making sense of heritage

Bristol Waste Water Treatment Works Avonmouth

Stage 3: Palaeoenvironmental assessment report

Ref: 67322.04
November 2013

geoservices

Bristol Waste Water Treatment Works, Avonmouth

Stage 3: Palaeoenvironmental assessment report

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Bristol Waste Water Treatment Works, Avonmouth

Stage 3: Assessment report

Summary
Wessex Archaeology was commissioned by Triodos Renewables (Severn) Ltd to undertake a programme of geoarchaeological work on core samples through sequences within the footprint of three proposed wind turbine locations.

An initial stage of geoarchaeological recording and interpretation (Stage 2) was followed by palaeoenvironmental assessment of subsamples taken from the core samples (Stage 3). The results of both stages of work are reported on here.

In all three locations (BH1, BH2 and BH4) the sequences are generally typical of what would be expected for this area, namely the sediments of the upper and middle Wentlooge Formation. No peats were found to be present on site.

In one sequence (BH4), two apparent buried soils or stasis horizons were recorded, at *c*.5.2m and 4.8m above Ordnance Datum (aOD) respectively. These levels correlated very well with similar horizons at the immediately adjacent site of Katherine Farm, where the upper horizon was securely dated to the late Bronze Age.

In the other sequences (BH1 and BH2) a layer of quite 'clean', apparently well-sorted clay was recorded at *c*.3.75m aOD, which was interpreted as pooling of marine or brackish water in a lagoonal or backwater environment, probably resulting from a marine incursion event.

A series of research questions were identified following geoarchaeological description and interpretation (Stage 2), which focussed on attempting to date the stasis horizons and compare them with the examples at Katherine Farm; identify any indicators of human activity; and refine the nature of the depositional environment before and after stasis formation, as well as the possible lagoonal deposits.

A programme of subsampling and palaeoenvironmental assessment was designed to address these questions (Stage 3). This work targeted indicators such as pollen, plant macrofossils, molluscs, foraminifera and ostracods, and also aimed to retrieve material for radiocarbon dating.

No waterlogged or charred material was found to be preserved in any of the samples, nor was any other material suitable for radiocarbon dating. Molluscs and ostracods were also almost entirely absent, indicating the probable presence of acidic conditions at some point following deposition. Foraminifera from brackish and marine-tolerant taxa were present in some of the samples.

The report discusses soils and stases in the Wentlooge Formation, compares the results with those from local sites, and makes some general recommendations regarding the radiocarbon dating of similar deposits.

The results can be summarised as:

- *Estuarine alluvial sediments typical of the upper and middle Wentlooge Formation have been recorded;*
- *No peat horizons were present;*
- *Two stasis horizons have been recorded which can be equated with a high degree of confidence to those nearby at Katherine Farm (Trench 5A), inferring a late Bronze Age date for the upper horizon; and*
- *The absence of a wide range of indictors, as well as material suitable for radiocarbon dating, makes further palaeoenvironmental or chronological refinement impractical.*

The assessment has shown that the samples do not have the potential to address the project aims, and no further work is recommended.

Bristol Waste Water Treatment Works, Avonmouth

Stage 3: Assessment report

Acknowledgements
Wessex Archaeology would like to thank Triodos Renewables (Severn) Ltd who commissioned the work, and Bob Jones of Bristol City Council for guidance during the project.

The samples were described and interpreted geoarchaeologically by David Norcott and Nicki Mulhall, and the pollen assessment undertaken by Michael Grant. Pollen sample preparation and loss on ignition were undertaken by Kevin Attree, CEESR, Kingston University. Plant macrofossil assessment was carried out by Sarah Wyles, and the assessment of foraminifera and ostracods by Jack Russell. This report was compiled by David Norcott and Andrew Bicket, and the illustrations prepared by Ken Lymer. The project was managed on behalf of Wessex Archaeology by Caroline Budd.

Bristol Waste Water Treatment Works, Avonmouth

Stage 3: Assessment report

Contents

Tables

Figures

Bristol Waste Water Treatment Works, Avonmouth

Stage 3: Assessment report

1 INTRODUCTION

1.1 Project background

1.1.1 Wessex Archaeology was commissioned by Triodos Renewables (Severn) Ltd to undertake a programme of geoarchaeological work as specified in the Written Scheme of Investigation (WSI; WA 2013).

1.1.2 Geotechnical work was carried out in compliance with conditions applied to full planning permission for the development (ref 11/04977/X) which has been granted for the erection of four wind turbines and associated ancillary works at Bristol Waste Water Treatment Works (NGR 353350 179620), hereafter the Site (**Figure 1**).

1.1.3 Following discussions on-site and with the Senior Archaeological Officer for BCC, archaeological advisor to the Local Planning Authority (LPA) it was agreed that sleeved cores be obtained from each turbine location and assessed geoarchaeologically, in conjunction with review of geotechnical logs obtained during site investigations.

1.2 Staged approach

1.2.1 To help frame geoarchaeological investigations of this nature, Wessex Archaeology has developed a five stage approach, encompassing different levels of investigation appropriate to the results obtained, accompanied by formal reporting of the results at the level achieved. The stages are summarised below:

Table 1: Staged approach to geoarchaeological investigations

Stage 1: Planning	Desk-based Assessment (DBA) of samples and logs generated by geotechnical contractors. This assessment will establish the presence and location of sediment units with likely archaeological, palaeo-environmental and/or dating potential, as a basis for deciding what Stage 2 archaeological recording is required. The Stage 1 report will state the scale of Stage 2 work proposed. Should no further works be required a brief Stage 1 report outlining the results of the assessment will be prepared.

Stage 2: Geoarchaeological description & interpretation	Each sample containing sediment units identified as having archaeological, palaeo-environmental or dating potential in Stage 1 will be cleaned, recorded, and the sediments described geoarchaeologically following Hodgson (1997). Preliminary interpretations will be made, those units of particular archaeological/palaeo-environmental interest will be highlighted, and an outline deposit model will be constructed if appropriate. The Stage 2 report will set out the nature and scope of any Stage 3 work which may be required to further characterise and interpret the sediment units in order to identify areas of potential archaeological or palaeoenvironmental significance. If during Stage 2 the potential is shown to be limited to well-defined areas which could be addressed by specific targeted sampling, a programme of investigation combining limited Stage 3/4 works may be proposed. This work would output to a final client report or straight to publication, depending on the requirements of the client and curator.
Stage 3: Palaeoenvironmental Assessment	Sub-sampling and assessment of any units of archaeological and/or palaeo-environmental interest. Sub-samples for the assessment of microfossil environmental indicators (including pollen, diatoms, plant macrofossils, molluscs, ostracods and/or foraminifera) will be taken. As far as possible the subsamples will be taken in such a manner that the remaining core is retained intact should further sub-sampling be required. The subsamples will be assessed, with the relevant ecofacts being identified to at least main Taxon, with quality of preservation and approximate quantification). This enables the value of the palaeo-environmental material surviving within the samples to be identified. Should radiocarbon dating have been specified at this stage by the Stage 2 report, then suitable material will be extracted from appropriate subsamples and submitted. If not, then sub-samples will also be taken and retained at this stage in case radiocarbon dating is required during Stage 4. The Stage 3 report will set out the results of each laboratory assessment, and summarise the archaeological implications of the combined results. The potential of the material will be summarised, and recommendations will be made as to whether any Stage 4 work is warranted. If Stage 4 work is recommended, then the specifics will be laid out.
Stage 4: Analysis and Dating	Full analysis of environmental indicators (including pollen, diatoms, plant macrofossils, molluscs, ostracods and/or foraminifera) from subsamples specified in the Stage 3 report. Typically, Stage 4 will be supported by radiocarbon dating of suitable sub-samples. Should Stage 3 assessment indicate that there is no further analytical work required on the microfossil assemblages, consideration will still be given for a programme of radiocarbon analyses to provide a chronological framework for the deposits encountered unless no suitable samples could be procured. The Stage 4 report will provide an account of the palaeo-environment(s) at each relevant sample location within a chronological framework (absolute or relative) and an outline of the archaeological implications of the analysis.
Final Reporting	If the archaeological results are sufficiently significant, a final report will be compiled for submission to a suitable journal, to be agreed with the client and curator. This publication report will cover all aspects of the palaeo-topography and prehistory of the area affected by the development, incorporating the results of each stage. If the archaeological results are not significant then the relevant Stage Report(s) will constitute the final documents for the investigation.

1.3 Scope of Document

1.3.1 This report presents the results of the Stages 2 and 3 (see **Table 1**), assesses the potential of the deposits, and makes recommendations for further work if appropriate.

1.3.2 In format and content it conforms with current best practice and to the guidance outlined in *Management of Research Projects in the Historic Environment* (MoRPHE) (English Heritage 2006) and *Geoarchaeology. Using Earth Sciences to Understand the Archaeological Record* (English Heritage 2004). It will be submitted to and approved by the LPA prior to fieldwork commencing.

1.4 Geoarchaeological background

1.4.1 In order to put the Site in its geoarchaeological context, the sub-surface sediments of the area are summarised below (after Brown 2005).

1.4.2 Underlying the area of the Severn Estuary Levels (encompassing these Avon Levels, as well as the North Somerset Levels and the Gwent and Wentlooge Levels of southeast Wales) is a deep sedimentary sequence, consisting of a series of alternating estuarine alluvial silt and peat deposits up to 15m in depth, and extending over some 840 km^2 of intertidal zone and now reclaimed and drained former wetland.

1.4.3 These deposits have accumulated over the last 8000 years as a result of an upward, but fluctuating trend in sea-level rise following the end of the last glaciation. Estuarine silts are laid down on saltmarshes and mudflats during periods of sea-level-rise, whilst peats represent stable or falling sea-levels, within which a succession of plant communities can become established.

The Wentlooge Formation

1.4.4 Named after the intertidal sediment exposures on the Wentlooge Levels, southeast Wales, the Wentlooge Formation - sub-divided into lower, middle and upper Wentlooge - represents the principal sedimentary deposit within the Severn Estuary, covering all but the last 2000 years of deposition.

1.4.5 Classification of the Wentlooge sequence is based largely on research into the sedimentary sequence in the Severn Estuary by John Allen (e.g., Allen 1987, 1990, 1997), upon which these descriptions are partially based.

1.4.6 The lower Wentlooge Formation, usually only exposed at lowest tides, consists of several metres of estuarine clayey-silts, grading from pale greenish grey to blue-grey in colour. Networks of tidal creeks, latterly infilled and present as palaeochannels, are widely distributed across the exposed Levels. Lower Wentlooge sediments are not typically deposited to the same extent within the interior of the levels.

1.4.7 The middle Wentlooge is characterised by a series of intercalating estuarine alluvial silt and peat deposits of varying date. The earliest basal peats have been radiocarbon dated to the Mesolithic, in the first half of the 6th Millenium BC (at Porlock on the north Somerset coast, Jennings *et al* 1998), whilst the latest peat formation (on the Welsh side of the Severn Levels) has been dated to the Late Bronze and Iron Ages (e.g. Barland's Farm and Vurlong Reen, Walker *et al* 1998; and Greenmoor Arch, Locock 1999b)

1.4.8 The exact sequence of silts and peats varies between individual sites, reflecting complex patterns of relative sea-level rise, involving multiple phases of marine transgression and regression. The overall thickness of peat units also varies, from thin peats of only a few centimetres thick, to reed, wood and succeeding raised mire peats between 2 to 4m deep.

1.4.9 For reasons that are not fully understood, the peat deposits of the Gwent Levels attain a greater maximum thickness than those occurring on either the Wentlooge, Avon or North Somerset Levels.

1.4.10 The upper Wentlooge witnessed a return to the deposition of estuarine clayey-silts, dating to the Iron Age and Romano-British periods. It represents a period of rapid sediment accumulation, with between 3-5m of sediment accumulating between the 3rd century BC and the 2nd century AD, ceasing in some areas with the Romano-British drainage of the Levels (Bell 1999).

1.5 Archaeological background

1.5.1 The archaeological and historical background of the Site has been discussed in detail in an earlier DBA undertaken by Wessex Archaeology in December 2007 (WA 2007) and Environmental Statement (ES; WA 2008).

1.5.2 Although no archaeological remains have been recorded within the footprint of the proposed turbine sites, previous archaeological investigations at the Site and within the area studied during the DBA revealed the presence of buried archaeological remains ranging in date from the Mesolithic to the post-medieval period.

1.5.3 Key local sites are shown on the location plan (Figure 1), and include Katherine Farm (Allen 2002), Cabot Park (MoLAS 2007), Hallen (Graham and Barnes 1993), Rockingham Farm (Locock & Lawler 2000) and Smoke Lane (WA 2013b).

Katherine Farm

1.5.4 At the site of Katherine Farm (which lies within the extents of the present Site; **Figure 1**), two humic layers interpreted as stasis horizons were recorded within the alluvial clays of the Wentlooge Formation. The upper layer (523) contained archaeological material of Late Bronze Age date including pottery (nearly all from a single vessel) and charcoal. The activity represented (although its precise nature was unclear) seems to have been short-lived or possibly even related to a single event (Allen 2002, 100).

1.5.5 A number of later ditches, although undated, are thought to related to the medieval or post medieval Katherine Farm itself.

1.6 Aims and objectives

1.6.1 Within the overarching aims and objectives of the programme of archaeological work, the specific aims and objectives of the geoarchaeological and palaeoenvironmental works were to

- *Confirm the existence and extent of the 'BaRAS' Bronze Age land surface identified by previous archaeological work within the Avonmouth area;*
- *Obtain material to allow further assessment, where warranted, to be carried out on the buried land surface or any other deposits which are of archaeological interest;*
- *Inform further assessment, analysis and publication work, if warranted.*

1.6.2 From the results of the geoarchaeological recording during Stage 2, the following research questions were identified:

- *Are the stasis horizons reliably dateable, and if so what date are they?*
- *Do the palaeoenvironmental indicators tally with the results from Katherine Farm, supporting the conclusion that the stases can be correlated?*
- *Is there any evidence of human activity, particularly within the stasis horizons?*
- *What is the broad nature of the depositional environment before, between, and after these stases (i.e. in terms of salt marsh, mudflats, brackish, marine etc)?*

- *Are the banded deposits lagoonal, or of another nature, and are they reliably dateable?*

2 METHODOLOGY

2.1 Introduction

2.1.1 Outlined below are the methods employed during the sample collection, processing, recording and assessment of the extracted borehole samples.

2.2 Boreholing

2.2.1 Three boreholes were obtained by specialist sub-contractor WYG Environment using a track-mounted rig. Four boreholes were proposed and intended, but due to extensive flooding of the site the location of Turbine 3 was impossible to reach.

2.3 Location

2.3.1 The borehole locations are shown on **Figure 1**. The drill OS NGR co-ordinates and height above Ordnance Datum (Newlyn) were recorded using a GPS device.

2.4 Sample Collection

2.4.1 A standard percussion-drilling rig capable of drilling 100mm diameter boreholes up to a depth of *c.*10m was used to recover sleeved core samples of 1m length.

2.4.2 The cores were sealed and marked with site code, borehole code, sample depth *etc.*, before being returned to the Wessex Archaeology environmental laboratory at Salisbury for further investigation.

2.5 Sediment description

2.5.1 Description and interpretation of the sampled sediments was undertaken by a geoarchaeologist following Hodgson (1997), to include information regarding:

- *Depth;*
- *Texture;*
- *Composition;*
- *Colour;*
- *Inclusions;*
- *Structure (bedding, ped characteristics etc.);*
- *Contacts between deposits.*

2.5.2 Following description and interpretation the cores were subsampled for a range of micro- and macro-fossil indicators, as well as radiocarbon dating (**Table 2 - 4**).

2.6 Charred and waterlogged plant macrofossils, molluscs and insects

2.6.1 The samples were processed for the recovery of macrofossils, including charred and waterlogged plants, insects and molluscs. Laboratory flotation was undertaken with flots retained on a 0.25mm mesh and residues on a 0.5mm mesh.

2.7 Pollen & Loss on ignition

2.7.1 A pollen assessment was made on nine samples from select deposits within BH1 and BH4, taken during investigations at Bristol Sewage Treatment Works, Avonmouth. Loss on ignition (LOI) was also undertaken to quantify the percentage of organic material within each of the nine samples.

2.7.2 Samples were processed using standard procedure (Moore et al. 1991) 1cm^3 of sediment was sampled. A Lycopodium spike was added to allow the calculation of pollen concentrations. All samples received the following treatment: 20 mls of 10% KOH (80°C for 30 minutes); 20mls of 60% HF (80°C for 120 minutes); 15 mls of acetolysis mix (80°C for 3 minutes); stained in 0.2% aqueous solution of safranin and mounted in silicone oil following dehydration with tert-butyl alcohol. Identification was made using a Nikon SE at x400 magnification. Pollen nomenclature is based on Bennett (1994; Bennett et al., 1994)

2.7.3 An anticipated minimum count of 100 Total Land Pollen (TLP), excluding Aquatics and Pteridophytes, was required from each level to enable results to be calculated as a percentage of the pollen sum; however this was not reached so the number of occurrences of each taxa are recorded instead.

2.7.4 Loss-on-ignition (LOI) was undertaken following the method of Bengstsson and Enell (1986).

2.8 Foraminifera & Ostracods

2.8.1 Twelve sediment subsamples taken from two boreholes BH1 and BH4 were assessed and analysed for the presence and environmental significance of ostracods and foraminifera.

2.8.2 Sediment samples of c.25g were disaggregated in a weak solution of Hydrogen Peroxide and water, then wet sieved through a 63µm sieve. The sediment was dried and sieved through 500µm, 250µm, 125µm sieves. Microfossils were identified under 10-60x magnification and transmitted and incident light using a Vickers binocular microscope. The identification and environmental interpretation of ostracods follows Athersuch *et al*. (1989) and Meisch (2000) and of foraminifera (Murray 1976, 2000).

2.9 Dating

2.9.1 Samples for radiocarbon dating will be selected from amongst suitable identified plant macrofossils (i.e. not from submerged aquatics). Dating will not be carried out on unidentified organic material or bulk sediments.

2.9.2 The radiocarbon dates will be calibrated against the IntCal13 Northern Hemisphere radiocarbon curve (Reimer *et al*. 2013) using the program OxCal 4.1 (Bronk Ramsey 1995; 2001). Calibrated dates are quoted as calibrated years AD/ BC. Date ranges are quoted using the 2σ calibrated range (95.4%) with the end point rounded outwards to 10 years (or five years when error terms are less than ±25 BP) (Bayliss *et al*. 2008, xii).

3 RESULTS

3.1 Geoarchaeological recording

Overview

3.1.1 In all three locations (**BH1**, **BH2**, **BH4**) the sequences are generally what would be expected for this area, namely the sediments of the upper and middle Wentlooge Formation.

3.1.2 Broadly speaking, upper Wentlooge sediments are characterized by their predominantly brown, oxidised colouration, clay to clay loam texture, and lack of lamination or horizontal layering. The middle Wentlooge sediments are grey to blueish/ greenish grey, with textures varying from silts through silty clay to clay, and often exhibit horizontal layering and lamination. They often contain peat layers, although none were present on this site.

Possible lagoonal sediments

3.1.3 In cores BH1 (3.83m to 3.71m OD) (**Table 2**) and BH2 (**Table 3**) a layer of quite 'clean', apparently well-sorted clay was recorded, which had a banded dark grey to slightly blueish grey colouration. In contrast to the layers above it (and also below in the case of BH1), it was not iron-stained nor apparently bioturbated.

3.1.4 It is possible that the colouration in the darker bands are a result of the presence of either comminuted charcoal or fine humic matter (possibly with highlighting of humic content by manganese precipitation).

3.1.5 It is suggested that this layer presents pooling of marine or brackish water in a lagoonal or backwater environment, probably resulting from a marine incursion event.

Buried soils/ stasis horizons

3.1.6 In BH4 (**Table 4**), two apparent stasis horizons were recorded, at 5.23-5.18m and 4.83-4.79m OD respectively.

3.1.7 These horizons were very dark grey to black clays, and contained no plant remains or discernible charcoal lumps (even at x40). Under magnification, the sediment did have the glister, which can indicate the presence of comminuted charcoal (or manganese content).

Table 2: Sediment descriptions: BH1

Location:		353076.46 179564.37	**Borehole ID:**	BH1	**Comments:**	
Level (top):		7.33m OD	**Drg:**	-		
Depth		**Samples**	**Sediment description**		**Interpretation**	
Mono	mOD	metres below ground (mOD)				
0-1.00	7.33-6.33		Mortary & rubbly dump		Made ground	Made Ground
1.00-1.30	6.33-6.03		10YR 5/2 greyish brown clay, with grit & debris. Concreted hard.		Made ground	
1.30-2.00	6.03-5.33		*sample very hard & dried due to cracked liner* 10YR 5/1 to 5/2 grey to greyish brown clay, stonefree		Oxidised estuarine alluvium	Upper Wentlooge
2.00-2.20	5.33-5.13		10YR 5/1 grey clay, slight iron staining, stonefree, clear boundary		Oxidised estuarine alluvium	
2.20-3.54	5.13-3.83	F+O 3.49 (3.84)	10YR 5/2 to 5/3 greyish brown to brown clay, 20% 5/1 grey; occasional manganese concretions, (product of gleying). Gap @3-3.22. Sharp (c.2cm) boundary.		Oxidised estuarine alluvium	
3.54-3.66	3.83-3.71	P 3.54 (3.79) PM & 14C 3.55-3.63 (3.70-3.78) F+O 3.56 (3.77) P 3.58 (3.75) F+O 3.59 (3.74) P 3.61 (3.72) F+O 3.63 (3.70) P 3.64 (3.3.69) F+O 3.65 (3.68)	Banded dark grey and grey (10YR 4/1 and 5/1) clay. 'Clean', unmixed, unoxidised and apparently well-sorted. No iron staining – *possible* comminuted charcoal content but not as dark as the c.f. 'BaRAS layer' in BH4. Suggest clay deposition without vegetation; possible lagoon/ pooling of some kind.		Banded alluvium, unoxidised, ?lagoonal	Middle Wentlooge
3.66-4.10	3.71-3.23	F+O 3.70 (3.63)	10YR 5/2 to 5/3 greyish brown to brown clay, 20% 5/1 grey; occasional manganese concretions, (product of gleying).		Oxidised estuarine alluvium	
4.10-5.60	3.23-1.73		10YR 5/1 grey clay, soft and moist, some horizontal banding (sometimes more silt than clay). Decaying root (non-horizontal) @ 4.80m		Estuarine alluvium	
5.60-6m	1.73-1.33		Gley 1 5/1 greenish grey, horizontally laminated silty clay loam and silt loam.		Estuarine alluvium	

Samples: P = Pollen LOI = Loss on ignition F+O = Foraminifera and Ostracods PM = Plant Macrofossil 14C=radiocarbon date

Table 3: Sediment descriptions: BH2

Location:	352888.14 179783.27	**Borehole ID:**	BH2	**Comments:** Level data is suspect – this is recorded as nearly 4m higher then BH1, but the banded ?lagoonal alluvium ties in at the same level. Combined with the lack of a huge pile of made ground at the top of the sequence, we can conclude that the level is incorrect.
Level (top):	10.96m OD	**Drg:**	-	

Depth		**Sediment description**	**Interpretation**	
Mono	mOD			
0-1.00	-	Made ground	Made ground	Made ground
1.00-3.40	-	10YR 5/3 brown clay, fine distinct iron mottling dominates with c.20% 5/1 grey in between. Occasional small manganese nodules present (product of gleying), c. 2mm. Stonefree, clear to sharp boundary. Thin dark smear @ 1.32-1.33m	Oxidised estuarine alluvium	Upper Wentlooge
3.40-3.52	-	Banded dark grey and grey (10YR 4/1 and 5/1) clay. No iron staining – *possible* comminuted charcoal content but not as dark as the c.f. 'BaRAS layer' in BH4. Suggest clay deposition without vegetation; possible lagoon/ pooling of some kind.	Banded alluvium, unoxidised, ?lagoonal	Middle Wentlooge
3.53-4.28	-	10YR 5/2 greyish brown silty clay loam, slippy, stonefree, no manganese or iron staining. Thin dark bank @ 3.92m. Clear bndy	Estuarine alluvium	
4.28-5.0	-	10YR 5/1 grey silty clay loam to clay, soft and wet.	Estuarine alluvium	

Table 4: Sediment descriptions: BH4

Location:		353458.62 179771.71	**Borehole ID:**	**BH4**	**Comments:**
Level (top):		7.06m OD	**Drg:**	-	

Depth		**Samples**	**Sediment description**	**Interpretation**	
Mono	mOD	metres below ground (mOD)			
0-0.09	7.06-6.97		Dark brown leaf litter & decayed organics	Humic modern ground surface	Made ground
0.09-0.80	6.97-6.26		10YR 5/3 brown clay to clay loam, angular gravelly from 0.6-0.8m, manganese flecks, slight iron staining	Made ground (of redeposited upper alluvium)	
0.8-1.0m	6.26-6.06		gap	gap	
1.0-1.83	6.06-5.23	P+LOI 1.77 (5.29) F+O 1.79 (5.27) P+LOI 1.82 (5.24) PM & 14C 1.83 (5.23)	10YR 5/3 brown clay, fine distinct iron mottling dominates with c.20% 5/1 grey in between. Occasional small manganese nodules present (product of gleying), c. 2mm. Stonefree, clear to sharp boundary.	Oxidised estuarine alluvium	Upper Wentlooge

Location:		353458.62 179771.71	**Borehole ID:**	**BH4**	**Comments:**	
Level (top):		7.06m OD	**Drg:**	-		
Depth		**Samples**	**Sediment description**	**Interpretation**		
Mono	mOD	metres below ground (mOD)				
1.83-1.88	5.23-5.18	P+LOI 1.84 (5.22) P+LOI 1.88 (5.18)	10YR 3/1 very dark grey to black clay, stonefree, no visible plant remains or discernible charcoal lumps (even viewed at x40). Under magnification however it does have the appearance of containing comminuted charcoal . Sharp to clear boundary.	Probable stasis with comminuted charcoal		
1.88-2.23	5.18-4.83	F+O 1.91 (5.15) P+LOI 1.95 (5.11 F+O 2.01 (5.05) F+O 2.13 (4.93)	10YR 5/3 brown clay, fine distinct iron mottling dominates with c.20% 5/1 grey in between. Occasional small manganese nodules present (product of gleying), c. 2mm. Stonefree, clear to sharp boundary.	Oxidised estuarine alluvium		
2.23-2.27	4.83-4.79	PM & 14C 2.28 (4.78) F+O 2.36 (4.70) F+O 2.45 (4.61)	As above, 10YR 3/1 very dark grey to black clay, stonefree, no visible plant remains or discernible charcoal lumps (even viewed at x40). Sample is not ideal here – core partial and fragmentary (avoid sampling this one).	Probable stasis with comminuted charcoal		
2.27-2.78	4.79-4.28		10YR 5/3 brown to 5/2 greyish brown clay, with 30% 5/1 grey, grey increasing to base. Iron staining is fine and varies from faint to distinct. Layer is moist, contains occasional molluscs.	Oxidised estuarine alluvium		
2.78-3.80	4.28-3.26		10YR 5/1 grey silty clay loam to silt loam (mostly fine silt), Moist, slippy. Observable horizontal lamination, diffuse boundary.	Estuarine alluvium		Middle Wentlooge
3.80-4.00	3.26-3.06		As above, but more clay content (clay loam)	Estuarine alluvium		
4.00-5.50	3.06-1.56		10YR 5/1 grey silty clay loam, horizontally laminated, occasional laminae of well sorted fine silt inwashes (e.g. @ 4.9m), becoming increasingly wet and sticky down profile.	Estuarine alluvium		
5.50-5.65m	1.56-1.41		Gley 1 5/1 greenish grey silty clay loam	Estuarine alluvium		

Samples: P = Pollen LOI = Loss on ignition F+O = Foraminifera and Ostracods PM = Plant Macrofossil 14C=radiocarbon date

3.2 Pollen

3.2.1 Pollen counts were low in all samples with insufficient pollen encountered to enable assessment counts of 100 TLP. Consequently, no reliable interpretation of the local vegetation or indicative time period covered by the pollen can be inferred. Pollen preservation was generally poor. LOI was low in all samples, between 8-18%.

3.2.2 The results are presented in **Table 5**.

Table 5: Results of pollen assessment (counts) and LOI on samples from BH1 and BH4

Borehole	BH1				BH4				
Depth (m BGL)	3.54	3.58	3.61	3.64	1.77	1.82	1.84	1.88	1.95
Depth (m OD)	3.79	3.75	3.72	3.69	5.29	5.24	5.22	5.18	5.11
Pinus sylvestris		2		1	1				1
Quercus						1			1
Betula							1		17
Alnus glutinosa						2		1	2
Corylus avellana-type			1			1			1
Frangula alnus						1			
Hedera helix									1
Urtica dioica									1
Chenopodiaceae					2	2			
Plantago lanceolata					2				
Lactuceae undiff.						1			1
Cyperaceae undiff.					4			1	
Poaceae undiff.				3	3	2	2	3	2
Polypodium			1	1	5	2	5	5	4
Pteridium aquilinum			1	1	1	3			3
Pteropsida (monolete) indet.	3	1	5		10	2	6	4	6
TLP SUM	0	2	1	4	12	10	3	5	27
Pollen Concentration (grains cm3)	4170	933	1668	1148	5837	4726	2412	3105	3418
LOI (%)	16	18	15	10	8	11	15	11	10

3.3 Plant Macrofossils

3.3.1 Three subsamples were taken from boreholes BH1 and BH4; BH1 3.55-3.63m, BH4 1.83m and 2.28m of 200ml, 100ml and 50ml respectively.

3.3.2 No material was seen in the flots and no residue remained. As such no material was retained.

3.4 Foraminifera & Ostracods

3.4.1 The sampled sediments are predominantly alluvial silts and clays. Ostracods occurred in one sample and foraminifera occurred in five of the eleven samples.

3.4.2 The abundance of foraminifera and ostracods within the samples is summarised in **Table 6**.

3.4.3 Abundance of ostracods was very low with only one sample (BH4, 2.45m) containing a singular broken valve. Foraminifera were absent (at 3.70, 3.65, 3.59 and 3.56m) or occasionally present as singular (at 3.63 and 3.49m) occurrences within the borehole BH1

samples. Within the borehole BH4 samples foraminifera were abundant and well preserved in the samples at 2.45 and 2.36m, occasionally present at 2.13 and 2.01m and absent in the samples at 1.91 and 1.79m.

BH1

3.4.4 At 3.63m singular occurrences of small foraminifera, a *Rotaliid* and *Astergerinata mamilla* were recorded. At 3.49m a singular occurrence of the foraminifera *Brizalina variabilis* was recorded.

BH4

3.4.5 At 2.45 and 2.36m good foraminferal assemblages were recovered. These were dominated by the brackish and marine tolerant taxa *Ammonia beccarrii* and *Jadamimmina macrescens* with occasional occurrences of shallow marine taxa such as *Brizalina variabilis*, *Astergerinata mamilla*, *Lagena straita* and species of the genus *Elphidium*. A singular broken valve of the marine ostracod *Aurila* sp. was also recorded at 2.45m.

3.4.6 At 2.13m occasional specimens of marine and brackish water tolerant taxa *Ammonia beccarii* and *Jadammina macrescens* were recorded with singular occurrences of marine taxa including *Globigerina* sp.. At 2.01m a singular occurrence of the foraminifera *Astergerinata mamilla* was recorded.

Table 6: Abundance of Foraminifera and Ostracod taxa per sample in BH1 and BH4

Borehole	**BH1**						**BH4**					
Ostracods / mbGL	**3.49**	**3.56**	**3.59**	**3.63**	**3.65**	**3.7**	**1.79**	**1.91**	**2.01**	**2.13**	**2.36**	**2.45**
Aurila sp.												o
Foraminfera												
Ammonia sp.												
Ammonia beccarii										x	xx	xx
Astergerinata mamilla				o					o			x
Brizalina variabilis	o										x	
Cassidulina obtusa											x	
Elphidium aculeatum												x
Elphidium crispum											o	
Elphidiumsp.											o	x
Elphidium williamsoni											o	o
Haynesina germanica										o	xx	xxx
Glabratella milletti											x	
Globigerina sp.										o		
Lagena striata												o
Rotaliid				o							x	x

Abundance:
0 – singular occurrence
x – 2-9 specimens
xx – 9-50 specimens
xxx – greater than 50 specimens

3.5 Dating

3.5.1 No suitable material (e.g. identifiable plant macrofossils) were identified in the samples selected for dating. Without suitable macrofossils, radiocarbon dating of the layers would have to rely on bulk sediment dates.

3.5.2 Dating unidentified or amorphous organic matter is unreliable, and can produce results which are dramatically too old (e.g. if it contains calcareous material or redeposited organics outwashed from elsewhere) or too young (e.g. if much of the organic material present is from later roots).

3.5.3 As such no material was submitted for radiocarbon dating.

4 POTENTIAL AND RECOMMENDATIONS

4.1 Introduction

4.1.1 The likely potential of the sampled sediments to address the project aims (in particular the identified research questions) with respect to the various palaeoenvironmental and geoarchaeological techniques is given below, together with any recommendations for further work.

4.2 Sediments

4.2.1 The sediments have no further potential *per se*. Subsampling for the various palaeoenvironmental assessment techniques has consumed most of the available material for the layers of interest in any case.

4.2.2 No further work is recommended.

4.3 Charred plant remains

4.3.1 No charred plant remains were observed and as such potential is low.

4.3.2 No further work is recommended.

4.4 Waterlogged plant remains

4.4.1 No waterlogged plant remains were observed and as such potential is low.

4.4.2 No further work is recommended.

4.5 Insect remains

4.5.1 No insect remains were observed and as such potential is low.

4.5.2 No further work is recommended.

4.6 Land snails and fresh/brackish water molluscs

4.6.1 No examples were identified during the processing of the selected samples, and as such potential is low.

4.6.2 No further work is recommended.

4.7 Pollen and microcharcoal

4.7.1 Pollen counts were found to be too low to enable pollen counting even assessment level.

4.7.2 No further work is recommended.

4.8 Loss on ignition

4.8.1 Organic contents of the stasis horizons as determined by LOI was low. In the absence of contextual pollen and other palaeoenvironmental indicators additional interpretation of LOI values would not produce meaningful results.

4.8.2 No further work is recommended.

4.9 Foraminifera and Ostracods

4.9.1 Foraminifera were preserved within the sequences and, if supported by other evidence, would have reasonable potential for analysis level work.

4.9.2 Given the lack of dating and supporting palaeoenvironmental evidence to contextualise the results, no further work is recommended.

4.9.3 The assemblages from borehole BH4 at 2.36 and at 2.45m have good enough preservation and numbers of foraminifera for analysis, from which a more detailed environmental interpretation could be detailed and if coupled with scientific (^{14}C) dating could provide an insight into Holocene sea levels if warranted.

4.9.4 Due to the likely unreliability of radiocarbon dating from the assessed sediments to contextualise this additional analysis, no further work is recommended.

4.10 Dating

4.10.1 No identifiable plant macrofossils were identified in the samples selected for dating. Without suitable macrofossils, radiocarbon dating of the layers would have to rely on bulk sediment dates, such have been carried out elsewhere in the area.

4.10.2 Dating unidentified or amorphous organic matter is unreliable, and can produce results which are significantly too old (e.g. if it contains calcareous material or redeposited organics outwashed from elsewhere) or too young (e.g. if much of the organic material present is from later roots).

4.10.3 As such, no radiocarbon dating is recommended.

5 DISCUSSION

5.1 Introduction

5.1.1 Although the results of the Stage 3 palaeoenvironmental assessment work are largely negative, it is useful to discuss the site in the context, particularly with reference to the buried soils or stasis horizons at the immediately adjacent site of Katherine Farm.

5.2 Soils and stasis horizons in the Wentlooge Formation

5.2.1 Foraminifera and diatom data has shown that the fine sediments of the Wentlooge were generally deposited in an upper saltmarsh estuarine environment (Locock 1999a). The slight organic content and bioturbation reflects the presence of a surface cover of vegetation (halophytic salt-marsh plants and reeds) which trap the silts and clays on each tide and continue to grow through the deposited sediments. This creates a 'permanently immature soil' (Eyre 1963, 40).

5.2.2 Rather than reflecting periods of fully terrestrial conditions, soil horizons such as those identified at this site and at others nearby should be seen as temporary stabilizations of the upper saltmarsh – albeit representing a period of perhaps decades or longer – which still lie firmly within the coastal margin environment (Locock 1999).

5.2.3 As discussed by Locock (1999a), Allen (2002) and others, buried soils, stases or soil ripening horizons have been recorded at varying depths in the local area (**Figure 2** and **Table 7**). These – although probably quite heterogeneous in level, date and character – are often referred to colloquially as the 'BaRAS' layer or the 'N-layer' (after a buried soil, dated to the Neolithic, which was recorded during a watching brief by Bristol and Regional Archaeological Services (BaRAS 1998)).

5.2.4 As can be seen from **Figure 2** and **Table 7**, the buried soils in the area vary quite widely in level OD, and also in chronology, varying from possibly Mesolithic to later Bronze Age in date (although as will be discussed below, the dating of these layers is problematic).

5.2.5 It is therefore suggested that - although it may be possible to follow specific horizons between adjacent sites with some degree of confidence – attempting to link a broadly contemporary land surface between widely spaced sampling points may be a significant red herring, and should be avoided.

Correlation between Bristol WWTW and Katherine Farm sequences

5.2.6 As shown in **Figure 1**, the location of the stasis horizons described here (BH4) is located within the area of the Katherine Farm site, around 125m to the northeast of Trench 5A.

5.2.7 In **Figure 2** and **Table 7**, close correlation can be seen between the thicknesses and OD heights of the soil horizons recorded on this site (BH4), and in Trench 5A at Katherine Farm (5.23-5.18m compared with 5.21-5.28m OD; and 4.83-4.79m compared with 4.85-4.74mOD for the upper and lower horizons respectively). The sediment descriptions also tally closely (Allen *et al*. 2002, 93).

5.2.8 The upper horizon (523) at Katherine Farm contained archaeological material which was indicative of temporary use of the site, with activity of indeterminate nature. Two radiocarbon determinations (obtained on *Acer* charcoal and a cows tooth; **Table 7**), both returned dates from the late Bronze Age. Although not statistically consistent (failing the chi-squared test), these dates do provide a *terminus post quem* for the stasis horizon.

5.2.9 A layer or layers very probably equivalent to those recorded here and in Trench 5A were also recorded in geotechnical test pits 6 and 8 (**Figure 1**) during an earlier watching brief (WA 2008), and were described as 'an organic light greyish-brown clayey silt with pockets of dark brown peaty material' in TP6 at 1.90-2.10m below ground level (bgl), and a 'dark brown peaty layer' in TP8 at 2.10-2.15m bgl.

5.2.10 Although other trenching during Katherine Farm works did not reveal similar layers, these results do suggest that the two soil horizons - the upper of which is associated with late Bronze Age archaeological activity, albeit ephemeral and of relatively low significance - may survive in patches over an area extending over a few hundred metres including BH4, Trench 5A, TP6 and TP8 (**Figure 1**).

Difficulties in radiocarbon dating

5.2.11 As Locock (1999a) points out, the basic methodological problem with investigating stasis horizons such as these is one of dating. With the low carbon levels of these layers (typically as little as 5%), even AMS dating can produce unreliable dates.

5.2.12 The key factor is that - especially in a dynamic alluvial environment such as the Severn Estuary - it is impossible to be certain about the provenance of organic content within sediments. This is particularly true when that organic content is a very small fraction of what is effectively a mineralogenic sediment.

5.2.13 Despite these problems, due of the lack of alternative material some of the stasis horizons in the area have been dated using radiocarbon dates on humic acids from sediment samples.

5.2.14 For example, from the lower stasis horizon (525) at Katherine Farm (which at *c*.4.8m aOD is presumed to be equivalent to the lower horizon recorded during the current works) two radiocarbon dates were obtained on humic acid extracted from bulk sediments. This layer had an organic content measured by LOI of just 5.84% (Allen *et al* 2002, 94).

5.2.15 The resulting dates, from sediments just half a metre below the securely dated late Bronze Age layer 523, both returned late Mesolithic determinations (4930-4550 and 5880-5660 cal. BC; **Table 7**).

5.2.16 Given the extent of relative sea level rise during the Holocene - and the fact that the deposits upon which these stasis horizons are formed are closely linked to the contemporary tidal range – a surface formed upon Mesolithic salt marsh could be expected to be significantly lower in elevation than 4.8m aOD. To illustrate, a recent example of a securely dated local Mesolithic landsurface (a thin peat at Smoke Lane, **Figure 1**) was located over 12 metres lower, at 7.88m below OD.

5.2.17 This difference in elevation will be exaggerated by the Smoke Lane layer being slightly earlier (at 6410-6250 cal. BC; **Table 7**) and further seaward, which would reduce elevation both from the natural downward slope towards the coast and through the increased effect of sediment autocompaction (Allen 1999), but nonetheless the disparity is striking.

5.2.18 Although the work at Katherines Farm was thorough, with two dates being taken from the layer (525) to provide mutual verification, both returned similar results. If the dates do not reflect the actual age of the stasis horizon - as seems probable - the exact mechanism for error is unclear, but could be due to several factors, most likely being that a proportion of the humic content is derived from reworked exposures of much earlier layers.

5.2.19 Emphasis should be placed on the difficulties in accurately dating sediments using radiocarbon methods where recognisable plant macrofossils or other suitable materials are not available. In some cases - such as at this site - deciding not to attempt to obtain a date when the outcome may not be reliable may be the best course of action.

Table 7: Stasis horizons in the Wentlooge sequence (adapted from Locock 1999 and Allen *et al.* 2010, with additions from Allen *et al* 2002, WA 2013b)

Site	Layer	mOD	Result	Date (cal BC)	Description
Rockingham Farm		5.7	2850±40 BP, Beta-134902	1190–910	'upper gleyed layer'
Later Bronze Age soils					
Katherine Farm	523	5.3-5.25	2778±55 BP, NZA-12725	1110–810	Pale blue clay, incipient stabilisation horizon, archaeological material (*Acer* charcoal & cow tooth dates respectively)
			2957±55 BP, NZA-12726	1370-1010	
Rockingham Farm	729	5.20-5.10	2810±70 BP, Beta-118379	1190–820	thin bands of organic material
			3040±60 BP, Beta-118378	1430–1120	
Kites Corner	462	5.1	2610±70 BP, Beta-129554	920–520	charcoal patch archaeological activity
Little Googs/ Kites Corner		5.1-5.2	2970±60 BP, Beta-134900	1390–1020	non humic soil
			3350±60 BP, Beta-134901	1870–1500	
Soils referred to as 'BaRAS' layer					
Cabot Park	162-4	4.5	3970±60 BP, Beta-125795	2830–2290	organic clay 'BaRAS' charcoal - activity in vicinity
			4170±70 BP, Beta-125794	2900–2570	
Seabank site	'BaRAS'	4.7	3930±50 BP, Wk-5804	2580–2280	
Katherine Farm	525	4.85-4.75	5879±70 BP, NZA-12478	4930–4550	Dark bluish grey humic clay (humic acid dates)
			6866±50 BP, NZA-12495	5880–5660	
Other pre-Late Bronze Age stasis horizons					
Awkley Lane	107	4.61-4.46	R26327/2	no result	Dark grey (10YR 4/1) stonefree clay with up to 10% flecks of black material
Vimpennys Lane	207	4.20-4.05	4182±55 BP, NZA-12527	2900–2620	Very dark grey (10YR 3/1) stonefree
Smoke Lane	-	7.88 below OD	7460±34;SUERC-48403	6410-6250	Thin peat (Monocot stem dated)

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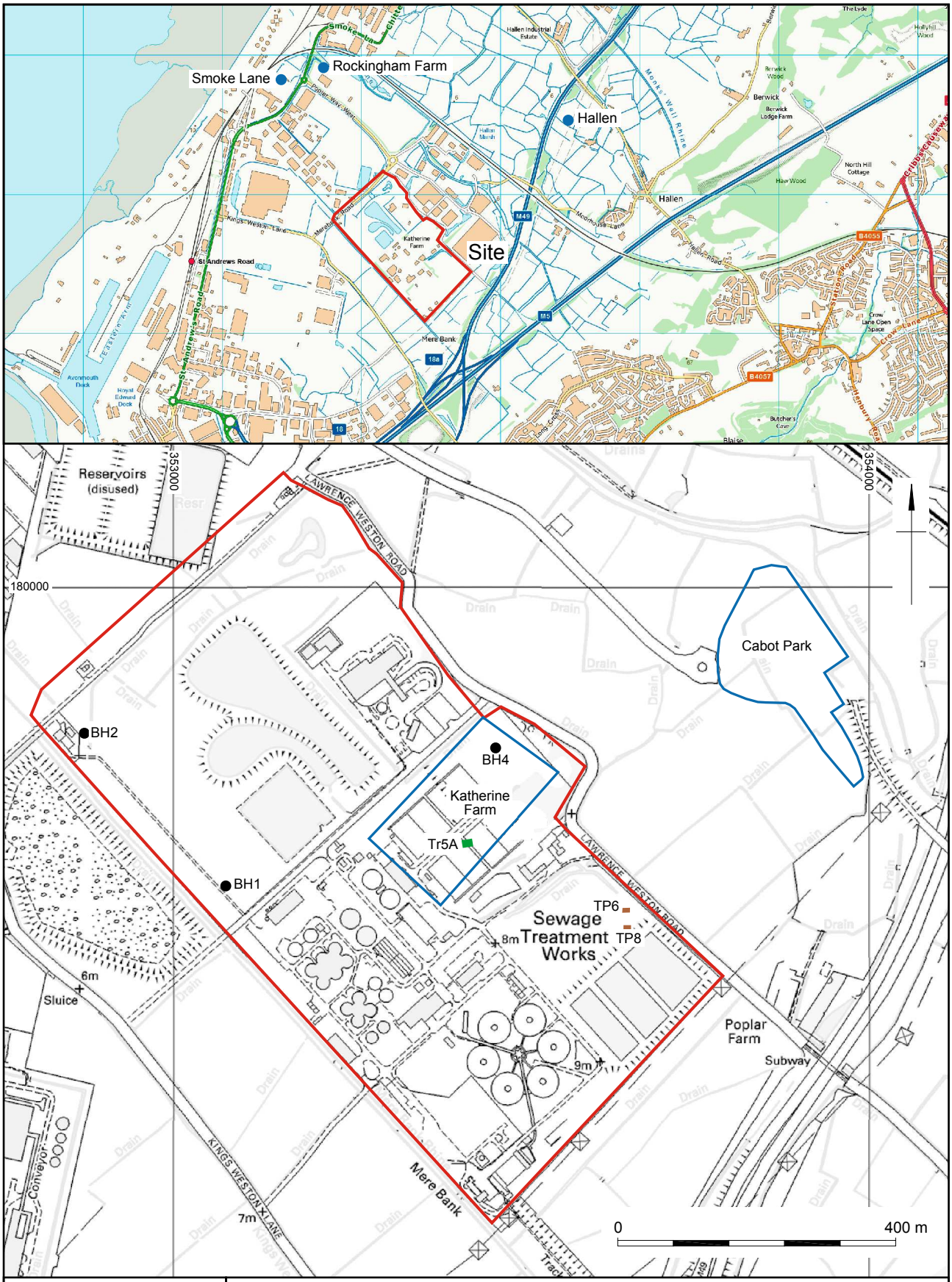

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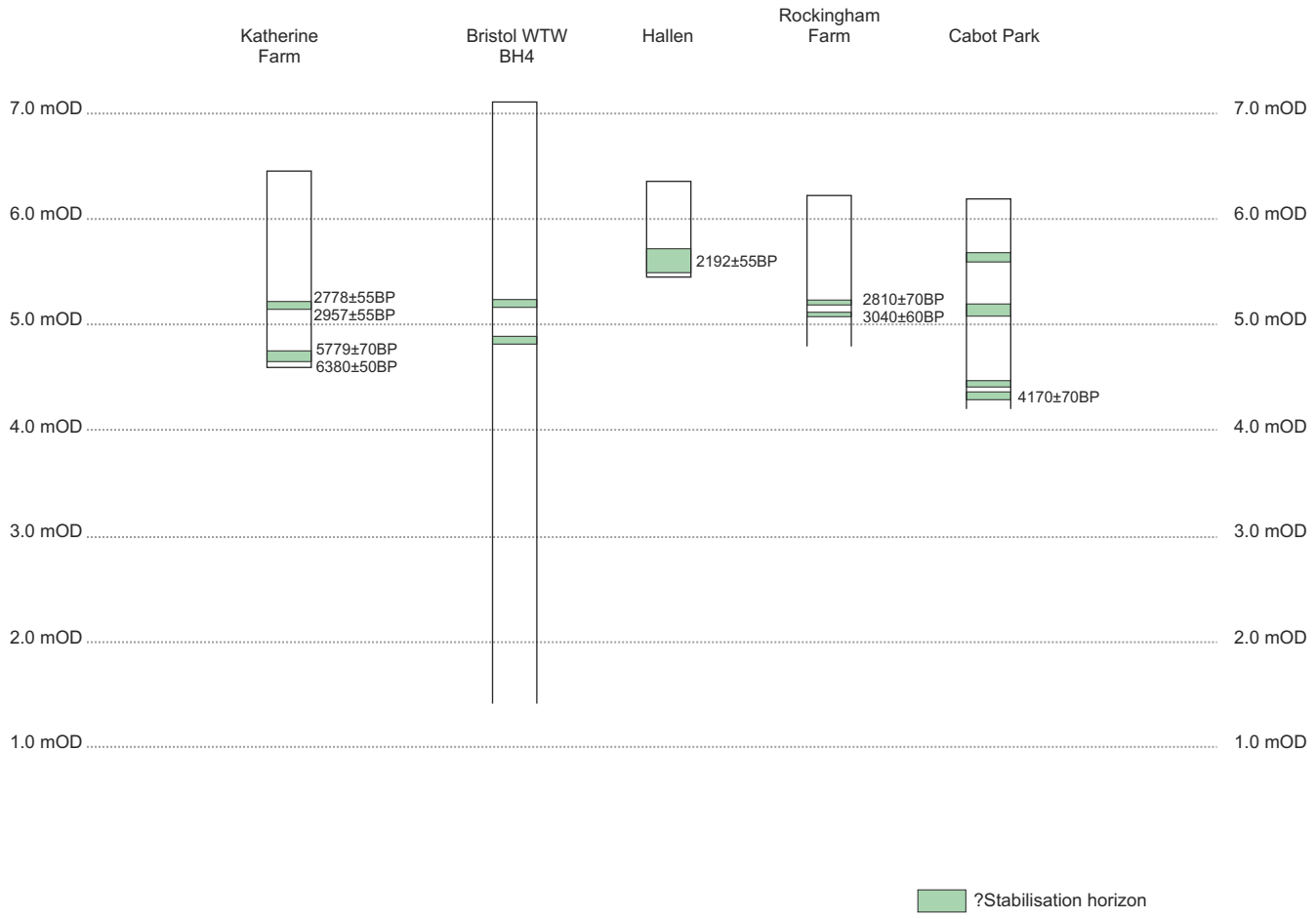
Location plan showing borehole locations, previous works and local sites

Figure 1



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Relative heights of soils and stasis horizons recorded locally (adapted from Allen 2010)

Figure 2

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