QUEST
QUATERNARY SCIENTIFIC

University of Reading

FORMER FORD STAMPING FACTORY, KENT AVENUE LONDON BOROUGH OF DAGENHAM

Geoarchaeological and Palaeoenvironmental Analysis Report

NGR: TQ 49828 83203

Date: 16th November 2018

Written by: Dr C.R. Batchelor, Dr N.A.F Marini
Dr D.S. Young & Dr T. Hill

QUEST, School of Archaeology, Geography and Environmental Science, Whiteknights, University of Reading, RG6 6AB

Tel: 0118 378 7978 / 8941
Email: c.r.batchelor@reading.ac.uk
http://www.reading.ac.uk/quest

DOCUMENT HISTORY:

REVISION	DATE	PREPARED BY	SIGNED	APPROVED BY	SIGNED	REASON FOR ISSUE
v2	16/11/18	C.R. Batchelor		C.R. Batchelor		Updated report
v1	15/10/17	C.R. Batchelor		C.R. Batchelor		First edition

CONTENTS

1. NON-TECHNICAL SUMMARY 3
2. INTRODUCTION 4
   2.1 Site context 4
   2.2 Geoarchaeological, palaeoenvironmental and archaeological significance 5
   2.3 Aims and objectives 6
3. METHODS 9
   3.1 Previous investigations (Field investigations, lithostratigraphic descriptions and deposit modelling) 9
   3.2 Organic matter determinations 10
   3.3 Radiocarbon dating 10
   3.4 Pollen analysis 10
   3.5 Diatom assessment 11
   3.6 Macrofossil assessment 11
4. RESULTS, INTERPRETATION & DISCUSSION OF THE GEOARCHAEOLOGICAL FIELD INVESTIGATIONS, DEPOSIT MODELLING & RADIOCARBON DATING 13
   4.1 Gravel 13
   4.2 Sand 14
   4.2 Lower Alluvium 14
   4.3 Peat 15
   4.4 Upper Alluvium 16
   4.5 Made Ground 17
5. RESULTS & INTERPRETATION OF THE POLLEN ANALYSIS 31
6. RESULTS & INTERPRETATION OF THE DIATOM ASSESSMENT 36
7. RESULTS & INTERPRETATION OF THE MACROFOSSIL ASSESSMENT 37
8. DISCUSSION & CONCLUSIONS 40
9. REFERENCES 42
10. APPENDIX 1: OASIS FORM 48

1. NON-TECHNICAL SUMMARY

Geoarchaeological and palaeoenvironmental analysis was carried out by Quaternary Scientific (University of Reading) in connection with the proposed development of land at the Former Ford Stamping Plant. The work was commissioned by CgMs Heritage. The aim of the investigation was to provide a detailed reconstruction of the stratigraphic, hydrological and vegetation history (including evidence of human activity). In order to carry out the work, a program of radiocarbon dating and an assessment of the palaeobotanical (pollen, seeds, wood, diatoms) and palaeofaunal (insects, molluscs, ostracods and foraminifera) remains was undertaken.

The results of the geoarchaeological and palaeoenvironmental analysis have built upon the previous fieldwork, deposit modelling and assessment exercises indicating that the sediments present beneath the site are similar to those recorded elsewhere in the Lower Thames Valley. A sequence of Shepperton Gravel is overlain by Holocene alluvial sediments, buried beneath modern Made Ground. The surface of the Gravel slopes downwards from north-west to south/south-east across the site, largely resting between -4 and -6m OD. The site clearly lies close to the floodplain/dryland edge, with Gravel surfaces typical of the Taplow Gravel terrace towards the northwest. A similar sequence of deposits is recorded across the neighbouring Beam Park site to the east. The Shepperton Gravel (and occasional sand) is overlain by a tripartite sequence of Lower Alluvium, Peat and Upper Alluvium. The Peat generally ranges between 1.5 and 3m in thickness, reaching over 3.5m in five records. Peat accumulation began at the site during the Late Mesolithic or Middle Neolithic, continuing until the Late Bronze Age, falling within the general period of peat formation in this area.

The results of the palaeoenvironmental analysis indicate that from the late Mesolithic to late Neolithic / early Bronze Age, the floodplain environment was dominated by wetland woodland comprising alder and a ground flora of sedges, grasses, aquatics and ferns. Oak, hazel and birch may have occupied the wetland woodland, but more likely formed mixed deciduous woodland on the dryland with lime. The vegetation history of the Ford Stamping Plant site during this period is broadly similar to that recorded at nearby sites. There are however important variations at the current site which are not recorded elsewhere, including: (1) the localised growth of birch woodland during the early stages of peat formation (late Mesolithic); (2) a transition from alder fen carr towards alder carr and sedge fen communities on the floodplain reflective of wetter conditions around 6000 cal BP (early Neolithic), (3) the expansion of yew woodland from the middle Neolithic to middle Bronze Age and (4) a decline in dryland woodland from the middle Bronze Age onwards, not matched by a decline of floodplain woodland.

2. INTRODUCTION

2.1 Site context

This report summarises the findings arising out of the geoarchaeological and palaeoenvironmental investigations undertaken by Quaternary Scientific (University of Reading) in connection with the proposed development of land at the Former Ford Stamping Factory, Kent Avenue, London Borough of Dagenham (National Grid Reference: centred on TQ 49280 83203; Figures 1 & 2). Quaternary Scientific were commissioned by CgMs Heritage to undertake the geoarchaeological investigations. The site lies on the floodplain of the Lower Thames Valley, between the tributaries of the River Beam and Gores Brook; the northern boundary of the site borders the edge of the floodplain. The modern course of the River flows broadly north-west to south-east *ca*. 1km to the south of the site. The British Geological Survey (BGS) show the site underlain by Lambeth Group bedrock, described as 'clay, silt and sand' on the southern part of the site, and London Clay to the north. The bedrock is overlain by Holocene alluvium across the vast majority of the site (described as 'clay, peaty, silty, sandy'), with deposits of the Wolstonian (Marine Isotope Stages (MIS) 6-10) Taplow Gravel terrace towards its northern border. In fact, the alluvial deposits of the Lower Thames and its tributaries are almost everywhere underlain by Late Devensian (MIS 2) Late Glacial Gravels (in the Thames valley, the Shepperton Gravel of Gibbard, 1985, 1994), and this gravel is widely recorded in boreholes in the vicinity of the site.

Following on from an initial desk-based deposit modelling exercise (Batchelor, 2017a), the results of subsequent geoarchaeological field investigations (Young & Batchelor, 2017) indicated that the sediments present beneath the site are similar to those recorded elsewhere in the Lower Thames Valley. A sequence of Shepperton Gravel is overlain by a sequence of Holocene alluvial sediments buried beneath modern Made Ground. The surface of the Gravel slopes downwards from north-west to south/south-east across the site, largely resting between -4 and -6m OD. The surface of the Gravel is consistently recorded below *ca*. -5.5m OD towards the east of the site, and encompassing the western part of Beam Park (Young & Batchelor, 2016; see Figure 1). The Gravel rises towards the north of the site, consistent with the position of the site on the edge of the floodplain. In one of the new geoarchaeological boreholes towards the northwest the elevation of the Gravel rose sharply to 1.7m OD, a level consistent with the surface of the older Wolstonian Taplow Gravel terrace (MIS 6-10; 352,000 to 130,000 BP) which in this area forms the edge of the floodplain.

The Shepperton Gravel (and occasional sand) is overlain by a tripartite sequence of Lower Alluvium, Peat and Upper Alluvium. The Peat generally ranges between 1.5 and 3m in thickness, reaching over 3.5m in five records. Peat accumulation began at the site from the Late Mesolithic continuing until the Late Bronze Age, falling within the general period of peat formation in this area of the Lower Thames Valley. The results of a palaeoenvironmental assessment (Young et al., 2017) are indicative of a peat surface dominated by alder, with an understorey of sedges and occasional grasses and aquatics. Hazel, ash and birch may have occupied the peat surface with alder, but are more likely to grown on the dryland forming mixed deciduous woodland with oak and lime. Although there is no definitive evidence for human activity in the sequence, evidence for burning and a decline on oak towards the top of the sequence provide possible evidence for human impact on the landscape during the late prehistoric period.

2.2 Geoarchaeological, palaeoenvironmental and archaeological significance

The existing geoarchaeological borehole records in the area of the site indicate considerable variation in the height of the Gravel surface, 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 pre-Holocene river terraces, former channels and bars; (2) the presence of peat represents former terrestrial or semi-terrestrial land-surfaces, and (3) the various alluvial units represent periods of changing hydrological conditions. Thus by studying the sub-surface stratigraphy across the site in greater detail, it will be possible to build an understanding of the former landscapes and environmental changes that took place across space and time.

Organic-rich sediments (in particular peat) also have high potential to provide a detailed reconstruction of past environments on both the wetland and dryland. In particular, they provide the potential to increase knowledge and understanding of the interactions between hydrology, human activity, vegetation succession and climate. Significant vegetation changes 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. Such investigations are carried out through the assessment/analysis of palaeoecological remains (e.g. pollen, plant macrofossils & insects) and radiocarbon dating. For example, at Hornchurch Marshes, *ca*. 2km to the southeast (Batchelor, 2009; Branch *et al*., 2012) analysis of fine-grained mineral-rich sediments and peat revealed the presence of freshwater during the Late Mesolithic, at which point peat accumulation began, corresponding to a regional reduction in sea level. Significant changes in both the wetland and dryland environment were recorded here, including the establishment of alder carr woodland, yew; the decline of both elm during the Neolithic, and decline of lime during the Neolithic & Bronze Age. A subsequent transition to estuarine conditions was dated to *ca*. 3900 cal BP, coinciding with a decline in woodland cover and the expansion of plant communities typically found within reed swamp. Analysis of borehole sequences from Barking Riverside, *ca*. 2km to the southwest (see Figure 1), indicated that peat accumulation began at *ca*. 6000 cal BP (late Mesolithic), and continued until at least *ca*. 3500 cal BP (Bronze Age) (Green *et al*., 2014). The peat at Bridge Road meanwhile, *ca*. 3km to the east, was found to be of Late Neolithic to Bronze Age date (Meddens & Beasley, 1990). Palaeoenvironmental analysis here revealed that during its accumulation, dense alder carr woodland dominated the wetland, with oak, lime and hazel on the surrounding dryland (Meddens & Beasley, 1990). Palaeoenvironmental assessment carried out immediately to the west of the site revealed a thin sequence of peat and alluvial deposits dating to the Bronze Age. This indicated similar vegetation communities, but the local environment became more open in response to wetter conditions and clearance (Krawiec, 2014). Peat deposits have also been recorded accumulating from the Late Mesolithic to the Iron Age East of Ferry Lane on the High Speed 1 route (Bates & Stafford, 2013).

Finally, areas of high gravel topography, soils and peat represent potential areas that might have been utilised or even occupied by prehistoric people, evidence of which may be preserved in the archaeological (e.g. features and structures) and palaeoenvironmental record (e.g. changes in vegetation composition). This is of particular significance at the present site, since <750m to the west at Hays Storage Services Ltd. (Divers, 1996), a possible 4m wide Bronze Age causeway, constructed of gravel and burnt flint (MLO59097, TQ 4850 8320 was identified (Divers, 1996; see Figure 1). In addition, a series of prehistoric archaeological features were identified less than *ca.* 3km to the east at Bridge Road (Meddens & Beasley, 1990; Beasley, 1991). The features recorded at Bridge Road included stake holes and spreads of fire-cracked pebbles associated with the foreshore of a former channel, and later, stakes, wattling and a brushwood trackway associated with peat formation (Meddens & Beasley, 1990; Beasley, 1991). Radiocarbon dating of the trackway at Hays Storage Service Ltd. suggested that the possible causeway was in use for over 100 years between 1520 and 1400 BC (Divers, 1996). The trackway was orientated NNE/SSW and recorded at a depth of -1.70m OD, and traced for 23m within the upper level of a peat deposit also dated to the Bronze Age. On the Former Ford Factory itself, archaeological remains were recorded on either side of the Peat during archaeological evaluation; a cattle bone (potentially domesticated) was recorded within deposits equivalent to the Lower Alluvium, and a series of pits and post holes of possible late Iron Age date were cut into the Upper Alluvium on the northern part of the site (CgMs Heritage, 2018)

2.3 Aims and objectives

Five significant research aims were originally proposed within the geoarchaeological Written Scheme of Investigation (WSI; Batchelor, 2017) for the site as follows:

1. To clarify the nature of the sub-surface stratigraphy across the site;
2. To clarify the nature, depth, extent and date of any alluvium 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)
5. To integrate the new geoarchaeological record with other recent work in the local area for publication in an academic journal

The original geoarchaeological and palaeoenvironmental fieldwork and assessment successfully achieved the first two of these aims and demonstrated the potential of aims 3-5 being addressed through further investigation. Specifically, the sequence from the Former Ford Stamping Factory site provides a unique opportunity to consider the vegetation history of this part of the Lower Thames Valley, where prehistoric human activity is known to have taken place: the results can be integrated with other sites being investigated along an east-west transect close to the floodplain edge, including investigations at Goresbrook Park (CgMs, 2016a)/Hays Storage Services Ltd.

(Divers, 1996), Hornchurch Marshes (Batchelor, 2009; Branch *et al*., 2012),Beam Park (Young & Batchelor, 2016), and Merrielands, Dagenham (Batchelor *et al*., 2018) (see Figure 1).

It was therefore recommended that a targeted program of analysis is carried out focussed on: (1) radiocarbon dating to provide a better chronological framework for the sequence that can be used to compare the data with other sites in this area; (2) pollen analysis of existing samples from QBH3 to increase knowledge/understanding of vegetation history and evidence of human activity. This work will complete aims 1-4, and provide a detailed environmental reconstruction that can be used to address aim 5.

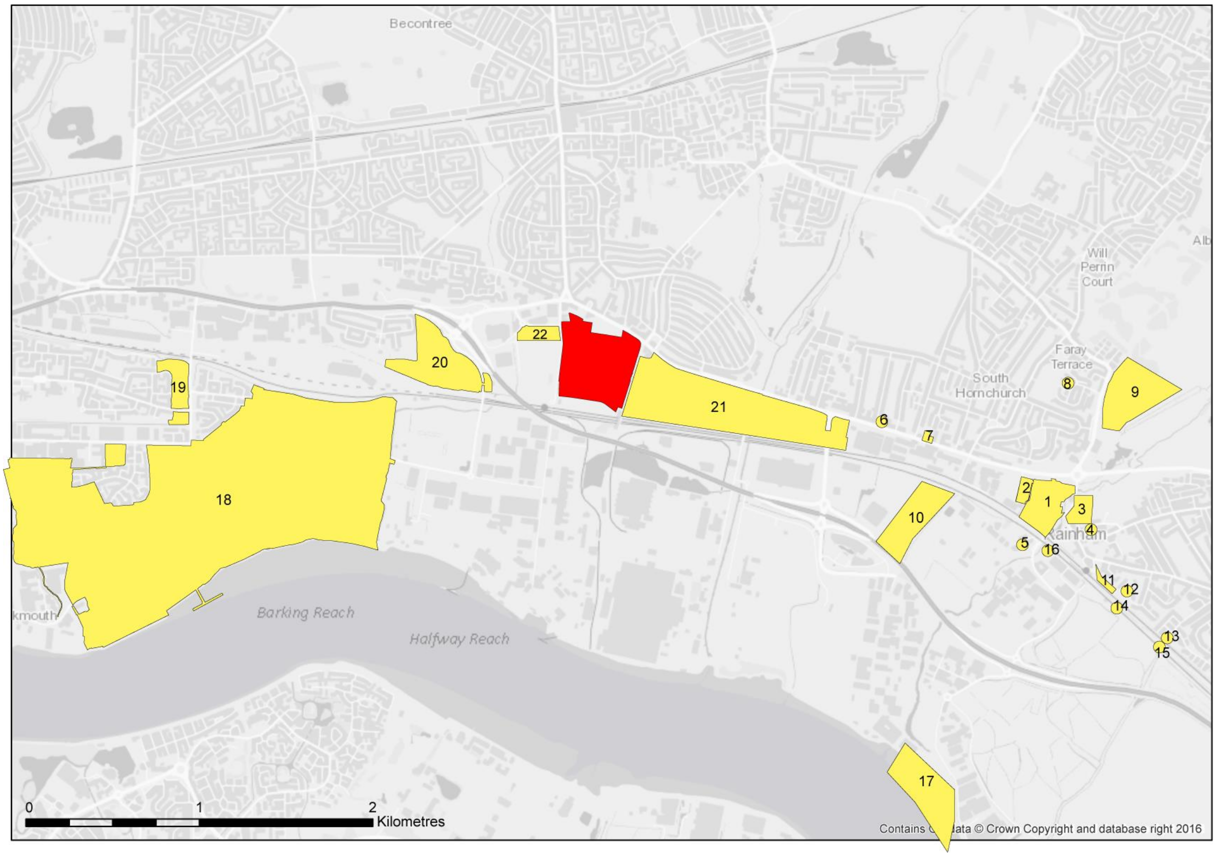

Figure 1: Location of the Former Ford Stamping Factory, London Borough of Havering (highlighted in red) and selected other archaeological and palaeoenvironmental sites: (1) Dovers Corner (Batchelor & Young, 2016); (2) the Passivhaus Housing Development (NRD13; Dyson, 2013); (3) Bridge Road (RA-BR89; Meddens & Beasley, 1990; Beasley, 1991); (4) Viking Way (RA-VW 96; Beasley, 1996); (5) Union Railways (URA97; MoLAS, 1997); (6) the former Manser Works (MNM03; Potter, 2003); (7) 155-163 New Road (NRI07; Pre-Construct Archaeology, 2007); (8) the Lessa Sports Ground (LSA98; MoLAS, 1998, 2001); (9) Scott & Albyn's Farm, Rainham Road (RNH96; HO-CP95; Hertfordshire Archaeological Trust, 1995, 2000); (10) Hornchurch Marshes (MOY03; Branch et al., 2012; Batchelor 2009), (11) the former Rainham Squash and Snooker Club (RSQ04; Archaeological Solutions Ltd, 2005); (12) the former Rainham Football Club (RA-FG95; Thames Valley Archaeological Society, 1995); (13) Brookway Allotments (RA-BA92; Newham Museum Service, 1992); (14) 24.455, East of Ferry Lane, HS1 (Bates & Stafford 2013); (15) 24.755, East of Ferry Lane, HS1 (Bates & Stafford 2013); (16) Rainham Creek (Bates & Stafford 2013); (17) Frog Island (MER11; Batchelor *et al*., 2011); (18) Barking Riverside (Green et al., 2012); (19) Renwick Road (Green et al., 2012); (20) Goresbrook Park (CgMs, 2016a)/Hays Storage Services Ltd. (Divers, 1996); (21) Beam Park (Young & Batchelor, 2016) and (22) Merrielands Crescent (Batchelor *et al*., 2018).

Figure 2: Location of boreholes across the Former Ford Stamping Factory site, including the location of geoarchaeological boreholes QBH1 to QBH5.

3. METHODS

3.1 Previous investigations (Field investigations, lithostratigraphic descriptions and deposit modelling)

A total of five geoarchaeological boreholes (boreholes QBH1 to QBH5) were put down at the site in July 2017 by Quaternary Scientific (Figure 2). Within the previous desk-based deposit modelling report (Batchelor, 2017a) and subsequent WSI (Batchelor, 2017b) it was recommended that a total of six boreholes were put down at the site; however, it was not possible to put down the most south-easterly of these boreholes since this area of the site was in use as the site compound (see Young & Batchelor, 2017).

The borehole core samples were recovered using an Eijkelkamp window sampler and gouge set using an Atlas Copco TT 2-stroke percussion engine. This coring techniques provide a suitable method for the recovery of continuous, undisturbed core samples and provides sub-samples suitable for not only sedimentary and microfossil assessment and analysis, but also macrofossil analysis. Spatial co-ordinates for each borehole were obtained using a Leica Differential GPS (see Table 1). A combination of laboratory- and field-based lithostratigraphic descriptions of the new borehole samples was carried out using standard procedures for recording unconsolidated sediment and peat, noting the physical properties (colour), composition (gravel, sand, clay, silt and organic matter) and inclusions (e.g. artefacts). The procedure involved: (1) cleaning the samples with a spatula or scalpel blade and distilled water to remove surface contaminants; (2) recording the physical properties, most notably colour; (3) recording the composition e.g. gravel, fine sand, silt and clay; (4) recording the degree of peat humification, and (5) recording the unit boundaries e.g. sharp or diffuse. The results are displayed in Tables 2 to 6.

The deposit model for the site was based on a review of over 160 borehole records. Sedimentary units from the boreholes were classified into six groups: (1) Bedrock (London Clay / Lambeth Group), (2) Gravel (Shepperton/Taplow Gravel), (3) Lower Alluvium. (4) Peat, (5) Upper Alluvium and (6) Made Ground. In addition, 596 geoarchaeological, archaeological and geotechnical records were collated to examine key deposits across the wider area. The classified data for groups 1-6 were then input into a database within the RockWorks 16 geological utilities software, the output from which was displayed using ArcMAP 10. Models of surface height were generated for the Gravel, Lower Alluvium, Peat and Upper Alluvium using an Inverse Distance Weighted algorithm (Figures 3-5, 7 and 9). Thickness of the Peat, total Holocene alluvium (incorporating the Lower Alluvium, Peat and Upper Alluvium) and Made Ground (Figures 6, 8 and 10) were also modelled (also using an Inverse Distance Weighted algorithm). Borehole transects are displayed in Figures 11 (site wide) & 12 (wider area).

As reported in Young & Batchelor (2017), in general both the distribution and density of boreholes across the site is good; however, not all boreholes record the entire Holocene alluvial sequence, and thus for selected stratigraphic units the reliability is better in certain areas of the site. The reliability of the models generated using RockWorks is therefore variable. In general, reliability improves from outlying areas where the models are largely supported by scattered archival records towards the core area of boreholes. Because of the 'smoothing' effect of the modelling procedure, the modelled levels of stratigraphic contacts may differ slightly from the levels recorded in borehole logs and section drawings. As a consequence of this the modelling procedure has been manually adjusted so that only those areas for which sufficient stratigraphic data is present will be modelled. In order to achieve this, a maximum distance cut-off filter equivalent to a 50m radius around each record is applied to all deposit models. In addition, it is important to recognise that multiple sets of boreholes are represented, put down at different times and recorded using different drilling/descriptive terms and subject to differing technical constraints in terms of recorded detail including the exact levels of the stratigraphic boundaries.

3.2 Organic matter determinations

A total of 19 subsamples from borehole QBH3 were taken for determination of the organic matter content (Table 7; Figure 12). These records were important as they can identify increases in organic matter possibly associated with more terrestrial conditions. The organic matter content was determined by standard procedures involving: (1) drying the sub-sample at 110^{0}C for 12 hours to remove excess moisture; (2) placing the sub-sample in a muffle furnace at 550°C for 2 hours to remove organic matter (thermal oxidation), and (3) re-weighing the sub-sample obtain the 'loss-on-ignition' value. The samples were then re-weighed after 2 hours at 950°C for determination of the calcium carbonate content (see Bengtsson & Enell, 1986).

3.3 Radiocarbon dating

Two subsamples were extracted from the base and top of the peat in each of boreholes QBH1 and four from QBH3 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 2007) and the IntCal13 atmospheric curve (Reimer *et al*., 2013). The results are displayed in Figure 12 and in Tables 8 and 9.

3.4 Pollen analysis

Eight subsamples from borehole 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. 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 analysis procedure consisted of counting all pollen to 300 Total Land Pollen where possible (TLP; trees, shrubs and herbs) where possible. Aquatic pollen and spores were also counted. 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). 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 Figure 13.

3.5 Diatom assessment

A total of five samples from borehole QBH3 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 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 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). However, due to the nature of the rapid assessment, many taxa were only identified to genera level. The results of the assessment are shown in Table 10.

3.6 Macrofossil assessment

A total of five small bulk samples from borehole QBH1 and ten from QBH3, were extracted and processed for the recovery of macrofossil remains, including waterlogged plant macrofossils, wood, insects and Mollusca (Tables 11 and 12). The samples were focussed on the peat horizons in both boreholes. 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 13 and 14). Preliminary identifications of the waterlogged seeds (Tables 14 and 15) 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).

Table 1: Spatial attributes and lithostratigraphic data for the new geoarchaeological boreholes at the Former Ford Stamping Factory site.

Borehole	Easting	Northing	Elevation (m OD)	Total Depth (m)	Upper Alluvium surface (m bgl)	Peat surface (m bgl)	Lower Alluvium surface (m bgl)	Gravel surface (m bgl)
QBH1	549451.73	183304.40	0.80	6.00	n/a	2.50	5.44	n/a
QBH2	549451.73	183246.92	0.80	7.00	1.00	3.93	6.30	6.85
QBH3	549285.15	183212.83	0.80	6.00	1.20	1.95	4.26	5.30
QBH4	549194.55	183040.39	0.50	1.30	n/a	n/a	n/a	n/a
QBH5	549145.84	183468.07	3.70	5.00	n/a	n/a	n/a	2.00

4. RESULTS, INTERPRETATION & DISCUSSION OF THE GEOARCHAEOLOGICAL FIELD INVESTIGATIONS, DEPOSIT MODELLING & RADIOCARBON DATING

The results of the lithostratigraphic descriptions and deposit modelling were reported previously (Young & Batchelor, 201&) and are shown in Tables 2 to 6, with the deposit modelling displayed in Figures 3 to 12. Figures 3 to 10 are surface elevation and thickness models for each of the main stratigraphic units. Figures 11 and 12 are two-dimensional transects across the site and wider area respectively. The results of the deposit modelling indicate that the number and spread of the logs is sufficient to permit modelling with a high level of certainty across the majority of the site. Areas of exception include beneath the basement of a former building on the southwestern part of the site (which truncates the entire sequence down to the Shepperton Gravel surface), and small areas of the north-western/eastern parts of the site.

The full sequence of sediments recorded in the boreholes comprises:

Made Ground
Upper Alluvium – widely present
Peat – widely present
Lower Alluvium – widely present
Gravel – widely present

4.1 Gravel

Gravel was present in all the boreholes that penetrated to the bottom of the Holocene sequence. The modelling exercise indicates that the surface of the Gravel falls from the northern part of the site, where it is recorded between -2 and -3m OD (e.g. A-BH803; A-BH811) to between -4 and -6m OD across much of the rest of the site (Figures 3 & 11). During subsequent archaeological evaluation (CgMs Heritage, 2018), the Gravel surface was recorded as falling from 2.90m OD to -1.94 towards the north-west, and from 2.02m OD to -1.43m towards the north-east of the site. This actually enhances the deposit model, as there were significant gaps in this area previously. This unit most likely represents the Shepperton Gravel deposited during the Late Glacial (MIS2; 15,000 to 10,000 BP) 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.

Towards the east of the present site (broadly east of the alignment of boreholes QBH1 and QBH2), and encompassing the western part of Beam Park (Young & Batchelor, 2016), the surface of the Gravel is consistently recorded below *ca.* -5.5m OD, perhaps indicative of a broadly north-south aligned channel that may dissect the terrace to the north, in a similar nature to that recorded towards the centre of Beam Park. However, in the absence of additional data to the north of this possible channel, it is not currently possible to confirm its presence, character or orientation. At the Princess

Bowl site (MoLAS, 2002), *ca*. 100m to the north of this depression, the Gravel surface was recorded at between 4.4 and 4.85m OD, indicating that if a palaeochannel exists, it most likely lies to the east of the Princess Bowl site.

Where the Gravel rises towards the north and northwest of the site, this is consistent with the position of the site on the edge of the floodplain. In one of the new geoarchaeological boreholes (QBH5), the elevation of the Gravel rises sharply to 1.7m OD, a level consistent with the surface of the older Wolstonian Taplow Gravel terrace (MIS 6-10; 352,000 to 130,000 BP) which in this area forms the edge of the floodplain. Gibbard (1994) shows the surface of the Mucking (Taplow) Gravel falling to around 1m OD in the area of South Hornchurch (p 54). However, it should be noted that it is difficult to differentiate the deposits of the Taplow and Shepperton Gravel on the basis of elevation alone.

Beyond the margins of the site to the east, the surface of the Taplow Gravel can be more confidently recognised, where it reaches between *ca*. 1.5 and -1m OD on the northern part of the Beam Park site (Figure 4 & 12). From here, the Gravel surface falls to between -6 and -9.5m OD on the southern part of the site, representative of the Shepperton Gravel. Two particularly deep depressions are recognised: Towards the south-west of Beam Park the Gravel surface is consistently recorded at between *ca*. -7.5 and -9.58m OD; although the extent and orientation of this depression is not yet fully understood, due to the absence of data to the south, it is possible that this feature represents a former channel that might have been orientated broadly west-east. Towards the north-west of Beam Park, three borehole records indicate thick alluvial deposits resting directly on Bedrock at up to -14m OD. It is possible that these records are erroneous, but it is of note that similarly deep depressions are recorded adjacent to the terrace edge at Barking Riverside (Green *et al*., 2014).

4.2 Sand

A horizon of sand is the lowest unit in the Holocene alluvial sequence, and where present, it rests directly on the surface of the underlying Shepperton Gravel. Where it is identified, it can be interpreted as being deposited under low to moderate energy fluvial conditions, most likely within former channel features. On the present site, Sand is recognised in 17 geotechnical records (but not in any of the new geoarchaeological boreholes), varying in thickness between 0.2 and at least 1.2m (Figure 11). However, its absence in the other geotechnical logs does not necessarily mean it is not present as an individual unit; it is rarely possible to confidently separate Sand from Shepperton Gravel or indeed the silty sandy deposits of the Lower Alluvium, due to the nature of the coring methods and less precise method of description. In the case of the modelling exercise, differentiation between the Sand and Gravel is made based upon the presence of more than rare occurrences of Gravel within the sediment.

4.2 Lower Alluvium

The Lower Alluvium rests directly on either the Shepperton Gravel or Sand and was recorded in the majority of those records that penetrated sufficiently deeply across the site. The surface of the Lower Alluvium (Figures 5 & 11) tends to slope downwards from north-west (-2m OD) towards the south and east (-5m OD); in the new geoarchaeological boreholes it was recorded at between -3.46 (QBH3) and -5.50m OD (QBH2). Once again, the results of the model have been enhanced by the subsequent arcaheolgoical evaluation, which demonstrated the Lower Alluvium reduced in thickness to absence at the very northern end of the site. Towards its northern edge, its surface reached -0.04m OD (CgMs Herigate, 2018).

The deposits of the Lower Alluvium are described as a predominantly silty or clayey tending to become increasingly sandy downward in most sequences. The Lower Alluvium frequently contains detrital wood or plant remains, and in many cases is described as organic and with occasional Mollusca remains; in borehole QBH3, the results of the organic content determinations indicate that this unit is generally less than 4% organic (see Table 7 and Figure 12).

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 Shepperton Gravel.

4.3 Peat

Overlying the Lower Alluvium / Sand or in some cases Shepperton Gravel in the vast majority of the boreholes is a unit of Peat. The peat is indicative of a transition towards semi-terrestrial (marshy) conditions, supporting the growth of sedge fen/reed swamp and/or woodland communities across the floodplain. The results of the radiocarbon dating (see Tables 8 & 9 and Figure 12) of the base and top of the peat in boreholes QBH1 and QBH3 indicate that peat accumulation began earlier at the location of QBH3 (despite its higher elevation here), at around 6310-6450 cal BP (Late Mesolithic; -4.54 to -4.59m OD), with accumulation beginning at around 5320-5580 cal BP (Middle Neolithic; -3.41 to -3.46m OD) in QBH1. A large bog oak recorded at the base of the peat (-2.90m OD) within one of the archaeological evaluation trenches was radiocarbon dated to 6650-6490 cal BP (CgMs Heritage, 2018). Peat formation continued at a uniform rate (certainly within the vicinity of QBH3), and ceased within a broadly similar period during the Late Bronze Age at both locations, with the top of the peat at the location of QBH1 dated to 3000-3210 cal BP; -1.79 to -1.89m OD) and near the top of the peat in QBH3 dated to 3400-3565cal BP (-1.56 to -1.66m OD). These dates fall within the general period of peat formation in this area; nearby sites such as Hornchurch Marshes (Batchelor, 2009; Branch et al., 2012), Barking Riverside (Green et al., 2014) and Bridge Road (Meddens & Beasley, 1990; Beasley, 1991) have all recorded Peat accumulation from the late Mesolithic to Bronze Age.

The Peat generally varies between 1.5 and 3m in thickness, with the thickest horizons occurring on the eastern and south-eastern parts to the site (see Figures 6 & 11), with thicker horizons recorded within the possible north-south aligned palaeochannel identified above (see 4.1). Horizons exceeding 3.5m in thickness are recorded in A-BH3030, A-BH618, A-BH807, A-VBH715 & A-VBH719. In one of the archaeological evaluation trenches, 3.4m of peat was recorded including frequent felled trees and roots (CgMs Heritage, 2018). In the new geoarchaeological boreholes, Peat was recorded in borehole QBH1 at between -1.70 and -4.64m OD, in QBH2 between *ca*. -3.13 and -5.50m OD, and QBH3 between -1.15 and -3.46m OD. In borehole QBH3, the peat is generally between 70 and 85% organic (see Table 7 and Figure 12). It should be noted that sample retention was poor in borehole QBH2 due to difficulties drilling through the overlying Made Ground.

Peat was absent in a small number of sequences, largely located on the northern margins of the site (A-BH803, A-BH603, A-BH805 & A-BH504) towards the northern part of the site. Within these sequences, mineral-rich deposits were recorded ranging in size from clay to gravel sized clasts. The surface of the Peat is relatively even, generally lying between -1 and -2m OD (Figure 6 & 11).

The Peat also has the potential to contain archaeological remains as demonstrated by findings at both Hays Storage Dagenham (Divers, 1996) and Bridge Road, Rainham (Meddens & Beasley, 1990; Beasley, 1991). Generally, these remains have been recorded towards the top of the Peat and relatively close to the floodplain edge.

4.4 Upper Alluvium

The Upper Alluvium rests directly on the Gravel (towards the north) or the peat/Lower Alluvium (towards the south), and was recorded in all records across the site with the exception of selected sequences towards the northern boundary of the site. The deposits of the Upper Alluvium are described as predominantly silty or clayey which are very occasionally organic-rich. The surface of the Upper Alluvium is relatively even, generally lying at between -1.0 and 2m OD (Figure 8 & 11). The sediments of the Upper Alluvium are indicative of deposition within low energy fluvial and/or semi-aquatic conditions during the Holocene. 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.

During the course of the archaeological evaluation (CgMs Heritage, 2018), a 0.28m thick layer of peat was recorded at 0.43m OD in one of the trenches, overlying the deposits of an infilled palaeochannel. This may represent a much later period of peat formation, or possibly even redeposited material.

In areas of high Gravel topography on the very northern margins of the site, it is possible that the silty or clayey deposits might instead represent brickearth (rather than Upper Alluvium). This was the case at Beam Park, though there, the Gravel surface was recorded above 0m OD.

The combined Holocene alluvial sequence, incorporating the Lower Alluvium, Peat and Upper Alluvium ranges between 3 & 5m in thickness, and is generally thicker where the Shepperton Gravel surface is lower towards the south of the site (Figure 9).

4.5 Made Ground

Between 1 & 2m of Made Ground caps the Holocene alluvial sequence across the vast majority of the site, reaching up to 5m in isolated areas (Figure 10).

Table 2: Lithostratigraphic description of borehole QBH1, Former Ford Stamping Factory.

Depth (m OD)	Depth (m bgl)	Description	Stratigraphic group
0.80 to -1.20	0.00 to 2.00	Made Ground of concrete hardstanding over brick and concrete rubble.	MADE GROUND
-1.20 to -1.70	2.00 to 2.50	Redeposited alluvium (grey silty clay) and concrete rubble.	
-1.70 to -2.20	2.50 to 3.00	Sh2 Tl^{2}1 Th^{2}1; humo. 2; dark reddish brown moderately humified woody and herbaceous peat.	PEAT
-2.20 to -3.20	3.00 to 4.00	VOID CORE	VOID
-3.20 to -4.20	4.00 to 5.00	Sh2 Tl^{2}2; humo. 2; reddish brown moderately humified wood peat. Diffuse contact in to:	PEAT
-4.20 to -4.64	5.00 to 5.44	Sh2 Th^{2}1 Tl^{2}1; humo. 3; reddish brown well humified woody and herbaceous peat. Diffuse contact in to:	
-4.64 to -5.20	5.44 to 6.00	As2 Ag2 Ga+; blueish grey clay and silt with a trace of sand.	LOWER ALLUVIUM

Table 3: Lithostratigraphic description of borehole QBH2, Former Ford Stamping Factory.

Depth (m OD)	Depth (m bgl)	Description	Stratigraphic group
0.80 to -0.20	0.00 to 1.00	Made Ground of concrete hardstanding over brick and concrete rubble.	MADE GROUND
-0.20 to -0.40	1.00 to 1.20	As3 Ag1; brown silty clay. Diffuse contact in to:	UPPER ALLUVIUM
-0.40 to -1.20	1.20 to 2.00	As3 Ag1; blueish grey silty clay. Diffuse contact in to:	
-1.20 to -1.72	2.00 to 2.52	Ag2 Sh2 Dl+; dark greyish brown very organic silt with a trace of detrital wood. Diffuse contact in to:	
-1.72 to -2.20	2.52 to 3.00	Ag3 As1 Dh+ Sh+ Dl+; grey silty clay with traces of detrital herbaceous material, organic matter and detrital wood.	
-2.20 to -3.13	3.00 to 3.93	VOID	VOID
-3.13 to -3.20	3.93 to 4.00	Sh2 Tl^{2}1 Th^{2}1; humo. 2; dark reddish brown moderately humified woody and herbaceous peat.	PEAT
-3.20 to -4.20	4.00 to 5.00	VOID	VOID
-4.20 to -5.50	5.00 to 6.30	Sh2 Tl^{2}2 Th+; humo. 2; dark reddish brown moderately humified wood peat with a trace of herbaceous material. Sharp contact in to:	PEAT
-5.50 to -6.05	6.30 to 6.85	Ga2 Ag1 Gg1; greenish grey gravelly silty sand. Sharp contact in to:	LOWER ALLUVIUM
-6.05 to -6.20	6.85 to 7.00	Gg3 Ga1; grey sandy gravel. Clasts are flint, sub-angular to well-rounded, average diameter 20mm.	SHEPPERTON GRAVEL

Table 4: Lithostratigraphic description of borehole QBH3, Former Ford Stamping Factory.

Depth (m OD)	Depth (m bgl)	Description	Stratigraphic group
0.80 to -0.40	0.00 to 1.20	Made Ground of concrete hardstanding over brick and concrete rubble.	MADE GROUND
-0.40 to -0.80	1.20 to 1.60	As3 Ag1; blueish grey silty clay. Some iron staining in worm and root hollows. Diffuse contact in to:	UPPER ALLUVIUM
-0.80 to -1.15	1.60 to 1.95	As3 Ag1 Sh+; dark blueish grey grading to greyish brown silty clay with a trace of organic matter. Contact with underlying unit obscured.	
-1.15 to -3.20	1.95 to 4.00	Sh2 $Th^1$1 $Tl^2$1; humo. 2; dark brown moderately humified woody and herbaceous peat. Diffuse contact in to:	PEAT
-3.20 to -3.46	4.00 to 4.26	Sh2 $Tl^2$2 Th+; humo. 2; dark brown moderately humified wood peat with a trace of herbaceous material. Sharp contact in to:	
-3.46 to -3.57	4.26 to 4.37	Ag2 Sh1 As1; dark grey organic clayey silt. Diffuse contact in to:	LOWER ALLUVIUM
-3.57 to -4.20	4.37 to 5.00	Ag3 As1 Ga+ Gg+; grey clayey silt with traces of sand and occasional gravel clasts. Diffuse contact in to:	
-4.20 to -4.50	5.00 to 5.30	Ag2 Ga2; grey sand and silt. Sharp contact in to:	
-4.50 to -5.20	5.30 to 6.00	Gg2 Ga1 Ag1; grey sandy silty gravel. Clasts are flint, average diameter 40mm, sub-angular to well-rounded.	SHEPPERTON GRAVEL

Table 5: Lithostratigraphic description of borehole QBH4, Former Ford Stamping Factory.

Depth (m OD)	Depth (m bgl)	Description	Stratigraphic group
0.50 to -0.80	0.00 to 1.30	Made Ground of concrete hardstanding over brick and concrete rubble.	MADE GROUND
-0.80	1.30	Concrete slab	

Table 6: Lithostratigraphic description of borehole QBH5, Former Ford Stamping Factory.

Depth (m OD)	Depth (m bgl)	Description	Stratigraphic group
3.70 to 1.70	0.00 to 2.00	Made Ground of concrete over gravelly sand.	MADE GROUND
1.70 to 1.35	2.00 to 2.35	Gg3 Ga1; orangey red sandy gravel. Clasts are flint, average diameter 30mm, sub-angular to rounded. Diffuse contact in to:	TAPLOW GRAVEL
1.35 to -1.30	2.35 to 5.00	Gg3 Ga1 Ag+; orangey red sandy gravel with a trace of silt. Clasts are flint, average diameter 30mm, sub-angular to rounded.	

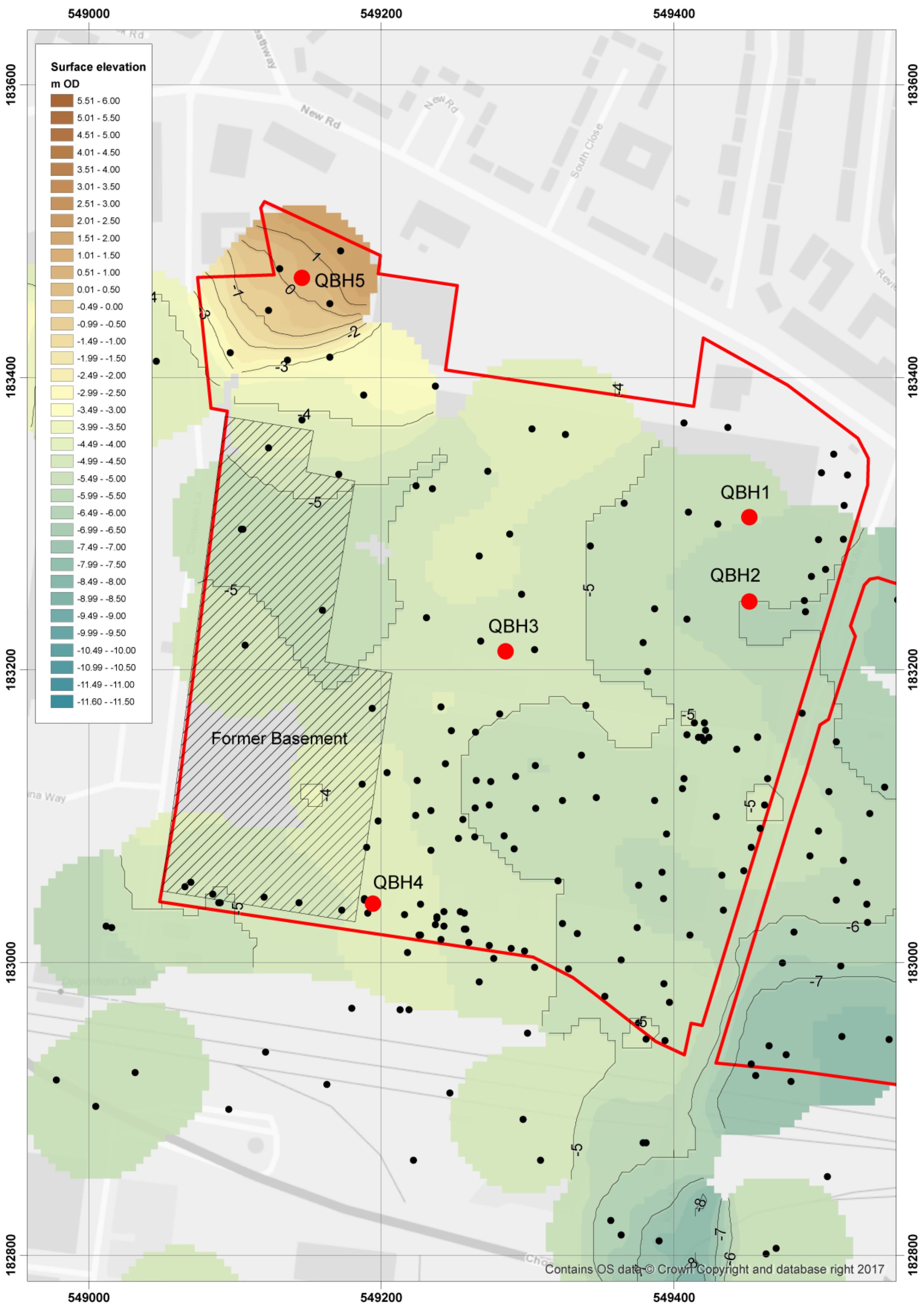

Figure 3: Top of the Gravel (m OD)

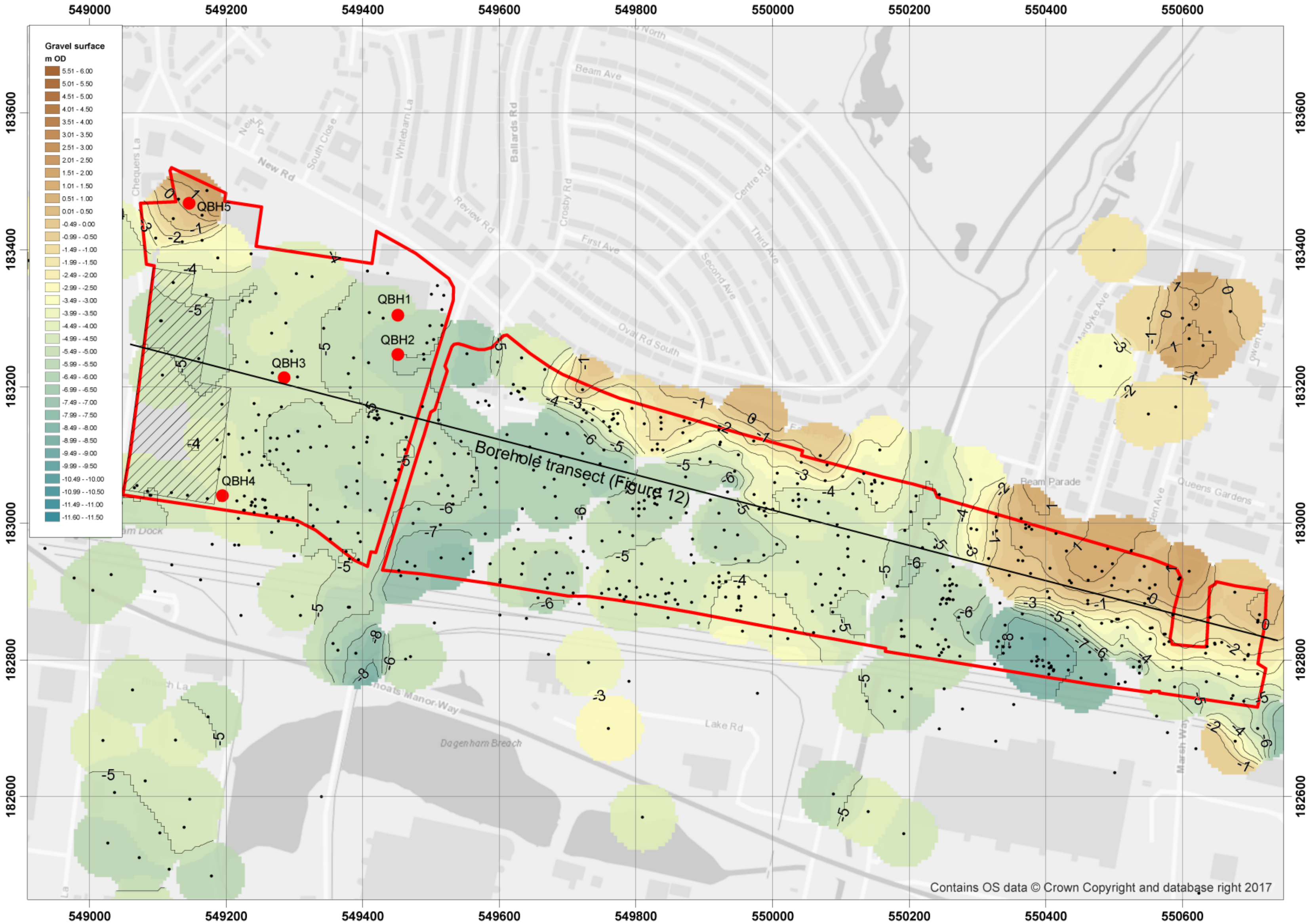

Figure 4: Top of the Gravel across the wider area (m OD) (site outline in red)

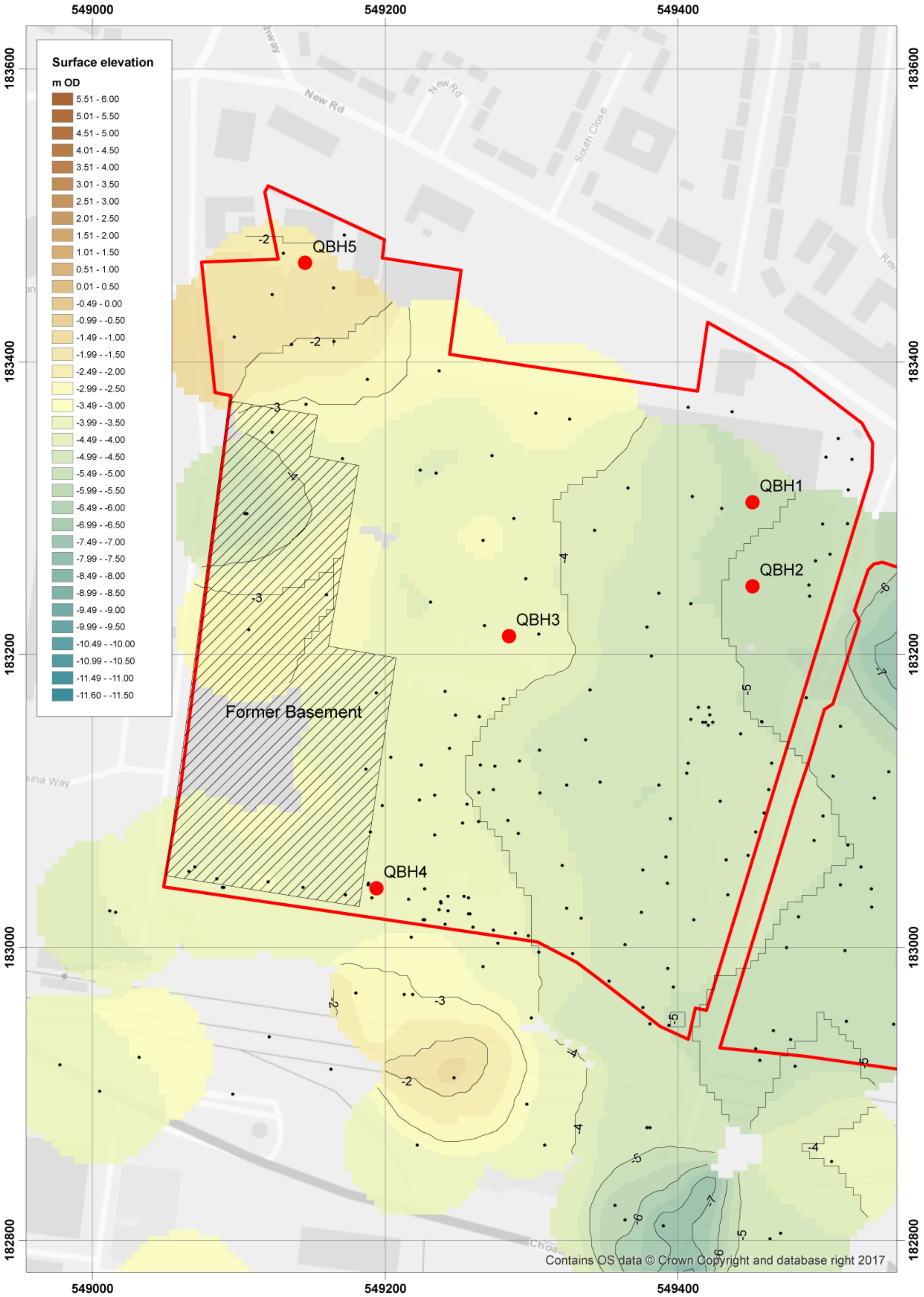

Figure 5: Top of the Lower Alluvium (m OD)

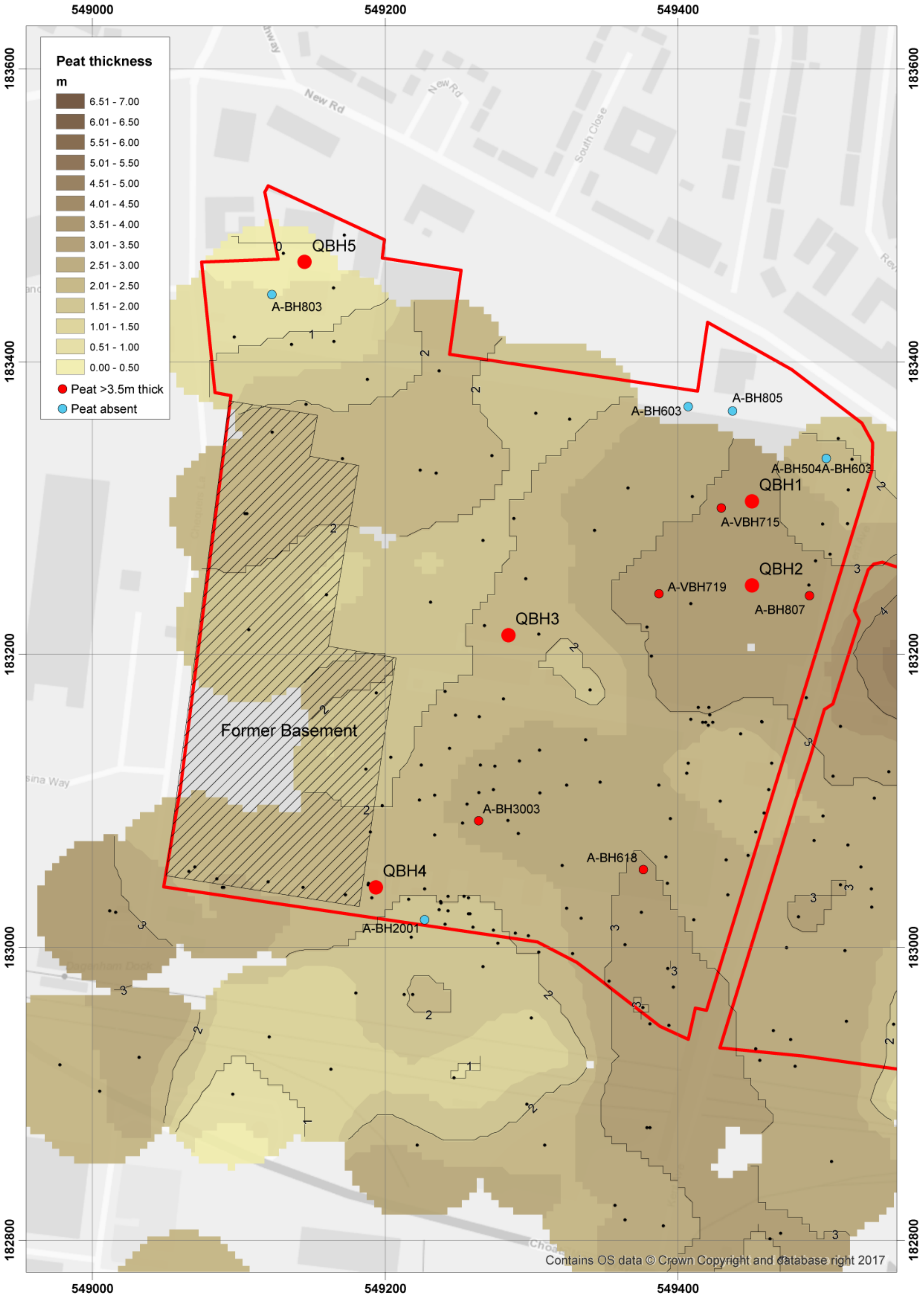

Figure 6: Thickness of the Peat (m)

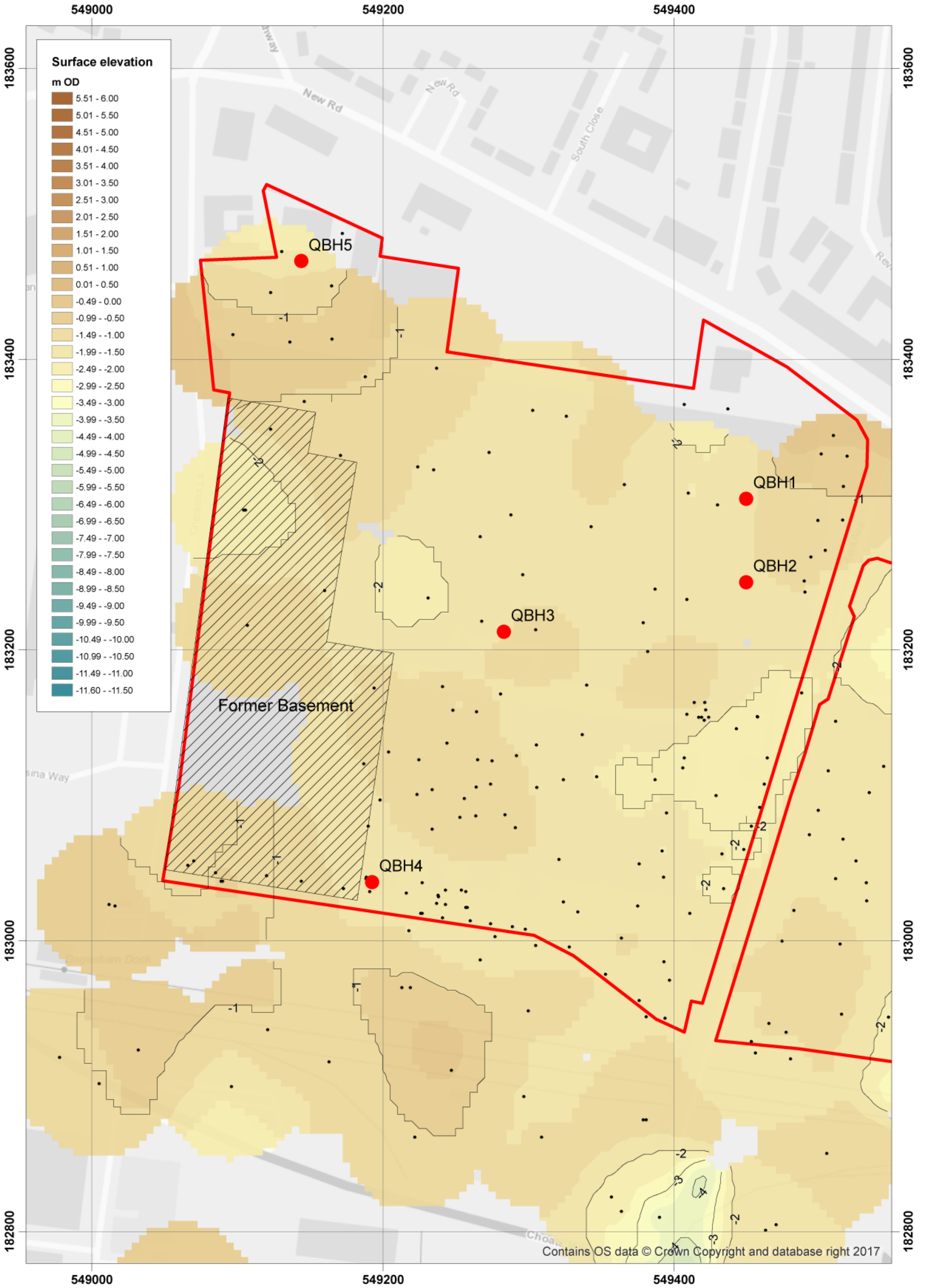

Figure 7: Top of the Peat (m OD)

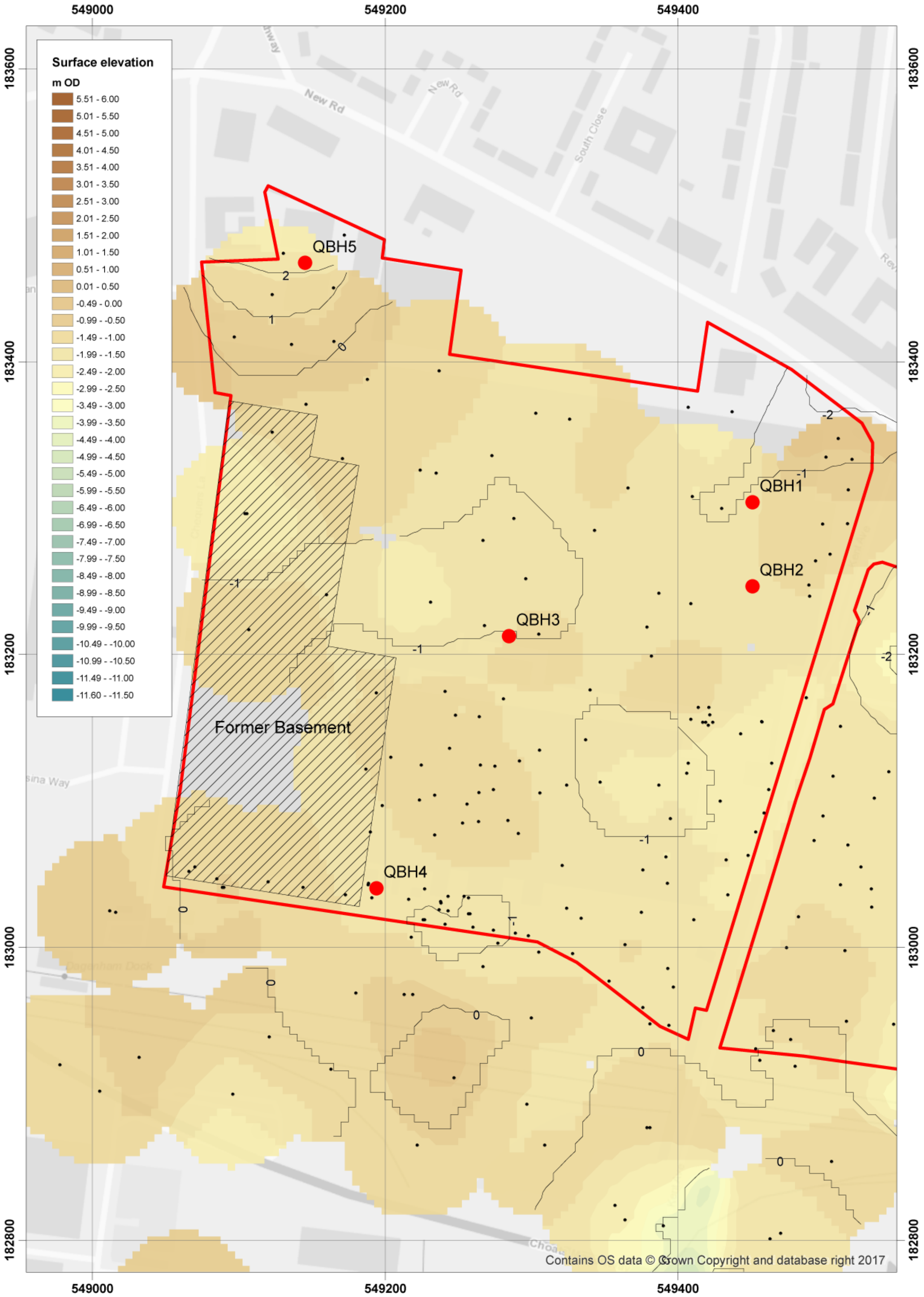

Figure 8: Top of the Upper Alluvium (m)

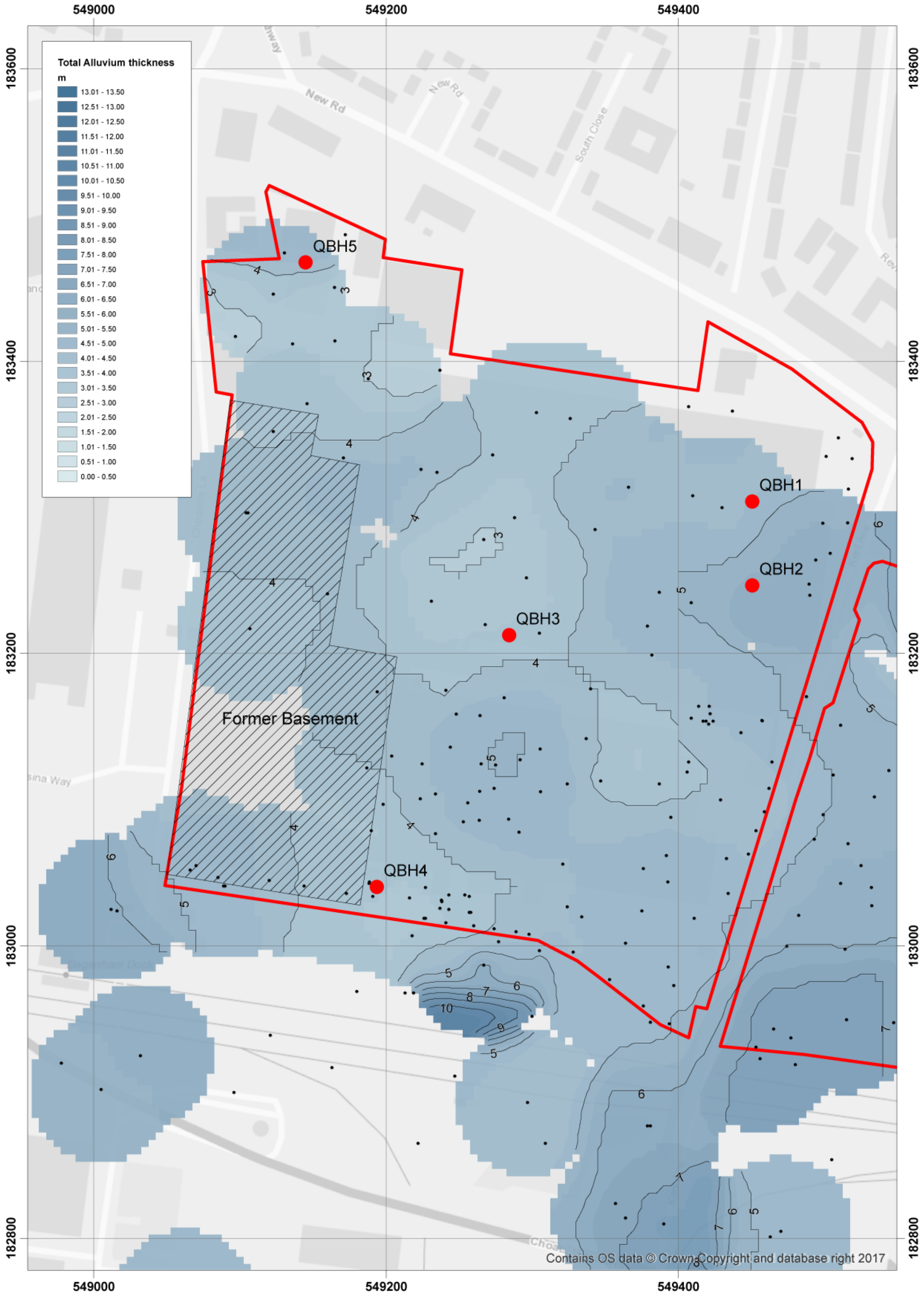

Figure 9: Thickness of the Total Alluvium (Lower Alluvium, Peat and Upper Alluvium) (m)

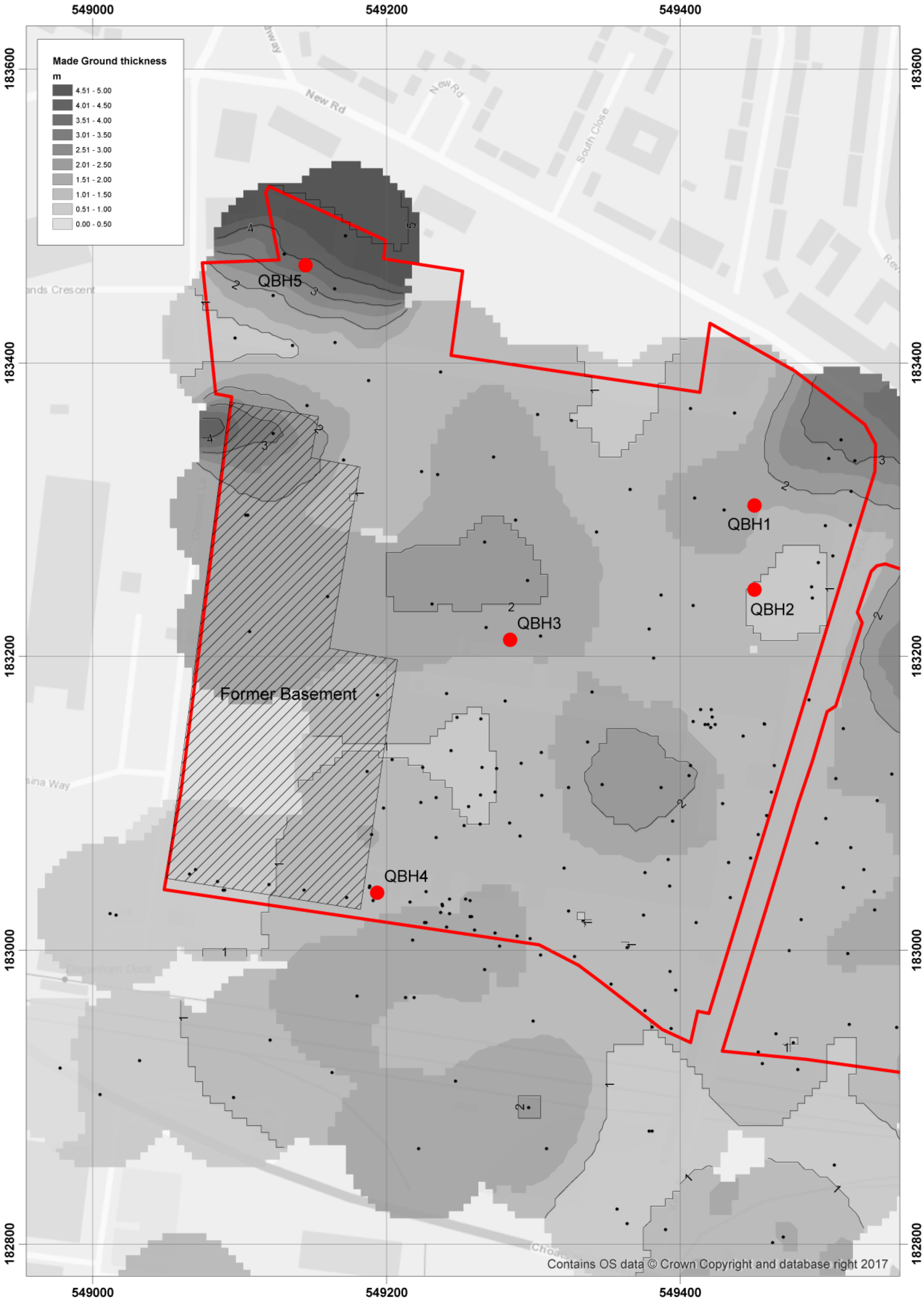

Figure 10: Thickness of Made Ground (m)

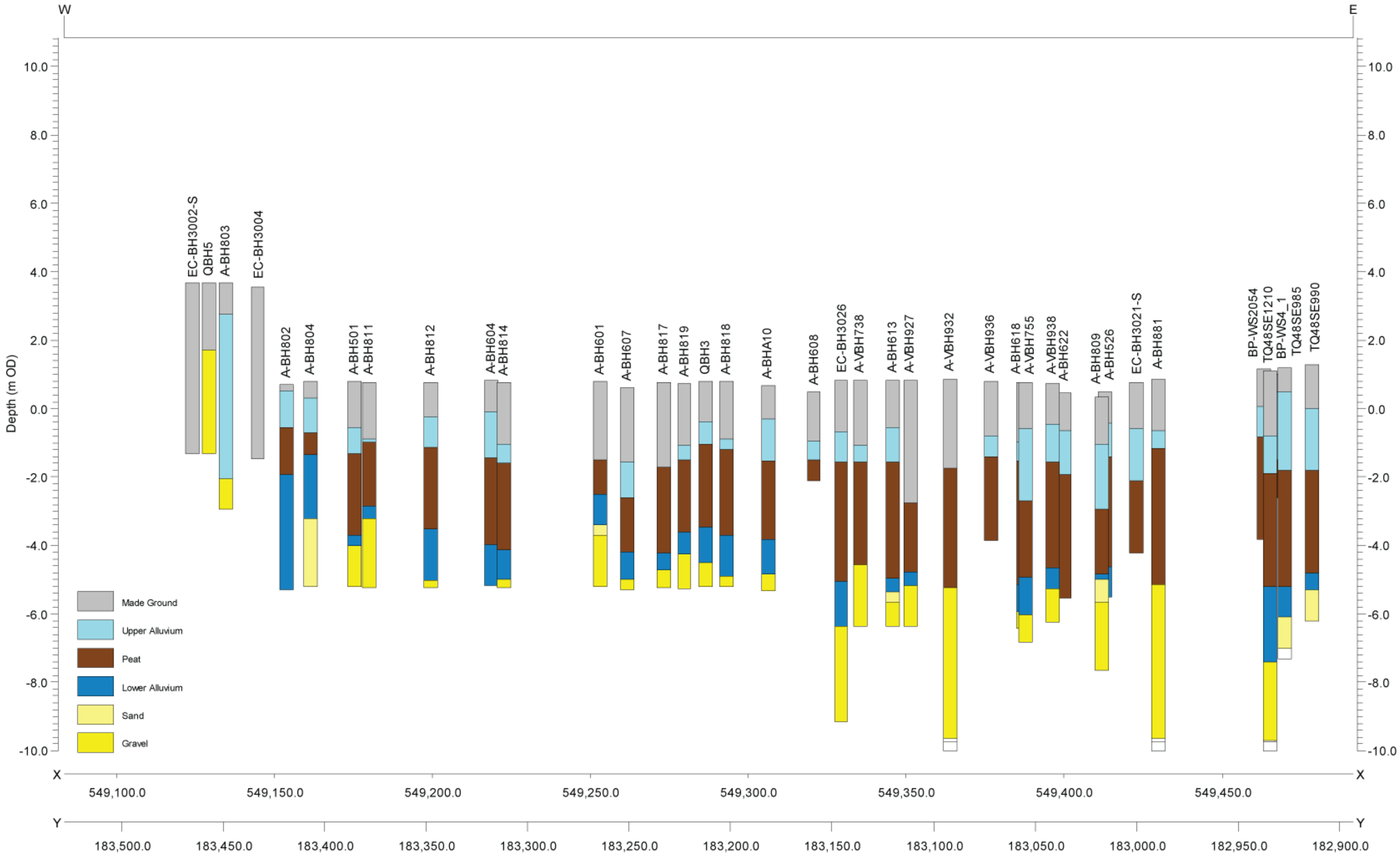

Figure 11: Site-wide borehole transect

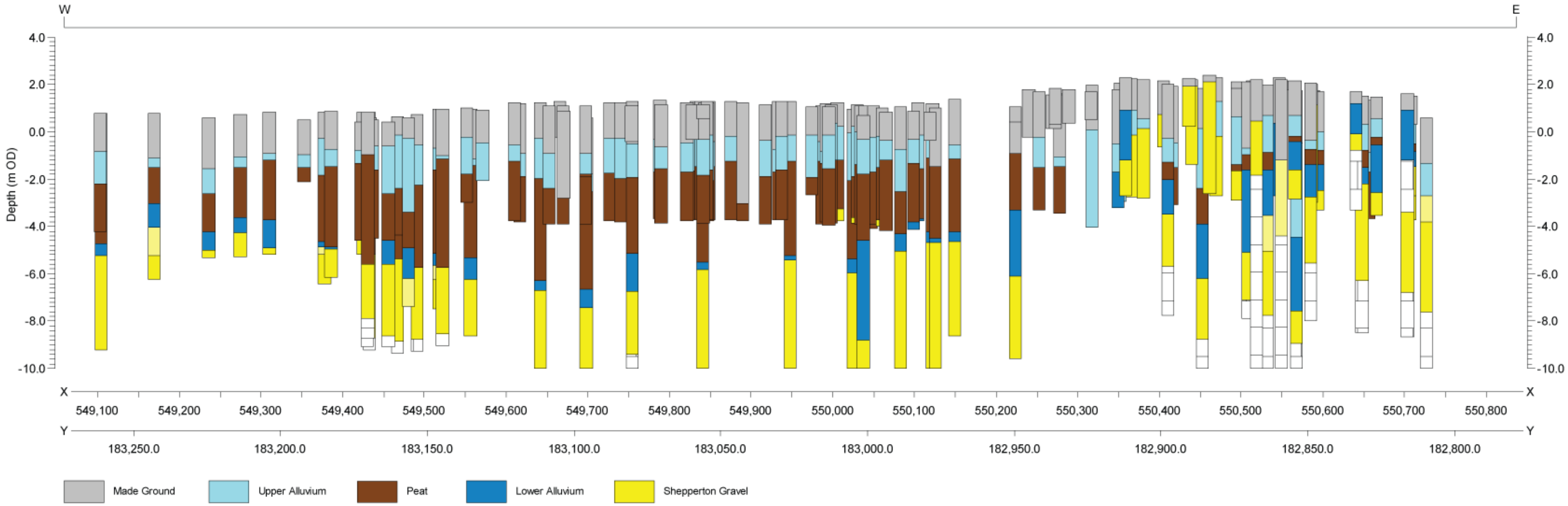

Figure 12: Borehole transect across the wider area

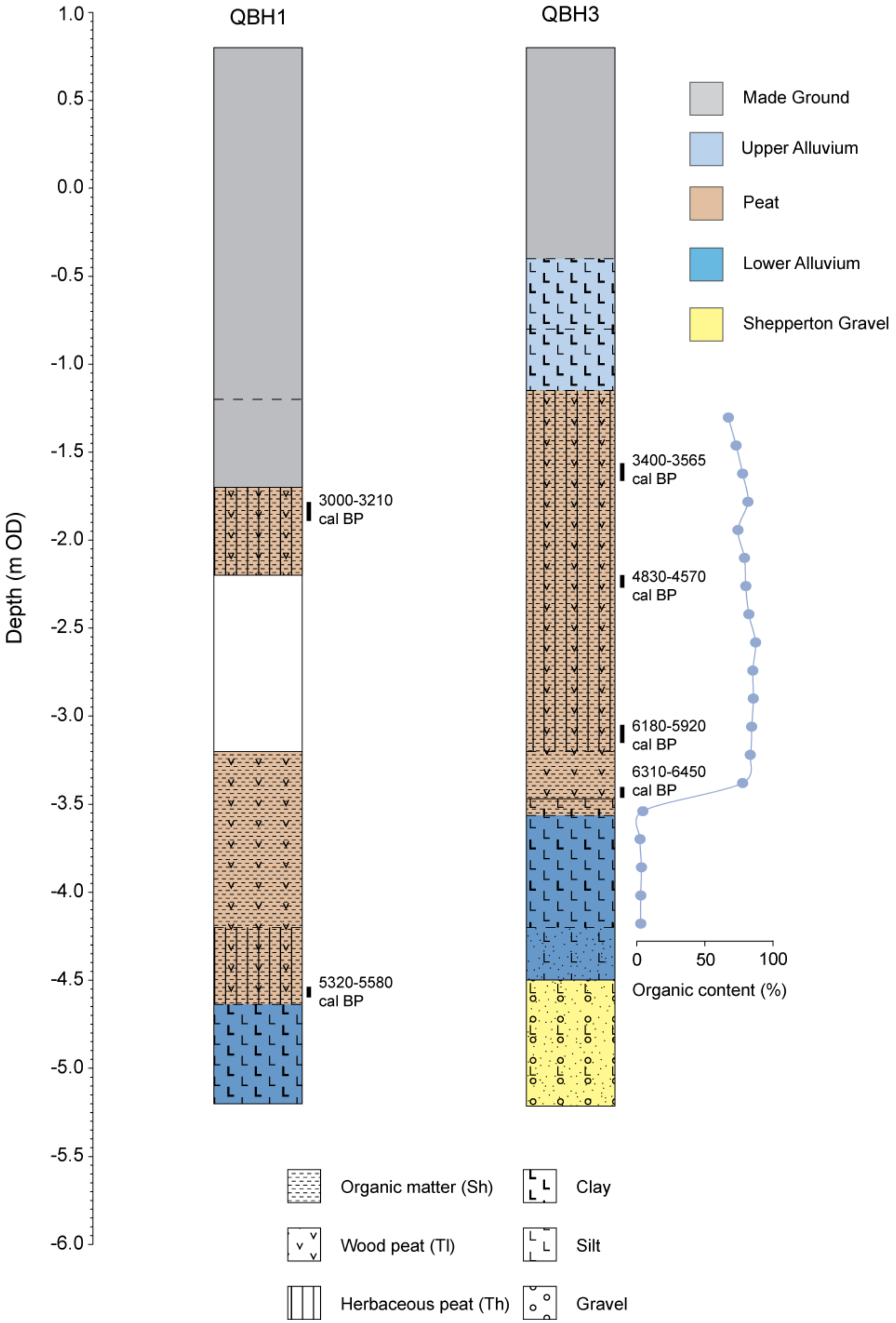

Figure 12: Results of the lithostratigraphic descriptions, organic content determinations and radiocarbon dating of boreholes QBH1 and QBH3 at the Former Ford Stamping Factory.

Table 7: Results of the borehole QBH3 organic matter determinations, Former Ford Stamping Factory.

Depth (m OD)		Organic matter content (%)
From	To	
-1.29	-1.30	67.35
-1.45	-1.46	73.13
-1.61	-1.62	78.00
-1.77	-1.78	81.82
-1.93	-1.94	74.55
-2.09	-2.10	79.37
-2.25	-2.26	80.28
-2.41	-2.42	82.54
-2.57	-2.58	87.50
-2.73	-2.74	85.54
-2.89	-2.90	85.94
-3.05	-3.06	84.71
-3.21	-3.22	83.67
-3.37	-3.38	77.92
-3.53	-3.54	3.96
-3.69	-3.70	1.96
-3.85	-3.86	2.93
-4.01	-4.02	2.45
-4.17	-4.18	2.42

Table 8: Results of the borehole QBH1 radiocarbon dating, Former Ford Stamping Factory.

Laboratory code / Method	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 478990 AMS	Twig wood; top of peat	-1.79 to -1.89	2950 ± 30	1050 to 1260 cal BC (3000 to 3210 cal BP)	-27.1
BETA 478991 AMS	Twig wood; base of peat	-4.54 to -4.59	4710 ± 30	3370 to 3565 cal BC (5320 to 5580 cal BP)	-28.3

Table 9: Results of the borehole QBH3 radiocarbon dating, Former Ford Stamping Factory.

Laboratory code / Method	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 478993 AMS	Twig wood; near top of peat	-1.56 to -1.66	3260 ± 30	1455 to 1615 cal BC (3400 to 3565 cal BP)	-27.2
BETA 502626 AMS	Twig wood; middle of peat	-2.20 to -2.26	4150 ± 30	2880-2620 cal BC (4830-4570 cal BP)	-27.0
BETA 502627 AMS	Twig wood; middle of peat	-3.06 to -3.16	5240 ± 30	4230-3970 cal BC (6180-5920 cal BP)	-29.1
BETA 478992 AMS	*Alnus* catkin; base of peat	-3.41 to -3.46	5610 ± 30	4360 to 4500 cal BC (6310 to 6450 cal BP)	-26.9

5. RESULTS & INTERPRETATION OF THE POLLEN ANALYSIS

5.1 Results of the pollen analysis

Pollen analysis was carried out on the peat deposit of QBH3. The resultant pollen percentage diagram has been divided into three local pollen assemblage zones (FSP3-1, FSP3-2 and FSP3-3) based upon variations in pollen content. The characteristics of the zones are as follows:

LPAZ FSP3-1 -3.55 to -3.40m OD *Alnus– Betula – Corylus* type
ca. 6450-6310 cal BP

The basal sample of QBH3 is characterised by the high values of tree taxa (80%), and to a lesser extent shrub pollen (10%). *Alnus* (40%) dominates with *Betula* (25%), *Corylus* type (10%), *Quercus* (7%), *Tilia*, *Pinus*, *Salix* and *Taxus* (<5%). Herbs (3%) comprise few occurrences of Cyperaceae (1.5%), Apiaceae, Asteraceae Lactuceae and Poaceae (<1%). No aquatics are recorded. Spores are mainly represented by *Pteridium aquilinum* (3%), with occurrences of *Polypodium vulgare* and *Dryopteris type* (<1%). Total pollen concentration is low with less than 15,000 grains/cm^3,

LPAZ FSP3-2 -3.40 to -2.10m OD *Alnus– Quercus – Cyperaceae*
ca. 6180-5920 to 4830-4570 cal BP

This zone is characterised by high values of tree taxa, ranging from 68-93%, with shrubs (3-10 %). *Alnus* dominates (despite decreasing to 23%), with *Quercus* (increasing from 10-25%) *Corylus* type (increasing from 3-10%), *Tilia* (2-4%) and *Fraxinus* (ca. 1%), with sporadic occurrences of *Betula*, *Pinus*, *Ulmus*, *Hedera, Sambucus nigra* and *Salix* (<1%); *Taxus* is recorded towards the end of the zone. The herbs are largely dominated by Cyperaceae which show a peak of concentration, rising from 2 to 36% towards the base of the zone, Apiaceae values rise towards the top of the zone (4%) with sporadic occurrences of *Ranunculus* type, *Sinapis* type, *Chenopodium* type, Rosaceae and Poaceae. The presence of aquatics is limited (<1%), comprising *Typha latifolia*, *Nuphar* type and cf *Stratiotes aloides*. Spores values are highly variable (3-82%) with peaks of *Dryopteris* type and sporadic occurrences of *Polypodium vulgare* (<1%). Total pollen concentration varies from 190,000 to 360,000 grains/cm^3,

LPAZ FSP3-3 -2.10 to -1.30m OD *Alnus– Quercus – Corylus* type
ca. 4830-4570 to 3400-3565 cal BP

This zone is characterised by high values of tree and shrub taxa (*ca.* 60 and 10% respectively) dominated by *Alnus* (40%), associated with *Quercus* (15%), *Corylus* type (7%). *Taxus*, *Tilia* and *Fraxinus* (>5%), with sporadic occurrences of *Ulmus*, *Betula*, *Pinus,* cf *Juglans*, *Ilex*, *Hedera* and *Salix* (<1%). Herb (<25%) comprise rising values of Poaceae (<1 to 14%), with Cyperaceae (<10%), Apiaceae (<3%), and sporadic occurrences of *Ranunculus* type, *Sinapis* type, *Chenopodium* type, *Filipendula* type, *Plantago lanceolate*, *Plantago media-major* type, Asteraceae, *Artemisia* type and Lactuaceae (all <1%), Aquatics are limited to sporadic occurrences of *Typha latifolia*, *Sparganium* and *Menyanthes* type. Values of spores are variable, ranging from 10 to 55%, dominated by *Dryopteris* type with *Pteridium aquilinum* and *Polypodium vulgare*. Total pollen concentration varied between 30,322 to 220,528 grains/cm^3,

5.2 Results of the pollen analysis

As outlined in 5.1, the pollen and non-pollen palynomorph analysis focused on parts of the sedimentary sequence QBH3 most likely to represent semi-terrestrial or terrestrial environments on the wetland; i.e. the peat sediments. Whilst this prevented a reconstruction of vegetation history through the complete sedimentary sequence (as carried out and advocated by Allen and Scaife, 2000), there are 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) 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 investigations on the semi-terrestrial peat 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; see for example Wheeler, 1980a, b). These issues are taken into account in the following results and interpretations.

LPAZ FSP3-1 -3.55 to -3.40m OD *Alnus– Betula – Corylus* type

This zone consists of a single pollen sample dating to approximately 6450-6310 cal BP (the end of the Mesolithic cultural period). The results of the pollen-stratigraphic analysis indicate that during this period, *Alnus* (alder) dominated the wetland environment with sporadic *Salix* (willow) and a ground flora including Cyperaceae (sedges), Poaceae (grasses – e.g. *Phragmites australis* – common reed), *Dryopteris* type (buckler ferns), and *Polypodium vulgare* (polypody fern). Combined, these taxa indicate the presence of alder fen carr growing on the peat surface most likely near still or standing dominantly freshwater. No taxa indicative or potentially indicative of saltmarsh taxa are recorded, suggesting that the site was probably not influenced by saline conditions during this period.

Quercus (oak), *Betula* (birch) and *Corylus* type (e.g. hazel) may have accompanied alder and willow on the peat surface. However, these taxa more commonly occur on dryland where they would have formed a mosaic of mixed deciduous woodland with *Tilia* (lime). Indeed, since lime is of entomophilous (insect pollinated) even the relatively low *Tilia* pollen values recorded could indicate it was a dominant component of the adjacent dryland woodland during this period. The percentage values of birch are relatively high, suggesting that it formed a larger proportion of the local woodland than might normally be anticipated for this period of the Holocene. The understorey would have comprised hazel shrubs together with grasses and a range of herbs more commonly found in rough grassland.

Ulmus pollen values are very low during LPAZ FSP3-1, suggesting elm represented only a small proportion of the local woodland cover near. The reduction of elm populations is recorded within pollen diagrams across north-western Europe during the early Neolithic; in the Lower Thames Valley (e.g. Batchelor *et al.*, in press) and British Isles (Parker *et al.*, 2002) it is recorded between approximately 6300 and 5300 cal BP. It is therefore possible (but by no means certain), that the reason for the low values within the Ford Stamping Plant record, is that the sequence post-dates this well-documented decline.

There are no definitive indicators of human activity during LPAZ FSP3-1.

LPAZ FSP3-2 -3.40 to -2.10m OD *Alnus– Quercus – Cyperaceae*

The transition into LPAZ FSP3-2 is characterised by a reduction in *Betula* pollen indicating the decline of birch from the local woodland. This is initially reflected by an increase in *Alnus* pollen values, suggesting the expansion of alder woodland. It is therefore possible that the decline of birch was caused by the expansion of peat onto areas of dryland previously occupied by birch, resulting in it to being out-competed by other species (such as alder). This is a well-documented process known as paludification (e.g. Waller, 1994). It is also noticeable that the vegetation change occurs at the same time as a change in lithostratigraphy from predominantly wood to wood and herbaceous peat, possibly suggestive of a shift towards wetter conditions.

Following an initial peak, alder values reduce whilst sedge and aquatic (e.g. *Typha latifolia* – bulrush & *Nuphar* type - water lily) taxa increase. Combined this is indicative of a shift from alder fen carr towards a wetter and more open sedge fen vegetation community on the peat surface. The presence of *Chenopodium* type (goosefoot family) is also of note, since genera of the Chenopodiaceae family can occur in two main locations: (1) waste, dry ground and cultivated land (e.g. *Chenopodium album* – fat hen), and (2) salt marshes (e.g. *Suaeda maritima* – annual sea-blite. Since there are no other indicators of disturbance, the presence of *Chenopodium* type pollen is considered more likely to represent occasional fluvial inundation of the site and the influence of estuarine conditions.

The reduction in alder woodland on the peat surface is reflected by an apparent increase in woodland on the dryland, largely represented by oak with hazel. Whether this expansion of dryland woodland was real is unlikely, instead it is probable that pollen from the dryland was previously being filtered by the dense alder woodland; opening it up would therefore increase the amount of pollen reaching the borehole location.

Similarly to LPAZ FSP3-1, there are no definitive indicators of human activity during LPAZ FSP3-2.

LPAZ FSP3-3 -2.10 to -1.30m OD *Alnus– Quercus – Corylus* type

The transition into LPAZ FSP3-3 is characterised by the increase of Taxus pollen, indicating that yew increased to become an important component of the local woodland. In other records from the Lower Thames Valley (e.g. Branch et al., 2012), yew expands between ca. 5000 and 4000 cal BP to be a co-dominant component of the floodplain woodland on the peat surface with alder. The record from Ford Stamping Plant is therefore of interest, as yew expands sometime after 4830-4570 cal BP, declining around 3400-3565 cal BP; i.e. later than that ordinarily recorded elsewhere.

The reduction in *Quercus* pollen towards the top of the zone suggests that the oak-dominated dryland woodland declined markedly. Due to the Bronze Age date, it would seem likely that late prehistoric land clearance was the main cause. Indeed, the increased range of herbaceous and spore taxa, to include grasses, ribwort plantain (*Plantago lanceolata*), dandelions (Lactuceae) and bracken (*Pteridium aquilinum*) is potentially supportive of land clearance for both animal grazing and cultivation. There are however, no definitive indicators of human activity during this period (such as cereal pollen), and many of the taxa recorded may also result from changing hydrological conditions on the peat surface caused by an increasing saline influence.

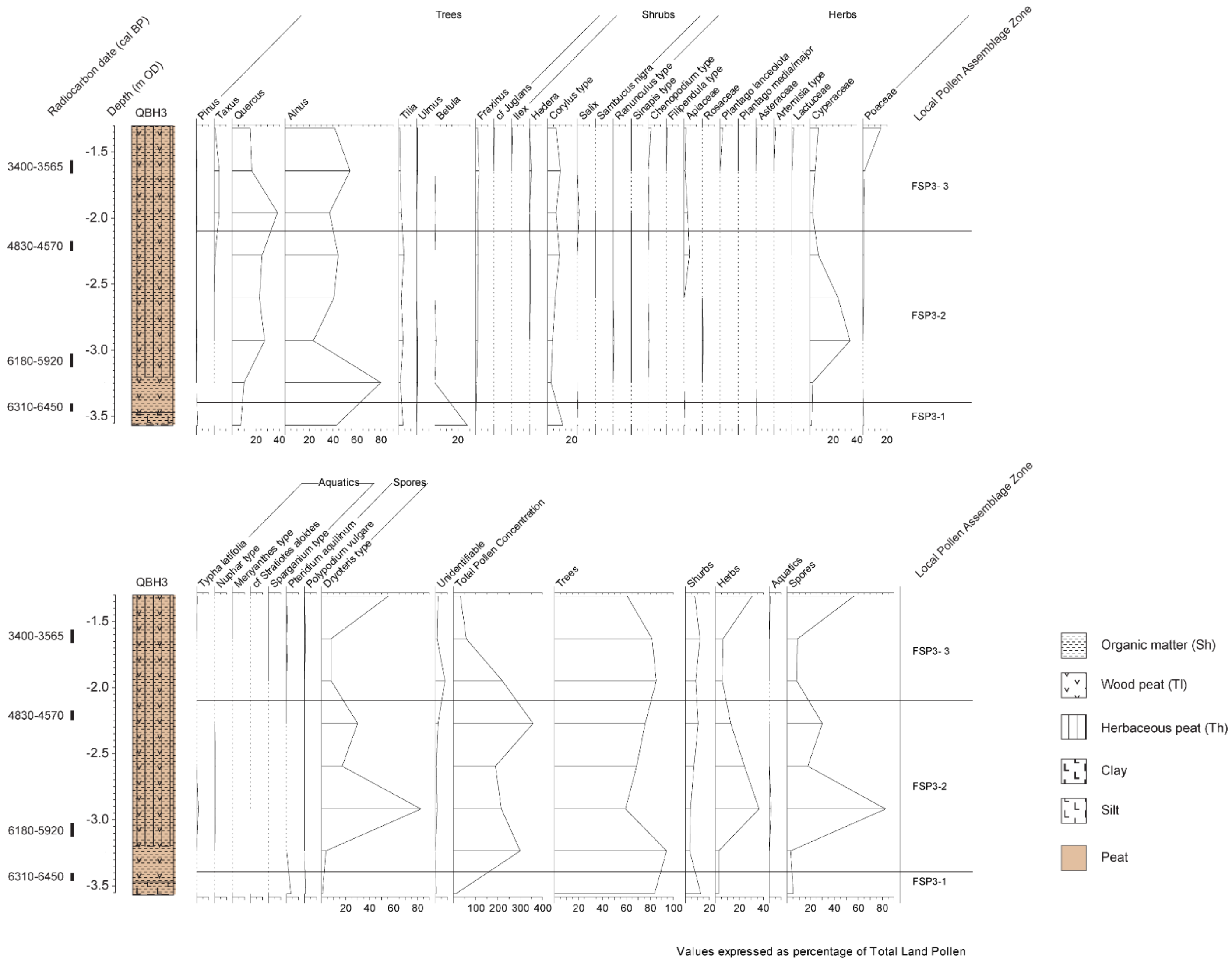

Figure 13: Pollen percentage diagram for Former Ford Stamping Factory, Kent Avenue, London Borough of Dagenham

6. RESULTS & INTERPRETATION OF THE DIATOM ASSESSMENT

A total of five samples, focussed on the interface between the peat and overlying/underlying alluvium in borehole QBH3, were submitted for assessment of diatoms. The results are displayed in Table 10. The results of the assessment indicate that diatoms are absent in all four samples. A number of factors influence diatom preservation, and it is probable that in the sediments examined here diatom concentrations were always low and that post-depositional destruction of the frustules has occurred due to drying-out, abrasion and possibly unfavourable chemical conditions. Dissolution of the diatom silica, for example, can occur as a response to the ambient dissolved silica concentration, the pH in open water, and the interstitial water in sediments. Using both fossil and modern diatoms, these and other environmental factors have been shown to affect the quality of preservation of assemblages (Flower, 1993; Ryves *et al.*, 2001).

Table 10: Results of the diatom assessment of samples from QBH3, Former Ford Stamping Factory.

Borehole	Depth (m OD)	Stratigraphy	Diatom concentration	Quality of preservation	Diversity
QBH3	-1.22 to -1.23	Organic peat	0	-	-
QBH3	-1.29 to -1.30	Organic peat	0	-	-
QBH3	-3.37 to -3.38	Organic peat	0	-	-
QBH3	-3.45 to -3.46	Silt-rich peat	0	-	-
QBH3	-3.53 to -3.54	Silt-rich peat	0	-	-

7. RESULTS & INTERPRETATION OF THE MACROFOSSIL ASSESSMENT

A total of five small bulk samples from borehole QBH1 and ten from QBH3, were extracted and processed for the recovery of macrofossil remains, including waterlogged plant macrofossils, wood, insects and Mollusca (Tables 11 and 12). The samples were focussed on the peat horizons in both boreholes.

The samples in borehole QBH1 were dominated by waterlogged wood, with high concentrations recorded in all but two samples (-1.70 to -1.80m OD (absent) and -1.80 to -1.90m OD (low concentrations)). Waterlogged seeds were recorded in relatively low concentrations in three samples (-1.79 to -1.89, -2.10 to -2.20 and -4.54 to -4.59m OD). Sedge remains, generally lacking the diagnostic epidermal tissues necessary for identification, were recorded in low concentrations in the samples from -1.79 to -1.89 and -1.80 to -1.90m OD. No charred remains were identified in the samples from QBH1, other than a small quantity of charred fragments (too small for identification) in the sample from -1.79 to -1.89m OD. No Mollusca, bone or insects were recorded during the assessment of samples from QBH1.

Similarly to the samples from QBH1, the samples from QBH3 were dominated by high to moderate quantities of waterlogged wood, with the exception of the samples from -2.16 to -2.20, -2.76 to -2.86 and -3.06 to -3.16m OD, in which wood was absent. Sedge remains, again generally lacking the diagnostic epidermal tissues necessary for identification, were present in low to moderate quantities in all but the samples from -1.86 to -1.96, -2.76 to -2.86 and -3.06 to -3.16m OD; high quantities were recorded in the sample from -2.16 to -2.20m OD. Waterlogged seeds were recorded in very low concentrations in the samples from -1.86 to -1.96 and -2.16 to -2.20m OD. Insect remains, generally present as fragments too small for identification, were recorded in moderate concentrations in the sample from -1.56 to -1.66m OD. No charred remains, Mollusca or bone were recorded in the samples from QBH3.

The waterlogged seed assemblage in the peat sequence from both boreholes QBH1 and QBH3 is very limited, and is therefore too small to attempt a full environmental interpretation. However, the taxa recorded in both boreholes are typical of alder carr or sedge fen environments, including *Rubus* cf. *fruticosus* (bramble), *Scirpus* sp. (bulrush) and *Alnus glutinosa* (catkin) alder in QBH1 (Table 13), and alder and cf. Brassicaceae (e.g. mustard family) in QBH3 (Table 14). The abundance of both wood and sedge remains throughout the sequences in both boreholes is consistent with this interpretation, although the greater dominance of woody material in QBH1 may provide a tentative indication that alder carr was more dominant at this particular location. Also of note is the identification of oak and yew wood towards the very northern edge of the site during the archaeological evaluation (CgMs Heritage, 2018).

Table 11: Results of the macrofossil assessment of samples from borehole QBH1, Ford Stamping Plant,

			Charred					Waterlogged			Mollusca		Bone			
Depth (m OD)	Volume processed (ml)	Fraction	Charcoal (>4mm)	Charcoal (2-4mm)	Charcoal (<2mm)	Seeds	Chaff	Wood	Seeds	Sedge remains (e.g. stems/roots)	Whole	Fragments	Large	Small	Fragments	Insects
-1.70 to -1.80	0.05	>300µm	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-1.79 to -1.89	0.05	>300µm	-	-	1	-	-	4	1	1	-	-	-	-	-	-
-1.80 to -1.90	0.05	>300µm	-	-	-	-	-	1	-	1	-	-	-	-	-	-
-2.10 to -2.20	0.05	>300µm	-	-	-	-	-	4	1	-	-	-	-	-	-	-
-4.54 to -4.59	0.05	>300µm	-	-	-	-	-	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 12: Results of the macrofossil assessment of samples from borehole QBH3, Ford Stamping Plant,

			Charred					Waterlogged			Mollusca		Bone			
Depth (m OD)	Volume processed (ml)	Fraction	Charcoal (>4mm)	Charcoal (2-4mm)	Charcoal (<2mm)	Seeds	Chaff	Wood	Seeds	Sedge remains (e.g. stems/roots)	Whole	Fragments	Large	Small	Fragments	Insects
-1.25 to -1.30	0.05	>300µm	-	-	-	-	-	3	-	1	-	-	-	-	-	-
-1.56 to -1.66	0.05	>300µm	-	-	-	-	-	3	-	3	-	-	-	-	-	2
-1.86 to -1.96	0.05	>300µm	-	-	-	-	-	3	1	-	-	-	-	-	-	-
-2.16 to -2.20	0.05	>300µm	-	-	-	-	-	-	1	4	-	-	-	-	-	-
-2.20 to -2.26	0.05	>300µm	-	-	-	-	-	2	-	2	-	-	-	-	-	-
-2.76 to -2.86	0.05	>300µm	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-2.46 to -2.56	0.05	>300µm	-	-	-	-	-	4	-	1	-	-	-	-	-	-
-3.06 to -3.16	0.05	>300µm	-	-	-	-	-	4	-	-	-	-	-	-	-	-
-3.36 to -3.41	0.10	>300µm	-	-	-	-	-	1	-	2	-	-	-	-	-	-
-3.41 to -3.46	0.05	>300µm	-	-	-	-	-	3	-	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 QBH1, Ford Stamping Plant

Depth (m OD)	Unit	Seed identification		Quantity
		Latin name	Common name	
-1.70 to -1.80		-	-	-
-1.79 to -1.89		*Rubus* cf. *fruticosus*		4
-1.80 to -1.90		-	-	-
-2.10 to -2.20		*Scirpus* cp.	bulrush	1
-4.54 to -4.59		*Alnus glutinosa* (catkin)	alder	1

Table 14: Results of the seed identifications of samples from borehole QBH3, Ford Stamping Plant

Depth (m OD)	Unit	Seed identification		Quantity
		Latin name	Common name	
-1.25 to -1.30		-	-	-
-2.46 to -2.56		-	-	-
-1.25 to -1.30		*Alnus glutinosa* (fruit)	alder	1
-1.56 to -1.66		cf. Brassicaceae	e.g. mustard family	1
-1.86 to -1.96		-	-	-
-2.16 to -2.20		-	-	-
-2.20 to -2.26		-	-	-
-2.76 to -2.86		-	-	-

8. DISCUSSION & CONCLUSIONS

As outlined in section 2.3, the overarching aims of the geoarchaeological and palaeoenvironmental investigations at the Ford Stamping Plant site were as follows:

1. To clarify the nature of the sub-surface stratigraphy across the site;
2. To clarify the nature, depth, extent and date of any alluvium 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)
5. To integrate the new geoarchaeological record with other recent work in the local area for publication in an academic journal

The following section addresses these aims by comparing the findings from Ford Stamping Plant with those resulting from previous similar investigations undertaken in the local area, and includes information derived from the archaeological evaluation (CgMs Heritage, 2018). Thereby, placing the findings and their importance within a wider regional context.

8.1 Stratigraphic and hydrological history

The combined results of a wider deposit modelling exercise indicate that the sediments recorded at the Ford Stamping Plant site are similar to those recorded elsewhere in the Lower Thames Valley, A sequence of Shepperton Gravel is overlain by alluvial sediments, including peat, buried beneath modern Made Ground. The surface of the Gravel slopes downwards from north to south/south-east across the site, largely resting between -4 and -6m OD. The surface of the Gravel is consistently recorded below *ca*. -5.5m OD towards the east of the site, and encompassing the western part of Beam Park (Young & Batchelor, 2016). As discussed by Young & Batchelor, (2017), this feature may indicate a broadly north-south aligned channel that could dissect the terrace to the north, in a similar nature to that recorded towards the centre of Beam Park; as stated above however, in the absence of additional data to the north of this possible channel, it is not currently possible to confirm its presence, character or orientation. The elevated Gravel surface at the Princess Bowl site to the north (MoLA, 2002; 4.4-4.85m OD) indicates that if a north-south aligned channel exists, it most likely lies to the east of this site.

Where the Gravel rises towards the north of the site, this is consistent with the position of the site on the edge of the floodplain. The archaeological evaluation (CgMs Heritage, 2018) confirms that the Gravel surface rises above 2m OD at the northern end of the site, a level consistent with the surface of the older Wolstonian Taplow Gravel terrace (MIS 6-10; 352,000 to 130,000 BP) which in this area forms the edge of the floodplain. Significant prehistoric archaeological remains have been found towards the top of the peat close to the floodplain/dryland edge at Bridge Road, Rainham (Meddens & Beasley, 1990; Beasley, 1991), Hays Storage, Dagenham (Divers, 1996) and more recently within brickearth in the north-eastern corner of Beam Park (PCA, in press). At Bridge Road, these included a Bronze Age causeway, constructed of gravel and burnt flint, stakes, spreads of fire-cracked pebbles, wattling and a brushwood trackway.

Within the Holocene alluvial sequence at the site and overlying the Lower Alluvium, Sand or in some cases Shepperton Gravel in the vast majority of the boreholes is a unit of peat. The Peat generally varies between 1.5 and 3m in thickness, with the thickest horizons occurring on the eastern and south-eastern parts to the site, with thicker horizons recorded within the possible north-south aligned palaeochannel identified above. The peat is indicative of a transition towards semi-terrestrial (marshy) conditions, supporting the growth of sedge fen/reed swamp and/or woodland communities across the floodplain. It is important to note that the peat at the site also has the potential to contain archaeological remains as demonstrated by findings at both Hays Storage Dagenham (Divers, 1996) and Bridge Road, Rainham (Meddens & Beasley, 1990; Beasley, 1991). Generally, these remains have been recorded towards the top of the Peat and relatively close the floodplain edge.

Peat accumulation began earlier at the location of QBH3, at around 6450-6310 cal BP (Late Mesolithic), with accumulation beginning at around 5320-5580 cal BP (Middle Neolithic) in QBH1. Peat cessation probably took place within a broadly similar period during the Late Bronze Age at both locations, with the top of the peat at the location of QBH1 dated to 3000-3210 cal BP) and near the top of the peat in QBH3 dated to 3400-3565 cal BP). These dates fall within the general period of peat formation in this area; nearby sites such as Hornchurch Marshes (Batchelor, 2009; Branch et al., 2012), Barking Riverside (Green et al., 2014) and Bridge Road (Meddens & Beasley, 1990; Beasley, 1991) have all recorded peat accumulation from the late Mesolithic to Bronze Age.

9.2 Vegetation history

The radiocarbon-dated palaeoenvironmental record from the Ford Stamping Park site contains a relatively low-resolution record of vegetation history from the late Mesolithic to late Bronze Age period. Nevertheless, the results of the pollen and plant macrofossil assessment indicate that from the late Mesolithic to late Neolithic / early Bronze Age, the floodplain environment was dominated by wetland woodland comprising alder and a ground flora of sedges, grasses, aquatics and ferns. Oak, hazel and birch may have occupied the wetland woodland, but more likely formed mixed deciduous woodland on the dryland with lime. The growth of oak and yew on at least the very northern edge of the site is confirmed by findings during the archaeological evaluation (CgMs Heritage, 2018).

The vegetation history of the Ford Stamping Plant site during this period is broadly similar to that recorded at the Merrielands Crescent (Batchelor et al., 2018), Barking Riverside (Green et al, 2014) and Hornchurch Marshes sites (Branch, 2012). There are however important variations at the current site which are not recorded elsewhere, including: (1) the localised growth of birch woodland during the early stages of peat formation around 6450-6310 cal BP (late Mesolithic); (2) a transition from alder fen carr towards alder carr and sedge fen communities on the floodplain reflective of wetter conditions around 6180-5920 cal BP (early Neolithic), (3) the expansion of yew woodland from shortly after 4830-4570 to 3400-3565 cal BP (middle Neolithic to middle Bronze Age) and (4) a decline in dryland woodland after 3400-3565 cal BP, not matched by a decline of floodplain woodland (middle Bronze Age).

Most locally at Merrielands Crescent (Batchelor et al., 2018), the results of a higher resolution analysis indicated a peat surface occupied by alder and willow, forming carr woodland, with an understorey of sedges and grasses. Oak, elm and hazel are likely to have either accompanied alder on the floodplain or formed part of a mosaic of mixed deciduous woodland on the dryland. Lime formed an important component of the dryland woodland, particularly during the early stages of peat formation, but underwent an abrupt decline around 5300-5040 cal BP, most likely as a consequence of paludification. Similarly to Ford Stamping Plant, elm pollen values were low suggestive of a sequence post-dating the Neolithic decline. Towards the end of peat formation, woodland declined on both the floodplain and dryland. The increase in a wide variety of herbaceous taxa together with high levels of microcharcoal indicate the importance of Bronze Age activity in this process (Batchelor *et al.*, 2017).

At Hornchurch Marshes, *ca*. 2km to the southeast (Batchelor, 2009; Branch *et al*., 2012) analysis of fine-grained mineral-rich sediments and peat revealed the presence of freshwater during the Late Mesolithic, at which point peat accumulation began, corresponding to a regional reduction in sea level. Significant changes in both the wetland and dryland environment were recorded here, including the establishment of alder carr woodland, the presence of yew, the decline of elm during the Neolithic, and decline of lime during the Neolithic & Bronze Age. A subsequent transition to estuarine conditions was dated to *ca*. 3900 cal BP, coinciding with a decline in woodland cover and the expansion of plant communities typically found within reed swamp.

9. REFERENCES

Allen, M.J. & Scaife, R.G. (2010) *The physical evolution of the North Avon Levels: A review and summary of the archaeological implications*. Wessex Archaeology Internet Reports.

Archaeological Solutions Ltd (2005) *Former Rainham Squash & Snooker Club, Ferry Lane, Rainham, Essex: Archaeological Excavation - An Interim Report*. Archaeological Solutions Ltd Unpublished Report.

Batchelor, C.R. (2009) *Middle Holocene environmental changes and the history of yew (Taxus baccata L.) woodland in the Lower Thames Valley*. Royal Holloway Unpublished PhD thesis.

Batchelor, C.R., Green, C.P., Young, D.S. & Austin, P. (2011) *Merchant Waste Treatment Plant, Frog Island, London Borough of Havering: geoarchaeological assessment report*. Quaternary Scientific (QUEST) Unpublished Report April 2011; Project Number 022/11.

Batchelor, C.R. and Young, D.S. (2016) *Dovers Corner, New Road, Rainham, London Borough of Havering Geoarchaeological Deposit Model Report*. Quaternary Scientific (QUEST) Unpublished Report August 2016; Project Number 126/16.

Batchelor, C.R. (2017a) *Former Ford Stamping Factory, Kent Avenue, London Borough of Dagenham: Desk-Based Geoarchaeological Deposit Model Report*. Quaternary Scientific (QUEST) Unpublished Report May 2017; Project Number 190/16.

Batchelor, C.R. (2017b) *Former Ford Stamping Factory, Kent Avenue, London Borough of Dagenham: Geoarchaeological and Palaeoenvironmental Written Scheme of Investigation*. Quaternary Scientific (QUEST) Unpublished Report May 2017; Project Number 190/16.

Batchelor, C.R., Young, D.S., Hill, T. and Austin, P. (2018) *Merrielands Crescent, London Borough of Barking and Dagenham Palaeobotanical Analysis Report.* Quaternary Scientific (QUEST) Unpublished Report July 2018; Project Number 086/17.

Bates, M. & Stafford, L. (2013) *Thames Holocene: A geoarchaeological approach to the investigation of the fiver floodplain for High Speed I, 1994-2003*. Oxford Wessex Archaeology Monograph.

Beasley, M. (1991) *Excavations at Bridge Road, Rainham, Essex, London Borough of Havering, RA-BR89, Level III Report*. Passmore Edmunds Museum Unpublished Report.

Beasley, M. (1996) *Watching Brief at Viking Way, Rainham, RA-VW 96*. Newham Museum Service. Unpublished Report

Bengtsson, L. & Enell, M. (1986) Chemical Analysis. In (Berglund, B.E. ed.) *Handbook of Holocene palaeoecology and palaeohydrology*, 423-451. Chichester: John Wiley and Sons.

Branch, N.P., Canti, M.G., Clark, P. and Turney, C.S.M. (2005) *Environmental Archaeology: Theoretical and Practical Approaches*, Edward Arnold, London.

Branch, N.P., Batchelor, C.R., Cameron, N.G., Coope, R., Densem, R., Gale, R., Green, C.P. & Williams (2012) Holocene Environmental Changes at Hornchurch Marshes, London, UK: implications for our understanding of the history of Taxus (L.) woodland in the Lower Thames Valley. *The Holocene*, 22 (10) 1143-1158.

Bronk Ramsey C. (1995) Radiocarbon Calibration and Analysis of Stratigraphy: The OxCal Program, *Radiocarbon* 37 (2), 425-430.

Bronk Ramsey C. (2001) Development of the Radiocarbon Program OxCal, *Radiocarbon* 43 (2a), 355-363.

Bronk Ramsey, C. (2007) Deposition models for chronological records. *Quaternary Science Reviews* (INTIMATE special issue; 27(1-2), 42-60.

Campbell, I.D. (1999) Quaternary pollen taphonomy: examples of differential redeposition and differential preservation. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 149, 245-256.

Cappers, R.T.J., Bekker R.M. & Jans J.E.A. (2006) *Digital Seed Atlas of the Netherlands*. Groningen Archaeological Series 4. Barkhuis, Netherlands

CgMs Heritage (2018) Archaeological Evaluation, Former Ford Stamping Plant, Kent Avenue, Dagenham, RM9 6SA. CgMs Heritage Unpublished Report, February 2018.

CgMs Heritage (2016) *Cultural Heritage Desk Based Assessment, Former Ford Stamping Plant, Kent Avenue, Dagenham RM9 6SA*. CgMs Heritage Unpublished Report, October 2016.

Cushing, E.J. (1967) Evidence for differential pollen preservation in late Quaternary sediments in Minnesota. *Review of Palaeobotany and Palynology*, 4, 87-101.

Devoy, R.J.N. (1979) Flandrian sea-level changes and vegetational history of the lower Thames estuary. *Philosophical Transactions of the Royal Society of London,* B285, 355-410.

Divers, D. (1996) *Archaeological investigation of Hays Storage Services Ltd., Pooles Lane, Ripple Road, Dagenham, Essex*. Unpublished Report, June 1996.

Dyson, A. (2013) *Archaeological evaluation at the Passivhaus Housing Development, New Road, Rainham*, London Borough of Havering. Archaeology South East Report Number 2013208.

Flower, R.J. (1993) Diatom preservation: experiments and observations on dissolution and breakage in modern and fossil material. *Hydrobiologia* 269/270, 473-484.

Gibbard, P. (1985) *The Pleistocene History of the Lower Thames Valley*. Cambridge University Press, Cambridge.

Gibbard, P. (1994) *The Pleistocene history of the Lower Thames Valley*. Cambridge: Cambridge University Press.

Green, C.P., Batchelor, C.R., Austin, P., Cameron, N.G. and Young, D.S. (2014) Holocene alluvial environments at Barking, Lower Thames Valley (London, UK). *Proceedings of the Geologists Association,* 125(3), 279-295.

Haggart, B.A. (1995) A re-examination of some data relating to Holocene sea-level changes in the Thames Estuary. In (D.R. Bridgland, P. Allen & B.A. Haggart, eds.) *The Quaternary of the lower reaches of the Thames Estuary*, 329-338. Durham: Quaternary Research Association.

Hendy, N.I. (1964). *An introductory account of the smaller algae of the British coastal waters*. Part V: Bacillariophyceae (Diatoms). Fisheries Investigation Series, I, H.M.S.O., London.

Hertfordshire Archaeological Trust (1995) *Evaluation at Scott and Albyn's Farm. HO-CP 95*. Hertfordshire Archaeological Trust Unpublished Report.

Hertfordshire Archaeological Trust (2000) *A Late Bronze Age Landscape at Hornchurch, Greater London.* Hertfordshire Archaeological Trust Unpublished Report.

Krammer, K. & Lange-Bertalot, H. (1986-1991). *Subwasserflora von Mitteleuropa*. Bacciliarophyceae: 2 (1) Naviculaceae; 2 (2) Bacillariacceae, Epithemiaceae, Surirellaceae; 2 (3) Centrales, Fragilariaceae, Eunotiaceae; 2 (4) Achnanthaceae. Fischer, Stuttgart.

Krawiec, K. (2014) *A palaeoenvironmental assessment of deposits at New Road, Rainham, London Borough of Havering*. Archaeology South East Unpublished Report.

Long, A.J. (1995) Sea-level and crustal movements in the Thames Estuary, Essex and East Kent. In (D.R. Bridgland, ed.) *The Quaternary of the lower reaches of the Thames Estuary*, 99-105. Durham: Quaternary Research Association.

Meddens, F & Beasley, M. (1990) Wetland Use In Rainham, Essex. London Archaeologist **6(9)**: 242-248.

MoLAS (1997) *Union railways, Phase 4, Area 3, 10, Rainham, Purfleet, West Thurrock, London Borough of Havering: archaeological watching brief*. MoLAS Unpublished Report.

MoLAS (1998) *The Lessa Sports Ground, Rainham Road, South Hornchurch, London, RM13: Evaluation Report*. MoLAS Unpublished Report.

MoLAS (2001). *The Lessa Sports Ground, RM13: An Archaeological Post-excavation Assessment*. MoLAS Unpublished Report.

MoLAS (2002) *Site of the Former Princess Bowl Review Road Dagenham RM9, London Borough of Barking and Dagenham. An archaeological evaluation report*. MoLAS Unpublished Report, December 2002.

Moore, P.D., Webb, J.A. & Collinson, M.E. (1991) *Pollen Analysis*. Oxford: Blackwell Scientific.

NIAB (2004) *Seed Identification Handbook Agriculture, Horticulture & Weeds. 2nd edition*. NIAB, Cambridge.

Newham Museum Service (1992) *Rainham - Brookway Allotments: Evaluation and Excavation*. Newham Museum Service Unpublished Report.

Potter, G. (2003) *Former Manser Works, 137-139 New Road, Rainham, Essex, LB Havering: interim archaeological post-excavation assessment*. Compass Archaeology Ltd Unpublished Report.

Pre-Construct Archaeology (2007) *An Archaeological Evaluation at 155-163 New Road, Rainham*. Pre-Construct Archaeology Unpublished Report, September 2007.

Reille, M. (1992) *Pollen et spores D'Europe et D'Afrique du Nord*. Laboratoire de Botanique historique et Palynologie, Marsaille.

Reimer, P.J., Bard, E., Bayliss, A., Beck, J.W., Blackwell, P.G., Bronk Ramsey, C., Buck, C.E., Edwards, R.L., Friedrich, M., Grootes, P.M., Guilderson, T.P., Haflidason, H., Hajdas, I., Hatté, C., Heaton, T.J., Hoffmann, D.L., Hogg, A.G., Hughen, K.A., Kaiser, K.F., Kromer, B., Manning, S.W., Niu, M., Reimer, R.W., Richards, D.A., Scott, E.M., Southon, J.R., Turney, C.S.M., and van der Plicht, J., (2013) IntCal13 and Marine13 radiocarbon age calibration curves, 0-50,000 years cal BP. *Radiocarbon* 55: 1869-1887.

Ryves, D.B., Juggins, S., Fritz, S.C. & Battarbee, R.W. (2001) Experimental diatom dissolution and the quantification of microfossil preservation in sediments. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 172, 99-113.

Scaife, R.G. & Burrin, P.J. (1992) Archaeological inferences from alluvial sediments: some findings from southern England. In (Needham, S. & Macklin, M.G. eds), *Alluvial Archaeology in Britain*. Oxford: Oxbow Monograph 27, 75–91.

Sidell, E.J. (2003) *Relative sea-level change and archaeology in the inner Thames estuary during the Holocene.* University College, London, Unpublished PhD Thesis.

Stace, C. (2005) *New Flora of the British Isles. Cambridge*: Cambridge University Press.

Thames Valley Archaeological Services (1995) *Former Rainham, Football Ground, Rainham, London: An Archaeological Evaluation*. TVAS Unpublished Report.

Tröels-Smith, J. (1955) Karakterisering af løse jordater (Characterisation of unconsolidated sediments), *Danm. Geol. Unders.,* Ser IV 3, 73.

van Der Werff & Huls (1958-1974). *Diatomeeënflora van Nederland*. Eight parts, published privately by van der Werff, De Hoef (U), The Netherlands.

Waller, M.P. (1993) Flandrian vegetational history of south-eastern England. Pollen data from Pannel Bridge, East Sussex. *New Phytologist*, 124, 345-369.

Waller, M.P. (1998) An investigation in the palynological properties of fen peat through multiple pollen profiles from south-eastern England. *Journal of Archaeological Science* 25, 631-642.

Waller, M. & Grant, M.J. (2012) Holocene pollen assemblages from coastal wetlands: differentiating natural and anthropogenic causes of change in the Thames estuary, UK. *Journal of Quaternary Science*, 27(5) 461-474.

Waller, M.P., Binney, H.A., Bunting, M.J. & Armitage, R.A. (2005) The interpretation of fen carr pollen diagrams: pollen-vegetation relationships within fen carr. *Review of Palaeobotany and Palynology,* 133, 179-202.

Wheeler, B.D. (1980a) Plant communities of rich-fen systems in England and Wales I: introduction, tall sedge and reed communities. *Journal of Ecology,* 68, 365-395.

Wheeler, B.D. (1980b) Plant communities of rich-fen systems in England and Wales III: fen meadow, fen grassland and fen woodland communities, and contact communities. *Journal of Ecology,* 68, 761-788.

Young, D.S. & Batchelor, C.R. (2016) *Beam Park Riverside, London Boroughs of Havering & Rainham: Desk-based geoarchaeological deposit model report*. Quaternary Scientific (QUEST) Unpublished Report March 2017; Project Number 216/16.

Young, D.S. & Batchelor, C.R. (2017) *Former Ford Stamping Factory, Kent Avenue, London Borough of Dagenham. Geoarchaeological Deposit Model Report.* Quaternary Scientific (QUEST) Unpublished Report September 2017; Project Number 190/16.

Young, D.S. & Batchelor, C.R., Hill, T. (2017) *Former Ford Stamping Factory, Kent Avenue, London Borough of Dagenham. Environmental Archaeological Assessment Report.* Quaternary Scientific (QUEST) Unpublished Report September 2017; Project Number 190/16.

10. APPENDIX 1: OASIS FORM

Printable version

OASIS ID: quaterna1-293958

Project details

Project name	FORMER FORD STAMPING FACTORY, KENT AVENUE
Short description of the project	Geoarchaeological and palaeoenvironmental analysis of selected sequences was carried out at the Former Ford Stamping Plant Factory site. The results indicate a sequence of Shepperton Gravel, overlain by Holocene alluvial sediments, buried beneath modern Made Ground. The surface of the Gravel slopes downwards from north-west to south/south-east across the site, largely resting between -4 and -6m OD. The site clearly lies close to the floodplain/dryland edge, with Gravel surfaces typical of the Taplow Gravel terrace towards the northwest. A similar sequence of deposits is recorded across the neighbouring Beam Park site to the east. The Shepperton Gravel (and occasional sand) is overlain by a tripartite sequence of Lower Alluvium, Peat and Upper Alluvium. The Peat generally ranges between 1.5 and 3m in thickness, reaching over 3.5m in five records. Peat accumulation began at the site during the Late Mesolithic continuing until the Late bronze Age, falling within the general period of peat formation in this area. The results of the assessment of the peat are indicative of a peat surface dominated by alder, with an understorey of sedges and occasional grasses and aquatics. Hazel, ash and birch may have occupied the peat surface with alder, but are more likely to grown on the dryland forming mixed deciduous woodland with oak and lime.
Project dates	Start: 01-05-2017 End: 14-10-2018
Previous/future work	No / Not known
Type of project	Environmental assessment
Significant Finds	PEAT Late Mesolithic
Significant Finds	PEAT Late Bronze Age
Survey techniques	Landscape

Project location

Country	England
Site location	GREATER LONDON BARKING AND DAGENHAM DAGENHAM Former Ford Stamping Factory
Postcode	RM9 6YQ
Site coordinates	TQ 49828 83203 51.527327529171 0.160125149563 51 31 38 N 000 09 36 E Point

Project creators

Name of Organisation	Quaternary Scientific (QUEST)
Project brief originator	CgMs Heritage
Project design originator	Dr C.R. Batchelor
Project director/manager	C.R. Batchelor

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	Former Ford Stamping Factory, Kent Avenue, London Borough of Dagenham. Environmental Archaeological Assessment Report.
Author(s)/Editor(s)	Young, D.S.
Author(s)/Editor(s)	Batchelor, C.R.
Author(s)/Editor(s)	Hill, T.
Other bibliographic details	Quaternary Scientific (QUEST) Unpublished Report August 2017; Project Number 086/17
Date	2017
Issuer or publisher	Quaternary Scientific
Place of issue or publication	University of Reading

Project bibliography 2

Publication type	Grey literature (unpublished document/manuscript)
Title	Former Ford Stamping Factory, Kent Avenue, London Borough of Dagenham: Desk-Based Geoarchaeological Deposit Model Report.
Author(s)/Editor(s)	Batchelor, C.R.
Other bibliographic details	Unpublished Report May 2017; Project Number 190/16.
Date	2017
Issuer or publisher	Quaternary Scientific
Place of issue or publication	University of Reading

Project bibliography 3

Publication type	Grey literature (unpublished document/manuscript)
Title	Former Ford Stamping Factory, Kent Avenue, London Borough of Dagenham: Geoarchaeological and palaeoenvironmental analysis report
Author(s)/Editor(s)	Batchelor, C.R.
Author(s)/Editor(s)	Young, D.S.
Author(s)/Editor(s)	Austin, P.
Other bibliographic details	Quaternary Scientific (QUEST) Unpublished Report October 2018; Project Number 190/16
Date	2018
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	14 October 2018

