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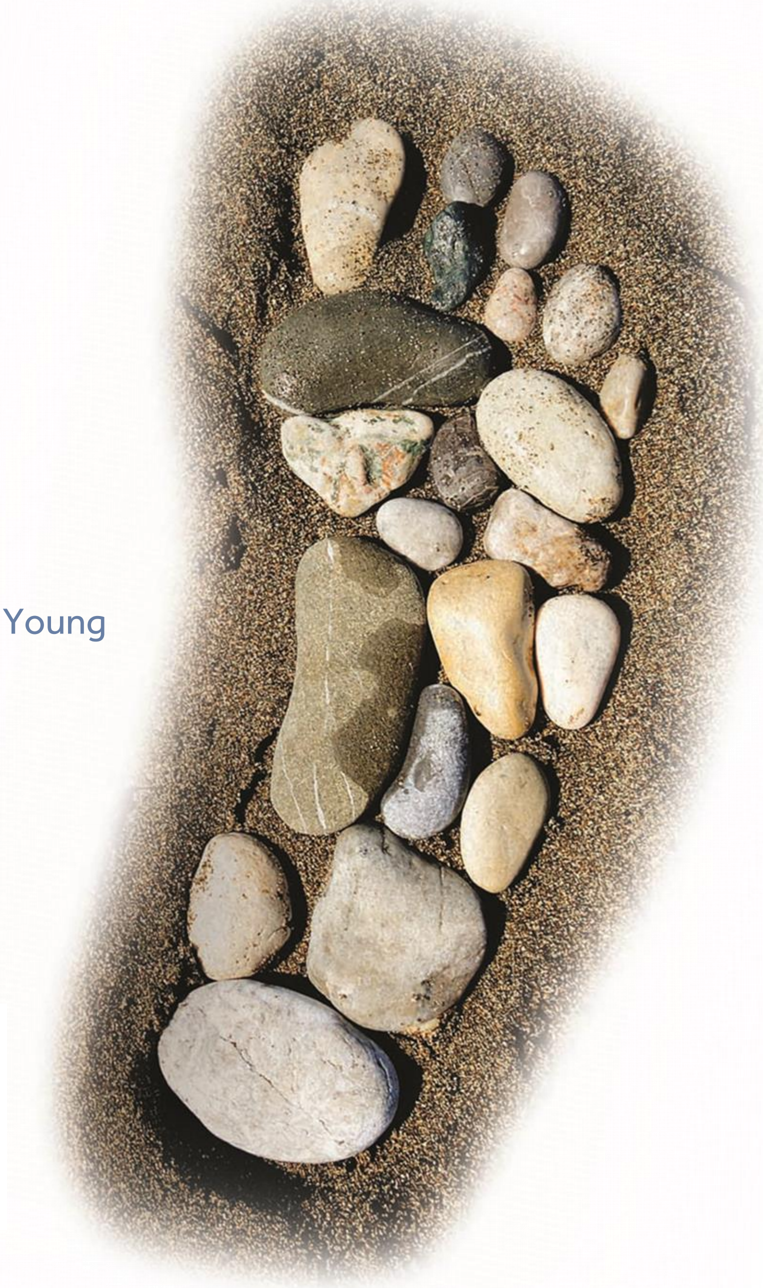
2-3 ROBERT STREET, CITY OF WESTMINSTER

Geoarchaeological and Palaeoenvironmental Analysis Report



NGR: TQ 30372 80549

Date: 20th February 2020

Site Code: ROB17

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DOCUMENT HISTORY

REVISION	DATE	PREPARED BY	SIGNED	APPROVED BY	SIGNED	REASON FOR ISSUE
v2	20/02/20	Rob Batchelor		Rob Batchelor		Minor alterations from client
v1	20/02/20	Rob Batchelor		Rob Batchelor		First edition

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1. NON-TECHNICAL SUMMARY

Following previous geoarchaeological and palaeoenvironmental field and assessment works, the sequences from 2-3 Robert Street were identified to have the potential to provide greater insights into human economy, diet & health and hydrology, as well as to establish any differences between the assemblages in the naturally deposited peat of QBH2, and reworked/redeposited peat of QBH3. Furthermore, since relatively few palaeoenvironmental records are available for this area of London for the Saxon period, any further analysis also has the potential to contribute to our understanding of the interaction between Saxon societies and the natural environment at this time. Palaeoenvironmental analysis was thus carried out incorporating pollen, diatoms and further radiocarbon dating.

The combined results of geoarchaeological and palaeoenvironmental investigations have revealed a sequence of London Clay bedrock, overlain by Late Devensian Shepperton Gravel, Holocene alluvium (in places including peat), ground-raising/levelling deposits and modern Made Ground. The Gravel is overlain at the site by variable thicknesses of Holocene alluvium, recorded to levels of between *ca*. 1.75 and -0.80m OD. The deposits of the alluvium are predominantly silty, clayey and occasionally sandy; however, a peat unit dated to the Saxon period was recorded within the alluvial sequence, generally at levels between *ca*. 0.2 and -0.35m OD, but not recorded in the interventions to southeast. Above this, the ground-raising/levelling deposits incorporate alluvial sediments from the underlying unit, including organic matter, and contain anthropogenic material of Saxon date onwards, including charcoal, bone, worked wood and shell (in places including oyster).

The deposits at the 2-3 Robert Street site thus appear to represent natural foreshore deposits associated with the floodplain of the River Thames, overlain by alluvial sediments and a series of ground-raising/levelling deposits that incorporate material from the alluvial sediments below. During the period of alluvium and peat accumulation, the site was subject to an increasingly saline influence. The deposits here are very similar in character to those recorded at both Adelphi House and 18-20 York Buildings. However, at the 2-3 Robert Street site, the lower alluvial deposits, including the peat/richly organic units dated to the Saxon period and recorded at between *ca*. 0.2 and -0.35m OD, appear to have accumulated mainly by natural processes.

The vegetation near 2-3 Robert Street, and nature of the human activities remained relatively consistent from 650-770 to 680-890 cal AD. The local environment was very open, and largely occupied by plants growing in a number of open habitats, including, wetlands, meadow, pasture and disturbed/waste ground. Cereals and their associated weeds are also present suggestive of either nearby crop-growth, or that material was being brought to site for processing, consumption or dumping. Damp ground and open water supporting sedges, grasses and mixed herbs/aquatics is indicated, with a limited amount of alder and willow woodland. by the presence of sedges, grasses and bur-reed, together with buttercup, mint, and marsh valerian. The combined presence of the dung fungal spores and ova, together with consistently high values of microcharcoal suggest some dumping of faeces and other waste, in an otherwise naturally accumulating deposit.

2. INTRODUCTION

2.1 Introduction

This report summarises the findings arising out of the geoarchaeological field investigations and subsequent palaeoenvironmental analysis undertaken by Quaternary Scientific (University of Reading) in connection with the proposed redevelopment of 2-3 Robert Street, City of Westminster (National Grid Reference: *centred on* TQ 30372 80549; Site Code: ROB17; Figures 1 and 2). The work was commissioned by Archaeology Collective (on behalf of the overall client). Geoarchaeological and palaeoenvironmental investigation of the site will enable a reconstruction of its environmental history, which can be compared and integrated with records from other sites in this area, such as those at Adelphi House (Young *et al.*, 2015) and 18-20 York Buildings (Cowie & Whytehead, 1989) (see Figure 1). The latest phase of geoarchaeological investigations follows previous geoarchaeological monitoring at the site (Young, 2017), archaeological evaluation by MoLA (2015) and AOC (2017; 2018a; 2018b), and radiocarbon dating undertaken by ARCA (2018).

2.2 Site context

The area of investigation at 2-3 Robert Street is in Central London on the north side of the River Thames between the Strand and the Victoria Embankment and about 150m from the modern waterfront. The ground level of the site lies at approximately 13m OD, with the basement level lying at around 3.9m OD. The British Geological Survey (BGS) (1:50,000 Sheet 256 North London, 1994) shows the site underlain by Kempton Park Gravel which forms a very narrow terrace here parallel with the river, and with a surface level at about 5m OD (cf. Gibbard, 1985 Fig. 33, upper section). Within or very close to the 2-3 Robert Street site, the Holocene Alluvium of the Thames is shown by BGS immediately abutting the Kempton Park Gravel. Topographic and geological description of the site carried out by MoLA (2015) indicates that the surface of the terrace gravels slopes downwards from 1m to -5m OD, from north to south across the site. The bedrock beneath the site is mapped by BGS as the Lower Tertiary London Clay.

Previous archaeological and geoarchaeological evaluation work carried out by MOLA in 2015, comprised the opening of three trenches on the southern part of the 2-3 Robert Street site.

Trench 1 measured 2 x 1.6 x 2.4m, with a base at 1.51m OD
Trench 2 measured 3 x 1.6 x 2.2m, with a base at 2.27m OD
Trench 3 measured 2.4 x 1.7 x 2m, with a base at 1.92m OD

Within each trench, a series of levelling and make-up deposits was recorded, together with evidence of an 18th century brick and concrete wall foundations in the southeast corner of site; most likely the result of repeated demolition and reconstruction prior to the construction of the current grade II* building (MoLA, 2015). Natural alluvial deposits were only recorded within a single auger hole, put down through the base of Trench 2, reaching it at 0.87m OD (3.06m below ground level (bgl)).

Between 2017 and 2019, a programme of geoarchaeologoical and palaeoenvironmental investigations have been carried out on the site (Young, 2017, 2019; Young et al., 2019). These have revealed a sequence of London Clay bedrock, overlain by Late Devensian Shepperton Gravel, Holocene alluvium (in places including peat), ground-raising/levelling deposits and modern Made Ground. The Gravel is overlain at the site by variable thicknesses of Holocene alluvium, recorded to levels of between *ca*. 1.75 and -0.80m OD. The deposits of the alluvium are predominantly silty, clayey and occasionally sandy; however, a peat unit dated to the Saxon period was recorded within the alluvial sequence, generally at levels between *ca*. 0.2 and -0.35m OD, but not recorded in the interventions towards the south-east of the site. Above this, the ground-raising/levelling deposits incorporate alluvial sediments from the underlying unit, including organic matter, and contain anthropogenic material of Saxon date onwards, including charcoal, bone, worked wood and shell (in places including oyster).

The deposits recorded are very similar in character to those recorded at both Adelphi House (Young *et al*., 2015) and 18-20 York Buildings (Cowie & Whytehead, 1989). However, at the 2-3 Robert Street site, the lower alluvial deposits, including the peat/richly organic units dated to the Saxon period and recorded at between *ca*. 0.2 and -0.35m OD, appear to have accumulated entirely by natural processes. The biological remains in both the naturally accumulated and reworked/redeposits organic deposits are very similar. A generally open, damp and disturbed environment is indicated, with a range of herbaceous taxa recorded potentially representing their growth in a number of open habitats, including wetlands, meadow, pasture, disturbed/waste ground with crops and their associated weeds.

Archeological evaluation by AOC (2018a) carried out in tandem with the geoarchaeological investigations interpreted the overlying ground-raising/levelling deposits as Made Ground used to found a building or buildings constructed using chalk and ragstone blocks, and thought likely to date to the medieval period. These buildings appear to have been largely demolished when 2-3 Robert Street was built in the latter half of the 18th century (AOC, 2018a). A further phase of evaluation by AOC (2018b) characterised one of the associated chalk walls (recorded previously in TP8), which ran parallel to the Listed chalk wall in the vaults. The work by AOC (2018b) concluded that there is no evidence to suggest the chalk walls were contemporary or part of the same structure and there is no direct link between the chalk wall in the evaluation trench and the section of chalk wall in the standing basement.

2.3 Geoarchaeological, Palaeoenvironmental and Archaeological potential

The site represents a rare opportunity to study the Middle Saxon waterfront in London, including its management and tidal regime, currently poorly understood and highlighted as a research priority for London (Nixon *et al*., 2002). Excavations at Adelphi House uncovered significant remains of Middle Saxon date of regional if not national importance, including foreshore deposits in which a silver coin gilded with gold was found (provisionally dated to AD 655-675), embankment and waterfront structures including a wattle structure, brushwood and a timber river wall, levelling deposits, a timber building, metalled surfaces and cut features including pits and ditches. These were overlain by the latest features recorded at the site, which included medieval or post-medieval post-holes and a post-medieval floor. As outlined above, the earliest deposits recorded at the site were sand and gravels thought to represent natural accumulation but in places containing animal bone and pottery, dated to AD 600-750.

Both the 2-3 Robert Street and Adelphi House sites are situated in the western part of the Middle Saxon settlement of Lundenwic which was occupied between the late 7th century and the mid-9th century and located in Westminster centred on the Strand, Covent Garden and Aldwych areas. The Strand was the heart of the trading 'emporium' where boats were beached to trade goods from the Continent. The Middle Saxon waterfront of Lundenwic was identified during excavations at 18-20 York Buildings (next door to the Adelphi Building; Cowie & Whytehead, 1989; see Figure 1). Here, sandy foreshore deposits (containing anthropogenic material including bone and oyster shell) were interpreted as accumulating naturally at the edge of a river. Stakes and revetment structures constructed in AD 679 or shortly after were driven in to these deposits, along with material laid down to create an embankment with a surface at between 0.8 and 1.3m OD (Cowie & Whytehead, 1989). The embankment structure was overlain by Alluvial sediments containing seeds and Mollusca indicative of shallow, bankside and possibly tidal conditions to a level of 1.6m OD (Cowie & Whytehead, 1989). Possible Middle Saxon foreshore deposits and associated embankment structures have also been recorded at 12 Buckingham Street (BHM88) and Charing Cross Station (CHA87); the top of a wooden stake at the latter was recorded at 1.19m OD (Cowie, 1992).

Environmental archaeological investigations were carried out on column and bulk samples extracted from the lift-pit at Adelphi House, incorporating lithostratigraphic analysis and assessment of the palaeoecological remains (Young *et al*., 2015). Investigation of the column samples revealed a range of inorganic and organic sediments (inlcuding peat) representative of foreshore deposits, ground raising and dumped material. The samples were rich in archaeobotanical (pollen, diatoms, plant macrofossils, charcoal and wood) and zooarchaeological (animal bone, insects, Mollusca), providing important insights into the former environmental conditions, vegetation communities, hydrology, diet and economy of the site.

2.4 Aims and objectives

Within the original environmentl archaeological Written Scheme of Investigaiton for the site, the following aims were proposed for the site:

1. To clarify the nature, depth, extent and date of the sub-surface stratigraphy across the site;
2. To determine the height of the contact between the natural and archaeological deposits;
3. To determine whether redeposited peat deposits are present beneath the site as recorded at Adelphi House;
4. To investigate whether the sequences contain any artefact or ecofact evidence for prehistoric or historic human activity;
5. To investigate any change in the former environmental conditions, vegetation communities and hydrology of the site as a consequnce of either natural and/or anthropogenic change;
6. To provide insights into human economy and diet;

7. To compare the environmental archaeological findings with those from other sites within the main Lundenwic settlement for publication (if appropriate, pending the results of the investigations).

As a consequence of the geoarchaeological and palaeoenvironmental field and assessment works carried out to date, aims 1 to 3 have largely been addressed. However, it was highlighted that the sequences had the potential to further address aims 4-6 by providing greater insights into human economy, diet & health and hydrology, as well as to establish any differences between the assemblages in the naturally deposited peat of QBH2, and reworked/redeposited peat of QBH3. Furthermore, since relatively few palaeoenvironmental records are available for this area of London for the Saxon period, any further analysis also has the potential to contribute to our understanding of the interaction between Saxon societies and the natural environment at this time. The results of the analysis could be combined with the results of the investigations at Adelphi House (Young *et al*., 2015) and 18-20 York Buildings (Cowie & Whytehead, 1989) to form a useful publication that contributes to our knowledge of Saxon Lundenwic, in particular at the foreshore (aim 6).

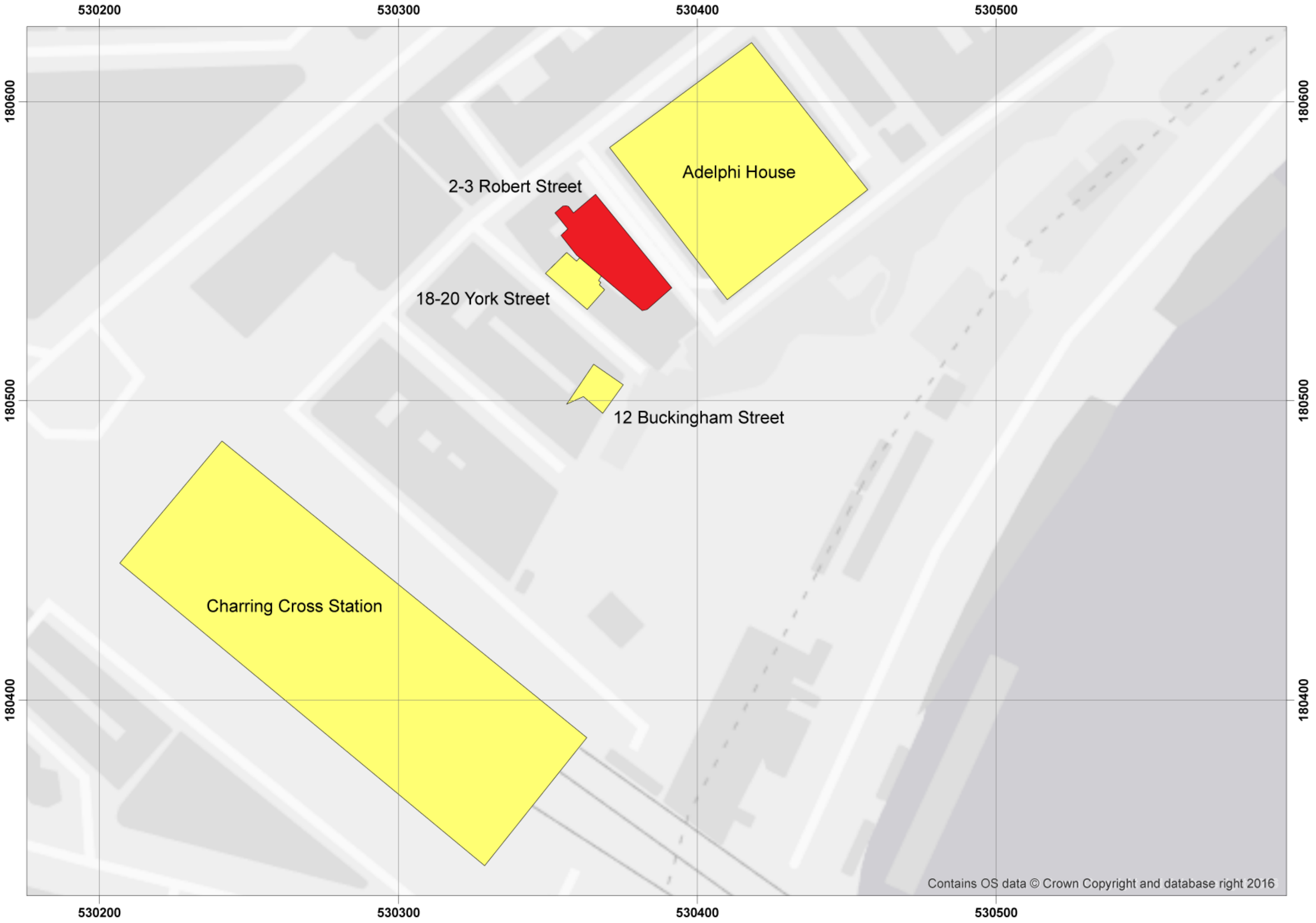

Figure 1: Location of 2-3 Robert Street, City of Westminster, and select nearby sites: Adelphi House (PCA, 2015; Young et al., 2015; Austin, 2016); 18-20 York Buildings (Cowie & Whytehead, 1989); 12 Buckingham Street & Charring Cross Station (Cowie, 1992).

Figure 2: Location of the new geoarchaeological boreholes (QBH1 to QBH4), and previous archaeological/geotechnical interventions carried out by MoLA (2015), AOC (2017), AOC (2018a) and AOC (2018b) at 2-3 Robert Street, City of Westminster. Figure adapted from AOC (2018b). Orientation of NW-SE transect (see Figure 3) also shown.

3. METHODS

3.1 Field investigations and lithostratigraphic descriptions

A total of four boreholes were put down at the site by Geotechnical and Environmental Associates (GEA) under the supervision of Quaternary Scientific in April 2018 (see Figure 2). The borehole core samples were recovered using a Terrier rig, with the resultant core material retained in sealed plastic tubing and described in the laboratory by a geoarchaeologist. The boreholes were put down until the surface of the underlying river gravel was reached. The borehole locations were obtained by GEA; a level of 3.5m OD (following the breaking out of the concrete slab) has been adopted for the surface level of the four boreholes.

The lithostratigraphy of the core samples was described in the laboratory using standard procedures for recording unconsolidated sediment and organic sediments, noting the physical properties (colour), composition (gravel, sand, clay, silt and organic matter) and inclusions (e.g. artefacts) (Tröels-Smith, 1955). The procedure involved: (1) cleaning the sample using a scalpel; (2) recording the physical properties, most notably colour using a Munsell Soil Colour Chart; (3) recording the composition; gravel (Grana glareosa; Gg), fine sand (Grana arenosa; Ga), silt (Argilla granosa; Ag) and clay (Argilla steatoides); (4) recording the degree of peat humification and (5) recording the unit boundaries e.g. sharp or diffuse. The results of the lithostratigraphic descriptions of the new geoarchaeological boreholes are displayed in Tables 4 to 7 and in Figure 3. The descriptions for the previously monitored geotechnical boreholes described in Young (2017) are shown in Tables 1 to 3.

3.2 Radiocarbon dating

A total of four samples were submitted for radiocarbon dating. Three subsamples of twig wood (less than 2-3 growth rings) were extracted from the lower organic unit (-0.12 to -0.17m OD) and base/top of the peat (0.00 to -0.05m OD & 0.20 to 0.14m OD) in borehole QBH2, as well as a fragment of *Corylus avellana* (hazel) nut shell from the base of the possibly reworked peat in borehole QBH3 (0.50 to 0.52m OD). The samples were submitted for AMS radiocarbon dating to the BETA Analytic Radiocarbon Dating Facility, Miami, Florida. The results have been calibrated using OxCal v4.2 (Bronk Ramsey, 1995; 2001 and 2007) and the IntCal13 atmospheric curve (Reimer *et al*., 2013). The results are displayed in Figures 3, 4 and in Table 8.

3.3 Pollen and non-pollen palynomorph analysis

Eleven subsamples from borehole QBH2 and three from QBH3 were extracted for pollen analysis. The pollen was extracted as follows: (1) sampling a standard volume of sediment (1ml); (2) adding two tablets of the exotic clubmoss *Lycopodium clavatum* to provide a measure of pollen concentration in each sample; (3) deflocculation of the sample in 1% Sodium pyrophosphate; (4) sieving of the sample to remove coarse mineral and organic fractions (>125μ); (5) acetolysis; (6) removal of finer minerogenic fraction using Sodium polytungstate (specific gravity of 2.0g/cm^3); (7) mounting of the sample in glycerol jelly. Each stage of the procedure was preceded and followed by thorough sample cleaning in filtered distilled water. Quality control is maintained by periodic checking of residues, and assembling sample batches from various depths to test for systematic laboratory effects.

The analysis procedure consisted of counting all pollen and non-pollen palynomorphs to a total of 300 Total Land Pollen where possible (TLP; trees, shrubs and herbs) where possible. Aquatic pollen, spores and non-pollen palynomorphs were also counted. Pollen grains were identified using the keys, photographs and diagnostics features published in Moore *et al* (1991) and Beug (2004), and the S. Richer's reference collection. Identification of cereal pollen followed the criteria of Dickson (1988). Identification of indeterminable grains was according to Delcourt and Delcourt (1980). Reference photographs and criteria from Cugny et al (2010), Fernandes, et al (2005), Florenzano et al (2012), van Geel (1978) and van Geel et al (2003) were used to aid in the specific identification of NPPs. Types of microscopic charcoal were identified according to Courtney Mustaphi and Pisaric (2014).

Pollen percentage and pollen concentration diagrams were produced in 'Tilia'. Pollen percentage values were calculated as follows: Tree, shrub and herb taxa were calculated as a percentage of total land pollen (TLP); other remains (aquatics, spores, unidentifiable grains) were calculated as a percentage of TLP. The concentration of microcharcoal with dimensions >20um along at least one axis, was also recorded together with total pollen concentration. The results are displayed in Figures 5 and 6.

3.3 Diatom analysis

Eight samples were prepared for diatom analysis from QBH2. 0.5g of sediment was required for the diatom sample preparation. Samples were first treated with hydrogen peroxide (30% solution) and/or weak ammonia (1% solution) depending on organic and/or calcium carbonate content, respectively. Due to the high silt and clay content of most samples, all samples chosen for analysis were then treated with sodium hexametaphosphate and left overnight, to assist in minerogenic deflocculation. Samples were finally sieved using a 10μm mesh to remove fine minerogenic sediments. The residue was transferred to a plastic vial from which a slide was prepared for subsequent assessment.

A minimum of 400 diatoms were identified for each sample depth. Diatom species were identified with reference to van der Werff and Huls (1958-74), Hendy (1964) and Krammer & Lange-Bertalot (1986-1991). Ecological classifications for the observed taxa were then achieved with reference to van der Werff and Huls (1958-74), Vos and deWolf (1988; 1993), Van Dam *et al.*, (1994), Denys (1991-92; 1994) and Round *et al.* (2007). The results are displayed in Tables 9, 10 and Figure 7.

3.4 Macrofossil assessment

A total of five small bulk samples from borehole QBH2 and two from QBH3, each measuring approximately 0.05 litres in volume, were extracted and processed for the recovery of macrofossil remains, including waterlogged and charred plant macrofossils, charcoal, wood, insects and Mollusca. The samples were focussed on the lower organic unit and peat in borehole QBH2 (Table 11), and the reworked/redeposited peat in QBH3 (Table 12). The extraction process involved the following procedures: (1) measuring the sample volume by water displacement, and (2) processing the sample by wet sieving using 300µm and 1mm mesh sizes. Each sample was scanned under a stereozoom microscope at x7-45 magnifications, and sorted into the different macrofossil classes. The concentration and preservation of remains was estimated for each class of macrofossil (Tables 11 and 12), whilst preliminary identifications of the waterlogged seeds (Tables 13 and 14) have been made using modern comparative material and reference atlases (e.g. Martin & Barkley, 2000; NIAB, 2004; Cappers *et al.* 2006). Nomenclature used follows Stace (2005).

4. RESULTS & INTERPRETATION OF THE GEOARCHAEOLOGICAL INVESTIGATIONS & RADIOCARBON DATING

The results of the lithostratigraphic descriptions of the four new geoarchaeological boreholes are shown in Tables 4 to 7, with the descriptions of the existing geotechnical boreholes described in Young (2017) shown in Tables 1 to 3. A revised northwest-southeast stratigraphic profile of these sequences, incorporating the new geoarchaeological boreholes, the existing geotechnical boreholes and MoLA Trench 2, is shown in Figure 3. As described by Young (2017), the full sequence of sediments recorded in the boreholes comprises:

- Made Ground (modern)
- Ground raising/levelling deposits (unknown date; Middle Saxon or later)
- Holocene alluvium (including peat/organic units)
- Sand and gravel (Shepperton Gravel)
- Bedrock (London Clay)

4.1 Bedrock (London Clay)

A horizon of stiff, slightly silty and slightly sandy clay interpreted as the London Clay bedrock was recorded at the base of borehole QBH4 at -1.42m OD, and in geotechnical borehole BH1 at -2.8m OD. As might be expected at this location on the edge of the River Thames floodplain, the bedrock rises sharply north-westwards; in the geotechnical logs provided by GEA the surface of the London Clay was recorded in boreholes BH2 and BH3 at levels of -4.3 and -5.4m OD respectively.

4.2 Sand and gravel (Shepperton Gravel)

Overlying the London Clay bedrock in all three of the previous geotechnical boreholes (BH1 to BH3) and reached in three of the new geoarchaeological boreholes (QBH2 to QBH4) was a horizon of sand and gravel. On the basis of the elevation of the Gravel (see below), it seems unlikely to represent the Kempton Park terrace, which north of here forms a very narrow terrace parallel with the river with a surface level at about 5m OD (Gibbard, 1985 Fig. 33, upper section). This Gravel is therefore interpreted as the Shepperton Gravel of Gibbard (1985; 1994). This gravel unit was deposited during the Devensian Late Glacial (*ca*. 15,000 to 11,700 years before present) and comprises the sands and gravels of a high-energy braided river system which, while it was active would have been characterised by longitudinal gravel bars and intervening low-water channels in which finer-grained sediments might have been deposited. Such a relief pattern would have been present on the valley floor at the beginning of the Holocene when a lower-energy fluvial regime was being established.

In all but one of the boreholes the surface of the Gravel is relatively even, lying at between -1.1 (BH2 and BH3) and -1.50m OD (QBH3). Only in BH1 is it significantly higher, recorded at -0.15m OD. Given the close proximity of this borehole to QBH3 and QBH4, it is possible the level of the Gravel in BH1 is artificial, potentially the result of anthropogenic disturbance of the Gravel (perhaps during the emplacement of the overlying ground raising deposits) at this location of the site.

4.3 Holocene alluvium (including peat/organic horizons)

Holocene alluvium was recorded in varying thicknesses in all eight of the interventions shown in Figure 3, overlying the Gravel. The surface of this unit was interpreted as 0.20, 1.75 and -0.80m OD in boreholes BH1, BH2 and BH3 during the previous investigations undertaken by Young (2017); in the new geoarchaeological boreholes it is recorded at -0.98, 0.50, 0.58 and 0.18m OD in boreholes QBH1, QBH2, QBH3 and QBH4 respectively. However, it was acknowledged previously (Young, 2017) that this unit is in some cases difficult to differentiate from the overlying ground-raising/levelling deposits that incorporate material from this alluvial unit, and it seems likely that the 'natural' (untruncated) level of the alluvium probably lies at about 1m OD, The deposits of the alluvium are generally described as predominantly silty, clayey and occasionally sandy. Significantly, a peat unit is present in the alluvial sequence, generally at levels between *ca*. 0.2 and -0.35m OD, but not recorded in the interventions southeast of BH2 (MoLA Trench 2, QBH1 and BH3). In these latter boreholes the sequence appears to be truncated by the overlying anthropogenic deposits to levels lower than the peat (to *ca*. -1m OD).

In the previous report (Young, 2019), the relationship between the peat unit described above and the organic sediments recorded higher up in the sequence, and potentially forming part of the ground raising/levelling deposits) in QBH3 and BH1 was unclear. On the basis of its elevation (1.1-0.2m OD) it was considered likely to represent either a different, later phase of peat formation to that recorded between *ca*. 0.2 and -0.35m OD: potentially either contemporary with or forming part of the ground-raising/levelling deposits recorded at similar elevations in the adjacent boreholes, or simply redeposited organic material from the lower peat horizon.

On the basis of the new radiocarbon dates, the organic units recorded at the site are of a very similar Saxon date, all falling within the period 605-770 cal AD (see Table 8 and Figures 3 & 4). The two dates now obtained on the upper, potentially reworked organic units are 645-765 cal AD (1305-1185 cal BP) at 0.50 to 0.52m OD (QBH3) and 605-665 cal AD (1345-1285 cal BP) at 1.10m OD (BH1; ARCA, 2018). With regards to the potentially *in situ* organic/peat units, the lower organic unit in QBH2 at -0.12 to -0.17m OD is dated to 650-770 cal AD (1300-1180 cal BP), whilst the base of the peat unit in QBH2 (-0.05 to 0.00m OD) is dated to 615-765 cal AD (1335-1185 cal BP). The similarity of these dates, and the apparent age reversal between the lower organic unit and the uppermost (potentially reworked) organic unit in BH1, lends support to the notion that the upper organic units above ca. 0.2m OD are redeposited or reworked remnants of the naturally accumulated peat recorded between *ca*. 0.2 and -0.35m OD. In addition, the macrofossil remains recorded within both the lower, potentially *in situ* peat and the upper reworked peat are very similar, with anthropogenic waste such as bone, fragments of oyster shell and charcoal recorded in both sets of deposits. This indicates that if the peat between *ca*. 0.2 and -0.35m OD is naturally accumulated, it did so in a marshy or boggy location that must have been on the margins of an environment heavily modified by human activity.

Where the sediments of the alluvium are described as predominantly silty or clayey they are indicative of deposition within low energy fluvial and/or semi-aquatic conditions during the Holocene, in most cases at a distance from any active channels but with occasional higher-energy flood events. The high mineral content of the sediments may reflect increased sediment loads resulting from intensification of agricultural land use from the later prehistoric period onward, combined with the effects of rising sea level. Where peat/very organic units are recorded, these are indicative of a transition towards semi-terrestrial (marshy) conditions, supporting the growth of sedge fen/reed swamp and/or woodland communities.

The combined Holocene alluvial sequence across the site, incorporating the peat and alluvium, is between 0.3 (BH3) and 2.85m thick (BH2); these thicknesses are clearly influenced by the thickness of the overlying ground-raising/levelling deposits and probable truncation of the natural alluvial sequence. The alluvial sequence to the southeast in BH2 (MoLA Trench 2, QBH1 and BH3) is noticeably thinner, with a much lower level of truncation by the overlying ground-raising/levelling deposits (to *ca*. -1m OD).

4.4 Ground raising/levelling deposits (unknown date)

A series of ground-raising/levelling deposits, incorporating redeposited alluvium and various inclusions indicative of human activity of unknown date (e.g. bone, shell, worked wood and charcoal) is recorded in the majority of the boreholes overlying (and probably truncating) the natural alluvial sequence. It was not always possible to differentiate this unit from the underlying alluvium, since it incorporated material from this deposit (including peat), but on the basis of the new radiocarbon dates, the organic unit in BH1 appears to be a reworked remnant of the lower peat, and in fact forms part of the ground-raising/levelling deposits at this level across the site.

The surface of this unit is variable across the site, recorded at between 2.7 (BH2) and 1.35m OD (QBH4). In all boreholes this unit was predominantly composed of brick, bone, shell (in places including oyster), sand, gravel and charcoal, generally in a silty clay matrix, and most likely incorporating material from the underlying alluvium; in several places this unit is highly organic, potentially incorporating material from the underlying peat unit. Where no anthropogenic material was identified in this unit, it has been distinguished from the underlying alluvium by the 'reworked' appearance of the units, which are generally homogenous and poorly sorted in comparison to the underlying alluvium. In BH3 a large (>0.5m thick) horizontal timber was recorded at between 0.4 and 0.9m OD.

4.5 Made Ground

Modern Made Ground was encountered in all eight interventions, present in thicknesses of between 2.8 (BH1) and 1m (BH3). The Made Ground was between 2.3 (QBH1) and 1.68m (QBH3) thick in the new geoarchaeological boreholes. In BH3 a layer of chalk cobbles with lime mortar was recorded between 2.90 to 2.20m OD, perhaps associated with a wall or foundation of unknown date; this feature lies at a similar elevation to the wall foundation identified by MoLA (2015) in Trench 2.

Table 1: Lithostratigraphic description of geotechnical borehole BH1, 2-3 Robert Street, City of Westminster

Depth (m OD)	Depth (m bgs)	Description	Interpretation
3.90 to 1.30	0.00 to 2.60	Made Ground of concrete hardstanding on to brick and concrete rubble	MADE GROUND
1.30 to 1.10	2.60 to 2.80	Redeposited alluvium of grey silty clay with frequent brick fragments, mortar and concrete rubble.	
1.10 to 0.20	2.80 to 3.70	Sh2 Tl^{1}1 Th^{1}1; humo. 2; black moderately humified woody and herbaceous peat.	GROUND-RAISING/LEVELLING DEPOSITS
0.20 to -0.15	3.70 to 3.95	Ag2 As1 Sh1; dark greyish brown organic clayey silt.	ALLUVIUM
-0.15 to -2.80	3.95 to 6.70	Gg3 As1 Ga+; orange clayey gravel with a trace of sand. Clasts are flint, average diameter 40mm, well rounded.	SHEPPERTON GRAVEL
<-2.80	6.70+	As4 Ag+ Ga+; stiff grey clay with traces of silt and sand.	LONDON CLAY

Table 2: Lithostratigraphic description of geotechnical borehole BH2, 2-3 Robert Street, City of Westminster

Depth (m OD)	Depth (m bgs)	Description	Interpretation
3.90 to 3.20	0.00 to 0.70	Made Ground of concrete hardstanding on to brick and concrete rubble	MADE GROUND
3.20 to 3.10	0.70 to 0.90	Dark brown brick and charcoal in clayey matrix	
3.10 to 2.70	0.90 to 1.20	Concrete rubble	
2.70 to 2.20	1.20 to 1.70	Clayey silt with brick, bone, sand and gravel	GROUND-RAISING/LEVELLING DEPOSITS
2.20 to 2.00	1.70 to 1.90	Chalk rubble	
2.00 to 1.75	1.90 to 2.15	Sandstone	
1.75 to -0.10	2.15 to 4.00	Ag3 As1 Sh+ Dl+ Gg+; dark grey clayey silt with traces of organic matter, detrital wood and occasional gravel clasts. Occasional Mollusca fragments. Diffuse contact in to:	ALLUVIUM
-0.10 to -0.40	4.00 to 4.30	Ag2 Sh2 Dl+ Gg+; dark greyish brown very organic silt with traces of detrital wood and occasional gravel clasts. Diffuse contact in to:	
-0.40 to -1.10	4.30 to 5.00	Ag3 As1 Dh+; blueish grey clayey silt with traces of detrital herbaceous material.	
-1.10 to -1.60	5.00 to 5.50	Gg3 Ga1 Ag+; orangey grey sandy gravel with a trace of silt. Clasts are flint, up to 50mm in diameter, sub-angular to well-rounded.	SHEPPERTON GRAVEL

Table 3: Lithostratigraphic description of geotechnical borehole BH3, 2-3 Robert Street, City of Westminster

Depth (m OD)	Depth (m bgs)	Description	Interpretation
3.90 to 2.90	0.00 to 1.00	Made Ground (concrete hardstanding over concrete, brick and chalk rubble	MADE GROUND
2.90 to 2.20	1.00 to 1.70	Layer of chalk cobbles with large flint nodules and lime mortar (wall/foundation?). Fragments of charcoal observed in places.	WALL/FOUNDATION
2.20 to 1.90	1.70 to 2.00	Ag2 Dh2 As+; dark greyish blue silt and detrital herbaceous material with a trace of clay. Diffuse contact in to:	GROUND-RAISING/LEVELLING DEPOSITS

1.90 to 1.80	2.00 to 2.10	Ag2 As2 Ga+ Dl+; dark grey silt and clay with traces of sand and detrital wood. Diffuse contact in to:	
1.80 to 0.90	2.10 to 3.00	Ag3 As1 Ga+ Dl+; dark greenish grey clayey silt with traces of sand and detrital wood. Diffuse contact in to:	
0.90 to 0.40	3.00 to 3.50	Large horizontal ?worked timber	
0.40 to 0.10	3.50 to 3.80	Ag2 As2 Sh+; dark blueish grey silt and clay with occasional organic lenses. Several large bone fragments throughout this unit. Diffuse contact in to:	
0.10 to -0.10	3.80 to 4.00	Ag2 As2 Sh+ Dl+; dark blueish grey silt and clay with occasional organic lenses. Several large bone fragments and wood throughout this unit. Diffuse contact in to:	
-0.10 to -0.80	4.00 to 4.70	Ag2 Ga1 As1 Gg+; dark grey sandy clayey silt with occasional gravel clasts and frequent bone fragments. Diffuse contact in to:	
-0.80 to -0.90	4.70 to 4.80	As3 Ag1; grey silty clay. Diffuse contact in to:	ALLUVIUM
-0.90 to -1.10	4.80 to 5.00	Ag2 Ga1 As1 Gg+; dark grey sandy clayey silt with occasional gravel clasts. Diffuse contact in to:	
-1.10 to -2.10	5.00 to 6.00	Gg2 Ga1 Ag1; dark grey sandy silty gravel. Clasts are flint, up to 40mm in diameter, well-rounded to sub-angular.	SHEPPERTON GRAVEL

Table 4: Lithostratigraphic description of geoarchaeological borehole QBH1, 2-3 Robert Street, City of Westminster

Depth (m OD)	Depth (m bgs)	Description	Interpretation
3.50 to 1.70	0.00 to 1.80	Made Ground of brick, concrete and stone rubble in a matrix of brown sandy clay with oyster shell.	MADE GROUND
1.70 to 1.20	1.80 to 2.30	Flint sand and gravel – assumed part of Made Ground.	
1.20 to 0.80	2.30 to 2.70	Gley1 4/N; As2 Ag2 Dh+; dark grey silt and clay with a trace of detrital herbaceous material. Diffuse contact in to:	GROUND-RAISING/LEVELLING DEPOSITS
0.80 to 0.50	2.70 to 3.00	7.5YR 3/1; Ag2 As2; very dark grey silt and clay with Mollusca fragments and small (<10mm) peaty lenses. Diffuse contact in to:	
0.50 to 0.02	3.00 to 3.48	7.5YR 3/1; Ag2 As2; very dark grey silt and clay. Diffuse contact in to:	
0.02 to -0.15	3.48 to 3.65	7.5YR 3/1; Ag2 Ga2 As+ Sh+ Dl+; very dark grey silt and sand with traces of clay, organic matter, detrital wood and Mollusca fragments. Diffuse contact in to:	
-0.15 to -0.50	3.65 to 4.00	7.5YR 3/1; Ga1 Gg1 Sh1 Ag1; very dark grey horizontally bedded variously organic, sandy, gravelly silt, Includes oyster shell. Diffuse contact in to:	
-0.50 to -0.86	4.00 to 4.36	7.5YR 3/1; Ga2 Gg2; very dark grey sand and gravel. Clasts are flint, sub-angular to well-rounded, average diameter 10mm. Sharp contact in to:	
-0.86 to -0.98	4.36 to 4.48	7.5YR 3/1; Ag2 Ga1 Gg1 Dl+; very dark grey sandy gravelly clay with oyster shell. Sharp contact in to:	

-0.98 to -1.13	4.48 to 4.63	7.5YR 3/1; Ga3 Ag1 Gg+ Dl+; very dark grey silty sand with occasional gravel clasts and traces of detrital wood. Sharp contact in to:	ALLUVIUM
-1.13 to -1.34	4.63 to 4.84	7.5YR 3/1; Ag2 As2 Sh+; very dark grey silt and clay with a trace of organic matter. Diffuse contact in to:	
-1.34 to -1.50	4.84 to 5.00	Gley1 3/N; Ag2 As2 Gg+; very dark grey silt and clay with occasional gravel clasts, becoming more frequent towards base.	

Table 5: Lithostratigraphic description of geoarchaeological borehole QBH2, 2-3 Robert Street, City of Westminster

Depth (m OD)	Depth (m bgs)	Description	Interpretation
3.50 to 1.70	0.00 to 1.80	Made Ground of brick, concrete and stone rubble in a matrix of brown sandy clay with oyster shell.	MADE GROUND
1.70 to 1.50	1.80 to 2.00	7.5YR 2.5/1; Gg1 Ag1 As1 Sh1 Ga+; black organic, clayey silty gravel. Diffuse contact in to:	GROUND-RAISING/LEVELLING DEPOSITS
1.50 to 0.50	2.00 to 3.00	7.5YR 2.5/1; As2 Ag1 Gg1 Sh+; black gravelly silty clay with a trace of organic matter. Includes oyster shell. Diffuse contact in to:	
0.50 to 0.20	3.00 to 3.30	Gley1 4/10Y; As3 Ag1; dark greenish grey silty clay. Sharp contact in to:	ALLUVIUM
0.20 to -0.05	3.30 to 3.55	7.5YR 2.5/1; Sh2 Tl^{2}1 Ag1 Ga+; humo. 2/3; black moderately to well humified woody silty peat with traces of sand. Sharp contact in to:	(PEAT)
-0.05 to -0.13	3.55 to 3.63	Gley1 4/10Y; As3 Ag1; dark greenish grey silty clay. Sharp contact in to:	
-0.13 to -0.16	3.63 to 3.66	7.5YR 2.5/1; Sh2 Tl^{2}1 Ag1 Ga+; humo. 2/3; black moderately to well humified woody silty peat with traces of sand. Sharp contact in to:	(PEAT)
-0.16 to -0.31	3.66 to 3.81	Gley1 4/10Y; As3 Ag1; dark greenish grey silty clay. Diffuse contact in to:	
-0.31 to -0.50	3.81 to 4.00	7.5YR 3/2; Ag1 As1 Dl1 Sh1; dark brown organic clay and silt with detrital wood.	
-0.50 to -0.83	4.00 to 4.33	NO RECOVERY	
-0.83 to -0.85	4.33 to 4.35	7.5YR 3/2; Ag1 As1 Dl1 Sh1; dark brown organic clay and silt with detrital wood. Very sharp contact in to:	
-0.85 to -1.05	4.35 to 4.55	Gley1 4/10Y; Ga2 Ag1 Gg1; dark greenish grey gravelly silty sand. Diffuse contact in to:	
-1.05 to -1.27	4.55 to 4.77	Gley1 4/10Y; Ag3 Ga1; dark greenish grey sandy silt. Diffuse contact in to:	
-1.27 to -1.34	4.77 to 4.84	Gley1 3/10Y; Ga3 Ag1; dark greenish grey silty sand. Sharp contact in to:	
-1.34 to -1.50	4.84 to 5.00	Gg3 Ga1; sandy gravel. Clasts are flint, 20mm in diameter, sub-angular to well-rounded.	SHEPPERTON GRAVEL

Table 6: Lithostratigraphic description of geoarchaeological borehole QBH3, 2-3 Robert Street, City of Westminster

Depth (m OD)	Depth (m bgs)	Description	Interpretation
3.50 to 2.50	0.00 to 1.00	Made Ground of brick, concrete and stone rubble in a matrix of brown sandy clay with oyster shell.	MADE GROUND
2.50 to 2.00	1.00 to 1.50	Brick	
2.00 to 1.82	1.50 to 1.68	Chalk	
1.82 to 1.50	1.68 to 2.00	7.5YR 2.5/1; Gg1 Ag1 As1 Sh1 Ga+; black organic, clayey silty gravel. Diffuse contact in to:	GROUND-RAISING/LEVELLING DEPOSITS
1.50 to 1.18	2.00 to 2.32	NO RECOVERY	
1.18 to 0.58	2.32 to 2.92	7.5YR 3/1; As2 Ga1 Ag1; very dark grey silty sandy clay with oyster shell, brick, gravel and charcoal. Sharp contact in to:	
0.58 to 0.50	2.92 to 3.00	7.5YR 2.5/1; $Tl^1$3 Sh1; humo. 3; wood in a matrix of black well humified peat.	
0.50 to 0.20	3.00 to 3.30	NO RECOVERY	
0.20 to -0.03	3.30 to 3.53	7.5YR 3/1; Sh1 Ga1 Ag1 Gg1 Dl+; very dark grey organic sand, silt and gravel with a trace of detrital wood. Diffuse contact in to:	ALLUVIUM
-0.03 to -0.12	3.53 to 3.62	7.5YR 4/2; Dl2 Ag1 Sh1; detrital wood in a matrix of brown organic silt. Sharp contact in to:	
-0.12 to -0.20	3.62 to 3.70	2.5Y 2.5/1; Ga2 Gg1 Dl1; black gravelly sand with detrital wood. Sharp contact in to:	
-0.20 to -0.35	3.70 to 3.85	7.5YR 4/2; Dh2 Sh1 Ag1 Dl+; brown organic silt with frequent detrital herbaceous material and traces of detrital wood.	
-0.35 to -0.43	3.85 to 3.93	Large wood macrofossil (greater than width of sample).	
-0.43 to -0.50	3.93 to 4.00	2.5Y 2.5/1; Ga2 Gg1 Ag1; black silty gravelly sand.	
-0.50 to -0.75	4.00 to 4.25	NO RECOVERY	
-0.75 to -0.90	4.25 to 4.40	7.5YR 3/1; Gg2 Ga2; very dark grey sand and gravel. Clasts are flint, sub-angular to well-rounded, average diameter 15mm. Sharp contact in to:	
-0.90 to -1.25	4.40 to 4.75	Gley2 4/10G; Ag3 Ga1 Gg+; dark greenish grey sandy silt with occasional gravel clasts. Sharp contact in to:	
-1.25 to -1.30	4.75 to 4.80	7.5YR 3/1; Ga4 Ag+; very dark grey sand with a trace of silt. Sharp contact in to:	
-1.30 to -1.44	4.80 to 4.94	Gley2 4/10G; Ag3 Ga1 Gg+; dark greenish grey sandy silt with occasional gravel clasts. Sharp contact in to:	
-1.44 to -1.50	4.94 to 5.00	7.5YR 3/1; Ga4 Ag+ Gg+; dark brown sand with a trace of silt and occasional gravel clasts.	
-1.50 to -1.60	5.00 to 5.10	Gg3 Ga1; sandy gravel. Clasts are flint, 20mm in diameter, sub-angular to well-rounded.	SHEPPERTON GRAVEL

Table 7: Lithostratigraphic description of borehole geoarchaeological QBH4, 2-3 Robert Street, City of Westminster

Depth (m OD)	Depth (m bgs)	Description	Interpretation
3.50 to 1.50	0.00 to 2.00	Made Ground of brick, concrete and stone rubble in a matrix of brown sandy clay with oyster shell.	MADE GROUND
1.50 to 1.35	2.00 to 2.15	Brick	
1.35 to 1.18	2.15 to 2.32	7.5YR 3/1; Ga2 Gg1 As1; very dark grey clayey gravelly sand with frequent brick fragments and some Mollusca fragments probably oyster shell). Sharp contact in to:	GROUND-RAISING/LEVELLING DEPOSITS
1.18 to 1.04	2.32 to 2.46	10YR 7/2; Ag2 As2; light grey calcareous silt and clay. Sharp contact in to:	
1.04 to 0.50	2.46 to 3.00	7.5YR 2.5/1; Sh1 Ga1 Ag1 As1 Gg+ Dl+; black organic sand, silt and clay with occasional gravel clasts and traces of detrital wood.	
0.50 to 0.23	3.00 to 3.27	NO RECOVERY	
0.23 to 0.18	3.27 to 3.32	7.5YR 2.5/1; Sh1 Ga1 Ag1 As1 Gg+ Dl+; black organic sand, silt and clay with occasional gravel clasts and traces of detrital wood. Sharp contact in to:	
0.18 to 0.11	3.32 to 3.39	7.5YR 4/1; Ag4 As+; dark grey silt with a trace of clay and Mollusca fragments. Very diffuse contact in to:	ALLUVIUM
0.11 to -0.16	3.39 to 3.66	7.5YR 2.5/1; Sh2 Ag1 Dl1; black very organic silt with detrital wood. Sharp contact in to:	
-0.16 to -0.34	3.66 to 3.84	Gley1 3/10G; Ag2 Ga2 Gg+; very dark greenish grey silt and sand with occasional gravel clasts. Very sharp contact in to:	
-0.34 to -0.36	3.84 to 3.86	7.5YR 4/2; Ga4 Ag+; brown sand with a trace of silt. Very sharp contact in to:	
-0.36 to -0.50	3.86 to 4.00	7.5YR 4/2; Ag3 Ga1 Dl+; brown sandy silt with a trace of detrital wood. Diffuse contact in to:	
-0.50 to -1.40	4.00 to 4.90	NO RECOVERY	
-1.40 to -1.42	4.90 to 4.92	7.5YR 4/2; Gg2 Ga1 As1; brown sandy clayey gravel. Clasts are flint, 20mm in diameter, sub-angular to rounded. Sharp contact in to:	SHEPPERTON GRAVEL
-1.42 to -1.50	4.92 to 5.00	7.5YR 4/3; As4 Ag+; brown moderately stiff clay with a trace of silt.	LONDON CLAY

Table 8: Results of the radiocarbon dating of boreholes QBH2 and QBH3, 2-3 Robert Street, City of Westminster and the existing date from BH1 (ARCA, 2018).

Laboratory code/ Method	Borehole number	Material and location	Depth (m OD)	Uncalibrated radiocarbon years before present (yr BP)	Calibrated age BC/AD (BP) (2-sigma, 95.4% probability)	δ13C (‰)
BETA-551297	QBH2	Unidentified twig wood (2-3 growth rings); top of peat	0.20 to 0.14	1230 ± 30	680-890 cal AD (1270-1060 cal BP)	-27.3
BETA-531202	QBH2	Unidentified twig wood (2-3 growth rings); base of peat	0.00 to -0.05	1360 ± 30	615-765 cal AD (1335-1185 cal BP)	-28.0
BETA-531203	QBH2	Unidentified twig wood (2-3 growth rings); lower organic unit	-0.12 to -0.17	1320 ± 30	650-770 cal AD (1300-1180 cal BP)	-29.3
BETA-531201	QBH3	*Corylus avellana* nut shell from base of reworked peat	0.50 to 0.52	1340 ± 30	645-765 cal AD (1305-1185 cal BP)	-26.6
SUERC-77375 (GU46940))	BH1	Peat – humic acid from top of reworked peat	1.10	1399 ± 24	605-665 cal AD (1345-1285 cal BP)	-28.8

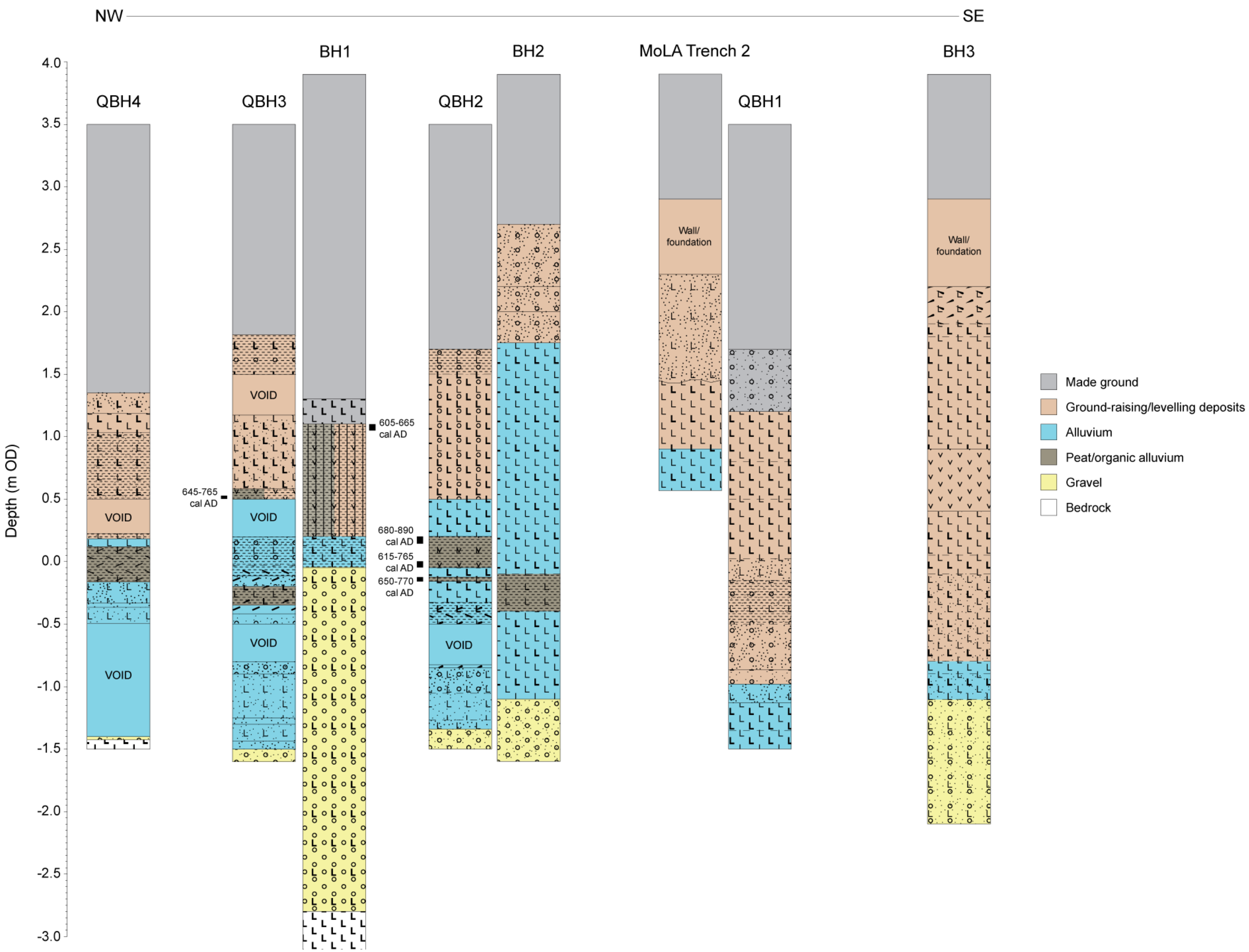

Figure 3: Northwest-Southeast transect of boreholes across the 2-3 Robert Street, City of Westminster incorporating data from MoLA (2015) and showing the results of the radiocarbon dating undertaken by ARCA (2018) and in the present investigation.

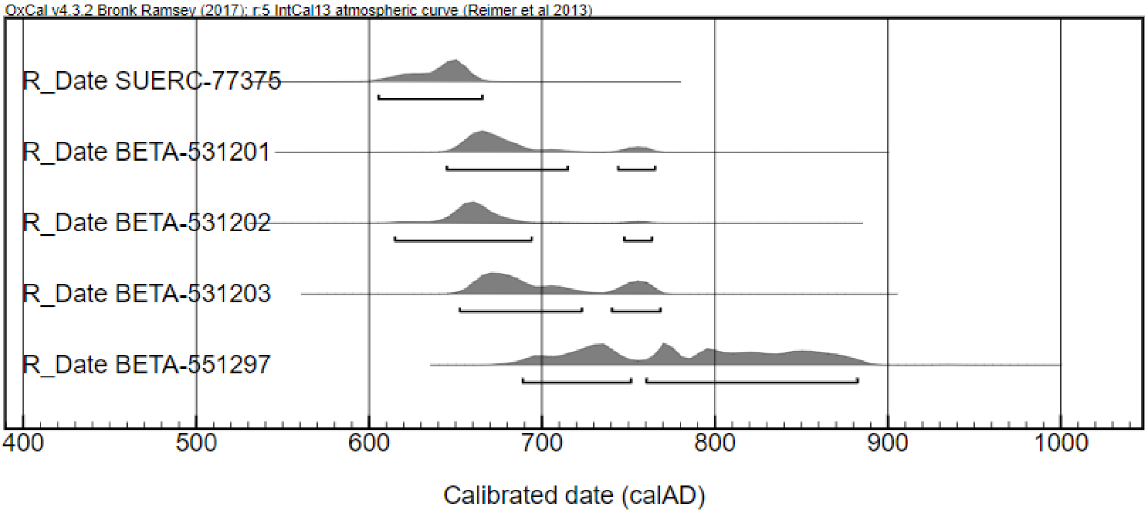

Figure 4: Radiocarbon dates (in stratigraphic order; see Table 8) from the organic horizons at 2-3 Robert Street, City of Westminster.

5. RESULTS & INTERPRETATION OF THE POLLEN ASSESSMENT

5.1 Results of the pollen analysis

Pollen analysis was carried out on the peat and alluvium immediately above / below it, from boreholes QBH2 and QBH3. The pollen assemblage is consistent within both sequences, and thus has not been divided into local pollen assemblage zones.

Borehole QBH2 *ca.* 650-770 to 680-890 cal AD

The samples from this sequence are characterised by high values of herbaceous pollen (60%): Poaceae (grasses) dominate (25%) with Cyperaceae (sedges; 10%), Chenopodium type (goosefoot family), Lactuceae (dandelions) (both 5-10%), *Cereale* type (cereals), Asteraceae (daisies), Urticaceae (nettles), Apiaceae (carrot family), *Plantago* type / *lanceolata* (plantain / ribwort plantain), *Filipendula* type (meadowsweet), *Sinapis* type (brassica family), *Trifolium* / *Vicia* type (buttercup / vetch), *Centaurea nigra* (black knapweed) (all <3%), and sporadic occurrences including *Triticum* / *Avena* (wheat / oat), *Cirsium* type (thistle), *Artemisia* (mugwort), Caryophyllaceae (pinks), *Rumex acetosa* / *acetosella* (sorrel), *Ranunuculus* type (e.g. buttercup), *Galium* type (bedstraw), *Polygonum* type (knotweed) and *Centaurea cyanus* (cornflower) (all <1%).

Trees (30%) and shrubs (15%) included Corylus type (hazel; 15%), *Alnus* (alder), *Quercus* (oak) (both <10%), *Pinus* (pine), *Tilia* (lime), *Ulmus* (elm), *Betula* (birch), *Salix* (willow) and *Calluna vulgaris* (heather) (all <5%) and sporadic occurrences including *Picea* (spruce), *Fagus* (beech), *Hedera* (ivy), *Ilex* (holly), *Lonicera periclymenum* (honeysuckle) and *Erica* (heath). Aquatics were absent with the exception of a few grains of *Sparganium* type (bur-reed). Spores (<3%) included *Filicales* (ferns), *Polypodium vulgare* (polypody) and *Pteridium* (bracken). Unidentified grains represented a very low proportion of the pollen sum. A variety of non-pollen palynomorphs were recorded including *Tilletia*, *Entophlyctus lobata*, *Glomus*, *Sporormiella* type, *Sordaria* type, *Podospora* type, *Cercophera* type, algal spores, chironomids and *Trichuris* (whipworm) eggs.

Total pollen concentration was generally around 20-30,000 grain/cm^3, with a peak of 84,000 grains/cm^3 at 1.18m OD. Microcharcoal concentration varied between 7500 and 25,000 fragments/cm^3.

Borehole QBH3 From *ca.* 645-765 cal AD

The samples from this sequence are characterised by high values of herbaceous pollen (>80%): Poaceae dominate (30-40%) with Cyperaceae (10%), Lactuceae, *Plantago* type / *lanceolata, Filipendula* type (all >5%), *Cereale* type, Asteraceae, *Achilea* type (yarrow), *Chenopodium* type, *Centaurea nigra* (all <3%) and sporadic occurrences including *Mentha* type, Apiaceae *Trifolium* / *Vicia* type, *Centaurea cyanus*, Caryophyllaceae, *Rumex acetosa* / *acetosella*, *Ranunuculus* type, *Galium* type, *Polygonum* type and Campanulaceae (campanula) (all <1%).

Trees (<10%) and shrubs (15%) included *Corylus* type, *Alnus*, *Quercus* and *Calluna* vulgaris. Aquatics were absent. Unidentified grains represented a very low proportion of the pollen sum. A limited range of non-pollen palynomorphs were recorded including *Sporormiella* type, *Sordaria* type, *Podospora* type, and *Trichuris* eggs.

Total pollen concentration was generally around 20,000 grain/cm^3. Microcharcoal concentration varied between 30,000 fragments/cm^3.

5.2 Interpretation of the pollen analysis

The peat sediments were focussed on for analysis as they are the most likely parts of the sedimentary sequence to represent semi-terrestrial or terrestrial environments on the wetland. Whilst this did not permit investigation of the pollen through the complete sedimentary sequence, it does avoid a number of taphonomic issues that complicate the interpretation of palynological data from the mineral-rich sediments of low-energy fluvial and estuarine environments, including: (1) the long distance travel of pollen by fluvial or aeolian means (e.g. Moore *et al*., 1991; Scaife & Burrin, 1992), and (2) the reworking and redeposition of pollen from older sediments (e.g. Cushing, 1967; Waller, 1993; Campbell, 1999). Concentration of the pollen assessment on the semi-terrestrial deposits reduces the impact of these particular taphonomic issues. However, another issue specific to pollen studies in coastal lowland wetlands is that of taxonomic precision and distinguishing the environment of origin. The identification of pollen grains (in particular herb taxa) is frequently limited by morphological similarities between grains of different species, and often only the genus can be established. In addition, the herbs found in one wetland habitat are often palynologically indistinguishable from other members of their genera/family that may have originated from different wetland or dryland environments (Waller, 1993, 1998; Waller *et al*., 2005). These issues are taken into account in the following interpretation.

The similarity of the pollen assemblage in the sequences from QBH2 and QBH3, suggests that the vegetation near 2-3 Robert Street, and nature of the human activities remained relatively consistent from 650-770 to 680-890 cal AD.

The limited percentage values of tree and shrub pollen indicate and open environment, with woodland either very limited nearby to the site, or more likely growing at distance. Stands of (possibly managed) dryland woodland, scrub and/or hedgerow are indicated by oak, birch, hazel, lime, beech and pine. There are also a few grains of *Picea* (spruce) grains, which wasn't introduced to Britain until the 1500s. There were two whole grains and one broken one, which seems unlikely to have derived from the continent or Scandinavia. So, their occurrence either provides a chronological marker for the alluvium, or (less likely) they've been introduced somehow.

Alder and willow may have grown in niches along the margins of the river nearby to the site, or on marshy/boggy regions of the floodplain. Damp ground is also indicated by the presence of sedges and grasses (possibly reeds – *Phragmites australis*) and bur-reed in particular, together with buttercup, mint, and marsh valerian. Furthermore, areas of open water (either still or moving) are suggested by the presence of *Pediastrum,* dinoflagellate cysts and other algal spores/plankton, as well as chironomid (midge) mouth parts. A brackish water influence is also potentially indicated by the presence of *Chenopodium* type (goosefoot family). Plants of the Chenopodiaceae family may be split into two broad groups, those associated with brackish and marine environments such as *Salsola kali* (glasswort), and those commonly found in waste places and the edges of arable fields on dryland, such as *Chenopodium album* (fat hen). Thus, the pollen values of Chenopodium type recorded may indicate the growth of saltmarsh plants (and therefore a brackish water influence) or more open, disturbed conditions on dryland.

A range of other herbaceous plants are recorded potentially representing their growth in a number of open habitats in addition to wetlands, including, meadow, pasture, disturbed/waste ground, cereals and their associated weeds. Grasses (frequently the most dominant herbaceous taxa), with ribwort plantain, sorrel, daises, dandelions species may have grown in a pastoral community either nearby to the site, or possibly even derived from hay being brought to the site for animal husbandry purposes. Heather may also have formed a bedding material; its presence in the samples being confirmed by the occurrence of *Entophlyctis lobata*, a fungus which grows on Ericaceous species including *Calluna vulgaris* (van Geel 1978).

Cereal pollen grains are present in nearly every sample. In most cases these are undifferentiated, but in a few, they are more confidently identified as oat or wheat. Associated disturbed ground and weed taxa such as knapweed, cornflower, fat hen and brassica are also recorded, Other cultivated species include a few grains of Cannabaceae pollen (hemp / cannabis). The presence of these taxa suggest either nearby crop-growth, or that material was being brought to site for processing, consumption or dumping. It is however important to highlight that it is not possible to separate cereals from wild grasses with complete confidence (e.g. Andersen, 1979), and that previous studies have indicated the association of these grains with other wetland herbaceous and aquatic taxa (such as Poaceae, Cyperaceae, Sparganium) means that they could (at least in part) represent wild grasses found in wetland habitats (e.g. Glyceria sp.) (Waller & Grant, 2012; Perez et al., 2015). As such, whilst the presence of cereals on this site seems highly likely, it cannot be determined with absolute certainty.

Finally, a variety of dung fungal spores were recorded including *Sporormiella* type, *Sordaria* type and *Podospora* type together with regular occurrences of ova from the parasitic whipworm. It was not possible to ascertain whether the species of whipworm present infected humans or pigs. However, the combined presence of the spores and ova, together with consistently high values of microcharcoal may have become incorporated into the sediment through the dumping of faeces and other waste, in an otherwise naturally accumulating deposit.

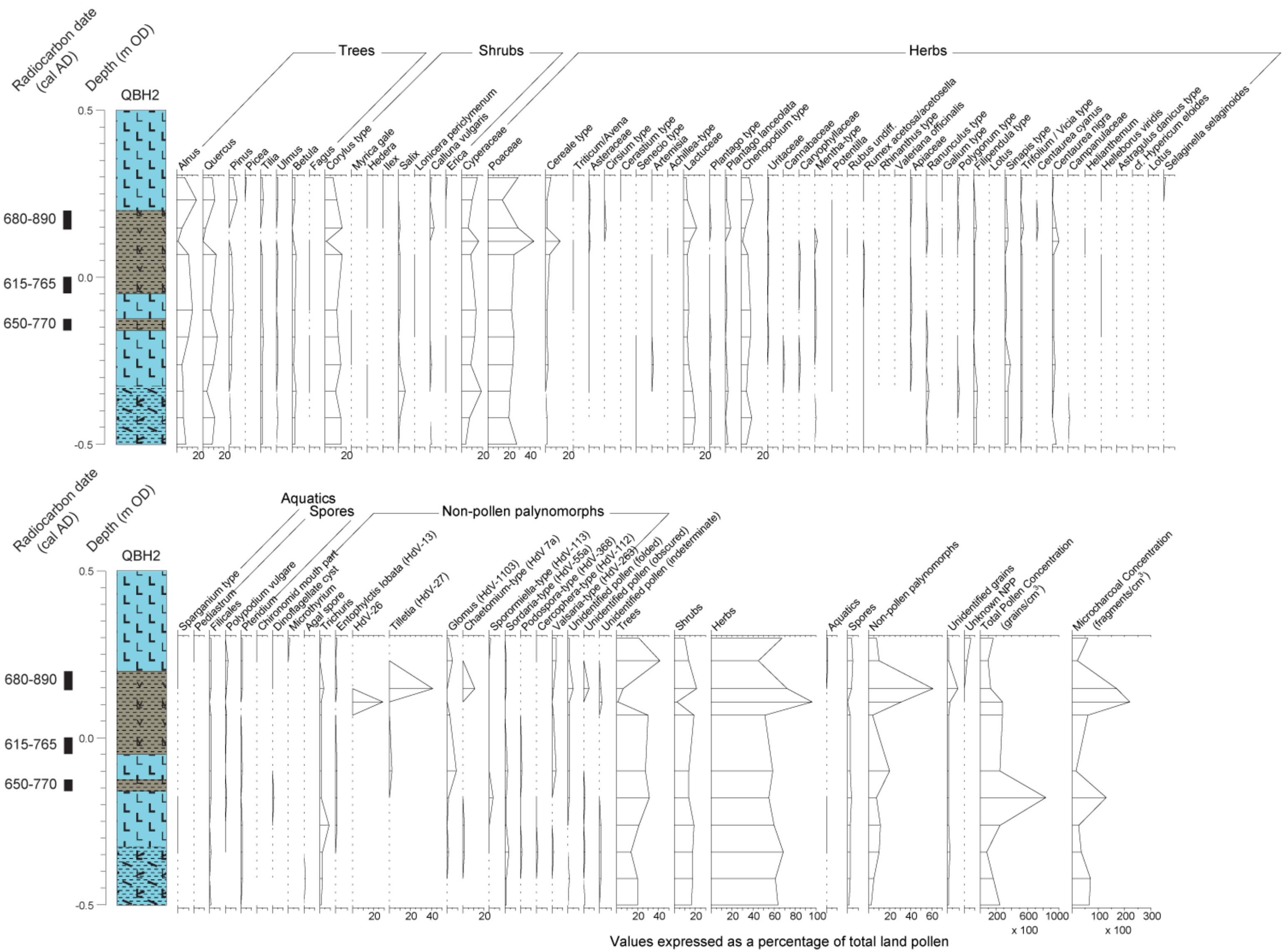
Radiocarbon date (cal AD)
Depth (m OD)
QBH2
Trees
Shrubs
Herbs
Alnus
Quercus
Pinus
Picea
Tilia
Ulmus
Betula
Fagus
Corylus type
Myrica gale
Hedera
Ilex
Salix
Lonicera periclymenum
Calluna vulgaris
Erica
Cyperaceae
Poaceae
Cereale type
Triticum/Avena
Asteraceae
Cirsium type
Cerastium type
Senecio type
Artemisia
Achillea-type
Lactuceae
Plantago type
Plantago lanceolata
Chenopodium type
Urticaceae
Cannabaceae
Caryophyllaceae
Mentha-type
Potentilla
Rubus undiff.
Rumex acetosa/acetosella
Rhinanthus type
Valeriana officinalis
Apiaceae
Ranunculus type
Galium type
Polygonum type
Filipendula type
Lotus
Sinapis type
Trifolium / Vicia type
Centaurea cyanus
Centaurea nigra
Campanulaceae
Helianthemum
Helleborus viridis
Astragulus danicus type
cf. Hypericum eloides
Lotus
Selaginella selaginoides
680-890
615-765
650-770
0.5
0.0
-0.5
Aquatics
Spores
Non-pollen palynomorphs
Sparganium type
Pediastrum
Filicales
Polypodium vulgare
Pteridium
Chironomid mouth part
Dinoflagellate cyst
Microthyrium
Agal spore
Trichuris
Entophylctis lobata (HdV-13)
HdV-26
Tilletia (HdV-27)
Glomus (HdV-1103)
Chaetomium-type (HdV 7a)
Sporormiella-type (HdV-113)
Sordaria-type (HdV-55a)
Podospora-type (HdV-368)
Cercophera-type (HdV-112)
Valsaria-type (HdV-263)
Unidentified pollen (folded)
Unidentified pollen (obscured)
Unidentified pollen (indeterminate)
Trees
Shrubs
Herbs
Aquatics
Spores
Non-pollen palynomorphs
Unidentified grains
Unknown NPP
Total Pollen Concentration (grains/cm³)
Microcharcoal Concentration (fragments/cm³)
x 100
x 100
Values expressed as a percentage of total land pollen

Figure 2: Borehole QBH2 pollen percentage diagram, Robert Street

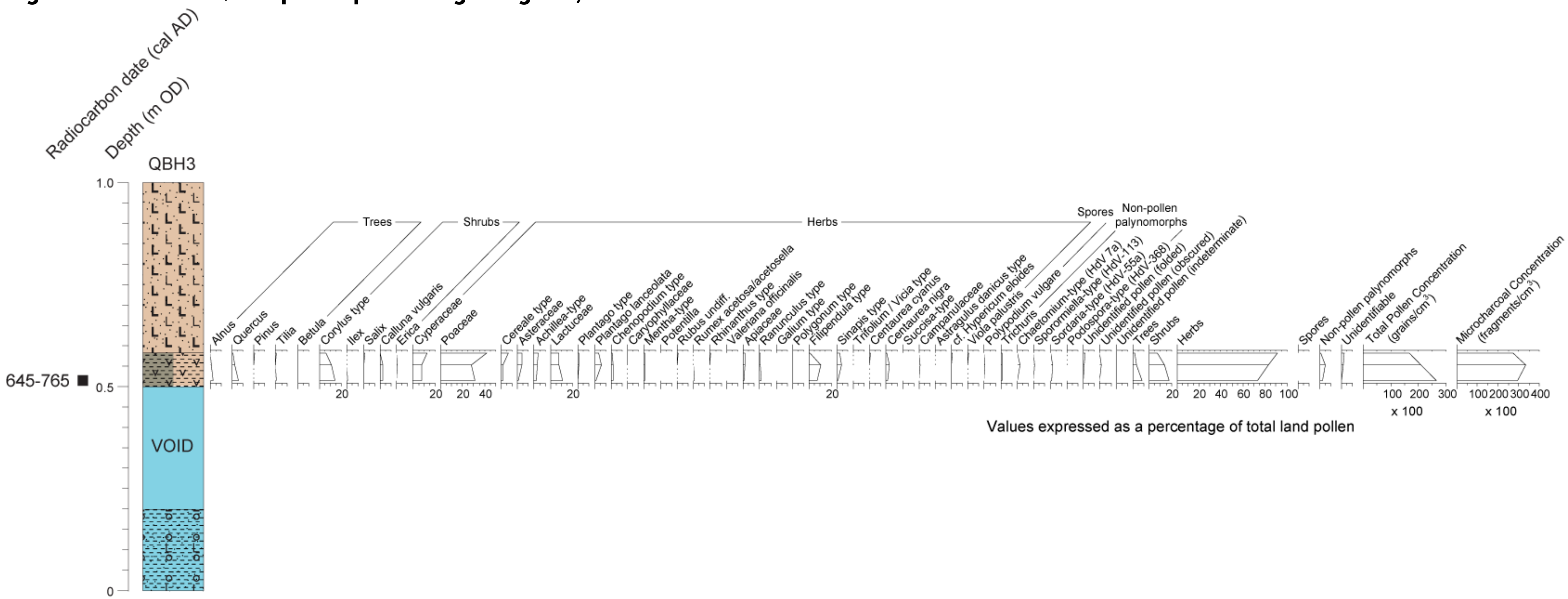

Figure 3: Borehole QBH2 pollen percentage diagram, Robert Street

6. RESULTS & INTERPRETATION OF THE DIATOM ASSESSMENT

6.1 Results of the diatom analysis

Diatom analysis was focussed on eight samples extracted from QBH2. A summary of the diatom results are provided in Table 9. In the majority of cases, taxa were identifiable to species level, but in some instances, identifications were only possible to genera level (primarily when broken fragments of larger frustules were encountered).

The results of the diatom assemblages have been displayed in a number of ways for ease of analysis and subsequent interpretation. Table 9 displays the diatom species present within each sample. The diatoms encountered are presented according to their broad salinity and life form classifications (please refer to the colour coding and ecological abbreviations). For example, 'marine planktonic' species are those that are encountered in open marine waters with salinities typically greater than 20-30‰ and are found floating in the water column. In contrast 'brackish benthic' species are those encountered in waters more typically associated with shallow estuarine settings with salinities closer to 1-9‰. In addition, their benthic status indicates that these species live attached to or within the sediment substrate under investigation. Benthic taxa can be further divided, based on substrate preference as follows: (1) Epiphytic taxa are often found attached to organic material (plants and decomposing organic debris); (2) Epipelic taxa attach themselves for muddy deposits; (3) Epipsammic taxa are associated with sandy substrates, and (4) Aerophilous taxa require a period of both aquatic submergence and emergence, and in the case of coastal sequences are strongly associated with the intertidal zone.

These additional benthic subdivisions will be referred to, where relevant, within Table 9 and section 6.2. In addition, the importance of differentiating between planktonic and benthic species will be outlined in greater detail at a later stage, but in essence benthic taxa are seen as providing a more reliable indicator of the more detailed environmental conditions that prevailed in the past. This is due to the fact they are likely to have lived *in-situ* within the sediment under analysis. This is in contrast to the planktonic taxa which live suspended in the water column and hence have *the potential* to be carried into a depositional environment after death.

Table 9 also provides greater focus on the salinity requirements of the diatom taxa encountered, dividing the species into the following categories: Polyhalobous (>30‰; fully marine), Mesohalobous (0.2-30‰; brackish water), Oligohalobous (<0.2‰; salt tolerant) and Halophobous (0‰; exclusively freshwater). The Oligohalobous category can be further subdivided into Oligohalobous halophilous (salt-tolerant freshwater) and Oligohalobous indifferent (tolerant of slightly saline water). Such an approach enables the overall salinity of the depositional environment to be taken into account, incorporating both planktonic and benthic taxa together. In the case of the samples under investigation, no halophobous taxa were encountered.

Table 9: Diatom flora encountered during analysis of samples from QBH2, Robert Street

	Species	lifeform	Salinity	Sample Depth (m O.D)							
				QBH2							
				+0.24	+0.21	-0.05	-0.09	-0.12	-0.16	-0.24	-0.32
	Actinoptychus senarius	M Plank	A	8	10	8	7	5	8		5
	Actinoptychus splendens	M Plank	A			4					
	Auliscus sculptus	M Plank	A	4	3						
	Cerataulis smithii	M Plank	A					4	7		1
	Paralia sulcata	M Plank	A	15	19	10	30	12	23		1
	Pseudomelorira westii	M Plank	A	7	4		6	2	3		4
	Pseudopodosira stelligera	M Plank	A	3	2	2		2			
Planktonic	*Thalassiosira sp.*	M Plank	A	9	10	4	10	8	6	5	
	Triceratum favus	M Plank	A	3		1					
	Odontella aurita	M Tych	A		3				1		1
	Delphineis surirella	M Tych	A	3	1		6	5			
	Rhaphoneis amphiceros	M Tych	A	18	4	6	7	3	5		1
	Cyclotella striata	B Plank	C	211	245	261	231	228	209	214	122
	Stephanidiscus sp.	F Plank	E		1	1			1		
	Melosira varians	F Plank	E							7	6
	Diploneis weisflogii	M Epipel	A	5		4				2	
	Trachyneis aspera	M Epipel	A		4		2				
	Diploneis ovalis	MB Aero	B	1	2	1	9	2	8		1
	Diploneis interrupta	MB Aero	B	3		2	6	4		1	
	Caloneis formosa	MB Epipel	B	1						1	
	Campylodiscus echeneis	MB Epipel	B								
	Diploneis didyma	MB Epipel	B		2	4				4	
	Caloneis formosa	MB Epipel	B	2				1			
	Navicula peregrina	MB Epipel	B				4			1	
	Nitzschia navicularis	MB Epipel	B	12	16	1	23	15	5	8	2
	Nitzschia punctata	MB Epipel	B	1	1		2				
	Nitzschia sigma	MB Epipel	B		4	1			2	7	2
	Scoliopleura tumida	MB Epipel	B					3		1	1
	Surirella ovalis	MB Epipel	B		2	1	28	23	3	56	57
	*Surirella ovata**	MB Epipel	B	15	14	8		8		31	121
	Tryblionella littoralis	MB Epipel	B		5		2		6	6	
	Achnanthes brevipes	MB Epiphyt	B								
	Cocconeis scutellum	MB Epiphyt	B		4						
	Rhophalodia gibba	MB Epiphyt	B			2			1		
	Rhophalodia gibberula	MB Epiphyt	B	4							
	Dimmerogramma minor	MB Epipsam	B			2	3				
	Gyrosigma acuminatum	B epipel	C	6	2		4	4	12	8	4
	Hantzschia amphioxys	BF Aero	D	5		7	15	3	4	2	
Benthic	*Pinnularia viridis*	BF Aero	D			7	1		9	1	1
	Navicula pusilla	BF Aero	D			1	3	3	6		3
	Stauroneis phoenicenteron	BF Epipel	D								
	Cocconeis placentula	BF Epiphyt	D	14	23	18	8	43	34	43	28
	Synedra capitata	BF Epiphyt	D		2	2				2	20
	Amphora ovalis	F Epipel	D	8	10	6	2	12	8	1	1
	Cymatopleura elliptica	F Epipel	D	6	6	1			2		3
	Cymatopleura solea	F Epipel	D			4		4			1
	Encyonema leibleinii	F Epipel	D							2	
	Navisula bacillum	F Epipel	D								2
	Placoneis gastrum	F Epipel	D						14		
	Pseudostaurosira brevistriata	F Epipel	D	14	8	4			3		
	Staurosira construens	F Epipel	D		4						2
	Achnanthes lanceolata	F Epiphyt	D								
	Cymbella aspera	F Epiphyt	D					1		1	6
	Diatoma vulgare	F Epiphyt	D							7	3
	Eunotia monodon v. bidens	F Epiphyt	D								2
	Epithemia sorex	F Epiphyt	D							8	
	Epithemia zebra	F Epiphyt	D			8				2	2
	Gomphonema acuminatum	F Epiphyt	D	7							
	Gomphonema constrictum	F Epiphyt	D								
	Gomphonema gracile	F Epiphyt	D								
	Synedra ulna	F Epiphyt	D	9						4	
	Pinnularia sp.	unknown	D								

Key: M Plank = marine planktonic; M Tych = marine tychoplanktonic, B Plank = brackish planktonic; F Plank = fresh planktonic; M Epipel = marine epipelon, MB Aero = marine-brackish aerophilous; MB Epipel = marine-brackish epipelon; MB Epiphyt = marine-brackish epiphytic; MB Epipsam = marine-brackish epipsammic; B epipel = brackish epipelon, BF epipel = brackish-fresh epipelon; BF Epiphyt = brackish-fresh epiphytic; F Epipel = Fresh epipelon; F Epiphyt = fresh epiphytic.
Salinity preferences: A = polyhalobous; B = mesohalobous; C = oligohalobous halophilous; D = oligohalobous indifferent; F = unknown. Graded colour scheme used to display taxa associated with marine, brackish and freshwater environments.

Diatom preservation was good in all samples and consequently full counts were achieved. The diatom assemblages display the presence of a mixture of marine, brackish and freshwater taxa, with both planktonic and benthic species contributing to the floral diversity. Of the planktonic taxa present, open marine (polyhalobous) taxa were encountered in all samples, although their abundance was lower in the lower most 3 samples (from beneath the lower peat (-0.16m, -0.24m and -0.32m OD). The dominant taxa throughout the sequence was the brackish plankton *Cyclotella striata*, often contributing over 50% of the total diatom valves (TDV). When considering the benthic taxa present, a mixture of marine-brackish, brackish-fresh and fresh taxa are most common, with the majority of the taxa associated with either muddy or organic rich substrates (epipelic and epiphytic taxa respectively). However, there are some marine-brackish and brackish-fresh aerophilous taxa also present (and hence infer periods of sub-aerial exposure), but their abundances remain low (rarely contributing over %5 TDV when combined). When taken as a whole, such groupings would therefore indicate that a coastal setting prevailed for much of the depositional history of the minerogenic units.

Throughout the sequence under analysis, there remains a continued presence of planktonic taxa from a mixture of marine, brackish and freshwater (although limited) sources. As s such ecological groupings are present throughout the sediment samples derived from QBH2, this suggests that deposition of all minerogenic units found interbedded with the assumed freshwater peat deposits, took place within the intertidal zone.

When comparing the diatom assemblages from the three minerogenic units that are interbedded with the discreet peat units, the flora encountered are broadly comparable. This would suggest that similar depositional conditions prevailed during the deposition of these minerogenic units. If *Cyclotella striata* is disregarded, in light of its abundance and planktonic provenance (see section 6.2) and focus on the benthic assemblages, the most abundant diatom species are found present in most samples within QBH2, although their relative abundances are seen to vary between samples. These key taxa are *Nitzschia navicularis, Surirella ovalis, Surirella ovata, Gyrosigma acuminata, Cocconeis placentula* and *Amphora ovalis* present throughout the sequence. Many other benthic species are also present, but not necessarily consistently throughout the samples under investigation.

The three minerogenic units from QBH2 however, contain interesting temporal variations in assemblage. The lowermost samples (-0.16m to -0.32m OD) have an initial overall lack of marine planktonic diatoms, and indeed a lower overall contribution from planktonic species. Instead, benthic taxa dominate, with *Surirella ovata* the most abundant initially, supported by *Surirella ovalis, Cocconeis placentula* and *Synedra capitata*. With height through the basal minerogenic unit however, there is an increase in planktonic influence and *Surirella sp* almost entirely disappear. Also worthy of note is the relative abundance of brackish-fresh and freshwater taxa, which are much less common in the overlying units. But the freshwater taxa show a similar reduction in abundance with height though the basal unit. In contrast, the upper two minerogenic units, are dominated by marine planktonic taxa throughout, contain less in terms of freshwater taxa, and are typified the same marine-brackish and brackish-fresh benthic species; *Nitzschia navicularis, Surirella ovata, surirella ovalis, Hantzschia amphioxys, Cocconeis placentula*. It is also evident that certain taxa are more common at the stratigraphic boundaries with the overlying/underlying peat units, particularly the aerophilous species.

6.2 Interpretation of the diatom analysis

The diatom assemblages in QBH2 reveal an interesting palaeoenvironmental story. The diatoms encountered essentially mirror the expected palaeoenvironmental changes elucidated through the stratigraphy present within sequence, in that there are slightly higher amounts of lower salinity taxa proximal to the peat stratigraphic boundaries, in addition to the greater abundance of aerophilous taxa proximal to these boundaries. Hence, there is more freshwater influence and greater subaerial exposure (indicating the respective reduction in tidal influence) prior to (or shortly after) peat development.

Prior to the onset of Saxon peat accumulation, the diatom flora suggest deposition in a coastal setting but with a limited tidal influence (due to overall absence of marine plankton), with a mixture of marine-brackish, brackish, brackish-fresh and fresh benthic taxa present. The two overlying minerogenic units are then dominated by marine and brackish plankton, with a smaller marine-brackish and brackish-fresh benthic component; this suggests a greater tidal influence with height through the profile.

Due to the presence of a mixture of marine, brackish and fresh diatoms, from both the planktonic and benthic realm, the results have the potential to be incorporated into the palaeoenvironmental scheme of Vos and de Wolf (1993). This scheme enables the diatom assemblages to be interpreted to infer a likely position of the sediment sample within the palaeo-tidal frame (at the time of deposition). Table 10 summarises the diatoms assemblage compositions that are associated with differing elevations within the littoral zone. The benefit of the Vos and deWolf (1993) scheme is that whilst it does take into account the presence of planktonic taxa, it also provides substantial windows in which planktonic species can be present. For example, marine planktonic species can contribute anywhere between 10-70% TDV in many of the diatom assemblages associated with deposition within the supratidal realm. This approach is however necessary due to the potential for large amounts of planktonic diatoms to 'flood' into sediments due to their allochthonous nature, biasing salinity classes allocated to each sample and subsequently resulting in potentially erroneous palaeoenvironmental interpretations. This is indeed important in the context of Robert Street, due to the presence of brackish and marine planktonic taxa that often contribution 50-70% TDV. This potential bias is therefore often displayed within diatom data due to the abundance of planktonic taxa in most deposits (and yet not necessarily reflecting the depositional conditions).

The value of the Vos and deWolf (1993) classification approach is the ability to infer the altitude at which the sample developed on the coastal zone (subtidal, intertidal, supratidal) which, when applied to multiple samples within a sequence, can be used to infer changes in palaeo-depositional altitude over time. This can then provide a semi-quantitative indicator of changes in relative sea level. For example, if a diatom sequence displays a gradual shift from assemblages indicating deposition in supratidal settings, to those more associated with subtidal conditions, this would be interpreted as indicating a progressive increase in the influence of relative sea level. Such shifts are suggested by the interbedded stratigraphy. These apparent marine 'transgressions' or 'regressions' can be caused by a number of (or indeed a combination of) factors. These include (but are not restricted to) an increase in eustatic (global) sea-level, a decrease in the rate of terrestrial sedimentation along the coastal zone (to effectively lower the coastline above that of rising sea level) or crustal movements often resulting from glacio-istostasy (an artefact of the impact previous glacial episodes in the UK).

A note of caution is required with regards to the interpretation based on Vos and deWolf (1993). The scheme requires the grouping of diatom taxa into ecological categories (marine-brackish epipelon, brackish aerophilous etc) and unfortunately not all species have been allocated such groupings through contemporary ecological studies. This does therefore require some assumptions to be made with regards to likely lifeform and salinity preferences of some lesser known taxa for example. Another issue associated with the approach of Vos and deWolf (1993) is that some of the ecological categories require grouping together to implement the scheme. For example, the scheme highlighted in Table 10 doesn't include a brackish epipelon category, and so those taxa that are defined as brackish epipelon (e.g. *Gyrosigma acuminata*) must be incorporated into the marine brackish epipelon group.

When supplying the scheme of Vos and deWolf (1993), the issue associated with the relative abundance of the brackish benthic taxa *Cyclotella striata*, must first be accounted for. According to Vos and deWolf (1993), whilst there can be some margin of error in terms of floral abundance as outlined above, brackish plankton are only really encountered in any abundance above 30%TDV in estuarine tidal conditions (hence within the subtidal zone), due to this being where the greatest amount of water mixing takes place (hence the greatest opportunity for fresh, brackish and marine plankton to be encountered together). In almost all samples however, this taxa contributes at least 50% TDV. Indeed, previous studies also by Vos and deWolf (1988) associate the species *Cyclotella striata* specifically with tidal channels in estuaries. However, the other taxa associated with such a tidal channel setting are absent (*Actinocyclus normannii, Coscinodiscus lacustris, Cyclotella meneghiniana*). This also contrasts markedly with the benthic story of both borehole sequences, which is on the whole dominated by a mixture of epipelon, epiphytic and aerophilous taxa of a variety of salinity tolerances.

The overall abundance of taxa other than those affiliated with freshwater conditions, clearly indicates that for the duration of the period of deposition, the environmental setting was located below Highest Astronomical Tide (HAT), in which tidal submergence was a regular and influential occurrence. Retaining focus on the benthic assemblages, the freshwater component of the diatoms encountered only exceeds 10% TDV in the lower most samples, whilst the combined fresh and brackish-fresh component rarely exceeds 25% TDV. The lowermost samples however are more interesting in light of the reduction in marine plankton when compared to the overlying samples. On face value, this would infer a reduced tidal influence for the initial period of minerogenic sedimentation, prior to the deposition of the first peat unit.

When applying the scheme of Vos and deWolf (1993), the lowermost three samples all plot themselves as being deposited towards the top of the tidal frame, within the supratidal setting of 'pools within saltmarshes'. This allocation is primarily as a consequence of their higher brackish-fresh and freshwater component, the abundance of epiphytic taxa (those that live attached to plants) and the retained influence of marine-brackish epipelon species. The most dominant taxa, *Surirella ovata*, whilst stated as being a marine-brackish taxon by Vos and deWolf (1993), is referred to as a fresh-brackish taxa by van Der Werff & Huls (1958-1974). Its relative abundance (>35% TDV) within the lowermost sample therefore makes the interpretation more confusing. However due to the abundance of other taxa intolerant to highly saline waters, it is inferred that this taxa is indeed fresh-brackish in ecological preference. A similar interpretation of 'pools within saltmarshes' is proposed for the sample immediately above the lowermost discrete peat unit. Whilst there are indeed less freshwater indicators within this sample, the strong brackish-fresh epiphytic signal confirms deposition high up on the saltmarsh. The fact that a very thin peat unit is interbedded between diatom assemblages that suggest deposition within a saltmarsh pool, could be an indicator that the peat unit itself developed in a saltmarsh pool or abandoned tidal creek (or similar coastal setting), rather than being an actual terrestrial peat unit. This is further likely due to the very thin nature of a peat unit which is surrounded by estuarine sediments.

The remaining samples (positioned between +0.24m OD and -0.09m OD), contain a reduced freshwater and/or epiphytic component, whilst aerophilous taxa (whether they be marine-brackish or fresh-brackish) are also encountered in lower abundance. As a result, the classification scheme infers that these samples were deposited slightly lower down the tidal frame, within 'saltmarshes around mean high waters (MHW)'. As such, this infers that for the latter period of sedimentation, which based on the radiocarbon dating postdates 615-765 cal AD, the influence of marine inundation was slightly higher to have caused deposition to take place lower down the tidal frame. Such an interpretation is surprising given that there is a second upper peat unit interbedded between these estuarine sediments, but this could be either explained by unconformable boundaries between the stratigraphic units (i.e. erosion took place to remove some of the evidence for lower salinity conditions *prior* to the onset of peat deposition), or, as with the underlying peat unit, the organic strata similarly was deposited *within* the intertidal zone (rather than at an elevation higher than the influence of tidal conditions). If the latter is correct, the peat unit is not likely evidence for a reduction in relative sea level.

Table 10: Relation between the relative abundance (%TDV) of the ecological groups & the sedimentary environments (modified from Vos & de Wolf, 1993)

Ecological groups	Macro- and mesotidal environments							Microtidal and non-tidal environments		
	Subtidal area		Intertidal area		Supratidal area			Marine/brackish		non-marine (fresh)
	open marine tidal channels	estuarine tidal conditions	sand-flats	mud-flats	salt-marshes, around MHW	salt-marshes, above MHW	pools in the salt-marshes	tidal lagoons, small tidal inlet	laoons, no tides	rivers, ditches, lakes
Marine plankton	10-80	10-60	1-25	10-70	10-70	10-70	10-50	10-60	0-10	0-5
Marine tychoplankton	20-90	15-60	1-25	10-70	10-70	10-70	10-50	10-60	0-10	0-5
Brackish plankton	1-10	20-70	1-10	1-30	1-30	1-30	1-15	1-15	0-10	0-5
Marine/brackish epipsammon	1-40	1-45	50-95	1-45	0-15	0-15	0-15	0-25	0-5	0-1
Marine/brackish epipelon	0-5	0-5	1-30	15-50	1-40	0-5	5-30	5-50	5-60	0-1
Marine/brackish aerophilous	0-1	0-1	0-1	0-1	10-40	15-95	10-40	0-1	0-1	0-1
Brackish/freshwater aerophilous	0-1	0-1	0-1	0-1	10-40	15-95	10-40	0-1	0-1	0-10
Marine/brackish epiphytes	0-1	0-1	0-5	0-5	0-5	0-5	10-60	10-75	10-90	0-5
Brackish/freshwater plankton	0-1	0-25	0-1	0-1	0-1	0-1	0-1	0-20	0-25	0-5
Brackish/freshwater tychoplankton	0-1	0-1	0-5	0-5	0-5	0-5	5-50	5-50	5-80	0-10
Brackish/freshwater epiphytes	0-1	0-1	0-5	0-5	0-5	0-5	1-50	1-50	1-80	0-10
Freshwater epiphytes	0-1	0-1	0-1	0-1	0-5	0-5	0-10	0-10	0-10	1-75
Freshwater epipelon	0-1	0-1	0-1	0-1	0-1	0-1	0-10	0-5	0-10	1-75
Freshwater plankton	0-1	0-1	0-1	0-1	0-1	0-1	0-5	0-15	0-20	10-95

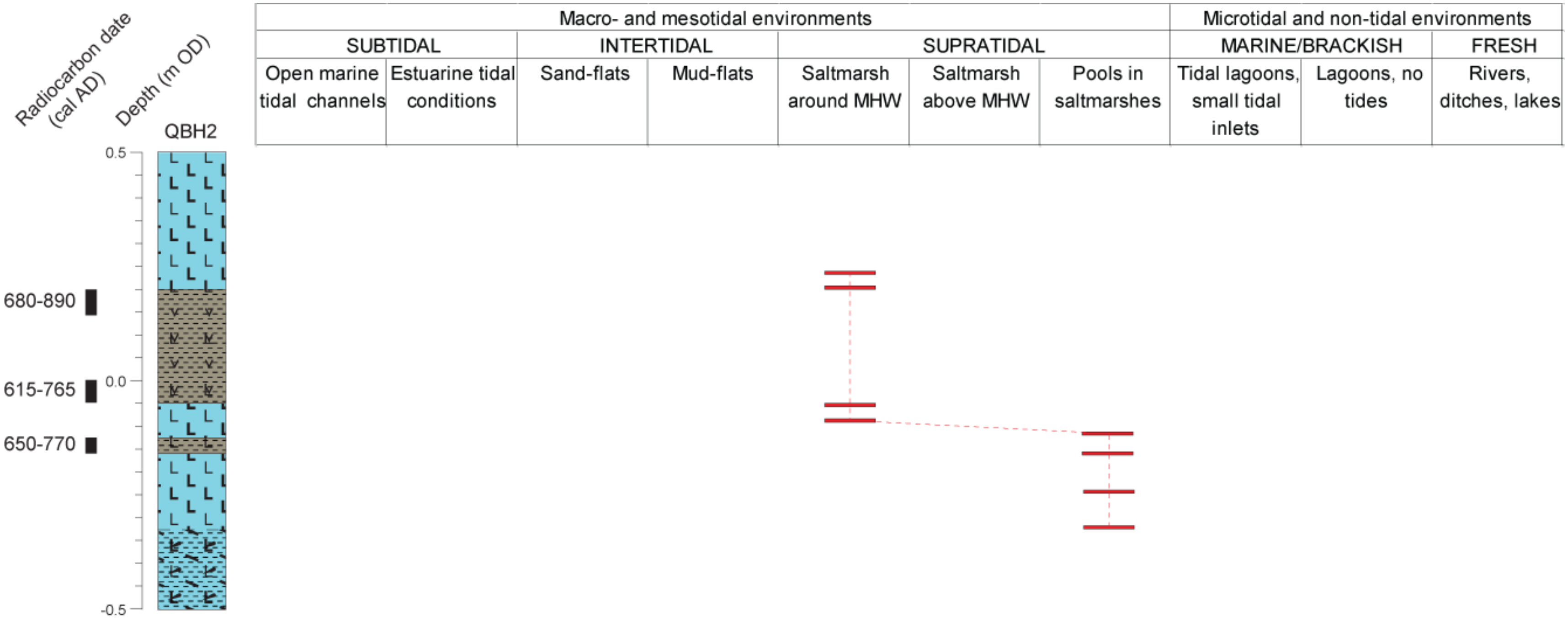

Figure 7: Summary of the costal conditions that prevailed at QBH2 Robert Street, based on the application of Vos & deWolf (1993)

7. RESULTS & INTERPRETATION OF THE MACROFOSSIL ASSESSMENT

A total of five small bulk samples from borehole QBH2 and two from QBH3 were extracted and processed for the recovery of macrofossil remains, including waterlogged and charred plant macrofossils, charcoal, wood, insects and Mollusca. The samples were focussed on the lower organic unit and peat in borehole QBH2 (Table 11), and the reworked/redeposited peat in QBH3 (Table 12). The samples all measured approximately 0.05 litres in volume.

Borehole QBH2

Moderate to high quantities of waterlogged wood were recorded in the samples from QBH2, with moderate quantities recorded in the lower organic unit and moderate to high quantities in the peat. Waterlogged seeds were present in low concentrations throughout. In the lower organic unit, these included *Ranunculus repens* (creeping buttercup), whilst in the peat *Ranunculus repens*, *Chenopodium* sp. (e.g. fat hen), *Carex* sp. (sedge) and *Rumex* sp. (dock/sorrel) were recorded, along with fragments of *Corylus avellana* (hazel) nut shell and a charred caryopsis of *Triticum*/*Hordeum* sp. (wheat/barley) (Table 13). Charcoal was present throughout the sequence from QBH2, generally present in low to moderate concentrations and with the exception of the sample from -0.05 to 0.00m OD, present as fragments large enough for identification.

Fragments of Mollusca (cf. oyster) were recorded in all samples with the exception of the basal sample in the peat, from -0.05 to 0.00m OD. Fragments of bone were recorded in the samples from 0.14 to 0.20 and 0.00 to 0.05m OD, whilst insects were present in low concentrations in the sample from the lower organic unit (-0.12 to -0.17m OD). A fragment of CBM was observed in the peat, in the sample from 0.09 to 0.14m OD.

Although limited, the seed assemblage recorded in the samples from borehole QBH2 is typical of that recorded in an open sedge fen, with herbaceous taxa indicative of wet or damp ground including sedges, creeping buttercup and dock/sorrel. The latter two taxa are also typical of disturbed or waste ground, and along with the edible/economic taxa recorded in the form of wheat/barley and hazelnut, are indicative of human activity within the vicinity of the site. The anthropogenic components of the peat (in the form of charcoal, bone and oyster shell) may be indicative of peat accumulation within a landscape heavily influence by human activity, or disturbance of the peat by reworking/redeposition.

Borehole QBH3

Waterlogged wood was present in high concentrations in both samples from the peat in QBH3, along with low to moderate concentrations of charcoal, present in both samples in fragments large enough for identification. Waterlogged seeds were present in low concentrations in the uppermost sample, from 0.52 to 0.54m OD, consisting of *Chenopodium* sp. (e.g. fat hen) and *Ranunculus repens* (creeping buttercup) (Table 14). Fragments of bone were recorded in the sample from 0.52 to 0.54m OD, with fragments of Mollusca (c.f. oyster) in the sample from 0.50 to 0.52m OD.

Much like the macrofossil record from the peat in borehole QBH2, the waterlogged seed assemblage is limited but typical of relatively open, damp or waste ground, and the anthropogenic components of the peat may be indicative of peat accumulation within a landscape heavily influenced by human activity, or disturbance of the peat by reworking/redeposition.

Table 11: Results of the macrofossil assessment of samples from borehole QBH2, 2-3 Robert Street, City of Westminster.

				Charred					Waterlogged			Mollusca		Bone				
Depth (m OD)	Unit	Volume processed (ml)	Fraction	Charcoal (>4mm)	Charcoal (2-4mm)	Charcoal (<2mm)	Seeds	Chaff	Wood	Seeds	Sedge/grass remains (e.g. stems/roots)	Whole	Fragments	Large	Small	Fragments	Insects	CBM
0.14 to 0.20	Peat	0.05	>300µm	1	1	-	1	-	5	1	-	-	3	-	-	1	-	-
0.09 to 0.14		0.05	>300µm	2	2	-	-	-	2	1	-	-	1	-	-	-	-	1
0.00 to 0.05		0.05	>300µm	2	2	-	-	-	3	-	-	-	2	1	-	2	-	-
-0.05 to 0.00		0.05	>300µm	-	1	1	-	-	5	1	-	-	-	-	-	-	-	-
-0.12 to -0.17	Lower organic unit	0.05	>300µm	3	2	-	-	-	2	1	-	-	1	-	-	-	1	-

Key: 0 = Estimated Minimum Number of Specimens (MNS) = 0; 1 = 1 to 25; 2 = 26 to 50; 3 = 51 to 75; 4 = 76 to 100; 5 = 101+

Table 12: Results of the macrofossil assessment of samples from borehole QBH3, 2-3 Robert Street, City of Westminster.

				Charred					Waterlogged			Mollusca		Bone			
Depth (m OD)	Unit	Volume processed (ml)	Fraction	Charcoal (>4mm)	Charcoal (2-4mm)	Charcoal (<2mm)	Seeds	Chaff	Wood	Seeds	Sedge/grass remains (e.g. stems/roots)	Whole	Fragments	Large	Small	Fragments	Insects
0.52 to 0.54	Upper Reworked peat	0.05	>300µm	3	2	-	-	-	4	2	-	-	-	-	-	2	-
0.50 to 0.52		0.05	>300µm	1	1	-	-	-	4	-	-	-	1	-	-	-	-

Key: 0 = Estimated Minimum Number of Specimens (MNS) = 0; 1 = 1 to 25; 2 = 26 to 50; 3 = 51 to 75; 4 = 76 to 100; 5 = 101+

Table 13: Results of the seed identifications of samples from borehole QBH2, 2-3 Robert Street, City of Westminster.

Depth (m OD)	Unit	Seed identification		Quantity
		Latin name	Common name	
0.14 to 0.20	Peat	*Hordeum*/*Triticum* sp. (charred) *Corylus avellana* (nut shell fragment)	wheat/barley hazelnut	2 1
0.09 to 0.14		*Ranunculus repens* *Chenopodium* sp.	creeping buttercup e.g. fat hen	1 2
0.00 to 0.05		-	-	-
-0.05 to 0.00		*Carex* sp. *Rumex* sp.	sedge dock/sorrel	1 2
-0.12 to -0.17	Lower organic unit	*Ranunculus repens*	creeping buttercup	1

Table 14: Results of the seed identifications of samples from borehole QBH3, 2-3 Robert Street, City of Westminster.

Depth (m OD)	Unit	Seed identification		Quantity
		Latin name	Common name	
0.52 to 0.54	Upper Reworked peat	*Chenopodium* sp. *Ranunculus repens*	e.g. fat hen creeping buttercup	1 5
0.50 to 0.52		-	-	-

8. DISCUSSION & CONCLUSIONS

Following previous geoarchaeological and palaeoenvironmental field and assessment works (Young, 2017, 2019; Young et al., 2019), the sequences from 2-3 Robert Street were identified to have the potential to provide greater insights into human economy, diet & health and hydrology, as well as to establish any differences between the assemblages in the naturally deposited peat of QBH2, and reworked/redeposited peat of QBH3. Furthermore, since relatively few palaeoenvironmental records are available for this area of London for the Saxon period, any further analysis also has the potential to contribute to our understanding of the interaction between Saxon societies and the natural environment at this time.

8.1 Sedimentary and hydrological history

The results of the geoarchaeological investigations have revealed a sequence of London Clay bedrock, overlain by Late Devensian Shepperton Gravel, Holocene alluvium (in places including peat), ground-raising/levelling deposits and modern Made Ground. The surface of the bedrock rises sharply towards the northwest, as might be expected at this location on the edge of the Thames floodplain, from -5.4m OD in BH3 to -1.42m OD in QBH1. In all but one of the boreholes the surface of the overlying Gravel is relatively even, lying at between -1.1 and -1.50m OD; only in BH1 is it significantly higher, recorded at -0.15m OD. It seems likely that this higher level is a result of anthropogenic disturbance of the sequence at the location of BH1, potentially during the emplacement of the overlying ground raising deposits. On the basis of the elevation of the Gravel, it is considered to represent the Late Devensian Shepperton Gravel, rather than the deposits of the earlier (Devensian) Kempton Park terrace (see Gibbard, 1985).

The Gravel is overlain at the site by variable thicknesses of Holocene alluvium, recorded to levels of between *ca*. 1.75 and -0.80m OD. It should be noted however that in some cases it is difficult to differentiate between the alluvium and the overlying ground-raising/levelling deposits, since the former incorporates material from the latter in most cases, and it is likely that the 'natural' level of the alluvium probably lies at about 1m OD. The deposits of the alluvium are predominantly silty, clayey and occasionally sandy; however, a peat unit was recorded within the alluvial sequence, generally at levels between *ca*. 0.2 and -0.35m OD, but not recorded in the interventions southeast of BH2. In these latter boreholes the sequence appears to be truncated by the overlying anthropogenic deposits to levels lower than the peat (to *ca*. -1m OD). The organic/peat units within the alluvium are of Saxon date, radiocarbon dated in QBH2 to 650-770 cal AD (1300-1180 cal BP; -0.12 to -0.17m OD) and from 615-765 cal AD (1335-1185 cal BP; -0.05 to 0.00m OD) to 680-890 cal AD (1270-1060 cal BP; 0.20 to 0.14m OD.

On the basis of the new radiocarbon dates, the organic units recorded within the overlying ground raising/levelling deposits at the site are of a very similar Saxon date, all falling within the period 605-890 cal AD. The similarity of these dates, and the apparent age reversal between the lower organic unit and the uppermost (potentially reworked) organic unit in BH1, lends support to the notion that the upper organic units above *ca*. 0.2m OD, and forming part of the ground raising/levelling deposits, are redeposited or reworked remnants of the naturally accumulated peat recorded within the alluvium. In addition, the macrofossil remains recorded within both the lower, potentially *in situ* peat and the upper reworked peat are very similar, with anthropogenic waste such as bone, fragments of oyster shell and charcoal recorded in both sets of deposits. This indicates that if the peat between *ca*. 0.2 and -0.35m OD is naturally accumulated, it did so in a marshy or boggy location that must have been on the margins of an environment heavily modified by human activity.

Elsewhere, the ground-raising/levelling deposits incorporate alluvial sediments from the underlying unit, including organic matter, and contain anthropogenic material of Saxon date onwards such as charcoal, bone, worked wood and shell (in places including oyster). The surface of this unit is variable across the site, recorded at between 2.7 and 1.35m OD, with its base generally lying at between *ca*. 0.3 and 1.0m OD; however, as described above it appears to have truncated the underlying alluvium to much lower levels of about -1m OD in the southeastern area of the site (southeast of BH2). Modern Made Ground caps the sequence, present in thicknesses of between 2.8 and 1m; in one borehole (BH3) a layer of chalk cobbles with lime mortar was recorded at the base of the Made Ground between 2.90 to 2.20m OD, perhaps associated with a wall or foundation of unknown date; this feature lies at a similar elevation to the wall foundation identified by MoLA (2015) in Trench 2.

The results of the diatom analysis indicate that prior to, and after the initial period of peat formation in QBH2 (around 650-770 cal AD), the alluvial deposits accumulated within the supratidal setting of 'pools with saltmarshes', on the basis of their higher brackish-fresh and freshwater component. The fact that this very thin peat unit is interbedded between diatom assemblages that suggest deposition within a saltmarsh pool, could be an indicator that the peat unit itself developed in a saltmarsh pool or abandoned tidal creek (or similar coastal setting), rather than being an actual terrestrial peat unit.

The remaining samples, which both pre and post date the main period of peat accumulation between 615-765 and 680-890 cal AD, contain a reduced freshwater and/or epiphytic component, whilst aerophilous taxa (whether they be marine-brackish or fresh-brackish) are also encountered in lower abundance. As a result, it is inferred that accumulation during this period took place when the influence of marine inundation was slightly higher, in a setting of 'saltmarshes around mean high waters (MHW)'. This is slightly unusual given that a transition towards peat formation would ordinarily mean a more terrestrial setting, but could perhaps be explained by either unconformable boundaries between the stratigraphic units (i.e. erosion took place to remove some of the evidence for lower salinity conditions *prior* to the onset of peat deposition), or, as with the underlying peat unit, the organic strata similarly was deposited *within* the intertidal zone (rather than at an elevation higher than the influence of tidal conditions). If the latter is correct, the peat unit is not likely evidence for a reduction in relative sea level.

A brackish water influence is also potentially indicated by the presence of *Chenopodium* type (goosefoot family) pollen throughout the analysed QBH2 sequence. Plants of the Chenopodiaceae family may be split into two broad groups, those associated with brackish and marine environments such as *Salsola kali* (glasswort), and those commonly found in waste places and the edges of arable fields on dryland, such as *Chenopodium album* (fat hen). Thus, the pollen values of Chenopodium type recorded may indicate the growth of saltmarsh plants (and therefore a brackish water influence) or more open, disturbed conditions on dryland.

The deposits at the 2-3 Robert Street site thus appear to represent natural foreshore deposits associated with the floodplain of the River Thames, overlain by alluvial sediments and a series of ground-raising/levelling deposits that incorporate material from the alluvial sediments below. The archaeological deposits here are therefore very similar in character to those recorded at both Adelphi House (Young *et al*., 2015) and 18-20 York Buildings (Cowie & Whytehead, 1989). However, at the 2-3 Robert Street site, the lower alluvial deposits, including the peat/richly organic units recorded between *ca*. 0.2 and -0.35m OD, appear to have accumulated by natural processes. In contrast, the upper organic units, forming part of the ground raising/levelling deposits, is similar in character, and lies at a similar elevation, to the deposits at both Adelphi House and 18-20 York Buildings, where much of the material recorded was not in its primary depositional context, but has been brought to the site from elsewhere and dumped.

8.2 Vegetation history

The pollen records from QBH2 and QBH3 suggest that the vegetation near 2-3 Robert Street, and nature of the human activities remained relatively consistent from 650-770 to 680-890 cal AD. The local environment was very open, and largely occupied by plants growing in a number of open habitats, including, wetlands, meadow, pasture and disturbed/waste ground. Cereal pollen is frequently recorded with occasional charred grain and other cultivated species such as Cannabaceae, Disturbed ground and weed taxa associated with crops such as knapweed, cornflower, fat hen and brassica are also present. Combined, these taxa suggest either nearby crop-growth, or that material was being brought to site for processing, consumption or dumping.

Alder and willow may have grown in niches along the margins of the river nearby to the site, or on marshy/boggy regions of the floodplain. Damp ground is also indicated by the presence of sedges, grasses and bur-reed, together with buttercup, mint, and marsh valerian. Areas of open water (either still or moving) are suggested by the presence of algal spores/plankton and chironomid (midge) mouth parts. As outlined above, the wetland is likely to have been under brackish water influence, and this may in part be the reason for the presence of plants from the goosefoot family.

A variety of dung fungal spores are also recorded including *Sporormiella* type, *Sordaria* type and *Podospora* type together with regular occurrences of ova from the parasitic whipworm (from either pigs or humans). However, the combined presence of the spores and ova, together with consistently high values of microcharcoal may have become incorporated into the sediment through the dumping of faeces and other waste, in an otherwise naturally accumulating deposit. This is enhanced by the frequent occurrence of anthropogenic components in the peat (in the form of charcoal, bone and oyster shell), suggestive of its accumulation within a landscape heavily influenced by human activity, or perhaps at least some disturbance of the peat by reworking/redeposition.

Much of the palaeoecological data from Saxon organic deposits is derived from macrofossil data from archaeological assemblages, and is often dated artefactually. There are very few sequences that provide palaeoenvironmental data derived from a range of analyses (including pollen), and that have been radiocarbon dated. One other example is from the adjacent Adelphi House site (Young et al., 2015). Here, the reworked/redistributed Saxon peat deposits are indicative of a similarly open environment, with limited growth of alder on the wetland, and stands of oak, hazel and heather on the neighbouring dryland. Disturbed ground taxa and cereals provided direct evidence for human activity, whilst the presence of possible thrift pollen may be indicative of a saline influence at this time.

When combined with the results of the investigations at Adelphi House (Young *et al*., 2015) and 18-20 York Buildings (Cowie & Whytehead, 1989), the new geoarchaeological and palaeoenvironmental record from 2-3 Robert Street represents a valuable contribution to our knowledge and understanding of understanding of the interaction between Saxon societies and the natural environment at this time in the main Lundenwic settlement.

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10. OASIS

Project details

Project name	2-3 Robert Street
Short description of the project	Geoarchaeological and palaeoenvironmental investigations have revealed a sequence of London Clay, overlain by Pleistocene Gravel, Holocene alluvium (in places including peat), ground-raising/levelling deposits and modern Made Ground. The Gravel is overlain at the site by variable thicknesses of Holocene alluvium, recorded to levels between ca. 1.75 and -0.80m OD. The alluvium is predominantly fine-grained and mineral-rich; however, a peat unit dated to the Saxon period was recorded between 0.2 and -0.35m OD. Above this, the ground-raising/levelling deposits incorporate alluvial sediments from the underlying unit, including organic matter, and contain anthropogenic material of Saxon date onwards (including charcoal, bone, worked wood and shell). The sediments appear to represent natural foreshore deposits associated with the floodplain of the River Thames, overlain by alluvium and a series of ground-raising/levelling deposits. They are very similar in character to those recorded at Adelphi House and 18-20 York Buildings. The biological remains in both the naturally accumulated and reworked/redeposits organic deposits are very similar. A generally open, damp and disturbed environment is indicated, with a range of herbaceous taxa recorded potentially representing their growth in a number of open habitats, including wetlands, meadow, pasture, disturbed/waste ground with crops and their associated weeds.
Project dates	Start: 01-01-2017 End: 20-02-2020
Previous/future work	Yes / No
Any associated project reference codes	ROB17 - Sitecode
Type of project	Environmental assessment
Monument type	PEAT Early Medieval
Significant Finds	NONE
Survey techniques	Landscape

Project location

Country	England
Site location	GREATER LONDON CITY OF WESTMINSTER CITY OF WESTMINSTER 2-3 Robert Street
Study area	0 Square metres
Site coordinates	TQ 30372 80549 51.508313696656 -0.121186868886 51 30 29 N 000 07 16 W Point

Project creators

Name of Organisation	Quaternary Scientific (QUEST)
Project brief originator	Archaeology Collective
Project design originator	D.S. Young
Project director/manager	D.S. Young

Project supervisor	D.S. Young
Type of sponsor/funding body	Developer

Project archives

Physical Archive Exists?	No
Digital Archive Exists?	No
Paper Archive recipient	LAARC
Paper Contents	"Environmental","Stratigraphic"
Paper Media available	"Report"

Project bibliography 1

Publication type	Grey literature (unpublished document/manuscript)
Title	2-3 ROBERT STREET, CITY OF WESTMINSTER A Report on the Geoarchaeological Field Investigations
Author(s)/Editor(s)	Young, D.S.
Other bibliographic details	Quaternary Scientific (QUEST) Unpublished Report May 2019; Project Number 051/17
Date	2019
Issuer or publisher	University of Reading
Place of issue or publication	Reading
Description	A4 report

Project bibliography 2

Publication type	Grey literature (unpublished document/manuscript)
Title	2-3 ROBERT STREET, CITY OF WESTMINSTER: Geoarchaeological and Palaeoenvironmental Assessment Report
Author(s)/Editor(s)	Young, D.S.
Author(s)/Editor(s)	Batchelor, C.R.
Author(s)/Editor(s)	Williams, K.
Other bibliographic details	Quaternary Scientific (QUEST) Unpublished Report August 2019; Project Number 051/17
Date	2019
Issuer or publisher	Quaternary Scientific (QUEST)
Place of issue or publication	University of Reading

Project bibliography 3

Publication type	Grey literature (unpublished document/manuscript)
Title	2-3 ROBERT STREET, CITY OF WESTMINSTER Geoarchaeological and Palaeoenvironmental Analysis Report
Author(s)/Editor(s)	Batchelor, C.R.
Author(s)/Editor(s)	Young, D.S.
Author(s)/Editor(s)	Hill, T.
Author(s)/Editor(s)	Richer, S.
Other bibliographic details	Quaternary Scientific (QUEST) Unpublished Report February 2020; Project Number 051/17
Date	2020
Issuer or publisher	Quaternary Scientific
Place of issue or publication	University of Reading

Entered by	Rob Batchelor (c.r.batchelor@reading.ac.uk)
Entered on	19 February 2020