with the expansion of Britain's military and her engagements in the late 19th and early 20th centuries, this is cogent. Yet it may also be the case that due to the massive size and expansion of the Arsenal at these times, materials for construction were purchased *en masse*, and that these were stockpiled to be used as necessary, leading to such variations in brick origins. To a lesser extent, the same may be true for the steel and iron remains as well.

9.3.2 What implications do the results of the Phase 3a and Phase 4 works have on the work at RYR 03?

9.3.2.1 A reinterpretation of some conclusions from the work at RYR 03 must be made in light of the work at Site 2. A number of timber and iron remains from the former site were tentatively phased⁸⁰ as being part of the timber seasoning field which occupied parts of Zones 17, 21, 22 and 23. However ground reduction within the NFP in Site 2 revealed layers of mulch-like deposits that could be consistent with the storage and processing of timber. These layers were found at substantially lower heights than the remains at RYR 03, and therefore those remains may have been from an ephemeral and unmapped 19th century structure.

9.3.2.2 The work by Pre-Construct Archaeology Ltd. in Zones 17, 21, 22 and 23 has covered an area of approximately 32,650m² around the South Forge, Boiler House and Rolling

⁷⁵ <http://myweb.tiscali.co.uk/> 1;

⁷⁶ Hogg 1963, 817

⁷⁷ <http://www.blackcountriesociety.co.uk/> 2;

⁷⁸ <http://www.blackcountriesociety.co.uk/> 1;

⁷⁹ <http://www.blackcountriesociety.co.uk/> 2;

⁸⁰ Mayo 2004a, 27: the remains were interpreted as Phase 5.

Mill, and the South Boring Mill. The complete groundplans of all of these structures have been exposed (in combination with the work by OA beneath Armstrong Road) revealing minute and complex details of their construction, use and demise.

- 9.3.2.3 An extension to the main exhaust flue that separated the Boiler House and Rolling Mill in Site 2 lines up precisely with an extension to the main flue at the western end of the Boiler House in RYR 03. It is highly likely that the two remains are the same flue that was built to increase the circulation of air around the Boiler House. A speculated conclusion has been drawn above (see 9.1.6.1) about the re-use of heat from the furnaces in the Rolling Mill into the Boiler House to produce the steam. However it seems more likely that this heat-production happened elsewhere, and given the lack of evidence for this on Site 2 and RYR 03 it must have happened to the north of the sites (or in the area beneath Armstrong Road).
- 9.3.2.4 The South Boring Mill has been seen archaeologically to measure approximately 93.0m east-west by 104.0m north-south. The dates provided by Hogg for the construction of the various Bays have proved invaluable in the phasing of these remains at Site 2 and also, now, for the works at RYR 03. In that area it was impossible from the remains to differentiate between the northern and southern halves of the Bays and the southern ends as documented by Hogg, largely because the western side of the structure was a straight edge. The diagnostic eastern edge now revealed at Site 2 has allowed confident comparison with historical maps so that the components of the Bays across the entire mill can be identified.
- 9.3.2.5 Within the South Boring Mill differences were seen between the remains at Site 2 and at RYR 03. At the latter site, lathe beds and associated drive mechanisms were found to survive *in situ*, where as at Site 2 only two lathe beds survived within Bay 5. Those in Bay 6 had been stripped leaving only foundation girders to allow the installation of concrete slabs. That this happened in the east of the South Boring Mill and not the west suggests that the building was downsized to respond to lower production requirements.
- 9.3.2.6 A set of bogie tracks found in the SFP at Site 2 is accurately identifiable from a map of 1960. From the same map a set of tracks found in RYR 03 can now be seen to be the same set.
- 9.3.3 Has the work at Sites 1 and 2 affected the conclusions made following the evaluations at the same sites?**
- 9.3.3.1 These large-scale investigations at Sites 1 and 2 followed evaluations⁸¹ by Pre-Construct Archaeology Ltd. A number of interpretations based on the results of the evaluations now need to be reassessed.
- 9.3.3.2 The complete lack of structural remains found in Trench 1 at Site 2, despite the position of the trench within the Rolling Mill and Building D72, was most likely caused by the internal clearing of the mill to accommodate the coiling machine and quenching tank.
- 9.3.3.3 The remains found within Trench 5 at Site 2, which were interpreted as being part of Building D72, were seen during work within the NFP to be merely service runs.
- 9.3.3.4 The remains found at the western end of Trench 6 in Site 2, interpreted as being structural, have now been seen to be service runs.
- 9.3.3.5 Two concrete footings found in Trench 7 in Site 2 were positioned immediately to the east of the coiling machine as seen in the NFP, and as such were part of the foundations of that installation.

⁸¹ Mayo 2004b & c

9.3.4 How do the results of the investigations by Pre-Construct Archaeology Ltd. compare with other archaeological work in the vicinity?

- 9.3.4.1 The work at Site 1 has almost completed the archaeological assessment of Zone 17, the majority of which was undertaken by OA. The walls found at Site 1 were part of the Cartridge Establishment, comprising a range of buildings aligned roughly east-west, and fitting with others found by OA.
- 9.3.4.2 The work by Pre-Construct Archaeology Ltd. at RYR03 and Site 2 is bisected by an archaeological assessment undertaken by OA during the construction of Armstrong Road. That work found the continuation of two lathe beds in Bay 5 exposed at Site 2. With the total plan of these now recorded, they can be seen to stretch through all of Bay 5. Bay 5 is particularly important when assessing the South Boring Mill, for it is the only full-length bay in the mill within which intact lathe remains have been found. Lathe beds were only found in the northern halves of Bays 3 and 4, whilst none were found in Bays 1 and 2; Bay 6 was a shorter building than the rest. Hence Bay 5 provides the only complete long specimen of structure and *in situ* machinery in the whole mill.
- 9.3.4.3 Further archaeological work may reveal more of Building C47 to the east of Site 2 and Street N^o 10 to the northeast.

9.3.5 To what extent can the historical maps of the Arsenal assist in the archaeological interpretation?

- 9.3.5.1 The phasing and interpretation of the archaeological remains at Site 2, and to a lesser extent Site 1, has only been made possible by use of numerous historical maps of the Arsenal. The risks in using such sources are clear: the inaccuracies of the maps; the non-continual coverage provided; the likelihood of misleading features due to the military necessity of secrecy; the potential subjectivity of them. However, the analysis of the remains at Site 2, as with those from RYR 03, has shown that cartographic evidence can be used safely. The archaeological evidence, used in conjunction with historical maps and documentary sources, has been used to convincingly phase elements of the Boiler House and Rolling Mill, and their successors, and the South Boring Mill, in a way that the physical remains alone might not. This is due to the fact that the remains have been constructed over very narrow periods of time, using similar techniques and materials, and serving similar purposes. Also, the necessary fieldwork methodology employed at Site 2, relying heavily on mechanical excavators due to the nature of the remains and the size of the site, prevented the subtle distinction of stratigraphic relationships that are normally retrieved from archaeological sites with 'soft' features. That such a fieldwork methodology can be employed on an industrial site such as the Arsenal resulting in detailed conclusions and phasing is testament to the usefulness of the historical maps and their role in the interpretations presented here.

10 CONTENTS OF THE ARCHIVE

10.1 SITE 1 (RYG 04)

10.1.1 PAPER ARCHIVE

Type		Number
Records	Context sheets	24
	Plan sheets	12
	Section sheets	2
Photographs	Colour prints (medium format)	0
	Colour slides (35mm)	15
	Black and White prints (medium format)	0
	Black and White prints (35mm)	15

10.1.2 ARTEFACTS

Type	Number
Pottery	3 objects
Ceramic building material	2 boxes
Small Finds	1 object
Lead	1 box

10.2 SITE 2 (RYW 04)

10.2.1 PAPER ARCHIVE

Type		Number
Records	Context sheets	516
	Plan sheets	53
	Section sheets	19
Photographs	Colour prints (medium format)	45
	Colour slides (35mm)	546
	Black and White prints (medium format)	45
	Black and White prints (35mm)	546

10.2.2 ARTEFACTS

Type	Number
Pottery	2 objects
Clay Tobacco Pipe	1 box
Ceramic building material	33 boxes (est.)
Stone	1 box
Mortar	1 box
Small Finds	9 objects
Iron	3 crates (est.)
Cu alloy	1 crate (est.)

11 IMPORTANCE OF THE RESULTS AND PUBLICATION OUTLINE

11.1 IMPORTANCE OF THE RESULTS

- 11.1.1 The investigation by Pre-Construct Archaeology Ltd. at Sites 1 and 2 has deposits and structural remains providing information about their industrial and military history.
- 11.1.2 At Sites 1 and 2 the natural sequence has suggested that the edge of the gravel terrace may actually be aligned northeast to southwest, sloping down rapidly towards the northwest and the current route of the Thames. These lower areas are filled with riverine deposits of alluvial sand, clay and peat - evidence of the marshland environment of the area until its reclamation in the post-medieval period.
- 11.1.3 At Site 1 a residual piece of pottery has suggested the presence of Romano-British activity at the edge of the gravel terrace, especially when considered with the remains of a Roman cemetery to the west beneath Dial Square.
- 11.1.4 Substantial deposits of made ground complement those found during works at RYR 03 to the west, part of a massive process of ground reclamation and consolidation. The discovery of pieces of timber from naval gun carriages and of two cannon has provided information on the 18th and early 19th century output and undertakings of the Arsenal.
- 11.1.5 The discovery of deposits that may be attributable to the use of Site 2 as a timber seasoning field reveal the potential ground height of the area in the first half of the 19th century.
- 11.1.6 Further walls of the Cartridge Establishment have been recorded at Site 1, thereby expanding the known position of this building.
- 11.1.7 Widespread remains of the Boiler House and Rolling Mill were found in Site 1, built in the 1870s. The association of the Boiler House with the South Forge found at RYR 03 has been further established; the connection of the Rolling Mill with them by a series of flues is suggested. The striking survival of the Boiler House remains has allowed conclusions to be made regarding its construction and precise use. The original Rolling Mill was only internally attested at its western end, but again the remains have provided detailed information on its construction and use. The variety of brick manufacturer's represented within the remains have allowed the provenance of the materials to be researched.
- 11.1.8 Combined with previous work by Pre-Construct Archaeology Ltd. and OA the full extent of the South Boring Mill and various outbuildings, including Building D80, has now been exposed. The superstructure and its dimensions have been identified, and internal machinery remains have been recorded. With the watching brief at RYR 03, at least three manufacturer's of metalwork within the mill have been identified. Extensive evidence has been found for the external arrangements of the mill, including bogie tracks and cobbled surfaces. The bogie tracks in particular can be traced from historical maps. Evidence for the change in use of the South Boring Mill, from machine shop to storage, has been seen.
- 11.1.9 The Boiler House and Rolling Mill were altered in the 1910s, probably with the demise of the 35-ton steam hammer, to become Buildings D71, D72 and D74. It seems that at this stage only Building D72, with a function different from that of the Rolling Mill, necessitated an overhaul of the internal elements. New machinery, representing technological advancement, was installed, replacing the old flues and furnaces but also incorporating retained features that were still workable. By the 1930s Building D71 - developed from the Boiler House - had been demolished leaving Buildings D72 and D74 as a freestanding structure.

- 11.1.10 A sub-station, Building C47, was built at the eastern side of Site 2 by 1917. The numerous cables found in association with this structure are important evidence for the electrification of manufacturing processes in the Arsenal.
- 11.1.11 Remains of the post-World War II Street N^o 10 were found traversing Site 2, but very little of its earlier manifestations had survived. Bogie tracks at the north end of Site 2 were built into the road, in the manner of tram-tracks.
- 11.1.12 The investigations have revealed that the transmission of power to the South Boring Mill occurred at either ceiling or roof level. Numerous services were found at Site 2 but these could not usually be connected to the structures on site and were mainly drains.
- 11.1.13 Little in the way of artefactual material was recovered from Sites 1 and 2. A number of pieces of unstratified metalwork were hand-tools or scrap metal. A clay tobacco pipe bowl, bearing the inscription of the Inniskilling Royal Fusiliers who fought 19th century campaigns in Egypt and made locally in Plumstead, was noteworthy.
- 11.1.14 As was the case with the assessment of work at RYR 03, this report has relied heavily on cartographic evidence and documentary sources to phase the results. Considering the risks of using such data, it has proven to be a useful and reliable method of interpreting archaeological remains of similar types and with similar date ranges.

11.2 PUBLICATION OUTLINE

- 11.2.1 It is planned that the Phase 2, 3a and 4 works of the IO Group development at the Arsenal will initially be published as a Pre-Construct Archaeology Ltd. monograph. Such a document will incorporate the history of the Arsenal in relation to Zones 17, 21, 22 and 23, and present the archaeological results assessed in this and other volumes⁸².
- 11.2.2 The works by Pre-Construct Archaeology Ltd. in Zone 22 and Zones 21 and 23 have been bisected by archaeological investigations by OA beneath Armstrong Road. The same company have also completed a number of evaluation trenches within the areas of the three sites, as well as monitoring the remediation of the Radial Crane base in RYR03. The data from these works would be ideally incorporated into this monograph to allow the publication of all the remains from the sites, particularly of the South Boring Mill and the Boiler House, in their entirety.
- 11.2.3 For the publication stage, further research of historical maps covering this area of the Arsenal will need to be undertaken to cover as much of the sites as possible, both geographically and historically. A great deal more documentary research will also be necessary, including studies of archive material at the Public Record Office and the Royal Arsenal and Woolwich Historical Society. Further work will also be necessary on the artefactual remains recovered, particularly a graphite mould, parts of timber gun carriages and the cannons from made ground deposits. Extended research into the metal and brick manufacturer's will also be required.
- 11.2.4 It is also intended that a monograph will be produced covering all of the regeneration in the Arsenal. The publication is likely to include contributions from all of the archaeological contractors who have worked at the Arsenal. The plans for this are currently being developed⁸³.

⁸² Mayo 2004a, b & c

⁸³ Stevenson 2004

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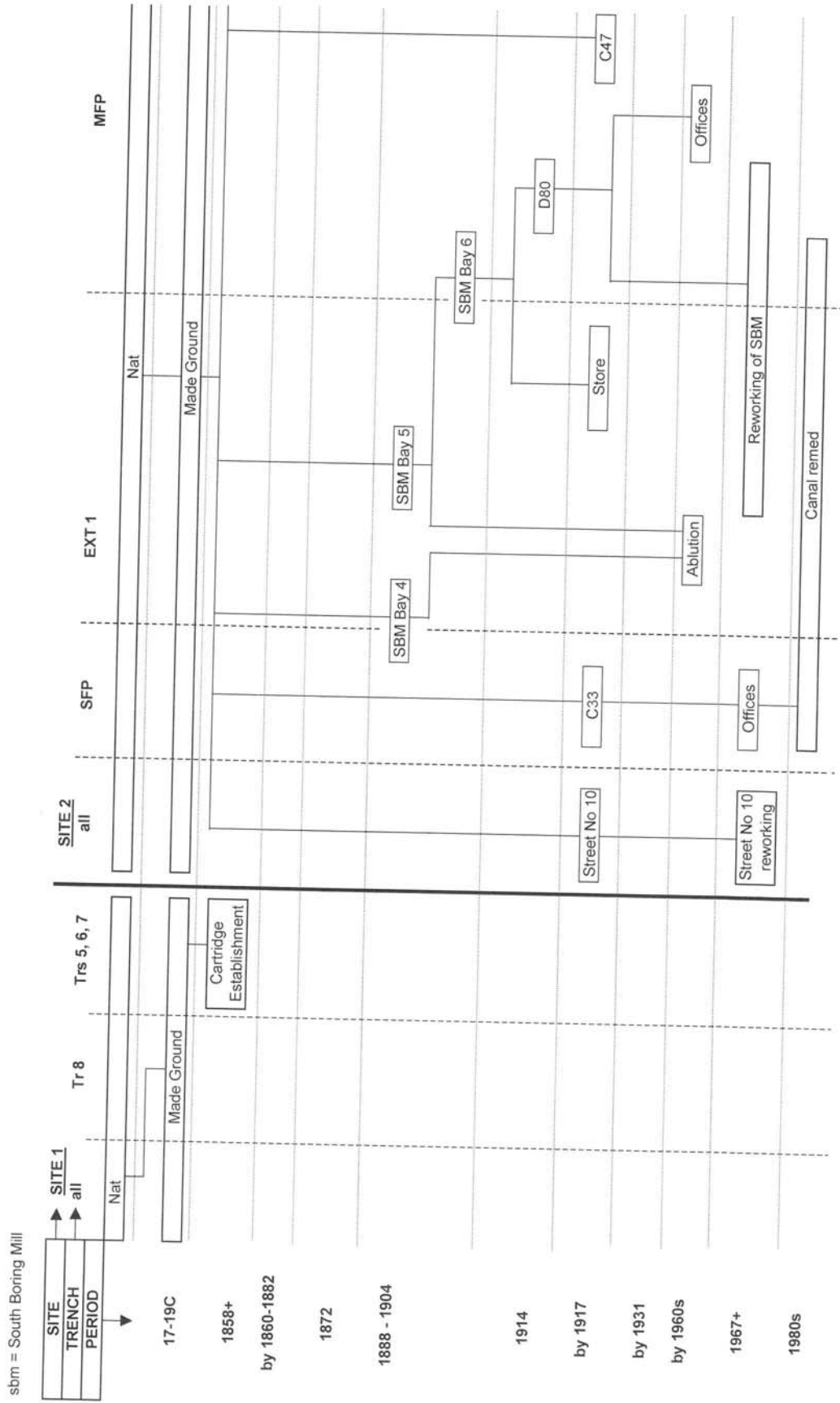
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APPENDIX 1: SITES 1 AND 2 LAND-USE DIAGRAM

	Struc / Gr Number	Date	Phase	Sub-phase
SITE 1				
Natural			1	
Made ground		17-19c	2	
Cartridge Establishment		by 1858	3	

SITE 2				
Natural	498		1	
Made ground	497	17-19c	2	
Timber Field		by 1860 - 1882	3	
Boiler House	238	1872	4	1
Rolling Mill	239	1872	4	2
South Boring Mill Bays 4, 5 & 6	235	1888 - 1904	5	
Building D80	241	1914	6	
Street No 10	496?	by 1917 ?	7?	1
Buildings D71, D72, D74		by 1917	7	2
Store		by 1917	7	3
Building C47	237	by 1917	7	4
Dining Room C33	501	by 1917	7	5
Building D72, D74	240	by 1931	8	
South Boring Mill Offices	495	by 1960s	9	1
Ablution		by 1960s	9	2
Reworking of South Boring Mill	236	1967 + ?	10	1
Street No 10 reworking	496?	1967 +	10	2
Petrol Station	492	1967 +	10	3
Offices		1967 +	10	4
Canal remediation		1980s	11	
External	499			

APPENDIX 2: SITES 1 AND 2 PHASED SEQUENCE



APPENDIX 3: SITE 1 (RYG 04) CONTEXT INDEX

Context	Struc / Group	Type	Trench	Description	Plan / Dwg	Sect	SF	CBM	Same as	Phase
60	84	masonry	5	wall	tr 5				61?	3
61	84	masonry	5 & 7	wall	61	11			60?	3
62		masonry	4	manhole?	tr 4					?
63		fill	4	demo backfill of 62	tr 4					?
64		surface	4	compact chalk	tr 4	1				?
65		natural	all	terrace gravel	tr 4					?
66		fill	4	fill of 67					eval 47 & 54	1
67		cut	4	construction cut for 62	tr 4					?
68	84	fill	5	fill of 69	tr 4				71?	?
69	84	cut	5	construction cut for 61	61	11				3
70		fill	4	fill of 71	61	11				3
71		cut	4	construction cut for services ass with 62	tr 4					?
72		layer	4	made ground	tr 4					?
73		fill	8	fill of 74	tr 4					2
74		cut	8	pit (or ditch)	74	12				3
75	84	cut	5	construction cut for 60	60	12				3
76		layer	6	made ground	tr 6					3
77	84	fill	6	fill of 79	tr 6					2
78	84	masonry	6	wall	tr 6					3
79	84	cut	6	construction cut for 78	tr 6		y		83?	3
80		natural	6	sand	tr 6					3
81		fill	6	fill of 82	tr 6					1
82		cut	6	pit?	tr 6					?
83	84	masonry	6	wall or collapsed wall	tr 6					?
84	*	structure	*	cartridge establishment	tr 6				78?	3

APPENDIX 4: SITE 2 (RYW 04) CONTEXT INDEX

Context	Struc / Group	Type	Area	Description	Plan / Dwg	Sect	SF	CBM	Same as	Phase
100	235	ext metal	SFP	bogey tracks	cad					5
101	235	ext metal	SFP	bogey tracks	cad					5
102	235	ext surface	SFP	cobbled surface	cad					5
103	235	ext surface	SFP	cobbled surface	cad					5
104	235	ext surface	SFP	cobbled surface	cad					5
105	499	concrete	SFP	surface	cad					5
106	235	ext surface	SFP	cobbled surface	cad					no
107	235	ext metal	SFP	bogey tracks	cad					5
108	496	concrete	SFP	pavement	cad				poss 325 (ph 2)	5
109	496	surface	SFP	pavement	cad					10.2
110	496	concrete	SFP	road	cad					10.2
111	496	metal	EXT 1 & SFP	manholes in 110	cad					10.2
112	496	concrete	EXT 1 & SFP	concrete w metal fittings	cad					10.2
113	496	concrete	SFP	service cover	cad					10.2
114	235	ext concrete	SFP	slab w iron girders	cad					10.2
115	235	ext concrete	EXT 1 & SFP	concrete w metal fittings	cad					5
116	496	? surface	EXT 1	cobbled surface	cad					5
117	235	ext surface	EXT 1	cobbled surface	cad					7.1
118	235	ext concrete	EXT 1	manhole in 117	cad					5
119	235	metal	EXT 1 & SFP	stanchion bases	cad					5
120	ablution	surface	EXT 1	internal floor?	cad					5
121	235	metal	EXT 1 & SFP	girder / fitting	cad					9.2
122	236	concrete	EXT 1 & SFP	floor slab	cad					5
123	235	metal	EXT 1 & SFP	stanchion base	cad				136	10
124	235	masonry	EXT 1	E-W wall	cad					5
125	235	ext timber	EXT 1	telegraph posts	cad					5
126	235	ext concrete	SFP	conc slab and manhole	cad					5
127	store	concrete	SFP	conc slab and manhole	cad					5
128	store	concrete	EXT 1	girder settings	cad					7.3
129	235	ext metal	EXT 1	manhole	cad					7.3
130	235	? concrete	EXT 1	girder settings	cad					5
131	235	? metal	EXT 1 & MFP	girder settings	cad					5
		? metal	MFP	stanchion base	cad					5

Context	Struc / Group	Type	Area	Description	Plan / Dwg	Sect	SF	CBM	Same as	Phase
132	499	concrete	EXT 2	kerbline and slab	cad					no
133	241	metal	EXT 2 & MFP	girder settings	cad					6
134	241	metal	EXT 2	door rail?	cad					6
135	235	metal	EXT 2	stanchion base	cad					5
136	236	concrete	EXT 2 & MFP	floor slab	cad				122	10
137	495	concrete	MFP	floor slab	cad					10.4
138	236	concrete	MFP	ramp from 136 to 139	cad					10.1
139	236	concrete	EXT 2 & MFP	floor slab	cad					10.1
140	241	metal	MFP	machine fixing	cad					6
141	241	masonry	EXT 2 & MFP	brick wall	cad					6
142	500	concrete	MFP	wall footing	cad					no
143	496	surface	MFP	road surface	cad					7.1
144	496	concrete	MFP	makeup for 110	cad					10.2
145	500	masonry	SFP	brick culvert	cad					no
146	235	concrete	SFP	footing and pier bases	cad					5
147	499	concrete	SFP	signpost bases?	cad					no
148	499	concrete	SFP	strip footing	cad					no
149	235	timber	SFP	pile below 146	cad					5
150	500	metal	SFP	pipe	cad					no
151	499	concrete	SFP	pier base	cad					no
152	235	concrete	SFP	pier base	cad					no
153	500	concrete	SFP	pier base	cad					5
154	501	concrete	SFP	footing	cad					no
155	501	masonry	SFP	masonry	cad					7.5
156	canal	cut	SFP, MFP, EXT 1	canal remediation	cad				22 eval	7.5
157	offices	concrete	SFP	piles	cad				11 eval	11
158	500	timber	SFP	service duct	cad					10.4
159	237	masonry	MFP	brick and concrete wall	cad					no
160	237	masonry	MFP	floor slab	cad					7.4
161	237	masonry	MFP	floor slab	cad					7.4
162	237	metal	MFP	girder settings	cad					7.4
163	237	metal	MFP	girder	cad				14? Eval	7.4
164	237	concrete	MFP	service duct or flue?	cad					7.4
165	237	concrete	MFP	service duct	cad					7.4

Context	Struc / Group	Type	Area	Description	Plan / Dwg	Sect	SF	CBM	Same as	Phase
166	237	masonry	MFP	manhole	cad					7.4
167	237	concrete	MFP	pipe duct	cad					7.4
168	237	concrete	MFP	service duct	cad					7.4
169	500	concrete	MFP	service duct	cad					no
170	canal	? timber	MFP	disturbed revetting, poss from canal	cad	11				2
171	241	metal	MFP	bogey tracks?	cad					6
172	241	metal	MFP	bogey tracks?	cad					6
173	241	metal	MFP	base plate for 171 and 172	cad					6
174	241	metal	MFP	bogey tracks?	cad					6
175	241	metal	MFP	bogey tracks?	cad					6
176	241	metal	MFP	base plate for 174 and 175	cad					6
177	241	concrete	MFP	floor slab	cad					6
178	235	metal	MFP	girders for lathe bed	cad					5
179	235	metal	MFP	girders for lathe bed	cad					5
180	235	metal	MFP	girders for lathe bed	cad					5
181	235	metal	MFP	girders for lathe bed	cad					5
182	235	metal	MFP	girders for lathe bed	cad					5
183	235	metal	MFP	girders for lathe bed	cad					5
184	236	concrete	MFP	tank	cad					10
185	235	concrete	MFP	pier bases	cad					5
186	235	ext masonry	MFP	poss manhole	cad					5
187	235	? masonry	MFP	manhole	cad					5
188	235	concrete	MFP	floor slab	cad					5
189	236	? concrete	MFP	footing?	cad					10
190	235	concrete	MFP	pier base	cad					5
191	235	ext concrete	MFP	pier bases	cad					5
192	235	? concrete	MFP	pier base	cad					5
193	241	surface	MFP	concrete slab	cad					6
194	235	metal	MFP	machine fixing	cad					5
195	241	concrete	MFP	pier base	cad					6
196	241	metal	MFP	machine fixing	cad					6
197	235	? masonry	MFP	wall	cad					5
198	235	concrete	MFP	floor slab	cad					5
199	235	? metal	MFP	pier bases	cad					5

Context	Struc / Group	Type	Area	Description	Plan / Dwg	Sect	SF	CBM	Same as	Phase
200	235	surface	MFP	floor slab	cad				291	5
201	235	? masonry	MFP	wall	cad					5
202	235	? surface	MFP	concrete slab with shaft	cad					5
203	241	concrete	MFP	pier base	cad					5
204	236	? masonry	MFP	wall	cad					6
205	236	? concrete	MFP	floor slab	cad					10
206	235	masonry	MFP	wall	cad					10
207	235	masonry	MFP	wall	cad					5
208	235	? concrete	MFP	floor slab	cad					5
209	235	? metal	MFP	machine fixing	cad					5
210	497	layer	MFP	redep alluvial clay	cad				132 (ph 2)	5
211	canal	? concrete	MFP	conc assoc'd with 170		11	1, 2			5
212	497	layer	MFP	made ground		11				2
213	497	layer	MFP	made ground		11				2
214	235	? concrete	MFP	made ground		11				2
215	235	? metal	MFP	pier base		11				2
216	235	masonry	MFP	machine base	cad					5
217	235	concrete	MFP	manhole	cad					5
218	235	ext concrete	MFP	pier base	cad					5
219	235	ext masonry	MFP	pier base	cad					5
220	235	ext masonry	MFP	pipe duct	cad					5
221	235	ext metal	MFP	manhole	cad					5
222	235	ext masonry	MFP	sluice	cad					5
223	*	* timber	MFP	manhole	cad					5
224	235	ext metal	MFP	rear axle tree	cad					no
225	235	ext metal	MFP	quench / storage tank	cad					5
226	235	ext masonry	MFP	quench / storage tank	cad					5
227	235	ext concrete	MFP	footing	cad					5
228	*	* metal	MFP	surround for 224 / 225	cad					5
229	235	metal	MFP	plate	cad					no
230	235	concrete	MFP	manhole	cad					5
231	235	concrete	MFP	service casing?	cad					5
232	235	ext masonry	MFP	floor slab	cad					5
233	235	concrete	MFP	manhole	cad					5
				footing	cad					5

Context	Struc / Group	Type	Area	Description	Plan / Dwg	Sect	SF	CBM	Same as	Phase
234	241	metal	MFP	pipe or rail	cad					6
235	*	structure	MFP	South Boring Mill					835 (RYR03)	5
236	*	structure	MFP	reworking of 235						10.1
237	*	structure	MFP	Building C47						7.4
238	*	structure	NFP	Boiler House					530 (RYR03)	4.1
239	*	structure	NFP	Rolling Mill						4.2
240	*	structure	NFP	Building D72 / D74						8
241	*	structure	MFP	Building D80						6
242	?	metal	NFP	cast iron tank	cad				409	7.2
243	235	concrete	MFP	footing	cad					5
244	?	layer	NFP	demolition rubble				y		no
245	*	VOID	*	*	*	*	*	*	*	*
246	238	masonry	NFP	moulded bricks as pipe carriers	cad					4.1
247	238	masonry	NFP	pier base	cad					4.1
248	238	metal	NFP	plate	cad					4.1
249	238	masonry	NFP	flue base	cad					4.1
250	238	masonry	NFP	pier base	cad					4.1
251	238	masonry	NFP	flue base	cad					4.1
252	238	masonry	NFP	pier base	cad					4.1
253	238	masonry	NFP	flue base	289					4.1
254	238	masonry	NFP	pier base	289					4.1
255	238	masonry	NFP	flue base	289					4.1
256	238	masonry	NFP	pier base	cad					4.1
257	238	masonry	NFP	flue base	cad					4.1
258	238	masonry	NFP	pier base	cad					4.1
259	238	masonry	NFP	flue base	cad					4.1
260	238	masonry	NFP	pier base	cad					4.1
261	238	masonry	NFP	flue base	cad					4.1
262	238	masonry	NFP	pier base	cad					4.1
263	238	masonry	NFP	flue base	cad					4.1
264	238	masonry	NFP	pier base	cad					4.1
265	238	masonry	NFP	flue base	cad					4.1
266	238	masonry	NFP	pier base	cad					4.1
267	238	masonry	NFP	flue base	cad					4.1

Context	Struc / Group	Type	Area	Description	Plan / Dwg	Sect	SF	CBM	Same as	Phase
268	238	masonry	NFP	pier base	cad					4.1
269	*	fill	NFP	fill of 270	cad					10.3
270	492	cut	NFP	cuts for poss footings of 492	cad					10.3
271	492	concrete	NFP	pier bases	cad					10.3
272	492	concrete	NFP	concrete tanks for 492	cad					10.3
273	238	metal	NFP	louvres for flues	289			y		4.1
274	238	masonry	NFP	lintels over 274	289					4.1
275	238	masonry	NFP	arched flues	cad					4.1
276	238	masonry	NFP	N-S flue	cad					4.1
277	492	concrete	NFP	pier base?	cad					10.3
278	?	timber	MFP	pile	cad					7.4
279	?	timber	MFP	pile	cad					7.4
280	?	timber	MFP	pile	cad					7.4
281	239	metal	NFP	stanchion bases	cad					7.4
282	492	metal	NFP	pipe	cad, 281					4.2
283	239	metal	NFP	unknown	cad					10.3
284	?	metal	NFP	stanchion bases	cad					4.2
285	?	concrete	NFP	footing	cad					no
286	239	masonry	NFP	wall	cad					no
287	?	concrete	NFP	pier base?	cad					4.2
288	238	masonry	NFP	arched flues	cad					no
289	238	masonry	NFP	arched flues	289					4.1
290	238	masonry	NFP	arched flues	cad					4.1
291	235	concrete	MFP	floor slab	cad	12			200	4.1
292	497	layer	MFP	made ground		12				5
293	497	layer	MFP	made ground		12				2
294	497	layer	MFP	made ground		12				2
295	497	layer	MFP	made ground		12				2
296	497	layer	MFP	made ground		12				2
297	492	fill	NFP	fill of 298		12				2
298	492	cut	NFP	unknown						10.3
299	238	masonry	NFP	arched flues	cad					10.3
300	238	masonry	NFP	arched flues	cad					4.1
301	238	masonry	NFP	arched flues	cad					4.1

Context	Struc / Group	Type	Area	Description	Plan / Dwg	Sect	SF	CBM	Same as	Phase
302	492	? concrete	NFP	slab	cad					10.3
303	238	masonry	NFP	arched flues	cad					4.1
304	238	masonry	NFP	arched flues	cad			y		4.1
305	238	masonry	NFP	flue	cad			y		4.1
306	238	masonry	NFP	pier base	cad					4.1
307	238	masonry	NFP	flue	cad			y		4.1
308	238	masonry	NFP	pier base	cad			y		4.1
309	238	? ceramic	NFP	pipe	cad					4.1
310	238	? layer	NFP	surface	cad					4.1
311	238	? metal	NFP	possible tank	cad					4.1
312	238	? masonry	NFP	manhole	cad					4.1
313	238	? metal	NFP	pipe run?	cad					4.1
314	238	? metal	NFP	plate	cad					4.1
315	492	fill	NFP	fill of 316	cad					4.1
316	492	masonry	NFP	service duct	cad					10.3
317	?	? fill	NFP	fill of 318	cad					10.3
318	?	? cut	NFP	unknown	cad					no
319	238	? masonry	NFP	manhole?	cad					no
320	238	? masonry	NFP	flue built onto 276	cad				267 (RYR03)	4.1
321	?	? fill	NFP	fill of 322	cad					4.1
322	?	? cut	NFP	unknown	cad					no
323	238	masonry	NFP	flue	cad					no
324	238	metal	NFP	braces in 323	cad			y		4.1
325	238	metal	NFP	doors in flue 323	cad					4.1
326	492	? metal	NFP	stanchion bases	cad					4.1
327	238	? concrete	NFP	slab	cad					10.3
328	492	? concrete	NFP	slab	cad					4.1
329	492	? concrete	NFP	slab	cad					10.3
330	?	? masonry	NFP	possible flue	cad					no
331	239	? concrete	NFP	slab	cad					4.2
332	239	masonry	NFP	furnace	cad			y		4.2
333	239	? concrete	NFP	slab	cad					4.2
334	239	concrete	NFP	slabs	cad					4.2
335	?	? fill	NFP	fill of 336	cad					no

Context	Struc / Group	Type	Area	Description	Plan / Dwg	Sect SF	CBM	Same as	Phase
336	?	?	NFP	robbed footings?	cad				no
337	239	masonry	NFP	furnace	cad				4.2
338	239	masonry	NFP	furnace	cad				4.2
339	239	masonry	NFP	base of furnace?	cad		y		4.2
340	500	concrete	NFP	pipe duct	cad				4.2
341	239	masonry	NFP	stepped flue	cad				no
342	?	concrete	NFP	pier base	cad		y		4.2
343	239	masonry	NFP	pier base	cad				no
344	492	concrete	NFP	footing	cad		y		4.2
345	492	concrete	NFP	pier base	cad				10.3
346	239	masonry	NFP	pier base	cad				10.3
347	239	ceramic	NFP	pipe	cad				4.2
348	239	masonry	NFP	walls around 347	cad				4.2
349	239	masonry	NFP	wall	cad				4.2
350	492	concrete	NFP	footing	cad				4.2
351	500	masonry	NFP	wall	cad				10.3
352	500	masonry	NFP	wall	cad				no
353	492	concrete	NFP	pier base	cad				no
354	239	masonry	NFP	base of flue	cad				10.3
355	239	masonry	NFP	stanchion bases	cad				4.2
356	239	cut	NFP	unknown	cad		y		4.2
357	239	masonry	NFP	base of furnace	cad				4.2
358	239	masonry	NFP	pier base	cad		y		4.2
359	239	masonry	NFP	base of furnace	cad				4.2
360	239	masonry	NFP	unknown	cad		y		4.2
361	239	masonry	NFP	pier base	cad				4.2
362	?	concrete	NFP	pier base	cad				4.2
363	?	concrete	NFP	footing	cad				no
364	239	masonry	NFP	wall	cad				no
365	239	masonry	NFP	flue into 341	cad				4.2
366	?	concrete	NFP	pier bases	cad				4.2
367	?	concrete	NFP	pier base	cad				no
368	238	masonry	NFP	wall	cad				no
369	239	concrete	NFP	slab	cad				4.1
									4.2

Context	Struc / Group	Type	Area	Description	Plan / Dwg	Sect	SF	CBM	Same as	Phase
370	?	? metal	NFP	slag deposit	cad					no
371	*	* VOID	*	*	*	*	*	*	*	*
372	?	? concrete	NFP	foundation slab	cad					no
373	238	masonry	NFP	wall over flues	cad					4.1
374	499	metal	NFP	bogie tracks	cad					no
375	499	metal	NFP	bogie tracks	cad					no
376	499	metal	NFP	infilled soot trap?	cad					no
377	496	surface	NFP	road	cad					10.2
378	496	surface	NFP	cobbles	cad					10.2
379	499	timber	NFP	sleepers?	cad					no
380	496	masonry	NFP	kerb	cad					10.2
381	496	surface	NFP	tarmac surface	cad					10.2
382	496	surface	NFP	tarmac surface	cad					10.2
383	496	surface	NFP	concrete slab	cad					10.2
384	239	? fill	NFP	infill around 385	cad					10.2
385	239	? masonry	NFP	circular chimney	385			y		4.2
386	239	? masonry	NFP	flue	387					4.2
387	239	? masonry	NFP	square chimney	387			y		4.2
388	239	? masonry	NFP	flue	388					4.2
389	239	? layer	NFP	base slab	387					4.2
390	496	surface	NFP	tarmac surface	cad					10.2
391	496	surface	NFP	tarmac surface	cad					10.2
392	496	surface	NFP	tarmac surface	cad					10.2
393	496	surface	NFP	cobbles	cad					10.2
394	496	surface	NFP	concrete slab	cad					10.2
395	239	? metal	NFP	plate	cad					10.2
396	239	? concrete	NFP	slab with 395	387					4.2
397	239	? masonry	NFP	early chimney?	387					4.2
398	239	? metal	NFP	hammer base	397					4.2
399	239	? timber	NFP	lining to 398	398, cad					4.2
400	240	? concrete	NFP	machine base	399					4.2
401	240	? metal	NFP	machine base	cad					4.2
402	240	? masonry	NFP	wall	401					4.2
403	240	? metal	NFP	base of coiling flywheel pit	403			7		4.2

Context	Struc / Group	Type	Area	Description	Plan / Dwg	Sect	SF	CBM	Same as	Phase
404	240	? metal	NFP	fixing pins	cad					4.2
405	240	? concrete	NFP	pier base?	cad					4.2
406	239	? concrete	NFP	machine base	cad					4.2
407	?	? concrete	NFP	pier base	cad					no
408	239	? masonry	NFP	manhole	cad					4.2
409	240	? metal	NFP	quench tank	409, cad				242	7.2
410	240	? concrete	NFP	pier base	cad					4.2
411	240	? metal	NFP	pins in 410	cad					4.2
412	240	? concrete	NFP	pier base	cad					4.2
413	240	? metal	NFP	pins in 412	cad					4.2
414	239	? masonry	NFP	wall of furnace	414					4.2
415	239	? masonry	NFP	buttresses in 415?	414					4.2
416	239	? masonry	NFP	angled wall in 414	414		y			4.2
417	239	? metal	NFP	furnace	414					4.2
418	?	? concrete	NFP	pier base	cad					no
419	500	? metal	NFP	pipe	cad					no
420	?	? concrete	NFP	slab?	cad					no
421	500	? masonry	NFP	pier base	cad					no
422	?	? concrete	NFP	pier base	cad					no
423	500	? masonry	NFP	manhole and drain	cad					no
424	?	? concrete	NFP	pier base?	cad					no
425	?	? concrete	NFP	pier base?	cad					no
426	239	masonry	NFP	flue remains	cad					no
427	239	concrete	NFP	pier base	cad					4.2
428	239	concrete	NFP	pier base	cad					4.2
429	239	? metal	NFP	stanchion bases	cad					4.2
430	239	? concrete	NFP	pier base	cad					4.2
431	239	masonry	NFP	furnace	cad					4.2
432	239	concrete	NFP	base of 431	cad		y			4.2
433	239	concrete	NFP	base plate in furnace	414					4.2
434	?	? concrete	NFP	pier base	cad					no
435	?	? concrete	NFP	footing	cad					no
436	?	? concrete	NFP	footing	cad					no
437	235	timber	MFP	piles	cad					5

Context	Struc / Group	Type	Area	Description	Plan / Dwg	Sect	SF	CBM	Same as	Phase
438	235	concrete	MFP	piles	cad					5
439	499	metal	NFP	bases of bogie tracks	cad					no
440	239	masonry	NFP	rebuild of 341	414					4.2
441	?	timber	NFP	pile	cad					no
442	?	concrete	NFP	pier base	cad					no
443	?	concrete	NFP	pier base	cad					no
444	?	concrete	NFP	pier base	cad					no
445	?	concrete	NFP	pier base	cad					no
446	238	timber	NFP	piles	cad					4.1
447	239	concrete	NFP	base slab	cad					4.2
448	239	concrete	NFP	machine base	cad					4.2
449	500	metal	NFP	pipe	414, cad					no
450	239	deposit	NFP	burnt stone in furnace 431						4.2
451	?	concrete	NFP	infill of 403	cad, 403					no
452	239	metal	NFP	pipe	cad					4.2
453	238	concrete	NFP	pile caps						4.1
454	239	timber	NFP	piles	cad					4.2
455	241	concrete	MFP	footing and pier base	cad					6
456	?	concrete	MFP	footing	cad					no
457	500	masonry	MFP	tank	cad					no
458	496	surface	MFP	cobbles	cad				30?	7.1
459	241	concrete	MFP	pier base	cad					6
460	235	metal	EXT 1	lathe bed	cad				815 (ph 2)	5
461	*	timber	MFP	group number for carriage parts						2
462	*	timber	MFP	carriage truck						2
463	*	timber	MFP	carriage truck						2
464	*	timber	MFP	carriage truck						2
465	*	timber	MFP	carriage truck						2
466	*	timber	MFP	carriage truck						2
467	*	timber	MFP	carriage truck						2
468	*	timber	MFP	carriage truck						2
469	*	timber	MFP	carriage truck						2
470	235	metal	EXT 1	lathe bed	cad					5
471	235	timber	EXT 1	piles	cad					5

Context	Struc / Group	Type	Area	Description	Plan / Dwg	Sect	SF	CBM	Same as	Phase
472	497	layer	NFP	made ground		14				2
473	497	layer	NFP	made ground		14				2
474	497	layer	NFP	made ground		14				2
475	497	layer	NFP	made ground		14				2
476	497	layer	NFP	made ground		14				2
477	497	layer	NFP	made ground		14				2
478	497	layer	NFP	made ground		14				2
479	497	layer	NFP	made ground		14				2
480	498	natural	MFP	alluvial clay		21				2
481	498	natural	MFP	ballast		21				1
482	498	natural	MFP	alluvial clay		21			505, 508, 510, 512, 515	1
483	498	natural	MFP	peat		21			506	1
484	498	natural	MFP	alluvial sand		21				1
485	498	natural	MFP	ballast		21				1
486	497	layer	SFP	made ground		22				1
487	497	layer	SFP	made ground		22				2
488	497	layer	SFP	made ground		22				2
489	497	layer	SFP	made ground		22				2
490	497	layer	SFP	made ground		22				2
491	497	layer	SFP	made ground		22				2
492	*	structure	NFP	petrol station						2
493	239	? timber	NFP	piles						10.3
494	238	concrete	NFP	foundation slab		493				4.2
495	*	structure	NFP	offices against 235						4.1
496	*	group	MFP	group no for street no. 10						9.1
497	*	group	SFP, MFP, NFP, EXT 1	group no for made gnd deposits						no
498	*	group	all	group no for natural deposits						2
499	*	group	all	group no for natural deposits						1
500	*	group	all	group no for misc external features						no
501	*	structure	all	group no for misc services						no
502	497	layer	SFP	Dining Room / bng C33						7.5
503	497	layer	NFP	made ground						2
504	497	layer	NFP	made ground						2
505	498	natural	NFP	made ground					482, 508, 510, 512, 515	2
			NFP	alluvial clay						1

Context	Struc / Group	Type	Area	Description	Plan / Dwg	Sect	SF	CBM	Same as	Phase
506	498	natural	NFP	peat					483	1
507	canal	layer	SFP	black canal fill?					10 eval	2
508	498	natural	SFP	alluvial clay				482, 505, 510, 512, 515		1
509	498	natural	SFP	ballast						1
510	498	natural	SFP	alluvial clay				482, 505, 508, 512, 515		1
511	498	natural	SFP	ballast						1
512	498	natural	SFP	alluvial clay				482, 505, 508, 510, 515		1
513	498	natural	SFP	ballast						1
514	498	natural	SFP	alluvial sand						1
515	498	natural	MFP	alluvial clay				482, 505, 508, 510, 512		1
516	498	natural	MFP	ballast						1

APPENDIX 5: POTTERY ASSESSMENT

Pottery assessment- Archaeological Investigations at IO Group Phase 3a (Zone 17) and Phase 4 (Zones 21 & 23), The Royal Arsenal, Woolwich, London Borough of Greenwich (RYG 04) and (RYW 04).

Chris Jarrett

Introduction

A small sized assemblage of pottery was recovered from the two sites (2 boxes). Most sherds are in a good condition, small to large in size, indicating that they had not been subject to much redeposition and discarded soon after breakage. All the individual contexts produced small groups of pottery (under 30 sherds). Three contexts from RYG 04 and one context from RYW 04 produced pottery.

All the pottery (ten sherds from RYG 04, of which none are unstratified, and eight sherds from RYW 04, of which seven are unstratified) was examined macroscopically and microscopically using a binocular microscope (x20), and recorded in an ACCESS 2000 database, by fabric, form, decoration, sherd count and estimated number of vessels, using standard Museum of London Specialist Services codes for fabric, form and decoration. Its types and distribution discuss the pottery.

Pottery types

The pottery types consist of a single Roman sherd and the rest are post-medieval in date.

Roman

A single sherd of residual grog-tempered pottery is present from an uncertain form.

Post-medieval

Surrey-Hampshire Border ware

Green-glazed Border ware (BORDG), dated 1550-1700, one sherd. Form: drinking jug.

Local coarse red earthenware

Post-medieval redware (PMR), dated 1580-1900, two sherds. Forms: bowl or dish and chimney pot

Stonewares

English stoneware with Bristol glaze (ENGS BRST), dated 1700-1900, one sherd. Form: cylindrical jar.

London stoneware (LONS), dated 1670-1900, one sherd. Form: industrial vessel. Possibly part of chemical apparatus ('false arm') as a tube with an internal Bristol-glaze and external oval stamp 'J. STIFF & SONS, LAMBETH', dated C.1870-1913.

Industrial finewares

Refined whiteware (REFW), dated 1800-1900, four sherds. Forms: teacup, saucer and plates.

Transfer-printed white earthenware (TPW), dated 1780-1900, seven sherds. Forms: rounded bowl, plate and teapot lid.

Uncoded (XX), late 19th-century refined redware with brown-glaze. Form: teapot.

Distribution

The pottery is discussed by site and context and Table 1 shows the size of pottery groups and a spot date for the deposit.

Site code	Context	Size	Spot date for context
RYG04	[10]	S	1835-1900+
RYG04	[73]	S	0-400
RYG04	[76]	S	1580-1800
RYW04	[244]	S	1840-1860

Table 1. List of contexts containing pottery, the site it comes from and a spot date for the deposit. S: small (1-30 sherds).

RYG 04

Context [73] produced the sherd of residual Roman grog-tempered pottery.

A sherd of a 17th- or 18th century Post-medieval redware bowl or dish was solely recovered from deposit [76].

19th-century pottery types were only recovered from deposit [10] as single sherds from a tea cup, saucer and plate in Refined whiteware, while four sherds came from a Transfer-printed ware rounded bowl with a design that could be late 19th or 20th-century in date. There is also a sherds of an English stoneware cylindrical jar with a fluted body and a Bristol-glaze of a type dating to after c.1850.

RYW 04

Most of the pottery from this site is unstratified and includes of note the green-glazed Border ware drinking jug and the London stoneware industrial tube, stamped 'J. STIFF & SONS, LAMBETH'.

Only one sherd is stratified and comes from deposit [244], demolition rubble in Area NFP. The fabric is a Refined whiteware from a shell-edge ware plate and dates to c.1840-60 dated by its unscalloped rim and moulded pattern.

Significance and Potential

The pottery has little significance because of the small sized assemblages which are mundane for the period. However, the presence of an industrial vessel in the form of London stoneware 'tube' is of note and may be related to ammunition manufacturing on the site. None of the pottery appears to have a military connection: services might be expected bearing the motto of the armed forces or a regiment.

The potential of the pottery is to date the deposits it was recovered from.

Recommendations

The only noteworthy component of this assemblage is the London stoneware industrial vessel, which for a publication report deserves to be discussed and illustrated. The rest of the pottery is fragmentary and present in such small numbers that its presence is difficult to interpret, except to say that it comprises domestic wares from Woolwich Arsenal.

APPENDIX 6: CLAY TOBACCO PIPE ASSESSMENT

ASSESSMENT OF THE CLAY TOBACCO PIPES - INVESTIGATIONS AT IO GROUP PHASE 3A (ZONE 17) AND PHASE 4 (ZONES 21 & 23), THE ROYAL ARSENAL, WOOLWICH, LONDON BOROUGH OF GREENWICH.

Chris Jarrett

Introduction

A small sized assemblage of clay tobacco pipes was recovered from the site (1 box). Most fragments are slightly battered, indicating that they were not deposited immediately after breakage. Clay tobacco pipes occur as small groups in contexts and always as under six fragments.

All the clay tobacco pipes (eight fragments, of which two are unstratified) were recorded in an ACCESS 2000 database and classified by Atkinson and Oswald's (1969) typology (AO) and 18th-century examples by Oswald's (1975) typology. The pipes are further coded by decoration and quantified by fragment count. The tobacco pipes are discussed by their types and distribution.

THE CLAY TOBACCO PIPE TYPES

The stratified clay tobacco pipe assemblage from the site consists of three bowls and three stems. Additionally the unstratified material consists of two bowls. The clay tobacco pipe bowls range in date between 1660 and 1910.

1660 - 1680 type bowls

There is a single example of an AO18 unstratified bowl, of good quality but damaged.

1820-1840

A single damaged AO 28 bowl is present and is of a Royal Antediluvian Order of the Bull (RAOB) type with the letters OB surviving and part of the horns of the bull. The spur is initialled W G and this maker cannot be traced in Oswald (1975).

1840-1880

The heel of a probable AO29 bowl exists and is very nicely moulded with relief decoration. The heel has a shield on each side and on both sides of the bowl is a sphinx with the legend 'EGYPT' below a band with the name '[INNIS]KILLINGS'. Stamped incuse writing is found on the left side of the stem with the name 'HILL · LATE · DUDMAN' and on the other side of the stem 'PLUMSTEAD'. The bowl refers to the Inniskilling Royal fusiliers and the sphinx was part of their badge awarded to the regiment after 19th-century campaigns in Egypt. The stamp refers to two Plumstead pipe makers, firstly Henry Dudman who is recorded between 1881-1894 and John Hill who is known from directories between 1900-1902. The 'LATE' refers to the takeover of Dudman's workshop by Hill, but the bowl probably dates to the turn of the 19th-century (Peter Hammond, pers. comm.).

1850-1910

There are two AO30 bowls, firstly as a plain bowl with a square stem with lettering, but difficult to read because of iron staining. The second bowl is a good quality, medium sized bird's claw, but is in a slightly battered condition.

DISTRIBUTION

Stratified tobacco pipes are restricted only to the RYW 04 excavation and only deposit [244], demolition rubble, as the AO28 RAOB bowl marked W G, and two AO30 bowls as the bird claw example and the square stemmed example. There are also three stems in this deposit, one with pinching the other with part of a possible spiral foot. The dating of the context, based upon the types of bowls present, indicates a c.1850-1880 deposition date, but an early 20th-century period is also possible as these bowl types do continue beyond their usual period of production.

SIGNIFICANCE AND POTENTIAL OF THE ASSEMBLAGE

The clay tobacco pipes are only significant at a local level, but it is interesting to note that a bowl for the Inniskilling Royal fusiliers is present on a military site. However, this may be coincidence as the bowl is by a local pipe maker and may relate to the fashion for Irish bowls and related ephemera in the late 19th-century, rather than the stationing of this particular regiment at the Woolwich Arsenal. Additionally, the Inniskilling-Egypt bowl is known to have been made by other pipemakers.

As smoking around munitions manufacture would not have been allowed, then the distribution of the clay tobacco pipes on the site may be of significance. Surprisingly there are very few clay tobacco pipes recovered from the site. This may be for a temporal reason as clay tobacco pipes are rare after the First World War, but equally the absence of tobacco pipes from certain areas may indicate that a strict non-smoking policy was maintained in these zones. Therefore, where clay tobacco pipes are found then it should be correlated to the types of activities in those areas, for example, perhaps the locations of barracks etc.

The potential for the clay tobacco pipes is to date the deposit they were excavated from. One avenue of research may be to determine if the Inniskilling Royal fusiliers were stationed at Woolwich Arsenal. If so then this might indicate that a special order was placed with John Hill to supply tobacco pipes to the garrison.

RECOMMENDATIONS FOR FURTHER WORK

The clay tobacco pipes from this site should be published, even if they are a small group. Some of the bowls are of local interest for not being previously reported and the AO28 Inniskilling-Egypt bowl and the AO30 bowl with a square stem require illustrating. However, their fragmentary nature may require visits to local museums to enquire if more complete examples exist for the completion of illustrations.

Bibliography

- Atkinson D. and Oswald. A. (1969), London clay tobacco pipes. *Journal of British Archaeology Association*, 3rd series, Vol. 32, 171-227.
- Oswald, A. (1975). *Clay pipes for the Archaeologist*, British Archaeological Reports, British series, No.14.

APPENDIX 7: BUILDING MATERIAL ASSESSMENT

ASSESSMENT OF THE BUILDING MATERIALS AT THE ROYAL ARSENAL, WOOLWICH. RYW04, RYG04 JOHN BROWN BA, MA

1.0 QUANTITY AND CONDITION

	<i>RYW04</i>	<i>RYG04</i>
1.1 Total No. Assessed boxes:	33 (est.)	2
Total No. Assessed contexts producing Building material:	48	5
Total Count:	95*	10
Total Weight kg: 11.455	228.456*	
Total No. Complete pieces:	79*	2
Total No. Masonry Samples:	80*	4

*Totals for RYW04 do not include weights for individual objects over 5kg in weight, and do not include quantification for objects examined onsite.

2.0 INTRODUCTION

- 2.1 The material recovered from The Woolwich Royal Arsenal is indicative of the technology and application of the Industrial Revolution to specialised production of ceramics for large-scale industrial purposes and represents highly manufactured goods intended for purpose-built structures. The majority of the material consists of specially manufactured bricks, intended for use in extreme-temperature environments. The majority of these show maker's names, a feature of brick making that became popular during the second half of the 19th century, as manufactured building products were increasingly exported to the furthest corners of the Old and New Worlds, as far afield as Russia, the West Coast of America and New Zealand. In particular, the firebrick products represented at Woolwich include manufacturers from all over Britain; some of these companies are still in operation today, albeit under different names. Most of the material came from in situ structures, frequently constructed with a combination of 'London Stock' bricks with firebrick linings.

3.0 METHODOLOGY

- 3.1 The building materials were examined using the London system of fabric classification. Examples and descriptions of the fabrics can be found in the archives of PCA and/or the Museum of London.
- 3.2 Quantification of items was undertaken and the data recorded and entered onto a computer database (Microsoft Access 2000). After analysis common fabric types were discarded, with a type sample kept for archive. Unusual pieces or uncommon fabrics were also kept for archive.

4.0 BUILDING MATERIAL TYPES

- 4.1 Fabrics and forms are tabulated below and shown in order of period and occurrence. Medieval and post-medieval forms follow the Museum of London DUA guide to identifying ceramic building material.

4.2 RYW04 forms and fabrics

Period	Source	Fabric	Form	Description
OTHER	OTHER STONE	3120	S	Stone (uncertain form)
PMED	Local Post-Fire brick fabrics	3032	BU	Unfrogged brick
	'London stock' Bricks, London, Essex, Kent	3035	B	Brick (uncertain form)
MODERN	Cement/Mortar	3101PM	BF	Frogged brick
			CO	Concrete
	Firebrick (Coal Measures)	3261	M	Mortar
			BW	Wire cut/machine made brick (standard)
			BM	Moulded/special form fireclay products
			BM1	Moulded/special form brick (type 1 spacer)
			BM3	Moulded/special form brick (type 3 closer)
			BM5	Moulded/special form brick (type 5 bull nose)
			BM2	Moulded/special form brick (type 2 radial)
			BM4	Moulded/special form brick (type 4 3/4 bat)
			BM7	Moulded/special form brick (type 7 'stretcher plinth')
			BM8	Moulded/special form brick (type 8 trapezoidal)
			BM6	Moulded/special form brick (type 6 'header plinth')
			BVS	Voussoir brick (standard)
			BVS1	Voussoir brick (type 1 triangular)
			BVS2	Voussoir brick (type 2 wedge)
			PIPE	Water/gas pipe
			T	Tile (uncertain form)
			Stoneware	LONS
Local red-firing 'Tudor' brick fabrics	3033	BWF	Wire cut, frogged brick	

4.3 RYG04 CBM forms and fabrics

Period	Source	Fabric	Form	Description
MED/PMED	Local London clay sources	2586	TC	Curved roof tile (uncertain form)
		3216	T	Roof tile (uncertain form)
PMED	Black iron oxide clay sources	3094	T	Roof tile (uncertain form)
	Local London clay sources	2276	T	Roof tile (uncertain form)
	Local Post-Fire brick fabrics	3034	B	Brick (uncertain form)
	'London stock' Bricks, London, Essex, Kent	3034	BF	Frogged brick
		3035	B	Brick (uncertain form)
MODERN	Machine-pressed brick	3035	BF	Frogged brick
		3038	BW	Wirecut/machine made brick

4.4 Uncommon fabrics/forms

Material recovered from RYG04 consists of typical forms and fabrics for later post-medieval assemblages of ceramic building material in the London area. These included local brickearth, hand-made stock moulded bricks with frogs on the lower bedface, indicating manufacture after the mid 18th century. The small tile fragments were largely non-diagnostic, but probably represent peg tile roofing of post-medieval date. Some brick samples returned from RYW04 consisted of frogged brickearth bricks, occasionally with makers' stamps visible in the frog, although where visible these were not very legible. However the majority of the brick samples specialised products intended for use in industrial structures. It has been assumed that, given the date of construction of the structures, these materials were machine-pressed, but it should be noted that many firebrick products were moulded by hand in a similar manner to stock bricks.

- 4.5 Firebricks of regular 'brick' shape are referred to in this report as 'standards', and account for the majority of the brick samples returned from site. Some of these bricks were unstamped; some were clearly machine pressed, showing 'flashing' from the press. Typically bricks of this type showed two circular impressions on each bedface, c.20mm in diameter and c.80mm apart along the long centre axis of the face. Raised rectangular marks across the diameter of the circles give the impression of 'screw heads'. The majority of standards however retain makers' stamps, applied by hand, often at irregular angles to the brick. At least eight different manufacturers have been observed, and most of these are reasonably well represented. This is in marked contrast to some other contemporary industrial sites such as the Doulton potteries at Lambeth, where one supplier accounted for almost all the stamped firebrick at Lambeth Bridge Road (Killock et al 2003) and Salamanca Street (Tyler K, pers. Comm.). Makers' names and forms of brick are tabulated below.

Fabric	Stamp	Manufacturer	Region	Forms
3261a	DOUGALL	? James Dougall & Sons. Bonnyside	Scotland	Standard Bull nose
3261b	FOSTER	? R Foster & Co. Gateshead	?Newcastle	Standard Voussoir (standard)
3261c	HARRIS & PEARSON STOURBRIDGE	Harris & Pearson Brettle Lane, Stourbridge	Worcestershire Staffordshire	Standard
3261d	HICKMAN AND CO STOURBRIDGE	Hickman & Co. Lye, Stourbridge	Worcestershire Staffordshire	Standard
3261e	LUCAS	Unknown	Unknown	Standard Bull nose
3261f	MARTIN LEEMOOR	Martin Bros. Lee Moor, Dartmoor	Devon	Standard Bull nose
3261g	RAMSAY	G.H. Ramsay, Blaydon, Gateshead	Newcastle	Standard Spacer Radial
3261h	RUFFORD STOURBRIDGE	Rufford and Co. Ltd. Hungary Hill, Stourbridge	Worcestershire Staffordshire	Standard
3261i	STARWORKS * GLENBOIG	Glenboig Star Fireclay Works	Scotland	Spacer
3261j	...IFF ...LEY	Uncertain	Uncertain	Standard
3261k	(3) (Number 3 stamped within circle)	Uncertain	Uncertain	Standard

- 4.6 Special forms included 'Standard voussoirs' where the two bedfaces are angled slightly to create a thicker stretcher on one side. Such bricks are typically used in arches for flue linings etc. Other 'Voussoir' types included bricks cut diagonally along the header face to give a steeper angle than the standard voussoir, with virtually no thickness along one stretcher. Another type was wedge-shaped and cut diagonally along the stretcher face. Further types included spacer bricks, with similar length and width to standards, but typically one or two thirds thickness, and bar shaped closers with similar length and depth, but half width of standards. Bull nosed bricks had similar dimensions to standards, with one rounded edge on one header face, while radial bricks had two curved stretchers for use in construction of circular structures. Spacer, closer and radial bricks are paralleled at other sites of contemporary date,

such as Doulton pottery works in Lambeth (Killock et al, 2003). More unusual forms included plinth bricks, chamfered either along one stretcher, or canted at one header, and trapezoidal bricks where one stretcher narrowed towards one header.

- 4.7 Other fireclay products included large, specialised forms of kiln furniture. Large fireclay brackets or braces were aligned within the furnace flues and obviously intended to support pipes. A large piece of kiln furniture recovered from demolition rubble [244] was probably also intended for such purpose, a large hexagonal fireclay 'bracket', with 4 angled faces of unequal length (lower faces c.225mm; upper faces c.130mm) and two long convex faces of differing diameter. Stamped 'EG19 3'. The demolition rubble also contained fragments of rectangular fireclay pipe with square cross-section with circular cut-away and female socket at end. The interior dimensions of the opening were 80x78mm. One had a cut-away in one face with diameter 55mm. Both were stamped with oval stamp, 'JOHN YOUNG & SONS HEATHFIELD WORKS GLASGOW'. The machine-pressed '(3)' brick also came from this context and may be engineering brick rather than fireclay.

5.0 DISTRIBUTION

5.1 RYW04 Fabrics/types observed in structures

STRUC	FABRIC	TYPE	Suffix	STRUC	FABRIC	TYPE	Suffix	STRUC	FABRIC	TYPE	Suffix	STRUC	FABRIC	TYPE	Suffix
238	3032	BU		239	3035	BF	si	385	3261	BM1		492	3035	BF	si
	3033	BWF			3101PM	M	i			BM3			3101PM	CO	
	3035	B			3261	BM1				BM8			LONS	DS	
		BF				BM4			3261f	BW	si				
		BF	si			BM5									
	3261	BM				BVS									
		BM1			3261a	BM5	si								
		BM3				BW	si								
		BM5			3261b	BW	si								
		BM5	si		3261c	BW	si								
		BM7			3261e	BW	si								
		BVS2			3261f	BW	si								
		BW			3261g	BW	si								
		BW	i												
		BW	si												
	3261a	BW	si												
	3261d	BW	si												
	3261e	BM5	si												
		BW	si												
	3261f	BM5	si												
		BW	si												
	3261g	BM1	si												
		BM2	si												
		BW	si												
	3261h	BW	si												
	3261i	BM1	si												
	3261j	BW	si												

5.2 Structure 238 Boiler House

Most of the assessed material was recovered from the Boiler house structure, which was constructed principally of frogged (in some cases stamped) stock moulded bricks with skins of firebrick along the flues and other surfaces to protect the structure from intense heat. Both stamped and unstamped firebricks were used. With the exception of FOSTER and HARRIS & PEARSON, all of the named firebrick manufacturers were observed in the construction of the boiler house. Special firebrick forms used in

construction included spacer and closer bricks, radial brick in pier bases and wedge voussoirs and stretcher plinths in the main flue section. Fireclay skins were generally bonded with a clayey mortar containing no lime and varying amounts of quartz. This would facilitate the removal of heat damaged bricks, which in structures of this nature would require replacing on a regular basis, perhaps as often as two to three years. Bull nose bricks were used at flue openings, presumably as their curved surfaces would prove less vulnerable to acidic attack from exhaust fumes. The presence of STARWORKS * GLENBOIG stamped bricks suggests a construction date on or after 1873, when the starworks company was formed by James Dunnachie.

5.3 *Structure 239 Rolling Mill*

The rolling mill was constructed in similar fashion to the boiler house, with core masonry of stock-moulded frogged bricks surrounded by firebrick skins. A smaller range of stamped bricks was noted however, with examples of DOUGALL, FOSTER, HARRIS & PEARSON, LUCAS, MARTIN LEEMOOR and RAMSAY bricks. Likewise a smaller range of special brick forms were noticed, including bull nose bricks and voussoirs used in flues, spacer bricks and ¾ bats.

5.4 *Structure 385 Square chimney*

Uncommon trapezoidal bricks were used in the construction of a square chimney, but only one named manufacturer was noted, MARTIN LEEMOOR. Both closer bricks and spacer bricks were also used. It is thought that these bricks were manufactured by the Martin Brothers of Lee Moor, Devon, who are recorded as manufacturers of 'porcelain firebricks' in Kelly's business directory of Cornwall 1883.

5.5 *Structure 492 Petrol station*

Structural remains of a petrol station uncovered in the northern footprint utilised stamped, frogged stock-moulded bricks, and concrete surrounding a stoneware drain. Such construction is typical of the last quarter of the 19th century to the 1940's.

6.0 SIGNIFICANCE AND POTENTIAL

- 6.1 The bricks sampled from the Royal Arsenal are of local, regional and possibly national interest. The range of manufacturers contrasts with other contemporary industrial sites investigated by the author, and likely to be indicative of different procurement strategies, possibly governed by bureaucratic practices.
- 6.2 The presence of different stamped bricks may indicate different phases of construction for the boiler house and rolling mill.
- 6.3 The remaining material is typical of Late post-medieval CBM assemblages in the London area and merits no further work.

7.0 RESEARCH AIMS

- 7.1 *Is there any evidence of archaeological activity prior to the post-medieval period?*
No CBM recovered from the site indicates activity prior to the post-medieval period.
- 7.2 *On the early 19th century maps several buildings appear only for a very short period. What is the nature of these structures and is it possible to assign a function to them?*
Building samples were only returned from three structures relating to the industrial activity, and their nature is well established.

8.0 RECOMMENDATIONS FOR FURTHER WORK

- 8.1 Further analysis is recommended, primarily focusing on sourcing the fireclay fabrics, including fabric analysis and comparison of unstamped and stamped bricks. On

resolving issues of form terminology and fabric it may also be important to consult with an industrial building material specialist.

- 8.2 Documentary research, particularly census searches, should be carried out on the individual makers in order to aid with provenance and dating. The records of the Mines inspectorate from the 1850's to the 20th century often include mention of companies mining fireclay, and can provide information as to tonnage produced, the number of employees, the names of the owners and under-managers, and information on accidents and fatalities. Some items may show patent numbers that may be possible to trace.

9.0 DATE RANGES

- 9.1 The **Date range** is the earliest date for the earliest CBM within the context and the latest date of the latest CBM in the context. The **Latest Date** represents the range for the latest dated CBM fabric. The **Best-fit date** compares the latest date for the earliest CBM and the earliest date for the latest CBM. The **Deposition Date** is the suggested date of deposition for the materials in the context. Also noted is the **Size** (number of sherds) and **Weight** (grams) of each context. Groups are determined as small (1-30 sherds), medium (31-100 sherds), large (over 100 sherds), very large (over 10 boxes).

9.2 RYW04 CBM by context with size/weight and date ranges

Context	Size	Weight	Date Range	Latest Date	Best Fit Date	Deposition Date
0	2	2590	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
239	1	2660	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
244	13	20699	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
246	*	*	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
247	*	*	1770 1940	1770 1940	1770 1940	1770 to 1940 (1850 to 1920)
252	*	*	1666 1950	1800 1950	1800 1900	1770 to 1940 (1850 to 1920)
253	*	*	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
254	*	*	1770 1950	1800 1950	1800 1940	1850 to 1950 (1870 to 1920)
255	*	*	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
256	*	*	1770 1940	1770 1940	1770 1940	1770 to 1940 (1850 to 1920)
257	*	*	1770 1950	1800 1950	1800 1940	1850 to 1940 (1870 to 1920)
259	*	*	1770 1950	1800 1950	1800 1940	1850 to 1940 (1870 to 1920)
260	*	*	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
262	1	2885	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
263	1	*	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
265	2	3066	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
266	2	5895	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
267	*	*	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
268	3	7150	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
271	*	*	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
273	1	1698	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
274	*	*	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
275	*	*	1770 1950	1800 1950	1800 1940	1800 to 1940 (1850 to 1920)
276	*	*	1770 1950	1800 1950	1800 1940	1800 to 1940 (1850 to 1920)
290	*	*	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
304	2	5600	1770 1950	1800 1950	1800 1940	1800 to 1940 (1850 to 1920)
305	4	11450	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
306	10	22013	1770 1950	1800 1950	1800 1940	1800 to 1940 (1850 to 1920)
307	8	23395	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
308	4	10059	1770 1950	1800 1950	1800 1940	1800 to 1940 (1850 to 1920)
316	*	*	1770 1940	1770 1940	1770 1940	1850 to 1950 (1870 to 1920)
320	*	*	1666 1940	1770 1940	1770 1900	1850 to 1900 (1870 to 1900)

Context	Size	Weight	Date Range	Latest Date	Best Fit Date	Deposition Date
323	2	5450	1450 1950	1800 1950	1800 1700	1800 to 1940 (1850 to 1920)
332	4	11195	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
337	4	11910	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
338	3	8305	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
339	1	2825	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
341	5	11691	1770 1950	1800 1950	1800 1940	1800 to 1940 (1850 to 1920)
343	2	4214	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
346	2	6045	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
355	1	3070	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
357	1	1932	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
385	4	12055	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
387	4	7109	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
388	1	3225	50 1950	50 1950	50 1950	1850 to 1950 (1870 to 1920)
416	3	7723	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
431	1	3282	1800 1950	1800 1950	1800 1950	1850 to 1950 (1870 to 1920)
450	3	9265	50 1950	50 1950	50 1950	1850 to 1950 (1870 to 1920)

9.4 RYG04 CBM by context with size/weight and date ranges

Context	Size	Weight	Date Range	Latest Date	Best Fit Date	Deposition Date
46	2	3789	1666 1940	1770 1940	1770 1900	1770 to 1900
55	2	4250	1666 1940	1770 1940	1770 1900	1770 to 1900
73	4	82	1180 1950	1180 1950	1180 1800	1180 to 1950
76	1	24	1200 1800	1200 1800	1200 1800	1200 to 1800 (post-medieval)
78	1	3310	1666 1900	1666 1900	1666 1900	1666 to 1900 (1700 to 1850)

Contexts in *italics* are samples from masonry contexts.

[!] Possibly inclusive material

[r] Residual material

10.0 BIBLIOGRAPHY

Killock, D, Brown, J., and Jarrett, C., 2003. 'The industrialization of an ecclesiastical hamlet: stoneware production in Lambeth and the sanitary revolution'. *Post-Medieval Archaeology*, 37/1.

APPENDIX 8: SMALL FINDS / FINDS ASSESSMENT

Assessment of the Small Finds, Metal and Timber Artefacts from the I O Group Phase 3a (RYG 04 - Site 1) and Phase 4 (RYW 04 - Site 2)

Chris Mayo

Introduction

A number of metal artefacts were recovered during the investigations at Sites 1 and 2. The majority of these are undiagnostic and therefore of limited value for dating. A number were also unstratified. However, they do help to illustrate a sequence of manufacturing and industry.

Small finds account for 10 of the artefacts.

The metalwork is generally in a good state of preservation.

Small Finds

The small finds are detailed below in Table 2. Firepower: The Royal Artillery Museum in Woolwich has taken custody of the cannon for conservation, study and hopefully display.

Other finds

Other finds of note included eight timber trucks (group number [461]) from naval gun carriages. Six of these were incomplete, while one [463] was only a half piece. The best example [462] was in very good condition and had its two halves still bolted together. On one face the inscription of the War Department (WD) was visible; this suggests that the piece dates to after 1855, when the WD was founded, although it is possible that the truck was earlier in date and merely stamped with the sign of the new department. The truck [462] was 0.41m in diameter with a complete width of 0.15m. Explosion! The Museum of Naval Firepower in Gosport have taken custody of all the pieces.

A number of unstratified hand tools were found. These included a close-head spanner, 1.22m long, and a probable piece of ship ballast - an iron sphere with a shackle or chain attachment. The piece weighed 24 kilos / 52 lb.

Recommendations for Further Work

Further research at specialist level may be necessary for the cannon and ammunition to perhaps refine their dates and provenance.

Specialist study should also be made of the graphite mould to more clearly define its function.

Site	Small Find	Context	Type	Material	Comments	Date
RYG 04	1	63	Bullet	Lead	28mm long, 11mm diameter. Post-Crimean War minié ball	1850s +
RYW 04	1	210	Cannon	Cast Iron?	Probable 24 pdr cannon, 3.07m long and 2.2 tonnes. Bore measurement = 11". Inscribed with a 'G' on truncheon = Graham and Sons, operating from Thames Street, London between 1779 and 1795. Gun has a flintlock platform on top. Has concrete scarring around breech end where the gun has been set vertically as a mooring post. Also has a plug in the muzzle end.	1779 to 1795
RYW 04	2	210	Chain	Wrought Iron	A chain and plug attachment for SF 1 to use the cannon as a mooring post	19 th century?
RYW 04	3	+	Tobacco pipe bowl	Clay	Inscribed with 'EGYPT' below a band with the name 'JINNISKILLINGS'. Stamped incuse writing is found on the left side of the stem with the name 'HILL · LATE · DUDMAN' and on the other side of the stem 'PLUMSTEAD'. The bowl refers to the Inniskilling Royal Fusiliers and the sphinx was part of their badge awarded to the regiment after 19 th -century campaigns in Egypt. See Appendix 6.	1840 to 1880
RYW 04	4	+	Cannonball	Iron	15 kilo / 32 lb shot	unknown
RYW 04	5	+	Cannonball	Iron	15 kilo / 32 lb shot	Unknown
RYW 04	6	+	Mould?	Graphite	Graphite mould or crucible. Such items are commonly found in industrial environments due to the high-temperature resistance of plumbago. Used in bricks, electrodes, rocket nozzles, paint and lubricants.	Unknown
RYW 04	7	403	Hook?	Iron?	Possible hook or machine fixing.	Unknown
RYW 04	8	+	Cannon	Cast Iron?	Probable 24 pdr cannon, 3.6m long. Bore measurement = 11". Inscribed with a 'T' on truncheon = Tanner, operating from Wales between c 1788 and 1820, or Todd, operating from Hull between 1793 and 1828. Gun has a George III crest. Has concrete scarring where the gun has been set vertically as a mooring post. Also has a plug in the muzzle end. See Figure 10.	1788 to 1828
RYW 04	9	+	Wheel	Iron	Spoked iron cartwheel, 0.49m diameter and 0.1m wide.	Unknown

Table 2: Small Finds from Sites 1 and 2

APPENDIX 9: SITE 1 (RYG 04) OASIS REPORT FORM

13.1 OASIS ID: preconst1-7511

Project details

Project name	I O Group Phase 3a, The Royal Arsenal, Woolwich
Short description of the project	A watching brief was conducted within the area of Zone 17 of the Royal Arsenal on the excavation of strip footings and foundation pads. The natural sequence was recorded. A modern (?) pit contained a sherd of residual Roman pottery, and walls of the 19th century Cartridge Establishment were found.
Project dates	Start: 14-12-2004 End: 21-12-2004
Previous/future work	Yes / Not known
Any associated project reference codes	RYG 04 - Sitecode
Type of project	Research project
Site status	Local Authority Designated Archaeological Area
Current Land use	Vacant Land 1 - Vacant land previously developed
Monument type	ARSENAL Post Medieval
Investigation type	'Full survey','Part Excavation','Watching Brief'
Prompt	Planning condition
Project location	
Country	England
Site location	GREATER LONDON GREENWICH WOOLWICH IO Group Phase 3a (Zone 17)
Postcode	SE28
Study area	400.00 Square metres
National grid reference	TQ 4435 7903 Point

Height OD	Min: 3.20m Max: 3.39m
Project creators	
Name of Organisation	Pre-Construct Archaeology Ltd
Project brief originator	English Heritage
Project design originator	English Heritage
Project director/manager	Jon Butler
Project supervisor	Chris Mayo
Sponsor or funding body	Fitzpatrick Contractors Limited
Project archives	
Physical Archive recipient	LAARC
Physical Contents	'Ceramics','Metal'
Physical Archive Exists?	No
Digital Archive recipient	LAARC
Digital Contents	'Ceramics','Metal','Stratigraphic','Survey'
Digital Media available	'Database','Images raster','Spreadsheets','Survey','Text'
Digital Archive Exists?	No
Paper Archive recipient	LAARC
Paper Contents	'Ceramics','Industrial','Metal','Stratigraphic','Survey'

Paper Media available	'Context sheet', 'Correspondence', 'Diary', 'Drawing', 'Map', 'Miscellaneous Material', 'Photograph', 'Plan', 'Report', 'Section', 'Survey '
Paper Archive Exists?	No
Project bibliography 1	
Publication type	Grey literature (unpublished document/manuscript)
Title	Assessment of an Archaeological Watching Brief at I O Group Phases 3a (Zone 17) and Phase 4 (Zones 21 and 23), The Royal Arsenal, Woolwich, London Borough of Greenwich
Author(s)/Editor(s)	Mayo, C
Date	2005
Issuer or publisher	Pre-Cnstruct Archaeology
Place of issue or publication	London
Description	A4 document
Entered by	archivist (archive@pre-construct.com)
Entered on	20 April 2005

APPENDIX 10: SITE 2 (RYW 04) OASIS REPORT FORM

13.2 OASIS ID: preconst1-7514

Project details

Project name	I O Group Phase 4 (Zones 21 and 23), The Royal Arsenal, Woolwich
Short description of the project	A watching brief over Zones 21 and 23 revealed substantial industrial remains of the Royal Arsenal. The natural and made ground sequence was recorded. The remains of the Boiler House and Rolling Mill, and its successors Buildings D71, D72 and D74, were found in the north of the site. In the centre and south of the site expansive remains of the South Boring Mill were recorded including its superstructure and machinery. External features associated with the building were found. Other structures included Buildings C33, C47 and D80, and peripheral buildings. The route of Street No 10 was visible across the site, as was the remediated Pilkington Canal.
Project dates	Start: 18-10-2004 End: 15-12-2004
Previous/future work	Yes / No
Any associated project reference codes	RYW 04 - Sitecode
Type of project	Research project
Site status	Local Authority Designated Archaeological Area
Current Land use	Vacant Land 1 - Vacant land previously developed
Monument type	ARSENAL Post Medieval
Monument type	ARSENAL Modern
Investigation type	'Full survey', 'Part Excavation', 'Test-Pit Survey', 'Watching Brief'
Prompt	Planning condition
Project location	
Country	England
Site location	GREATER LONDON GREENWICH WOOLWICH I O Group Phase 4 (Zones 21 and 23)

Postcode	SE28
Study area	17250.00 Square metres
National grid reference	TQ 4435 7915 Point
Height OD	Min: 1.63m Max: 1.83m
Project creators	
Name of Organisation	Pre-Construct Archaeology Ltd
Project brief originator	English Heritage
Project design originator	English Heritage
Project director/manager	Jon Butler
Project supervisor	Chris Mayo
Sponsor or funding body	Fitzpatrick Contractors Limited
Project archives	
Physical Archive recipient	LAARC
Physical Contents	'Ceramics','Industrial','Metal'
Physical Archive Exists?	No
Digital Archive recipient	LAARC
Digital Contents	'Ceramics','Industrial','Metal','Stratigraphic','Survey'
Digital Media available	'Database','Images raster','Spreadsheets','Survey','Text'
Digital Archive	No

Exists?	
Paper Archive recipient	LAARC
Paper Contents	'Ceramics','Industrial','Metal','Stratigraphic','Survey'
Paper Media available	'Context sheet','Correspondence','Diary','Drawing','Map','Miscellaneous Material','Photograph','Plan','Report','Section','Survey '
Paper Archive Exists?	No
 Project bibliography 1	
Publication type	Grey literature (unpublished document/manuscript)
Title	Assessment of an Archaeological Watching Brief at I O Group Phases 3a (Zone 17) and Phase 4 (Zones 21 and 23), The Royal Arsenal, Woolwich, London Borough of Greenwich
Author(s)/Editor(s)	Mayo, C
Date	2005
Issuer or publisher	Pre-Construct Archaeology
Place of issue or publication	London
Description	A4 document
Entered by	archivist (archive@pre-construct.com)
Entered on	20 April 2005