ARCA Geoarchaeology

February 2017

Report Number: 1617-16

LYMINSTER BYPASS, LYMINSTER, WEST SUSSEX: GEOARCHAEOLOGICAL DESK-BASED ASSESSMENT

Prepared for Cotswold Archaeology

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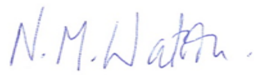
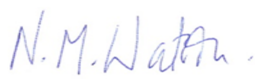
Version	Date	Status*	Prepared by	Author's signature	Approved by	Approver's Signature
01	10/02/17	I	Nick Watson		Keith Wilkinson	
02	16/02/17	E	Nick Watson		Keith Wilkinson	
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SUMMARY

A geoarchaeological desk-based assessment was carried out of geotechnical records collected along the route and British Geological Survey (BGS) records in the vicinity of the proposed A284 Lyminster Bypass, West Sussex. Locational and lithological data were extracted from these records and transferred to a RockWorks 15 database. Lithologies were interpreted and placed into formal BGS stratigraphic categories using the appropriate BGS maps.

The bedrock underlying the proposed route of the Bypass sub-crops at +2m OD along most of the route and comprises rock of the White Chalk Group. Deposits on the Reading Formation may outcrop at the extreme north end of the route. The relatively flat Chalk superface is probably a result of marine planation in the Middle Pleistocene/early Upper Pleistocene. BGS mapping suggests that raised beach deposits, which are here attributed to the Pagham Formation, sit on the planation surface and extend to the present ground surface. The Pagham Formation is of Ipswichian interglacial age (123-130,000 BP), a time when humans were absent from Britain. However, the lithological data from the geotechnical survey are equivocal with regards formation processes of the mapped raised beach deposits.

A palaeochannel of c. 21m depth is cut into the Chalk in the Black Ditch and filled with fine-grained fossiliferous deposits. The BGS map the fills as intertidal deposits of Holocene age. The c. -19.5m OD lower contact of the fine-grained fills with the underlying Chalk suggests flow through the channel either in the Early Holocene, or during the Ipswichian/Middle Pleistocene.

The Quaternary deposits along the route of the proposed Lyminster bypass are presently *assessed as of moderate (palaeochannel fills) to low (raised beach) archaeological, and high (palaeochannel fills) to moderate (raised beach) palaeoenvironmental potential. However, a geoarchaeological borehole survey is recommended both to clarify interpretations presently made on the basis of relatively low detail geotechnical description and refine the assessments made in this report.*

1 INTRODUCTION

1.1 Project background

1.1.1 This text is a geoarchaeological desk-based assessment (DBA) carried out on behalf of Cotswold Archaeology (CA) and their clients WSP UK Ltd of a proposed bypass at Lyminster, West Sussex (henceforth 'the scheme'). The present report has been compiled using geological data held by the British Geological Survey (BGS) and from a prior geotechnical examination of the Bypass route carried out by WSP (Endsor and Burrows 2014), as well as from published accounts of the Quaternary stratigraphy of the West Sussex coastal plain. The research leading to the production of the present text was undertaken between 6 and 16 February 2017.

1.1.2 The Lyminster Bypass – or rather the northern section that is part of the current proposal - would comprise a 980m link between the A284 Lyminster Road and the B2187 East Street (Figure 1). The road will be 7.5m wide and will possess an additional 1m-wide hardstand strip on either side. Beyond the latter will be a 3.85m-wide verge and a 2.5m-wide footpath on one side only (Endsor and Burrows 2014, 8). The total impact of the proposed road is therefore a 980 x 19.7m, north-south orientated strip (henceforth the 'study area'). In addition to construction of the road, a bridge will be built over an east bank tributary of the River Arun, the Black Ditch. The Bypass will approach the bridge via embankments built on top of the floodplain. The latter will be constructed of deposits removed from the floodplain margin during the excavation of two compensation basins (Endsor and Burrows 2014, 8). The sub-surface impact of the road and associated features will depend upon the engineering approaches that are adopted, the specification of which were not available at the time this assessment was written.

1.1.3 The remaining sections of the report are arranged as follows: Section 1 provides essential background to the project, i.e. the geographic and geological situation of the site, and the aims of the present work. Section 2 outlines the methodology employed in collecting and utilising the geological data. The lithostratigraphy of the study area is presented and interpreted in Section 3, while Section 4 assesses the significance of the lithological data recovered in relation to the aims that have been set. A bibliography, and appendices providing the locations and stratigraphy of the geological records that were used complete the report.

Figure 1. Map of the Lyminster Bypass site showing location of BGS and WSP lithostratigraphic records
Labelled BGS boreholes and all WSP lithostratigraphic records are discussed in this report.

1.2 Location, topography and geology

1.2.1 The proposed Lyminster Bypass will pass to the east of Lyminster and will run between NGR TQ 02882 05222 and TQ 03193 03936. It will start from the A284 north of Lyminster where the ground lies at c. +2m OD, climb a slight ridge on which the village of Lyminster sits (c. +6m OD), descend to cross the Black Ditch (c. +1.5m OD) before finally climbing to its junction with East Street at the south of the study area (c. +3m OD). The terrain over which the road will run presently comprises arable and pasture, while the southernmost portion passes through Holland Nursery.

1.2.2 The BGS map the bedrock of the study area as undifferentiated strata of the White Chalk Group (formerly the Middle and Upper Chalk) (BGS 1996, 2017a, b). The White Chalk Group comprises formations that were laid down in the Upper Cretaceous between 101 and 66 million years ago (Ma) (BGS 2017c), i.e. the New Pit Chalk Formation and the undifferentiated Lewes Nodular Chalk Formation, Seaford Chalk Formation, Newhaven Chalk Formation, Culver Chalk Formation and Portsdown Chalk Formation. According to the 1/50,000 BGS map (1996), the following strata overlie the bedrock: 'Raised Beach deposits 1' in the northern part of the study area and 'Raised Marine deposits' in the south. However, the 1/10,000 BGS map (2017b) plots 'Raised Beach deposits 1' in the north, and 'Tidal River or Creek deposits' in the south. The raised beach strata are discussed further in the next paragraph, but it should be noted that 'Raised Beach deposits 1' and 'Raised Marine deposits' are not equivalents (BGS 2017b). The Tidal River or Creek/Raised Marine deposits are shown as outcropping in the floodplain of the Black Ditch, the implication being that they are of Holocene age [11,500 BP (11.5 Ka) to present] and were deposited by tidal incursions along the River Arun).

1.2.3 The study area lies on the West Sussex Coastal Plain (WSCP), an area of considerable Pleistocene geological and Palaeolithic archaeological interest. Excavations on the highest of the raised beaches (Goodwood-Slindon) at Boxgrove first highlighted the potential of marine marginal interglacial strata to preserve Palaeolithic materials and associated fauna in associations that are extremely rare elsewhere (Roberts 1986, Roberts et al. 1994, Roberts and Parfitt 1999). Although archaeological materials are have rarely been found in the lower raised beaches, the potential of such strata remains high (Hosfield et al. 2009). Roberts and Parfitt (1999) and successive authors (e.g. Bates et al. 2000) classify

Pleistocene strata on the WSCP by altitude as outlined in Table 1[1]. Given the outcrop elevation of the Raised Beach 1 deposits identified by the BGS in the study area (< +5m OD), they are likely to be of the Pagham Formation.

Group	Formation	Elevation	Member	Age (MIS[2])
Lower Coastal Plain	Pagham	-2 to +3m OD	Pagham Gravel	5e
	Norton	+5-+12m OD	Norton Gravels and Brickearth	6
			Norton Silts	7
			Norton Sands	7
			Norton Beach	7
	Aldingbourne	+17.5-+27.5m OD	Aldingbourne Upper Gravel	7 or 9
			Aldingbourne Sands	7 or 9
			Aldingbourne Lower Gravel	7 or 9
Upper Coastal Plain	Eartham	+32-+43m OD	Eartham Upper Gravel	12
			Eartham Lower Gravel	12
	Slindon		Slindon Silt	13-16
			Slindon Sand	13-16
			Slindon Gravel	13-16

Table 1. Pleistocene strata of the West Sussex Coastal Plain (Roberts and Parfitt 1999, 30; Bates et al 1998, 153 modified after Bates and Briant 2009)

1.3 Aims

The aims of the present DBA are to:

1.4.1 Determine the extent, nature and genesis of Quaternary[3] sedimentation within the study area;

1.4.2 Assess the archaeological and palaeoenvironmental potential of Quaternary strata present within the study area;

1.4.3 Assess the likely impact of the development on strata of high-moderate archaeological and palaeoenvironmental potential.

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[1] In the Geological Society's Revised correlation of Quaternary deposits in the British Isles, Gibbard and Preece (1999) ascribe Member status to the Slindon, Eartham , Aldingbourne and Norton Formations of Roberts and Parfitt (1999)

[2] Marine Isotope Stage – MIS 5e = 123-130 Ka, MIS 6 = 130-191 Ka, MIS 7 = 191-243 Ka, MIS 8 = 243-300 Ka, MIS 9 = 300-337 Ka, MIS 10 = 337-374 Ka, MIS 11 = 374-424, mis Ka, MIS 12 = 424-478 Ka, MIS 13 = 478-533 Ka, MIS 14 = 533-563 Ka, MIS 15 = 563-621 Ka and MIS 16 = 621-676 Ka (Lisiecki and Raymo 2005).

[3] The last 2.6 million years (Ma) – made up of two stages, the Pleistocene (2.6 Ma to 11.5 Ka) and Holocene (the last 11.5 thousand years)

1.4.4 Make recommendations for further geoarchaeological works necessary to further test Aims 1.4.1-1.4.3 above.

2 METHODOLOGY

2.1 Data for the geoarchaeological DBA have been derived from three sources: first, the BGS 1:50,000 and 1:10,000 maps (BGS 1996, 2017b), secondly from geotechnical works carried out by WSP in 2014 (Endsor and Burrows 2014) and thirdly, from a search made of the BGS borehole database (BGS 2017b).

2.2 The WSP geotechnical study was carried out during the design phase of the present Bypass project. Its purpose was to identify geotechnical problems that might be associated with sub-surface deposits and the assess the likelihood of contamination (Endsor and Burrows 2014, 9). As well as reviewing desktop cartographic sources (which are not considered in this report), the geotechnical works included the drilling of 10 dynamic probe boreholes (WSP BH1-10) and 7 window samples (WSP WS1-7), and the excavation of 20 test pits (WSP TP1-10, WSP TP12, WSP TP14-22) (Appendix 1 and 2). The dynamic probe boreholes were drilled with a Comacchio MC300 percussion/rotary device to depths of up to 20.24m below ground level (BGL), the window samples with a Terrier rig to a maximum of 5m BGL and the test pits dug to <3.6m BGL with a 360^{o} mechanical excavator.

2.3 Nine borehole records are available in the BGS borehole database within *c.* 600m of the study area (none within); however, the borings were completed for wells in the first half of the twentieth century and the quality of the data are poor (Appendix 1 and 2). Within *c.* 1km there are an additional 45 borehole records in the database. These are located primarily along the two major trunk roads (A27 and A259) that run east-west to the north and south of the site respectively, and are of a higher quality (Appendix 1 and 2).

2.4 Lithological descriptions and positional data from both the WSP geotechnical study and the BGS borehole database were combined within a RockWorks database (RockWare 2013). The lithological unit descriptions of the geotechnical and BGS records were then interpreted in terms of the stratigraphic taxonomy of the BGS (1996, 2017b) mapping. For example sand and gravel strata in a borehole drilled in a location mapped as 'Raised Beach 1' was accorded that designation[4]. The RockWorks software package was then used to plot the cross sections in Section 3. Location data for all records utilised in the compilation of this report are presented

[4] The is the only viable approach given the lack of detail inherent in geotechnical (cf. geoarchaeological/geological) description. However, there are inherent dangers of circular reasoning – see Section 4.4.

in Appendix 1, while stratigraphic interpretations are given in Appendix 2.

3 RESULTS

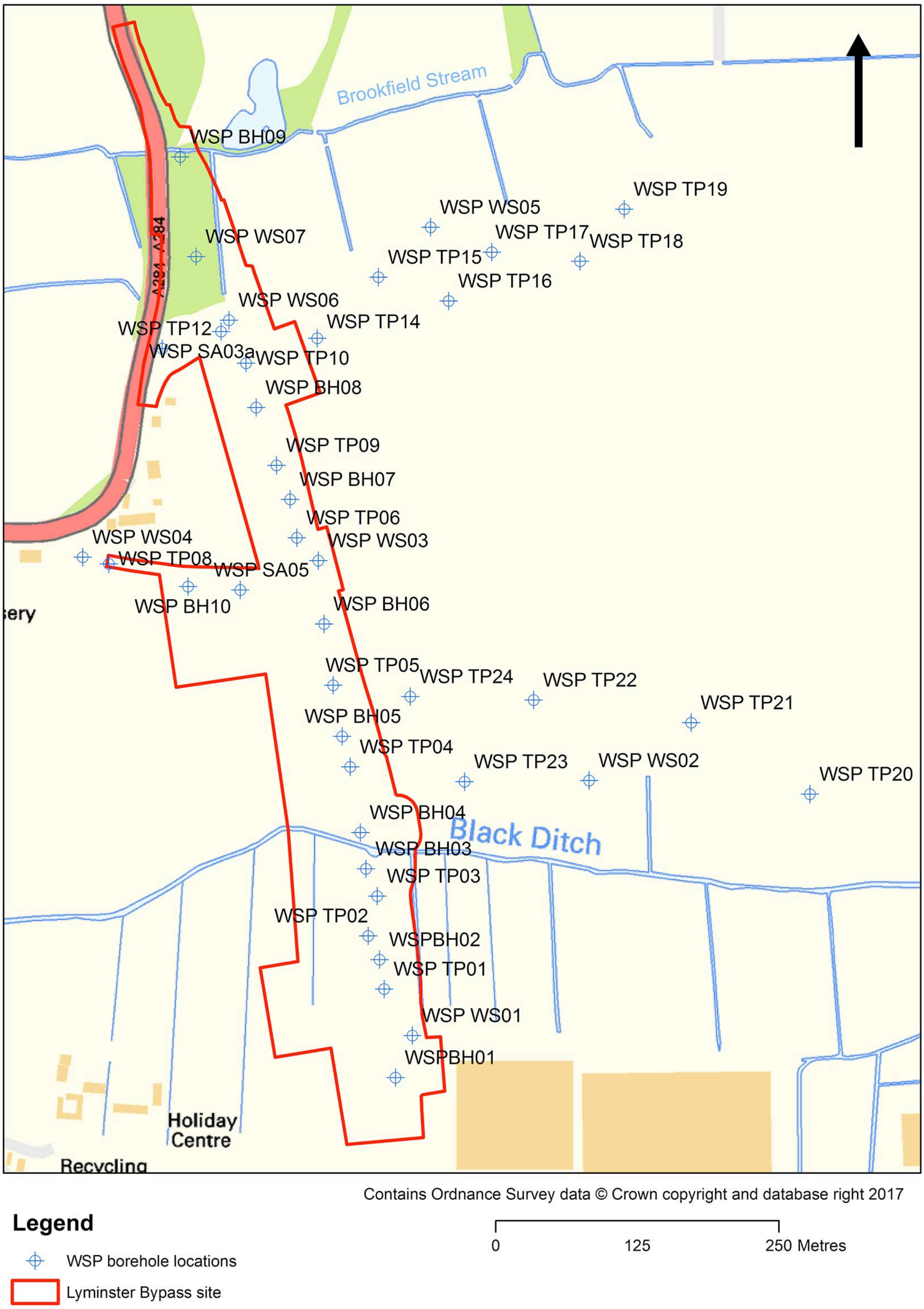

Figure 2. Location of the WSP records within the study area

3.1 In the following discussion the lithology and stratigraphy of the Bypass route is described from the southern terminal at East Street northwards to the northern terminal on the Lyminster Road (A284), in the vicinity of Brookfield (Figure 2).

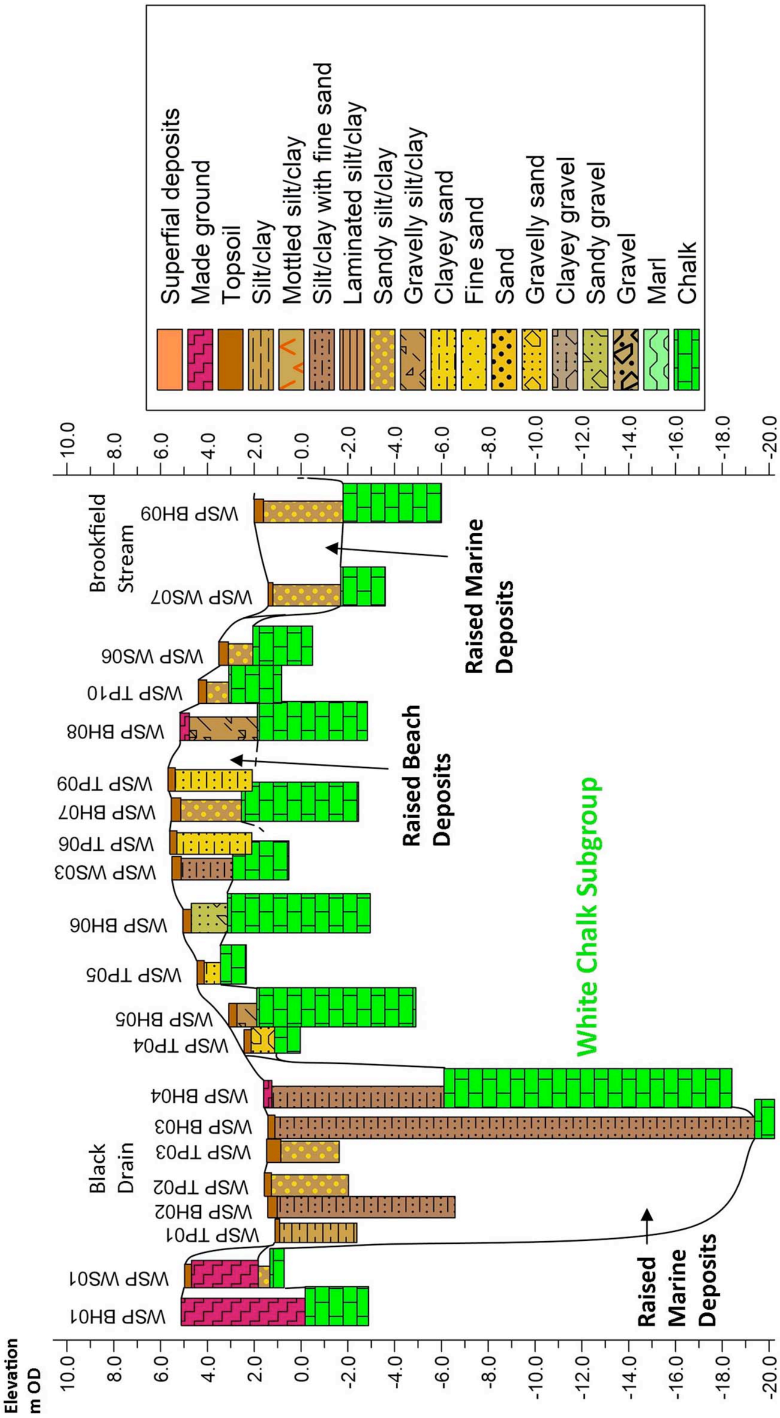

Figure 3. North (top)-south (bottom) composite cross section through the study area

3.2 The southern terminal is located on deposits mapped as Brickearth and which outcrops at *c.* +6m OD (BGS 2017b). Borehole TQ00SW50 is located *c.* 100m to the east of the terminal and records clay, sand and gravel to a depth of 3.66m BGL, which in turn overlies deposits of the New Pit Chalk Formation (sub-cropping at +2.34m OD). Borehole TQ00SW50 was drilled in 1964 and the records reinterpreted in 1981 as Brickearth overlying Raised Beach deposits 1. Brickearth is described variously as 'soft orange brown silty fine sandy clay with occasional chert gravel' in borehole TQ00SW189 (*c.* 800m south west on the A256) and 'firm dark orange brown sandy very clayey silt with occasional flint gravel' in borehole TQ00SW102 (*c.* 800m south east on the A256).

3.3 WSP BH01 and WS01 both register thick deposits of Made Ground at the southern terminal: 5.3m thick in WSP BH01 and 3.15m in WSP WS01, at elevations of +5.12m OD and +4.98m OD respectively (Figure 3). In the latter borehole the Made Ground overlies 0.5m of sandy clay that sub-crops at +1.83m OD and can be assigned to Raised Beach deposits 1. Brickearth deposits are not recorded by the WSP survey but as noted in Section 3.2, might lie south of WSP BH01.

3.4 Approximately 400m north of Toddington Lane the ground slopes gently towards the Black Ditch. In the valley of the latter six WSP boreholes and test pits record deep deposits of Tidal River or Creek deposits/Raised Marine deposits (Figure 3), the latter filling a palaeochannel cut into the Chalk. The Chalk bedrock is recorded in two boreholes: WSP BH03 where it sub-crops at -19.39m OD and in WSP BH04 where it sub-crops at -6.11m OD. The deposits from WSP BH03 are described as: soft, blue grey, silty clay with traces of decomposed vegetation at 17.2 – 20.8m BGL; soft, light grey silt with shell fragments at 6.2 - 17.2 m BGL; fine sand at 4.0 - 6.2m BGL; soft, blue-grey mottled orange-brown, very sandy, slightly clayey silt at 1.0 - 4.0 m BGL; and capped by firm orange-brown mottled blue grey, slightly sandy clay overlain by topsoil. The palaeochannel, if indeed filled by the Tidal River or Creek deposits mapped by the BGS (1996) would date to the Holocene. If so, it would have to date very early in that stage given the minimum outcrop elevation and the known sea level history of the last 11,500 years. However, another, and perhaps equally plausible explanation is that the palaeochannel is of Middle Pleistocene or Ipswichian (MIS 5e) date. Such an interpretation has been made for other similar features between Selsey and West Wittering, albeit that in these latter cases the channel fills occur beneath raised beach deposits (West and Sparks 1960, West et al. 1984, Bates et al. 1998).

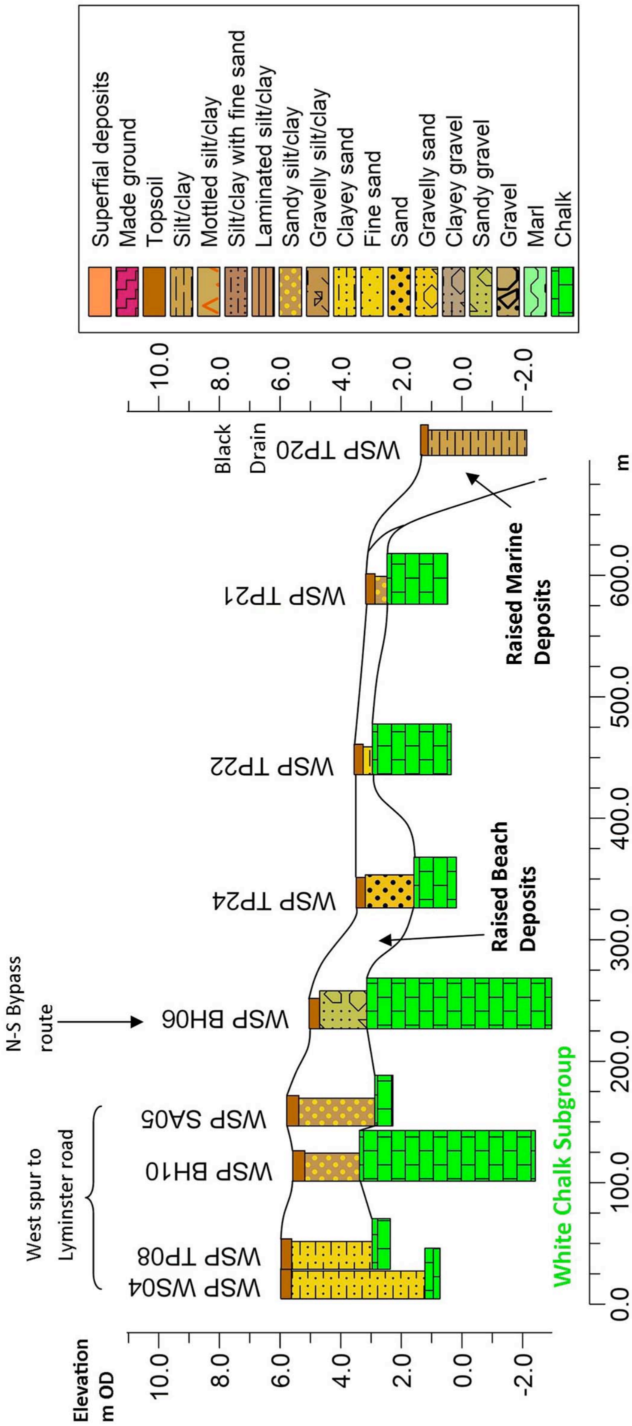

Figure 4. West (bottom)-east (top) composite cross section through the northern part of the study area.

3.5 Boreholes TQ00SW46/A and TQ00SW46/B located *c.* 1km west of the site provide further evidence for the depth of the Tidal River or Creek deposits/Raised Marine deposits. The boreholes were drilled for wells in 1955 and the distance between them is not known, although they are assumed to be close to each other. Both record the Chalk bedrock, however, in TQ00SW46/A the Chalk sub-crops at -11.89m OD (13.11m BGL) whereas in TQ00SW46/B it sub-crops close to the ground surface at -0.30m OD (1.52m BGL). The superficial deposits overlying the chalk are described as 'Drift (Alluvium, Brickearth and Valley Gravels)' (BGS 2017b). Borehole TQ00SW46/A therefore likely records the same palaeochannel as that of the Black Ditch sampled in WSP records. Similar depths of Tidal River or Creek deposits/Raised Marine deposits (20.5m) are also recorded in borehole TQ00NW148 1.5km northwest of the site close to the River Arun.

3.6 North of the 'valley' of the Black Ditch the land surface rises from +1.59m OD (WSP BH04) to +5.60m OD (WSP TP06) (Figure 3). This reflects a slight rise in the bedrock that sub-crops at +3.44m OD (WSP TP05) before falling towards the Brookfield Stream further north. Bedrock elevation falls to the east too, in WSP TP21 it is recorded at +2.47m OD *c.* 350m east of the N-S Bypass route (Figure 4). West of the main route, on the proposed west spur road that links to the Lyminster Road, WSP WS04 records the Chalk as sub-cropping at +1.22m OD. However, in this western part of the study area the superficial deposits do not reflect the bedrock elevation and rather maintain their altitude (*c.* +6m OD).

3.7 Between the two stream courses the Raised Beach deposits 1 are mapped by the BGS (1996, 2017B). Deposits assigned to this stratum outcrop between +5.97m OD in WSP WS04 and +2.43m OD in WSP TP04. The thickness of the deposits varies from 4.75m in WSP WS04 to 0.6m in WSP TP22. In WSP WS04 the strata are typical of the Raised Beach deposits 1 across the study area as a whole and are described as: loose, orange-brown, very clayey, silty sand at 2.70 - 4.75m BGL; soft to firm orange-brown, sandy, slightly silty clay with a little sub-angular chert gravel at 1.70 - 2.70m BGL; loose becoming medium dense, orange-brown, silty, gravelly, fine to medium sand with medium to coarse chert gravel and rare, thin, sandy silt horizons at 0.35 - 1.70m BGL; with the sequence finally capped by the topsoil. However, a note of warning should be sounded as the angularity of the gravel particles, the moderate sorting and the presence of sub-medium sand-sized material questions whether these strata are marine marginal and therefore of 'Raised Beach deposits 1'.

3.8 The 'valley' of the Brookfield Stream is *c.*100m wide and marks the northern terminal of the Bypass route. Tidal River or Creek deposits/Raised Marine deposits are mapped in this location by the BGS (1996, 2017b). Deposits attributable to this unit are recorded in two WSP boreholes, WSP WS07 and WSP BH09, to depths of 3.10m and 3.80m BGL, respectively, where they overly the Chalk bedrock. In WSP BH09 the strata are described as: soft, orange-brown, very sandy, gravelly silt at 3.30 - 3.80m BGL; soft, light brown, very sandy, slightly gravelly (chert) clay at 1.80 - 3.30m BGL; firm, light brown mottled orange-brown clay at 0.40 - 1.80m BGL; with the sequence capped by the topsoil. However, it should be noted that the sorting properties implied in the description do not accord with those that would be expected of intertidal mud flat deposition.

3.9 At the northern terminal of the Bypass, bedrock of the Reading Formation is mapped by the BGS (1996, 2017b) as a small outcrop where it has been exposed by erosion of the overlying Raised Beach deposits 1 on the north bank of the Brookfield Stream – the north bank tracing the +5m OD contour. The BGS (2017a) describe the lithology of the Reading Formation as mottled clay coloured reddish, blue-grey and brown with the possible presence of sand beds. However, the northernmost record of the WSP transect (WSP BH09) did not encounter deposits of the Reading Formation.

3.10 North of the northern Bypass terminal, thinning Raised Beach deposits 1 are recorded in the BGS (1996, 2017b) mapping as the land surface rises to the +15m OD contour where the London Clay Formation outcrops. The maximum altitude of the Raised Beach deposits 1 coincides with the probable line of the Brighton-Norton cliff, the (buried) Middle Pleistocene feature that separates the Lower Coastal Plain from the Upper Coastal Plain to the west of the River Arun (the Upper Coastal Plain is not recorded east of the River) (Bates et al. 1998, 2000). Borehole TQ00NW104 located on the A27 Crossbush roundabout at +19.3m OD, records the weathered top of the London Clay Formation as a ‘soft mottled orange-brown and brown-grey sandy silty clay with occasional pockets and layers of medium sand’ (BGS 2017c). With depth it becomes darker, very stiff and fissured.

4 ASSESSMENT

4.1 Extent, nature and genesis of Quaternary sediments

4.1.1 Quaternary deposits within the study area sit on a Mesozoic (White Chalk Group) and Tertiary (Reading Formation) basement. Quaternary channel formation and other erosive processes associated with marine, alluvial and periglacial environments have subsequently sculpted the bedrock geology resulting in the surface and rockhead topography of today.

4.1.2 On the basis of BGS (1996, 2017b) mapping the earliest Quaternary deposits in the study area are Pleistocene Raised Beach deposits 1 which appear to occur across the whole length of the bypass route except where removed by channelling (see Section 3.7 for caveats). Except in the Black Ditch and Brookfield Stream valleys therefore, Raised Beach deposits 1 sit on a platform in the Chalk bedrock at *c.* +2 to +3m OD, the latter most likely formed as a result of marine planation during the Middle Pleistocene. It is likely that the Raised Beach deposits 1 over the study area can all be attributed to the Pagham Formation. They therefore formed in marine marginal conditions during the Ipswichian interglacial (MIS 5e) (Table 1) (Bates et al. 1998).

4.1.3 Brickearth deposits outcrop south of the study area, but might also extend into the southernmost margin (south of WSP BH01). Should they prove to coincide with the study area it is likely that they will overlie the Raised Beach deposits 1 and thereby prove to be of Devensian (MIS 5d-2) age. Brickearths in the present context are the result of the aerial deposition of windblown loess during Pleistocene cold stages.

4.1.4 In theory the Tidal River or Creek deposits/Raised Marine deposits that infill the channel in the Black Ditch valley are of Holocene date (BGS 2017a). If this designation applied, relevant deposits in the Black Ditch and Brookfield Stream valleys would be intertidal sediments deposited in channels, creeks and mudflats within an estuarine environment. However, as has been discussed in Sections 3.4 the basal contact of Tidal River or Creek deposits/Raised Marine deposits in WSP BH3 is at c. -19m OD, which seems too low given the inland setting and Holocene sea level history of the South coast. Rather, it is possible that the infilling strata of the Black Ditch valley are of Middle Pleistocene-Ipswichian date.

4.2 Archaeological and palaeoenvironmental potential;

4.2.1 The raised beach deposits along on the Bypass route are likely of elevation grounds to be of the Pagham Formation. They will therefore date to the Ipswichian interglacial (MIS 5e, 123-130 Ka). The Ipswichian is a period in which hominins were probably absent from Britain (Sutcliffe 1995) and that they did not re-colonise until MIS 3 (i.e. after 57 Ka) (Pettitt and White 2012). Although discoveries of artefacts at Dartford dated by optically stimulated luminescence to MIS 5a-d (82-123 Ka), suggests the presence of humans during the early part of the Devensian (Wenban-Smith 2010), there remains no similar evidence for the Ipswichian. In other words, were the raised beach deposits in the study area to be of the Pagham Formation, they would have a LOW archaeological potential.

4.2.2 Pagham Formation raised beach deposits have been studied at various locations between Selsey and West Wittering, and fossil material has been recovered West and Sparks 1960, West et al. 1984, Bates et al. 1998). The palaeoenvironmental potential of the raised beach deposits on the site are therefore considered MODERATE, albeit that they are very unlikely to correspond with a time when humans were present.

4.2.3 Brickearth is may be present in the southernmost extreme of the study area and if so, probably dates to the Devensian cold stage. The archaeological potential of such deposits would depend upon the exact age of the deposits and whether palaeosols (indicating episodes of stability) are present. Present data do not therefore allow a view to be taken and any brickearths that might be present are therefore assessed as having UNKNOWN archaeological and palaeoenvironmental potential.

4.2.4 Intertidal deposits are present in the Black Ditch and Brookfield Stream valleys, and may date either to the Early Holocene period or the Middle Pleistocene-Ipswichian. The present records do not suggest the present of palaeosols or deposits that might indicate anything other than intertidal or alluvial deposition. Therefore the likelihood of finding *in situ* archaeological material in the strata is slight (but would be of considerable significance if present) and archaeological potential is assessed as LOW-MODERATE. However, biological preservation appears to be good in the Black Ditch valley sediments at least, and therefore palaeoenvironmental potential is assessed as HIGH.

4.3 Impact of the development

4.3.1 In the present absence of exact engineering details, it is unclear what extent road and bridge construction, and excavation of compensation basins, will have on Quaternary strata in the study area. However, for the purpose of discussion it is assumed that grading is required to 0.5m BGL along the road route[5] except where the embankments are to built on the approach to the Black Ditch bridge, that the latter is supported on piles and that excavation is to 1.5m BGL in the compensation basins. Were this approach taken, the upper portions of raised beach deposits would be impact south of Black Ditch and between Black Ditch and Brookfield Stream. Furthermore the entire thickness of the infill of the Black Ditch palaeochannel would be penetrated by the piling activities, and the upper part removed over a moderate area in the compensation basins. In such a scenario strata of moderate and high archaeological/palaeoenvironmental potential would be affected by the bypass scheme.

4.4 Recommendations

4.4.1 As has been noted implicitly in the discussion above, there is considerable uncertainty regarding the assignation of the deposits in the WSP geotechnical survey and BGS borehole database to formal stratigraphic units. The uncertainty has profound implications for the assessments made in Sections 4.2 and 4.3. It is presently unclear whether the 'raised beach' deposits that sub-crop between the two stream valleys did in fact form in marine marginal locations. BGS (1996, 2017b) mapping would suggest that the relevant sediments did form in such an environment, but the lithological properties reported in the WSP records are equivocal in this regard. Furthermore, while the infills of the palaeochannel underlying the Black Ditch are characterised as fine-grained, locally organic and fossil-rich in the geotechnical logs, their attribution to Tidal River or Creek deposits/Raised marine deposits may not be correct.

4.4.2 In order to address the problems of uncertainty outlined above, the following course of action is recommended:

1. A further dynamic probe borehole be drilled to the Chalk bedrock between WSP BH2 and WSP BH3 to better characterise the fine-grained sediments infilling the Black Ditch palaeochannel;

[5] Drainage pipes dug to a deeper depth would also presumably be required.

2. Window(less) boreholes or further dynamic probe boreholes be drilled between WSP WS03 and WSP BH9 to further examine deposits presently interpreted as raised beach;
3. A further window(less) borehole or dynamic probe borehole drilled at the southernmost margin of the study area to test to the presence of brickearth and if present, its relationship with raised beach deposits
4. Auger samples/cores collected in the boreholes would be described by a geoarchaeologist;
5. Biological materials recovered from the cores would be used to aid interpretation, for absolute/relative dating and for palaeoenvironmental assessment.

Such an approach might be carried out as part of a follow-up geotechnical study or separately, but is needed to reliably assess the potential of the 'raised beach' deposits and palaeochannel fills.

5 ACKNOWLEDGEMENTS

5.1 ARCA would like to thank Richard Greatorex (Cotswold Archaeology), John Mills (West Sussex County Council), Andrew Rudge (Parsons Brinckerhoff) and Dr Eleanor Standley (University of Oxford) for their help in providing data for this report.

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APPENDIX 1 BGS BOREHOLE LOCATIONS

Record	Easting	Northing	Elevation
BGS boreholes			
TQ00NW102	502510	105970	16.7
TQ00NW104	502850	105930	19.30
TQ00NW105	502870	105860	17.30
TQ00NW107	502900	105830	16.65
TQ00NW108	503050	105850	18.05
TQ00NW109	503250	105810	16.50
TQ00NW110	503590	105770	11.60
TQ00NW111	503770	105770	10.50
TQ00NW132	501984	106060	1.79
TQ00NW148	501481	105815	1.63
TQ00NW149	501827	105903	0.98
TQ00NW151	502270	105973	9.36
TQ00NW170	502850	105740	13.93
TQ00NW171	503020	105850	18.09
TQ00NW172	503360	105750	13.59
TQ00NW173	503600	105750	11.27
TQ00NW198	502887	105880	18.16
TQ00NW48	502647	106050	19
TQ00NW50	502802	106045	22.20
TQ00NW65	504270	105140	6.00
TQ00NW98	502160	106170	10.45
TQ00SW100	502395	103455	4.10
TQ00SW101	502536	103445	4.55
TQ00SW102	502660	103444	5.10
TQ00SW173	502300	103456	5.00
TQ00SW189	503290	103330	7.73
TQ00SW192	503420	103330	7.71
TQ00SW246	502380	103570	3.00
TQ00SW247	502350	103590	3.00
TQ00SW248	502330	103620	3.00
TQ00SW33	502350	104610	6.10
TQ00SW37	501700	103680	7.62
TQ00SW38	501710	103650	7.62
TQ00SW41	502070	103680	5.20
TQ00SW43	501510	104030	4.57
TQ00SW44	502080	103650	6.10
TQ00SW45	502570	103940	2.70
TQ00SW46/A	502280	104050	1.22
TQ00SW46/B	502280	104050	1.22
TQ00SW48	503400	103500	5.80
TQ00SW49	503470	103670	3.96
TQ00SW50	503300	104000	6.00

Record	Easting	Northing	Elevation
TQ00SW51	503790	104110	6.40
TQ00SW93	501755	103228	7.00
TQ00SW94	501866	103343	8.00
TQ00SW96	501996	103418	6.95
TQ00SW97	502100	103454	5.65
TQ00SW98	502252	103467	5.15
WSP Records			
WSP BH01	503126.679	104277.707	5.120
WSP BH02	503112.812	104381.895	1.420
WSP BH03	503101.138	104461.516	1.415
WSP BH04	503095.535	104493.926	1.593
WSP BH05	503079.820	104578.853	3.090
WSP BH06	503063.919	104678.131	5.042
WSP BH07	503033.845	104788.459	5.542
WSP BH08	503003.870	104869.402	5.166
WSP BH09	502936.940	105090.320	2.002
WSP BH10	502944.404	104711.481	5.582
WSP SA03a	502972.533	104935.752	3.719
WSP SA05	502989.559	104707.727	5.779
WSP TP01	503116.511	104355.766	1.112
WSP TP02	503103.066	104402.966	1.569
WSP TP03	503111.204	104437.940	1.465
WSP TP04	503087.085	104551.621	2.431
WSP TP05	503071.992	104623.904	4.438
WSP TP06	503039.645	104753.695	5.607
WSP TP08	502874.486	104731.064	5.963
WSP TP09	503021.747	104818.208	5.680
WSP TP10	502995.143	104907.957	4.384
WSP TP12	502921.094	104921.180	4.170
WSP TP14	503057.900	104929.800	4.187
WSP TP15	503111.700	104983.900	3.981
WSP TP16	503174.400	104963.400	4.378
WSP TP17	503212.400	105006.000	3.688
WSP TP18	503289.700	104997.600	4.764
WSP TP19	503328.800	105044.100	4.105
WSP TP20	503493.412	104527.770	1.368
WSP TP21	503388.239	104590.755	3.172
WSP TP22	503249.451	104611.354	3.557
WSP TP23	503188.024	104539.110	1.640
WSP TP24	503139.834	104613.617	3.488
WSP WS01	503142.332	104315.058	4.976
WSP WS02	503298.245	104540.415	1.836
WSP WS03	503059.065	104734.335	5.517
WSP WS04	502850.826	104736.673	5.975
WSP WS05	503158.100	105028.151	2.684

Record	Easting	Northing	Elevation
WSP WS06	502980.422	104946.008	3.509
WSP WS07	502951.461	105002.353	1.404

APPENDIX 2 BOREHOLE STRATIGRAPHY

Record	Top (m)	Base (m)	Stratigraphy
TQ00NW102	0.00	0.25	Head
	0.25	0.75	Head
	0.75	1.00	Head
	1.00	8.00	London Clay Formation
TQ00NW104	0.00	0.25	London Clay Formation
	0.25	1.40	London Clay Formation
	1.40	16.00	London Clay Formation
TQ00NW105	0.00	0.45	Raised Beach deposits
	0.45	0.55	Raised Beach deposits
	0.55	1.50	Raised Beach deposits
	1.50	3.50	Raised Beach deposits
	3.50	4.50	Raised Beach deposits
	4.50	16.00	London Clay Formation
TQ00NW107	0.00	0.25	Raised Beach deposits
	0.25	0.50	Raised Beach deposits
	0.50	3.50	Raised Beach deposits
	3.50	4.50	Raised Beach deposits
	4.50	5.50	Raised Beach deposits
	5.50	16.00	London Clay Formation
TQ00NW108	0.00	0.30	Raised Beach deposits
	0.30	0.50	Raised Beach deposits
	0.50	1.90	Raised Beach deposits
	1.90	2.45	Raised Beach deposits
	2.45	3.50	Raised Beach deposits
	3.50	4.50	Raised Beach deposits

Record	Top (m)	Base (m)	Stratigraphy
TQ00NW108	4.50	6.05	Raised Beach deposits
	6.05	6.20	Raised Beach deposits
	6.20	8.00	London Clay Formation
TQ00NW109	0.00	0.35	Raised Beach deposits
	0.35	0.50	Raised Beach deposits
	0.50	3.05	Raised Beach deposits
	3.05	3.50	Raised Beach deposits
	3.50	4.10	Raised Beach deposits
	4.10	5.50	Raised Beach deposits
	5.50	6.30	Raised Beach deposits
	6.30	7.00	London Clay Formation
TQ00NW110	0.00	0.05	Raised Beach deposits
	0.05	0.50	Raised Beach deposits
	0.50	1.50	Raised Beach deposits
	1.50	2.20	Raised Beach deposits
	2.20	3.50	Raised Beach deposits
	3.50	4.15	Raised Beach deposits
	4.15	4.35	Raised Beach deposits
	4.35	6.00	London Clay Formation
TQ00NW111	0.00	0.30	Raised Beach deposits
	0.30	1.20	Raised Beach deposits
	1.20	3.50	Raised Beach deposits
	3.50	5.00	London Clay Formation
TQ00NW132	0.00	0.30	Tidal River or Creek deposits/Raised Marine deposits
	0.30	0.70	Tidal River or Creek deposits/Raised Marine deposits
	0.70	1.30	London Clay Formation
	1.30	16.50	Lambeth Group

Record	Top (m)	Base (m)	Stratigraphy
TQ00NW148	0.00	0.40	Tidal River or Creek deposits/Raised Marine deposits
	0.40	1.50	Tidal River or Creek deposits/Raised Marine deposits
	1.50	20.50	Tidal River or Creek deposits/Raised Marine deposits
TQ00NW149	0.00	0.30	Tidal River or Creek deposits/Raised Marine deposits
	0.30	11.20	Tidal River or Creek deposits/Raised Marine deposits
	11.20	11.80	Tidal River or Creek deposits/Raised Marine deposits
	11.80	13.30	London Clay Formation
TQ00NW151	0.00	0.40	Head
	0.40	0.70	Head
	0.70	3.30	Head
	3.30	5.80	Raised Beach deposits
	5.80	16.00	London Clay Formation
TQ00NW170	0.00	0.35	Raised Beach deposits
	0.35	1.05	Raised Beach deposits
	1.05	2.60	Raised Beach deposits
	2.60	3.20	Raised Beach deposits
	3.20	3.50	Raised Beach deposits
	3.50	5.00	London Clay Formation
TQ00NW171	0.00	0.30	Raised Beach deposits
	0.30	1.45	Raised Beach deposits
	1.45	2.10	Raised Beach deposits
	2.10	3.30	Raised Beach deposits
	3.30	4.85	Raised Beach deposits
	4.85	5.25	Raised Beach deposits
	5.25	7.00	London Clay Formation
TQ00NW172	0.00	0.30	Raised Beach deposits
	0.30	1.85	Raised Beach deposits

Record	Top (m)	Base (m)	Stratigraphy
TQ00NW172	1.85	2.80	Raised Beach deposits
	2.80	3.60	Raised Beach deposits
	3.60	3.80	Raised Beach deposits
	3.80	5.00	London Clay Formation
TQ00NW173	0.00	0.25	Raised Beach deposits
	0.25	1.20	Raised Beach deposits
	1.20	3.15	Raised Beach deposits
	3.15	3.40	Raised Beach deposits
	3.40	5.00	London Clay Formation
TQ00NW198	0.00	0.70	London Clay Formation
	0.70	3.50	London Clay Formation
	3.50	5.50	London Clay Formation
	5.50	6.00	London Clay Formation
TQ00NW48	0.00	0.40	Made Ground
	0.40	0.95	Raised Beach deposits
	0.95	10.00	London Clay Formation
TQ00NW50	0.00	0.30	London Clay Formation
	0.30	10.00	London Clay Formation
TQ00NW65	0.00	0.22	Raised Beach deposits
	0.22	0.69	Raised Beach deposits
	0.69	1.22	Raised Beach deposits
	1.22	1.52	Raised Beach deposits
	1.52	26.21	Lambeth Group
TQ00NW98	0.00	0.25	Raised Beach deposits
	0.25	0.75	Raised Beach deposits
	0.75	1.50	Raised Beach deposits
	1.50	2.60	Raised Beach deposits

Record	Top (m)	Base (m)	Stratigraphy
TQ00NW98	2.60	3.00	Raised Beach deposits
	3.00	7.00	London Clay Formation
TQ00SW100	0.00	0.30	Brickearth
	0.30	2.70	Brickearth
	2.70	3.10	White Chalk Subgroup
	3.10	7.05	White Chalk Subgroup
TQ00SW101	0.00	0.60	Brickearth
	0.60	1.70	Brickearth
	1.70	2.20	Brickearth
	2.20	3.00	Brickearth
	3.00	3.85	White Chalk Subgroup
	3.85	8.00	White Chalk Subgroup
TQ00SW102	0.00	0.45	Brickearth
	0.45	0.80	Brickearth
	0.80	1.55	Brickearth
	1.55	2.70	Brickearth
	2.70	3.40	Brickearth
	3.40	7.00	White Chalk Subgroup
TQ00SW173	0.00	0.70	Brickearth
	0.70	2.60	Brickearth
	2.60	4.80	Brickearth
	4.80	5.90	Brickearth
	5.90	6.40	Brickearth
	6.40	7.40	White Chalk Subgroup
TQ00SW189	0.00	1.20	Made Ground
	1.20	2.10	Made Ground
	2.10	4.60	Brickearth

Record	Top (m)	Base (m)	Stratigraphy
TQ00SW189	4.60	6.00	White Chalk Subgroup
TQ00SW192	0.00	2.60	Made Ground
	2.60	3.80	Brickearth
	3.80	5.00	White Chalk Subgroup
TQ00SW246	0.00	2.70	Brickearth
	2.70	10.00	White Chalk Subgroup
TQ00SW247	0.00	3.00	Brickearth
	3.00	7.00	White Chalk Subgroup
TQ00SW248	0.00	3.00	Brickearth
	3.00	7.50	White Chalk Subgroup
TQ00SW33	0.00	2.70	Superficial deposits
	2.70	4.90	White Chalk Subgroup
	4.90	20.11	White Chalk Subgroup
TQ00SW37	0.00	1.83	Raised Beach deposits
	1.83	5.18	Raised Beach deposits
	5.18	5.79	White Chalk Subgroup
	5.79	18.28	White Chalk Subgroup
TQ00SW38	0.00	2.74	Brickearth
	2.74	4.27	Raised Beach deposits
	4.27	5.79	Raised Beach deposits
	5.79	6.40	White Chalk Subgroup
	6.40	30.48	White Chalk Subgroup
TQ00SW41	0.00	1.50	Brickearth
	1.50	3.10	Raised Beach deposits
	3.10	21.30	White Chalk Subgroup
TQ00SW43	0.00	3.35	Superficial deposits
	3.35	4.57	Superficial deposits

Record	Top (m)	Base (m)	Stratigraphy
TQ00SW43	4.57	6.40	Superficial deposits
	6.40	11.28	White Chalk Subgroup
TQ00SW44	0.00	2.74	Brickearth
	2.74	5.64	Raised Beach deposits
	5.64	30.48	White Chalk Subgroup
TQ00SW45	0.00	0.30	Raised Beach deposits
	0.30	2.74	Raised Beach deposits
	2.74	4.57	Raised Beach deposits
	4.57	23.09	White Chalk Subgroup
TQ00SW46/A	0.00	13.11	Superficial deposits
	13.11	15.20	White Chalk Subgroup
TQ00SW46/B	0.00	1.52	Superficial deposits
	1.52	15.70	White Chalk Subgroup
TQ00SW48	0.00	0.15	Brickearth
	0.15	2.40	Brickearth
	2.40	3.30	Raised Beach deposits
	3.30	30.50	White Chalk Subgroup
TQ00SW49	0.00	0.61	Brickearth
	0.61	3.05	Brickearth
	3.05	3.96	Raised Beach deposits
	3.96	38.10	White Chalk Subgroup
TQ00SW50	0.00	3.66	Superficial deposits
	3.66	21.00	White Chalk Subgroup
TQ00SW51	0.00	0.91	Brickearth
	0.91	1.82	Raised Beach deposits
	1.82	2.43	Raised Beach deposits
	2.43	3.46	White Chalk Subgroup

Record	Top (m)	Base (m)	Stratigraphy
TQ00SW51	3.46	45.70	White Chalk Subgroup
TQ00SW93	0.00	0.20	Raised Beach deposits
	0.20	1.60	Raised Beach deposits
	1.60	2.40	Raised Beach deposits
	2.40	2.70	Raised Beach deposits
	2.70	3.25	Raised Beach deposits
	3.25	4.95	Raised Beach deposits
	4.95	8.05	White Chalk Subgroup
TQ00SW94	0.00	0.15	Brickearth
	0.15	2.60	Brickearth
	2.60	3.05	Brickearth
	3.05	4.05	Raised Beach deposits
	4.04	4.40	Raised Beach deposits
	4.40	9.00	White Chalk Subgroup
TQ00SW96	0.00	0.70	Brickearth
	0.70	1.50	Brickearth
	1.50	2.60	Brickearth
	2.60	3.80	Brickearth
	3.80	7.00	White Chalk Subgroup
TQ00SW97	0.00	0.60	Brickearth
	0.60	2.70	Brickearth
	2.70	3.20	Brickearth
	3.20	4.25	White Chalk Subgroup
TQ00SW98	0.00	0.30	Brickearth
	0.30	2.80	Brickearth
	2.80	4.00	White Chalk Subgroup
	4.00	8.00	White Chalk Subgroup

Record	Top (m)	Base (m)	Stratigraphy
WSP BH01	0.00	5.30	Made Ground
	5.30	8.00	White Chalk Subgroup
WSP BH02	0.00	8.00	Tidal River or Creek deposits/Raised Marine deposits
WSP BH03	0.00	20.80	Tidal River or Creek deposits/Raised Marine deposits
	20.80	21.65	White Chalk Subgroup
WSP BH04	0.00	0.35	Made Ground
	0.35	7.70	Tidal River or Creek deposits/Raised Marine deposits
	7.70	20.00	White Chalk Subgroup
WSP BH05	0.00	1.20	Raised Beach deposits
	1.20	8.00	White Chalk Subgroup
WSP BH06	0.00	1.90	Raised Beach deposits
	1.90	8.00	White Chalk Subgroup
WSP BH07	0.00	3.00	Raised Beach deposits
	3.00	8.00	White Chalk Subgroup
WSP BH08	0.00	0.40	Made Ground
	0.40	3.30	Raised Beach deposits
	3.30	8.00	White Chalk Subgroup
WSP BH09	0.00	3.80	Tidal River or Creek deposits/Raised Marine deposits
	3.80	8.00	White Chalk Subgroup
WSP BH10	0.00	2.20	Raised Beach deposits
	2.20	8.00	White Chalk Subgroup
WSP SA03a	0.00	1.40	Raised Beach deposits
	1.40	1.90	White Chalk Subgroup
WSP SA05	0.00	2.90	Raised Beach deposits
	2.90	3.50	White Chalk Subgroup
WSP TP01	0.00	3.50	Tidal River or Creek deposits/Raised Marine deposits
WSP TP02	0.00	3.60	Tidal River or Creek deposits/Raised Marine deposits

Record	Top (m)	Base (m)	Stratigraphy
WSP TP03	0.00	3.10	Tidal River or Creek deposits/Raised Marine deposits
WSP TP04	0.00	1.30	Raised Beach deposits
	1.30	2.40	White Chalk Subgroup
WSP TP05	0.00	1.00	Raised Beach deposits
	1.00	2.34	White Chalk Subgroup
WSP TP06	0.00	3.50	Raised Beach deposits
WSP TP08	0.00	3.00	Raised Beach deposits
	3.00	3.60	White Chalk Subgroup
WSP TP09	0.00	3.60	Raised Beach deposits
WSP TP10	0.00	1.30	Raised Beach deposits
	1.30	3.55	White Chalk Subgroup
WSP TP12	0.00	1.70	Raised Beach deposits
	1.70	3.50	White Chalk Subgroup
WSP TP14	0.00	1.45	Raised Beach deposits
	1.45	3.50	White Chalk Subgroup
WSP TP15	0.00	1.85	Raised Beach deposits
	1.85	3.40	White Chalk Subgroup
WSP TP16	0.00	1.60	Raised Beach deposits
	1.60	3.40	White Chalk Subgroup
WSP TP17	0.00	1.45	Raised Beach deposits
	1.45	2.80	White Chalk Subgroup
WSP TP18	0.00	1.50	Raised Beach deposits
	1.50	3.60	White Chalk Subgroup
WSP TP19	0.00	1.90	Raised Beach deposits
	1.90	3.30	White Chalk Subgroup
WSP TP20	0.00	3.50	Tidal River or Creek deposits/Raised Marine deposits
WSP TP21	0.00	0.70	Raised Beach deposits

Record	Top (m)	Base (m)	Stratigraphy
WSP TP21	0.70	2.70	White Chalk Subgroup
WSP TP22	0.00	0.60	Raised Beach deposits
	0.60	3.20	White Chalk Subgroup
WSP TP23	0.00	3.60	Tidal River or Creek deposits/Raised Marine deposits
WSP TP24	0.00	1.90	Raised Beach deposits
	1.90	3.30	White Chalk Subgroup
WSP WS01	0.00	3.15	Modern Made Ground
	3.15	3.65	Tidal River or Creek deposits/Raised Marine deposits
	3.65	4.25	White Chalk Subgroup
WSP WS02	0.00	3.00	Tidal River or Creek deposits/Raised Marine deposits
WSP WS03	0.00	2.60	Raised Beach deposits
	2.60	5.00	White Chalk Subgroup
WSP WS04	0.00	4.75	Raised Beach deposits
	4.75	5.25	White Chalk Subgroup
WSP WS05	0.00	1.60	Tidal River or Creek deposits/Raised Marine deposits
	1.60	4.00	White Chalk Subgroup
WSP WS06	0.00	1.45	Raised Beach deposits
	1.45	4.00	White Chalk Subgroup
WSP WS07	0.00	3.10	Tidal River or Creek deposits/Raised Marine deposits
	3.10	5.00	White Chalk Subgroup