Geoarchaeological Report

Newhaven

Flood Alleviation Scheme, East Sussex

Geoarchaeological Deposit Model Report

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Summary

Oxford Archaeology was commissioned by Arcadis on behalf of the Environment Agency, to develop a geoarchaeological deposits model for the Newhaven Flood Alleviation Scheme, East Sussex. The Scheme is designed to offer improved flood protection for the town of Newhaven from the River Ouse. The Scheme covers a total of 0.55km² (55 hectares) which has been sub-divided into five areas - two on the west bank of the river (Area 3 and 4) and three on the east bank (Areas 1, 2 and 5)

Following the recommendations made in the Cultural Heritage Statement and in consultation with East Sussex County Council, an updated site deposit model was developed for the Scheme using data from 40 geotechnical boreholes, a proportion of which was not available to the original 2015 geoarchaeological study.

The model demonstrates a considerable depth of Late Glacial deposits and Holocene alluvium (up to 26m in depth) preserved within the Ouse Valley. Deeply incised valley sequences like the mouth of the Lower Ouse were in-filled with marine and estuarine sedimentation following the rapid rise in sea-level at the end of the last glaciation. Pleistocene sandy gravel deposits were identified at the base of the sequence between 26m to 18m in depth, and were mostly identified on the east bank, due to the greater depth of sampling within this area.

Basal lower organic and alluvial deposits were recorded overlying the gravels but their formation and date have yet to be fully established. These deposits were sealed by sandy gravel deposits representing either beach gravels and/or Head deposits located between 18m to 4m (-22m to -8m OD) on the eastern bank and 5m to 3m in depth (0m to +2m OD) on the western bank.

The Holocene sequence were sand dominated estuarine deposits with marine shells and tidal laminations. This corresponds with an increase in sedimentation across the South Coast related to marine inundation of the valleys during the mid Holocene. They vary in thickness from 8m to 20m, accumulating between -22m aOD to +2m aOD.

On the western banks the estuarine sands are not recorded at similar depths indicating that the main Ouse channel was originally located on the eastern bank. During the medieval period the mouth of the Ouse was located further east at Seaford and the course of the current river is a more recent man-made development. In contrast the western bank, is dominated by silty clay and organic alluviums indicating lower-energy deposition away from the main estuarine channel.

A sequence of alluvial and organic deposits were recorded on the western bank. The upper surface of these mid Holocene peat sequences have previously produced evidence of prehistoric activity in other valley sequence, most notably at Shinewater, in the Willingdon Levels and within the Combe Haven, Bexhill. The absence of significant organic deposits on the east bank may limit the archaeological and palaeoenvironmental potential in this area.

The accumulation of the upper alluvial deposits of inter-digitating silts and silty clays mark a major phase of marine incursion and channel migration recorded across the sequence. Similar incursions by the sea at this time are recorded at a number of other locations along the coast of England and is often referred to as the 'Romano-

British Transgression'. It is widely believed that large-scale deforestation and sediment availability may have also played a significant role in the increased flooding and rising water-levels in many of the valleys during this period. The weathered upper surface of the alluvium reflects the drying out and the beginning of reclamation of tidal flats during the early medieval period.

Thick made-ground deposits between 0.30m to 4m were identified overlying the alluvium sequence, which requires further investigation and characterisation. The nature of these deposits is poorly defined within the geotechnical logs and could contain archaeological horizons and deposits. The west bank and area around the historical core will in particular need further investigation to establish the archaeological potential in these areas.

The results of the deposit model have demonstrated significant potential for palaeolithic and early prehistoric remains to be impacted within Scheme Areas 3 and 4. The thickness and poorly defined nature of the made-ground deposits close to the historical core also has the potential to contain historical archaeological remains.

The preliminary deposit model was based on paper records only and would benefit from further development based on biostratigraphic assessment and dating of organic deposits. The confusion over the basal sequence of organic alluvium underlying sandy gravel in particular can only be resolved through further sampling and a programme of suitable dating techniques.

Newhaven Flood Alleviation Scheme, East Sussex

Geoarchaeological Deposit Model Report

1 INTRODUCTION

1.1 Scope of works

1.1.1 Oxford Archaeology (OA) was commissioned by Arcadis on behalf of the Environment Agency to develop a geoarchaeological deposit model as part of the proposed Newhaven Flood Alleviation Scheme (FAS). The proposed Scheme comprises a variety of flood defences, either to be newly constructed or as improvements to the existing defences, along the eastern and western banks of the River Ouse, Newhaven, East Sussex, centred on NGR TQ 756 107 (Figure 1).

1.1.2 The Scheme crosses an area with a diverse range of heritage and landscape assets that will need to be investigated, recorded and if necessary mitigated. The impacts may include both direct and indirect impacts from activities such as the excavation of flood banks, ground reduction and drainage features. A previous deposit model was produced for the Scheme following a geoarchaeological watching brief on ground investigations (ASE 2015). The model concluded that the Scheme could potentially impact important palaeoenvironmental and archaeological remains dating from the Palaeolithic to the Roman period. The previous deposit model has been updated with more recent geotechnical investigations undertaken as part of the Scheme.

1.1.3 The primary objective of the updated deposit model is to provide base-line data regarding the nature of the sub-surface stratigraphy in order to help define areas of potential archaeological significance. Subsurface deposit modelling has the ability to reconstruct past geographies (palaeogeographies) for areas where the surface expression bears little or no relationship to that buried at depth. This type of approach is particularly valuable in floodplain or estuarine environments where the archaeological potential is difficult to assess by traditional evaluation methods. This is often due to thick deposits of alluvium effectively masking earlier, potentially waterlogged deposits that frequently lie at great depth.

1.1.4 The results of the model will be used as a framework within which the subsurface topography and human environment of the Scheme areas can be understood. This will provide the basis to model development impacts and aid in the production of further mitigation strategies.

1.1.5 All work was carried out in accordance with Historic England's guidelines for geoarchaeology (HE 2015) and East Sussex County Council Standards and Guidance (ESCC 2015).

1.2 Location, geology and topography

1.2.1 Newhaven is a coastal town in the Lewes District of East Sussex. The town is located at the mouth of the River Ouse, which flows southwards from Lower Beeding in West Sussex through the Low Weald and on through the chalk landscape of the South Downs to the sea at Newhaven.

1.2.2 The Newhaven FAS Area covers a total of 0.55km² (55 hectares) which has been sub-divided into five 'Scheme Areas'. These comprise two on the west bank of the river known as Scheme Area 3 - Riverside Park to Swing Bridge (west) and Scheme Area 4 -

Swing Bridge (west) to West Quay, and three on the east bank known as Scheme Area 1 - Energy Recovery Facility to A26, Scheme Area 2 - Energy Recovery Facility to Swing Bridge, and Scheme Area 5 - Swing Bridge (east) to Newhaven Beach (Fig 4).

1.2.3 The solid geology along the Scheme comprises Newhaven Chalk, which outcrops to the west (BGS sheet 334). The drift geology of the development area consists of a complex sequence of estuarine alluvium and Head deposits of different ages. With the exception of the shoreline, the bulk of the very low-lying east bank (Scheme Areas 1, 2 and 5) is reclaimed tidal flats comprising alluvial deposits of fine silt and clay, potentially also with some peat. Similar alluvial deposits are also evident in some parts of the west bank, for example, to the north of Scheme Area 3, on Denton Island and along the edge of the river course throughout Scheme Area 4. To the west of Denton Island and in the majority of Scheme Area 4, the superficial geology is composed of clay, silt, sand and gravel Head deposits

1.2.4 Modern ground levels across the Scheme areas lie between approximately 3m and 6m OD, with the highest areas located in the north-western sector of the proposed Scheme (Fig. 3). The historic core of the town is located on the west side of the river valley on a slight spur of the downs that rises from c.3m m OD at the lower end of Bridge Street to c.54m OD at the old workhouse on Church Hill (Harris 2004, 11). The settlement lies on the old coast road (A259), although this has been modified to bypass the church and, via a ring road, the town centre.

1.2.5 The historical centre of Newhaven is an archaeological notification area (ANA), which covers an area of 8.44ha (centred on TQ 4450 0137). It is crossed by Scheme Areas 3 and 4. It demarcated an area of multi-period activity, dating from the Palaeolithic to modern periods.

1.3 Previous Investigations of the current scheme

1.3.1 Previous ground investigation works in connection or within the Scheme area has included the following:

- Geoarchaeological Survey Report (Wessex Archaeology 2004)
- Ground Investigation Report (Southern Testing 2007)
- Ground Investigation Report Desktop Study (URS 2014)
- Geoarchaeological Watching Brief on Ground Investigations (ASE 2015)
- Cultural Heritage Statement (Capita / URS 2015)

1.3.2 A geoarchaeological survey has also been undertaken at the ERF site (Wessex Archaeology 2004) offering an archaeological interpretation of 14 boreholes which were up to 45m deep. The Chalk was recorded at a depth between 26-29m (c.-22-25m OD), over which there was found to be a thick sequence of clays, silts, sands and organic layers. These were interpreted as Holocene age alluvial deposits, some of which included marine sediments, indicated by the identification of marine mollusc shells in sand dominated portions of the sequence. No fully developed peat layers were observed but highly organic/peaty alluvium and the presence of minerogenic layers may indicate periods of partial stabilisation and drying of the immediate landscape. The sediment types and depths were noted to be similar to the floodplain deposits near Lewes (e.g. Thorley 1971, 1981, Jones 1971, Bell 1977), suggesting that there is generally lateral consistency of deposits in the Lower Ouse valley.

1.3.3 A geoarchaeological watching brief was also undertaken during geotechnical site investigations within Scheme Areas 1-5 in June 2015. The results of the watching brief enabled a basic deposit model of shallow Pleistocene deposits and Holocene palaeochannel margins to be constructed, which helped informed the impact assessment process.

1.4 Geoarchaeological background

1.4.1 In order to understand the character and distribution of archaeological activity in the East Sussex Levels and the reasons behind major changes in settlement patterns in the past, it is necessary to understand the changing nature of the South Coast. Fluctuations in relative sea-level (RSL) and tectonic land adjustment throughout the Holocene (post-glacial period, 12,000 BP to present) have created an exceptionally full and complex sequence of valley sediments and coastal geomorphology. The present-day topography of the area has undergone significant modification and bears little resemblance to the landscape of the prehistoric past. Within such a rapidly vertically-accreting environment, archaeological deposits can be sealed at multiple horizons within the valley sequences. Evidence of early prehistoric surfaces and sites can therefore be deeply buried below later accumulations of alluvium, colluvium and made-ground deposits, beyond the reaches of modern archaeological surface survey techniques.

1.4.2 A model of sedimentation proposed by Jennings and Smyth (1990) for the Sussex coast emphasises the importance of local factors such as coastal barrier formation and variations in the quantity and nature of the sediment supply as the key controlling factors on the nature of valley sedimentation. A broadly similar, three-phase, model of barrier development was applied by Long and Innes (1995) to Romney Marsh/Dungeness, although the chronology differed significantly in terms of the timing of major sedimentation changes to that of Jennings and Smyth (1990). Lastly, Long *et al*. (2000) proposed a three-phase model of estuary development from their work in Southampton Water, which by emphasising regional changes in RSL may be applicable to southern England, including the Sussex and Kent coasts (Long 2001).

1.4.3 The peats which are consistently recorded in the coastal deposits of East Sussex began to accumulate *c*. 7200 cal. yr BP, though interruptions during the early stages of peat growth appear common, with marine conditions returning to areas like the Combe Haven and the western side of the Romney Marsh (Waller and Long 2010). Neither the onset of peat formation nor the age of the intercalated clays appears consistent along the coast due to issues of compaction, deflation and field sampling errors. Comparisons between the valleys and levels (e.g. Jennings and Smyth 1987) are difficult to justify since where data is available the continuity of sequences and the influence of localised factors is often unclear. Recent comparative studies by Waller and Long (2010) indicate that while thick peat accumulations have been identified in the East Sussex Levels this is in contrast to West Sussex, where no significant depths of peat deposits have been recorded. The absence of thick peat deposits from West Sussex is attributed to more exposed conditions in this area and the potential absence of coastal barrier protection in the past (Waller and Long 2010).

1.4.4 These stratified prehistoric alluvial sequences have significant potential to provide information about changes in the wetland/dryland interface zone in river valleys and floodplains within the area. Organic sediments include woody and reedswamp peats which have been seasonally or permanently waterlogged, resulting in the often excellent preservation of organic remains and palaeoenvironmental indicators such as pollen, insects, plant macrofossils including seeds and wood, diatoms, ostracods, foraminifera and, in some locations, animal bone. The organic-rich deposits correspond to periods of marine regression, when coastal plains would have provided a mosaic of freshwater habitats with a rich flora and fauna. Higher 'islands' within this environment would have provided favourable locations for human settlement. The formation of these organic deposits has been radiocarbon dated to the late Mesolithic and early-middle Bronze Age in East Sussex. At the scheduled site of Shinewater, in the Willingdon

Levels, the Bronze Age wooden trackways and platform are located within peat sequences. It is likely that other wetland sites and areas of activity will lie under alluvium in similar but less well investigated coastal and valley edge locations.

1.4.5 Archaeological evidence for extensive prehistoric flint scatters and other activity at the floodplain edge has been found in recent excavations around the Combe Haven, dating from the Late Upper Palaeolithic to the Bronze Age (Oxford Archaeology 2014).

1.4.6 The bedrock surface in the lower Ouse Valley, shown in detail by Burrin and Jones (1991), extends below –25m OD at Newhaven, shallowing to c. –10m OD in the Vale of the Brooks. Basal sands and gravels (a maximum 3m thick) of uncertain origin are widespread. Burrin and Jones (1991) dividing the overlying fill into an inland sequence and, from the Chalk outcrop downstream, a peri-marine sequence. The former comprise fluvial and colluvial derived deposits and locally peat (Robinson and Williams 1983) and the latter include estuarine sediments – clays with interbedded peats, which are thickest (*c*. 10m) in the Vale of the Brooks. Above the basal unit, the only gravel encountered was that forming the contemporary beach (estimated at *c*. 5 m thick) across the valley mouth.

1.4.7 Although outside the main Scheme areas, significant floodplain sequences including dated peat sequences have been assessed for biostratigraphic remains in the Ouse-Glynde valley system. At the Vale of the Brooks and Lewes, pollen sequences from a thick deposit of greyish clays with interbedded peats show a landscape dominated by alder dating from about 7200 cal. BP (at Lewes I in the Glynde Valley) to 6500 cal. BP (Lewes II) and 5800 cal. BP (Vale of Brooks) (Thorley 1981; Waller and Hamilton 2000). The top of this peat deposit has been dated to c. 3350 cal. BP (Lewes II) indicating that alder carr persisted in the valley for much of the prehistoric period, with no clear evidence of any environmental change which could be attributed to human activity. However, a pollen sequence taken from a sequence of silty clays and peat from the nearby Caburn valley seems to indicate human influence possibly from the early Neolithic, with an expansion of herbs followed by a period of high lime and oak values and the appearance of cereal-type pollen (Waller and Hamilton 2000).

1.4.8 The nearby valley sequences at Cuckmere identified a buried land surface at –21.1m OD, composed of bluish grey silty clay with a few shells and inter-bedded peats overlying chalk bedrock and probably solifluction deposits (OA 2011). The interface between this surface and those above represents the transition from freshwater to brackish conditions, as evidenced by preliminary assessment of the ostracods and foraminifera. The top of the buried surface has been dated to the late Mesolithic at 7070-6820 cal. BC at 95.4% (SUERC-33111: 8030±30 BP; 9020-8770 cal. BP). It was overlain by sequential laminated sands, silty clays and clays representing brackish, tidal mudflats giving way to mid-high saltmarsh (ibid).

1.4.9 From this summary it should be evident that the wetland sequences, particularly those of coastal plains and valleys between Eastbourne and Hastings, are a significant palaeoenvironmental resource, with high potential to preserve direct occupation evidence around the margins, within the upper layers of peat and at the interface between bedrock and alluvial sands and silty clays. What is less certain is to what extent the river valleys of the Ouse and Cuckmere have the same potential.

1.4.10 Undoubtedly the material and sites recorded in this area to date provide only a glimpse of they true potential. The preservation of late Mesolithic-Iron Age pollen, plant macrofossils and insects (Coleoptera) within the peat sequences demonstrates that they have excellent potential for local landscape reconstruction. Together with evidence from ostracods, foraminifera and diatoms, the sequences can also provide information pertaining to Holocene sea-level change.

1.5 Archaeological background

1.5.1 The archaeological and historic background to the Scheme has been extensively covered previously in the Cultural Heritage Statement (Capita / URS 2015) and only a brief summary is presented here to help place the Scheme within a wider archaeological context.

Palaeolithic period (700,000-10,000 BC)

1.5.2 The HER records four entries for Palaeolithic activity in Newhaven, including two handaxe find-spots although the exact number and location of their discovery is unclear. One is recorded as being located within ANA which is located within both Scheme Areas 3 and 4, and the other is recorded as being located approximately 100m west of Scheme Area 4.

1.5.3 Two further flint working sites, one at the Newhaven Fire Station and the other at South Way are also recorded. Excavated in the 1970s identified a large assemblage of *in-situ* flint debitage and one tool was recovered from yellow silt that filled a fissure in the Pleistocene clay and gravels (Bell 1976). These were originally dated to the upper Palaeolithic but this has been subject to several revisions and more recently it has been suggested that they are older relating to biface manufacture of either Neanderthal or Archaic Homo Sapien origin (Pope, 2007).

1.5.4 In 2014 an evaluation undertaken at Newhaven Fire Station, some 140m west of the South Way site, identified further flintwork again from a yellow loess deposit that filled an involution within the underlying Head gravel. Both of these sites provide possible evidence of seasonal activity and highlight the potential for deposits to survive from this period (Johnson and Chuter 2009, 19).

1.5.5 The previous geoarchaeological deposit model suggested that similar Head deposits are located close to the surface within Scheme Areas 3, 4 and 5.

Late Prehistoric period (10,000-100 BC)

1.5.6 Research in Sussex has shown that Mesolithic sites are clustered on the Head outcrops; with the coastal plain being used for seasonal hunting camps with longer-stay base camps frequently located alongside or near watercourses (Butler 2008, 29).

1.5.7 Evidence for human activity along the coastline mainly comprises flintwork, such as the Thames pick that has been recorded in the wider area to the south-west of Scheme Area 4. Details of the circumstances of the find and its exact location are unknown.

1.5.8 The only other recorded Neolithic evidence relates to two HER records detailing four isolated axe finds. One of these was recovered from the garden of a property in Lee Way, just 75m west of Scheme Area 3.

1.5.9 Evidence of Bronze Age activity in the area typically includes settlements and burial sites; both are known in Newhaven. At Castle Hill ANA the remains of a possible Late Bronze Age enclosure or hillfort, is known. The earthworks no longer survive, in part destroyed by the construction of the 19th century fort (Harris 2004, 13).

1.5.10 At Tideway School, which is on the western side of the ANA, just beyond the boundary of the area, a Bronze Age cremation in an inverted urn was discovered during terracing in 1973 for the construction of a new gymnasiun (Harris 2004, 13). On the east bank evidence suggesting settlement is limited to a few pieces of pottery and worked flints, which were found during a watching brief at Grange Farm in Scheme Area 1. A round barrow is recorded as having existed at South Heighton Caravan Park, which is to the north of the east bank.

1.5.11 Alluvium sequences recorded within the Ouse Valley may contain artefacts dating from this period or structures associated with river-edge activities, and in the later Bronze Age in Western Europe tools, weapons and ornaments were deliberately deposited in wet places such as bogs and streams.

1.5.12 The geoarchaeological watching brief undertaken in June 2015 aimed to characterise Holocene alluvium within the Ouse Valley with particular reference to the western side of Scheme Areas 3 and 4, where there is the potential for wetland edge archaeological deposits. No evidence of in-situ organic remains was encountered during the watching brief; however the geotechnical logs for the wider area did indicate the potential for preservation within the site.

Late Iron Age and Roman Period (100 BC – AD 407)

1.5.13 By the later Iron Age, East Sussex appears to have formed part of the territory of the Atrebate tribe, who dominated much of south-east Britain. Only two sites dating from the Iron Age period are recorded, both of which are located south of Scheme Area 4 on the cliffs of the west bank at Newhaven. Here finds of Iron Age pottery and coins have been recovered, suggesting some continuity of occupation from the Bronze Age.

1.5.14 There is clear archaeological evidence for an early Roman presence in Sussex: from Chichester, which developed into the civitas capital, and Fishbourne Palace, which is the largest known domestic Roman building in Northern Europe. Two villa sites are suspected along the west bank of Newhaven. Excavations at South Way (in ANA), revealed the partial remains of five wooden and stone buildings that were occupied during the second half of the 1st and much of the 2nd century AD (Harris 2004, 13) and 500m to the east the foundations of a flint-built structure was discovered at The Rose Walk (also in ANA) which appears to date to the 2nd – 3rd centuries. Their close proximity may mean that the two, although often individually referred to as villas, are actually buildings that form part of one large villa estate complex.

1.5.15 A third Roman settlement is also evidenced at Castle Hill where Bronze Age and Iron Age settlement has also been discovered. Here finds of Romano-British pottery, coins and other artefacts were found during levelling of the east side of Newhaven Fort in 1970. Finds of Roman date were also recovered from this area during the construction of the fort in the 1860s.

1.5.16 A road network is likely to have accompanied the development of settlements along and into the Ouse Valley but physical evidence for this is scarce, with the only known Roman road in the Newhaven area being the major London-Lewes road. However, it has been suggested by Margary (1948,185-6) that a Roman road ran from Newhaven to Selmeston and on to Dicker, and that a coastal road also ran from the Brighton area to Newhaven, passing the church and crossing the Ouse along the pre-1863 route (Harris 2004, 13). The HER records this road and its purported route would have crossed the northern part of Scheme Areas 2 and 3 and would potentially include a river crossing.

Saxon to Medieval Period (AD 407 – 1540)

1.5.17 After the final withdrawal of the Roman army from England in the early 5th century AD, when the whole country appears to have fallen into an extended period of socio-economic decline, this region appears to have been inhabited by groups of Saxons.

1.5.18 Evidence of settlement during the early medieval period is scarce in East Sussex. What little there is mainly comes from cemetery sites, which in other areas have been found

to be in close proximity to settlements (Johnson and Chuter 2009, 22). There is evidence along the Ouse Valley for expansion of population and settlement around the 7th century AD (Johnson and Chuter 2009, 22). Newhaven, then known as 'Meeching' may have developed around this time as the Old English place-name suggests Anglo-Saxon origins (Harris 2004, 14). Archaeologically though, there is little to attest to this with just a few sherds pottery having been found at South Way in Scheme Area 4 (Harris 2004, 13) and at Newhaven Fort.

1.5.19 At Orchard Meadow, Heighton Road, Denton, to the north-east of Scheme Areas 1 and 2, pieces of quern and pottery (late Saxon, early Medieval) have been found, although not in clear association with a settlement.

1.5.20 Within the wider area there are three medieval settlements, South Heighton and Denton, to the north-east of Scheme Areas 1 and 2, and Meeching (now Newhaven) to the west of Scheme Areas 3 and 4; all of these areas are now designated ANAs. The medieval settlement of Meeching is first recorded as *Mechinges* c.1090 and *Mecinges* c.1095, which possibly means 'dwellers at mece (the sword)', referring to the long coastal spit of land deflecting the River Ouse towards Seaford during this period (Harris 2004, 14). Although archaeological evidence for this settlement is limited to a few pits found during the excavations at South Way in the 1970s, documentary evidence indicates that in 1095, a church, a mill and four acres of land were granted at Meeching by William de Warenne to the Cluniac priory of St Pancras at Lewes. The Grade II* listed St Michael's church, located south-west of Scheme Areas 3 and 4, was built around 1120. It is the only surviving medieval building in Newhaven – only the original Norman chancel, eastern tower and unusual semi-circular apse survive from the early church. Church Road, Lewes Road, and the High Street are also historic medieval streets (Sussex EUS, Newhaven).

1.5.21 By 1524, only eight taxpayers were recorded in Meeching parish, indicating that the settlement had declined following the deterioration of the Ouse Valley meadows, coastal sedimentation silting-up its harbour and the impact of the Black Death.

Post-Medieval / Modern Period (1540-present)

1.5.22 Large areas of the Scheme area retain a rural character, consisting of reclaimed marsh land. In 1539 a new exit for the Ouse was cut back by Castle Hill but the Armada Survey of 1587 shows that by then a small spit marked as 'beache' had accumulated and diverted the river 200m eastward. By the end of the 17th century, cartographic sources indicate that a shingle barrier had extended another 800m east, effectively closing the exit at 'Newhaven'. Instead the river reached the sea through a maze of channels and low-lying shingle banks at Tidemills, while the old river channel running towards Seaford now formed a lagoon behind the shingle beach.

1.5.23 It was not until 1731 that the western exit at Newhaven was re-excavated and this time piers were installed in an attempt to stabilise the outlet. This proved ineffective and by 1766 shingle had again formed across the mouth. Little changed until in 1791 when a short breakwater was built to the west of the harbour and the river was straightened at several points and provided with drainage sewers.

1.5.24 In the mid-19th century railway lines were introduced to Newhaven and with the arrival of these its significance as a maritime centre increased. The breakwater was improved by a groyne of over 150m and the lagoon east of Tide Mills was embanked, forming the Mill Pond in the channel feeding Mill Creek. The Salts situated between the river and the pond was a man-made inlet controlled by sluices to the creek; it was constructed for oyster cultivation until disease curtailed the industry.

1.6 Acknowledgement

1.6.1 The deposit model report was compiled by Carl Champness and the drawings were produced by Gary Jones and Matt Bradley. The work was overseen by Tom Davies, Arcadis Senior Archaeological Consultant, on behalf of the Environment Agency. The project was monitored on behalf of ESCC by Greg Chuter, Assistant County Archaeologist.

2 Aims and Methodology

2.1 Aims

2.1.1 The general aims of the updated deposit model were to:

General:

(i) Generate a deposit model that will characterise the nature of the deposits across the Scheme areas in terms of basic composition, formation processes, likely period or periods of deposition;

(ii) help develop a further understanding of past human activity and changing environments and landscapes within the Ouse Valley from the Pleistocene to the present day;

(iii) assess the influence of sea-level change both directly and indirectly on the sedimentation and vegetation history of the valley;

(iv) identify any potentially palaeoenvironmental significant deposits that may be directly impacted by the schemes;

(v) provide information on the alluvial sedimentary sequence to aid in the identification of archaeological significant deposits or horizons;

(vi) identify the need and potential for further work to mitigate the impact on significant geoarchaeological and palaeoenvironmental deposits.

2.2 Methodology and dataset

2.2.1 In order to create the deposit model 40 borehole records were examined across the five Scheme areas (Fig. 4). The logs derive from a series of geotechnical ground investigations undertaken since 2007 (Table 1), in addition to the boreholes drilled in May 2015 and supplemented by a selection of historical boreholes from the British Geological Society website.

2.2.2 A summary of the borehole samples taken are shown in the table below:

Geotechnical Investigation report	Year of boreholes	Boreholes	Geoarchaeological monitoring ASE
Southern Testing Valley	2007	ST 1-8	
OPUS	2015	OPS BH1-24	5 boreholes
Arcadis	2015	ARC BH1-19	

Table 1: Geotechnical Investigations summary

2.2.3 The lithological data from the logs was input into geological modelling software (©Rockworks17©) for analysis and correlation of deposits into key stratigraphical units. These units have been used to demonstrate the nature and the extent of sediment accumulation patterns across the Scheme. Various elevation plots (Figs. 5-8) and cross- sections (Figs. 9-11) have been produced in order to illustrate the main points of the discussion.

2.2.4 It should be noted that apart from the observations made during the geoarchaeological watching brief (ASE 2015), no core or sample data were available to verify any of the observations made in this report. All information comprised paper copies of boreholes records and consequently a range of problems may exist with this type of dataset (Bates *et al* 2000).

2.2.5 The elevation and thickness plots were produced in Rockwork 17 using an inverse distance correlation between data points with a smoothing algorithm applied (value 1). The cross-sections were produced as hole to hole data with correlation of litho-stratigraphic units with correct distances and elevations.

3 RESULTS

3.1 Introduction and presentation of results

3.1.1 The results of the study are presented below, beginning with a discussion of the palaeotopography and updated Scheme deposit model, followed by a summary of each of the Scheme areas in turn. A summary table of the data used in the deposit model can be found in Appendix A, where the deposits are described with their dimensions and stratigraphical units.

3.1.2 Each sedimentary unit is referred to in terms of depths below ground level (bgl) and metres above sea-level (m aOD). The borehole numbering is based on the a prefix of the company (i.e. OPS) and their original borehole numbering (i.e. BH1)

3.2 Updated deposit model

3.2.1 The geotechnical data was used to update the existing Scheme deposit model presented within the previous field geoarchaeological investigation report (ASE 2015). The stratigraphic correlations have been revisited in the light of the more detailed geoarchaeological recording and better spatial coverage of the valley sequences from the new dataset. In addition, the valley cross-sections have been updated with more detailed lithological data in order to illustrate the complexity of the sediment sequences and topographic features that exist along the proposed Scheme areas.

3.2.2 The stratigraphy across the valleys is relatively consistent and comprises the following updated stratigraphic units (discussed in order of deposition):

- **Chalk bedrock:** Very stiff fissured chalk clasts;
- **Basal Gravel:** Very stiff grey sandy and clayey gravel;
- **Lower alluvium:** Organic and minerogenic silty clays
- **Head gravels:** Fine-grained silty/sandy clays/sands gravels;
- **Flavial sands:** laminated sands containing shells
- **Middle alluvial silts: L**ight grey silty clay;
- **Organic alluvium:** Spongy dark greyish black silty and fibrous peat lenses
- **Upper alluvial silts:** Soft light grey/greyish brown sandy clay and silty clay;
- **Topsoil/Made ground:** Firm mixed dark brown slightly sandy clay/sandy silt.

3.2.3 The survey revealed a sequence of broadly laterally equivalent deposits where firm assignment to particular stratigraphic units could be made with a level of confidence. The model was based on paper geotechnical logs only and no samples were available for more detailed observations. These units were correlated based on sediment types, elevations and descriptions. Only a preliminary deposit model is presented in this report which simplifies some of the sedimentary complexity encountered across the valley sequences, in order to aid in assessing the archaeological potential across the Scheme. No dating or biostratigraphic information was available to help correlate the deposits within the sequence.

Pre-Holocene deposits and basement topography

Bedrock

3.2.4 The underlying bedrock across the site is mapped as Newhaven Chalk. The Chalk was recovered as very stiff chalk clasts that in places was deeply fissured and fractured. The chalk was encountered at a shallower depth of 5m on the west bank (BH20) within Areas 3 and the north of Area 4. On the east bank, the chalk extends to much greater depths of up 26m to 20m bgl, although it rises up considerably in the north of Area 1 (OPS BH 1).

3.2.5 The modelled surface of the chalk (Fig. 5) indicates a deeply incised valley sequence concentrated toward the east bank of the current river. The plot indicates higher elevations between +1.5m to -10m OD towards the west, dipping down to -30m OD towards the east.

Basal sandy gravel

3.2.6 The basal gravel unit consists of mixed deposits of fine to coarse weathered bedrock with well-sorted angular to rounded cobble gravel. These deposits are confined to the valley bottoms and edges, varying in thickness from 1m to 3m. They were found at depths of between 18m to 26m bgl, and were mostly identified on the east bank due to the greater depth of sampling within this area.

3.2.7 These gravels represent material deposited through glacial outwash, by rivers swollen by spring and summer melting. These rivers helped to shape the deeply incised valleys of the area when most of the water was trapped in glacial ice and sea-level was much lower than present day.

Lower alluvium/organic alluvium

3.2.8 Overlying the basal gravel was a sequence of organic and silty clay alluvium deposits that were identified at depths of between 24m to 8m bgl (-28m to -13m OD). These deposits are described as dark greyish black silty clays with organic lenses, with occasional fine flint and quartz gravel inclusions. Distinct organic deposits were identified within this unit, but these could not be traced laterally across the Scheme areas.

3.2.9 The date and sedimentary environment of the lower alluvial unit has yet to be fully established. The fact they are overlain by soliflucted or terrace gravels may suggest they represent an intriguing interglacial or late glacial sequence of freshwater fluvial deposits. However, the nature of the overlying gravels is currently unclear and consequently they may be of early Holocene (post-glacial) date, associated with a pre-inundation landsurface. The organic nature of the deposits is likely to indicate good potential for palaeo-environmental analysis and possibly radiocarbon dating.

Head deposit or sandy gravels

A considerable thickness of sandy gravels potentially represent a mixture of Pleistocene terrace gravels and/or Head deposits located between depths 18m to 4m bgl (-22m to -8m OD) on the eastern bank and 5m to 3m bgl (0m to +2m OD) on the western bank. These deposits are recorded within the geotechnical records as dense brownish grey fine to coarse sub-angular gravels to sub-rounded flint gravel.

3.2.10 The high-energy nature of the deposits would normally indicate a Pleistocene date associated with either solifluction or glacial outwash channels and it is possible that these deposit represent reworked Head gravels within an abandoned channel.

However, another possibility would be storm beach deposit or reworked material associated with a Holocene date.

The late Devensian/early Holocene topographic template

3.2.11 The modelled surface of the Head gravels is shown in Figure 6, which lies between elevations of *c* -22.5m and +1.5m aOD. The shape of this surface essentially defines the topography of the early Holocene landscape across the Scheme. Bates (2000) refers to this as the 'topographic template' and suggests that variations in the template largely dictated patterns of subsequent sedimentation patterns as flooding ensued during the post-glacial period.

3.2.12 Examination of this surface reveals a series of estuarine channels running north-west to south-east through Areas 1 and 2.

Holocene sedimentation

Estuarine silts and sands

3.2.13 These deposits consist of pale grey fine-grained gleyed silty/clay sands that occupy the valley bottom and have been recorded further inland. They vary in thickness from 8m to 20m, accumulating between -22m aOD to +2m aOD. These sediments can be finely laminated and contain estuarine shells reflecting their tidal influence. They represent a rapid phase of sea-level rise and marine transgression, when the Ouse and surrounding valleys would have developed into major tidal inlets.

3.2.14 These deposits were found to be concentrated on the east bank within Scheme areas 1, 2 and 5, indicated fluvial active associated with a main channel environment compared to the west bank. The thickness plot in Fig. 9 shows a concentration of these deposits towards the east bank of the present river. Similar basal sands deposits have been recorded at the same elevation within the Cuckmere Valley accumulating from the later Mesolithic period onwards.

3.2.15 Such a fluvially active sedimentary environment may have less potential to preserve or favour archaeological activity due to the high-energy nature of the sedimentary environment.

Organic alluvial sequence

3.2.16 During the mid Holocene there was a major reduction in the rate of sea-level rise and a sequence of freshwater peats and clays started to accumulate as the marine influence in the Ouse Valley decreased or became cut off from the marine influence. This may have been caused through the develop of a shingle barrier at the mouth of the valley.

3.2.17 The peat and organic deposits were found to be better preserved on the west bank within Scheme Areas 3 and 4, away from the more fluvially active environment of the east bank.

3.2.18 This sequence represents the main phase of marine regression, which is characterised by phases of peat accumulation and humic silty clays. This sequence of deposition indicates that a mosaic of different freshwater wetland environments would have existed at any one time in the valley bottoms.

Upper alluvial silty clays

3.2.19 The upper silts mark a shift away from the deposition of organic sediments to minerogenic silty clays, representing a return to marine conditions. These deposits consist of soft light-grey / greyish-brown, sandy clays and silty clays, occasionally with organic lenses near to the base. They range in thickness from 0.5m to 7m (Fig. 8) and are thickest at the edges of the valley. They are located at approximately -4m aOD to +3m aOD.

3.2.20 These deposits are currently undated but based on comparison with other valley sequence along the Sussex coast are believed to date from the late Iron Age to the medieval period.

Topsoil / Made ground

3.2.21 These consist of mixed series of deposits that range from firm, brown, sandy clay and clay with occasional to frequent partially sorted angular to sub-rounded gravel. Inclusions of wood, chalk, brick and tile are recorded from these deposits. They range in thickness from 0.30m to 4m, representing different sediment types and comprising ground make-up deposits and thin marshy topsoil deposits.

3.2.22 It is worth noting that the geotechnical investigations only briefly describe these deposits, which are in turn lumped together into a single lithographic unit. It is possible that these deposits represent a series of more complex modern and historical deposits than are represented within these records.

3.2.23 It is worth noting that the geoarchaeological watching brief did not record any archaeological material from the monitored boreholes on the east river bank. However, there remains the possibility that these deposits may also contain archaeological remains and horizons dating from the Roman period onwards. In particular there is the possibility of historic ground make-up deposits and river revetments and management features to be located within these deposits, especially near to the historical core of the town.

4 DISCUSSION

4.1 Reliability of the field investigation

4.1.1 The deposit model was based on paper records only and a range of problems are known to exist with this type of dataset. No sample data was available in order to confirm or test the sedimentary correlations made within the model. The previous geoarchaeological watching brief helped to identify and characterise key litho-stratigraphic units but was not able to confirm the archaeological potential of these units, particularly the thick deposits of made-ground deposits that would be mainly impacted by the Scheme.

4.1.2 The spatial coverage of the geotechnical investigation was limited in some areas of the Scheme due to land access issues. This was a particular problem within Scheme Areas 3 and 4, which are heavily urbanised. Also due to the great depth of the sequence, not all investigations reached bedrock, with the Chalk being in places 30m below the current ground surface. Therefore the understanding offered for some areas of the Scheme were more limited and correlation made more tentatively, due the fact that they were represented by fewer samples and not all covered the full sequence.

4.1.3 Despite these limitations in the geotechnical dataset, the model was able to achieve sufficient spatial coverage of the areas and samples to bedrock in order to achieve the aims of the study. The updated deposit model was able to offer a more detailed understanding of the sedimentary sequence based on the new geotechnical dataset undertaken in Areas 3 and 4.

4.2 Sequence of landscape development

4.2.1 Based on the deposit model a sequence of landscape development can be offered for the Scheme.

Pleistocene deposits

4.2.2 During the course of the last glaciation sea-level became progressively lower as ice sheets expanded over the continents. The sea retreated southwards leaving the bed of the Channel as dry land. When the Devensian ice-masses reached their maximum extent about 15,000 years ago sea-level probably stood at -130m OD. The lowering of sea-level during the last glaciation allowed rivers like the Ouse to incise their channels, particularly in their lower valleys near what is now the coastline. The modelled surface of the chalk bedrock indicated such a deeply incised valley that extended to a depth of 31m below the current ground level. The former floors of the valleys are now buried beneath a considerable thickness of Late-glacial and Post-glacial sediments.

4.2.3 A thin basal sandy gravel was recorded overlying the Chalk. This indicates episodes of high-energy deposition associated with glacial melt-waters during the Pleistocene. During the winter months the ground would have been frozen as permafrost and the valley edges would have been subject to solifluction processes. Some of these gravel deposits may also represent soliflucted material.

4.2.4 The origins and dating of the lower organic and alluvial deposits at the base of the sequence has yet to be fully established and is more intriguing. If the assumption about the overlying gravels being Pleistocene in date is correct, than the lower units could potentially be of interglacial or Late Glacial age. If the overlying gravels are reworked and/or Holocene in date, than the deposits represent the early post-glacial land surface and freshwater channel sequences. Similar pre-inundation surfaces have been identified at Langney Point, where the transgressive contact was recorded by Jennings

(1985) at a depth of -24.7m O.D. at c.9850 cal. BP. This is also consistent with the lower Cuckmere Valley date of 8030±30 BP (SUERC-33111), where similar deeply buried organic rich silts were present at a depth of 22m (-21.10m OD). This nature of the deposit can not be established based on paper records alone and further sampling and dating would be necessary in order to establish the true character of these deposits.

4.2.5 The thick sandy gravel units overlying the alluvium represent high-energy deposits accumulating within the base of the valley. Based on their description a Pleistocene dated would be anticipated representing Head or gravel terrace deposits. On the west bank mapped Head deposit are located within 3-5m depth from the surface, particular near to the ANA.

Early Holocene landscape

4.2.6 The basal deposits of the Holocene sequence were sand dominated estuarine deposits with marine shells and tidal laminations. This corresponds with an increase in sedimentation across the south coast related to the rapid rise in sea-level following the end of the last glacial. Deeply incised valley sequences like the mouth of the Lower Ouse were rapidly in-filled with marine and estuarine sedimentation. Similar estuarine sand dominated lower sequences are recorded within the Cuckmere and Adur Valleys (Waller and Long 2010 and OA 2011). In contrast, freshwater peat formation is extensively recorded from the valley sequence to the east of Beachy Head and from the middle Ouse valley during the mid Holocene, which began at Lewes c. 7200 cal. BP in the Glynde valley (Waller and Hamilton 2000).

4.2.7 On the western banks the sands are not recorded at similar depths indicating that the main channel was originally located on the eastern bank, and the modern river course is a more recent development. In contrast the western bank is dominated by silty clay and organic alluviums indicating lower-energy deposition away from the main estuarine channel. Organic deposits are recorded within the upper sequence on the eastern bank associated with the channel edges.

4.2.8 Other sequences record a phase of peat accumulation during the mid Holocene associated with a phase of estuarine contraction. These peats are consistently described as comprising detrital peat, overlain by brackish/marine silts. The upper surface of these mid Holocene peat sequences have previously produced evidence of Bronze Age activity, most notably at the site of Shinewater, in the Willingdon Levels, East Sussex (Greatorex 2003) and evidence of woodland clearance and extensive wetland edge prehistoric activity within Combe Haven (Jennings 1985; OA 2008). The absence of significant organic deposits on the eastern bank may limit their archaeological and palaeoenvironmental potential.

4.2.9 The accumulation of the upper alluvial deposits of inter-digitating silts and silty clays mark a major phase of marine incursion and channel migration. Previous studies of the ostracods contained within the upper silts from the Cuckmere Valley and Combe Haven suggests the establishment of mid to upper salt-marsh followed by tidal mudflats on the valley floor. Similar major incursions by the sea at this time are recorded at Combe Haven and Romney Marsh, and at a number of other locations along the coast of England. It is often referred to as the ‘Romano-British Transgression’, with a number of potential causes cited for the rise in sea-level. It is widely believed that large-scale deforestation and sediment availability may have also played a significant role in the increased flooding and rising water-levels in many of the valleys during this period.

4.2.10 The weathered upper surface of the alluvium reflects the drying out and the beginning of the process of marshland reclamation of the area from the early medieval period. In some areas ground raising activities may have occurred with the deliberate

accumulation of made-ground deposits, while some areas remained low-lying and continued to be used as arable or pasture.

4.2.11 The great thickness of made-ground deposits identified within the model across the Scheme requires further investigation and characterisation. The nature of these deposits is poorly defined within the geotechnical logs and could contain archaeological horizons and deposits.The west bank and area around the historical core will in particular need further investigation to establish the archaeological potential in this area of the Scheme.

4.3 Archaeological landscape zones

4.3.1 The mapping of the palaeotopography and sedimentary sequence across the Scheme areas have helped to identify different landscape zones that may have been the focus for different periods and types of archaeological activity. The following Scheme Areas are discussed in terms of their archaeological and palaeoenvironmental potential:

Western bank - Scheme Areas 3 and 4

4.3.2 The valley slopes comprised a mixture of bedrock and Head deposits overlain by organic and minerogenic alluvium and either thin ploughsoils or a deepening thickness of made-ground deposits.

Palaeolithic potential

4.3.3 Chalk and Head gravel deposits are recorded within the model close to the surface within OPAS BH21 and ARC BH7. The Scheme therefore has the potential to impact upon Palaeolithic remains associated with Head deposits.

4.3.4 Several Palaeolithic axes and significant flint working sites have been found associated with Pleistocene remains in both the ANA and west bank. Geotechnical investigation undertaken in June 2015 recorded river gravels and Chalk in the central part of Scheme Area 3 at relatively shallow depth, approximately 2m AOD (BH21). Therefore there is a high potential for Pleistocene deposits to be present within Scheme Area 3 and artefacts from this period may be present within the chalk Head and river gravels.

Prehistoric potential

4.3.5 The deposit model confirmed organic deposits within the Holocene alluvial sediments within Scheme Areas 3 and 4, which have a high potential to preserve important archaeological remains and palaeoenvironmental data. Edge environments between the higher elevations of the Head deposit and its transition into the upper organic and minerogenic alluvium may can often be the focus for early prehistoric remains.

4.3.6 Any early prehistoric activity (Mesolithic-Bronze Age) associated with the formation of the organic sequence is likely to be found buried at depth, sealed below, within or just above the peat. Activity of this period is therefore likely to be very difficult to identify and problematic to investigate using traditional trial trenching methods. Prehistoric trackways and wooden platforms have been identified elsewhere within similar contexts on the floodplains of the Combe Haven and the Willingdon Levels.

4.3.7 The wetland edge environment would have offered a particularly attractive environment for early prehistoric communities. These sequences comprise shallow sloping bedrock sequences overlain by thin deposits of peat and alluvium that get progressively deeper towards the wetlands. These locations offer access to multiple environments which would have offered a diverse range of resources.

4.3.8 No significant archaeology has so far been associated with the Ouse wetland environments or in association with the deeper channel sequence. Often these areas

would have experienced low-level activity associated with hunting, fishing and trapping and river transport. Settlement activity is rare from these deposits due to the potential of flooding, but features like flint scatters, burnt mounds, wooden trackways and platforms are known from these environments at the Willingdon Levels (Jennings *et al* 2003) Pevernsey Levels and Combe Haven (OA 2015). Tantalisingly, wooden boats could also potentially be preserved within the anoxic sediments.

Roman potential

4.3.9 Two Roman villas are recorded in the ANA approximately 500m to the south. It is possible that known Roman remains are associated with a much larger villa complex and there is therefore the potential to encounter additional remains within Scheme Area 3 outside of the ANA. In addition, there is also potential for the course of the Roman road to extend across the river from Scheme Area 2 and into the northern section of Scheme Area 3.

Medieval and post-medieval

4.3.10 There is no archaeological evidence for early medieval activity in Scheme Area 3, however there is a possibility that the medieval town of Meeching may have originated at this time. Scheme Area 3 lies in close proximity to the medieval core of Newhaven, which is believed to have extended from the swing bridge by the river westwards, towards the church of St Michael and All Angels. To date, only very limited archaeological evidence for this settlement has been recovered and the north part of Scheme Area 3 was probably used for pasture or crop cultivation.

4.3.11 There is a low potential to encounter features associated with agricultural practices or field enclosure in previously undeveloped areas.

Eastern bank - Scheme Areas 1, 2 and 5

4.3.12 There is potential for Pleistocene (or earlier) deposits within the northern part of Scheme Area 1 to be impacted. Depending on the depth of construction impacts, there is also potential for organic material recorded within the alluvial sequence to be impacted.

Palaeolithic and prehistoric potential

4.3.13 The Head and sandy gravel deposits have the potential to preserve Palaeolithic remains but they are sealed by 8m of Holocene deposits, which makes them beyond the proposed Scheme impact depth and the practical limits of excavation depth. Only in the north of Scheme Area 1 do the deposits rise up to potential impact depth.

4.3.14 The sand-dominated estuarine sequence is also likely to have been less favourable for early prehistoric activity. These environments have varying archaeological potential due to the nature and energy of these sedimentary environments.

Roman potential

4.3.15 The purported route of the Roman road runs through the northern part of Scheme Area 2 and may be located within the made-ground deposits.

Medieval and post-medieval

4.3.16 Based on historical mapping we know that the path of the medieval Ouse once ran through Area 1 and 2. This will have potentially removed any earlier deposits and reduced the archaeological and palaeoenvironmental significance of the sequence.

5 Conclusions

5.1.1 The results of the deposit model have shown significant potential for Palaeolithic and early prehistoric remains to be impacted within Scheme Areas 3 and 4. The thickness and poorly defined nature of the made-ground close to the historical core also has the potential to contain archaeological remains.

6 Recommendations for further work

6.1.1 The inferences and conclusions developed from the deposit model require further ground-testing by field investigations to address the levels of archaeological preservation and potential that exists across the Scheme. Questions remain over the archaeological potential of the 'made-ground' and the potential for palaeolithic/early prehistoric remains to be preserved within, or on, the surface of the Head gravels. These will need to be field tested.

6.1.2 The preliminary deposit model was based on paper records only and would benefit from further development based on biostratigraphic assessment and dating of organic deposits. The confusion over the basal sequence of organic alluvium underlying sandy gravel in particular can only be resolved through further sampling and a suitable programme of scientific dating.

6.1.3 Dating of the upper organic and alluvial deposits will also be beneficial in order to help assess the archaeological potential of wetland edge environment and buried organic sequences.

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APPENDIX A. GEOARCHAEOLOGICAL BOREHOLE DATA

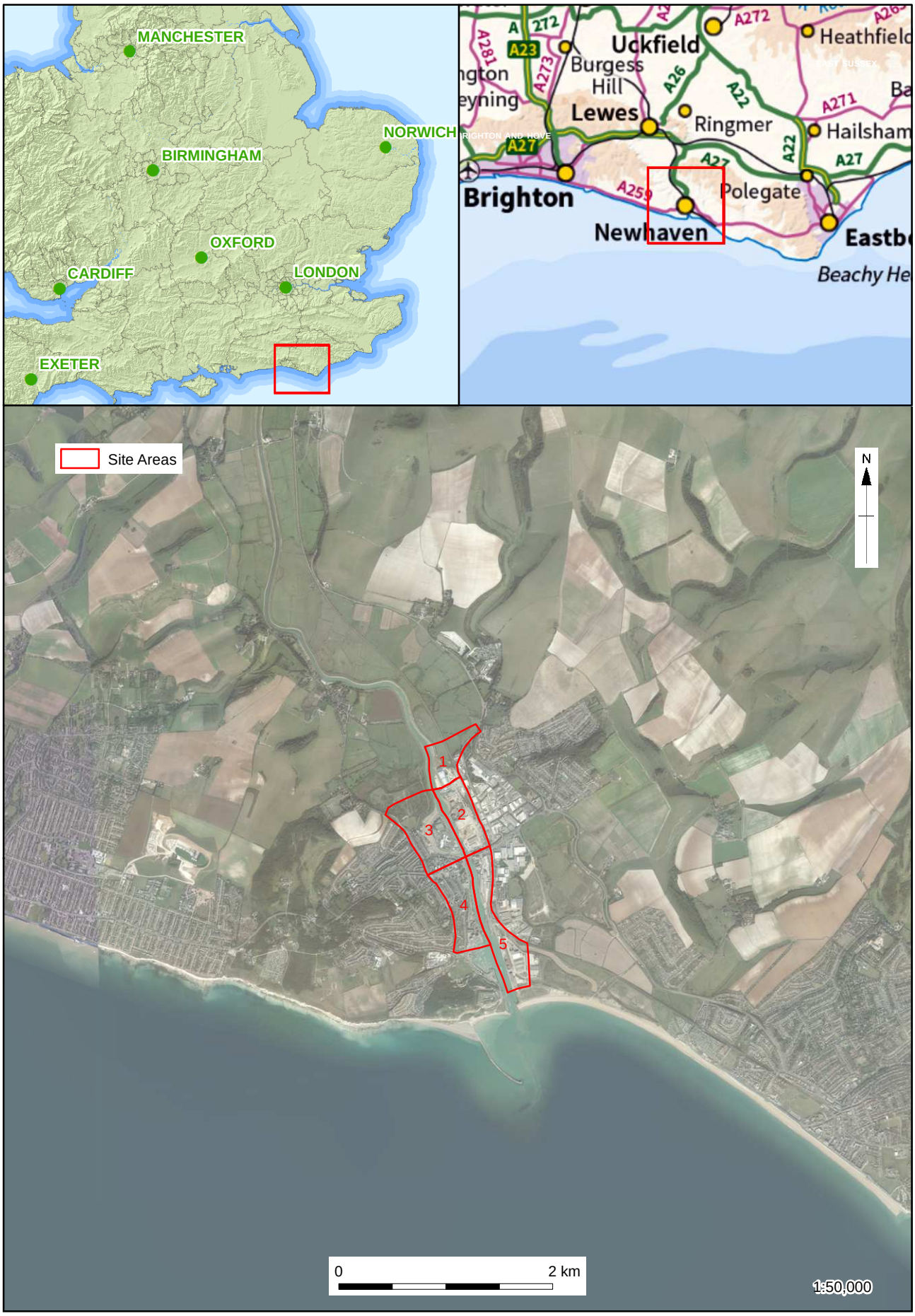
Borehole	Eastings	Northings	Elevation	Made-ground	Upper alluvium	Upper organics	Middle alluvium	Sand deposits	sandy gravels	lower alluvium	sandy gravels	chalk
ARC BH1	544278.3	101882.74	4.74	1.44	-2.26	-3.71	-3.26					
ARC BH3	544304.4	101844.47	4.16	1.76	-1.64	-4.29						
ARC BH2	544290.2	101863.43	1.97	1.77	-1.93	-2.93	-5.83			-6.48		
ARC BH4	544290.2	101817.49	4.09	1.74	-1.71	-3.71	-4.36					
ARC BH5	544275.9	101795	2.53	1.18	-1.14	-3.07	-5.92					
ARC BH6	544273.5	101760.08	2.65	1.2	-2.1		-4.1				-4.35	-4.75
ARC BH14	544727.9	101153.44	4.34	1.99	-2.16		-4.11					
ARC BH7	544590.5	101501.85	4.15	1.4	0.25		-6.05				-9.35	
ARC BH09	544712.8	101402.17	4.5	1.5	-0.2		-3.95					
ARC BH15	544723.2	101107.98	4.26	2.16	-0.34	-1.74	-3.44				-3.64	-3.74
ARC BH16	544741.5	101066.67	4.67	1.37	-1.03	-1.93	-3.78					
ARC BH18A	544776.1	100796.62	3.72	1.62	-1.73							
ARC BH19A	544763.6	100769.51	3.78	2.23	-1.67							
ST BH1	544841.8	101228.9	4.05	3.05	0.95			-5.15	-12.95	-17.95	-19.95	-24.45
ST BH2	544837.6	101283.6713	4.17	3.17	0.97			-3.63	-15.33	-18.83	-20.33	-25.83
ST BH3	544839.7	101330.5	4.19	-0.41				-6.31	-20.31			-28.81
ST BH4	544814.6	101388.2	4.26	3.86	-3.44				-17.24	-19.94	-20.24	-30.24
ST BH6	544854.4	101445.48	4.19	2.99				-6.61	-22.81	-25.81	-28.81	-31.81
ST BH7	544791.2	101435.95	4.05	2.85	-2.45			-7.45	-20.45	-26.95	-30.95	-34.95
ST BH8	544789.6	101498.79	4.24	3.04	-2.06			-22.56		-24.56		-28.26
OPS BH1	544777.5	102659.62	3.27	0.27	-1.73		-2.73					-11.73
ST BH5	544840.1	101410.11	4.19	1.19				-3.81	-21.31	-27.31	-29.31	-33.31
OPS BH2	544710.8	102579.71	3.24	0.24	-7.76				-14.06	-17.06	-18.76	-26.76
OPS BH3	544633.6	102580.24	2.24	2.04	-1.06			-12.76				
OPS BH4	544593.4	102459.59	2.16	1.96	0.9			-16.84				
OPS BH5	544603.4	102414.09	2.96	2.06	0.66			-12.04				
OPS BH6	544562.7	102390.27	2.08	1.73	-0.32			-8.92	-15.72	-23.72		-28.42
OPS BH7	544475.3	102096.06	3.97	1.17	-0.53			-12.03	-15.03	-25.93	-26.13	
OPS BH8	544562.1	102015.09	3.66	2				-11.34				
OPS BH9	544585.9	101911.38	3.71	0.91	-0.79			-11.29				
OPS BH10	544643.6	101809.25	3.96	-2.14				-10.99				
OPS BH11	544701.3	101671.13	3.9	1.6	-0.1			-21.1				
OPS BH12	544627.2	102191.31	3.22	-0.78				-12.23				
OPS BH20	544731.1	101189.56	4.1	1.1				-5.9				
OPS BH21	544257.8	101741.32	4.98	2.08	1.68							-10.02
OPS BH13	544671.1	102066.95	3.4	1.8	-0.6			-11.6				
Geo 88	545000	101500	5	3.8	-2			-9.4	-16	-22.25	-25.2	-31.5
OPS BH24	544300.9	101814.62	4.12	2.72	-3.88		-8.88		-11.33			
GEO 51	544900	101600	2.4	2.1	-1.1	-2.1		-12.1	-17.6	-23.4	-24.6	-26.6

Appendix B. Summary of Site Details

Site name:	Newhaven Flodd Alleviation Scheme, East Sussex
Site code:	-
Grid reference:	centred on NGR TQ 756 107
Type:	Deposit Model Report
Date and duration:	October 2016
Area of site:	55 hectares
Summary of results:	The model demonstrates a considerable depth of Late Glacial deposits and Holocene alluvium (up to 26m in depth) preserved within the Ouse Valley. Deeply incised valley sequences like the mouth of the Lower Ouse were in-filled with marine and estuarine sedimentation following the rapid rise in sea-level at the end of the last glaciation. Pleistocene sandy gravel deposits were identified at the base of the sequence between 26m to 18m in depth, and were mostly identified on the east bank, due to the greater depth of sampling within this area.
Location of archive:	The archive is currently held at OA, Janus House, Osney Mead, Oxford, OX2 0ES, and will be sent to the HER.

Appendix C. Table of Archaeological Periods

Period	Environmental period	Date range	Technology
Terminal Upper Palaeolithic	Late Glacial	10300-9700 BP (10,400-9,400 BC)	Long blade, faceted platforms, bruised blade, occasional broad blade microliths and backed pieces, limited tool kit, opposed platform blade cores. **Hunter-gatherers**
Early Mesolithic	Pre-Boreal	9,600-7,800 BC	Blade technology, usually without faceted platforms, core tablets common, opposed platform and single platform blade cores, opposed second platform often corrective, tranchet axes/adzes, burins, end of blade scrapers, broad blade non-geometric microliths. **Hunter-gatherers**
Late Mesolithic	Boreal Atlantic 6,000 BC	7,800-4,000 BC	Bladelet technology common, geometric narrow blade microlithic forms, highly prismatic cores, axes awls and piercers, scrapers often expedient. **Hunter-gatherers**
Early Neolithic	Atlantic (Elm decline 4,000 BC)	4,000-3,500 BC	(Assumes a Middle Neolithic is accepted) Blade technology still in use, complex multi-platform cubic blade cores, wide range of tools, elongated end of blade scrapers, leaf-shaped arrowheads, awl, piercers and fabricators, less burins, polished axes, pottery, Long houses, causeway camps, domesticated plants and animals and wooden trackways. **First farmers**
Middle-Late Neolithic	sub-Boreal	3,500-2,500 BC	Peterborough and groove ware pottery, long barrows, henge monuments and stone circles **Early farmers**
Early Bronze Age		2,500-1,500 BC	Beaker pottery, Bronze socketed axes, burnt mounds, barbed and tanged flint arrow heads, thumb nail scrappers, flint knives, round houses, wooden trackways/platforms and round barrows. **Settled landscapes**
Mid-late Bronze Age		1,500-800 BC	
Iron Age	sub-Atlantic	800 BC-43 AD	Iron working, coinage, hillforts and tribal elites. **Tribal communities**
Roman		43-407 AD	Villa estates, metal smelting, Roman military, fineware pottery, water management, towns and roads. **Part of the Roman Empire**
Saxon		407-1066 AD	**Settled Invaders**
medieval		1066-1540 AD	**Norman Invasion**
Post-medieval		1540 AD-present	



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Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User

Figure 1: Site location

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Figure 2: Bedrock and drift geology

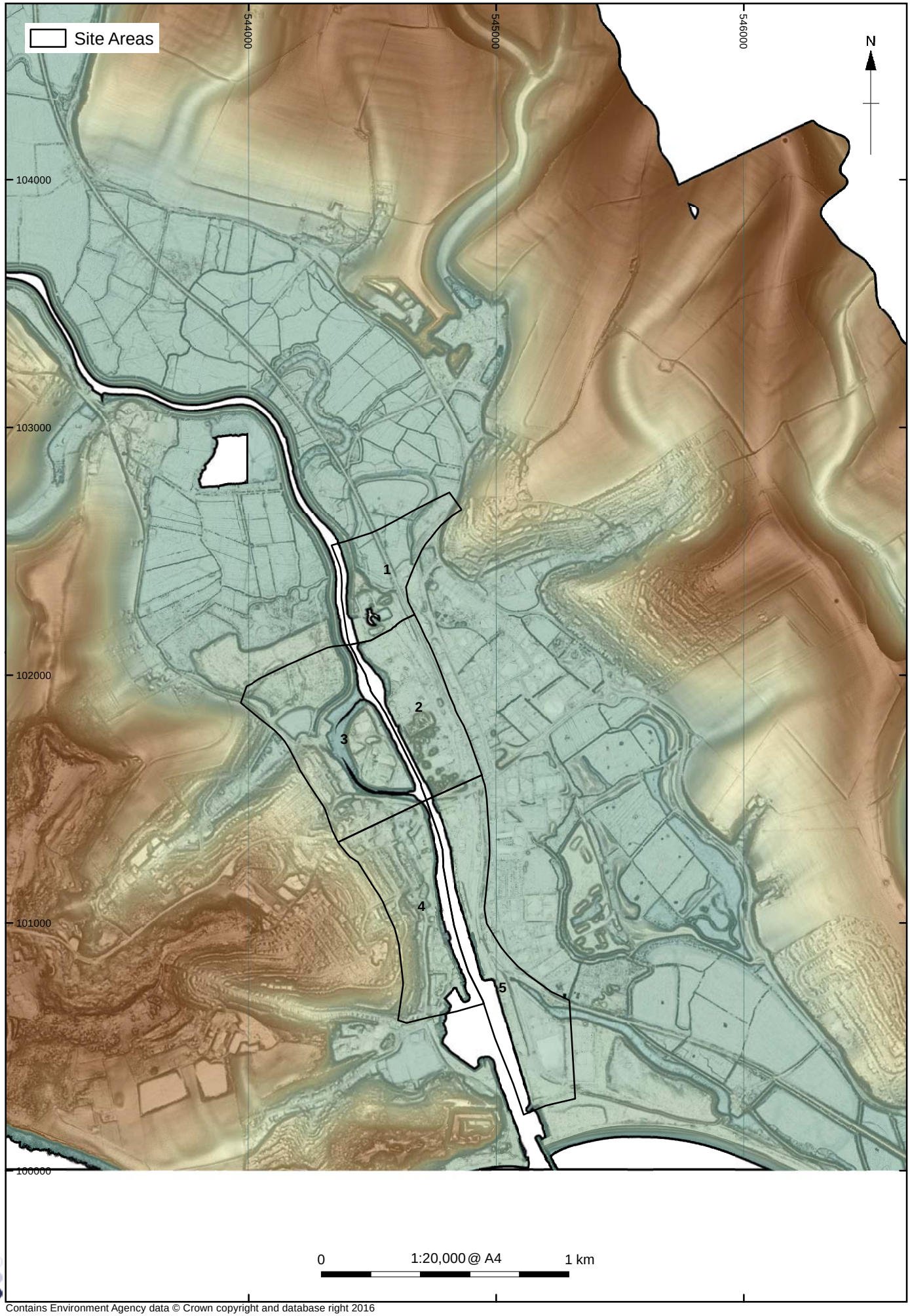
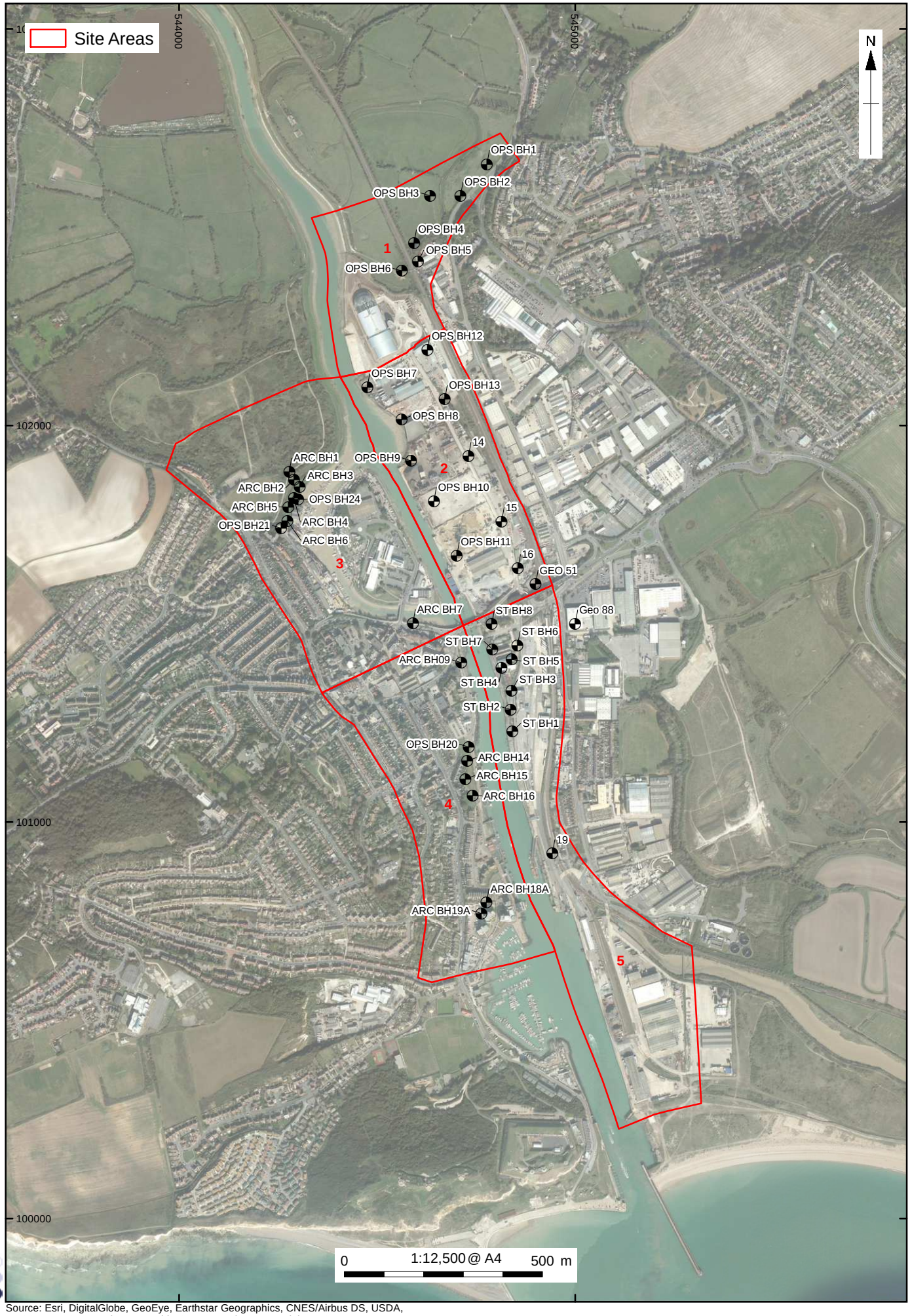


Figure 3: LIDAR of the Scheme area



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Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User

Figure 4: Site areas and geotechnical investigations

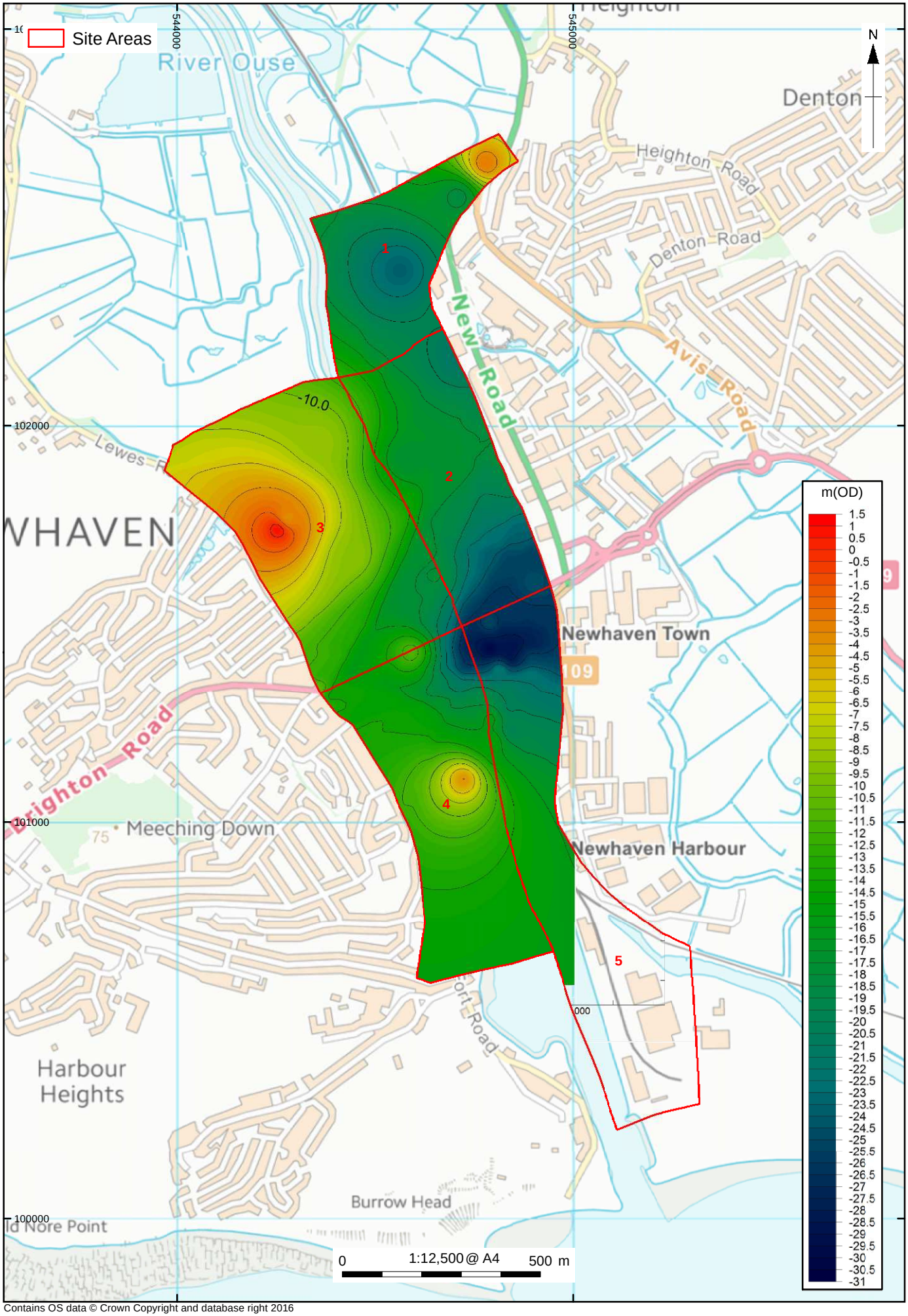

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Figure 5: Modelled topography of the chalk surface

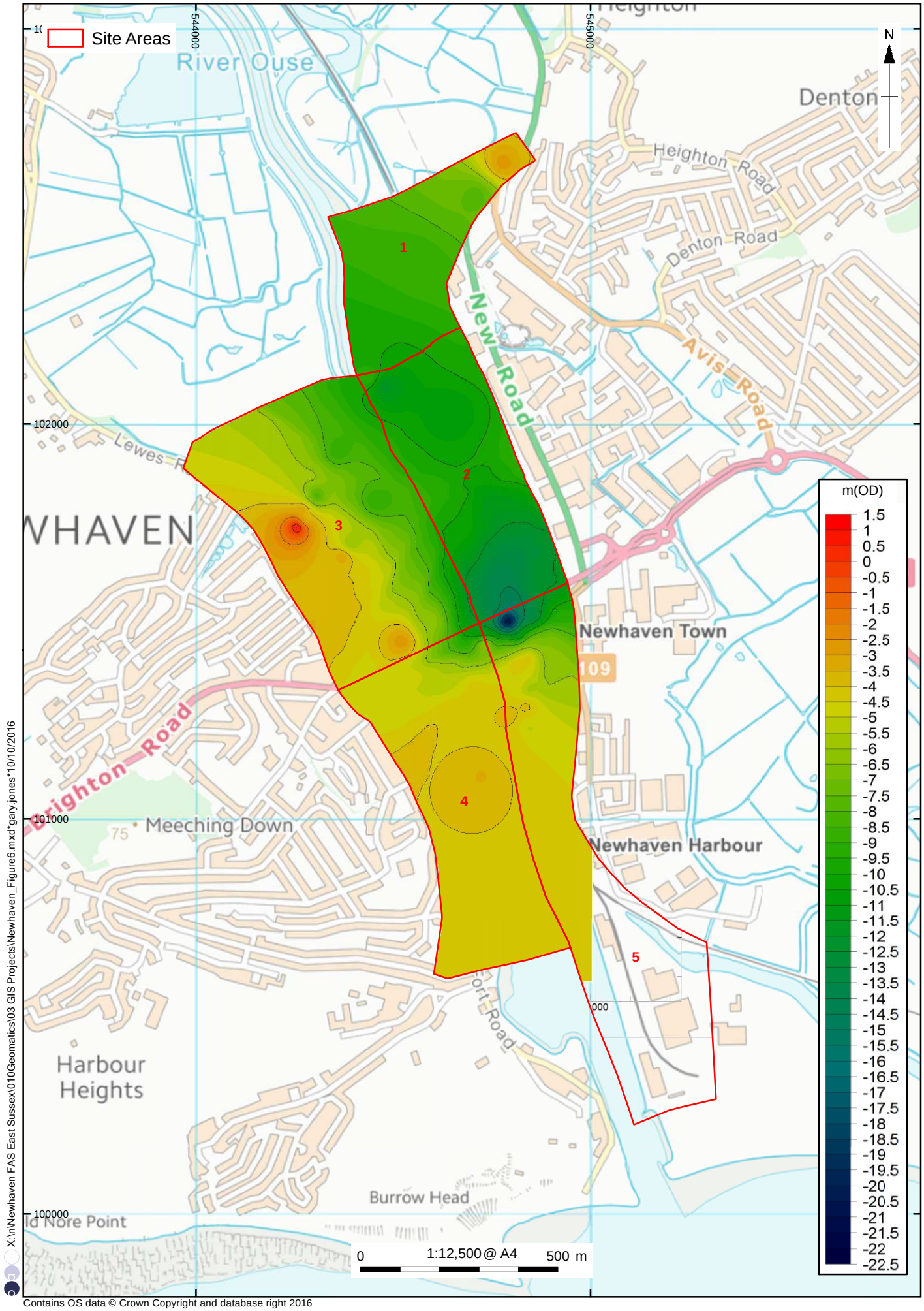

Figure 6: Modelled topography of the Head deposits

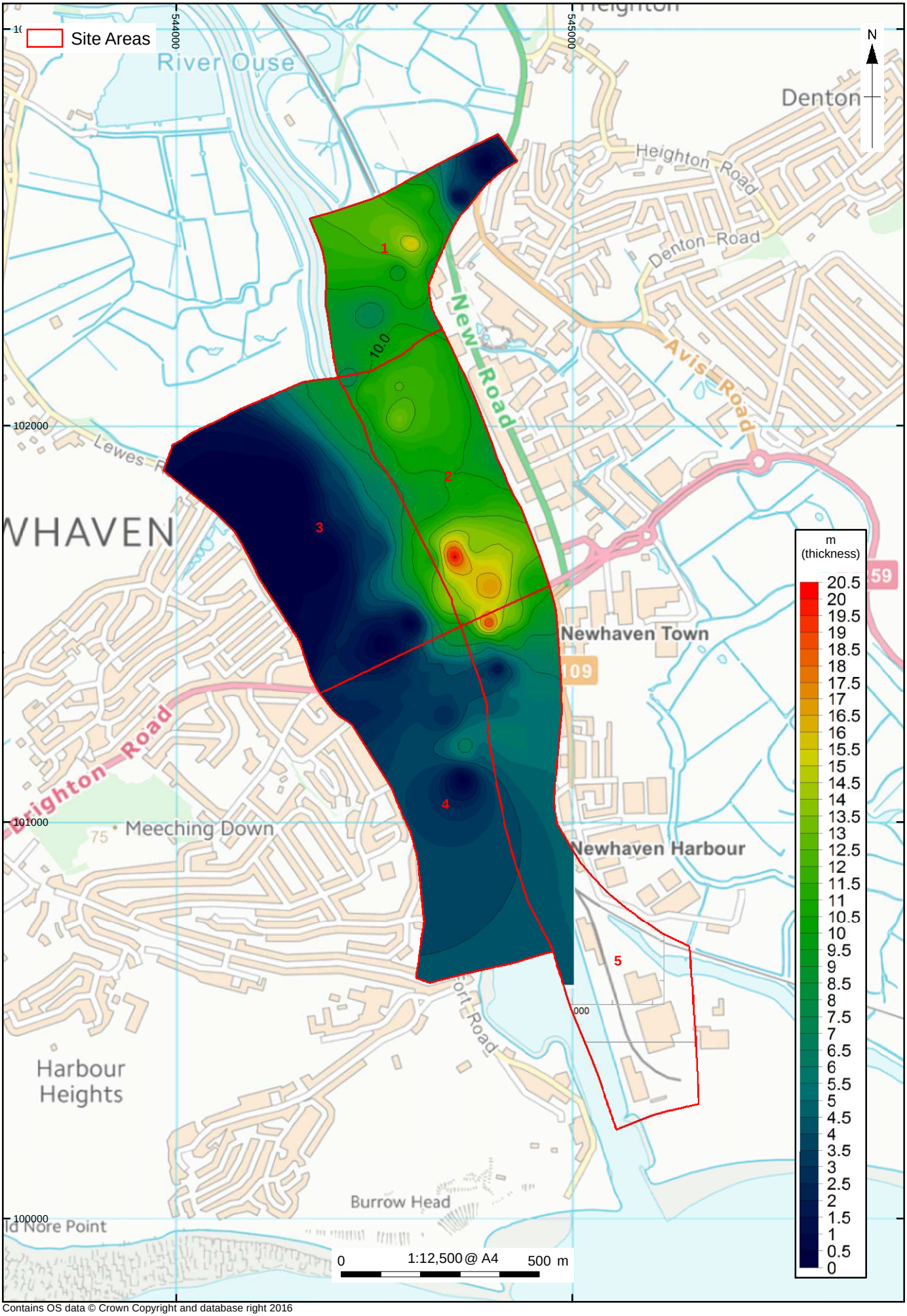

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Figure 7: Modelled thickness of the estuarine sands

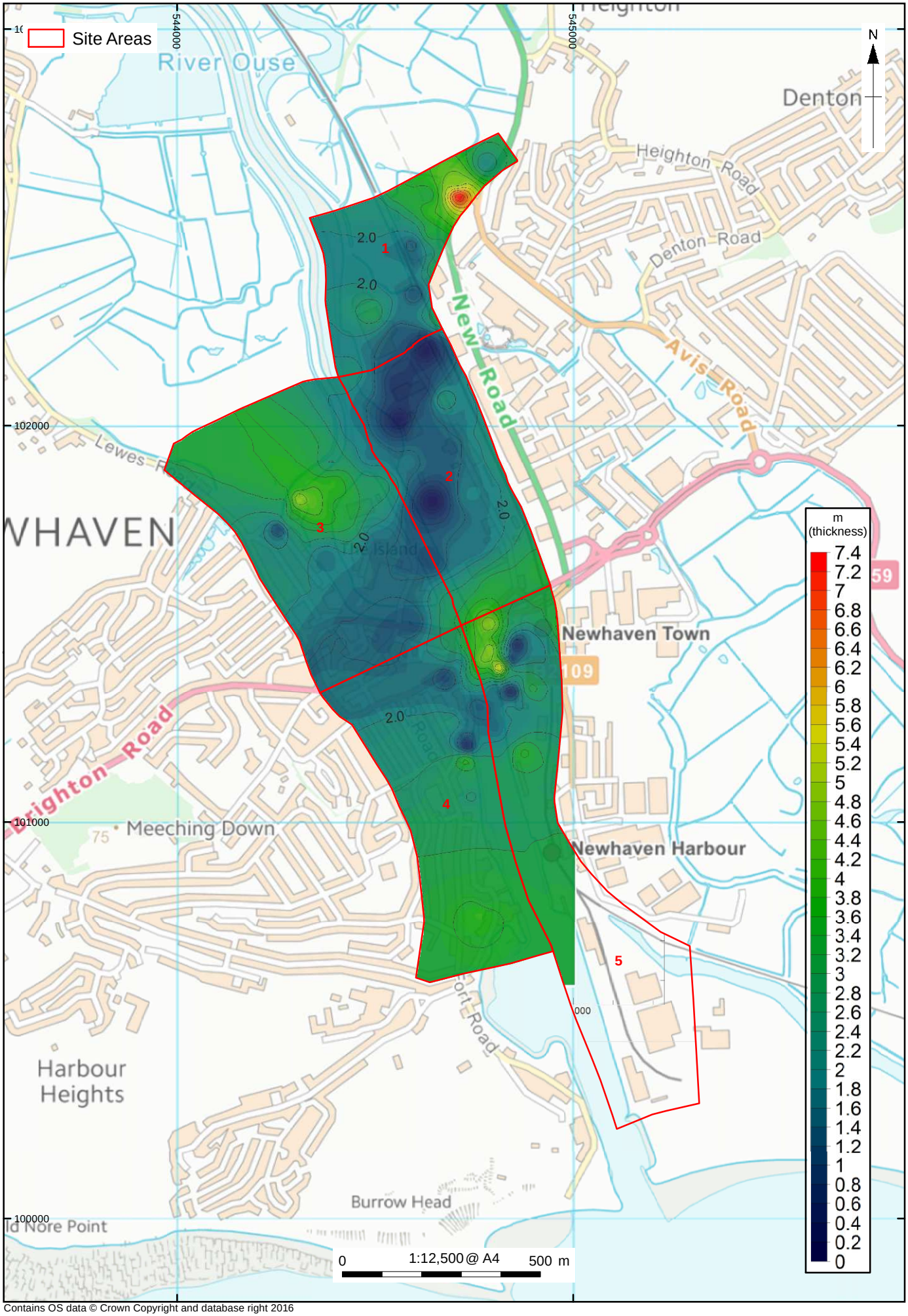

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Figure 8: Modelled thickness of the upper alluvium

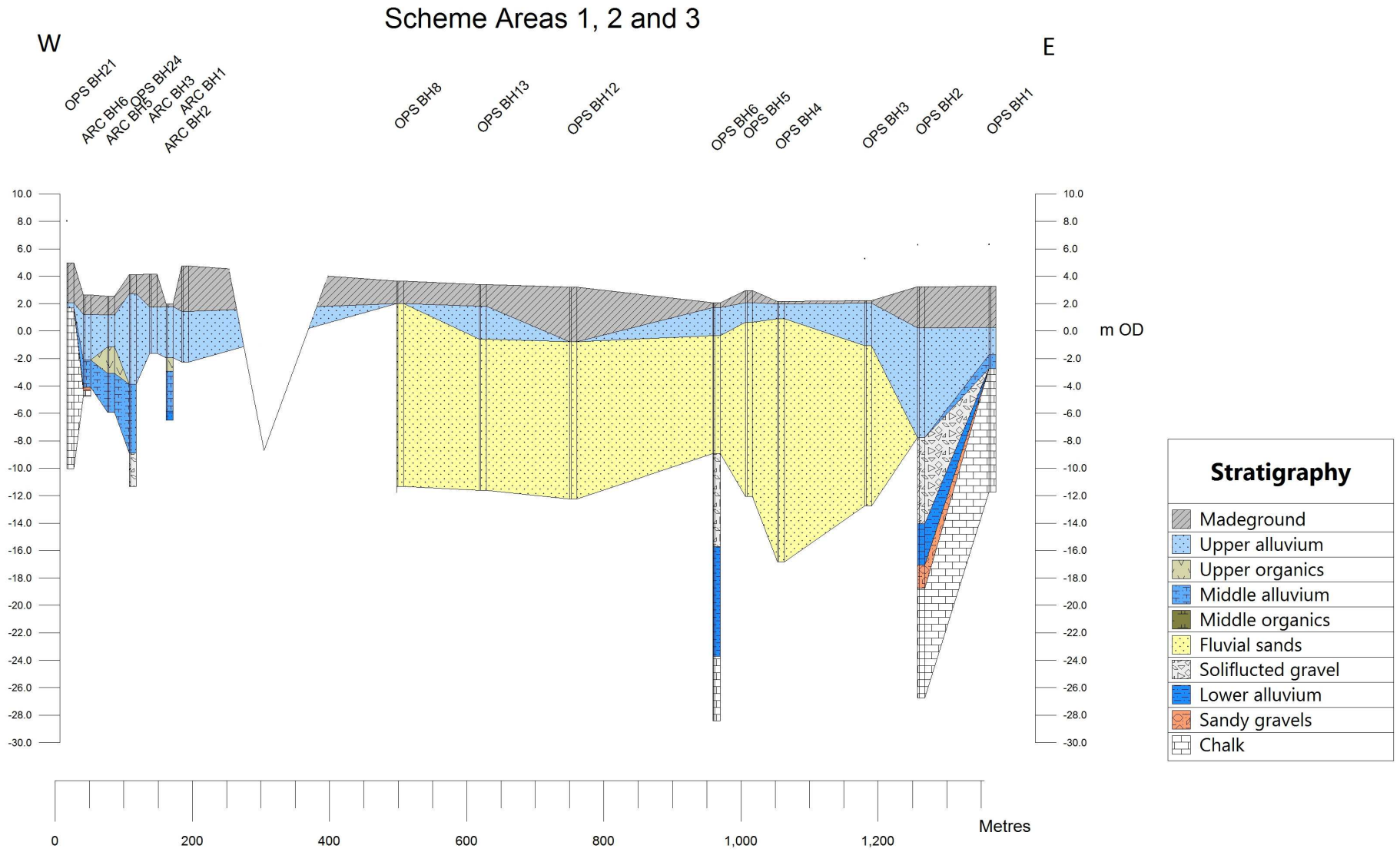

Figure 9: Cross-section of the Lower Ouse Valley

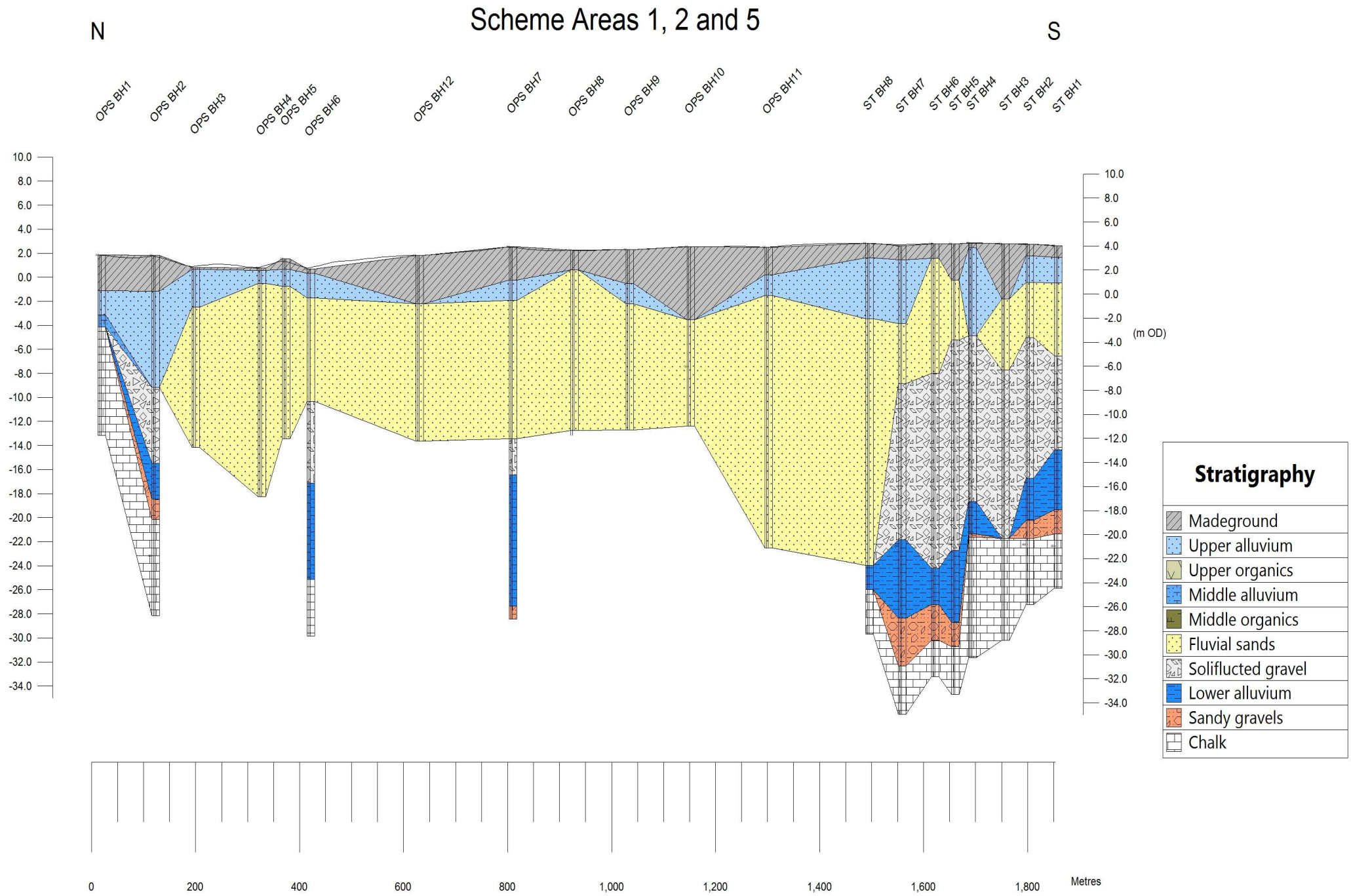

Figure 10: Cross-section of the eastern river bank

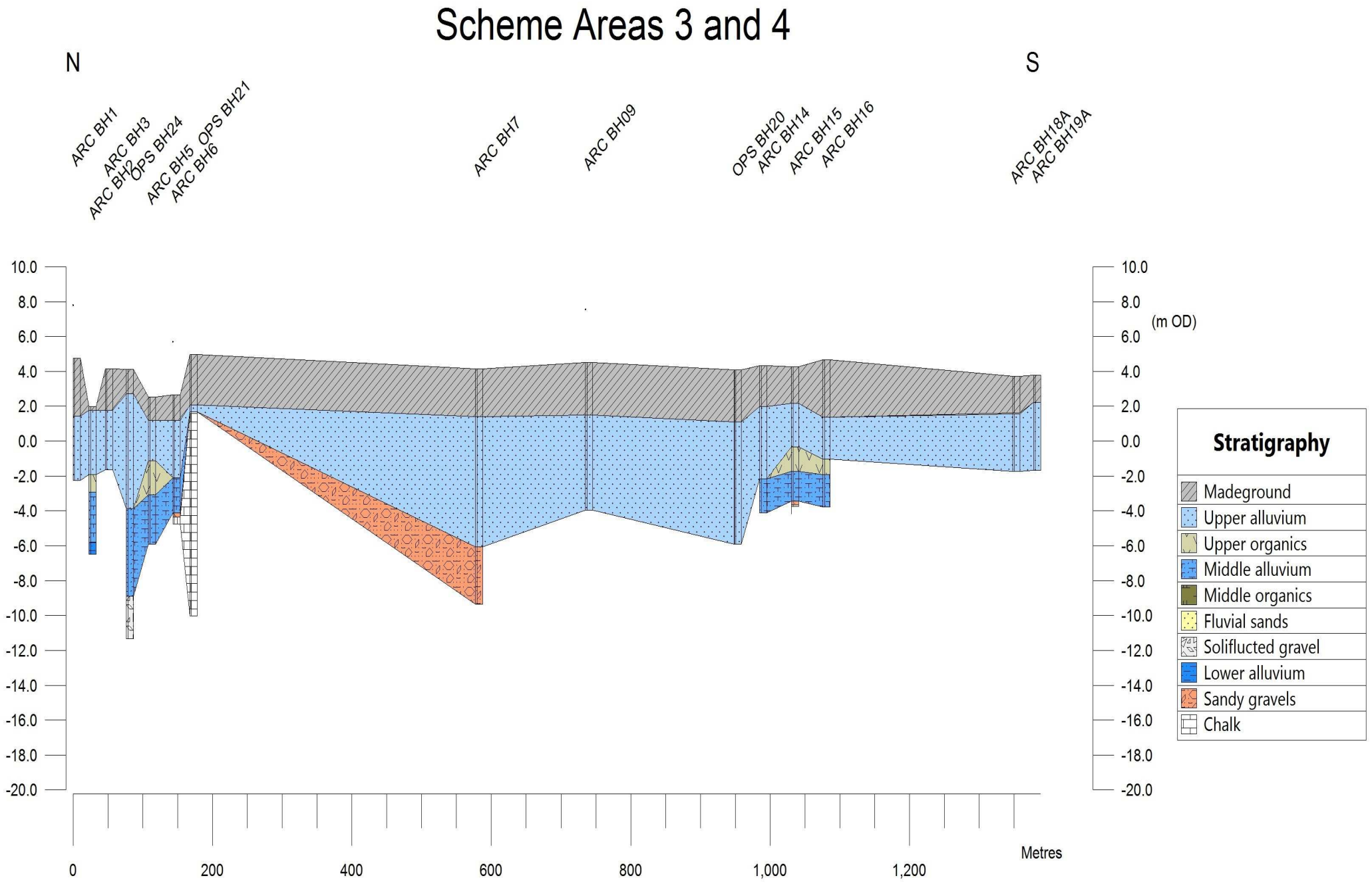

Figure 11: Cross-section of western river bank

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