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Stanford Wharf Nature Reserve, London Gateway, Stanford-le-Hope, Essex

Post-excavation assessment and updated project design, volume 2

Artefactual, geoarchaeological and palaeoenvironmental appendices

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A.1 Prehistoric pottery

Edward Biddulph

Introduction

A total of 759 sherds, weighing 10829 g, were recovered from context groups dated to the prehistoric period. The assemblage was rapidly scanned to identify diagnostic forms and fabrics. In addition to sherd count and group weight, the number of vessels represented by rims was counted, giving a total of 65. Iron Age forms were identified using the type series at Little Waltham (Drury 1978, 52-6), while parallels for late Bronze Age material were sought in the report for the North Ring, Mucking (Barrett and Bond 1988, 25-37). The chronological distribution of the assemblage is summarised in Table 1.

Period	Sherds	Weight (g)	Vessel count (approx)
Neolithic	7	34	1
Late Bronze Age	54	950	1
Late Bronze Age/Iron Age	121	2348	0
Middle Iron Age	551	7246	62
Undated (Iron Age)	26	251	2
TOTAL	759	10829	66

Table 1: Quantification of prehistoric pottery

Neolithic

The earliest pottery was a small group in a flint-tempered fabric recovered from context 1454. The sole diagnostic fragment was a simple, flat-topped rim from a jar or bowl.

Late Bronze Age

All the material assigned to the late Bronze Age was flint-tempered, though fabrics varied in coarseness. One vessel, an angular bowl or jar, was tentatively identified from a rim, which was recovered from context 2002. The remainder of the assemblage was confined to base and body sherds.

Middle Iron Age

The majority of prehistoric pottery belonged to the middle Iron Age. Two broad fabric groups were recognised: a greensand- or glauconite-tempered fabric and a fine to medium sandy fabric; some examples of the latter included flint fragments. Vessels in both fabrics either had black /dark-grey or red/orange surfaces. Decorated was restricted to burnishing. There was a narrow range of vessel types available. Three bowls were recorded. These had everted rims and fairly slack S-shaped profiles (Little Waltham type F13). A number of base sherds with shallow footrings probably belonged to bowls and were typical of the period. Jars were much more numerous. Rim fragments attest to some 50 vessels. Jars with everted rims (Little Waltham type F12), available in both sandy and glauconitic fabrics, were the best represented, but a barrel-shaped jar with upright rim (Little Waltham type F10A) and globular jar with small bead rim (Little Waltham type F15C) were also present. The remaining rim fragments were broken at the neck and could either have been jars or bowls.

Undated - Late Bronze Age/Iron Age and Iron Age

Pottery assigned a broad Iron Age date included an out-turned rim from a jar or bowl in flint/grog/organic-tempered fabric. Another rim, from a jar, had been made in a flint-tempered fabric. In addition, twelve context groups contained undiagnostic flint-tempered pottery that at this stage cannot be dated with certainty either to the Bronze Age or Iron Age.

Discussion

The assemblage of prehistoric pottery indicates middle Iron Age occupation in the vicinity of the site. The earlier-dated Neolithic and late Bronze Age pottery also suggests that activity occurred during these periods, though the material may have originated in Mucking, where Neolithic and Bronze Age occupation is much better represented (eg Bond 1988). The middle Iron Age forms were standard products for the region and were very similar to, say, the small assemblage of middle Iron Age pottery from the Orsett 'Cock'. This comprised a number of vessels with everted rims and footring bases primarily in flint- and sand-tempered fabrics (Brown 1998, 88-9). However, glauconitic fabrics do not appear to have been as well represented there as at Stanford Wharf, while flint-tempered fabrics were comparatively more important at Orsett, although the fabric group may have included residual Neolithic and Bronze Age material (Brown 1998, 89). After petrological examination of glauconitic sherds from Little Waltham, Peacock and Williams (1978, 58) suggested that the source of the pottery was the same as that for similar Kentish material. This does not necessarily rule out an Essex source for the site's glauconitic pottery, although the quantity of glauconitic pottery is more consistent with an Essex source, and local geologies could in any case and have supported production of the fabric. Comparison of stylistic attributes of Kentish and Essex vessels will, of course, add crucial information about the development of the cultural traditions represented here.

A.2 Roman pottery

Edward Biddulph

A total of 14,363 sherds of Roman pottery, weighing 212,083 g, were recovered from the site. The assemblage was rapidly scanned to identify diagnostic forms and wares and date context groups. Each group was quantified by sherd count and group weight. In addition, the number of vessels represented by rims was counted, giving a total of 1,926. Forms were identified using Going's type series for Chelmsford (Going 1987), supplemented by other corpora, including Young's Oxford series (Young 1977) and the Camulodunum typology (Hawkes and Hull 1947). Wares were assigned codes from standard OA's fabric series (Booth nd). The chronological distribution of the assemblage is summarised in Table 2.

Period	Sherds	Weight (g)	Vessel count (approx)
Early Roman	625	10989	65
Early/mid Roman	255	3697	29
Mid Roman	1362	18235	187
Mid/late Roman	1340	20287	156

Late Roman	9895	146098	1425
Undated (Roman)	886	12777	67
TOTAL	14363	212083	1929

Table 2: Quantification of Roman pottery

Early Roman (AD 43-130)

Pottery from context groups dating to the early Roman period accounted for 5% of the assemblage by weight. Wares which were available in the late Iron Age and continued in use after the Roman conquest were recorded in half of the fifty or so early Roman groups. Such pottery generally allowed groups to be dated up to *c* AD 70. Sandy wares (E20 and E30) were the best represented of these, although forms appeared to be limited to two types, a barrel-shaped jar and a ledge-rimmed jar (Going G5.1). Grog-tempered ware (E80) had a relatively minor presence; high-shouldered cordoned necked jars (Going G19) were recorded in this ware. These wares were often found alongside shell-tempered ware C19. Three forms were encountered: a bead-rimmed jar (Going G1), a jar with a short neck (*Cam* 258), and Going G5.1. This last type was the commonest, but this is unsurprising, since the form was manufactured nearby at Mucking; jars in the sandy fabric are also likely to be local products (Jones and Rodwell 1973, 24). Post-conquest reduced wares were recovered from 20 context groups. Medium sandy grey ware (R30) was prolific within this ware category, and relatively wide range of forms were available. These included bead-rimmed jars (Going G3) and Going types G19 and G5.1, seen in other fabrics. A globular beaker (Going H1) was also recorded. Fine grey ware (R10), sandy grey ware (R20), and coarse-tempered ware (R90) were present in smaller amounts. North Kent fine grey ware (R16) reached the site during the second half of the 1st century. Most vessels in the fabric were dining forms – a platter (Going A2), bowl (Going C1), and beaker (H1). The same workshops were also responsible for the small amount of white-slipped oxidised ware (Q50); a platter (Going A4) and jar were identified. Fine oxidised ware (O10) recorded in four early-Roman groups is also likely to have been made in North Kent, though no forms were recognised. Grog-tempered Patchgrove ware (O85) is another type of pottery that arrived from Kent. The fabric was manufactured, probably in west Kent, during the early Roman period, although production of storage jars continued into the 3rd century. The vessel recorded in this phase (cf. Going G16) is a later 1st-century form. It is worth noting that the ware's distribution beyond west and north Kent is extremely rare. Sandy oxidised wares (O20), available as necked jars (Going G20 and G23), were present. The Verulamium region and Colchester (W15 and W41) provided white ware. Continental pottery was confined to a small amount of South Gaulish samian. A Drag. 18 platter was recorded.

Mid Roman (AD 130-260)

The amount of pottery being used and deposited increased slightly during the 2nd and 3rd centuries. Pottery recovered from groups dating to this period amounted to 9% of the assemblage by weight. Coarse reduced wares dominated in this period, occurring in 44 of the 54 groups dated to the phase. The most important category by far was sandy grey ware (R30). A wide range of forms was available. Plain-rimmed (B1/B3) and bead-rimmed dishes (Going B2/B4) were introduced in the mid 2nd century and continued to be made throughout the period. Another form, a flanged dish with incipient bead (Going B5) was a later type which reached the site in the mid 3rd century. Jars were largely restricted to ledge-rimmed jar Going G5.5, oval-bodied necked jar Going G24, bifid-rimmed necked jar Going G28. Most occurrences were undoubtedly local products, as these types of vessels were manufactured at Mucking. Another Mucking form, a cupped-rimmed jar (Jones and Rodwell 1973, 26 – type H), was also represented at London Gateway. Wide-mouthed jars or bowl-jars present at the site (Going E2 and E5) were of types manufactured at Mucking (Jones and Rodwell 1973, 24-6 – types G and K). The vessels typically date to the late Roman period at Chelmsford and other sites in central and north Essex, but their chronology in south Essex appears to commence in the late 2nd or early 3rd century. The evidence from Stanford Wharf Nature Reserve is consistent with this earlier chronology. Other grey wares were recorded, but in comparatively small amounts. Consequently, few vessels were identified. A poppy-headed beaker (Going H6) was seen in fine grey ware, while bifid-rimmed jar G28 was recorded in a fine sandy ware from Hadham (east Hertfordshire). A similar form was also available in a coarser sandy grey ware (R20).

A range of dark grey or black sandy fabrics with highly burnished surfaces, present exclusively as dishes (Going types B1, B2/B4 and B3), were identified as black-burnished category 2-style wares (B30 or BB2). Sources included Colchester and North Kent, but BB2 is attested in the Mucking kilns and it is likely that most vessels originated there. As the fabric of these vessels was practically identical to the (often burnished) local sandy grey ware (R30), separation was largely on the basis of form. In reality, the use of fabric B30/BB2 is problematic at a site so close to the Mucking kilns, although since the fabric was traded more widely than the standard grey ware, the attempt to isolate the fabric does not seem inappropriate. A similar problem was noted at Springhead/Northfleet, where the Kentish BB2 fabric closely matched the local Thameside grey wares (Seager Smith *et al.*, in press).

Some of the forms available in fabric R30 were also present in sandy oxidised ware (O20). These included jars Going G24 and G28 and dish B2. A poppy-headed beaker was present in fine oxidised ware (R10), and Kentish fabrics – Patchgrove ware O85 and North Kent oxidised ware – survived as body sherds only. Further occurrences of Verulamium-region white ware and Colchester buff ware were recorded. Mortaria – specialist mixing bowls – appeared from the late 2nd century onwards. Forms seen in this phase included hammerhead-rimmed vessels (Going D11) in a buff ware (M29 – probably Colchester), and a white-slipped oxidised ware (M30). The source of the latter is unknown, but another white-slipped vessel – a bead and flanged type (Going D5) – reached the site from Hadham. The late 2nd and first half of the 3rd century also saw the arrival of fine wares from Britain and the continent. Including samian, these were present in 32 of the 54 mid Roman groups. Nene Valley colour-coated ware (F52) was present in the more groups than other fine wares, though East Gaulish Rhenish ware (F44) was not far behind. The former was available as a bag-shaped or funnel-necked beaker, while an undiagnostic beaker rim was seen in the latter. Other fine wares – Central Gaulish Rhenish ware (F43), Hadham oxidised ware (F56) and Colchester colour-coated ware (F55) – were recorded as body and base sherds, although all the sherds belonged to beakers. A similar range of forms were present in both Central Gaulish and East Gaulish samian. This included dishes (forms 18/31, 31 and 79), mortaria (form 45), and bowls (forms 37 and 38). One East Gaulish f37 bowl (represented by a large body sherd) had been crudely manufactured and was probably among the latest samian imports to arrive during the second quarter of the 3rd century.

Late Roman (AD 260-410)

The amount of pottery that was available to be discarded continued to increase into the late Roman period. Some 69% of pottery by weight was recovered from context-groups dated to this phase. Inevitably, reduced ware dominate the assemblage, occurring in almost all 97 context-groups. Sandy grey ware (R30) remained the most important fabric. The standard dish and jar forms seen in the mid Roman period continued be be supplied into the late Roman period (B2/B3 bead-rimmed dishes are likely to have been residual by the late 3rd century, though remained prolific in groups of this and later date). Forms introduced in this phase included the dropped-flanged dish (Going B6, a development of the B5 type), a small, neckless storage jar

(Going G42), an everted-rim cooking pot (Going G9), a large narrow-necked jar (Going G35), and a small, globular bowl-jar (Going E3). Some vessels very closely paralleled forms fired in the Mucking kilns, including cordoned jars with flattened rims and narrow-necked jars with dropped flanges (Jones and Rodwell 1973, 28 – types M and N respectively). In addition, two vessels – a B6 dish and a G24 jar – had firing faults, and were probably seconds or wasters from the nearby kilns. Fine grey ware (R10) took a small share of the assemblage as expected, but the range of forms was widest in this phase. Beakers were the commonest vessel class in the fabric and included the funnel-necked beaker (Going H41), which was a standard late Roman type. Bifid-rimmed jars (Going G28) continued to be supplied in coarse sandy grey ware (R20), while fine grey ware dropped-flange dishes arrived from Hadham. Handmade black-burnished ware (B11) from Dorset reached the site only after AD 250, a little later than its early 3rd-century introduction recorded at other Essex sites. Forms are confined to plain-rimmed and drop-flanged dishes (Going B1 and B6). Wheel-made BB2 continued to be deposited well into the late Roman period, with dishes again being the principal class. Two groups contained examples of late Roman grog-tempered ware (R97). The fabric is rare in Essex, but appears more readily on sites in north Kent, where it is likely to have originated. Other coarse wares present for the first time in this phase included shell-tempered ware from Bedfordshire (C11), in which a necked jar (Going G27) was available, Portchester D ware from Hampshire (O24), and Mayen ware (W41) from Germany.

The range of oxidised wares available was not significantly different from that seen in the mid Roman period, although G9-type cooking pots joined the standard necked jar (Going G24). Fine parchment ware bowls (W11) arrived from Oxford, probably alongside Oxford white ware (M22) and white-slipped oxidised ware (M31) mortaria, which were present in nine context groups. These were less important than Oxford red colour-coated ware (F51), which was recorded in 19 groups, although just two forms were identified – a bead-rimmed dish (Young 1977, type C45) and flanged hemispherical bowl (Young 1977, type C51). It is possible that the fabric reached the site from *c* AD 250, but it more usually dates from AD 360 in Essex (Going 1987, 3), and it is likely that most occurrences at Stanford Wharf arrived then. Hadham oxidised ware, though less common than the Oxford fine ware, was nevertheless better represented in the late Roman period, compared with the previous phase, and four forms were identified: a bead-rimmed dish (Going B4), shallow flanged dish (Going B10); a wide-mouthed necked jar (probably Going E6) and a folded beaker (Going H39). Despite these developments, Nene Valley colour-coated ware (F52) continued to dominate the fine ware supply. The principal forms were unchanged from the mid Roman period, although funnel-necked beakers (Going H41) were joined by the occasional dropped-flange dish or carinated bowl, the so-called Castor box. White-ware mortaria also arrived from the same source.

Continental imports largely consisted Rhenish wares and East Gaulish samian ware. Funnel-necked beakers were recorded in the former, while the main samian forms were the Drag. 31 dish, Drag. 37 decorated bow, Drag. 38 flanged bowl, and Drag. 45 mortarium. These finewares were residual by AD 250, although their increased quantity in this phase suggests that new pottery continued to reach the site up to the end of the importation period, or were traded in the region after the date. A single fragment of céramique à l'éponge (sponged or marbled ware), normally dating after AD 360, was recorded.

Chronology

Just two context-groups were dated with reasonable certainty to the late Iron Age, and most groups that contain pottery of a late Iron Age tradition are likely to date to after the Roman conquest of AD 43. That said, the level of deposition in the early Roman did not increase to any significant extent. The pottery indicates episodes of deposition from AD 120/30 – and suggests continuity from the early Roman period – but it is telling that, excluding those that are broadly dated from the mid 2nd to mid 3rd century, most context groups date after AD 170, with a number being placed in the 3rd century. This suggests that pottery deposition (and the activity requiring pottery use) was at a similar level to the early Roman phase in the mid 2nd century, but increased in intensity from the late 2nd century onwards. The level of recording means that it cannot be confirmed at this stage to identify when the site was abandoned, but fabrics, such as Oxford red colour-coated ware, Mayen ware and shell-tempered ware provide useful chronological markers, as they generally indicate deposition in the second half of the 4th century or a little way into the 5th.

Potential of assemblage

This is a very large pottery assemblage which offers significant potential for further study. Although the pottery itself offers few surprises, with the material largely conforming to the expected regional pattern, its significance is considerably enhanced by its association with an important salt-making site. The pottery has good potential to address a number of key research aims as set out in the London Gateway scoping report (OA 2009, appendix 1). Certain types of pottery, such as samian and amphora, have long been appreciated as indices of site ranking. For instance, the proportion of samian that is decorated rises with increased status – military and urban sites have higher proportions that minor nucleated settlement and rural sites (cf Willis 2005, section 7.3.2). These measures will allow the question of where Stanford Wharf, a salt-production site, sits in terms of regional settlement hierarchy (**B.2.1**). Establishing a chronology of the various activities represented at the site remains a key area of research (**B.2.2**). The ceramic spot-dates resulting from the assessment take us a considerable way towards resolving this, but fuller picture will emerge with detailed recording as relative quantities of pottery, in addition to a simple presence/absence record, are taken into account. Pottery can also contribute to questions relating to saltern-related features (**B.2.10**). How significant are any differences between the assemblages of the salterns of areas A and B and the early and late Roman salterns? Does the pottery reflect social differences, differences in the origin of the salters, or reflect changes in the use of pottery (eg from domestic use to industrial use)? To what extent is a saltern-related assemblage different from those of other site types in terms of composition? It is interesting to note, for example, that early Roman shelly-ware lid-seated jars (G5.1) were found almost exclusively in the Area B saltern, and it is possible that they were related to the salt industry, perhaps being used for salt transportation.

There are also questions that are worth pursuing from a ceramic standpoint. The assemblage has raised intriguing questions of pottery supply. Given the presence of standard Mucking types at Stanford Wharf, it is extremely likely that most of the grey ware, which accounts for the bulk of the assemblage, derives from the Mucking kilns. A large, jar-sized, beaker recovered from area A pit 1249, can be matched with one from Mucking kiln II, sharing shape, fabric, and diamond-rouletted decoration, a characteristic Mucking trait (Jones and Rodwell 1973, fig. 10.105). Jones and Rodwell's report lacks reliable quantification, but the English Heritage-funded project to fully publish the Roman sequence (CAU 2008) is likely to bring more suitable data. These will give insights into the marketing patterns of local wares, the relative success of pottery types, and the interaction between producer and consumer. That said, the possibility of pottery production existing closer to Stanford Wharf should not be ignored. Another interesting aspect of pottery supply is the apparent connections between Stanford Wharf and north and west Kent industries. Certain wares, such as North Kent (Upchurch) fine grey ware, are well known in Essex, but Patchgrove ware and late Roman grog-tempered ware are much rarer visitors. Some of the grey wares may well include Kentish Thameside products. This raises the prospect of a Thameside cultural zone that existed on both sides of the river. To what extent pottery can show sustained trade links, as well as transmission of ideas and movement of inhabitants, will be explored.

The beaker from pit 1249 is one of at least nine complete or near-complete vessels. These are largely confined to dishes and beakers, and they should be considered as potential examples of ritual deposition. More generally, the calculation of mean sherd weight and other measures of pottery condition by deposit and/or feature type will reveal aspects of pottery deposition. What was the nature of pottery deposition? Was it used and discarded on site? Does it show areas of activity and middening, or was the pottery incidental to the episodes of deposition, for example, brought in with the soil as landscaping material? Can we detect associations between pottery and feature type?

A.3 Medieval and post-medieval pottery

John Cotter

Introduction and methodology

A total of 261 sherds of pottery weighing 3888 g. were recovered from 16 contexts. This comprises a mixture of medieval and early post-medieval pottery. All the pottery was examined and spot-dated during the present assessment stage. For each context the total pottery sherd count and weight were recorded, followed by the context spot-date which is the date-bracket during which the latest pottery types in the context are estimated to have been produced or were in general circulation. Comments on the presence of datable types were also recorded, usually with mention of vessel form (jugs, bowls etc.) and any other attributes worthy of note (eg. decoration etc.). Fabric codes assigned in the comments are those of the Essex County Council medieval pottery reference collection (Cunningham 1985; Cotter 2000), or, where appropriate, those of the Museum of London.

Date and nature of the assemblage

Overall the pottery assemblage is in a fragmentary condition, although several sherds are quite large and fresh - particularly the late medieval and post-medieval wares. Ordinary domestic pottery types are represented. These are summarised here.

The pottery types comprise a mixture of wares commonly found in south Essex and the London area and range in date from the 12th to the 16th centuries. Although early post-medieval wares are present (mainly Fabric 40 post-medieval red earthenwares), there is nothing in the assemblage that obviously dates later than *c* 1600. The earlier part of the assemblage includes some very soft and fragmentary examples of jars/cooking pots in 12th-13th century shelly wares, probably from south Essex. Other grey sandy medieval coarsewares are present including jars/cooking pots and a few jugs. Most of these are probably Essex products (Fabric 20), but a few wheel-turned jar rims may be in South Hertfordshire Greyware (SHER). One or two coarsely flint-tempered sherds may be a flintier variant of the latter. White-slipped jugs in London-type ware (LOND, mainly *c* 1150-1350) are also fairly common in the earlier assemblage. Three or four sherds in off-white sandy ware may be medieval Surrey whitewares, but these are plain and unglazed and difficult to assign to specific sources although the finer sherds in contexts 7055 and 7056 are probably from 15th-century Cheam whiteware jugs (CHEA).

A few sherds of Mill Green ware (Fabric 35 or MG) jugs were noted from medieval contexts and residual in later contexts. This was made around Ingatestone near Chelmsford and has a London date range of c 1270-1350 but may have continued in production as late as c 1400 but with a more restricted distribution. Mill Green fineware jugs can occur, as here, with an all-over white slip under a clear or green glaze, or with white slip-painted decoration under a clear glaze or no glaze at all. A few Mill Green coarseware jars/cooking pots also occur. In central and southern Essex there may have been a number of late medieval production sites producing fine red earthenwares in the Mill Green tradition and these seem to have evolved in the late 15th century into the first 'post-medieval' red earthenwares - heavier thicker-walled vessels with thin white slip decoration and little or no glaze (Cunningham and Drury 1985). Two contexts in particular (7054 and 7055) have large quantities of these transitional late medieval/early post-medieval redwares, including jugs, jars and plain large bowls, which seem to belong to the 15th or early 16th century. One of these (7055) produced sherds from two thumbed jug bases in an unusual pink-buff fabric which may be late medieval Hertfordshire glazed ware (LMHG) dating to c 1350-1450. Context 7056, dated *c* 1500-1575, is the only definite post-medieval context. This produced a small collection of early post-medieval redwares (Fabric 40) and also the base of a Beauvais sgraffito ware dish with traces of incised and polychrome decoration. This relatively costly tableware is the only continental import in the entire assemblage. No obviously later wares were recovered.

A.4 Briquetage

Janice Kinory

Introduction

19,985 sherds of fired clay weighing 220,185 g were recovered from 609 contexts. This represents one of the largest collections of Essex briquetage from a single site, giving the collection regional significance for the range of Roman artefact forms recovered. The mean sherd weight (msw) overall was 11.0 g. However, individual context msw ranged from 0.6 g to 550 g as the assemblage included both small abraded briquetage sherds and substantial segments of kiln furniture. Weight by individual context ranged from 1 g up to 9,651 g. The assemblage was rapidly reviewed to assess type and frequency of fabrics and artefact forms, with a 20x hand lens used in some instances to examine a small number of sherds.

The majority of sherds of identifiable forms are consistent with dating to the Roman period in Essex, beginning in the mid-1st century AD or later, consistent with analysis of pottery also found at the site. Evidence for an earlier, Iron Age phase, is equivocal rather than definitive. A few possible pedestal pieces and a highly fragmentary group of sherds in a single fabric, which may represent the remains of a single pedestal, were found. However, no sherds which were indisputably from pedestals, a form linked with Iron Age production, are part of the assemblage. A firebar end (recovered from context 1900), a form that spans both the Iron Age and Roman salt production industries, has a notch which might have accommodated the flattened top of a pedestal, though other interpretations are possible for this feature. Several sherds appear to resemble pieces termed "luting" by Reader and Wilmer (1908; fig 15, no. 12), recovered from red hills, which have subsequently been identified as being of late Iron Age date. Additionally, the highly abraded forms of many small sherds in the sandy and organic fabrics (detailed below) suggest that they were residual from an earlier phase of activity.

Fabrics

The rapid scan identified seven fabrics in the assemblage, all of which were probably made from locally available clays as is typical of briquetage. All the fabrics in the shelly group share a common clay matrix which is characterised by the presence of fossiliferous shell fragments up to 3 mm long by 2 mm wide making up 2-3% of the fabric, visually detectable without use of a magnifying glass. Also present in most sherds are small natural inclusions of water-rounded red gravel up to 4 mm in length and 2 mm wide making up a further 2-3% of the fabric.

- Fabric A – *Sandy*: Made from sandy clay, abrasive to the touch, without organic temper. Present in 16.3% of contexts.
- Fabric B – *Organic*: Made from a silty clay with organic temper ranging from 5-15% of the matrix. Temper material had been finely chopped into pieces of varying lengths from 3-8 mm and includes seeds as well as stems. Sherds are often pink, light orange or lavender in colour, highly abraded and smooth to the touch. Present in 36.3% of contexts.
- Fabric C – *Silty Organic*: Made from silty clay to which 10-20% finely cut organic material has been added as a tempering material. The fabric is highly friable and beige coloured throughout. Sherds feel extremely light weight, almost cork-like, to the touch. This is the least common fabric, found in only 4.1% of contexts.
- Fabric D – *Shell and Sand*: Shelly clay matrix as described above with sand temper. Highly abrasive to the touch. Present in 30.4% of contexts.
- Fabric E – *Shell, Sand and Low Organic Temper*: Shelly clay matrix as above, but with both sand and finely chopped organic temper. Organic material represents less than 10% of the fabric and has been cut into pieces less than 10mm in length. Organic content may not be readily visible on the surface of the sherds which are generally finger-smoothed. This is the most common fabric, appearing in 58.8% of the contexts.
- Fabric F – *Stony Organic*: The same as Fabric E, but with the inclusion of stones up to 10 x 10 mm in size making up 1-2% of the matrix. Present in 5.3% of contexts.
- Fabric G – *Shell, Sand and High Organic Temper*: The same shelly clay matrix as Fabrics D through F, but with both sand and organic temper. The organic material is chopped into 5-8 mm lengths, and comprises 15 to 20% of the fabric. Residual imprints where organic material burned away are clearly visible on the surface of sherds, which are poorly finished. Sherd thickness is often increased to offset the high proportion of organic temper. Present in 22.3% of contexts.

Forms

The fired clay has been reviewed with respect to pre-existing form classification systems for Essex briquetage which will assist in comparison of this material with that from other sites. As may be expected for this type of assemblage, many sherds are too fragmentary to associate with specific forms. Other sherds, however, were readily classified and belong to the group of objects identified as Type B forms (Rodwel, 1979, 143-153; Fawn *et al*., 1990), known to be correlated with production in the Canvey Island area and the Roman period.

Vessels

A total of 72 vessel bases and 510 rims were identified during the rapid scan of the assemblage, none of which represented complete vessels. Vessel bases suggest the use of both rectangular and the less common circular vessels at this site (Rodwell 1979, 142). Rims were formed by cutting, finger-pinching and thumb- or finger-smoothing, and examples existed of both everted and inverted forms. While generally undecorated, both “pie crust” and bone impressed examples were noted. Thirty-seven contexts had sherds which could be identified as corners, but while the corner form was distinct, in the majority of cases the source of the corner, from a vessel, firebar or kilnbar, could not be determined from a rapid scan.

Kiln furniture and structures

The assemblage included firebar fragments in 25 contexts. Most of the fragments fell within the size parameters outlined in Fawn *et al.* (1990, 13), though at least one had a minimum thickness of 10 mm, while another was unusually short, estimated to have been approximately 75 mm long. Most sherds were firebar ends, occurring in both rounded and trapezoidal cross-section form. Due to the small number of middle firebar samples, no pattern between the flat topped and peaked variants could be determined.

Wedges in a variety of geometric forms were found in 14 contexts. The shapes included the previously published equilateral and isosceles triangle variants and the plectrum form, though the latter shape was quite rare (Fawn *et al.* 1990, 13). A set of three matching isosceles pyramids from context 6031, features 1571, 1574 and 1575, may be unique. One of the three pyramids was recovered as a complete object, approximately 108 mm tall, each edge of the base being 54 mm long, with slightly rounded corners and a thumb smear clearly visible down one side. The slightly rounded tip of the pyramid has salt coating showing a gravitational flow towards the base.

At least 50 contexts contain hand formed fired clay lumps, also known as pinch props or packing rods, which appear to have been formed to help stabilise brine vessels or kiln furniture. These lumps occur in the range of identified fabrics.

Seventy-five contexts contained sherds which were identified as kilnbars, bulky forms intended to support brine vessels during salt production, with some sherds up to 140 mm in length. Unfortunately, in no case was a complete kilnbar preserved. The kilnbars are quite variable, being formed in a range of geometric shapes including square up to 80 mm on a side, rectangular, ovoid or circular in cross-section, up to 90 mm in diameter. Although some were a consistent size throughout their length, others tapered down to ends c. 40 mm across. Only some of the kilnbar sherds had their complete exterior surfaces present, in other cases the form and size of the kilnbar could only be approximated. The ends of kilnbars, where present, were flat or angled upwards at approximately 30 degrees, as if configured to match with a curved surface. Three bar ends composed of four sherds from context 4241, dated by pottery to AD 250-410, had identical heat patterns and salt staining which allowed for their identification as a set. The kilnbar fabric was highly variable, with samples identified in all the shelly fabrics. Organic temper impressions on two samples were reviewed by an archaeobotanist who identified one as having wild grass temper and the other domestic crop temper. Where firebars are typically brick red in colour, the kilnbars ranged from deep purple to black to orange, and were often found with salt surface encrustations up to 3mm thick, suggesting significant usage periods. Some of the sherds identified here as kilnbar sherds may have been components of “firebar grids” as illustrated by Rodwell (1979, 146). An ovoid cross section kilnbar sherd from context 6064, feature 1576, appeared to have a flake of metal, *c* 17 x 9 mm, 1.5 mm thick, adhering to its surface.

Context 5489, a natural sand layer, produced more than 2 kg of material thought to represent a clay hearth floor. The 74 sherds are flat on one side and salt-stained white to a depth of 6 mm. Attached to the flat surfaces are varying depths of material up to 32 mm thick, apparently clay which had been applied over uneven ground to create the level hearth floor and fired through hearth usage.

A 204 gm section thought to be hearth wall was recovered from context 6445. It is approximately 118 x 80 mm, 18-38 mm thick, fired terracotta colour, and hand smoothed with a slight curvature on one side. The back surface is fired clay of irregular form and thickness. There is no visible temper in this material.

Discussion

The forms of briquetage present confirm the site dating as Roman, correlating with dating based on the pottery assemblage. There is very limited evidence of earlier salt production at the site. The absolute size and range of forms within this assemblage makes it significant as evidence of Roman salt production in Essex. However, of particular significance are the range of kilnbars and other kiln furniture, including the pyramidal wedge set, and structures which form a substantial portion of the assemblage by weight.

A.5 Ceramic building material

By Ruth Shaffrey, with contributions by Cynthia Poole

Introduction

Excavations at London Gateway produced 1837 fragments (*c* 250 kg) of ceramic building material from 195 contexts, which included *in situ* salt production kilns. The assemblage consists of mostly large fragments with a relatively small proportion classified as indeterminate, reflected in the mean fragment weight of 149 g. The majority is Roman in date with small quantities of medieval to modern roof-tile and brick.

The whole assemblage was scanned and divided into basic functional types (tegulae, bricks, imbrices and flat tile). Material from *in situ* structures was examined in more detail for any evidence pertaining to function, including burning/heat damage and presence of bedding clay.

Fabric

It was not possible to consider fabric within the time constraints of the assessment. However, general notes appear to suggest that there was very little variation in fabrics present with three broad groupings readily recognisable. A fine red fabric appeared to be the most common, with a grittier variety sometimes used for brick. One distinctive type is a pale cream fabric of which a small number of fragments were made; this may be a known fabric type commonly found in Essex and Kent in the 2nd to 3rd centuries AD (Betts and Foot 1994).

Form

The Roman assemblage consists entirely of tegulae, brick, imbrices and flat tile with a small proportion of indeterminate fragments. Almost 7% of fragments bare signature marks. The percentage of tile with signature marks in retained archives is quite high, but in general, excavation assemblages examined in full tend to have fewer than 10% with signatures and often it as little as 1%. For example, at Higham Ferrers, Northamptonshire (Poole 2009), only eight out of 745 tiles had signature marks, while at Somerford Keynes (Poole 2010), 26 out of 2134 fragments had marks. The 7% seen here may be worth further analysis, as they were found in only 38 contexts (out of 195 containing ceramic building material). The reason for these findings are not currently clear, although they may relate to the generally large size of fragments in certain contexts – a less fragmented assemblage produces smaller numbers and yet because the fragments are bigger, a greater number of them are likely to also have a signature mark surviving.

A single fragment of box tile was recovered. This has the remains of a circular vent hole, (of which Brodribb recorded 44 examples) and some keying (Brodribb 1987, 75).

Roofing

No detailed recording was carried out at this stage, although 103 tegulae flange types were observed and found to be mainly of the square type (A) with a few other variants. Lower cutaways appeared to fall within groups C and D as defined by Warry (2006), which are relevant to the dating of the tile. In terms of numbers, tegulae are present in double the quantity of imbrices, although the latter are generally much smaller fragments (so the weights will be significantly lower), and much of the flat tile is likely to be broken tegulae, especially the 72 fragments with signature marks. These proportions are not typical of use as roofing.

Post-Roman tile

A small quantity of peg-tile and brick fragments of medieval or post-medieval date were found together with three bricks with the stamp of the London Brick Company in the frogs and a fragment of drain pipe of early modern date. These will be included in the archive, but no further analysis of them is required.

Condition

Almost all the CBM in this assemblage is relatively freshly broken material demonstrating little wear or weathering other than breakage and a very small proportion of smaller fragments of indeterminate form. The lack of wear is unusual and may either indicate material cracked *in situ*, which fragmented on lifting and processing, or rapid re-use of broken or damaged tile in the structures.

No complete items are present, which is surprising in view of the fact that a large proportion comes from *in situ* structures. The generally fresh breaks and large groups from some contexts may allow fragments to be refitted. It may be possible to supplement this with information on individual tile sizes from the site record (if the structures were recorded in any detail).

Some of the material is very heavily burnt suggesting use in the hottest part of the kilns, with consistent exposure to extremes of heat. However, the proportion of heavily burnt pieces appears relatively low. Other fragments are burnt only on one side or at one edge, in particular several of the tegulae are burnt only on the flanges. A limited number of pieces retain what appears to be bedding clay and several contexts produced fragments with blackish deposits, probably sooting, on one or more faces. These features can frequently be related to position and function within the kiln structure and could provide information on the construction of collapsed superstructure.

Some contexts appear on first recording to contain significantly more worn material than the rest of the assemblage (e.g. 6062, 5136). The distribution of burnt and / or worn material will need further analysis to elucidate the construction and functioning of the kilns.

Reporting and archiving

All CBM data will be tabulated and summarised for the publication report. A full database of all CBM will be prepared and included within the archive. Once material has been discarded, the database will need to be revised to take account of discard decisions and to reflect new box numbers (if altered) and to add final phasing information. It is crucial that the records can be easily linked to the final archived material. It is anticipated that a selection of the signature marks will be illustrated, as well as the fragment of box tile.

A.6 The lithics

David Mullin

Introduction and methods

The majority of the material was recovered in small amounts from a number of features and comprises waste flakes from late in the reduction sequence, but much of the diagnostic material is of Neolithic date. The flint was catalogued according to a broad debitage, core or tool type. Information about burning and breaks was recorded and where identifiable raw material type was also noted. Where possible dating was attempted.

Cores were classified according to the number and position of their platforms, following Clark (1960), and core maintenance pieces were classified to the following criteria. Core rejuvenation flakes are pieces representing the removal of the top or bottom of a core in order to improve the flaking angle of the platform. Core trimming flakes are flakes which remove a substantial part of a core in order to aid working by removing an imperfection in the core, a miss-hit or other impediment to flaking. The nature of any remnant flake scars on the dorsal surface of core trimming flakes was noted.

Flakes were classified following Saville (1990, 155), which allows an identification of the stage in the core reduction process to which the flake belongs. Terminations such as hinge fractures were noted. Chips are defined as pieces measuring less than 10 mm by 10 mm. Flakes having a length to breadth ratio of greater than 2:1 were classified as blade-like; those with a greater length to breadth ratio being classified as blades. Mid-sections of blades with no bulb of percussion were classified as blade shatter (Andrefsky 1998, 81-3).

Retouched pieces were classified according to standard morphological descriptions (Bamford 1985, Healy 1988, Bradley 1999, Butler 2005).

No attempt was made at refitting or use-wear analysis. Worked flint recovered from the environmental sample residues were also recorded and the presence of burnt unworked flint was noted.

Results

Flint occurred in low numbers from a variety of features, probably indicating that it is residual. The largest amount of flint was recovered from context 1213, which contained a total of 391 objects, predominantly small waste flakes, but including core fragments (SFs 1235, 1416, 1133, 1066), a narrow blade core (SF 1264), a core rejuvenation tablet (SF 11840), core maintenance pieces (SFs 1343, 1169, 1311), blades and blade-like flakes (SFs 1308, 1287, 1192, 1198) and two end and side scrapers (SFs 1125 and 1122). Context 1213 was a number given to flints recovered during cleaning of a deposit identified as a Pleistocene sand. Related contexts are 1553, 1554 and 1555, from which a total of 88 flints including narrow blade fragments were recovered, and 1670 (3 flints), 1672 (7 flints), 1909 (3 flints) and 1627 (4 flints), which were the upper layers of sand in test-pits designed to test the distribution of the flints. A total of 17 items were recovered from context 4843, which is also described as a sand deposit and may be related. Finds comprised several large pieces of angular waste (SFs 4053, 4044, 4050, 4043 and 4051) which may date to the later Bronze Age. Although there are few formal tools present in the material from this context, the blade-based industry and the two end and side scrapers suggest an early Neolithic date. However, there is the potential for a chronologically mixed assemblage with earlier and later elements present.

Context 1454 contained a total of 28 flints, including narrow blade fragments, a utilised flake and scraper. Pottery of probable Neolithic date was also recovered from this context. Narrow-blade flints were amongst the eight recovered from context 4113 (SFs 4015 and 4018) within pit 4111, the other two fills of which (4102 and 4112) contained a further nine flints including a utilised flake and a blade (SF 4016).

Other notable items are an end scraper on a flake with blade flakes (SF 1398) from 1491, which occurred alongside a further six undiagnostic flints. An end and side scraper was recovered from context 4245, a finely flaked end scraper (SF 1018) from 1346 and core fragments from 1308 (SF 1091) and 5579. A finely retouched flint knife (SF 1488) was also recovered, and a rather crudely flaked borer from alluvial layer 6459 (SF 1599).

A.7 Worked stone

Ruth Shaffrey

A total of 1085 pieces of stone were retained during the excavation. The vast majority of these are small rounded pebbles. The stone was examined with the aid of a x10 magnification hand lens.

Description

The assemblage of worked stone includes an estimated 11 rotary querns or millstones made from Lava and Millstone Grit (Table 3), the two most commonly occurring Romano-British rotary quern materials in this region. Millstone Grit quern SF 1566 (5949) may be of an earlier date as it is of an unusual profile but this will need to be investigated further. Several of the Millstone Grit fragments are likely to be from mechanically operated millstones, although no fragments are large enough to be sure. The vast majority of these are from late Roman (second half of the 4th century) contexts and most likely to represent domestic activity rather than to processing on site, although analysis of the pottery may suggest otherwise. The possibility also exists that they were collected elsewhere to be reused as building material, so their contexts of discovery will need close examination. This is especially true given that there are also several large blocks of stone of a possible structural nature (although they are not worked). The presence of greensand is unusual in a Roman context (Lavander 1993) and may indicate reuse of earlier saddle querns.

Other worked stone includes two whetstone fragments of micaceous sandstone of as yet indeterminate source. These were probably associated with the metalworking evidence also found on the site.

SF	Ctx	Description	Notes	Lithology
	1539	Possible quern fragment	Small bit of quern lithology with one flat worked surface	Millstone Grit
1503	1539	Upper rotary quern (10 frags)	Disc style quern with slightly angled but parallel faces. All the faces are worn. The upper surface has a thin line demarcating the usual rim that is found on lava querns	Lava

1509	5041	Rotary quern	Slightly weathered fragments (2). Centre missing. Appears pecked all over. Edges are straight and lean in slightly. Flat top and tapered to centre. Grinding surface is worn with a wide concentric groove towards the rim	Lava
	4294	Upper rotary quern fragment	Thin quern fragment. Centre missing. Flat parallel faces. Rounded slightly damaged edges	Millstone Grit
	5250	Lower rotary quern or millstone fragment	Broken on all sides so not possible to determine much but has deep parallel straight grooves which are probably segmented radial grooves	Millstone Grit
1513	5136	Lower rotary quern or millstone fragment	One possible edge survives - if it is original it suggests this was from a millstone, but it may be damaged. Possible evidence for concentric grooving on the grinding surface	Millstone Grit
	6676	Upper probable millstone fragment	Burnt and stained orange. Grinding surface is heavily worn smooth but traces of the segmented radial grooving survive. Edges damaged so no longer circular	Millstone Grit
	6676	Upper probable millstone fragment	One of three fragments from this context, not apparently from same quern. Deep regularly spaced radial grooves, segmented, on grinding surface	Millstone Grit
	6676	Lower rotary quern fragment	One of three fragments from this context, not apparently from same quern. Deep regularly spaced radial grooves, presumably segmented, on grinding surface	Millstone Grit
1007	6720	Rotary quern fragment	Three fragments, probably adjoining. Tapered to centre but weathered so not clear if upper or lower stone. Radial grooving on grinding surface	Lava
1566	5949	Upper rotary quern fragment	Damaged and burnt/blackened. Top is flat/slightly rounded and grinding surface has segmented radial grooves, which is surprising for a quern of this sort of shape	?Possibly Millstone Grit
1507	5101	Possible structural stone	Possibly worked but not of clear function, possibly structural - need context information	Fine grained probable Greensand
	5489	Worked stone of unknown function	Needs looking at more closely. Shaped on several faces, possibly used as a hone	Quartz sandstone
1593	6228	Possible structural stone	Unworked but could be structural	Fine grained probable Greensand

1600	6228	Possible structural stone	Block, roughly squared, presumably structural	Fine grained probable Greensand
1602	6228	Possible structural stone	Unworked but could be structural	Fine grained probable Greensand
1620	6228	Possible structural stone	Possibly shaped and slightly different shape to other blocks, slightly curved with slight look of rotary quern about it although this does not seem a very likely interpretation	Fine grained slightly glauconitic Greensand
1009	1111	Whetstone	Primary whetstone, with one end damaged. Oval cross section with some bevelling through use	Reigate stone?
	1648	Chalk	Possible worked bit of chalk, very soft. Indeterminate function	Chalk
1603	1416	Whetstone	Primary whetstone, with one end damaged. Oval cross section with some bevelling through use	Reigate stone?

Table 3: Catalogue of worked stone

A.8 Coins

Paul Booth

Six Roman coins were recovered during the excavation and are tabulated below (Table 4). These range in date from the later 2nd century to at least the mid 4th century, but all were in poor condition and cleaning by a conservator is required for five of the six coins in order that the identifications can be refined. The sixth coin is in too poor a condition to merit such cleaning.

The coins are broadly characteristic of the range of pieces that can occur on rural sites, but the (possibly total) absence of coins of the second quarter of the 4th century, normally much the best -represented period in rural con loss patterns, is notable, particularly given the presence of earlier and later 4th century pieces (SF 1496 and SF 4031 respectively), both of types which are considerably less common than the standard issues of the House of Constantine, particularly in the period AD 330-348. The overall size of the assemblage is such, however, that negative evidence, while potentially of interest, does not carry conclusive significance.

Context	SF	Est Date	Denomination	Reverse	Mint	Obverse	Comment	Clean
5279	1522	260-296?	antoninianus? 17-20mm	?	-	?radiate head r	encrusted, particularly reverse	Y
4225	4031	351-353	nummus AE2	(Salus DD NN Aug et Caes) Chi-rho	Trier?	head r	encrusted	Y
4090	4011	260-296	antoninianus frag 14mm	figure l - eg Pax etc		radiate head r	irregular, broken	N
1637	1489	161-192?	as	?		bearded head r	encrusted, ID very uncertain	Y
1817	1495	4C?	nummus AE3 14mm	?		?	encrusted and broken	Y
1534	1496	310-318?	nummus AE2 20mm	SOLI INVICT[O COMITI	?	head r	encrusted and broken (c one third missing)	Y

Table 4: Coins

A.9 Metal objects

Ian Scott

Methods

The assemblage of metal objects has been fully recorded. The provenance and, where appropriate, the dimensions of the objects have been recorded, together with an identification and a description. The assemblage has been quantified both in terms of the number of fragments present and by the number of objects. Nails have been quantified terms of the total numbers of fragments and the likely minimum number of nails present in any one context. This provides a crude guide to the maximum and minimum numbers of nails present. This assessment has been undertaken prior to the assemblage being sent for x-ray.

Assemblage composition

The metals assemblage comprises some 596 fragments, including 518 iron fragments, 41 copper alloy fragments and 35 pieces of lead (Table 5). There is also one object apparently of copper alloy and iron. These figures include 6 coins (7 fragments), which have been identified and assessed separately from the other metal finds.

	Function											
Metal	Coin	Military	Personal	House-hold	Structural	Nails	Misc	Query	Industrial	Waste	Unk	Total
Cu alloy	7		14					6			14	41
Cu alloy & Iron								2				2
Iron		3	2	1	2	164	15	70	8		253	518
Lead			1	3	6		1	4		20		35
Total	7	3	17	4	8	164	16	82	8	20	267	596

Table 5a: Metalwork: Fragment count by metal and function

	Function											
Metal	Coin	Military	Personal	House-hold	Structural	Nails	Misc	Query	Industrial	Waste	Unk	Total
Cu alloy	6		5					3			*	14
Cu alloy & Iron								1				1
Iron		1	2	1	2	112	7	63	7		*	195
Lead			1	3	6		1	4		20		35
Total	6	1	8	4	8	112	8	71	7	20		245

Table 5b: Metalwork: Object count by metal and function

The figure of 596 is somewhat misleading because the assemblage is unusual in the number of small unidentified fragments (classified as ‘Unk’ = ‘Unknown’ in the tables) that it includes. In addition, a number of larger fragments have been classified as ‘Query’. These are objects which have not yet been identified, in many cases because they require x-rays. In both these groups there may be pieces of corrosion or pieces of slag, as well as small pieces of metal and/or objects. X-rays will help to sort these groups more certainly. There are also 164 nail fragments. If these three categories are omitted the total number of fragments (Table 5a) left is 83. If the number of objects (Table 5b), including the minimum number of nails, is counted and the small unidentified objects ('Unk') are omitted from the count, the assemblage numbers 245, including 112 nails and 71 objects classified as 'Query'.

The composition of the assemblage is not typical of a rural settlement. There is a very limited range of objects and these are quite few in number. There is a single possible spearhead (Area A, context 1633). An x-ray will be required to confirm the identification this object which is in three pieces. There are seven personal items including two two-piece Colchester brooches of mid-1st-century date, both from currently undated contexts (Area B, context 4090; Area A, context 6744). Both of these brooches are quite well preserved. By contrast, there is a fragmentary 2nd-century plate brooch with enamel inlay (Area A, context 1539) and three pieces of a hair pin (Area A, context 1007) which are poorly preserved. A possible pair of tweezers (Area A, context 1384) is also very poorly preserved. There are two hobnails from Area A context 5381. The final personal item is a lead button from a context of Roman date; it is likely to be intrusive. Household items are limited to three lead rivets from ceramic vessels (Area A, contexts 1817, 5133, and Area B, context 4090) and possible knife blade (Area A, context 5136). Structural items, which could be associated with buildings, and which exclude nails, comprise six pieces of lead and two pieces of iron. These include possible pieces of lead poured or 'yotted' into joints between stones (Area A, context 1539 and Area B, context 4090, two pieces), two possible lead washers (Area A, contexts 1539 and 5133) and an L-shaped fragment of lead with mortar attached (Area B, context 4090). The iron objects comprise a possible clamp or dog (Area A, context 5133), and a washer (Area A, context 1387). The range of objects is very limited and much more restricted than might be expected from a settlement site of any date.

Provenance and dating of the assemblage

Most of the metalwork assemblage was recovered from contexts in Area A (Table 6a-b) and from contexts of Roman date (Table 7a-b).

	Function											
Area	Coins	Military	Personal	House -hold	Structural	Nails	Misc	Query	Industrial	Waste	Unk	Total
A	5	3	16	3	5	163	15	79	8	14	258	568
B	2		1	1	3	1	1	3		6		18
C											10	10
Total	7	3	17	4	8	164	16	82	8	20	268	596

Table 6a: Metalwork: Fragment count by area and function

	Function											
Area	Coins	Military	Personal	House -hold	Structural	Nails	Misc	Query	Industrial	Waste	Unk	Total
A	4	1	7	3	5	111	7	68	7	14	0	227
B	2		1	1	3	1	1	3		6		18
C											0	0
Total	6	1	8	4	8	112	8	71	7	20	0	245

Table 6b: Metalwork: Object count by area and function

	Function											
Phase	Coins	Militar y	Personal	House -hold	Structural	Nails	Misc	Query	Industrial	Waste	Unk	Total
LIA											10	10
ER						4			1	4	12	21
MR	3	3	2			72	3	32			64	179
LR	1		13	1	2	31	11	18	7	3	125	212
Ro					1	22		2			21	46

Med								1				1
Undat.	3		2	3	5	35	2	29		13	35	127
Total	7	3	17	4	8	164	16	82	8	20	267	596

Table 7a: Metalwork: Fragment count by phase and function

	Function											
Phase	Coins	Military	Personal	House -hold	Structural	Nails	Misc	Query	Industrial	Waste	Unk	Total
LIA											*	*
ER						4			1	4	*	9
MR	3	1	2			52	1	25			*	84
LR	1		4	1	2	19	5	16	6	3	*	57
Rom					1	14		2			*	17
Med								1				1
Undat.	2		2	3	5	23	2	27		13	*	77
Total	6	1	8	4	8	112	8	71	7	20		245

Table 7b: Metalwork: Object count by phase and function

Late Iron Age–early Roman

There was a single late Iron Age context (Area C, context 3053), which produced a few small unidentified fragments. Five early Roman-period contexts produced 21 fragments, including four small pieces of lead waste, four nails and the rest unidentified fragments.

Mid Roman

In total, mid Roman contexts produced 84 objects (179 fragments, including 64 unidentified fragments), mainly nails and objects of uncertain identification. The identifiable finds include, in addition to three coins, the possible spearhead (Area A, context 1633), and two hobnails (Area A, context 5381).

Late Roman

Late Roman contexts produced 212 fragments, including 125 unidentified small fragments. There are a mere 57 objects and these include 19 nails (a surprisingly small number), and 16 unidentified objects. The personal items from late Roman contexts comprise a fragmentary enamel inlaid plate brooch (Area A, context 1539), a fragmentary hair pin, with decorative baluster moulding (Area A, context 1007), and a possible pair of tweezers (Area A, context 1384). There is also a probable lead button from context 1539 which must be intrusive. There is a possible fragment of blade, which might be from a household knife (Area A, context 5136), but this requires an X-ray. There also two pieces of possible structural lead work (Area A, context 1539).

Other contexts

A limited number of finds (46 fragments; 17 objects) are from contexts of broadly Roman date, but mainly comprise nails. There is a single unidentified object from a medieval context. Contexts that have yet to be dated produced some 27 fragments or 77 objects. These include two two-piece Colchester brooches of mid 1st-century date (Area A, context 6744; Area B, context 4090) and three lead rivets from ceramic vessels (Area A, context 1817 & 5133; Area B, context 4090).

Discussion

The metalwork assemblage is quite large in terms of numbers of fragments, but includes a very large number of small unidentifiable fragments. The assemblage is mainly from Area A and predominantly from contexts of Roman date. The small number of datable finds, as well as the coins, are almost all of Roman date. The assemblage therefore has some group value, but this is strictly limited by the small size of the assemblage.

A.10 Metalworking

Edward Biddulph

A total of 5034 fragments of iron slag, weighing over 12 kg, were recovered. The metalworking evidence spans the Roman period, but was concentrated in the mid and late Roman periods (Table 8). The metalworking debris was recovered in several forms. Much of the assemblage consisted of undiagnostic ironworking slag, which can be produced by both iron smelting and iron smithing processes. Of the diagnostic slag, micro slags (hammerscale) and bulk slags (smithing hearth bottoms) were identified. Smithing hearth bottoms, typically plano-convex in shape, are formed in the high temperatures of a smithing hearth by the combination of iron compounds, silica and fluxes. Such evidence was found in Area A, for example in feature 6258, which was a hearth or an anvil setting. Hammerscale consists of fish-scale like fragments of iron dislodged during working, or spheroidal droplets of liquid slag expelled during hot working. It is important in interpretation of activity on sites, because it is highly diagnostic of smithing and tends to build up in the immediate vicinity of the smithing hearth and anvil. Hammerscale may therefore give a more precise location of smithing than the bulk slags, which can be deposited away from activity areas. Some of the of the hammerscale from Area A had been redeposited into postholes and ditches, but evidence was also recovered from areas of burning that may well mark the locations of metalworking activity, and, more intriguingly, the mid Roman roundhouse, suggesting that the structure accommodated blacksmiths as well as salters.

Phase	Area A	Area B	Total
Middle Iron Age	607		607
Late Iron Age-Early Roman	45	3	48
Early-Mid Roman	589		589
Mid-Late Roman	3620		3620
Late Roman	2039	2196	4235
Roman	877	1301	2178
Unphased	1087	1	1088
Total	8864	3501	12365

Table 8: Iron slag by phase and context

A.11 Glass

Ian Scott

Assemblage composition

The glass assemblage from the site is small, comprising 43 sherds or fragments, representing some 25 vessels or objects (Table 9a and b). The assemblage comprises 37 sherds of vessel glass and six fragments from beads. Most of the glass is from Area A. The sherd totals for Areas C and D are inflated by numerous sherds from single vessels. In Area C, there are 14 sherds from a single modern jar (context 3004), and in Area D, five sherds from one small medicine bottle (context 2003; Table 9b). The vessel/object count gives a better picture of the distribution of the glass (Table 9a). The vessel glass comprises for the most part single small sherds from vessels, with only the jar from Area C and the medicine/tonic bottle from Area D having more than single sherds. Both of these are of recent date. Many of the vessel sherds recovered are small and undiagnostic to vessel type.

Overall, the glass assemblage comprises a small quantity of mainly small sherds of vessel glass and a small number of beads. The absence of more and larger sherds of vessel glass suggests that occupation of the site did not include any significant settlement element. The absence of any window glass points in the same direction.

Area	beads	bottles	flask or jug	jug	jars	wine bottle	vessels	Total
A	4	1	1	1			13	20
B	1							1
C					2			2
D		1				1		2
Total	5	2	1	1	2	1	13	25

Table 9a: Vessel/object count by area and type

Area	beads	bottles	flask or jug	jug	jars	wine bottle	vessel	Total
A	5	1	1	1			13	21
B	1							1
C					15			15
D		5				1		6
Total	6	6	1	1	15	1	13	43

Table 9b: Sherd count by area and type

Provenance and date

The bulk of the glass beads and vessels are from contexts assigned Roman dates (Table 10a and b). Two vessels are from modern contexts and comprise two modern screw-top jars (Area C contexts 3004 and 3005). These need no further consideration. The four vessels from as yet undated contexts include three modern vessels: a late 19th- or early 20th-century medicine bottle (context 2003) and a small sherd from a modern wine bottle still with part of its paper label attached (context 2079) both Area D, and a large body sherd from a thin walled vessel or bottle (context 6085) from Area A. The fourth vessel from an undated context is a blue green jug of Roman date represented by a sherd from its handle (Area A context 1018). The sherds from Roman contexts are all either of Roman date or, in the case of many of the small sherds, probably of Roman date.

Phase	beads	bottles	flask or jug	jug	jar	wine bottle	vessel	Total
ER							1	1
MR	2						2	4
LR	3	1	1				8	13
Roman							1	1
modern					2			2

undated		1		1		1	1	4
Total	5	2	1	1	2	1	13)	25

Table 10a: Glass: Vessel/object count (and sherd count) by phase/date and type

Phase	beads	bottles	flask or jug	jug	jar	wine bottle	vessel	Total
ER							1	1
MR	3						2	5
LR	3	1	1				8	13
Roman							1	1
modern					15			15
undated		5		1		1	1	8
Total	6	6	1	1	15	1	13	43

Table 10b: Glass: Sherd count by phase/date and type

Discussion

The assemblage is small; where datable much of the glass is of Roman date and from contexts of the the same broad date. The assemblage therefore has some group value, but this is strictly limited by the small size of the assemblage. Nonetheless, the absence of any significant quantities of vessel glass is in itself of interest and presumably gives an indication of the character of the occupation of the site.

A.12 Leather

Edward Biddulph

A leather object (SF 1595, context 1248), provisionally identified as a shoe, was recovered from late Roman pit 1249. The object is one of a number of complete or unusual items from the feature, and potentially has a bearing on the function of the pit (a cess-pit, for example).

The leather, lifted with the surrounding soil, is currently being stored wet in two self-sealing polythene bags within a self-sealing plastic storage box. If, following conservation, identification of a shoe is confirmed, it may be possible to examine the grain surface of the leather and identify the skin (for example, immature (calfskin) or mature cattle hide). If in good condition, the size of the shoe can be estimated using the modern English shoe-size scale.

A.13 Structural woodwork

Damian Goodburn

Background

This summary assessment concerns the woodwork uncovered and recorded, to various levels to date, and some factors related to its context of use and wider potential for understanding the site. The site is low lying former grazing marsh won from the Thames estuary salt marsh in the post-medieval period and bounded to the east and west by tidal creeks. The intended use of the site as a wildlife refuge required the stripping of *c* 0.5 m or more of topsoil. As much of the land surface lay at around 2 m OD, or just over, judging from other sites along the estuary, the waterlogged remains of medieval and earlier timbers were likely to be uncovered. Woodwork of various kinds was indeed revealed, much of it surviving up to *c* 1.5 m OD, no doubt partly an effect of the location but also the local details of drainage since around 1600. In the following brief report, the woodwork discussed is considered against the backdrop of a huge archive of early woodwork records from the London region.

Specialist site visits

On the initial exposure of groups of timbers, the writer was requested to visit the site and provide advice on the interpretation, initial broad dating, recording and sampling of the material. This visit was made in July 2009, and several groups of structural woodwork then partially exposed were examined and provisional suggestions were made as to the function and dating of some of them. Some of the key features of the site, such as the existence of salt making structures and several buildings were just becoming apparent. Tentative suggestions were made as to possible dating of some structures based on the OD level of survival and general character of the material seen. Predominantly, the date ranges were early Roman or middle Saxon based largely on analogy with findings higher up the estuary in terms of levels rather than woodworking technology. The Roman dating was beginning to be supported by finds spot dating. During this visit, some extra driven posts of the possible 'boathouse' in Area A were spotted.

A second visit was made in September 2009 when the majority of the timbers had been lifted to help carry out the basic recording and sampling of *c* 50% of the larger items. About half the larger timbers and nearly all the small items were double wrapped and labelled and retained for more detailed recording. By then, some of the piled and wattle structures had been radiocarbon dated.

Dealing with the waterlogged ancient woodwork

The site archaeological team had to deal with the unusual circumstances of partially masked structures and stratigraphy. The *c* 0.5 m pasture soil stripping was not always parallel to the horizon at which woodwork became apparent nor the ancient stratigraphy. Despite this limitation and restriction on following down some woodwork, most structures noted below were fully exposed. However, in a small number of cases worked wood, such as stake alignments, was partially exposed in plan and then had to be left *in situ*. Natural decay and ancient estuarine erosion have also cases some erosion to woodwork.

Recording and processing methods

Apart from the two site visits, OA site excavation staff filled out pro-forma 'timber sheets' with measured sketches on the reverse. This very basic level of record is adequate for *c* 50% of the more repetitive and less well preserved items, such as round log piles when set along side more detailed recording with scale drawings and selected photography.

Once the second stage of recording and sampling is complete, the samples taken on site can also be scanned for species and tree-ring (dendro) viability, and a more accurate index of samples and recorded timbers can be created. Once the latter is complete, the assemblage can be said to have been recorded and processed to the standard laid out in English Heritage guidelines (English Heritage 2010).

Quantification of the woodwork revealed and the level to which it has been recorded

The overall size of the assemblage partially or fully excavated at this site is *c* 113 listed items, where some numbers identify whole light wattle structures and groups of woodworking debris. In regional and national terms, this has to be categorised as a medium to large assemblage, though one dominated by substantial repetition of fairly simply worked items, such as piles and stake tips. About 25 of these timbers could not be fully excavated, or broke up on lifting. About 15 of the larger repetitive pile timbers were recorded, sampled and discarded on-site. The rest remain either double wrapped or in tubs in cool dark storage at Oxford (L Allen, pers. comm.). Of the remaining worked roundwood and timber items awaiting the completion of recording, *c* 30 are over 0.4 m long; the rest are small, including a number of partially decayed post and stake bases from the roundhouse in Area A.

Assessment of the character and range of the woodwork

The woodwork is listed by structural group in approximate chronological order.

Structure 1376: a possible boathouse

In Area A, the truncated remains of a structure built on a NW-SE alignment was uncovered. It comprised a U-shaped arrangement of 12 oak log piles, with what may have been an open or lightly built end to the south, facing an ancient silted estuarine channel. The driven oak posts survived up to 1.17 m long by 180 mm in diameter, though others were smaller. The main posts were set on the long walls around 2 m apart and could have supported a weather board or vertical paling cladding. The surviving plan form on the building was *c* 13 m by 6 m across, but it may have been longer and eroded by the channel to the south. Although no diagnostic finds were found (probably due to truncation of the original floor levels), the very unusual building form and its location end-on to a tidal channel suggest that an original function as a boathouse is a likely interpretation. Radiocarbon offers a date of cal 20 BC-cal AD 130 (GU-19628; 95.4%).

Until the discovery of modern paints, lightly built wooden vessels were prone to damage by being dried out and split by the wind and sun, and also damaged by fresh water falling as rain or snow. Boathouses are therefore a feature of the coastal scene from the Iron Age onwards in northern Europe. In a Roman context, small fortlets were built along the Rhine and set within enclosures for their crews, resembling the fortlets on Hadrian's wall. Further recording remains to be done on some of the piles from this group.

Loose group of piles or driven posts to the north of boathouse

A small group of round log piles was found about 12 m to the NW of the boathouse, but their function and date is as yet uncertain. Some at least appeared to be oak when seen during the first site visit.

Possible small piled footbridge 9517

Over in the NW corner of the compensation site in Area B, a roughly rectangular tidally-filled ditch had been cut to drain and contain a saltern activity area. A small group of varied piles extended across the ditch. They included crooked oak poles, non oak (?willow) roundwood, and very unusually for the Roman period, elm log piles. The use of elm in Roman London is unknown, possibly due to the passage of disease. At least one of the elm piles (4388) also has a relict long, narrow, through-mortice more typical of medieval or later carpentry. The stakes and piles varied in size and must represent several phases of building activity. The largest diameter pile was *c* 180 mm across, while the smallest was only 60 mm.

Timbers from wall of roundhouse 9501

The construction trenches of a large roundhouse *c* 12 m in diameter were found near the middle of Area A. In places, remains of wall uprights were found in the inner trench of the roundhouse. These have not been seen directly by the writer, but are important, though decayed, as surviving elements from such buildings are very rare. From the records, the uprights are of varied character, ranging between cleft and round examples. This collection of material warrants careful further recording and sampling. Given the size of this roundhouse, the lack of internal post holes is surprising, perhaps suggesting a large 'bender'-type structure

Post bases from a rectangular enclosure 9502

To the north in Area A, the clear plan of a rectangular enclosure was found demarcated by lines of post holes set *c* 2m apart. In a small number of these holes, the remains of post bases were found (for example 5848). That post survived, with axe felling cut preserved, to a height of *c* 0.32 mm and diameter of *c* 120 mm. It is likely that these posts supported fence rails to which light cleft oak paling was nailed, a system of fencing well known from a range of Roman London sites. Providing a wind-proof screen in this coastal setting might be particularly important.

Structure 6292: small pile group

This pile group, uncovered in Area A, contains a mix of piles, some with round sections, others with cleft sections.

Structure 2027: heavy wattle channel revetment

In area D, the remains of a very robust wattle revetment, one of a pair revetting a causeway across a shallow ditch or fleet (its sister remaining unexcavated), was found. The uprights were mainly heavy oak poles hewn flat on two faces together with some round stakes. Some of the uprights were over 130 mm across and including some of the very heaviest wattle work seen by the writer. The tips often had well preserved axe marks. Wattle revetted causeways were a very common multi-period feature along the Thames foreshore. The structure was radiocarbon dated to cal AD 60-250 (GU-19379; 95.4%).

Pair of oak piles

A pair of carefully-made oak piles found in Area D (2058 and 2059) were thought to be possible Saxon jetty timbers, as they had unusually flat and broad axe marks on their tips. However, such woodworking is known, though very rare, in dated Roman contexts.

Building timber off-cuts used in structure 5755

A circular building on the west side of Area A and of uncertain function contained an arrangement of four post pads, with one additional pad in the SE, that formed a square *c* 5 m across. One of the post pad holes contained rammed chalk and oak building timber off-cuts used as make-up material (or possibly piles). The debris is typical of that produced by carpentry operations in which squared oak timbers were involved. The assemblage will need more cleaning and recording.

A post-medieval to recent farm structure in Area A

The gridwork-like spread of oak posts in the south part of Area A has been radiocarbon dated to the late post-medieval to modern periods (GU-19378; 69.3%), and is shown on a 19th century map. The spread of dates is possibly explainable by the use of an assortment of old oak timbers from old buildings and ships demolished in the timber hungry surrounds of the site. In plan, the structure looks like some form of stock yard where animals are sorted, marked dehorned, etc. rather than a sheep fold as such.

A few specific features and timbers of particular interest

There are several general themes of interest in this woodwork assemblage, such as the glimpse it provides of varied forms of locally managed woodlands, and variation in axes through the Roman period. Reused and abandoned timbers are also of particular interest, such as 4388 and 4399, as they may shed light on activities we have little knowledge of. One recorded item (6505), so far only partially cleaned, is a hewn oak pole section pierced by oval through-mortices, suggesting that it may have been part of a litter frame or possibly gate head.

An assessment of the importance of the assemblage

It is clear that the site provides an important series of views of a stretch on the Roman period industrial estuary coastline at a scale and depth that is just about unique in Britain. The woodwork is part of the archaeology of the site and clearly warrants further recording and sampling to complete the archive. Following a brief trawl of the published literature on Roman saltern sites in the Thames region and the Fens, it seems that very little woodwork has survived on other sites, making this a special feature of this project.

A.14 Human remains

Sharon Clough and Edward Biddulph

Cremated human bone was recovered from an isolated grave 3052 (group 3055) in Area C. Though disturbed from later agricultural activity, the bone appeared to be contained within a shelly-ware jar (3054) dating to the late Iron Age or early Roman period.

Appendix B. Assessment of Palaeoenvironmental Evidence

B.1 Animal bone

Lena Strid

Introduction

The total assemblage comprised an estimated 5368 fragments. Of these, 3970 re-fitted fragments (74%) were hand collected and 1353 (26%) were recovered from sieved bulk samples. The assessment included only the hand collected fragments. The sieved samples were rapidly scanned; most bones were unidentifiable to species and no bird bones were observed. The full assessment-level record of the assemblage, documented in a Microsoft Access database, will be incorporated with the site archive.

Four periods contained faunal remains: the Bronze Age, Iron Age, Roman and medieval. There are also a considerable number of contexts which have not yet been phased.

Methodology

The bones were identified at Oxford Archaeology using a comparative skeletal reference collection, in addition to standard osteological identification manuals, such as Hillson (1992) and Schmid (1972). For this assessment, the number of fragments, total weight, bone condition and species present were recorded by context. Sheep and goat bones were not identified to species at this stage, but rather classified as 'sheep/goat'. Long bone fragments, ribs and vertebrae, with the exception of the atlas and axis, were classified by size: 'large mammal' representing cattle, horse and deer, 'medium mammal' representing sheep/goat, pig and large dog, and 'small mammal' representing small dog, cat and hare. The number of measureable, ageable and potentially sexable bones was also counted in each context. Butchery marks, pathologies and other pre-depositional modifications were noted.

The general condition of the bones/context was graded on a 6-point system (0-5), Grade 0 equating to very well preserved bone, and grade 5 indicating that the bone had suffered such structural and attritional damage as to make it unrecognisable.

Of value for ageing, the numbers of mandibles with two or more recordable teeth (Grant 1982), cattle horncores (Armitage (1982) and fused and unfused epiphyses (Habermehl 1975) were noted. The number of sexable elements, i.e. cattle pelves, sheep/goat skulls and pelves, and pig canine teeth, were also noted, using data from Boessneck *et al.* (1964), Prummel and Frisch (1986), Schmid (1972) and Vretemark (1997). Measurable bones were noted according to criteria published by von den Driesch (1976).

Preservation

Bone condition was mostly fair to poor regardless of time period (Table 11), suggesting that minor pathologies and cut marks may be slightly under-represented. Gnaw marks from carnivores, probably dogs, were observed on a proportion of fragments and burnt bones were present, although not quantified at this stage.

	n	0	1	2	3	4	5
BRONZE AGE	2			50.0%		50.0%	
Late Bronze Age	2			50.0%		50.0%	

IRON AGE	23		21.7%	30.4%	30.4%	17.4%	
Mid Iron Age	16		12.5%	37.5%	31.1%	18.8%	
Iron Age	7		42.9%	14.3%	28.6%	14.3%	
ROMAN	141	2.1%	12.1%	34.0%	44.7%	11.3%	1.4%
Early Roman	22	4.5%	40.9%	22.7%	59.1%	13.6%	
Mid Roman	46		8.7%	37.0%	41.3%	10.9%	2.2%
Late Roman	39		5.1%	38.5%	46.2%	7.7%	
Roman	34	5.9%	5.9%	32.4%	38.2%	14.7%	2.9%
MEDIEVAL	4		25.0%	25.0%	50.0%		
Early Medieval	2		50.0%		50.0%		
Late Medieval	1			100.0%			
Medieval	1				100.0%		
UNPHASED	114	1.8%	8.8%	30.7%	32.5%	26.3%	

Table 11: Animal bone – preservation level for contexts from all phases

Species

Of the 3970 bones included in the assessment, an estimated 591 (14.9%) could be assigned to taxon (Table 12). The identified animals included cattle, sheep/goat, pig, horse, dog, ?cat and deer. Amphibians and micromammals were noted in some sieved samples, but have not been included in the assessment.

Bearing in mind that almost 60% of the bones have not yet been phased, most bones derive from the early Roman and late Roman phases. Cattle is the dominant species throughout, which is consistent with other Essex sites from the Roman period (Johnstone and Albarella 2002, 46-47).

Species	Bronze Age	Iron Age		Roman				Medieval			Unphased
	LBA	MIA	IA	ER	MR	LR	R	EMed	LMed	Med	
Cattle		8	2	5	86	185	37		1		88
Sheep/goat		2	1	3	11	23	5		1		62
Pig				3	4	17	1		1		12
Horse		1		2	1	6	7		1		11
Dog							1		1		
Cat											?1
Rabbit											2
Deer sp.					1						
Small mammal		x	x	x	x		x		x		x
Medium mammal		x	x	x	x		x	x	x	x	x
Large mammal	x	x									x
Indeterminate	x	x	x	x	x	x	x	x	x	x	x
Total fragment count	27	55	17	121	824	1313	415	3	18	6	2320
Identifiable to species	0	11	3	13	107	230	50	0	5	0	172
Total weight (g)	47	1095	372	967	7971	16905	5829	57	161	11	12675

Table 12: Animal bone – presence of identified species for all phases

Data on ageing, sexing, biometrics, butchery and pathology

It is clear that the mid Roman and late Roman assemblages will potentially provides a corpus of ageing, sexing and biometrical data (Table 13). The other phase assemblages at present are less useful, though would be worth further study if significant numbers of as yet unphased bones were assigned to these periods.

Species	Iron Age		Roman				Medieval			Unphased
	MIA	IA	ER	MR	LR	R	EMed	LMed	Med	
Ageable mandibles	2		1	4	11	5				8
Ageable bones	2	1	5	33	58	16		1		50
Sexable bones			1	1	3	1				1
Measureable bones	1			2	9	4				3

Table 13: Number of mandibles and bones providing ageing, sexing and biometrical data

Butchery marks and pathologies were very rare (Table 14) but may prove significant in a discussion of animal husbandry and meat processing.

	Roman				Medieval			Unphased
	ER	MR	LR	R	EMed	LMed	Med	
Butchery marks		2	4	1	0			3
Pathologies		1	3	2	0	1		3

Table 14: Number of contexts containing bones with butchery marks and/or pathological conditions

Potential

The London Gateway assemblage is extremely valuable as a substantial animal bone assemblage from a Roman salt-making site. Animal bone assemblages from salt extraction sites in Britain have been previously studied (eg Canvey Island, Goldhanger, Langenhoe and Osea Road in Essex, Middleton in Norfolk, Ower in Dorset and the Lincolnshire sites of Billingborough, Langtoft, Cowbit and Morton (Albarella and Mulville 2001; Coy 1987; Fawn *et al.* 1990; Iles 2001)), but tend to be limited. With the exception of late Bronze Age/early Iron Age Billingborough and mid-late Roman Ower, these assemblages were small and thus of little comparative value.

Essex as a whole is rich in animal bone assemblages from the Roman period, both from towns and rural settlements (Johnstone and Albarella 2002, 46). Since the bones from Stanford Wharf is the largest assemblage yet recovered from a salt-making site in Essex, it would be interesting to compare species abundance and slaughter age patterns to those from other rural and urban sites. Studies have shown similarities in species abundance and age patterns between smaller towns as well as between larger towns, whereas the rural sites are more varied with regards to species frequency and age ratio (Johnstone and Albarella 2002, 46).

Of particular significance is the question of whether meats were processed at the site. Contexts of particular interest include the late Roman ditch 5099, which contained 11 cattle scapulae, two of which had a perforation in the blade. The perforation is considered an indication of hanging the shoulder joint for smoking or brining (Dobney 2001, 40-41).

B.2 Fish bones

Rebecca Nicholson

Fish remains were collected, generally in small quantities, from the dry residues of bulk soil samples sieved to 0.5 mm at OA South. Additionally, fragments of fish bone have been observed in some of the flots from these samples, as discussed by W Smith (below). No fish bones were hand collected on site. While in most cases the residues contained fewer than five fish bones, usually from small marine fish including flatfishes and clupeids (herring/sprat), one sample was markedly different and of particular significance. This sample was quickly scanned using a binocular microscope at x10 magnification.

Sample 1160, from a deposit (5103) within Roman ditch 5099, was almost completely comprised of tiny fish bones. The flot (780mls) from the processed sub-sample (10L) included tens of thousands of tiny fish bones and scales, almost all either from either juvenile herrings (*Clupea harengus*) or sprats (*Sprattus sprattus*). The residues (c 1.5L) were also virtually exclusively composed of these tiny fish remains. The majority of the identifiable skeletal elements were vertebrae and otic bullae; other cranial bones were occasionally identifiable, but those from the clupeids were mostly crushed beyond recognition. Apart from juvenile clupeids, occasional bones from other fish, including stickleback (*Gasterostidae*), eel (*Anguilla anguilla*), whiting (*Merlangius merlangus*), pogge (*Agonus cataphractus*), pipefish/seahorse (*Syngnathinae*), tiny flatfishes including plaice (*Pleuronectes platessa*), sea scorpion (*Taurulus bubalis*) and possibly also tiny sea bream (*Sparidae*), smelt (*Osmerus eperlanus*) and anchovy (*Engraulidae*) were seen, although these last identifications were very tentative. Very occasional seeds were also present, as were fragments of tiny crustaceans (probably mostly shrimps).

A possible explanation for the concentration of tiny fish remains in sample 1160 is that it represents the remains of garum – a popular fermented fish sauce produced by the Romans. Evidence for garum and similar salted and fermented fish products has been recovered from several sites in Britain, the most significant of which was Peninsular House in London, where it was suggested that the product had been manufactured locally from whole juvenile clupeids (Bateman and Locker 1982; Locker 2007).

B.3 Charred and waterlogged plant remains

Wendy Smith

Introduction

Assessment of the charred and waterlogged plant remains from London Gateway was carried out in order to establish:

- if plant remains were present and of interpretable value
- if charred plant remains might provide information on the selection of fuels for salt working
- if charred plant remains might provide information on the importation of fuel to the area
- if waterlogged plant remains might provide information on the surrounding environment
- if waterlogged plant remains might provide information on the food waste and other debris in the area

In total, 274 samples were assessed for charred plant remains/charcoal and a further 64 samples were assessed for waterlogged plant macrofossils (including waterlogged wood). Staff at OA South used a modified Siraf-style flotation machine to process the samples. For charred plant remains (CPR), flots were collected in a 0.25 mm mesh sieve and heavy residues were retained in a 0.5 mm mesh. Heavy residues were subsequently washed through graduated sieves at >10 mm, 10-4 mm, 4-2 mm and 2-0.5 mm and each heavy residue fraction was dried in a heated drying room at 25℃. CPR flots were als o dried at 25℃. Waterlogged plant remains (WPR) were treated differently. Waterlogged flots were processed using the bucket flotation method and washed over a 0.25 mm mesh sieve, but the residues were also retained in a 0.25

mm mesh to ensure that small-sized seeds, and in particular insect remains which do not successfully float in water without paraffin (Coope and Osborne 1968), were fully recovered. Where possible, unprocessed sediment was reserved for subsequent insect analysis. Both the flot and heavy residue from processing for WPR were stored in water at between 4℃ – 8℃ in the OA South cold store.

Flot and residues were scanned by the author under a low-power binocular microscope at magnifications between x10–x15. The flots were rapidly scanned and, therefore, smaller seeds and plant parts may have been overlooked. Unless otherwise stated on Tables 15-18, the entire flot was scanned for CPR and/or WPR. Heavy residues were sorted by eye.

Identification of charcoal to an individual genus or group was made at x35 magnification on the transverse section using existing breaks. Radial and tangential features, which require higher powers of magnification, were not examined for this assessment. As a result, wood identifications should be seen as provisional, and primarily used as an indication of whether assemblages are varied. No attempt was made during this assessment to create 'fresh breaks' on charcoal to aid identification during this assessment, since this could impair results for the charcoal specialist. Small round wood fragments from two samples were submitted to Dana Challinor for identification and the provisional results are indicated within Table 15.

Comparative material was not consulted during this assessment and quantification is only a subjective approximation. As a result, all the identifications and relative proportions of plant remains presented here should be seen as highly provisional, and are only meant to provide a general indication of the relative diversity and richness of the samples assessed. Nomenclature follows Stace (1997) for indigenous taxa, and Zohary and Hopf (2000) for economic plants. The traditional binomial system for the cereals is maintained here, following Zohary and Hopf (2000, tables 3 and 5).

COMMENT	Site Area	Sample No	Context	Provisional Phase	Feature Type	CPR Potential	Full Analysis CPR	Charcoal Potential	Full Analysis Charcoal	Other Comment
PRIMARY CONTEXT SAMPLES										
	A	1322	6202	LBA-IA	Hearth	B	YES	D	No	possibly combine CPR/ Charcoal with results from other contexts from this same feature (if possible).
	A	1213	5538	MIA	Possible rake out from salt production hearth 5537.	A	YES	D	No	
	A	1222	5477	MIA	top fill of Ditch 5476	C	?YES	D	No	Given early phase - this sample is significant. Appears to mainly be rush. Cut by modern field drain - but CPR does appear to be ancient - ?AMS dating. No samples from related contexts 5611/ 5616
	B	4011	4333	LIA/ ERO	pit 4012	A/B	YES	D	No	
CHARCOAL	B	4099	4764	LIA/ ERO	post hole 4763	F	No	A/B	Yes	D. Challinor examined <4099> charcoal: Quercus (roundwood) ++. Alnus/ Corylus (roundwood) +++, 3 fragments of which identified as Corylus. Bark also present. Sample not promising for CPR/ but worth analysis for charcoal
CHARCOAL	A	1353	6057	ERO-MRO	surface made up of rake out from tile kiln structure [6061]	B	YES	B/C	?Y	CPR will be time consuming to sort because of charcoal rich flot - but unusual weed flora for the site, likely to represent material brought to the marsh. CPR will need to be sorted by WS & may require riffling to 1/2. 10-4mm HR retained burnt clay
	A	1297	6052	MRO	Layer dumping deposit running along western edge of [5989]	B/C	?	D	No	FOR CPR: combine with other samples from the same feature if possible
	A	1345	6099	MRO	Layer - possibly from hearth	B	Yes	D	No	Barley more prevalent in this sample - which is unusual. Unless the context in insecure - would recommend this was analysed.
	B	4013	4228	MRO	kiln 4227	B/C	?Yes	F	No	

	A	1030	1375	MRO-LRO	industrial hearth waste possibly from hearth [1406] to north	A/B	YES	B	Yes	
<1356> best analysed as WPR	A	1153	1538	MRO-LRO	possible hearth rake-out	A/B	YES	C/D	?No	will require additional time to sort because of density of charcoal fragments.
	A	1175	5139	MRO-LRO	Pit 5139 (single context)	A/B	YES	D	No	
? COMBINE DATA FROM THESE TWO SAMPLES	B	4001	4069	MRO-LRO	Ditch 4061	C	?	D	No	interesting flot - but small given it is from 40L of sediment. Analysis may require combination of this deposit with other sample 4005 from this same ditch? No reserved sediment - processed as CPR only.
	B	4005	4255	MRO-LRO	Ditch 4061	C/D	?No	D	No	sample clearly waterlogged - possibly best analysed as WPR. Looks good for insects. ? combine CPR results from samples 4001 & 4005
	A	1111	1531	LRO	pottery-rich deposit - ? trample	A/B	Yes	B/C	?	unclear whether this is a primary feature or not - if primary may be worth analysing charcoal. Would recommend more time to sort flot because charcoal rich. 2 - 0.5mm HR has been retained for CPR - may need to consider riffling (?1/2 flot & 2 - 0.5mm HR or even sub-sample HR & factored back up)
	A	1160	5103	LRO	Ditch 5099	F	No	F	No	Very interesting deposit for FISH. OTHER HR FRACTIONS retained. 4-2mm & 2-0.5mm HR retained for FISH BONE
CHARCOAL	A	1162	5041	LRO	floor below context 5039	C/D	?	A/B	Yes	Because this is a primary floor deposit, even though the charcoal is fairly small-sized, I'd recommend analysis. (this is below context 5039 sample <1156> - potentially the CPR data could be merged.)
	A	1163	1536	LRO	possible fill of shallow ditch [5191]	B	YES	D	No	
CHARCOAL	A	1166	5134	LRO	occupation spread (single context)	B	Yes	A/B	Yes	looks to have good range of wood taxa. CPR is not particularly rich - but context is significant. 10L sediment available to process for CPR - Recommend this is processed for analysis.
	A	1170	5136	LRO	cessy dump (single context)	A/B	YES	D	No	10-4/ 4-2/ 2-0.5mm HR retained for 'chaffy' CPR

	A	1192	5429	LRO	ditch terminus (not on context DB)	A	Yes	C	?no	charcoal from secondary context - however, interesting to find with 'turf' type fuels.
? MERGE DTA FROM SAMPLES 1216, 1217 AND 1218 TOGETHER FOR DITCH 5010	A	1216	5565	UNPHASED/ ?LRO	spent fuel deposit (Ditch on enviro transfer)	C/D	?No	D	No	very white nodules are interesting - and may imply a specific process. Fill of 5510 - can combine with <1217> & <1218> 10-4/ 4-2/ 2-0.5mm retained for fuel ash/ kiln waste Sample borderline for CPR - but of interest because contains white nodules, which may be worth further study
	A	1217	5564	UNPHASED/ ?LRO	Patch of charred material exhibiting range of colours (red, yellow, green and orange), reminiscent of the hearth found in the centre of the roundhouse (Ditch on enviro transfer)	D	?No	D	No	possibly study in combinations with other samples from this ditch. Fill of 5510 - can combine with <1216> & <1218>
	A	1218	5563	LRO	very dark fill at the bottom of Ditch 5010	C	?Yes	C	?	possibly analyse either charocal or CPR in combination with other deposits from this feature. First sample with possible emmer grain - so may be worth analysis. Fill of 5510 - can combine with <1217> & <1216>
CHARCOAL	A	1208	5536	LRO	spread overlying red deposit (5548)	B	YES	A	Yes	unsure if the spread is associated with a particular feature - certainly worth analysis if primary. Will require more time to sort CPR, because flot is charcoal rich. 4-2/ 2-0.5mm HR retained for CPR.

Data from 1334 & 1335 can be combined - or just study 1335	A	1334	1007	LRO	deposit (large quantity of pottery/ glass)	B	No	B/C	?No	Could be combined with sample 1335. Charcoal may not quite achieve 100 fragments >2mm. Analysis may be dependent on whether this is a primary 'deposit' or not & its phase. NB this is a charcoal-rich flot so CPR will be time consuming to sort. 4-2mm HR retained for CPR.
	A	1335	1008	LRO	deposit = 1007/ sample 1334 - more mixed deposit	A/B	No	D	No	Could be combined with sample 1334. CPR will require additional time to sort because sample is charcoal-rich. 4-2mm HR retained for CPR
FOR CHARCOAL	A	1344	6225	LRO	Fill of Roman furnace/salt making kiln [6061]. C3rd/C4th AD	F	No	A	Yes	Charcoal-rich kiln sample - abundant roundwood fragments noted and a variety of wood taxa observed. Looks very good for charcoal analysis.
FOR CHARCOAL	A	1346	6092	LRO	Fill of Roman furnace/salt making kiln [6061]. C3rd/C4th AD	D	No	A	Yes	Charcoal is primarily oak with twiggy roundwoood frags as well.
	A	1360	5250	LRO	Layer - ?re-deposited silty-clay	A/B	YES	D	No	?riffle to 1/2 4-2mm HR retained for fuel ash/ 2-0.5mm HR retained for CPR
	B	4014	4230	LRO	rake out deposit 4229 - north of kiln 4227	A	Yes	B/C	?yes	not particularly rich - but interesting context for fuel use. 2-0.5mm HR retained for CPR.
	A	1029	1374	ROMAN	industrial hearth waste - within hollow 1408 contains burnt daub/ hearth rake out from oven to north.	A	YES	C	?	charcoal does appear frequently to be roundwood. <50 identifiable items. Analyse only if richer samples from similar feature/ phase are not available.
FOR CHARCOAL	A	1121	1890	ROMAN	post hole 1889/ west side of round house	C/D	?	A	Yes	no other context to combine with.

	A	1178	5234	ROMAN	fill (single context)	A	YES	D	No	10-4mm HR retained for ‘cessy material’
	A	1193	5374	ROMAN	post hole 5373/ part of fence within enclosure	B/C	?No	D	No	(does not appear to be part of post-hole grouping - according to context relationship table).
	A	1215	5566	ROMAN	patch of charred material within Ditch 5510 - west of roundhouse	B/C	YES	C	No	Charcoal 4mm or less - unlikely that many frags are >2 growth rings.
? COMBINE 1233/ 1234	A	1233	1331	ROMAN	tank 1316 (within tank 1)	A/B	Yes	F	No	? combine with <1234> 4-2mm/ 2 - 0.5mm retained for slag/ fuel ash
	A	1234	1361	ROMAN	tank 1316 (within tank 1)	B	Yes	F	No	?combine with <1233> 4-2mm/ 2 - 0.5mm retained for slag/ fuel ash
	A	1235	1362	ROMAN	tank 1316 (within tank 2)	A/B	YES	F	No	4-2mm/ 2 - 0.5mm retained for slag/ fuel ash
	A	1236	1363	ROMAN	tank 1316 (within tank 2)	A/B	YES	F	No	4-2mm HR retained for slag/ fuel ash
	A	1237	1365	ROMAN	tank 1316 (within tank 3)	A/B	Yes	F	No	4-2mm HR retained for slag/ fuel ash
	A	1282	5388	ROMAN	area of burnt material within Gully 5245	B	YES	F	No	
	A	1320	1618	ROMAN	Possible use layer of kiln 1581	F	No	F	No	extremely white nodules may be worth chemical assay. 10-4MM & 4-2MM HR FULL OF 'FUEL ASH' NODULES RETAINED AND WORTH ANALYSIS
COMBINE DATA FROM THESE 3 SAMPLES - OR ONLY STUDY 4037	B	4036	4599	ROMAN	Layer - Fill of ditch [4844] - Briquetage temper	B/C	?	D	No	? Combine with sample <4037> & <4038> from same feature 10-4 mm retained for fuel ash/ 2 - 0.5mm for CPR
	B	4037	4600	UNPHASED	Layer - Fill of ditch [4844]	A/B	YES	F	No	?combine with sample <4036> & <4038> from same feature 10-4mm HR retained for fuel ash/ 2-0.5mm HR retained for small bone/ seed

	B	4038	4618	UNPHASED	Layer - Fill of ditch [4844]	B/C	?yes	D	No	appears to be pure rush - of interest dependent on nature of 'layer' and phase. ?combine with sample <4036> & <4037> from same feature 2-0.5mm Hr retained for seeds/ fuel ash/ slag
	A	1103	1821	?ROMAN	post hole 1795	C	?	D	No	interesting that there might be emmer - worth spending some time on this if this is the only example. [if there is reserved unprocessed sediment - it should be processed. Unfortunately primary processing sheet is unclear as to whether 7L or 1L of sediment retained - If more sediment is available float for full analysis.
CHARCOAL	A	1037	1437	UNPHASED	Hearth (area of rake-out - hearth/ oven context not provided on DB)	B/C	Yes	A	YES	Not particularly rich to CPR - but pulses are interesting. Analyse if no other pulse-rich assemblages of this phase & context type recovered.
	A	1058	1485	UNPHASED	Hearth 1484 (thin charcoal layer at base)	B	YES	F	No	Looks to only be Juncus - not particularly rich for seeds - but EXTREMELY NOTEWORTHY AND MUST BE ANALYSED & FULLY REPORTED. 9L of sediment retained - so process remainder of sediment for this sample. (no related contexts to merge with) 4-2/ 2-0.5mm HR retained for fuel ash
	A	1060	1567	UNPHASED	burnt layer within beam-slot 1569 - context 1567 described as possible rake-out - but may just be burnt structural timbers	A	YES	D	No	4 -2mm & 2 - 0.5mm retained for CPR
CHARCOAL	A	1096	1643	UNPHASED	Burnt basal fill of slot (later re-cut as [1640]). Possible rake-out fill	B	YES	A	Yes	interesting barley rich. Will require more time to sort because charcoal-rich flot.
	A	1113	1784	UNPHASED	post hole 1771	A/B	Yes	D	No	

	A	1126	1942	UNPHASED	Ditch 1941	B/C	?Yes	D	No	clearly both charred & WPR. WPR sub-sample only produced ?ancient frass no seeds observed. Recommend if 9L or 10L of sediment was retained (see notes in WPR Flots) then this should be processed for CPR. (no corresponding contexts to merge data with ava
	A	1149	5015	UNPHASED	fill of slot [5016] - ?Oven	B	YES	D	No	Charcoal is small-sized - however, given importance of the feature identification of the fuel may need to be attempted. Will require additional time to sort because flot is charcoal rich.
	A	1159	5042	UNPHASED	trampled occupation layer in context DB (rake out deposit on enviro transfer)	B	YES	D/C	?No	same as contexts 5074; 5042; 5091; 5142; G3/ part of 1386 G4
	A	1200	5315	UNPHASED	Pit	B	YES	D	No	Emmer glume bases are well preserved - interesting that these are found with anthracite/ coal frags as emmer is likely to be LIA/ ERO & subsequently replaced by spelt.
	A	1211	5435	UNPHASED	spread - also described as 'turf deposit'	B/C	Yes	F	No	different from 1210 - but similar stalk-rich deposit - briquetage frags don't appear to be linear/ tube
	A	1277	5872	UNPHASED	Ditch 5621 fill (tertiary)	A	YES	F	No	riffle to 1/16th - super-abundant spelt remains.
CHARCOAL	A	1286	5951	UNPHASED	oven 5551 (outer wall)	F	No	B	Yes	<100 fragments, but primary context. Looks to be all oak.
	A	1319	1619	UNPHASED	Kiln 1581	A/B	YES	D	No	9L sediment retained - should be processed to increase CPR & possibly charcoal quantity.
	A	1321	1617	UNPHASED	Kiln 1581	D	No	F	No	extremely white nodules may be worth chemical assay. Noteworthy silicified minute plant stalk frags. CPR not promising but noteworthy for silicified awns and therefore should be fully analysed/ sample may also be interest because of white nodules which may be worth further analysis.

	A	1329	1597	UNPHASED	kiln/ hearth 1484	D	No	F	No	extremely white nodules may be worth chemical assay. Noteworthy. Entire HR retained for hearth ash CPR not promising/ but sample of interest because of white nodules which may be worth further analysis.
	A	1330	1593	UNPHASED	waste from hearth (kiln on enviro transfer)	D	No	D	No	extremely white nodules may be worth chemical assay. Noteworthy. 10-4/ 4-2/ 2-0.5mm HR retained for hearth ash
	B	4009	4329	UNPHASED	tank 4330 (western-most tank)	B	YES	D	No	ridged seed pod best preserved in this sample so far. 4-2mm HR retained for hearth ash/ 2-0.5mm HR retained for bone/ seed
	B	4010	4331	UNPHASED	cut 4332/ tank 4330 (middle tank)	B	YES	D	No	
CHARCOAL	B	4035	4441	UNPHASED	Layer (not described in context DB)	A	YES	A/B	Yes	analyse charcoal if context is linked to primary fuel use or from a phase of particular interest. 4-2mm HR retained for slag/ 2-0.5mm Hr retained for bone/ seed
	B	4096	4721	UNPHASED	ashy fill of settling tank	B/C	?No	D	No	dependent on nature of context/ phase. 10-4mm HR retained for mineralised material/ 4-2mm HR retained for slag/ fuel ash/ ?MPR
	B	4098	4755	UNPHASED	fill of Linear feature (ditch/ elongated pit) 4753	B	Yes	D	No	
some confusion in numbering for 4103/ 4106	B	4103 (2 of 2) - ???? <4106> which is otherwise missing	4814	UNPHASED	shallow pit - functioned as Hearth 4813	A/B	YES	D	No	problem with sample numbering but highly likely to be the missing flot to ditch sample 4106 from context 4787. 4-2mm HR retained or marine shell/ 2 - 0.5mm HR retained for shell/ seed
	B	4106	4787	UNPHASED	Ditch 4786 - ? is flot <4103> 2 of 2 actually <4106>					flot missing - is this <4103> sample 2 of 2????
	B	4109	4409	UNPHASED	occupation layer (Ditch on enviro transfer - but context database notes cut by channel 4412 on south side)	B	YES	D	No	4-2mm HR retained for slag/ fuel ash/ 2-0.5m HR retained for small mammal bone (scan HR for CPR)

BRIQUETAGE TEMPER SAMPLES										
	A	1210	5434	UNPHASED	spread (described as very 'turfy' deposit) - part of dish/ ?salt pan recovered	A/B	YES	F	No	pink briquetage in plates and often curved to closely match charred plant stalks in flot - likely to be use of Juncus spp. as temper. NOTEWORTHY FOR ANALYSIS. 2-0.5mm HR retained for 'turf'
	B	4037	4600	UNPHASED	Layer - Fill of ditch [4844]	A/B	YES	F	No	?combine with sample <4036> & <4038> from same feature 10-4mm HR retained for fuel ash/ 2-0.5mm HR retained for small bone/ seed DUPLICATE ENTRY - THIS IS ALSO DITCH FILL TO BE STUDIED WITH 4036 & 4037] - HOWEVER SAMPLE HAS WHAT APPEARS TO BE BRIQUETAGE TEMPER REMAINS AS WELL
RED HILL SAMPLES (MOST ARE BORDERLINE & WILL NEED TO MERGE DATA WITH OTHER SAMPLES)										
RH 1	A	1117	1745	MIA	test pit through red hill layer	C	?	D	No	RED HILL Type 1 (not possible to combine with other contexts) but possibly combined with <1119> from similar RED HILL type
	A	1261	5815	MIA	red earth layer/ dump	C	?No	D	No	context type unknown at present - if other samples from this feature are available possible study in combination with them.
	A	1284	5985	MIA	test pit through red hill	B	?	D	No	analysis depending on nature of context - which as yet is not clear.
	A	1292	5985	MIA	test pit (red hill deposit)	C	?	D	No	CPR analysis depends if this sample can be combined with others.
	A	1337	6255	MIA	test pit - red hill	B/C	?	D	No	CPR analysis dependent on nature of context - not particularly rich sample.
	A	1372	6027	MIA	redhill deposit	C	?No	D	No	Only analyse of context or phase is particularly significant.
	A	1373	6028	MIA	deposit of charcoal partially overlain by redhill deposit 6026	B/C	?Y	B/C	?Y	Analysis dependent on nature of context & possibly phase - interesting that this sample has abundant plant stalk & twigs + grain. Unusual mixture of CPR for this site, usually chaff would be present even dominant. 2-0.5mm HR retained CPR
RH 1	A	1119	1875	IRON AGE	test pit through built up deposit	C	?	D	No	RED HILL Type 1 (not possible to combine with other contexts) - but possibly combine with <1117> from similar RED HILL type

	A	1064	1590	ERO	test pit red hill deposit	B	?Yes	F	No	no related context to merge with. BORDERLINE for CPR
RH 2	A	1147	5026	ERO	test pit through red hill	B	YES	D	No	note on database that context 5026 <1147> = 5070 <1154> - same as 1384 RED HILL TYPE 2. Similar to <1139> and <1144> - ?merge CPR data from these deposits.
RH 2	A	1154	5070	ERO	test pit trough red hill layer	C	?	F	No	note on database that context 5026 <1147> = 5070 <1154> - equivalent 1384 Red Hill Type 2 Similar to <1139>, <1144> & <1147> - ?merge CPR data from these deposits.
RH 2	A	1144	5024	MRO	test pit through red hill	C/D	?	F	No	fill of 1384 (RED HILL 2) - ? Merge with sample 1139 from context 5005 = context 1384 & sample 1147/ context 5026 also from 1384 Red Hill Type 2 2 - 0.5mm HR retained SLAG
RH 2	A	1139	5005	ERO-LRO	test pit of red hill	C/D	?	D	No	BORDERLINE for CPR. Context is described as same as 1384 (RED HILL Type 2) - ? merge with sample 1144/ context 5024 & sample 1147/ 5026
RH 2	A	1019	1233	ROMAN	test pit through red hill	A/B	YES	C	?Yes	No retained sediment. NO WPR corresponding sample - so study dried-WPR. Context is described as same as 1384 (RED HILL Type 2) - ?merge with sample 1139/ context 5005, 1144/ context 5024 & sample 1147/ 5026
	A	1022	1339	ROMAN	LAYER ?within redhill 1338	A	YES	F	No	
RH 4	A	1145	1958	?ROMAN	test pit through ?Roman made ground (Red Hill TYPE 4)	B	YES	D	No	potentially merge with <1146> RED HILL TYPE 4
RH 4	A	1146	1958	?ROMAN	test pit through Roman made ground layer (Red Hill TYPE 4)	B	YES	D	No	potentially merge with <1145> RED HILL TYPE 4
	A	1260	5814	UNPHASED	red earth layer/ dump	C	?No	D	No	context type unknown at present - if other samples from this feature are available possible study in combination with them.
	A	1315	5807	UNPHASED	Layer from in situ red hill deposit	F	No	C/D	?No	All HR sorted.
RH 3	A	1351	6343	UNPHASED	Red Hill Type 3 (stakehole on enviro transfer)	D	No	F	No	?8 L of unprocessed sediment retained - recorded on Enviro DB (not on primary processing form) - Glume bases noted in WPR flot - possibly process remainder unprocessed sediment if this is an important context/ phase.

BORDERLINE SAMPLES - ONLY ANALYSE IF PHASE/ CONTEXT IS OF ARCHAEOLOGICAL SIGNIFICANCE										
	A	1281	5742	ERO-LRO	Layer (small patch of burnt material)	D	No	B/C	?No	only analyse if context is primary or otherwise significant.
	A	1276	5740	MRO-LRO	Fill of gully/ 'lozenge' shaped linear cut [5741]	D	No	C	?No	ca. 50 fragments available for charcoal analysis total - analyse only if context of paritcular importance.
	A	1356	1248	MRO-LRO	quarry pit [1249]	F	No	D	No	BEST ANALYSED AS WPR - recommend that the dried CPR processed flot is also scanned to increase range of taxa - 9L sediment also retained for insect analysis. 2-0.5mm HR retained dried WPR/ w/l WOOD
	A	1142	5019	LRO	post hole 5018	C/D	?	D	No	no related context to merge with. BORDERLINE for CPR
	A	1251	5736	LRO	Briquetage charred debris (kiln on enviro transfer)	C	?	C	?	primary context but not particularly rich for either CPR or Charcoal. Probably only worth study if context/ phase is significant (does not appear to be related to other contexts - not on context relationship database)
	A	1070	1618	ROMAN	kiln 1581	C	?	C	?	not paricularly rich to CPR/ Charcoal - but context may make this of interet as it is primary (unable to merge with related contexts - none available).
	A	1097	1568	ROMAN	fill of beam-slot 1569 (enviro transfer had ? hearth)	C/D	?	C/D	No	no related context to merge with. BORDERLINE for CPR
	A	1169	5135	UNPHASED	burnt dump (single context)	C	?No	D	No	only analyse if critical context - not paritcularly rich and similar, but richer deposits already assessed. Not on context relation database.
	A	1189	5362	UNPHASED	fill of pit 5368 (post hole on enviro transfer)	B/C	?Yes	D	No	?analyse in combination with other postholes from this feature? Or if context/ phase are significant. (does not appear to be part of post-hole grouping - according to context relationship table).

	A	1212	5571	UNPHASED	spread - turf deposit - possibly associated with hearth 5537	C/D	?	F	No	?best analysed in combination with other material from same deposit/ feature. ?combine result with <1214> if related to hearth 5537
	A	1214	5537	UNPHASED	hearth 5537	C/D	?	F	No	possibly study in combination with other samples from this feature - if available? <1214> possibly related to this feature - ?combine
	A	1255	5800	UNPHASED	surface Layer	D	No	D	No	Sample best analysed as WPR. However WPR flot labelled <1255> doesn't look anything like this. Is mostly charred with some waterlogged plant frass - and has charred grain, weed seeds, plant stalks.
	A	1266	5774	UNPHASED	Layer of industrial debris	C/D	No	C	?	analysis of charcoal may be dependent on context type and whether deposit is primary or not.
	A	1279	5834	UNPHASED	Pit 5883 (clay lining)	C	?No	F	No	?worth analysis if there are other samples from this feature.
	A	1299	5839	UNPHASED	Deposit of turf-possibly a turf used as fuel for salterns. Sheet (6441) says (6441) is below (5839).	C/D	?	D	No	10-4/ 4-2/ 2-0.5mm HR retained for 'turf'

Table 15: Charred and waterlogged plant remains samples with potential for further study

Charred plant remains

In general, the preservation of charred plant remains was remarkably good. However, charcoal from these areas was often small-sized (<2 mm), which means that we will have limited data for wood fuel use from this site. The assemblage (meaning seeds and other reproductive parts) from areas A and B were remarkably productive with charred wild taxa such as rushes (Juncus spp.), grasses (POACEAE), possible maritime plantain (Plantago cf. maritima L.) and sea lavender (Limonium spp.) often super-abundant in samples. Charred cereal remains, especially cereal chaff, were frequently encountered as well. Areas A and B, being areas of saltern activity, would have necessitated frequent use of fuel stuffs. Areas C and D were less productive, but this may reflect the fact that there clearly are lower levels of archaeological remains in these area. A breakdown of the results for charred plant remains (CPR - seeds and other reproductive parts of plants) is presented by phase and area below.

		CPR Potential									
Site Area	Provisional Phase	A	A/B	B	B/C	C	C/D	D	F	blank	Total
Area A	LBA							1			1
	LBA/ IA							1			1
	LBA-IA			1							1
	MIA	1		1	2	6	1	5	2		18
	IRON AGE					1					1
	LIA/ ERO							4			4
	ERO			2		1					3
	ERO-MRO			1				1	1		3
	MRO			1	1	1	1	9			13
	MRO-LRO		3					4	3		10
	LRO	1	4	4		1	2	2	2		16
	ROMAN	3	5	2	3	1	3	11	4		32
	UNPHASED	2	3	8	4	6	9	52	38	3*	125
Area A Total		7	15	20	10	17	16	90	50	3*	228
Area B	LBA							1			1
	LIA/ ERO		1						1		2
	MRO				1				1		2
	MRO-LRO					1	1				2
	LRO	1						1			2
	ROMAN				1						1
	UNPHASED	1	2	4	2			10	6	2*	27
Area B Total		2	3	4	4	1	1	12	8	2*	37
Area C	UNPHASED								1		1
Area C Total									1		1
Area D	UNPHASED							2	10		12
Area D Total								2	10		12
GRAND TOTAL		9	18	24	14	18	17	104	69	5*	278

*Table 16: CPR Potential: A = Rich (>300 identifiable items), B = good (between 100 - 300 identifiable items), C = Moderate (50 - 100 identifiable items), D = Poor (<50 identifiable items, usually <10) and F = Unproductive (no identifiable items noted). Shading of results by phase indicates those periods where a concentration of archaeobotanical data occurs for a particular area of Stanford Wharf Nature Reserve. *samples in the 'blank' column did not generate a flot or were clearly dried out WPR and were assessed as WPR.*

A breakdown of the charcoal results is presented below:

		Charcoal Potential										
Site Area	Provisional Phase	A	A/B	B	B/C	C	C/D	D	D/C	F	blank	Total
Area A	LBA							1				1
	LBA/ IA						1					1
	LBA-IA							1				1
	MIA				1			13		4		18
	IRON AGE							1				1
	LIA/ ERO							2		2		4
	ERO							1		2		3
	ERO-LRO				1			3				4
	ERO-MRO				1					2		3
	MRO	1				2	1	7		2		13
	LRO	1	2		2	2		9				16
	MRO-LRO		1	1		2	1	5				10
	ROMAN	2				5	2	8		11		28
	UNPHASED	6		1		5	3	54	1	52	3*	124
Area A Total		10	3	2	5	16	8	105	1	75	3*	228
Area B	LBA							1				1
	LIA/ ERO		1					1				2
	LRO				1			1				2
	MRO							1		1		2
	MRO-LRO							2				2
	ROMAN							1				1
	UNPHASED		1					14		10	2*	27
Area B Total			2		1			21		11	2*	37
Area C	UNPHASED							1				1
Area C Total								1				1
Area D	UNPHASED							4		8		12
Area D Total								4		8		12
Grand Total		10	5	2	6	16	8	131	1	94	5*	278

*Table 17: Charcoal Potential: A = Rich (>300 identifiable items), B = good (between 100 - 300 identifiable items), C = Moderate (50 - 100 identifiable items), D = Poor (<50 identifiable items, usually <10) and F = Unproductive (no identifiable items noted). *samples in the 'blank' column did not generate a flot or were clearly dried out WPR and were assessed as WPR.*

CPR from Area A

Out of the 228 samples assessed, 83 (36%) were considered to have produced good to rich assemblages of interpretable value and merit further analysis. In some cases, moderate quantities of charred plant remains were recovered from a number of samples within the same feature and these could be usefully combined to generate interpretable assemblages.

Charred cereal grain and chaff remains often are abundant. They include emmer (*Triticum diccocum* Schübl.), spelt (*Triticum spelta* L.) and hulled barley (*Hordeum* spp.). Emmer has been noted in both Iron Age and Roman deposits, and suggests that this crop continued in cultivation during the Roman period, alongside spelt. It is unclear whether spelt is present in

Iron Age assemblages at this stage; further analysis may clarify the timing of the use of spelt at this site. In addition to charred cereal remains (grain or chaff), a suite of weed/wild taxa are ubiquitous in these deposits. This includes rush (*Juncus* spp. – a taxon/taxa with multi-seeded fruit capsules), wild grasses (POACEAE) and sea lavender (*Limonium* spp.). Identification of sea lavender and possible sea plantain (*Plantago* cf. *maritima* L.) can overlap with poor preservation, so will require further analysis. However, it is likely that both taxa can occur together and certainly they are listed in a recent survey of the middle salt marsh zone of Stiffkey Salt Marsh in Norfolk (Boorman and Ashton 1997, 113). Both seeds and plant stalks of this group of taxa are frequently encountered, which could suggest that turf from the Mucking marshes/mud flats were actively collected for use as fuel. The use of turf for fuel in the English lowlands is rarely researched (Hall 2003, 5) and, therefore, these results will be of regional, potentially national, importance. There clearly is a distinct succession of plants within salt marsh zones (eg Boorman and Ashton 1997) and, therefore, there is the potential to establish what areas of the Mucking salt marsh/mud flats were exploited for fuel.

Charcoal from Area A is not particularly promising and appears to be primarily limited to later phases of activity. In general, charcoal occurs in relatively low densities and when present, frequently is relatively small sized (often <2mm). As a result, only a very limited number of samples are sufficiently rich to merit further analysis. Out of the 228 samples from Area A, only 20 have generated at least 100 identifiable wood fragments (scored as Good (B) to Rich (A)). These are all from Roman features and the provisional phasing suggests this is restricted to middle to late Roman deposits. The pattern in the wood fuel data is of interest in that it may suggest a change in the fuel supply used in these late salt working activities. Establishing what fuel or fuels were used in specific periods of saltern activity is a major research question at Stanford Wharf Nature Reserve. In addition, the wood fuel and charred plant remain results should be integrated as it is likely that a mixture of cereal crop processing waste, salt marsh vegetation (possibly turf) and wood fuels may have been utilised. Therefore, samples which provide interpretable assemblages for both charred plant remains and charcoal should be specifically targeted for analysis and their results should be integrated.

CPR from Area B

Area B was roughly half the size of Area A and clearly did not possess as complicated archaeological remains. With the exception of one isolated late Bronze Age sample (sample 4000/pit context 4112), all other remains span the late Iron Age/early Roman transition to the end of the Roman period. Fourteen samples have been identified as having good to high potential for charred plant remains. Like Area A, Area B charred plant remains include cereal processing debris (charred grain and cereal chaff) accompanied by associated weeds of crop and marsh plants, which potentially could represent the use of turf as fuel. Only three samples were considered good to rich for charcoal remains, and again these are from Roman phases. In cases where a number of samples have been collected from the same feature which have only generated relatively moderate assemblages, it is recommended that the results from these samples should be combined for analysis.

Although Area B has generated a relatively small archaeobotanical assemblage, the analysis of the charred plant remains and charcoal from these deposits will provide information on the use of crop processing debris, salt marsh vegetation (possibly turf) and wood for fuel in saltern activities taking place within Area B. Analysis of these remains should also explore whether the assemblages between Areas A and B are similar or different. Certainly marked differences in the fuels used on site may indicate chronological and/or social differences in the activities taking place at these two saltern areas.

CPR from Area C

One unphased sample from Area C was assessed for CPR and charcoal. It was generally unproductive and, therefore, no further analysis is necessary for this sample.

CPR from Area D

Twelve unphased samples from Area D were assessed for charred plant remains and charcoal. These were generally unproductive and, therefore, no further analysis is necessary for these samples.

Waterlogged plant remains

Seventy samples were assessed for waterlogged plant remains, seven of which were either entirely unproductive or clearly were samples of charred plant remains and were, therefore, assessed as such.

		WPR Potential									
Area	Provisional Phase	A (including bran)	A/B	B	B/C	C	C/D	D	F	blank	Total
Area A	MIA								2		2
	ERO-MRO					1			1	1	3
	MRO							1	3		4
	MRO-LRO		3								3
	ROMAN					1		1	2	1	5
	UNPHASED	1	1	1	1	2	2	9	15	5	37
Area A Total		1	4	1	1	4	2	11	23	7	54
Area B	MRO-LRO							1			1
	LRO							1			1
	UNPHASED								2		2
Area B Total								2	2		4
Area D	UNPHASED						3	6	3		12
Area D Total							3	6	3		12
Grand Total		1	4	1	1	4	5	19	28	7	70

Table 18: WPR: Breakdown of results for areas A, B and D (no waterlogged samples collected from Area C)

Only a few samples from Area A merit further analysis for WPR and, therefore, they will be discussed by feature and phase below.

Mid–late Roman pit 1249

Three samples were collected from pit 1249, two of which (samples 1356 and 1357) were from the same context (1248). The third sample (sample 1358) is from context 1368. All three deposits were clearly relatively rich waterlogged assemblages. Indeterminate sloe/small plum/ greengage/damson/bullace type (*Prunus spinosa* L./*Prunus domestica* ssp. *insititia* (L.) Bonnier and Layens) and possible cherry (indeterminate *Prunus cerasus* L./ *avium* L.) stones and stone fragments were frequently noted. Weed/wild taxa observed include henbane (*Hyoscyamus* *niger* L.), knotgrass (*Polygonum aviculare* L.) and buttercup (*Ranunculus acris* L./ *repens* L./ *bulbosus* L.) seeds. Fly (Diptera) puparia and beetle (Coleoptera) fragments were noted in all the flots, but were particularly abundant in sample 1356. The contents of all three samples are quite similar, so it is recommended that the waterlogged plant remains are fully analysed from sample 1356 (which had the best insect remain potential) and, possibly, sample 1358, if this is from a distinctly different deposit to sample 1356.

Sample 1377 was a remarkably rich deposit recovered from within a complete ceramic vessel (context 1248, SF 1596) from within pit 1249. Fragments of seed/fruit cell wall (possibly bran but potentially fruit), fish vertebrae, fly puparia and beetle fragments, dock seed, cherry stones, plum and blackberry/bramble pips were noted. This is an extremely interesting deposit potentially representing food contents, food waste or even cess. It is recommended that both the WPR flot and residue are fully analysed for waterlogged plant macrofossils. Any accompanying bone (at present only fish identified) and insect remains should also be fully identified.

Waterlogged results from rural sites are extremely limited in Roman Britain (eg van der Veen 2008; van der Veen *et al.* 2007) and, therefore, analysis of this assemblage is of regional importance. In addition, this pit deposit has potential to either represent food waste or possibly cess and analysis of the accompanying insect remains may clarify the source(s) of this deposit. It is recommended that at least one of the pit fill deposits and the pot fill are analysed, with particular emphasis on establishing whether the pot fill is a primary food residue or is in fact simply more of the general fill of pit 1249.

Fill around wattle 5790

Sample 1253 from a wattle-lined feature was a relatively moderate assemblage primarily producing low levels of wild taxa such as orache (*Atriplex* spp.), rush (*Juncus* spp.), sedge (*Carex* sp.), mouse-ear (*Cerastium* sp.) and elderberry (*Sambucus nigra* L.). Only a few insect fragments were noted in the WPR flot during assessment, so it was not considered particularly promising assemblage for insect remains. Analysis of this moderate assemblage is unlikely to be particularly informative, but may be worthwhile if the phase or context is of particular importance.

Possible Roman surface (context 5800)

Both charred and waterlogged remains from sample 1255 were assessed as rich. However, the sub-sample for charred plant remains was more productive for WPR than the waterlogged sub-sample. Conversely, the waterlogged sub-sample was more productive for charred plant remains. There is no error with labelling or processing, so it is presumed that this deposit must have had discrete patches of charred material within it. However, this may have implications for the analysis of insect remains, in that the retained sediment is associated with the sub-sample which was not productive for waterlogged plant remains. Should this context be securely phased and be of importance to the site narrative, it is recommended that both the charred and waterlogged components of this deposit are fully analysed. Furthermore, although there is the chance that it will not be productive, it is recommended that the retained sediment is processed for insect remains since the insect fauna may be useful in determining if this ‘surface’ is within a building or not (cf. Kenward and Carrot 2006).

Alluvium/peat (context 1915)

Two samples (1125 and 1137) from this context were collected, with sample 1125 slightly more productive than 1137. The waterlogged flot contained abundant leaf/stem debris and insect remains (mainly Coleoptera) were frequently noted. Only wild plant taxa were noted in this flot, such as club-rush (*Bolboschoenus* spp./*Schoenoplectus* spp.) seeds, orache (*Atriplex* spp.) seeds and a small-sized grass (?Phragmites - compressed POACEAE) caryopsis. This is likely to reflect the natural vegetation and may help characterise the nature of the salt marsh. Certainly there is potential to date this deposit using AMS radiocarbon determination on plant macrofossils from the assemblage. However, further analysis will be dependent on whether this feature is of significance to the overall site narrative.

Layer/dump of waste material (context 5660) and fill of alluvial channel 6000 (context 5999)

Relatively small assemblages of primarily wild plant taxa were recovered from these layers (samples 1238 and 1309). A few beetle fragments were also noted. At present these sample are not particularly significant. However, they do clearly contain plant macrofossils characteristic of the surrounding environment and, therefore, should their archaeological context or phase be of particular interest to the site narrative, then it is recommended that these samples be analysed. If, however, other samples are from the same period or are richer (possibly from similar deposits), it is advised that these borderline sample should be reviewed and possibly dropped from the full archaeobotanical analysis programme.

Waterlogged samples with roundwood fragments from red hill deposits

Two samples – samples 1305 (context 6231) and 1378 (context 6027) – were relatively productive for waterlogged wood fragments (especially roundwood or twig fragments). Both samples need to be reviewed in terms of whether the round wood is contemporary with activity or belongs to a subsequent abandonment/flood deposit in the area. Certainly, the fact that this is material from general layers of salt working debris will make the interpretation of these deposits somewhat problematic.

Additional non-archaeobotanical samples

Samples with retained fuel ash/white nodules

Several samples generated glassy to white nodules which are likely to have been generated from saltworking. Some of these appear to be likely candidates for some form of sulphate, possibly lead sulphate. It is recommended that a chemical assay of sub-samples of these white nodules is undertaken, especially for samples 1216 (context 5565), 1320 (context 1618), 1321 (context 1617), 1329 (context 1597) and 1330 (context 1593). There seems a real possibility that other industrial processes took place at the site, and a straightforward chemical analysis of these nodules could reveal other activities, apart from salt working, were carried out here.

Samples with apparently plant tempered briquetage

A few samples contained hollow tubular pink briquetage structures and charred plant stalks which strongly suggests that this is briquetage tempered with plant matter. It is recommended that the briquetage from these deposits and the plant remains are targeted to establish what plants are being used to temper the briquetage. In addition to this possible charred temper material, some of the briquetage sampled during excavations has clear plant impressions and these also should be fully analysed and recorded.

Unquantifiable silicified plant stalks

One sample produced abundant highly silicified (charred to grey or white colour, highly ashy, frequently exploding upon contact) plant remains.

Comparanda

There are no previously published archaeobotanical data available on salt-working sites in Essex. As such, this means that the data produced form Stanford Wharf is of clear regional importance. Moreover, it is clear that archaeobotanical data from such sites for East Anglia is remarkably limited. Although saltern sites are known and excavated, the charred plant remains clearly have not been a major priority (eg Potter 1981, 106; Murphy 2001f, 382).

Only one potential salt-working site in Kent has had archaeobotanical results. Pat Hinton (1998) has reported results from Scotney Court in Kent, which may potentially be associated with a saltworking site. However, Hinton has argued that the charred plant remains represent cereal processing activities and the waterlogged remains reflect the surrounding environment. As a result, these data are not easily comparable to the London Gateway assemblage.

Previous archaeobotanical data from salt working sites in East Anglia (including Lincolnshire/Norfolk Fenlands) are limited. Peter Murphy has published results from several saltern sites in Lincolnshire (Murphy 2001a-f). Muphy (2001f, table 94) has approached the issue of fuel supply for salterns by integrating reporting of charcoal and charred plant macrofossil results. This approach seems highly suited to the remains from London Gateway. Murphy (2001f) argues his remains are derived from peat and this can serve as a useful comparison to the London Gateway archaeobotanical data, which do not appear to be derived from peat.

B.4 Pollen

Sylvia Peglar

A total of 44 samples were submitted for a rapid assessment for their potential for full pollen analysis. It is hoped that it will be possible to reconstruct the vegetational history and environment of the sites.

Two tablets containing a known number of Lycopodium spores were added to 1 cc of sediment so that approximate concentrations of pollen and spores in the sediment could be calculated. The sediment was prepared for analysis by a chemical method to remove the surrounding matrix and concentrate the pollen and spores. The resulting residue was suspended in 2000 cc silicone oil and examined at x400 magnification at equally spaced traverses until twenty Lycopodium spores had been counted and the sediment pollen and spores identified and counted.

The results are presented in Table 19. Some attempt has been made to evaluate the inferred vegetation represented by the pollen and spores found, but the identification of such small numbers means that these are only very tentative suggestions. The final column of the table gives some idea of whether the samples are worth analysing fully.

To summarise:

AREA A: Sequence 1 is variable but could be possible
Sequence 6 again is variable but possible
Sequence 8 is good
Sequence 9 is not good
Sequence 12 is good
Sequence 14 is good
Sequence 19 is not good
Sequence 23 is not good

AREA B: Sequence 25 is variable but could be possible
Sequence 26 is not good

AREA D: Sequence 38 is good

The Palaeochannel sequence is good

Acknowledgements

The samples were prepared by Sandra Bonsall at OA North who is to be thanked. The Geography Department at Lancaster University kindly provided laboratory facilities.

	Section	Context	Sample no.	Conc/cc (x1000)	Preservation	Pollen types	Inferred vegetation	Potential
AREA A								
Sequence 1								
	1027	1132	1004 5-6cm	5	Good	Grass, chenopods, alder, sedge, dandelion-type,fern, bracken	Saltmarsh, grassland/pasture, ruderal, alder carr,	Yes
	1027	1135	1004 15-16cm	15	Quite good	Chenopods, grass, sedge, ribwort plantain, willow, hazel, dandelion-t	Saltmarsh, grassland/pasture	Yes
	1027	1136	1004 30-31cm	30	Quite good	Chenopods, sedge, grass, dandelion-t, bracken	Saltmarsh, grassland/pasture	Possible
	1027	8506	1004 G5 43-44cm	43	Not v. good	Fern, bracken	Ferns(?)	No
	1027	8502	1002 G4b 28-29cm	28	Quite good	Sedge, grass, oak, hazel, pine, bracken, daisy-type, alder, dandelion-t	Sedge fen/fen carr, grassland,	Yes
	1027	8503	1002 G4b 32-33cm	32	Quite good	Sedge,grass, dandelion-t, ribwort plantain	Sedge fen, pasture	Possible
	1027	G3	1002 38-39cm	38	Uncountable			No
Sequence 6								
	1097	1746	1380 20-21cm	20	Quite good	Sedge, alder, fern, chenopods	Saltmarsh, sedge fen/fen carr	Possible
	1097	1747	1381 0-1cm	2	Quite good	Alder, sedge, chenopods, pine, bracken, dandelion-t.	Saltmarsh, alder carr/sedge fen	Possible
	1097	1793	1381 6-7cm	6	Good	Grass, sedge, chenopods, fern, bracken, alder, daisy-t, mugwort, ribwort plantain	Saltmarsh, grassland/pasture, ruderal/arable	Yes
	1097	1794	1381 16-17cm	16	Not v. good	Dandelion-t, daisy-type	Grassland/ruderal(?)	No
	1097	1837	1381 49-50cm	49	Quite good	Oak, hazel, lime, alder, grass, sedge, chenopods, cabbage family, dandelion-t, carrot family	Mixed deciduous woodland, grassland/pasture	Yes
Sequence 8								
	1319	5980	1289 29-30cm	29	Quite good	Sedge, chenopods, elm, hazel, fern	Sedge fen(?), saltmarsh(?), deciduous woodland(?)	Yes
	1319	5980	1289 34-35cm	34	Good	Grass, sedge, oak, hazel, birch, willow, chamomile-t, meadowsweet, daisy-t, mugwort, ribwort plantain, rose family, chenopods,ferns, cereal	Saltmarsh, sedge fen, grassland/pasture, arable, deciduous woodland	Yes
	1167	1996	1136 45-47cm	45	Quite good	Hazel, oak, pine, lime, rose family, grass , bracken	Deciduous woodland, grassland	Yes
	1167	1995	1133 40-42cm	40	Quite good	Lime, maple, alder, grass	Deciduous woodland, grassland	Possible
Sequence 9								
	1306	5872	1274 17-18cm	17	Not v. good	Chenopods, grass, nettle, pink family	Saltmarsh, grassland(?)	No
	1306	5875	1274 25-26cm	25	Good	Grass, cereal, ribwort plantain	Grassland/pasture, arable	Yes
	1306	5620	1274 33-34cm	33	Poor	Grass, chenopods, sedge, dandelion-t	Saltmarsh, grassland	No
Sequence 12								
	1051a	1351	1026 30-31cm	30	Quite good	Grass, cereal, chenopods, ribwort & buck's horn plantain, chamomile-type, pine, oak,	Grassland/pasture, arable, woodland (?)	Yes

						bracken		
	1051a	1350	1026 50-51cm	50	Quite good	Grass, cereal, ribwort plantain	Grassland/pasture, arable	Possible
	1051a	1348	1027 30-31cm	30	Not v. good	Chenopods, grass, cereal, ribwort plantain	Saltmarsh, grassland/pasture, arable	Possible
Sequence 14								
	1239	5430	1203 0-1cm	2	Good	Grass, dandelion-t, ribwort plantain, buttercup, bracken, chenopods, cereal,sedge, hazel, daisy-t, fern, mugwort, carrot family	Grassland/pasture, arable	Yes
	1239	5429	1203 12-13cm	12	Quite good	Grass, hazel, oak, cereal, dandelion-t, cabbage family	Grassland, arable, woodland(?)	Possible
	1239	5428	1203 22-23cm	22	Quite good	Grass, daisy-t, chamomile-t, mugwort, birch	Grassland	Possible
Sequence 19								
	1367	6373A	1366 12-13cm	12	No pollen			No
Sequence 23								
	1049	1252	1363 0-3cm	0	Uncountable			No
AREA B								
Sequence 25								
	4093	4433	4031 28-29cm	28	Good	Grass, ribwort plantain, dandelion-t, sedge, chenopods, chamomile-t,, cabbage family, carrot family	Grassland/pasture, arable/ruderal	Yes
	4093	4435	4032 0-1cm	2	Quite good	Grass, dandlion-t, rose family, daisy family, chamomile-t, cereal, birch	Grassland/pasture, arable	Yes
	4093	4437	4032 20-21cm	20	Poor	Hoary plantain, chamomile-t, elm, pine	Grassland(?), woodland (?)	No
	4093	4440	4032 35-35cm	35	Not v. good	Chenopods	Saltmarsh	No
	4097	4641	4092 0-1cm	2	Quite good	Alder, hazel, chenopods, sedge, oak, dandelion-t, cabbage family, chamomile-t, polypody	Alder carr(?), saltmarsh, grassland, deciduous woodland	Possible
	4097	4642	4092 30-31cm	30	Good	Grass, ribwort plantain, dandelion-t, daisy-t, chamomile-t, oak, alder, hazel, pine, chenopods, redshank, rose family, cabbage family,hoary plantain, buttercup, sedge, carrot family	Grassland/pasture, arable,/ruderal saltmarsh, alder carr(?)	Yes
	4097	4643	4092 45-46cm	45	Good	Grass, ribwort plantain, hoary plantain, cabbage family, clover-t, chenopods, carrot family, daisy-t, rose family, buttercup, chamomile-t	Grassland/pasture, arable/ruderal, saltmarsh(?)	Yes
Sequence 26								
	4049C	4291	4007 15-16cm	15	Uncountable			No

	4049C	4307	4007 34-35cm	34	Not v. good	Chenopods, bracken	Saltmarsh(?)	No
	4049C	4308	4007 50-51cm	50	No pollen			No
	4049C	4210	4008 26-27cm	26	Quite good	Sedge, grass, hazel, pine, alder, oak, willow, bracken, mugwort	Saltmarsh, alder carr(?), deciduous woodland	Possible
AREA D								
Sequence 38								
	2007	2108	2009 25-26cm	25	Good	Chenopods, grass, sedge, bracken, mugwort, fern, hazel	Saltmarsh, grassland	Yes
	2007	2109	2010 12-13cm	12	Quite good	Alder, grass, fern, hazel, birch, chenopods	Saltmarsh, alder carr	Yes
	2007	2100	2010 30-31cm	30	Quite good	Grass, mugwort, chenopods, hazel	Saltmarsh, grassland	Possible
	2007	2111	2010 45-46cm	45	Quite good	Sedge, grass, ribwort plantain, polypody, pine, chenopods	Saltmarsh, grassland/pasture	Possible
Palaeo channel sequence			OA BH3 3.8m	15	Quite good	Grass, hazel, oak, alder, ribwort plantain, fern, sedge	Grassland/pasture, deciduous woodland	Yes

Table 19: Results of pollen assessment

B.5 Diatoms

Nigel Cameron

Introduction

Forty-five sediment sub-samples were prepared from the site and assessed for diatoms. These were taken from three areas of the site (A – 30 samples; B – 11 samples; D – 4 samples). The diatom assessment was carried out as part of a wider palaeoenvironmental evaluation at the site that employs other techniques such as pollen, plant macrofossil, ostracod, foraminiferan and phytolith analyses. The purpose of the diatom assessment was to assess the potential to use diatom analysis of the London Gateway sequences for environmental reconstruction. The diatom assessment takes into account the numbers of diatoms, their state of preservation, species diversity and diatom species environmental preferences.

Diatom preparation followed standard techniques (Battarbee 1986; Battarbee *et al.* 2001). Two cover-slips were made from each sample and fixed in Naphrax for diatom microscopy. A large area of the cover-slips on each slide was scanned for diatoms at magnifications of x400 and x1000 under phase contrast illumination.

Diatom floras and taxonomic publications were consulted to assist with diatom identification; these include Hendey (1964), Werff and Huls (1957-1974), Hartley *et al.* (1996), and Krammer and Lange-Bertalot (1986-1991). Diatom species' salinity preferences are discussed in part using the classification data in Denys (1992), Vos and de Wolf (1988; 1993) and the halobian groups of Hustedt (1953; 1957, 199). These salinity groups are summarised as follows:

1. Polyhalobian: >30 g l-1
2. Mesohalobian: 0.2-30 g l-1
3. Oligohalobian - Halophilous: optimum in slightly brackish water
4. Oligohalobian - Indifferent: optimum in freshwater but tolerant of slightly brackish water
5. Halophobous: exclusively freshwater
6. Unknown: taxa of unknown salinity preference

Results and discussion

Area	Seq.	Section	Cont.	Sample	Diatom Sample Number
A	1	1027	1132	1004	D1
A	1	1027	1135	1004	D2
A	1	1027	1136	1004	D3
A	1	1027	8506	1004	D4
A	1	1027	8505	1002	D5
A	1	1027	8502	1002	D6
A	1	1027	8503	1002	D7
A	1	1027	G3	1002	D8
A	6	1097	1746	1380	D9
A	6	1097	1747	1381	D10

A	6	1097	1793	1381	D11
A	6	1097	1794	1381	D12
A	6	1097	1837	1381	D13
A	8	1319	5980	1289	D14
A	8	1319	5981	1289	D15
A	8	1167	1996	1136	D16
A	8	1167	1995	1133	D17
A	9	1306	5872	1274	D18
A	9	1306	5875	1274	D19
A	9	1306	5620	1274	D20
A	12	1051a	1351	1026	D21
A	12	1051a	1350	1026	D22
A	12	1051a	1348	1027	D23
A	14	1239	5430	1203	D24
A	14	1239	5429	1203	D25
A	14	1239	5428	1203	D26
A	16	1050	1365	1225	D27
A	19	1367	6373	1366	D28
A	23	1049	1252	1363	D29
B	25	4093	4433	4031	D30
B	25	4093	4435	4032	D31
B	25	4093	4437	4031(2)	D32
B	25	4093	4440	4031(2)	D33
B	25	4097	4641	4092	D34
B	25	4097	4642	4092	D35
B	25	4097	4643	4092	D36
B	26	4049C	4291	4007	D37
B	26	4049C	4307	4007	D38
B	26	4049C	4308	4007	D39
B	26	4049C	4210	4008	D40
D	38	2007	2108	2009	D41
D	38	2007	2109	2010	D42
D	38	2007	2100	2010	D43
D	38	2007	2111	2010	D44
OA3	Palaeochannel sequence				D45

Table 20: Assessment samples selected for diatom evaluation

The results of the diatom evaluation for the London Gateway samples are summarised in Table 21. Diatom species along with their halobian classifications have been recorded on a spreadsheet and retained in the project archive.

Sample No.	Diatoms	Diatom numbers	Quality of preservation	Diversity	Assemblage type	Potential for % count

D1	+	mod	mod to poor	mod	mar bk	mod good
D2	-	-	-	-	-	none
D3	-	-	-	-	-	none
D4	+	very low	very poor	low/mod	aero, mar bk, fw	none
D5	-	-	-	-	-	none
D6	+	very low	ex poor	very low	aero (bk aero?)	none
D7	-	-	-	-	-	none
D8	+	ex low	ex poor	ex low	indet	none
D9	+	very low	very poor	low	bk	none
D10	+	ex low	ex poor	ex low	aero, pos mar	none
D11	+	low	very poor	low	bk mar aero	none
D12	+	low	poor	low/mod	bk mar fw aero	low
D13	+	low	very poor	low	bk mar	none
D14	+	mod	mod to poor	low	hal bk mar	some
D15	+	mod-low	mod to poor	mod	bk mar	some
D16	-	-	-	-	-	none
D17	+	mod/low	mod to poor	mod	bk mar fw aero	some
D18	+	low	poor to mod	mod/low	hal bk	low
D19	+	very low	poor to mod	low	bk mar	none
D20	+	low	poor	low	bk	none
D21	+	very low	very poor	ex low	bk mar	none
D22	+	ex low	ex poor	very low	bk mar	none
D23	+	mod	poor to mod	low/mod	bk mar aero	some/low
D24	+	low/mod	poor to mod	low/mod	bk mar	some/low
D25	+	low	poor	low	bk mar	low
D26	+	very low	poor to mod	low	bk mar aero	none
D27	+	mod high	poor	low	bk mar aero	some
D28	+	very low	poor to mod	low	bk mar aero	none
D29	+	very low	poor to v poor	very low	bk mar	none
D30	+	very low	very poor	very low	bk aero	none
D31	+	very low	very poor	low	bk	none
D32	+	low	poor to mod	mod	bk mar	mod
D33	+	very low	very poor	ex low	cf. bk	none
D34	-	-	-	-	-	none
D35	+	ex low	very poor	ex low	bk	none
D36	+	very low	very poor	low	bk mar hal	none
D37	+	low	poor	mod	mar bk hal fw	low
D38	+	ex low	very poor	very low	bk, bk aero	none
D39	+	ex low	very poor	mod	bk, bk aero, mar	none
D40	+	low	very poor	low	bk mar	none
D41	+	low/mod	very poor	mod	bk mar hal	low/none
D42	-	-	-	-	-	none
D43	-	-	-	-	-	none
D44	+	low/mod	poor	mod	mar bk hal fw	some/low
D45	+	ex low	very poor	very low	bk	none

Table 21: Summary of diatom evaluation results (+ present, - absent, mod – moderately high, ex.low- extremely low, fw – freshwater, aero- aerophilous, bk – brackish, mar – marine, hal – halophilous, indet – indeterminate)

Area A Sequence 1

Four sub-samples from sample 1002 and four from sample 1004 were selected for assessment from sequence 1. This was identified as a key sequence of an anthrosol over alluvium. The lower part of the sequence contains a pre-Roman, possibly Bronze Age, palaeosol (Chris Carey pers. comm).

The top diatom sample (D1) from context 1132 is from the upper alluvial layer, a flood deposit sealing the archaeology at Stanford Wharf. In D1 there is a relatively well-preserved and moderately diverse assemblage of marine and brackish water diatoms, such as the marine planktonic species *Rhaphoneis minutissima*, *Rhaphoneis surirella*, *Campylosira cymbelliformis*, the estuarine planktonic species *Cyclotella striata*, with benthic estuarine diatoms such as *Nitzschia navicularis* and *Diploneis didyma*. Exceptionally, amongst the samples assessed, this sample (D1) has moderately good potential for percentage diatom counting.

Diatoms are absent in D2 (context 1135) and D3 (context 1136), consistent with the interpretation of these contexts as anthropogenic soil-like deposits (possibly from the Roman period). However, there is no diatom evidence for flood deposits in D2. In D4 (context 8506), there is a poorly preserved mixed assemblage of marine, brackish and freshwater diatom species. It is notable that aerophilous diatoms are present in D4, such as the freshwater *Pinnularia major* and *Hantzschia amphioxys*, along with the halophile *Navicula mutica*. Aerophilous diatom species are tolerant of desiccation and are able to grow in habitats that are subject to drying out for prolonged periods (Johansen 1999). They may originate from within the water body, for example on the bank or bottom of a water body that has occasionally dried out. Alternatively, they may be introduced with eroded material including soil (Lund 1945; 1946). Aerophilous diatoms were found elsewhere in the Area A sequences occasionally with chrysophyte stomatocysts (the resting stages of another group of siliceous algae) that may also be indicative of periodic drying out. Some fragments of large, robust (heavily silicified) aerophilous *Pinnularia* sp. are preferentially preserved. However, although these fragments were not identifiable to specific level they are types that are very likely to be aerophilous.

Diatoms are absent from diatom sample D5 (context 8505). In D6 (context 8502) there are a very low number of poorly preserved aerophilous diatoms (cf. *Hantzschia amphioxys*; cf. *Pinnularia major* and the benthic brackish water diatom cf. *Diploneis interrupta*). Diatoms are absent from diatom sample D7 (context 8503), and the basal sample D8 (context G3) has an extremely low number of indeterminate diatom fragments.

Area A Sequence 6

One sub-sample from 1380 and four sub-samples from 1381 were assessed for diatoms. The sequence comprises three sequential anthrosols separated by alluvium (Chris Carey pers. comm.). Diatoms are present in all of the five sub-samples. However, the quality of preservation is generally very poor and the number of diatoms is low. There is no potential to make percentage diatom counts for seven of the samples and little potential for percentage diatom counting in one sample (D12).

In the top sub-sample, D9 from sample 1380 (context 1746), the diatoms represent brackish water habitats with benthic taxa such as *Nitzschia navicularis*, *Scoliopleura tumida* and *Diploneis interrupta*, and the brackish water planktonic diatom *Cyclotella striata*. The extremely low number of diatom fragments in D10 (context 1747) are probably from a marine planktonic and freshwater aerophilous source, but are preferentially preserved types, being heavily silicified valve components. A mixture of brackish water, marine, halophilous and freshwater diatoms was identified in D11 (context 1793). The marine planktonic diatoms *Paralia sulcata* and *Actinoptychus undulatus* are present with the brackish water planktonic species *Cyclotella* *striata*. Benthic mesohalobous diatoms in D11 include *Diploneis interrupta* and *Navicula navicularis*. Freshwater non-plankton comprised *Frustulia vulgaris*, the aerophiles *Hantzschia amphioxys* and *Navicula mutica* (also halophilous) and chrysophyte stomatocysts. Similarly the diatom assemblage of D12 (context 1794) is comprised of a mixture of brackish, marine, freshwater and aerophilous components. These diatoms include the marine diatoms *Paralia sulcata* and *Rhaphoneis amphiceros*. A dominant component in D12 is the estuarine planktonic species *Cyclotella striata*, along with other, benthic, mesohalobes such as *Diploneis interrupta*, *Nitzschia navicularis* and *Nitzschia sigma*. Freshwater taxa in D12 include *Diploneis ovalis*, *Fragilaria capucina* and the aerophile *Hantzschia amphioxys*. The basal sub-sample D13 in sample 1381 (context 1837) has a low concentration of very poorly preserved brackish and marine diatoms; these include the marine species *Paralia sulcata* and *Rhaphoneis amphiceros*, and the brackish water species *Cyclotella striata*, *Diploneis didyma* and *Nitzschia navicularis*.

Area A Sequence 8

Sequence 8 is the only sequence at Stanford Wharf that is possibly medieval, lying below a post-medieval boundary or drainage ditch (Chris Carey pers. comm.). Four diatom sub-samples have been assessed. The two uppermost samples, D14 (context 5980) and D15 (context 5981) from sample 1289, have moderate or moderate to low numbers of diatoms with moderate to poor preservation and low to moderate species diversity. Both D14 and D15 have brackish and marine diatom assemblages with the aerophilous halophile *Navicula cincta* common in the top sample D14. Both D14 and D15 have at least some potential for percentage diatom counting. In D14 the marine diatoms *Paralia sulcata* and *Rhaphoneis amphiceros* are present along with the mesohalobous diatoms *Nitzschia navicularis* and *Navicula digitoradiata* var. minima. In D15 the marine species *Cymatosira belgica*, *Plagiogramma staurophorum*, *Plagiogrammopsis vanheurckii*, *Rhaphoneis minutissima*, *Thalassionema nitzschiodes* and *Actinoptychus undulatus* are present. Brackish water taxa in D15 are the benthic diatoms *Cyclotella striata*, *Diploneis didyma* and *Nitzschia levidensis*. Diatoms are absent from D16 (context 1996). In D17 (context 1995) there is a mixed assemblage of moderately well to poorly preserved valves representing marine (eg *Cymatosira belgica*, *Rhaphoneis* spp.), brackish (eg *Cyclotella striata*, *Navicula digitoradiata* var. minima and *Nitzschia navicularis*), marine and aerial (*Navicula cincta*, *Ellerbeckia arenaria*, *Hantzschia amphioxys*), and freshwater (*Gomphonema angustum* var productum, *Fragilaria brevistriata*) habitats. There is some potential for percentage diatom counting of D17.

Area A Sequence 9

Three sub-samples from the inner sequence 9 (sample 1274, enclosure ditch) were assessed for diatoms. Diatom numbers in samples D18-D20 are low or very low, with poor to moderate or poor preservation. The three samples have only low potential (D18) or no potential for percentage diatom analysis. The top sample D18 (context 5872) has a mixture of halophilous (*Navicula cincta*), marine (Cymatosira belgica, Rhaphoneis spp.) and brackish water diatoms (*Achnanthes brevipes*, *Cyclotella striata*, *Diploneis didyma*, *Nitzschia punctata*, *Nitzschia navicularis*). D19 (context 5875) has a poorly preserved assemblage of marine-brackish (cf. *Pseudopodosira westii*) and brackish water diatoms (*Caloneis westii*, *Nitzschia navicularis*). The bottom sample D20 (context 5620) has only one diatom identifiable to the species level, the estuarine planktonic species *Cyclotella striata*.

Area A Sequence 12

Sequence 12 was taken through the outer enclosure ditch. Three slides have been assessed for diatoms D21 to D23; these slides were prepared from two monolith samples, 1026 and 1027. The top sample D21 (context 1351) has a very low number of very poorly preserved diatoms with only the benthic brackish water diatom *Nitzschia navicularis* identifiable to species level.

Nitzschia navicularis is also the only diatom species identifiable in sample D22 (context 1350). In D23 (context 1348, sample 1027), *Nitzschia navicularis* also appears to be the most common diatom taxon. However, there is a moderate number of diatoms present. Other mesohalobous diatoms in D23 are *Cyclotella striata*, *Diploneis didyma*, *Nitzschia granulata* and *Scoliopleura tumida*. Marine diatoms in D23 include *Cymatosira belgica*, *Paralia sulcata*, *Rhaphoneis minutissima* and *Actinoptychus undulatus*. Freshwater species are *Fragilaria brevistriata* and the aerophile *Hantzschia amphioxys*. D23 has a low potential for percentage diatom analysis. D21 and D22 have no further potential for diatom analysis.

Area A Sequence 14

Three diatom slides were prepared from sample 1203 in sequence 14. This was taken from the roundhouse outer ditch. Sample D24 has a poor to moderately well preserved assemblage of brackish and marine diatoms. There is some potential for percentage diatom counting of this sequence. Marine diatoms in D24 include *Paralia sulcata*, *Cymatosira belgica*, *Rhaphoneis* spp. *Trachyneis aspera*, *Cocconeis scutellum* and *Pseudopodosira westii*. Mesohalobous taxa include *Nitzschia navicularis*, *Cyclotella striata*, *Diploneis didyma* and *Nitzschia granulata*. The freshwater species *Fragilaria brevistriata* is present. Sample D25 has a poorly preserved brackish and marine diatom assemblage with low potential for percentage counting. Brackish water diatoms include *Nitzschia navicularis* and *Nitzschia granulata*. Marine diatoms include *Paralia sulcata* and *Rhaphoneis* sp. The freshwater aerophile *Ellerbeckia arenaria* is also present. In diatom slide D26 there is a very low number of diatoms, including marine (the planktonic species *Triceratium favus*), brackish (the benthic species *Campylodiscus echeneis*) and freshwater (the aerophilous *Ellerbeckia arenaria*) diatoms.

Area A Sequence 16

A single sample (D27) from sample 1366 (context 6376) was evaluated for diatoms. A moderately high number of poorly preserved diatoms are present. Brackish (*Diploneis interrupta*, *Caloneis westii*) and marine (*Paralia sulcata*) diatoms are present. There is some potential for percentage diatom counting, although the assemblage is of low diversity being dominated by a single mesohalobous benthic diatom, *Diploneis interrupta*. *Diploneis interrupta* has been classified as a marine-brackish aerophilous diatom that is associated in natural environments, when occurring at very high abundances, with salt marshes above Mean High Water (Vos and de Wolf 1993). It is thus able to grow at sites with high salinity levels and with prolonged periods of desiccation. The dominance of *Diploneis interrupta* in sediments from the roundhouse settling tanks is consistent with high salinity levels and prolonged dry periods as a result of evaporation during salt-production.

Area A Sequence 19

A single sample from the red hill in the eastern side of Area A was analysed for diatoms. Diatom slide D28 (sample 1366, context 6373) has a very low number of brackish marine and aerophilous diatoms but has no potential for diatom counting. Marine diatoms include the planktonic diatom *Paralia sulcata*; brackish water diatoms include the benthic diatoms *Diploneis* *didyma* and *Nitzschia navicularis*. The freshwater aerophile *Hantzschia amphioxys* is also present.

Area A Sequence 23

Sample 1366 is from a quarry pit fill, a local site-wide receptor (Chris Carey pers. comm.). A single diatom slide (D29) was prepared from context 1252. The number of diatoms is very low and the quality of preservation very poor. There is no potential for further, percentage diatom analysis. The marine planktonic diatom *Paralia sulcata* is present and the mesohalobous benthic species *Nitzschia navicularis* and *Nitzschia clausii*.

Area B Sequence 25

Seven diatom samples D30 to D36 were assessed from sequence 25, a salt-making sequence at the edge of the platform, with alluvium interspersing salt making detritus (Chris Carey pers. comm.). The top sub-sample (D30, context 4433) in the sample 4031/4032 sequence of monoliths has a very poorly preserved assemblage of brackish (*Synedra tabulata*, *Diploneis interrupta*) and aerophilous (*Hantzschia amphioxys*) diatoms. The assemblage in D31 is also very poorly preserved and is composed of brackish diatom taxa (*Nitzschia navicularis*, *Diploneis interrupta*, *Cyclotella striata*, and *Campylodiscus echeneis*). D30 and D31 have no further potential for diatom analysis. The moderately diverse brackish and marine diatom assemblage in D32 (context 4437) has moderately good potential for percentage diatom counting. The assemblage is composed of marine taxa such as *Paralia sulcata*, *Rhaphoneis amphiceros*, *Rhaphoneis surirella*, *Podosira stelligera*, *Cocconeis scutellum*, and brackish water taxa such as *Cyclotella striata*, *Nitzschia navicularis*, *Nitzschia sigma*, *Diploneis didyma* and *Diploneis interrupta*. Diatom slide D33 from context 4440 has a very low number of very poorly preserved diatoms; a probable fragment of the benthic brackish water species, *Nitzschia granulata*, was identified. There is no potential for percentage diatom counting.

Diatoms are absent from the top sub sample (D34) from sample 4092 (context 4641). Only the planktonic estuarine species, *Cyclotella striata*, was identified from D35 (context 4642). This sample has no potential for diatom analysis. A very low number of diatoms is present in D36 (context 4643); the brackish water benthic diatoms *Diploneis interrupta* and *Nitzschia navicularis* are most common, and marine, *Rhaphoneis* sp. are also present, as well as the halophilous aerophillic species *Navicula cincta*.

Area B Sequence 26

Four diatom sub-samples (D37 to D40) were assessed from monolith samples 4007 and 4008. The samples represent pre-Roman alluvium. In all four, diatom numbers are low or extremely low, the quality of preservation is poor or very poor and there is no potential for percentage diatom counting in the lower three samples and little potential for percentage diatom counting in the top sample (D37). D37 contains a mixed diatom assemblage of marine (*Paralia sulcata*, *Rhaphoneis minutissima*, *Rhaphoneis amphiceros*), brackish (eg *Diploneis interrupta*, *Rhopalodia musculus*, *Achnanthes brevipes*, *Scoliopleura tumida*, *Cyclotella striata*), halophilous (*Navicula cincta*), and freshwater (*Cocconeis placentula*, *Cyclotella kuetzingiana*) species. The dominant component in D37 are brackish water, benthic types. Samples D38, D39 and D40 are also dominated by brackish water diatoms, such as *Nitzschia navicularis*, *Nitzschia hungarica*, *Diploneis didyma* and *Diploneis interrupta*, with some marine taxa (*Paralia sulcata*, *Rhaphoneis* sp.) in D39 and D40.

Area D Sequence 38

Four sub-samples (D41-D44) were assessed for diatoms from Area D Sequence 38, taken in proximity to a wattle structure (Chris Carey pers. comm.). These sub-samples were taken from two monoliths, samples 2009 and 2010. Diatoms are absent from D42 and D43. In the top sample, D41 (context 2108), there is a very poorly preserved assemblage of brackish (*Nitzschia hungarica*, *Nitzschia sigma*, *Synedra tabulata*, *Diploneis interrupta*) and marine (*Actinoptychus undulatus*, *Paralia sulcata*) and halophilous (*Navicula cincta*) diatoms. In the bottom sample from the sequence, D44, there is a poorly preserved marine (*Cymatosira belgica*, *Campylosira cymbelliformis*, *Plagiogrammopsis vanheurckii*, *Paralia sulcata*, *Rhaphoneis* spp. *Thalassionema nitzschiodes*, *Actinoptychus undulatus*), brackish (*Cyclotella striata*), halophilous (*Navicula cincta*) and freshwater (*Navicula tripunctata*) diatom assemblage. However, the dominant component in D44 appears to be of marine diatoms. The potential for percentage diatom analysis of D41 and D44 is low because of the poor or very poor quality of preservation.

Palaeochannel

One sub-sample from OA3, diatom sample D45, was assessed for diatoms. There was an extremely low number of very poorly preserved diatoms with no potential for further analysis. Brackish water benthic diatoms were identified (*Diploneis interrupta* and cf. *Nitzschia navicularis*).

Conclusions

Diatoms are present in 37 samples and absent from eight samples. The diatom assemblages are generally poorly or very poorly preserved in most samples from the sequences, and 31 of the 45 samples have no further potential for percentage diatom counting.

The mixtures of diatoms with a wide range of salinity preferences in a single assemblage are not uncommon in sediments associated with estuarine environments. However, the presence of freshwater aerophiles and desiccation-tolerant brackish water diatoms (eg *Diploneis interrupta*) is consistent with the archaeological evidence in some contexts for salt production.

Relatively few samples have any potential for percentage diatom counting and the majority of these samples are only moderately well preserved. There are few continuous sequences of diatom samples with good enough preservation to warrant further investigation. However, there are spot samples associated with particular structures that could through diatom analysis provide useful information on salinity and aquatic habitat changes.

Given the ubiquity of diatoms in natural water bodies, the poor preservation, absence or low numbers of their remains from many of the sediment samples here can be attributed to taphonomic processes. This may be the result of silica dissolution caused by factors such as high sediment alkalinity, very high acidity, the under-saturation of sediment pore water with dissolved silica, cycles of prolonged drying and rehydration exposure of sediment to the air, or physical damage to diatom valves from abrasion or wave action (eg Flower 1993; Ryves *et al.* 2001).

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B.6 Microfauna (foraminifera and ostracoda)

John E Whittaker

Introduction

A total of 45 samples were submitted for microfossil assessment. The purpose of the microfossil assessment (using foraminifera and ostracods), along with sedimentological, palynological and diatom assessments by other specialists, was to further the palaeoenvironmental reconstruction of several of the important sequences that were found.

A sample inventory giving details of all the 45 samples, including context, section, sample number, depth in the sequence and weight processed, are given in Table 28. Processing was undertaken as follows. Each sample was placed in a ceramic bowl and first dried in an oven, then soaked in hot water with a little sodium carbonate added to help remove the clay fraction. It was then washed through a 75 micron sieve with hot water. The resultant residue was returned to the bowl and dried again in the oven. All the samples, even those with some organic content, broke down readily. The residues were finally placed in labelled plastic bags for storage and subsequent examination. For analysis, each dry sample was put through a nest of sieves (>500, >250,>150 microns and pan) and a little of each residue at a time sprinkled on a picking tray. For the most part, each sample was merely observed under a microscope and notes made on its content. The organic content was recorded on a presence/absence basis, whilst the abundance of each species of foraminifera and ostracods (where present) was estimated semi-quantitatively by experience and by eye and this information can be found on the figures accompanying this report.

Results

The results of the microfossil assessment are shown in Tables 22-27. Of the 45 samples, approximately half (23 samples) contained microfossils (all the 23 had foraminifera, but only six contained ostracods) and these form the main subject of this report. Their occurrence is summarised in Table 27, whilst the species are listed in full with their ecological preferences colour-coded in Tables 23-6. The foraminifera in all the samples (which contained them) were brackish in aspect, most of them being specialised agglutinating forms which make their shell of mineral grains attached to an organic template; these are all typical of mid-high saltmarsh. Eight of them also contained calcareous foraminifera which live on low saltmarsh and tidal mudflats, whilst six contained brackish ostracods of tidal flats and creeks. Only one sample (from the palaeochannel) had, in addition, ostracods and foraminifera of an outer estuarine/marine aspect (colour-coded light blue), no doubt emphasising the occurrence here of a stronger tidal influence and perhaps influence of storm surges, as well as introductions via floating seaweed.

Foraminifera, it must be remembered, do not live in freshwater, and their absence in the remaining 22 samples could be taken, on negative evidence alone, that they were laid down in a non-marine environment. On the other hand, there is unfortunately no direct evidence (except a little in the palaeochannel seen in BH3) of a freshwater component in any of the samples, although this may well have been removed by a reducing environment and/or subsequent decalcification.

Other useful ‘organic remains’ were noted during examination of the samples and these are also listed in Tables 20, 22-4. No fewer than 37 of the 45 samples contained plant debris and seeds. Based on this occurrence it is considered that a specialist palynological and plant/seed assessment should prove most instructive in any overall palaeoenvironmental reconstruction. In

16 samples some plant remains were also either represented by charcoal or they were burnt, probably associated with the salt making process, and thus it is interesting that a reddish-pink clay – a by-product of this process – was recorded in twelve samples (shown in Tables 22 and 24, and in Table 27, placed in association with the microfossil occurrence). Large circular diatoms were noticed in only four samples (sequences 8 and 38 and the palaeochannel), but as the samples were sieved through a 75 micron sieve, smaller diatoms may well be preserved in other samples. Seven samples contained fish/amphibian bones but they were small pieces and are probably undiagnostic. Insect remains were noticed in 11 samples, while molluscs were found in only found in two (sample 1133 in Sequence 8, and in the palaeochannel). Finally, the occurrence of iron minerals (limonite and/or goethite), a sure sign of weathered sediments, was only seen in two samples. No earthworm granules were observed in any of the samples. This could mean that, throughout, the soils were unsuitable for the presence of earthworms, either due to its saline nature, strong disturbance, or because of waterlogging.

Briefly, the site is an incised gravel river terrace of the Thames which the Romans (or Romano-British) utilised for various activities, especially salt production. On such a site near the tidal fringe the main ecological question posed by OA was whether it was brackish or freshwater at any one time, and whether it changed over time? A slightly more detailed interpretation, based mainly on the observed microfossil occurrence, is now attempted for the various sequences examined.

Area A

Sequence 1: Anthrosol over alluvium; lower part contains pre-Roman palaeosol

Foraminifera only occur in samples including and above 1002, G4a (25-26cm). Context 8505: These are comprised solely of the agglutinating mid-high saltmarsh species *Jadammina macrescens*, and are rare. This species is epifaunal on decaying vegetation or is infaunal down to 60 cm, and is an herbivore and detrivore (Murray 2006). Its shell is made of mineral grains attached by organic cement to a thick organic inner layer. It is however quite fragile and often collapses, but usually and even in the most reducing of environments, the organic template will be preserved. Its rarity at this site could mean it is not *in situ*, having been introduced via clay extraction of the nearby saltmarsh for the saltmaking industry. Red clay and charcoal are indeed present in sample 1004 (30-31cm). However, it would seem to indicate that a brackish tidal connection had now become established here (or close by) and at this point in the sequence, which then continues (more or less) to the top, even though the uppermost sample examined (004, 5-6 cm) shows signs of weathering. The sequence including G4b, 28-29 cm and below could well have been freshwater, although there is no direct evidence; only a palynological analysis may finally prove or disprove this.

Sequence 6: Three sequential anthrosols separated by alluvium

Foraminifera are only found in the lowermost sample examined - 1381, 49-50 cm (context 1837). Here there are two agglutinating species present (*Trochammina inflata* and *Jadammina macrescens*), both being epifaunal and infaunal down to 60 cm; they are herbivores and detrivores, living exclusively on mid-high saltmarsh (Murray 2006). They are also both common in this sample and ought thus to be *in situ*, suggesting the brackish tidal connection had already been made at this point. Samples above do not contain any foramanifera but they do have abundant red clay fragments, charcoal and burnt organics, which would seem to indicate an active salt extraction industry was established. The lack of foraminifera might indicate that the upper four samples were non-marine, but it is thought unlikely that the ecology would have reverted to freshwater. Abundant plant debris throughout this sequence should produce a useful palynological profile that would settle the case.

Sequence 8: Only sequence at Stanford Wharf which is possibly medieval, below post-medieval ditch

Only the uppermost sample examined did not contain any microfauna of any sort; however, there was virtually no residue here after processing. The bottom two samples – 1133, 40-42 cm and 1136, 45-47 cm (contexts 1995 and 1196, respectively) – contain abundant foraminifera and ostracods, indicative of tidal mudflats and creeks, backed by saltmarsh (the species being listed in Table 23). Moreover, large circular diatoms (>75 microns in diameter) were readily seen in these samples which are usually harbingers of a healthy foraminiferal fauna, as there is a symbiotic relationship between the two, calcareous foraminifera (in life), being bright green in colour as they act as “greenhouses” for the symbiotic diatoms within. The lowermost sample even contained molluscs, the only sample from Area A to do so. Sample 1289, 45-46 cm (context 5981) did not contain any tidal flat species which may indicate a final accretion of saltmarsh at the site.

Sequence 9: Roman-period inner enclosure ditch

Of the three samples examined from sample 1274, two, at 17-18cm and 33-34cm, contained agglutinating foraminifera, albeit rare, whereas the middle one in the sequence (at 25 cm) did not. Red clay in 1274, 33-34 cm, attests to waste from the salt making process so it is thought that the foraminifera (both mid-high saltmarsh) species may not be *in situ*, but occur in the ditch amongst sediment either washed in or introduced by man.

Sequence 12: Roman-period outer enclosure ditch

The top sample of the three examined did not contain any microfossils, but the lower two (1027, 30-31 cm and 1026, 50 cm – contexts 1348 and 1350, respectively) did. Two species of mid-high saltmarsh foraminifera are present which could indicate this outer ditch was flooded from time to time by high tides particularly as there is no direct evidence of saltmaking waste. However, their rarity may be evidence that they are not really *in situ*.

Sequence 14: Roman-period roundhouse outer ditch

As in the previous sequence, the lower two samples examined (1026, 50 cm and 1027, 390-31 cm – contexts 5429 and 5428, respectively) contained microfossils – just rare Jadammina macrescens. The top sample did not. The occurrence of red clay, charcoal and burnt organics attests to salt making nearby and therefore, the roundhouse ditch probably contains accumulated waste washed in, or accumulated when the site was cleared from time to time.

Sequence 16: Roman-period roundhouse settling tanks

No microfossils were found in the one sample examined.

Sequence 19: Roman-period red hill site; eastern side of Area A

Only one sample was examined (1366, 12-13 cm – context 6373A), but it was an interesting one nonetheless. Much pinkish-red clay was present in the residue, as one would expect, but in addition there were quite a large number of one species of foraminifera, *Trochammina inflata*, burnt and recrystallised. This species has an agglutinating shell made of mineral grains cemented onto an organic template, like *Jadammina macrescens*, but unlike that species the shell is robust and thick and the grains are arranged like a Roman mosaic, covered, in addition, with an outer organic layer. These foraminiferal shells are undoubtedly coming from the clay and have survived the subsequent burning in the evaporation of the salt. They surely indicate, without doubt, that clay must be have been excavated from a nearby saltmarsh.

Sequence 23: Quarry pit fill

Only one sample was examined. In such a locale one might expect much waste from the salt working, but only plant debris and seeds were seen in the residue.

Area B

Sequence 25: Salt making sequence at edge of platform; alluvium interspersing salt making detritus.

Brackish foraminifera occur in three of the seven samples examined, and ostracods in one. Indeed, the occurrence of three species of agglutinating foraminifera in sample 4092, 0 cm (context 4641) might actually attest to the onset of tidal conditions at this point in the sequence. All are typical of mid-high saltmarsh, but appear to be *in situ*; moreover, there is no red clay in the sample. Above, there are two samples with not only agglutinating foraminifera, but also calcareous species of tidal mudflats, and in one, ostracods of mudflats and creeks. The occurrence of red clay, charcoal and much burnt organics in the same samples would seem to suggest salt making was taking place at least in this, the upper part of the sequence, but the site itself must have been tidal from and including context 4641.

Incidentally, the occurrence of *Tiphotrocha comprimata*, albeit at this one and only site, is not without interest. It is another epifaunal herbivore and detrivore living in saltmarshes, and was originally described from the Caribbean and the eastern seaboard of North America (Murray 2006). Its occurrence in NW Europe has been accredited to human introduction with American shellfish in recent times, but here it has clearly been indigenous since at least Roman times!

Sequence 26: Pre-Roman alluvium

Unfortunately, no foraminifera or ostracods were found in the four samples examined. The occurrence, however, of red clay in one sample and charcoal/burnt organics in two, seems to indicate there was a salt making industry nearby, and would surely contradict the suggestion that this is pre-Roman alluvium. The plant debris ought to indicate that a palynological analysis will provide useful information on its true ecology.

Area D

Sequence 38: Adjacent to Roman-period wattle structure

All four samples examined contained two species of agglutinating saltmarsh foraminifera in abundant to superabundant quantities. Three, in addition, contained two species of calcareous foraminifera, typical of low-mid saltmarsh and tidal mudflats (one with associated tell-tale diatoms in large numbers). Finally, two samples contained brackish ostracods of tidal flats and creeks. The complete sequence at this site, therefore, most have had tidal access throughout. The occurrence of only mid-high saltmarsh foraminifera in the uppermost sample (2009, 25-25 cm – context 2108) may indicate a gradual accretion of the saltmarsh, which ultimately saw the complete loss of the tidal mudflats.

Palaeochannel, borehole OA3: Channel fill

The archaeological areas examined above occur adjacent to a large palaeochannel. One sample (at 3.83-3.85 m) from a borehole (OA BH3) put down through this palaeochannel was examined for microfossils and was shown to contain a diverse fauna and flora. The foraminifera and ostracods were seen to be comprised of an abundant brackish component containing saltmarsh foraminifera (of two species) together with four species of calcareous foraminifera, which live mainly on tidal mudflats, and five species of ostracods, also of tidal flats and creeks. Most of these had been present in some of the samples examined from Areas A, B and D. To this was added an outer estuarine and marine component, not seen before, with the most common (eg miliolid foraminifera and the ostracod genus *Paradoxostoma*), which both live on marine algae, attesting to their introduction via floating seaweed. The other outer estuarine/marine foraminifera and ostracods, being benthonic by nature, come in via the silt fraction of the tide or during storm surges. There were even a couple of non-marine species, attesting to some freshwater drainage through this channel. This mixed assemblage is typical of sites within the outer parts of the present Thames Estuary.

SEQUENCE	1								6					8				9			12			14			16	19	23
CONTEXT	1132	1135	1136	8506	8505	8502	8503	G3	1746	1747	1793	1794	1837	5980	5981	1996	1995	5872	5875	5620	1351	1350	1348	5430	5429	5428	1365	6373A	1252
SAMPLE	1004	1004	1004	1004	1002	1002	1002	1002	1380	1381	1381	1381	1381	1289	1289	1136	1133	1274	1274	1274	1026	1026	1027	1203	1203	1203	1225	1366	1363
Depth	5-6cm	15-16cm	30-31cm	43-44cm	G4a 25-26cm	G4b 28-29cm	G4b 32-33cm	G3 38-39cm	20-21cm	0-1cm	6-8cm	16-17cm	49-50cm	29cm	45-46cm	45-47cm	40-42cm	17-18cm	25cm	33-34cm	30-31cm	50cm	30-31cm	0cm	12cm	22-23cm	11-12cm	12-13cm	0-3cm
iron minerals	x																												
brackish foraminifera	x		x	x	x								x		x	x	x	x		x		x	x		x	x		x	
plant debris + seeds		x	x	x	x	x	x		x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x		x
fish/amphibian remains		x	x																x										
red clay			x						x	x		x								x				x	x			x	
charcoal/burnt organics			x						x	x	x	x												x	x		x		
insect remains						x									x	x			x		x	x	x						
large diatoms (>75μ)																x	x												
brackish ostracods																x	x												
molluscs																	x												

Table 22: Presence/absence of microfauna in Area A

FORAMINIFERA

SEQUENCE	1								6					8				9			12			14			16	19	23
CONTEXT	1132	1135	1136	8506	8505	8502	8503	G3	1746	1747	1793	1794	1837	5980	5981	1996	1995	5872	5875	5620	1351	1350	1348	5430	5429	5428	1365	6373A	1252
SAMPLE	1004	1004	1004	1004	1002	1002	1002	1002	1380	1381	1381	1381	1381	1289	1289	1136	1133	1274	1274	1274	1026	1026	1027	1203	1203	1203	1225	1366	1363
Species Depth	5-6cm	15-16cm	30-31cm	43-44cm	G4a 25-26cm	G4b 28-29cm	G4b 32-33cm	G3 38-39cm	20-21cm	0-1cm	6-8cm	16-17cm	49-50cm	29cm	45-46cm	45-47cm	40-42cm	17-18cm	25cm	33-34cm	30-31cm	50cm	30-31cm	0cm	12cm	22-23cm	11-12cm	12-13cm	0-3cm
Jadammina macrescens	x		x	x	x								xx		x	xx	xx	x		x		x	x		x	x			
Trochammina inflata													xx			xx	xx			x		x						x	
Haynesina germanica																xx	xxx												
Elphidium williamsoni																x													
Ammonia (brackish) sp.																x													

OSTRACODS

SEQUENCE	1								6					8				9			12			14			16	19	23
CONTEXT	1132	1135	1136	8506	8505	8502	8503	G3	1746	1747	1793	1794	1837	5980	5981	1996	1995	5872	5875	5620	1351	1350	1348	5430	5429	5428	1365	6373A	1252
SAMPLE	1004	1004	1004	1004	1002	1002	1002	1002	1380	1381	1381	1381	1381	1289	1289	1136	1133	1274	1274	1274	1026	1026	1027	1203	1203	1203	1225	1366	1363
Species Depth	5-6cm	15-16cm	30-31cm	43-44cm	G4a 25-26cm	G4b 28-29cm	G4b 32-33cm	G3 38-39cm	20-21cm	0-1cm	6-8cm	16-17cm	49-50cm	29cm	45-46cm	45-47cm	40-42cm	17-18cm	25cm	33-34cm	30-31cm	50cm	30-31cm	0cm	12cm	22-23cm	11-12cm	12-13cm	0-3cm
Cyprideis torosa																x	xx												
Leptocythere porcellanea																x	xx												
Loxoconcha elliptica																x	x												
Leptocythere castanea																	x												
Leptocythere lacertosa																	x												

Foraminifera and ostracods are recorded: x - several specimens; xx - common; xxx - abundant/superabundant

Agglutinating foraminifera of mid-high saltmarsh

Calcareous foraminifera of low-mid saltmarsh and tidal flats

Brackish ostracods of tidal flats and creeks

Table 23: Abundance of formanifera and ostracods in Area A

SEQUENCE	25							26			
CONTEXT	4433	4435	4437	4440	4641	4642	4643	4291	4307	4308	4210
SAMPLE	4031	4032	4032	4032	4092	4092	4092	4007	4007	4007	4008
Depth	28-29cm	0cm	20-21cm	35-36cm	0cm	30-31cm	45-46cm	15-16cm	34-35cm	50cm	26-27cm
red clay	x	x	x					x			
charcoal/burnt organics	x	x	x	x		x	x	x		x	
brackish foraminifera		x	x		x						
brackish ostracods		x									
fish/amphibian remains		x				x	x	x			
plant debris + seeds			x		x	x	x	x	x		x
insect remains					x		x				
iron minerals					x						

Organic remains are recorded on a presence (x)/absence basis only

FORAMINIFERA

SEQUENCE	25							26			
CONTEXT	4433	4435	4437	4440	4641	4642	4643	4291	4307	4308	4210
SAMPLE	4031	4032	4032	4032	4092	4092	4092	4007	4007	4007	4008
Species Depth	28-29cm	0cm	20-21cm	35-36cm	0cm	30-31cm	45-46cm	15-16cm	34-35cm	50cm	26-27cm
Trochammina inflata		x	x		x						
Jadammina macrescens					xx						
Tiphotrocha comprimata					x						
Haynesina germanica		x									
Elphidium williamsoni		x									
Ammonia (brackish) sp.			x								

OSTRACODS

SEQUENCE	25							26			
CONTEXT	4433	4435	4437	4440	4641	4642	4643	4291	4307	4308	4210
SAMPLE	4031	4032	4032	4032	4092	4092	4092	4007	4007	4007	4008
Species Depth	28-29c	0cm	20-21c	35-36c	0cm	30-31c	45-46c	15-16c	34-35c	50cm	26-27c
Cyprideis torosa			x								
Leptocythere porcellanea			x								

Foraminifera and ostracods are recorded: x - several specimens; xx - common

Agglutinating foraminifera of mid-high saltmarsh
Calcareous foraminifera of low-mid saltmarsh and tidal flats
Brackish ostracods of tidal flats and creeks

Table 24: Microfauna in Area B

SEQUENCE	38			
CONTEXT	2108	2109	2100	2111
SAMPLE	2009	2010	2010	2010
Depth	25-26cm	12-13cm	30-31cm	45-46cm
brackish foraminifera	x	x	x	x
plant debris + seeds	x	x	x	x
large diatoms (>75µ)		x		
brackish ostracods			x	x
insect remains				x

Organic remains are recorded on a presence (x)/absence basis only

FORAMINIFERA

SEQUENCE	38			
CONTEXT	2108	2109	2100	2111
SAMPLE	2009	2010	2010	2010
Depth	25-26cm	12-13cm	30-31cm	45-46cm
Trochammina inflata	xx	xx	xxx	xx
Jadammina macrescens	xx	xx	xx	xx
Haynesina germanica		x	x	x
Ammonia (brackish) sp.			x	x

OSTRACODS

SEQUENCE	38			
CONTEXT	2108	2109	2100	2111
SAMPLE	2009	2010	2010	2010
Depth	25-26cm	12-13cm	30-31cm	45-46cm
Cyprideis torosa			x	x
Loxoconcha elliptica				x
Leptocythere porcellanea				x
Leptocythere lacertosa				x

Foraminifera and ostracods are recorded: x - several specimens; xx - commo

OSTRACODS

SEQUENCE	38			
CONTEXT	2108	2109	2100	2111
SAMPLE	2009	2010	2010	2010
Depth	25-26cm	12-13cm	30-31cm	45-46cm
Cyprideis torosa			x	x
Loxoconcha elliptica				x
Leptocythere porcellanea				x
Leptocythere lacertosa				x

Foraminifera and ostracods are recorded: x - several specimens; xx - common; xxx - abundant

Agglutinating foraminifera of mid-high saltmarsh

Calcareous foraminifera of low-mid saltmarsh and tidal flats

Brackish ostracods of tidal flats and creeks

Table 25: Microfauna in Area D

DEPTH	3.82-3.83m
plant debris + seeds	x
insect remains	x
large diatoms (>75µ)	x
brackish foraminifera	x
brackish ostracods	x
outer estuarine/marine foraminifera	x
outer estuarine/marine ostracods	x
freshwater ostracods	x
molluscs	x

BRACKISH FORAMINIFERA

DEPTH	3.82-3.83m
Trochammina inflata	xx
Jadammina macrescens	xx
Haynesina germanica	xxx
Ammonia (brackish) sp.	xxx
Elphidium williamsoni	x
Elphidium incertum	x

OUTER ESTUARINE & MARINE FORAMINIFERA

DEPTH	3.82-3.83m
miliolids	xx
laginids	x
Nonion depressulus	x
Elphidium margaritaceum	x
Cyclogyra involvens	x

BRACKISH OSTRACODS

DEPTH	3.82-3.83m
Leptocythere porcellanea	xx
Leptocythere lacertosa	x
Leptocythere castanea	x
Loxoconcha elliptica	x
Leptocythere psammophila	x

OUTER ESTUARINE & MARINE OSTRACODS

DEPTH	3.82-3.83m
Paradoxostoma spp.	xx
Pontocythere elongata	x
Hemicythere villosa	x
Hirschmannia viridis	x
Loxoconcha rhomboidea	x

FRESHWATER OSTRACODS

DEPTH	3.82-3.83m
Limnocythere inopinata	x
Candona sp. (juveniles)	x

Organic remains are recorded on a presence (x)/absence basis only

Foraminifera and ostracods are recorded: x - several specimens; xx - common; xxx - abundant

agglutinating foraminifera of mid-high saltmarsh

calcareous foraminifera of low-mid saltmarsh and tidal flats

essentially marine foraminifera and ostracod species, but able to penetrate outer estuaries

brackish ostracods of tidal flats and creeks

freshwater ostracods of coastal pools

Table 26: Microfauna from Borehole 3: Palaeochannel

AREA A

SEQUENCE	1								6					8				9			12			14			16	19	23
CONTEXT	1132	1135	1136	8506	8505	8502	8503	G3	1746	1747	1793	1794	1837	5980	5981	1996	1995	5872	5875	5620	1351	1350	1348	5430	5429	5428	1365	6373A	1252
SAMPLE	1004	1004	1004	1004	1002	1002	1002	1002	1380	1381	1381	1381	1381	1289	1289	1136	1133	1274	1274	1274	1026	1026	1027	1203	1203	1203	1225	1360	1363
Depth	5-6cm	15-16cm	30-31cm	43-44cm	G4a 25-26cm	G4b 28-29cm	G4b 32-33cm	G3 38-39cm	20-21cm	0-1cm	6-8cm	16-17cm	49-50cm	29cm	45-46cm	45-47cm	40-42cm	17-18cm	25cm	33-34cm	30-31cm	50cm	30-31cm	0cm	12cm	22-23cm	11-12cm	12-13cm	0-3cm
red clay (salt working)			x						x	x		x								x				x	x			x	
mid-high saltmarsh foraminifera	x		x	x	x								x		x	x	x	x		x		x	x		x	x		x	
tidal mudflat foraminifera																x	x												
tidal mudflat ostracods																x	x												
outer estuarine/marine foraminifera																													
outer estuarine/marine ostracods																													
freshwater ostracods																													
Ecology																													

AREA B

SEQUENCE	25							26			
CONTEXT	4433	4435	4437	4440	4641	4642	4643	4291	4307	4308	4210
SAMPLE	4031	4032	4032	4032	4092	4092	4092	4007	4007	4007	4008
Depth	28-29cm	0cm	20-21cm	35-36cm	0cm	30-31cm	45-46cm	15-16cm	34-35cm	50cm	26-27cm
red clay (salt working)	x	x	x					x			
mid-high saltmarsh foraminifera		x	x		x						
tidal mudflat foraminifera		x	x								
tidal mudflat ostracods			x								
outer estuarine/marine foraminifera											
outer estuarine/marine ostracods											
freshwater ostracods											
Ecology											

AREA D / BH

SEQUENCE	38				BH
CONTEXT	2108	2109	2100	2111	OABH3
SAMPLE	2009	2010	2010	2010	
Depth	25-26cm	12-13cm	30-31cm	45-46cm	3.82-3.85m
red clay (salt working)					
mid-high saltmarsh foraminifera	x	x	x	x	x
tidal mudflat foraminifera		x	x	x	x
tidal mudflat ostracods			x	x	x
outer estuarine/marine foraminifera					x
outer estuarine/marine ostracods					x
freshwater ostracods					x
Ecology					

Tidal access. Estuarine brackish saltmarsh or mudflat fauna (or nearby saltmarsh component, reworked via salt extraction industry)

Tidal access. Channel with estuarine saltmarsh and mudflat fauna. Outer estuarine/marine components washed in

Table 27: Microfauna: ecological synopsis

Context	Section	Sample no.	Weight processed
AREA A			
Sequence 1			
1132	1027	1004 5-6cm	30g
1135	1027	1004 15-16cm	20g
1136	1027	1004 30-31cm	10g
8506	1027	1004 G5 43-44cm	20g
8505	1027	1002 G4a 25-26cm	25g
8502	1027	1002 G4b 28-29cm	25g
8503	1027	1002 G4b 32-33cm	40g
G3	1027	1002 38-39cm	30g
Sequence 6			
1746	1097	1380 20-21cm	10g
1747	1097	1381 0-1cm	10g
1793	1097	1381 6-8cm	40g
1794	1097	1381 16-17cm	25g
1837	1097	1381 49-50cm	50g
Sequence 8			
5980	1319	1289 29cm	20g
5981	1319	1289 45-46cm	30g
1996	1167	1136 45-47cm	30g
1995	1167	1133 40-42cm	25g
Sequence 9			
5872	1306	1274 17-18cm	20g
5875	1306	1274 25cm	20g
5620	1306	1274 33-34cm	30g
Sequence 12			
1351	1051a	1026 30-31cm	20g
1350	1051a	1026 50cm	30g
1348	1051a	1027 30-31cm	25g
Sequence 14			
5430	1239	1203 0cm	55g
5429	1239	1203 12cm	40g
5428	1239	1203 22-23cm	30g
Sequence 16			
1365	1050	1225 11-12cm	20g
Sequence 19			
6373A	1367	1366 12-13cm	20g
Sequence 23			
1252	1049	1363 0-3cm	40g
AREA B			
Sequence 25			
4433	4093	4031 28-29cm	20g
4435	4093	4032 0cm	80g

4437	4093	4032 20-21cm	10g
4440	4093	4032 35-36cm	25g
4641	4097	4092 0cm	50g
4642	4097	4092 30-31cm	25g
4643	4097	4092 45-46cm	25g
Sequence 26			
4291	4049C	4007 15-16cm	25g
4307	4049C	4007 34-35cm	30g
4308	4049C	4007 50cm	20g
4210	4049C	4008 26-27cm	30g
AREA D			
Sequence 38			
2108	2007	2009 25-26cm	30g
2109	2007	2010 12-13cm	30g
2100	2007	2010 30-31cm	30g
2111	2007	2010 45-46cm	30g
Palaeochannel sequence			
OABH3		3.82-3.85m	60g

Table 28: Microfauna: sample inventory

B.7 Soil micromorphology

Richard I Macphail

Introduction

Compensation Sites A and B were visited in August 2009 (a previous visit had taken place in June). Pleistocene and Holocene sediments, soils and landscape, and associated archaeology were discussed on site with Oxford Archaeology staff. The results outlined below rely heavily on information communicated by them, and this input is gratefully acknowledged.

General geology and soils

This Thames coastal site is characterised by:

- Pleistocene sands and gravels (and likely matrix-supported gravelly head at Site B, patches of brickearth at Stanford Wharf),
- Holocene terrestrial soils formed in this river terrace drift (argillic brown earths? ~Hucklesbrook soil association) and patches of aeolian drift (~Hamble 2 soil association) (Jarvis et al., 1983),
- Alluvium (eg, from Mucking Creek), and
- Marine alluvium (currently mapped as pelo-alluvial gley soils [‘cracking clays’] of the Wallasea 1 soil association)(Jarvis et al., 1983). Peaty and humic topsoil variants occur, which provide a resource for organic environmental material. Such peats may possibly also have provided a source of fuel at the redhills (see below).

Stanford Wharf displays examples of important soil-sediment and occupation sequences, which include mottled (rooted) prehistoric soils, overlain by alluvium, upon which a ripened soil surface formed. These early Holocene soil-sediments contain flint work, including Mesolithic material. These soils are preserved only in patches across the site, and are variously affected by alluviation and marine inundation, most likely governed to altitude and proximity to Mucking Creek and other channels. The early to middle Holocene landscape and occupation pattern was probably governed by these variations.

There appears to be a hiatus between this early prehistoric soil at Stanford Wharf and later prehistoric and Roman red hill activity. Also this soil is reported as being trampled below red hill deposits. Lastly, lowermost redhill deposits may be intercalated with alluvium.

It will be useful therefore to analyse the microstratigraphy of these lowermost soils and sediments, employing soil micromorphology in association with bulk analyses (grain size, LOI, fractionated phosphate, magnetic susceptibility (including χmax)), that can also employ pH and electrical conductivity (a measure of saline salts) as specifically carried out by the Soil Survey of England and Wales and in coastal salt marsh monitoring and experimental studies (Avery, 1990; Boorman *et al.* 2002; Jarvis *et al.* 1984). Such studies can be correlated with microfossil recovery (Macphail, 2009; Macphail et al. Forthcoming).

Stanford Wharf Nature Reserve

Red hill deposits have not been studied through soil micromorphology, although sediments associated with salt working and use of briquetage were investigated briefly at Brean Down, Somerset (Bell 1990). Four types of red hill deposits have been identified at Stanford Wharf, which conjecturally include Late Iron Age to early Roman primary sediment formation (with *in situ* hearths, for example), and redeposited materials – some possibly for ground raising (sea levels?). There are also Middle and later Roman putative salt manufacturing areas and structures. Associated with all these are questions concerning the employment of:

- different fuels (for slow burning, low heat fires); peat, dung, wood/charcoal and coal,
- local clay – alluvium, marine alluvium and brickearth – for constructing salt pans (as well as floors, briquetage), and
- putative use of lead tanks (in later Roman Period).

In addition, occupation surface and floor deposits, clay lining layers, and relationships between various red hill layers (eg as demarcated in one area by an enclosure ditch), require study in order to try and extract some details of the activities and methods employed, and how these developed/changed through time; this includes domestic activities and possible animal management in addition to industrial processes.

Again, the microstratigraphy requires study, employing the techniques noted above. In addition, it is hoped that analyses of heavy metals (Cu, Pb and Zn) from bulk samples will permit the identification of where lead was employed. This and other heavy metals data can be studied statistically alongside measurements of P, magnetic susceptibility and LOI, in order to recognise inputs from likely industrial activities rather than from organic accumulations (cess, bone etc). Such studies were successfully applied at Roman and early medieval London Guildhall and Whitefriars, Canterbury (Macphail and Crowther 2007; Macphail *et al.* 2007b; 2008). Equally, burning temperatures, different fuel residues and enigmatic materials, including ‘green glaze’ on briquetage at Stanford Wharf, can be studied using petrography, uncovered thin sections, and employing SEM/EDAX and microprobe, and possibly FTIR (Fourier Transform Infra-Red Flourescence)(Berna *et al.* 2007; Goldberg and Macphail, 2006; Goldberg et al., 2009). Such results can then be discussed with ancient materials specialists (eg Thilo Rehren and John

Merkel at UCL). Bronze Age cassiterite (tin ore) processing at Bodmin Moor, weathered lead fragments at late Roman Vine St, Leicester and medieval bronze bell casting droplets at Magdeburg, Germany have all been studied in this way (Macphail and Crowther, 2008; *Macphail et al.* 2007a).

Area B

In contrast to Area A, Area B has a different, more blackish coloured 'redhill'. Here a series of three early Roman hearths and tanks have been recognised. One chief question is to identify why this red hill is blackish in colour. Red hill deposits in Area A are presumably reddish because of the large amounts of rubefied (iron-containing) mineral material present – both from briquetage fragments but also from a possible mineral-rich fuel such as minerogenic peat. Such reddish burned (domestic) peat ash deposits have been well-studied from Scotland, for example, where it was also employed as a fertiliser (Adderley *et al.* 2006; Carter 1998). At Area B, the fuel source may have been different, and contained less mineral material. One possibility is dung. When burned this produces ash with charred fine inclusions (recognisable ashed dung fragments, melted phytoliths, etc), as found for example in LBA-EIA 'middens' at Chisenbury and Potterne, Wiltshire and universally in sites occupied by pastoralists (Boschian and Montagnari-Kokelji 2000; Lawson 2000; Shahack-Gross *et al.* 2004). The coastal zone is also well-known for being an area that was exploited for grazing, including the Essex coast during the Iron Age for instance (Bell *et al.* 2000; Wilkinson and Murphy 1995).

Rapid testing

It was suggested on site that some rapid chemical results could be gained from running element analyses employing XRF (X-Ray Fluorescence) to test the possibility that Pb is concentrated in areas where late Roman lead tanks may have been located. (Note that detection levels may not be as high as in some wet chemical analyses or as achieved by microprobe.) Equally, soil efflorescence noted in the field seems to record possibly two types of 'salts': CaCO3 (calcium carbonate) from the weathering of ashy deposits for example, and NaCl (halite) where saline ground water has been exposed by trenching. Although NaCl is highly labile, XRF may also possibly pick up these elements if concentrated.

Conclusions

Sites of A and B offer extraordinary opportunities for the detailed microstratigraphic study of an intact area of prehistoric to Roman coastal landscape. In fact, because of the nature of the local topography, both the landscape utilised by hunter gatherers and the occupation deposits formed by presumed salt manufacture, can be studied in 3D. This is a rare opportunity to investigate the detail of such natural and anthropogenic sequences, when red hills and their underlying archaeology have been so little studied previously. In fact, because of recent coastal management such archaeological sequences may well have been lost by landscaping, as at Wallasea Island on the River Crouch, Essex (Heppel, 2004). It is important recognise and record in detail such sites as this one, because when they occur they can provide essential type-site analogues for the study of more commonly occurring less well-preserved sites.

B.8 Additional sediment analyses

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In addition to the sediment analyses described above, provision is made for analysis of further specific sediment properties that are not required across all the monoliths, but will significantly aid interpretation of specific parts of the sequences. The application of these samples must be made on an iterative basis, when some analyses have been undertaken, so these techniques can be targeted in a cost-effective manner. These techniques are magnetic susceptibility fractionation, bulk phosphate measurement and particle size analysis. Provision is made for the analysis of 40 samples of each technique.

Phosphate and particle size analysis will provide much information on the development and use of anthrsols and palaeosols, especially in relation to soil development, manuring and cat-ion exchange. This is where most samples will be targeted, although some characterisation of the red hills will also occur, especially to study differences in contexts within the red hills. Magnetic susceptibility fractionation provides information on the magnetic susceptibility potential of sediments when they have been fired. This technique will be extremely useful for the characterisation of the red hill sequences and the anthrosols.

Appendix C. Scientific Dating

C.1 Radiocarbon dating

Radiocarbon determinations were obtained from eight samples (Table 29):

Area	Feature/ layer	Sample no.	Context no.	Material	Lab code	$\delta^{13}C$ (‰)	C14 Age BP	Calibrated date (2σ, OxCal v.3.10)
A	U-shaped structure 'Boathouse'	9001	1119	Oak sapwood	GU-19377	-26.0	1885±40	AD20-40 (1.4%) AD50-240 (94.0%)
A	U-shaped structure 'Boathouse'	9065	1424	Oak sapwood	GU-19628	-25.3	1945±30	20BC-AD130 (95.4%)
A	Sheepfold	9002	1326	Oak sapwood	GU-19378	-28.3	185±40	AD1640-1690 (69.3%) AD1830-1890 (8.3%) AD1910-1960 (17.8%)
D	Wattle structure	9005	2027	Oak sapwood	GU-19379	-24.5	1860±40	AD60-250 (95.4%)
A	Deposit, sequence 1	1052	1077	Plant remains	OxA-22430	-24.9	2853±27	929BC (95.4%)
A	Surface	1255	5800	Charred seeds	OxA-22431	-22.5	2120±27	327BC (2.7%) 53BC (92.7%)
A	Sand (G3), sequence 1	1073	1145	Charcoal	OxA-22432	-24.8	4619±32	3398BC (67.1%) 3345BC (28.3%)
A	Peat under alluvium, sequence 5	1268	5845	Seeds	OxA-22575	-26.3	2601±34	752BC (89.1%) 667BC (4.9%) 596BC (1.3%)

Table 29: Radiocarbon dates

C.2 Optically Stimulated Luminescence (OSL)

OSL dates were obtained from seven samples (Table 30):

Area	Description	Sample no.	Context	Lab ref.	Age (1000 years - ka)	Date range
A	Alluvium (G5)	1385	5980	GL09085	2.2 ± 0.2	450-50BC
A	Alluvium (G22)	1386	5982	GL09086	2.9 ± 0.3	1250-650BC
A	Alluvial clay beneath the roundhouse	1387	6001	GL09087	2.5 ± 0.2	750-350BC
A	Palaeosol G4 above sand (G3)	1388	6196	GL09088	3.6 ± 0.2	1850-1450BC
A	Sand (G3)	1389	6195	GL09089	9.8 ± 1.7	9550-6150BC
A	The earliest red hill deposit on the western red hill	1355	6350	GL09090	2.0 ± 0.2	250BC-AD150
	Palaeochannel		OA5	GL09091	329 ± 36	Pleistocene

Table 30: OSL dates

Appendix D. Palaeoenvironmental Assessment Overview

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D.1 Materials and methods: assessment of sequences

On receipt within the laboratory at Oxford Archaeology all samples were catalogued. All column samples were cleaned photographed and had a log made of their sediment stratigraphy. After recording, sub-samples were collected for assessment of pollen, diatoms, and ostracods/ foraminifera from each context. A series of samples were collected in the field for Optical Stimulated Luminescence (OSL) dating and these were supplement by material selected for radiocarbon dating from key lithiostratigraphic units.

In relation to geochemical analyses and soil micromorphology, only a descriptive assessment of applicability for further analysis was made at the assessment stage. This is due to the high costs associated with sample laboratory preparation for these techniques, which is not cost effective at the assessment stage. Comment is given below on the key sequences and their applicability for geochemical analysis and soil micromorphology.

The specialists' reports from which this assessment is drawn are given as separate appendices (above), as is the analysis of fish bone and charred and waterlogged plant remains from the bulk sample remains. Section (3.0) details the inter-relationship between the bulk and monolith sequence samples.

D.2 Sequence assessment summaries

Sequence 1, Area A

Description: A Roman-period anthrosol located on the top of alluvium, with alluvium overlying a palaeosol G4 and early Holocene Sand G3. Associated monoliths: <1001>, <1002>, <1004>, <1005>, <1006>, and <1007>. Section and plan: S. 1027. Assessed contexts: <1004> (1132, 1135, 1136, 8506); <1002> (8505, 8502, 8503, G3).

This sequence contains an early Holocene sand (G3), with a Neolithic-Bronze Age palaeosol located immediately above it (G4a and G4b, landscape zone 4). Above this is an alluvium (G5), with a Roman-period anthrosol located above the alluvium (1136). There are two sets of monoliths moving through this sequence, providing enough material for soil micromorphology to elucidate depositional/transitional environments and sediment formation histories, and to also analyse palaeoenvironmental proxies. A key question to address during the assessment was the age of the alluvial deposit and palaeosol beneath the Roman-period deposits, with the palaeosol dated to the mid Bronze Age and the alluvium above it to the late Bronze Age.

The foraminifera demonstrate an increasing marine influence with vertical movement up through the sequence, with a true saline environment dating from context (8505, G4a). The lack of either ostracods or foraminifera in the contexts below (8505, G4a) are potentially indicative of a freshwater environment. The lack of diatoms in these lower contexts beneath (8505) is potentially consistent with freshwater soil, perhaps with seasonal waterlogging, being regularly dessicated, creating poor preservation conditions for diatoms. The pollen data, whilst at times variable, provides further evidence of transitional environment from the early Holocene freshwater/dryland terrace (sedge fen/fen carr, pasture) to one of an inter-tidal mudflat.

The G3 sands (<1002> 38-39cm) did not provide a countable assemblage for pollen assessment. The G4 palaeosol could be subdivided into contexts in this sequence (contexts

8502 and 8503), with both producing pollen data consistent with a freshwater wetland (sedge fen, fen carr, grassland) and also a subsequent lack of foraminifera remains. The alluvial silty clay (8506) above this produced poor preservation and a deposit of low potential for pollen. The three contexts above this (1136, 1135 and 1132) all provide relatively well preserved pollen, derived from saltmarsh/pasture habitats. Context (1136) represents the Roman anthrosol in the sequence, with an associated lower pollen potential. Undoubtedly this is a key sequence for Area A, providing the landscape setting before, during and after the Roman-period salt production.

Sequence 5, Area A

Description: Alluvium associated with potential boathouse, south end of Area A. Associated monoliths: <1263>, <1264>, <1288>, <1289>. Section and plan: s.1318 and s. 1281. Assessed contexts: <1289>, (5981, 5980).

This sequence comprises two monolith sets, sampling an alluvial silty clay deposit (contexts 5979, 5980), with an associated organic rich peaty clay deposit (5981). The alluvium is associated with Roman-period archaeology, with timbers driven into the alluvium. This alluvium is currently interpreted as pre-dating the Roman activity on the site and represents evidence of marine transgressions/regressions in the preceding Bronze Age, with an associated immature peaty clay, dating to 752 calBC (OxA-22575, 835 (89.1%). The timbers that were driven into the alluvium have been radiocarbon dated to the Roman period (GU-19377 AD 50-240 (94.0%)).

Context (5981) is the peaty clay sandwiched between two blocks of inter-tidal alluvium. It probably represents a marine regression, and although no foraminifera were present in this deposit, the diatom assessment revealed marine and brackish water assemblages. Whilst the diatoms might have been deposited from an erosional contact at the top of the deposit, more research would be required to resolve this depositional environment. Context (5980) is a grey brown silty clay above (5981) and this does record a marine/brackish diatom assemblage and a mixed pollen picture, potentially consistent with a series of habitats at the tidal margin. The pollen record describes a mixed picture, with pollen from many different habitat types in context (5980), with pollen from saltmarsh, sedge fen and deciduous woodland. This undoubtedly represents a mixing of pollen from freshwater (lowland terrace communities), and local inter-tidal plant communities, with a further possible component of localised freshwater floodplain ecology.

Sequence 6, Area A

Description: Three sequential anthrosols separated by alluvial deposition, toward the southern edge of Area A. Associated monoliths: <1262>, <1380>, <1381> . Section and plan: s. 1097. Assessed context list: <1380> (1746); <1381>, (1747), (1793), (1794), (1837)

The monoliths of <1380> and <1381> represent a transition through Roman-period anthrosols separated by alluvial-derived silty clays. The anthrosols are contexts 1588, 1747 and 1794, with interspersed silty clays contexts, 1873, 1793 and 1746. The silty clays have a slightly different composition to the lower inter-tidal silty clay alluvium seen across Area A, and potentially this may indicate an increased input of sediment from a freshwater source. Alternatively, these clays could represent laid surfaces and hence are floors/human lain sediments, rather than ‘naturally deposited’. This series of alluvium interspersing anthrosols represents an interesting sequence of anthrosol development. Critically, why are there three anthrosol phases and what were the functions of the anthrosols?

Foraminifera are only found in the lowermost sample <1381> (context 1873), with two agglutinating species present (*Trochammina inflata* and *Jadammina macrescens*), both living exclusively on mid-high saltmarsh. Samples above this context do not contain any foraminifera, with the lack of foraminifera potentially indicating that the upper four samples were non-marine and could represent largely freshwater storm pulses from the nearby Mucking Creek. Interestingly, the diatoms record brackish and freshwater species, both heavily degraded in context 1747. The assemblage of 1794 contains a mixture of brackish, marine, freshwater and aerophilous diatoms. In common with the foraminifera, the basal context 1873 has a low concentration of very poorly preserved brackish and marine diatom species. In this case, the diatoms do appear to indicate mixing of sediments from freshwater and marine sources in both the anthrosols and interspersing alluvium.

The brown grey silty clay at the base of the sequence, <1381> (1837), has a relatively well-preserved pollen assemblage, with an inferred vegetation of mixed deciduous woodland, grassland and pasture, typical of a lowland freshwater assemblage. Above this, <1381> (1794) produced a poor pollen collection from a Roman-period anthrosol. Sample <1381> (1793) produced a well preserved and abundant pollen assemblage consistent with a saltmarsh community. Sample <1381> (1747) is also a Roman-period anthrosol and in contrast to <1381> (1794) produced a relatively abundant and well preserved pollen assemblage, indicative of saltmarsh, alder carr/sedge fen. Sample <1380> (1747), which is a clay thin clay between anthrosols, also had a relatively well preserved relatively abundant saltmarsh, alder carr/sedge fen, pollen assemblage. In this respect, the pollen and the diatoms both indicate a mixing of sediment from freshwater/dryland terrace and marine components.

The pollen assessment requires further analysis to fully reconcile with the foraminifera data. The foraminifera are only recorded in the lowest context (1387), whereas the pollen records deciduous woodland, grassland/pasture habitats, although there is an obvious implication of pollen mixing. Conversely, the contexts above this record no foraminifera, potentially indicating a large freshwater component, whilst the pollen records a mix of freshwater and saline tolerant plants, and marine and brackish diatoms. The diatoms record a mixing of freshwater, marine and brackish species throughout the sequence.

Sequence 8, Area A

Description: Sequence at the southern edge of Area A, potentially containing post Roman (medieval) alluvial sequence. Associated monoliths: <1123>, <1124>, <1133>, <1134> <1135>, <1136>. Section: s. 1167. Assessed contexts: <1136> (1996); <1133> (1995)

This sequence was collected from the alluvium toward the southern end of Area A, where a peaty clay (1915) was sandwiched between two silty clay alluvium deposits (1914 and 1916). The proximity of this sequence to the post-medieval ditch (1998) and its sedimentology suggests that this sequence pre-dates the post-medieval land reclamation and post-dates the Roman-period use of the terrace.

The two contexts of <1136> (1996) and <1133> (1995) both contain abundant foraminifera and ostracods, indicative of tidal mudflats and creeks, backed by saltmarsh. Diatoms are absent from context 1996, with context 1995 containing a mixed assemblage of moderately well to poorly preserved valves representing, brackish, marine, marine and aerial, and freshwater habitats.

Overall the pollen showed good potential for further analysis, with the entire sequence sampled from alluvium. Whilst the depositional environment is clearly described as saline inter-tidal deposits by the abundant ostracods and foraminifera, the diatoms and pollen also show a mixing of water from both marine and freshwater sources. The pollen assemblage infers habitats of deciduous woodland and grassland. This can be subjectively interpreted as the localised post-Roman and/or medieval landscape surrounding the northern edge of the estuary.

Sequence 9, Area A

Description: Roman-period enclosure, inner ditch. Associated monoliths: 1273, 1274, 1275. Section: s. 1306. Assessed contexts: <1274>, (5872), (5873), (5620)

An alluvial clay (G5, 5871) covers the top of the ditch, with three ditch fills (5872, 5873, and 5620). All these fills have a silty clay matrix, but all contain in-washed ceramic material associated with red hills. The cutting of this ditch (5621) is dated firmly in the Roman period and further scientific dating of this feature is not required.

Of the three samples examined from sample <1274>, contexts 5872 and 5620 contained agglutinating foraminifera, albeit rare, whereas the middle one in the sequence (5873) did not. The lack of foraminifera in context 5873 is potentially surprising, as the matrix of this context appears to be inter-tidal in common with 5620 below and 5872 above it. Diatom numbers in all three contexts are low or very low, with poor to moderate or poor preservation. Context 5872 has a mixture of halophilous, marine and brackish water diatoms. Context 5873 has a poorly preserved assemblage of marine-brackish and brackish water diatoms, making the lack of foraminifera remains difficult to explain.

The sequence from the inner enclosure ditch produced relatively poor preservation of pollen and relatively low numbers of pollen and spores, except for context 5873, which provides a picture of grassland and arable vegetation. Context 5620 has an inferred vegetation of saltmarsh and grassland. Both contexts 5872 and 5620 contain high levels of salt-making debitage, whilst 5873 is a silty clay with only small ceramic flecks, indicating a greater degree of mixing. Context 5873 did not contain any foraminifera and the markedly different pollen preservation stands this context out as having a different depositional history to 5872 and 5620. The establishment of whether the ditches are inter-tidal when cut or when in use is a key issue. Whilst the results of this sequence were disappointing in the preservation of all proxies, substantial but partial results have been obtained from the foraminifera, diatom and pollen.

Sequence 12, Area A

Description: Roman-period enclosure outer ditch. Associated monoliths: <1024>, <1025>, <1026>, <1027>, <1056> and <1057>. Section: s. 1051a. Assessed contexts: <1026> (1350), (1351); <1027> (1348)

This sequence represents the sampling of three separate phases of ditch construction, grouped into <1024> and <1025>, <1026> and <1027>, and <1056 and 1057>. Of these, only <1026> and <1027> were assessed for palaeoenvironmental proxies. Monoliths <1026> and <1027> represent a sequential sample through the fills of ditch cut 1319. The ditch is capped by a blue grey silty clay alluvium (G5, 1352), underlain by a blue grey silty clay alluvium, with a grey brown silt clay primary fill with ceramic flecks (1348). No further scientific dating is required of this sequence as it is dated by the stratified archaeology.

Context 1351 did not contain any foraminifera or ostracods, but the lower two, <1027> (1348) and <1026> (1350), did. Two species of mid-high saltmarsh foraminifera are present in contexts 1348 and 1350, which could indicate this outer ditch was flooded from time to time by high tides, suggesting an increasing tidal influence. Context 1351 contained no microfossils. Contexts 1351 and 1350 have a very low number of very poorly preserved diatoms with only a benthic brackish water diatom identifiable to species level. Context 1348 has benthic brackish water diatoms, mesohalobous diatoms, marine diatoms, freshwater diatoms and an aerophile species.

The lowest context (1348) contains saltmarsh and grassland/pasture pollen. Above this, 1350 has an inferred vegetation of grassland/pasture and arable, with 1351 having an inferred vegetation of grassland, pasture, arable and woodland. Although the lowest context reveals a saltmarsh influence in the pollen assemblage, both contexts above it do not. The uppermost context revealed a largely freshwater/dryland terrace signature in pollen and did not contain any foraminifera or ostracoda. This potentially represents a localised ecological signature from the terrace top, with little in the way of marine sediment input and its associated mixed pollen assemblage.

Sequence 14, Area A

Description: Roman-period roundhouse outer ditch. Associated monoliths: <1198>, <1203>, <1207>, <1209>, <1227>. Section. s. 1247, s. 1239, s. 1237, s. 1162. Assessed contexts: <1203>, (5430), (5429), (5428)

There are several discrete sections through the roundhouse outer ditch. Monolith <1203>, s. 1239, displays a simple stratigraphy of three contexts infilling cut 5427, all containing inclusions of anthropogenic origin. The lowest fill (5428) is a dark grey silty clay, overlain by 5429, a brown grey silty clay, which is overlain by 5430, a brown grey silty clay.

Both contexts 5429 and 5428 contained microfossils, rare *Jadammina macrescens*, whilst 5430 contained no microfossils. Context 5430 has a poor to moderately well preserved assemblage of brackish and marine diatoms, with one freshwater species. Context 5429 has a poorly preserved brackish and marine diatom assemblage, with a freshwater aerophile also present. In context 5428, there is a very low number of diatoms including marine brackish and freshwater diatoms.

The pollen assessment revealed a general good level of preservation and general good potential. The localised nature of pollen in this ditch is consistent with a pollen assemblage containing freshwater/dryland species on top of the red hill through which the ditch is cut. There seems to be little in the way of in-washed plant pollen from saltmarsh communities, although the diatom and foraminifera records both indicate mixing of sediment/water from freshwater and marine sources.

Sequence 16, Area A

Description: Roman-period roundhouse, set of three tanks. Associated monoliths: <1223>, <1224>, <1225>, <1226>. Section: s. 1050. Assessed contexts: <1225> (1365)

Sample <1225> had a very simple sedimentology, with 1366, a brown grey to red grey silty clay being the lining of the tank. Context 1365 was the fill, a dark grey ash with clay, containing pottery, organic matter, etc. No oxidation gradient was visible in 1366, indicating it had not been exposed to heating. No further scientific dating is required of this material.

No foraminifera or ostracods were found in the one context (1365) examined. Plant debris, much of it burnt, was visible, which may aid in elucidating function of these tanks and whether this material has been redeposited. In contrast to the foraminifera, a moderately high number of poorly preserved diatoms are present in 1365, including brackish and marine species. The dominance of *Diploneis interrupta* in the assemblage from the sediments in the roundhouse settling tanks is consistent with high salinity levels (potentially derived from brine) and prolonged dry periods as a result of evaporation during salt-production.

These tanks have been referred to as ‘settling tanks’, tanks in which brine was pumped, to allow sediment to settle from the brine before evaporation. The presence of a large volume of ash, with abundant plant debris would seem at odds with this description, although the ash/plant detritus could be a secondary deposit from ditches that the brine was captured in during high tides. No oxidation gradient is visible in 1366, indicating the tanks were not heated/fired. An alternative explanation for the ash/plant debris is that it was used to settle out sediment in the captured brine. The diatoms indicate an environment of high salinity, consistent with tanks used to make concentrated brine water.

Sequence 19, Area A

Description: Roman-period red hill, eastern side of Area A. Associated monoliths: <1298>, <1307>, <1308>, <1361>, <1362>, <1364>, <1365>, <1366>, <1371>. Section and plan: s.1273, s.1271, s.1370, s.1369, s.1367. Assessed contexts: <1366> (6373)

The excavation of a limited area of a red hill (group 5664) provided six sections for column sampling of the redhill stratigraphy. Sample <1366> was sub-sampled for assessment and had a stratigraphy of a trampled floor surface on top of the brickearth (6377), above which was a series of red hill deposits with differing proportions of clay, ceramic and burnt clay (contexts 6371, 6372, 6373a, 6373b, 6024, 6378, 6379, 6377 and 6389).

Context 6373A produced a relatively large number of one species of foraminifera, *Trochammina inflata*, burnt and recrystallised. These foraminifera shells undoubtedly came from an inter-tidal clay and appeared to have survived heating during the salt production process. They indicate that clay might be have been excavated from a nearby saltmarsh/tidal flats to provide a resource for salt production. Context 6373A also revealed a low number of brackish marine and aerophilous diatoms, again consistent with an inter-tidal clay origin for the red hill.

No pollen was recovered from sample <1366>, context 6373a. This is a significant result, not least when combined with the evidence from the foraminifera and diatoms.

The results of the assessment are difficult to interpret, and care must be taken not to confuse fact with speculative interpretation. The characterisation of the red hill sample showed there to be marine, brackish and freshwater diatoms present, typical of the poorly preserved mixed saltmarsh communities witnessed from around Area A. There are a substantial number of burnt foraminifera that are associated with inter-tidal alluvium, but the same deposit has no pollen contained within it. Potential explanations are that heating of an inter-tidal clay caused destruction of the pollen grains and not the foraminifera and diatom remains. Alternatively, the foraminifera and diatoms could be present as a result of spilling/processing saline water, containing diatoms and foraminifera but with very low pollen concentrations. This sequence does require further analysis of microfossils, pollen and diatoms from a number of red hill contexts to establish if this pattern is repeated elsewhere, in combination with further sediment analyses. The reason for the lack of pollen is potentially interesting and significant in explaining the creation of red hills and subsequent site taphonomic processes.

Sequence 23, Area A

Description: Cess fill of potential quarry pit. Associated monoliths: <1363>. Section: s. 1049. Assessed contexts: 1252 (and WPR of <1356>, <1357> and <1358> bulk samples)

A large pit was dug through a red hill deposit and into the underlying brickearth deposit during the Roman period. This cut was presumably made to quarry the brickearth (G42), with a series of organic rich clay deposits back filling the pit. On excavation the nature of these deposits was very distinct and interpreted as cess, with the pit postulated as a latrine. The contexts of 1252, 6457 and 6458 were mixed clays with frequent organic matter. This interpretation is considerably aided by the WPR analysis of this deposit, samples <1356>, <1357> and <1358>. In addition to the monolith and WPR samples, specific samples were collected for insect analysis of Diptera and Coleoptera.

Only one sample was assessed from the sequence. Context 1252 contained a very low number of diatoms, but these had a distinct marine and brackish orientation. Other indicators from this feature indicate a freshwater environment waterlogged from ground water, including Diptera and

Coleoptera remains. Thus, the presence of a marine/brackish diatom assemblage (albeit with a low species count) in a feature of known freshwater requires further explanation, not least in how the diatom assemblages are interpreted in a semi-qualitative way over the rest of Area A.

A low concentration of pollen was recovered from 1252. This could be considered surprising, due to the richness of the waterlogged plant remains from this deposit. However, if this deposit was waterlogged primarily from groundwater, especially in its lower contexts, combined with its relatively small size, it would provide a small catchment for pollen.

The potential of the deposit for analysis is low for all three palaeoenvironmental proxies assessed from the monolith sample. This is in contrast with the assessment of the waterlogged plant remains, which provided a rich and abundant assemblage. The low levels of diatoms, foraminifera and pollen are consistent with an interpretation of this deposit as a latrine, potentially with only a groundwater influence. The presence of frequent insect remains, namely Diptera casts in the waterlogged plant remains assessment, lends further evidence to this being a freshwater deposit.

Sequence 25, Area B

Description: Salt making sequence at edge of platform; alluvium interspersing salt making detritus. Associated monoliths: <4031>, <4032>, <4033>, <4034>, <4035>, <4091>, <4092>, <4093>, <4003> and <4004>. Section and plan: s. 4903, s. 4097, s. 4056. Assessed contexts: <4031>, (4433, 4437, 4440); <4032>, (4435); <4092>, (4641, 4642, 4643)

Monoliths <4031> and <4032> comprise a complex sequence of contexts, formed from a series of deposits associated with salt-making, interspersed with clays and silts derived from the inter-tidal zone. In total, 16 sequential deposits are recognisable. From this sequence, a finely laminated dark grey brown sandy silt with ceramic building material (cbm) and charcoal (4440), a pink red brown clayey silt with organic material/charcoal (4437) and finely laminated yellow grey silt clay (4433), with hearth lining, cbm, charcoal, etc. were assessed.

Monolith <4092> is part of a series including samples <4091> and <4093>. Again the series represents salt-making detritus at the edge of the platform interspersed with silts and clays derived from the inter-tidal zone. The stratigraphy recognises multiple context deposits, 10 in total through the three monoliths. The contexts sampled in monolith <4092> are a grey brown silty clay alluvium (4641), a grey brown silty clay matrix with cbm, charcoal, etc. (4642) and mixed salt making detritus deposit (4643).

Brackish foraminifera occur in three of the seven contexts examined and ostracods in one. Three species of agglutinating foraminifera occur in sample <4092> (context 4641) all are typical of mid-high saltmarsh and appear to be *in situ*. Below this there are two samples with agglutinating foraminifera, calcareous species of tidal mudflats, and in one, ostracods of mudflats and creeks (contexts 4642 and 4643).

Context 4433 has a very poorly preserved assemblage of and aerophilous diatoms. The assemblage in 4435 is also poorly preserved and is composed of brackish diatom taxa. Context 4437 has a moderately diverse brackish and marine diatom assemblage. Context 4440 has a very low number of very poorly preserved diatoms; a probable fragment of the benthic brackish water species, *Nitzschia granulata*, was identified. Diatoms are absent from 4641. Only the planktonic estuarine species, *Cyclotella striata*, was identified from 4642. A very low number of brackish water benthic, marine and halophilous aerophillic diatoms are present in 4643.

Although variable in nature, overall the deposits showed a moderate level of pollen preservation, with a moderate abundance of pollen. The discussion of this sequence is split into samples <4092> (part of a sequence of <4091>, <4092> and <4093>), and samples <4031 and <4032>, which sample different areas of the same sequence. All contexts from <4092> show moderate to good levels and good preservation of pollen, describing pasture, grassland, ruderal and saltmarsh plant communities. Samples <4031> and <4032> show a much more variable level of preservation and abundance of pollen, but describe similar habitats to sample <4092>. Likewise, the foraminifera remains were more abundant in sample <4092>, describing an inter-tidal depositional environment.

The sample group of <4091>, <4092> and <4093> showed a better level of overall preservation than <4031, <4032> and <4033>. Again the diatoms preservation was poor, but enough detail was gleaned from the foraminifera and diatom assessment remains to qualitatively identify an inter-tidal depositional environment and associated in-washed pollen, with interleaving Roman contexts. The sample group of <4091>, <4092> and <4093> should be analysed for pollen for interest in their own right, as well as providing a useful comparative sequence to Area A.

Sequence 26, Area B

Description: A sequence of pre-Roman alluvium, with salt production deposits on top of the alluvium. Associated monoliths: <4007>, <4008>. Section and plan: s. 4049. Assessed contexts: <4007> (4291, 4307, 4308); <4008> (4210).

The sequence starts at the early Holocene sand (G3). This is overlain by a brown grey silty clay (G5, 4210), which in turn is overlain by 4308, a clayey silt with salt-making detritus. Above this is 4307, a brown grey silty slay with cbm/charcoal inclusions, in turn overlain by 4291 a dark brown silty clay with frequent cbm/charcoal inclusions. Above this is 4305, a brown silty clay with cbm/charcoal/pottery inclusions, with 4000 being the modern topsoil. The pre-Roman alluvium is 4210.

No foraminifera or ostracods were found in the four samples examined and diatom numbers were low or extremely low, with a poor quality of preservation. Context 4291 contains a mixed diatom assemblage of marine and freshwater diatoms. The dominant components in 4291 are brackish water and benthic types. Contexts 4307, 4308 and 4210 are also dominated by brackish water diatoms. Of the contexts assessed, only 4210 provided a decent pollen assemblage for assessment. Inferred vegetation is saltmarsh, alder carr(?) and deciduous woodland. The context 4210 comes from the pre-Roman sediments, and provides a reasonable indication of the pre-Roman environment. The other three contexts above this (4291, 4307 and 4308) all contain salt-making debitage and conversely poor pollen assemblages.

Sequence 38, Area D

Description: Sampling of alluvium adjacent to Roman wattle structure. Associated monoliths: <2001>, <2006>, <2007>, <2009>, <2010>. Section: s. 2007. Assessed contexts: <2009>, (2108); <2010>, (2109, 2100, 2111)

Samples <2009> and <2010> sampled the sediment wedge to the north of the wattle structure in Area D. The sediment stratigraphy was simple, with five alluvial ‘contexts’ recognised of varying colours of silty clay (2111, 2100, 2109, 2108, 2107). Area D had a slightly lower topographic template than Areas A and B. The wooden stakes that formed the wattle structure were radiocarbon dated to (GU-19379, 60-250AD (95.4%)), showing Area D to already be within full inter-tidal conditions by the Roman period.

All four contexts contained two species of agglutinating saltmarsh foraminifera in abundant to superabundant quantities. Three, in addition, contained two species of calcareous foraminifera, typical of low-mid saltmarsh and tidal mudflats (one with associated tell-tale diatoms in large numbers). Finally, two contexts contained brackish ostracods of tidal flats and creeks. The complete sequence at this site, therefore, must have been tidal throughout. The occurrence of only mid-high saltmarsh foraminifera in the uppermost sample (<2009>, context 2108) may indicate a gradual accretion of the saltmarsh to an upper saltmarsh habitat.

Diatoms are absent from 2109 and 2100. In context 2108, there is a very poorly preserved assemblage of brackish and marine diatoms. In the bottom sample from the sequence (2111), there is a poorly preserved marine and freshwater diatom assemblage. However, the dominant component in 2111 appears to be of marine diatoms.

All four contexts provided either quite good to good preservation of pollen, with potential throughout the whole sequence for analysis. In general a consistent vegetation type of saltmarsh and grassland was witnessed, typical of the pollen washed into the inter-tidal zone at the floodplain edge.

Borehole OA3, Palaeochannel

Description: Palaeochannel sequence of the large palaeochannel at the southern edge of Areas A, B, C and D. Sampled from south of Area A. Associated boreholes: OABH1, OABH2, OABH3, OABH4, OABH5 and OABH6. Section and plan: n/a, borehole sample. Assessed sub-sample: 3.83 - 3.85m

The boreholes revealed a sand gravel bed at the base of the palaeochannel and a series of alluvial clay deposits through the palaeochannel infill. The OSL date of the sands in this borehole (329ka, =/-36ka, OA5, GL09091) confirmed this to be a Pleistocene palaeochannel, which had probably been periodically reactivated throughout the Pleistocene and, as the environmental proxies show, in the early to mid Holocene. Above the sand and gravel basal units was a largely homogeneous block of silty clay alluvium.

OA BH3, 3.83-3.85m, was shown to contain a diverse foraminifera fauna and flora. This mixed assemblage is typical of sites within the outer parts of the present Thames Estuary, with the palaeochannel holding occasional flow in the inter-tidal zone.

Conversely, there were an extremely low number of very poorly preserved diatoms in OA3 3.83 - 3.85m with no potential for further analysis. Brackish water benthic diatoms were identified. The pollen of OA BH3 was relatively well preserved and abundant. It infers pollen from a vegetation structure of grassland and deciduous woodland, consistent with a depositional palaeochannel at the edge of the inter-tidal floodplain in the early Holocene.

This borehole provides an overview of the palaeoenvironment directly to the south of Area A, whilst also containing a sequence of sediment from the early Holocene to post-Roman periods, providing a context for the terrace site and its archaeology. As this palaeochannel is at the estuarine edge and not on the terrace, it gives a comparable sequence to stitch Stanford Wharf into the site-wide palaeoenvironmental programme and also possibly Devoy's model of estuarine evolution.

D.3 Integration of sequences with bulk samples

The assessment has considered bulk samples and contexts as separate entities. However, there are inter-relationships between column and bulk samples and these are important for relating charred and waterlogged plant remains analyses with column sampling.

Monolith	Monolith contexts	Overlapping bulks	Comments
Sequence 1			
1001	8500		
	8501		
	G5		
1002	G5		
	G4a 8505		
	G4b 8502		

Monolith	Monolith contexts	Overlapping bulks	Comments
	G4b 8503		
	G3		
	8504		
1004	1132	Bulk <1071> WPR	Alluvium
	1135	Bulk <1048> CPR	
	1136	Bulk <1049> CPR	
	8506		
1005	1132	Bulk <1071> WPR	Alluvium
	1135	Bulk <1048> CPR	
	1136	Bulk <1049> CPR	
	G5		
1006	1135	Bulk <1048> CPR	
	1136	Bulk <1049> CPR	
	8506/G5		
1007	1142	Bulk <1050> CPR	
	1143	Bulk <1072> WPR	Alluvium
	1144	Bulk <1051> CPR	Peaty clay
	1077	Bulk <1052> CPR1	
	G3/1145	Bulk <1073> CPR	G3 layer, contained charcoal of unknown provenance
	G42		
Sequence 5			
1263	5732		
	5783		
1264	5783		
	5784		
	5845	Bulk <1268> WPR	Peat layer under alluvium
1288	5980		
	5981		
	5982		
1289	5979		
	5980		
	5981		
Sequence 6			
1262	5732		
	5731		
	5727		
1380	1588		
	1746		
	1747		
	1793		
	1794		
1381	1747		
	1793		
	1794		
	1837		
Sequence 8			
1123	1916		
	1915	Bulk <1125> CPR Bulk <1137> CPR	Clayey peat deposit Clayey peat deposit

Monolith	Monolith contexts	Overlapping bulks	Comments
	1914		
1124	Duplicate of 1123		
1133	5000		
	1999		
	1997		
	1995		
1134	Duplicate of 1133		
1135	1995		
1136	1995		
	1996		
Sequence 9			
1273	5878		
	5880		
1274	5871		
	5872	Bulk <1277> CPR	Organic rich ditch fill
	5875		
	5620		
1275	5620		
	5904		
Sequence 12			
1024	1220		
	1198	Bulk <1032> WPR	Wood in ditch fill
1025	1198		
	1283	Bulk <1033> WPR	Wood in ditch fill
	1285		
1026	1352		
	1351		
	1350	Bulk <1036> WPR	Wood in ditch fill
1027	1350		
	1348		
	G42		
1056	1513	Bulk <1045> CPR	Redhill sample between ditches
	1612		
	1381	Bulk sample <1028>, WPR/CPR	Ditch fill
1057	1513		
	1612		
	1381	Bulk sample <1028>, WPR/CPR	Ditch fill
	1549		
Sequence 14			
1198	5365		
	5414		
	5418		
	5450		
	G3		
1203	5430		
	5429	Bulk <1192> CPR	Outer roundhouse ditch terminus
	5428		

Monolith	Monolith contexts	Overlapping bulks	Comments
	5433		
1207	1945		
	1946		
	1947		
	1948		
	1949		
	1950		
1209	5564		
	5863		
	8520		
	8521		
1227	5565	Bulk <1216> CPR	Ashy ditch terminus fill (poss quarry pit)
	5564	Bulk <1217> CPR	Ditch terminus with burnt clay and fired sand - again poss quarry pit
Sequence 15			
1202	5317		
	5328		
	G4		
	G3		
	G42		
Sequence 16			
1223	1361	Bulk <1234> CPR	Roundhouse tank fill
	8517		
	1366		
	G3		
1224	1362	Bulk <1235> CPR	Roundhouse tank fill
	1363	Bulk <1236> CPR	Roundhouse tank fill
	1364		
	1366		
	G3		
1225	1365	Bulk <1237> CPR	Roundhouse tank fill
	1366		
1226	1331	Bulk <1233> CPR	Roundhouse tank fill
	1361	Bulk <1234> CPR	Roundhouse tank fill
	1366		
	G4		
	G3		
Sequence 17			
1151	1593	Bulk <1330> CPR	Fill of kiln
	1484		
	8511		
	8512		
	8513		
	8514		
	8515		
1152	1597	Bulk <1329> CPR	Fill of kiln
	1595		
	1594		
	1593	Bulk <1330> CPR	Fill of kiln

Monolith	Monolith contexts	Overlapping bulks	Comments
Sequence 19			
1298	5650		
	5651		
	5654		
	G3		
1307	5650		
	5651		
	5652		
	6123/G4		
	G3		
1308	5648		
	5649		
	5654		
	G42		
1362	6234		
	6235		
	6236		
	6239		
	6238		
	6241		
	6240		
1364	6234		
	6235		
	6030		
	6236		
	6239		
	6238		
	6241		
	6240		
1365	6375		
	6373		
	6370		
	6371		
	6373		
1366	6371		
	6372		
	6373		
	6374		
	6024		
	6378		
	6379		
	6377		
	6389		
1371	6238		
	6241		
	6240		
	6022		
	6138		
	G42		
Sequence 21			
1324	5753		

Monolith	Monolith contexts	Overlapping bulks	Comments
	5752	Bulk <1341> CPR	Trampled floor surfaces with slag
1328	6145		
	6146		
	6144		
Sequence 22			
1332	1009		
	1008	Bulk <1335> CPR	Charcoal rich late roman deposit
	1007	Bulk <1334> CPR	Charcoal rich late roman deposit
	1006		
	1002		
1333	1002		
	1024		
	1025		
Sequence 23			
1363	1252	Bulk <1368> WPR/insects	Organic rich quarry pit fill
	6457		
	6458	Bulk <1369> WPR/insects	Organic rich quarry pit fill
	G42		
Sequence 25			
4031	4426		
	4427		
	4428		
	4429		
	4430		
	4431		
	4432		
	4433		
	4434		
	4435		
4032	4435		
	4436		
	3347		
	4438		
	4439		
	4440		
	4441	Bulk <4035> WPR	Organic layer
4033	4447		
	4431		
	4444		
	4433		
	4443		
	4442		
4034	4457		
	4459		
4091	4641		
	4629		

Monolith	Monolith contexts	Overlapping bulks	Comments
	4630		
	4658		
4092	4641		
	4642		
	4643		
4093	4643		
	4645		
	4647		
	4648		
4003	4253		
	4251		
4004	4251		
	4252		
	4253		
Sequence 26			
4007	4000		
	4289		
	4305		
	4291		
	4307		
	4308		
4008	4307		
	4308		
	4210		
	4320		
Sequence 38			
2001	2073		
	2076	<2021> CPR	
	2081		
	2091		
	2076		
2008	2061		
	2062		
	2063		
2009	2107	<2014> CPR <2015> CPR	
	2108	<2016> CPR	
	2109	<2017> CPR	
2010	2109	<2017> CPR	
	2110	<2018> CPR	
	2111	<2019> CPR	

Table 31: Suggested sequences to be analysed with the bulk samples for WPR and CPR

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