THE UPPER AND MIDDLE WENTLOOGE SEQUENCE AND ENVIRONMENTS AT PLOT 8000, THE WESTERN APPROACH DISTRIBUTION PARK, AVONMOUTH, SOUTH GLOUCESTERSHIRE

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A borehole survey and archaeological investigations undertaken in advance of development at Plot 8000 of the Western Approach Distribution Park, Avonmouth, South Gloucestershire, enabled examination of the deep Wentlooge Formation (lower, middle and upper). The recovered sedimentary sequence of middle Wentlooge estuarine silts and peats and their associated palaeoenvironmental remains were analysed and dated to the middle Neolithic to middle Bronze Age using radiocarbon. It is demonstrated that following fully marine conditions at the Site in the early-middle Holocene, lower energy estuarine conditions expanded. A subsequent shift in the proximity of the Site to the estuary mouth in the middle Holocene is demonstrated by a microfaunal assemblage indicative of intertidal mudflats and low marsh environment. Stabilisation of sediments by emergent vegetation and the formation of stretches of wet marsh and terrestrial fen environments adjacent to mudflats with brackish creeks occurred from the middle Neolithic. Drier areas were well-wooded and there is evidence for the expansion in heathland and/or raised mire vegetation at this time. A reversion to dominantly estuarine and salt marsh conditions occurred, still within the middle Neolithic period, in response to positive eustatic change. Evidence for prehistoric human activity is scarce but pieces of comminuted charcoal occur in two thin layers of middle Neolithic and early Bronze Age date, the latter followed by possible evidence for expansion of pasture. Unlike the adjacent Plot 4000, the Site showed no evidence for Roman activity, with only ephemeral features of 18th-20th century date found, indicating this area was more marginal to settlement due to its topography and waterlogged nature.

INTRODUCTION

The Site (NGR 354580 183740, Figure 1) is situated on the Henbury Level, an area of low lying, flat, artificially drained land, forming part of the Avon Levels that lies at *c* 5-6 m above Ordnance Datum (aOD). The geology of the area is characterised by Holocene age estuarine alluvium over Triassic Mercia Mudstone (formerly known as Keuper Marl) (British Geological Survey Sheet 264). Drainage and sea defence construction from post-Roman times have resulted in the formation of a relatively stable terrestrial landscape. Today, extensive sea defences prevent the marine inundation that might otherwise be expected. The Site was investigated in 2006 in response to a planning application for a warehouse and office development, using 51 trial trenches and 12 geoarchaeological boreholes. No significant archaeological remains were found; a small number of insubstantial gullies were recorded and, where associated with artefacts, proved to be of 18th century or later date. Many of the gullies reflected the layout of the existing drainage regime. However, the investigations also provided the opportunity to examine the deep sedimentary sequence at the site and to recover samples for palaeoenvironmental and dating purposes.

The deep Holocene age deposits revealed are part of the Wentlooge Formation, comprising

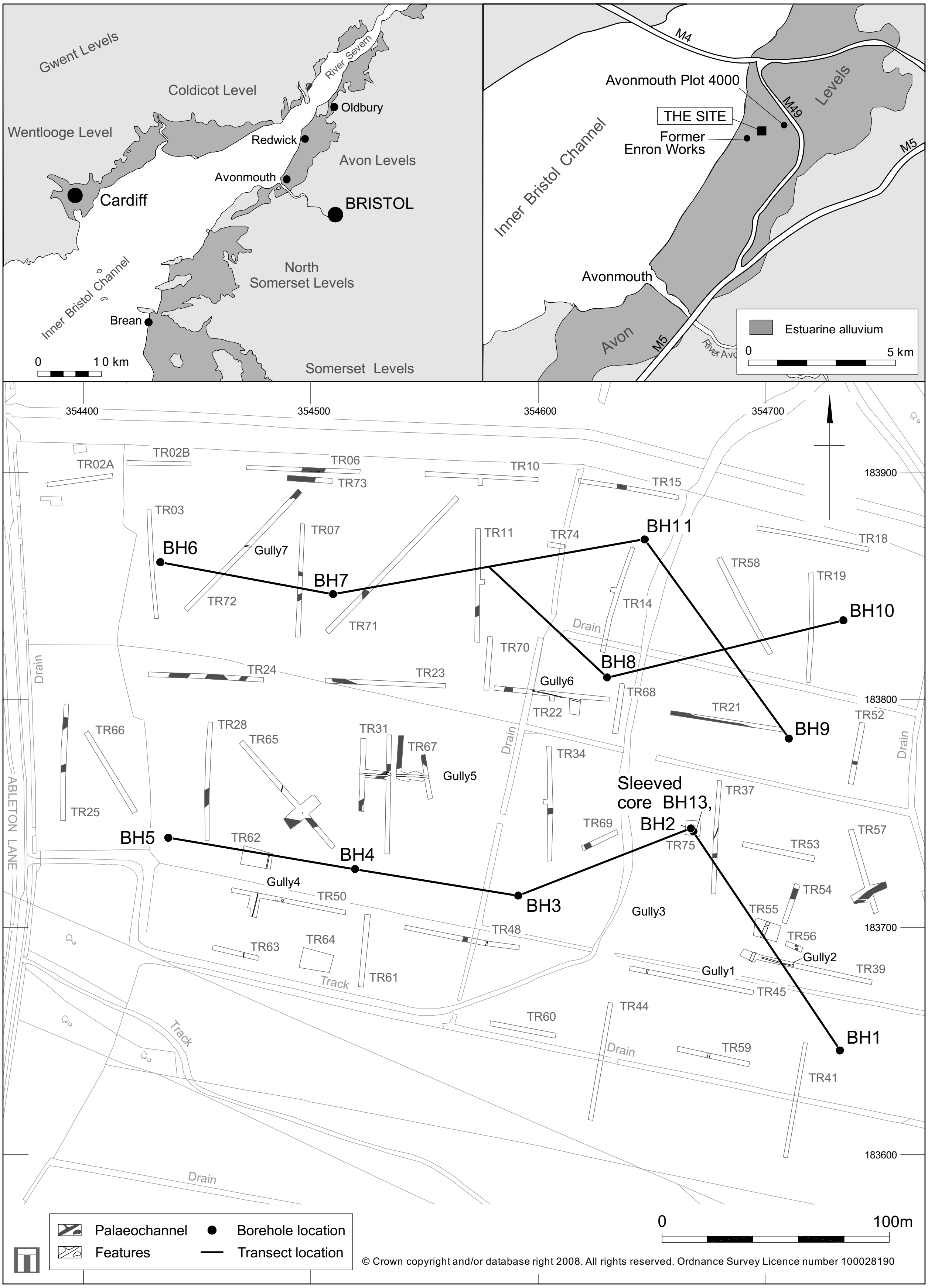


Figure 1. Site location, borehole transects and other sites mentioned in the text.

a series of alluvial silts/sands and peat, formed under estuarine and marsh conditions, as described and defined by Allen and Rae (1987) and Allen (1992). The sequence at Plot 8000 includes layers seemingly equating to the lower Wentlooge, not commonly exposed due to its patchy occurrence and substantial depth of burial. The middle and upper Wentlooge sediments at the Site are described in detail below, and the analysis of several palaeoenvironmental indicators presented, in order to provide a detailed picture of the prehistoric environments represented.

The sequence can be broadly compared to that at a number of sites, but adds substantial local detail to the body of existing regional sedimentological, microfaunal and vegetation data for the prehistoric Avonmouth area and beyond, as provided by those such as Allen (1987, 1990), Allen and Rae (1987), Allen *et al* (2002), Gardiner *et al* (2002), Carter *et al* (2003), Bell *et al (*2004) and Masser *et al* (2005). There is evidence for the repeated occurrence of major changes in environmental conditions over a relatively small area through late prehistory in response to eustatic changes at Plot 8000, the detailed manifestation and timing of which apparently varies from those other sites, demonstrating the dynamic nature of this coastal and estuarine landscape.

These local variations would have presented significantly variable opportunities and challenges for human settlement and activity in the area. As discussed in this paper, major changes in environmental conditions parallel those demonstrated by palaeoenvironmental analyses resulting from recent excavations on the adjacent site at Plot 4000 (Ritchie *et al* 2008). However, in stark contrast to that site, which revealed a substantial complex of Romano-British features cut into the upper Wentlooge, scant archaeological evidence was found here, indicating the Site was more marginal to settlement and focused activity perhaps due to its slightly lower-lying position and hence greater susceptibility to flooding and waterlogging.

ARCHAEOLOGICAL EVALUATION (NT)

The field evaluation was undertaken in accordance with a specification produced by John Samuels Archaeological Consultancy (JSAC, 2006) that was drawn up in response to a brief issued by South Gloucestershire Council. This required the excavation of 51 trenches, each measuring 50 m by 2 m in plan (Figure 1), equating to a 5% sample of the proposed development area. A contingency for a further 2.5% sample of the development area was also allowed for but was not required. An attempt was also made to investigate the Site using Caesium vapour gradiometry but a combination of the overgrown nature of the Site and the amount of dumped material rendered this impossible.

The ground surface was roughly level and varied between 5.7 m and 6.1 m aOD and was cut by several substantial extant drainage ditches. Following the excavation and cleaning of the trial trenches, the only archaeological features present comprised small ditches or gullies, none wider than 1.2 m or deeper than 0.4 m. All were straight with some being traceable for over 50 m. Most if not all were aligned east to west or north to south, and parallel to the present drainage ditches and may, therefore, have formed an early stage in the drainage of the site, to be abandoned as fewer ditches were excavated to a greater depth, possibly indicating a move to larger fields in the late 19th century.

A small quantity of pottery was recovered, all of a late 18th or 19th century date and no evidence of settlement was present. As a consequence no further archaeological fieldwork was required.

THE WENTLOOGE FORMATION (CB)

Geoarchaeology

Eleven boreholes were initially sunk across the Site to between 7 m and 9 m depth, using a percussion corer with window sampler (location shown on Figure 1). These were logged in detail in the field and the data used to compile two transect profiles (Figure 2). A series of sedimentary units were defined across the Site, which can be summarised as follows (Table 1).

Based on the findings of the borehole survey, an attempt was made to recover two targeted sleeved core sequences for palaeoenvironmental analysis. Adverse ground 4-

Table 1. Summary of the Wentlooge Formation at Plot 8000.

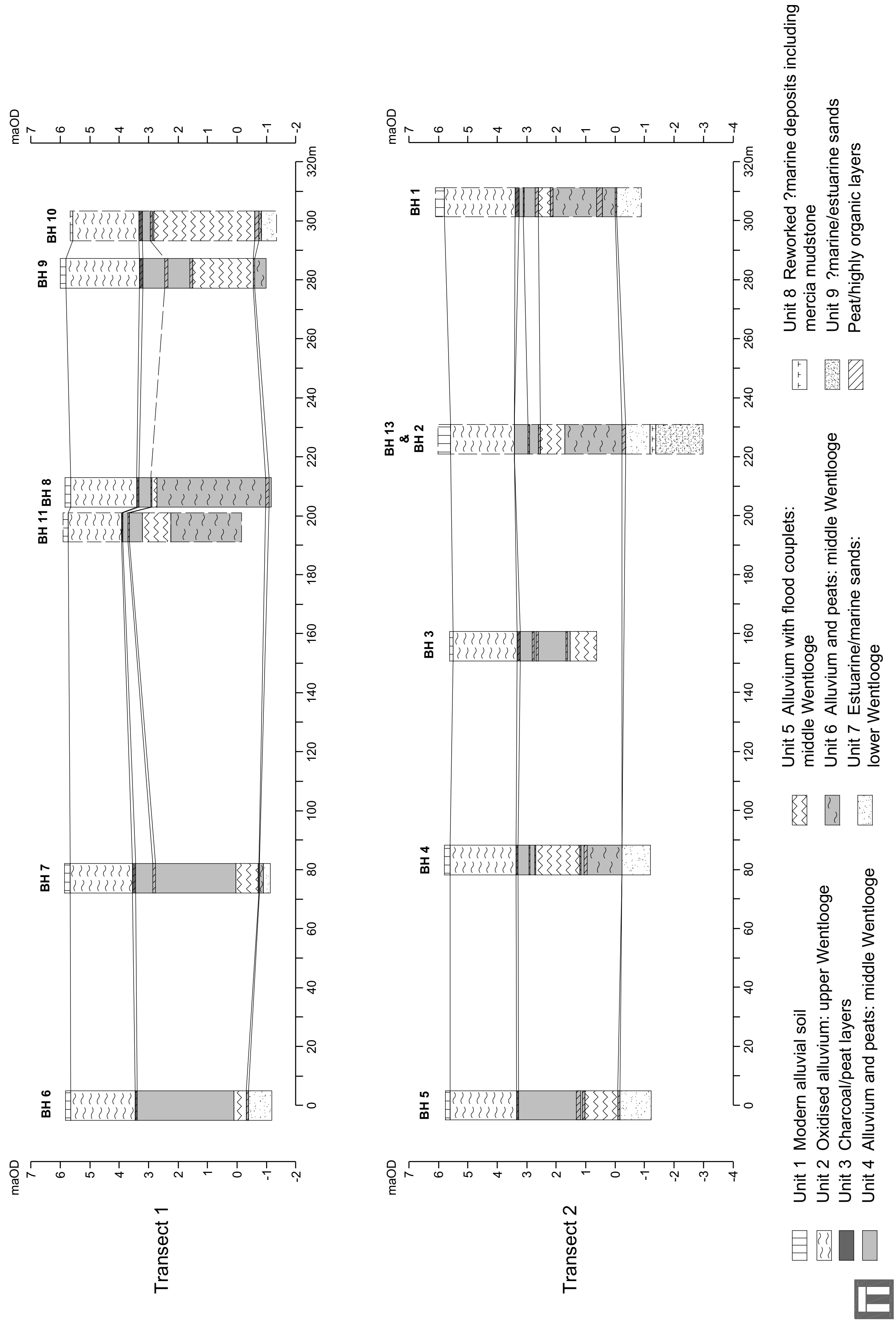
Unit no.	**Approximate depth (m)**	**Description**	**Interpretation**
1	0-0.18/0.44	Consistent across site. Dark brown highly organic crumbly silty loam, modern rootlets (A) over stiff mid brown slightly organic silty clay (B).	Modern alluvial soil A & B horizons
2	0.18/0.44-2.3/2.7 (up to 2 m thick)	Laterally consistent grey blue compact silty clay with abundant light to orange brown mottles and nodules of iron and black manganese specks.	Upper Wentlooge Formation: oxidised estuarine alluvium
3	1.99/2.7-2.04/2.85 (4 0-150 mm thick, the latter more diffuse)	Variable layer (though at consistent depth) of organic silt, peat and a sometimes well-defined dark grey alluvium with fine comminuted charcoal but variable: charcoal becoming more diffuse to NW of site and in places divided into two thin bands of peat.	Charcoal and peat layer at upper-middle Wentlooge boundary
4	2.04/2.85-3.5/3.73 (0.5-3.3 m thick)	NB Units 4-6, alluvium and alluvium with peat and tidal laminae, were variable and separated on sometimes fine detail, potentially can be treated as one major unit of the middle Wentlooge. Unit 4: Blue grey soft clay silts and silts, with faint tidal laminae and occasional iron stained root voids traceable to Unit 3, rare herbaceous plant remains. 1-3 thin peat layers occurred within the unit at variable depths: local variation and repeat stabilisation, flooding and erosion indicated. These include a black firm clay fen peat at 2.60-2.65 m in Bh13 with a gradual transition through organic silty clay to the alluvium below, indicating a gradual decline in water level and establishment of well-vegetated marsh/ fen conditions, but an erosional boundary to its top indicating truncation by subsequent estuarine activity. A fine (<2 mm) band of black clay peat with possible fine comminuted charcoal also occurs at 3.68 m in Bh 13.	Middle Wentlooge: estuarine alluvium and peats
5	3.5/5.7- 3.9/7 (0.5-3.0 m thick)	Blue grey silts to fine sands but with well-defined regular *c* 1.5 mm tidal laminae. Regular fine organic bands between flood couiplets contained common herbaceous plant remains (likely reed) indicating some emergent vegetation Rare iron stained root voids.	Middle Wentlooge : estuarine alluvium with tidal laminae
6	3.9./ 6.5-6.1/6.5	Variable thickness, thinning to NW of site, bluish grey sandy silt and silty sand alluvium with irregular tidal laminae, occasional iron staining and 1-2 thin bands of dark brown silty peat at *c* 5.8m and 6.2 m depth. In BH 2 organic stained silty sand at 6.14-6.25 m instead of silty peat. In Bh 13 a dark organic stained stasis horizon occurs at 4.71-4.765 m, with emergent vegetation to the top and with roots traceable from that surface into the underlying Unit 6 not recovered in BH 3.	Middle Wentlooge: alluvium and peat
7	6.4-7.2	Laterally consistent, reached in 7 of the 11 boreholes. Mid grey silty sands, faint horizontal sedimentary laminations, becoming increasingly coarse and iron-stained with depth to reddish brown coarse sand. Shells (?marine) and rare rounded small stones normally up to 10 mm (but up to 40 mm and common in BH 10) occur below 6.9 m.	Lower Wentlooge: estuarine/ marine sands
8	7.2-7.4	Reached only in BH 2, mixed layer of a pale brown silty clay matrix, rounded clasts of dry compact red clay (?degraded Mercia mudstone), patches of organic stain and an irregular band of coarse yellow sands.	Weathered bedrock (Mercia Mudstone): Reworked ?marine deposit with eroded Mercia Mudstone fragments)
9	7.4-9.0	Reached only in BH 2, well sorted clean mid grey blue fine sands, faint horizontal Laminations.	?marine/ estuarine sands

Conditions meant that only one full profile (Borehole 13 and monolith 109a-c) was recovered, for which detailed descriptions are given in Table 2. These sediments were sub-sampled for pollen, diatoms, foraminifera, ostracoda and to provide material suitable for radiocarbon dating. The samples were recorded in metres below ground level (mbgl) and in metres aOD and are listed in Table 2.

The major units (1-9) were found to be broadly laterally continuous across the Site, with generally little variation in presence, type and depth/height OD (see Figure 2). A series of wetland edge and channel deposits was identified, indicating a mosaic of depositional environments and formation in dynamic Holocene estuarine conditions. Substantial bodies of estuarine alluvial sediments of the upper, middle and lower Wentlooge Formation (Allen 1987; 1990; Allen and Rae 1987) are represented. Units 1-2 are believed to represent the upper Wentlooge and Units

Table 2 Detailed Sedimentary Descriptions of Monolith 109 and Sleeved Samples from Borehole 13. Sequence comprises overlapping monoliths 109A-C to top (to 2.75 m) and four continuous cores at 2-6 m. All samples and descriptions below 2.70m come from the cores.

Depth (m)	**m aOD**	**Unit no / summary description**	**Description**	**Interpretation**
0-0.20	6.01-5.81	Unit 1 modern alluvial soil	10YR 3/2 very dark greyish brown humic clay loam, abundant modern rootlets, defined crumb structure. Clear boundary.	Modern alluvial soil A horizon
0.20-0.44	5.81-5.57		10YR 4/2 dark greyish brown, dry & crumbly slightly organic silty clay. Friable, small blocky peds, common rootlets. Diffuse boundary.	Modern alluvial soil B horizon
0.44-1.99	5.57-4.02	Unit 2 oxidised alluvium: upper Wentlooge	0.44-0.80 m as below but rare fine rootlets, medium-large blocky structure, increasing number & coarseness of iron mottles & staining to 10YR 4/3 brown. Diffuse boundary. 0.80-1.99 m (as 2.05-2.22 m) 10Y 4/1 dark grey massive silty clay with abundant coarse medium iron mottles increasing up the unit, also becoming increasingly dry & friable up-wards. No visible inclusions or bedding. Abrupt boundary.	Becoming part of the B horizon of modern alluvial soil to top
1.99-2.05	4.02-3.96	Unit 3 charcoal/ peat layer	Two 15 mm peat bands (2.5Y 2.5/1 black soft silty peat). Well humified, no recognisable plant remains other than few vertical roots through it & into the underlying. Faint horizontal layering, intense black colour & glints in the light, suggesting may contain fine comminuted charcoal, at top & bottom divided by 2.5Y 3/1 very dark grey humic clay silt alluvium, possibly rich in fine comminuted charcoal. *['smear' sample taken at 2.05m from the dark clay silt for microscopic examination proved to contain numerous angular fragments of charcoal (?wood) as well as humified plant material].*	Charcoal and peat layer
2.05-2.22	3.96-3.79	Unit 4 alluvium, upper-middle Wentlooge	10YR 4/1 dark grey smooth soft silty clay with common medium iron mottles & staining along vertical root voids traceable to the overlying peat.	Alluvium
2.22-2.60	3.79-3.41	Unit 4 alluvium and peats: middle Wentlooge	2.5Y 4/1 with abundant strong coarse Fe (7.5YR 4/6 strong brown), faint, sometimes irregular/compressed, tidal laminae. Sharp (erosional) boundary.	Estuarine alluvium
2.60-2.68	3.41-3.33		2.60-2.65 m 10YR 2/1 black firm clay peat. Faint horizontal bedding & occasional <1 mm bands of inwashed alluvium as above. Few small strong iron mottles, rare degraded herbaceous remains. Clear boundary. 2.65-2.68 m 2.5Y2.5/1 black highly organic/peaty silty clay alluvium, grades into peat above. Occasional mottles of pale alluvium as below. Clear to abrupt boundary.	Organic allu-vium and edge fen peat, subject to brief inundations
2.68-3.73	3.33-2.28		2.68-3.68 m 2.5Y 4/1 dark grey soft smooth silty clay. Very fine tidal laminae 1-1.5 mm becoming diffuse and irregular/ distorted to top, regular fine (<1 mm) organic laminations between. Becoming increasingly mottled to the top to 2.5Y 4/1 with abundant strong coarse Fe (7.5YR 4/6 strong brown) including along vertical roots traceable to overlying peat and beyond to 2 m. Sharp (erosional) boundary to: (3.66 m curved to) 3.68 m <2 mm band of Gley 1 2.5/N black clay peat with possible fine comminuted charcoal *[too small to pollen sample but 'smear' sample taken for microscopic examination proved to contain rare an-gular pieces of comminuted charcoal].* 3.68-3.73 m as 2.68-3.68 m.	Fine (low-energy) estuarine alluvium, one fine charcoal/ organic band
3.73-4.0	2.28-2.01	Unit 5 estuarine alluvium with tidal laminae: middle Wentlooge	Gley 1 3/10Y very dark greenish grey firm slightly organic silty clay. Two fine bands of clean white calcareous fine sand (possibly tufaceous) at 4.97 m and 4.98 m. Common herbaceous plant remains & <1 mm organic bands between well-defined tidal laminae. Boundary lost.	Alluvium with possible emergent vegetation
4.0-4.06	2.01-1.95		*Loss in coring.*	
4.06-4.48	1.95-1.53		4.06-4.23 m 2.5Y 4/1 dark grey sticky silty clay with clear regular tidal laminae. Few moderately preserved herbaceous remains, likely not immediately *in situ.* 4.23-4.33 m Loss in coring. 4.33-4.48 m as 4.06-4.23 m.	Estuarine alluvium
4.48-4.71	1.53-1.3	Unit 6 alluvium and organic sands: middle Wentlooge	2.5Y 3/1 very dark grey humic silty clay, regular *c* 1 mm bands of pale clay alluvium as above, increasing to 50% at top of unit. Rare fine rootlets.	Semi-stabilised organic alluvium with emergent vegetation
4.71-4.765	1.3-1.245		2.5Y2.5/1 black highly organic fine sand with clay. Rare small degraded herbaceous plant remains. Crumbly but no discernible structure. Gradual boundary. NB the roots below indicate this was a stable vegetated surface formed on alluvium.	Organic stasis horizon in alluvial sands
4.765-6.00+	1.245 0.01+		Gley 1 5/10Y greenish grey fine sandy silt to silty sands with regular well-defined 1.5-3 mm tidal laminae. Few well-preserved vertical (& very rare horizontal) herbaceous (cf. *Phragmites)* roots, traceable to overlying organic sands.	Estuarine alluvium


Transect 1
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BH 1
320m
Unit 1 Modern alluvial soil
Unit 2 Oxidised alluvium: upper Wentlooge
Unit 3 Charcoal/peat layers
Unit 4 Alluvium and peats: middle Wentlooge
Unit 5 Alluvium with flood couplets: middle Wentlooge
Unit 6 Alluvium and peats: middle Wentlooge
Unit 7 Estuarine/marine sands: lower Wentlooge
Unit 8 Reworked ?marine deposits including mercia mudstone
Unit 9 ?marine/estuarine sands
Peat/highly organic layers

Figure 2 (left). Sedimentary transects across the Site.

6 m the middle Wentlooge estuarine alluvial sequence, with a transition between the two at *c* 2 m, with Unit 3 (charcoal/peat) in the base of he upper Wentlooge or top of the middle Wentlooge. Regular division into 1-3 mm lamineae (tidal laminae/ flood couplets; Allen 2004; Allen and Haslett 2006) was commonly noted, becoming prominent in Units 5-6, and provides evidence of the estuarine, tidal nature of this alluvial deposition. In Borehole 2 (not successfully retrieved in Borehole 13), Unit 6 continued to 6.4 m depth and overlay grey silty sands (Unit 7) which became iron stained with depth and with the appearance of shells and small rounded stones from 6.9 m; these are thought to represent estuarine/marine sands of the lower Wentlooge. The underlying Unit 8, a mixed deposit of probable marine origin, contained reworked clasts of Mercia Mudstone, the local bedrock. Unit 9, at 7.4-9.0 m depth, was of grey blue fine sands of marine/estuarine origin.

Some localised variation was recorded within the middle Wentlooge (Units 4-6). Units 4-6 can be grouped together for interpretive purposes but they were divided in the field on the basis of fine sedimentary detail, including the clarity/presence of tidal laminae/ flood couplets. A peat (or sometimes organic sand) at the base, just above the boundary to the lower Wentlooge sand deposits at *c* 0 m aOD, was ubiquitous. This was generally thin (maximum of 0.18 m) with sharp or abrupt boundaries to the overlying alluvium, indicating erosion/truncation by subsequent estuarine alluvial activity. However, the total number of peat (or *in situ* highly organic horizons) units within Units 4-6 varies from one to four. Some of the peat layers are tentatively correlated (Figure 2), however, variation in age is likely, these layers are diachronous and not laterally continuous, even locally.

The uppermost organic layer of Unit 3, which also includes a fine charcoal in-wash, was however constant, while becoming thicker and more diffuse to the north and west of the site, it was apparent across the site at *c* 2 m depth (*c* 3.5-4.0 m aOD). It is of note that a similar unit within the middle Wentlooge Formation was described at the nearby former Enron site (Wessex Archaeology 2004; 2005; Barnett and Armour-Chelu 2008). There, the layer (at 2.31 m below ground level *c* 4.3 m O D) was dated to 2570-2340 Cal BC (3952±29 BP, KIA 24862), indicating burning (and potentially later erosion of soil and charcoal) of early Bronze Age date in the area. The dates show the two events are not contemporary but did occur within the same broad archaeological period (see below). At Plot 8000, the layer was most discrete and well defined in Borehole 2 and the adjacent sleeved core Borehole 13. Microscopic examination of a smear sample at 2.05 m from the latter revealed numerous small angular charcoal fragments as well as humified plant material. None were identifiable but the angularity suggests they are more likely to be wood charcoal rather than charred herbaceous matter.

The estuarine alluvial sequence described is of post-glacial age, and, as noted, the majority directly comparable to the middle-upper Wentlooge Formation described by Allen (1987; 1990) and Allen and Rae (1987). The peat layers cannot, however, be directly correlated to those in other sequences since the peat horizons across the middle Wentlooge Formation are neither planar nor continuous but such horizons have been dated to between 5790-5590 Cal BC and 930-520 Cal BC (Allen *et al* 2002).

Radiocarbon dating the Wentlooge Formation

A series of key organic layers in the middle Wentlooge sequence was selected for dating in order to provide a chronological framework for the sediments and their contained palaeoenvironmental record. Few proved to contain material well suited to radiocarbon dating, with scarce well-preserved recognisable discrete plant remains. In several instances, therefore, bulk peat (humin) had to be used, introducing a degree of imprecision to the dateable sequence. The material was prepared and measured at the Rafter Radiocabon Dating Facility, New Zealand. All returned radiocarbon determinations were calibrated using OxCal ver 3.10 (Bronk Ramsey 1995; 2001) utilising the atmospheric data presented by Stuiver *et al* (1998) and expressed at the 94.5% confidence level and to 2 sigma level, with the end points rounded outwards to 10 years following the form recommended by Mook (1986).

Table 3. The Radiocarbon Dates from Plot 8000, Borehole 13.

Unit	Depth (at 6.01 m aOD)	Comments on context	Result no.	C13 ‰	Result BP	Fraction details	Cal date BC (2 sigma, 94.5% unless stated. OxCal v3.10	Phase
3	1.99 m	Top of humified peat layer with probable comminuted charcoal	NZA-29692	-26.3	3097±25	Treated bulk peat	1430-1300	middle Bronze Age
Base of 3	2.05 m	A. Base of humified peat layer with probable comminuted charcoal	NZA-29693	-26.5	3711±25	Treated (comminuted) charcoal	2200- 2160 (12.1%), 2150-2020 (83.3%)	early Bronze Age
Base of 3	2.05 m	B. Base of humified peat layer with probable comminuted charcoal	NZA-29689	-26.1	4290±25	Treated bulk peat	2930-2875	middle-late Neolithic
4	2.62 m	Black clay peat with horizontal bedding – fen edge peat with brief inundations	NZA-29691	-27.0	4334±25	Treated *Phragmites*	3020-2890	middle Neolithic
Base of 4	3.66 m	Black clay peat with possible comminuted charcoal	NZA-29690	-26.9	3917±45	Treated degraded plant material from bulk peat	2570-2520 (4.4%), 2500-2280 (89.6%), 2250-2230 (1.4%)	late Neolithic
Base of 5	4.46 m	Dark grey clay with tidal laminae and few moderately preserved herbaceous remains, likely local but not immediately in situ.	-	-	-	1st choice discrete plant remains; 2nd choice bulk sediment	Did not date- insufficient carbon content	?

Broadly, the six dates, as shown in Table 3, indicate that Units 3-5 were deposited from the middle Neolithic to the middle Bronze Age. However, the sequencing is problematic, with some inconsistencies identified. The two dates from Unit 4 at 2.62 m and 3.66 m are reversed, with the upper, using *Phragmites* remains, having a middle Neolithic date (3020-2890 Cal BC, 4334±2 BP, NZA-29691) and the lower, on degraded plant remains (picked by the dating laboratory from the bulk peat) being of late Neolithic date (2570-2230 Cal BC, 3917±45 BP, NZA-29690). If disturbance due to the erosion of the upper surface of Unit 4 (as shown by a sharp erosional boundary at 2.60 m) and infiltration of new material were to blame, an erroneously young date for the upper layer would be expected; instead the opposite is true. It could be that the *Phragmites* remains dated at 2.62 m were reworked and in-washed from an older layer, but the *in situ* terrestrial fen nature of the layer and horizontal layering of remains suggests this is unlikely. The problem might, however, be explained if the deeper layer comprised deep penetrating root material such as that of *Phragmites*, so dating a plant younger than the layer dated or the date measurement has been affected by the high degree of degradation at this level.

Two dates were gained on different remains, to act as comparators, from the base of Unit 3 at 2.05 m. These too have proved difficult to interpret. The bulk peat fraction has been dated to middle-late Neolithic (2930-2875 Cal BC, 4290±25 BP, NZA-29689) but the contained comminuted charcoal has been dated to the early Bronze Age (2200-2020 Cal BC, 3711±25 BP, NZA-29693). If the charcoal were eroded from an earlier land surface and washed into the peat layer during a minor alluvial event, it would be expected to be younger than the peat matrix and this has clearly not proved to be the case. Again it seems the bulk peat date may be the problematic one, with the peat matrix perhaps dominated by intrusive roots since degraded. What is of interest is that the charcoal date can be compared to the date for a similar layer noted at the former Enron site (Wessex Archaeology 2004; Barnett and Armour-Chelu 2008), there dated to 2570-2340 Cal BC (3952±29 BP, KIA 24862, comminuted charcoal) and to early Bronze Age layers at Plot 4000 (lower peat 421) dated to 2470-2290 Cal BC (3895±30 BP, NZA-29002 BP, *Phragmites* stem; Ritchie *et al* 2008). These cannot necessarily be considered to be the same event since the error terms do not all overlap, but instead highlight the probable presence of people and that repeated burning activity took place in the early Bronze Age in this part of the Severn Levels despite the lack of associated sites or artefacts found to date.

As shown by the date on bulk peat from the top of Unit 3, this upper peat ceased to accumulate and was inundated by estuarine waters in the middle Bronze Age (1430-1300 Cal BC, 3097±25 BP, NZA-29692), indicating it is an earlier deposit than upper peat (419) described for Plot 4000 (dated to the Iron Age at 930-800 Cal BC, 2717± 35 BP, NZA-23638; Ritchie *et al* 2008) or has been truncated to a greater degree.

POLLEN (RGS)

Pollen assessment was undertaken on 12 samples from the upper and middle Wentlooge Formation sediments from Borehole 13. Pollen was recovered from all samples, although the numbers and preservation was found to be very variable depending on the character of the sediment. A preliminary pollen diagram has been produced and some useful palaeoenvironmental data has been recovered from the assessment of this profile.

Standard extraction techniques were used on samples of 2 ml volume (Moore and Webb 1978; Moore *et al* 1991) at the Palaeoecology Laboratory of the School of Geography, University of Southampton. Pollen was identified and counted using an Olympus biological research microscope fitted with Leitz optics. Standard assessment sums of 100-200 grains per sample were counted. All samples produced sufficient numbers of pollen grains to enable preliminary pollen counts to be made. A pollen diagram was plotted using Tilia and Tilia Graph (Figure 3) in which the percentages for the latter have been calculated as follows, Sum = % total dry land pollen (tdlp), Marsh/aquatic herbs = % tdlp + sum of marsh/ aquatics, Spores = % tdlp + sum of spores, Misc. = % tdlp + sum of misc. taxa. Taxonomy in general follows that of Moore and Webb (1978) modified according to Bennett *et al* (1994) for pollen types and Stace (1997) for plant descriptions.

Four local pollen assemblage zones have been recognised in the sampled profile. These are characterised from the base at 5.11m as follows:

Zone 1: 5.11 m to c 4.0 m, Units 5-6. Trees are dominated by *Quercus* (oak, to 40%) with small numbers of *Tilia* (lime/linden), *Alnus glutinosa* (alder, 8%) and *Corylus avellana*-type (hazel, 10%). Herbs are important with Poaceae (grasses, to 45%) and Chenopodiaceae (goosefoots and oraches, peak to 19%). Marsh taxa are dominated by Cyperaceae (sedges, 15% in the basal level) with spores of *Dryopteris* type ferns (monolete forms, 10%), *Polypodium vulgare* (polypody, peak to 20%) and *Sphagnum* moss (to 19%). Small numbers of freshwater aquatic taxa are present from the top of the zone, including *Potamogeton* type (pondweeds) and *Myriophyllum* spp. (water-milfoils).

Zone 2: c 4.00 m to 2.55 m, Units 4-5. This zone comprises alluvial sediments with an upper peat horizon/lens (2.60 to 2.65 m) and is differentiated by a reduction of Poaceae and Pre-Quaternary palynomorphs, the latter especially reflecting a stratigraphic change and an associated change in taphonomy. There are expansions of *Corylus avellana*-type (to 29%) and incoming of *Calluna* (heather) and *Erica* (heaths). *Quercus* remains the dominant tree. The small numbers of freshwater aquatic taxa of zone 1 continue into this zone.

Zone 3: 2.55 m to 1.60 m, Units 2-4. There is a marked increase in the number of *Calluna* (to 46% at the base of the zone), Cyperaceae (12%) and *Sphagnum* (to 30%) and *Pteridium aquilinum* (bracken, to 30%). There is a corresponding reduction in trees (*Quercus*). Herbs remain dominated by Poaceae (20%). *Plantago lanceolata* (ribwort plantain) is incoming in small numbers.

Zone 4: 1.48 m, Unit 2. Although the zone is based on a single level, there appear to be changes associated with changing stratigraphy (ie taphonomic). There are increases in derived pre-Quaternary palynomorphs (22%), dinoflaggellates and algal *Pediastrum*. Pollen assemblages remain similar to the preceding zone. *Armeria* 'A' line (thrift or sea-lavender) is, however, present only in this zone; a single but never the less important record since this halophyte is extremely poorly represented in pollen spectra generally.

The pollen spectrum is comparable with earlier analyses of the Wentlooge Formation

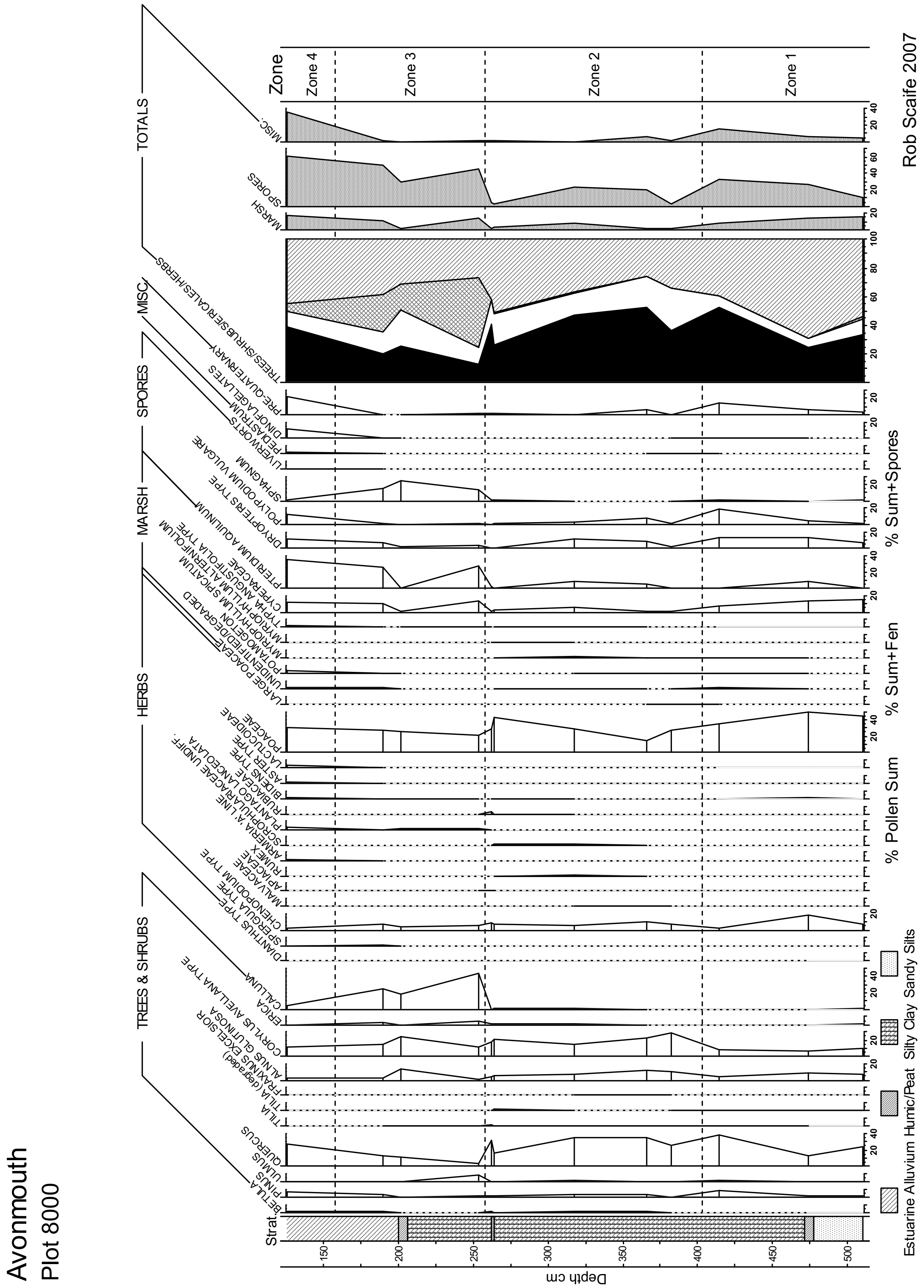
Avonmouth
Plot 8000
Rob Scaife 2007
Zone
Zone 4
Zone 3
Zone 2
Zone 1
TREES & SHRUBS
HERBS
MARSH
SPORES
MISC
TOTALS
% Pollen Sum
% Sum+Fen
% Sum+Spores
Depth cm
Strat
Estuarine Alluvium Humic/Peat Silty Clay Sandy Silts

Figure 3 (left). Pollen diagram Avonmouth Plot 8000.

(Scaife 2000a-d; Scaife unpub; Dark and Allen 2005; Allen and Dark 2007). Interpretation of the pollen sequence can be viewed in terms of the on-site (autochthonous) vegetation and associated sedimentary regime and, secondly, the local terrestrial/dry-land environment. Although this study is from an assessment, and as such the sampling interval for this substantial thickness of sediments is broad, some preliminary interpretations have been made.

The depositional habitat: Pollen in conjunction with diatom analysis shows that saline influences were present throughout the period represented by the sediments and peat. It seems likely that the Chenopodiaceae represented are halophytes and indicative of salt marsh. *Armeria* is also present in the uppermost level. Other taxa are less definable with *Spergula* (spurrey), Malvaceae (mallow: from the upper beach) and *Aster* type (sea aster from the middle and upper salt marsh zones). Diatoms of brackish water affinity have been recovered from pollen zones 2, 3 and 4 (see below). Whilst it appears that the Wentlooge Formation was deposited in tidal conditions, the taphonomy of the pollen in these sediments is complex. In the upper Zone 4, expansion of derived pre-Quaternary palynomorphs is associated with the stratigraphic change to estuarine alluvium and this may indicate a change to open mud flat in response to eustatic change. In addition to the halophytes noted, freshwater fen taxa occur including Cyperaceae, *Typha/Sparganium* (bur reed and reed mace), *Potamogeton* type, *Myriophyllum* spp. and cysts of algal *Pediastrum*. These are likely to have been fluvially transported from rivers exiting into the estuary.

The terrestrial zone: As noted, the taphonomy of pollen within these alluvial sediments is likely to be complex. The sources of pollen come from direct, airborne and fluvially derived transport (both freshwater and tidal), with the possibility also of reworked pollen and spores derived from earlier sediments. Thus, the pollen evidence of the terrestrial vegetation may come from a broad regional area. In pollen zones 1 and 2 (Units 4-6), there is strong evidence that *Quercus* and *Corylus avellana* were the main woodland constituents. A small but consistent presence of *Tilia*, which is usually under represented in pollen assemblages, also suggests that this may have been a significant woodland component. This is consistent with the Neolithic and Bronze Age periods as seen in other regional pollen data, so supporting the broad radiocarbon sequence reported above.

There is marked change in the pollen at *c* 2.62 m, the pollen zone 2/3 boundary within Unit 4. Zone 3 shows a significant change to acidophilous plant communities with expansion of *Erica*, *Calluna* and *Sphagnum*. This is also seen at Plot 4000 (Scaife in Ritchie *et al* 2008) where this expansion is also sharp and associated with the lithological change from peat to blue silty clay. It is, therefore, probable that these acidophilous elements may have been fluvially transported from elsewhere in the catchment where a dominant heathland and/ or raised mire community existed. At Plot 4000, this change has been radiocarbon dated to the Bronze Age at 930-800 Cal BC (2717±35BP, NZA-23638), but at Plot 8000 has proved to be earlier, of middle Neolithic date at 3020-2890 Cal BC (4334±25 BP, NZA-29691) suggesting that the oak, lime, hazel woodland discussed is of Neolithic date.

Human activity: Evidence for human activity is sparse in this sequence. *Plantago lanceolata* and a proportion of the Poaceae are probably indicative of grassland/pasture in Zone 3 (Units 2-4) during the middle Neolithic-early Bronze Age. Small numbers of 'large Poaceae' may be from cereals although certain wild grasses of salt marsh habitat have similar pollen grains. Thus, evidence of arable activity nearby is inconclusive.

DIATOMS (RGS)

The same 12 samples which were analysed for pollen were examined for presence or absence of diatoms which, if present, can provide a valuable indication of the saline, brackish or freshwater status of the environments in which the sediments were deposited.

Diatoms were extracted used digestion of humic/organic material using Hydrogen Peroxide. Samples were then dried on microscope cover-slips and mounted on microscope slide using

Table 4. Diatoms identified at Plot 8000, Borehole 13.

Depth (m)	**2.02**	**2.54**	**2.62**	**2.64**	**3.18**	**3.66**	**3.82**
Abundance * to *****	**	*	*	*	***	**	***
Actinoptychus senarius					*	*	*
Centric frags.		*		*	*	*	*
Cocconeis scutellum		*					*
Coscinodiscus sp.						*	
Diploneis sp.		*					
Diploneis interupta	*						
Navicula lyra							*
Nitzschia sp					*		
Nitzschia navicularis		*			*	*	
Nitzscia punctata						*	*
Paralia sulcata		*			*	*	*
Pinnularia sp.			*				
Pseudopodosira stelligera					*	*	
cf. *Rhaphoneis*					*		*
Unidentified							*

Naphrax mounting medium. Examination was carried out at high power x400 and x1000 using a biological microscope. Taxa noted are listed in Table 4. Small numbers of diatoms were observed, however, since much of the earlier material obtained from this region has been found to be devoid of diatoms, their presence here is of value. Detailed identification and counting was not carried for this assessment and indeed absolute numbers are small. There is, however, sufficient evidence to show that the whole of the sediment sequence was subject to saline, brackish water conditions. All of the diatoms identified are of saline affinity.

FORAMINIFERA AND OSTRACODA (JR)

Eight sub-samples were taken from the stratified sediment from monoliths/cores from Borehole 13 for detailed analysis, as listed in Table 5.

Sediment was wet sieved through a 63 µm sieve to remove the silt fraction. The residue was dried and sieved through 500 µm, 250 µm, 125 µm sieves. Foraminifera and ostracods were picked out under 10-60x magnification and transmitted and incident light using a Vickers binocular microscope and the specimens placed in card slides. Identification of foraminifera follows Murray (1979) and interpretation of their ecology follows Murray (1991) and Haslett *et al* (1997). Identification and interpretation of ostracods and their ecology follows Athersuch *et al* (1989) and Meisch (2000). The results are given in Table 5.

Where present, ostracods and foraminifera were well preserved. A relatively diverse fauna was recovered from the deepest samples from middle Wentlooge Unit 6 at 5.75 m (0.26 aOD) and 5.11 m (0.90 aOD), including a mixture of largely allochthonous marine, brackish and marsh taxa. The presence of an autochthonous assemblage of the ostracod *Leptocythere lacertosa* at 5.75 m (0.26 m aOD), in particular, is indicative of estuarine deposition. These samples show the largest numbers of marine taxa recorded from these samples and it is therefore likely that the depositional environment was fully estuarine probably towards the estuary mouth, with strong marine influence indicated. At 4.47 m (1.54 m aOD, Unit 5) the foraminifera are dominated by

Table 5. Abundance of Foraminfera and Ostracoda Per Sample at Plot 8000, Borehole 13.

Sample depth (m aOD)	**4.74**	**4.10**	**3.46**	**2.82**	**2.18**	**1.54**	**0.90**	**0.26**
Sample depth (m)	**1.27**	**1.91**	**2.55**	**3.19**	**3.83**	**4.47**	**5.11**	**5.75**
Foraminifera								
Ammonia aberdoveyensis	x					xxx		x
Ammonia limnites	x			x		xx		x
Ammonia tepida	x					xxx		x
Ammonia batavus							x	x
Astergerinata mamilla						x	x	
Cibicides lobatulatus		x						
Elphidium crispum								x
Elphidium gerthi							x	
Elphidium incertum							x	
Elphidium macellum							x	
Elphidium williamsoni	x	x				x	x	x
Jadammina macrescens	x	x				x	x	x
Lagena sp.							x	
Miliolinella subrotundata								x
Nonion depressulus							x	
Planorbulina mediterraneanensis							x	
Quinqueloculina cliarensis								x
Rosalina williamsoni							x	
Trochammina inflata	xx	x				x	x	x
Ostracoda								
Celtia sp.							x	
Cyprideis torosa						xx	x	x
Cytheropteron dorsocostatum							x	
Elofsonia baltica	x							
Hemicythere sp.								x
Hemicythere villosa								x
Leptocythere baltica	x			x				
Leptocythere lacertosa								xx
Leptocythere porcellanea								x
Leptocythere psammophila							x	
Loxoconcha elliptica							x	x
Propontocypris pirifera	x							
Semicytherura sp.						x	x	
Semicytherura tela							x	

ecophenotypes of the genus *Ammonia* (*A. aberdoveyensis, A. limnites* and *A. tepida*). These foraminifera have well-studied ecological preferences of fluctuating diurnal salinity (probably 0-35‰) and with a water temperature of around 15-20° *c* They are common on intertidal mudflats and low marsh environments (Murray 1991) and brackish lagoons (Murray 1979) and are recorded from the Severn Estuary from low marsh and mudflat environments below 5 m aOD (Haslett *et al* 1997). A small, largely monospecific and autochthonous assemblage of the ostracod *Cyprideis torosa* is indicative of brackish tidal creeks.

The samples from Unit 4 and the top of Unit 5 at 3.83 m (2.18 m aOD), 3.19 m (2.82 m aOD) and 2.55 m (3.46 m aOD) had very low abundances of both foraminifera and ostracods. Within the samples, frequent anhydrite/gypsum crystals and plant remains indicate a saltmarsh environment prone to desiccation. It is possibly this desiccation caused destruction of ostracod valves and foraminferal tests. Occasional sponge spicules noted are indicative of a marine connection at these levels.

In the upper Wentlooge Unit 2, saltmarsh foraminifera, including *Elphidium williamsoni*, *Jadammina macrescens* and *Trochammina inflata* return in low numbers at 1.91 m (4.10 m aOD). At 1.27 m (4.74 m aOD) the sample is dominated by *Trochammina inflata* a taxon recorded commonly in association with *Jadammina macresens* within the middle marsh zone just below the High Water Spring Tide Mark (*c* 5- 6.5 m aOD) by Haslett *et al* (1997) at Oldbury-on-Severn.

CHARRED AND WATERLOGGED PLANT REMAINS (CJS)

A series of bulk samples was taken to aid in characterising and evaluating the significance at the Site and the presence and significance of potential human activity associated with the few features cut into the upper part of that sequence, and an undated palaeochannel exposed in the evaluation trenches. Three were selected for assessment, from gully 3105 (fill 3108), gully 6301 (fill 6303) and palaeochannel 6705 (lowest fill, context 6704).

The bulk samples were processed by standard flotation methods; the flot retained on a 0.5 mm mesh, residues fractionated into 5.6 mm, 2 mm and 1 mm fractions and dried. The coarse fractions (>5.6 mm) were sorted, weighed and discarded. Flots were scanned using x10–x40 stereo-binocular microscopy and the charred remains quantified and identified, following the nomenclature of Stace (1997). The flots were all small with high numbers of roots, but only occasional modern seeds. This indicates a degree of disturbance and reworking.

The three samples were assessed for waterlogged remains, none were found. These samples also proved to contain very little material indicative of settlement activity, such as wood charcoal or cereal remains. Indeed, no charred plant remains were present in the samples from palaeochannel 6705 or gully 6301. The flot from post-medieval gully 5 (fill 3108) contained several fragments of parenchyma (soft plant tissue) identified as fruit pericarp. The outer surface was slightly tuberculate with several ‘bored’ holes that may be insect related. In cross section the material contained regularly spaced holes in which occasionally fragments of seeds could be seen. The date of the find is unknown, but in view of other artefacts from the site is likely to be 18th -20th century. Wood charcoal was largely absent from the samples, although that from gully 5 (fill 3108) did contain occasional ring-porous pieces, most probably of oak.

LAND AND FRESH/BRACKISH WATER MOLLUSCS (SFW)

During the processing of bulk soil samples for the recovery of charred remains, snails were noted in the flot of palaeochannel 6505 (fill 6704). Nomenclature is according to Kerney (1999). The majority of these were of *Hydrobia* sp., a species associated with brackish water and recovered from previous excavations at Avonmouth (Wessex Archaeology 2006a; 2006b; Masser *et al* 2005). Terrestrial molluscs were poorly represented and included single shells of *Trichia* sp. and *Pupilla muscorum*. The presence of brackish water snails in the lower fill of the palaeochannel indicates some marine influence during its initial silting.

DISCUSSION (CB)

Although samples could not be recovered successfully from the deepest and earliest sediments at Plot 8000, because of the nature of the sediments and degree of saturation (with aquifers believed to run across the site at this depth), a little environmental information can be gleaned from the field observations made during coring. Units 7-9 are believed to equate to the lower Wentlooge Formation, they comprise a series of grey laminated estuarine/ marine sands at 6.4-9.0+ m (*c* -0.3 to -5 m aOD), with the inclusion of reworked Mercia Mudstone bedrock in Unit 8 indicating marine erosion and deposition prior to the early-mid Holocene.

The onset of increasingly low energy estuarine conditions occurred from the mid Holocene, as indicated by the deposition of the fine alluvium of Units 4-6 (the middle Wentlooge Formation), with the occurrence of regular fine laminae attesting to the tidal nature of the environment. The foraminifera and ostracoda indicate a shift in the proximity of the Site to the estuary mouth during this period, with a change from full estuary and marine fauna in Unit 6 at 0.26-0.90 m aOD, to an assemblage indicative of intertidal mudflats and low marsh environments in Unit 6 at *c* 1.54 m aOD.

Repeated short-lived stasis horizons including terrestrial fen peats then formed at the Site, indicating irregular fluctuation in water levels, and/or local shifts in the major palaeochannels, resulting in first the stabilisation of estuarine sediments with emergent reeds and sedges then the formation of wet but fully terrestrial marsh and fen environments from the middle Neolithic. The diatom, foraminifera and ostracod assemblages attest to the continuous presence of saline/brackish water throughout this period with, salt marsh and mud-flat habitats traversed by brackish creeks but the presence of freshwater vegetation communities including pondweed have also been demonstrated by the pollen, perhaps reflecting small freshwater tributaries within the marshlands, feeding into the main estuary. The occurrence of frequent anhydrite/gypsum crystals within Unit 4 support an interpretation of repeated dessication of the saltmarsh environs at this time. The pollen also indicates the dryland was well wooded, with oak, lime and hazel in the middle Neolithic-Bronze Age. There is also evidence for a substantive increase in heathland and/or raised mire vegetation (heather, ling and bog moss) during the middle Neolithic, at 2.62 m (the pollen zone 2/3 boundary within Unit 4), also recognised at Plot 4000, but there dated to the early Bronze Age.

Evidence for human activity in the prehistoric landscape is scarce at this Site. There is some slight indication of human disturbance in the pollen assemblage at Plot 8000 for Units 3 and 2, with *Plantago lanceolata* and a proportion of the Poaceae probably indicative of grassland/pasture. The evidence for cereal cultivation at this time is inconclusive. Notably, however, rare pieces of comminuted angular (possibly wood) charcoal were found in a thin band of black clay peat at 3.66 m depth (2.31 m aOD) in Borehole 13. This layer has been dated to the late Neolithic but, as discussed above it may be the date is erroneous, being too young and the layer is more likely to be of middle Neolithic date. More substantial quantities of comminuted charcoal, also angular in nature and believed to be wood charcoal, was found at the boundary of the middle and upper Wentlooge Formation, represented by Unit 3 at *c* 2 m depth (*c* 3.5-4.0 m aOD), normally a peat or organic silt, this layer thinnest and most defined (least diffuse) in the area of Boreholes 2 and 13 (see Figure 1). The charcoal has been dated to the early Bronze Age at 2200-2020 Cal BC and can usefully be compared to a layer observed at the nearby former Enron site (Wessex Archaeology 2004; Barnett and Armour-Chelu 2008), there dated to 2570-2340 Cal BC (3952±29 BP, KIA 24862) and to an early Bronze Age layer at Plot 4000 (lower peat 421) dated to 2470-2290 Cal BC (3895±30 BP, NZA-29002; Ritchie *et al* 2008). The comminuted charcoal at Enron was dominated by charred herbaceous remains but at Plot 4000 wood charcoal of hazel and willow or aspen was found in addition to large grass stems. The activity at both Sites was interpreted as landscape burning possibly related to clearance (and in the case of the former Enron works, potentially later erosion of soil and charcoal) of early Bronze Age (Beaker) and later Bronze Age at Plot 4000, apparently as a mechanism to clear land for pastoral farming. (Ritchie *et al* 2008; Locock *et al* 1998).

Clear evidence for Romano-British age activity in the immediate area has previously been gained from the substantial archaeological features and from the palaeoenvironmental remains for this period at the adjacent Plot 4000 (Ritchie *et al* 2008). No such evidence was found at this Site and the environmental signal of this period shows only a possible sedimentological change (to Unit 2) and palynological change (to pollen zone 4) to more dominantly estuarine conditions in response to increasing relative sea-level during this time, as supported by the foraminifera and ostracod evidence. It can be suggested that activity was highly localised and dependent on the use of slightly raised ground (as at Plot 4000) away from the main channels during this period of rising water.

The only artefactual and feature-based evidence at Plot 8000 is, as described above, related to some ephemeral gullies believed to be of 18th-20th century date and related to drainage activity. The associated environmental remains are scarce with only rare wood charcoal and a single fragment of fruit pericarp. Clearly the Site has been somewhat marginal to settlement throughout the post-medieval to modern times, presumably due to its unstable and waterlogged nature, as indicated by the presence of occasional small palaeochannels traversing the Site in the upper sediment layers and the presence of molluscs that favour brackish water. Since that time, Plot 8000 has dried out, causing the oxidation of the upper Wentlooge Formation (Unit 2) and enabling the formation of the modern alluvial soil (Unit 1).

The sequence of deposits of the upper and middle Wentlooge Formation (Allen 1987; 1990; Allen and Rae 1987) described here for Plot 8000 compare well to records from evaluation at Plot 4000, Western Approach Business Park (Wessex Archaeology 2004; Ritchie *et al* 2008), the former Enron site (Wessex Archaeology 2004; 2005; Barnett and Armour-Chelu 2008), 6010-6020 (Moore *et al* 2002), Avlon Works, Severnside (Wessex Archaeology 2002) and Katherine Farm (Allen *et al* 2002) and the known general sequence (Allen 1987; 1990; Allen and Rae 1987; Gardiner *et al* 2002; Carter *et al* 2003). However, peat formation at the Site shows local variation in formation and/or truncation by estuarine alluvial activity, with a greater number of smaller peat bands and stases observed than on adjacent sites. Coring to the depths required to investigate the lower Wentlooge Formation is more rarely achieved, so the field descriptions provided add useful data to that known for these deep deposits.

The data from the pollen assessment, as well as providing detail on the local on and off-site flora, compares well with existing regional pollen data related to the middle and later Holocene environment of the Wentlooge formation (Scaife in Ritchie *et al* 2008; Scaife 2002a-d; Druce 2000; Walker *et al* 1998, 1999a, 1999b and Scaife 2001; Scaife in Gardiner *et al* 2002). All indicate marsh areas characterised by reed and sedge communities, with dominant woodland on the edges in prehistoric times. They show a gradual diminution in tree types towards the top of the middle Wentlooge Formation, accompanied by some expansion of open, grass dominated, herb communities, but that truly open conditions did not exist in dryland areas until the upper Wentlooge/late prehistoric-historic period. The expansion in heath/ raised mire vegetation has been demonstrated for the wider catchment in the middle Neolithic period. A reversion to dominantly estuarine and salt marsh conditions in late prehistory has also been shown for both Plots 4000 and 8000, in response to positive eustatic change. Indeed generally in this area, eustatic change (reflected in the stratigraphy and the changing frequencies of salt tolerant plants) during the late-prehistoric period (Haslett *et al* 1988; Hibbert 1980; Jennings *et al* 1988) led to a decline in local woodland and the progressive development of salt marsh and influence of brackish water on the floodplain.

ARCHIVE

The site archive will be deposited with Bristol City Museum.

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