



WE ROBERTS – J1 EXTENSION LOWER ROAD NORTHFLEET

Geoarchaeological Fieldwork & Palaeoenvironmental Assessment Report

Planning reference number: 20221142

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1. NON-TECHNICAL SUMMARY

The results of the geoarchaeological fieldwork have revealed a sequence of Chalk Bedrock overlain by River Terrace Gravels, Colluvium/Alluvium, a tripartite sequence of Lower Alluvium, Peat & Upper Alluvium, capped by Made Ground. These deposits slope downwards from north-west to south-east across the site, as would be expected given the position of the site on the western edge of the Ebbsfleet Valley. Radiocarbon dating of borehole LR-QBH2 indicates that peat accumulation took place from the late Mesolithic through to the Bronze Age. Palaeoenvironmental assessment has revealed a dryland environment initially occupied by mixed deciduous woodland. Peat initiation led to the development of alder woodland and sedge fen / reed swamp conditions at the very end of the late Mesolithic, whilst mixed deciduous woodland continued to occupy the dryland. Towards the top of the peat, the pollen and macrofossil records suggest opening of the woodlands on both the wetland and dryland in response to both wetter conditions and Bronze Age land clearance for settlement / agricultural purposes. The results of the diatom assessment suggest that the transition from Peat into the Upper Alluvium reflects an increase in saline conditions. Given the variable and often limited concentration of remains, and quality of the retained sequences from the site, no further work is recommended, and the core samples from the site should be discarded.

2. INTRODUCTION

2.1. Planning context

This report summarises the findings of the geoarchaeological fieldwork and palaeoenvironmental assessment undertaken at the WE Roberts – J1 Extension site, Lower Road, Northfleet (NGR: centered on TQ 61312 75108; Figures 1-2). The proposed development plans are provided in Figure 3 and is likely to involve the use of rotary or driven piles, with a suspended ground slab due to ground gas in the soil. There will no deep foundations or anti vibration mountings required below ground slab. The design proposals are shown in Appendix 1.

The Kent County Council Archaeological Advisor outlined the following with regards to the site:

‘The site lies within an area of high archaeological and palaeoenvironmental potential but is a site about which there is uncertainty in terms of stratigraphy. It lies within Zone 3 of the deposit modelling characterisation undertaken by Martin Bates and Francis Wenban-Smith in 2021. Little is known of this zone. It is anticipated that sequences may be complex and vary laterally in all directions. Archaeological material may exist within these sequences from Late Glacial (e.g. Long Blade sites) to recent in age and there is good palaeoenvironmental potential in this zone.’

‘Because of the nature of the deposits and the uncertainty I would like to start with geoarchaeological boreholes rather than trial trenching. This email represents Part A of the specification for the first stage of work and I have attached Part B, which must be considered in detail and attached as an appendix to the WSI for evaluation. Could you arrange for a WSI for 3 geoarchaeological boreholes to collect window samples and to cover the area as shown on the attached copy of your site plan.’

The following condition has been placed on the site:

20221142 - WER Packing Supplies, Unit J1, Lower Road, Northfleet Gravesend
Erection of two storey side extension to existing factory/warehouse unit with mezzanine.

5. No development shall take place until the applicant, or their agents or successors in title, has secured the implementation of: i. archaeological field evaluation works in accordance with a Written Scheme of Investigation and timetable which has been submitted to and approved in writing by the Local Planning Authority; and ii. following on from the evaluation, any safeguarding measures to ensure preservation in situ of important archaeological remains and/or further archaeological investigation and recording in accordance with a Written Scheme of Investigation

and timetable which has been submitted to and approved in writing by the Local Planning Authority.

Reason: To ensure appropriate assessment of the archaeological implications of any development proposals and the subsequent mitigation of adverse impacts through preservation in situ or by record, in accordance with Policy CS20 of the Gravesham Local Plan Core Strategy 2014

2.2. Geoarchaeological context

The site is approximately triangular in shape and 0.025 hectares in size. The British Geological Survey (BGS) maps the site as being located on the very edge of the floodplain of the Lower Ebbsfleet Valley, at its confluence with the floodplain of the River Thames (Figure 1). Indeed, BGS mapping shows almost the entire site is underlain by floodplain alluvium of Holocene age (the last 11,500 years), described as comprising clay, silt, sand & gravel deposits, resting on chalk bedrock. In fact, the alluvial deposits of the Lower Thames and its tributaries are almost everywhere underlain by Pleistocene Gravels (2.6 million to 11,500 years ago), and this gravel is widely recorded in boreholes in the vicinity of the site. However, the very western end of the site is close to the valley side, as defined by the junction between the alluvium and the Head shown by BGS to be covering the lower valley side slopes, whilst the upper slopes expose the Chalk. The Head deposits are described as clay, silt, sand & gravel also dating to the Pleistocene.

No boreholes have previously been put down within the confines of the site or immediate area. However, four BGS boreholes have been put down on the western side of Lower Road (see Figure 2). Three of these record a sequence of Made Ground over Head deposits resting on Chalk bedrock, with one sequence (TQ67SW724) recording Made Ground directly over Chalk. Thus these borehole records correspond with the BGS mapping.

Ebbsfleet Football Stadium is located in almost exactly the same landscape position as the Lower Road site, but on the opposite bank of the Ebbsfleet Valley. A combined geoarchaeological and geophysical exercise on the site revealed a Chalk surface that slopes downwards from southeast to northwest. The Pleistocene Gravels overlying follow the same trend, declining from ca. -3m OD (northeast) to at least -7m OD (southeast). Overlying the Pleistocene Gravels is a complex sequence of Holocene alluvial and peat deposits. Investigations as part of the HSI route have also revealed a thick and complex sequence of alluvium that has been radiocarbon dated as accumulating from the early Mesolithic through to the Saxon period (Bates & Stafford, 2013; Wenban-Smith et al., 2020).

2.3. Geoarchaeological & palaeoenvironmental significance

The existing records therefore indicate considerable variation in the height of the Chalk, Pleistocene Gravels/Head, and the type, thickness and age of the subsequent Holocene deposits within the vicinity of the site. Such variations are significant as they represent different environmental conditions that would have existed in a given location. For example: (1) the varying surface of the Gravel may represent the location of former channels and bars (as outlined above); (2) the presence of peat represents former terrestrial or semi-terrestrial land-surfaces, and (3) the Alluvium represents periods of channel activity / changing hydrological conditions. The apparent location of the site on the very edge of the Ebbsfleet floodplain, towards its confluence with the Lower Thames Valley floodplain is also clearly of importance.

The nature and thickness of the Holocene alluvial sequence has the potential to provide a detailed reconstruction of past environments. In particular, there is the potential to increase knowledge and understanding of the interactions between relative sea level, human activity, vegetation succession and climate in this area of the Lower Thames Valley. Significant known prehistoric vegetation changes recorded in the Lower Thames Valley include the Mesolithic/Neolithic decline of elm woodland, the Neolithic colonisation and decline of yew woodland; the Late Neolithic/Early Bronze Age growth of elm on Peat, and the general decline of wetland and dryland woodland during the Bronze Age.

Significantly, at the northern end of the Ebbsfleet Football Stadium site, two very well-preserved flint artefacts were recorded just above the Pleistocene Gravel surface (Batchelor, 2015). The artefacts were thought to be of Mesolithic age, and their preservation (together with the associated plant remains), suggests that they are *in situ*, and thus lying on a former land-surface. A further 9 potential lithics were recorded during geoarchaeological/archaeological monitoring of piling works (Young & Hosfield, 2016). The nature of the piling works meant that it was impossible to determine the depth of the samples, and in the majority of cases the definitive sediment type with which the artefacts were associated. Nevertheless, the character and distribution of the artefacts most likely suggests Holocene, and perhaps also late Upper Palaeolithic, hunter-gatherer knapping activity on the floodplain of the Ebbsfleet Valley, near or at its confluence with the Thames.

The Pleistocene deposits present on the sides of the Ebbsfleet Valley are also considered of national importance, and in places are associated with rich archaeological remains (Wenban-Smith *et al.*, 2006; Bates and Stafford, 2013). The archaeological potential of the alluvial deposits within the valley itself are less well known, although Mesolithic, Neolithic, Bronze and Iron Age remains have been recorded (Bates and Stafford, 2013). Indeed, during the recent the High Speed 1 (HS1) and South Thameside

Development Route 4 (STDR4) site excavations, *in situ* early Neolithic flint scatters were recorded on a former land-surface (Wenban-Smith *et al.* 2020; Bates and Stafford, 2013).

2.4. Aims and objectives

Four significant research aims were originally outlined within the Written Scheme of Investigation for the site (Batchelor, 2023):

- 1 To clarify the nature of the sub-surface stratigraphy across the site;
- 2 To enhance our understanding of the nature, depth and of any former land surfaces, chalk, head, alluvial and peat deposits;
- 3 To investigate whether the sequences contain any artefact or ecofact evidence for prehistoric or historic human activity;
- 4 To investigate whether the sequences contain any evidence for natural and/or anthropogenic changes to the landscape (wetland and dryland);

A program of geotechnical site investigation works was undertaken at the site in March 2023 (Figure 2). These investigations were subject to geoarchaeological monitoring, the results of which have been used to address the first two of these aims. The following objectives were undertaken in order to achieve these aims:

- 1 To monitor three geotechnical boreholes being put down on the site
- 2 To use the stratigraphic data from all locations, and existing records to produce a deposit model of the major depositional units across the site and wider area
- 3 To compare the findings with previous investigations undertaken across the local area

In addition, during the course of the monitoring, an opportunity arose to obtain one core sequence from the location of QBH2 for offsite palaeoenvironmental assessment. It was agreed through discussion with the KCC archaeological advisor, that this would be carried out as part of this report to determine the potential of fulfilling the final two aims of the project. This exercise incorporated radiocarbon dating, and assessment of the concentration and preservation of pollen, diatom and macrofossil remains.

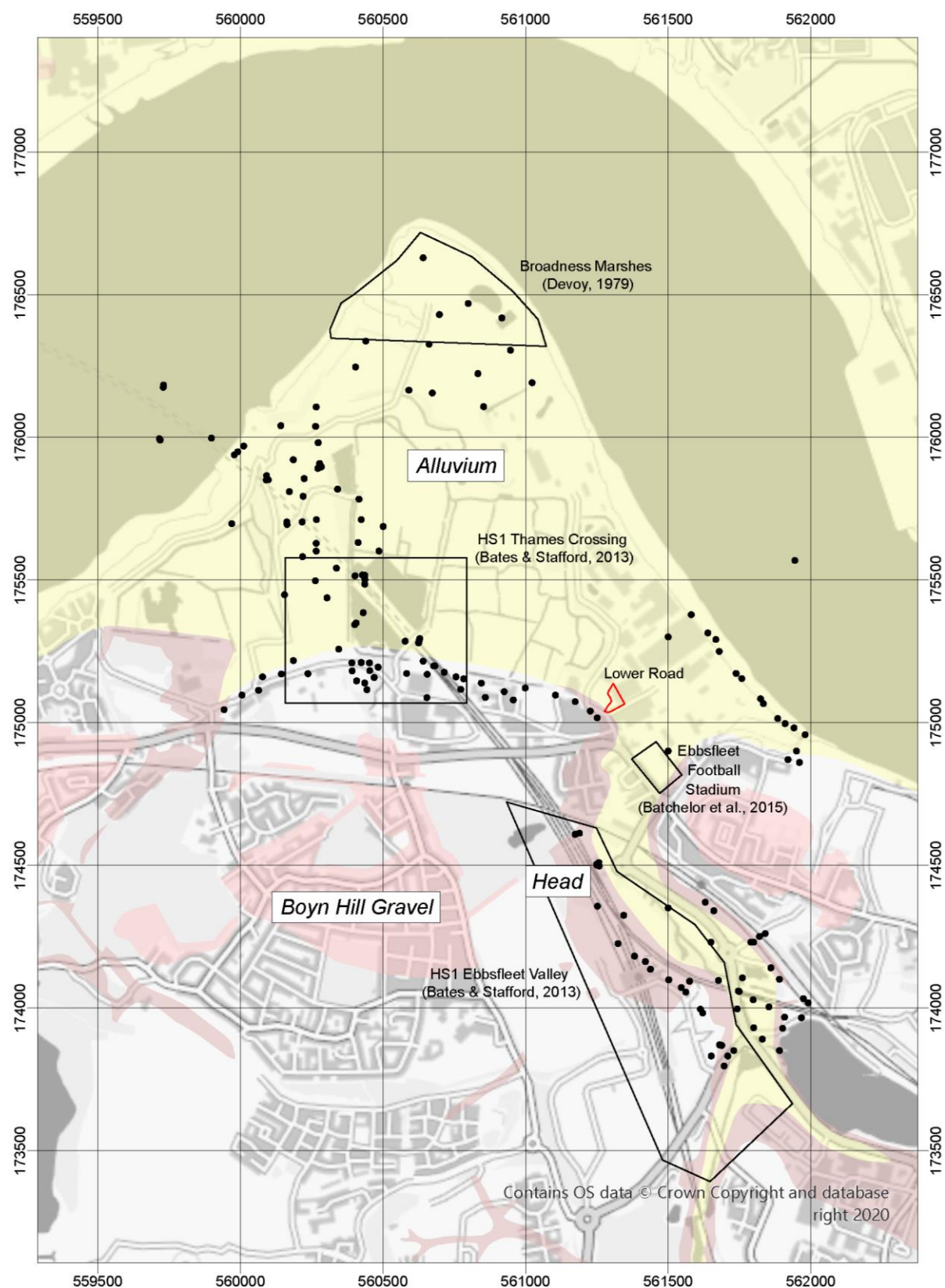


Figure 1: Location of the Lower Road site, other local sites and BGS boreholes (black dots).

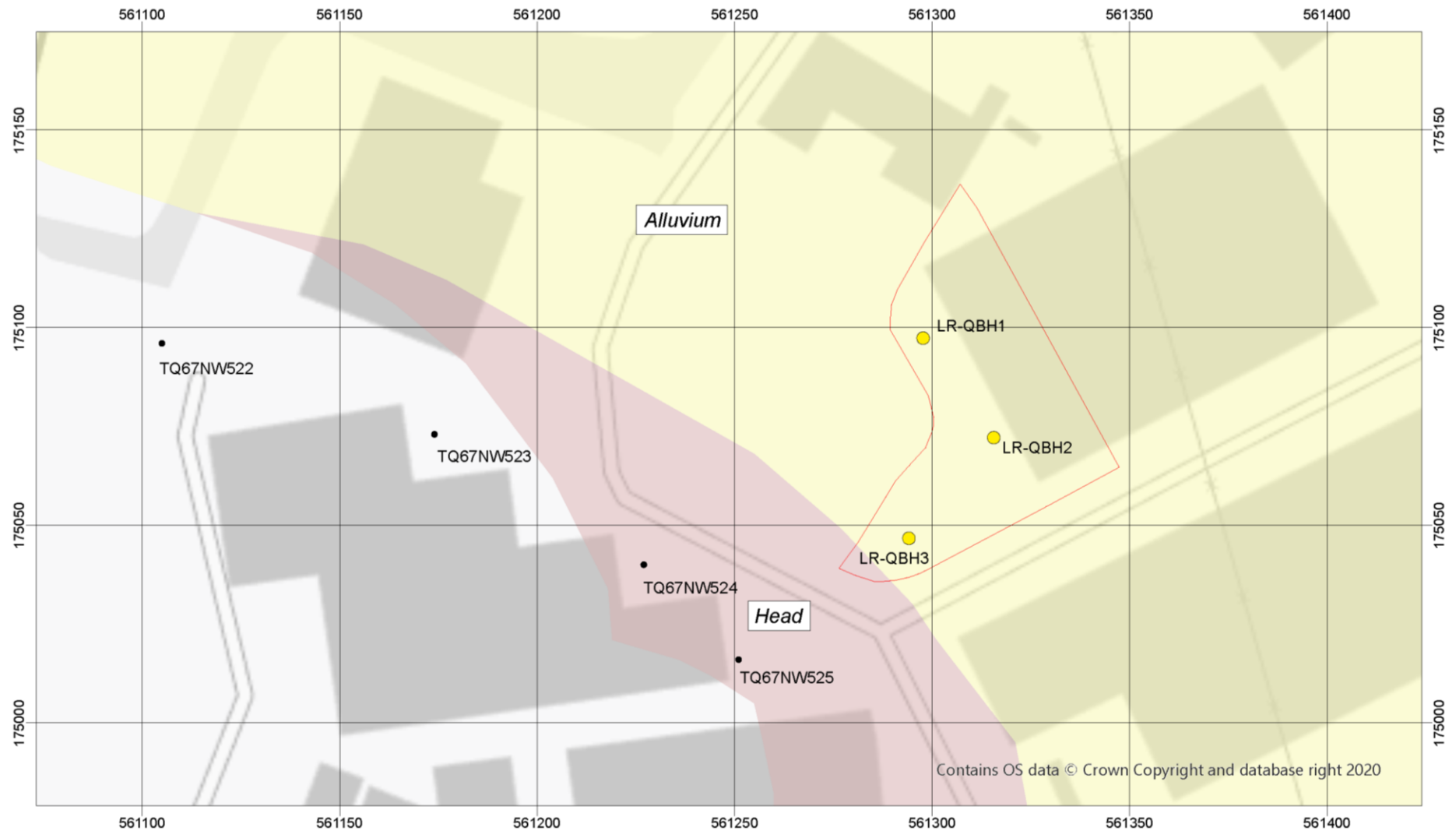
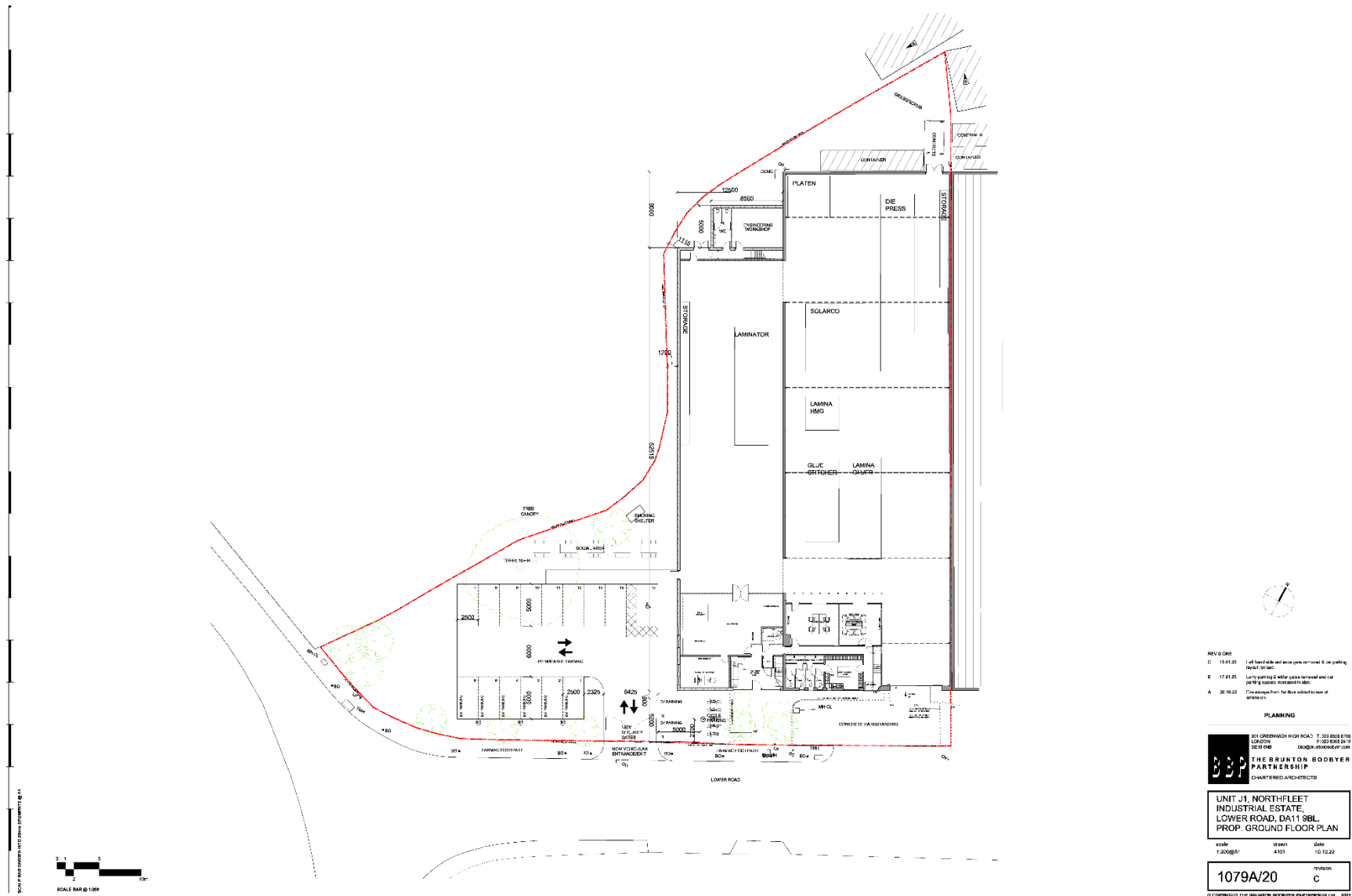


Figure 2: Location of the proposed geoarchaeological boreholes (LR-QBH1 to QBH3)



3. METHODS

3.1. Fieldwork

Three geotechnical boreholes were put down across the site by Site Analytical Services using a Premier window sampling rig. The spatial attributes were estimated for each borehole from GIS software and Ordnance Survey 50m DTM data (Table 1 and Figure 2).

Boreholes LR-QBH1 and LR-QBH3 were put down by rotary means. This technique is essentially a corkscrew driven into the ground and extruded in 1m samples. It is a crude method, and not suitable for detailed description or palaeoenvironmental sampling, but does provide an adequate guide to the nature and depth of the major stratigraphic units. The sequences were monitored and recorded by a Quest geoarchaeologist.

The deposits in LR-QBH2 were recovered as 1.0m cores in plastic liners that were described offsite in University of Reading laboratories.

Table 1: Spatial co-ordinates of the geoarchaeological boreholes

Name	Easting	Northing	Elevation (m OD)	Total Depth (m)
QBH1	561297	175097	4.74	10
QBH2	561315	175072	4.59	9
QBH3	561294	175047	4.64	7

3.2. Lithostratigraphic descriptions

The three borehole sequences were described using standard procedures for recording unconsolidated sediments and organic remains, noting the physical properties (colour), composition (particle size, organic content and sorting), and any archaeological inclusions (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; As); (4) recording the degree of peat humification and (5) recording the unit boundaries e.g. sharp or diffuse. The results of the lithostratigraphic descriptions are presented in Tables 2-4 and section 4. Photographs of the core samples from QBH2 are provided in Figure 4.

3.3. Deposit Modelling

Sedimentological descriptions from the monitored/sampled boreholes were classified into five different lithologies which were grouped into three lithostratigraphic units: (1) Bedrock, (2) Gravel, (3) Lower Alluvium / Colluvium; (4) Peat, (5) Upper Alluvium and (6) Made Ground. Due to the limited

number and spatial distribution of the boreholes, it was not possible to produce topographic surface plots of the height and thickness of each lithostratigraphic unit from deposit modelling. Instead, the results of the geoarchaeological and geotechnical records have been summarised in a two-dimensional west-east stratigraphic profile (Figure 5).

3.4. Radiocarbon dating

Samples of waterlogged twig wood from four depths in QBH2 were sent for radiocarbon dating. 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 2010) and the IntCal20 atmospheric curve (Reimer et al., 2020). Results are displayed in Figure 5 and Table 6.

3.5. Pollen assessment

Twelve samples from borehole QBH2 were extracted for an assessment of pollen content. The pollen was extracted as follows: (1) sampling a standard volume of sediment (1ml); (2) adding one tablet 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 ($>125\mu\text{m}$); (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. Pollen grains and spores were identified using the University of Reading pollen type collection and the following sources of keys and photographs: Moore et al (1991); Reille (1992). The assessment procedure consisted of scanning the prepared slides and recording the concentration and preservation of pollen grains and spores, and the principal taxa either on four transects (10% of the slide) or up to 100 total land pollen. The results are displayed in Table 7.

3.6. Diatom assessment

Four samples from borehole QBH2 were submitted for an assessment of diatom presence. 0.5g of sediment was required for the diatom sample preparation. All samples were first treated with sodium hexametaphosphate and left overnight, to assist in minerogenic deflocculation. Samples were then treated with hydrogen peroxide (30% solution) to remove organic material. Samples were finally sieved using a $10\mu\text{m}$ 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 four slide traverses were undertaken across each slide sample. When encountered, diatom species were identified with

reference to van der Werff and Huls (1958-74), Hendy (1964) and Krammer & Lange-Bertalot (1986-1991). The results are displayed in Table 8.

3.7. Macrofossil assessment

A total of four samples from borehole QBH2 were processed for the recovery of macrofossil remains, including waterlogged plant macrofossils, wood, insects, Mollusca, Foraminifera and Ostracoda. 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 (Table 9).

4. RESULTS OF THE GEOARCHAEOLOGICAL FIELDWORK

The tabulated descriptions of QBH1 to QBH3 are displayed in Tables 2-4 with photos of QBH2 shown in Figure 4.

4.1. LR-QBH1

LR-QBH1 was put down by rotary means, which as outlined in section 3.1 provided an adequate guide to the nature and depth of the major stratigraphic units.

The lowermost units comprised silty sand with occasional flint gravel fragments between -5.26 and -4.06m OD. This is considered to possibly represent the upper surface of the River Terrace Gravel. From -4.06 to -3.26m OD a fining up sequence of sandy silt, then silty clay is recorded. These units are grouped together and interpreted as being representative of the Lower Alluvium and Colluvium. Between -2.26 and -0.26m OD, peat deposits are recorded, comprising brown well-humified disintegrated organic matter and wood remains. From -0.26 to 0.74m OD, a greyish brown organic-clay was recorded and is interpreted as the sediments of the Upper Alluvium. Above 0.74m OD to the present day surface (4.74m OD), a mixture of predominantly fine-grained deposits are recorded, including clays, silts and sands. The arrangement of these deposits is unusual however, and includes both very black clays and chalky remains, as well as brick fragments. These deposits are all interpreted as reworked alluvium and Made Ground.

4.2. LR-QBH2

LR-QBH2 was recovered in 1.0m cores in plastic liners that were described offsite in University of Reading laboratories. As can be seen from the photographs in Figure 4 and descriptions in Table 3,

collapsed material represented between 40% and 60% of the sediment collected in each 1m core between 4 and 9m. Despite the inevitable compression issues and sequence voids this creates, the cores provide a good insight into the sediments, and material suitable for radiocarbon dating and palaeoenvironmental assessment (see sections 6-8).

Similarly to LR-QBH1, the lowermost sediments retained in the LR-QBH2 sequence comprises a silty sand with occasional flint gravel fragments from -4.21 to -3.79m OD. This is interpreted as possibly representing the upper surface of the River Terrace Gravel. Between -3.38 and -3.25m OD a sandy clay material is recorded with a clear carbonate (chalk) component. This is considered to represent a combination of alluvial and colluvial sediment. From -3.25 to -2.71m OD, then -2.41 to -1.89m OD and finally -1.41 to -1.18m OD, peat deposits are recorded, initially comprising organic or wood remains within clay, developing into a well humified wood peat with disintegrated organic material. From -1.18m OD to 1.59m OD, silty clay deposits are recorded that become oxidised and brown above 1.19m OD. The uppermost 3m were not obtained as it all represented Made Ground.

4.3. LR-QBH3

LR-QBH3 was put down by rotary means, which as outlined in section 3.1 provided an adequate guide to the nature and depth of the major stratigraphic units.

The lowermost unit recorded below -1.96m OD comprised white chalk and is interpreted as the bedrock surface. From -4.06 to -3.26m OD a fining up sequence of sandy silt, then silty clay is recorded, with chalk fragments frequently recorded. The lowermost unit is thought to probably represent River Terrace Gravel, but also incorporate material representative of soil creep during permafrost conditions. It is overlain by a thin layer of Lower Alluvium. Between 0.56 and 0.14m OD, peat deposits are recorded, comprising brown well-humified disintegrated organic matter and wood remains. This is overlain by silty clay deposits representative of the Upper Alluvium, that are initially organic-rich in nature. The sequence is capped by 2.2m of Made Ground deposits.

Table 2: Geoarchaeological description of borehole LR-QBH1

Depth (m OD)	Depth (m bgl)	Description	Stratigraphic Group
4.74 to 3.84	0 to 0.90	Made Ground	MADE GROUND
3.84 to 3.44	0.90 to 1.30	10YR 5/2; As3, Ag1; Greyish brown silty clay	
3.44 to 3.24	1.30 to 1.50	10YR 6/1; Ag2, As2, Dh+; Soft pale grey chalky silty clay with detrital plant remains	
3.24 to 2.94	1.50 to 1.80	10YR 4/1; As3, Ag1; Dark grey silty clay	
2.94 to 2.74	1.80 to 2.00	10YR 4/1 to 10YR 6/1; As2, Ag2; Mixture of dark grey silty clay and pale grey chalky silty clay	
2.74 to 1.74	2.00 to 3.00	10YR 2/1; As4; Black very soft clay	
1.74 to 0.74	3.00 to 4.00	10YR 2/1 to 10YR 5/1; As4; Black becoming grey clay with chalk and brick fragments	
0.74 to -0.26	4.00 to 5.00	10YR 5/2; As2, Sh2; Greyish brown organic-rich clay	UPPER ALLUVIUM
-0.26 to -2.26	5.00 to 7.00	10YR 5/3; Sh3, T11; Humo3; Brown well humified disintegrated organic matter and wood peat; strong odour	PEAT
-2.26 to -3.26	7.00 to 8.00	10YR 5/1; Ag2, As2, Ga+; Grey silty clay with occasional flint gravel	LOWER ALLUVIUM / COLLUVIUM
-3.26 to -4.06	8.00 to 8.80	10YR 5/1; Ga2, Ag2; Grey silty sand	
-4.06 to -5.26	8.80 to 10.00	10YR 5/1; Ga2, Ag2, Gg+; Grey silty sand with flint gravel fragments	GRAVEL

Table 3: Geoarchaeological description of borehole LR-QBH2

Depth (m OD)	Depth (m bgl)	Description	Stratigraphic Group
4.59 to 1.59	0 to 3.00	Not recovered	MADE GROUND
1.59 to 1.19	3.00 to 3.40	10YR 5/3; As4; Brown clay; gradual contact into:	UPPER ALLUVIUM
1.19 to 0.87	3.40 to 3.72	Gleyl 3/1; As3, Dh1; Very dark greenish gray clay with black mottling and some detrital organic fragments, slightly higher concentrations of organic detritus in weakly developed bands; gradual contact into:	
0.87 to 0.59	3.72 to 4.00	10YR 5/1; As4, Dh+; Grey clay with black mottling and occasional organic fragments	
0.59 to -0.11	4.00 to 4.70	10YR 5/3; As4; Brown clay with black mottling; disturbed; sharp contact into:	COLLAPSE
-0.11 to -0.41	4.70 to 5.00	10YR 5/1; As4, Dh+; Grey clay with black mottling and occasional organic fragments	UPPER ALLUVIUM
-0.41 to -0.87	5.00 to 5.46	10YR 5/3; As4; Brown clay with black mottling; disturbed; uneven contact into:	COLLAPSE
-0.87 to -1.18	5.46 to 5.77	Gleyl 3/1; As4, Dh+, humo3; Very dark greenish gray clay with trace detrital organic fragments; sharp contact into:	UPPER ALLUVIUM
-1.18 to -1.41	5.75 to 6.00	10YR 2/2; T12, Sh2 humo3; Very dark brown firm peat with small humified fragments of woody material	PEAT
-1.41 to -1.51	6.00 to 6.10	VOID	VOID

-1.51 to -1.89	6.10 to 6.48	GleyI 3/I; As4, Dh+, humo3; Very dark greenish gray clay with trace detrital organic fragments, likely to be collapse fill; sharp and uneven contact into:	COLLAPSE
-1.89 to -2.21	6.48 to 6.80	10YR 2/2; TI3, Sh1, humo2; Very dark brown firm woody peat with medium sized fragments of woody material; gradual contact into:	PEAT
-2.21 to -2.41	6.80 to 7.00	10YR 3/2; TI2, As2, Sh+, humo2; Very dark grayish brown woody peat in a clay matrix with large pieces of woody material	
-2.41 to -2.71	7.00 to 7.30	GleyI 4/I; As4; Very dark greenish gray clay, likely to be collapse fill; sharp and uneven contact into:	COLLAPSE
-2.71 to -2.99	7.20 to 7.58	10YR 2/2; TI2, Sh2, humo3; Very dark brown firm woody peat with large wood fragments and abundant well humified unidentifiable organic remains; gradual contact into:	PEAT
-2.99 to -3.25	7.58 to 7.84	10YR 2/2; Sh2, As2, TI+ humo4; Very dark brown well humified organics remains within a clay matrix; sharp contact into:	
-3.25 to -3.36	7.84 to 7.95	GleyI 3/I; As2, Ga1, Lc1; Very dark greenish gray slightly sandy clay with a notable carbonate component; gradual contact into:	LOWER ALLUVIUM / COLLUVIUM
-3.36 to -3.38	7.96 to 7.97	GleyI 7/N; Lc3, Gg1; Light gray carbonate substrate with minor rounded gravel fraction	
-3.38 to -3.41	7.97 to 8.00	VOID	VOID
-3.41 to -3.79	8.00 to 8.38	10YR 2/2; Sh2, As2, TI+ humo4; Very dark brown well humified organics remains within a clay matrix, likely to be collapse fill; sharp contact into:	COLLAPSE
-3.79 to -4.21	8.38 to 8.80	10YR 5/1; Ga2, Gg1, As1; Grey silty sand with occasional flint fragments	GRAVEL
-4.21 to -4.41	8.80 to 9.00	VOID	VOID

Table 4: Geoarchaeological description of borehole LR-QBH3

Depth (m OD)	Depth (m bgl)	Description	Stratigraphic Group
4.64 to 2.44	0 to 2.20	Made Ground	MADE GROUND
2.44 to 0.44	2.20 to 4.20	10YR 5/2; As3, Ag1, Ga+; Stiff greyish brown silty clay with a trace of sand	UPPER ALLUVIUM
0.44 to 0.14	4.20 to 4.50	10YR 5/2; As3, Sh1; Greyish brown organic-rich clay	
0.14 to -0.56	4.50 to 5.20	10YR 4/3; Sh3, TI1; Humo 3; Dark brown well humified disintegrated organic matter and wood peat	PEAT
-0.56 to -0.76	5.20 to 5.40	10YR 5/1; As2, Ag2, Ga+; Grey silty clay with a trace of sand	LOWER ALLUVIUM
-0.76 to -1.96	5.40 to 6.60	10YR 5/1 to 10YR 7/1; Ag2, Ga2, As+, Gg+; Grey to white silty sand with a trace of clay, chalk and flint gravel fragments	GRAVEL
< -1.96	>6.60	White chalk	CHALK

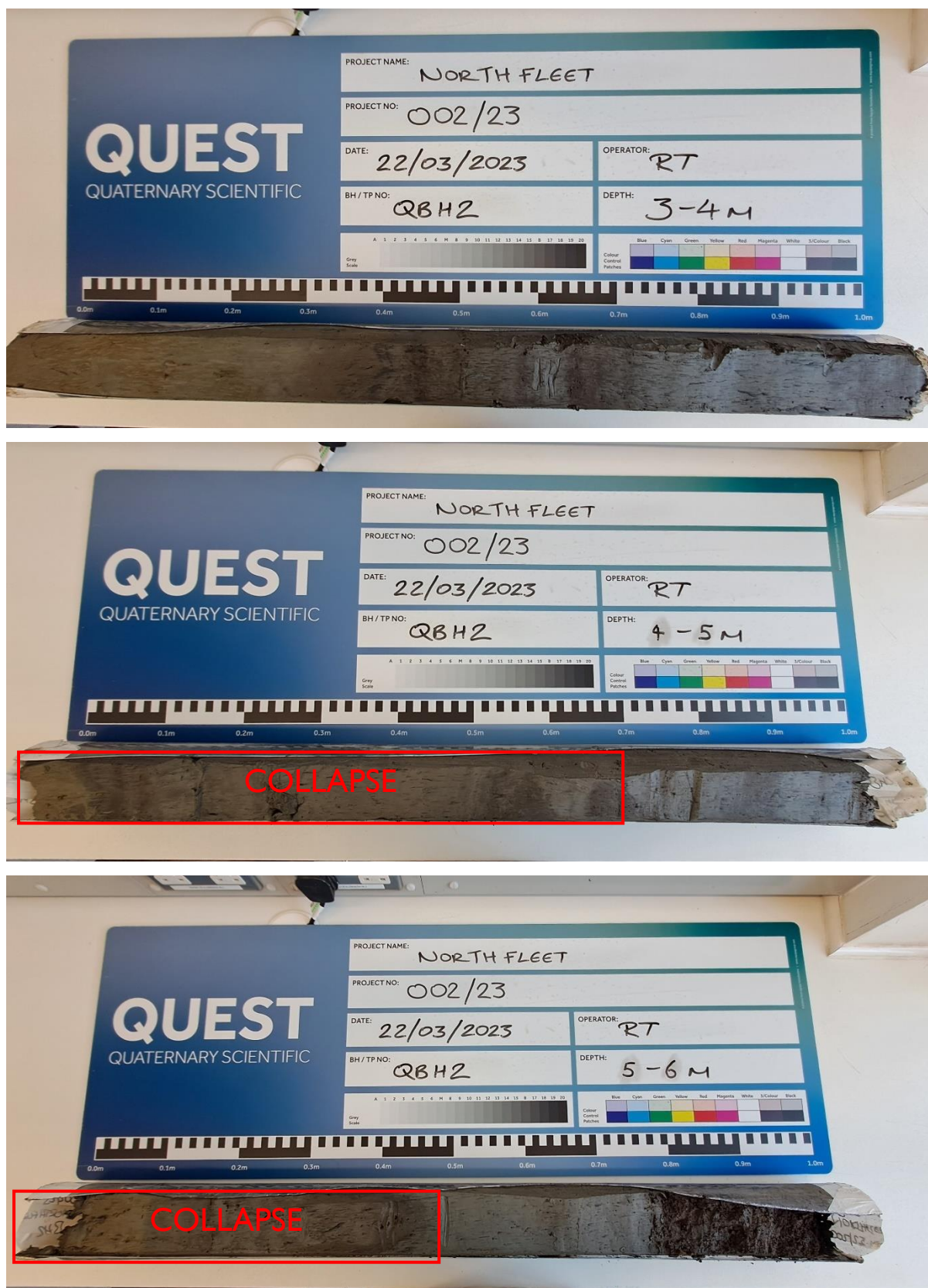


Figure 4: Photographs of LR-QBH2 core samples

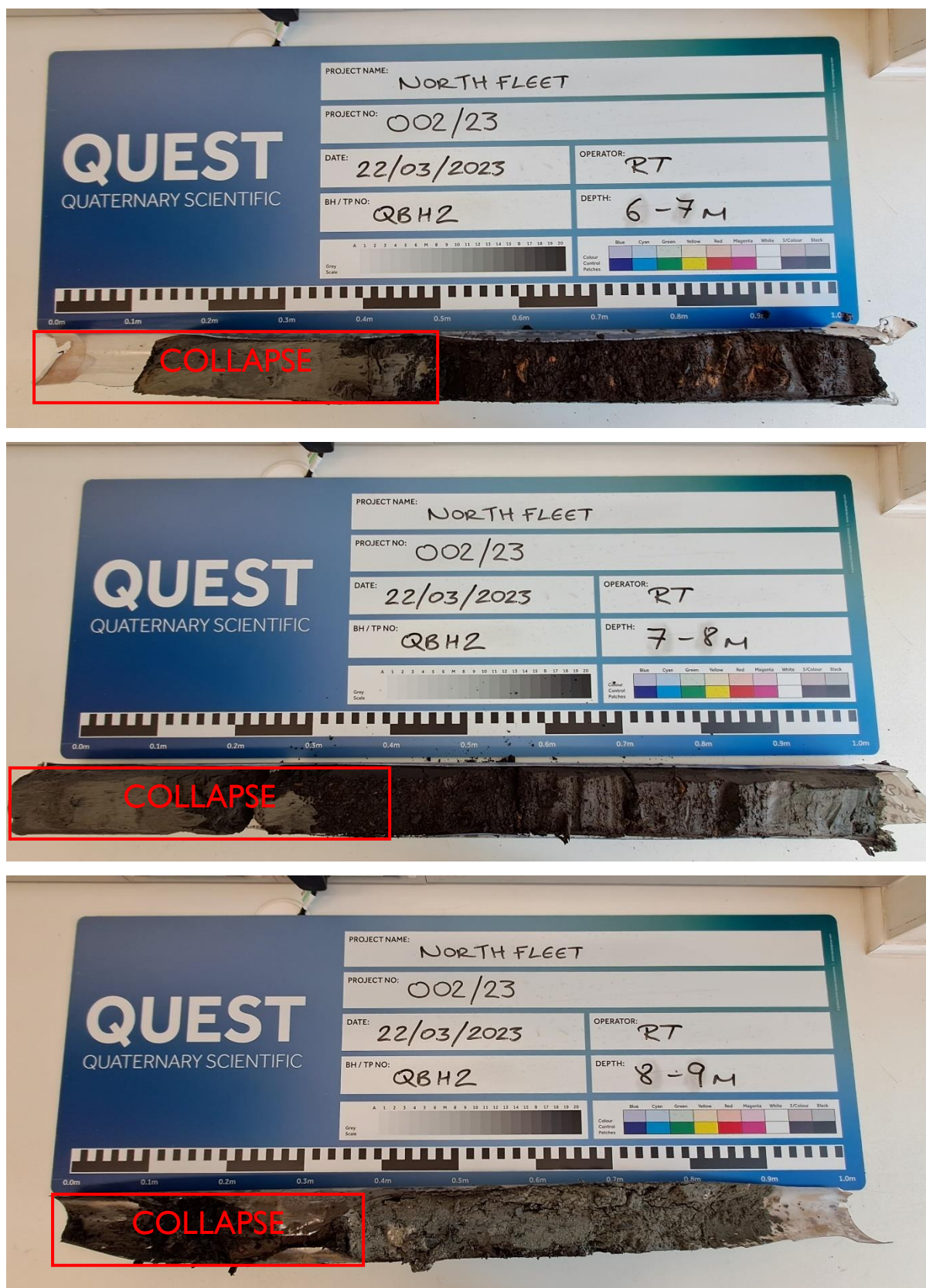


Figure 4 (continued): Photographs of LR-QBH2 core samples

5. RESULTS & INTERPRETATION OF THE DEPOSIT MODELLING & RADIOCARBON DATING

A transect of boreholes from the dryland edge onto the Lower Road site is displayed in Figure 5 (orientated approximately south-west to north-east). For comparative purposes, a transect of boreholes from the nearby Ebbsfleet Football Stadium illustrates the type, thickness and elevation of each major stratigraphic unit recorded on the opposite bank of the Ebbsfleet Valley (Batchelor, 2016; Figure 6). The results of the radiocarbon dating are provided in Figure 5 and Table 6.

The new geotechnical and geoarchaeological records provide a useful insight into the sub-surface stratigraphy of the site. The full sequence of sediments recorded in the boreholes comprises:

Made Ground – widely present

Holocene Alluvial Deposits – widely present on the floodplain

Upper Alluvium with inclusions - Ebbsfleet Football Stadium site only

Upper Alluvium

Peat

Lower Alluvium

Sand – occasionally present on Ebbsfleet Football Stadium site only

Colluvium-Alluvium – occasionally present

Gravel – widely present

Bedrock – widely present

5.1. Bedrock - Chalk

Bedrock chalk is recorded in boreholes TQ67SW523-525 as outcropping between 2.5 and 3.0m OD on the dryland to the west of the site. From here it slopes sharply downwards onto the floodplain reaching -1.96m OD in the south-western corner of the Lower Road (LR-QBH3), and at least -5.26m OD beneath boreholes LR-QBH1 and LR-QBH2 (Figure 5).

On the Ebbsfleet Football Stadium site to the south-east the chalk is recorded as resting between ca. -12.4 and -8m OD (BHX, BHA, BHI-BH3), before rising again to approximately -4m OD (Figure 6). This range of Chalk bedrock surface heights is broadly analogous to those recorded within other boreholes from the HSI and STDR4 investigations (e.g. Bates and Stafford, 2013).

5.2. River Terrace Gravels

The results of the geoarchaeological investigations reveal the presence of sand and sub- to well-rounded flint/chalk gravel overlying the bedrock Chalk; these are not recorded in boreholes beyond the floodplain edge (TQ67SW523-525). Occasionally, finer grained deposits of sandy, silty clay with chalk and pebbles are also recorded within/beneath the gravel deposits (e.g. LR-QBH3). The sand and gravel deposits represent deposition within a high energy braided river environment; the finer-grained sediment with chalk and pebbles (where present) more likely represents material derived from soil creep during permafrost conditions (solifluction). Both sediment types (collectively termed here the River Terrace Gravels) were deposited during the Pleistocene (2.6 million to 11,500 years ago).

These gravel deposits slope downwards towards the centre of the floodplain, as demonstrated by the transects across both the Lower Road and Ebbsfleet Football Stadium sites (Figures 5 & 6). On the Lower Road site, the surface of the Gravels reduces from ca. -0.8 to -4m OD. The transect of boreholes traversing Ebbsfleet Football Stadium show the surface of the River Terrace Gravels sloping gradually downwards in a south-easterly direction, from -5.6 to -8.4m OD (BHX to BHI), before rising very steeply at the end of the transect to -5.61m OD in QBH4. The thickness of the River Terrace Gravels also appears to increase in the same direction.

5.3. Colluvium-Alluvium

During work associated with Ebbsfleet Football Stadium, the River Terrace Gravels were occasionally found to be overlain by deposits comprising silts, sands, flint and chalk gravels. The unit was distinguished from the River Terrace Gravels by the poor sorting and angular to rounded nature of the chalk and flint, together with the greater amount of finer grained deposits. The deposits range from 0.5 to 3.5m in thickness (QBH4 & BHI respectively; Figure 6).

On the current Lower Road site, these deposits are only tentatively identified. As outlined in section 5.2, deposits similar to this were recorded in LR-QBH3 immediately above the Chalk. These were interpreted as River Terrace Gravels but could potentially represent a mixture of colluvial and alluvial material. A thin layer of carbonate rich deposits was also noted in LR-QBH2.

These deposits are considered likely to reflect a combination of alluvial (fluvial) and colluvial (hillwash) processes; the latter being a consequence of the sites being adjacent to the Ebbsfleet valley side. It is also considered likely that deposit dates to the late Devensian / early Holocene when the valley sides would have been less stable as a consequence of limited vegetation cover. The presence of this unit corresponds to BGS mapping which records Head deposits along the edge of the Ebbsfleet Valley (Figure 2) and includes the head deposits identified in TQ67SW523 and 525 adjacent to the Lower Road.

5.4. Sand

Overlying the River Terrace Gravels (BHX, QBH1, QBH3) or Colluvium / Alluvium (QBH4, BHY; QBH4) in boreholes from the Ebbsfleet Football Stadium site is a dense light grey silty sand, ranging between 0.07 and 0.30m in thickness (Figure 6). Fine-grained laminations recorded in QBH1 confirm the alluvial origin of the deposit in all boreholes regardless of elevation. However, the presence of *in situ* flint/plant remains at the top of the deposit in BHX at the north-western end of the Ebbsfleet Football Stadium site indicate that it became a former, probably periodically inundated land-surface. No obvious evidence of soil forming processes were noted during description of the sequences, but the highly compacted nature of the sediment enhanced this interpretation.

The apparent absence of this unit in boreholes from the Lower Road site is not unsurprising, given the location of the site on the floodplain edge. However, whether the sand did/did not originally form across the rest of the site, was subsequently eroded, or was missed due to differing drilling/descriptive methods is unknown. The age of the deposit is also currently unclear. However its age is constrained by the Mesolithic artefacts which rest above the unit in BHX.

The surface of the Sands (or Colluvium-Alluvium / River Terrace Gravels where not recorded), is interpreted as representing the early Holocene surface. This horizon is illustrated in both borehole transects (Figures 5 & 6), indicating a surface that slopes steeply downwards from the floodplain edge.

5.5. Holocene Alluvial Deposits

A sequence of Holocene alluvial and peat/organic-rich sediments overlie the early Holocene surface, which are divided here into: (1) the Lower Alluvium; (2) Peat and organic-rich sediments, and (3) the Upper Alluvium. The tripartite sequence detailed below is commonly recorded along the course of the Lower Thames Valley and its tributaries. However, the sequences from Ebbsfleet Football Stadium also contain a variation of the Upper Alluvium not widely recorded, which are referred to here as: 'Upper Alluvium with inclusions'.

5.6. Lower Alluvium

The Lower Alluvium is a predominantly silty or clayey unit which frequently contains detrital wood or plant remains, and in certain records from the Ebbsfleet Football Stadium site is described as organic rich, or peaty, or with traces of peat. Where present, it rests sharply on the early Holocene surface. The sharpness of the contact suggests that there is likely to have been a hiatus in sediment accumulation. The surface of the Lower Alluvium (Figures 5 & 6) is highly variable, resting between -7m and -0.56 OD and ranges in thickness from 0m to >4m. The thicker occurrences of the Lower Alluvium tend to be present where the surface of the preceding sediment is at a lower level.

The sediments of the Lower Alluvium are indicative of deposition during the Early to Mid-Holocene, when the main course of the Thames was probably confined to a single meandering channel. During this period, the surface of the Shepperton Gravel was progressively buried beneath the sandy and silty flood deposits of the river. The richly-organic nature of the Lower Alluvium suggests that this was a period during which the valley floor was occupied by a network of actively shifting channels, with a drainage pattern on the floodplain that was still largely determined by the relief on the surface of the underlying Gravel.

5.7. Peat

Overlying the Lower Alluvium in the majority of cases is a complex of Peat and organic-rich sediments. In Lower Road boreholes LR-QBH1 and LR-QBH2, these are approximately 1.5-2.0m in thickness, when taking into account the voids in the window-sampled sequence. It is thinner in LR-QBH3 (0.7m) reflecting the position of the sequence closer to the floodplain edge (Figure 5). The surface of Peat ranges between 0 and -1.2m OD. Across the Ebbsfleet Valley Football Stadium site, the peat and organic-rich deposits are more variable in thickness, ranging from 1m (BHY) to 5m (QBH3). The surface of the peat by comparison, is fairly level between -2.0m and -3.0m OD. Further organic-rich horizons also occur higher up in the borehole BHY between 1.0 and -0.5m OD,

The occurrence of these semi-terrestrial floodplain deposits indicates a general transition from the fluvial environmental conditions of Lower Alluvium. The type of Peat / organic-rich deposits recorded include: (1) clays with high amounts of sedge and reed remains; (2) clays with high amounts of wood remains; (3) herbaceous peat and (4) wood peat. These are suggestive of shifts between reed swamp, alder carr, sedge fen and fen woodland environments respectively; all of which are typical of floodplain environments. However, unlike the sequences recorded during the HSI / STDR4 investigations which recorded a clear arrangement of deposits from wood peat to reed peat, the sequences from both Lower Road and Ebbsfleet Football Stadium site represent a much more complex and less uniform arrangement of deposit types (Bates and Stafford, 2013). This is considered to be a reflection of the marginal location of both sites adjacent to the valley side.

Radiocarbon dating of the peat in LR-QBH2 indicates that it accumulated from 6670-6490 cal BP (4790-4540 cal BC) to 3700-3490 cal BP (1750-1540 cal BC). This equates to accumulation from the late Mesolithic to Bronze Age period. No radiocarbon dating of the sequences from Ebbsfleet Football Stadium have yet been carried out. However, the HSI / STDR4 investigations also recorded these deposits as accumulating from the late Mesolithic / early Neolithic through to the late Bronze Age / early Iron Age (Bates and Stafford, 2013), with Roman and middle-late middle Saxon deposits also recorded.

5.8. Upper Alluvium

The uppermost unit in the Holocene alluvial sequence across both the Lower Road and Ebbsfleet Football Stadium sites is the Upper Alluvium, the deposits of which comprise clays and silty clays, ranging between 0.5 and 3.5m in thickness. The Upper Alluvium is often sterile, but certain sequences contain organic-rich remains (e.g. LR-QBH1). The deposition of the Upper Alluvium had the effect of infilling the remaining inequalities in the relief of the floodplain, so that the surface of the Upper Alluvium (Figure 5) is relatively level around +1-+2m OD (with a few exceptions).

The Upper Alluvium is typical of the mineral-rich sediments that are present as the uppermost element of the Holocene sequence beneath most floodplains in southern and south-east England. It is generally considered to 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.

5.9. Upper Alluvium with inclusions

Overlying the Upper Alluvium in sequences from the Ebbsfleet Football Stadium, is a coarser deposit often described as silty sandy clay with iron-staining and occasional chalk and gravel fragments. The base of this unit is generally recorded between -0.5 and 1.6m OD with an upper surface ranging between 1.6 and 2.8m OD (Figure 6). This deposit is considered to represent a continuation of the environmental conditions resulting in the deposition of the Upper Alluvium. However, the occurrence of chalk/gravel clasts is unlike that recorded elsewhere in the Ebbsfleet or Lower Thames Valleys; it is not recorded in the Lower Road sequences, and there is no mention of such clasts being present in the HSI / STDR4 geoarchaeological boreholes for example (Bates and Stafford, 2013).

It is possible the occurrence of these clasts is a consequence of the location of the site, which as outlined above, lies across most of the Ebbsfleet floodplain close to its confluence with the Thames and adjacent to the valley side along Phase 1B. It seems very likely that the Ebbsfleet in its semi-natural condition in the late prehistoric and early historic periods (i.e. when the Upper Alluvium was being deposited) had the opportunity to cut into and erode chalk/flint-bearing head and hence for chalk and flint to be present in the Upper Alluvium. Such erosion need not have been more than very localised which would explain the presence of chalk at Stonebridge Road but not in the area upstream investigated by Bates and Stafford. Alternatively, and bearing in mind that chalk clasts are apparently exclusively recorded in the upper part of the Upper Alluvium (probably of historic age), their presence might reflect some land-use activity leading to localised soil erosion and wash of chalky debris onto the floodplain within, adjacent to, or just upstream from the site.

5.10. Made Ground

Made Ground caps the Holocene alluvial deposits in all boreholes, ranging in thickness up to 4m.

Table 5: Results of the borehole LR-QBH2 radiocarbon dating

Lab code	Borehole & Material	Depth (m OD)	Uncalibrated years before present (yr BP)	Calibrated age BC/AD (BP) (2-sigma, 95.4% probability)	$\delta^{13}\text{C}$ (‰)
BETA-661062	QBH2; twig wood	-1.26 to -1.28	3380 $\pm$ 30	1750-1540 cal BC 3700-3490 cal BP	-25.3
BETA-661063	QBH2; twig wood	-2.01 to -2.03	4230 $\pm$ 30	2910-2690 cal BC 4860-4640 cal BP	-29.2
BETA-661064	QBH2; twig wood	-2.81 to -2.83	4140 $\pm$ 30	2880-2580 cal BC 4830-4530 cal BP	-29.0
BETA-661065	QBH2; twig wood	-3.16 to -3.18	5800 $\pm$ 30	4790-4540 cal BC 6670-6490 cal BP	-25.5

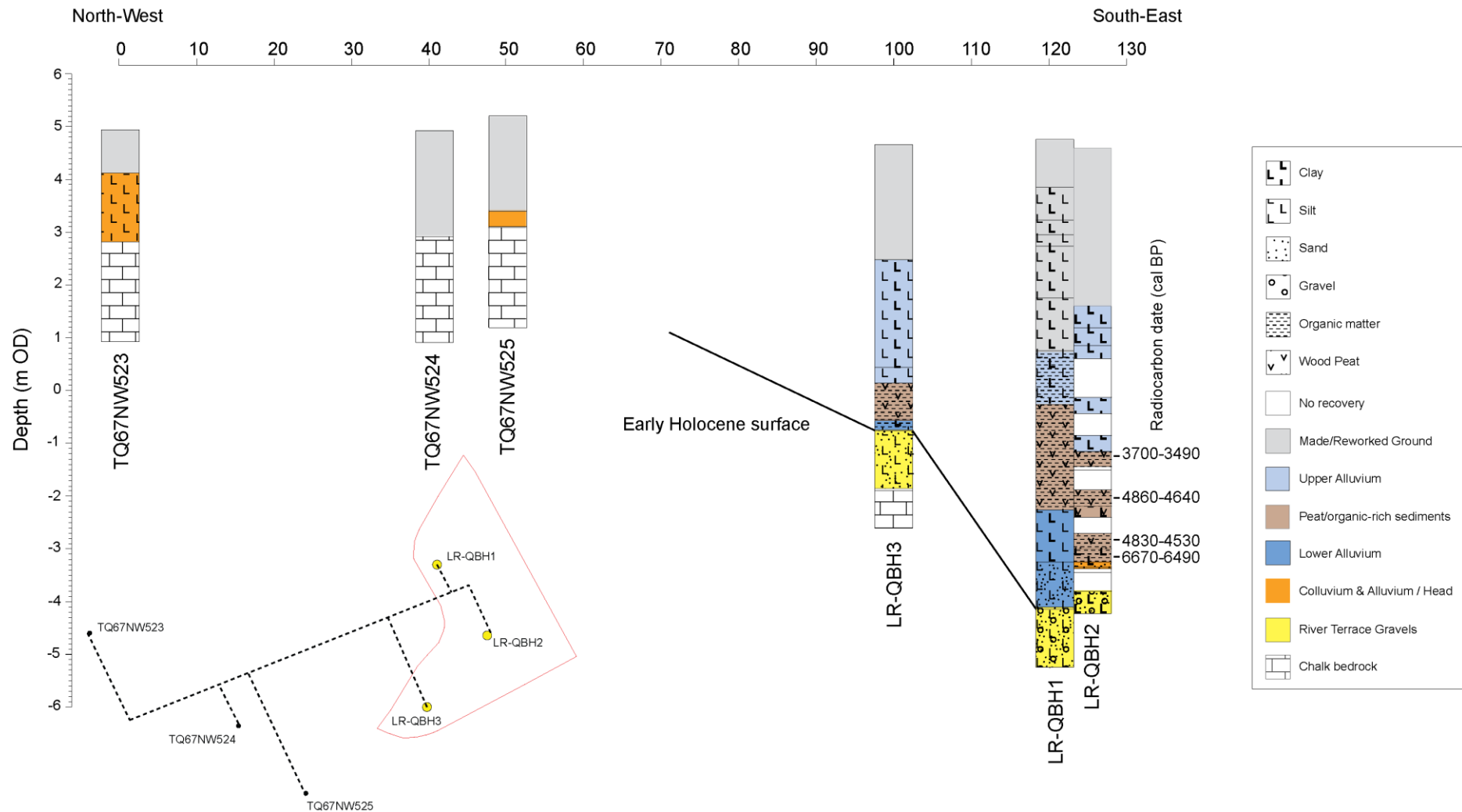


Figure 5: North-west to south-east transect projecting from the dryland edge across the Lower Road site



Figure 6: North-west to south-east transect across Ebbsfleet Football Stadium

6. RESULTS & INTERPRETATION OF THE POLLEN ASSESSMENT

The results of the pollen assessment indicate a variable concentration and preservation of remains (Table 6).

In the lowermost sample at -3.27m OD, no pollen is preserved. This is not unsurprising given the 'slightly sandy clay with a notable carbonate component' from which the sample originates; pollen preserves best in acidic and anoxic environments, the opposite of a carbonate type deposit.

The two overlying samples at -3.19 and -3.11m OD both contain a very high concentration of pollen in a good state of preservation. However, the two assemblages differ markedly in their pollen assemblage. The lower of the two samples is dominated by *Quercus* (oak) with *Corylus* type (hazel), and sporadic occurrences of *Tilia* (lime), *Sambucas nigra* (elder) and herbs Poaceae (grasses), Asteraceae (daisies) and *Chenopodium* type (goosefoot family). The sample at -3.11m OD is also characterised by high values of tree and shrub pollen, but this time is dominated by *Alnus* (alder) with *Quercus*, *Corylus* type, *Tilia* and *Ulmus* (elm); herbs include Poaceae, Cyperaceae (sedges) and *Chenopodium* type. Both samples originate from a deposit of organic-rich remains within a clay matrix.

The lowermost sample is indicative of a dryland woodland environment dominated by oak, lime and hazel, with a ground flora of grasses and mixed herbs; there is no definitive evidence for local wetland conditions within this sample. Mixed deciduous woodland of oak, lime, elm and hazel still occupied the dryland environment within the subsequent sample at -3.11m OD, but wetland conditions were clearly now present on the Lower Road site, with the expansion of alder woodland and sedge fen / reed marsh type communities in the pollen record. This recorded change is a clear indication of paludification; the expansion of wetland onto former areas of dryland, leading to the retreat of dryland vegetation communities. The presence of *Chenopodium* type pollen is also of note in both samples. These can be split into two broad groups, those associated with brackish and marine environments such as *Salsola kali*, (saltwort) and those commonly found in waste places and the edges of arable fields on dryland, such as *Chenopodium album* (fat hen). In the absence of diatom data, it is uncertain which of these environments the *Chenopodium* pollen might represent. Ordinarily, a brackish signal would be the most likely (on the basis of other records from the Lower Thames Valley). However, there is clear evidence of human activity (and thus probable disturbance) in the archaeological record dating to the late Mesolithic / early Neolithic.

The samples between 2.95 and -1.37m OD all contain a low or very low concentration of pollen in a moderate state of preservation. This is somewhat unusual given that these samples all originate from

peat deposits, which ordinarily have good potential for pollen concentration and preservation, due to the anoxic and acidic environment in which they form. The most likely explanation is that the peat recorded on the Lower Road site was described as predominantly highly humified, unidentifiable and woody in nature; it also had a very strong odour. All these factors suggest that the peat surface was very dry at or after the time that it accumulated, leading to its highly humified nature, and thus poorer pollen concentration/preservation. Nevertheless, the continuing presence of *Alnus*, *Quercus*, *Tilia*, *Corylus* type and occasional herbs, is suggestive of a continuance of wetland woodland on the floodplain, and mixed deciduous woodland on the dryland.

The final three samples (-1.21 to -1.13m OD) all contain a high concentration of remains characterised by high values of herbaceous taxa. Cyperaceae and Poaceae dominated with Asteraceae, and other taxa including Lactuceae (dandelions), *Artemisia* (mugwort), Caryophyllaceae (pinks) and *Ranunculus* type (buttercups); aquatic *Sparganium* type (bur-reed) was also recorded. Trees and shrubs were reduced to lower values of *Quercus*, *Alnus* and *Corylus* type. On the floodplain, the reduction of alder and increase of sedge fen / reed swamp communities occur at the transition from peat to alluvium, and thus are almost certainly related to peatland inundation. The diatom record strongly indicates an increasing saline influence during this period. On the dryland, oak values fluctuate but generally reduce, whilst hazel and lime pollen values decline representing a reduction in mixed deciduous woodland. Due to the synchronous nature of the transition into the alluvium, it is likely that this is at least in part due to changes taking place on the wetland – waterlogging perhaps causing the retreat of dryland taxa close to the floodplain edge. However, this transition also dates to the Bronze Age, and a greater number of herbaceous taxa are also recorded, suggestive of land clearance for both animal grazing and cultivation.

Table 6: Results of the borehole LR-QBH2 pollen assessment

	Depth (m OD)	-1.13	-1.17	-1.21	-1.37	-2.01	-2.17	-2.33	-2.79	-2.95	-3.11	-3.19	-3.27
	Stratigraphy	UA		Peat									LA / C
Latin name	Common name												
Trees													
<i>Alnus</i>	alder	4	1		2	1	2		2	2	69		
<i>Quercus</i>	oak	7	1	7	1		1	1	4	1	20	51	
<i>Pinus</i>	pine										1		
<i>Ulmus</i>	elm										4		
<i>Tilia</i>	lime				1	1			3		6	1	
<i>Fraxinus</i>	ash												
<i>Betula</i>	birch										1		
Shrubs													
<i>Corylus</i>	hazel	1	5	4	2	3	1	3	2		16	4	
<i>Hedera</i>	ivy					2							
<i>Sambucas nigra</i>	elder											1	
Herbs													
Cyperaceae	sedge family	11	9	12	2	3			1		1		
Poaceae	grass family	8	3	7		1					4	2	
Asteraceae	daisy family	1	1	1								3	
Lactuceae	dandelion family			1					1				
<i>Artemisia</i>	mugwort		1										
<i>Plantago lanceolata</i>	ribwort plantain	1											
<i>Chenopodium</i> type	goosefoot family										2	1	
Caryophyllaceae	pink family	1											
<i>Ranunculus</i> type	buttercup		1										
Aquatics													
<i>Sparganium</i> type	bur-reed	1											
Spores													
<i>Filicales</i>	ferns				4	11			34		1		
<i>Polypodium vulgare</i>	polypody			1		1							

	Depth (m OD)	-1.13	-1.17	-1.21	-1.37	-2.01	-2.17	-2.33	-2.79	-2.95	-3.11	-3.19	-3.27
	Stratigraphy	UA		Peat									LA / C
Latin name	Common name												
Total Land Pollen (grains counted)		34	22	32	8	11	4	4	13	3	124	62	0
Concentration*		5	3	5	2	2	1	1	2	1	5	5	0
Preservation**		4	4	4	3	3	3	3	3	3	4	4	0
Microcharcoal Concentration***		1	1	2	1	1	0	1	1	1	1	1	0
Suitable for further analysis		Y	Y	Y	N	Y	N	N	Y	N	Y	Y	N

Key: Stratigraphy: LA / C = Lower Alluvium / Colluvium; UA = Upper Alluvium; *Concentration: 0 = 0 grains; 1 = 1-75 grains, 2 = 76-150 grains, 3 = 151-225 grains, 4 = 226-300, 5 = 300+ grains per slide; **Preservation: 0 = absent; 1 = very poor; 2 = poor; 3 = moderate; 4 = good; 5 = excellent; ***Microcharcoal Concentration: 0 = none, 1 = negligible, 2 = occasional, 3 = moderate, 4 = frequent, 5 = abundant

7. RESULTS & INTERPRETATION OF THE DIATOM ASSESSMENT

Diatom presence varied between samples, with two of the four samples yielding no diatoms. These barren samples derived from beneath the thick peat unit. In contrast, the two samples from the upper section of QBH2 contained diatoms in high abundance and diversity. Table 7 provides a summary of the most common diatoms encountered during provisional presence-absence assessment. The most abundant species are highlighted in bold within the Table, followed by a list of the most common subordinate taxa encountered during assessment. If no species are highlighted in bold, it indicates that either no single species was encountered in relative abundance when compared to other species present or, or overall diatom abundance was very low. Those samples in which diatoms were absent are highlighted in Table 7 with '*'.

Subsequent interpretations are deemed provisional and based on very limited diatom counts. Diatoms were encountered in contrasting abundance and diversity within the samples under consideration. The basal samples, derived from beneath the extensive ca. 3m peat unit, were found to be barren of diatoms. As such, the diatoms assessment is unable to provide any preliminary comments with regards the depositional environmental that were responsible for the development of the basal alluvium underlying the peat.

In contrast, those samples from the alluvium encountered overlying the peat contained diatoms in very high abundance and species diversity. In addition to this, there also appears to be some species diversity between the two samples. The unit immediately overlying the peat (-1.17m OD) contains a mixture of diatoms with varying salinity tolerances, including diatoms more often associated with marine and brackish conditions (e.g. *Nitzschia navicularis*, *Caloneis formosa*, *Navicula peregrina*, *Diploneis didyma*) and species more often associated with lower salinity conditions (*Cosmioneis pusilla*, *Navicula viridula*, *Epithemia turgida*, *Gyrosigma wansbeckii*, *Tryblionella* sp). In addition, one of the most abundant species is *Diploneis interrupta*, which is typical of deposition within the supratidal zone. In contrast, the sample from a higher elevation within the alluvium (-1.01m OD) contains an assemblage much more typified by marine and brackish diatoms (e.g. *Nitzschia navicularis*, *Navicula peregrina*, *Caloneis formosa*, *Actinoptychus senarius*, *Paralia sulcata*, *Nitzschia sigma*, *Nitzschia punctata*, *Navicula digitoradiata*), with those diatoms typical of lower salinity conditions being almost wholly absent. This variation with height tentatively suggests an increase in saline influence with height through the stratigraphy (and hence with time) after the development of the (assumed) freshwater peat unit.

Table 8: Summary of key diatom taxa encountered during presence-absence assessment of LR-QBH2, Lower Road, Northfleet.

Depth (m OD)	Diatoms encountered
-1.01	Nitzschia navicularis Navicula peregrina Caloneis formosa <i>Paralia sulcata</i> <i>Cyclotella striata</i> <i>Diploneis didyma</i> <i>Actinopterychus senarius</i> <i>Nitzschia sigma</i> <i>Nitzschia punctata</i> <i>Nitzschia digitoradiata</i> <i>Cerataulis smithii</i> <i>Gyrosigma acuminatum</i>
-1.17	Navicula peregrina Diploneis interrupta Nitzschia navicularis <i>Epithemia turgida</i> <i>Gyrosigma wansbeckii</i> <i>Tryblionella</i> sp. <i>Surirella striatula</i> <i>Caloneis formosa</i> <i>Cosmioneis pusilla</i> <i>Navicula viridula</i> <i>Diploneis didyma</i> <i>Rhaphoneis amphicaros</i>
-3.25 7.84-7.85m	n/a
-3.37 7.96-7.97m	n/a

If preservation was good, the most abundant taxa are present in bold, at the top of each sample list. Samples with limited/poor assemblages are highlighted with “*” next to the sample depth

8. RESULTS OF THE MACROFOSSIL ASSESSMENT

Samples were taken from four horizons for the recovery of macrofossil remains from the peat of borehole LR-QBH2. Waterlogged wood was recorded in all samples. The majority of this was <2mm in size and thus unidentifiable. Occasional fragments >2mm were recorded in samples -2.01 to -2.06 and -2.81 to -2.86m OD that could be identified. Waterlogged seeds were also occasionally recorded in each sample, with very high quantities recorded in the uppermost sample at -1.26 to -1.31m OD. These included most frequently *Carex* sp. (sedges) with *Sambucas* (elder), *Rubus* sp. (bramble), and *Chenopodium* sp. (goosefoot) as well as some unknown taxa. Other noted macrofossil remains included ostracods in the uppermost two samples, and insects in the top sample.

Table 8: Results of the macrofossil assessment of samples from borehole LR-QBH2

Depth (m OD)	Unit	Volume processed (ml)	Fraction	Charred					Waterlogged			Mollusca		Ostracods	Bone			Insects	Notes
				Charcoal (>4mm)	Charcoal (2-4mm)	Charcoal (<2mm)	Seeds	Chaff	Wood	Seeds	Sedge remains (e.g. stems/roots)	Whole	Fragments		Large	Small	Fragments		
-1.26 to -1.31	Peat	<100	>300	-	-	-	-	-	4	5	-	-	-	3	-	-	-	1	WPM total (~105); Carex sp. (>90); c.f. Sambucus (1); c.f. Chenopodium (1); c.f. Rubus (1); Unknown (3*). Most seeds handpicked.
-2.01 to -2.06		<100	<300	-	-	-	-	-	5	1	-	-	-	1	-	-	-	-	Misc seed casing c.f. Carex sp. (2)
-2.81 to -2.86		<100	<300	-	-	-	-	-	5	1	-	-	-	-	-	-	-	-	Misc seed casing (1); Carex sp. (1); larger wood fragments root/bark: no ID
-3.16 to -3.21		<100	<300	-	-	-	-	-	2	1	1	-	-	-	-	-	-	-	Misc seed casings (>10); indet seeds (2)

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+

9. CONCLUSIONS & RECOMMENDATIONS

Geoarchaeological fieldwork and palaeoenvironmental assessment was undertaken at the Lower Road site in order to: (1) to clarify the nature of the sub-surface stratigraphy across the site; (2) to enhance our understanding of the nature, depth, extent and date of any former land surfaces, chalk, head, alluvial and peat deposits, and (3) determine the palaeoenvironmental potential of the site through pollen, diatom and macrofossil assessment.

The results of these works have revealed a sequence of Chalk Bedrock overlain by River Terrace Gravels, Colluvium/Alluvium, a tripartite sequence of Lower Alluvium, Peat & Upper Alluvium, capped by Made Ground. These deposits slope downwards from north-west to south-east across the site, as would be expected given the position of the site on the western edge of the Ebbsfleet Valley. Radiocarbon dating of borehole LR-QBH2 indicates that peat accumulation took place from the late Mesolithic through to the Bronze Age. The nature and age of the sequence has parallels with the findings from Ebbsfleet Football Stadium on the opposite side of the Ebbsfleet Valley, and with the HSI / STDR4 investigations (Bates and Stafford, 2013).

Prior to the formation of peat deposits, the results of the pollen assessment indicate a dryland environment occupied by mixed deciduous woodland. Peat initiation led to the development of alder woodland and sedge fen / reed swamp conditions at the very end of the late Mesolithic, whilst mixed deciduous woodland continued to occupy the dryland. Pollen concentrations are very low throughout the accumulation of the peat, but sporadic counts suggest a continuation of these wetland and dryland woodland communities. Towards the top of the peat however, the pollen and macrofossil records suggest opening of the woodlands on both the wetland and dryland in response to both wetter conditions and Bronze Age land clearance for settlement / agricultural purposes. The results of the diatom assessment suggest that the transition from Peat into the Upper Alluvium reflects an increase in saline conditions.

Further palaeoenvironmental analysis of the pollen, diatom and macrofossil remains has the potential to provide further insights into the former environments and to increase knowledge and understanding of the interactions between relative sea level, human activity, vegetation succession and climate in this area of the Lower Thames Valley. However, given the variable and often limited concentration of remains, and quality of the retained sequences from the site, the degree of additional information that might be gained is considered to be limited. As such no further work is recommended, and the core samples from the site should be discarded. Nevertheless, the work undertaken on the Lower Road site provides important information on the stratigraphic sequences from this part of the Ebbsfleet Valley.

10. SITE ARCHIVE

Since no further work is considered worthwhile, the material archive (the core samples, sub-samples, pollen and diatom samples) is to be discarded upon completion of this assessment stage. The site archive therefore comprises: (1) the lithological descriptions; (2) digital photographs of the cores; (3) co-ordinates of the boreholes; (4) results of the radiocarbon dating; (5) data arising from assessment of the palaeobotanical remains (i.e. the pollen, diatoms and macrofossils). All of this data is inserted directly into this report, which is to be submitted to the HER. Copies of the HER summary form and OASIS form can be found in Appendix 2 & 3 respectively.

11. REFERENCES

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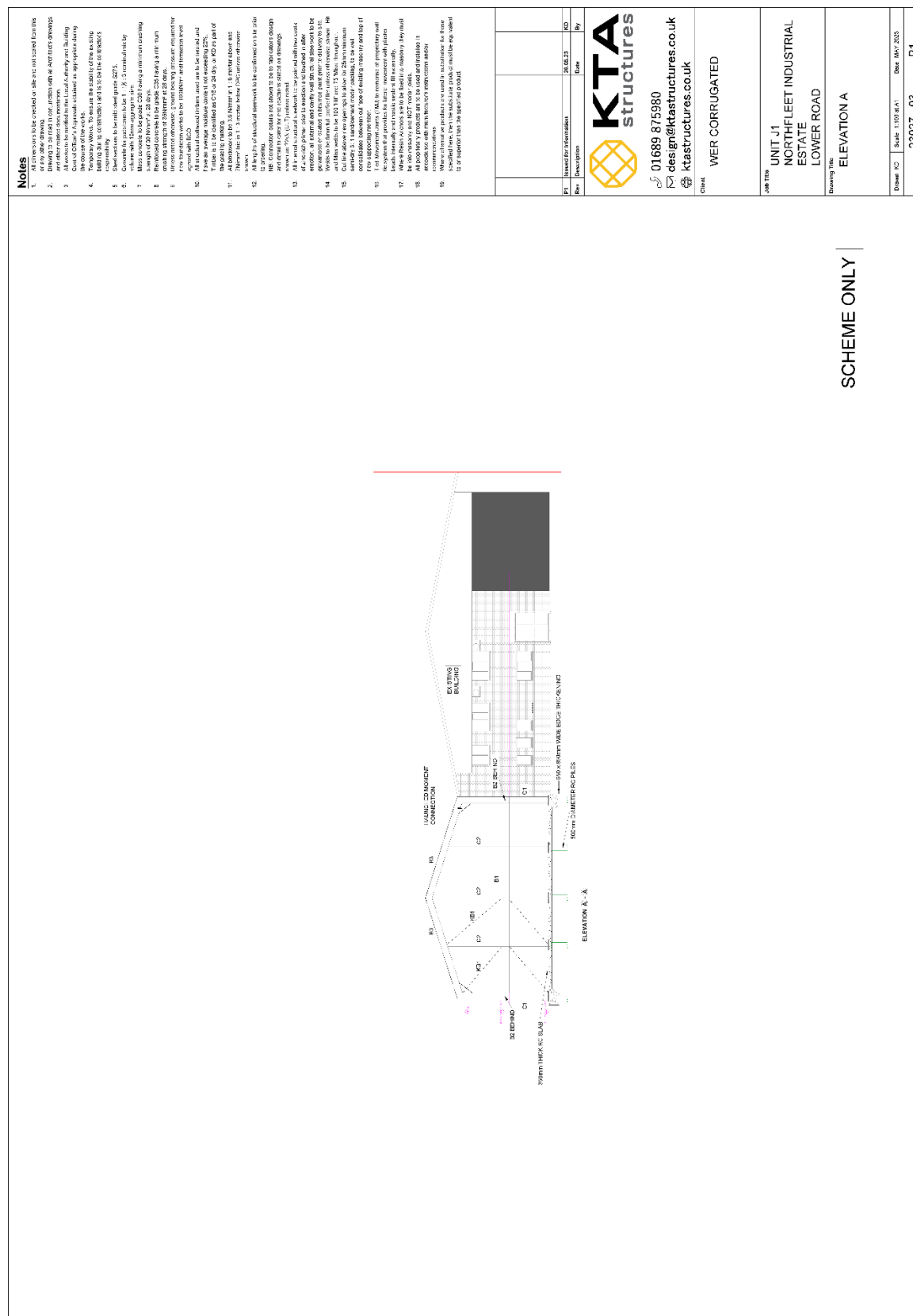
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I2. APPENDIX I: DESIGN PLANS

[illegible]



13. APPENDIX 2: HER SUMMARY FORM

APPENDIX 1 Kent County Council HER summary form

Site Name: WER Packing Supplies, Unit J1,											
Site Address: Lower Road, Northfleet Gravesend											
Summary: (50 words max): A geoarchaeological borehole survey revealed a sequence of alluvial and peat deposits overlying Pleistocene Gravels. Subsequent assessment revealed the peat dated from the late Mesolithic to Bronze Age periods. Pollen, diatom and waterlogged wood remains were present, but not in sufficient concentrations to recommend further analysis.											
District/Unitary: Gravesham	Parish: Gravesham, unparished area										
Period(s): Late Mesolithic to Bronze Age											
NGR (centre of site: 8 figures): TQ 61312 75108 (NB if large or linear site give multiple NGRs)											
Type of archaeological work (underline) <table border="0"> <tr> <td>Evaluation:</td> <td>Watching Brief</td> <td>Field Walking</td> </tr> <tr> <td>Documentary study</td> <td>Building recording</td> <td>Earthwork survey</td> </tr> <tr> <td>Excavation:</td> <td>Geophysical Survey</td> <td>Field Survey</td> </tr> </table> <u>Geoarchaeological investigation</u>			Evaluation:	Watching Brief	Field Walking	Documentary study	Building recording	Earthwork survey	Excavation:	Geophysical Survey	Field Survey
Evaluation:	Watching Brief	Field Walking									
Documentary study	Building recording	Earthwork survey									
Excavation:	Geophysical Survey	Field Survey									
Date of Recording:											
Unit undertaking recording: Quest, University of Reading											
Geology:											
Title and author of accompanying report: Batchelor, C.R., Hill, T., Timms, R. & Dudgeon, K. (2023) WE Roberts – J1 Extension, Lower Road, Northfleet: Geoarchaeological Fieldwork & Palaeoenvironmental Assessment Report. Quaternary Scientific (QUEST) Unpublished Report June 23; Project Number 002/23.											
Summary of fieldwork results (begin with earliest period first, add NGRs where appropriate) (200 words max) The results of the geoarchaeological fieldwork have revealed a sequence of Chalk Bedrock overlain by River Terrace Gravels, Colluvium/Alluvium, a tripartite sequence of Lower Alluvium, Peat & Upper Alluvium, capped by Made Ground. These deposits slope downwards from north-west to south-east across the site, as would be expected given the position of the site on the western edge of the Ebbsfleet Valley. Radiocarbon dating of borehole LR-QBH2 indicates that peat accumulation took place from the late Mesolithic through to the Bronze Age. (cont on attached sheet)											
Location of archive/finds: Digital archive only, held within this report and at Quest, University of Reading											
Contact at Unit: Rob Batchelor	Date: 08/06/23										

I 4. APPENDIX 3: SUMMARY OASIS FORM

Summary for quaterna1-516371

OASIS ID (UID)	quaterna1-516371
Project Name	Environmental Intervention at WE Roberts - J1 Extension, Lower Road
Sitename	WE Roberts - J1 Extension, Lower Road
Activity type	Environmental Intervention
Project Identifier(s)	WE Roberts – J1 Extension, Lower Road
Planning Id	20221142
Reason For Investigation	Planning: Pre application
Organisation Responsible for work	Quaternary Scientific (QUEST)
Project Dates	13-Mar-2023 - 08-Jun-2023
Location	WE Roberts - J1 Extension, Lower Road NGR : TQ 61312 75108 LL : 51.45197900407582, 0.320197491161676 12 Fig : 561312,175108
Administrative Areas	Country : England County : Kent District : Gravesham Parish : Gravesham, unparished area
Project Methodology	Geoarchaeological borehole survey Palaeoenvironmental assessment (including radiocarbon dating, pollen, diatoms, macrofossils)
Project Results	The results of the geoarchaeological fieldwork have revealed a sequence of Chalk Bedrock overlain by River Terrace Gravels, Colluvium/Alluvium, a tripartite sequence of Lower Alluvium, Peat & Upper Alluvium, capped by Made Ground. These deposits slope downwards from north-west to south-east across the site, as would be expected given the position of the site on the western edge of the Ebbsfleet Valley. Radiocarbon dating of borehole LR-QBH2 indicates that peat accumulation took place from the late Mesolithic through to the Bronze Age. Palaeoenvironmental assessment has revealed a dryland environment initially occupied by mixed deciduous woodland. Peat initiation led to the development of alder woodland and sedge fen / reed swamp conditions at the very end of the late Mesolithic, whilst mixed deciduous woodland continued to occupy the dryland. Towards the top of the peat, the pollen and macrofossil records suggest opening of the woodlands on both the wetland and dryland in response to both wetter conditions and Bronze Age land clearance for settlement / agricultural purposes. The results of the diatom assessment suggest that the transition from Peat into the Upper Alluvium reflects an increase in saline conditions. Given the variable and often limited concentration of remains, and quality of the retained sequences from the site, no further work is recommended, and the core samples from the site should be discarded.
Keywords	
Funder	
HER	Kent HER - unRev - STANDARD
Person Responsible for work	Tom, Hill, Kate, Dudgeon, Rhys, Timms, C R, Batchelor
HER Identifiers	
Archives	