PLANNING ACT 2008
INFRASTRUCTURE PLANNING
(APPLICATIONS: PRESCRIBED FORMS AND PROCEDURE) REGULATIONS 2009
REGULATION 5(2) (a)

PROPOSED PORT TERMINAL AT FORMER TILBURY POWER STATION

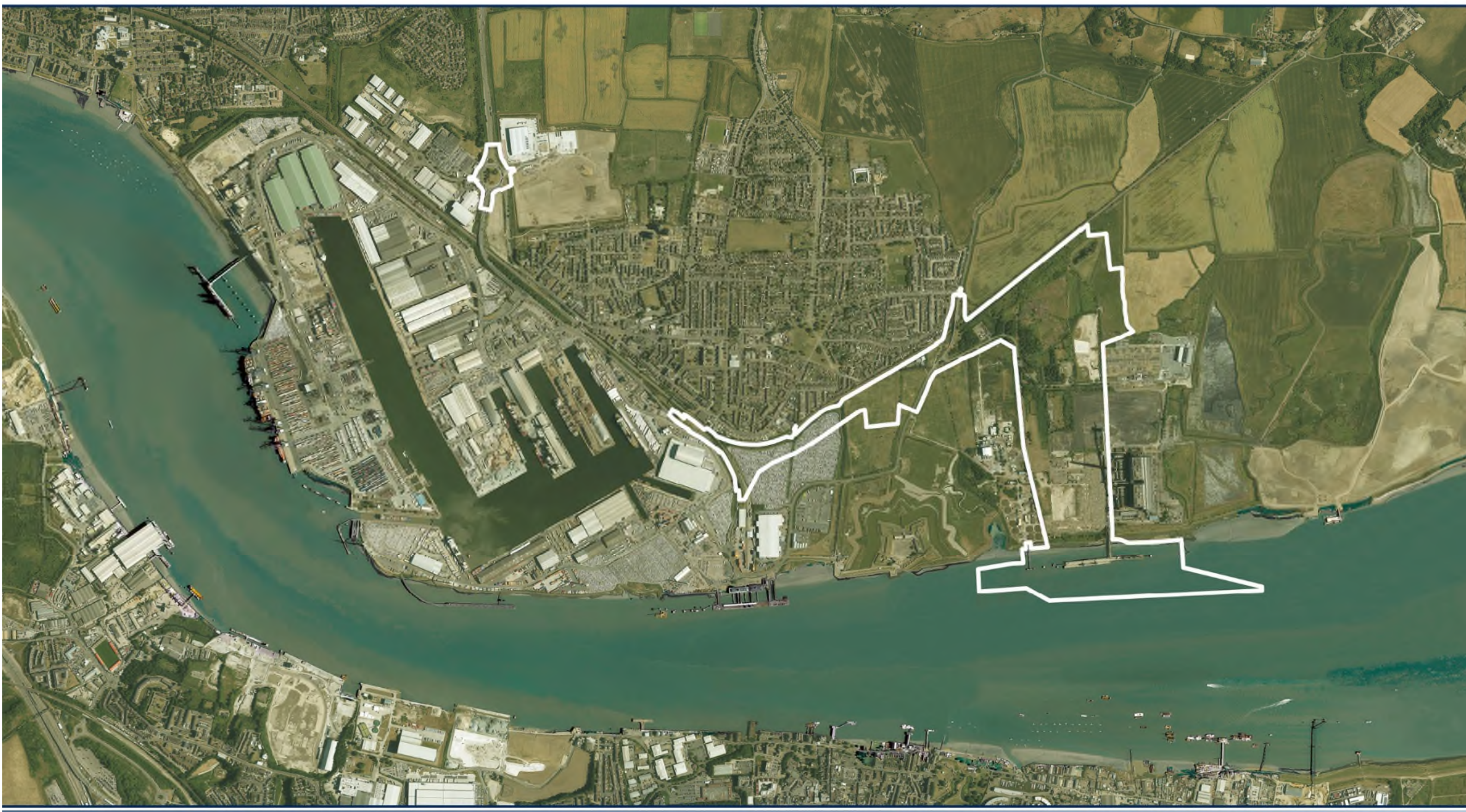
TILBURY2

TRO30003

Appendix 12A: Archaeological Statement

Errata Submission – Highlighted Changes

DOCUMENT REF: PoTLL/T2/EX/14



TILBURY2

ARCHAEOLOGICAL STATEMENT

TILBURY2
LAND AT FORMER RWE POWER STATION
TILBURY
ESSEX

October 2017

CONTENTS

1.0 ARCHAEOLOGICAL STATEMENT

1.1 This Archaeological Statement has been prepared by Suzanne Gailey of CgMs Consulting on behalf of the Port of Tilbury London and refers to the Site (Tilbury2, infrastructure corridor and sections of the tidal Thames required for the construction of expanded berthing capacity and associated dredging). The Statement summarises the archaeological baseline conditions on the Site. It is supported by the findings of an Archaeological Desk-Based Assessment (CgMs 2017 AS 1), a Geo-archaeological Deposit Model (QUEST 2017 AS 2), a Marine Archaeological Desk- Based Assessment (Wessex Archaeology 2017 AS 3), an Archaeological Watching Brief undertaken during recent remediation works (ASE 2017 AS 4) and An Archaeological Assessment of Marine Geophysical Survey Data (Wessex Archaeology 2017 AS 5).

1.2 GEOLOGY AND TOPOGRAPHY

1.2.1 The recent geoarchaeological fieldwork resulting in the updated geo-archaeological deposit model (AS 2) confirmed the sequence of sediments at the Tilbury2 site as Made Ground c0.5m to c3m thick (thickest towards the east of the site) capping a Holocene alluvial sequence of Lower Alluvium, Lower, Middle and Upper Peat and Upper Alluvium, recorded in thicknesses of between c12 and c16m across the site. The greatest depths of alluvium are recorded towards the south of the site probably as a result of slightly lower Gravel surfaces. Underlying the Holocene sequence was the Shepperton Gravels deposited during the Late Glacial and comprising the sands and gravels of a high-energy braided rivers system.

1.2.2 The Gravel surface is relatively even and lies approximately -12.5m and -15m OD. The gravel topography is typical of a braided river system with undulations in the surface of the Gravel indicative of shallow channels separating longitudinal gravel bars.

1.2.3 The sediments of the Lower Alluvium are indicative of deposition during the Early to Mid-Holocene when the surface of the Gravel was progressively buried beneath the sandy and silty flood deposits of the River Thames. The surface of the Lower Alluvium is variable but generally lies between -3m OD and -8m OD.

1.2.4 Lower Peat deposits were recorded either directly overlying the Shepperton Gravels or within the Lower Alluvium and was predominantly recorded towards the south of the Site. The recent geoarchaeological fieldwork identified two or more distinct peat horizons representing different mechanisms and ages of peat. Previously no borehole record contained evidence of more than one peat horizon (Quest 2017 AS2). These peat deposits are indicative of a transition towards marshy conditions such as saltmarsh, sedge fen/reed swamp or woodland (Section 5 Quest 2017 AS 2). Radiocarbon dating indicates that the Lower Peat accumulated from the Early to Late Mesolithic date (Section 4 Quest 2017 AS 2).

1.2.5 Middle Peat deposits were recorded generally across the Site between the Lower and Upper Alluvium. The Middle Peat is indicative of a transition towards semi-terrestrial (marshy) conditions supporting the growth of sedge fen/reed swamp and/or woodland communities (Section 5 Quest 2017 AS2). Radiocarbon dating indicates that the Middle Peat accumulated from the Early Mesolithic to Mid Neolithic date (Section 2 Quest 2017 AS 2).

1.2.6 The Upper Peat was recorded within the Upper Alluvium most located in the south of the Site. Again the Upper Peat is indicative of a localised transition toward marshy conditions supporting the grown of sedge fen/reed swamp and/or woodland communities (Section 5 Quest 2017 AS). Radiocarbon dating indicates that the Upper Peat accumulated during the Iron Age date (Section 4 Quest 2017 AS 2).

1.2.7 The recent archaeological watching brief undertaken during remediation works on Tilbury2 recorded the upper surface of Alluvium to be flat and level suggesting a degree of horizontal truncation of this deposit occurred as part of the development of the power station site (AS 4).

1.2.7 The Site is approximately level at c2.3m AOD. The presence of Made Ground indicates that the present landform is not a valid indicator of the former topography of the Site. Current ground level is entirely a product of Post-Medieval and more recent reclamation and 20th century industrial development. This is confirmed by the recent watching brief undertaken during remediation works which recorded Made Ground 0.55m and 1m deep relating to the construction of Tilbury Power Station A on reclaimed marsh land (AS 4).

1.3 ARCHAEOLOGICAL BASELINE CONDITIONS

Tilbury2 Site (Terrestrial)

1.3.1 There are no Scheduled Monuments or other designated assets on the Site. A number of designated assets lie in close proximity including Tilbury Fort (a Scheduled Monument). The potential effect on the setting of these designated assets are considered in a separate Heritage Assessment.

1.3.2 The area of Tilbury is considered to be the type site for palaeoenvironmental and relative sea level studies evidencing the environmental history of the River Thames. The recent geoarchaeological fieldwork and updated geo-archaeological deposit model (AS 2) confirms that the sediments recorded at Tilbury2 are similar to those recorded extensively in the Lower Thames Valley, comprising Late Devensian Shepperton Gravel overlain by a sequence of Holocene alluvial sediments including peat buried beneath modern Made Ground. The radiocarbon dating of the peat deposits suggest that there is a wide range of different elevations and ages of peat horizons in Tilbury indicating peat formation varies from place to place and in some places it is highly localised. Whilst in situ archaeological activity is yet to be recorded in the area, the sediments have a potential to contain further information on the past landscape through the assessment/analysis of palaeoenvironmental remains. The sequences at Tilbury 2 therefore has the potential to provide further information on past environmental change and human activity within the area as well as having the potential to contribute to the ongoing research regarding Relative Sea Level within the Lower Thames Valley (AS 2).

1.3.3 No archaeological finds or features pre-dating the Second World War have been recorded during previous terrestrial archaeological investigations on the Site (AS 1). The remains of World War II anti-glider ditches have been identified from cropmarks and an archaeological watching brief in the north of the site (AS 1). No archaeological finds or features were recorded during the recent terrestrial archaeological watching brief during remediation works (AS 4).

1.3.4 Based on the available information the Site is considered to have a low potential for prehistoric evidence (AS 1). Whilst isolated Palaeolithic flint tools might be found at depth within the gravel deposits, it is rare to find lithics of this date in a primary context associated with contemporary activity. Consequently Palaeolithic evidence of national significance is considered unlikely at the site. The remains of a late Mesolithic skeleton was found approximately 10m deep in the upper sands overlying the gravels beneath the lower peat deposits at Tilbury Docks approximately 1500m west of the Site (Schulting 2013). It is rare to find human remains dating to this period and consequently the skeleton is considered to be of national if not higher significance. The potential for human remains of this importance to be found at Tilbury2 is considered unlikely (and difficult to identify using current evaluation techniques due to the likely depth of remains) but if found would be considered to be of equivalent significance.

1.3.5 The Site appears to have lain within a reasonably exploited landscape during the Roman period (AS 1). In particular a Roman settlement (possible landing place) has been recorded c700m east of the Site and salt extraction sites have been identified across the region (AS 1). The Site therefore has a moderate potential for Roman evidence of occupation on the site in particular for evidence of salt extraction.

1.3.6 During the Saxon, Medieval and Post Medieval periods the Site comprised marshland and so settlement evidence dating to these periods is considered highly unlikely (AS 1). The Site is considered to have a low potential for Saxon or Medieval settlement evidence.

Tidal Thames within the Order Limits (Marine and Intertidal Zone)

1.3.7 A World War II pillbox lies within the intertidal zone in the South-East of the site. A line of timber stakes of unknown date are located to the west of the pillbox within the intertidal zone (AS 3).

1.3.8 A number of anomalies of uncertain origin but of 'possible' archaeological interest were identified during the assessment of marine geophysical data (AS 5). No Archaeological Exclusion Zones have been recommended for any of these anomalies and it is highly likely that many represent modern debris and natural seabed features.

1.3.9 Based on the available evidence the Intertidal zone has a low potential for the full sequence of Palaeoenvironmental deposits whilst the marine zone has no potential (AS 3 and Technical Appendix 12C). The Marine and Intertidal Zone has a low to moderate potential for archaeological assets dating from prehistoric to Post Medieval periods in particular evidence relating to the Roman occupation further east and the maritime commercial history of the Thames (AS 3). It is considered unlikely that prehistoric or Roman wreck sites of national importance will be found at the Site due to their rarity within the archaeological record but there is a moderate potential for Medieval, Post Medieval and modern wrecks although no evidence was identified during the recent geophysical survey (AS 3 and AS 5).There is a low potential for the remains of Saxon/Medieval fish traps to survive on the edge of the river. A small number of fish traps within Essex have been designated as monuments of national significance where they have been found to be in a good state of preservation, however such evidence is considered rare and so unlikely at the Site.

1.3.10 In summary the Tilbury2 and the Infrastructure corridor has a known potential for a full sequence of palaeo-environmental deposits and a low to moderate potential for prehistoric and Roman evidence. Further evidence of World War II anti-glider ditches on Tilbury2 can be anticipated. The section of the tidal Thames within the order limits has a low potential for a full sequence of palaeo-environmental deposits, a moderate potential for Roman evidence associated with the Roman occupation further east, a low potential for Saxon/Medieval fish traps, a moderate potential for Medieval, Post Medieval and Modern wreck sites and good potential for modern debris of no or limited archaeological interest.

1.4 IMPACT ON ARCHAEOLOGICAL ASSETS

1.4.1 The detailed construction methodology will not be resolved prior to submission consequently this document considers the likely worst case scenario ('Rochdale Envelope').

1.4.2 **Tilbury2 Site (Terrestrial)**

Piling

- Piles are likely to be driven piles (large displacement) or bored piles (replacement). The effects of each pile type is considered in relation to Historic England's guidance note 'Archaeology and Piling' (Historic England 2015) as follows:
  Driven Piles
  Piles can potentially cause damage to archaeological deposits through displacement of sediments both vertically and horizontally. There is a potential for 'down dragging' of deposits resulting from pile installation which appears to be localised within 1.5 pile diameters of the centre line of the pile (Historic England 2015). Piling through perched water tables has a potential for a change in recharge which could lead to the drainage of previously water logged deposits. In addition small amounts of contaminants could be carried down with the pile into underlying deposits however 'the impact that limited amounts of contaminant will have on archaeological deposits…is not likely to be excessive' (Historic England 2015).
  Bored Piles
  There will be a loss of archaeological material within the cross-section of the bore but there should not be a zone of disturbance around the hole unless obstructions are encountered which are pushed aside or dragged down. There is a potential risk that the concrete casing will damage waterlogged archaeological deposits however where concrete cures quickly and bonds with the sediment of the bore wall the potential transport of contaminated materials into the groundwater should be reduced and by installing temporary or permanent casing this potential impact can be avoided.

- The Historic England guidance advises that new piling impact should be no more than 2% of the site.

- Piled foundations will be used for the construction of the Maritime warehouse, Ro Ro Terminal workshop/admin/welfare, lighting columns, CMAT Conveyor support structure, CMAT structures, to support the Fort Road bridge and railway track, booking gate and inspection shed.

- The worst case number of these new piles across the terrestrial zone has been calculated and the resulting area of impact is 0.18% (AS 6). When taking into account the potential zone of disturbance around each pile Historic England recommend that 4x the pile area should be considered for displacement piles when considering 'loss' of archaeology. Consequently if a worst case is considered where each pile is a displacement pile, the area of impact including the zone of disturbance will be 0.70% of the Terrestrial site.

- The number of existing piles has also been calculated (AS 7) and taking into account the assumed pile area and Historic England's recommended potential zone of disturbance for displacement piles, the area of impact from the existing development is c0.19%.

- Consequently the potential cumulative impact from the existing and proposed development structures would still be less than 2% of the terrestrial site.

- Historic England guidance (2015) suggests that piling a waterlogged site could potentially effect the underlying hydrology and consequently the recharge through the alluvial sequence which may ultimately impact on the preservation of any archaeological or palaeoenvironmental remains. However the alluvium and peat deposits' sensitivity as controlled water receptor is considered to be negligible and the thick alluvium sealing the peat is likely to seal the piles during operation so if there is any moisture loss in the peat it would be localised and temporary during construction. The results of future ground water testing and a piling risk assessment will outline mitigation measures and confirm the most appropriate piling methodology to minimise effects on the controlled waters. The thick alluvium will also act to slow the migration of contamination and the future piling risk assessment will identify mitigation measures/construction methodologies necessary to further reduce the risk of contamination during piling.

- Historic England guidance (2015) suggests that in most cases isolated piles are less damaging to deposits then grouped piles of three or more as the sediment enclosed within a pile group will be more disturbed.

- The results of future ground investigations undertaken post consent will determine the final piling layout. Geoarchaeological monitoring of future ground investigations will form part of a programme of geoarchaeological mitigation measures to mitigate against the impact of piling on palaeoenvironmental remains (see Terrestrial Written Scheme of Investigation for further information at Technical Appendix 12D).

Ground Improvement

- The development is proposed to incorporate ground stabilisation/improvement. Future assessment at the design stage post consent will determine the most appropriate strategy. For the purposes of this assessment ground improvement piling is considered the worst case option due to the potential to impact palaeoenvironmental and archaeological remains preserved within the peat deposits. However the cumulative impact from any ground improvement piling works and new structural piling (as discussed above) will still sit within the 2% guidelines recommended by Historic England (Historic England 2015). Ground improvement works at the site is likely to include the excavation and replacement of Made Ground and the upper alluvial sequence. This will comprise excavation of soil and then subsequent stabilisation of this soil with a suitable material to make it safe to retain and then ultimately compacting the stabilised soil back into the ground. These works could have a direct impact on potential archaeological remains underlying the Made Ground. The depths of ground excavation will not have a direct effect on any palaeoenvironmental or archaeological remains preserved within the peat deposits.

- The results of future ground investigations undertaken post consent will determine the appropriate ground improvements strategy.

Geoarchaeological monitoring of future ground investigations will form part of a programme of geoarchaeological mitigation measures to mitigate against the potential impact of ground improvement works on palaeoenvironmental remains (see Terrestrial Written Scheme of Investigation for further information at Technical Appendix 12D).

Compression

- There is a risk of a potential indirect effect on the underlying alluvial sequence caused by compression where shallow foundations are proposed eg the proposed pavement and storage areas. However, compression of the peat deposits 'will not change their particle density or dry them out. In the case where the peat is not completely saturated, compression will decrease porosity leading to a reduction in the volume of air-filled voids relative to the volume of water-filled voids. Where the peat is fully saturated, further compression will result in a reduction of the volume of voids but those voids will remain water-filled. Thus, while the overall volume of water in the layer is reduced, the peat will remain saturated' (Suzanne White Principal Environmental Consultant Contaminated Land and Hydrogeology Atkins pers comm). Consequently the indirect effect of compression on any palaeoenvironmental and archaeological remains is therefore currently considered to be negligible.

- There is also a risk that compression of peat deposits may damage the palaeoenvironmental and archaeological remains that may be preserved within them due to the pressure the proposed development could exhibit on these deposits. However the large amount of sediment currently overlying the peat deposits will already be causing some level of compression. Consequently the indirect effect of compression on any palaeoenvironmental and archaeological remains is therefore currently considered to be negligible.

Services

- The cutting of services is likely to have a direct but localised effect on the potential archaeological remains.

1.4.3 Tidal Thames within the Order Limits (Marine and Intertidal Zone)

Piling

- Piling operations to build the upstream berth, the downstream berth (jetty A), the CMAT berth, the RoRo Pontoon and Approach bridge new jetty, berthing dolphins, link bridge and sheet piling along the northern edge of the eastern dredge box has the potential to have a localised impact on the palaeoenvironmental sequence, the anomalies of possible archaeological interest identified during the survey and any as yet to be discovered archaeological assets, if they occur, within both the intertidal and marine zones.

- Piling options will be either multipile or monopile and for the purposes of the Rochdale Envelope the impact from the multipile option will be considered. The worst case number of new piles to be used across the marine and intertidal zone has been calculated and the resulting area of impact is 0.19% (AS 7). When taking into account the potential zone of disturbance around each pile Historic England recommend that 4x the pile area should be considered for displacement piles when considering 'loss' of archaeology. Consequently if a worst case is considered where each pile is a displacement pile, the area of impact including the zone of disturbance will be 0.76% of the Marine zone.

- A recent Hydrodynamic and Sediment Study (HR Wallingford August 2017) considers the secondary impacts from the proposed piling will be small and localised and consequently a negligible effect is anticipated on the sediments protecting archaeological receptors outside the Site boundary including that part of the Scheduled fort that extends into the Thames.

Dredging

- Dredging operations within the berth and approach will have a wider impact on the palaeoenvironmental sequence, the anomalies of unknown but possible archaeological interest and any as yet to be discovered archaeological assets, if they occur within the marine zones. In relation to the downstream (CMAT) jetty, the depth of the dredging pocket will be circa 15m and cater for the largest likely bulk aggregate vessels to visit the site in the future (100,000 tonnes). The current river depth in relation to the downstream jetty varies between c-9.2m CD and c-14CD this will therefore mean that dredging will lower the riverbed by approximately c1 - c5.8m. A sheet pile wall will be installed to run along the northern edge of the dredge pocket. The RoRo berthing pocket (next to the western end of the existing jetty and around its westward extension) will require less dredging in order to create a depth of c7.88m. The current river depth in relation to the upstream jetty varies between c-5.8m CD and c-7.7m CD and so this will mean that dredging in this area will lower the river bed by approximately c0.10m to c2m.

- The dredging methodology is yet to be finalised but it will comprise backhoe dredging or water injection dredging (dispersal dredging). For the purposes of the Rochdale Envelope the impact of dispersal dredging has been considered. This is because dispersal dredging has the potential to be damaging to archaeological receptors within the dredge area and lacks the opportunity to identify and recover unexpected or previously unknown archaeological receptors buried within the silt.

- The Hydrodynamic and Sediment Study (HR Wallingford August 2017) considers the worst case secondary impacts from dispersal dredging to effect the sedimentation of a large area c 15km either side of the dredging zone, consequently there could be an effect on archaeological receptors down slope (mid channel) and potentially further down stream as the sediment is deposited there. The effect would either be beneficial (burying currently exposed receptors) or adverse (exposing receptors currently close to the surface of the river bed) however the effect will be very limited due to the small increase in sediment depth (c1-10mm).

- The proposed sheet piling should protect the integrity of the sub-tidal and intertidal bank slopes around the dredging works although this will need to be carefully designed to avoid any adverse impacts.

- Consequently therefore there should be no secondary effect on that part of the Scheduled fort that extends into the river.

1.5 CONCLUSIONS

Tilbury2 Site (Terrestrial)

1.5.1 Palaeo-environmental deposits considered to be of regional significance survive on the site (see AS 2). This significance has a low to moderate potential to increase to national significance if important palaeoenvironmental signatures are recorded during future assessment post consent.

1.5.2 Non designated assets of national significance should in line with NPS for Ports and NPPF be given the same weight as designated assets and consequently any harm to the significance of the asset should be weighed against the public benefit of the development 'recognising the greater harm to the significance of the asset the greater the justification will be needed for any loss'. In this instance as the worst case loss from the new piling falls within Historic England's acceptable range, the development will have a less than substantial harmful impact on the significance of the palaeoenvironmental deposits.

1.5.3 The proposed piled foundations will have a localised impact on the full palaeo-environmental sequence. The results of future geotechnical ground investigations and ground water monitoring (to be undertaken in detailed design and controlled by the DCO) will be used to confirm the most appropriate piling methodology and layout to minimise effects on the hydrology. Geoarchaeological monitoring of future ground investigations will form part of a programme of geoarchaeological mitigation measures to mitigate against the potential impact of piling and ground improvement works on palaeoenvironmental remains (see Terrestrial Written Scheme of Investigation for further information at Technical Appendix 12D).

1.5.4 There is a low to moderate potential for archaeological remains of a local-regional significance to survive on the Site. In addition there is a very low potential for remains of a national significance.

1.5.5 The proposed development has the potential to impact on archaeological remains of a local to regional significance. Remains of potential national significance (late

Mesolithic human remains) is considered unlikely but if present, the proposed piling would have a localised impact at most, with preservation in situ also possible if piling avoids any impact. Consequently when given due weight the impact would be considered less than substantial.

Tidal Thames within the Order Limits (Marine and Intertidal Zone)

1.5.6 Whilst peat deposits are present within the Intertidal Zone a full sequence comparable to the Terrestrial part of the site is not anticipated and the potential for Palaeoenvironmental deposits of National Significance is considered to be low. The Marine Zone has no potential.

1.5.7 There is a moderate potential for remains of Local to Regional Significance (Romano British occupation, Saxon/Medieval fish traps and Medieval-Modern wrecks). Remains of national significance (prehistoric and Roman wrecks, Prehistoric/Saxon/Medieval fish traps in very good state of preservation) are rare and considered highly unlikely based on the available information. A number of anomalies of uncertain origin but of 'possible' archaeological interest were identified during the assessment of marine geophysical data but no Archaeological Exclusion Zones have been recommended for any of these anomalies and it is highly likely that many represent modern debris and natural seabed features.

1.5.8 The proposed piled foundations will have a localised impact on palaeoenvironmental deposits that may be preserved within the peat deposits buried within the Intertidal Zone. The overall impact falls well within Historic England's acceptable range. The proposed dredging will have no palaeoenvironmental impact due to the absence of peat deposits within the Marine Zone.

1.5.9 The proposed piled foundations will have a localised impact on potential archaeological receptors of a local to regional significance and the overall impact falls well within Historic England's acceptable range. The proposed dredging will have a wider potential archaeological impact. Remains of potential national significance (Prehistoric/Saxon/Medieval fish traps in a good state of preservation, prehistoric/Roman wrecks) are considered unlikely but if present could be potentially effected by the proposed marine works. Consequently if identified during future investigations appropriate mitigation measures will be undertaken to allow for preservation in situ as an archaeological exclusion zone or if not possible then full recovery and recording will be undertaken.

1.5.10 The proposed works within the intertidal and marine zone could have a limited secondary impact (beneficial or adverse) on sediments protecting archaeological receptors mid channel downstream. The proposed works are likely to have a negligible secondary effect on that part of the Scheduled fort that extends into the River Thames.

1.6 Further Archaeological Work

1.6.1 A programme of mitigation measures will be required to mitigate against the impact on the known and potential non-designated archaeological assets. The detail of the proposed mitigation measures are set out in the Written Scheme of Investigation secured through the DCO.

AS 1

Archaeological Desk Based Assessment

(CgMs October 2017)

ARCHAEOLOGICAL DESK-BASED ASSESSMENT

TILBURY2 SITE
LAND AT FORMER RWE POWER STATION
TILBURY
ESSEX

OCTOBER 2017

Planning Authority:
Thurrock District Council

Site centred at:
TQ6570075951

Author:
Suzanne Gailey BA (Hons) MA MCIFA

Report Status:
Final

Issue Date:
October 2017

CgMs Ref:
22460

CONTENTS

LIST OF ILLUSTRATIONS

LIST OF PLATES

EXECUTIVE SUMMARY

There are no Scheduled Monuments or other designated assets on the Site. A number of designated assets lie in close proximity to the Site including Tilbury Fort (Scheduled Monument). The potential effect on the setting and significance of these designated assets will be considered in a separate Heritage assessment.

The area of Tilbury is considered to be the type site for palaeo-environmental and Relative Sea Level studies evidencing environmental history of the River Thames. Geo-archaeological investigations on the Tilbury2 site have identified important palaeo-environmental deposits. A separate Geoarchaeological Deposit Model considers this aspect in more detail.

The remains of World War II anti-glider ditches have been identified from cropmarks and an archaeological watching brief in the north of the Site. No archaeological finds or features pre-dating the Second World War have been recorded during a number of previous archaeological investigations on the Site.

On the basis of the available information the proposals have the potential to impact on underlying archaeological deposits of a local to regional significance. The proposed piling will have a localised impact on the palaeo-environmental sequence of a known regional and potential national significance.

Consequently on the basis of the available information further archaeological matters should form part of the DCO application for the proposals.

1.0 INTRODUCTION AND SCOPE OF STUDY

1.1 This Archaeological Desk Based Assessment has been prepared by Suzanne Gailey of CgMs Consulting on behalf of the Port of Tilbury London Ltd.

1.2 The subject of this assessment, also referred to as the study site, is land at Tilbury2 Site, Tilbury, Essex and the infrastructure corridor. The study site is approximately 81.6ha in extent and is centred on National Grid Reference TQ6570075951 (Fig. 1).

1.3 The project constitutes a Nationally Significant Infrastructure Project (NSIP) and consequently in line with the National Policy Statement for Ports (NPS) as well as the National Planning Policy Framework (NPPF), this assessment draws together the available archaeological, historic, topographic and land-use information in order to clarify the significance of archaeological assets on the site and to identify any archaeological interest on the site.

1.4 Additionally, in accordance with the 'Standard and Guidance for Historic Environment Desk-Based Assessments' (Chartered Institute for Archaeologists 2014), the assessment includes an examination of published and unpublished material and charts historic land-use through a map regression exercise. A site visit was undertaken in August 2016.

1.5 As a result, the assessment enables relevant parties to assess the significance of archaeological assets on and close to the Site, assesses the potential for hitherto undiscovered archaeological assets and thus enable potential impacts on assets to be identified along with the need for design, civil engineering or archaeological solutions.

2.0 PLANNING BACKGROUND AND DEVELOPMENT PLAN FRAMEWORK

2.1 National Policy Statement for Ports

2.1.1 In 2012 the government published the National Policy Statement for Ports (NPS).

2.1.2 Section 5.12 of the NPS considers the potential environmental effects on the historic environment. It describes heritage assets as 'the elements of the historic environment that hold value to this and future generations because of their historic, archaeological, architectural or artistic interest..' and describes significance as 'the sum of the heritage interest that a heritage asset holds..'.

2.1.3 Designated heritage assets are World Heritage Sites, Scheduled Monuments, Listed Buildings, Protected Wreck Sites, Protected Military Remains, Registered Parks and Gardens, Registered Battlefields and Conservation Areas.

2.1.4 Non-designated assets of equivalent status should be subject to the same policy considerations as designated heritage assets

2.1.5 The impacts on non-designated heritage assets of lesser value should also be considered where it is has been demonstrated that these assets have a significance that merit consideration as part of the decision making process.

2.1.6 The direct and indirect impacts of port development on underwater buried features through dredging, dredge spoil deposition, marine landing construction etc should also be considered.

2.1.7 Paragraph 5.12.6 of the NPS requests that the applicant provide a level of detail 'proportionate to the importance of the heritage assets and no more than is sufficient to understand the potential impact of the proposal on the significance of the asset. As a minimum the applicant should have consulted the relevant Historic Environment Record and assessed the heritage assets themselves using expertise where necessary according to the proposed developments impact'.

2.1.8 Paragraph 5.12.7 of the NPS requests that where the development site has the potential to include heritage archaeological assets, the applicant 'should carry out an appropriate desk based assessment and where such desk based research is insufficient to properly assess the interest, a field evaluation'.

2.1.9 Where loss of the whole or part of the significance of a known heritage asset is justified on the merits of the new development, the decision maker should consider imposing a condition on the consent to record and enhance the understanding of the assets significance before it is lost. The extent of the requirement should be proportionate to the nature and level of the assets significance and should be undertaken in accordance with a Written Scheme of Investigation. Where the development site has the potential to include as yet undiscovered archaeological heritage assets, the decision maker should consider requirements to ensure that appropriate measures are in place to record such assets prior to and during construction.

2.2 Marine Planning

2.2.1 The UK Marine Policy Statement sets out High Level Marine Objectives for ensuring that marine resources are used in a sustainable way. It was published by the government in 2011.

2.2.2 Section 2.6.6 relates to the Historic Environment in marine planning and advises that heritage assets should be conserved through marine planning in a manner appropriate and proportionate to their significance.

2.2.3 Designated heritage assets in coastal/intertidal zones are inshore/offshore waters may include Scheduled Monuments, Protected Wreck Sites and sites designated under the protection of Military Remains Act 1986. Non designated heritage assets of equivalent status should be considered under the same policy principles as designated heritage assets.

2.2.4 Where the loss of the whole or material part of a heritage asset's significance is justified suitable mitigation measures should be in place. Requirements should be based on advice from relevant regulators and advisors.

2.3 National Planning Policy Framework

2.3.1 In March 2012, the government published the National Planning Policy Framework (NPPF), this was supplemented by Planning Practice Guidance (PPG) in March 2014.

2.3.2 Section 12 of the NPPF, entitled *Conserving and enhancing the historic environment* provides guidance for planning authorities, property owners, developers and others on the conservation and investigation of heritage assets. Overall, the objectives of Section 12 of the NPPF can be summarised as seeking the:

- Delivery of sustainable development

- Understanding the wider social, cultural, economic and environmental benefits brought by the conservation of the historic environment
- Conservation of England's heritage assets in a manner appropriate to their significance, and
- Recognition of the contribution that heritage assets make to our understanding of the past.

2.3.3 Section 12 of the NPPF recognises that intelligently managed change may sometimes be necessary if heritage assets are to be maintained for the long term. Paragraph 128 states that planning decisions should be based on the significance of the heritage asset and that the level of detail supplied by an applicant should be proportionate to the importance of the asset and should be *no more than sufficient* to review the potential impact of the proposal upon the significance of that asset.

2.3.4 *Heritage Assets* are defined in Annex 2 of the NPPF as: a building, monument, site, place, area or landscape positively identified as having a degree of significance meriting consideration in planning decisions. They include designated heritage assets (as defined in the NPPF) and assets identified by the local planning authority during the process of decision-making or through the plan-making process.

2.3.5 Annex 2 also defines *Archaeological Interest* as a heritage asset which holds or potentially could hold evidence of past human activity worthy of expert investigation at some point. Heritage assets with archaeological interest are the primary source of evidence about the substance and evolution of places, and of the people and cultures that made them.

2.3.6 A *Designated Heritage Asset* comprises a: World Heritage Site, Scheduled Monument, Listed Building, Protected Wreck Site, Registered Park and Garden, Registered Battlefield or Conservation Area.

2.3.7 *Significance* is defined as: The value of a heritage asset to this and future generations because of its heritage interest. This interest may be archaeological, architectural, artistic or historic. Significance derives not only from a heritage asset's physical presence, but also from its setting.

2.3.8 In short, government policy provides a framework which:

- Protects nationally important designated Heritage Assets (which include World Heritage Sites, Scheduled Ancient Monuments, Listed Buildings, Protected Wreck Sites, Registered Parks and Gardens, Registered Battlefields or Conservation Areas)
- Protects the settings of such designations
- In appropriate circumstances seeks adequate information (from desk based assessment and field evaluation where necessary) to enable informed decisions
- Provides for the excavation and investigation of sites not significant enough to merit *in-situ* preservation.

2.4 **Thurrock Local Development Framework (LDF)**

2.4.1 The Thurrock Core Strategy was adopted in December 2011 and contains the following policy relating to the historic environment:

PMD4 - HISTORIC ENVIRONMENT
THE COUNCIL WILL ENSURE THAT THE FABRIC AND SETTING OF HERITAGE ASSETS, INCLUDING LISTED BUILDINGS, CONSERVATION AREAS, SCHEDULED ANCIENT MONUMENTS AND OTHER IMPORTANT ARCHEOLOGICAL SITES, AND HISTORIC LANDSCAPE FEATURES ARE APPROPRIATELY PROTECTED AND ENHANCED.
1. THE COUNCIL WILL ALSO REQUIRE NEW DEVELOPMENT TO TAKE ALL REASONABLE STEPS TO RETAIN AND INCORPORATE NON-STATUTORILY PROTECTED HERITAGE ASSETS CONTRIBUTING TO THE QUALITY OF THURROCK'S BROADER HISTORIC ENVIRONMENT.
2. APPLICATIONS MUST DEMONSTRATE THAT THEY CONTRIBUTE POSITIVELY TO THE SPECIAL QUALITIES AND LOCAL DISTINCTIVENESS OF THURROCK, THROUGH COMPLIANCE WITH LOCAL HERITAGE GUIDANCE INCLUDING:
I. CONSERVATION AREA CHARACTER APPRAISALS;
II. CONSERVATION AREA MANAGEMENT PROPOSALS;
III. OTHER RELEVANT THURROCK-BASED STUDIES, INCLUDING THE LANDSCAPE CAPACITY STUDY (2005), THE THURROCK URBAN CHARACTER STUDY (2007) AND THE THURROCK UNITARY HISTORIC ENVIRONMENT CHARACTERISATION PROJECT (2009).
IV. FURTHER LOCAL GUIDANCE AS IT IS DEVELOPED.
3. THE COUNCIL WILL FOLLOW THE APPROACH SET OUT IN 'PPS 5: PLANNING FOR THE HISTORIC ENVIRONMENT' IN THE DETERMINATION OF APPLICATIONS AFFECTING THURROCK'S BUILT OR ARCHAEOLOGICAL HERITAGE ASSETS. THIS WILL INCLUDE CONSIDERATION OF ALTERATIONS, EXTENSIONS OR DEMOLITION OF LISTED BUILDINGS OR THE DEMOLITION OF UNLISTED BUILDINGS WITHIN CONSERVATION AREAS, AND REQUIREMENTS FOR PRE-DETERMINATION ARCHAEOLOGICAL EVALUATIONS AND FOR PRESERVATION OF ARCHAEOLOGY *IN SITU* OR BY RECORDING.

2.5 In line with the requirements set out in paragraphs 5.12.6 and 5.12.7 of the NPS and paragraph 128 of NPPF, this assessment has been prepared to examine the available archaeological and historical evidence to establish the archaeological potential of the site and to establish whether field assessment is 'necessary' to allow for an informed planning decision.

2.6 No Scheduled Monuments or other designated heritage assets lie on the study site. Tilbury Fort (Scheduled Monument) lies approximately 200m west of the study site at its closest point. The closest Listed Building is the Officers Barracks that lie within Tilbury Fort. The setting of these designated heritage assets will be considered in a separate Heritage Statement.

2.7 A separate Marine Desk-Based Assessment has been prepared in line with the requirements of the UK Marine Policy Statement and paragraph 5.12.8 of the NPS (Wessex Archaeology 2017).

2.8 The Thurrock Unitary Historic Environment Characterisation Project records the landscape character area of the application site as having a high potential for palaeo-environmental deposits (ECC 2009).

3.0 GEOLOGY AND TOPOGRAPHY

3.1 Geology

3.1.1 The Site is shown by the British Geological Survey on solid deposits of Seaford Chalk Formation and Newhaven Chalk Formation which is overlain by Alluvium – Clay, Silty, Peaty, Sandy formed out of the floodplain of the River Thames.

3.1.2 A number of geoenvironmental and geotechnical ground investigations have been undertaken across Tilbury2 (DBA 1 and Halcrow Group Ltd 2007, Structural Soils Ltd 2013, Vertase Ltd 2014, RPS 2015). Boreholes from the site record a sequence which comprises Made Ground ranging in thickness between 0.2m and 3.3m (thicker areas were identified closer to the east) overlying alluvial deposits comprising clay/silt with frequent layers of peat and organic material ranging in thickness of between 13.3m and 15.7m. Peat bands up to 1.6m in thickness were encountered in a large number of the boreholes excavated. River Terrace Gravels were recorded underlying the Alluvium ranging in thickness between 2m-8.7m thick and the Gravels in turn sealed the Seaford and Newhaven Chalk Formation (RPS 2015).

3.1.3 The recent geoarchaeological fieldwork and updated deposit model (Quest 2017) confirms the sequence of sediments at the Tilbury2 site as Made Ground c0.5m to c3m thick (thickest towards the east of the site) capping a Holocene alluvial sequence of Lower Alluvium, Lower, Middle and Upper Peat and Upper Alluvium, recorded in thicknesses of between c12 and c16m across the site. The greatest depths of alluvium are recorded towards the south of the site probably as a result of slightly lower Gravel surfaces. Underlying the Holocene sequence was the Shepperton Gravels deposited during the Late Glacial and comprising the sands and gravels of a high-energy braided rivers system.

3.2 Topography

3.2.1 The Tilbury2 Site lies within the Tilbury Marshes on the north bank of the River Thames.

3.2.2 The Tilbury2 Site is approximately level at c2.5m AOD. The presence of Made Ground indicates that the present landform is not a valid indicator of the former topography of the site. Current ground level is entirely a product of Post-Medieval and more recent reclamation and 20th century industrial development.

3.2.3 In periods of marine transgression (sea level rise) the Site would have become increasingly saline and prone to regular inundation by seasonal and tidal high water. In-turn these conditions affected the southward drainage of rivers and streams running off the gravel terraces of south– west Essex. However, in phases of marine regression, stable land surfaces capable of supporting farming/grazing prevailed. The result is an area which, through time, has changed from well drained land to estuarine conditions, with extensive mud flats criss-crossed with brackish streams and, with increasing efforts from man, the stabilisation of a zone of pasture with a maze of streams, open drains and ditches.

4.0 ARCHAEOLOGICAL AND HISTORICAL BACKGROUND, INCLUDING AN ASSESSMENT OF SIGNIFICANCE

Timescales used in this report:

Prehistoric		
Palaeolithic	450,000 -	12,000 BC
Mesolithic	12,000 -	4,000 BC
Neolithic	4,000 -	1,800 BC
Bronze Age	1,800 -	600 BC
Iron Age	600 -	AD 43
Historic		
Roman	AD 43 -	410
Saxon/Early Medieval	AD 410 -	1066
Medieval	AD 1066 -	1485
Post Medieval	AD 1486 -	AD1799
Modern	AD 1800 -	Present

4.1 Introduction

4.1.1 Archaeological information from a 'study area' comprising land within a 2km radius of the centre of the Tilbury2 Site held in the Essex and Kent Historic Environment Record (HER) has been collected and reviewed (DBA 3). In addition past geotechnical, archaeological and geo-archaeological investigations have been undertaken on the study site (DBA 1, DBA 2 and DBA 4).

4.1.2 This chapter reviews existing archaeological evidence for the Tilbury2 Site and the archaeological/historical background of the general area, and, in accordance with NPPF, considers the potential for as yet undiscovered archaeological evidence on the site.

4.1.3 Chapter 5 subsequently considers the site conditions and whether the proposed development will impact on the theoretical archaeological potential identified below.

4.2 Palaeolithic

4.2.1 This section of the Lower Thames Valley is one of the archaeologically richest in the country for evidence of the Palaeolithic period. Many finds of flint hand-axes and other flint tools and debris have been recovered from Gravel Terrace deposits bordering the Thames (Wymer 1999).

4.2.2 An isolated piece of worked flint of possible Palaeolithic date was found at Tilbury Dock in the early 20th century approximately 500m west of the Tilbury2 Site at its closest point (1784 TQ652753). A pointed hand-axe was found in Tilbury town approximately 750m north-west of the north-western part of the Tilbury2 Site (1730 TQ646767). An isolated hand axe was also found in Tilbury Town approximately 250m north of the western most part of the Site (1778 TQ644760). The HER records 'Palaeolithic implements found at Tilbury' the precise provenance of which is unknown, but the HER provides a generic findspot in the western 'arm' of the Tilbury2 Site (1669 TQ6576).

4.2.3 An isolated Palaeolithic axe was recorded at Gun Hill gravel pit approximately 1250m north of the Tilbury2 Site (1786 TQ655779), West Tilbury approximately and at Chadwell St Mary approximately 1500m north-west of the Tilbury2 Site (18617 TQ648779).

4.2.4 These isolated finds are indicative of at least a sporadic low-level human activity during the Palaeolithic period in the area. The presence of further evidence of isolated lithics buried at depth is possible though their potential to be found in situ associated with other remains of archaeological interest is considered remote.

4.3 **Mesolithic/Neolithic/Bronze Age/Iron Age**

4.3.1 From the beginning of the Holocene, the River Thames underwent a gradual transition from a braided river system to a single meandering channel and the chalk and gravel was progressively buried under deep alluvial deposits as a result of relative sea rise. In some areas where deep gravel deposits have been recorded, including the Tilbury2 site, peat accumulation dating to the Mesolithic period have been identified underlying the alluvial sedimentation. During the course of the Holocene, further periods of stabilisation of the valley floor and changes in sea level are indicated in the Tilbury area by peat horizons. The peat deposits have been shown to provide significant palaeoenvironmental information providing detail of environmental and landscape change during the prehistoric periods (Quest 2013 and 2017). Although evidence of prehistoric archaeology is limited in the Lower Thames Valley, the paleoenvironmental record indicates woodland clearance, cultivation and animal husbandry was taking place which suggests the presence of prehistoric farming settlements close-by.

4.3.2 Residual worked flints dating to the Mesolithic period were found during excavations at Gun Hill approximately 1250m north of the Tilbury2 Site (1787 TQ655779).

4.3.3 In the late 19th century the remains of a Mesolithic skeleton was found approximately 10m deep in the upper sands overlying the gravels beneath the lower peat deposits at Tilbury Docks c1500m west of the Tilbury2 Site (Schulting 2013 1721 TQ641751).

4.3.4 A Neolithic flint axe was found in West Tilbury Marsh immediately to the south of the north-western part of the Tilbury2 Site (1808 TQ652760).

4.3.5 Residual worked flints dating to the Neolithic period were recorded during excavations at Gun Hill approximately 1250m north of the Tilbury2 Site (1788 TQ655779). A Neolithic arrowhead and a flint axehead was found in Tilbury although the precise provenance of either find is unknown (1670 TQ6777 1639 TQ6476).

4.3.6 Excavations at Gun Hill on the site of a cropmark complex recorded evidence of Bronze Age and Iron Age settlement activity approximately 1250m north of the Tilbury2 Site (1789 1790 TQ655779 1797 TQ654777).

4.3.7 No evidence of later prehistoric activity has been recorded within the immediate vicinity of the Tilbury2 Site and the Tilbury2 Site's location on the Thames floodplain suggests that evidence of settlement is unlikely.

4.3.8 Consequently, the Tilbury2 Site is considered to have a low potential for prehistoric settlement evidence. No finds were identified during the archaeological watching brief undertaken by Wessex Archaeology during previous geotechnical investigations across the site (DBA 2). Evidence of early prehistoric human remains though possible based on the findings at Tilbury Docks, is considered unlikely based on their rarity within the archaeological record and would be difficult to identify due to the likely depth of survival.

4.3.9 The palaeoenvironmental potential at the Tibury2 Site is considered to be very good and further assessment including desk based research, field investigations and radiocarbon dating has been undertaken in a separate Geoarchaeological report (Quest 2017).

4.4 **Roman**

4.4.1 The Tilbury2 Site appears to have lain within an area that was reasonably heavily exploited during the Roman period.

4.4.2 Roman burials with associated grave goods were found in West Tilbury (the precise provenance is unknown, but the HER records a generic point approximately 300m north-east of the north-eastern part of the Site (1672 TQ6677). However, it is likely to have been located on the gravel terraces further north. The HER records a fragment of a Roman lamp closeby, but again the precise provenance is unknown (18615 TQ6677).

4.4.3 Roman pottery sherds were recorded along the Thames foreshore approximately 400m east of the south-east of the Site (1828 TQ665754 1734 TQ666755). These finds may be associated with the remains of a Roman settlement recorded approximately 700m east of the south-east of the Site (1694 TQ672756). The settlement comprised a number of hut circles, a trackway and an oven and a large assemblage of pottery sherds including Samian ware. The settlement was possibly a landing–place for traffic from Kent or elsewhere. Further east, a salt extraction site was identified based on evidence of waste briquetage and Roman pottery. Roman Red hills were also recorded at Bowaters Farm approximately 1500m east of the Tilbury2 Site (1745 TQ675768). Roman remains identified as a possible Red hill site is recorded on the marshes approximately 1250m east of the Tilbury2 Site (1829 TQ67137651).

4.4.4 'Roman remains' were also found at Tilbury Fort approximately 700m west of the Tilbury2 Site including Samian ware and fibulae (1783 TQ64727510 1785 TQ650751) whilst to the east of the Tilbury2 Site a large assemblage of Roman pottery was found along the foreshore including Samian ware suggesting a population of some density (1735 TQ667756) closeby.

4.4.5 The excavations undertaken at Gun Hill confirmed that occupation continued into the early Roman period when a series of Roman kilns were identified. By the later Roman period the area had reverted to agricultural activity (1791 TQ655779).

4.4.6 Isolated finds of Roman pottery were found in a gravel pit approximately 750m north-east of the Tilbury2 Site (1693 TQ66547750) and a single isolated coin was found in Tilbury approximately 750m north of the westernmost part of the Tilbury2 Site (1716 TQ644766).

4.4.7 On the other side of the river a substantial Roman settlement site was identified during excavations approximately 1200m south-west of the Tilbury2 Site (TQ67SW110 TQ647744).

4.4.8 Based on the available evidence the potential for Roman evidence on the Tilbury2 Site, particularly evidence for salt extraction is considered to be moderate.

4.5 Saxon and Medieval

4.5.1 In c 628 Tilbury was recorded as being the location of Bishop Cedda's Palace. The site of the Palace is thought to be the series of earthworks, a Scheduled Monument, near St James Church at West Tilbury approximately 1.5km north of the Tilbury2 Site (1674 TQ660777).

4.5.2 An isolated Anglo Saxon bronze bowl was found in Tilbury although the precise provenance is unknown (1650 TQ6477).

4.5.3 A possible Anglo Saxon settlement was identified during the excavations at Gun Hill approximately 1250m north of the Tilbury2 Site (1792).

4.5.4 Tilbury (East and West) is mentioned three times in the Domesday Survey of 1086.

4.5.5 The Tilbury2 Site lay in uninhabited coastal salt marsh, a length of the Medieval sea wall is thought to survive approximately 450m east of the Tilbury2 Site (1827 TQ66557575).

4.5.6 Overall the potential for Saxon and Medieval evidence of settlement activity is considered to be low.

4.6 Post-Medieval and Modern

4.6.1 Tilbury Fort lies approximately 200m west of Tilbury2 Site at its closest point and was originally constructed as a blockhouse and part of Henry VIII's defences in mid-16th century. It was subsequently rebuilt in 17th century following the Dutch raids as a 'star fort' with an improved artillery battery, bastions and a double moat (1678). It was subsequently expanded and updated as recently as the Second World War and is currently owned by English Heritage and protected as a Scheduled Monument (the effect on the setting of the monument will be considered in a separate report).

4.6.2 The foundations of the former Tudor blockhouse at Milton were identified during excavations on the Kent side of the river approximately 1km south of the Tilbury2 Site (TQ67SE32 TQ65507429). The remains of the Tudor blockhouse at Gravesend are protected as a Scheduled Monument on the Kent side of the river approximately 1km south-west of the Tilbury2 Site (TQ67SW5 TQ64997440) (the effect on the setting of the monument will be considered in a separate report).

4.6.3 The former site of Tilbury market place was sited close to the ferry crossing and the Worlds End Inn to the south-west of the Fort (48401 TQ65167575).

4.6.4 During the Post-Medieval period the Tilbury2 Site was occupied by the marshes. Marsh Farm was located on land immediately adjacent to the Site to the south and west. An archaeological watching brief recorded the remains of wall foundations and posts associated with the farm prior to the construction of the water treatment works (45888 TQ65547561). Ridge and Furrow were recorded during an earthwork survey of land which included the western part of the Tilbury2 Site (19506 TQ64527564).

4.6.5 Post-Medieval oyster beds were recorded c250m to the north-east of the Tilbury2 Site (14556 TQ67007628).

4.6.6 During the 18th century the Tilbury2 Site lay within the East Tilbury Marsh, the south of the site comprising salt marsh. Chapman and Drury's map of 1777 shows the Tilbury2 Site extending back from the foreshore behind the flood defences of the sea wall. A further defence known as the 'Old Counter Wall' crossed the centre of the Tilbury2 Site in an east-west alignment. The north-west of the Tilbury2 Site crossed the Fort Road that led from Tilbury town to Tilbury Fort. A north-south aligned water channel extended from the foreshore north-wards into the southern part of the Tilbury2 Site (Fig. 2).

4.6.7 By the early 19th century the Tilbury2 Site had been reclaimed from the saltmarsh and comprised low lying pasture and arable fields separated by drainage channels. The north-west corner of the Tilbury2 site lay within Tilbury Fort Common, whilst the west of the Tilbury2 Site crossed a road junction and a couple of farm buildings comprising a second Marsh Farm (Figs. 3 -5).

4.6.8 Across the river in Kent, the Gravesend river banks were occupied by a number of wharves, piers, ferry points and landing steps in use from 19th century for trade and industry. Some of these non-designated assets have been lost but some are still in use and some have been incorporated into more recent redevelopment along the river (TQ67SE1005 TQ66627423, TQ67SE1016 TQ6522674447, TQ67SE1017 TQ6525974450, TQ67SE1018 TQ6654974324, TQ67SE1032 TQ6672274339, TQ67SE1042 TQ6523774408, TQ67SW1026 TQ6466974507, TQ67SW1037 TQ6440974489, TQ67SW1038 TQ6449974479, TQ67SW1039 TQ6454774470, TQ67SW1040 TQ6461374466, TQ67SW1041 TQ6465174485, TQ67SW1042, TQ67SW1043, TQ67SW1044, TQ67SW1045, TQ67SW1046, TQ67SW1048, TQ67SW1049, TQ67SW1057). In the early 19th century work began on the Kent and Medway Canal, the entrance to which lies approximately 1km south-west of the study site. The canal was abandoned in the early 20th century (TQ67SE20 TQ6996471860).

4.6.9 By the 1860s, the London Tilbury and Southend Railway was constructed bounding the north of the Tilbury2 Site and bisecting the north-western corner of the Tilbury2 Site. A gatehouse had been constructed where the railway crossed the Old Fort Road whilst railway lines crossed the western-most part of the Site (Fig. 6). There was little change by the late 19th century, although by this date a footpath crossed the Tilbury2 Site leading from Marsh Farm to the west of the study site over a footbridge within the west of the study site and along the Old Counter Wall (Fig 7).

4.6.10 There was no change to the Tilbury2 Site during the early 20th century.

4.6.11 During the Second World War, Tilbury Docks was heavily bombed and whilst there is no evidence of direct hits on the Tilbury2 Site, it is known that stray bombs did hit the marshes (1st Line Defence 2016). A number of Second World War defences have been recorded on the study site and its vicinity. An anti-glider ditch may have been identified during a watching brief in the north-east of the Tilbury2 Site during the construction of a bund and a pond (Essex Archaeological Unit 2010 (Appendix 3) 47492 TQ65917662). A spread of anti-glider ditches were identified from aerial photographs in the north of the Tilbury2 Site (14559 Appendix 3). A road barrier was located in the north-east of the Tilbury2 Site crossing Fort Road, but has since been destroyed (10281 TQ65307637). A 'turret' was located on the Fort Road close to the Road Barrier within the site boundary which has also been destroyed (10282 TQ65337642).

4.6.12 Between 1949 and 1957 Tilbury 'A' Power Station was constructed on the Tilbury2 Site. The functional layout was similar to that used in other Power Stations. The site faced the Thames, with offices, workshops and stores in the south of the site in a range around a quadrangle to the south of the large Boiler House, Turbine House, Boiler House, Ash Plant and Chimneys. To the north were the Canteen and Engineering Offices and the Substation. The Jetty was constructed in the foreshore and comprised a Coal and Ash Jetty. A conveyor belt and inlet and outlet tunnels led from the Power Station to the Jetty (Fig. 8). The foundations required to construct the Power Station comprised 13,000 precast reinforced concrete piles. The boilers were designed to burn coal, gravity fed from bunkers via mills. The Station was later adapted to burn heavy fuel oil which was stored in tanks to the east of the Boiler House. The coal and oil were delivered by ships to the reinforced concrete jetty. Railway lines were constructed leading from the railway line which bound the site to the north along the western part of the site towards the Power Station in the south of the Site.

4.6.13 Tilbury 'B' was constructed adjacent to the Tilbury2 Site to the east in the 1960s. At this time the jetty was lengthened to the east and its original coal-handling cranes were replaced.

4.6.14 By the 1970s works buildings and an electricity sub-station had been constructed in the north and north-west of the Tilbury2 Site and a number of overhead power lines crossed the Tilbury2 Site (Fig. 9). A house had been constructed to the west of the sub-station and a new north-south aligned drainage ditch was laid out in the western part of the Tilbury2 Site.

4.6.15 In 1990, two 800-tonne coal unloaders were installed on the jetty (Williams 1995) and a number of additional buildings had been constructed on the Tilbury2 Site (Fig. 10 and 11). The Power Station was identified by the Monument Protection Programme (MPP) as being of potential national importance (Williams 1995 and Chitty 2000 15093 TQ659759).

4.6.16 Tilbury 'A' was partly demolished in 1999, whilst Tilbury 'B' was converted to biomass in 2011. The jetty was enlarged in 2004 to take carrying up to 65,000 tons of coal.

4.6.17 Following the closure of the Power Station, a programme of demolition commenced across the remainder of 'A' and 'B'.

4.6.18 The potential for significant Post-Medieval or more recent archaeological remains is considered to be low/nil. Buried foundations and remnant industrial features associated with the former power station 'A' are considered to have a limited heritage interest.

4.7 **Negative Evidence**

4.7.1 Archaeological monitoring of geotechnical boreholes and test pits across the study site in 2008 recorded no archaeological finds or features (Wessex Archaeology 2008 DBA 2)

4.7.2 Archaeological monitoring of trial pits and groundworks during the construction of a pond and bund in the north-eastern part of the Tilbury2 Site recorded no archaeological finds or features (47473 47492 TQ65957670 DBA 4).

4.7.3 An archaeological aerial photographic and walkover survey across the northern part of the Tilbury2 Site (as part of a wider survey) recorded no archaeological finds or features on the Site itself (ECC 2010 Cox 2010).

4.7.4 An archaeological monitoring exercise during the excavation of the Stanford Le Hope STW Water Pipeline was undertaken as it crossed the Tilbury2 Site on an east-west alignment. The width of the pipeline easement was 20m and no archaeological finds or features were identified (18713 TQ669788).

4.7.5 Archaeological trial trenching and test pits undertaken to the south of the western 'arm' of the Tilbury2 Site recorded no archaeological finds or features (19487).

4.7.6 An archaeological evaluation and monitoring exercise ahead of and during the instalment of a new 400KV Gas Insulated Switchgear Substation was undertaken in 2008 approximately 400m east of the Tilbury2 Site recorded no archaeological finds or features (46888 TQ654762 ECC 2008).

4.7.7 Archaeological monitoring during the cutting of drainage ditches on West Tilbury Common approximately 400m north-west of the Tilbury2 Site recorded no archaeological finds or features (18454 TQ653770).

4.8 <u>**Assessment of Significance**</u>

4.8.1 Paragraph 5.12.6 of the NPS and paragraph 128 of the NPPF states that planning decisions should be based on the significance of the heritage asset, and that the level of detail supplied by an applicant should be proportionate to the importance of the asset and should be no more than sufficient to review the potential impact of the proposal on the significance of that asset.

4.8.2 There are no Scheduled Monuments on the Tilbury2 Site. A number of designated assets lie in close proximity to the study site and any effect on their significance will be addressed in a separate Built Heritage assessment.

4.8.3 Quest conclude in their recent report that based on the available information the palaeoenvironmental deposits on the site are of regional significance although the results of radiocarbon dating confirm the importance of Tilbury as the type site for palaeoenvironmental and Relative Sea Level studies (Quest 2017). There is a low to moderate potential the significance might increase to national significance if important palaeoenvironmental signatures are recorded during future assessment.

4.8.4 The remains of World War II anti-glider ditches have been identified from cropmarks and an archaeological watching brief in the north of the Tilbury2 Site.

4.8.5 No archaeological finds or features pre-dating the Second World War have been recorded during previous archaeological investigations on the Tilbury2 Site.

4.8.6 Overall the Tilbury2 Site is considered to have a low potential for prehistoric evidence of a local significance and a moderate potential for Roman evidence of a local to regional significance. The discovery of early prehistoric (Mesolithic) human remains on the study site would be considered of national significance, but based on their rarity within the archaeological record the potential for finding such remains on the study site has to be considered unlikely and would be difficult to identify due to the likely depth of any survival.

5.0 SITE CONDITIONS, THE PROPOSALS AND IMPACT ON HERITAGE ASSETS

5.1 Site Conditions

5.1.1 The Tilbury2 site was visited in August 2016. The Tilbury2 site is divided by an access road which runs east-west, known as 'Sub-Station Road'. To the south of this road, the site comprises the former Tilbury 'A' Power Station and its associated jetty, areas previously used for coal storage and ancillary buildings and land. The south of the site comprises flat and well drained ground comprising hardstanding, reinforced concrete, coarse gravel or grassed landscaping. The buildings of the 'A' Station have mostly been demolished to ground level with only a handful of ancillary buildings still extant including the cooling water pumps, electricity sub-station, environmental centre and former clubhouse (Plates 1-21). The remains of railway tracks cross the site (Plates 22-23), whilst a levelled green space lies to the north-west of the former clubhouse, once used as a sports pitch (Plate 24). Underground structures including the former cooling water culverts and all associated drainage and services are also still in situ (RPS 2015). The jetty extends into the foreshore in the south of the site (Plates 25-27).

5.1.2 To the north of Sub-Station Road the land has in part been stripped and is used for the storage of new vehicles (Plates 28- 29). A former railway line crossed the northern part of the site on a north-south alignment connected to the main London-Southend line to the north; last used in the 1960s, the railway cutting can be observed on the site (Plate 29). Parts of the northern area were formerly used to manufacture 'Lytag' blocks as a by-product of fuel ash from the Power Station. Vegetation on the site comprises scrub and poor quality grassland together with some areas of more significant vegetation. A number of ponds and drainage ditches (some of which are recut natural channels) cross the overgrown rough grass and scrub in the north of the site (Plates 30-31).

5.1.3 The remainder of the Tilbury2 Site comprises an electrical sub-station, a collection of industrial buildings, part of Fort Road, part of Ferry Road, part of a railway line, pasture, drainage ditches and overgrown vegetation.

5.1.4 The industrial development across the bulk of the Tilbury2 Site will have had a cumulative below-ground impact. In particular the cutting of foundations, services, culverts, tunnels, pumps (the cooling water pumps are 14m deep), ditches and ponds will have likely removed any archaeological deposits and had a localised impact on the palaeoenvironmental sequence.

5.1.5 The depth of Made Ground recorded on the Tilbury2 site is the product of land reclamation and industrial development of the site. Palaeoenvironmental deposits are known to survive at depth beneath the deep Made Ground.

5.2 **The Proposals**

5.2.1 The redevelopment of the Site as a new port terminal will comprise two principal port uses that of a Roll-on/Roll-off (Ro-Ro) terminal located south of Substation Road and a Construction Materials and Aggregates Terminal to the north of Substation Road.

Jetty/Marine Works

5.2.2 To facilitate its use for both the roll-on roll-off (ro-ro) terminal and the aggregates facility the existing jetty will be modified at both its upstream and downstream arms. The ro-ro berth, located at the western end of the existing jetty, will accommodate two vessels at a time and thus the existing jetty will be modified and extended to enable this. Similarly, the CMAT berth located at the eastern end of the existing jetty will be extended to accommodate barges and vessels of the required size.

5.2.3 Dredging will take place around the improved terminal jetty to create a berthing pocket. In relation to the downstream (CMAT) jetty, the depth of pocket will be circa 15m and cater for the largest likely bulk aggregate vessels to visit the site in the future (100,000 tonnes). The current river depth in relation to the downstream jetty varies between c-9.2m CD and c-14CD this will therefore mean that dredging will lower the riverbed by approximately c1 - c5.8m. A sheet pile wall will be installed to run along the northern edge of the dredge pocket. The RoRo berthing pocket (next to the western end of the existing jetty and around its westward extension) will require less dredging in order to create a depth of c7.88m. The current river depth in relation to the upstream jetty varies between c-5.8m CD and c-7.7m CD and so this will mean that dredging in this area will lower the river bed by approximately c0.10m to c2m.

5.2.4 The immediately adjoining approaches to the berth pockets will also need dredging and are included within the Order limits.

Ro-ro terminal landside facilities

5.2.5 The land south of Substation Road will be developed to accommodate associated storage areas and access to the RoRo jetty over an area of approximately 20ha. This will include:

- Installation of a single storey rail served warehouse.
- Storage of imported shipping containers stacked up to 6 high with a maximum height of 15.5m.

5.2.6 These works will comprise formation of a concrete pavement for the storage of shipping containers, surface water drainage features, installation of column mounted and high mast luminaries, potential single storey welfare buildings, operation and security gate systems, a single storey warehouse, access and associated landscaping.

Construction Materials and Aggregates Terminal (CMAT) landside facilities

5.2.7 The CMAT facilities are likely to include:

- concrete silo, located in close proximity to the river;
- an open aggregates distribution yard with stockpiles up to circa 15 metres high;
- a block and pre-cast concrete manufacturing facility;
- cement facility comprising importing sheds/silos;
- readymix concrete batching plant; and
- asphalt batching plant.

Other structures

5.2.8 Remaining land within the site may be used for external storage uses, with the principal use likely to be the storage of new imported motor vehicles that is already taking place within the site, or for storage of bulk materials.

Surface Access Strategy

5.2.9 In addition a surface access strategy is proposed comprising new and improved road and rail links. In principal it is proposed to construct a new public highway to link the A1089 Ferry Road along an alignment which closely follows the existing railway line through the northern part of the site.

5.2.10 Rail provision will be established by a connection from the existing port sidings and will be routed along the existing main line railway.

5.2.11 In addition an improved road bridge will be constructed close to the entrance to the main site.

Lighting

5.2.12 Lighting will be required across the site to facilitate the 24 hour operation of the terminal.

5.2.13 Piled foundations will be used for the construction of the Maritime warehouse, Ro Ro Terminal workshop/admin/welfare, lighting columns, CMAT Conveyor support structure, CMAT structures, to support the Fort Road bridge and railway track, booking gate and inspection shed. The worst case number of these new piles has been calculated and the resulting area of impact is 0.18% (Atkins Technical Note 11th August 2017, see AS6). Historic England guidance advises that new piling impact should be no more than 2% of the site (Historic England 2015). When taking into account the potential zone of disturbance around each pile Historic England recommend that 4x the pile area should be considered for displacement piles when considering 'loss' of archaeology. Consequently if a worst case is considered where each pile is a displacement pile, the area of impact of these new piles including the zone of disturbance will be 0.70% of the Site.

5.2.14 Historic England guidance (2015) suggests that piling a waterlogged site could potentially effect the underlying hydrology and consequently the recharge through the alluvial sequence which may ultimately impact on the preservation of any archaeological or palaeoenvironmental remains. However the alluvium and peat deposits' sensitivity as controlled water receptor is considered to be negligible and the thick alluvium sealing the peat is likely to seal the piles during operation so if there is any moisture loss in the peat it would be localised and temporary during construction. The results of future ground water testing and a piling risk assessment will outline mitigation measures and confirm the most appropriate piling methodology to minimise effects on the controlled waters. The thick alluvium will also act to slow the migration of contamination and the future piling risk assessment will identify mitigation measures/construction methodologies necessary to further reduce the risk of contamination during piling.

5.2.15 Historic England guidance (2015) suggests that in most cases isolated piles are less damaging to deposits then grouped piles of three or more as the sediment enclosed within a pile group will be more disturbed. The results of future ground investigations undertaken post consent will determine the final piling layout.

5.2.16 The development is proposed to incorporate ground stabilisation/improvement. Future assessment at the design stage post consent will determine the most appropriate strategy. For the purposes of this assessment ground improvement piling is considered the worst case option due to the potential to impact palaeoenvironmental and archaeological remains preserved within the peat deposits. However the cumulative impact from any ground improvement piling works and new structural piling (as discussed above) will still sit within the 2% guidelines recommended by Historic England (Historic England 2015). Ground improvement works at the site is likely to include the excavation and replacement of Made Ground and the upper alluvial sequence. This will comprise excavation of soil and then subsequent stabilisation of this soil with a suitable material to make it safe to retain and then ultimately compacting the stabilised soil back into the ground. These works could have a direct impact on potential archaeological remains underlying the Made Ground. The depths of ground excavation will not have a direct effect on any palaeoenvironmental or archaeological remains preserved within the peat deposits.

5.2.17 There is a risk of a potential indirect effect on the underlying alluvial sequence caused by compression where shallow foundations are proposed eg the proposed pavement and storage areas. However, compression of the peat deposits will not change their particle density or dry them out. In the case where the peat is not completely saturated, compression will decrease porosity leading to a reduction in the volume of air-filled voids relative to the volume of water-filled voids. Where the peat is fully saturated, further compression will result in a reduction of the volume of voids but those voids will remain water-filled. Thus, while the overall volume of water in the layer is reduced, the peat will remain saturated (Suzanne White Principal Environmental Consultant Contaminated Land and Hydrogeology Atkins *pers comm*). There is also a risk that compression of peat deposits may damage the palaeoenvironmental and archaeological remains that may be preserved within them due to the pressure the proposed development could exhibit on these deposits. However the large amount of sediment currently overlying the peat deposits will already be causing some level of compression. Consequently the indirect effect of compression on any palaeoenvironmental and archaeological remains is therefore currently considered to be negligible.

5.2.18 The cutting of services is likely to have a direct but localised effect on the potential archaeological remains.

5.3 **Impact on Archaeological Assets**

5.3.1 There are no designated archaeological assets on the Tilbury2 Site and consequently the proposals will not have a direct impact on any designated archaeological assets.

5.3.2 Based on the available evidence the proposals have the potential to have a direct impact on underlying archaeological deposits of a local to regional significance. Any impact on remains of a national significance (Mesolithic human remains) is considered unlikely but if present would at most be limited to localised impacts from piling at depth.

5.3.3 The proposed piling will have a localised impact on the palaeo-environmental sequence of a regional to potential national significance.

6.0 SUMMARY AND CONCLUSIONS

6.1 In accordance with central and local government planning policy, an assessment has been undertaken to clarify the significance of any archaeological assets and the archaeological potential of the Tilbury2 Site

6.2 There are no Scheduled Monuments or other designated assets on the Tilbury2 Site.

6.3 Palaeoenvironmental deposits of a regional and potential national significance are present on the study site. The remains of World War II anti-glider ditches of local significance have been identified from cropmarks and an archaeological watching brief in the north of the study site. No archaeological finds or features pre-dating the Second World War have been recorded during previous archaeological investigations on the Tilbury2 Site. Overall, the Tilbury2 Site has a known potential for palaeoenvironmental deposits, and low to moderate potential for prehistoric and Roman evidence.

6.4 The industrial development across the bulk of the Tilbury2 Site will have had a cumulative and destructive below-ground impact.

6.5 Based on the available evidence the proposals are likely to have a potential impact on underlying archaeological deposits of a local to regional significance. Any impact on remains of a national significance (Mesolithic human remains) is considered unlikely but if present would at most be limited to localised impacts from piling at depth. The proposed piling will have a localised impact on the palaeo-environmental deposits of regional to potential national significance.

6.6 Consequently a programme of archaeological mitigation measures will be required and on the basis of the available evidence these measures could follow consent, secured as part of a WSI.

SOURCES CONSULTED

1. General

Essex Historic Environment Record

Essex Record Office

British Library

2. Bibliographic

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Chitty 2000	Electric Power Generation Step 4 Report
Cox 2010	Tilbury CCGT Pipeline Project, Stage 1. Interpretation of Aerial Photographs for Archaeology
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EAA 2008	Revised Research Framework for the Eastern Region
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ECC 2010	Tilbury CCGT Pipeline Project Tilbury Archaeological Walkover Survey
1st Line Defence 2016	Detailed UXO Risk Assessment
Halcrow 2007	Tilbury C Power Station Geotechnical Desk Study
Historic England 2015	Piling and Archaeology
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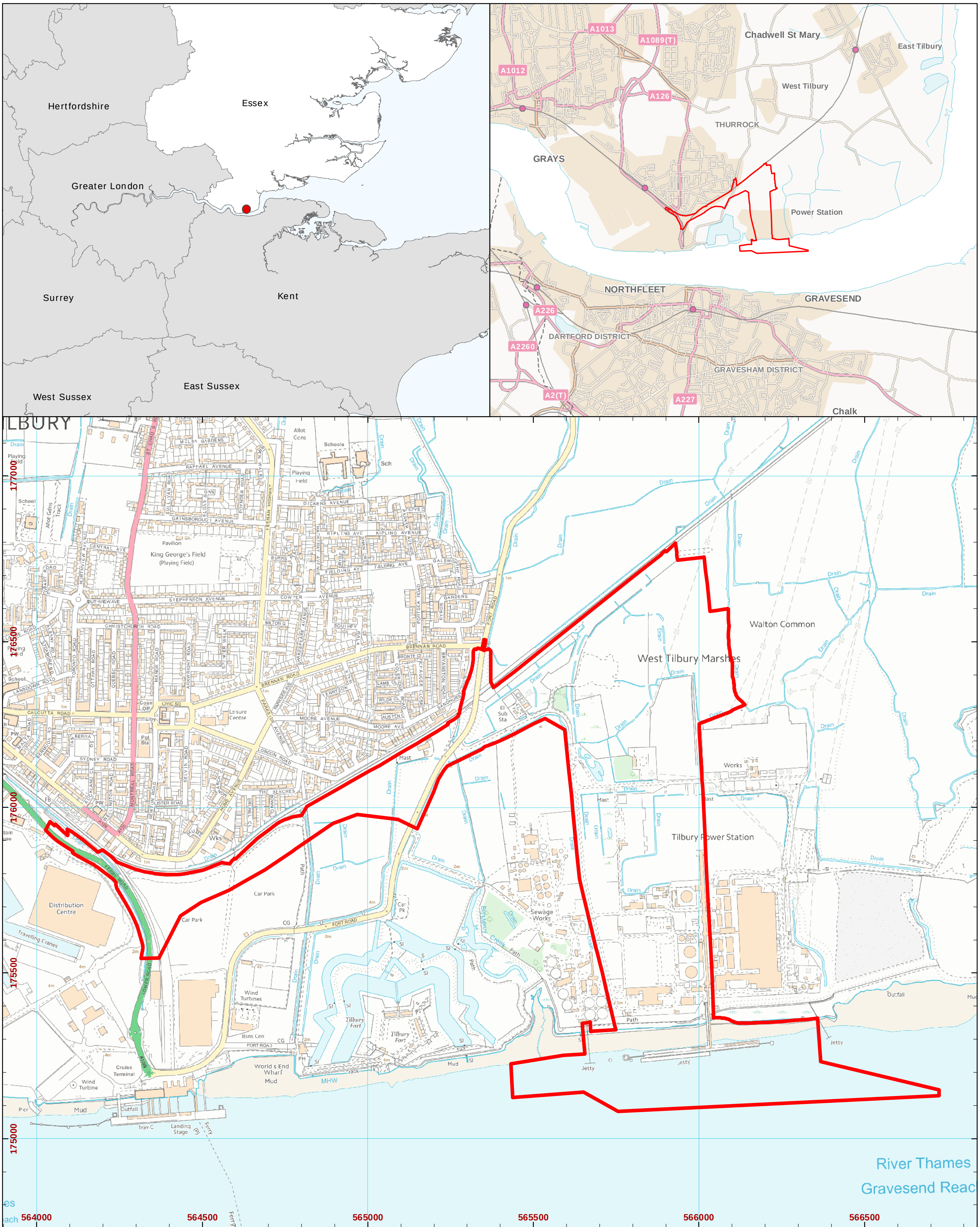
Quest 2013	London Distribution Park, South Essex Geo-archaeological Analysis Report
Quest 2017	Tilbury2, The Former RWE Power Station Geoarchaeological Fieldwork, Radiocarbon Dating and updated Deposit Model Report
RCHME 1995	The Power Stations of the Lower Thames
RPS 2015	Ground Investigation Factual Report Tilbury Power Station
Structural Soils Ltd 2013	Interpretive Report on Ground Investigation
Schulting 2013	Tilbury Man: A Mesolithic Skeleton from the Lower Thames
Vertase 2014	Tilbury A Power Station
Wessex Archaeology 2017	Tilbury2 Marine Desk Based Assessment
Wymer J 1968	Lower Palaeolithic Archaeology in Britain

3. **Cartographic**

1777 Chapman and Andre
1846 Tithe Map
1865 Ordnance Survey
1898 Ordnance Survey
1923 Ordnance Survey
1955 Ordnance Survey
1991 Ordnance Survey



Site Boundary

N

Scale at A4: 1:16,000

0 440 m

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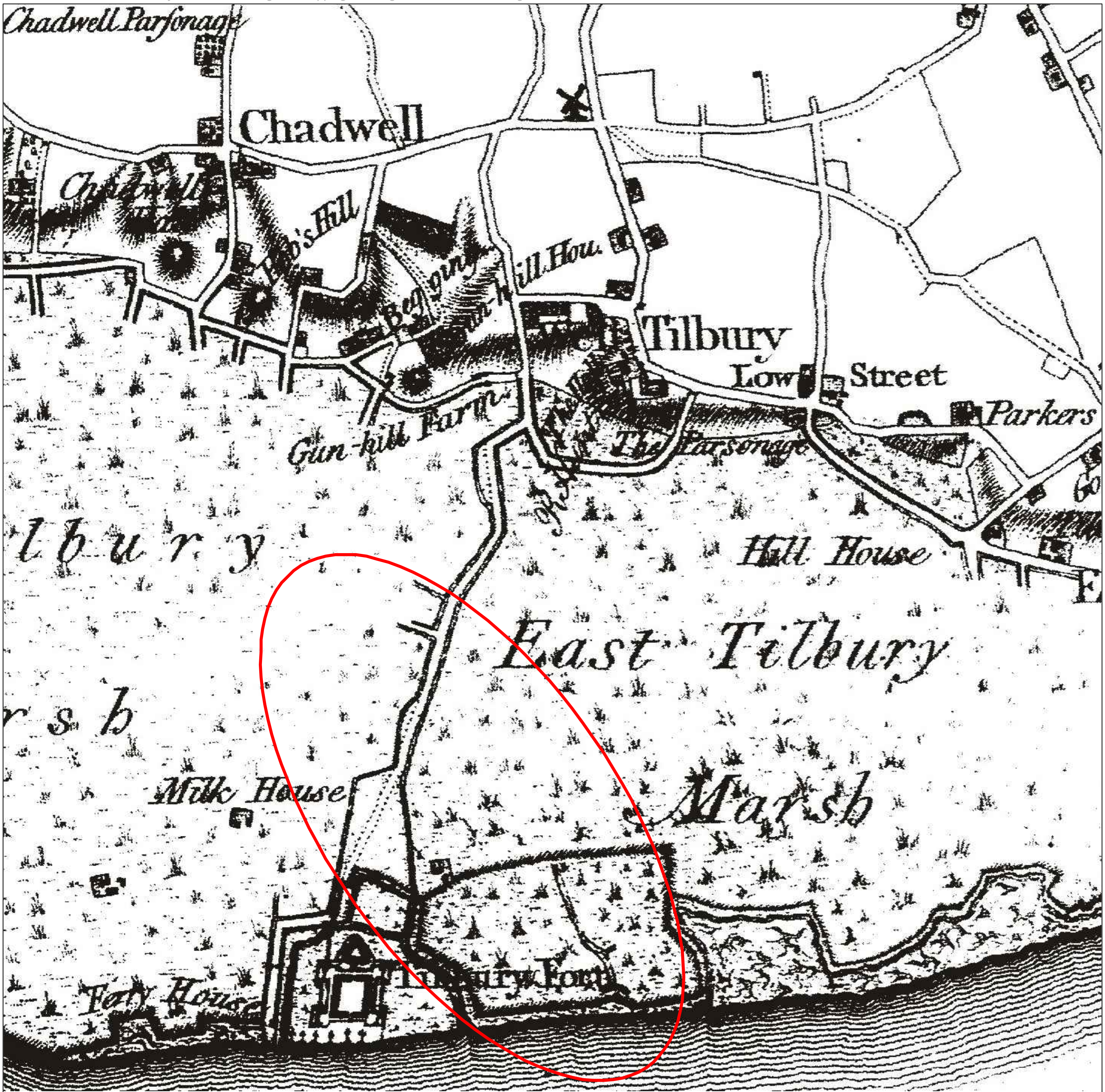
Figure 1:
Site Location



Site Location

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Not to Scale:
Illustrative Only

Figure 2:
1777 Chapman and Andre

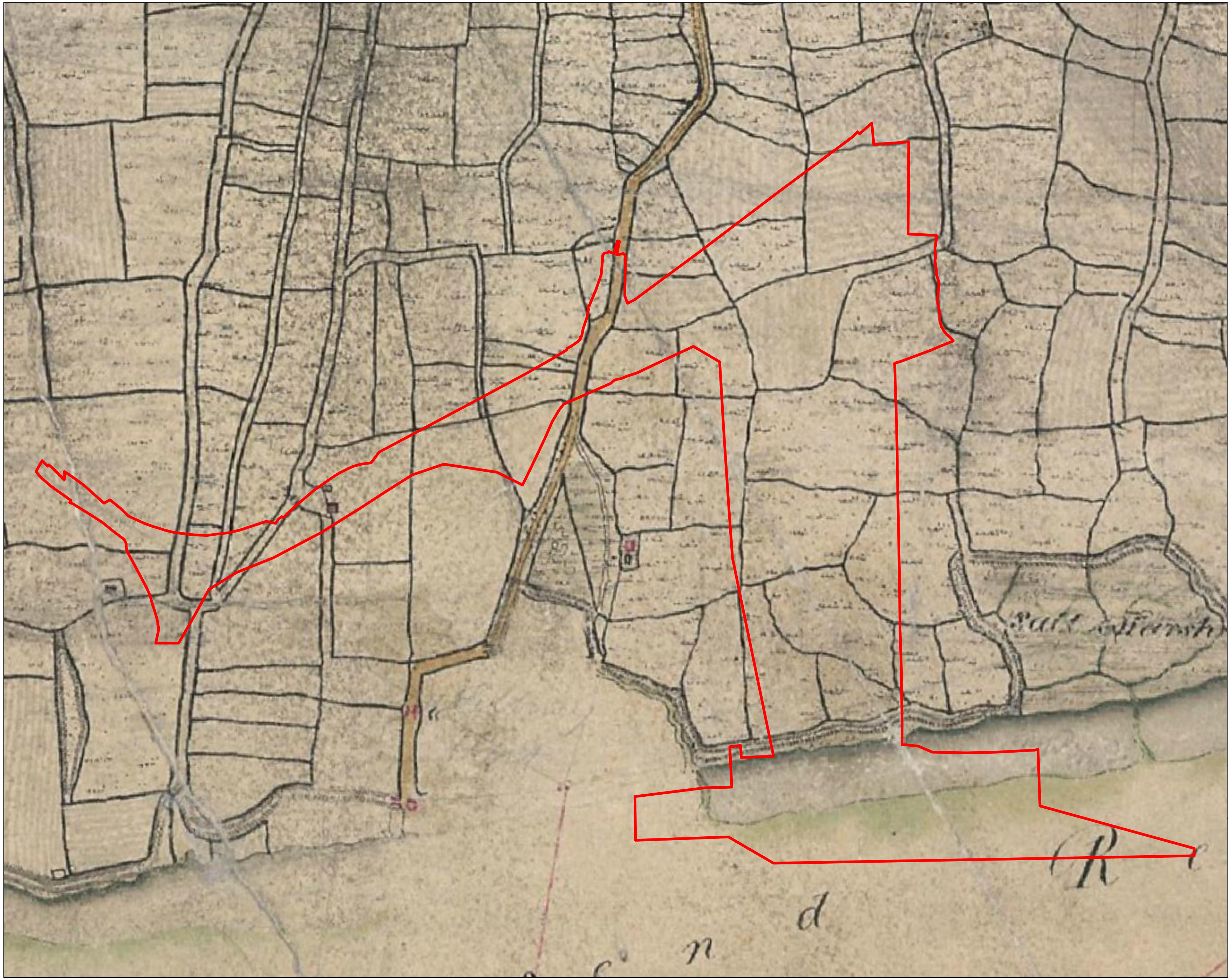

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Figure 3:
1808 Ordnance Survey

Site Boundary

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Figure 4:
1838 West Tilbury Tithe

Site Boundary

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Figure 5:
1839 Chadwell St Mary Tithe

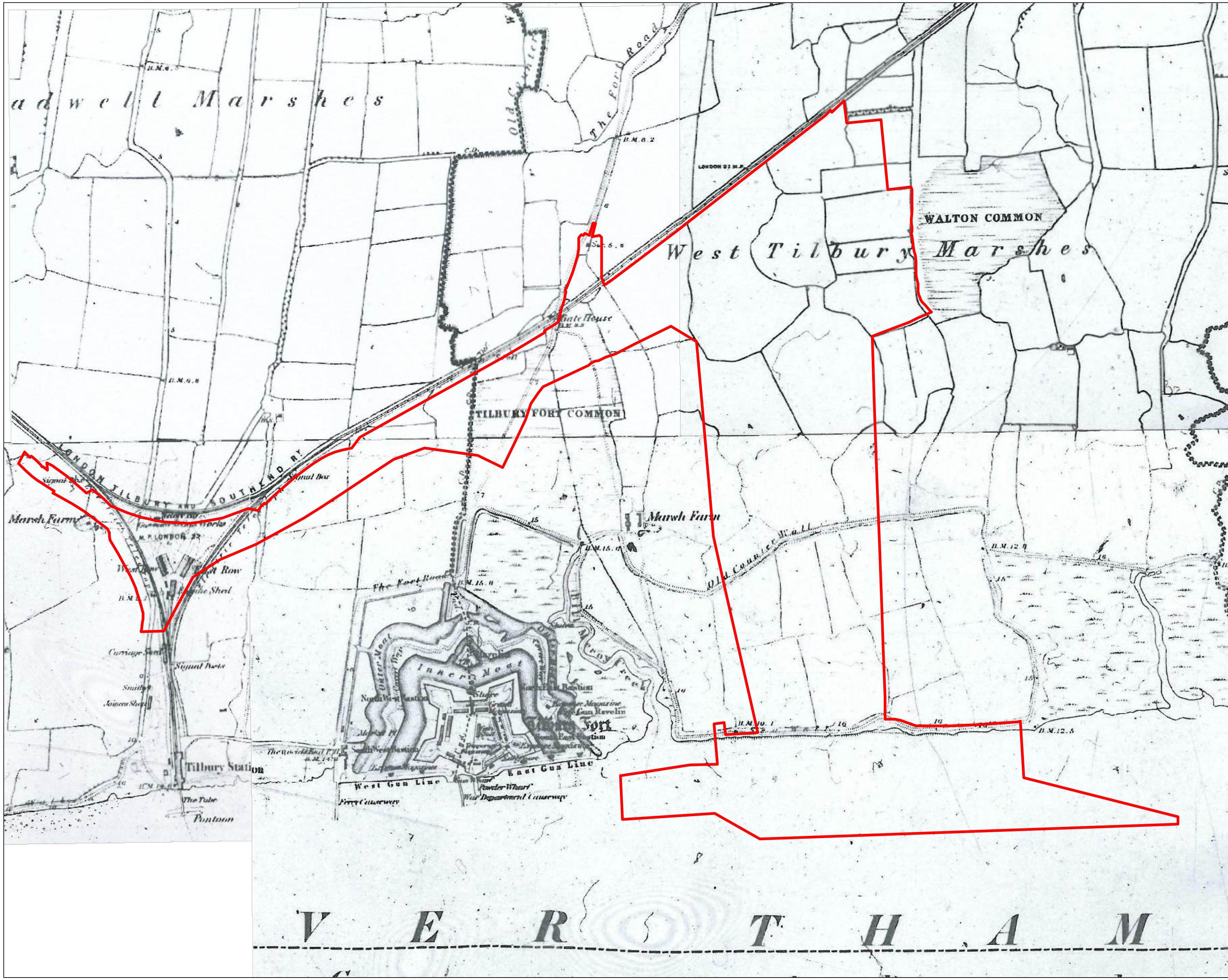

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Figure 6:
1863 Ordnance Survey

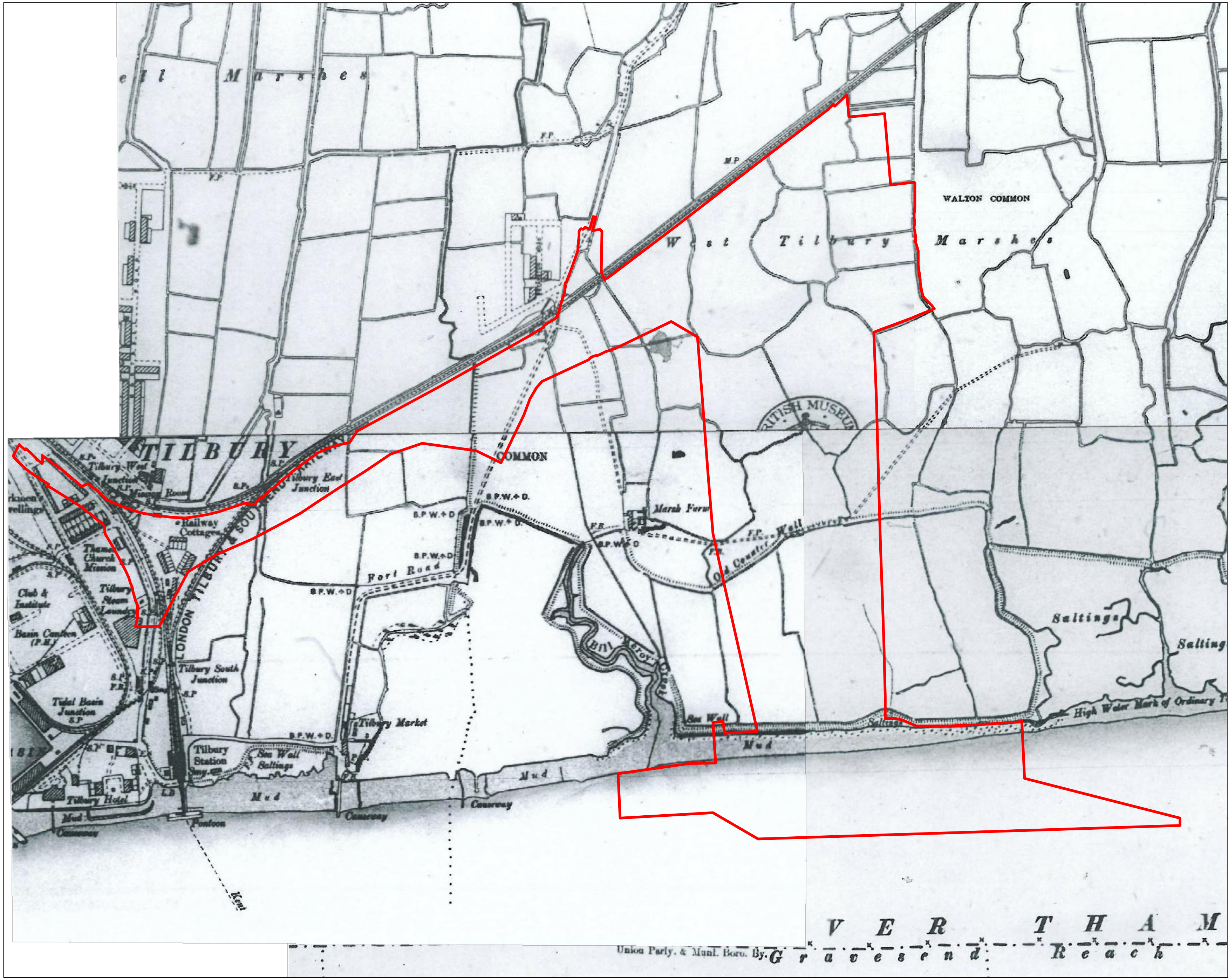

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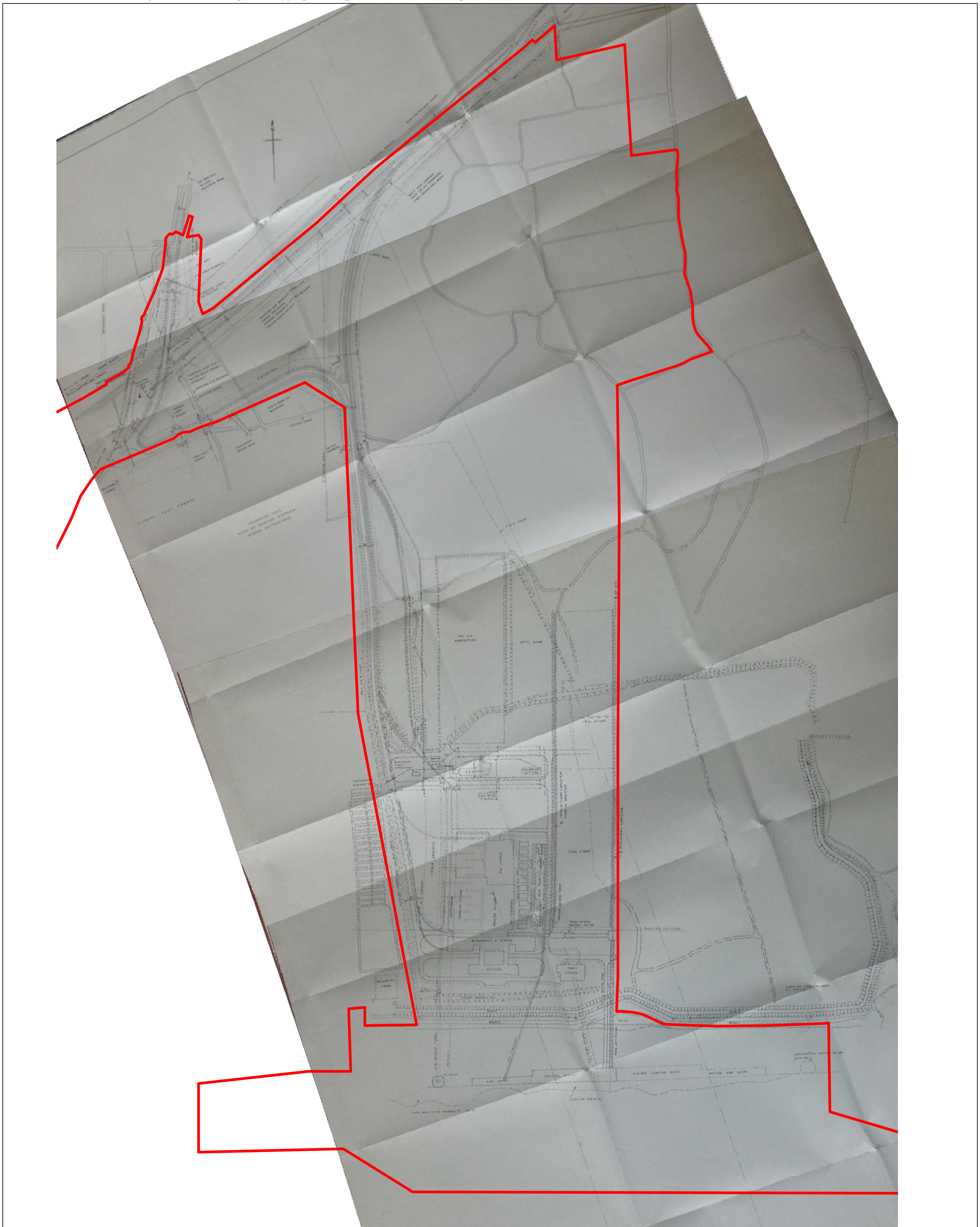
Figure 7:
1898 Ordnance Survey



Site Boundary

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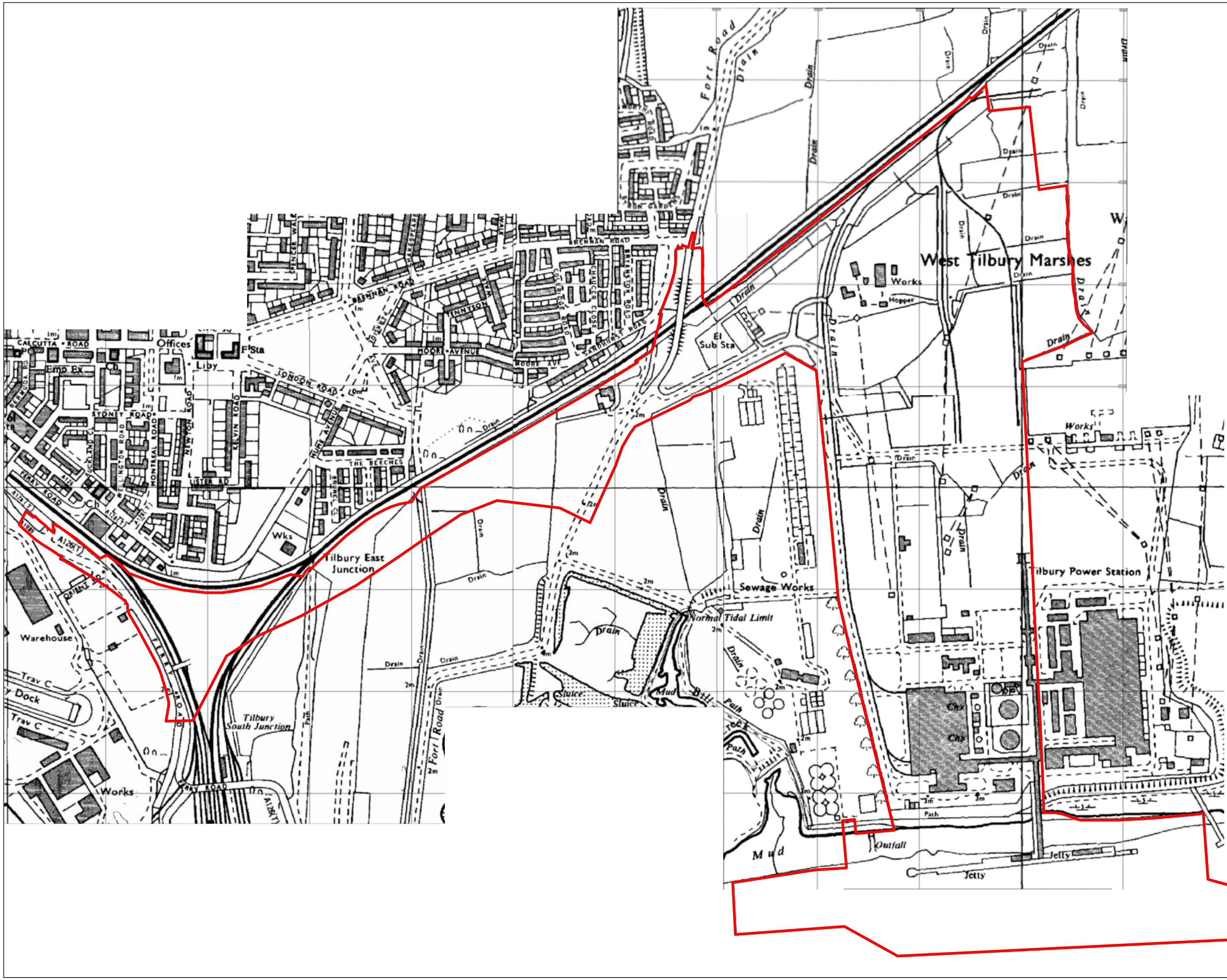
Figure 8: 1952 General Site Plan Tilbury Generating System



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Site Boundary

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Figure 9:
1975 Ordnance Survey

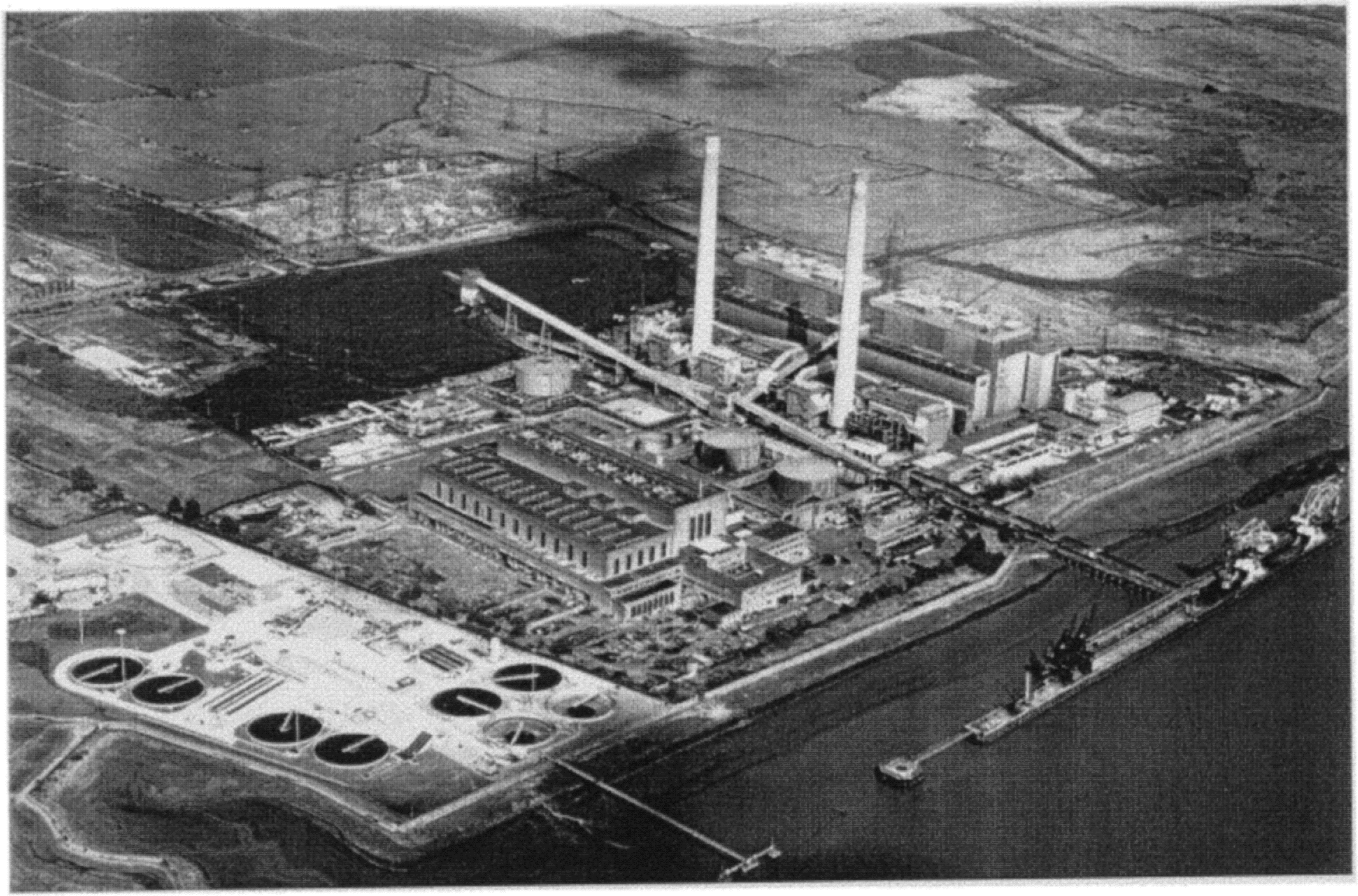

Figure 10: Tilbury Power Station Aerial View from the Southwest in 1994 showing 'A' Station to the left and 'B' Station to the right (RCHME 1994)

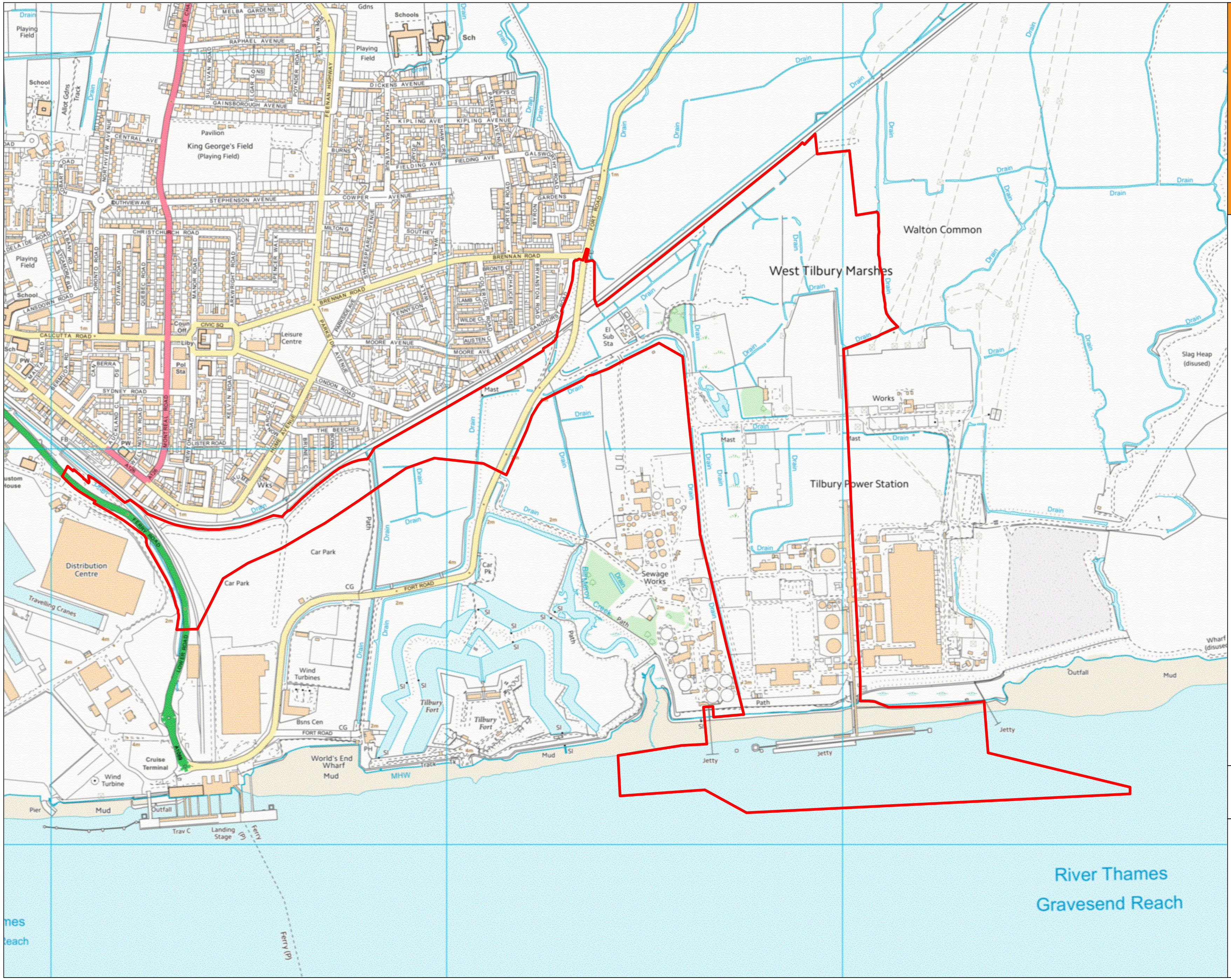

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Figure 11:
Site as Existing

Plate 1: West facing photograph with the former Tilbury A clubhouse and temporary accommodation to the right of photograph

Plate 2: Small single storey sub-station in the east of the site

Plate 3: Small single storey sub-station in the south-east of the site

Plate 4: South-east facing photograph of standing Tilbury A structure in south-east of the study site

Plate 5: West facing photograph of rectilinear building in the eastern boundary of the study site with steps accessing the conveyor belt in the foreground

Plate 6: South facing detailed photograph of eastern elevation of rectilinear building in east of site

Plate 7: South facing photograph of extant former Tilbury A building and conveyor belt

Plate 8: South-west facing photograph of cooling water pump in south-west of study site

Plate 9: Close-up of cooling water pump

Plate 10: North facing photograph of western elevation of the former Environmental Centre located to the north of Tilbury A

Plate 11: South facing photograph looking across the site of former Tilbury A towards the Thames

Plate 12: West facing photograph showing former building plots

Plate 13: South-west facing photograph showing
former Tilbury A building plots

Plate 14: West facing photograph showing site clearance

Plate 15: North facing photograph looking towards the former circular tanks (concrete slab still in situ) in the east of the site

Plate 16: West facing photograph looking towards the location of the former circular tanks in the east of the site

Plate 17: Overgrown landscaped area in the south-east of the site

Plate 18: North-east facing photograph across paved yard and demolition zone towards Tilbury B

Plate 19: North facing photograph taken from the south-western corner of the site

Plate 20: Paved former yard surface

Plate 21: South-west facing photograph of overgrown zone in the west of Tilbury A

Plate 22: East facing photograph of former railway tracks in the south of Tilbury A

Plate 23: East facing photograph of former railway tracks in the north of Tilbury A

Plate 24: East facing photograph of levelled former sports pitch to the north of Tilbury A

Plate 25: North west facing photograph taken from the Jetty of the southern flood defences to the south of Tilbury A

Plate 26: South-west facing photograph of western arm of Jetty

Plate 27: East facing photograph of eastern arm of Jetty

Plate 28: North-east facing photograph of open car storage area

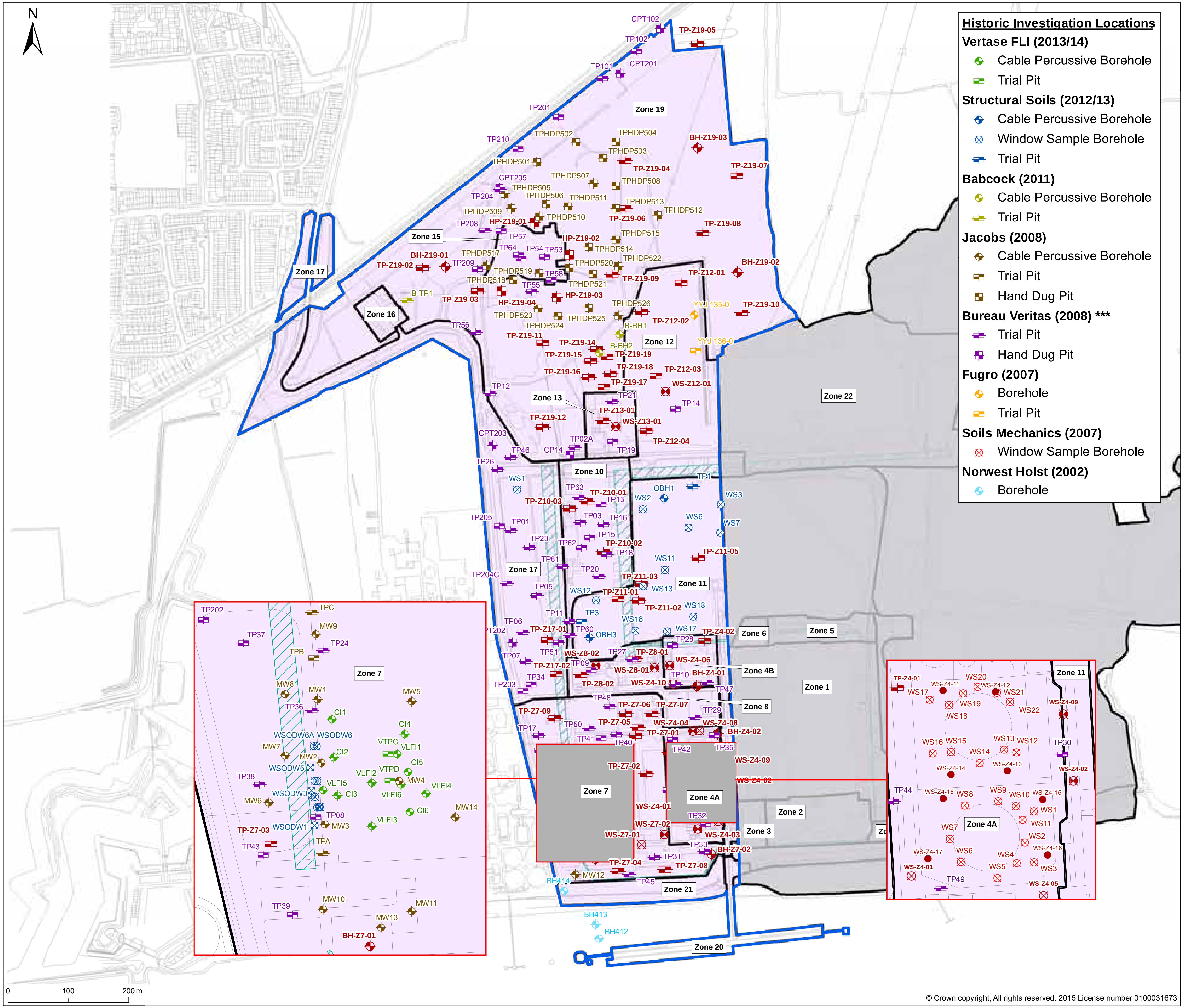
Plate 29: North facing photograph of car storage area and route of former railway line that once crossed the site

Plate 30: West facing photograph of overgrown scrub

Plate 31: North-east facing photograph of pond surrounded by overgrown vegetation

DBA 1:

Geotechnical Investigation Locations (RPS 2015)



Notes

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Legend

- Surplus Land
- Land Ownership Boundary
- Site Zones
- Cable Reserve / Pipe Trench

RPS Investigation Locations (2015)

- Cable Percussive Borehole with Monitoring Well Installation
- Window Sample Borehole with Monitoring Well Installation
- Window Sample Borehole (No Installation)
- Hand-Held Window Sample Borehole
- Trial Pit
- Hand Dug Pit

*** - Some Bureau Veritas investigation locations had follow-on monitoring well installations. The logs for these are not available.

Rev	Description	Date	Initial	Checked

RPS

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Client: RWE GENERATION

Project: TILBURY POWER STATION

Title: INVESTIGATION LOCATIONS (SURPLUS LAND AREA)

Status	Drawn By	PM/Checked By
PRELIMINARY	JGB	GM
Job Ref	**Scale @ A3**	**Date Created**
JER6376	1:6,000	AUG 15

Drawing Number: JER6376-TB-041 Rev: -

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DBA 2:

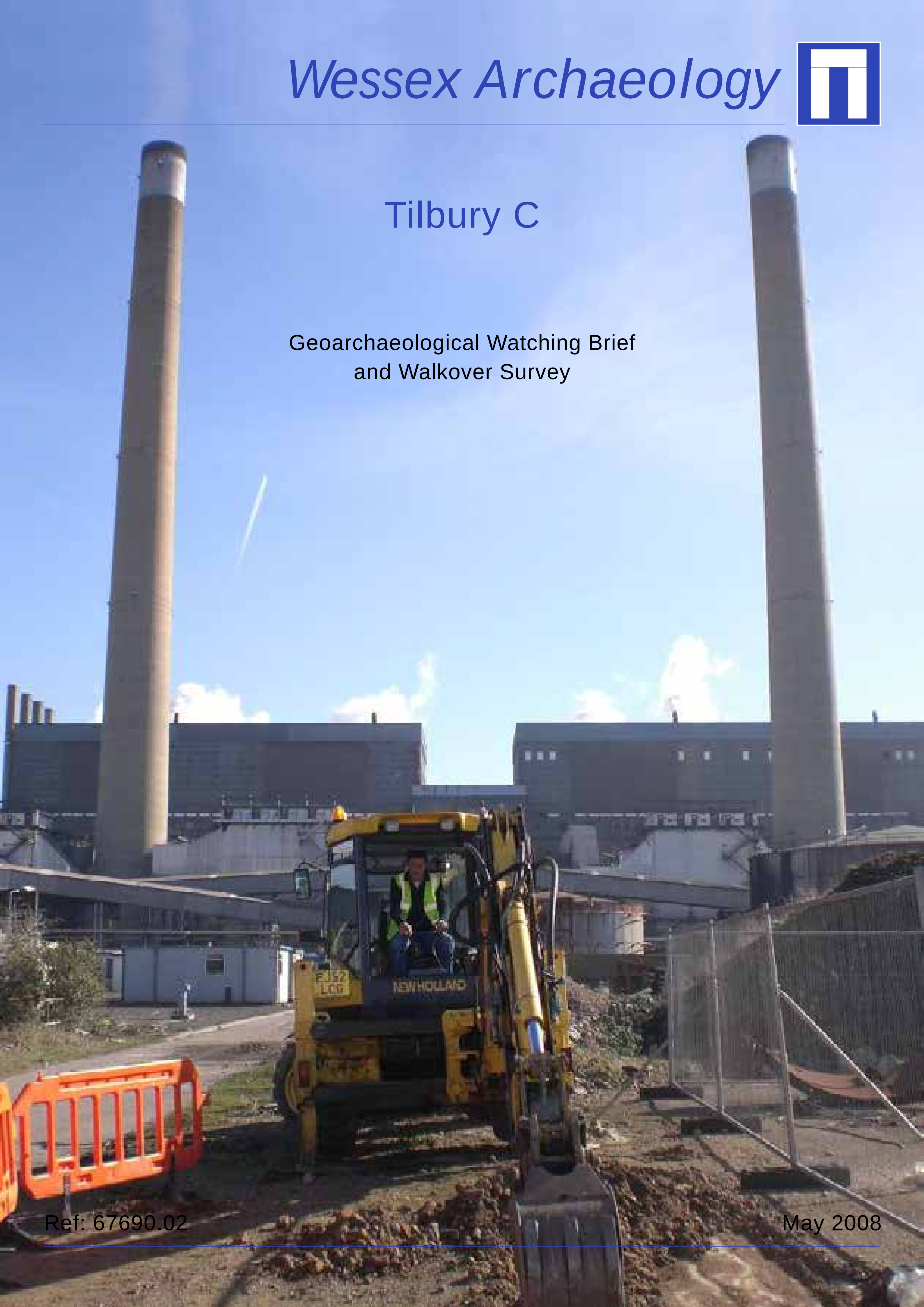
Tilbury C Geoarchaeological Watching Brief and Walkover Survey

Wessex Archaeology 2008

Wessex Archaeology

Tilbury C

Geoarchaeological Watching Brief and Walkover Survey



Ref: 67690.02

May 2008

TILBURY C POWER STATION

GEOARCHAEOLOGICAL WATCHING BRIEF, HISTORIC BOREHOLE REVIEW AND WALKOVER SURVEY

By:

Wessex Archaeology Ltd.
Portway House
Old Sarum Park
Salisbury
SP4 6EB

For:

Ove Arup and Partners Ltd

On Behalf of:

RWE npower

Report Ref: 67690.02

May 2008

TILBURY C POWER STATION

GEOARCHAEOLOGICAL WATCHING BRIEF, HISTORIC BOREHOLE REVIEW AND WALKOVER SURVEY

Ref: 67690.04

SUMMARY

Wessex Archaeology was commissioned by ARUP on behalf of RWE npower to undertake an archaeological watching brief of geotechnical works, a review of historic borehole logs and a walkover survey of the Thames foreshore as part of the Environmental Impact Assessment for the proposed development of the new power station, known as Tilbury C, at Tilbury Power Station, Essex.

The watching brief comprised the recording and archaeological description of sediments contained within seven boreholes and 39 test pits, and was undertaken in February and March 2008. The footprint of the main operational area was the focus of the survey.

The review of historic borehole logs comprised the archaeological interpretation of sixty borehole logs. Nine of these (which were drilled in 2002 prior to the enhancement works to the jetty), were included within the overall geoarchaeological assessment of the area.

A walkover survey of the riverside was also undertaken during the archaeological watching brief. One element of archaeological interest was identified.

On the basis of the geoarchaeological interpretation and walkover survey, the archaeology of the area surveyed can be summarised as follows:

- The sedimentary sequence recorded from the test pits and boreholes contains four major units, Chalk bedrock (Unit 1), Pleistocene fluvial gravels (Unit 2), Peat and alluvial layers (Unit 3) and made ground (Unit 4);
- Unit 2 has the potential to contain derived artefacts from the Palaeolithic period;
- Unit 3 has the potential to contain derived or *in situ* artefacts from the Upper Palaeolithic to the Roman period.
- Mitigation work is recommended to record the sedimentary sequence of the site;
- One built heritage element of twentieth century date was recorded in the walkover survey. This was a Second World War pill box.

TILBURY C POWER STATION

GEOARCHAEOLOGICAL WATCHING BRIEF, HISTORIC BOREHOLE REVIEW AND WALKOVER SURVEY

Ref: 67690.04

ACKNOWLEDGEMENTS

Wessex Archaeology was commissioned to undertake this project by ARUP on behalf of RWE npower. Wessex Archaeology would like to thank ARUP and RWE npower for their help during the project, especially Helen Glass from Arup for help and guidance throughout all stages of the Tilbury C Cultural Heritage impact assessment. Also the cooperation of the staff at Bureau Veritas, the geotechnical contractor, and Jacobs, the geotechnical consultants, during the watching brief was gratefully received.

John Russell and Kevin Stratford carried out the archaeological watching brief. The walkover survey was undertaken by John Russell. John Russell compiled this report. Kitty Brandon prepared the figures and Stuart Leather managed the project for Wessex Archaeology.

TILBURY C POWER STATION

GEOARCHAEOLOGICAL WATCHING BRIEF, HISTORIC BOREHOLE REVIEW AND WALKOVER SURVEY

Ref: 67690.04

CONTENTS

TILBURY C POWER STATION

GEOARCHAEOLOGICAL WATCHING BRIEF, HISTORIC BOREHOLE REVIEW AND WALKOVER SURVEY

Ref: 67690.04

1. INTRODUCTION

1.1. PROJECT BACKGROUND

1.1.1. Wessex Archaeology (WA) was commissioned by ARUP on behalf of RWE npower to undertake elements of the cultural heritage aspects of the Environmental Impact Assessment for the proposed development of the Tilbury ‘C’ power station on the site of the existing Tilbury ‘B’ Power Station.

1.1.2. The elements addressed in this report are: a watching brief during geotechnical investigations (test pits and boreholes); a review of historic borehole data and walkover survey of the foreshore. The report also addresses the potential impact of the scheme on the known and potential archaeology within the area.

1.1.3. The boreholes were drilled under the supervision of the geotechnical contractor Bureau Veritas. The test pits were excavated by Neil Sullivan and Sons Ltd, under the supervision of the geotechnical contractor Bureau Veritas. Both the test pit and borehole investigations were conducted during February and March 2008.

1.1.4. Borehole logs and samples from the geotechnical works were made available for review on site by the geotechnical contractors and by RWE npower.

1.1.5. A series of sixty borehole logs, from several previous drilling campaigns, held in the Tilbury Power Station archive were made available for archaeological interpretation.

1.1.6. The proposed development area is located on the northern side of the Thames Estuary (**Figure 1**). The geotechnical investigations were undertaken in the area of the proposed Tilbury C development (**Figure 1**). The walkover survey was conducted along the Thames foreshore in the study area (**Figure 1**).

1.1.7. Prior to geotechnical site investigations WA prepared a Written Scheme of Investigation (Wessex Archaeology 2008a) which set out the scope of the Archaeological Watching Brief and walkover survey.

1.2. CHARACTERISTICS OF THE AREA

1.2.1. The Tilbury Power Station site is mapped by the British Geological Survey as made ground overlying Holocene locally peaty alluvium overlying Upper Chalk bedrock (British Geological Survey: *1:50,000 series; Sheet 271 Solid and Drift*). The site lies within a reclaimed area of marshland, part of the northern floodplain of the river Thames.

2. AIM AND OBJECTIVES

2.1.1. The aim of this study, with its various components, is to assess the area that will be impacted by the development of the proposed new Tilbury C Power Station for the presence of archaeological material, and to contribute to the overall Environmental Impact Assessment which is being undertaken as part of the planning requirements.

2.1.2. The objectives of the study are:

- To describe the sediments contained within the boreholes and test pits in terms of their structure and form, and the depth and thickness of the horizons;
- To assess historic boreholes undertaken in the area;
- To identify sediments that may be of archaeological interest;
- To identify by walkover survey archaeological features along the foreshore, including the intertidal zone.

3. METHODOLOGY

3.1. WATCHING BRIEF

3.1.1. The watching brief was conducted between the 27th February and 12th March 2008.

3.1.2. During the drilling of the boreholes a sedimentary log was kept by the drillers (Bureau Veritas 2008). The method of drilling known as shell and auger achieved a 200mm width and *c*.20m deep borehole with sediment removed in stages. Geotechnical sediment samples were taken and the remaining sediment was heaped next to the operation. No archaeological finds were observed in the discarded sediment.

3.1.3. The archaeological watching brief was maintained during the drilling of boreholes BH7, BH9, BH13, BH14, BH16, BH17 and BH18. The watching brief was not maintained during the drilling of boreholes BH1, BH2, BH3, BH4, BH5, BH6, BH8, BH10, BH11, BH12, BH15, BH19, BH20, BH 21, BH22, BH23, BH24, BH25, BH26, BH27, BH28, BH29 and BH30.

3.1.4. The test pits were excavated by a backhoe JCB in trenches *c*.0.5m in width and 2.5m in length and up to 2.5m deep. The pits were too deep to enter safely; however basic logs were kept noting the excavated material and what could be observed in section (**Appendix 1** of this report).

3.1.5. In the test pits basic sedimentary characteristics were recorded including, where possible, depositional structure as well as texture, colour and stoniness (cf. Hodgson 1976). The descriptions are presented in **Appendix 1** of this report.

3.1.6. On the basis of core logs major sedimentary units were ascribed to four principal phases. The profile created by the phasing **(Figure 2)** provides both an interpretative framework and enables comment on their palaeo-environmental and geoarchaeological significance to be made.

3.2. REVIEW OF HISTORIC BOREHOLE LOGS

3.2.1. Most of the historic data reviewed (where location could be ascertained) falls within the area of geotechnical investigations shown in **Figure 1**. A notable exception was the boreholes drilled in advance of enhancement works on the Jetty in 2002 (**Figure 1**, **4** and **5**). These boreholes are located within the River Thames. The borehole logs have been geoarchaeologically interpreted and added to the sedimentological data recovered from the most recent geotechnical investigations. These boreholes are: BH401, BH402, BH403, BH404, BH405, BH406, BH409, BH412 and BH413.

3.3. WALKOVER SURVEY

3.3.1. The walkover survey was conducted in the area marked on **Figure 1**. Features of archaeological interest were located on a site plan. One feature of archaeological interest was noted.

4. RESULTS

4.1. WATCHING BRIEF

4.1.1. Sediments were logged and excavated material scanned for archaeological finds from the following test pits:

Test Pit	Easting	Northing
TP1	565664.86	175951.87
TP2	565771.14	176088.85
TP3	565779.91	175964.98
TP4	565665.05	175901.32
TP5	565708.44	175843.96
TP6	565684.91	175782.74
TP7	565689.91	175735.01
TP8	565774.99	175478.66
TP13	565815.09	175995.16
TP15	565796.04	175939.74
TP16	565819.26	175961.71
TP18	565711.37	175611.51
TP20	565810.86	175876.41
TP23	565696.36	175923.77
TP24	565779.22	175570.57
TP28	565933.44	175762.41
TP29	565970.17	175642.33
TP30	566018.79	175547.55
TP31	565902.97	175410.08
TP32	565998.02	175465.95
TP34	565698.73	175696.27
TP35	566001.86	175612.87
TP36	565773.08	175537.53
TP37	565735.02	175575.47
TP38	565744.16	175497.40
TP40	565839.94	175613.93
TP41	565814.69	175607.72

TP42	565933.35	175605.41
TP44	565925.63	175521.66
TP45	565860.72	175382.48
TP46	565665.23	176073.21
TP49	565951.64	175473.93
TP51	565744.07	175765.70
TP53	565721.01	176404.85
TP54	565682.27	176402.34
TP55	565610.78	176347.75
TP56	565606.79	176279.55
TP57	565648.60	176448.07
TP58	565732.07	176367.04

4.1.2. Logs of the following test pits were received from Bureau Veritas (Bureau Veritas 2008). These logs have been reviewed and pertinent sedimentological data added to the results:

Test Pit	Easting	Northing
TP9	565797.80	175720.73
TP10	565937.58	175696.97
TP11	565761.63	175801.23
TP12	565630.88	176178.94
TP14	565937.69	176153.45
TP17	565711.37	175611.51
TP19	565834.00	176098.68
TP21	565833.12	176165.93
TP22	566295.54	176035.93
TP25	566271.68	175872.95
TP26	565642.99	176052.74
TP27	565866.47	175738.47
TP33	565986.28	175419.59
TP39	565762.37	175425.29
TP43	565745.62	175457.70
TP47	565989.90	175699.71
TP48	565829.30	175659.55
TP50	565795.43	175623.69
TP52	566280.38	175778.03
TP59	565753.28	175535.52
TP60	565762.83	175777.89
TP61	565751.34	175891.96
TP62	565781.93	175922.79
TP63	565778.13	176007.49
TP64	565678.19	176407.60
TP65	565773.59	175519.45
TP66	565771.71	175552.80
TP201	565743.65	176636.51
TP202	565712.77	175588.19
TP203	565685.14	175685.96
TP204	565647.25	176517.05
TP205	565645.65	175958.61
TP208	565622.21	176449.45
TP209	565609.93	176384.86
TP210	565677.13	176584.46

4.1.3. No archaeological material was noted during the archaeological watching brief.

Boreholes

4.1.4. The excavated material from the following boreholes was scanned for archaeological finds:

	Easting	Northing
BH7	565744.07	175765.70
BH9	565665.05	175901.32
BH13	565698.73	175696.27
BH14	565779.91	175964.98
BH16	565773.08	175537.53
BH17	565606.79	176279.55
BH18	565682.27	176402.34

4.1.5. Borehole logs were received from the Bureau Veritas (Bureau Veritas 2008) from the following boreholes drilled subsequent to the archaeological watching brief. These logs have been reviewed and the sedimentological data added to the deposit model:

Borehole	Easting	Northing
BH1	565665.23	176073.21
BH2	565989.90	175699.71
BH3	565762.37	175425.29
BH4	565970.17	175642.33
BH5	565998.02	175465.95
BH6	565860.72	175382.48
BH8	565933.44	175762.41
BH10	565711.37	175611.51
BH11	565937.69	176153.45
BH12	565986.28	175419.59
BH15	565797.80	175720.73

4.2. HISTORIC BOREHOLE AND SAMPLE REVIEW

4.2.1. A total of sixty historic boreholes were reviewed as part of this study. These borehole logs were generated during several engineering projects mainly involving the construction of Tilbury A and B power stations and associated structures during the 1950s and 1960s. The earliest dated boreholes were conducted by Le Grand Sutcliff and Gill Ltd in 1924 in advance of a potential tunnel from Tilbury to Gravesend. Data quality, location information, levels and detail of sediment description have been reviewed in order to find suitable data for adding to the deposit model presented in **Figures 2**, **3**, **4** and **5**.

4.2.2. Boreholes conducted in advance of the construction of Tilbury A and B power stations were reviewed. These all fell within the area covered by the deposit model generated from the borehole logs BH1 to BH18 provided by the geotechnical contractor (Bureau Veritas 2008).

4.2.3. The most recent borehole data reviewed were borehole logs and samples collected in advance of jetty modifications by Norwest Holst in 2002. These have been added to the deposit model (**Figure 1**, **4** and **5**) as they are well described and located in areas not covered by boreholes BH1 to BH18, the geotechnical investigations subject to archaeological monitoring (Bureau Veritas 2008). Core samples from some of the Norwest Holst jetty boreholes were available on site for review. These samples were from boreholes BH401, BH402, BH403, BH404, BH405 and BH406. These samples were from deep rotary cores all elevated below *c*.30mbOD.

4.2.4. Of the borehole logs the following were chosen to add to the deposit model as they were outside of the area covered by boreholes BH1 to BH18:

Borehole	Easting	Northing
BH401	565711.86	175207.68
BH402	565720.07	175199.3
BH403	565814.66	175240.15
BH404	565848.23	175216.76
BH405	565917.57	175226.62
BH406	565997.75	175234.62
BH409	565817.11	175182.72
BH412	565811.17	175276.03
BH413	565805.42	175299.43

4.3. SEDIMENTARY UNITS

4.3.1. Four major sedimentary units were identified from the boreholes, test pits and historic borehole logs. These units have been split into subunits where appropriate.

Unit 1 Chalk (16.41m below OD to 20.34m below OD)

4.3.2. This unit comprised white and off-white chalk recovered as gravel with occasional flint and was recorded in all of the boreholes and none of the test pits. The full depth of this unit was not reached in any of the boreholes. The maximum thickness recorded was 3.1m in borehole BH17. The unit is interpreted as upper Cretaceous Chalk.

Unit 2 Sandy Gravel (11.36m below OD to 19.14m below OD)

4.3.3. This unit comprised grey sandy gravels and was recorded in all of the boreholes and none of the test pits. The unit ranged between 4.2 and 6.8m in thickness and comprised predominantly rounded to angular flint (<60mm) with white, brown and black patina. Occasional quartz, rose quartz and greensand were noted. This unit overlies unit 1. The unit was interpreted as Pleistocene fluvial gravels.

Unit 3 Alluvium and Peat (2.43m above OD to 15.01m below OD)

4.3.4. This unit comprised grey and occasionally oranges and brown silts, sands and clays interleaved with brown and black peat deposits. This unit was recorded in all of the test pits except TP24, TP, 28, TP31, TP41, TP42, TP44, TP53 and TP57. The full extent of this unit was not reached in any of the test pits. The unit was recorded in all of the boreholes and its full extent reached in all of them. The unit ranged in thickness from 11.7m in borehole BH9 to 14.7m (BH17) in thickness. This unit overlies Unit 2. The unit was interpreted as Holocene alluvial and peat deposits.

4.3.5. Peat layers were recorded in all of the boreholes and none of the test pits. Peat layers were recorded between 0.96m below OD to 12.36m below OD. Unit 3 was predominantly grey clay; however silt, sand and occasional flint gravel were also recorded. In some of the test pits orange and brown mottling indicative of oxidisation of the sediment was noted. This unit was interpreted as Holocene alluvium and peat.

4.3.6. An enigmatic deposit, recorded as peat by the drillers (Bureau Veritas 2008) in BH18 was noted between 4.54 to 5.14m below OD. Pink in colour, laminar and with a fibrous/rubbery texture the deposit contained numerous molluscs, arthropod carapaces and small flecks of charcoal. A sample of this deposit was retained.

Unit 4 Clay, silt, sand and gravel (2.88m above OD to 0.31m below OD)

4.3.7. This unit comprised black, grey, orange and brown clay, silt, sand and gravel. It was recorded in all of the test pits and boreholes. The full extent of this unit was reached in all of the boreholes and test pits except TP24, TP28, TP31, TP41, TP42, TP44, TP53 and TP57. This unit comprised a mixture of sediment groups due to its somewhat recent origin. It encompasses made ground, structural elements of the Tilbury A and B Power Stations, disposal and destruction layers associated with the A and B stations and a modern topsoil, all of post *c*.1950 in date.

4.4. OVERVIEW OF SEDIMENTARY SEQUENCE

4.4.1. The sediment sequence recovered from the cores represents Chalk bedrock, Pleistocene fluvial, Holocene alluvial and more recent deposits. Peat deposits indicative of former land surfaces are common within the Holocene alluvial sequence.

4.4.2. The four principal phases of deposition are illustrated in **Figure 2** and can be summarised as follows:

Unit 4 2.88m to -0.31m OD	Gravel, sand, silt and clay	Made ground and construction/destruction/waste debris and soil associated with the 20th century Power Station.
Unit 3 2.43m to – 15.01m OD	Clay, silt, sand and peat	Holocene (probably estuarine) alluvium and stasis peat horizons possibly caused by salt marsh development.
Unit 2 -11.36m to - 19.14m OD	Gravel	This gravel is indicative of high energy deposition, probably Pleistocene fluvial deposition within the Thames Valley
Unit 1 -16.41to -20.34m OD	Chalk	The lowest horizon described in the boreholes. This deposit represents Upper Cretaceous chalk bedrock

4.4.3. The location of the boreholes and test pits on the northern side of the Thames supports the phasing suggested above.

4.5. WALKOVER SURVEY

4.5.1. The walkover survey was conducted in the area marked on **Figure 1**. This survey identified one feature of archaeological interest. This feature is a WWII pill box and is marked on **Figure 1**. This pill box appears on the Essex County Council Historic Environment Record no. 10827.

5. CONCLUSIONS

5.1. WALKOVER SURVEY

5.1.1. The walkover survey identified one site of archaeological interest along the foreshore. It must be noted that the foreshore mud may contain archaeological remains not visible by walkover survey. **Figure 4** shows a north to south transect across the survey area and it demonstrates the type and depths of sediments in that area. At the locations of boreholes BH412 and BH413, Units 2 and 3, which may contain archaeological remains are *c*.20m in thickness.

5.2. TEST PITS AND BOREHOLES

5.2.1. The elevation of peats within these boreholes has been compared to published dated sediments in the vicinity. There is a large amount of published work relating to intercalated and dated peat and minerogenic deposits in the Thames Estuary and North Kent Marshes. Samuel Pepys noted the occurrence of hazel trees within excavations at Tilbury Docks nearly 350 years ago (Reid 1913).

5.2.2. More recently, Sidell *et al*. (2000) have studied sites in advance of the Jubilee Line Extension in London; these sites are 10 to 15 miles upstream of Tilbury Power Station, Essex, and focussed on shallow sediments (above 2m below OD). The peat deposits recorded at the Tilbury Power Station site are all below this depth. The sequence recorded by Wessex Archaeology (2008a) is more directly comparable to the work of Devoy (1979) where data was obtained within a few hundred metres of the Power Station site and from depths 2m above OD to *c*.20m below OD.

5.2.3. Devoy classified sequences of peats (Tilbury I–V) and minerogenic sediments (Thames I–V), which are named in order to classify regressive and transgressive sea level cycles respectively (1979; 1980; 1982). The elevation of these peats recorded by Devoy at the Worlds End Borehole, Tilbury *c*. 0.5km west of the site is shown in the table below:

Devoy 1979	Depths and Heights
Tilbury V	1.5maOD to 1.65maOD
Tilbury IV	1.9mbOD to 2.10mbod
Tilbury III	5.2mbOD to 6.5mbOD
Tilbury II	10mbOD to 10.2mbOD
Tilbury I	13.1mbOD to 13.4mbOD

5.2.4. The radiocarbon dates and archaeological periods for the inception of deposition of the Thames and Tilbury sediments at the Worlds End Borehole is given in the table below:

Devoy 1979	Uncalibrated 14C dates	calibrated date	Archaeological period
Thames V			Late Roman to ?Modern
Tilbury V	*c*.1700BP	260 to 400AD	Late Roman
Thames IV	3020±65 BP	1420 to 1050 BC	Middle to late Bronze age
Tilbury IV	3240±75 BP	1690 to 1380 BC	Early to Middle Bronze Age
Thames III	3850±80 BP	2600 to 2000 BC	Later Neolithic to Early Bronze Age
Tilbury III	6200±90 BP	5400 to 4850 BC	Late Mesolithic
Thames II	6575±95BP	5670 to 5340 BC	Late Mesolithic
Tilbury II	7050±100 BP	6100 to 5710 BC	Late Mesolithic
Thames I	7830±110BP	7050 to 6450 BC	Late Mesolithic
Tilbury I	8170±110BP	7500 to 6800 BC	Late Mesolithic

5.2.5. The occurrence (x) of minerogenic and peat deposits within the Tilbury Power Station boreholes at depths similar to those of the classifications of Devoy (1979) is shown figuratively in section (**Figures 2 and 3**) and in the table below:

Devoy 1979	Borehole (BH) no.																	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Thames V	x	x	x	x	x			x			x		x			x		x
Tilbury V																		
Thames IV	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Tilbury IV			x						x		x					x		
Thames III	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Tilbury III		x	x			x	x	x	x	x	x	x	x	x	x	x	?x	x
Thames II	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Tilbury II		x	x	x			x	x	x	x	x	x	x	x	x	x	?x	?x
Thames I		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Tilbury I																		?x

5.2.6. Tilbury I, the basal peat of Devoy (1979) was not positively identified in any of the boreholes. The only borehole with a basal peat lying directly on top of the Pleistocene gravels was BH18 however this was similar in elevation to the Tilbury II peat, which according to Devoy (1979) can also be basal. This layer is approximately one metre thick which is substantially thick than the Tilbury I and II peats identified by Devoy (**Figure 1**).

5.2.7. Peat equivalent in elevation to Tilbury II was seen more extensively, occurring in 15 of the 18 boreholes. Similarly 15 of the 18 boreholes contained peat at similar levels to the Tilbury III peat. Peat at similar elevation to the Tilbury IV peat was recorded in 4 of the 18 boreholes. No peat was recorded at elevations attributable to the Tilbury V peat.

5.2.8. Minerogenic sediments equivalent in elevation to the Thames I was found in all the boreholes except BH1. Sediments equivalent to Thames II, III, and IV were found in all of the boreholes. Similar sediments to Thames V were found in 10 of the 18 boreholes. Minerogenic sediments overlying the Pleistocene gravels at the equivalent level of the Tilbury I peat were identified in 12 of the 18 boreholes (**Figure 2 and 3**).

5.2.9. Some interesting sedimentary horizons were found to be present within the test pits and boreholes. Unit 4 relates to the more recent post *c*.1950 Tilbury A and B power station developments. Features relating to the Tilbury A and B stations were recorded in most of the test pits including the southern wall of the partially demolished Tilbury A station, recorded in test pit 41 (**Appendix 1**, **Figure 1**).

Peats and minerogenic sequences

5.2.10. The Peat and minerogenic sediments that are comparable to the sedimentary sequences described by Devoy (1979) are all found within Unit 3 and relate to Holocene sea level rise and saltmarsh and alluvial deposition.

5.2.11. The peat layers from Unit 3 are elevated from 15.92mbOD in borehole BH412 (**Figure 4**) to 1.56mbOD in borehole BH11 (**Figure 2**). The alluvial layers within Unit 3 are elevated between 15.47m below OD in borehole BH412 (**Figure 4**) to 2.80m above OD boreholes BH6 and BH8 (**Figure 2**). The sequence recorded by Devoy ranges from 14m below OD to *c*.1.5maOD and has been radiocarbon dated to *c*.8200BP to *c*.1700BP or Mesolithic to Roman periods. Unit 3 is noted to be a thicker sequence than that recorded by Devoy at the Worlds End Borehole (Devoy 1979).

5.2.12. The peats recorded within Unit 3 are noted to be laterally discontinuous over the site except where boreholes are within 100m of each other. This is a phenomenon well recorded within Holocene deposits and is in part a result of differential sediment compaction, dessication, erosion and depositional processes (Allen 2000). It is of note that researchers have encountered difficulties in the extrapolation of Devoy's sequence downstream of the World End borehole at Tilbury Docks (Haggart 1995 and Long 1995).

5.2.13. When comparing Holocene sediments and particularly peat elevation from a large river system such as the Thames it should be noted that the development of such a river is constant but with regards to sedimentation, dissimilar along both its length and breadth. Large scale changes have their effect; however these may be expressed in similar terms within a 100mm diameter borehole as a small term change.

5.2.14. Opposite the site, approximately 1km south at Gravesend, early Romano British pottery and associated domestic refuse was recovered from alluvial sediments at 1.4m above OD (Firth 2000).

Gravels

5.2.15. Unit 2 is interpreted as Pleistocene fluvial gravels. The gravels may potentially contain prehistoric artefacts of archaeological interest. Comparison of its elevation on the site with the Thames terrace sequence of gravels would suggest that Unit 2 is possibly equivalent to the Shepperton gravel which is thought to date to the middle of the Devensian, Oxygen Isotope Stage 2, *c*.30,000 years BP, or Upper Palaeolithic period.

5.2.16. Unit 1 is interpreted as upper Cretaceous Chalk bedrock. This deposit is not of archaeological interest; however, it marks the edges of the Thames Valley.

5.2.17. The sediments therefore of archaeological significance identified on the site are Units 2 and 3. Unit 2 may contain reworked Palaeolithic archaeological material. Unit 3 may contain *in situ* archaeological material from the Mesolithic to present. Archaeological material within this unit is likely to be waterlogged. The presence of charcoal within sediments at 4.54 to 5.14m below OD is an indication that archaeological material could be present within Unit 3.

6. IMPORTANCE

6.1.1. The peat deposits identified at the Tilbury power station site relate to the deposits identified by Devoy as well as deposits identified by other researchers. The problem in correlating different deposits has already been described. However, the extents of the horizons identified at the power station site do relate to the overall depositional sequence proposed by Devoy and others. The extents of the deposits over the site vary and do not appear in all the boreholes, but are distributed throughout the main operational area of the proposed development area.

6.1.2. The importance of these deposits (Unit 3) is two fold: they have the potential to contain archaeological artefacts dating from the Mesolithic period to the late Bronze Age; and they hold palaeoenvironmental information that will inform research on sea level rise, landscape and environment development. The additional boreholes that have been taken as part of the mitigation strategy will address the palaeoenvironmental concerns in general terms for the whole site. It is important to note that the minerogenic sediments are also of archaeological interest and contain equally valuable paleoenvironmental data as the peat deposits. The minerogenic sediments are extensive throughout the site.

6.1.3. It is considered that archaeological material contained within Unit 4 is likely to relate to the Industrial and Modern power industry heritage of the area.

6.1.4. Any archaeological material contained within Unit 3 is likely to date from the Mesolithic to the post-Medieval periods. This material, if present within the minerogenic and peat deposits is likely to be exceptionally preserved with other palaeoenvironmental evidence. For this reason, archaeological material within this unit is potentially of national and potentially international importance.

6.1.5. Archaeological material contained within Unit 2 is likely to date from the Palaeolithic period. Archaeological material present within this unit is likely to be of between regional and national importance.

7. IMPACT OF GROUND WORKS

7.1.1. Unit 3 will effectively be removed in the area of major construction of the new turbine halls, boiler houses and the stack. However to the north of the site in the vicinity of the car park and transformer locations the impact will be minimal and part of the deposit will be preserved. This is the area covered by boreholes BH17, 18 and 11 (Figure 2, 3, 4 and 5).

7.1.2. Units 4, 3, 2 and 1 are likely to be disturbed in those areas where piled foundations are used for construction. The type of and amount of piling will determine the degree of disturbance. Piling can affect areas up to 5 times its own cross section and in areas of soft waterlogged sediments (Unit 3) deformation of the sediments can be a problem (English Heritage 2007).

7.1.3. Borehole BH11 shows two peat deposits which could relate to Devoy's system Tilbury IV and Tilbury III which were dated to the Neolithic and Bronze Age respectively. Minerogenic sediments within boreholes BH1 and BH11 are elevated at similar levels to those thought to date from the Mesolithic to Roman periods. No peats were recorded in BH1 and this may be due to either localised non-deposition, erosion or a channel.

8. RECOMMENDATIONS

8.1.1. When comparing Holocene sediments, and particularly peat elevation, from a large river system such as the Thames it should be noted that its development is constant, and with regards to sedimentation, dissimilar along both its length and breadth. Large scale changes have their effect; however these may be expressed in similar terms within a borehole as a small term change. Extrapolation of elevation data based upon geotechnical borehole data is not an exact science.

8.1.2. Extrapolation of Devoy's system has proved problematic to some researchers because elevations and dates correlate in some areas but not others (Haggart 1995, Long 1995, Sidell *et al.* 2000). This is not unexpected as in the area between Tilbury Docks and the Tilbury C Power Station site Devoy (1979) describes the peat layers as follows: "Tilbury V and IV were found to be only locally persistent with Tilbury IV the most widely developed…the irregular profile of Tilbury III can be best be explained by two main processes. First by peat growth upon an originally hummocky, uneven clay/silt surface formed by Thames II, resulting from differential deposition rates and second by erosion of the peat due to channel and creek formation…the sediments of Tilbury II have a more uniform surface…Tilbury I lies between the maximum limits of -12 to -16.5m O.D.".

8.1.3. On balance however Devoy's system provides a framework which suggests that peats probably dating from the late Mesolithic (Tilbury II and Tilbury III) to late Bronze Age (Tilbury IV) are present on site. Devoy's system was developed in order to better understand Holocene environment and sea level. In order to correlate the peats at the Tilbury Power Station site with those recorded and dated by Devoy (1979) a methodology similar to that adopted by Devoy could be attempted. The key to Devoy's methodology is that the character and nature of the sediments are determined to establish the transitional points by palaeoenvironmental assessment and analysis, followed by C14 dating to provide an objective chronology.

8.1.4. This methodology has formed the basis of most sea level and environment studies of this type in southern England since its publication. Further investigative mitigation of the cores recovered form the Site is recommended, based on the Devoy methodology, and would comprise:

- Identification of in *situ* development of the sediments (regressive and transgressive contacts) shown by gradual stratigraphic change between the organic and inorganic deposits.
- Analysis of the vegetational changes through the organic sediment and over the transition zones with inorganic sediments using pollen and macrofossil techniques.
- Determination of environment represented by the silts and clays in support of the vegetational analyses.
- Once the transitional points have been established material is taken for C^{14} dating to provide as objective chronology.
- Determination of the correct heights of the transgression and regression contacts by precise levelling to Ordnance Datum, Newlyn.

8.1.5. Any further boreholes that may be undertaken will be subject to archaeological monitoring and recording.

8.1.6. Such proposals would be developed in consultation with the Essex County Council Senior Historic Environment Officer and would form part of the wider mitigation proposals for the scheme.

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APPENDIX I: SEDIMENT DESCRIPTIONS

TP1

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.20	1.81 to 1.61	Brown sandy silt, humic roots. **Topsoil**	4
0.20 to 0.50	1.61 to 1.31	Sandy gravelly clay, clinker inclusions. **Made Ground**	4
0.50 to 1.20	1.31 to 0.61	Brown clay, mottled grey. **Alluvium**	3

TP2

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.22	1.51 to 1.29	Brown sandy silt, stiff, sorted, moderate well rounded flint up to 60mm, gradual boundary. **Topsoil**	4
0.22 to 0.40	1.29 to 1.11	Grey very fine silt, firm, well sorted, no inclusions, sharp boundary. **Alluvium**	3
0.40 to 0.76	1.11 to 0.75	Brown mottled grey clay, firm, well sorted, no inclusions, slight water ingress. **Alluvium**	3

TP3

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.08	2.08 to 2.00	Brown sandy silt, frequent roots. **Topsoil**	4
0.08 to 0.95	2.00 to 1.13	Orange sandy gravel, sub to rounded to rounded flint up to 35mm slightly sorted. **Made Ground**	4
0.95 to 1.60	1.13 to 0.48	Grey sandy gravel, flint up to 75mm and concrete lumps up to 500mm, occasional pieces of wood, petrochemical smell. **Made Ground**	4
1.60 to 1.80	0.48 to 0.28	Grey silty clay, mottled black (organic), orange iron oxide staining, 20mm boundary. **Alluvium**	3
1.80 to 2.00	0.28 to 0.08	Greyish brown clayey silt, organic look, becomes darker (black) with more organic parts with depth. **Alluvium**	3

TP4

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.15	1.64 to 1.49	Brown sandy silt, humic roots, occasional chalk/flint. **Modern Soil**	4
0.15 to 0.30	1.49 to 1.34	Orange sandy gravel, sorted, flint sub to rounded to sub to angular. **Made Ground**	4
0.30 to 0.70	1.34 to 0.94	Black ash/clinker, sorted. **Power Station Waste Material**	4
0.70 to 0.90	0.94 to 0.74	Brownish grey silty clay, mottled orange, firm, iron oxide stained, water ingress. **Alluvium**	3

TP5

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.10	1.56 to 1.46	Brown sandy silt, humic, roots. **Topsoil**	4
0.10 to 0.40	1.46 to 1.16	Brown sandy gravely clay, occasional brick and concrete. **Made Ground**	4
0.40 to 1.10	1.16 to 0.46	Brown mottled light grey clay. **Alluvium**	3

TP6

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.10	1.99 to 1.89	Brown sandy silt, modern roots, sub to angular to sub to rounded flint inclusions up to 30mm. **Topsoil**	4
0.10 to 1.30	1.89 to 0.69	Black silty gravel, gravel to black clinker, occasional flint/brick, 1950's rubbish at 1.2m where it gets wet. **Made Ground**	4
1.30 to 1.40	0.69 to 0.59	Grey clayey silt, mottled orange (20%). **Alluvium**	3

TP7

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.10	2.18 to 2.08	Brown sandy silt, frequent modern root inclusions. **Topsoil/Lid Turf**	4
0.10 to 0.25	2.08 to 1.93	Yellowish orange silty sand, compact, frequent sub to rounded to rounded flint gravel up to 40mm. **Made Ground**	4
0.25 to 1.20	1.93 to 0.98	Black ash/clinker sandy gravel, power station clinker, concrete slab in southern end at 0.3m. **Made Ground**	4
1.20 to 1.30	0.98 to 0.88	Dark grey silty clay, stiff, inclusions ash and rubbish, 1940's/50's screw top bottle pushed into it. **Alluvium**	3

TP8

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.10	2.77 to 2.67	Grey gravel, clinker. **Made Ground**	4
0.10 to 1.20	2.67 to 1.57	Sandy gravel, orange brown. **Made Ground**	4
1.20 to 1.30	1.57 to 1.47	Dark grey sandy gravel, sub to angular and sub to rounded fine to coarse flint, strong hydrocarbon odour, solid base. **Alluvium**	3

TP13

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.20	2.52 to 2.32	Brown silt, becoming orange and sandy, frequent roots. **Topsoil**	4
0.20 to 0.60	2.32 to 1.92	Orange clayey sandy gravel, poorly sorted. **Made Ground**	4
0.60 to 1.20	1.92 to 1.32	Black sandy gravel, poorly sorted clinker. **Made Ground**	4
1.20 to 1.50	1.32 to 1.20	Grey, stiff, silty clay, well preserved organics. **Alluvium**	3

TP15

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.10	2.31 to 2.21	Brown sandy silt. **Topsoil**	4
0.10 to 0.60	2.21 to 1.71	Orange sandy gavel, sorted. **Made Ground**	4
0.60 to 1.10	1.71 to 1.21	Black sandy ashy gavel, clinker. **Made Ground**	4
1.10 to 1.25	1.21 to 1.06	Grey silty clay, stiff, wet, organic splodges, slight orange mottling. **Alluvium**	3

TP16

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.10	2.26 to 2.16	Brown sandy silt, frequent grass roots. **Topsoil**	4

Depth below ground (m)	Depth OD (m)	Description	Unit
0.10 to 0.60	2.16 to 1.66	Orange brown sandy gravel, sorted sub to angular to rounded flint inclusions up to 40mm. **Made Ground**	4
0.60 to 1.10	1.66 to 1.16	Greyish black sandy gravel, sub to angular clinker up to 50mm. **Made Ground**	4
1.10 to 1.20	1.16 to 1.06	Grey silty clay, compact. **Alluvium**	3

TP18

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.20	2.14 to 1.94	Brown sandy silt. **Topsoil**	4
0.20 to 0.55	1.94 to 1.59	Orange brown clayey sandy gravel. **Made Ground**	4
0.55 to 0.80	1.59 to 1.34	Dark grey clay. **Made Ground**	4
0.80 to 0.90	1.34 to 1.24	Red brown sandy gravel, clinker. **Made Ground**	4
0.90 to 1.20	1.24 to 0.94	Grey mottled dark grey clay. **Alluvium**	3

TP20

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.10	2.29 to 2.19	Brown sandy silt, frequent modern roots. **Topsoil**	4
0.10 to 0.60	2.19 to 1.69	Orange sandy gravel, sorted. **Made Ground**	4
0.60 to 1.10	1.69 to 1.19	Black sandy gravel, sorted clinker and ash up to 50mm, green sandy bands, becoming very wet at 1m. **Made Ground**	4
1.10 to 1.20	1.19 to 1.09	Grey silty clay, stiff and wet, black organic occasional inclusions. **Alluvium**	3

TP23

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.10	1.66 to 1.56	Brown sandy silt, frequent modern roots. **Topsoil**	4
0.10 to 0.25	1.56 to 1.41	Brown sandy gravely clay, sand to fine to course, gravel to fine to course sub to rounded to sub to angular. **Made Ground**	4
0.25 to 0.35	1.41 to 1.31	Dark grey sandy gravel, gravel to fine to course sub to rounded to sub to angular, ash and clinker. **Made Ground**	4
0.35 to 1.10	1.31 to 0.56	Brown mottled grey clay, firm becoming stiff. **Alluvium**	3

TP24

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.80	2.78 to 0.98	Concrete rubble and bricks, water ingression, hit slab at 0.8m, southern edge is concrete smooth. **Made Ground**	4

TP28

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.20	2.69 to 2.49	Clayey brown gravel. **Made Ground**	4
0.20 to 0.60	2.49 to 2.09	Dark grey sandy gravely clay, pipe at 0.6m. **Made Ground**	4

TP29

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.20	2.68 to 2.48	Brown gravely silty sand, lose frequent grass roots, moderate sub to rounded rounded flint. **Topsoil**	4
0.20 to 0.50	2.48 to 2.18	Greyish black sandy gravel, clinker up to 20mm. **Made Ground**	4
0.50 to 1.10	2.18 to 1.58	Orange / grey stiff silty clay, mottled orange 15%. **Alluvium**	3

TP30

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 1.10	2.53 to 2.43	Dark brown clayey gravely sand, sand is fine to coarse, gravel is sub to angular to sub to rounded brick concrete tile wire and metalwork, cobbles of brick and concrete, concrete slab at 0.4m. **Made Ground**	4
1.10 to 1.30	2.43 to 2.13	Soft greenish grey mottled dark grey clay. **Alluvium**	3

TP31

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.10	2.76 to 2.66	Tarmac. **Made Ground**	4
0.10 to 0.25	2.66 to 2.51	Concrete. **Made Ground**	4
0.25 to 0.50	2.51 to 2.26	Orange sandy gravel, sub to angular and sub to rounded fine to coarse flint. **Made Ground**	4
0.50 to 0.80	2.26 to 1.96	Grey silty clay, chalk gravel and concrete up to 60mm, hit concrete foundation at 0.8m. **Made Ground**	4

TP32

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.02	2.54 to 2.52	Yellow grey orange gravel, sub to angular and sub to rounded coarse flint. **Made Ground**	4
0.02 to 0.30	2.52 to 2.24	Brown slightly clayey sand, sand is fine and medium. **Made Ground**	4
0.30 to 0.55	2.24 to 1.99	Reddish brown sandy gravel, sand is fine to coarse, gravel is sub to angular to sub to rounded, brick. **Made Ground**	4
0.55 to 1.10	1.99 to 1.44	Stiff bluish grey clay, **Alluvium**	3

TP34

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.22	2.55 to 2.33	Dark brown to black sandy silt, stiff, unsorted, ash and flint inclusions, ash to frequent, fine, well sorted. Flint to sub to angular to sub to rounded up to 20mm, sharp boundary. **Made Ground**	4
0.22 to 1.00	2.33 to 1.55	Orange sandy gravel soft, well sorted. Flint gravel up to 110mm angular to rounded, sharp boundary. **Made Ground**	4
1.00 to 1.20	1.55 to 1.35	Firm orange brown clay, well sorted, no inclusions. **Alluvium**	3

TP35

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.20	2.66 to 2.46	Dark brown clayey gravel, sub to angular to sub to rounded coarse yellow/brown/grey flint. **Made Ground**	4
0.20 to 1.20	2.46 to 1.46	Orange brown slightly clayey sandy gravel, sand is fine to coarse, gravel is sub to angular to sub to rounded flint brick and chalk. **Made Ground**	4
1.20 to 1.60	1.46 to 1.06	Firm bluish grey clay, hydrocarbon odour at top of stratum. **Alluvium**	3

TP36

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.10	2.88 to 2.78	Grey gravel, clinker. **Made Ground**	4
0.10 to 0.30	2.78 to 2.58	Dark grey clayey sandy gravel, sub to angular to sub to rounded flint. **Made Ground**	4
0.30 to 1.50	2.58 to 1.38	Orange brown gravely sand, sand is fine to coarse, gravel is sub to angular and sub to rounded flint. **Made Ground**	4
1.50 to 1.60	1.38 to 1.28	Soft, bluish grey, mottled dark grey, clay. **Alluvium**	3

TP37

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.25	2.49 to 2.24	Brown gravely sand, flint up to 35mm and lumps of concrete. **Made Ground**	4
0.25 to 0.90	2.24 to 1.59	Brown/black clayey sandy gravel, flint up to 40mm clinker and ash. **Made Ground**	4
0.90 to 1.10	1.59 to 1.39	Stiff grey silty clay, mottled organic (20%). **Alluvium**	3

TP38

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.10	2.62 to 2.52	Brown sandy gravel. **Topsoil**	4
0.10 to 1.50	2.52 to 1.02	Grey brown black gravely clay. Petrol smell and small pieces of cloth, occasional concrete. **Made Ground**	4
1.50 to 2.20	1.02 to 0.42	Grey silty clay, mottled black organic spots (15%). **Alluvium**	3

TP40

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.10	2.66 to 2.56	Grey tarmac and concrete. **Made Ground**	4
0.10 to 0.40	2.56 to 2.26	Orange grey sandy gravel, including frequent red/yellow bricks, gravel is flint up to 40mm, very occasional metal. **Made Ground**	4
0.40 to 0.70	2.26 to 1.96	Black sandy gravel, gravel is clinker up to 55mm slightly sorted. **Made Ground**	4
0.70 to 1.10	1.96 to 1.56	Dark grey stiff silty clay, mottled black 35% organic spots, occasional preserved roots. **Alluvium.**	3

TP41

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.50	2.84 to 2.34	Concrete bricks, sand and clay, at 500mm concrete slab, north facing section has a six ounce redbrick wall English Bond. **Made Ground**	4

TP42

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.10	2.78 to 2.68	Grey, clayey, sandy, gravel, sand is fine to coarse, gravel is flint brick and tarmac. **Made Ground**	4
0.10 to 0.30	2.68 to 2.48	Dark brown sandy gravel. Sand is fine to coarse, gravel is sub to angular and sub to rounded flint, brick and concrete. **Made Ground**	4

TP44

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.10	2.86 to 2.76	Grey, clayey, sandy, gravel, sub to angular to sub to rounded flint, brick and concrete. **Made Ground**	4
0.10 to 0.25	2.76 to 2.61	Dark brown, sandy gravel. Sub to angular to sub to rounded flint, fine to coarse sand, brick and concrete. **Made Ground**	4

TP45

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.30	2.49 to 2.19	Dark brown silt, frequent roots, occasional chalk. **Topsoil**	4
0.30 to 0.50	2.19 to 1.99	Greyish brown gravely clay, frequent chalk sub to rounded to angular up to 60mm. **Made Ground**	4
0.50 to 1.30	1.99 to 1.19	Orange sandy gravel, sub to rounded to rounded flint up to 40mm. **Made Ground**	4
1.30 to 1.90	1.19 to 0.59	Grey stiff silty clay, mottled orange 15%, occasional preserved roots, heavily burrowed (possible shoreline). **Alluvium**	3

TP46

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.43	2.38 to 1.95	Brown sandy silt, stiff, sorted, moderate irregular chalk and flint inclusions sub to rounded to angular, frequent grass roots, gradual boundary. **Made Ground**	4
0.43 to 1.20	1.95 to 1.18	Grey fine silt, very firm, well sorted, no inclusions. **Alluvium**	3

TP49

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.20	2.35 to 2.15	Concrete slab and steel. **Made Ground**	4
0.20 to 0.50	2.15 to 1.85	Orange to grey silty sandy gravel, rounded to sub to rounded flint up to 40mm mixed with clinker and alluvium below. **Made Ground**	4
0.50 to 1.20	1.85 to 1.15	Light bluish grey stiff silty clay, mottled black 5% organic spots. **Alluvium**	3

TP51

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.21	2.16 to 1.95	Brown sandy silt, mottled yellow sand, unsorted, moderate sub to rounded to angular flint inclusions up to 50mm, gradual boundary. **Made Ground**	4
0.21 to 1.20	1.95 to 0.96	Greyish brown silty clay, unsorted, infrequent angular flint inclusions up to 20mm, gradual boundary, occasional concrete blocks of up to 0.40m. **Made Ground**	4
1.20 to 1.30	0.96 to 0.86	Stiff grey clay, infrequent well rounded flint up to 70mm, rotting vegetation at 1.2m. **Alluvium**	3

TP53

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.35	2.47 to 2.12	Concrete/steel reinforcement. **Made Ground**	4
0.35 to 1.00	2.12 to 1.47	Grey silty sand, becomes darker at 0.8m occasional orange mottling, iron oxide staining at the top, sand is fine with no obvious bedding, very firm ashy feel. **Made Ground**	4

TP54

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.80	2.36 to 1.56	Dark grey silty sand. Very frequent ash/coal dust. Occasional large (200mm) concrete. **Modern Soil/Made Ground**	4
0.80 to 1.70	1.56 to 0.66	Dark grey silt. Very frequent concrete up to 0.5m. Sheeting piling at 1.0m, occasional metal, wood and tile. **Made Ground**	4
1.70 to 1.80	0.66 to 0.56	Firm, grey mottled orange brown clay. **Alluvium**	3

TP55

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.14	2.15 to 2.01	Brown silty sand, modern roots. **Topsoil**	4
0.14 to 0.40	2.01 to 1.75	Black sandy gravel, gravel to clinker up to 15mm, occasional flint sub to rounded to sub to angular up to 10mm. **Made Ground**	4
0.40 to 1.10	1.75 to 1.05	Orange sandy gravel, well sorted, gravel to flint sub to angular to sub to rounded. **Made Ground**	4
1.10 to 1.30	1.05 to 0.85	Orange brown silty clay, iron oxide staining. **Alluvium**	3

TP56

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.20	2.49 to 2.29	Brown silty sand. Moderate brick. Small to medium up to 60mm sub to angular to sub to rounded chalk/flint. Frequent roots. **Modern topsoil/Made Ground**	4
0.20 to 0.47	2.29 to 2.02	Grey gravely loose sand. Very frequent ash/coal. Moderate sub to angular to sub to rounded flint. **Made Ground**	4
0.47 to 1.60	2.02 to 0.89	Orange slightly silty sandy gravel. Firm and sorted. Gravel is flint up to 160mm diameter rounded to sub to angular. Concrete slab at 0.80m. RSJ Beam at 0.5m. **Made Ground**	4

Depth below ground (m)	Depth OD (m)	Description	Unit
1.60 to 1.90	0.89 to 0.59	Firm becoming stiff, grey mottled orange sandy silty clay, no inclusions. **Alluvium**	3

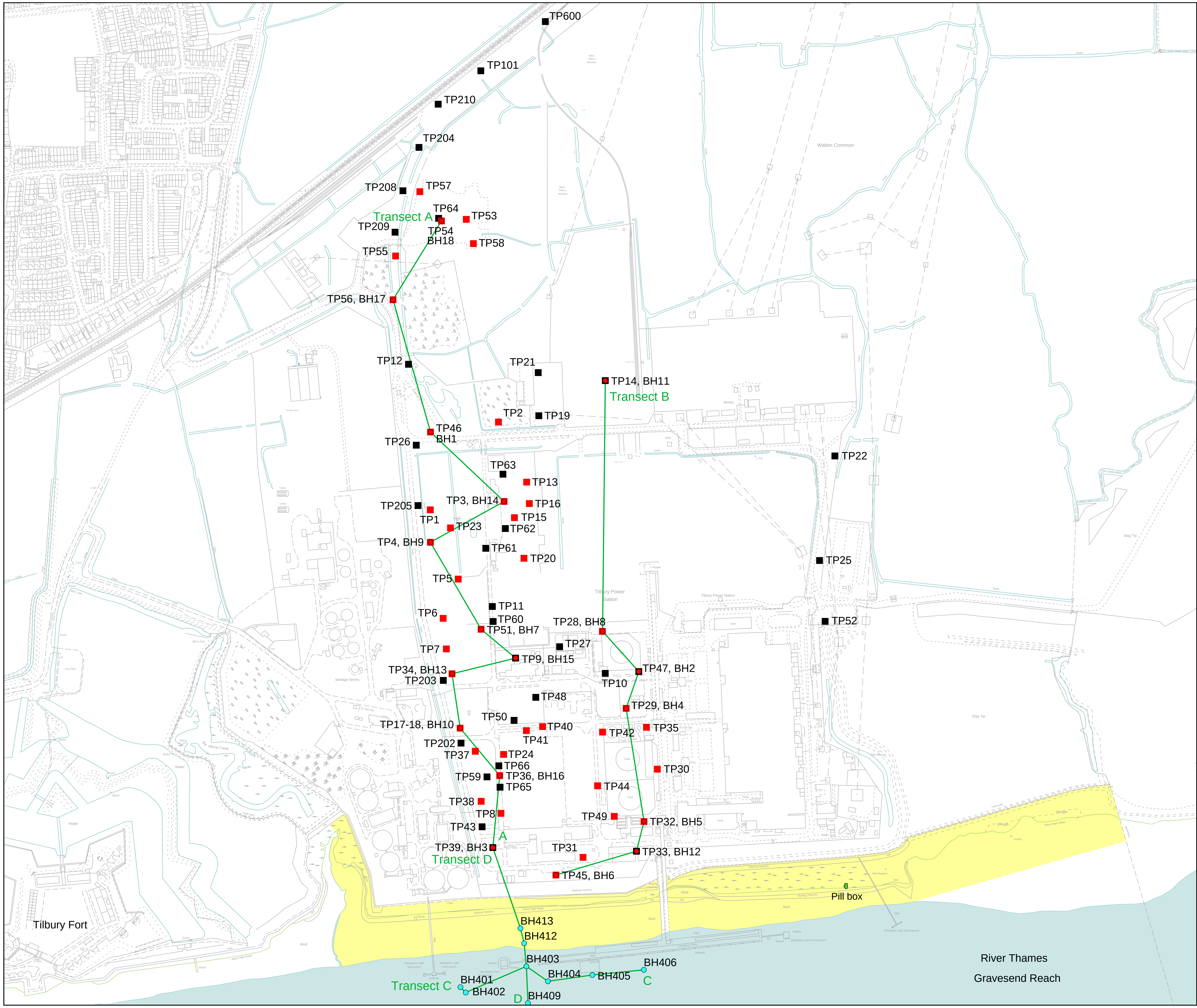
TP57

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.20	1.83 to 1.63	Brown sandy silt, moderate modern roots. **Topsoil**	4
0.20 to 0.60	1.63 to 1.23	Red grey brown black silty sandy gravel, occasional bricks and clinker. **Made Ground**	4
0.60 to 1.20	1.23 to 0.63	Grey fine silty sand, very firm ash, becomes darker as it gets deeper. **Made Ground**	4

TP58

Depth below ground (m)	Depth OD (m)	Description	Unit
0.00 to 0.20	2.33 to 2.13	Dark grey sandy silt, occasional concrete up to 250mm. **Topsoil**	4
0.20 to 1.20	2.13 to 1.13	Grey silty fine sand/ash. **Made Ground**	4
1.20 to 1.30	1.13 to 1.03	Grey silty clay, mottled orange (50%), iron oxide stained. **Alluvium**	3

Wessex Archaeology



- Area covered by walkover survey
- Borehole subjected to watching brief
- Jetty borehole (2002)
- Test pit subjected to watching brief
- Test pit not subjected to watching brief
- WWII pill box - SMR no. 10287
- Transect locations (see figs 2-5)

0 100 200m

Inset: Digital Map Data © (2008) XYZ Digital Map Company.

Basemap supplied by client.

Revision Number:	0
Illustrator:	KJB
Date:	15/05/08
Scale:	1:6000
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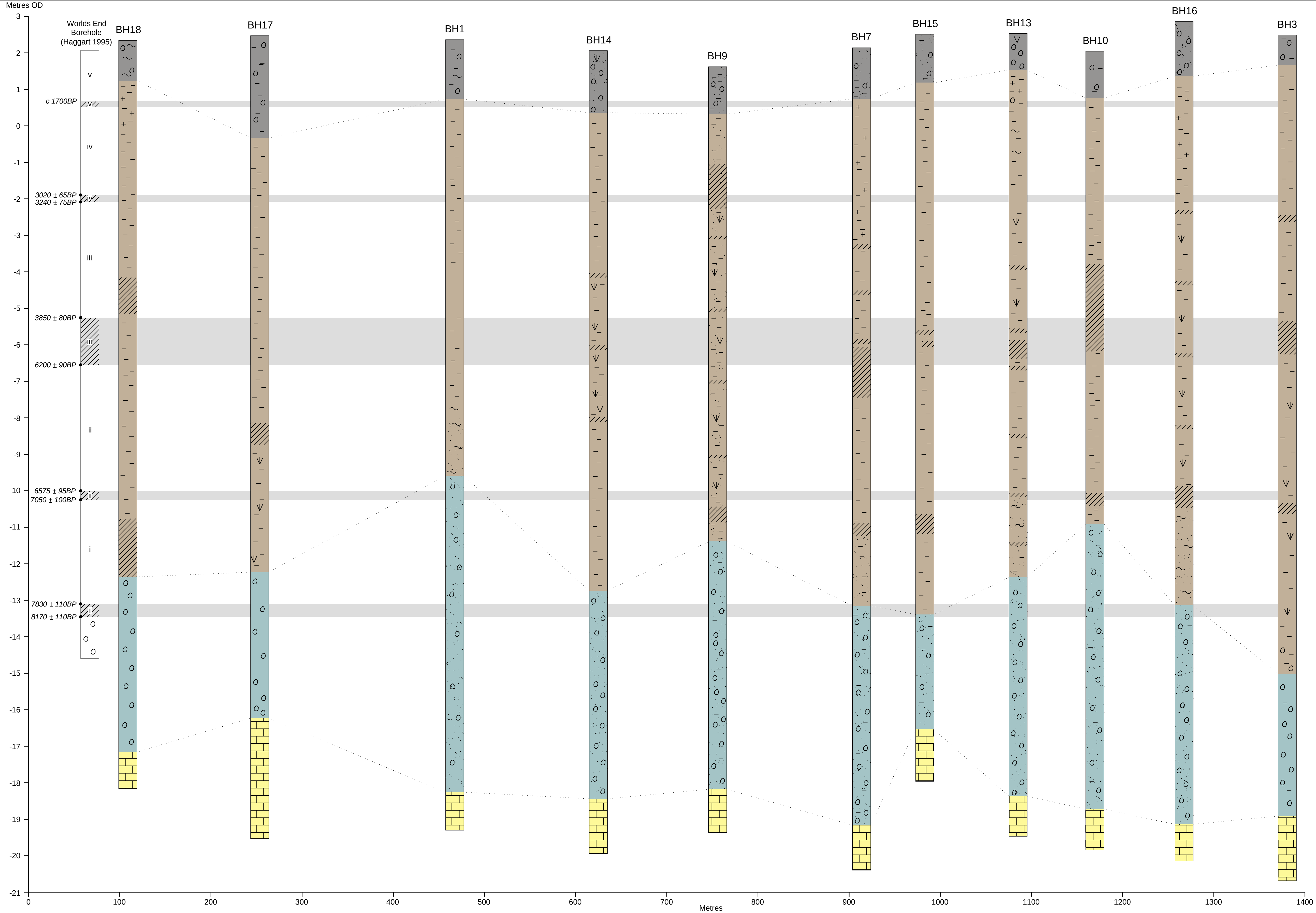
Report Figures\WB\08-05-14

Site location, including boreholes, test pits, walkover survey and pill box location

Figure 1



Unit 4 - Made ground
Unit 3 - Alluvium - peat
Unit 2 - Fluvial gravels
Unit 1 - Chalk bedrock

Gravel
Sand
Silt
Clay

Peat
Chalk
Organics
Oxidised sediments

Basemap supplied by client.

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Scale:	Vertical 1:100, horizontal 1:4000 (inset 1:10,000)	Illustrator:	KJB
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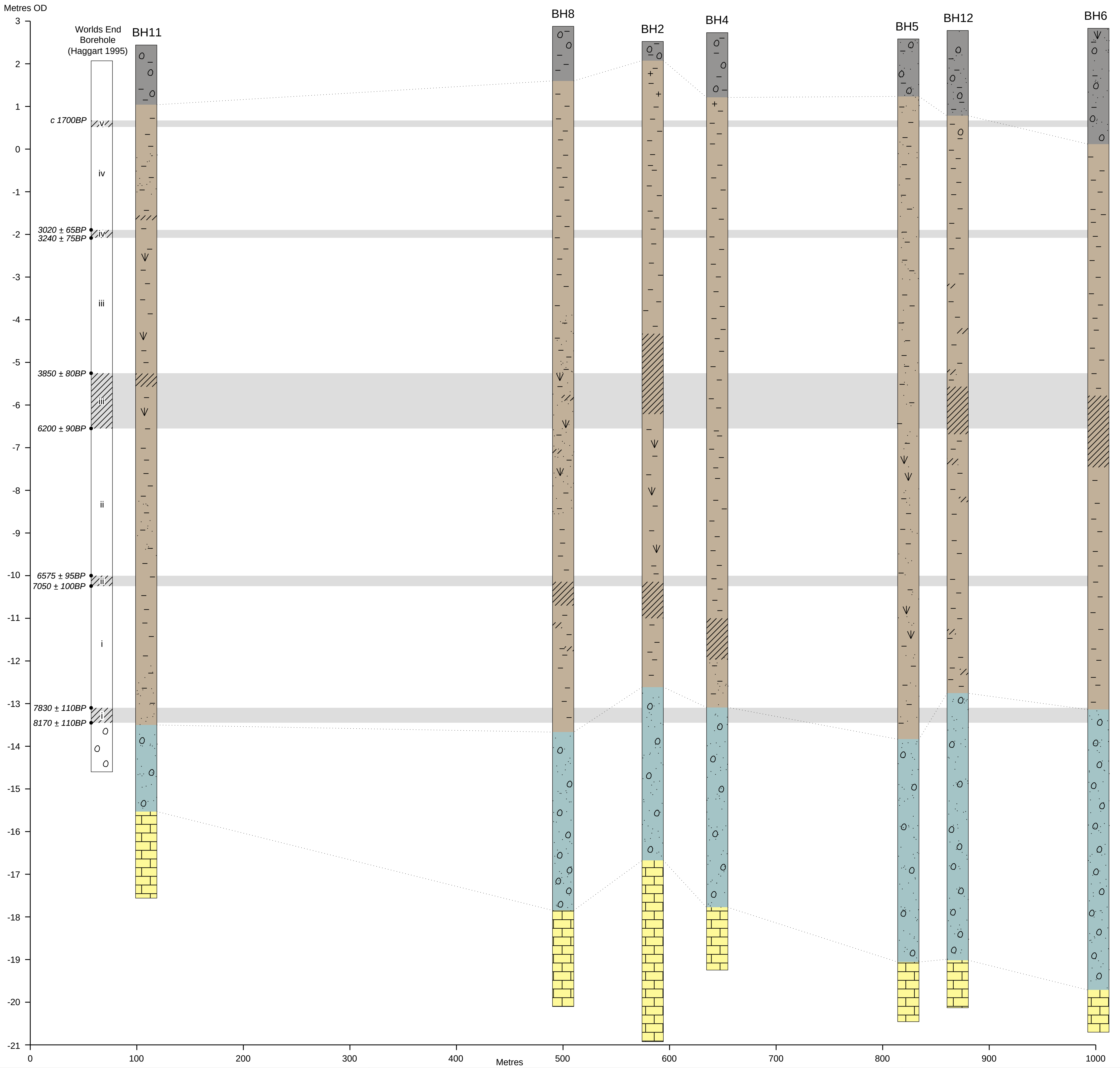
Borehole transect A

Figure 2



Unit 4 - Made ground
Unit 3 - Alluvium - peat
Unit 2 - Fluvial gravels
Unit 1 - Chalk bedrock

Gravel
Sand
Clay
Peat

Chalk
Organics
Oxidised sediments

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Scale:	Vertical 1:100, horizontal 1:4000 (inset 1:10,000)	Illustrator:	KJB
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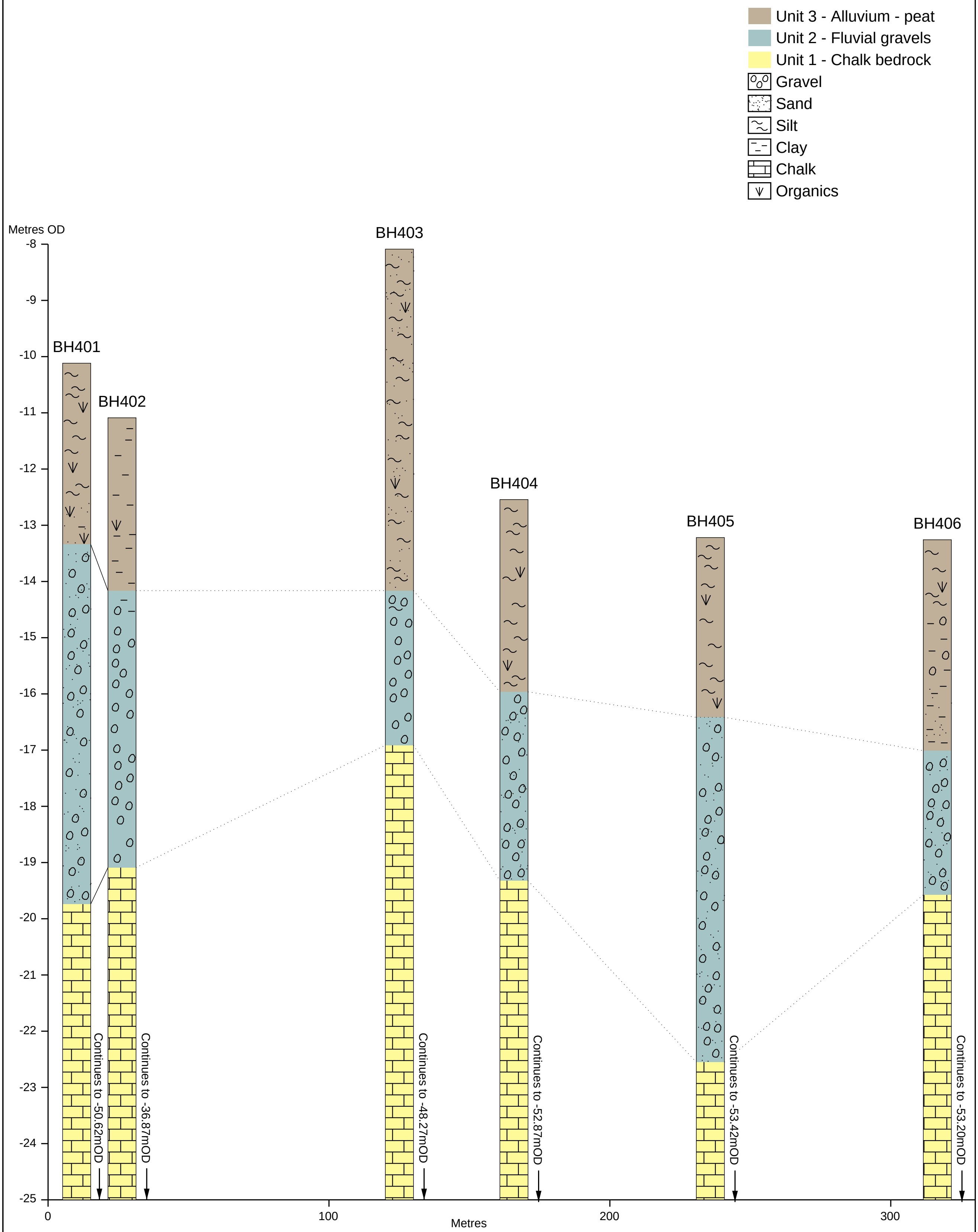
Borehole transect B

Figure 3



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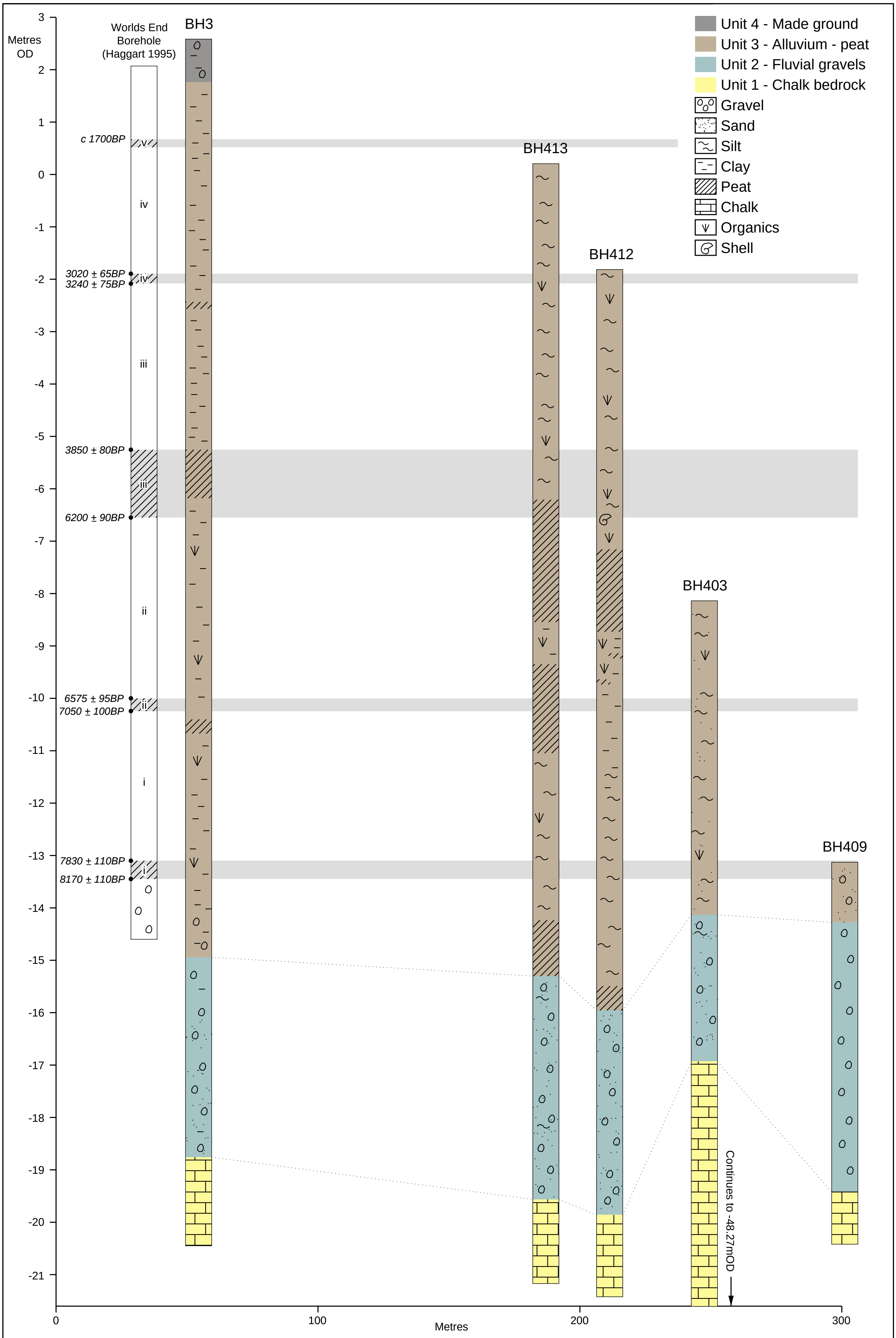
Borehole transect C

Figure 4



Wessex Archaeology

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Borehole transect D

Figure 5

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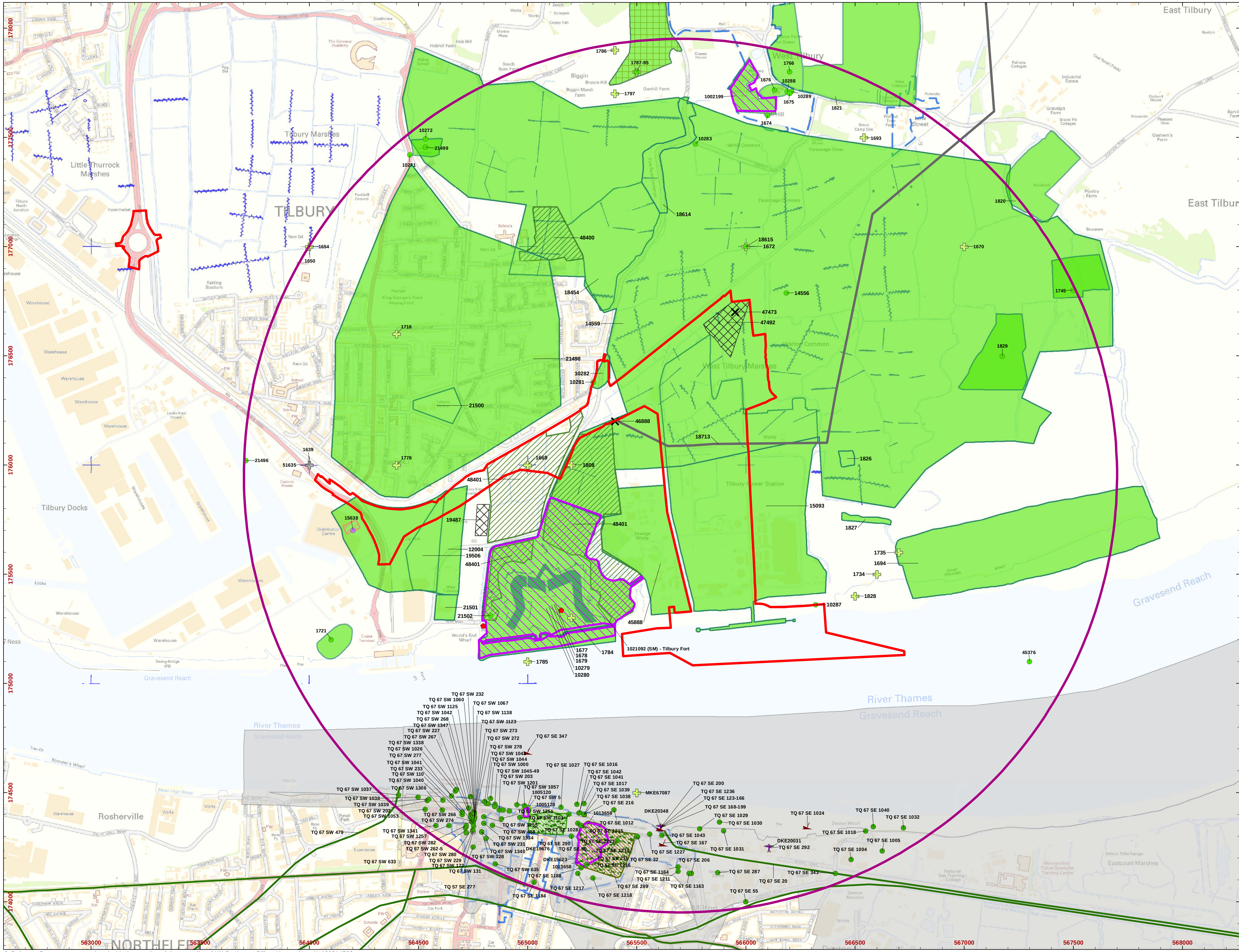
DBA 3:

HER Location Plan (Essex HER 2016/2017 and Kent HER 2017)



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Site Boundary
Search Radius 2km

Designated Assets:

Scheduled Monument
Protected Military Remains
Historic Park and Garden
Listed Building

Non-Designated Assets:

HER Record (Point)
Find Spot
Monument
Negative Evidence
Industrial
Portable Antiquities Scheme
Crash
Marine
Place

HER Record (Line)
Negative Evidence

HER Record (Polygon)
Monument
Land
Negative Evidence
Aerial Photographic Plot
Find Spot
Industrial

N

Scale at A3: 1:16,000
0 500 m

Appendix 3:
HER Location Plan
(Essex HER 2016/17 and Kent HER 2017)

DBA 4:

Tilbury Wildlife Pond Site, Tilbury, Essex: Archaeological Monitoring and Recording

Essex CC FAU 2010

[redacted]

2074

TILBURY WILDLIFE POND SITE
TILBURY
ESSEX:
ARCHAEOLOGICAL MONITORING AND RECORDING

Essex County Council
FIELD ARCHAEOLOGY UNIT
November 2010

TILBURY WILDLIFE POND SITE

TILBURY

ESSEX:

ARCHAEOLOGICAL MONITORING AND RECORDING

Prepared By: Phillippa Sparrow Position: Supervisor	Signature: Date:
Checked By: Adrian Scruby Position: Project Manager	Signature: Date:

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Report Issue Date	
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As part of our desire to provide a quality service, we would welcome any comments you may have on the content or the presentation of this report. Please contact the Archaeological Fieldwork Manager, at the

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Fax: 01376 331428

CONTENTS

TILBURY WILDLIFE POND SITE
TILBURY
ESSEX:
ARCHAEOLOGICAL MONITORING AND RECORDING

SUMMARY

Client: RWE Npower
FAU Project No.: 2074
NGR: TQ 65900 76700
Planning Application No.: 09/00008/TTGFUL
Site Code: THWS10
Dates of Fieldwork: 6th August 2010 & 1st October 2010

Archaeological monitoring of trial pits and groundworks for a pond and bund revealed no archaeological finds or features. A thin layer of peat was present across the site at an average mean depth of 1.5m, sealed below orange-grey clay and the topsoil. The presence of the peat deposit conforms to the general deposit model along the marshland of the Thames Estuary, although the relatively shallow depth beneath the present ground surface of this peat, compared with the much deeper deposits found elsewhere along the Thames marshland, may suggest that it formed after the prehistoric period.

One modern feature, containing plastic bags, was located in trial pit 4. This may represent an anti-glider ditch, excavated during the Second World War, but backfilled after the 1950s.

1.0 INTRODUCTION

This report presents the results of a programme of archaeological monitoring and recording at Tilbury wildlife pond, Tilbury Power Station (TQ 65900 76700), conducted by Essex County Council Field Archaeology Unit (ECC FAU) during groundworks for the excavation of a new pond. The fieldwork was undertaken in response to a condition (09/00008/TTGFUL) placed upon the development by Thurrock Borough Council following advice from Essex County Council Historic Environment Management team (ECC HEM), given in line with Planning Policy Guidance note 16 (DoE 1990), now replaced by Planning Policy Statement 5: Planning for the Historic Environment. The fieldwork was carried out in accordance with a written scheme of investigation provided by ECC FAU (2009), and was monitored by ECC HEM on behalf of the local planning authority.

Bound and digital copies of this report will be supplied to RWE Npower (including a copy for the Local Planning Authority), ECC HEM and the Essex Historic Environment Record (EHER). A digital copy of the report will be uploaded on the online access to the index of archaeological investigations (www.oasis.ac.uk). The site archive and copies of the report will be deposited at Thurrock Museum.

2.0 BACKGROUND

2.1 Location, Geology and Topography (Fig. 1)

The site is located on the West Tilbury Marshes, to the north of Tilbury Power Station and to the south of the Fenchurch Street to Shoeburyness railway line. A former breeze block factory was situated less than 1km to the south-east of the pond location. It is known that the West Tilbury Marshes, the area on which the site is located, were used as dumping grounds for the waste material produced by the manufacture of breeze blocks and by the power station itself. This material comprised ash and clinker. A disused railway line, that once connected the power station to the main railway line, runs along the north-western boundary of the site (Plate 1).

The site land-use comprised arable farmland. The geology of the site comprises alluvial marsh deposits beneath which are Thames alluvial gravels overlying chalk.

2.2 History and Archaeology

This historical and archaeological background is based on information held in the Essex Historic Environment Record (EHER) at County Hall, Chelmsford, and the RWE Npower New Build Development Project Consultancy Statement of Requirements for Contract number: MPC0928.

Buried peat beds in the Tilbury marshes are well-known sources of palaeo-environmental material that provides evidence for changes in climate, sea level and plant cover in the Mesolithic and Neolithic. Archaeological and geotechnical investigations along the Thames Estuary have revealed the presence of peat deposits. These are likely to be associated with a reduction in the rate of sea level rise at around 4000 to 1500 cal BC (Dr. Jane Sidell, pers. comm.) which resulted in the optimum environmental conditions for the formation of peat along the Thames Estuary.

There is evidence for Roman settlement and salt-working on the coastal marshland in the general area of the site. In 1920 the waterlogged remains of four wattle "hut circles" were found on the Thames foreshore at low tide (EHER 1694), together with large quantities of Roman pottery, including samian ware, dated to the 1st-2nd centuries AD (EHER 1734-5 and 1828). A salt extraction site is also suspected approximately 1km east of the site, as waste briquetage and Roman pottery have been found in this area (EHER 1829). These sites are generally known as 'red hills' from the colour of the briquetage debris found on them.

The wildlife pond site is located approximately 1.5km north-east of Tilbury Fort, a scheduled monument (SM 26309; EHER 1678). The original fort was built in the 1540s as a simple blockhouse, but after the Dutch raid up the Thames and Medway in 1667 it was completely rebuilt between 1670 and 1685 as a star fort with an improved artillery battery, bastions and a double moat. It was added to and refurbished in the 18th, 19th and 20th centuries.

The fort was situated in an area of largely uninhabited coastal salt marsh, as shown on Chapman and Andre's map of 1777, and the 1872 First Edition Ordnance Survey map still depicts the surrounding area, including the development site itself, as sparsely inhabited farmland and common, with a characteristic network or irregular field boundaries suggestive of piecemeal reclamation, and areas of true salt marsh still surviving towards the foreshore.

Construction of Tilbury A Power Station began in 1951, with the first unit synchronised to the national grid in 1956. Initially commissioned as a coal-fired station, the boilers were converted to burn oil before coming into full commercial operation. In 1981 Tilbury A effectively ceased operation and the station boilers and turbine hall were demolished in 1999. Construction of the coal-fired Tilbury B Power Station began in 1961 and the station was fully operational by 1969, following partial synchronisation to the national grid in 1967. In 2004 the coal jetty was extended to enable larger vessels, carrying up to 65,000 tons of coal, to be brought alongside. The power station has been identified in the National Monuments Protection Programme as an industrial site of "potential national importance" (EHER 15093).

Anti glider ditches, constructed during World War II, have been identified on aerial photographs to the north and north east of the power station (EHER 3967), including within the development site.

3.0 AIMS AND OBJECTIVES

The aim of the archaeological monitoring was to preserve by record any archaeological deposits that may be damaged or destroyed by the development. With specific objectives to identify:

- Evidence for the anti-glider ditches known to cross the site;
- Evidence for any earlier activity in the area relating to the settlement and exploitation of the marsh;
- Any palaeo-environmental material that may provide evidence for changes in climate, sea level and plant cover in the Mesolithic and Neolithic.

4.0 METHOD

The excavation of four, out of a total of six, trial pits was monitored prior to the start of the groundworks for the pond and bund area. Topsoil stripping across part of the development area was monitored by an archaeologist and the stripped area was inspected for archaeological deposits and artefacts. Unfortunately the bund area and the south-western half of the pond area were stripped of topsoil prior to archaeological monitoring and subsequently tracked over by plant, thereby obscuring the surface of the natural orange grey clay (Fig. 1, Plate 2).

The archaeological fieldwork was carried out in accordance with *IFA* standards and by-laws (IFA 1997), and especially the IFA *Standard and Guidance for Archaeological Watching Briefs* (IFA 1999), and ALGAO's *Standards for Field Archaeology in the East of England*, EAA Occ Paper 14 (Gurney 2003) throughout the project. The ECC FAU is a registered archaeological organisation with the *IFA*.

5.0 FIELDWORK RESULTS (Fig. 1)

5.1 Trial Pit 1

4m x 1m(max) x 3m

Aligned NW-SE

Depth (m)	Description
0.0 – 0.3	Topsoil
0.3 – 1.3	Orange grey clay
1.3 – 1.7	Peat
1.7+	Blue grey clay

5.2 Trial Pit 2

4m x 1m (max) x 3m

Aligned NW-SE

Depth (m)	Description
0.0 – 0.4	Topsoil
0.4 – 1.4	Orange grey clay
1.4 – 1.7	Peat
1.7+	Blue grey clay

5.3 Trial Pit 3

4m x 1m (max) x 3m

Aligned NW-SE

Depth (m)	Description
0.0 – 0.2	Topsoil
0.2 – 1.7	Orange grey clay
1.7 – 2.0	Peat
2.0+	Blue grey clay

A modern pit, measuring 3.9m+ x 1m+ x 1m, was sealed by topsoil (Fig. 2, Plate 3). It contained one fill, an orange-brown sandy silt with gravel inclusions. Finds included a length of cloth, plastic bags and blue waxed rope; none were retained for further analysis.

5.4 Trial Pit 4

4m x 1m (max) x 3m

Aligned NW-SE

Depth (m)	Description
0.0 – 0.3	Topsoil
0.3 – 1.7	Orange grey clay
1.7 – 2.1	Peat
2.1+	Blue grey clay

5.5 Pond and bund area excavation

No archaeological finds or features were identified. A similar deposit model, to that recorded in the trial pits, was present in the area of the pond.

6.0 CONCLUSION AND ASSESSMENT

Archaeological monitoring revealed no archaeological finds or features. One modern pit in Trial Pit 3 was identified. A thin layer of peat was present across the site at an average mean depth of 1.5m, sealed below orange-grey clay and the topsoil (Plate 4). The presence of the peat deposit conforms to the general deposit model along the marshland of the Thames Estuary. The relatively shallow depth of this thin peat deposit, compared with the much deeper peat deposits containing Mesolithic and Neolithic finds revealed elsewhere along the Thames marshland, might suggest that it formed after the prehistoric period.

It would appear that the West Tilbury Marshes were not greatly impacted upon by the human population until the 1940s with the excavation of anti-glider ditches, as shown in aerial photographs. It is possible that the modern pit was an anti-glider ditch, as it extended beyond both the south-western and north-eastern trial pit edges. However the finds within its fill, specifically the plastic bags, indicate that it was backfilled after the 1950s.

ACKNOWLEDGEMENTS

The ECC FAU would like to thank RWE Npower for commissioning and funding the archaeological investigation. Thanks are also due to Lorna Heffron of Tilbury Energy and Environment Centre.

The archaeological fieldwork was undertaken by Phillippa Sparrow. The figures were drawn by Andrew Lewsey.

BIBLIOGRAPHY

ECC FAU	2009	*Written scheme of investigation for archaeological monitoring and recording at Tilbury Pond Wildlife Site, Tilbury, Essex.*
Gurney, D.	2003	*Standards for Field Archaeology in the East of England*, E. Anglian Archaeol. Occ. Paper **14**

APPENDIX 1: ARCHIVE INDEX

THWS10 TILBURY POND WILDLIFE SITE, TILBURY, ESSEX

Index to the Archive

File containing:

1. Introduction

1.1 Brief for evaluation
1.2 WSI for evaluation

2. Research Archive

2.1 Client report
2.2 CD Rom

3. Site Archive

3.1 Trial pit record sheets
3.2 Context record register
3.3 Photographic register
3.4 Photograph contact sheet
3.5 Miscellaneous maps and plans
3.6 Section drawing of trial pit 3

APPENDIX 2: ESSEX HISTORIC ENVIRONMENT RECORD SUMMARY

Site Name/Address: Tilbury Pond Wildlife Site, Tilbury, Essex	
Parish: East Tilbury	***Borough:*** Thurrock
NGR: TQ 65900 76700	***Site Code:*** THWS10
Type of Work: Archaeological Monitoring and Recording	***Site Director/Team:*** Phillippa Sparrow ECC FAU
Dates of Work: 06/08/10 & 01/10/10	***Size of Area Investigated:*** c. 22000m²
Curating Museum: Thurrock Museum	***Funding Source:*** RWE Npower
Further Work Anticipated? No	***Related HER Nos.*** None
Final Report: Summary in EAH	***OASIS Ref:*** essexcou1-83818
Periods Represented: modern	
SUMMARY OF FIELDWORK RESULTS: *Archaeological monitoring of trial pits and groundworks for a pond and bund revealed no archaeological finds or features. A thin layer of peat was present across the site at an average mean depth of 1.5m, sealed below orange-grey clay and the topsoil. The presence of the peat deposit conforms to the general deposit model along the marshland of the Thames Estuary, although the relatively shallow depth beneath the present ground surface of the peat, compared with the much deeper deposits found elsewhere along the Thames marshland, might suggest that it formed after the prehistoric period.* *One modern feature, containing plastic bags, was located in trial pit 4. This may represent an anti-glider ditch, excavated during the Second World War, but backfilled after the 1950s.*	
Previous Summaries/Reports: None	
Author of Summary: P. Sparrow	***Date of Summary:*** 5th November 2010

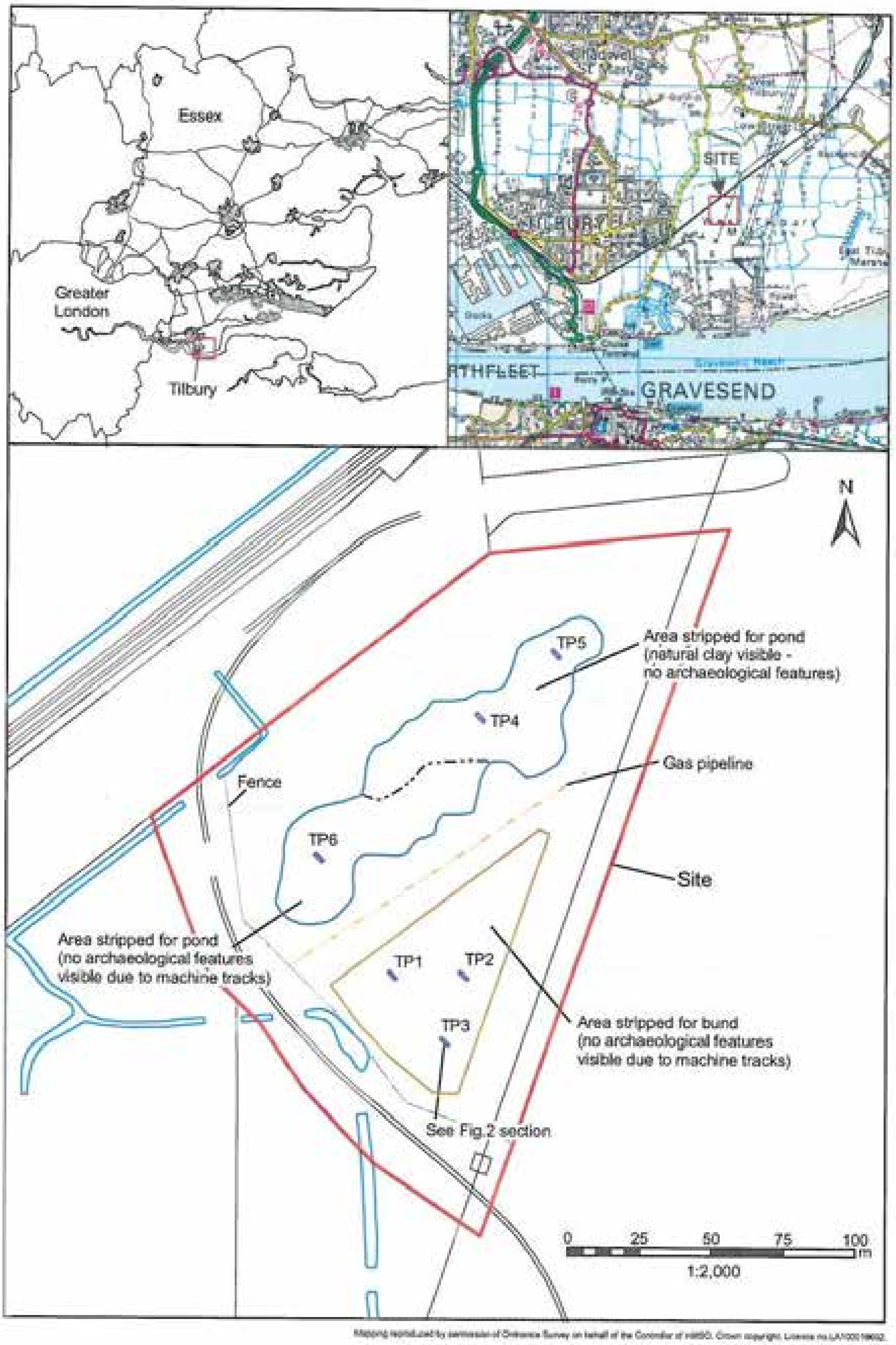


Fig.1. Site location

Essex County Council
Field Archaeology Unit

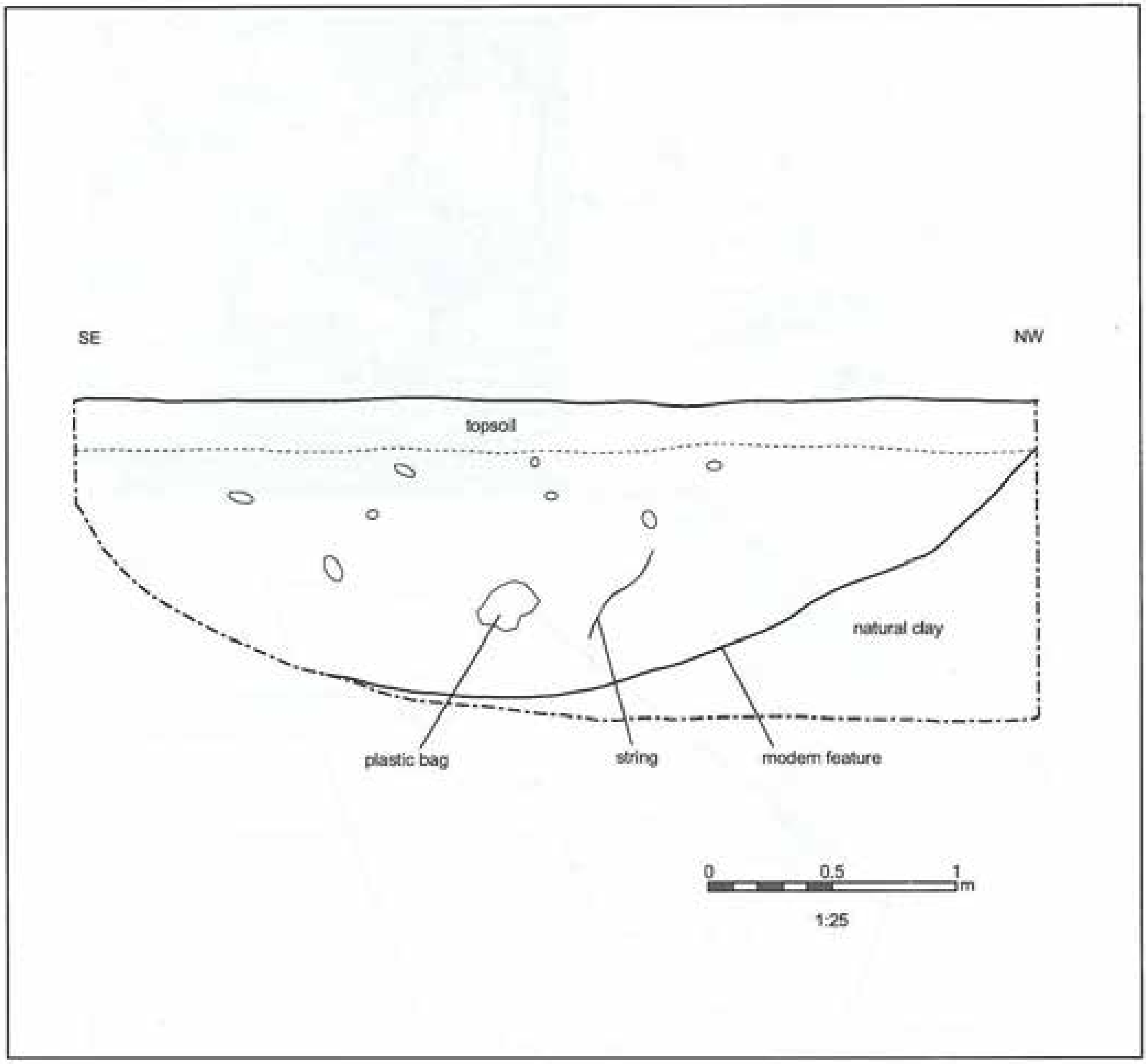


Fig.2. North-east facing section through test pit 3

Essex County Council
Field Archaeology Unit

Plates

Plate 1. Disused railway line along the north-western site boundary. Looking south.

Plate 2. Bund area stripped but obscured by plant tracks.

Plate 3. Modern pit in Trial Pit 4. Looking south-east. 1m scale.

Plate 4. Site stratigraphy

AS 2

Geo-archaeological Deposit Model

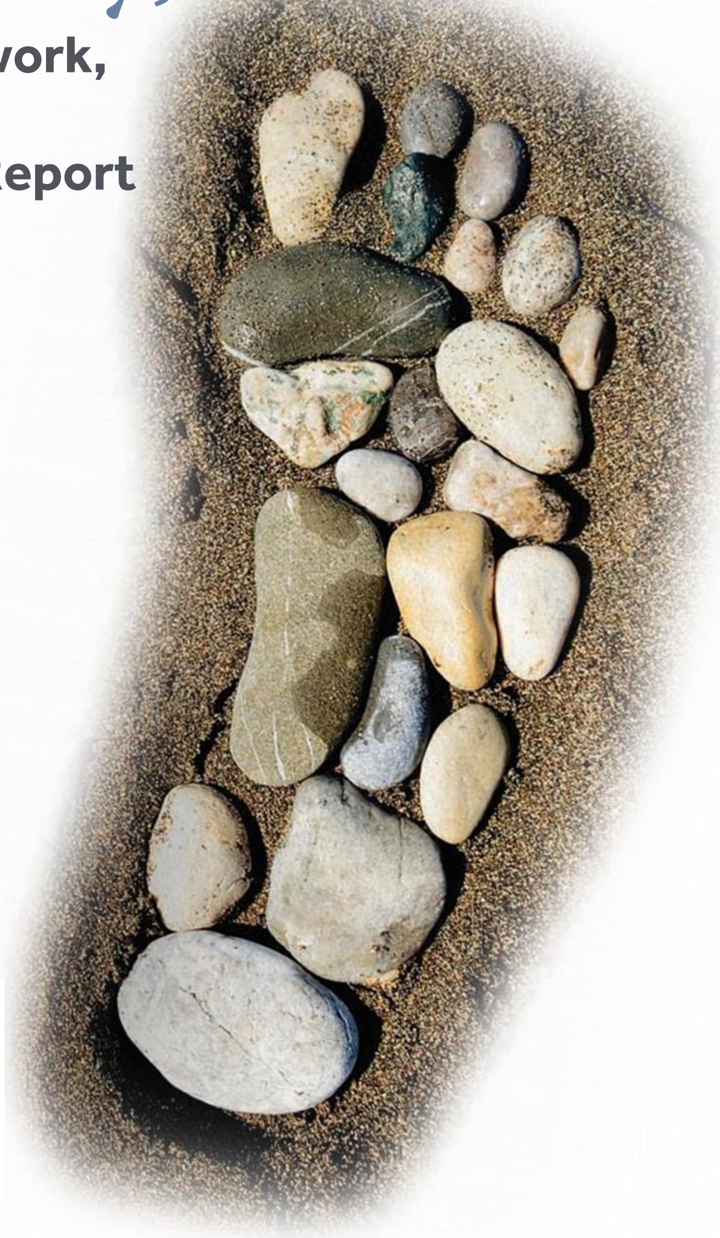
(QUEST 2017)

QUEST
QUATERNARY SCIENTIFIC

University of Reading

Tilbury2, land at Former RWE Power Station, Tilbury, Essex

Geoarchaeological Fieldwork, Radiocarbon Dating & Updated Deposit Model Report



NGR: TQ 65800 76000

Date: 20th October 2017

Written by: C.R. Batchelor
D.S. Young

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DOCUMENT HISTORY:

REVISION	DATE	PREPARED BY	SIGNED	APPROVED BY	SIGNED	REASON FOR ISSUE
v1	20/10/17	C.R. Batchelor		C.R. Batchelor		First edition

CONTENTS

1. NON-TECHNICAL SUMMARY

A programme of geoarchaeological fieldwork, radiocarbon dating and updated deposit modelling was carried out at the Tilbury 2 site to: (1) clarify in more detail the nature of the sub-surface stratigraphy across the site; (2) enhance our understanding of the nature, depth, extent and date of any former land surfaces, alluvial and peat deposits, and (3) make recommendations for any further geoarchaeological investigations at the site.

The results of the deposit modelling indicate that the sediments recorded at the site are similar to those recorded elsewhere in the Lower Thames Valley, with Late Devensian Shepperton Gravel overlain by a sequence of Holocene alluvial sediments, including peat, and buried beneath modern Made Ground. Similarly to other investigations in this area of Tilbury, at least three distinct horizons of peat are identified, towards the base, middle and top of the sequence. Radiocarbon dating of the sequences indicate they correlate most closely with Devoy's 1979 Tilbury I, II, III and IV peats. However, the range of different elevations and ages of the peat horizons in this area of Tilbury suggests that peat formation was diachronous and in some cases was highly localised. The sequences are still considered to be of regional significance, but the results of the radiocarbon dating of one borehole in particular (QBH3/3A) emphasises the importance of Tilbury which has been (and probably always will be) used as the type site for palaeoenvironmental and relative sea level studies in the Thames. Each sequence has the potential to provide information on past environmental change and human activity, through the preservation of biological remains; in particular, the sequences may provide additional information on the possible transition to ombrotrophic conditions recorded at the nearby London Distribution Park site (Batchelor *et al*., 2014), the Early Neolithic elm decline, the Late Neolithic/Early Bronze Age lime decline, and relative sea level rise (RSL).

It is recommended that further assessment works continue on the three boreholes that contain the best sequences and are well distributed across the site. However, it is also highly recommended that a repeat borehole is taken in the location of QBH3 as it is the most important of all. Furthermore, whilst the coverage of the updated deposit model is in the region of 75% and thus very good; advantage should be taken of any further planned site investigation works that might infill the remaining voids.

2. INTRODUCTION

2.1 Site context

This report summarises the findings arising out of the fieldwork, radiocarbon dating and updated geoarchaeological deposit modelling undertaken by Quaternary Scientific (University of Reading) in connection with the proposed redevelopment of land at Tilbury 2, Tilbury, South Essex (National Grid Reference: centred on TQ 65800 76000; Figures 1 & 2). Quaternary Scientific were commissioned by CgMs Consulting to undertake the geoarchaeological investigations.

The site is situated on the River Thames floodplain, immediately to the north of the present course of the river and east of Fort Road. The British Geological Survey (BGS) show the site underlain by Cretaceous Seaford and Newhaven Chalk Formation bedrock, and describes the Alluvium overlying it as 'Clay, Silty, Peaty, Sandy' (http://mapapps.bgs.ac.uk/geologyofbritain/home.html). In fact, the alluvial deposits of the Lower Thames and its tributaries are almost everywhere underlain by Late Devensian Late Glacial Gravels (in the Thames valley, the Shepperton Gravel of Gibbard, 1985, 1994), and this gravel is widely recorded in boreholes in the vicinity of the site. The site lies *ca*. 1.25km to the south of the geological and topographical boundary of the East Tilbury Marshes Gravel (Gibbard, 1985).

Early work carried out by Spurrell (1889) during the construction of Tilbury Docks (Figure 1) revealed a thick sequence of alluvial and peat deposits. Subsequently, Devoy (1979, 1982) carried out a detailed stratigraphic analysis of the southern Tilbury area by sinking over 30 boreholes; these sequences confirmed the presence of a thick sequence of intercalated alluvial and peat deposits overlying sands and gravels of the Shepperton Gravel between *ca*. -11m OD and -17m OD. Devoy (1979, 1982) proposed a model that identified the peat as representing semi-terrestrial conditions caused by periods of reversed, or lower Relative Sea Level Rise (RSL) rise (regression; known as Tilbury I to V), whilst periods of alluvial deposition (known as Thames I to V) represent inundation caused by increased RSL rise (transgression). At The World's End, Tilbury (Figures 1 & 2), Devoy dated these five peat horizons as follows:

Tilbury I	9440-8770 to 8990-8420 cal BP	*ca*. -13.40 to -13.20m OD
Tilbury II	8050-7660 to 7620-7290 cal BP	*ca*. -10.40 to -10.10m OD
Tilbury III	7320-6860 to 4520-3990 cal BP	*ca*. -6.50m to -5.30m OD
Tilbury IV	3680-3260 to 3370-3000 cal BP	*ca*. -2.00m to -1.90m OD
Tilbury V	Undated	*ca*. -0.70m OD

More recent work carried out at Tilbury Fort (Batchelor, 2009; Figure 1) captured a 10m alluvial sequence that contained a thick peat horizon between *ca*. -5.65m and -4.50m OD. This semi-terrestrial deposit was dated between 6570-6350 and 4100-3880 cal BP, and interpreted as being representative of Devoy's Tilbury III peat horizon. To the north of the World's End and Tilbury Fort, and northwest of the present site, the work of Gibbard (1994) contains a borehole transect along the A1089. The ground surface along Gibbard's transect is shown slightly above OD and the surface of the Shepperton Gravel rather consistently at about -10m OD. The borehole sequences show a thick sequence of floodplain deposits including silt, clay, peat and tufa. Finally, investigations at London Distribution Park revealed three peat horizons equivalent in date to Devoy's Tilbury II, III and between IV and V (Batchelor e*t al*., in prep) overlying the Shepperton Gravel at *ca*. -12m OD.

A number of geotechnical investigations have taken place either within the area of the present site or adjacent to it, the majority of which are associated with the development of Tilbury Power Station. A geoarchaeological watching brief was undertaken within the area of the site by Wessex Archaeology (2008), who recognised a sequence of deposits that could be divided as follows:

1. Bedrock Chalk, widely present with a surface elevation generally recorded at between -16 and -21m OD;
2. Sandy gravel, widely present with a surface elevation of between -11.36 and -19.14m OD;
3. Alluvium and peat, recorded at between *ca*. 2.5 and -15m OD and consisting of sands, silts and clays with intercalated peat horizons. In general, up to three peat horizons are recorded: a lower peat, recorded at elevations between *ca*. -16 and -10m OD and either lying directly on top of the Gravel or within the Lower Alluvium; a middle peat, widely present and generally recorded at elevations between *ca*. -4 and -8m OD; and an upper peat, only locally present and generally recorded at elevations between *ca*. -1 and -3m OD, within the Upper Alluvium;
4. Made Ground, widely present but variable in thickness.

On the basis of the existing geotechnical records, a more recent programme of deposit modelling was undertaken by Quaternary Scientific (Young & Batchelor, 2016), comprising a comprehensive review of 365 borehole and test pit records for the site. The results of these investigations broadly correlate with other investigations in this area of Tilbury: the surface of the Gravel was found to be generally relatively even, lying at between *ca*. -13 and -15m OD, falling to between *ca*. -15 and -17m OD in the modern channel of the Thames. There was some indication of higher (*ca*. -9.5 to -12m OD) Gravel surfaces to the west and within the central-western area of the site, where the Gravel surface was recorded at -9.62m OD. These areas were considered to have greater archaeological potential, since they may have been elevated above the surrounding floodplain during the prehistoric period (e.g. Mesolithic/Neolithic).

At least three distinct horizons of peat were identified, each present at similar elevations to those recorded at sites nearby: a Lower Peat, present at elevations of between *ca*. -16 and -10m OD; a Middle Peat, lying at elevations of between *ca*. -3.5 and -8.5m OD, and an Upper Peat, lying at between *ca*. -1 and -3m OD. It was considered that these horizons may correlate to Devoy's (1979) Tilbury II, III and IV peats respectively. However, the range of different elevations and ages of the peat horizons in this area suggests that peat formation may have been highly localised, and may have occurred at various different times (particularly in the case of the upper peat horizons) (Young & Batchelor, 2016).

2.2 Geoarchaeological, palaeoenvironmental and archaeological significance

The existing geotechnical borehole records in the area of the site thus indicate considerable variation in the height of the Gravel surface, and the type, thickness and age of the subsequent Holocene deposits. Such variations are significant as they represent different environmental conditions that would have existed in a given location. For example: (1) the varying surface of the Gravel may represent the location of former channels and bars; (2) the presence of soil and peat represents former terrestrial or semi-terrestrial land-surfaces, and (3) the various fine-grained minerogenic units represent periods of changing alluvial/estuarine hydrological conditions. Thus by studying the sub-surface stratigraphy across the site in greater detail, it will be possible to build an understanding of the former landscapes and environmental changes that took place across space and time. In addition, given the location of the site, it has the potential to contribute to highly important investigations on relative sea level rise that are applicable to the Tilbury region and the rest of the Lower Thames Valley (e.g. Devoy, 1979, 1982; Long, 1995; Haggart, 1995; Sidell and Long, 2000; Long *et al.*, 2000; Wilkinson *et al.*, 2000; Sidell *et al.*, 2000; Sidell, 2003).

The alluvial and organic-rich sediments (in particular peat) also have high potential to provide a detailed reconstruction of past environments on both the wetland and dryland. In particular, they provide the potential to increase knowledge and understanding of the interactions between hydrology, human activity, vegetation succession and climate. Significant vegetation changes include the Mesolithic/Neolithic decline of elm woodland, the Neolithic colonisation and decline of yew woodland; the Late Neolithic/Early Bronze Age growth of elm on Peat, and the general decline of wetland and dryland woodland during the Bronze Age. Such investigations are carried out through the assessment/analysis of palaeoecological remains (e.g. pollen, plant macrofossils & insects) and radiocarbon dating, and have been undertaken at the nearby sites such as London Distribution Park (Batchelor *et al.*, in prep), Tilbury Fort (Batchelor, 2009), Tilbury Docks (Spurrell, 1889) and The World's End (Devoy, 1979) (see Figures 1 & 2).

Finally, areas of high gravel topography, soils and peat represent potential areas that might have been utilised or even occupied by prehistoric people, evidence of which may be preserved in the archaeological (e.g. features and structures) and palaeoenvironmental record (e.g. changes in vegetation composition). No prehistoric archaeological features have thus far been recorded in the Tilbury area, however, human interaction with the local environment is demonstrated by the recording of Palaeolithic and Neolithic flint artefacts during excavation of the Tilbury Docks and at West Tilbury Marshes (CgMs Consulting, 2017). Furthermore, a partial skeleton was found in 1883 within peat at *ca*. 10m below ground level (bgl) at the Tilbury Docks site (Spurrell, 1889). More recent analysis (Schulting, 2013) has revealed the skeleton to be of Late Mesolithic date (8015–7860 cal BP); the Late Mesolithic is a period for which human skeletal finds are very rare in Britain (Schulting, 2013), and such a find highlights the presence of humans, and the potential utilisation of the floodplain not far from the Tilbury 2 site, during this period. Palaeoenvironmental investigations at the nearby London Distribution Park also indicate episodes of burning and changes in vegetation during the prehistoric period which may be associated with human activity (Batchelor *et al*, in prep).

Although units indicative of soil formation have not yet been identified in the geotechnical records from the present site, this could be due to the nature of the geotechnical coring and description. At nearby sites such as London Distribution Park/Tilbury North (Batchelor *et al*., 2014) and Tilbury Fort (Batchelor, 2009) sites, peaks in magnetic susceptibility were recorded prior to the accumulation of the Middle and/or Upper Peats. Such peaks are thought to represent periods of pedogenesis (soil formation) prior to peat formation. Importantly, the timing and elevation of peat and soil formation are significant for our understanding of relative sea level (RSL) in this area of the Lower Thames Valley, and more broadly in southern England (e.g. Devoy, 1979; Long and Tooley, 1995). In addition, the processes behind peat and soil formation in relation to marine transgression and regression are not yet fully understood (e.g. Haggart 1995), and further analysis of such horizons may contribute to the understanding of these mechanisms. The existing models for the rates of RSL rise, such as that proposed by Devoy (1979; 1982) and Sidell (2003) for the Lower Thames Valley itself, and by Long *et al*. (2000) from three major southern England estuaries, are critical areas of research for studies of Holocene vegetation history and human activity in the Lower Thames Valley. Devoy's original model of peat formation and RSL was produced for the Lower Thames Valley as a whole, based upon a small number of records, and heavily influenced by the record from the World's End, Tilbury, and subsequent work in the Tilbury area has revealed inconsistencies in the timing and extent of peat formation (e.g. Batchelor, 2009, Batchelor *et al*., 2014). Subsequently, Sidell's (2003) model demonstrates that it is not possible to apply this model to the whole of the Lower Thames Valley. In addition, it has been argued (e.g. Haggart, 1995; Sidell and Long, 2000; Long *et al*., 2000) that the site-specific factors may mean that the World's End borehole (Devoy, 1979) represents an anomalous record. New RSL index points from the Tilbury 2 site would therefore contribute significantly to the debate in this area of research, and our understanding of rates of RSL rise in this area of the Lower Thames Valley.

2.3 Aims and objectives

On the basis of the existing deposit model (Young & Batchelor, 2016), and the geoarchaeological, palaeoenvironmental and archaeological potential of the site, further records are required to enhance our understanding of the sub-surface stratigraphy of the Tilbury 2 site and its infrastructure corridor, and for any further assessment/analysis of the deposits (where possible). This work will be integrated with that being carried out by Wessex Archaeology in the marine and intertidal zones adjacent to the present site; the aims, objectives and methodology adopted here will therefore be consistent with these investigations (see Wessex Archaeology, 2017).

Six significant research aims relevant to the geoarchaeological investigations were outlined within the geoarchaeological WSI for the site (Young, 2017a):

1. To clarify in more detail the nature of the sub-surface stratigraphy across the site;
2. To enhance our understanding of the nature, depth, extent and date of any former land surfaces, alluvial and peat deposits;
3. To make recommendations for any further geoarchaeological investigations at the site (including monitoring of future Site Investigation works);
4. To investigate whether the sequences contain any artefact or ecofact evidence for prehistoric or historic human activity;
5. To investigate whether the sequences contain any evidence for natural and/or anthropogenic changes to the landscape (wetland and dryland);
6. To integrate the new geoarchaeological record with other recent work in the local area, including that being undertaken by Wessex Archaeology (2017) in the marine and intertidal zones adjacent to the present site, for publication in an academic journal.

In order to address the first three of these aims, the following objectives are proposed:

1. To obtain borehole core samples from six locations across the site suitable for subsequent laboratory investigation (see Figure 2);
2. To radiocarbon date the top and base of each of the main peat horizons to provide a provisional chronological framework for the new sequences
3. To use the stratigraphic data from the new locations, and existing records to produce a deposit model of the major depositional units across the site, integrating the data with the existing geoarchaeological deposit model and the work being undertaken by Wessex Archaeology (2017) in the marine and intertidal zones adjacent to the present site;
4. To make recommendations for any further geoarchaeological, palaeoenvironmental and archaeological investigation at the mitigation stage.

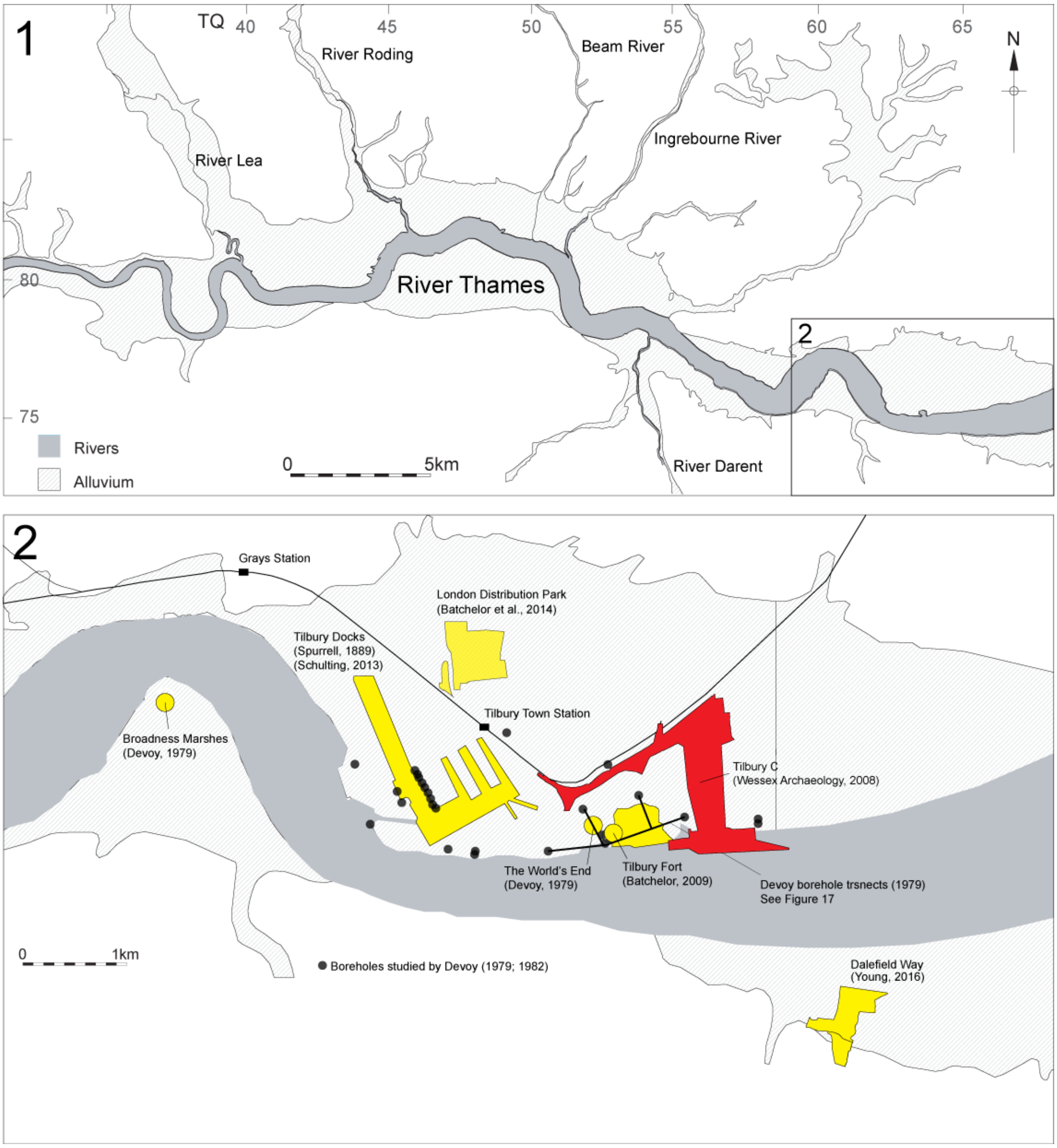

Figure 1: Location of the Tilbury 2 site, Tilbury, South Essex site and other sites of geoarchaeological / palaeoenvironmental interest, showing the extent of the floodplain alluvium.

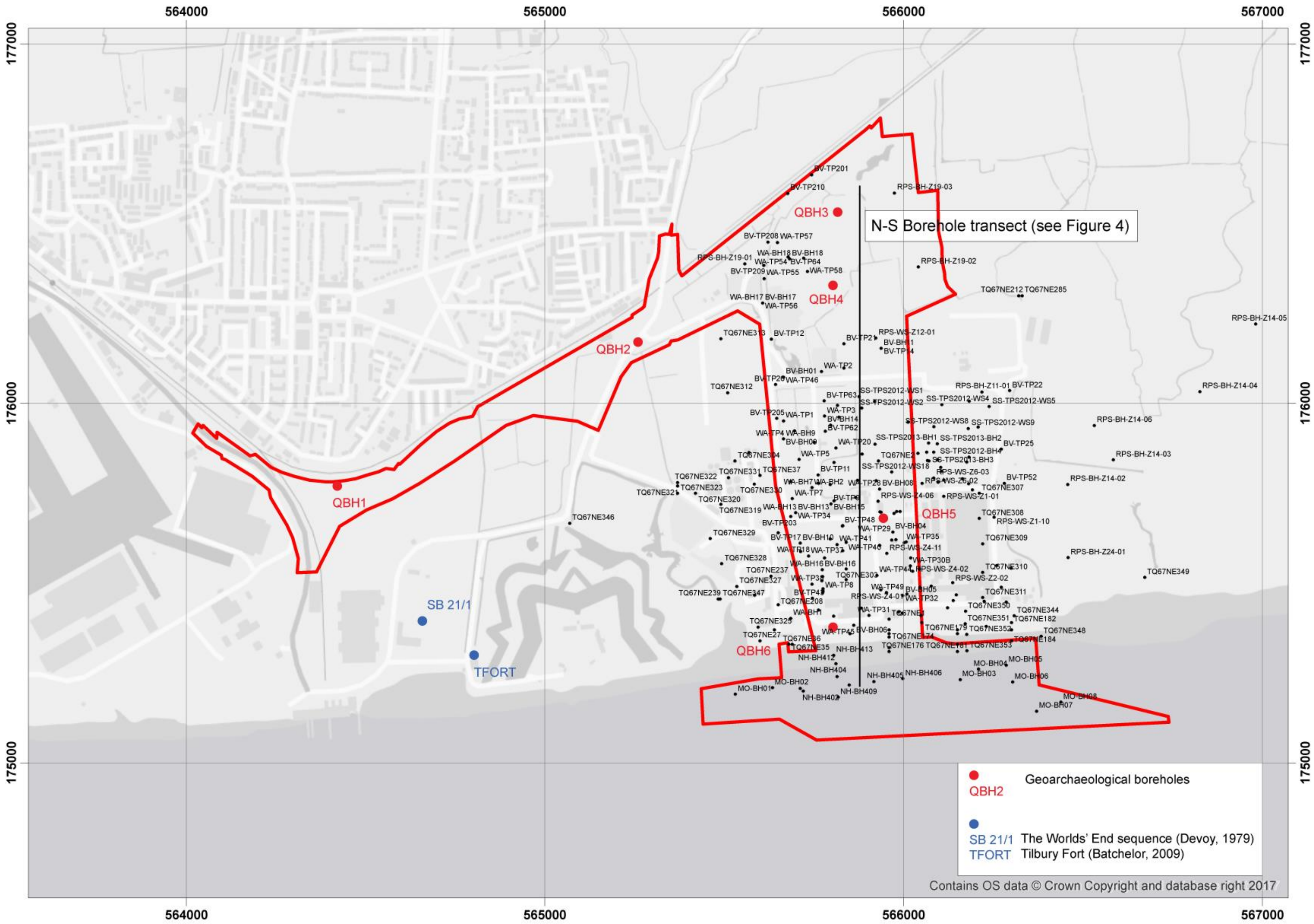

Figure 2: Location of the geotechnical borehole sequences used in the deposit model at Tilbury 2, Tilbury, South Essex. Position of the N-S transect (Figure 4) also shown. For display purposes only those records shown in the transect, or discussed in the text, are highlighted.

3. METHODS

3.1 Field investigations

A total of six new geoarchaeological boreholes (QBH1 to QBH6) were put down by Geosphere Environmental Limited in August 2017 using a cable percussion rig, and monitored by Quaternary Scientific. This coring techniques provide a suitable method for the recovery of continuous, undisturbed core samples and provides sub-samples suitable for not only sedimentary and microfossil assessment and analysis, but also macrofossil analysis. The core samples were correctly orientated, labelled, wrapped and returned to the University of Reading for cold storage. Spatial co-ordinates for each borehole were obtained using a Leica Differential GPS (Table 1).

Table 1: Spatial co-ordinates for the geoarchaeological boreholes

Geoarchaeological borehole	Easting	Northing	Elevation
QBH1	564421.921	175770.423	1.787
QBH2	565259.869	176170.236	1.430
QBH3	565819.286	176532.076	1.842
QBH3A	565814.511	176534.835	1.755
QBH4	565804.062	176327.273	2.209
QBH5	565948.091	175679.612	2.765
QBH6	565809.159	175378.189	2.811

3.2 Laboratory-based descriptions

Laboratory-based lithostratigraphic descriptions of the new borehole samples was carried out using standard procedures for recording unconsolidated sediment and peat, noting the physical properties (colour), composition (gravel, sand, clay, silt and organic matter) and inclusions (e.g. artefacts). The procedure involved: (1) cleaning the samples with a spatula or scalpel blade and distilled water to remove surface contaminants; (2) recording the physical properties, most notably colour; (3) recording the composition e.g. gravel, fine sand, silt and clay; (4) recording the degree of peat humification, and (5) recording the unit boundaries e.g. sharp or diffuse (Troels-Smith, 1955). Wherever possible, notes were made on the quality of the samples and percentage recovery. The results are displayed in Tables 2-8 and Figure 3.

3.4 Radiocarbon dating

Fifteen range-finder radiocarbon determinations were carried out on material from the top and base of each major peat horizon in QBH1, QBH3/3A and QBH6 where possible. The radiocarbon dating strategy was agreed with the Historic England Regional Science Advisor prior to commencement. Horizontally bedded aerial cf *Phragmites* sp. stems or twigs were prioritised for dating (9 samples); where these were not present, the humic acid and humin fractions of bulk peat samples were selected (3 x 2 samples). Whilst preferred, it was not always possible to obtain suitable material from the very top or base of each peat unit. This is highlighted within the results section where relevant. The samples were submitted for AMS radiocarbon dating to the BETA Analytic Radiocarbon Dating Facility, Miami, Florida. The results have been calibrated using OxCal v4.2 (Bronk Ramsey, 1995; 2001 and 2007) and the IntCal13 atmospheric curve (Reimer *et al.,* 2013). The results are displayed in Figure 3 and in Table 9.

3.3 Deposit modelling

The updated deposit model incorporates new and existing records from the site and surrounding area as follows: (1) the 6 new onsite geoarchaeological boreholes, (2) the 8 offsite boreholes monitored by Wessex Archaeology (2017); (3) select palaeoenvironmental sequences analysed by Batchelor (2009) and Devoy (1979); (4) 249 geotechnical borehole and test pit records from the site and (5) 116 BGS archive boreholes (http://mapapps.bgs.ac.uk/geologyofbritain/home.html). Sedimentary units from the boreholes were classified into seven groupings: (1) Gravel, (2) Lower Alluvium. (3) Lower Peat, (4) Middle Peat, (5) Upper Peat, (6) Upper Alluvium and (7) Made Ground. The classified data for groups 1-7 were then input into a database with the RockWorks geological utilities software. Models of surface height were generated for the Gravel (Figure 4), Lower Alluvium (Figure 5), Lower (Figure 6), Middle (Figure 8) and Upper Peat (Figure 10) and the Upper Alluvium (Figure 12). Thickness of the Lower (Figure 7), Middle (Figure 9) and Upper Peat (Figure 11), the combined Holocene alluvial sequence (Figure 13), and the Made Ground (Figure 14) were also modelled (also using a nearest neighbour routine). Because the boreholes are not uniformly distributed over the area of investigation, the reliability of the models generated using RockWorks is variable. In general, reliability improves from outlying areas where the models are largely supported by scattered archival records towards the core area of boreholes. This is particularly true of the northern area of the site, where relatively few records are located.

Because of the 'smoothing' effect of the modelling procedure, the modelled levels of stratigraphic contacts may differ slightly from the levels recorded in borehole logs and section drawings. As a consequence of this the modelling procedure has been manually adjusted so that only those areas for which sufficient stratigraphic data is present will be modelled. In order to achieve this, a maximum distance cut-off filter equivalent to a 50m radius around each record is applied to all deposit models, with the exception of the more widely present Gravel, Upper Alluvium and Made Ground, to which a 100m radius is applied. Finally, it is important to recognise that multiple sets of boreholes are represented, put down at different times and recorded using different descriptive terms and subject to differing technical constraints in terms of recorded detail including the exact levels of the stratigraphic boundaries.

4. RESULTS OF THE FIELD INVESTIGATIONS, LITHOSTRATIGRAPHIC DESCRIPTIONS & RADIOCARBON DATING

The laboratory-based descriptions are displayed in Tables 2 to 7, and the results of the radiocarbon dating are displayed in full in Table 8. A profile of the six boreholes inclusive of radiocarbon determinations is displayed in Figure 3.

4.1 Borehole QBH1

Recovery within borehole QBH1 was generally good. Sand and flint gravels representative of the Shepperton Gravel terrace were recorded below -11.05m OD (12.84m bgl). This surface is overlain by fine-grained occasionally laminated mineral-rich deposits dominated by silt and clay with occasional sand and *Phragmites* sp. remains to 0.19m OD (1.6m bgl), capped by 2m of Made Ground. These mineral rich layers are equivalent to the Lower and Upper Alluvium and are separated by peat and/or organic-rich units were recorded at two distinct levels:

1. A 14cm thick layer of organic-rich silty sand was recorded immediately above the Shepperton Gravel between -11.16 and -11.05m OD (12.84to 12.70m bgl) and was separated by a thin layer of silty clay from a 45cm thick moderately humified herbaceous peat between -10.56 and -10.11m OD (12.35 and 11.90m OD). Due to the elevation and position of these units, they are both considered representative of the Lower Peat. *Phragmites* sp. stems within the organic-rich silty sand at -10.95m OD have been radiocarbon dated to 7960-7830 cal BP; the same remains have been radiocarbon dated to 7570-7440 cal BP at -10.31m OD within the overlying herbaceous peat. These dates indicate the accumulation of the Lower Peat units during the late Mesolithic in QBH1.
2. A 1.25m thick layer of moderately humified herbaceous peat with silt was recorded between -6.86 and -5.61m OD (8.65 to 7.40m bgl). Due to the elevation and position of this peat, it is considered representative of the Middle Peat. *Phragmites* sp. stems from towards the base of the peat at -6.76m OD were radiocarbon dated to 6400-6280 cal BP. The top of the peat could not be dated due to a lack of suitable material. A bulk sample was therefore taken for radiocarbon dating of the humic acid and humin fractions at -6.06m OD; these returned very similar determinations of 5580-5320 and 5470-5300 cal BP. These results indicate that the Middle Peat accumulated from the Mesolithic-Neolithic transition until at least the middle Neolithic in QBH1.

4.2 Borehole QBH2

Recovery within borehole QBH2 was poor to moderate due to the very soft nature of the sediment in this area of the site. Whilst not recovered, the solidity of the material below -11.57m OD (13m bgl) infers the presence of sand and flint gravel representative of the Shepperton Gravel terrace. This surface is overlain by fine-grained occasionally laminated mineral-rich deposits dominated by silt and clay with occasional sand, *Phragmites* sp. and Mollusca remains to 1.28m OD (0.15m bgl) capped by 0.15m of Made Ground. These mineral rich layers are equivalent to the Lower and Upper Alluvium and are separated by Peat and/or organic-rich units were recorded at two distinct levels:

1. An 84cm thick sequence of sandy peat overlain by silt and unidentifiable peat, potentially separated by a 20cm thick layer of wood was recorded overlying the Shepperton Gravel between -11.57 and -10.73m OD (13.00 to 12.16m bgl). Due to the elevation and position of this peat it is considered equivalent to the Lower Peat. This horizon was not radiocarbon dated in this borehole in QBH2.
2. A 1.43m thick horizon of well humified herbaceous peat was recorded between -4.17and -5.60m OD (5.60 to 7.03m bgl). Due to the elevation and position of this peat, it is considered representative of the Middle Peat. This horizon was not radiocarbon dated in this borehole in QBH2.
3. A thin unit of sandy peat was recorded towards the very top of the sequence around -0.8m OD (2.25m bgl). Due to voids in the sequence, its precise thickness is unclear, but appears to be at least 7cm (possibly up to 32cm). Due to the elevation and position of this peat, it was considered to represent the Upper Peat recorded elsewhere. Originally, this horizon was targeted for radiocarbon dating, however closer inspection indicates this horizon may not be *in situ*, and contained limited dating material; as such radiocarbon dating was not progressed.

4.3 Borehole QBH3/3A

Borehole QBH3 reached 6.3m below ground surface prior to a magnetic anomaly being reached. Due to the risk of UXO, the borehole was subsequently moved 5m to QBH3A and sampling recommenced at 5.3m bgl, thus providing a 1m overlap in sampling between the two locations. Sampling was good throughout much of the sequence, but voids in important parts of the sequence.

Whilst not recovered, the solidity of the material below -12.94m OD (14.7m bgl) infers the presence of sand and flint gravel representative of the Shepperton Gravel terrace. This surface is overlain by fine-grained occasionally laminated mineral-rich deposits dominated by silt and clay with occasional sand, *Phragmites* sp. and Mollusca remains to 0.54m OD (1.4m bgl). These mineral rich layers are equivalent to the Lower and Upper Alluvium and are separated by Peat and/or organic-rich units were recorded at three distinct levels:

1. A 1.3m thick sequence of highly organic-rich sand, overlain by organic silt/clay and finally well humified wood peat was recorded immediately above the Shepperton Gravel between -12.94 and -11.64m OD (14.70 to 13.50m bgl). Due to the elevation and position of these units, they are both considered representative of the Lower Peat. Sufficient material for dating was only present at the base of the unit at -12.79m OD, from which a bulk sample was taken for radiocarbon dating of the humic acid and humin fractions; these returned very different determinations of 9450-9250 and 10,500-10,240 cal BP respectively. The results are sufficiently different (T'=317.9; T'(5%)=3.8; v=1; Ward & Wilson, 1978) that taking a weighted mean of the results is inappropriate. It is therefore only possible to state at this stage that the

humin fraction (10,500-10,240 cal BP) represents the oldest age the sample could be. It is often the base of peat deposits which include the greatest inhomogeneity, like in this case, probably because there is older material within the humin fraction (Marshall, pers. comm.). Whichever is the correct date, the result indicate that accumulation of the Lower Peat commenced during the early Mesolithic in QBH3/3A.

2. A 2.65m thick sequence of well humified herbaceous peat was recorded between -7.24 and -4.58m OD (6.35 to 9.00m bgl). This is equivalent in position and age to the aforementioned Middle Peat. The humic acid and humin fractions of a bulk sample extracted from near the base of the peat at -6.84m OD provided very similar ages of 6000-5890 and 6000-5760 cal BP respectively. *Phragmites* sp. stems from the top of the peat provided a date of 3720-3570 cal BP. These results indicate that accumulation of the Middle Peat commenced during the early Mesolithic in QBH3/3A.
3. A 30cm thick horizon of organic rich clay with herbaceous peat was recorded between -1.56 and -1.96m OD (3.50 to 3.80m OD). This is equivalent in elevation and position to the Upper Peat. Two radiocarbon determinations were carried out on Phragmites sp. stems from the base and middle of the peat (insufficient material was present from the top). These provided analogous ages of 2340-2150 and 2350-2150 cal BP. These results indicate the accumulation of the Upper Peat occurred during the Iron Age in QBH3/3A.

4.4 Borehole QBH4

Borehole QBH4 was the only sequence that could not be recovered within 10m of the proposed locations outlined within the WSI for the site (Young, 2017); however, it was within the 100m radius outlined and fills a useful void within the deposit model (see below). Recovery within borehole QBH4 was poor to moderate due to the very soft nature of the sediment in this area of the site. Whilst not recovered, the solidity of the material below -14.09m OD (16.3m bgl) infers the presence of sand and flint gravel representative of the Shepperton Gravel terrace.

Unlike boreholes QBH1 to QBH3/3A, the overlying sequence is characterised by frequently laminated mineral-rich deposits dominated by silt and sand overlying the Shepperton Gravel to -2.74m OD (4.95m bgl), followed by the deposition of silty clay to 1.01m OD (1.2m bgl). Peat horizons are recorded as follows:

1. A 20cm of sandy peat is recorded immediately above the Shepperton Gravel surface between -13.94 and -13.74m OD (16.15 to 15.95m bgl) separated by 2.2m of silty clay from an 18cm thick layer of well humified herbaceous peat. These units are both within the elevation and position previously ascribed to the Lower Peat. No radiocarbon dating was carried out on this horizon.
2. A 5cm thick layer of herbaceous peat is recorded towards the top of the sequence between -0.44 and -0.49m OD (2.65 to 2.70m bgl). The position and elevation of this unit is equivalent to the Upper Peat. No radiocarbon dating was carried out on this horizon.

Thus, another important characteristic of the QBH4 sequence is the absence of any Peat that might equate to the Middle Peat recorded elsewhere. This might be because the unit did not accumulate or was truncated and infilled by silty sand prior to the later accumulation of the Upper Peat.

4.5 Borehole QBH5

Sand and flint gravel representative of the Shepperton Gravel terrace was recorded below -12.68m OD (15.45m bgl). The overlying sequence to -5.93m OD (8.55m bgl) comprised silty clay with occasional organic/plant remains and detrital wood. Similarly to QBH4, the lower part of the sequence contained a 35cm unit of sandy peat immediately above the Shepperton Gravel surface between -12.43 and -12.28m OD (15.20 to 14.85m bgl) separated by 1.2m of silty clay with various inclusions from an 4cm thick lense of well humified herbaceous peat. These units are both within the elevation and position previously ascribed to the Lower Peat. No radiocarbon dating was carried out on this horizon.

Also similarly to QBH4, the borehole contained no evidence for any peat equivalent to that recorded elsewhere. The final characteristic, is the accumulation of a black silty clay with traces of sand from -5.78 to 0.77m OD (8.70 to 2.00m bgl). This sediment is unique to QBH5; it unusual because of its colour and texture, and its origin uncertain. It may represent the later deposition of a naturally accumulating layer (perhaps the result of a process that truncated the Middle Peat). However, because of its location adjacent to the former power-station, the possibility of contamination and/or disturbance cannot be ruled out.

4.6 Borehole QBH6

Sand and flint gravel representative of the Shepperton Gravel terrace was recorded below -14.08m OD (16.89m bgl). This surface is overlain by fine-grained occasionally laminated mineral-rich deposits dominated by silt and clay with occasional sand and *Phragmites* sp. remains to 1.61m OD (1.2m bgl). These mineral rich layers are equivalent to the Lower and Upper Alluvium and are separated by Peat and/or organic-rich units recorded at three distinct levels:

4. Unlike the other 5 boreholes, no peat horizon was recorded immediately above the Shepperton Gravel, but a 22cm thick horizon of silty peat was recorded between -9.77 and -9.99m OD (12.58 to 12.80m bgl). This is within the range of heights for the Lower Peat recorded elsewhere. Phragmites sp. stems were radiocarbon dated from the base of this horizon at -9.89m OD to 7430-7270 cal BP. These results indicate that accumulation of the Lower Peat commenced during the late Mesolithic in QBH6.
5. A 60cm thick sequence of well humified silty peat was recorded between -7.59 and -6.99m OD (10.40 to 9.80m bgl). This is equivalent in elevation to the Middle Peat recorded elsewhere. Phragmites sp. stems extracted from the near base of the peat at -7.54m OD provided an age of 5310-5050 cal BP. This result indicates that accumulation of the Middle Peat commenced during the middle Neolithic in QBH6.

6. A 10cm thick horizon of organic rich silt was recorded between -1.84 and -1.74m OD (4.65 to 4.55m bgl). This is equivalent in elevation and position to the Upper Peat. Phragmites sp. stems from the unit at -1.74m OD. This provided a determination of 2730-2380 cal BP. This result indicates the accumulation of the Upper Peat occurred during the Iron Age in QBH6.

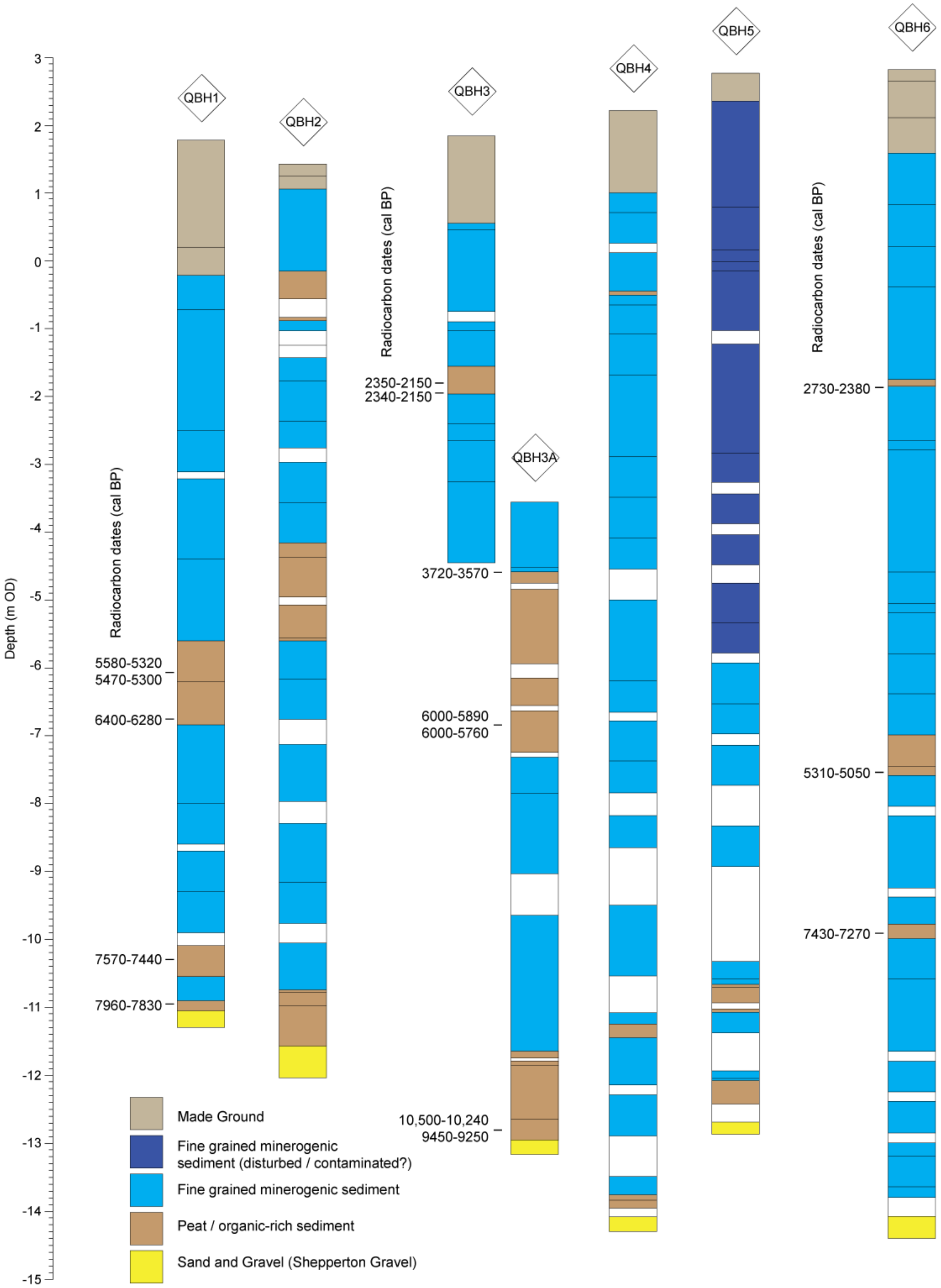

Figure 3: Results of the lithostratigraphic description of boreholes QBH1 to QBH6, incorporating the results of the radiocarbon dating, Tilbury 2, Tilbury, South Essex

Table 2: Lithostratigraphic description of QBH1, Tilbury 2, Tilbury, South Essex

Depth (m bgl)	Depth (m OD)	Sample type / degree of recovery	Lithostratigraphic description	Stratigraphic unit
0 to 1.60	1.79 to 0.19	Not recovered	Tarmac & black ash; sharp contact into:	MADE GROUND
1.60 to 2.00	0.19 to -0.21	Not recovered	10YR 5/1 to 10YR 2/1; Ag2, As2; Grey mottled black silty clay with occasional brick fragments and iron staining; unknown contact into:	
2.00 to 2.50	-0.21 to -0.71	Not recovered	10YR 5/1; Ag2, As2; Grey silty clay; unknown contact into:	UPPER ALLUVIUM
2.50 to 2.95	-0.71 to -1.16	U100 – good recovery	10YR 5/1; Ag2, As2, Dl+; Grey silty clay with traces of detrital wood, worm burrows and rootlets	
2.95 to 3.10	-1.16 to -1.31	Shoe sample – GR		
3.10 to 3.55	-1.31 to -1.76	U100 – GR		
3.55 to 3.70	-1.76 to -1.91	Shoe sample – GR		
3.70 to 4.15	-1.91 to -2.36	U100 – GR		
4.15 to 4.30	-2.36 to -2.51	Shoe sample – GR		
4.30 to 4.75	-2.51 to -2.96	U100 - GR	10YR 5/1; Ag2, As2, Dh+, Ga+; Grey silty clay with traces of sand and detrital plant remains	
4.75 to 4.90	-2.96 to -3.11	Shoe sample – MR		
4.90 to 5.00	-3.11 to -3.21	Not recovered	NOT RECOVERED	
5.00 to 5.45	-3.21 to -3.66	U100 – GR	10YR 5/3; Ag2, As2, Ga+, Sh+, Dh+; Greyish brown silty clay with occasional lenses of slightly organic alluvium and sand – possibly forming fine horizontal bedding. Lense of brown organic silt between 6.26 to 6.30m bgl.	
5.45 to 5.60	-3.66 to -3.81	Shoe sample – GR		
5.60 to 6.05	-3.81 to -4.26	U100 – GR		
6.05 to 6.20	-4.26 to -4.41	Shoe sample – GR		
6.20 to 6.65	-4.41 to -4.86	U100 – GR	10YR 5/1; Ag2, As1, Dh1; Grey clayey silt and detrital herbaceous plant remains (cf Phragmites australis)	
6.65 to 6.80	-4.86 to -5.01	Shoe sample – GR		
6.80 to 7.25	-5.01 to -5.46	U100 - GR		
7.25 to 7.40	-5.46 to -5.61	Shoe sample – GR		
7.40 to 7.85	-5.61 to -6.06	U100 – GR	10YR 3/3; Sh2, Th^{2}2, Ag+; Humo 2; Dark reddish brown moderately humified unidentifiable and herbaceous peat with traces of silt	MIDDLE PEAT
7.85 to 8.00	-6.06 to -6.21	Shoe sample – GR		
8.00 to 8.45	-6.21 to 6.66	U100 – GR	10YR 3/3; Sh2, Ag1, Th^{2}1; Humo 2; Dark reddish brown moderately humified unidentifiable and herbaceous peat with silt; sharp contact into:	
8.45 to 8.60	-6.66 to -6.81	Shoe sample – GR		
8.60 to 8.65	-6.81 to -6.86	U100 – GR		
8.65 to 9.05	-6.86 to -7.26		10YR 5/1; Ag2, As1, Dh1; Grey clayey silt with detrital herbaceous plant remains	LOWER ALLUVIUM
9.05 to 9.20	-7.26 to -7.41	Shoe sample – GR		
9.20 to 9.65	-7.41 to -7.86	U100 – GR		
9.65 to 9.80	-7.86 to -8.01	Shoe sample – GR		
9.80 to 10.25	-8.01 to -8.46	U100 - PR	10YR 5/1; Ag3, As1, Dh+; Grey clayey silt with detrital herbaceous plant remains	
10.25 to 10.40	-8.46 to -8.61	Shoe sample – PR		
10.40 to 10.50	-8.61 to -8.71	Not recovered	NOT RECOVERED	
10.50 to 10.95	-8.71 to -9.16	U100 – MR	10YR 5/1; Ag3, As1, Dh+, Dl+; Grey clayey silt with detrital wood and herbaceous plant remains	
10.95 to 11.10	-9.16 to -9.31	Shoe sample – GR		
11.10 to 11.55	-9.31 to -9.76	U100 – GR	10YR 4/1; Ag3, As1, Dh+, Dl+; Dark grey clayey silt with detrital wood and	

11.55 to 11.70	-9.76 to -9.91	Shoe sample	herbaceous plant remains	
11.70 to 11.90	-9.91 to -10.11	Not recovered	NOT RECOVERED	
11.90 to 12.35	-10.11 to -10.56	U100 - GR	10YR 3/3; Sh3, Th^{2}1, Ag+; Humo 2-3; Dark reddish brown moderately humified unidentifiable and herbaceous peat with traces of silt; diffuse contact into:	LOWER PEAT
12.35 to 12.50	-10.56 to -10.71	Shoe sample	10YR 5/1; Ag3. As1, Dh+; Grey clayey silt with traces of detrital herbaceous plant remains; sharp contact into:	
12.50 to 12.70	-10.71 to -10.91	U100		
12.70 to 12.84	-10.91 to -11.05		10YR 4/3; Ag2, Sh1, Ga1, As+, Gg+; Dark greyish brown organic-rich sandy silt with traces of clay and gravel; sharp contact into:	
12.84 to 12.95	-11.05 to -11.16		10YR 4/1; Gg3, Ga1; Dark grey sandy well-rounded to sub-angular flint gravel, ranging from 30-50mm	GRAVEL
12.95 to 13.10	-11.16 to -11.31	Shoe sample		

GR = Good recovery; MR = Moderate recovery; PR = Poor recovery

Table 3: Lithostratigraphic description of QBH2, Tilbury 2, Tilbury, South Essex

Depth (m bgl)	Depth (m OD)	Sample type / degree of recovery	Lithostratigraphic description	Stratigraphic unit
0 to 0.15	1.43 to 1.28	Not recovered	Fill	MADE GROUND
0.15 to 0.35	1.28 to 1.08	Not recovered	10YR 4/3; Gg2, Ga2; Brown gravelly sand	
0.35 to 1.60	1.08 to -0.17	Not recovered	10YR 4/3; As4; Stiff brown clay	UPPER ALLUVIUM
1.60 to 2.00	-0.17 to -0.57	Not recovered	10YR 3/1; As2, Ag1, Sh1; Very dark grey organic-rich silty clay	UPPER PEAT
2.00 to 2.25	-0.57 to -0.82	U100 – 50% recovery	VOID	
2.25 to 2.32	-0.82 to -0.89		10YR 2/1; Sh3, Ga1; Humo 4; Black very well humified sandy unidentifiable peat; very sharp contact into:	
2.32 to 2.45	-0.89 to -1.02		10YR 3/1 to 10YR 5/6; As4, Gg+; Very dark grey to yellowish brown clay with traces of gravel.	UPPER ALLUVIUM
2.45 to 2.60	-1.02 to -1.17	Shoe sample – 0% recovery	NOT RECOVERED	
2.60 to 2.67	-1.17 to -1.24	U100 – 100% recovery	VOID	
2.67 to 2.86	-1.24 to -1.43		10YR 5/1 to 10YR 2/1; As4; Grey to black clay; sharp contact into:	
2.86 to 3.05	-1.43 to -1.62		10YR 5/1; As4, Dh+, Ga+; Grey clay with traces of detrital herbaceous plant remains (cf Phragmites australis). Traces of sand infilling worm/root burrows?	
3.05 to 3.20	-1.62 to -1.77	Shoe sample – 100% recovery, non-orientated		
3.20 to 3.65	-1.77 to -2.22	U100 – 100% recovery	10YR 5/1; As4, Dh+, Ga+; Grey clay with traces of detrital herbaceous plant remains (cf Phragmites australis). Traces of sand infilling worm/root burrows. Lenses of 10YR 2/1; As2, Sh1, Dl1 at 3.30 to 3.34 and 3.45 to 3.48m bgl.	
3.65 to 3.80	-2.22 to -2.37	Shoe sample – 100% recovery, non-orientated		
3.80 to 4.05	-2.37 to -2.62	U100 – 0% recovery; Grab sample obtained	10YR 5/1; As4, Dh+; Grey clay with traces of detrital herbaceous plant remains (cf Phragmites australis).	
4.05 to 4.20	-2.62 to -2.77	Shoe sample – 0% recovery		
4.20 to 4.40	-2.77 to -2.97	Not recovered	NOT RECOVERED	
4.40 to 4.85	-2.97 to -3.42	U100 – 0% recovery; Grab sample obtained	10YR 5/1; As4, Dh+; Grey clay with traces of detrital herbaceous plant remains (cf Phragmites australis).	
4.85 to 5.00	-3.42 to -3.57	Shoe sample – 0% recovery		
5.00 to 5.45	-3.57 to -4.02	U100 – 0% recovery; Grab sample obtained	10YR 5/1; As4, Dh+; Grey clay with traces of detrital herbaceous plant remains (cf Phragmites australis).	
5.45 to 5.60	-4.02 to -4.17	Shoe sample – 0% recovery		
5.60 to 5.80	-4.17 to -4.37	Grab sample - <25%	10YR 2/1; Sh3, $Th^2$1; Humo 3; Black well humified unidentifiable and	MIDDLE PEAT

		recovery	herbaceous peat	
5.80 to 6.25	-4.37 to -4.82	U100 – 100% recovery	10YR 2/1 to 2.5Y 4/3; Sh3, Th^{3}1; Humo 3-4; Black to olive brown well humified unidentifiable and herbaceous peat	
6.25 to 6.40	-4.82 to -4.97	Shoe sample – <25% recovery, non-orientated		
6.40 to 6.51	-4.97 to -5.08	U100 – 75% recovery	VOID	
6.51 to 6.85	-5.08 to -5.42		10YR 2/1; Sh3, Th^{3}1; Humo 3; Black well humified unidentifiable and herbaceous peat	
6.85 to 7.00	-5.42 to -5.57	Shoe sample – 50% recovery; non orientated		
7.00 to 7.03	-5.57 to -5.60	U100 – 100% recovery	10YR 3/1; As2, Sh1, Th31; Very dark grey organic-rich clay with well-humified herbaceous peat (possibly disturbed); diffuse contact into:	
7.03 to 7.45	-5.60 to -6.02		10YR 4/1 to 10YR 5/1; As3, Dh1, Sh+; Dark grey to grey clay with detrital herbaceous plant remains (cf Phragmites australis) and traces of organic-remains	LOWER ALLUVIUM
7.45 to 7.60	-6.02 to -6.17	Shoe sample – 80% recovery; non orientated		
7.60 to 8.05	-6.17 to -6.62	U100 – 100% recovery	10YR 5/1; As2, Ag2, Dh+; Grey silty clay with traces of herbaceous plant remains	
8.05 to 8.20	-6.62 to -6.77	Shoe sample – 80% recovery; non orientated		
8.20 to 8.55	-6.77 to -7.12	U100 – 30% recovery	VOID	
8.55 to 8.65	-7.12 to -7.22		10YR 5/1; Ag2, As1, Ga1; Grey sandy clayey silt	
8.65 to 8.80	-7.22 to -7.37	Shoe sample – 100% recovery		
8.80 to 9.25	-7.37 to -7.82	U100 - <25% recovery – Grab sample		
9.25 to 9.40	-7.82 to -7.97	Shoe sample - <25% recovery – Grab sample		
9.40 to 9.73	-7.97 to -8.30	U100 - <25% recovery	VOID	
9.73 to 9.85	-8.30 to -8.42		10YR 5/1; Ag2, As1, Ga1; Grey sandy clayey silt	
9.85 to 10.00	-8.42 to -8.57	Shoe sample - 100% recovery; non orientated		
10.00 to 10.45	-8.57 to -9.02	U100 – 100% recovery		
10.45 to 10.60	-9.02 to -9.17	Shoe sample – 80% recovery; non orientated		
10.60 to 11.05	-9.17 to -9.62	U100 – 100% recovery	10YR 5/1; As2, Ag2; Grey faintly laminated silty clay with Mollusca	
11.05 to 11.20	-9.62 to -9.77	Shoe sample - 100% recovery; non		

		orientated		
11.20 to 11.50	-9.77 to -10.07	U100 – 40% recovery	VOID	
11.50 to 11.65	-10.07 to -10.22		10YR 5/1; Ag3, As1, Ga+, Sh+; Grey clayey silt with traces of sand and organic remains	
11.65 to 11.80	-10.22 to -10.37	Shoe sample - 100% recovery; non orientated		
11.80 to 12.16	-10.37 to -10.73	U100 – 100% recovery		
12.16 to 12.21	-10.73 to -10.78		10YR 5/1 to 10YR 2/1; Sh2, As2; Grey to black mixture of silt and unidentifiable peat; diffuse contact into:	LOWER PEAT
12.21 to 12.25	-10.78 to -10.82		Wood?	
12.25 to 12.40	-10.82 to -10.97	Shoe sample - 100% recovery		
12.40 to 12.85	-10.97 to -11.42	U100 – 100% recovery	10YR 2/1 to 10YR 5/1 to 10YR 5/4; Sh3, Ga1 to Ga3, Sh1; Black / grey / yellowish brown unidentifiable peaty sand, with traces of gravel, herbaceous peat and Mollusca	
12.85 to 13.00	-11.42 to -11.57	Shoe sample - 50% recovery		
13.00 to 13.45	-11.57 to -12.02	U100 - <25% recovery	Very loose material; >35 blows; Gravel inferred	GRAVEL

Table 4: Lithostratigraphic description of QBH3, Tilbury 2, Tilbury, South Essex

Depth (m bgl)	Depth (m OD)	Sample type / degree of recovery	Lithostratigraphic description	Stratigraphic unit
0 to 1.30	1.84 to 0.54	Not recovered	Fill	MADE GROUND
1.30 to 1.40	0.54 to 0.44	Not recovered	10YR 5/3; As2, Ag2; Greyish brown oxidised silty clay	UPPER ALLUVIUM
1.40 to 1.85	0.44 to -0.01	U100 – 100% recovery	10YR 5/1 to 10YR 4/3; As2, Ag2; Grey oxidising to brown silty clay with fine brown concretions	
1.85 to 2.00	-0.01 to -0.16	Shoe sample – 100% recovery		
2.00 to 2.45	-0.16 to -0.61	U100 – 100% recovery		
2.45 to 2.60	-0.61 to -0.76	Shoe sample – <50% recovery		
2.60 to 2.75	-0.76 to -0.91	U100	VOID	
2.72 to 2.89	-0.91 to -1.05		10YR 5/1 to 10YR 4/3; As2, Ag2; Grey oxidising to brown silty clay with fine brown concretions	
2.89 to 3.05	-1.05 to -1.21		10YR 5/1; As2, Ag2, Dh+; Grey silty clay with traces of detrital herbaceous plant remains	
3.05 to 3.20	-1.21 to -1.36	Shoe sample – 100% recovery		
3.20 to 3.50	-1.36 to -1.56	U100 – 100% recovery		
3.50 to 3.65	-1.56 to -1.81		10YR 4/2; As2, Sh1, Th31; Dark greyish brown organic-rich clay with moderately humified herbaceous peat with Mollusca	UPPER PEAT
3.65 to 3.80	-1.81 to -1.96	Shoe sample – 100% recovery		
3.80 to 4.25	-1.96 to -2.41	U100 – 100% recovery	10YR 5/1; As2, Ag1, Dh1; Grey silty clay with detrital herbaceous plant remains (cf Phragmites australis)	UPPER ALLUVIUM
4.25 to 4.40	-2.41 to -2.56	Shoe sample – 0% recovery	NOT RECOVERED	
4.40 to 4.50	-2.56 to -2.66	Not recovered	NOT RECOVERED	
4.50 to 4.95	-2.66 to -3.11	U100 – 100% recovery	10YR 5/1; As2, Ag1, Dh1; Grey silty clay with detrital herbaceous plant remains (cf Phragmites australis)	
4.95 to 5.10	-3.11 to -3.26	Shoe sample – 100% recovery – not orientated		
5.10 to 5.55	-3.26 to -3.71	U100 – 100% recovery	10YR 5/1; As2, Ag2, Dh+; Grey silty clay with detrital herbaceous plant remains (cf Phragmites australis)	
5.55 to 5.70	-3.71 to -3.86	Shoe sample – 100% recovery		
5.70 to 6.15	-3.86 to -4.31	U100 – 100% recovery		
6.15 to 6.30	-4.31 to -4.46	Shoe sample – 80% recovery		

Table 5: Lithostratigraphic description of QBH3A, Tilbury 2, Tilbury, South Essex

Depth (m bgl)	Depth (m OD)	Sample type / degree of recovery	Lithostratigraphic description	Stratigraphic unit
5.30 to 5.75	-3.54 to -3.99	U100 – 100% recovery	10YR 5/1; As2, Ag2, Dh+; Grey silty clay with detrital herbaceous plant remains (cf Phragmites australis)	UPPER ALLUVIUM
5.75 to 5.90	-3.99 to -4.14	Shoe sample – 75% recovery		
5.90 to 6.28	-4.14 to -4.52	U100 – 100% recovery		
6.28 to 6.34	-4.52 to -4.58		10YR 5/1; As2, Ag1, Dh1; Grey silty clay with detrital herbaceous plant remains (cf Phragmites australis); diffuse contact into:	
6.34 to 6.35	-4.58 to -4.59		10YR 4/1; Sh2, Th^{2}1, As1; Humo 3; Dark grey well humified unidentifiable and herbaceous peat with clay; diffuse contact into:	MIDDLE PEAT
6.35 to 6.50	-4.59 to -4.74	Shoe sample – 100% recovery		
6.50 to 6.60	-4.74 to -4.84	U100 – 80% recovery	VOID	
6.60 to 6.95	-4.84 to -5.19		10YR 2/1; Sh3, Th^{4}1; Humo 4; Black well humified unidentifiable and herbaceous peat	
6.95 to 7.10	-5.19 to -5.34	Shoe sample – 100% recovery		
7.10 to 7.55	-5.34 to -5.79	U100 - <40% recovery		
7.55 to 7.70	-5.79 to -5.94	Shoe sample - <50% recovery		
7.70 to 7.90	-5.94 to -6.14	U100 – 60% recovery	VOID	
7.90 to 8.15	-6.14 to -6.39		10YR 2/1; Sh3, Th^{4}1; Humo 4; Black well humified unidentifiable and herbaceous peat	
8.15 to 8.30	-6.39 to -6.54	Shoe sample – 100% recovery		
8.30 to 8.38	-6.54 to -6.62	U100 – 80% recovery	VOID	
8.38 to 8.75	-6.62 to -6.99		10YR 2/1; Sh4, Th+; Humo 4; Black well humified unidentifiable peat	
8.75 to 9.00	-6.99 to -7.24	Shoe sample - <50% recovery		
9.00 to 9.08	-7.24 to -7.32	U100 – 100% recovery – appears disturbed	10YR 5/1; As2, Ag2, Dh+; Grey silty clay with detrital herbaceous plant remains (cf Phragmites australis)	LOWER ALLUVIUM
9.08 to 9.45	-7.32 to -7.69		10YR 5/1; As2, Ag1, Dh1; Grey silty clay with detrital herbaceous plant remains (cf Phragmites australis); diffuse contact into:	
9.45 to 9.60	-7.69 to -7.84	Shoe sample - <50% recovery – not orientated		
9.60 to 10.05	-7.84 to -8.29	U100 – 100% recovery	10YR 5/1; Ag2, As1, Ga1; Grey silty sandy clay	
10.05 to 10.20	-8.29 to -8.44	Shoe sample - <50% recovery – not orientated		
10.20 to 10.65	-8.44 to -8.89	U100 – 100% recovery		
10.65 to 10.80	-8.89 to -9.04	Shoe sample - <50%		

		recovery		
10.80 to 11.25	-9.04 to -9.49	U100 – 0% recovery	NOT RECOVERED	
11.25 to 11.40	-9.49 to -9.64	Shoe sample – 0% recovery	NOT RECOVERED	
11.40 to 11.85	-9.64 to -10.09	U100 – 100% recovery	10YR 5/1; Ag2, As1, Ga1; Grey silty sandy clay	
11.85 to 12.00	-10.09 to -10.24	Shoe sample – 50% recovery		
12.00 to 12.45	-10.24 to -10.69	U100 – 75% recovery		
12.45 to 12.60	-10.69 to -10.84	Shoe sample – 50% recovery		
12.60 to 13.05	-10.84 to 11.29	U100 – 100% recovery		
13.05 to 13.20	-11.29 to -11.44	Shoe sample <25% recovery		
13.20 to 13.40	-11.44 to -11.64	Grab sample		
13.40 to 13.50	-11.64 to -11.74	Grab sample	10YR 3/1; Sh2, Tl32; Humo 3; Very dark grey well humified unidentifiable and wood peat	LOWER PEAT
13.50 to 13.55	-11.74 to -11.79	U100 – 90% recovery	VOID	
13.55 to 13.62	-11.79 to -11.86		10YR 3/1; Sh2, Tl32; Humo 3; Very dark grey well humified unidentifiable and wood peat; diffuse contact into:	
13.62 to 13.95	-11.86 to -12.19		10YR 5/1; As2, Sh1, Th/Tl31; Grey organic-rich wood/herbaceous peat with clay; diffuse contact into:	
13.95 to 14.10	-12.19 to -12.34	Shoe sample - <50% recovery		
14.10 to 14.40	-12.34 to -12.64	U100 – 100% recovery		
14.40 to 14.55	-12.64 to -12.79		10YR 2/1; Sh3, Ga1; Humo 4; Black well humified sandy unidentifiable peat	
14.55 to 14.70	-12.79 to -12.94	Shoe sample - <50% recovery		
>14.70	> -12.94	U100	No recovery after 50 blows – Gravel inferred	GRAVEL

Table 6: Lithostratigraphic description of QBH4, Tilbury 2, Tilbury, South Essex

Depth (m bgl)	Depth (m OD)	Sample type / degree of recovery	Lithostratigraphic description	Stratigraphic unit
0 to 1.20	2.21 to 1.01	Not recovered	Fill	MADE GROUND
1.20 to 1.50	-1.01 to 0.71	Not recovered	10YR 5/1 to 10YR 2/1; As3, Ag1; grey mottling to black silty clay.	UPPER ALLUVIUM
1.50 to 1.95	0.71 to 0.26	U100	10YR 5/3; As3, Ag1; Greyish brown silty clay with some iron staining	
1.95 to 2.10	0.26 to 0.11	Shoe sample	NOT RECOVERED	
2.10 to 2.55	0.11 to -0.34	U100	10YR 5/3; As3, Ag1; Greyish brown silty clay with some iron staining; sharp contact into:	
2.55 to 2.65	-0.34 to -0.44	Shoe sample		
2.65 to 2.70	-0.44 to -0.49		10YR 3/3; Sh2, $Th^2$1, Ag1, Tl+; Humo 3; Dark reddish brown well humified unidentifiable and herbaceous peat with silt and traces of wood peat	UPPER PEAT
2.70 to 2.85	-0.49 to -0.64	U100	10YR 4/1; Ag2, As1, Sh1, Dl+; Dark grey organic-rich clayey silt with traces of detrital wood; diffuse contact into:	UPPER ALLUVIUM
2.85 to 3.15	-0.64 to -0.94		10YR 5/1; Ag2, As2, Dl+; Grey silty clay with traces of detrital wood	UPPER ALLUVIIUM
3.15 to 3.30	-0.94 to -1.09	Shoe sample		
3.30 to 3.75	-1.09 to -1.54	U100	10YR 4/1; Ag2, As2; Dark grey silty clay	
3.75 to 3.90	-1.54 to -1.69	Shoe sample		
3.90 to 4.35	-1.69 to -2.14	U100	10YR 5/1; Ag2, As1, Ga1; Grey sandy, clayey silt with some horizontal bedding of sandy silt	
4.35 to 4.50	-2.14 to -2.29	Shoe sample		
4.50 to 4.95	-2.29 to -2.74	U100		
4.95 to 5.10	-2.74 to -2.89	Shoe sample		
5.10 to 5.55	-2.89 to -3.34	U100	10YR 5/1; Ga2, Ag2, As+; Grey silty sand with some horizontal bedding	LOWER ALLUVIUM
5.55 to 5.70	-3.34 to -3.49	Shoe sample		
5.70 to 6.15	-3.49 to -3.94	U100	10YR 4/1; Ga3, Ag1; Dark grey silty sand with some horizontal bedding	
6.15 to 6.30	-3.94 to -4.09	Shoe sample		
6.30 to 6.75	-4.09 to -4.54	U100	10YR 4/1; Ga3, Ag1, Dh+; Dark grey silty sand with traces of detrital herbaceous plant remains, and horizontal bedding of detrital wood	
6.75 to 6.90	-4.54 to -4.69	Shoe sample	NOT RECOVERED	
6.90 to 7.20	-4.69 to -4.99	Not recovered	NOT RECOVERED	
7.20 to 7.65	-4.99 to -5.44	U100	10YR 4/1; Ga3, Ag1, Dh+; Dark grey silty sand with layers of detrital herbaceous plant remains	
7.65 to 7.80	-5.44 to -5.59	Shoe sample		
7.80 to 8.25	-5.59 to -6.04	U100		
8.25 to 8.40	-6.04 to -6.19	Shoe sample		
8.40 to 8.85	-6.19 to -6.64	U100	10YR 5/1; Ag2, As1, Ga1, Dh+; Grey clayey sandy silt with frequent horizontal bedding of detrital plant remains	
8.85 to 9.00	-6.64 to -6.79	Shoe sample	NOT RECOVERED	
9.00 to 9.45	-6.79 to -7.24	U100	10YR 5/1; Ga3, Ag1; Grey silty sand with occasional vertical rooting of sedge remains	
9.45 to 9.60	-7.24 to -7.39	Shoe sample		

9.60 to 10.05	-7.39 to -7.84	U100	10YR 5/1; Ga3, Ag1; Grey silty sand	
10.05 to 10.20	-7.84 to -7.99	Shoe sample	NOT RECOVERED	
10.20 to 10.40	-7.99 to -8.19	Not recovered	NOT RECOVERED	
10.40 to 10.85	-8.19 to -8.64	U100	10YR 5/1; Ga2, Ag2; Grey silty sand with occasional vertical rooting of sedge remains	
10.85 to 11.00	-8.64 to -8.79	Shoe sample	NOT RECOVERED	
11.00 to 11.45	-8.79 to -9.24	U100	NOT RECOVERED	
11.45 to 11.60	-9.24 to -9.39	Shoe sample	NOT RECOVERED	
11.60 to 11.70	-9.39 to -9.49	Not recovered	NOT RECOVERED	
11.70 to 12.15	-9.49 to -9.94	U100	10YR 5/1; Ga3, Ag1; Grey finely laminated silty sand	
12.15 to 12.30	-9.94 to -10.09	Shoe sample		
12.30 to 12.75	-10.09 to -10.54	U100		
12.75 to 12.90	-10.54 to -10.69	Shoe sample	NOT RECOVERED	
12.90 to 13.30	-10.69 to -11.09	Not recovered	NOT RECOVERED	
13.30 to 13.48	-11.09 to -11.27	U100	10YR 5/1; Ga3, Ag1; Grey finely laminated silty sand; sharp boundary into:	
13.48 to 13.66	-11.27 to -11.45		10YR 3/3; Sh3, Th21, Ag+; Humo 3-4; Dark reddish brown well humified unidentifiable and herbaceous peat diffuse contact into	LOWER PEAT
13.66 to 13.75	-11.45 to -11.54		10YR 5/1; Ag2, As2, Dh+; Grey silty clay with detrital herbaceous remains	LOWER ALLUVIUM
13.75 to 13.90	-11.54 to -11.69	Shoe sample		
13.90 to 14.35	-11.69 to -12.14	U100	10YR 5/3; As2, Ag2, Dl+, Dh+; Greyish brown silty clay with traces of detrital herbaceous plant remains and wood	
14.35 to 14.50	-12.14 to -12.29	Shoe sample	NOT RECOVERED	
14.50 to 14.95	-12.29 to -12.74	U100	10YR 5/3; As2, Ag2, Dl+, Dh+; Greyish brown silty clay with frequent horizontal beds of detrital herbaceous plant remains and wood	
14.95 to 15.10	-12.74 to -12.89	Shoe sample		
15.10 to 15.55	-12.89 to -13.34	U100	NOT RECOVERED	
15.55 to 15.70	-13.34 to -13.49	Shoe sample	NOT RECOVERED	
15.70 to 15.95	-13.49 to -13.74	U100	10YR 4/3; Ag2, As2, Brown silty clay with frequent Mollusca remains and occasional laminations; sharp contact into:	
15.95 to 16.03	-13.74 to -13.82		10YR 5/3; Sh2, Ag1, Tl^{2}1; Humo 3; Greyish brown well-humified unidentifiable peat with wood plant remains, silt and occasional Mollusca; diffuse contact into:	LOWER PEAT
16.03 to 16.15	-13.82 to -13.94		10YR 4/1; Ga2, Ag1, Sh1, Gg+; Dark grey organic-rich silty sand with gravel clasts towards the base	
16.15 to 16.30	-13.94 to -14.09	Shoe sample	NOT RECOVERED	GRAVEL
16.30 to 16.50	-14.09 to -14.29	Not recovered	50 blows – no further penetration & no recovery – Gravel inferred	

GR = Good recovery; MR = Moderate recovery; PR = Poor recovery

Table 7: Lithostratigraphic description of QBH5, Tilbury 2, Tilbury, South Essex

Depth (m bgl)	Depth (m OD)	Sample type / degree of recovery	Lithostratigraphic description	Stratigraphic unit
0 to 0.40	2.77 to 2.37	Not recovered	Fill	MADE GROUND
0.40 to 2.00	2.37 to 0.77	Not recovered	10YR 5/1 to 10YR 4/3; Ag2, As2; Grey oxidising to brown silty clay	UPPER ALLUVIUM (DISTURBED / CONTAMINATED)
2.00 to 2.45	0.77 to 0.32	U100 – 100% recovery	10YR 5/1; As2, Ag2, Ga+; Grey silty clay with lenses of silty sand between 2.19-2.32 and 2.34-2.40m bgl	
2.45 to 2.60	0.32 to 0.17	Shoe sample – 100% recovery		
2.60 to 2.78	0.17 to -0.01	U100 – 100% recovery	10YR 5/1 and 10YR 2/1; As2, Ag2, Ga+; Grey and black silty clay with traces of sand; diffuse contact into:	
2.78 to 2.91	-0.01 to -0.14		10YR 5/1 and 10YR 2/1; Ag2, As1, Ga1; Grey and black clayey sandy silt; diffuse contact into:	
2.91 to 3.05	-0.14 to -0.28		10YR 2/1 and 10YR 4/3; As2, Ag2, Ga+; Black rapidly oxidising to brown faintly laminated silty clay with traces of sand; potential low organic-content	
3.05 to 3.20	-0.28 to -0.43	Shoe sample – 100% recovery		
3.20 to 3.65	-0.43 to -0.88	U100 – 100% recovery		
3.65 to 3.80	-0.88 to -1.03	Shoe sample – 100% recovery		
3.80 to 4.00	-1.03 to -1.23	U100 – 50% recovery	VOID	
4.00 to 4.25	-1.23 to -1.48		10YR 2/1 and 10YR 4/3; As2, Ag2, Ga+; Black rapidly oxidising to brown faintly laminated silty clay with traces of sand; potential low organic-content	
4.25 to 4.40	-1.48 to -1.63	Shoe sample – 100% recovery; non-orientated		
4.40 to 4.85	-1.63 to -2.08	U100 – 100% recovery		
4.85 to 5.00	-2.08 to -2.23	Shoe sample – 100% recovery		
5.00 to 5.45	-2.23 to -2.68	U100 – 100% recovery		
5.45 to 5.60	-2.68 to -2.83	Shoe sample – 100% recovery		
5.60 to 6.05	-2.83 to -3.28	U100 – 100% recovery	10YR 2/1 & 10YR 5/1; Ag2, As1, Ga1; Black and grey sandy clayey silt	
6.05 to 6.20	-3.28 to -3.43	Shoe sample – 0% recovery	NOT RECOVERED	
6.20 to 6.65	-3.43 to -3.88	U100 – 100% recovery	10YR 2/1 & 10YR 5/1; Ag2, As1, Ga1; Black and grey sandy clayey silt	
6.65 to 6.80	-3.88 to -4.03	Shoe sample – 0% recovery	NOT RECOVERED	
6.80 to 7.25	-4.03 to -4.48	U100 – 100% recovery	10YR 2/1 & 10YR 5/1; Ag2, As1, Ga1; Black and grey sandy clayey silt	
7.25 to 7.40	-4.48 to -4.63	Shoe sample – 0% recovery	NOT RECOVERED	
7.40 to 7.50	-4.63 to -4.73	Not recovered	NOT RECOVERED	

7.50 to 7.95	-4.73 to -5.18	U100 – 100% recovery	10YR 2/1 & 10YR 4/3; Ag2, As1, Ga1; Black oxidising to brown laminated sandy clayey silt	
7.95 to 8.10	-5.18 to -5.33	Shoe sample - <50% recovery		
8.10 to 8.55	-5.33 to -5.78	U100 – 100% recovery	10YR 2/1; As2, Ag2, Ga+; Black silty clay with traces of sand	
8.55 to 8.70	-5.78 to -5.93	Shoe sample – 0% recovery	NOT RECOVERED	
8.70 to 9.15	-5.93 to -6.38	U100 – 100% recovery	10YR 5/1; Ag2, As1, Dh1; Grey silty clay with detrital herbaceous plant remains	LOWER ALLUVIUM
9.15 to 9.30	-6.38 to -6.53	Shoe sample – 100% recovery		
9.30 to 9.75	-6.53 to -6.98	U100 – 100% recovery	10YR 5/1; Ag2, As2, Dh+, Ga+; Grey silty clay with traces of sand and detrital herbaceous plant remains	
9.75 to 9.90	-6.98 to -7.13	Shoe sample – 0% recovery	NOT RECOVERED	
9.90 to 10.35	-7.13 to -7.58	U100 – 100% recovery	10YR 5/1; Ag2, As2, Dh+, Ga+; Grey silty clay with traces of sand and detrital herbaceous plant remains; diffuse contact into:	
10.35 to 10.50	-7.58 to -7.73	Shoe sample – 100% recovery		
10.50 to 10.95	-7.73 to -8.18	U100 – 0% recovery		
10.95 to 11.10	-8.18 to -8.33	Shoe sample – 0% recovery		
11.10 to 11.55	-8.33 to -8.78	U100 – 100% recovery		
11.55 to 11.70	-8.78 to -8.93	Shoe sample – 100% recovery		
11.70 to 12.15	-8.93 to -9.38	U100 – 0% recovery		
12.15 to 12.30	-9.38 to -9.53	Shoe sample – 0% recovery		
12.30 to 12.75	-9.53 to -9.98	U100 – 0% recovery		
12.75 to 12.90	-9.98 to -10.13	Shoe sample – 0% recovery		
12.90 to 13.10	-10.13 to -10.33	No recovery		
13.10 to 13.35	-10.33 to -10.58	U100 – 100% recovery		
13.35 to 13.43	-10.58 to -10.66		10YR 4/1; As2, Ag1, Dh1, Sh+; Dark grey silty clay with detrital herbaceous plant remains; diffuse contact into:	
13.43 to 13.47	-10.66 to -10.70		10YR 3/1; As2, Sh1, Th31; Humo 3; Very dark grey organic-rich clay with well humified herbaceous peat; diffuse contact into:	LOWER PEAT

13.47 to 13.55	-10.70 to -10.78		Wood	
13.55 to 13.70	-10.78 to -10.93	Shoe sample – 100% recovery		
13.70 to 13.78	-10.93 to -11.01	U100 – 80% recovery	VOID	
13.78 to 13.85	-11.01 to -11.08		Wood	
13.85 to 14.15	-11.08 to -11.38		10YR 5/1 to 10YR 4/1; As2, Ag2, Sh+, Th+, Tl+; Grey to dark grey silty clay with traces of organic remains, wood and herbaceous plant remains; possibly laminated	LOWER ALLUVIUM
14.15 to 14.30	-11.38 to -11.53	Shoe sample – 0% recovery	NOT RECOVERED	
14.30 to 14.60	-11.53 to -11.83	Not recovered	NOT RECOVERED	
14.60 to 14.70	-11.83 to -11.93	U100 – 60% recovery	VOID	
14.70 to 14.81	-11.93 to -12.04		10YR 5/1 to 10YR 4/1; As2, Ag2, Sh+, Th+, Tl+; Grey to dark grey silty clay with traces of organic remains, wood and herbaceous plant remains; possibly laminated; sharp contact into:	
14.81 to 14.85	-12.04 to -12.08		10YR 3/1; Ag2, $Tl^3$1, As1, Dh+; Very dark grey clayey silt with wood; laminated; sharp contact into:	
14.85 to 15.05	-12.08 to -12.28		10YR 2/1; Sh2, Ga1, $Th^3$1; Black sandy unidentifiable and herbaceous peat	LOWER PEAT
15.05 to 15.20	-12.28 to -12.43	Shoe sample – 50% recovery		
15.20 to 15.45	-12.43 to -12.68	U100 - <50% recovery	VOID	GRAVEL
15.45 to 15.65	-12.68 to -12.88		10YR 3/1; Gg2, Ga2; Very dark grey sandy gravel	

Table 8: Lithostratigraphic description of QBH6, Tilbury 2, Tilbury, South Essex

Depth (m bgl)	Depth (m OD)	Sample type / degree of recovery	Lithostratigraphic description	Stratigraphic unit
0 to 0.15	2.81 to 2.66	Not recovered	Brick & concrete	MADE GROUND
0.15 to 0.70	2.66 to 2.11	Not recovered	10YR 5/1; As2, Ag2; Grey silty clay; membrane at 0.70m bgl; diffuse contact into:	
0.70 to 1.20	2.11 to 1.61	Not recovered	10YR 5/3; As2, Ag2; Greyish brown silty clay with iron staining, chalk fragments, fine gravel and rootlet inclusions; unknown contact into:	
1.20 to 2.00	1.61 to 0.81	Not recovered	10YR 5/1 to 10YR 4/3; As4; Stiff grey oxidising to brown clay; diffuse contact into:	UPPER ALLUVIUM
2.00 to 2.45	0.81 to 0.36	U100	10YR 5/1; As3, Ag1; stiff grey oxidising to brown silty clay, with worm and rootlet holes; unknown contact into:	
2.45 to 2.60	0.36 to 0.21	Shoe sample		
2.60 to 3.05	0.21 to -0.24	U100	10YR 5/1; As3, Ag1, Dh+; grey silty clay with occasional vertical sedge remains, worm and rootlet holes	
3.05 to 3.20	-0.24 to -0.39	Shoe sample		
3.20 to 3.65	-0.39 to -0.84	U100	10YR 5/1; As2, Ag2, Dh+; Grey silty clay with occasional vertical sedge root remains; diffuse contact into:	
3.65 to 3.80	-0.84 to -0.99	Shoe sample		
3.80 to 4.25	-0.99 to -1.44	U100		
4.25 to 4.40	-1.44 to -1.59	Shoe sample		
4.40 to 4.55	-1.59 to -1.74	Grab sample		
4.55 to 4.65	-1.74 to -1.84	U100	10YR 4/3; Sh2, Ag2, Th+; Humo 3; Brown well humified unidentifiable peat and silt with traces of herbaceous peat; sharp contact into:	UPPER PEAT
4.65 to 5.00	-1.84 to -2.19	U100	10YR 5/1; Ag2, As1, Dh1; Grey clayey silt with cf Phragmites australis reed remains; diffuse contact into:	UPPER ALLUVIUM
5.00 to 5.45	-2.19 to -2.64	U100		
5.45 to 5.60	-2.64 to -2.79	Shoe sample	10YR 5/1; As2, Ag2, Dh+; Grey silty clay with cf Phragmites australis reed remains; diffuse contact into:	
5.60 to 6.05	-2.79 to -3.24	U100	10YR 5/1; Ag2, As1, Dh1; Grey clayey silt with cf Phragmites australis reed remains; diffuse contact into:	
6.05 to 6.20	-3.24 to -3.39	Shoe sample		
6.20 to 6.65	-3.39 to -3.84	U100		
6.65 to 6.80	-3.84 to -3.99	Shoe sample		
6.80 to 7.25	-3.99 to -4.44	U100		
7.25 to 7.40	-4.44 to -4.59	Shoe sample		
7.40 to 7.85	-4.59 to -5.04	U100	10YR 5/1; As2, Ag2, Dh+; Grey silty clay with cf Phragmites australis reed remains; diffuse contact into:	
7.85 to 8.00	-5.04 to -5.19	Shoe sample		
8.00 to 8.45	-5.19 to -5.64	U100	10YR 4/1; Ag3, As1, Dh+; Dark grey clayey silt with cf Phragmites australis reed remains; diffuse contact into:	
8.45 to 8.60	-5.64 to -5.79	Shoe sample		
8.60 to 9.05	-5.79 to -6.24	U100	10YR 4/1; Ag3, As1; Dark grey clayey silt; diffuse contact into:	
9.05 to 9.20	-6.24 to -6.39	Shoe sample		
9.20 to 9.65	-6.39 to -6.84	U100	10YR 3/1; Ag3, As1, Sh+, Dh+; Very dark grey clayey organic silt with traces of organic remains, herbaceous plant remains and occasional	
9.65 to 9.80	-6.84 to -6.99	Shoe sample		

			Mollusca. Fine laminations towards very base of unit; unknown contact into:	
9.80 to 10.25	-6.99 to -7.44	U100	10YR 3/3; Sh3, Ag1, Th+; Humo 3/4; Dark reddish brown well humified unidentified peat with silt and traces of herbaceous peat. Lenses of more silty and Mollusca rich material throughout; diffuse contact into:	MIDDLE PEAT
10.25 to 10.40	-7.44 to -7.59	Shoe sample	10YR 3/3; Sh2, Ag1, Th^{2}1; Humo 3/4; Dark reddish brown well humified unidentified and herbaceous peat with silt; unknown contact into:	
10.40 to 10.85	-7.59 to -8.04	U100	10YR 5/1; Ag2, As1, Dh1; Grey clayey silt with herbaceous plant remains.	LOWER ALLUVIUM
10.85 to 11.00	-8.04 to -8.19	Shoe sample	NOT RECOVERED	
11.00 to 11.45	-8.19 to -8.64	U100	10YR 5/1; Ag2, As1, Dh1; Grey clayey silt with herbaceous plant remains (cf Phragmites australis).	
11.45 to 11.60	-8.64 to -8.79	Shoe sample		
11.60 to 12.05	-8.79 to -9.24	U100		
12.05 to 12.20	-9.24 to -9.39	Shoe sample	NOT RECOVERED	
12.20 to 12.58	-9.39 to -9.77	U100	10YR 5/1; Ag2, As1, Dh1; Grey clayey silt with herbaceous plant remains (cf Phragmites australis); sharp contact into:	
12.58 to 12.65	-9.77 to -9.84		10YR 5/3; Sh2, Ag1, Dh/Th1; Humo 3; Greyish brown well-humified unidentifiable peat with herbaceous plant remains an silt	LOWER PEAT
12.65 to 12.80	-9.84 to -9.99	Shoe sample		
12.80 to 13.25	-9.99 to -10.44	U100	10YR 5/1; Ag3, Dh1, As+; Grey silt and detrital herbaceous plant remains with traces of clay	LOWER ALLUVIUM
13.25 to 13.40	-10.44 to -10.59	Shoe sample		
13.40 to 13.85	-10.59 to -11.04	U100	10YR 5/1; Ag3, As1, Dh+; Grey clayey silt with traces of detrital herbaceous plant remains	
13.85 to 14.00	-11.04 to -11.19	Shoe sample		
14.00 to 14.45	-11.19 to -11.64	U100		
14.45 to 14.60	-11.64 to -11.79	Shoe sample	NOT RECOVERED	
14.60 to 15.05	-11.79 to -12.24	U100	10YR 5/1; Ag3, As1, Dh+; Grey clayey silt with traces of detrital herbaceous plant remains	
15.05 to 15.20	-12.24 to -12.39	Shoe sample	NOT RECOVERED	
15.20 to 15.65	-12.39 to -12.84	U100	10YR 4/1; Ag2, As2, Sh+; Dark grey silty clay with occasional organic lenses – possibly within former root/worm hollows?	
15.65 to 15.80	-12.84 to -12.99	Shoe sample	NOT RECOVERED	
15.80 to 16.00	-12.99 to -13.19	Grab sample	10YR 4/1; Ag2, As2, Sh+; Dark grey silty clay	
16.00 to 16.45	-13.19 to -13.64	U100	10YR 4/1; Ag2, As2, Sh+, Dh+; Dark grey silty clay with traces of organic and detrital herbaceous remains; becoming very stiff from 16.45-16.60m bgl.	
16.45 to 16.60	-13.64 to -13.79	Shoe sample		
16.60 to 16.89	-13.79 to -14.08	U100	NOT RECOVERED	GRAVEL
16.89 to 17.05	-14.08 to -14.24		10YR 4/1; Gg3, Ga1; Dark grey sandy well-rounded to sub-angular flint gravel, ranging from 30-50mm	
17.05 to 17.20	-14.24 to -14.39	Shoe sample		

Table 9: Results of the radiocarbon dating, QBH1, QBH3 & QBH6, Tilbury 2, Tilbury, South Essex

Laboratory code / Method	Borehole number	Material and location	Depth (m OD)	Uncalibrated radiocarbon years before present (BP)	Calibrated age BC/AD (BP) (2-sigma, 95.4% probability)	δ13C (‰)
BETA-474853	QBH1	Humic acid fraction of bulk peat; top of middle peat	-6.06	4690 ± 30	3630-3370 cal BC 5580-5320 cal BP	-27.8
BETA-474852	QBH1	Humin fraction of bulk peat; top of middle peat	-6.06	4640 ± 30	3520-3350 cal BC 5470-5300 cal BP	-26.9
BETA-474850	QBH1	Horizontally bedded aerial cf *Phragmites* sp. stems; base of middle peat	-6.76	5530 ± 30	4450-4330 cal BC 6400-6280 cal BP	-27.6
BETA-474849	QBH1	Horizontally bedded aerial cf *Phragmites* sp. stems; top of basal peat	-10.31	6610 ± 30	5620-5490 cal BC 7570-7440 cal BP	-25.1
BETA-474851	QBH1	Twig wood; base of basal peat	-10.95	7060 ± 30	6010-5890 cal BC 7960-7830 cal BP	-25.0
BETA-474859	QBH3	Horizontally bedded aerial cf *Phragmites* sp. stems; top of upper peat	-1.81	2250 ± 30	400-200 cal BC 2350-2150 cal BP	-26.2
BETA-474860	QBH3	Horizontally bedded aerial cf *Phragmites* sp. stems; base of upper peat	-1.96	2230 ± 30	390-200 cal BC 2340-2150 cal BP	-28.6
BETA-474858	QBH3	Horizontally bedded aerial cf *Phragmites* sp. stems; top of middle peat	-4.59	3400 ± 30	1770-1620 cal BC 3720-3570 cal BP	-27.0
BETA-474855	QBH3	Humic acid fraction of bulk peat; base of middle peat	-6.84	5170 ± 30	4050-3940 cal BC 6000-5890 cal BP	-27.0
BETA-474854	QBH3	Humin fraction of bulk peat; base of middle peat	-6.84	5160 ± 30	4050-3820 cal BC 6000-5760 cal BP	-27.7
BETA-474857	QBH3	Humic acid fraction of bulk peat; base of lower peat	-12.79	8320 ± 30	7500-7300 cal BP 9450-9250 cal BP	-26.7
BETA-474856	QBH3	Humin fraction of bulk peat; base of lower peat	-12.79	9200 ± 40	8550-8290 cal BC 10,500-10,240 cal BP	-25.8
BETA-474863	QBH6	Horizontally bedded aerial cf *Phragmites* sp. stems; centre of upper peat	-1.74	2480 ± 30	780-430 cal BC 2730-2380 cal BP	-24.6
BETA-474862	QBH6	Horizontally bedded aerial cf *Phragmites* sp. stems; base of middle peat	-7.54	4530 ± 30	3370-3100 cal BC 5310-5050 cal BP	-25.2
BETA-474861	QBH6	Horizontally bedded aerial cf *Phragmites* sp. stems; top of upper peat	-9.89	6420 ± 30	5480-5330 cal BC 7430-7270 cal BP	-27.3

5. RESULTS AND INTERPRETATION OF THE UPDATED DEPOSIT MODELLING

The original deposit model for the site (Young & Batchelor, 2016) has been updated to include the new terrestrial (this report) and offshore (Wessex Archaeology, 2017) geoarchaeological boreholes. Also integrated are the palaeoenvironmental sequences analysed at Tilbury Fort (Batchelor, 2009) and The Worlds' End (Devoy, 1979). The results of the deposit modelling are displayed in Figures 4 to 15. Figure 3 is a two-dimensional north-south transect of selected boreholes/test pits across the site; Figures 4 to 14 are surface elevation and thickness models for each of the main stratigraphic units.

Devoy's work also included borehole transects across the Tilbury area. Unfortunately, the individual borehole logs do not contain sufficiently precise levels or spatial data to be integrated into the model with confidence. Instead, those boreholes nearest the site have been reproduced in a transect in Figure 16.

The results of the deposit modelling indicate that the number and spread of the logs is sufficient to permit modelling with a high level of certainty across the majority of the southern and central areas of the site; the recent geoarchaeologcial investigations have also added to the relatively few records that were previously available for the northern area of the site (see Figure 2). This section does not include consideration of the radiocarbon dating which follows in the Discussion (section 8).

The full sequence of sediments recorded in the boreholes comprises:

Made Ground – widely present
Upper Alluvium – widely present
Upper Peat – only locally present towards the south of the site; recorded within the Upper Alluvium
Middle Peat – widely present across much of the site; separates the Lower and Upper Alluvium
Lower Peat – widely present; lies within or beneath the Lower Alluvium
Lower Alluvium – widely present
Gravel (Shepperton Gravel) – widely present but not reached in all boreholes/test pits

4.1 Shepperton Gravel

The Shepperton Gravel was present in all the boreholes that penetrated to the bottom of the Holocene sequence. It was deposited during the Late Glacial (15,000 to 10,000 years before present) and comprises the sands and gravels of a high-energy braided river system which, while it was active would have been characterised by longitudinal gravel bars and intervening low-water channels in which finer-grained sediments might have been deposited. Such a relief pattern would have been present on the valley floor at the beginning of the Holocene when a lower-energy fluvial regime was being established.

The surface of the Gravel (see Figures 3 and 4) generally lies at between *ca*. -12.5 and -15m OD across the site, falling to between *ca*. -15 and -17m OD to the south of the site within the channel of the Thames, in the area of boreholes NH-BH401 to NH-BH409 and new offshore geoarchaeological boreholes MO-BH03, MO-BH07 and MO-BH08 . In general the surface of the Gravel is relatively even, but there is some indication of slightly higher (-9.5 to -12m OD) surfaces to the west of the site and particularly in the area of BV-BH01 (within the site), where the Gravel surface is recorded at -9.62m OD; new geoarchaeological boreholes QBH1 and QBH2 also record the Gravel surface marginally higher than -12m OD. Approximately 500m to the west (Figure 16) Devoy (1979) produced a north-south transect of boreholes indicating that the Gravel surface that became progressively deeper towards the modern course of the Thames, recorded at between *ca*. -13 and -15m OD.

In general, the surface topography is typical of that in a braided river system as described above, with undulations in the surface of the Gravel indicative of shallow channels separating longitudinal gravel bars.

4.2 Lower Alluvium

The Lower Alluvium rests directly on the Shepperton Gravel and was recorded in the majority of records across the site (see Figure 5). The deposits of the Lower Alluvium are described as predominantly silty or clayey, tending to become increasingly sandy downward in most sequences. The Lower Alluvium frequently contains detrital wood or plant remains, and in many cases is described as organic and with occasional Mollusca remains. The surface of the Lower Alluvium (Figure 5) is variable, but generally lies at between *ca*. -3m and -8m OD. One notable exception to this is QBH4, which as outlined above, unlike other boreholes contains an absence of Middle Peat and laminated sandy silt to -2.74m OD. In general, thicker occurrences of Lower Alluvium are present where the surface of the Shepperton Gravel lies at a lower level.

The sediments of the Lower Alluvium are indicative of deposition during the Early to Mid-Holocene, when the main course of the Thames was probably confined to a single meandering channel. During this period, the surface of the Shepperton Gravel was progressively buried beneath the sandy and silty flood deposits of the river. The richly-organic nature of the Lower Alluvium suggests that this was a period during which the valley floor was occupied by a network of actively shifting channels, with a drainage pattern on the floodplain that was still largely determined by the relief on the surface of the underlying Shepperton Gravel. A horizon or horizons of peat/organic-rich sediment, described here as the Lower Peat, was recorded within the Lower Alluvium (see below).

4.3 Lower Peat

Recorded either directly overlying the Shepperton Gravel or within the Lower Alluvium in the majority of boreholes towards the southern part of the site, and in selected boreholes towards the north (including all new geoarchaeological boreholes), is a unit of organic-rich sediment and/or peat. This horizon was generally between 0.5 and 2.5m in thickness (Figure 7), and lay at elevations of between *ca*. -16 and -9m OD, its surface lying at variable elevations between *ca*. -7.8 and 15.4m OD (Figure 6).

Although this unit is referred to here as the Lower Peat for deposit modelling purposes, the new geoarchaeological boreholes confirm that two or more distinct horizons can often be identified, representing different mechanisms and ages of peat formation: particularly those that directly overlie the Gravel, and those that lie at higher elevations within the Lower Alluvium. Previously, no borehole record contained evidence for more than one peat horizon within the Lower Alluvium; the new geoarchaeological boreholes confirm however that this is not the case, with two recorded in QBH4 and QBH5. The geoarchaeological boreholes confirm that the Lower Peat is largely comprised of herbaceous remains with occasional wood. This is indicative of a transition towards semi-terrestrial (marshy) conditions, supporting the growth of either saltmarsh, sedge fen/reed swamp with less common woodland.

4.4 Middle Peat

Often separating the deposits of the Lower and Upper Alluvium is a horizon of peat, referred to here as the 'Middle Peat', present across much of the site and the surrounding area. The Middle Peat lies at elevations of between *ca*. -3.5 and -8.5m OD, and is generally present in thicknesses of between 0.5 and 3m OD (Figure 9). The thickness of this unit is highly variable across the site, but in general greater thicknesses appear to be recorded towards the southern part of the floodplain. Sometimes the Middle Peat is absent altogether. Within the historic geotechnical records, this should be taken with caution as the drilling and descriptive techniques may be insufficiently precise / accurate to detect them. However, peat is absent within new geoarchaeological boreholes QBH4 and QBH5.

The surface of the Middle Peat lies at between *ca*. -3.5 and -8m OD (Figure 8). The geoarchaeological boreholes confirm that the Middle Peat is almost solely composed of herbaceous remains. This is indicative of a transition towards semi-terrestrial (marshy) conditions, supporting the growth of saltmarsh and/or sedge fen/reed swamp.

4.5 Upper Alluvium

The Upper Alluvium rests on the Middle Peat, or on the occasional instances where this was not present, the Lower Alluvium, and more even more rarely directly on the Shepperton Gravel. Sometimes the confident distinction of the Upper and Lower Alluvium is inhibited by the absence of the Middle Peat which separates them – this is particularly the case in geotechnical logs. Where the combined thickness of the Upper / Lower Alluvium does directly overly the Gravel (e.g. in the area of boreholes QBH4, QBH5,RPS-BH-Z19-02, 03 and BV-BH05) such sequences may be indicative of erosion associated with channel scour in selected areas of the site, perhaps also explaining the absence of the Middle Peat and/or Lower Peat horizons in these areas. The deposits of the Upper Alluvium are described as predominantly silty or clayey which are very occasionally organic-rich. The surface of the Alluvium (Figure 12) is relatively even across the site, generally lying at between 0 and -2m OD. The sediments of the Alluvium are indicative of deposition within low energy fluvial and/or semi-aquatic conditions during the Holocene. The high mineral content of the sediments may reflect increased sediment loads resulting from intensification of agricultural land use from the later prehistoric period onward, combined with the effects of rising sea level. A horizon of peat, described here as the Upper Peat, was recorded within the Upper Alluvium at selected locations (see below).

4.6 Upper Peat

A horizon of peat was recorded within the Upper Alluvium in 14 of the historic boreholes and 4 new geoarchaeological boreholes, mostly located towards the south of the site but occasionally present towards the centre (WA-BH9 and BV-BH11) and north (e.g. QBH2 and QBH3). This horizon was much more localised in comparison to the Middle and Lower Peats, and was present in thickness of up to 1m (Figure 12), its surface generally lying at between *ca*. -1 and -3m OD. This unit is indicative of a localised transition towards semi-terrestrial (marshy) conditions, supporting the growth of sedge fen/reed swamp communities.

The combined Holocene alluvial sequence, incorporating the Lower Alluvium, Lower, Middle and Upper Peat, and the Upper Alluvium, is generally recorded in thicknesses of between *ca*. 12 and 16m across the site (Figure 14). Greater thicknesses of between 14 and 16m are recorded towards the south of the site (compared to 12-14m in the north), probably as a result of a combination of less truncation by the overlying Made Ground in this area and slightly lower Gravel surfaces. The offshore boreholes unsurprisingly indicate a much thinner thickness or even absence of Total Alluvium.

4.7 Made Ground

Between ca. 0.5 and 3m of Made Ground caps the Holocene alluvial sequence across the site (Figure 14). The Made Ground is generally thickest towards the east of the site (2-3m).

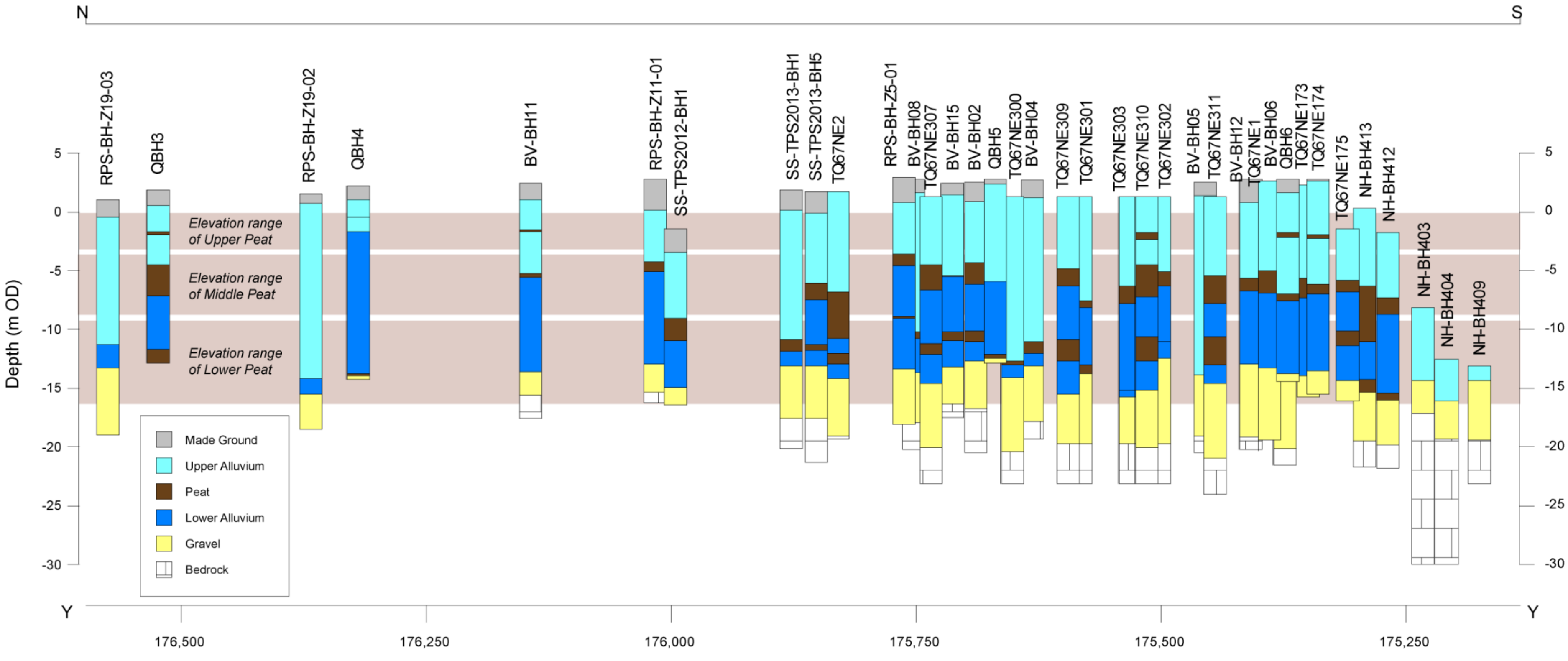

Figure 4: North-south transect of selected boreholes across the Tilbury 2, Tilbury, South Essex site.

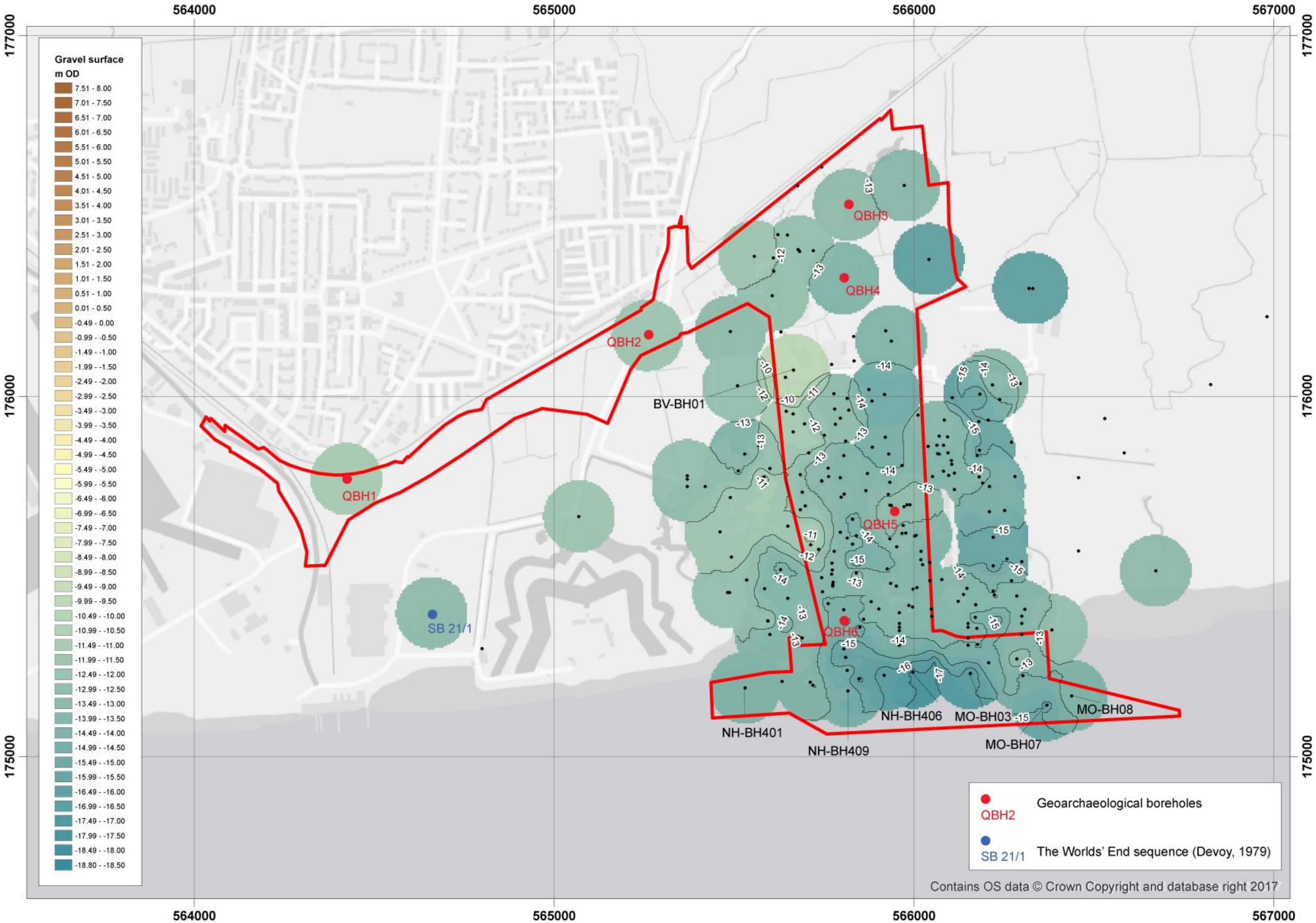

Figure 5: Surface of the Shepperton Gravel (m OD) (site outline in red).

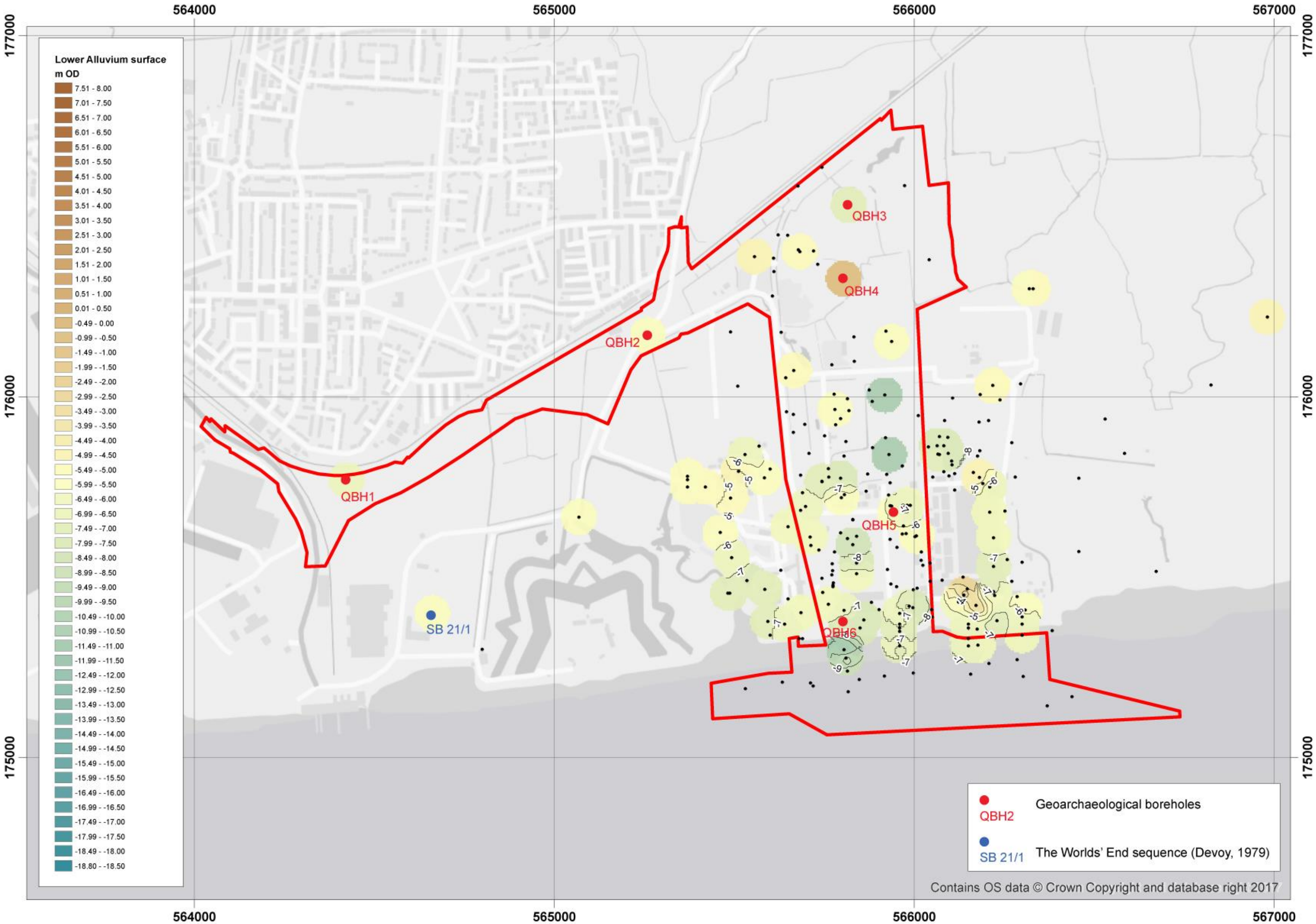

Figure 6: Surface of the Lower Alluvium (m OD) (site outline in red).

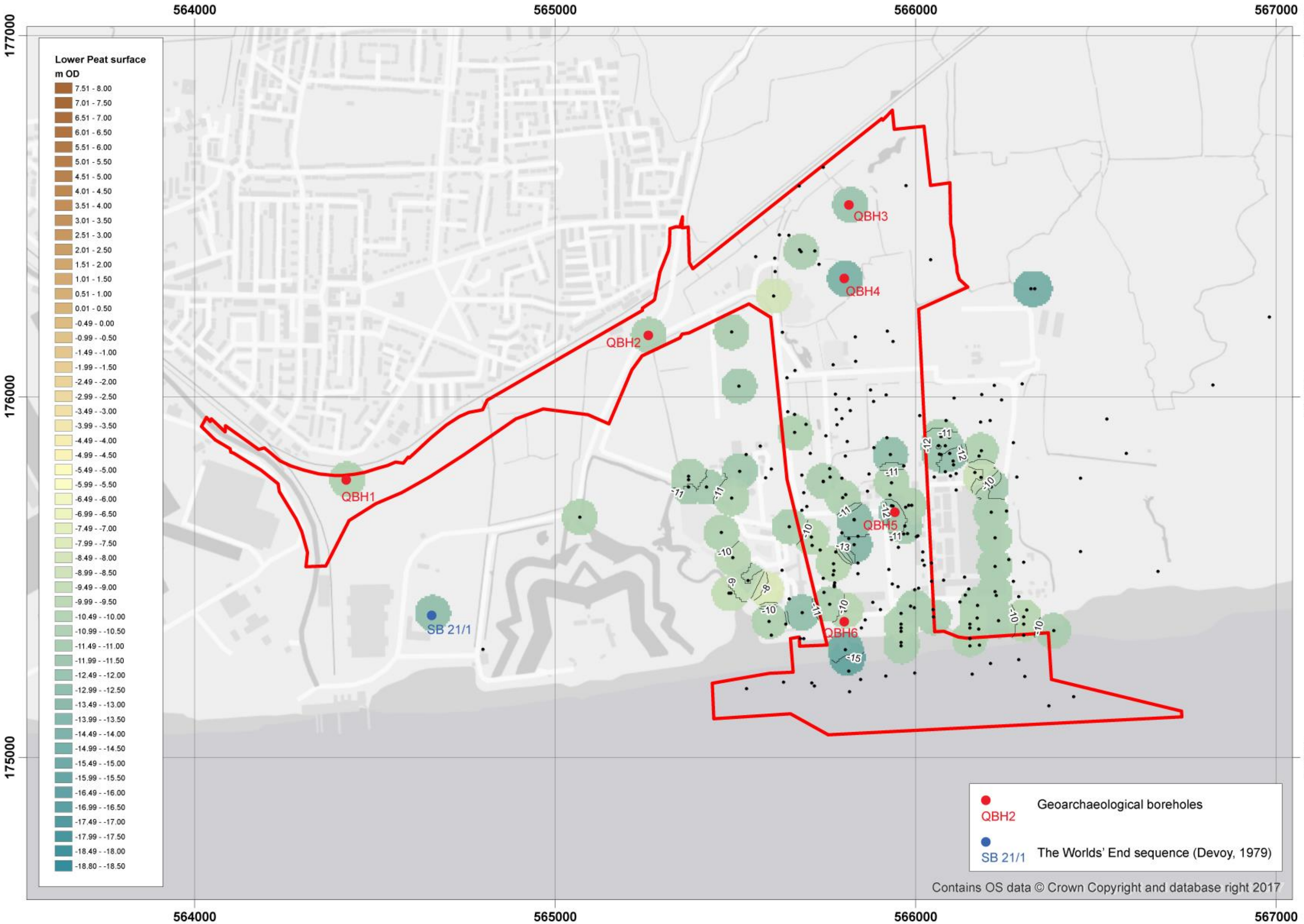

Figure 7: Surface of the Lower Peat (m OD) (site outline in red).

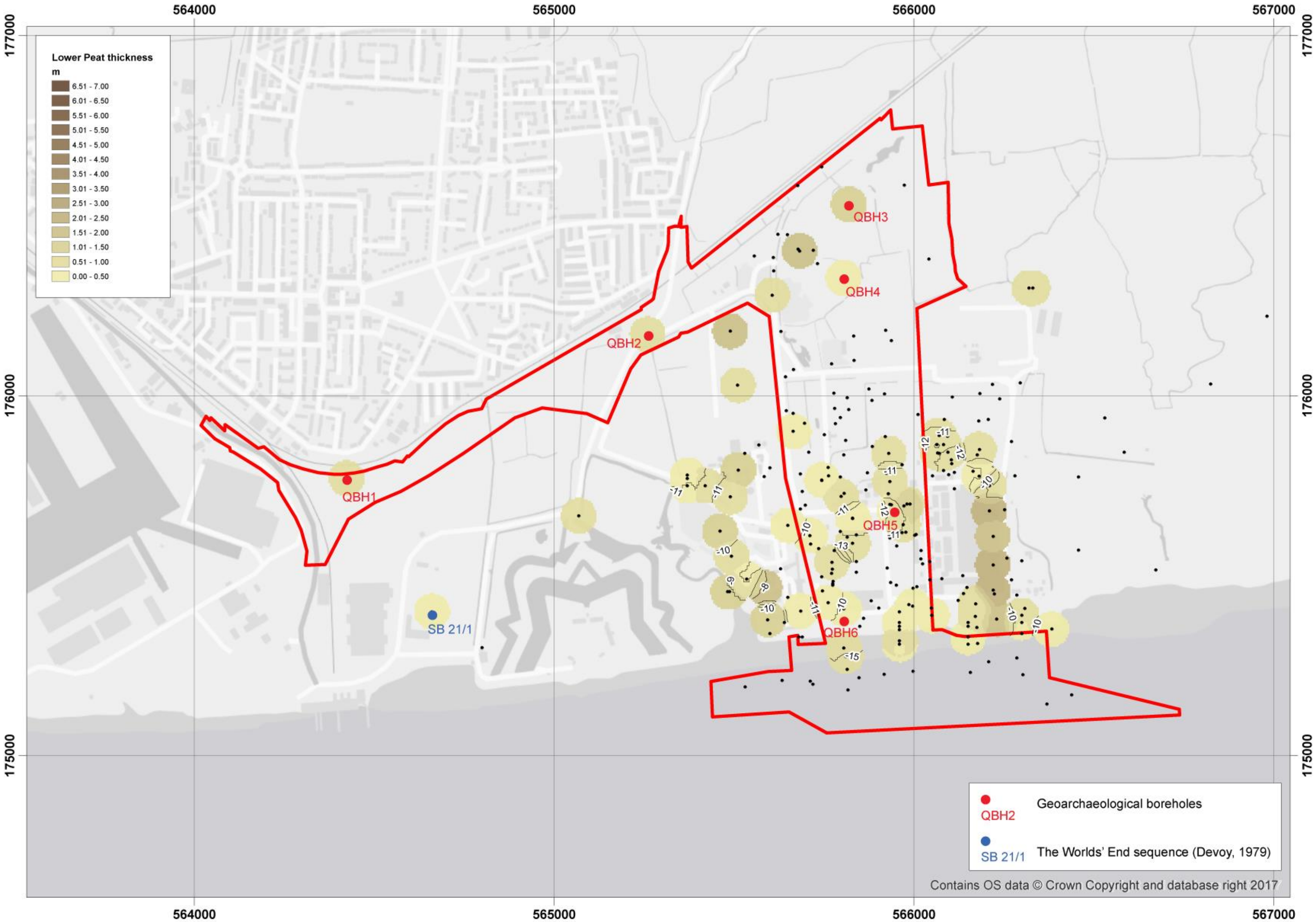

Figure 8: Thickness of the Lower Peat (m) (site outline in red).

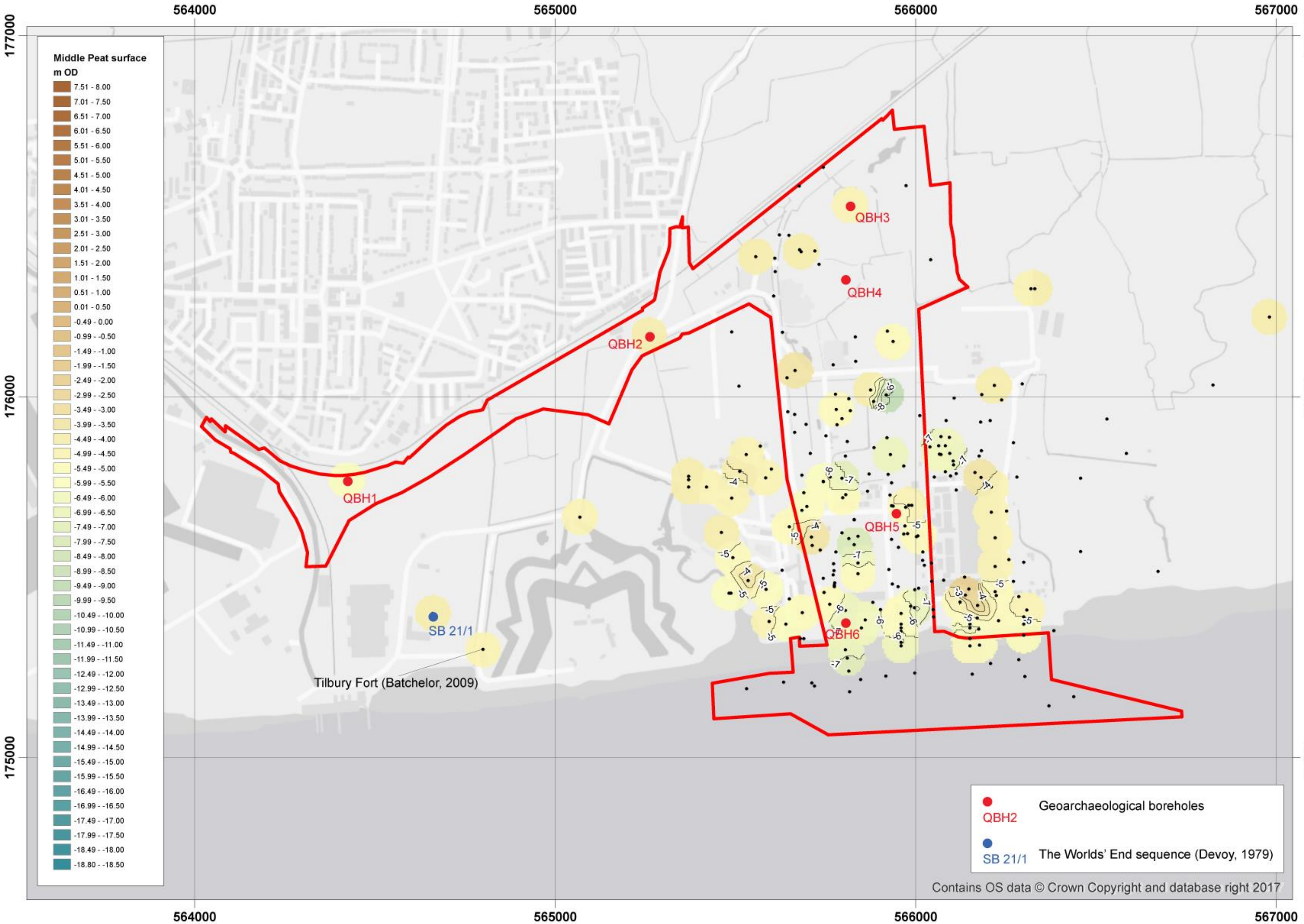

Figure 9: Surface of the Middle Peat (m OD) (site outline in red).

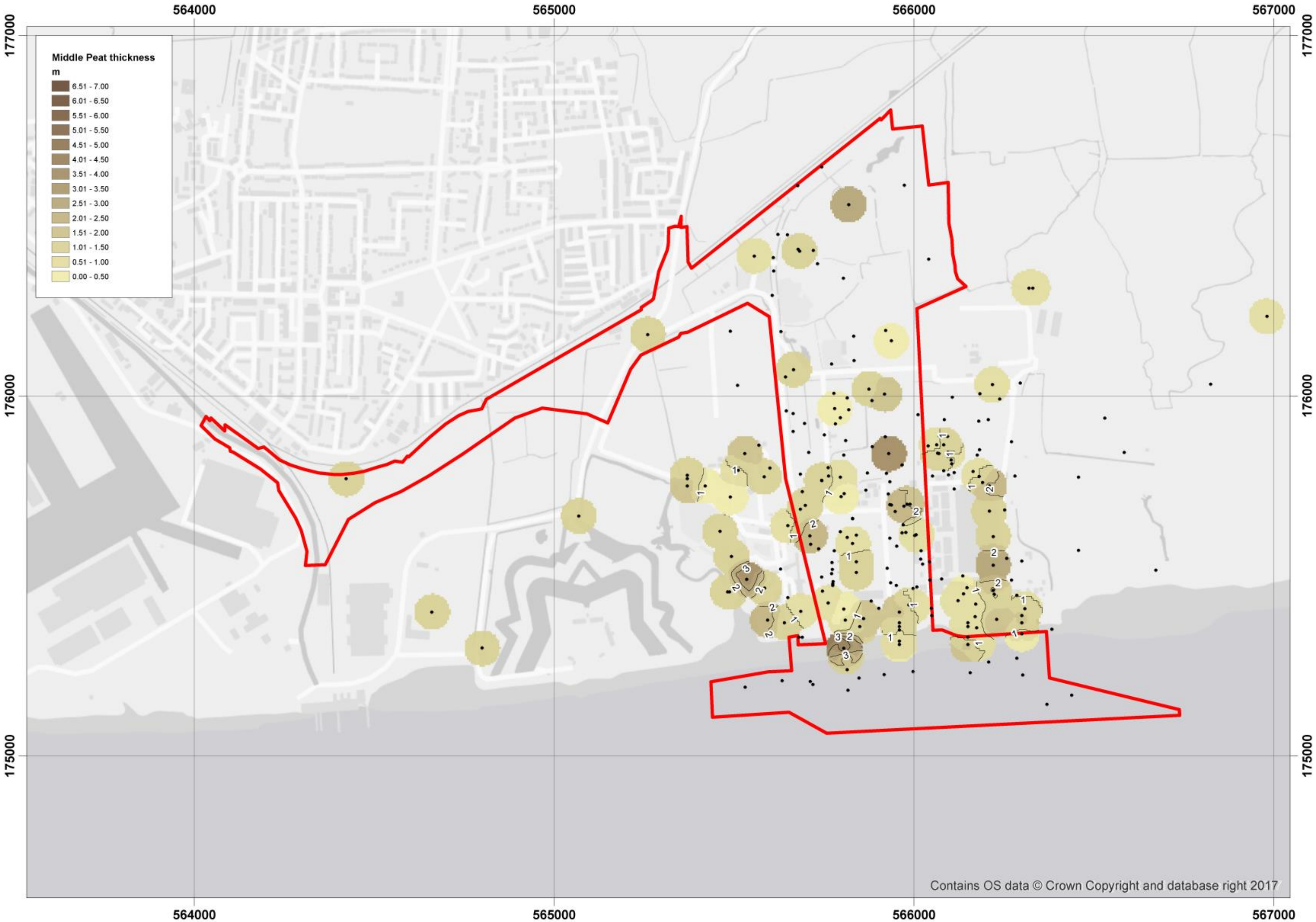

Figure 10: Thickness of the Middle Peat (m) (site outline in red).

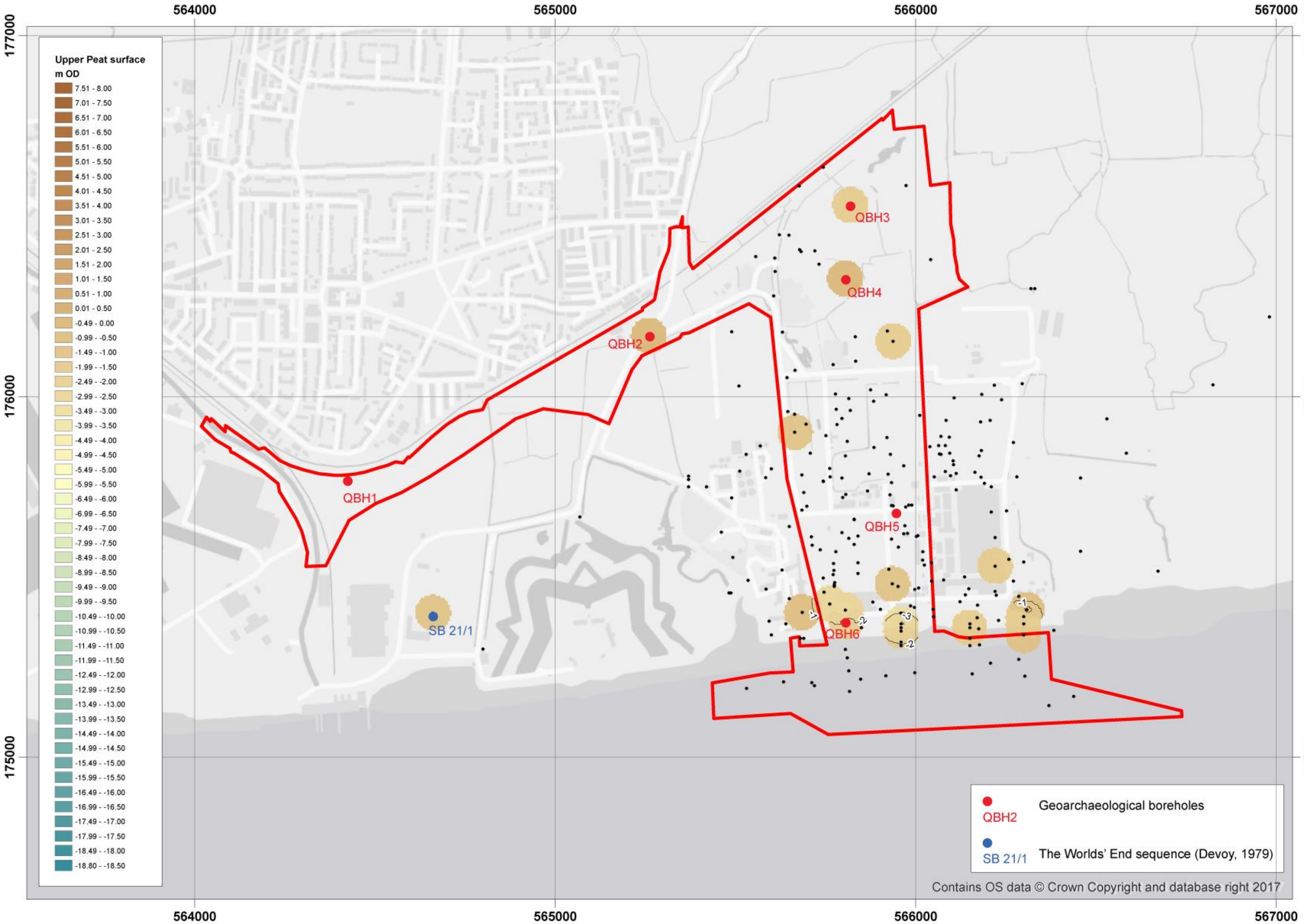

Figure 11: Surface of the Upper Peat (m OD) (site outline in red).

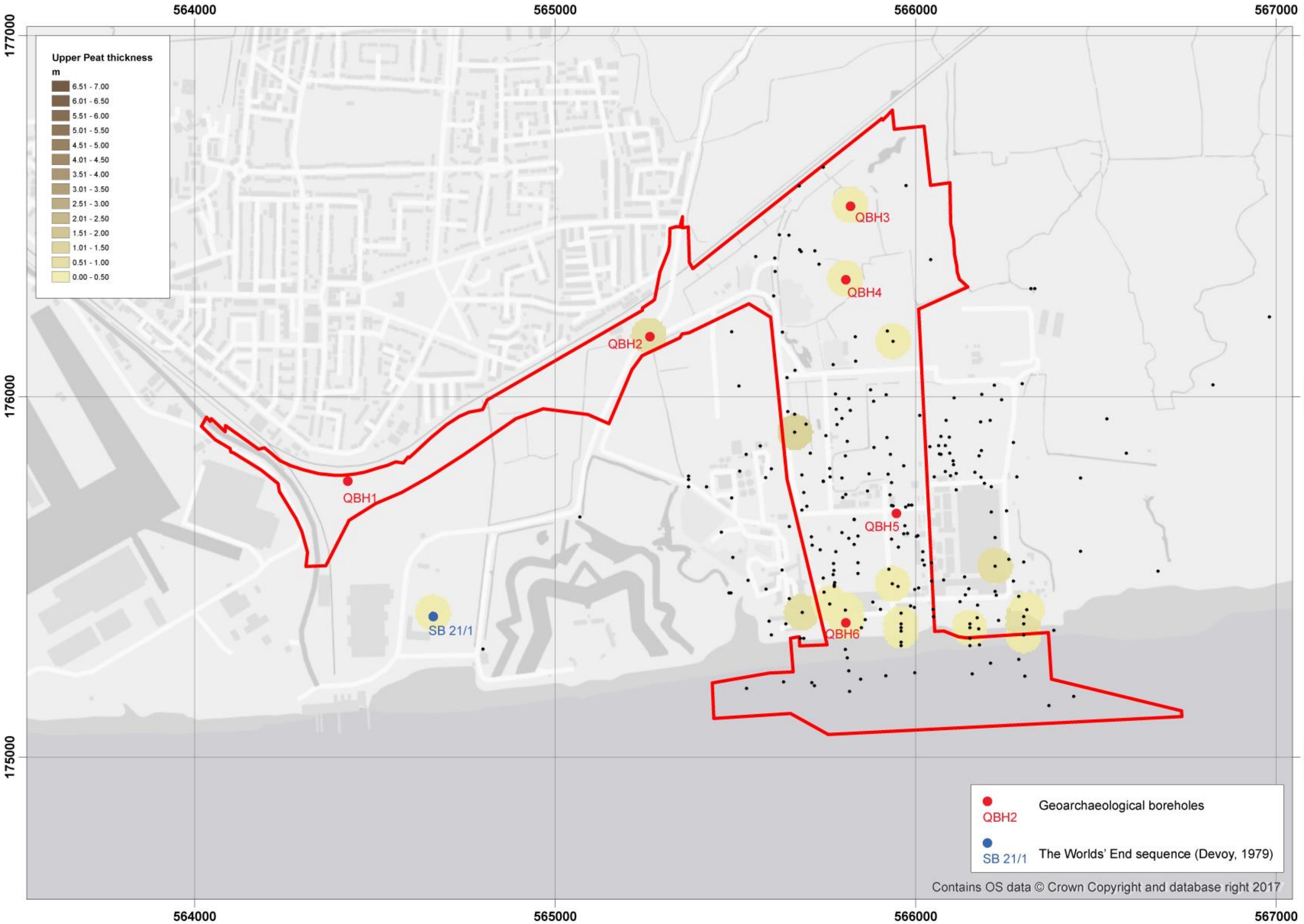

Figure 12: Thickness of the Upper Peat (m) (site outline in red).

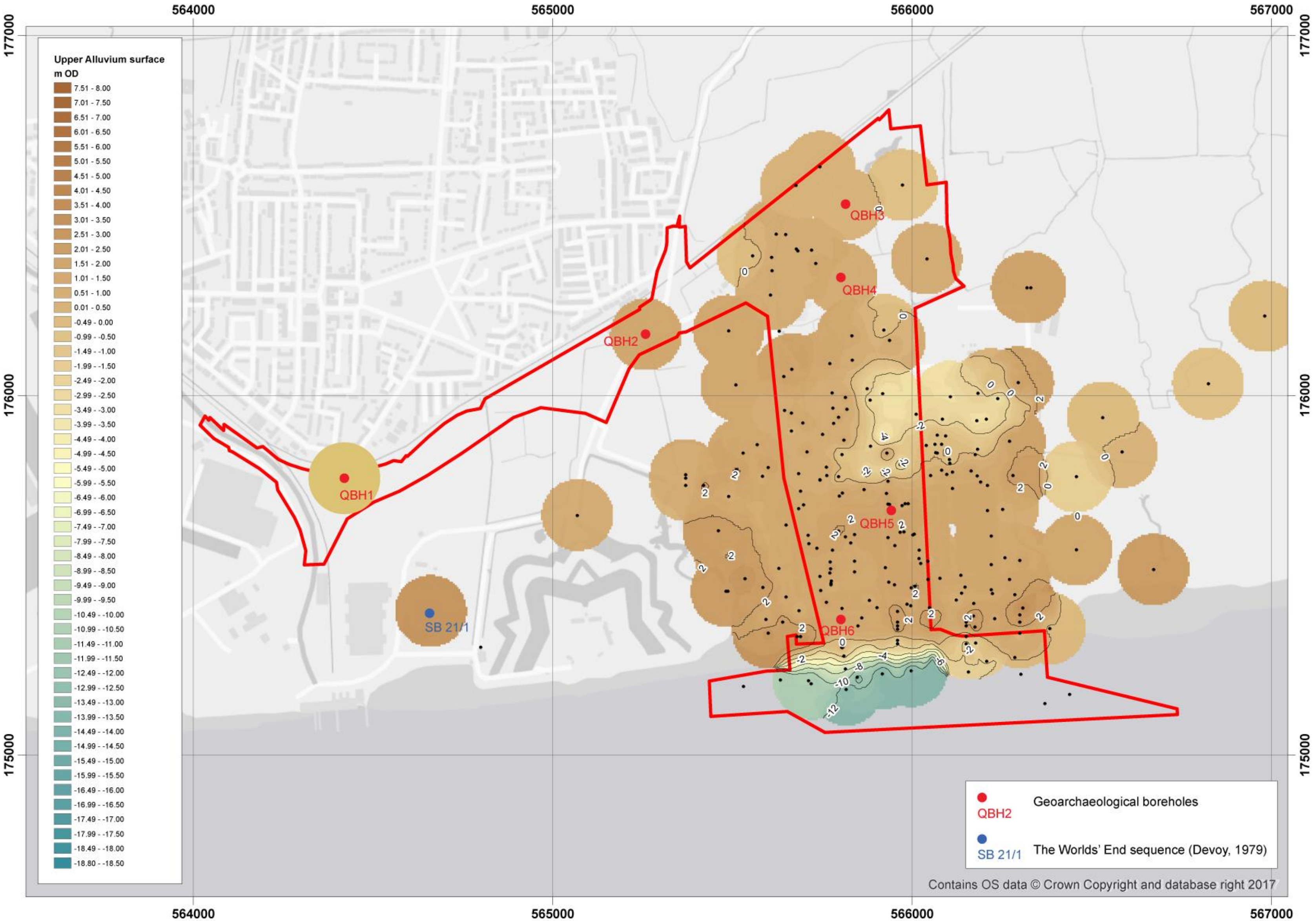

Figure 13: Surface of the Upper Alluvium (m) (site outline in red).

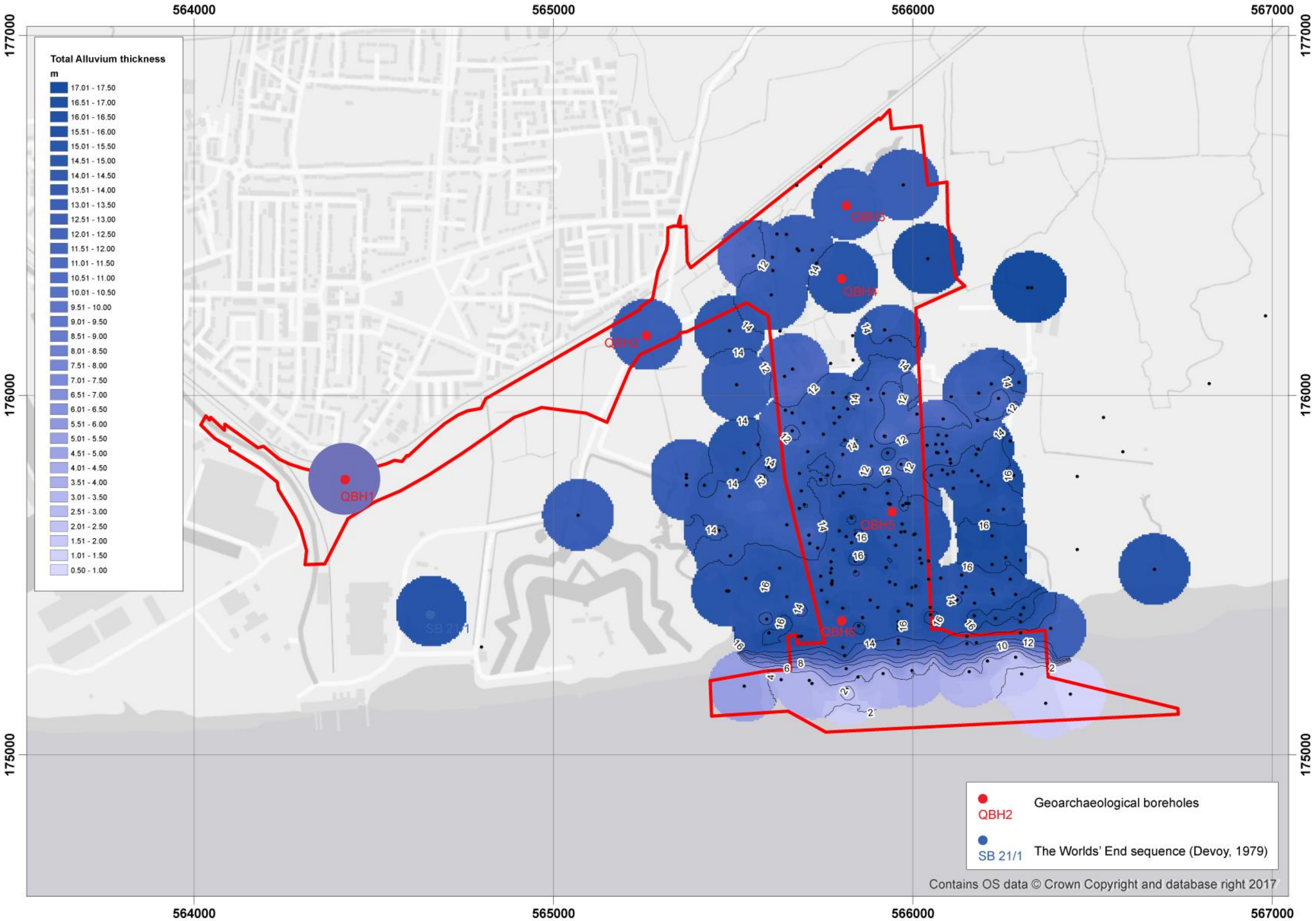

Figure 14: Thickness of the Holocene alluvial sequence (Lower Alluvium, Peat horizons and Upper Alluvium) (m) (site outline in red).

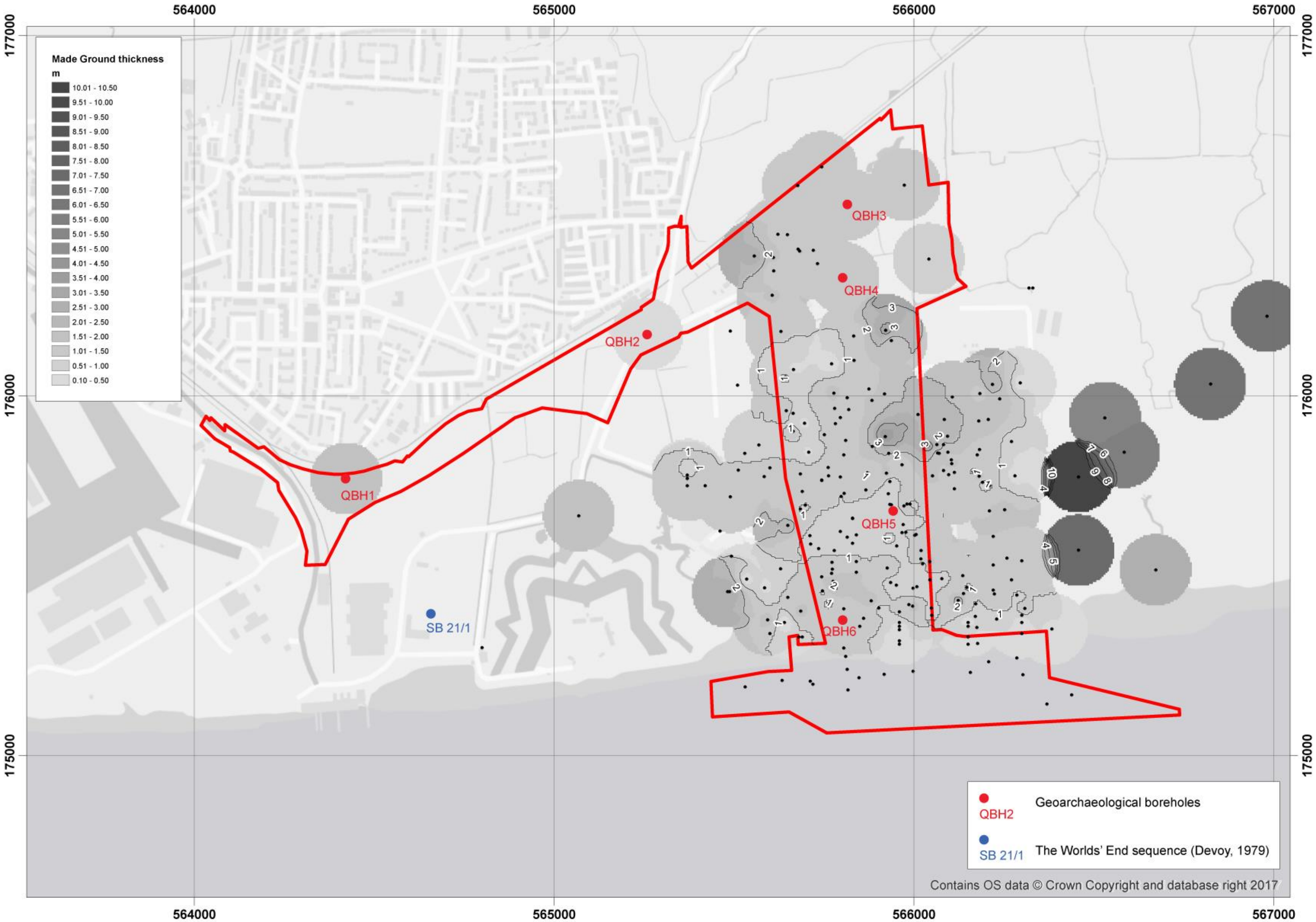

Figure 15: Thickness of Made Ground (m) (site outline in red).

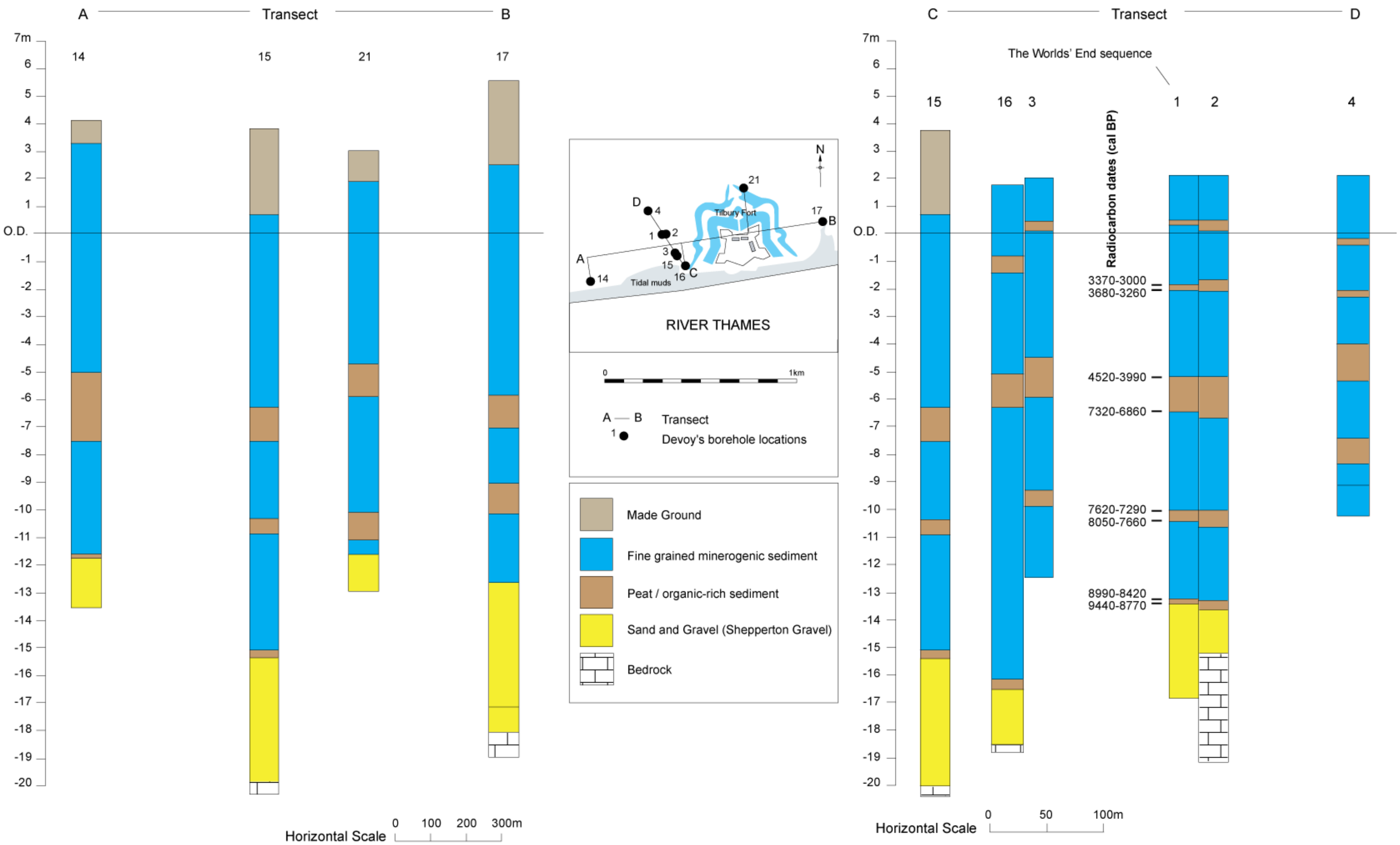

Figure 16: Devoy borehole transects (1979)

6. DISCUSSION

The aims of the geoarchaeological fieldwork, radiocarbon dating and updated deposit modelling exercise were: (1) to clarify in more detail the nature of the sub-surface stratigraphy across the site; (2) to enhance our understanding of the nature, depth, extent and date of any former land surfaces, alluvial and peat deposits, and (3) to make recommendations for any further geoarchaeological investigations. In order to address these aims, borehole core samples were obtained from six locations. The key peat horizons were radiocarbon dated, and the stratigraphic data from both the new onshore and offshore geoarchaeological works were integrated into the existing deposit model for the Tilbury 2 site.

The combined results indicate that the sediments recorded at the site are similar to those recorded elsewhere in the Lower Thames Valley, with Late Devensian Shepperton Gravel overlain by a sequence of Holocene alluvial sediments (including peat) buried beneath modern Made Ground. At the site and across the modelled area, the relief features of the Shepperton Gravel surface are typical of that in a braided river channel. The surface of the Gravel is generally relatively even, lying at between *ca*. -13 and -15m OD, falling to between *ca*. -15 and -17m OD in the modern channel of the Thames. There is some indication of higher (*ca*. -9.5 to -12m OD) Gravel surfaces to the west of the site (such as QBH1 and QBH2) and particularly in the area of BV-BH01, within the central-western area of the site, where the Gravel surface is recorded at -9.62m OD. These areas may have greater archaeological potential, since they may have been elevated above the surrounding floodplain during the prehistoric period (e.g. Mesolithic/Neolithic). Elsewhere, at Tilbury Fort (Devoy, 1979), *ca*. 500m to the west (Figure 1) a north-south transect of boreholes demonstrated a Gravel surface that became progressively deeper towards the modern course of the Thames, recorded at between *ca*. -13 and -15m OD. At the LDP site (Batchelor *et al*., in prep), *ca*. 1.5km to the north-west (Figure 1), the Gravel surface was recorded at similar elevations of between -9.76 and -15.59m OD, whilst *ca*. 1.5km to the west at Tilbury Docks (Devoy, 1979) the Gravel surface was recorded at between -11 and -13m OD. The amplitude of the Gravel topography at the present site thus appears to be consistent with other sites in this area of Tilbury. The wider deposit model for the area of Tilbury and Gravesend indicates that the Gravel surface rises relatively sharply to the south of the River, where it is recorded towards the southern edge of the floodplain at -9 rising to 0m OD at Dalefield Way (Young, 2016), and at between -1 and 0m OD between Denton and Gravesend (see Figure 17).

The Shepperton Gravel is overlain by a thick sequence of Holocene alluvium including various peat horizons. As outlined within the introduction (section 2.1), Devoy (1979, 1982) recovered a borehole from the Worlds' End (Figure 1) which included five radiocarbon dated peat horizons (referred to as Tilbury I to Tilbury V) within the thick sequence of Holocene alluvium overlying the Shepperton Gravel. These peat horizons were considered to represent periods of semi-terrestrial conditions in response to marine regression, whilst the alluvial layers represented periods of transgression. However, the radiocarbon dates from the Worlds' End are approaching 40 years old; methods of sample selection, pre-treatment and measurement for radiocarbon dating have moved on significantly and it is therefore unclear how much weight should be placed on the Devoy chronology (Outram, pers. comm.). Full details on the radiocarbon determinations from Devoy's work are displayed in Table 10. When compared with those from Tilbury 2 (Table 8) and other nearby / more recent sites including Tilbury Fort and London Distribution Park (Batchelor, 2009; Batchelor et al., in prep), it is clear that the error ranges on the uncalibrated dates are far greater (i.e. 65-110 years vs 30-40 years) but also, it is unclear what was radiocarbon dated. Furthermore, at Tilbury Fort, London Distribution Park and Tilbury 2, radiocarbon dating has been carried out on identifiable *in situ* terrestrial plant remains (e.g. sedges and reeds) or humic acid/humin fractions of peat, whilst within the Worlds' End sequence only *in situ* material is referred to; whether this is peat or plant remains is unclear. Finally, it is not stated whether the radiocarbon dating was carried out by AMS or radiometric methods by Devoy (though the latter is assumed). These factors are of key concern when radiocarbon dating peat since different fractions have been demonstrated to yield significantly different dates (e.g. Brock et al. 2011).

As outlined throughout this report, the peat horizons recorded at Tilbury 2 (and London Distribution Park) have been named the Lower, Middle and Upper Peat dependant on their elevation and position. The results of the radiocarbon dating indicate the Lower Peat units date to between 8000 and 7000 years ago in QBH1 and QBH6 (late Mesolithic). Bearing in mind the caveats outlined above, it would appear that these peat units most closely correlate to Devoy's Tilbury IV peat as recorded at the Worlds's End. However, in QBH3/3A, peat immediately overlying the Shepperton Gravel the Lower Peat is radiocarbon dated to 10,500-10,240 or 9450-9250 cal BP (early Mesolithic), As outlined above, it is only possible to state at this stage that the humin fraction (10,500-10,240 cal BP) represents the oldest age the sample could be. It is often the base of peat deposits which include the greatest inhomogeneity, like in this case, probably because there is older material within the humin fraction (Marshall, pers. comm.). If however the humin fraction is the correct date, the result is significant as it means the unit predates Devoy's Tilbury I by over 1000 years despite being at a higher elevation (see Figure 18). Even if the humic fraction is correct (9450-9250 cal BP it is approximately the same age as the Tilbury I peat which is an important result. Furthermore, the Lower Peat in QBH3/3A predates other peat horizons recorded elsewhere in the Tilbury region (such as London Distribution Park; Batchelor et al., 2014). However, whilst uncommon and therefore important, similarly aged deposits are recorded elsewhere in London: Silvertown (Wilkinson et al., 2000) and London Cable Car in Newham; Bramcote Green in Bermondsey (Thomas & Rackham, 1996) are just a few. At least two episodes of Lower Peat development would therefore appear to have occurred on the Tilbury 2 site, though in more likelihood, accumulation was diachronous.

The results of palaeoenvironmental investigations at the London Distribution Park site indicate that the peat dating between 8000 and 7000 cal BP was initially occupied by fen woodland prior to the dominant growth of sedge fen and reed swamp communities containing areas of open water. This change in peat surface vegetation is suggestive of a shift from dry to wet conditions driven by an increase in relative sea level rise. However, high values of charcoal, microcharcoal and pollen/spores from light-loving and disturbed ground plants are strongly suggestive of natural or anthropogenic burning during the period of fen carr woodland growth, and may have led to its eventual decline (Batchelor *et al.*, in prep). Similar evidence for burning during the Late Mesolithic has been recorded in other coastal lowland wetlands across the southern Britain (e.g. the Somerset Levels). Mixed deciduous woodland dominated by oak and lime with hazel and elm occupied the dryland during this period.

The results of the radiocarbon dating indicate that the onset of the Middle Peat was variable in age and altitude. In QBH1 and QBH3, it appears to have occurred between 6500 and 6000 cal BP around -7m OD, whilst in QBH6 (Mesolithic-Neolithic transition), It commenced over 1000 years later (5310-5050 cal BP; middle Neolithic) and at a lower elevation (-7.54m OD). Cessation of Middle Peat formation is less certain; in QBH1 the top could not be radiocarbon dated due to an absence of material, but an age of 5580-5300 (humic acid and humin fractions combined) was derived towards the centre (middle Neolithic); similarly the top of the peat in QBH6 could not be radiocarbon dated at this stage. The top of the Middle Peat in QBH3/3A was however radiocarbon dated to 3720-3570 cal BP (Bronze Age). Overall, the Middle Peat appears most closely to correlate to Devoy's (1979) Tilbury III peat. The range of dates for the Middle Peat also correlates closely with those recorded at London Distribution Park, though notably the elevation of the Peat appears on average lower by approximately 1-2m (Figure 18). Thus formation and cessation of the Middle Peat was once again somewhat diachronous across the Tilbury 2 and wider Tilbury area.

The results of palaeobotanical investigations at the London Distribution Park, Tilbury Fort and The World's End indicate that during this period, the peat surface was dominated by sedge fen and reed swamp type communities, similar to that recorded in the Lower Peat (Batchelor *et al.*, in prep). During this period however, two important events have been recorded in the Tilbury area: (1) the decline of elm woodland, and (2) the development of oligotrophic/ombrotrophic plants on the peat surface. These events are recorded most strongly at the LDP site and are important for the following reasons:

1. The early Neolithic decline of elm is a well-documented occurrence across north-western Europe, and represents one of the most significant changes in Holocene vegetation history, due to its rapidity, geographical extent and magnitude of impact. Across the British Isles and Lower Thames Valley, the decline was broadly synchronous, taking place between 6347 and 5281 cal BP (Parker *et al.*, 2002; Batchelor *et al.*, 2014). Multiple causes for the prehistoric elm decline have been proposed including: (1) climate change to cooler conditions (e.g. Smith, 1981); (2) soil deterioration (Peglar and Birks, 1993), (3) competitive exclusion (e.g. Huntley and Birks, 1983; Peglar and Birks, 1993); (4) human interference with natural vegetation (e.g. Scaife, 1988; Lamb and Thompson, 2005); (5) disease (e.g. Perry and Moore, 1987; Girling, 1988), and (6) multiple causes (e.g. Parker *et al.*, 2002; Batchelor *et al.*, 2014).
2. The recent results from the LDP site are considered of national/international importance because between *4570-4420* to *4510-4410* cal BP (Late Neolithic), the dominant growth of heather, heath, bog myrtle and sphagnum moss is suggestive of a transition from fen towards raised bog conditions. Such conditions evolve when peat ceases to be inundated and grows beyond the influence of the groundwater table, instead receiving its water and nutrients from rainwater alone. The temporal and spatial extent of this community would appear to be

relatively limited, growing for a maximum of 160 years; thus far it has not been recorded at other sites in the Tilbury area. Raised bog conditions have been recorded in other coastal lowland environments (e.g. the Somerset Levels and East Anglian Fens), but to date, LDP is the only site in the Lower Thames Valley where such conditions have been recorded.

Thin layers of peat are recorded intermittently across the Tilbury 2 site at a minimum of two different levels. These were encountered in the new geoarchaeological boreholes between -2 and -1.5m OD in QBH3/3A and QBH6, and between -0.5 and 0m OD in QBH2 and QBH4. It was only possible to radiocarbon date the peat in QBH3/3A and QBH6, which returned determinations of 2350-2150 (humic acid/humin fractions combined) and 2730-2380 cal BP respectively (Iron Age). These correlate in elevation with Devoy's Tilbury IV peat, but accumulated over a 1000 years later (3680-3270 to 3370-3000 cal BP). Upper Peat horizons recorded at London Distribution Park were recorded at a higher elevation (-1.5 to -0.5m OD) to the radiocarbon dated peat at Tilbury 2, and ranged in date from 2920 to 2120 cal BP (Batchelor et al., in prep). Both Devoy's Tilbury V and the thin peat lenses recorded towards the very top of QBH2 and QBH4 are undated and it is unclear how they might relate. Thus formation and cessation of the Upper Peat units was sporadic and diachronous across the Tilbury 2 and wider Tilbury area.

Palaeobotanical analysis of the Upper Peat at the London Distribution Park site indicates it was occupied by sedge fen/reed swamp and saltmarsh communities, consistent with the salt marsh communities recorded by Devoy (1979) in the Tilbury IV peat (within zone Tf) at The World's End site (Batchelor *et al.*, in prep). Again, no definitive indicators of human activity were recorded, but high concentrations of microcharcoal may be indicative of anthropogenic or natural burning either locally to the site or within the Thames catchment as a whole.

Finally, the various peat units are of consequence to our understanding of relative sea level (RSL) and environmental changes within the Lower Thames Valley. Whilst no units indicative of soil formation from description alone, such evidence may be forthcoming through the use of laboratory-based techniques; specifically magnetic susceptibility and potentially micromorphology. Peaks in magnetic susceptibility were recorded at nearby sites such as London Distribution Park (LDP) and Tilbury Fort sites, prior to the accumulation of the Middle and/or Upper Peats (Batchelor, 2009; Batchelor *et al.*, in prep). Such peaks are thought to represent a period of pedogenesis (soil formation) prior to peat formation. The timing and elevation of peat and soil formation are significant for our understanding of relative sea level (RSL) in this area of the Lower Thames Valley, and more broadly in southern England (e.g. Devoy, 1979; Long and Tooley, 1995). The processes behind peat and soil formation in relation to marine transgression and regression are not yet fully understood (e.g. Haggart 1995), and further analysis of such horizons may contribute to the understanding of these mechanisms. The existing models for the rates of RSL rise, such as that proposed by Devoy (1979; 1982) and Sidell (2003) for the Lower Thames Valley itself, and by Long *et al.* (2000) from three major southern England estuaries, are critical areas of research for studies of Holocene vegetation history and human activity in the Lower Thames Valley. Devoy's original model was produced for the Lower Thames Valley as a whole, based upon a small number of records, and heavily influenced by the record from the World's End, Tilbury. Subsequently, Sidell's model demonstrates that it is not possible to apply this model to the whole of the Lower Thames Valley. In addition, it has been argued (e.g. Haggart, 1995; Sidell and Long, 2000; Long et al., 2000) that the site-specific factors may mean that the World's End borehole (Devoy, 1979) represents an anomalous record. New RSL index points from the Tilbury 2 site would therefore contribute significantly to the debate in this area of research, and our understanding of rates of RSL rise in this area of the Lower Thames Valley. Radiocarbon dating using more recent AMS techniques of terrestrial plant macrofossils, as part of any further environmental archaeological assessment work at the site, would offer an opportunity to investigate the chronology of these peat horizons, and enable us to test or refine the models proposed Devoy (1979, 1982).

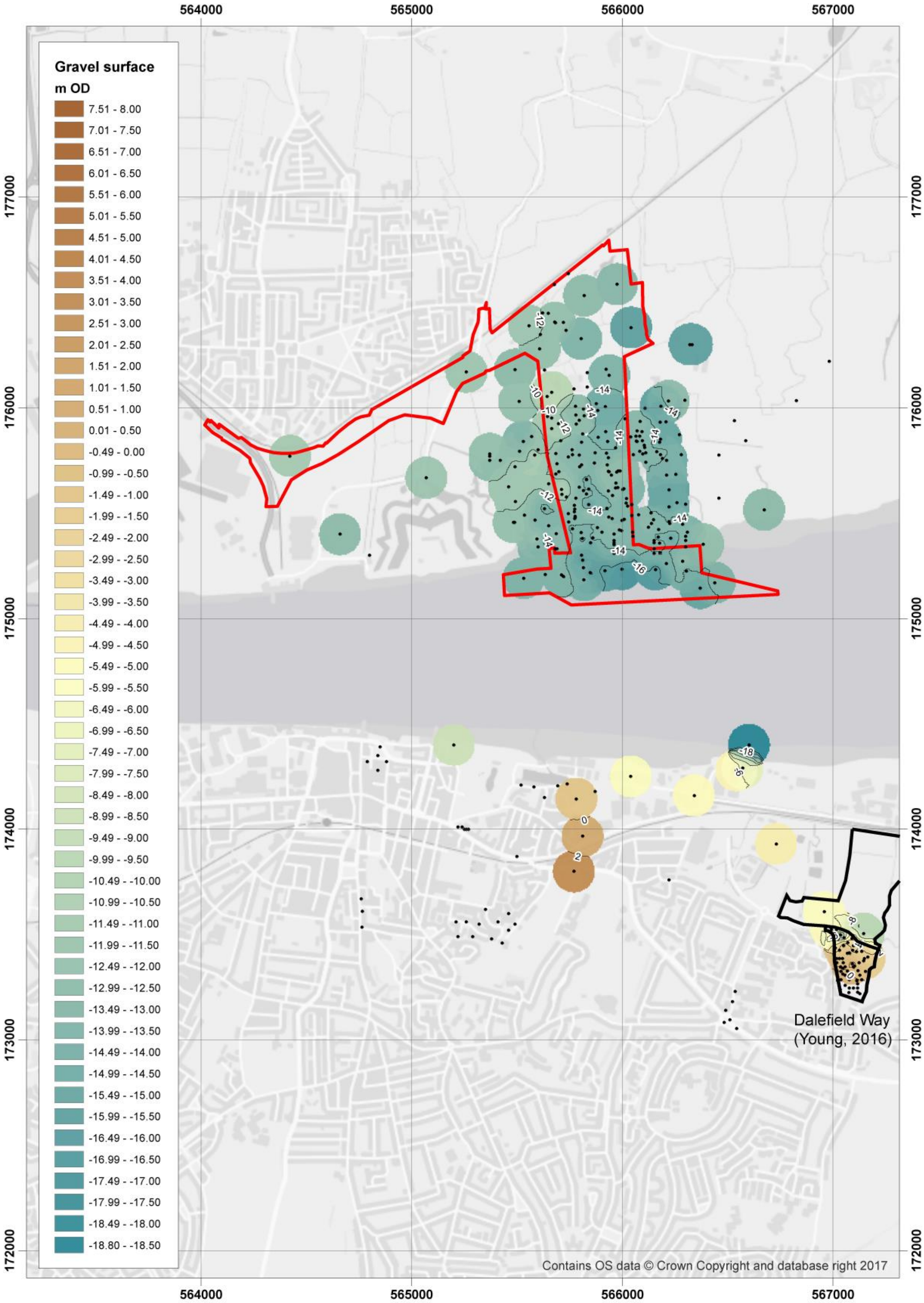

Figure 17: Surface of the Shepperton Gravel in the wider area, incorporating data from the present area of investigation (red outline), Dalefield Way and BGS archive boreholes (http://mapapps.bgs.ac.uk/geologyofbritain/home.html).

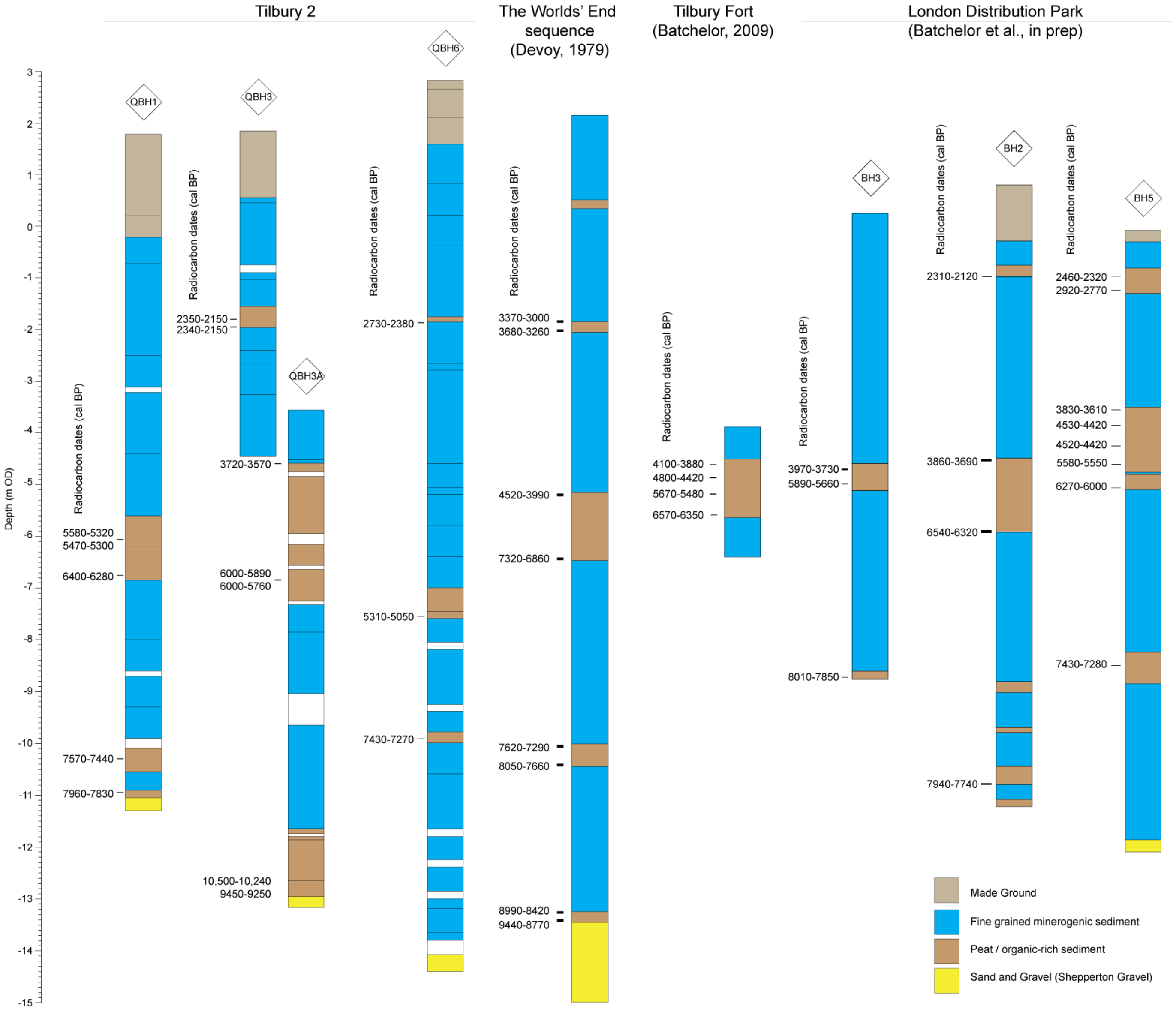

Figure 18: Radiocarbon dated sequences in the Tilbury area

Table 10: Radiocarbon dates from sequences in the Tilbury area

Laboratory code / Method	Borehole number	Material and location	Depth (m OD)	Uncalibrated radiocarbon years before present (yr BP)	Calibrated age BC/AD (BP) (2-sigma, 95.4% probability)	δ13C (‰)
The Worlds End (Devoy, 1979)			* = based upon estimated surface elevation of 2.10m OD			
Q1433 Radiometric?	SB21/1	Bulk peat?; Top of Tilbury IV	-1.82 to -1.84* (3.92-3.97m bgl)	3020 ± 65	1430-1050 cal BC 3370-3000 cal BP	?
Q1432 Radiometric?	SB21/1	Bulk peat?; Base of Tilbury IV	-2.00 to -2.05* (4.10-4.15m bgl)	3240 ± 75	1730-1310 cal BC 3680-3260 cal BP	?
Q1431 Radiometric?	SB21/1	Bulk peat?; Top of Tilbury III	-5.21 to -5.25* (7.31-7.35m bgl)	3850 ± 80	2570-2040 cal BC 4520-3990 cal BP	?
Q1430 Radiometric?	SB21/1	Bulk peat?; Base of Tilbury III	-6.42 to -6.44* (8.52-8.54m bgl)	6200 ± 90	5370-4910 cal BC 7320-6860 cal BP	?
Q1429 Radiometric?	SB21/1	Bulk peat?; Top of Tilbury II	-10.10 to -10.14* (12.20-12.24m bgl)	6575 ± 95	5670-5340 cal BC 7620-7290 cal BP	?
Q1428 Radiometric?	SB21/1	Bulk peat?; Base of Tilbury II	-10.38 to -10.42* (12.48-12.52m bgl)	7050 ± 100	6100-5720 cal BC 8050-7660 cal BP	?
Q1427 Radiometric?	SB21/1	Bulk peat?; Top of Tilbury I	-13.23 to -13.26* (15.33-15.36m bgl)	7830 ± 110	7040-6470 cal BC 8990-8420 cal BP	?
Q1426 Radiometric?	SB21/1	Bulk peat?; Base of Tilbury I	-13.37 to -13.40* (15.47-15.50m bgl)	8170 ± 110	7500-6820 cal BC 9440-8770 cal BP	?
Tilbury Fort (Batchelor, 2009)						
SUERC-11706 AMS	-	Sedge and grass stems; top of middle peat	-4.63 to -4.64	5678 ± 35	2150-1930 cal BC 4100-3880 cal BP	-27.0
SUERC-11707 AMS	-	Sedge and grass stems; centre of middle peat	-4.87 to -4.88	4870 ± 35	2860-2470 cal BC 4800-4420 cal BP	-27.9
SUERC-11708 AMS	-	Sedge and grass stems; centre of middle peat	-5.19 to -5.20	4059 ± 37	3720-3530 cal BC 5670-5480 cal BP	-26.9
SUERC-11709 AMS	-	Sedge and grass stems; base of middle peat	-5.59 to -5.60	3661 ± 36	4620-4400 cal BC 6570-6350 cal BP	-27.4
London Distribution Park (Batchelor et al., in prep)						
Beta-341919 / AMS	BH2	Aerial sedge remains; base of upper peat	-0.98 to -0.97	2180 ± 30	360-170 cal BC 2310-2120 cal BP	-25.4
Beta-341920 / AMS	BH2	Aerial sedge remains; top of middle peat	-4.50 to -4.55	3500 ± 30	1910-1740 cal BC 3860-3690 cal BP	-26.0
Beta-341921 / AMS	BH2	Aerial sedge remains; base of middle peat	-5.88 to -5.93	5660 ± 40	4590-4370 cal BC 6540-6320 cal BP	-26.3

Beta-341922 / AMS	BH2	Aerial sedge remains; base of lower peat	-10.76 to -10.79	7000 ± 40	5990-5790 cal BC 7940-7740 cal BP	-25.2
Beta-341923 / AMS	BH3	Aerial sedge remains; top of middle peat	-4.69 to -4.72	3560 ± 30	2020-1780 cal BC 3970-3720 cal BP	-26.3
Beta-341924 / AMS	BH3	Aerial sedge remains; base of middle peat	-4.98	5010 ± 30	3940-3710 cal BC 5890-5660 cal BP	-26.7
Beta-341925 / AMS	BH3	Aerial sedge remains; lower peat	-8.73	7110 ± 40	6060-5900 cal BC 8010-7850 cal BP	-27.8
Beta-358510 / AMS	BH5	Aerial sedge remains; top of upper peat	-0.98	2350 ± 30	520-370 cal BC 2470-2320 cal BP	-26.1
Beta-341926 / AMS	BH5	Aerial sedge remains; base of upper peat	-1.26 to -1.25	2740 ± 30	980-810 cal BC 2920-2760 cal BP	-26.2
Beta-341927 / AMS	BH5	Aerial sedge remains; top of middle peat	-3.55	3440 ± 30	1880-1660 cal BC 3830-3610 cal BP	-25.9
Beta-358077 / AMS	BH5	Aerial sedge remains; top of ombrotrophic shift	-3.86	4000 ± 30	2580-2460 cal BC 4530-4410 cal BP	-25.2
Beta-358076 / AMS	BH5	Aerial sedge remains; base of ombrotrophic shift	-4.26	3990 ± 30	2580-2460 cal BC 4530-4410 cal BP	-25.3
Beta-372844 AMS	BH5	Aerial sedge remains; elm decline	-4.60	4680 ± 30	3630-3360 cal BC 5580-5310 cal BP	-26.1
Beta-341928 / AMS	BH5	Aerial sedge remains; base of middle peat	-5.05	5350 ± 30	4330-4050 cal BC 6280-6000 cal BP	-25.6
Beta-341929 / AMS	BH5	Aerial sedge remains; centre of lower peat	-8.49	6450 ± 40	5490-5330 cal BC 7440-7280 cal BP	-25.7

7. CONCLUSIONS & RECOMMENDATIONS

The findings from the fieldwork, radiocarbon dating and updated deposit modelling have enhanced the conclusions made following the preceding desk-based deposit modelling exercise (Young & Batchelor, 2016). At least three distinct peat horizons broadly equivalent in depth to those recorded at other sites in the Tilbury area have been identified within the Holocene alluvial sequence at the Tilbury 2 site, overlying a Shepperton Gravel surface of variable height. The results of the investigation have demonstrated variation in the type and thickness of the Holocene alluvial sequence. Such variations are significant as they represent different environmental conditions that would have existed in a given location; for example, the peat horizons recorded represent former semi-terrestrial land surfaces, whereas fine to medium grained sediments such as sands, silts and clays represent periods of estuarine or freshwater flooding. Thus studying the sub-surface deposits at the site has enabled us to start building our understanding of the former landscapes and environmental changes that took place over both space and time across the site.

Areas of higher gravel topography and peat deposits represent potential areas that might have been utilised or even occupied by prehistoric and historic people, evidence of which may be preserved in the archaeological record (e.g. features and structures). Whilst archaeological features/structures are yet to be recorded in this area, prehistoric people were clearly interacting with the local environment, as demonstrated by the flint artefacts and human remains recorded within peat during construction of Tilbury Docks, and at West Tilbury Marshes (Schulting, 2013; CgMs Consulting, 2017). Even in the absence of the archaeological remains, the sediments have the potential to contain a wealth of further information on the past landscape, through the assessment/analysis of palaeoenvironmental remains (e.g. pollen, plant macrofossils and insects), magnetic susceptibility analysis, and further radiocarbon dating, as demonstrated at other sites in the wider area of Tilbury. So called environmental archaeological or palaeoenvironmental investigations can identify the nature and timing of changes in the landscape, and the interaction of different processes (e.g. vegetation change, human activity, climate change, hydrological change) thereby increasing our knowledge and understanding of the site and nearby area. In the case of human activity, palaeoenvironmental evidence can include: (1) decreases in tree and shrub pollen suggestive of woodland clearance; (2) the presence of herbs indicative of disturbed ground, pastoral and/or arable agriculture; (3) charcoal/microcharcoal suggestive of anthropogenic or natural burning, and (4) insect taxa indicative of domesticated animals. In particular, the Tilbury 2 site has the potential to contribute to our understanding of the possible transition to ombrotrophic conditions, the early Neolithic elm decline, and the late Neolithic/early Bronze Age lime decline previously identified in this area of Tilbury (Devoy, 1979; Batchelor, 2009; Batchelor *et al*., in prep.). Significantly, the peat and any soil horizons from the site have the potential to contribute to our understanding of the processes behind peat and soil formation, in relation to marine transgression and regression (relative sea level rise).

As a consequence of the findings from the present investigation, the Tilbury 2 site can still be considered of regional significance, but the results of the radiocarbon dating of QBH3/3A emphasises the importance of Tilbury which has been (and probably always will be) used as the type site for palaeoenvironmental and relative sea level studies in the Thames (Sidell, pers. comm.). It is therefore recommended that further assessment works continue on the sequences of QBH1, QBH3/3A and QBH6 as outlined within the WSI for geoarchaeological and palaeoenvironmental works (Young, 2017b). These boreholes have been selected as they represent a good spatial distribution across the site and contain the best sequences. However, it is also highly recommended that a repeat borehole is taken in the location of QBH3 as it is the most important of the three sequences. The current sequence contains voids at key points within the peat deposits; repeating this attempting a different methodology (such as dynamic sampling or geoarchaeological coring) is likely to increase the possibility of a non-disturbed and continuous set of samples. Furthermore, whilst the coverage of the updated deposit model is in the region of 75% and thus very good; advantage should be taken of any further planned site investigation works that might infill the remaining voids. Either the resultant borehole logs should be supplied, or (more preferably) a geoarchaeologist should be onsite to monitor the works. Finally, as outlined elsewhere, the offshore sequences are considered of limited palaeoenvironmental potential due to a lack of peat in the thin alluvium overlying the Shepperton Gravel; as such no further work was recommended (Wessex Archaeology, 2017).

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AS 3
Marine Archaeological Desk Based Assessment
(Wessex Archaeology 2017)

Tilbury 2
Land at the former RWE Power Station
Tilbury, Essex

Ref: 116220.01 v3
September 2017

wessexarchaeology

Tilbury 2
Land at the former RWE Power Station
Tilbury, Essex

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Marine Desk Based Assessment

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Summary

Wessex Archaeology was commissioned by CgMS Consulting Ltd on behalf of Port of Tilbury London Ltd to prepare a Marine Archaeological Desk Based Assessment of a proposals on land at the former RWE power station at Tilbury, Essex centred on National Grid Reference (NGR) 565700, 175951.

The assessment considers that part of the Tilbury2 proposals that has the potential to affect the intertidal and marine zones and for the purposes of this report this is known as the inter-tidal and marine parts of the Tilbury2 Site. The Proposals, within the inter-tidal and marine parts of the Tilbury2 Site, involves the upgrading of the present jetty with new berthing dolphins, a link bridge and additional hopper and conveyor belt and a new berth for roll-on/roll-off (Ro-Ro) ships. Dredging will take place around the improved terminal jetty to create a berthing pocket.

The aims of this study were to assess the known and potential cultural heritage resource within the inter-tidal and marine parts of the Tilbury2 Site and the wider Marine Study Area, and to note the likely primary and secondary impacts of the proposals on this resource.

This study has identified no known cultural heritage constraints which are likely to prohibit development.

The only known and dated archaeological receptor within the inter-tidal and marine parts of the Tilbury2 Site is a WWII concrete pillbox, which should be unaffected by the primary impacts of the Development. A line of timber stakes of unknown date and use is also present just to the west of the pillbox. It is likely that this will also be unaffected by the Development.

There is a low to medium potential for previously unknown archaeological deposits, including those possibly related to the Romano-British occupation further east and the maritime commercial history of the Thames since prehistory through to the modern period. Prehistoric and Roman wrecks remain rare and are therefore of low potential - but would be of high significance if encountered. Medieval and post-medieval wrecks have a medium potential due to their greater known numbers within the Thames estuary.

Any potential archaeological receptors could be affected by direct impacts of the piling works and dredging. Of these, the dredging has the greatest potential negative impact, as it seeks to remove 100000m3 of sediment from the river bed.

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Tilbury 2
Land at the former RWE Power Station
Tilbury, Essex

Marine Desk Based Assessment

1. INTRODUCTION

1.1. Project background

1.1.1. Wessex Archaeology was commissioned by CgMS Consulting Ltd (the Client) on behalf of Port of Tilbury London Ltd (PoTLL) to prepare a Marine Archaeological Desk Based Assessment of the proposals on land at the former RWE power station at Tilbury, Essex, (hereafter 'the inter-tidal and marine parts of the Tilbury2 Site', **Figure 1**) centred on National Grid Reference (NGR) 565700, 175951.

1.1.2. The proposals within the inter-tidal and marine parts of the Tilbury2 Site involves the re-development of the location as a new port terminal, upgrading the present jetty with new berthing dolphins, a link bridge and additional hopper and conveyor belt and a new berth for roll-on/roll-off (Ro-Ro) ships. The raised pipeline to the Anglian Water Services sewage treatment plant to the west of the site will be removed. Associated dredge pockets around the jetty to create the berth will also be included in the proposals, and are included within the Red Line Boundary (RBL) of the inter-tidal and marine parts of the Tilbury2 Site.

1.1.3. To facilitate its use for both the roll-on roll-off (Ro-Ro) terminal and the aggregates facility the existing jetty will be modified at both its upstream and downstream arms. The Ro-Ro berth, located at the western end of the existing jetty, will accommodate two vessels at a time and thus the existing jetty will be modified and extended to enable this. Similarly, the CMAT berth located at the eastern end of the existing jetty will be extended to accommodate barges and vessels of the required size.

1.1.4. These adaptations will be made up of the following:

1.1.5. The upstream berth will have five additional berthing dolphins, each with associated fenders, and four additional supports for a new footbridge. Should multipile foundations be used, each berthing dolphin will require 12 *c.*1.22 m diameter piles (making 60 in total), while the fenders will require three *c.*1.22 m diameter piles, making 15 in total. The four footbridge supports will require two *c.*0.914 m diameter piles, making a total of eight. Should monopile foundations be used, each berthing dolphin will require one *c.*3.5m diameter pile, making a total of five piles. There are not monopile foundation options for the fender foundations or footbridge supports.

1.1.6. The downstream berth (Jetty A) will have two additional berthing dolphins, each with associated fenders, and 13 new fenders for the jetty itself. Should multipile foundations be used, each berthing dolphin will require 12 *c.*1.22 m diameter piles (making 24 in total), while the dolphin and jetty fenders will each require three *c.*1.22 m diameter piles, making 45 in total. Should monopile foundations be used, each berthing dolphin will require one *c.*3.5m diameter pile, making a total of two piles. There are not monopile foundation options for the fender foundations.

1.1.7. The CMAT Berth (Jetty B and beyond) will have eight additional berthing dolphins, each with associated fenders, and two additional supports for a new footbridge, as well as a conveyor hopper platform and three additional supports for the conveyor. Should multipile foundations be used, each berthing dolphin will require 12 *c.*1.22 m diameter piles (making 96 in total), while the fenders will require three *c.*1.22 m diameter piles, making 24 in total. The two footbridge supports will require two *c.*0.914 m diameter piles, making a total of four. Should monopile foundations be used, each berthing dolphin will require one *c.*3.5m diameter pile, making a total of eight piles. There are not monopile foundation options for the fender foundations, footbridge supports, conveyor hopper platform or conveyor supports.

1.1.8. The Ro-Ro pontoon and approach bridges will have two additional restraint dolphins, one additional bank seat, six piled bents and an abutment. The six piled bents and the abutment will be onshore, while the bank seat and the dolphins will be within the intertidal and marine zones. Should multipile foundations be used, each restraint dolphin will require 14 *c.*1.22 m diameter piles (making 28 in total), as will the bank seat and the abutment, making a further 28 *c.*1.22m piles. The piled bents will require four *c.*1.22 m piles each, making a total of 24. Should monopile foundations be used, each restraint dolphin will require two *c.*3.5m diameter pile, making a total of four piles. There are not monopile foundation options for the bank seat, piled bents or abutment.

1.1.9. Dredging will take place around the improved terminal jetty to create a berthing pocket. In relation to the downstream (CMAT) jetty, the depth of pocket will be circa 15m and cater for the largest likely bulk aggregate vessels to visit the site in the future (100,000 tonnes). The current river depth in relation to the downstream jetty varies between *c.*-9.2 m CD and *c.*-14 m CD. This will therefore mean the river bed will need to be lowered by between approximately *c.*1 m– *c.*5.8 m. A *c.*330 m long, *c.*25 m high sheet pile wall will be installed to run along the northern edge of the dredge pocket. The Ro-Ro berthing pocket (next to the western end of the existing jetty and around its westward extension) will require less dredging in order to create a depth of *c.*7.88m. The current river depth in relation to the upstream jetty (next to the western end of the existing jetty and around its westward extension) varies between *c.*-5.8m CD and *c.*-7.7m CD. The river bed will be lowered by between approximately *c.*0.10 m and 2 m.

1.1.10. The immediately adjoining approaches to the berth pockets will also need dredging and are included within the indicative Order limits.

1.1.11. The Proposals are shown in **Figure 2**.

1.1.12. This report assesses the potential impacts, and the significance of those impacts, of the proposals in the inter-tidal and marine parts of the Tilbury2 Site.

1.2. The inter-tidal and marine parts of the Tilbury2 Site

1.2.1. The inter-tidal and marine part of the Tilbury2 Site lies across the Thames from Gravesend to the south-west of Tilbury and the west of the current extent of the Port of Tilbury. The west of the site is bordered by an Anglian Water Services sewage treatment plant, while the east boundary of the site is along the edge of the now-decommissioned Tilbury B power station. The Tilbury2 Site is shown in **Plate 1**, **Plate 2** and **Plate 3**.

1.2.2. The aspects of the proposals impacting on the inter-tidal and marine parts of the Tilbury2 Site include, but are not limited to:

- *improvement of and extensions to the existing jetty including creation of a new Ro-Ro berth and link bridge from jetty to shore;*
- *installation of a pontoon at the river end of the link bridge;*
- *Installation of berthing dolphins on the upgraded jetty; and*
- *associated dredging of berth pockets (approx. 80000m^3) around the proposed and extended jetty and on the approach to the jetty (approx. 20000m^3). A sheet pile wall will run along the north side of the eastern dredge pocket and be tied back into the existing riverbed to the north. The dredge will lower the river bed by c.1 m – c. 5.8m around the downstream jetty and c.0.1 m – c.2 m around the upstream jetty.*

1.2.3. As the volumes of import/export of Ro-Ro units exceeds the Planning Act 2008 threshold of 250,000 units, the project is considered a Nationally Significant Infrastructure Project.

1.2.4. The underlying bedrock geology of the local area is part of the Sussex White Chalk Formations, dating to the Cretaceous era, which is a highly productive aquifer for the area. The superficial drift geology is made up of alluvial clays, silts and sands, with potential for peat deposits, as discussed in Devoy 1979, Wessex Archaeology 2009 and Quest 2017.

1.2.5. The hydrodynamics and sediment study report (HR Wallingford 2017) has suggested that the secondary effects of the project on the sediment regime will be limited and localised in nature, generally focused on the re-depositing of fine sediments within the dredge pockets.

1.2.6. The inter-tidal and marine parts of the Tilbury2 Site shown in all figures, and which this report is based upon represents the maximum extent of ground disturbance within the inter-tidal and marine zones.

2. METHODOLOGY

2.1. Background

Study Areas

2.1.1. The recorded marine historic environment resource within 2 km of the limits of the offshore and inter-tidal portion of the inter-tidal and marine parts of the Tilbury2 Site was considered. This is referred to hereafter as the Marine Study Area (MSA). The MSA includes both the inter-tidal and marine zones within the inter-tidal and marine parts of the Tilbury2 Site. The recorded terrestrial historic environment resource is discussed in a separate report (CgMs Consulting 2017).

2.1.2. The 2 km buffer (forming the MSA) used for this assessment allows for the capture of relevant archaeological records that may have poor positional data, including for example historic wrecks and aircraft losses, both of which are prevalent in this area.

2.1.3. The recorded historic environment resource within the MSA was acquired for this assessment from sources listed in **Section 2.1.9**.

Scope

2.1.4. This assessment seeks to determine, as far as is possible from existing information, the nature, extent and significance of the historic environment and to assess the potential impact of the proposals on the heritage assets that embody that significance.

2.1.5. This Marine Archaeological Desk Based Assessment sets out the baseline data for onshore and offshore assets with reference to the presence and potential within the inter-tidal and marine zones of:

- *Geoarchaeology;*
- *Early Prehistoric archaeology;*
- *Later Prehistoric archaeology;*
- *Romano-British archaeology;*
- *Medieval archaeology;*
- *Post-medieval archaeology;*
- *Modern archaeology; and*
- *Undated archaeology.*

2.1.6. Each of these will refer to individual known heritage assets, as listed in the gazetteer in **Appendix 8.1.** Entries will be given a WA prefix for ease of reference and are illustrated in **Figure 3**. Events which did not produce any archaeological artefacts or deposits are not numbered but may be illustrated on the relevant figures and listed within the gazetteer tables.

2.1.7. Many of the entries are maritime in provenance. Maritime archaeological features can comprise a vessel (whole or partial) and/or associated debris. Debris is considered to range from a single artefact to an entire scatter of material that is either associated with a wreck site or has been accidently/deliberately lost from a vessel, for instance cargo or ballast.

2.1.8. The potential for unknown archaeology within inter-tidal zones and within inland waters has been recognised by Historic England as an important, under-utilised and under-recognised resource (Firth 2015) and because of this, these recommendations err on the side of caution.

Data Sources

2.1.9. A number of publicly accessible sources of primary and synthesised information were consulted, including:

- *The Essex Historic Environment Record (EHER) and Kent Historic Environment Record (KHER), comprising a database of all recorded terrestrial and marine archaeological sites, find spots, and archaeological events within the county and offshore;*
- *The National Record for the Historic Environment (NRHE) maintained by Historic England (formally English Heritage), comprising data for terrestrial and marine archaeological sites;*
- *United Kingdom Hydrographic Office (UKHO) data for charted wrecks and obstructions;*
- *National heritage datasets including the National Heritage List for England (NHLE), Images of England, PastScape, Viewfinder, NMR Excavation Index, and Parks and Gardens UK, Coastal and inter-tidal Zone Archaeological Network (CITiZAN); and*
- *Surveyed maps, historic maps and Ordnance Survey maps provided by CgMs Consulting Ltd*

2.1.10. Where duplicate records exist between these datasets these have been combined into one overall dataset. For instance, the dataset found within the CITiZAN database was noted to have duplicates of the EHER dataset (accessed 22/03/2017).

2.1.11. Positional data for these duplicate records uses the UKHO data in the first instance unless thought to be inaccurate whereby this is discussed in the text. Similarly, all the positions for the recorded losses use NRHE co-ordinates, unless otherwise specified in the text. In general, these are centre points of larger polygons that record Named Locations of losses. Where necessary, all co-ordinates have been converted to British National Grid (BNG) from their existing co-ordinate systems.

2.1.12. The UKHO records wrecks and obstructions around the UK for charting purposes and will provide the current state of the wreck: a ‘live’ wreck is considered to exist by the UKHO; a ‘dead’ wreck has not been detected on repeated surveys and therefore is considered not to exist; and a ‘lifted’ wreck has been salvaged. Dead and lifted wrecks are included in this archaeological assessment because although the wreck itself is not considered identifiable for charting purposes, it is possible that remains may still be present at these locations, albeit buried or fragmentary. Dangerous wrecks are defined as those which are considered to be dangerous to surface navigation; presumably due to their recorded height prominent from the seabed and the greatest low water depth at that location. More information on UKHO policy and the dataset is located in **Section 8.2**.

2.1.13. A bibliography of documentary, archive, and cartographic sources consulted is included in **Section 7.1** of this report. Online resources used are presented in **Section 7.2**.

Site visit

2.1.14. The Site was visited on 23/03/2017. The aim of the visit was to assess the general aspect, character, condition and setting of the inter-tidal and marine parts of the Tilbury2 Site and to identify any potential impacts not evident from secondary sources. Weather conditions were generally sunny with occasional cloud. A fieldwork record comprising notes and digital photography is held in the project archive.

2.2. Aims

2.2.1. The specific aims of this assessment are to:

- *outline the known and potential heritage assets within and around the inter-tidal and marine parts of the Tilbury2 Site based on a review of existing information within the MSA extending 2 km from the inter-tidal and marine parts of the Tilbury2 Site boundary;*
- *assess the significance of known and potential cultural heritage assets through weighted consideration of their valued components;*
- *assess the primary and secondary impacts of the Development or other changes on the significance of the assets; and*
- *make recommendations for strategies to mitigate potential adverse primary and secondary impacts arising from the proposals.*

3. PLANNING BACKGROUND

3.1. Introduction

3.1.1. There is national legislation and guidance relating to the protection of, and proposals on or near, important archaeological sites or historical buildings within planning regulations as defined under the provisions of the *Town and Country Planning Act* 1990. In addition, local authorities are responsible for the protection of the historic environment within the planning system.

3.1.2. The following section provides details of the national, regional and local planning and legislative framework governing the treatment of archaeological remains within the planning process.

3.2. National Planning Policy Framework

3.2.1. The *National Planning Policy Framework* (NPPF) was published by the Department for Communities and Local Government (DCLG) in March 2012, replacing Planning Policy Statement 5.

3.2.2. NPPF Section 12: *Conserving and enhancing the historic environment* sets out the principal national guidance on the importance, management and safeguarding of heritage assets within the planning process.

3.2.3. The aim of NPPF Section 12 is to ensure that Local Planning Authorities, developers and owners of heritage assets adopt a consistent and holistic approach to their conservation and to reduce complexity in planning policy relating to proposals that affect them.

3.2.4. To summarise, government guidance provides a framework which:

- *recognises that heritage assets are an irreplaceable resource;*
- *requires applicants to provide proportionate information on the significance of heritage assets affected by the proposals and an impact assessment of the proposals on that significance;*

- *takes into account the desirability of sustaining and enhancing the significance of heritage assets and their setting;*
- *places weight on the conservation of designated heritage assets;*
- *requires developers to record and advance understanding of the significance of any heritage assets to be lost (wholly or in part) in a manner proportionate to their importance and impact, and to make this evidence (and any archive generated) publicly accessible; and*
- *conserve heritage assets in a manner appropriate to their significance, so that they can be enjoyed for their contribution to the quality of life of this and future generations.*

3.3. National Planning Statement for Ports

3.3.1. As these proposals are listed as an NSIP, it is covered by the National Planning Statement (NPS) for Ports, published by the Government in 2012. Section 5.2 of this NPS deals with the Historic Environment and notes in Paragraph 5.12.1 that the construction of port infrastructure has the potential to result in adverse impacts on the historic environment and therefore states:

- *As part of the ES, the applicant should provide a description of the significance of the heritage assets affected by the proposals and the contribution of their setting to that significance. The level of detail should be proportionate to the importance of the heritage assets and no more than is sufficient to understand the potential impact of the proposal on the significance of the heritage asset. As a minimum, the applicant should have consulted the relevant Historic Environment Record and assessed the heritage assets themselves using expertise where necessary according to the proposals' impact.*
- *Where a development site includes, or the available evidence suggests it has potential to include, heritage assets with an archaeological interest, the applicant should carry out appropriate desk-based assessment and, where such desk-based research is insufficient to properly assess the interest, a field evaluation. Where proposals will affect the setting of a heritage asset, representative visualisations may be necessary to explain the impact.*
- *The possibility of damage to buried features from underwater disposal of dredged material should be taken into account.*
- *The applicant should ensure that the extent of the impact of the proposals on the significance of any heritage assets affected can be adequately understood from the application and supporting documents*

3.4. Marine Legislation

3.4.1. There are no known cultural heritage assets within the inter-tidal and marine parts of the Tilbury2 Site that are designated under the legislation outlined below. It is possible, however, that as yet undiscovered archaeological features may be present within the MSA (for example buried material). If discovered, the following legislation applies within the 12 nautical mile (nm) limit of English territorial waters:

- *Protection of Wrecks Act 1973: Section One;*
- *Protection of Wrecks Act 1973: Section Two;*
- *Ancient Monuments and Archaeological Areas Act 1979 (as amended);*
- *Protection of Military Remains Act 1986; and*

- *Merchant Shipping Act 1995.*

3.4.2. This legislation affords protection for wrecks of high historical, archaeological or artistic value as well as allowing military wrecks to be protected. Ownership of any wreck remains is determined in accordance with the *Merchant Shipping Act* (1995).

3.5. Marine Policy

3.5.1. The assessment presented in this report takes account of current government policy, comprising the *Marine Policy Statement* (Department for Environment, Food and Rural Affairs 2011) and *National Planning Policy Framework* (2012).

3.5.2. Under the *Marine and Coastal Access Act* (2009) the UK was divided into marine planning regions, with an associated planning authority responsible for preparing a marine plan for that area. The *Marine Policy Statement* (Department for Environment, Food and Rural Affairs 2011- https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69322/pb3654-marine-policy-statement-110316.pdf Accessed 06/06/2017) sets out the framework for preparing Marine Plans and taking decisions affecting the marine environment and was jointly adopted by the Secretary of State, Scottish Ministers, Welsh Ministers and the Department of the Environment in Northern Ireland in 2011.

3.5.3. The Marine Policy Statement notes that *"Marine activities have the potential to result in adverse effects on the historic environment both directly and indirectly, including damage to or destruction of heritage assets"*.

3.5.4. It sets out for consideration that:

- *Some heritage assets have a level of interest that justifies statutory designation, the purpose of which is to ensure that they are protected and conserved for the benefit of this and future generation;*
- *Many heritage assets with archaeological interest in these areas are not currently designated as scheduled monuments or protected wreck sites but are demonstrably of equivalent significance. The absence of designation for such assets does not necessarily indicate lower significance and the marine plan authority should consider them subject to the same policy principles as designated heritage assets;*
- *In considering the significance of heritage assets and their setting, the marine plan authority should take into account the particular nature of the interest in the assets and the value they hold for this and future generations; and*
- *Where the loss of the whole or a material part of a heritage asset's significance is justified, the marine plan authority should identify and require suitable mitigating actions to record and advance understanding of the significance of the heritage asset before it is lost. Requirements should be based on advice from the relevant regulator and advisors*

3.5.5. In England, marine licensing and marine planning was made the responsibility of the Marine Management Organisation (MMO), and inshore and offshore waters have been divided into 11 plan areas for which marine plans are to be produced. The planning process officially began on 1st April 2011. The South East Marine Plan, in which the inter-tidal and marine parts of the Tilbury2 Site is, is currently under development (https://www.gov.uk/government/collections/south-east-marine-plan Accessed 22/03/2017).

3.6. Marine Guidance

3.6.1. This assessment was carried out in a manner consistent with available guidance as described below in chronological order of issue:

- *Identifying and Protecting Palaeolithic Remains: Archaeological Guidance for Planning Authorities and Developers (English Heritage 1998);*
- *Managing Lithic Scatters: Archaeological Guidance for planning authorities and developers (English Heritage 2000);*
- *Military Aircraft Crash Sites: Guidance on their significance and future management (English Heritage 2002);*
- *Marine Aggregate Dredging and the Historic Environment; Guidance note (BMAPA, English Heritage and Wessex Archaeology 2003);*
- *Protocol for reporting finds of archaeological interest (BMAPA, English Heritage, The Crown Estate 2005);*
- *JNAPC Code of Practice for Seabed Development (Joint Nautical Archaeology Policy Committee and The Crown Estate 2006);*
- *Our Seas – A shared resource: High level marine objectives (DEFRA 2009);*
- *North Sea Prehistory Research and Management Framework (Peeters, H., Murphy, P., Flemming, N., English Heritage and others 2009);*
- *Model Clauses for Archaeological Written Schemes of Investigations (The Crown Estate and Wessex Archaeology 2010);*
- *Marine Geophysics Data Acquisition, Processing and Interpretation Guidance Notes (English Heritage and Bates, R., Dix, J. K., Plets, R. 2013); and*
- *The Assessment and Management of Marine Archaeology in Port and Harbour Development (Historic England 2016).*

3.7. Port of London Authority

3.7.1. The Port of London Authority (PLA), under the Port of London Act 1968 has jurisdiction over the Tidal Thames from Teddington to the outer limits of the Thames estuary up to the High Water Mark.

3.7.2. The proposed scheme falls within this jurisdiction of the PLA.

3.8. Local Plan

3.8.1. The Site also sits within the area covered by the Environment Agency's report *Thames Estuary 2100* (Environment Agency 2012).

3.8.2. The Site is within the Greater Thames Marshes Nature Improvement Area (NIA) but does not sit within any Special Protection Areas. The NIA is a non-statutory designation aiming to create resilient ecological networks on a landscape scale. A Planning Policy Advice Note has been issued by this organisation (Greater Thames Marshes 2012).

3.8.3. The Thurrock Local Development Framework (LDF) Core Strategy was adopted in December 2011 and contains the following policy relating to the historic environment:

> PMD4 - Historic Environment: the council will ensure that the fabric and setting of heritage assets, including listed buildings, conservation areas, scheduled ancient

monuments and other important archaeological sites, and historic landscape features are appropriately protected and enhanced.

1. The council will also require new development to take all reasonable steps to retain and incorporate non-statutorily protected heritage assets contributing to the quality of Thurrock's broader historic environment.

2. Applications must demonstrate that they contribute positively to the special qualities and local distinctiveness of Thurrock, through compliance with local heritage guidance including:

- *Conservation area character appraisals;*
- *II. Conservation area management proposals;*
- *III. Other relevant Thurrock-based studies, including the landscape capacity study (2005), the Thurrock urban character study (2007) and the Thurrock unitary historic environment characterisation project (2009).*
- *IV. Further local guidance as it is developed.*

  3. The Council will follow the approach set out in 'PPS 5: planning for the historic environment' in the determination of applications affecting Thurrock's built or archaeological heritage assets. This will include consideration of alterations, extensions or demolition of listed buildings or the demolition of unlisted buildings within conservation areas, and requirements for pre-determination archaeological evaluations and for preservation of archaeology in situ or by recording.

4. MARINE AND INTER-TIDAL BASELINE RESOURCE

4.1. Introduction

4.1.1. The following section provides a summary of the archaeological remains within the marine and inter-tidal part of the inter-tidal and marine parts of the Tilbury2 Site and MSA, with the overall aim being to establish the known and potential resource that may be affected by the proposals. All cultural heritage assets within the 2km buffer are illustrated in **Figure 3**.

4.1.2. The baseline will note where there are related features and finds within the terrestrial zone but will only apply **WA** numbers to receptors within the inter-tidal and marine zones for the purpose of this report. A full gazetteer of these will be presented in **Appendix 8.1**.

4.1.3. This will then inform **Section 5**, which discusses the potential for any impact on the identified cultural heritage assets within the inter-tidal and marine parts of the Tilbury2 Site and wider MSA.

4.2. Previous studies

4.2.1. An onshore archaeological assessment of the site was completed by Wessex Archaeology in 2007 and a marine assessment in 2009 for RWE nPower. Geoarchaeological studies have been completed by Wessex Archaeology (2008a) and Quest (2017) which build on the work of Devoy (1979) who completed an extensive study of the geoarchaeological potential of the Thames Estuary during the late 1970s and early 1980s. These have formed the basis of the current archaeological baseline, and has been updated with any new information uncovered or reported since then.

4.3. Historic map analysis

4.3.1. Analysis of the historic maps provided by the client has shown that, other than the Development of Tilbury Fort to the west of the inter-tidal and marine parts of the Tilbury2 Site, there was very little human activity beyond pastoral farming within the inter-tidal and marine parts of the Tilbury2 Site prior to the Development of the power stations in the 1950s and 1960s; with the area comprising open fields and salt marsh. The earliest map of 1777 from the Chapman and Andre map of Essex shows a potential for some improvement along the shoreline with shading suggesting a sea wall similar to that around the fort, but this could equally just be drainage ditches. The 1805 OSD map shows this possible seawall as a more solid structure, appearing to be an earth bund splitting drained open farmland from the Thames and the sea marshes. The 1863 OS map confirms the presence of the seawall, as well as noting the presence of “the Old Counter Wall” further inland, suggesting that in earlier periods the site may have been a dry island surrounded by salt marsh on two sides and the Thames on the third. The seawall is shown as potentially more developed in the 1898 6inch OS map, although this may be due to a change in cartography styles. The first evidence for an inter-tidal zone is present in the 1923 OS map, and again in the 1938 OS map, although with no features noted. It is marked only as “mud”.

4.3.2. The first feature noted in the inter-tidal zone is an L-shaped coaling jetty relating to the power plant on the 1961 OS map, as well as a small track leading down onto the inter-tidal foreshore slightly to the west of the end of the jetty. The most recent aerial photographs of the site (2015) indicate that this has become a small raised pipeline leading into the Anglian Water Services sewage treatment works that lie to the west of the site.

4.4. Geoarchaeology

Potential for Geoarchaeological research within the inter-tidal and marine zones

4.4.1. The Thames estuary has seen repeated changes due to repeated glacial periods during the Pleistocene, the most recent being the Devensian (c. 110,000-13,500 BP). Glacial conditions not only caused a global drop in sea levels to up to 120 m below present level, but also caused the shifting of the Thames from its previous northerly course draining into the North Sea in Norfolk and Suffolk, through the Watford Gap into the Vale of St Albans to roughly its present course. This was followed by later, smaller shifts within the wide Thames estuary during the Holocene. Such changes in sea level would have made the Thames estuary suitable for hominin exploitation during much of the Pleistocene. The Thames river terraces have for this reason been one of the most important sources for artefacts dating to the Lower Palaeolithic (c. 900,000 – 300,000 years ago) and Early Middle Palaeolithic (c. 300,000 – 60,000 BP) (Bridgland 1994). During the early Holocene, as post-glacial conditions warmed, global sea levels rose instigating a primary marine transgression, which flooded much of the lower Thames valley, developing into the wide estuary seen today. Following this the area saw repeated smaller regressions and transgressions up to the 3rd/4th Centuries AD. It is likely that these included inundations during the late Mesolithic, early Neolithic and much if not all of the Bronze Age (Pratt 1996: Section 1.7). This site has the potential to contain deep sediments relating to these events within British Prehistory, as well as providing a stepping stone for integrating offshore and onshore geoarchaeological records, allowing unified reconstructions, identified as an important research aim for palaeolandscapes research (Dix and Sturt 2013, Bicket and Tizzard 2015).

4.4.2. Salt marshes and estuaries have been heavily exploited throughout prehistory and history, and the potential for peat banks within the inter-tidal area in these reaches of the Thames has been demonstrated at other sites at Cliffe and on larger scale studies by Devoy (1979) would suggest buried old land surfaces within the MSA. It is currently unknown which period these peat banks belong to and while some are generally associated with Roman artefacts, some may relate to earlier land surfaces, covered by the accumulation of alluvial silts formed by each successive inundation. The phases of changing sea levels and therefore in the coastline throughout the Holocene within the Thames Estuary would have allowed areas of relatively dry salt marsh to become established before being inundated again. The potential for survival of environmental and organic materials is enhanced by the very favourable preservation conditions provided by water-logged, fine-grained sedimentary environments for the preservation of archaeological sites and materials including wooden structures, artefacts and ecofacts. These potential cultural heritage assets are of value to archaeological research as noted within the following guidance documents:

- *Animal Bones and Archaeology: Guidelines for Best Practice (English Heritage 2014)*
- *Environmental Archaeology: A Guide to the Theory and Practice of Methods from Sampling and Recovery to Post-excavation (English Heritage second edition 2011)*
- *Geoarchaeology: Using Earth Sciences to Understand the Archaeological Record (Historic England 2015)*

- *Guidelines for the Curation of Waterlogged Macroscopic Plant and Invertebrate Remains (English Heritage 2008)*

- *Waterlogged Organic Artefacts: Guidelines on their Recovery, Analysis and Conservation (English Heritage 2012)*

- *Waterlogged Wood: Guidelines on the recording, sampling, conservation and curation of waterlogged wood (English Heritage 2010)*

4.4.3. A full geoarchaeological survey of the onshore inter-tidal and marine parts of the Tilbury2 Site, including a N-S transect across the inter-tidal zone into the marine zone and an E-W transect across the south side of the existing jetty (Wessex Archaeology 2008a) demonstrated the presence of buried peat deposits within the terrestrial and inter-tidal zones in the upper 'Unit 3' deposit of alluvium, but these were not present in the marine cores. This may be due to the erosion of the upper layers of the alluvium by the river, suggesting that there may well be exposed edges of peat along the High Water Mark and within the inter-tidal deposits.

4.4.4. A more recent report into the geoarchaeological potential by Quest (2017) also noted the presence of three bands of peat (Lower, Middle and Upper), dating to the middle-late Mesolithic, late Mesolithic to early Bronze Age and Iron Age respectively. The Quest report notes the regional potential of all three of these layers of peat for containing palaeo-environmental evidence for occupation, habitat and sea transgression, and their potential for containing associated artefacts. The report also notes the recent analysis of human remains (Schulting 2013) found within the Lower Peat during the construction of Tilbury Docks in the 1880s which have dated these remains to the Late Mesolithic, a period for which minimal human remains have been found in the UK (Quest 2017).

4.5. Early Prehistory

4.5.1. When assessing the archaeological potential of the MSA for the Lower, Middle and Upper Palaeolithic, more general records of human occupation in Britain are considered alongside local climatic and geological conditions. A consideration of the potential of archaeology dating to the Mesolithic period onwards will be discussed with reference to known archaeological sites within the vicinity of the MSA.

4.5.2. Archaeological sites can appear in primary contexts, where the spatial relationship of finds has not altered, and in secondary contexts, where artefacts have been derived or moved from their original positions. The latter can be associated with fluvial re-depositing, glacial processes and marine transgressions. Recent work has shown that secondary sites have the potential to yield information on patterns of human land use and demography rather than merely providing a source for the typological comparison of undateable artefacts (Hosfield and Chambers 2004).

4.5.3. River terrace gravels provide an important source of Palaeolithic artefacts. For the most part, these finds do not appear in their primary context and are most likely to have derived from river beaches, old land surfaces or even earlier worked terrace deposits (Wymer 1999:21). However, there are the occasional sites where artefacts have occurred in sufficient quantity or in a state of preservation that suggests a primary context (Bridgland 2000:1299). Due to the predominance of Flandrian sediments within the MSA, there is little potential for pre-Flandrian archaeological artefacts to remain in situ. However, the existence of derived or secondary artefacts which were transported by Holocene marine transgression is possible within the MSA.

4.5.4. The MSA has been subject to somewhat extensive environmental changes prior to the Devensian glaciation. During periods in which the sea level fell, vegetation and fauna would colonise the exposed land close to the shoreline within a few decades (Flemming 1996), thus providing a landscape suitable for hominid exploitation. River valleys such as the Thames provided particularly attractive environments for occupation during interglacial periods, providing fresh water, exposed raw material for tools, open grassy floodplains and access to a variety of habitats up the valley sides (Wymer 1999:41).

Known Early Prehistoric Features and Finds in the inter-tidal zone

4.5.5. The HER includes a poorly located (it is unclear whether it was found in the Thames or at Tilbury Docks) worked flint (**WA 1007**- also noted in the CgMs 2017 terrestrial DBA) possibly dating to the Palaeolithic period which is listed as a hand-axe. This is likely to be redeposited rather than *in situ*.

4.5.6. Some of the most favoured areas for occupation during the Mesolithic were the margins of the swampy regions of the tributaries of the Thames, and remains of Mesolithic occupation sites have been discovered on a number of sites beneath peat, tufa or alluvium deposits (BGS 1996:136). The peat deposits Tilbury I and Tilbury II occurred during the Mesolithic period (c.10,000-6,000 BP) and as such it is possible that artefacts may remain within these sediments which relate to this period of human activity.

4.5.7. Tilbury III, the thickest peat in the succession, dates to the Neolithic period (c.6,000-4,000 BP). It is possible that Neolithic artefacts are discovered within this peat lens. Early Neolithic pottery has been found at Northfleet in deposits dating to this time (BGS 1996:127). There is little evidence for prolonged habitation of wetland areas during the Neolithic period, although human activities such as the clearance of fen woodland may have occurred (BGS 1996:127).

Potential Early Prehistoric Features in the inter-tidal and marine zones

4.5.8. The presence of Mesolithic and Neolithic palaeo-environmental data from the surrounding area would suggest that there is a low to medium potential for more to be found within the estuarine and fluvial sediments across the inter-tidal and marine parts of the Tilbury2 Site, and within the wider MSA. The area is likely to have been marsh/swamp for much of the Mesolithic and Neolithic, periods which saw extensive use of coastal and estuarine zones for subsistence. The estuarine silts are likely to preserve any features present from these periods, such as fish traps, if they are present.

4.6. Later Prehistory

Known Later Prehistoric Features and Finds in the inter-tidal zone

4.6.1. There are no known later prehistoric features or finds in the inter-tidal zone.

Known Later Prehistoric Features and Finds in the marine zone

4.6.2. There are no known later prehistoric features or finds in the marine zone.

Potential Later Prehistoric Features in the inter-tidal and marine zones

4.6.3. The estuarine nature of the MSA makes it a likely place for human exploitation of resources for subsistence during the late prehistoric periods with both hunting and grazing being common in these areas, which leave little archaeological evidence. The production of salt is noted in the wider area, as an Iron Age saltern called Red Hill (as most are in Essex) was discovered to the east, outside the MSA (Wessex Archaeology 2009). However as no receptors are noted from the MSA, the potential should be considered low.

4.7. Roman Archaeology

Known Roman Features and Finds in the inter-tidal zone

4.7.1. Evidence of Roman occupation has been found in the inter-tidal zone to the east of the inter-tidal and marine parts of the Tilbury2 Site, comprising the remains of four adjacent hut circles (**WA 1008**) which are thought to still be preserved below the mud. These remains, found in 1920 but not excavated, are extensive, with the largest two having three rings of stakes each, with wattlework still surviving and rings of stone in between the stake rings, suggesting complex building techniques. One of these huts also had evidence for floor planking and an oven. The smallest hut circle also contained evidence for daub covered walling, while a number of roofing tile fragments has also been discovered in the area, suggesting they were roofed. The foreshore 100m either side of the **WA 1008** site was covered with Romano-British ceramics, generally of “native” types but with some examples of Samian ware, along with other evidence for occupation. The record suggests this may have been a landing point for material from abroad during the Romano-British period. These features are highly significant, with the potential for high quality survival of organic material in the protective riverine silts. If the site was a landing point for goods, then there is potential for damaged, lost or abandoned examples to be preserved within the river bed sediments in the immediate area.

4.7.2. The discovery of more Roman ceramic fragments (**WA 1003**) from the foreshore is a further indication of Roman activity within the area. This record also notes Romano-British burial material from the area, although it doesn’t give more details of exact location and extent. Three other findspots for Roman material are also noted in the HER data, although there is minimal data for two (**WA 1004** and **WA 1005**), while the other, sherds of Samian ware (**WA 1002**) originally held by Tilbury Fort, has an uncertain origin, with a note suggesting the artefacts may have in fact come from Kent.

Known Roman Features and Finds in the marine zone

4.7.3. There are no known Romano-British features or finds in the marine zone.

Potential Roman Features in the inter-tidal and marine zones

4.7.4. Salt manufacturing during the Romano-British Period, particularly in the south-east of England has been identified as an important maritime archaeology research topic (Walsh 2013). The presence of a Romano-British settlement, artefacts relating to trade, and burial material in the area would also suggest that there may be further burials, particularly within the inter-tidal deposits, as sea level would have been lower in this period. The Thames was an important waterway for maritime trade and the potential for Romano-British wrecks has been noted previously (Marsden 1993: 222). Finally, because of the estuarine nature of the MSA, it is likely to have been exploited by humans for subsistence during this period. Due to these factors, the potential for encountering previously unknown Romano-British features within the MSA should be considered medium.

4.8. Early Medieval and Medieval Archaeology

Known Early Medieval and Medieval Features and Finds in the inter-tidal zone

4.8.1. There are currently no known early medieval or medieval features in the inter-tidal zone

Known Early Medieval and Medieval Features and Finds in the marine zone

4.8.2. There are currently no medieval shipwrecks subject to statutory protection within the MSA.

4.8.3. There are no known medieval features or finds in the MSA.

Potential Early Medieval and Medieval Features in the inter-tidal and marine zones

4.8.4. A linear series of medieval oyster beds are present on the estuary to the east of the inter-tidal and marine parts of the Tilbury2 Site. In addition to this, medieval sea wall defences forming an earthwork are recorded in the EHER to the north of the current sea defences. Tilbury is known to have been occupied during the Saxon period when Bede wrote that St Cedd had built churches in several places, including Tilaburg (the Saxon name for Tilbury) during the early Saxon period (Harrold 1994:36). It is likely that the terrestrial section of the inter-tidal and marine parts of the Tilbury2 Site was marsh during this period, and so may have been utilised for fishing and grazing. It is possible that evidence for these activities may extend and survive in the inter-tidal and marine zones, but this is considered of low potential.

4.9. Post-medieval Archaeology

Known post-medieval Features and Finds in the inter-tidal zone

4.9.1. There are currently no post-medieval shipwrecks subject to statutory protection within the MSA.

4.9.2. Tilbury Fort (SAM No. 26309) was initially constructed under Henry VIII as a blockhouse in 1539 to strengthen the coastal defences of the area. After the Restoration in 1660, Charles II began a complete reorganisation of the national defences, including at Tilbury Blockhouse which was redesigned as a fort and battery. The majority of the fort dates from the 17th century, although some additions took place within the 19th century. The original jetty for the Gravesend ferry stood in front of the fort until its relocation in 1681.

Known post-medieval Features and Finds in the marine zone

4.9.3. There are no known post-medieval features or finds within the MSA. The poorly located Recorded Losses from the NRHE will be discussed below in the potential section as their positions are neither definite nor their presence certain.

Potential post-medieval Features in the inter-tidal and marine zones

4.9.4. A number of other wrecks are located within the MSA but with very poorly defined locations. The 1636 wreck of the Third Rate ship of the line *Anne Royal* (**WA 1009**) is located to the south-west of the inter-tidal and marine parts of the Tilbury2 Site, having grounded on Tilbury Hope. The ship was floated off and taken to Blackwall where it was broken up. The potential of any remains relating to this event are considered to be low.

4.9.5. The wrecks of three English barges, the *Three Sisters* (**WA 1010**, sunk in 1880), *Sultan* (**WA 1011**, sunk in 1886) and *H C* (**WA 1014**, sunk in 1908) are also roughly located in the northern side of Tilbury Reach to the south-west of the inter-tidal and marine parts of the Tilbury2 Site. In the same area are the wrecks of the English cargo vessel *Georgian* (**WA 1012**, sunk in 1887) and the schooner *Pearl* (**WA 1013**, sunk in 1898). The exact location and state of each wreck is currently unknown.

4.9.6. The NRHE dataset contains location data of poor to very poor accuracy for a large number of post-medieval recorded losses within the MSA, which currently are located on the SW corner of the OS grid square, which happens to be just in land in Gravesend. All of these wrecks have the potential to be within the inter-tidal and marine parts of the Tilbury2 Site, but as the location data is so poor (and there are so many of them), they have not been included on the location map (**Figure 3**). They are described, with their location, in **Section 8.2** and are given WA numbers.

4.9.7. The potential post-medieval wrecks from the NRHE include: the 1716 wreck of *Russet Gally*, a galley (**WA 1033**); five vessels described only as ‘craft’- the 1752 wrecks of the

Pretty Sally (**WA 1072**) and *St George* (**WA 1108**); the 1780 wreck of the *Rodney* (**WA 1037**); the 1772 wreck of the *Jane* (**WA 1071**); and the 1815 wreck of the *William and Elizabeth* (**WA 1109**); the 1806 wreck of the *Aid,* a cargo vessel (**WA 1030**); the 1873 wreck of the *Larnax* (**WA 1039**) a composite English barque; six English cargo vessels - an unnamed 1726 wreck (**WA 1094**), the 1740 wreck of the *Dragon* (**WA 1045**), the 1763 wreck of the *Craike Castle* (**WA 1113**), the 1783 wreck of the *Matthew and Thomas* (**WA 1061**), the 1895 wreck of the *Edith* (**WA 1038**) and the 1987 wreck of the *Wear* (**WA 1046**); two Norwegian barques the *Einar* (**WA 1079**) sunk in 1897 and the *Stella* (**WA 1064**) sunk in 1981; the 1805 wreck of a British collier (**WA 1098**); two English cutters the *William* (**WA 1049**) and the *Charles and Henry* (**WA 1102**) both sunk in 1877; an English schooner the *Vixen* (**WA 1060**) sunk in 1895; an English brig the *Spray* (**WA 1062**) sunk in 1852; and 44 English barges or Spritsail barges of 19th Century date. The British tug the *Rose* was also wrecked in the area in 1888 (**WA 1056**), as was the ferry boat heading to Gravesend in 1735 (**WA 1086**). The Spanish craft *Juana Maria* (**WA 1082**) was also wrecked in the area in 1765, although it is again unclear what sort of vessel this was.

4.9.8. The large amount of river traffic entering and leaving the Port of London on the Thames during this period and the location of Tilbury Fort close by suggest that the potential for post-medieval archaeology, particularly artefacts and wrecks is medium. While marine losses were routinely recorded from the late 18th Century onwards in resources like the Lloyd's Lists, the accuracy of the locations is greatly reduced. Within the large number of Recorded Losses within the NRHE listed above, while there are a number of craft listed which were clearly large sea-going ships, it is likely that the majority of craft using the river during the post-medieval period would have been small coastal craft. The large number of reported losses of barges reflects this, and as these vessels were only occasionally insured (and their loss recorded), there is the potential for unreported losses of these types of craft within the MSA.

4.10. Modern Archaeology

Known Modern Archaeological Features in the inter-tidal zone

4.10.1. There are currently no modern shipwrecks subject to statutory protection within the inter-tidal and marine parts of the Tilbury2 Site or MSA.

4.10.2. An unusually shaped pillbox (**WA 1001**) dating to WWII is present on the inter-tidal zone to the east of the inter-tidal and marine parts of the Tilbury2 Site (**Plate 4**) It is 28ft x 15ft double ended octagon shape. This feature is half submerged at high tide.

4.10.3. A spigot mortar base (**WA 1006**) is located within a pre-WWII gun pit on the High Water Mark in Tilbury Fort and may suggest the presence of mortar round UXO within the inter-tidal and marine parts of the Tilbury2 Site.

4.10.4. Two steel/iron barge hulks (**WA 1015** and **WA 1016**) lie on the High Water Mark, partly covered by gravel, inter-tidal mud and vegetation (**Plate 5**), within the eastern half of the MSA 500m outside the inter-tidal and marine parts of the Tilbury2 Site. These are likely to be 20th century barges, more commonly known as lighters.

4.10.5. UKHO records note two further hulked wrecks further east (**WA 1022**) which appear on PLA surveys in 1992 as three areas of debris, suggesting that they have now broken up. These were not obvious during the site visit and may be multiples of the exact steel/iron barge wrecks noted above.

Known Modern Archaeological Features in the marine zone

4.10.6. Two barge wrecks are listed in the UKHO dataset to the east of the inter-tidal and marine parts of the Tilbury2 Site, **WA 1026** and **WA 1028**. Both of these are listed as Dead wrecks.

4.10.7. The wreck of the motor vessel *Hartnel* (**WA 1029**) is located by the UKHO as being almost mid-channel to the south-east of the inter-tidal and marine parts of the Tilbury2 Site, however the record also notes that the wreck was lifted around 1956. Some debris may remain. Similarly, the wreck of the SS *Southport* (**WA 1031**) was located to the west of the inter-tidal and marine parts of the Tilbury2 Site, having sunk following a collision. It was refloated in 1956 as well. Some debris may remain on the river bed.

4.10.8. Another wreck further east again (**WA 1023**) is known from a 2012 survey, and is located within the Thames, rather than in the inter-tidal zone.

4.10.9. Five UKHO obstructions or fouls are recorded on the north side of the Thames within the MSA, with one being a foul area of 80m x 30m (**WA 1021**), a set of three 8m long concrete piles listed as lifted (**WA 1027**), an uncategorised obstruction listed as dead (**WA 1030**) and two being remains of ground tackle from mooring buoys (**WA 1024** and **WA 1025**). The concrete piles **WA 1027** are within the dredging area but as the records say they have been lifted they should no longer be present.

4.10.10. There are a number of other UKHO fouls, obstructions and wrecks which are located on the southern side of the Thames, away from the inter-tidal and marine parts of the Tilbury2 Site. These are listed in **Section 8.3** but are not given WA numbers due to their location away from the inter-tidal and marine parts of the Tilbury2 Site and precise nature of their locations.

4.10.11. The poorly located Recorded Losses from the NRHE will be discussed below in the potential section as their positions are neither definite nor their presence certain.

Potential Modern Archaeological Features in the marine zone

4.10.12. The NRHE dataset contains location data of poor to very poor accuracy for a number of modern recorded losses within the MSA, which currently are located on the SW corner of the OS grid square, which happens to be just in land in Gravesend. All of these wrecks have the potential to be within the inter-tidal and marine parts of the Tilbury2 Site, but as the location data is so poor (and there are so many of them), they have not been included on the location map (**Figure 3**). They are described, with their location, in **Section 8.2** and are given WA numbers.

4.10.13. These include: six English barges or Spritsail barges of 20th Century date (the *Mary Francis* **WA 1112**, the *Britannia* **WA 1088**, the *Lily* **WA 1085**, the *Ruth* (**WA 1081**)**,** the *Quail* (**WA 1074**) and the *Granolithic* (**WA 1083**); the *Inger* (**WA 1092**), *Porro* (**WA 1043**), *Sigyn* (**WA 1091**) and *Langesund* (**WA 1066**), four Norwegian barques sunk in 1909, 1910, 1911 and 1914 respectively; the 1923 steel steamer *Slemish* (**WA 1070**) sunk in 1956 (but broken up soon after); the Scottish cargo vessel *Dundee* (**WA 1058**), sunk in 1909; the *Mirror* (**WA 1055**) an English ketch sunk in 1913; and the *T E Forster* (**WA 1051**), an English cargo vessel sunk in 1907. These all have the potential to be within the inter-tidal and marine parts of the Tilbury2 Site, but have no definite location and may be very well be located out-with the inter-tidal and marine parts of the Tilbury2 Site or no longer be extant.

4.10.14. A single aircraft crash is listed in the NRHE records: that of a Mk VI de Havilland Mosquito fighter bomber (**WA 1042**) which crashed in the area in 1944. The precise location of the crash site is unknown and so potentially could be within the inter-tidal and marine parts of the Tilbury2 Site. The Mosquito was built almost entirely of moulded wood and so is likely to be very broken up.

4.10.15. There is the potential for aircraft crash sites, or debris associated with aircraft crash sites, to be uncovered. These would particularly relate to WWII, with the high amount of Allied and Axis air traffic over this area during the Battle of Britain, Blitz, and bombing of Germany. There is also potential, although not as high, for pre- and post-WWII aircraft crashes in the area. These sites often have poor/non-existent locational data of crashes, particularly in water or lowly-populated areas such as the south Essex Marshes, in general due to poor weather conditions, inaccurate reporting, or a lack of survivors and witnesses. Previous reports into aircraft archaeology in the UK have noted that it is likely that over 10,000 aircraft have crashed in UK waters since the advent of flight in the early 20th Century (Wessex Archaeology 2008b: 18). Due to high population levels and the predominance of world war activity in the area, the Thames estuary can be considered to have a significant number of these losses. The potential for currently unknown aircraft remains should therefore be seen as low to medium.

4.10.16. As this part of Essex formed part of 'Bomb Alley' during the Second World War the likelihood of unexploded ordnance (UXO), generally but not exclusively aerial bombs, particularly with a known munitions factory 1.5 km to the north, is moderate. It is understood that a survey for UXO is to be undertaken, but was not carried out before this report was completed.

4.10.17. The potential for small unregistered barge and coastal craft wrecks within both the inter-tidal and marine zones is also low to medium, as for the post-medieval period, although generally during the modern period the reporting of wrecks became more routine.

4.11. Undated archaeology

4.11.1. During the walkover three additional potential archaeological features of unknown date were noted. The first was a linear feature of stones and stakes running ENE-WSW within the inter-tidal mud (**WA 1016**), with an arc of stones/stakes to the east of it, again within the inter-tidal mud **(Plate 6**). It is unclear what this feature is, or what date it relates to.

4.11.2. The second feature was a line of small stakes within the inter-tidal mud (**WA 1017**) to the east of the covered conveyor belt on the coaling jetty **(Plate 7**). These may be part of a fish trap or revetment but their definite purpose and date remains unknown.

4.11.3. The final undated feature noted was a set of parallel poured concrete blocks on the foreshore (**WA 1018**), just above the High Tide Mark (**Plate 8**) and therefore just outside the remit of this report. However, as they had not been noted before, it was decided to include them for completeness. They are likely to be modern in date, and may relate to the construction or use of the power station.

4.12. Conclusions from baseline research

4.12.1. The inter-tidal and marine parts of the Tilbury2 Site have been extensively studied geoarchaeologically, showing the potential for preserved environmental records dating to the Mesolithic and Neolithic within the Tilbury II and Tilbury III deposits. Recent surveys by Wessex Archaeology (2008a) and Quest (2017) demonstrated the potential for peat deposits and artefacts within the inter-tidal zone and along the mean high water edge, with no evidence for peat deposits within the marine zone; although there remains the potential for artefacts. The terrestrial peat deposits are covered in the onshore DBA (CgMs 2017) and Quest's Geoarchaeological Deposit Model Report (Quest 2017).

4.12.2. The area around the inter-tidal and marine parts of the Tilbury2 Site covered by the MSA appears to have been utilised during the Romano-British period, with the settlement of hut circles to the east and associated artefact scatter suggesting a landing point for goods, although no excavation has taken place to confirm this. The extensive presence of Romano-British burials and other artefacts around the lower Thames Estuary would add evidence to the Roman utilisation of similarly situated sites, and the presence of Samian Ware would suggest this presence begins early in the Roman occupation of Britain. The potential for Romano-British archaeological receptors is therefore considered to be medium.

4.12.3. The Thames Estuary has been the main artery for marine commerce since the prehistoric period through to now. Although rare, there remains a low potential for the remains of prehistoric watercraft within the MSA. The chances of preservation within the marsh sediments, alluvial inter-tidal and marine sediments, if the vessels were ever present, is also likely due to their anaerobic nature. The Graveney boat, a well-preserved example of a 9th Century coastal trading boat, was found in very similar marshes further east close to Faversham, Kent. This example was covered in 2 m of marsh clay, showing the amount of sediment which can build up in these areas (Fenwick 1972). As these remains are still rare in the UK, the potential is considered low, however should such remains be found it would be of national significance.

4.12.4. The area was also clearly utilised in the medieval period and there is the potential for any of the wrecks listed in the NRHE to be within the inter-tidal and marine parts of the Tilbury2 Site, hidden by the estuarine silts of the inter-tidal and marine zones. Unlocated losses likely to be on the northern side of the Thames include three barge wrecks, a schooner and a wooden cargo vessel. There are 83 other Reported Losses within the MSA, although these have very poor recorded loss positions and therefore may not be within the Development Boundary. There has also been a large number of unregistered barges and coastal craft which worked the Thames estuary during the post-medieval period, the potential for more unlocated and unknown wrecks should be taken as medium. There is also the potential for debris falling off ships and boats into the sediments, as this area was clearly well used during this time.

4.12.5. For the modern period, the same is true, although there is also the added potential for aircraft crash sites within the MSA. One aircraft know to have been lost in this general area is a de Havilland Mosquito. The potential for unknown crashes should be considered low to medium due to the high volume of air traffic over the Thames Estuary. There is as always the high potential for UXO, both from aerial attacks and from Anti-Aircraft fire.

5. ASSESSMENT OF POTENTIAL AND SIGNIFICANCE

5.1. Introduction

5.1.1. This section discusses the assessment of any potential archaeological remains and the significance of any such discoveries.

Offshore Assessment Criteria

5.1.2. The significance of effects upon marine heritage assets is derived from an assessment of the magnitude of impacts and the importance and/or sensitivity of the receptors, where this can be judged.

5.1.3. The magnitude of an impact is assessed and given a value ranging from small to large (**Table 1**).

Table 1: Definition of magnitude of impact

Magnitude	Definition
Large	Major loss or alteration to key elements/features of the baseline conditions such that post Development character/composition/attributes will be fundamentally changed.
Medium	Loss or alteration to one or more key elements/features of the baseline conditions such that post Development character/composition/attributes of baseline will be partially changed.
Small	Minor shift away from baseline conditions. Change arising from the loss/alteration will be discernible but underlying character/composition/attributes of baseline condition will be similar to pre-Development circumstances/patterns.

5.1.4. The assessed value takes account of the nature of the change (i.e. what is affected and how it is affected), the extent of the change and the duration of the change. The approach also considers the probability of that change occurring, taking account of any existing mitigation measures integral to the inter-tidal and marine parts of the Tilbury2 Site, and any uncertainty concerning the occurrence or scale of the effect.

5.1.5. Regarding marine heritage assets, the magnitude of impact is based on the level of change to known cultural heritage assets or potential cultural heritage assets relative to baseline conditions. This is derived from guidance provided by BMAPA and English Heritage (2003), the Joint Nautical Archaeology Policy Committee (JNAPC) (2006), and other guidance (**Section 3.3**).

5.1.6. A key factor for the consideration of impacts to cultural heritage assets is that once archaeological deposits and material, and the relationships between deposits and material and their wider surroundings, have been damaged or disturbed, it is not possible to reinstate or reverse those changes. All changes are permanent in duration and, as such, direct impacts to the fabric or setting will represent a total loss of an archaeological feature, or part of it, and the character, composition or attributes of the feature will be fundamentally changed or lost from the site altogether.

5.1.7. All negative direct impacts to cultural heritage assets, therefore, will be regarded as a major loss or alteration to baseline conditions resulting in fundamental change and the magnitude of impact will be **large**. Mitigation is possible, however, to reduce significant effects and this is discussed in **Section 6**.

5.1.8. Assessments of the sensitivity of an archaeological receptor consider the capacity of that receptor to accommodate change and reflect its ability to recover if it is affected. The key considerations in assessing sensitivity are:

- *The degree of adaptability (can a receptor avoid or adapt to an effect?);*
- *The degree of tolerance (can a receptor accommodate temporary or permanent change without a significant negative impact?);*
- *The degree of recoverability (can a receptor recover following an effect and how long would this take?); and*
- *The importance of a receptor (the intrinsic archaeological importance of a heritage asset as defined by agreed criteria).*

5.1.9. In terms of direct impacts to the physical fabric or context of an archaeological receptor, cultural heritage assets have no adaptability, tolerance or recoverability from negative effects. They are a finite resource and their *in situ* context (in terms of spatial relationships with other cultural heritage assets, sedimentary units and palaeogeographic location for example) is critical to their intrinsic archaeological importance.

5.1.10. The Marine Policy Statement (Department for Environment, Food and Rural Affairs 2011) states that the value of heritage assets, to this and future generations, lies in their heritage interest, which may be archaeological, architectural, artistic or historic.

5.1.11. In accordance with this definition, the importance of archaeological receptors are assessed by examining the receptor’s age, type, rarity, survival and condition, fragility and vulnerability, group value, documentation, associations, scientific potential and outreach potential. These factors help to characterise a receptor and to assess how representative it is in comparison to other similar archaeological, architectural, artistic or historic heritage assets. They also enable its potential to contribute to knowledge, understanding and outreach to be assessed. In the majority of cases, statutory protection is only provided to a site or feature judged to be an above average example in regard to these factors.

5.1.12. For the purposes of this assessment, archaeological importance is assessed from low to high in accordance with the definitions in **Table 2**.

Table 2: Definition of archaeological importance/sensitivity

Importance	Definition
High	Above average example and/or high potential to contribute to knowledge and understanding and/or outreach. Receptors with a demonstrable international or national dimension to their importance are likely to fall within this category. Sites of wrecked ships and aircraft with statutory protection plus as-yet undesignated sites that are demonstrably of equivalent archaeological importance. Palaeogeographic features with demonstrable potential to include artefactual and/or palaeoenvironmental material, possibly as part of a prehistoric site or landscape. All sites for which data limitations prevent an assessment of importance and to which the precautionary approach applies (**Section 3**).
Medium	Average example and/or moderate potential to contribute to knowledge and understanding and/or outreach. Includes wrecks of ships and aircraft that do not have statutory protection or equivalent significance, but have moderate potential based on a formal assessment of their importance in terms of build, use, loss, survival and investigation. Prehistoric deposits with moderate potential to contribute to an understanding of the palaeoenvironment.
Low	Below average example and/or low potential to contribute to knowledge and understanding and/or outreach. Includes wrecks of ships and aircraft that do not have statutory protection or equivalent significance, but have low potential based on a formal assessment of their importance in terms of build, use, loss, survival and investigation. Prehistoric deposits with low potential to contribute to an understanding of the palaeoenvironment.

5.1.13. Thus, the significance of an effect (positive or negative) is determined as a combination of magnitude and importance/sensitivity as set out in **Figure 4**.

5.1.14. Definitions of each grade of significance of effect are summarised in **Table 3** based upon the existing guidance (**Section 3**).

Figure 4: Assessment of significance of effects

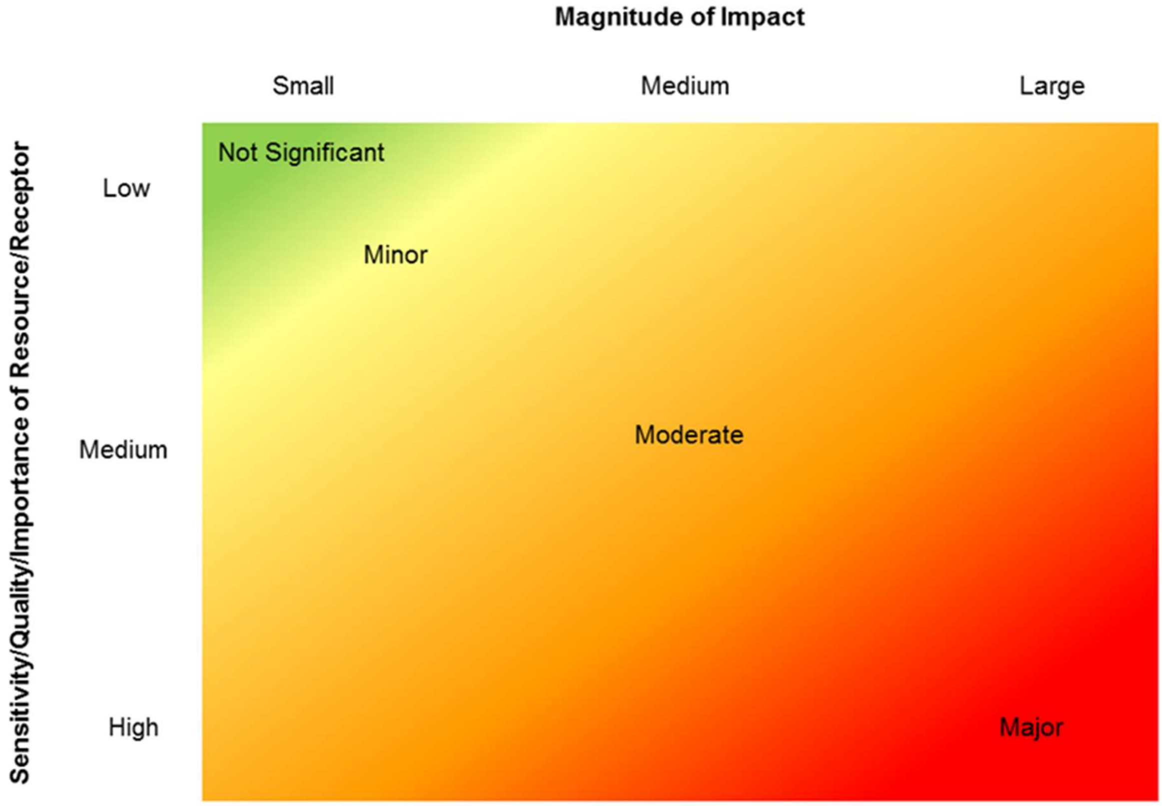

Table 3: Definition of significance

Significance	Definition
Not Significant	Effects that are slight or transitory and those that are within the range of natural environmental and social change.
Minor Negative	The effects is undesirable but of limited concern.
Moderate Negative	The effect gives rise to some concern but it is likely to be tolerable (depending on its scale and duration).
Major Negative	The effect gives rise to serious concern and is judged unacceptable.
Minor Positive	The effect is of minor significance but has some environmental benefits.
Moderate Positive	The effect provides some gain to the environment.
Major Positive	The effect provides a significant positive gain to the environment.

5.1.15. For potential receptors (e.g. unknown uncharted wreck sites and unknown uncharted aircraft crash sites and isolated finds of all periods), where there is insufficient site-specific data to fully assess the importance of individual receptors, the precautionary approach has been used in line with existing guidance and the sensitivity of each site has been judged as potentially high.

Table 4: Risk to known and potential cultural heritage assets within the inter-tidal and marine parts of the Tilbury2 Site and MSA

Risk	Period and Description		Significance	Value	Survival
Medium	Palaeo-environment	The estuarine silts within the site have a medium to high potential to hold important palaeo-environmental information of long-term landscape changes across the Thames estuary and locally, however the impact of the Development should be minor. The potential from geoarchaeological analysis of boreholes to address questions of landscape change is noted in the Regional Research Framework (Heppell 2010)	Regional/National	Evidential	Good
	Romano-British	Presence of Romano-British settlement and extensive artefact scatter in inter-tidal deposits to east of inter-tidal and marine parts of the Tilbury2 Site and other Romano-British features and finds within MSA suggest there may be more lying within inter-tidal and marine zones of inter-tidal and marine parts of the Tilbury2 Site, although there have been no reports of artefacts or features within the inter-tidal and marine parts of the Tilbury2 Site. The Thames was also an important maritime route during the Roman period, with sustained river traffic up to London for several centuries. A wreck would be of national significance. The potential to encounter Roman archaeology is therefore considered medium, but the potential to encounter wrecks is considered low.	Regional/National	Evidential	Good
	Medieval, post-medieval and modern	Due to the volume of maritime traffic within these periods there is potential for wrecks within the piling footprint and dredge pockets of the inter-tidal and marine parts of the Tilbury2 Site. There is also potential for unknown aircraft losses. Nearly 90 Recorded Losses of vessels are within the NRHE records for the MSA, ranging from the early 18th century through to 1956. The significance of any such finds will depend on their nature and preservation.	Local/ Regional	Evidential Historical	Potential to be good
Low	Saxon and medieval	Indications are that in Saxon and medieval times much of the inter-tidal and marine parts of the Tilbury2 Site was probably an area of saltmarsh and subject to periodic inundation. As such little permanent activity is likely to have been carried out within the inter-tidal and marine parts of the Tilbury2 Site but features associated with the exploitation of such habitats such as fish traps are possible. Salt production appears to have been a common industry in the area during the period.	Local/Regional /National	Evidential	Good

Risk	Period and Description		Significance	Value	Survival
	Early Prehistoric	Low to medium potential of artefacts and remains in association with peat deposits identified by Wessex Archaeology (2008a) and Quest (2016). No likelihood of settlement but potential for small fish traps or similar within inter-tidal and marine. Low potential for *ex situ* Palaeolithic artefacts within lower levels of inter-tidal and marine parts of the Tilbury2 Site.	Regional/National	Evidential	Good
Unknown	Bronze and Iron Age	Little is known about sea level and the position of the coastline in relation to the inter-tidal and marine parts of the Tilbury2 Site in the Bronze Age and Iron Age though much of it may have been under water. However potential for finds from this period cannot be ruled out.	Local	Evidential	Unknown

5.2. Impacts on the Historic Environment

Introduction

5.2.1. The management and mitigation of change to heritage assets resulting from the impact of the Development is based on the recognition that "…heritage assets are an irreplaceable resource…" (NPPF para. 126). These impacts arise when changes are made to the physical environment of heritage assets by means of the loss/or degradation of their physical fabric and/or setting, leading to a reduction of the significance of the historic environment record and its associated heritage assets. The impact of this Development will be split according to phase.

Statement of impact of the Development

5.2.2. The Development as described in **Section 1.2** relates to the upgrading of existing jetties with additional driven pile structures, installation of berthing dolphins and the dredging of river bed deposits within the berth. This location can be seen in **Plate 1** and **Plate 2**.

5.2.3. Two primary impacts have been identified:

- *the potential damage to the archaeological record from the piling operation to build the berthing dolphins, the link bridge and the sheet piling along the north edge of the eastern dredge box; and*
- *the potential damage to the archaeological record from the dredging operations within the berth and approach.*

5.2.4. This is not limited to the potential localised impact of buried land surfaces, wrecks and other archaeological assets by the piles themselves but also to any in the surrounding deposits which can be deformed and damaged by piling operations; or by the direct removal of supporting sediments or archaeology itself by the dredging operations.

5.2.5. Two secondary impacts have been identified: the first is the potential damage by prop wash and anchoring of the piling and dredging vessels used to construct the new jetty. This has the potential to damage or remove archaeological features, artefacts and their associated sediments. The second is the potential for a differential scour regime caused by the dredging and the additions to the jetty, which particularly in a river with a large fast flowing tide such as the Thames, can have effects on the sediments protecting archaeological receptors in the local area. The hydrodynamics and sediment study report (HR Wallingford 2017) has suggested that if backhoe dredging is conducted the secondary effects of the project on the sediment regime will be limited and localised in nature, generally focused on the re-depositing of fine sediments within the dredge pockets. Should dispersal dredging be used the impact will be larger (roughly 15km either side of the development- HR Wallingford 2017) but will remain of low impact due to the small increase in sediment depth associated with this (1-10mm). These secondary impacts will not be investigated further.

6. CONCLUSION

6.1.1. As demonstrated in **Section 5**, there are minimal known archaeological receptors within the inter-tidal and marine parts of the Tilbury2 Site, with only a WWII concrete Pillbox, which should be unaffected by the primary impacts of the Development.

6.1.2. The inter-tidal and marine parts of the Tilbury2 Site do have potential for previously unknown archaeological deposits, including those relating to the Romano-British occupation further east in the MSA and the maritime commercial history of the Thames since prehistory.

6.1.3. The large number of Recorded Losses present in the NRHE records for the MSA is representative of the long and extensive use of the Thames as a trade route, which became particularly busy from the 18th century onwards. All of these have the potential to be within the inter-tidal and marine parts of the Tilbury2 Site, although the exact locations of them are unknown. These could be affected by both the direct impacts of the piling works and dredging but are unlikely to be impacted by the secondary impacts of prop wash and scour. Of these, the dredging to lower the river bed by c.1 m – c. 5.8m around the downstream jetty and c.0.1 m – c.2 m around the upstream jetty has the greatest potential negative impact, as it seeks to remove 100000m^3 of sediment from the river bed.

6.1.4. Given the archaeological potential within the inter-tidal and marine parts of the Tilbury2 Site it is likely that an appropriate programme of archaeological works is developed to mitigate any potential impact on the archaeological resource.

6.1.5. This includes the preparation of a Written Scheme of Investigation (Wessex Archaeology 2017), outlining the nature of mitigation required, to be developed and agreed between CgMs Consulting on behalf of PoTLL and appropriate representatives from Historic England, the Port of London Authority and Essex CC.

6.1.6. The mitigation outlined in the WSI includes geoarchaeological sampling and assessment; pre-dredge investigations of anomalies; provision for diver assessment of submerged archaeological receptors; and a watching brief on board the dredger and during piling works.

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7.2. Online Resources

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8. APPENDICES

8.1. Gazetteer of Cultural Heritage Assets

WA ID	MonUID	EHCR_No	RecordType	Site_Name	MonType	Description	Easting	Northing
1001	MEX31812; NRHE 1423397	10287	MON	Pillbox, S of Tilbury Power Station	PILLBOX	An unusual pillbox standing on the mud at the river's edge. Basically, a 28' long x 15' wide double-ended octagon with the entrance on the W side - but built 3' high on top and across the middle is a 22" thick wall. This was probably intended as an extra firing position. This wall projects some 5' each side of the pillbox. The entire structure is now sinking into the mud which has filled the interior.	566200	175400
1002	MEX6471	1785	FS	West Tilbury - Tilbury Fort		Samian ware, RB vessel (1871) in BM, fibulae (Roman?). "I understand that Tilbury Fort had a Roman collection. Were the fibulae from that collection at its disposal or were they excavated. Material was brought from Kent for foundation consolidation, and all excavated items are suspect"	565000	175100
1003	MEX6630	1828	FS	Tilbury Foreshore		Roman pottery reported from foreshore along frontage. Notable collection of RB Burial material by P Benton of Southend-on-Sea. Mid 19th S.end of West Tilbury Manor Way". <1> May well duplicate other sites-see TQ67-008, 1694, TQ67-038, 1734, 1735.	566500	175400
1004	MEX6468	1783	FS	West of West Tilbury - Tilbury Fort		RB remains found around 1960?	564720	175100
1005	MEX6254	1734	FS	West Tilbury - Foreshore		RB ceramics (rim sherd) remains found around 1968?	566600	175500
1006	MEX31804	10280	MON	Spigot Mortar Base, SE Bastion, Tilbury Fort	SPIGOT MORTAR EMPLACEMENT	The SE bastion of Tilbury Fort has two pre-WWII 6" gun pits and the eastern pit has been converted to a spigot mortar position. The pit is constructed of concrete and is 12' in diameter. In the centre a 7' square x 2' high concrete platform has been constructed. On top of this a standard spigot mortar pedestal has been built so that the stainless steel pintle is 6" below the level of the parapet. Thus the mortar could have fired across the parapet onto the eastern approaches and the Thames. The iron cage inside the pedestal is now showing through due to deterioration of the concrete.	565210	175310
1007	MEX6469	1784	FS	Find from Tilbury Fort, West Tilbury		Worked flint found, possibly Palaeolithic. A Palaeolithic implement found at Tilbury dock in 1913 now in the British Museum is possibly from this same site. See TQ67-070, 1710, for `Tilbury Dock' finds, presumably the 1913 find is the 1st hand-axe mentioned there.	565200	175300

WA ID	MonUID	EHCR_No	RecordType	Site_Name	MonType	Description	Easting	Northing
1008	MEX6102; NRHE 413469	1694	MON	East Tilbury Foreshore	SETTLEMENT, HUT CIRCLE, WOOD, FLOOR, OVEN, TRACKWAY	Below 'present' high tide level, remains of settlement of hut circles, associated with much 1st-2nd century pottery. In 1920 3 adjacent huts and fragmentary remains of a 4th nearby were visible. The two largest circles had 3 rings of stakes forming a frame for wattlework which was still preserved below the mud. Between the 2 inmost stake rings were the remains of a stone ring, a similar ring seemed to have been outside the outer stake ring. One hut had traces of a partition, another had a small circular platform in the middle, probably a support for a central pole. The latter hut had a piece of floor-planking, close by this were foundations for an oven with hard clay walls, no indication of its function however. The smallest circle appeared to have an entrance marked by two thick posts. In and around the huts were fragments of clay daub for covering walls. The stone rings can't have gone up to a great height. Many roofing tile fragments may indicate roofing. East of the huts, a shallow channel ran north east-south west with traces of flanking stakes. This may have been a former trackway from the old river edge. The foreshore for c100yds either side of the huts was covered with pottery, including 1st-2nd century Samian of forms 15-17, 18, 18-31, 27, 30, 31, 37, 38, 54 (plain), 78, 79. Stamps-list in this source. Most pottery was "of native type, with marked late Celtic elements"-eg cordons, bosses, incised linear patterns-"and represents the production of native manufacturers working under Roman influence". No wasters were noticed, there was no evidence that pottery was made on the site. The site "may have been a landing-place for traffic from Kent or elsewhere", the amount of pottery "seems excessive for the ordinary requirements of a small hut settlement". Source 1 has plan and photos of the oven.	567100	175600
1009	CITIZAN 8737; NRHE 1180031		WRK	Anne Royal	Recorded Loss	1636 wreck of English Third Rate ship of the line which was bilged when she took the ground at Tilbury Hope, on her arrival at Tilbury from Chatham and/or Gillingham. She was afterwards weighed and taken to Blackwall but was judged too expensive to repair and instead broken up. Constructed of wood as a galleon in 1587 for Sir Walter Raleigh, she was purchased by the Crown and served as ARK ROYAL under Howard of Effingham against the Armada in 1588 (1583091). She was renamed ANNE ROYAL on the accession of James I of England and was rebuilt in 1608.	565180	175160
1010	CITIZAN 58503; NRHE 896342		WRK	Three Sisters	Recorded Loss	Wreck of an English Barge, 1880	565180	175160
1011	CITIZAN 58547; NRHE 896638		WRK	Sultan	Recorded Loss	Wreck of an English Barge, 1886	565180	175160
1012	CITIZAN 58558; NRHE 896657		WRK	Georgian	Recorded Loss	Wreck of an English cargo vessel, 1887	565180	175160
1013	CITIZAN 58690; NRHE 896945		WRK	Pearl	Recorded Loss	Wreck of an English schooner, 1898	565180	175160
1014	CITIZAN 58731; NRHE 897434		WRK	H C	Recorded Loss	Wreck of an English Barge, 1908	565180	175160

WA ID	MonUID	EHCR_No	RecordType	Site_Name	MonType	Description	Easting	Northing
1015	UKHO 13336		WRK	Iron Hulk	Wreck	Hulked iron/steel barge on the north Thames foreshore to east of Tilbury B power station. Overgrown with vegetation and partially covered with gravel and inter-tidal mud. Pointed bow and rounded stern with straight stem. Small fore and aft decks, now badly corroded and a large rectangular internal cargo space now filled with mud and gravel.	566764	175468
1016	UKHO 13337		WRK	Iron Hulk	Wreck	Hulked iron/steel barge on the north Thames foreshore to east of Tilbury B power station. Overgrown with vegetation and partially covered with gravel and inter-tidal mud. Snub-nosed punt bow and square stern. Small fore and aft decks, now badly corroded and a large rectangular internal cargo space now filled with mud and gravel.	566802	175452
1017			MON	Linear stakes and stones		A linear feature of stones and stakes running ENE-WSW within the inter-tidal mud, with an arc of stones/stakes to the east of it, again within the inter-tidal mud. Noted on the walkover	565091	175182
1018			MON	Linear stone pier		A linear pier/jetty feature running from foreshore out into Thames, made of stone. Broken and falling down on west side. Noted during walkover	565067	175168
1019			MON	Linear stakes		A line of small stakes within the inter-tidal mud to the east of the covered conveyor belt on the coaling jetty. These may be part of a fish trap or revetment but their definite purpose and date remains unknown. Noted on the walkover	566202	175340
1020			MON	Concrete blocks		A set of parallel poured concrete blocks on the foreshore, just above the High Tide Mark. They are likely to be modern in date, and may relate to the construction or use of the power station. Noted on the walkover	565709	175291
1021	UKHO 13400		FOUL	Obstruction	UKHO obstruction	FOUL AREA CENTRED ON 512711.2N, 002421E. ORIENTATED 083/263DEGS. 80MTRS LONG, 30MTRS WIDE. SHOWN ON PLA 337/13 [APR-SEP'97, REC'D 9.3.98]. BR STD.	567139	175478
1022	UKHO 12776		WRK	Wreck	Wreck	25.11.63 2 STF HULKS, OF OLD BARGES, SHOWN CENTRED IN 512711N, 002415E ON SURVEY K3034/47C - NE2151, 20.3.92 SHOWN AS 3 AREAS OF WRECKAGE ON PLA SURVEY - NE1186.	567050	175490
1023	UKHO 79651		WRK	Wreck	Wreck	30.10.12 ST SHOWN IN 5127.182N, 0024.059E [WGD] ON BA 1186 [EDN 11 DTD 12.5.11].	566919	175406
1024	UKHO 66740		FOUL	Obstruction	Cables/Chains/ Mooring/Nets/Tackle/Wires	6.10.05 GROUND TACKLE LOCATED IN 5127.024N, 0022.310E [WGD] USING DGPS. HEIGHT 0.25MTR. (HMSML GLEANER, HI 1092). INS AS FOUL. BR STD.	564903	175047
1025	UKHO 57638		FOUL	Obstruction	UKHO obstruction	3.8.99 OBSTN 5.3MTRS SHOWN IN 5127.091N, 0023.630E [OGB] ON PLA 336/12 [JAN 1999]. NE 1186. BUT 25.8.05 NOT LOCATED BY M/B, DCS3	566419	174592
1026	UKHO 12777		WRK	Wreck	Wreck	Barge wreck. 14.11.63 DWP SHOWN IN 512713.8N, 002432E [OGB] ON SURVEY [K2954]. NE 2151. 14.8.78 NO LONGER SHOWN ON PLA 337 DTD 19.9.77. AMENDED TO DEAD. DELETE. BR STD.	567465	175513
1027	UKHO 57638		FOUL	Obstruction	UKHO obstruction	3 x 8m long concrete piles. 5.3m depth. UKHO record says lifted	566313	175279
1028	UKHO 13228		WRK	Wreck	Wreck	Barge wreck. Listed as dead. 9.2.90 STBD HAND BUOY, FL G 5S, TEMPORARILY ESTABLISHED IN POSN 318 DEG, 1000MTRS FROM MILTON MILE MARK, TO MARK SUNKEN BARGE LYING CLOSE W. (PLA NAV WARNING NO.2 OF 1990). NCA YET.	567492	175267

WA ID	MonUID	EHCR_No	RecordType	Site_Name	MonType	Description	Easting	Northing
1029	UKHO 69976		WRK	Hartnel	Wreck	Motor vessel wreck. Listed as lifted. 13.2.56 WK IN 512656N, 002358E [OGB], LYING IN MID CHANNEL, GRAVESEND REACH, IS NOW REMOVED. (LLOYDS LIST & PLA NM 1/56). AMENDED TO LIFT. NFA.	566827	174942
1030	UKHO 13107		FOUL	Obstruction	UKHO obstruction	13.5.82 OBSTN 8.2MTRS SHOWN IN 512700N, 002204.5E ON PLA 96/5. NE 2151. 7.5.85 DELETE OBSTN, RETAIN AS SOUNDING ONLY. (PLA LTR, 15.4.85). AMENDED TO DEAD. NE 2151.	564515	175046
1031	UKHO 69991		WRK	Southport	Wreck	Steamship wreck. EX- YEWHILL [1937], EX- SPORTSMAN, BUILT 1914 BY ARDROSSAN D.D. & S.B CO LTD, WITH 3 CYLINDER TRIPLE EXPANSION ENGINE, SINGLE SHAFT. OWNED AT TIME OF LOSS BY PARK SHIPPING CO. LTD. PASSAGE ANTWERP FOR LONDON. SANK FOLLOWING A COLLISION. Wreck refloated in 1956. Amended to lifted.	564545	174991

8.2. NRHE Dataset

WA ID	Shape *	HOB_UID	NAME	DESCRIPTIO	CAPTURE_SC	Easting	Northing	AREA_HA
1032	Polygon	967283	WINTER	ENGLISH SPRITSAIL BARGE	Unknown	565610	174340	0.030901
1033	Polygon	1047847	RUSSET GALLY	GALLEY, 1716	Unknown	565610	174340	0.030901
1034	Polygon	967270	MAURYEEN	ENGLISH SPRITSAIL BARGE	Unknown	565610	174340	0.030901
1035	Polygon	967274	PITSEA	ENGLISH SPRITSAIL BARGE	Unknown	565610	174340	0.030901
1036	Polygon	884484	AID	CARGO VESSEL, 1806	Unknown	565610	174340	0.030901
1037	Polygon	894073	RODNEY	CRAFT, 1780	Unknown	565610	174340	0.030901
1038	Polygon	883170	CHARLES DEANE	ENGLISH BARGE, 1883	Unknown	565610	174340	0.030901
1039	Polygon	882965	LARNAX	1873 wreck of English barque which foundered at the Lower Reach, Gravesend, following a collision while outward-bound from London for Mauritius with a general cargo. Constructed of composite materials in 1868, she was a sailing vessel.	Unknown	565610	174340	0.030901
1040	Polygon	967266	GWYNHELEN	ENGLISH SPRITSAIL BARGE	Unknown	565610	174340	0.030901
1041	Polygon	967278	STAR	ENGLISH SPRITSAIL BARGE	Unknown	565610	174340	0.030901
1042	Polygon	1357503	MOSQUITO MK VI HR153	BRITISH FIGHTER BOMBER, 1944	Unknown	565610	174340	0.030902
1043	Polygon	897476	PORRO	1910 wreck of Norwegian barque or barquentine which foundered following a collision off Gravesend, while carrying ice from Oslo to London. Constructed of wood in 1876, she was a sailing vessel.	Unknown	565610	174340	0.030901
1044	Polygon	896897	EDITH	ENGLISH CARGO VESSEL, 1895	Unknown	565610	174340	0.030901
1045	Polygon	1587044	DRAGON	1740 wreck of British cargo vessel which was stranded at Gravesend, on her arrival from Jamaica, last from the Netherlands, in great distress. Constructed of wood, she was a sailing vessel.	Unknown	565610	174340	78.391423
1046	Polygon	896938	WEAR	ENGLISH CARGO VESSEL, 1897	Unknown	565610	174340	0.030901
1047	Polygon	967257	DAISY LITTLE	ENGLISH SPRITSAIL BARGE	Unknown	565610	174340	0.030901
1048	Polygon	967265	GRAVELINES I	ENGLISH SPRITSAIL BARGE	Unknown	565610	174340	0.030901
1049	Polygon	896318	WILLIAM	ENGLISH CUTTER, 1877	Unknown	565610	174340	0.030901
1050	Polygon	896852	JAMES AND ANN	ENGLISH BARGE, 1893	Unknown	565610	174340	0.030901
1051	Polygon	897425	T E FORSTER	ENGLISH CARGO VESSEL, 1907	Unknown	565610	174340	0.030901
1052	Polygon	1458810		1738 wreck of English cargo or fishing vessel which was "lost near Gravesend by the violence of the wind". Bound for Billingsgate with lobsters, she was a wooden craft: it is not known whether she was powered by oars or sail, or both.	Unknown	565610	174340	78.391423

WA ID	Shape *	HOB_UID	NAME	DESCRIPTIO	CAPTURE_SC	Easting	Northing	AREA_HA
1053	Polygon	967280	SUMMER	ENGLISH SPRITSAIL BARGE	Unknown	565610	174340	0.030901
1054	Polygon	967264	GRACE	ENGLISH SPRITSAIL BARGE, 1938	Unknown	565610	174340	0.030901
1055	Polygon	897532	MIRROR	ENGLISH KETCH, 1913	Unknown	565610	174340	0.030901
1056	Polygon	896685	ROSE	BRITISH TUG, 1888	Unknown	565610	174340	0.030901
1057	Polygon	896907	WINTER	ENGLISH BARGE, 1896	Unknown	565610	174340	0.030901
1058	Polygon	897468	DUNDEE	SCOTTISH CARGO VESSEL, 1909	Unknown	565610	174340	0.030901
1059	Polygon	896401	WATER LILY	ENGLISH BARGE, 1884	Unknown	565610	174340	0.030901
1060	Polygon	896901	VIXEN	ENGLISH SCHOONER, 1895	Unknown	565610	174340	0.030901
1061	Polygon	894125	MATTHEW AND THOMAS	1783 wreck of English cargo vessel which was burnt by lightning at Gravesend on her arrival at London from Norway with deals; a wooden sailing vessel.	Unknown	565610	174340	0.030901
1062	Polygon	896241	SPRAY	ENGLISH BRIG, 1852	Unknown	565610	174340	0.030901
1063	Polygon	967273	P A M	ENGLISH SPRITSAIL BARGE	Unknown	565610	174340	0.030901
1064	Polygon	896813	STELLA	NORWEGIAN BARQUE, 1891	Unknown	565610	174340	0.030901
1065	Polygon	967258	DELCE	ENGLISH SPRITSAIL BARGE	Unknown	565610	174340	0.030901
1066	Polygon	897539	LANGESUND	1914 wreck of Norwegian barque which stranded in Gravesend Reach on route from Langesund for London with ice. Constructed of wood in 1876, she was a sailing vessel, originally built for German owners, and sold on into Russian service in 1897. In 1899 she	Unknown	565610	174340	0.030901
1067	Polygon	967281	TINTARA	ENGLISH SPRITSAIL BARGE	Unknown	565610	174340	0.030901
1068	Polygon	967256	CROW	ENGLISH SPRITSAIL BARGE	Unknown	565610	174340	0.030901
1069	Polygon	967269	MADRALI	ENGLISH SPRITSAIL BARGE	Unknown	565610	174340	0.030901
1070	Polygon	1522965	SLEMISH	1956 wreck of an English cargo vessel which was beached and broken up around Stone Ness near Gravesend, after sinking following a collision. Built of steel in Sunderland in 1923, she was a steam driven vessel.	Unknown	565610	174340	78.391423
1071	Polygon	893733	JANE	BRITISH CRAFT, 1772	Unknown	565610	174340	0.030901
1072	Polygon	1081	PRETTY SALLY	CRAFT, 1752	Unknown	565610	174340	0.030901
1073	Polygon	967260	ECONOMY	ENGLISH SPRITSAIL BARGE	Unknown	565610	174340	0.030901
1074	Polygon	967275	QUAIL	ENGLISH SPRITSAIL BARGE, 1911	Unknown	565610	174340	0.030901
1075	Polygon	896888	WELLINGTON	ENGLISH BARGE, 1895	Unknown	565610	174340	0.030901
1076	Polygon	896941	JAMES AND ANN	ENGLISH BARGE, 1898	Unknown	565610	174340	0.030901
1077	Polygon	967271	MOCKING BIRD	ENGLISH SPRITSAIL BARGE	Unknown	565610	174340	0.030901
1078	Polygon	967262	GERTIE	ENGLISH SPRITSAIL BARGE	Unknown	565610	174340	0.030901
1079	Polygon	896925	EINAR	NORWEGIAN BARQUE, 1897	Unknown	565610	174340	0.030901

WA ID	Shape *	HOB_UID	NAME	DESCRIPTIO	CAPTURE_SC	Easting	Northing	AREA_HA
1080	Polygon	896382	EFFORT	ENGLISH BARGE, 1882	Unknown	565610	174340	0.030901
1081	Polygon	967276	RUTH	ENGLISH BARGE, 1950	Unknown	565610	174340	0.030901
1082	Polygon	894814	JUANA MARIA	SPANISH CRAFT, 1765	Unknown	565610	174340	0.030901
1083	Polygon	897422	GRANOLITHIC	ENGLISH BARGE, 1906	Unknown	565610	174340	0.030901
1084	Polygon	896310	RICHARD	ENGLISH BARGE, 1877	Unknown	565610	174340	0.030901
1085	Polygon	897516	LILY	ENGLISH BARGE, 1912	Unknown	565610	174340	0.030901
1086	Polygon	1434909		1735 wreck of an English ferry boat which capsized following a collision on her way to Gravesend with passengers. She was constructed of wood.	Unknown	565610	174340	0.030902
1087	Polygon	967259	EDWARD VII	ENGLISH SPRITSAIL BARGE	Unknown	565610	174340	0.030901
1088	Polygon	967254	BRITANNIA	ENGLISH SPRITSAIL BARGE, 1946	Unknown	565610	174340	0.030901
1089	Polygon	967272	NELLIE AUSTEN	ENGLISH SPRITSAIL BARGE	Unknown	565610	174340	0.030901
1090	Polygon	1382785	NEPHALITE	1877 wreck of British barge which foundered off Gravesend after a collision, while laden with lime; a wooden sailing vessel.	Unknown	565610	174340	0.030902
1091	Polygon	897490	SIGYN	1911 wreck of Norwegian cargo vessel which foundered at Shornmead in Gravesend Reach following a collision with a Port of London dredger. At the time of loss the SIGYN was outward-bound from London for Grimsby in ballast. Constructed of iron in 1872, she	Unknown	565610	174340	0.030901
1092	Polygon	897451	INGER	1909 wreck of Norwegian barque which foundered off Gravesend, following a collision on route from Langesund for London with ice. Constructed of wood in 1875, she was a sailing vessel.	Unknown	565610	174340	0.030901
1093	Polygon	896889	SALLY LITTLE	ENGLISH BARGE, 1895	Unknown	565610	174340	0.030901
1094	Polygon	1435030		1726 wreck of cargo vessel which foundered in Gravesend Reach on her passage to central London with cod for Billingsgate fish market; a wooden craft, described simply as a "boat", so that her propulsion is unknown.	Unknown	565610	174340	0.030902
1095	Polygon	967284	ZENOBIA	ENGLISH SPRITSAIL BARGE	Unknown	565610	174340	0.030901
1096	Polygon	896948	GAZELLE	ENGLISH BARGE, 1898	Unknown	565610	174340	0.030901
1097	Polygon	967277	SURPRISE	ENGLISH SPRITSAIL BARGE	Unknown	565610	174340	0.030901
1098	Polygon	1397083		1805 wreck of British collier which foundered near Gravesend following a collision, on her passage to London with coal; a wooden sailing vessel.	Unknown	565610	174340	0.030902

WA ID	Shape *	HOB_UID	NAME	DESCRIPTIO	CAPTURE_SC	Easting	Northing	AREA_HA
1099	Polygon	967282	TRUE LOVE	ENGLISH SPRITSAIL BARGE	Unknown	565610	174340	0.030901
1100	Polygon	896615	EDWARD	ENGLISH BARGE, 1884	Unknown	565610	174340	0.030901
1101	Polygon	967702	MAFEKING	ENGLISH SPRITSAIL BARGE	Unknown	565610	174340	0.030901
1102	Polygon	896316	CHARLES AND HENRY	ENGLISH CUTTER, 1877	Unknown	565610	174340	0.030901
1103	Polygon	967279	START	ENGLISH SPRITSAIL BARGE, 1938	Unknown	565610	174340	0.030901
1104	Polygon	896944	ROB ROY	BRITISH BARGE, 1898	Unknown	565610	174340	0.030901
1105	Polygon	896924	EDITH	ENGLISH BARGE, 1896	Unknown	565610	174340	0.030901
1106	Polygon	967268	KALULU	ENGLISH SPRITSAIL BARGE	Unknown	565610	174340	0.030901
1107	Polygon	967261	FLOWER OF ESSEX	ENGLISH SPRITSAIL BARGE	Unknown	565610	174340	0.030901
1108	Polygon	893704	ST GEORGE	BRITISH CRAFT, 1752	Unknown	565610	174340	0.030901
1109	Polygon	894015	WILLIAM AND ELIZABETH	CRAFT, 1815	Unknown	565610	174340	0.030901
1110	Polygon	967263	GLENBURN	ENGLISH SPRITSAIL BARGE	Unknown	565610	174340	0.030901
1111	Polygon	967255	CHARLOTTE AUSTEN	ENGLISH SPRITSAIL BARGE	Unknown	565610	174340	0.030901
1112	Polygon	897431	MARY FRANCES	ENGLISH BARGE, 1908	Unknown	565610	174340	0.030901
1113	Polygon	894833	CRAIKE CASTLE	1763 incident in which a British cargo vessel capsized at Gravesend, bound from Shields to London with coal, and was later recovered and rebuilt; a wooden sailing vessel.	Unknown	565610	174340	0.030901
1114	Polygon	1252243	JOHN	BRITISH BARGE, 1867	Unknown	566221	174316	77.254228

8.3. UKHO dataset

FID	WreckID	WreckCat	ObstrnCat	Depth	LstAmdDate	Name	Type	Easting	Northing
0	12764			0	19990615			566497	174384
1	57637			3.7	20070115			566419	174592
2	13213		foul ground	0	20121105		Anchor	565710	174837
3	66740		foul ground	0	20051006		Cables/Chains/Mooring/Nets/Tackle/Wires	564903	175047
4	65168		foul ground	0	20050126		Cables/Chains/Mooring/Nets/Tackle/Wires	566118	174565
5	79607		foul ground	0	20121012			564912	174563
6	13400		foul ground	0	20121030			567139	175478
7	65169		foul ground	0	20050126		Cables/Chains/Mooring/Nets/Tackle/Wires	566201	174563
8	79608		foul ground	0	20121012			565278	174557
9	63519		foul ground	0	20050826		Cables/Chains/Mooring/Nets/Tackle/Wires	565544	174769
10	63512		foul ground	0	20031211		Cables/Chains/Mooring/Nets/Tackle/Wires	565523	174770
11	57638			5.3	20060216		Lifted Wreck	566313	175279
12	13198		foul ground	0	20121012		Cables/Chains/Mooring/Nets/Tackle/Wires	565161	174608
13	13196		foul ground	0	20050825		Cables/Chains/Mooring/Nets/Tackle/Wires	565166	174737
14	79606		foul ground	0	20121012			564899	174674
15	79651	wreck showing any portion of hull or superstructure		0	20121030			566919	175406
16	69976	dangerous wreck		0	20071127	HARTEL	motor vessel. Lifted	566827	174942
17	12762	distributed remains of wreck		0	19990615			566016	174322
18	13337	wreck showing any portion of hull or superstructure		0	20121030		barge	566802	175452
19	12776	wreck showing any portion of hull or superstructure		0	20121106		barge	567050	175490
20	13336	wreck showing any portion of hull or superstructure		0	20121106		barge	566764	175468

FID	WreckID	WreckCat	ObstrnCat	Depth	LstAmdDate	Name	Type	Easting	Northing
21	69991	dangerous wreck		0	20071127	SOUTHPORT	Lifted Wreck	564545	174991
22	12765	dangerous wreck		0	20050118	TASHIKA	Dead Wreck	567341	174581
23	57716		foul ground	0	20121012			563787	174559
24	57718		foul ground	0	20121012			564016	174558
25	13197		foul ground	0	20050819			564802	174589
26	13195		foul ground	0	20121012			564780	174726
27	70545		foul ground	0	20071011			564152	174656
28	70546		foul ground	0	20071011			564194	174685
29	70547		foul ground	0	20071011			564199	174614
30	70548		foul ground	0	20071011			564508	174611
31	70549		foul ground	0	20071011			564518	174690
32	80165		foul ground	0	20130411			564062	174719
33	66737		foul ground	0	20051006			564081	174596
34	13107			8.2			Dead wreck	564515	175046
35	80166		foul ground	0	20130411			564086	174746
36	62752		foul ground	0	20030819			567172	174479
37	13228	dangerous wreck		0	20050823		Dead wreck	567492	175267
38	69972			0	20071127	HMS CORNWALL	Lifted Wreck	566602	174130
39	13120			0	20040928		Dead Wreck	566152	174295
40	84887		foul ground	0	20160426			564186	174570
41	12777			0	20070226		Dead Wreck	567465	175513

8.4. Glossary

The terminology used in this assessment follows definitions contained within Annex 2 of NPPF:

Archaeological interest	There will be archaeological interest in a heritage asset if it holds, or potentially may hold, evidence of past human activity worthy of expert investigation at some point. Heritage assets with archaeological interest are the primary source of evidence about the substance and evolution of places, and of the people and cultures that made them.
Conservation (for heritage policy)	The process of maintaining and managing change to a heritage asset in a way that sustains and, where appropriate, enhances its significance.
Designated heritage assets	World Heritage Sites, Scheduled Monuments, Listed Buildings, Protected Wreck Sites, Registered Park and Gardens, Registered Battlefields and Conservation Areas designated under the relevant legislation.
Cultural heritage asset	A building monument, site, place, area or landscape identified as having a degree of significance meriting consideration in planning decisions, because of its heritage interest. Heritage assets include designated heritage assets and assets identified by the local planning authority (including local listing).
Historic environment	All aspects of the environment resulting from the interaction between people and places through time, including all surviving physical remains of past human activity, whether visible, buried or submerged, and landscaped and planted or managed flora.
Historic environment record	Information services that seek to provide access to comprehensive and dynamic resources relating to the historic environment of a defined geographic area for public benefit and use.
Significance (for heritage policy)	The value of a heritage asset to this and future generations because of its heritage interest. That interest may be archaeological, architectural, artistic or historic. Significance derives not only from a heritage asset's physical presence, but also from its setting.
Value	An aspect of worth or importance

8.5. Chronology

Where referred to in the text, the main archaeological periods are broadly defined by the following date ranges:

Prehistoric		**Historic**	
Palaeolithic	970,000 – 9,500 BC	**Romano-British**	AD 43 – 410
Mesolithic	9500 – 4000 BC	**Medieval**	AD 410 – 1500
Neolithic	4000 – 2400 BC	**Post-medieval**	AD 1500 – 1900
Bronze Age	2400 – 700 BC	**Modern**	1900 – present day
Iron Age	700 BC – AD 43		

8.6. Copyright and Licencing

Details of archaeological sites in the Tilbury area were provided by CgMs Consulting Ltd originating from the local HER, maintained by Essex County Council. Copyright restrictions apply to all materials obtained from the HER.

Details of wreck were obtained from the UK Hydrographic Office and the Controller of Her Majesty's Stationary Office (www.ukho.gov.uk). All rights reserved.

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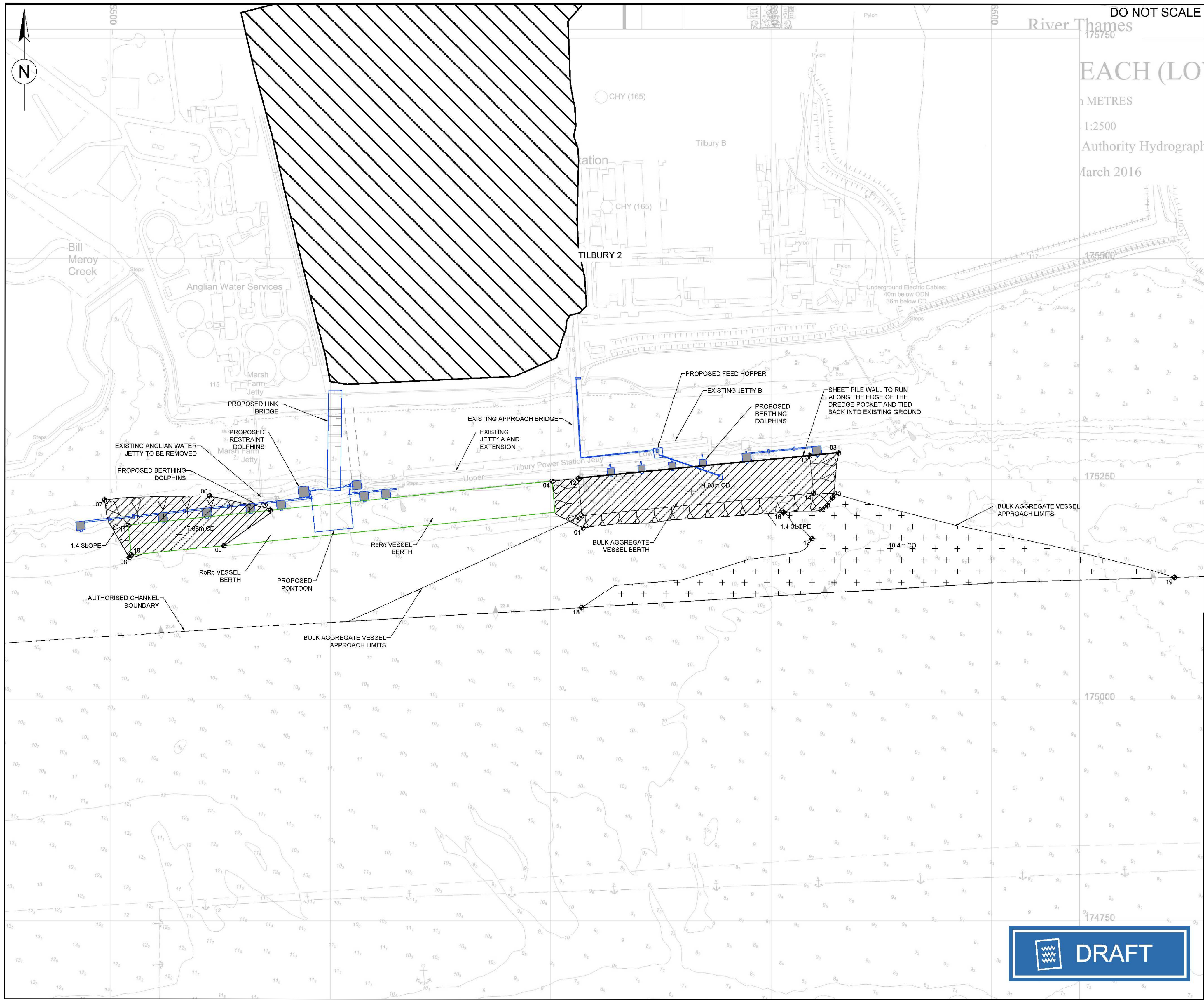
Date:	07/06/2017	Revision Number:	1
Scale:	Main: 1:30,000 at A4	Illustrator:	RG/KJF
Path:	Y:\PROJECTS_Edinburgh\116220\GIS\FigsMXD\DBA\2017_06_07		

Location map

Figure 1



NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. ALL LEVELS ARE TO METRES CHART DATUM (mCD) UNLESS NOTED OTHERWISE.
3. LAND SIDE LAYOUT OMITTED FOR CLARITY
4. THE BATHYMETRIC INFORMATION SHOWN HAS BEEN TAKEN FROM PLA CHART 336 MAY - OCTOBER 2015

CONFIDENTIAL

KEY:

- EXTENT OF BERTHING DREDGING WITH SLOPES NO GREATER THEN 1:4, VOLUME = 80,000m³
- EXTENT OF APPROACH DREDGING VOLUME = 20,000m³
- RORO VESSEL BERTH POCKET
- BULK VESSEL BERTH POCKET
- PROPOSED MARINE WORKS

LOCATION POINTS

ID	EASTING (m)	NORTHING (m)	PROPSOED LEVEL (mCD)
01	566036.70	175194.79	NO CHANGE
02	566313.94	175220.68	NO CHANGE
03	566326.63	175279.92	NO CHANGE
04	566001.37	175248.15	NO CHANGE
05	565681.88	175214.97	-7.88
06	565612.94	175231.34	NO CHANGE
07	565493.73	175226.77	NO CHANGE
08	565521.68	175161.13	NO CHANGE
09	565629.22	175174.87	-7.88
10	565524.09	175164.15	-7.88
11	565520.62	175198.21	-7.88
12	566031.23	175251.07	-14.98
13	566293.92	175276.72	-14.98
14	566298.02	175234.45	-14.98
15	566035.33	175208.79	-14.98
16	566263.86	175212.62	NO CHANGE
17	566296.28	175182.84	NO CHANGE
18	566040.84	175105.13	NO CHANGE
19	566707.97	175138.70	NO CHANGE
20	566319.70	175229.48	NO CHANGE

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Revision Number:	1
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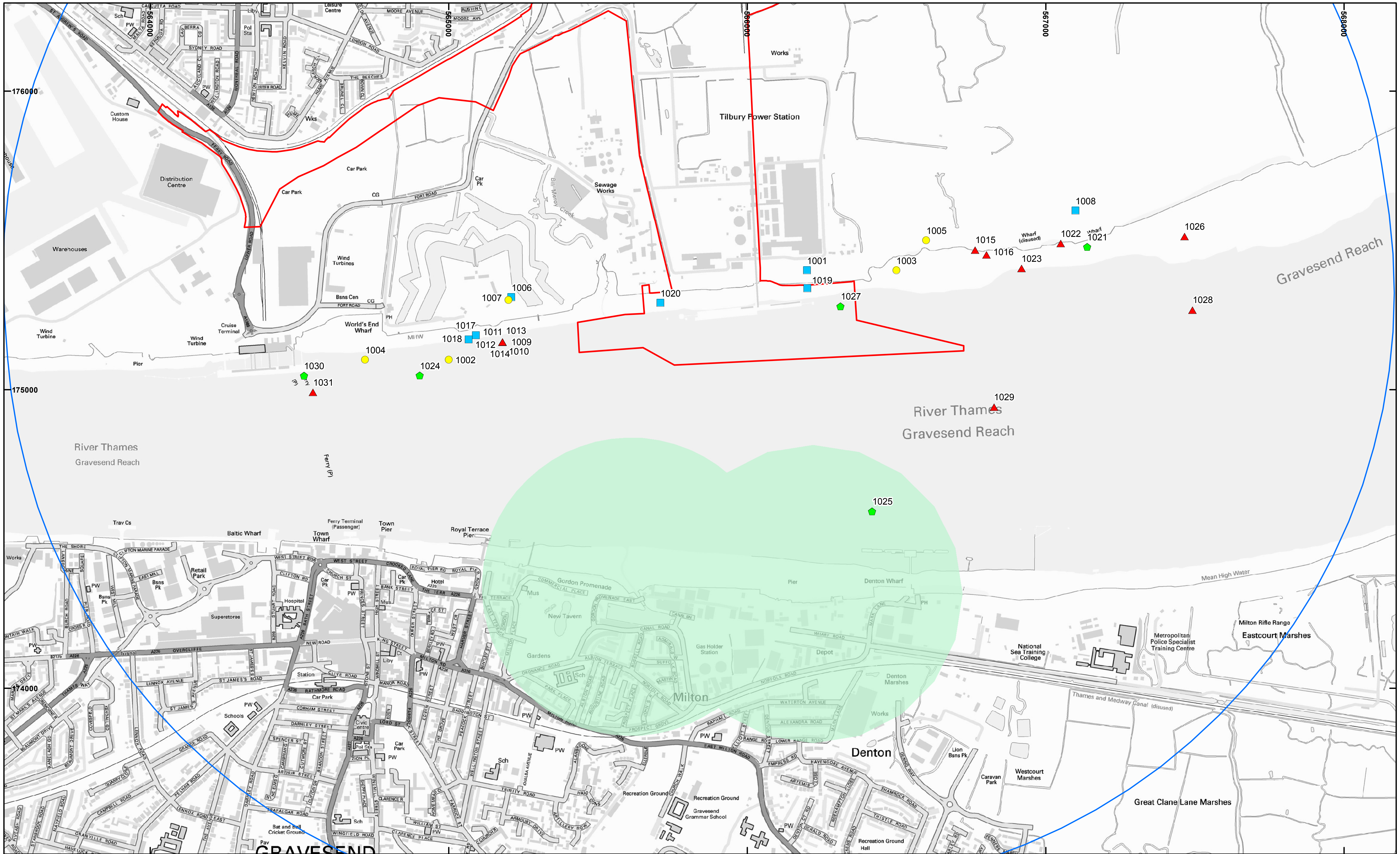
CAD drawing of Proposed Development, showing dredge areas, berthing dolphins and upgrades to jetty (© CgMs)

Figure 2



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2km MSA with inter-tidal and marine archaeological receptors

Figure 3

Plate 1: View from foreshore of Tilbury coaling jetty, facing SE

Plate 2: View from foreshore of Tilbury coaling jetty, facing SW

Date:	08/06/2017	Revision Number:	1
Scale:	N/A	Illustrator:	KJF
Path:	Y:\PROJECTS_Edinburgh\116220\Graphics_Office\Rep figs\DBA\2017_06_07		

Plate 3: View from foreshore of Tilbury coaling jetty covered conveyor, facing SW

Plate 4: Pillbox WA 1001 in inter-tidal mud facing SW

Date:	08/06/2017	Revision Number:	1
Scale:	N/A	Illustrator:	KJF
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Plate 5: Steel/iron barge hulk WA 1015 on foreshore/inter-tidal to east of Tilbury2 Site, facing SE

Plate 6: Undated linear of stones/stakes and arc of stones/stakes in inter-tidal mud, facing SW (WA 1017)

Date:	08/06/2017	Revision Number:	1
Scale:	N/A	Illustrator:	KJF
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Plate 7: Undated line of stakes in inter-tidal mud to east of coaling jetty, facing SE (WA 1019)

Plate 8: Undated concrete feature on foreshore, facing SW (WA 1020)

Date:	08/06/2017	Revision Number:	1
Scale:	N/A	Illustrator:	KJF
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AS 4

Archaeological Watching Brief Land at the Former RWE Power Station, Tilbury, Essex (ASE 2017)

Archaeology South-East

ASE

ARCHAEOLOGICAL WATCHING BRIEF

Land at the Former RWE Power Station
Tilbury
Essex

ASE Project No: 170367

Site Code: THTP17

ASE Report No: 2017190

April 2017

Archaeological Watching Brief

Land at the Former RWE Power Station
Tilbury
Essex

NGR: TQ 65700 75951

ASE Project No: 170376
Site Code: THTP17

ASE Report No: 2017190
OASIS id: 283397

By Mark Germany
Illustrations by Andrew Lewsey

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Date of Issue:	April 2017	
Revision:	Rev.1, 04/05/2017	

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Abstract

This report presents the results of archaeological monitoring of machine removal of contaminated ground within five separate areas at the former Tilbury Power Station site, Tilbury, Essex. The archaeological work was commissioned by CgMs Consulting and undertaken by Archaeology South-East on 06 April and 20 April 2017.

Excavation of all five areas revealed modern made-ground overlying alluvium. The modern made-ground consisted of compacted gritty sand and gravel and was between 0.55m and 1m thick. It included infrequent to occasional pieces of metal scrap and concrete, but no pre-modern archaeological artefacts. This made-ground relates to construction of Tilbury Power Station A, on grazing land from reclaimed salt marsh between 1949 and 1957 and its subsequent development.

The underlying alluvium was not investigated but was observed to be in excess of 1m thickness. This deposit was not cut by any features, either archaeological or modern, and it contained no artefacts.

CONTENTS

1.0 INTRODUCTION

1.1 Site Background

1.1.1 Tilbury Power Station flanks the north side of the River Thames and is located within former marshland east of London and south-east of Tilbury (NGR TQ 6570075951; Figure 1). It is no longer in use and its site is proposed for redevelopment.

1.1.2 The purpose of the archaeological work was to monitor groundworks for the removal of previously identified contaminated ground within Areas 1, 2A, 2B, 2C and 3 in the west half of the power station, for possible exposure of underlying, previously undiscovered, archaeological deposits, features and finds.

1.1.3 The wider purpose of the archaeological work was to obtain information so as to better inform future planning decisions.

1.1.4 Areas 1, 2A, 2B, 2C and 3 varied in size and plan. The extents of each are presented in Table 1 and their locations shown on Figure 2.

Area	Extent (m^2)
1	260
2A	590
2B	110
2C	346
3	350

Table 1: Extents of individual watching brief areas

1.1.5 Previous investigations within the grounds of the station and its surrounding area have revealed and recorded palaeo-environmental deposits of potential national and international academic interest (CgMs 2017).

1.2 Geology and Topography

1.2.1 Tilbury Power Station rest on Thames floodplain deposits of clay, silt, peat and sand above chalk (bgs.ac.uk). The south-side of the power station flanks the north side of the River Thames.

1.2.2 The current ground level of the power station is entirely a product of post-medieval and more recent reclamation and industrial development.

1.2.3 The topography of the power station and it surrounding area is flat, at *c.*2.5m AOD, and composed of existing and former marshland, beneath a man-made levelling deposit of compacted sand and gravel.

1.3 Aims and Objectives (Fig. 2)

1.3.1 The aim of the watching brief was to establish if Areas 1, 2A, 2B, 2C and 3 had any pre-modern archaeological remains and to report on its findings.

1.3.2 The objective of the archaeological work was to discover sediments with palaeoenvironmental remains, thereby enabling improved understanding of the site's past environment.

1.4 Scope of Report

1.4.1 This report presents the results of an archaeological watching brief undertaken on groundwork for removal of sub-surface contaminated ground within five areas (Areas 1, 2A, 2B, 2C and 3) at the former Tilbury Power Station, Essex, in April 2017.

1.4.2 The report describes the watching brief results, assesses their significance and considers the archaeological implication for the wider site.

2.0 ARCHAEOLOGICAL BACKGROUND

2.1 Overview

2.1.1 The main source of the following archaeological background information is derived from a desk-based assessment previously produced for the site (CgMs Consulting 2017).

2.2 Palaeolithic

2.2.1 The Gravel Terrace deposits of the Lower Thames Valley is a known productive area for Palaeolithic remains, including flint hand axes and other flint tools and debris.

2.3 Mesolithic to Iron Age

2.3.1 The River Thames underwent a gradual transition from a braided river system to a single meandering channel during the Holocene, during which thick layers of alluvium increasingly overlaid deposits of chalk and gravel due to relative sea-rise.

2.3.2 In some areas, where deep gravel deposits have been investigated, Mesolithic deposits of peat have been recorded underlying the alluvial sedimentation.

2.3.3 Peat horizons in the Tilbury area record further periods of stabilisation of the valley floor during the Holocene. They contain significant palaeoenvironmental information regarding past environmental and landscape change and are of international importance (Quest 2013).

2.3.4 Environmental evidence for prehistoric activity within the Lower Thames Valley during the later prehistoric period is currently poor, but nonetheless sufficient to indicate episodes of woodland clearance, cultivation and animal husbandry.

2.4 Roman

2.4.1 Roman remains have been found within the wider locality and include Roman graves and grave goods in West Tilbury, and Roman pot sherds from the foreshore of the nearby stretch of the River Thames. Remnants of a Roman settlement have also been found. They were discovered *c.*700m east of the power station and they included a trackway and ring-gullies defining roundhouses.

2.5 **Saxon and Medieval**

2.5.1 Tilbury was recorded as being the location of the palace of Bishop Cedda in *c.*692. The site of that palace is perhaps represented by a nearby series of earthworks, *c.*1.5km north of the power station.

2.5.2 The site consisted of uninhabited coastal marsh during the medieval and post-medieval periods. Part of a medieval sea wall is postulated to survive *c.*450m east of the site.

2.6 Post-medieval and Modern

2.6.1 Historic maps record the site to have been reclaimed from saltmarsh by the early 19th century and to have composed low lying pasture and arable fields separated by drainage channels.

2.6.2 Tilbury Power Station 'A' was built between 1947 and 1949. Its foundations consisted of 13000 precast concrete piles, and its boilers were designed to burn coal, gravity fed from bunkers via mills. Ships bringing oil and coal to the site were offloaded via a reinforced jetty.

2.6.3 Construction of Tilbury Power Station 'B' took place east of the site in the 1960s, during which time the site's jetty was lengthened.

2.6.4 Power station 'A' was partly demolished in 1999 and power station 'B' was converted to burn biomass in 2011. Both power stations were decommissioned in 2016.

2.3 Recent Archaeological Investigation

2.3.1 Archaeological investigations within or partly within the grounds of the site include archaeological monitoring of trial pits and groundworks in the north-east part of the application site, an archaeological aerial photographic and walkover survey (Cox 2010), monitoring of groundworks for the Stanford Le Hope STW water pipeline (ECC 2008) and archaeological trial-trenching and test-pitting ECC 2010. None of these works identified the presence of archaeological finds or features.

3.0 ARCHAEOLOGICAL METHODOLOGY

3.1 Fieldwork Methodology (Fig. 2)

3.1.1 A tracked excavator equipped with a broad toothless bucket was used by the groundworks contractor to strip Areas 1, 2A, 2B, 2C and 3 of their modern overburden. The surface of the underlying alluvium was then visually inspected for archaeological deposits, features and finds.

3.1.2 Details of each area and its contents were recorded on pro-forma watching-brief and context sheets. Digital photographs were taken of work in progress.

3.1.3 No modern artefacts were retained and no soil samples were collected because no datable pre-modern features containing deposits with potential for the survival of environmental remains were encountered.

3.2 Fieldwork Constraints

3.2.1 The only fieldwork constraint was that no excavation greater than *c.*1.2m was to be humanly accessed for reasons of safety.

3.3 Site Archive

3.3.1 The site archive consists of entirely of paperwork and digital files and will be deposited at Southend Museum, subject to agreement with the site's legal landowner. The contents of the site archive are tabulated below (Table 2).

Number of Contexts	3
No. of files/paper record	1 file
Plan and sections sheets	0
Colour photographs	0
B&W photos	0
Digital photos	50
Permatrace sheets	0
Trench Record Forms	5

Table 2: Quantification of site archive

4.0 RESULTS (Figs 2 to 4)

4.1 The recorded deposit sequences across the five areas were generally consistent and are described collectively below.

4.2 The groundwork for decontamination Areas 1, A, 2B, 2C and 3 revealed a simple sequence of modern-made ground [001] overlying alluvium [002] in all cases. The only other recorded deposit was a thin layer of topsoil [3] resting on modern-made ground in Area 3, on the western periphery of the site. No pre-modern modern deposits, features or finds were identified to overlie or cut into the deposit of alluvium.

4.1.1 The surface of alluvium [002] was level. This deposit consisted of grey, soft sandy silt with infrequent small stones. Although groundworks stopped at the top of this, where excavated deeper along one edge of Area 2C it was established to be in excess of 1m thick. No peat horizons were seen in this upper portion of the deposit.

4.1.2 The modern made-ground comprised compacted brownish orange friable to firm gritty sandy silt with variable amounts of gravel. Occasional modern artefacts were observed within it and included pieces of scrap iron and concrete. The thickness of the deposit varied between 0.55-1.0m across the five areas, but was greatest in Area 3 (Table 3).

Area	**Context**	**Type**	**Interpretation**	**Deposit Thickness m**
1	001	Layer	Made-ground	0.55
	002	Layer	Alluvium	0.05+
2A	001	Layer	Made-ground	0.60
	002	Layer	Alluvium	1.00+
2B	001	Layer	Made-ground	0.70
	002	Layer	Alluvium	0.30+
2C	001	Layer	Made-ground	0.70
	002	Layer	Alluvium	0.38+
3	001	Layer	Made-ground	1.00
	002	Layer	Alluvium	0.05+
	003	Layer	Topsoil	0.35

Table 3: List of recorded contexts

5.0 FINDS AND ENVIRONMENTAL REMAINS

5.1 Summary

5.1.1 The excavation of decontamination Areas 1, 2A, 2B, 2C and 3 revealed pieces of modern building materials, but no pre-modern artefacts. Due to their obviously modern date, none of these artefacts were collected and retained.

5.1.2 No deposits judged suitable for sampling for the presence of environmental remains were identified.

6.0 DISCUSSION AND CONCLUSIONS

6.1 Discussion

6.1.1 The watching brief undertaken on decontamination groundworks at the five locations within the former power station site has established that a consistent deposit sequence is present across the site. This comprises up to a 1.0m thickness of modern made-ground overlying an alluvial deposit of substantial thickness. A further modern topsoil layer was recorded over made-ground in Area 3, presumably reflecting the peripheral nature of this location on the western edge of the site.

6.1.2 The made-ground deposit is associated with the preparation/construction of the Power Station and has no archaeological significance. The underlying upper surface of the alluvium was observed to be flat and level, suggesting that some degree of horizontal truncation of this deposit has occurred as part of the preparation of the power station site. The extent of this truncation has not been established by these works.

6.1.3 The alluvium deposit has been established to be in excess of 1.0m thickness. Previous test-pit and borehole monitoring of this site recorded a similar deposit sequence and demonstrated the full thickness of the alluvium to be approximately 12m (Wessex Archaeology 2008). No artefacts were identified in, or extracted from, the exposed surface of the alluvium. It remains possible that significant palaeoarchaeological deposits (e.g. peat layers) are present at greater depth.

6.1.4 No archaeological features were found cutting into, or deposits overlying, the alluvium. While this may be due to truncation by power station construction-related activities, it is possible that this absence of archaeological remains is real and due to the site being located on reclaimed land (former saltmarsh) and that previous land use was of a wholly marginal nature (pastoral farming, etc).

6.2 Conclusion

6.2.1 The various areas of decontamination groundworks subject to this archaeological watching brief have been established to contain no surface/near-surface archaeological remains.

6.2.2 A consistent deposit sequence was recorded across all areas, comprising modern made-ground over alluvium. Although the top of the alluvium has been subject to modern truncation by power station construction, this Holocene deposit has been shown by a previous borehole survey to survive to a substantial thickness and it is possible that significant palaeoarchaeological deposits, such as peat horizons, survive at greater depth.

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ACKNOWLEDGEMENTS

Archaeology South-East thanks CgMs Consulting for commissioning the archaeological work and for its help and assistance. The archaeological work was managed by Andy Leonard and was undertaken by Mark Germany. The post-excavation process was managed by Mark Atkinson and figures 1 to 3 were drawn by Andrew Lewsey.

HER Summary

<table>
<tr><td colspan="2">Site name/Address: Former Tilbury Power Station site , Fort Road, Tilbury</td></tr>
<tr><td>Parish: Tilbury</td><td>District: Thurrock</td></tr>
<tr><td>NGR: TQ 65700 75951</td><td>Site Code: THTP17</td></tr>
<tr><td>Type of Work: Watching brief</td><td>Site Director/Group: Mark Germany
Archaeology South-East</td></tr>
<tr><td>Date of Work: 6/4/17 & 20/4/17</td><td>Size of Area Investigated: 1656m^2</td></tr>
<tr><td>Location of Finds/Curating Museum:
Thurrock Museum</td><td>Funding source: client</td></tr>
<tr><td>Further Seasons Anticipated?: No</td><td>Related HER No’s:</td></tr>
<tr><td>Final Report: EAH roundup</td><td>OASIS No: 283397</td></tr>
<tr><td colspan="2">Periods Represented: Modern</td></tr>
<tr><td colspan="2">SUMMARY OF FIELDWORK RESULTS:
Machine removal of contaminated land within five separate areas at the former Tilbury Power Station revealed a consistent deposit sequence of modern made-ground overlying alluvium, but no pre-modern archaeological features or finds.

Excavation of all five areas revealed modern made-ground overlying alluvium. The made-ground consisted of compacted gritty sand and gravel and was between 0.55m and 1m thick. It included infrequent to occasional pieces of metal scrap and concrete, but no pre-modern archaeological artefacts.

The underlying alluvium was not investigated but was observed to be in excess of 1m thickness. This deposit was not cut by any features, either archaeological or modern, and it contained no artefacts.

The layer of modern made-ground probably relates to construction of Tilbury power Station A, on grazing land from reclaimed salt marsh between 1949 and 1957. It provides a firm surface and it artificially raises the height of the site to prevent it from flooding. The underlying layer of alluvium is a Holocene deposit, but otherwise undated here.</td></tr>
<tr><td colspan="2">Previous Summaries/Reports: None</td></tr>
<tr><td>Author of Summary: Mark Germany</td><td>Date of Summary: April 2017</td></tr>
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OASIS Form

OASIS ID: archaeol6-283397	
Project details	
Project name	Former Tilbury Power Station, Tilbury, Essex
Short description of the project	Archaeological monitoring of machine removal of contaminated ground within five areas at the former Tilbury Power Station site, revealed modern made-ground overlying the Holocene alluvium deposit. No archaeological features or finds were identified.
Project dates	Start: 06-04-2017 End: 20-04-2017
Previous/future work	No / No
Any associated project reference codes	170367 - Contracting Unit No.
Type of project	Recording project
Site status	Listed Building
Current Land use	Transport and Utilities 3 - Utilities
Monument type	POWER STATION Modern
Monument type	ALLUVIUM Uncertain
Significant Finds	NONE None
Investigation type	'"Watching Brief"'
Prompt	Environmental (unspecified schedule)
Project location	
Country	England
Site location	ESSEX THURROCK EAST TILBURY Tilbury Power Station
Postcode	RM18 8UJ
Study area	81 Hectares
Site coordinates	TQ 65700 75951 51.457723284555 0.385349445632 51 27 27 N 000 23 07 E Point
Height OD / Depth	Min: 2m Max: 2.5m
Project creators	
Name of Organisation	Archaeology South East
Project brief originator	CgMs Consulting
Project director/manager	Andy Leonard
Project supervisor	Mark Germany
Type of sponsor/funding body	consultant
Name of sponsor/funding body	CgMs Consulting
Project archives	

Physical Archive Exists?	No
Digital Archive recipient	Thurrock Museum
Digital Contents	"Stratigraphic"
Digital Media available	"Images raster / digital photography","Text"
Paper Archive recipient	Thurrock Museum
Paper Contents	"Stratigraphic"
Paper Media available	"Context sheet","Photograph","Plan","Report"
Project bibliography	
Publication type	Grey literature (unpublished document/manuscript)
Title	Archaeological Watching Brief. Land at the former RWE power station, Tilbury, Essex
Author(s)/Editor(s)	Germany, M.
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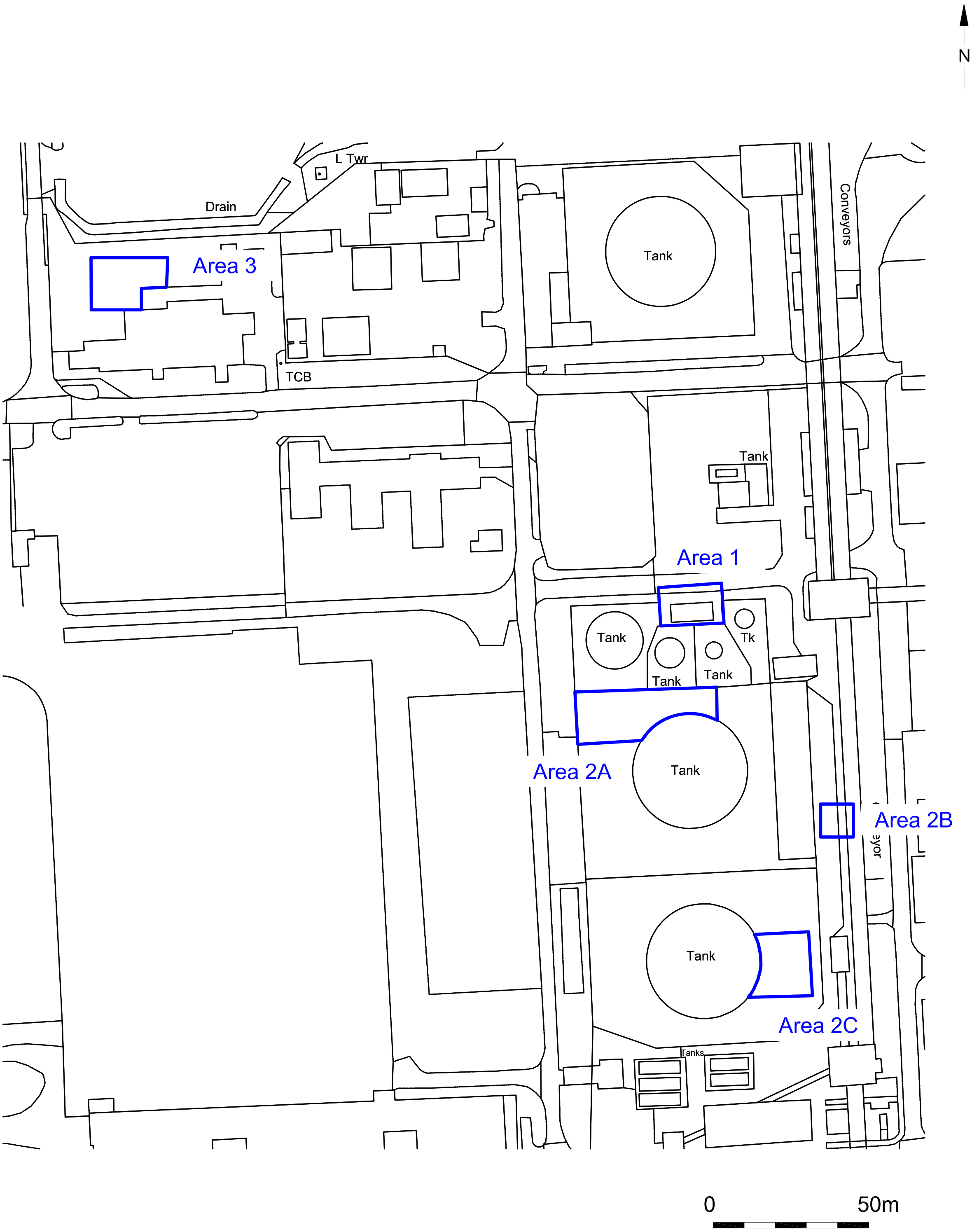
Entered by	Mark Atkinson (mark.atkinson@ucl.ac.uk)
Entered on	26 April 2017

© Archaeology South-East		Tilbury Power Station	Fig. 1
Project Ref: 170367	Apr 2017	Site location	
Report No: 2017190	Drawn by:		



© Archaeology South-East		Tilbury Power Station	Fig. 2
Project Ref: 170367	Apr 2017	Location of monitored areas	
Report Ref: 2017190	Drawn by: APL		

Area 1, looking west

Area 2A, looking east

Area 2A, modern-made ground, looking south

Area 2B, looking south

Area 2B, modern-made ground looking east

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Project Ref: 170367	Apr 2017	Photographs of Areas 1 - 2B	
Report Ref: 2017190	Drawn by: APL		

Area 2C, looking north

Area 2C, modern-made ground, looking east

Area 3, modern-made ground, looking south

Area 3, looking south

© **Archaeology South-East**		Tilbury Power Station	Fig. 4
Project Ref: 170367	Apr 2017	Photographs of Areas 2C - 3	
Report Ref: 2017190	Drawn by: APL		

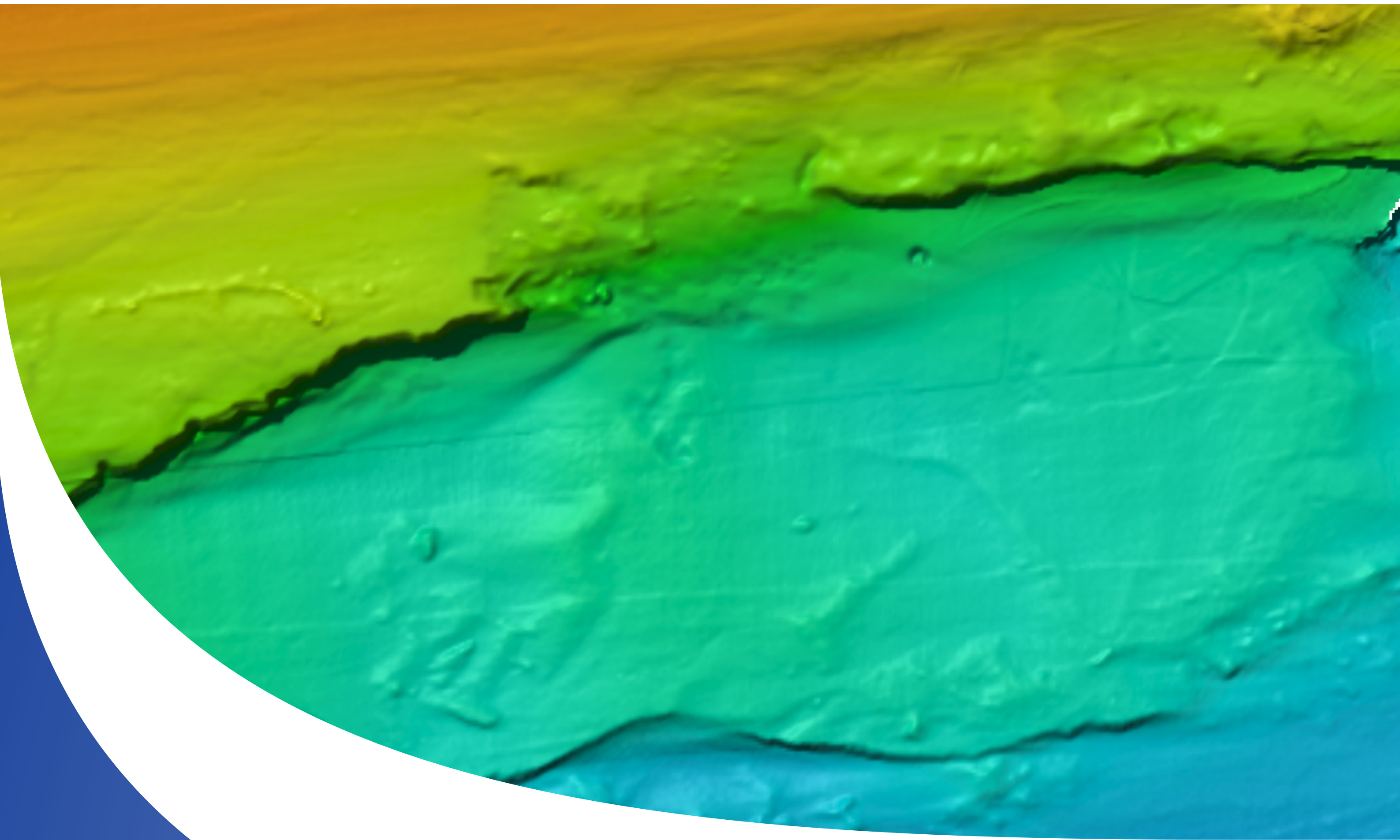
AS 5

Archaeological Assessment of Marine Geophysical Survey Data

(Wessex Archaeology 2017)

Tilbury 2
Land at the former RWE Power Station
Tilbury, Essex

Archaeological Assessment of Marine Geophysical Survey Data



Ref: 116220.03
September
2017

wessexarchaeology

Tilbury 2
Land at the former RWE Power Station
Tilbury, Essex

Archaeological Assessment of Marine Geophysical Survey Data

Prepared for:
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On behalf of:
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September 2017

116220.03

Quality Assurance

Project Code	116220	**Accession Code**		**Client Ref.**	22460
Planning Application Ref.	PINS TRO30003	**Ordnance Survey (OS) national grid reference (NGR)**	TQ6570075951		

Version	Status*	Prepared by	Checked and Approved By	Approver's Signature	Date
v01	E	*A Mynett*	*L Tizzard*	[redacted]	09/06/17
File:	116220_Tilbury_Marine_Geophysics_V01_20170609.pdf				
v02	F	*A Mynett*	*L Tizzard*	[redacted]	26/06/17
File:	116220_Tilbury_Marine_Geophysics_V02_20170627.pdf				
File:					
File:					
File:					

* I = Internal Draft; E = External Draft; F = Final

Tilbury 2
Land at the former RWE Power Station
Tilbury, Essex

Archaeological Assessment of Marine Geophysical Survey Data

Contents

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List of Illustrations

Tilbury 2
Land at the former RWE Power Station
Tilbury, Essex

Archaeological Assessment of Marine Geophysical Survey Data

Summary

Wessex Archaeology was commissioned by CgMs Consulting Ltd on behalf of Port of Tilbury London Ltd to undertake an archaeological assessment of marine geophysical survey data over the proposed Tilbury2 Site on land at the former RWE power station at Tilbury, Essex.

The current assessment interpreted geophysical survey data acquired by SAND Geophysics Limited and Port of London Authorities in April 2017. The data comprised sidescan sonar, magnetometer, multibeam bathymetry and *.pdf* images of 3D chip sub-bottom profiler data. Data from two survey areas, Study Area West and Study Area East within the development area, were assessed.

In total, throughout the Study Areas, 116 anomalies have been identified as being of possible archaeological interest; all of these are classified as A2 archaeological discrimination (uncertain origin of possible archaeological interest).

In addition to these there are an additional 70 isolated anomalies identified in the 3D chirp data that could represent buried material, with no associated magnetic anomaly indicating a non-ferrous composition. These anomalies could represent buried material which has the potential to be archaeological in nature.

Although, the features identified have been discriminated as potential archaeology it needs to be acknowledged that sections of the areas have been previously dredged and previous development in the area has considerably impacted the river-bed. It is possible that the debris identified is modern in nature rather than of archaeological interest. However, further investigation would ascertain the true nature of the material.

No Archaeological Exclusion Zones (AEZs) are recommended for any of these anomalies at this time. It is, however, likely that further investigations will be required to mitigate against any impact from the proposed development. Proposed mitigation measures are detailed in the Archaeological Written Scheme of Investigation (Wessex Archaeology 2017).

Tilbury 2
Land at the former RWE Power Station
Tilbury, Essex

Archaeological Assessment of Marine Geophysical Survey Data

1 INTRODUCTION

1.1 Background

1.1.1 Wessex Archaeology was commissioned by CgMs Consulting Ltd (CgMs) on behalf of Port of Tilbury London Ltd (PoTLL) to undertake an archaeological assessment of marine geophysical survey data at the proposed Tilbury2 Site port expansion Development Area in Tilbury, Essex. The site is located on the north bank of the Thames Estuary (**Figure 1**).

1.1.2 The proposals within the inter-tidal and marine parts of the Tilbury2 Site involves the re-development of the location as a new port terminal, upgrading the present jetty with new berthing dolphins, a link bridge and additional hopper and conveyor belt and a new berth for roll-on/roll-off (Ro-Ro) ships. The raised pipeline to the Anglian Water Services sewage treatment plant to the west of the site will be removed. Associated dredge pockets around the jetty to create the berth will also be included in the proposals, and are included within the Red Line Boundary (RBL) of the inter-tidal and marine parts of the Tilbury2 Site.

1.1.3 To facilitate its use for both the roll-on roll-off (Ro-Ro) terminal and the aggregates facility the existing jetty will be modified at both its upstream and downstream arms. The Ro-Ro berth, located at the western end of the existing jetty, will accommodate two vessels at a time and thus the existing jetty will be modified and extended to enable this. Similarly, the CMAT berth located at the eastern end of the existing jetty will be extended to accommodate barges and vessels of the required size.

1.1.4 Dredging will take place around the improved terminal jetty to create a berthing pocket. In relation to the downstream (CMAT) jetty, the depth of pocket will be circa 15m and cater for the largest likely bulk aggregate vessels to visit the site in the future (100,000 tonnes). A sheet pile wall will be installed to run along the northern edge of the dredge pocket. The Ro-Ro berthing pocket (next to the western end of the existing jetty and around its westward extension) will require less dredging in order to create a depth of 7.88m. The immediately adjoining approaches to the berth pockets are also to be dredged.

1.1.5 Wessex Archaeology has previously carried out an archaeological assessment of geophysical data over the proposed Tilbury ‘C’ coal jetty expansion associated with Tilbury Power Station in 2007 (Wessex Archaeology 2007). The data assessed consisted of multibeam bathymetry only, acquired by Port of London Authorities (PLA). A Marine Archaeological Desk Based Assessment over the land at the proposed Tilbury2 Site was undertaken by Wessex Archaeology in 2017 (Wessex Archaeology 2017).

1.1.6 This report presents the results of the archaeological review of geophysical data (sidescan sonar, magnetometer and multibeam bathymetry data, and 3D chirp interpretation) within two survey areas at Tilbury2, Study Area West and Study Area East (**Figure 1**). The data were acquired by SAND Geophysics Limited (SAND) and PLA in 2017 (Sand 2017).

1.2 Aims and objectives

1.2.1 The aim of this review was to undertake an archaeological assessment of 2017 geophysical survey data acquired over the Study Areas at Tilbury2. The objectives were as follows:

- *To assess the geophysical survey data acquired by SAND and PLA in 2017 to identify any material of possible archaeological and cultural heritage significance present within the Study Areas;*
- *To compare the results of the geophysical interpretation with the results of any historic records within the Study Areas and;*
- *To recommend mitigation measures for any potential archaeological or cultural heritage assets newly identified within the Study Areas, including the addition of Archaeological Exclusion Zones (AEZs) where necessary within the Study Areas.*

2 METHODOLOGY

2.1 Data sources

2.1.1 Wreck and obstruction data within the Study Areas were obtained from the United Kingdom Hydrographic Office (UKHO) and the National Record for the Historic Environment (NRHE) maintained by Historic England. Any records located within the Study Areas were integrated with the geophysical results as outlined in **Section 2.5**.

2.1.2 The geophysical survey data comprised sidescan sonar, magnetometer, multibeam bathymetry and sub-bottom profiler 3D chirp data acquired in 2017 by SAND and PLA between 18 and 27 April.

2.1.3 Any sites found to be outside the Study Areas, by any distance, are deemed beyond the scope of the current assessment and are subsequently not included in this report.

2.1.4 Data gaps have been identified for the sidescan sonar, magnetometer and multibeam bathymetry data within the Study Areas and are illustrated in **Figure 2**. Existing infrastructure likely restricted the survey coverage.

2.2 Geophysical data – technical specifications

2.2.1 The geophysical survey data were acquired by SAND and PLA between 18 and 27 April onboard survey vessel *Maplin*. SAND acquired the sidescan sonar, magnetometer and sub-bottom profiler data and PLA acquired the multibeam bathymetry data in parallel with the geophysical acquisition (SAND 2017).

2.2.2 The two survey areas consisted of a west and an eastern section, 400 m x 150 m and 750 m x 200 m respectively.

2.2.3 The sidescan sonar deployed for the survey was an Edgetech 4200 duel frequency towfish operating at high (900 kHz) and low (400 kHz) frequencies with a 50 m range. On playback of the data Wessex Archaeology found the effective range to be 35 m. The sonar was towed at approximately 2 - 6 m above the seabed (SAND 2017). Survey lines were run at a nominal line spacing of 25 m. The sidescan sonar files were provided to Wessex Archaeology as *.xtf* files.

2.2.4 Two Geometrics G-882 magnetometers were deployed for the survey, one of which had an altimeter and a depth sensor. These were spaced 1.5 m apart using an STR gradiometer frame. The magnetometers were towed at 5 m above the seabed and in shallow areas two fenders were attached to the sensors to prevent them hitting the seabed. A 3-m line spacing was used to cover the survey areas and a target of no greater than 5 m spacing between lines, infill lines run as necessary (SAND 2017). The magnetometer data were provided to Wessex Archaeology as a *.csv* file.

2.2.5 A Kongsberg GeoChirp 3D was used to acquire sub-bottom profiler data. The system has an array of 60 hydrophones fixed around four chirp transducers and was hull mounted to the port side of the *Maplin*. A grid of 1 m survey lines was used to acquire the sub-bottom profiler data with infill lines run as necessary. The 3D chirp data were provided as a series of *.pdf* images along with details of the anomalies identified.

2.2.6 A permanently mounted R2Sonic 2024 multibeam echosounder system was used to acquire the multibeam bathymetry data. The majority of the data was collected at 700 kHz and where full coverage was not achieved the resolution was lowered to 230 kHz allowing for greater coverage in shallow areas and underneath structures (PLA 2017). The bathymetry data were provided to Wessex Archaeology as *.xyz* files.

2.2.7 The survey data was acquired using WGS84 UTM31N. However, all results were converted to OSGB36 British National Grid co-ordinate system. All results are provided in OSGB36 British National Grid and were transformed using OSTN2 NTv2 transformation.

2.3 Geophysical data – data quality

2.3.1 The geophysical data comprised sidescan sonar, magnetometer, multibeam bathymetry and sub-bottom profiler 3D chirp datasets. Each of these was assessed for their quality and rating using the following criteria listed in **Table 1.**

Table 1: Criteria for assessing data quality rating

Data Quality	Description
Good	Data which are clear and unaffected by weather conditions or sea state. The dataset is suitable for the interpretation of standing and partially buried metal wrecks and their character and associated debris field. These data also provide the highest chance of identifying wooden wrecks and debris.
Average	Data which are affected by weather conditions and sea state to a slight or moderate degree. The dataset is suitable for the identification and partial interpretation of standing and partially buried metal wrecks, and the larger elements of their debris fields. Wooden wrecks may be visible in the data, but their identification as such is likely to be difficult.
Variable	This category contains datasets with the quality of individual lines ranging from good to average to below average. The dataset is suitable for the identification of standing and some partially buried metal wrecks. Detailed interpretation of the wrecks and debris field is likely to be problematic. Wooden wrecks are unlikely to be identified.

2.3.2 The sidescan sonar data have been rated as 'Variable' using the above criteria table, with some lines exhibiting good quality data and others being below average quality with some evidence of poor weather and/or river conditions. Overall the data were adequate for archaeological assessment.

2.3.3 The magnetometer data have been rated as 'Variable' using the above criteria table. The site contains high magnetic background variation which is visible throughout the data caused by the underlying geology throughout the area, as well as infrastructure which greatly impacted the background levels of the magnetic amplitude. These factors make identifying magnetic anomalies of archaeological potential difficult and may also mask smaller magnetic anomalies. As such, it cannot be guaranteed that all ferrous debris have been identified during this assessment.

2.3.4 The multibeam bathymetry data have been rated as ‘Good’ using the criteria table above, the data quality and resolution of 0.25 cm was found to be of a high standard and suitable for the archaeological assessment of seabed objects and debris over 0.25 cm.

2.4 Geophysical data – processing

2.4.1 The high frequency *.xtf* files sidescan sonar data files were processed by Wessex Archaeology using Coda Geosurvey software. This allowed for the data to be replayed with various gain settings in order to optimise the quality of the images. The data were initially scanned to give an understanding of the geological nature of the site and were then interpreted for any objects of possible anthropogenic origin. This involves creating a database of anomalies within Coda by tagging individual features of possible archaeological potential, recording their positions and dimensions and acquiring an image of each anomaly for future reference.

2.4.2 A mosaic of the sidescan sonar data is produced during this process to assess the quality of the sonar towfish positioning. The survey lines are smoothed and the navigation corrected. This process allows the positioning of anomalies to be checked between different survey lines and for the layback values to be further refined if necessary.

2.4.3 The form, size and/or extent of an anomaly is a guide to its potential to be an anthropogenic feature and therefore of archaeological interest. A single small but prominent anomaly may be part of a much more extensive feature that is largely buried. Similarly, a scatter of minor anomalies may define the edge of a buried but intact feature, or it may be all that remains as a result of past impacts from, for example, dredging or fishing.

2.4.4 The magnetometer *.csv* data files were processed in Geometrics MagPick software. The assessment was carried out in order to identify any discrete magnetic contacts which could represent buried debris or structures such as wrecks.

2.4.5 The software enables both the visualisation of individual lines of data and the gridding of data to produce a magnetic anomaly map. The data were smoothed to try and eliminate any observed noise, a trend was then fitted to the resulting data and the trend values subtracted from the smoothed values. This was carried out in an attempt to remove natural variations in the data (such as diurnal variations in magnetic field strength and changes in geology). The processed data were then gridded to produce a map of magnetic anomalies. Individual anomalies were tagged and images taken in a similar process to that undertaken for the sidescan sonar data.

2.4.6 The multibeam bathymetry data were analysed to identify any unusual seabed structures that could be shipwrecks or other anthropogenic debris. The data were gridded at the appropriate resolution and analysed using Fledermaus software, which enables a 3-D visualisation of the acquired data and geo-picking of seabed anomalies.

2.4.7 The sub-bottom profiler data were not processed by Wessex Archaeology, *.pdf* images of targets identified by SAND in the 3D chirp data were provided and assessed by Wessex Archaeology for their archaeological potential, for items such as buried objects.

2.5 Geophysical data – anomaly grouping and discrimination

2.5.1 The previous section describes the initial interpretation of all available geophysical datasets which were conducted independently of one another. This inevitable leads to the possibility of any one object being the cause of numerous anomalies in different datasets and apparently overstating the number of archaeological features in the Study Areas.

2.5.2 To address this fact, the anomalies were grouped together along with any features from NRHE and UKHO records of wrecks and obstructions that fall within the Study Areas. This allows for one ID number to be assigned to a single object for which there may be, for example, a UKHO record, a magnetic anomaly and multiple sidescan sonar anomalies.

2.5.3 Once all geophysical anomalies and desk-based information have been grouped, a discrimination flag is added to the record in order to discriminate against those which are not thought to be of an archaeological concern. These flags are as follows:

Table 2: Criteria discriminating relevance of seabed feature to proposed development

Non-Archaeological	U1	Not of anthropogenic origin
	U2	Known non-archaeological feature
	U3	Recorded loss
Archaeological	A1	Anthropogenic origin of archaeological interest
	A2	Uncertain origin of possible archaeological interest
	A3	Historic record of possible archaeological interest with no corresponding geophysical anomaly

2.5.4 The results of this assessment are presented in **Figures 3** and **4**, **Appendix I** and are discussed below.

2.5.5 Wessex Archaeology assessed *.pdf* images of the sub-bottom profiler 3D chirp data of anomalies identified by SAND (2017). The 3D chirp assessment results and images were cross-referenced with identified anomalies (from sidescan sonar, multibeam bathymetry and magnetometer data) to establish if the anomalies had the potential to be buried objects of possible archaeological interest. Those that were associated where integrated into the gazetteer (Appendix I). A full list of anomalies identified by SAND are listed in **Appendix II**.

2.5.6 The grouping and discrimination of information at this stage is based on all available information and is not definitive. It allows for all features of potential archaeological interest to be highlighted, while retaining all the information produced during the course of the geophysical interpretation and desk-based assessment for further evaluation should more information become available.

3 RESULTS

3.1 Overview

3.1.1 The results of this assessment are collated in gazetteer format and detailed in **Appendix I** and illustrated in **Figures 3** and **4**.

3.1.2 A total of 311 individual anomalies of possible archaeological potential were identified by Wessex Archaeology. A large number of these were interpreted during the anomaly grouping and discrimination stage to be probable natural seabed features such as boulders and cobbles on the seabed, natural magnetic fluctuations, existing infrastructure or modern debris. In total, 116 grouped seabed features have been identified as being of potential archaeological interest within the Study Areas. These anomalies are discriminated as follows:

Table 3: Features of archaeological potential within the Study Areas

Archaeological Discrimination	Interpretation	Study Area West Quantity	Study Area East Quantity	Total Quantity
A1	Anthropogenic origin of archaeological interest	0	0	0
A2	Uncertain origin of possible archaeological interest	25	91	116
A3	Historic record of possible archaeological interest with no corresponding geophysical anomaly	0	0	0
Total		**25**	**91**	**116**

3.1.3 Furthermore, these anomalies can also be classified by probable type, which can further aid in assigning archaeological potential and importance:

Table 4: Types of anomalies identified within the Study Areas

Feature Classification	Study Area West Quantity	Study Area East Quantity	Total Quantity
Debris	6	9	15
Debris field	0	2	2
Dark reflector	7	5	12
Bright reflector	1	1	2
Magnetic	11	74	85
Total	**25**	**91**	**116**

3.1.4 A total of 20 3D chirp anomalies were grouped with the above listed anomalies. In addition to these, SAND identified an additional 70 isolated anomalies that could represent buried material, with no surface expression or associated magnetic anomaly indicating a non-ferrous composition. These anomalies could represent buried material or natural variations. If buried material, there is potential for these to be archaeological in nature.

3.1.5 A more detailed assessment of each Study Area is provided below.

3.2 Study Area West

3.2.1 All 25 anomalies in Study Area West have been discriminated as A2 – Uncertain origin of possible archaeological interest.

3.2.2 Six of these anomalies (**7004**, **7006**, **7014**, **7021**, **7022** and **7025**) have been identified as debris. Anomaly **7006** and **7021** both have large magnetic signatures indicating ferrous composition. Anomaly **7006**, measuring 6.3 x 1.5 x 0.8 m, is a distinct complex curvilinear reflector with a magnetic amplitude of 870 nT and is interpreted as ferrous debris. A 3D chirp anomaly (TIL2_3DC_057) is situated within 7 m of the anomaly at a depth of 2.1 m sub-seabed and may be associated with this feature. Anomaly **7021**, measuring 2.8 x 2.2 x 0.4 m with a magnetic amplitude of 549 nT, is also interpreted as ferrous debris.

3.2.3 Anomaly **7004**, measuring 2.5 x 0.4 x 0.2 m is situated in an area not covered by magnetometer data and as such it is not possible to comment on whether the debris is ferrous or not. Anomalies **7014**, **7022** and **7025** are all interpreted as non-ferrous debris. A

3D chirp anomaly (TIL2_3DC_053) is situated within 5 m of **7025** at a depth of 0.22 m sub-seabed and may be associated with this feature.

3.2.4 One anomaly (**7023**) has been identified as a small bright reflector measuring 0.8 x 0.7 m. This is a feature of low reflectivity and could represent the presence of waterlogged wood or synthetic material (**Figure 5**).

3.2.5 Seven anomalies (for full list see **Appendix I**) have been classified as dark reflectors; objects of unknown origin. None of these anomalies have an associated magnetic amplitude. However, anomalies **7005** and **7024, 7028 and 7029** are not covered by magnetometer data and therefore it is unknown if these features have ferrous content.

3.2.6 These objects range in size from 0.3 x 0.3 x 0.1 m (**7024**) up to 2.4 x 0.3 x 0.1 m (**7005**) and are interpreted as pieces of non-ferrous debris or natural features. Anomaly **7003** (1.7 x 0.3 m) is possibly associated with a 3D chirp anomaly (TIL2_3DC_003) which indicates burial to 1 m sub-seabed.

3.2.7 The remaining 11 A2 anomalies (for full list see **Appendix I**) have been classified as magnetic only anomalies with no associated SSS or MBES contacts and have been interpreted as possible buried ferrous debris. These anomalies range in size from 67 nT (**7109**) up to 2741 nT (**7076**). Three magnetic anomalies are possibly associated with 3D chirp anomalies. A 3D chirp anomaly (TIL2_3DC_031) is situated within 5 m of **7058** at a depth of 0.29 m sub-seabed and may be associated with this feature. A 3D chirp anomaly (TIL2_3DC_043) is situated within 7 m of **7088** at a depth of 0.53 m sub-seabed and may be associated with this feature. A 3D chirp anomaly (TIL2_3DC_024) is situated within 6 m of **7089** at a depth of 1.81 m sub-seabed and may be associated with this feature.

3.2.8 There are no anomalies in the eastern section of the area which has previously been deepened. Any previously existing archaeology would have been removed during this process.

3.2.9 In addition to the seven 3D chirp anomalies mentioned above, SAND identified an additional 35 isolated anomalies that could represent buried material, with no surface expression or associated magnetic anomaly indicating a non-ferrous composition. These anomalies could represent buried material which has the potential to be archaeological in nature.

3.3 Study Area East

3.3.1 All 91 anomalies in Study Area East have been discriminated as A2 – Uncertain origin of possible archaeological interest.

3.3.2 There are two large debris fields identified on the surface of the seabed. Anomaly **7007 (Figure 5)** covers a large area measuring 80 x 30 m comprises tens of thin, linear and rounded features scattered across the seabed. This area is not fully covered by the magnetometer data and as such ferrous composition is unknown. It is located in the north of the area, to the south of existing infrastructure and may represent modern debris associated with its development. Further investigation would be required to establish the nature of this debris field.

3.3.3 Anomaly **7008** is situated in the north-east of the area and measures 6.6 x 6.0 m with a height of 0.6 m. Three distinct and thin linear objects aligned with smaller debris items in-between are observed. The area is not covered by the magnetometer data and may be ferrous debris. There is also a 3D chirp target (TIL2_3DC_240) located 9 m from this location and may be associated at a depth of 2.7 m sub-seabed.

3.3.4 Nine of these anomalies (**7000**, **7001**, **7009**, **7010**, **7011**, **7012**, **7017**, **7018** and **7020**) have been interpreted as debris.

3.3.5 Of these, all but **7010** and **7012**, have an associated magnetic response indicating ferrous composition. Anomalies **7010** and **7012** are situated in an area with no magnetometer data coverage and as such ferrous content is unknown.

3.3.6 Anomaly **7000**, measuring 1.8 x 1.4 x 0.2 m with a magnetic amplitude of 108 nT is interpreted as a possible anchor (**Figure 5**). Anomaly **7001**, measuring 5.3 x 1.0 x 0.2 m, is a distinct linear reflector with a very large magnetic amplitude of 4824 nT and is interpreted as a considerable item of ferrous debris. The largest piece of debris (**7020**, Figure 5) measures 18 x 1.8 x 0.2 with a magnetic amplitude of 423 nT.

3.3.7 A recorded obstruction (UKHO 57638) is situated in the north-east of the area situated 5 m north of anomaly **7009**. This is the location of three concrete piles, approximately 8m in length lifted from the seabed in 2011. It is possible that anomaly **7009**, measuring 7.0 x 3.0 x 0.5m represents a similar feature. If so, then this would be modern rather than archaeological in nature.

3.3.8 The remaining debris features vary in size and magnetic strength (see **Appendix I** for further details).

3.3.9 One anomaly (**7013**) has been identified as a small bright reflector measuring 10.9 x 2.0 m. A linear feature, possibly rope or chain, is attached to an object measuring 1.7 x 1.4 m. This feature of low reflectivity could represent the presence of waterlogged wood or synthetic material.

3.3.10 Five anomalies (**7002**, **7015**, **7016**, **7019** and **7030**) have been classified as dark reflectors; objects of unknown origin. None of these anomalies have an associated magnetic amplitude. However, anomaly **7030** is not covered by magnetometer data and therefore it is unknown if these features have ferrous content.

3.3.11 These objects range in size from 0.8 x 0.4 x 0.1 m (**7016**) up to 2.5 x 1.1 x 0.1 m (**7015**) and are interpreted as pieces of non-ferrous debris or natural features. Anomaly **7015** is possibly associated with two 3D chirp anomalies (TIL2_3DC_221 and _222) which indicates burial to 0.86 m and 1.02 m sub-seabed.

3.3.12 The remaining 74 A2 anomalies (for full list see **Appendix I**) have been classified as magnetic only anomalies with no associated SSS or MBES contacts and have been interpreted as possible buried ferrous debris. These anomalies range in size from 15 nT (**7037**) up to 6428 nT (**7078**). Eleven of these magnetic anomalies have associated 3D-chirp anomalies situated within close proximity to the magnetic anomaly and may indicate buried ferrous material.

3.3.13 In addition to the 13 3D chirp anomalies mentioned above, SAND identified an additional 35 isolated anomalies that could represent buried material, with no surface expression or associated magnetic anomaly indicating a non-ferrous composition. These anomalies could represent buried material which has the potential to be archaeological in nature.

3.3.14 There are two magnetic anomalies (**7085** and **7103**) located in the western section of the area which has previously been deepened through dredging. There is no surface expression at these locations indicating buried material. Due to past dredging, it is possible that these represent modern material, but buried archaeological material cannot be ruled out. There are also an additional five 3D chirp anomalies also situated in this area.

4 DISCUSSION AND RECOMMENDED MITIGATION

4.1.1 The proposed activities within the proposed dredge areas involve the direct removal of material from the seabed, which is potentially destructive to any shallow or surficial archaeological deposits. As such, steps must be taken to mitigate the potential impact upon such deposits wherever feasible.

4.1.2 In total, 116 anomalies have been identified as being of possible archaeological interest within the Study Areas, all of these features have been assigned an A2 archaeological potential rating (Uncertain origin of possible archaeological interest).

4.1.3 In addition to these there are an additional 70 isolated anomalies identified in the 3D chirp data that could represent buried material, with no associated magnetic anomaly indicating a non-ferrous composition. These anomalies could represent buried material which has the potential to be archaeological in nature.

4.1.4 Although, the features identified have been discriminated as potential archaeology it needs to be acknowledged that sections of the areas have been previously dredged and previous development in the area has considerably impacted the river-bed. It is possible that the debris identified is modern in nature rather than of archaeological interest. However, further investigation would ascertain the true nature of the material.

4.1.5 No Archaeological Exclusion Zones (AEZs) are recommended for any of these anomalies at this time. It is, however, likely that further investigations will be required to mitigate against any impact from the proposed development. Proposed mitigation measures are detailed in the Marine Archaeological Written Scheme of Investigation (Wessex Archaeology 2017).

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APPENDIX I: SEABED ANOMALIES OF POSSIBLE ARCHAEOLOGICAL POTENTIAL

WA ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Magnetic Amplitude (nT)	Description	External References	Area
7000	Debris	566266	175226	A2	1.8	1.4	0.2	108	A distinct right angled dark reflector with a bright and tapered shadow, distinct feature on a sandy and even area of the seabed and identified in the bathymetry data as a small mound. Has a large magnetic anomaly associated indicating ferrous debris. Interpreted as a possible anchor.		East
7001	Debris	566271	175264	A2	5.3	1	0.2	4824	A long, thin and distinct dark reflector with a bright shadow, possibly debris, located on a rough and uneven area of the seabed. Has a very large magnetic anomaly possibly associated with it, indicating ferrous debris.		East
7002	Dark reflector	566176	175249	A2	2.1	0.3	0	-	A long and very thin curvilinear dark reflector with no shadow, looks anthropogenic compared to surrounding seabed features, non-ferrous.		East
7003	Dark reflector	565479	175177	A2	1.7	0.3	0	-	A distinct and solid oval shaped dark reflector with no shadow, located on a sandy area of the seabed. Non-ferrous object. 3D chirp target is situated 2.8 m from this location buried less than 1m and may be associated.	TIL2_3DC_003	West
7004	Debris	565687	175222	A2	2.5	0.4	0.2	-	A thick linear dark reflector, possibly debris located on a rough and uneven area of the seabed. Located close to modern infrastructure and possibly related. This is not covered by the magnetometer data and as such ferrous composition unknown.		West
7005	Dark reflector	565681	175223	A2	2.4	0.3	0.1	-	An indistinct dark reflector with a bright shadow, long and thick linear item similar to other objects on this area of the seabed, possibly debris though not as distinct as other anomalies. Located close to modern infrastructure, possibly related. This is not		West

WA ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Magnetic Amplitude (nT)	Description	External References	Area
									covered by the magnetometer data and as such ferrous composition unknown.		
7006	Debris	565685	175191	A2	6.3	1.5	0.8	870	A large thick and distinct curvilinear dark reflector with some smaller dark reflector features coming off its centre and a bright bulbous shadow, possible large item of debris, has a very large magnetic anomaly associated indicating ferrous debris. 3D chirp target is located 7 m from this location at a depth of 2.10 m and could be associated.	TIL2_3DC_057	West
7007	Debris field	566146	175269	A2	80	30	2	-	A large spread of debris possibly related to the construction of the port seen next to the debris field. Tens of thin, linear and rounded dark reflectors scattered across the seabed, example dimensions of distinctive linear features 6.6 m x 0.6 m x 0.1 m; 3.4 m x 0.3 m x 0.1 m and 1 m x 0.3 m x 0.1 m. This area is not fully covered by the magnetometer data and as such ferrous composition is unknown.		East
7008	Debris field	566277	175277	A2	6.6	6	0.6	-	Possible debris field, three distinct and thin linear dark reflectors with bright shadows aligned with smaller debris pieces in-between. Highly anthropogenic debris field visible in the bathymetry data as aligned linear mounds, not covered by the magnetometer data and may be ferrous debris. 3D chirp target is located 9 m from this location and may be associated.	TIL2_3DC_240	East
7009	Debris	566313	175274	A2	7	3	0.5	185	A very long, thick and distinct linear piece of debris visible as a dark reflector with a bright, short shadow, has a large magnetic anomaly associated indicating ferrous debris, distinct in the bathymetry data as a long linear piece with one bulbous end		East
7010	Debris	566327	175279	A2	4.1	0.2	0.1	-	A long, thin and slightly curvilinear dark reflector with a dull shadow, possibly a rope or chain or debris feature, very indistinct linear depression in bathymetry data. This is not		East

WA ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Magnetic Amplitude (nT)	Description	External References	Area
									covered by the magnetometer data and ferrous composition is unknown		
7011	Debris	566317	175230	A2	1.7	1.3	0.5	302	An indistinct almost diamond shaped dark reflector with a dull, tapered shadow, has a large magnetic anomaly associated indicating ferrous debris		East
7012	Debris	566298	175280	A2	6.5	4.2	0.2	-	Very indistinct possible debris feature, a small circular hollow dark reflector with a possible rope or chain attached and a 'T' shaped object at one end with a dull shadow. This is not covered by the magnetometer data and as such ferrous composition is unknown		East
7013	Bright reflector	566233	175252	A2	10.9	2	0	-	An oval bright reflector object with a curvilinear bright reflector coming off this, possibly a rope or chain attached to something, oval object measures 1.7 x 1.4 m, probable non-ferrous debris		East
7014	Debris	565441	175168	A2	3.5	0.4	0.3	-	A very distinct curvilinear piece of debris, a long and thin dark reflector with a large and bright shadow located on a sandy area of the seabed, non-ferrous debris		West
7015	Dark reflector	566128	175235	A2	2.5	1.1	0.1	-	A hollow circular dark reflector feature, looks anomalous to the surrounding seabed, visible in the bathymetry as two small mounds within a depression, non-ferrous. Two 3D chirp targets are located 8 m from this location at depths of 0.86 and 1.02 m sub-seabed, which may be associated buried debris	TIL2_3DC_221, TIL2_3DC_222	East
7016	Dark reflector	566135	175242	A2	0.8	0.4	0.1	-	A very small hollow dark reflector feature with a bright shadow, possibly natural, non-ferrous		East
7017	Debris	566321	175251	A2	1.3	0.7	0.4	154	A hollow circular dark reflector with a bright shadow, possibly tyre. Has a large magnetic anomaly associated indicating ferrous debris		East
7018	Debris	566333	175223	A2	2.3	0.6	0.7	440	Possible debris. Dark reflector slightly right-angled at one end with a bright shadow. Located on a rough and uneven area of the seabed, has a large magnetic anomaly		East

WA ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Magnetic Amplitude (nT)	Description	External References	Area
									identified on more than one survey line indicating ferrous debris		
7019	Dark reflector	566121	175119	A2	1.2	0.8	0.1	-	A rounded dark reflector that does not appear to be solid, anomaly has no shadow and is situated on a rough and uneven area of the seabed, visible in the bathymetry data as a small mound identified within a geological depression. Possible non-ferrous debris or natural feature.		East
7020	Debris	566121	175119	A2	18	1.8	0.2	423	A very long thick and slightly curvilinear dark reflector with a short bright shadow, possibly large piece of debris, clearly visible in the bathymetry and has a large magnetic anomaly associated indicating ferrous debris		East
7021	Debris	565560	175220	A2	2.8	2.2	0.4	549	A distinct rectangular dark reflector with a large but dull shadow, has a large magnetic anomaly possible associated indicating ferrous debris		West
7022	Debris	565541	175210	A2	1	0.3	0	-	A long, thick and curvilinear dark reflector with a slight shadow and in a slight depression. Possibly non-ferrous debris		West
7023	Bright reflector	565560	175211	A2	0.8	0.7	0	-	A medium sized oval bright reflector, possibly debris or could just be natural		West
7024	Dark reflector	565627	175233	A2	0.3	0.3	0.1	-	A thick short linear dark reflector with a shadow and possibly in a slight depression. This is not covered by the magnetometer data and therefore ferrous composition unknown		West
7025	Debris	565620	175222	A2	2.1	0.1	0.4	-	An indistinct rounded dark reflector with an internal shadow, or hollow object on a rough area of seabed, in the bathymetry this is visible as a small but distinct mound within a depression measuring 2.2 x 2 m. Non-ferrous debris. 3D chirp target is located 5 m from this location at a depth of 0.22 m sub-seabed	TIL2_3DC_053	West
7026	Dark reflector	565611	175206	A2	0.5	0.4	0.3	-	A thick linear dark reflector with a slight shadow, distinctive on a sandy area of the seabed. Non-ferrous material.		West

WA ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Magnetic Amplitude (nT)	Description	External References	Area
7027	Dark reflector	565625	175189	A2	0.4	0.2	0.3	-	A distinct S shaped linear dark reflector with a bright shadow, possibly two stretched rocks but maybe anthropogenic non-ferrous feature		West
7028	Dark reflector	565719	175241	A2	1	0.4	0.6	-	An indistinct dark reflector with a bright and rectangular shadow, possibly in a slight depression. This is not covered by the magnetometer data and therefore ferrous composition unknown		West
7029	Dark reflector	565792	175247	A2	0.6	0.1	0	-	A very small linear dark reflector with no shadow. This is not covered by the magnetometer data and therefore ferrous composition unknown		West
7030	Dark reflector	566209	175275	A2	2.4	0.2	0	-	A long and thin curvilinear dark reflector with no shadow, very distinct. This is not covered by the magnetometer data and therefore ferrous composition unknown		East
7031	Magnetic	566627	175151	A2	-	-	-	379	Large anomaly identified on more than one survey line. Indicative of possible buried ferrous debris		East
7032	Magnetic	566583	175161	A2	-	-	-	69	Medium asymmetric dipole only identified on one survey line. Indicative of possible buried ferrous debris		East
7033	Magnetic	566418	175190	A2	-	-	-	87	Small negative monopole identified on more than one survey line. Indicative of possible buried ferrous debris		East
7034	Magnetic	566210	175139	A2	-	-	-	83	Medium asymmetric dipole only identified on one survey line. Indicative of possible buried ferrous debris		East
7035	Magnetic	566124	175132	A2	-	-	-	321	Large dipole only identified on one survey line. Indicative of possible buried ferrous debris		East
7036	Magnetic	566238	175144	A2	-	-	-	157	Large negative monopole only identified on one survey line. Indicative of possible buried ferrous debris		East
7037	Magnetic	566256	175155	A2	-	-	-	15	Small dipole identified on more than one survey line. Indicative of possible buried ferrous debris		East

WA ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Magnetic Amplitude (nT)	Description	External References	Area
7038	Magnetic	566450	175179	A2	-	-	-	56	Medium asymmetric dipole only identified on one survey line. Indicative of possible buried ferrous debris		East
7039	Magnetic	566435	175178	A2	-	-	-	31	Small positive monopole only identified on one survey line. Indicative of possible buried ferrous debris		East
7040	Magnetic	566380	175174	A2	-	-	-	58	Medium asymmetric dipole only identified on one survey line. Indicative of possible buried ferrous debris		East
7041	Magnetic	566396	175180	A2	-	-	-	23	Small positive monopole only identified on one survey line. Indicative of possible buried ferrous debris		East
7042	Magnetic	566290	175170	A2	-	-	-	63	Medium asymmetric dipole only identified on one survey line. Indicative of possible buried ferrous debris		East
7043	Magnetic	566419	175185	A2	-	-	-	208	Large dipole only identified on one survey line. Indicative of possible buried ferrous debris		East
7044	Magnetic	566450	175189	A2	-	-	-	83	Medium positive monopole only identified on one survey line. Indicative of possible buried ferrous debris		East
7045	Magnetic	566361	175182	A2	-	-	-	85	Medium asymmetric dipole only identified on one survey line. Indicative of possible buried ferrous debris		East
7046	Magnetic	566330	175179	A2	-	-	-	211	Large dipole weakly identified on more than one survey line. Indicative of possible buried ferrous debris		East
7047	Magnetic	566361	175192	A2	-	-	-	36	Small anomaly only identified on one survey line. Indicative of possible buried ferrous debris		East
7048	Magnetic	566360	175220	A2	-	-	-	42	Small dipole only identified on one survey line. Indicative of possible buried ferrous debris		East
7049	Magnetic	566188	175213	A2	-	-	-	112	Large anomaly only identified on one survey line. Indicative of possible buried ferrous debris		East
7050	Magnetic	566228	175218	A2	-	-	-	154	Large dipole weakly identified on more than one survey line. Indicative of possible buried ferrous debris		East

WA ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Magnetic Amplitude (nT)	Description	External References	Area
7051	Magnetic	566291	175224	A2	-	-	-	137	Large dipole identified on more than one survey line. Indicative of possible buried ferrous debris		East
7052	Magnetic	566164	175217	A2	-	-	-	195	Large asymmetric dipole only identified on one survey line. Indicative of possible buried ferrous debris		East
7053	Magnetic	566185	175220	A2	-	-	-	143	Large asymmetric dipole only identified on one survey line. 3D chirp target is located 4.6 m from this location, possibly buried ferrous object		East
7054	Magnetic	566276	175228	A2	-	-	-	59	Medium dipole only identified on one survey line. Indicative of possible buried ferrous debris		East
7055	Magnetic	566314	175241	A2	-	-	-	278	Large asymmetric dipole only identified on one survey line. Indicative of possible buried ferrous debris		East
7056	Magnetic	565685	175197	A2	-	-	-	462	Large anomaly identified on more than one survey line. Indicative of possible buried ferrous debris		West
7057	Magnetic	565701	175209	A2	-	-	-	2622	Very large dipole identified on more than on survey line. Indicative of possible buried ferrous debris		West
7058	Magnetic	565566	175201	A2	-	-	-	2163	Very large dipole identified on more than on survey line. 3D chirp target is located 5 m from this location, possibly buried ferrous object at depth of 0.29 m	TIL2_3DC_031	West
7059	Magnetic	566496	175136	A2	-	-	-	37	Small dipole only identified on one survey line. Indicative of possible buried ferrous debris		East
7060	Magnetic	566553	175141	A2	-	-	-	2307	Very large dipole identified on more than on survey line. Indicative of possible buried ferrous debris		East
7061	Magnetic	566618	175142	A2	-	-	-	118	Large asymmetric dipole identified on more than one survey line. Indicative of possible buried ferrous debris		East
7062	Magnetic	566672	175140	A2	-	-	-	1781	Very large negative monopole possibly identified on more than one survey line. Indicative of possible buried ferrous debris		East

WA ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Magnetic Amplitude (nT)	Description	External References	Area
7063	Magnetic	566178	175119	A2	-	-	-	66	Medium dipole possibly on more than one survey line, possibly natural. Indicative of possible buried ferrous debris		East
7064	Magnetic	566160	175118	A2	-	-	-	80	Medium positive monopole only identified on one survey line, possibly natural. Indicative of possible buried ferrous debris		East
7065	Magnetic	566134	175115	A2	-	-	-	56	Medium positive monopole only identified on one survey line. Indicative of possible buried ferrous debris		East
7066	Magnetic	566109	175113	A2	-	-	-	86	Medium dipole only identified on one survey line. Indicative of possible buried ferrous debris		East
7067	Magnetic	566066	175109	A2	-	-	-	65	Medium dipole only identified on one survey line. 3D chirp target is located 2 m from this location, possibly buried ferrous object at depth of 2.34 m	TIL2_3DC_100	East
7068	Magnetic	566331	175218	A2	-	-	-	113	Large dipole identified on more than one survey line. Indicative of possible buried ferrous debris		East
7069	Magnetic	566155	175236	A2	-	-	-	703	Very large anomaly only identified on one survey line, possibly natural. Indicative of possible buried ferrous debris		East
7070	Magnetic	566195	175238	A2	-	-	-	155	Large dipole identified on more than one survey line. Indicative of possible buried ferrous debris		East
7071	Magnetic	566483	175137	A2	-	-	-	56	Medium dipole only identified on one survey line. Indicative of possible buried ferrous debris		East
7072	Magnetic	566189	175133	A2	-	-	-	50	Medium asymmetric dipole identified on more than one survey line. Indicative of possible buried ferrous debris		East
7073	Magnetic	566349	175184	A2	-	-	-	115	Large negative monopole possibly identified on more than one survey line. Indicative of possible buried ferrous debris		East
7074	Magnetic	566349	175225	A2	-	-	-	73	Medium dipole only identified on one survey line. Indicative of possible buried ferrous debris		East

WA ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Magnetic Amplitude (nT)	Description	External References	Area
7075	Magnetic	566296	175254	A2	-	-	-	85	Medium negative monopole weakly observed on more than one survey line. Indicative of possible buried ferrous debris		East
7076	Magnetic	565695	175201	A2	-	-	-	2741	Very large anomaly only identified on one survey line. Indicative of possible buried ferrous debris		West
7077	Magnetic	566178	175252	A2	-	-	-	1732	Very large dipole identified weakly on more than one survey line. Indicative of possible buried ferrous debris		East
7078	Magnetic	566193	175254	A2	-	-	-	6428	Very large dipole identified on more than one survey line. Indicative of possible buried ferrous debris		East
7079	Magnetic	566461	175175	A2	-	-	-	215	Large anomaly identified on more than one survey line. Indicative of possible buried ferrous debris		East
7080	Magnetic	566446	175173	A2	-	-	-	150	Large positive monopole only identified on one survey line. Indicative of possible buried ferrous debris		East
7081	Magnetic	566538	175149	A2	-	-	-	94	Large negative monopole identified on more than one survey line. Indicative of possible buried ferrous debris		East
7082	Magnetic	565559	175240	A2	-	-	-	190	Large dipole only identified on one survey line. Indicative of possible buried ferrous debris		West
7083	Magnetic	566282	175228	A2	-	-	-	74	Medium dipole only identified on one survey line. Indicative of possible buried ferrous debris		East
7084	Magnetic	566277	175232	A2	-	-	-	74	Medium dipole possibly identified on more one survey line. Indicative of possible buried ferrous debris		East
7085	Magnetic	566077	175213	A2	-	-	-	150	Large dipole only identified on one survey line. 3D chirp target is located 10 m from this location, possibly buried ferrous object at depth of 0.54 m	TIL2_3DC_113	East
7086	Magnetic	566299	175220	A2	-	-	-	40	Small dipole identified on more than one survey line. 3D chirp target is located 5 m from this location, possibly buried ferrous object at depth of 1.92 m sub-seabed	TIL2_3DC_128	East

WA ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Magnetic Amplitude (nT)	Description	External References	Area
7087	Magnetic	565474	175169	A2	-	-	-	736	Very large dipole only identified on one survey line. Indicative of possible buried ferrous debris		West
7088	Magnetic	565614	175174	A2	-	-	-	391	Large negative monopole only identified on one survey line. 3 D chirp target is located 7 m from this location, may be buried ferrous object at a depth of 0.53 m	TIL2_3DC_043	West
7089	Magnetic	565575	175171	A2	-	-	-	81	Medium asymmetric dipole only identified on one survey line. 3D chirp target is located 6 m from this location, possibly buried ferrous object at a depth of 1.81 m	TIL2_3DC_024	West
7090	Magnetic	566145	175229	A2	-	-	-	591	Large asymmetric dipole identified on more than one survey line. Indicative of possible buried ferrous debris		East
7091	Magnetic	566263	175248	A2	-	-	-	560	Very large dipole only identified on one survey line. 3d chirp target is located 3.5 m from this location, possibly buried ferrous object at a depth of 1.42 m sub-seabed	TIL2_3DC_238	East
7092	Magnetic	565576	175181	A2	-	-	-	217	Large dipole only identified on one survey line. Indicative of possible buried ferrous debris		West
7093	Magnetic	566262	175252	A2	-	-	-	431	Large dipole only identified on one survey line. Indicative of possible buried ferrous debris		East
7094	Magnetic	566151	175241	A2	-	-	-	522	Very large anomaly identified on more than one survey line. Indicative of possible buried ferrous debris		East
7095	Magnetic	566376	175156	A2	-	-	-	60	Medium dipole possibly faintly seen on more than one survey line. 3D chirp target is located 6 m from this location, at a depth of 0.26 m sub-seabed. Possibly buried ferrous object	TIL2_3DC_118	East
7096	Magnetic	566184	175144	A2	-	-	-	176	Large dipole possibly faintly seen on more than one survey line. Indicative of possible buried ferrous debris		East
7097	Magnetic	566218	175256	A2	-	-	-	499	Large anomaly identified on more than one survey line. Indicative of possible buried ferrous debris		East
7098	Magnetic	566238	175261	A2	-	-	-	417	Large negative monopole faintly identified on more than one survey line. Indicative of possible buried ferrous debris		East

WA ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Magnetic Amplitude (nT)	Description	External References	Area
7099	Magnetic	566116	175248	A2	-	-	-	469	Large dipole only identified on one survey line. Indicative of possible buried ferrous debris at a depth of 0.43 m sub-seabed	TIL2_3DC_227	East
7100	Magnetic	566541	175143	A2	-	-	-	243	Large anomaly identified on more than one survey line. Indicative of possible buried ferrous debris		East
7101	Magnetic	566430	175139	A2	-	-	-	75	Medium dipole identified on more than one survey line. Indicative of possible buried ferrous debris		East
7102	Magnetic	566112	175203	A2	-	-	-	56	Medium dipole only identified on one survey line. Indicative of possible buried ferrous debris		East
7103	Magnetic	566055	175225	A2	-	-	-	619	Very large dipole only identified on one survey line. 3d chirp target is located 5 m from this location, possibly buried ferrous object at a depth of 0.48 m sub-seabed	TIL2_3DC_206	East
7104	Magnetic	566282	175265	A2	-	-	-	145	Large dipole only identified on one survey line. 3D chirp target is located 7 m from this location, possibly buried ferrous object at a depth of 0.89 m sub-seabed	TIL2_3DC_239	East
7105	Magnetic	566247	175258	A2	-	-	-	869	Very large dipole identified on more than one survey line. Indicative of possible buried ferrous debris		East
7106	Magnetic	566201	175255	A2	-	-	-	1350	Very large positive monopole only really seen on one survey line. Indicative of possible buried ferrous debris		East
7107	Magnetic	565598	175208	A2	-	-	-	312	Large dipole only identified on one survey line. Indicative of possible buried ferrous debris		West
7108	Magnetic	566098	175214	A2	-	-	-	291	Large dipole only identified on one survey line. 3D chirp target is located 7 m from this location, possibly buried ferrous object at a depth of 1.20 m sub-seabed	TIL2_3DC_216	East
7109	Magnetic	565593	175235	A2	-	-	-	67	Medium dipole only identified on one survey line. Indicative of possible buried ferrous debris		West
7110	Magnetic	566096	175230	A2	-	-	-	249	Large dipole only identified on one survey line, possibly buried ferrous object		East

WA ID	Classification	Easting	Northing	Archaeological Discrimination	Length (m)	Width (m)	Height (m)	Magnetic Amplitude (nT)	Description	External References	Area
7111	Magnetic	566143	175218	A2	-	-	-	71	Medium dipole only identified on one survey line. 3D chirp target is located 8 m from this location, possibly buried ferrous object at a depth of 0.96 m sub-seabed	TIL2_3DC_213	East
7112	Magnetic	566163	175248	A2	-	-	-	253	Large dipole only identified on one survey line, noisy area, they have picked it and it is quite large. 3D chirp target is located 7 m from this location, possibly buried ferrous object at a depth of 0.86 m sub-seabed	TIL2_3DC_237	East
7113	Magnetic	566316	175264	A2	-	-	-	652	Large dipole only identified on one survey line. Indicative of possible buried ferrous debris		East
7114	Magnetic	566283	175256	A2	-	-	-	134	Large positive monopole only identified on one survey line. Indicative of possible buried ferrous debris		East
7115	Magnetic	566148	175130	A2	-	-	-	46	Small asymmetric dipole only identified on one survey line. Indicative of possible buried ferrous debris		East

Notes:
1. All coordinates are in OSGB36 British National Grid
2. Positions are considered accurate to within approximately ±10 m

APPENDIX II: POTENTIAL BURIED ANOMALIES IDENTIFIED ON THE 3D CHIRP DATA

3D_CHIRP_ID	Easting	Northing	Depth (m) sub-seabed (@1600 m/s)	Width (m)	Length (m)	Thickness (m@1600 m/s)	Notes	WA ID	Area
TIL2_3DC_001	565451	175175	0.56	0.9	0.9	0.3	May be geology		West
TIL2_3DC_002	565466	175175	0.22	0.9	2.2	0.3			West
TIL2_3DC_003	565476	175178	0.59	0.8	0.8	0.2	May be geology	2.8 m from 7033	West
TIL2_3DC_004	565455	175165	1.38	0.7	2.1	0.15			West
TIL2_3DC_005	565465	175179	0.17	1.1	1.7	0.4			West
TIL2_3DC_006	565481	175181	0.44	1	1	0.3			West
TIL2_3DC_007	565465	175181	0.24	1.2	2.4	0.5			West
TIL2_3DC_010	565476	175190	0.26	2.5	3.7	0.3			West
TIL2_3DC_011	565488	175191	0.24	1.9	2.5	0.4	May be geology		West
TIL2_3DC_014	565470	175212	0.42	0.7	0.8	0.3			West
TIL2_3DC_015	565444	175213	1.79	1.1	1.1	0.5			West
TIL2_3DC_018	565475	175225	2.32	1.3	1.7	0.3			West
TIL2_3DC_019	565483	175231	2.62	0.7	0.7	0.3			West
TIL2_3DC_020	565505	175232	1.98	0.7	1.2	0.3			West
TIL2_3DC_024	565566	175172	1.81	0.6	1.4	0.2		6 m from 7089	West
TIL2_3DC_028	565514	175186	8.66	1.4	1.5	0.4			West
TIL2_3DC_030	565515	175192	1.03	0.7	0.9	0.3			West
TIL2_3DC_031	565565	175196	0.29	1.2	1.2	0.5		5 m from 7058	West
TIL2_3DC_032	565577	175197	0.29	1.5	1.6	0.3			West
TIL2_3DC_034	565552	175206	4.18	1	1.1	0.4			West
TIL2_3DC_039	565529	175229	1.90	0.8	2	0.4			West
TIL2_3DC_040	565533	175236	2.06	0.9	1	0.3			West
TIL2_3DC_041	565514	175237	2.41	0.6	0.6	0.3			West

3D_CHIRP_ID	Easting	Northing	Depth (m) sub-seabed (@1600 m/s)	Width (m)	Length (m)	Thickness (m@1600 m/s)	Notes	WA ID	Area
TIL2_3DC_042	565650	175179	1.06	0.8	0.9	0.4			West
TIL2_3DC_043	565620	175178	0.53	0.9	0.9	0.3		7 m from 7088	West
TIL2_3DC_045	565616	175189	2.78	0.8	1.8	0.4			West
TIL2_3DC_046	565642	175197	2.36	0.8	0.8	0.3			West
TIL2_3DC_051	565646	175215	0.23	1	1.5	0.2			West
TIL2_3DC_053	565625	175220	0.22	1.2	1.6	0.3		5 m from 7025	West
TIL2_3DC_054	565635	175222	0.26	1	2	0.3			West
TIL2_3DC_057	565691	175186	2.10	1.4	2.5	0.2		7 m from 7006	West
TIL2_3DC_058	565711	175191	1.72	1.3	2.4	0.2			West
TIL2_3DC_059	565712	175194	1.71	0.8	1.2	0.3			West
TIL2_3DC_060	565682	175212	1.19	0.9	1.7	0.2			West
TIL2_3DC_061	565721	175215	0.82	1.1	1.5	0.4			West
TIL2_3DC_063	565706	175217	1.51	1.2	2.3	0.3			West
TIL2_3DC_064	565694	175216	1.18	0.8	1.7	0.3			West
TIL2_3DC_065	565684	175217	1.42	2.1	2.7	0.3		5 m from 7004	West
TIL2_3DC_066	565698	175219	1.46	0.9	1.4	0.1			West
TIL2_3DC_067	565722	175220	1.07	1.6	1.7	0.4			West
TIL2_3DC_071	565733	175203	0.71	1.4	1.6	0.1			West
TIL2_3DC_074	565732	175218	1.48	0.9	1.3	0.2			West
TIL2_3DC_100	566068	175111	2.34	0.9	2	1.5		2 m from 7067	East
TIL2_3DC_113	566072	175203	0.54	1.5	1.8	0.4		10 m from 7085 Mag	East
TIL2_3DC_118	566370	175155	0.26	1.5	3.6	0.2			East
TIL2_3DC_119	566386	175164	0.19	1.6	2.4	0.3			East
TIL2_3DC_121	566376	175196	1.60	1.7	3.2	0.3			East
TIL2_3DC_124	566321	175208	1.84	2.4	3.5	0.4			East
TIL2_3DC_125	566317	175207	2.08	1.2	2.2	0.4			East

3D_CHIRP_ID	Easting	Northing	Depth (m) sub-seabed (@1600 m/s)	Width (m)	Length (m)	Thickness (m@1600 m/s)	Notes	WA ID	Area
TIL2_3DC_126	566302	175206	2.17	1.7	3.4	0.4			East
TIL2_3DC_127	566306	175211	1.84	2.2	3.1	0.4			East
TIL2_3DC_128	566300	175216	1.92	1	1.8	0.3		5 m from 7086	East
TIL2_3DC_131	566403	175194	1.62	1.6	3.8	0.3			East
TIL2_3DC_132	566576	175136	2.26	1.3	2	0.4			East
TIL2_3DC_133	566564	175137	2.06	1.2	1.5	0.4			East
TIL2_3DC_202	566057	175212	0.45	1.2	2.3	0.3			East
TIL2_3DC_203	566064	175213	0.38	0.9	3.3	0.3			East
TIL2_3DC_204	566044	175213	1.32	2.1	2.2	0.4			East
TIL2_3DC_205	566021	175216	0.64	1	1	0.5			East
TIL2_3DC_206	566051	175224	0.48	1.5	4	0.4		5 m 7103	East
TIL2_3DC_209	566089	175210	0.58	1.6	2.5	0.3			East
TIL2_3DC_210	566107	175213	1.10	2.1	2.1	0.3			East
TIL2_3DC_213	566135	175214	0.96	1.2	1.6	0.3		8 m from 7111	East
TIL2_3DC_214	566128	175218	1.46	2	2.3	0.3			East
TIL2_3DC_215	566120	175216	0.46	1.2	1.2	0.4			East
TIL2_3DC_216	566105	175217	1.20	1.6	2.5	0.3		7 m from 7108	East
TIL2_3DC_220	566109	175223	1.15	0.7	1.8	0.2			East
TIL2_3DC_221	566130	175227	0.86	1.5	1.5	0.4		8 m from 7015	East
TIL2_3DC_222	566133	175227	1.02	1.6	1.6	0.4		8 m from 7015	East
TIL2_3DC_223	566087	175231	1.06	0.9	1.3	0.3	L-shaped		East
TIL2_3DC_224	566102	175238	1.48	1.7	2.6	0.4			East
TIL2_3DC_225	566121	175245	0.45	1.8	3.7	0.5	Possibly geology?		East
TIL2_3DC_226	566128	175250	0.54	1.2	2	0.2			East
TIL2_3DC_227	566118	175249	0.43	1.1	2.7	0.3		2 m from 7099	East
TIL2_3DC_228	566136	175251	0.68	2.1	2.2	0.3			East

3D_CHIRP_ID	Easting	Northing	Depth (m) sub-seabed (@1600 m/s)	Width (m)	Length (m)	Thickness (m@1600 m/s)	Notes	WA ID	Area
TIL2_3DC_229	566141	175252	0.37	1.2	1.2	0.2	Possibly 2 targets		East
TIL2_3DC_230	566101	175253	1.70	1	1.9	0.3			East
TIL2_3DC_231	566111	175253	0.81	0.7	1.8	0.3			East
TIL2_3DC_232	566117	175253	3.05	1.1	3	0.2			East
TIL2_3DC_233	566121	175254	0.51	2	2.5	0.2			East
TIL2_3DC_234	566121	175263	4.33	1.9	2.6	0.6			East
TIL2_3DC_237	566156	175251	0.86	1.2	1.8	0.3		7 m from 7112	East
TIL2_3DC_238	566261	175245	1.42	1.3	2.2	0.5		3.5 m from 7091	East
TIL2_3DC_239	566289	175266	0.85	1.2	1.8	0.4		7 m from 7104	East
TIL2_3DC_240	566285	175282	2.74	2.5	2.5	0.5		9 m from 7008	East
TIL2_3DC_244	566314	175298	4.11	3	3	0.6	Possibly artifact		East
TIL2_3DC_246	566117	175228	1.32	1.5	2	0.4			East
TIL2_3DC_248	566114	175252	3.05	1.2	2.2	0.3			East
TIL2_3DC_249	566118	175225	1.32	1.5	2.5	0.4			East
TIL2_3DC_250	566116	175228	1.32	0.6	0.9	0.3			East

Notes:
1. All coordinates are in OSGB36 British National Grid
2. Data as provided in SAND (2017)

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Date:	08/06/2017	Revision Number:	0
Scale:	Main: 1:25,000 at A4	Illustrator:	KJF
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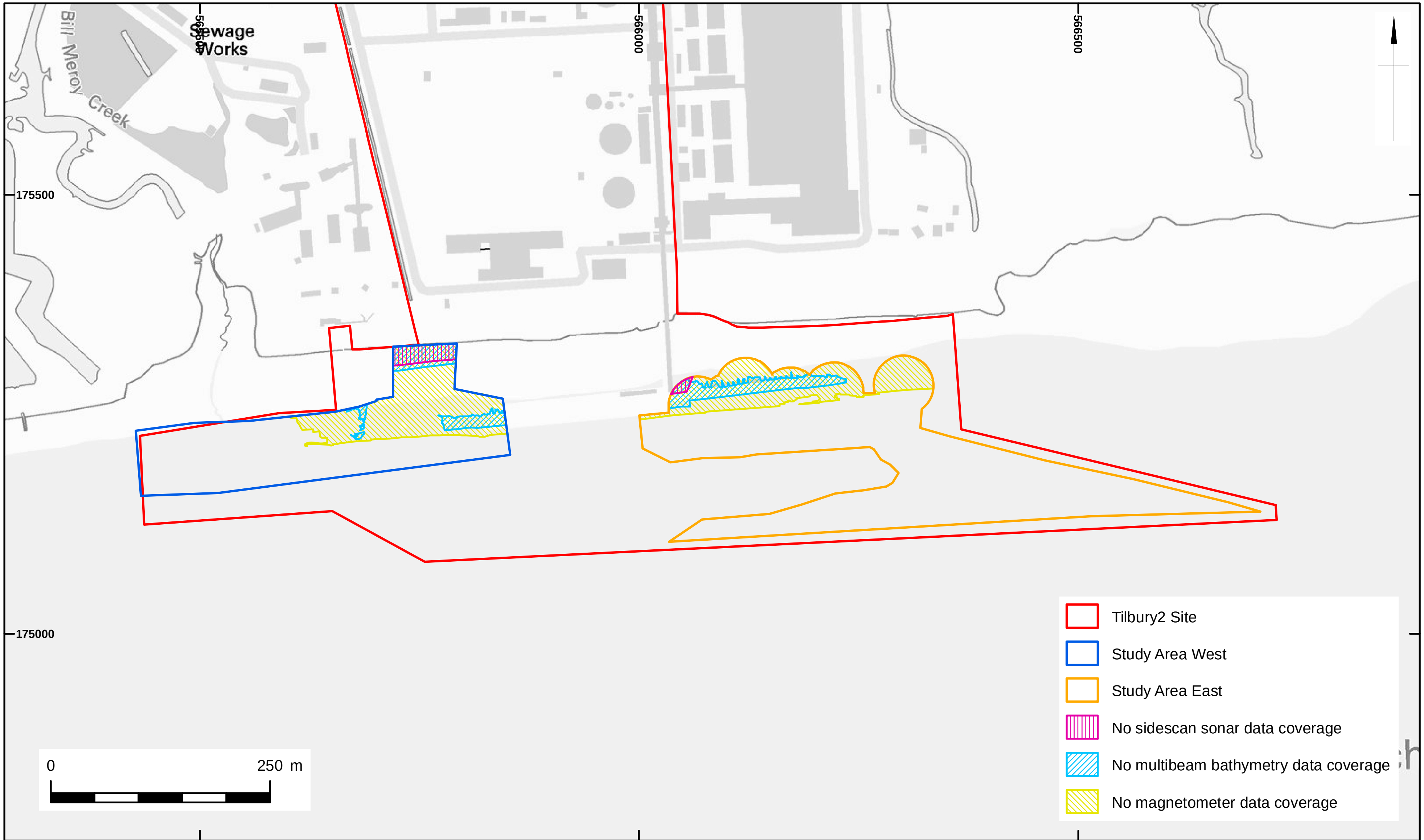
Location map

Figure 1



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Data coverage

Figure 2

Coordinate system:
OSGB36 (OSTN15/OSGM15)

Tilbury2 Site
Study Area West
Study Area East

Geophysical Anomalies

A2 (Uncertain origin of possible archaeological interest)

Potential buried features (SAND 2017)

0 50 m

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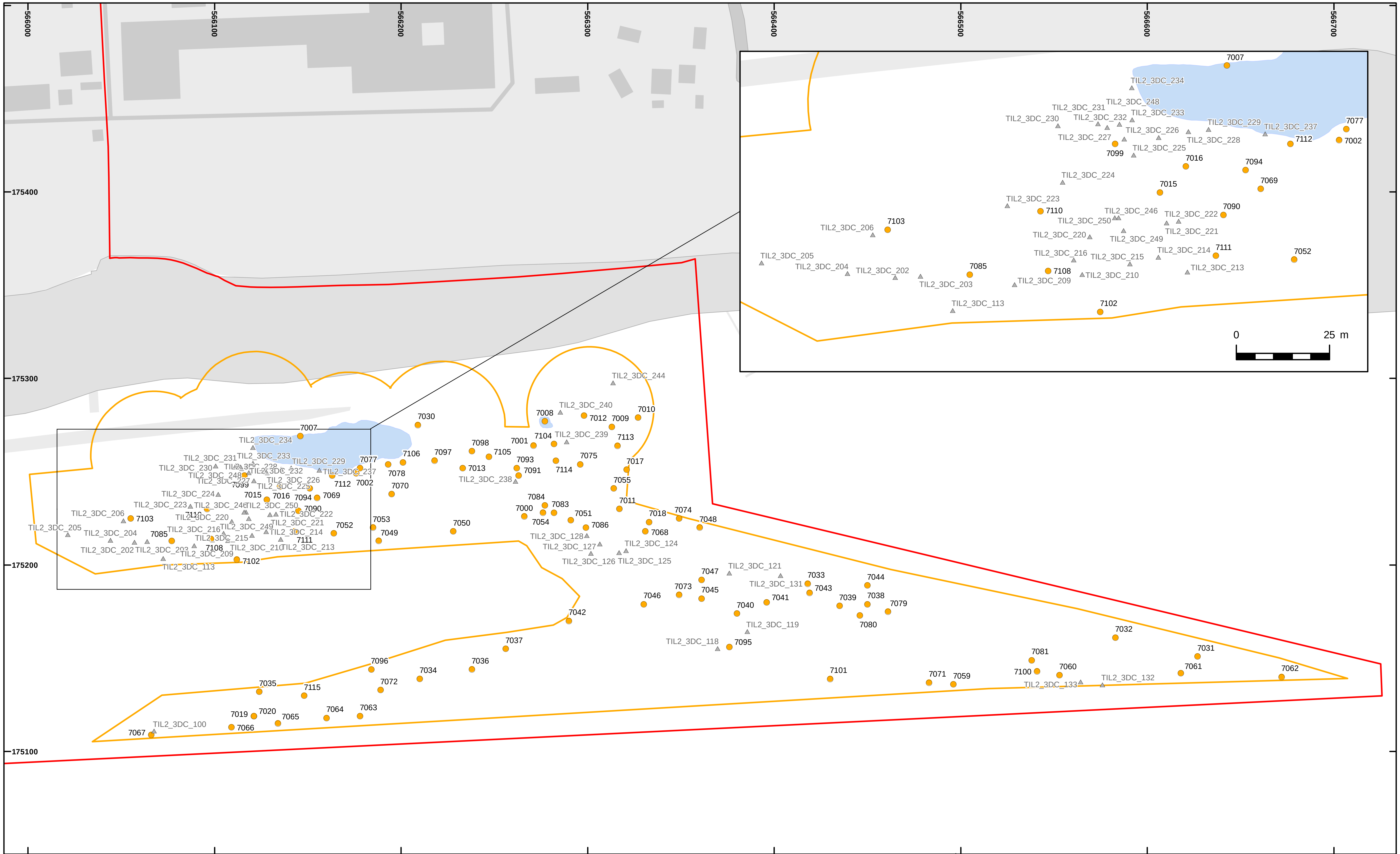
Seabed features of archaeological potential (Study Area West)

Figure 3



Tilbury2 Site

Study Area West

Study Area East

Debris field extents

Geophysical Anomalies

A2 (Uncertain origin of possible archaeological interest)

Potential buried features (SAND 2017)

0 50 m

Coordinate system:
OSGB36 (OSTN15/OSGM15)

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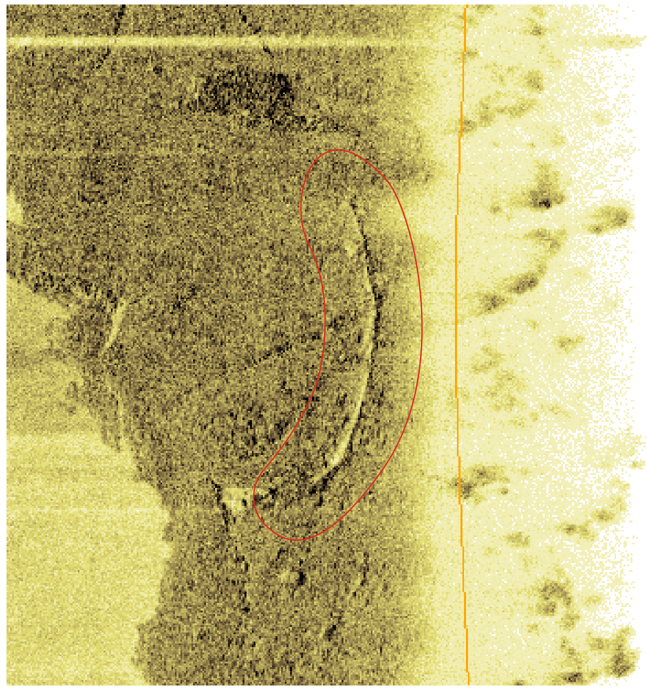
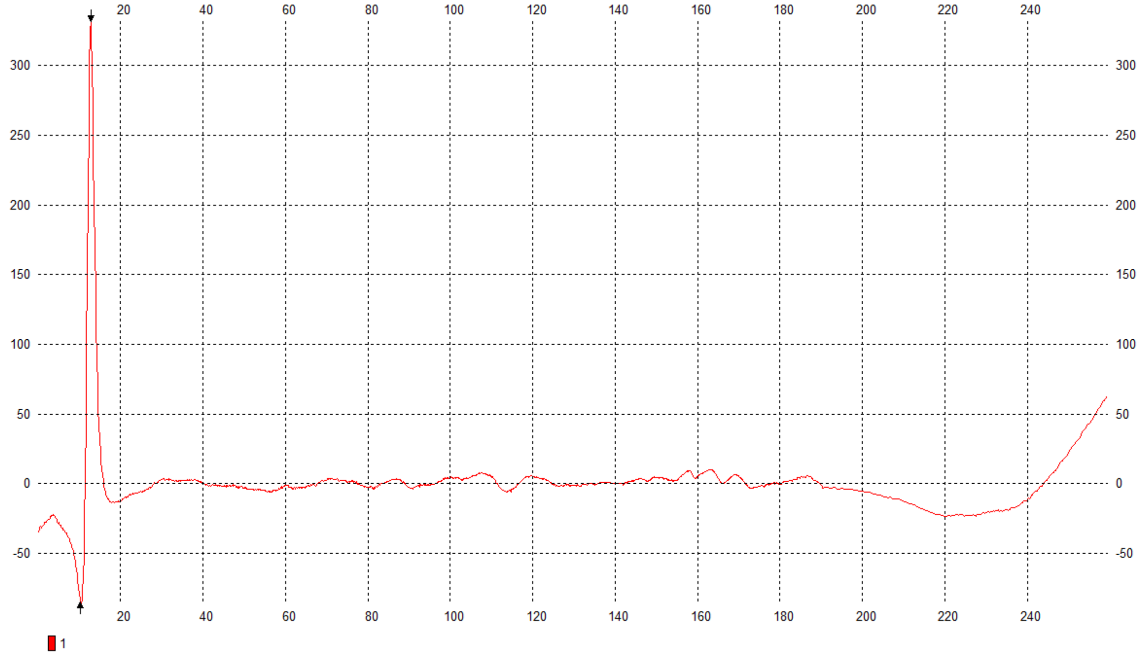
Seabed features of archaeological potential (Study Area East)

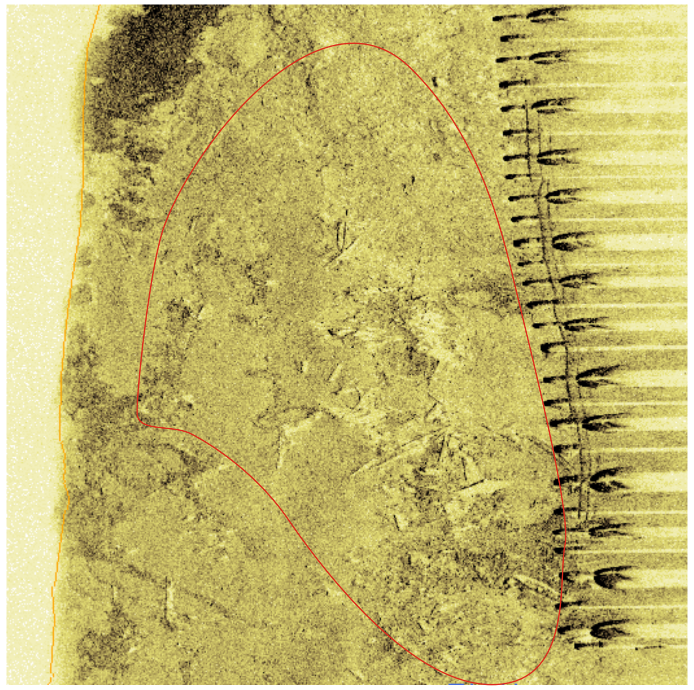
Figure 4



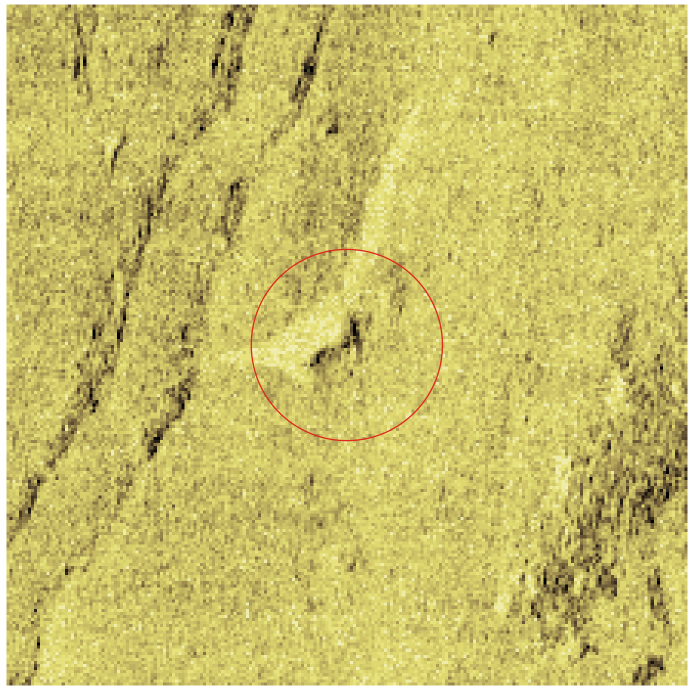
Sidescan sonar image of ferrous debris 7020, 18 m x 1.8 m x 0.2 m



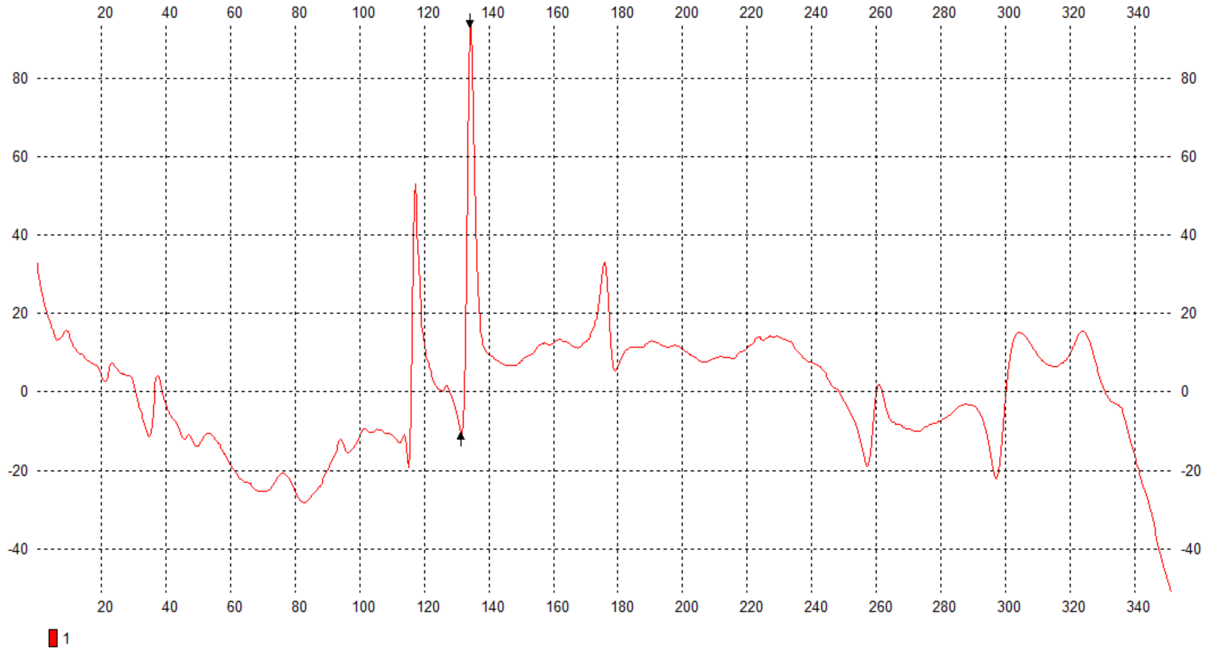
Magnetic profile of ferrous debris 7020 measuring 423 nT



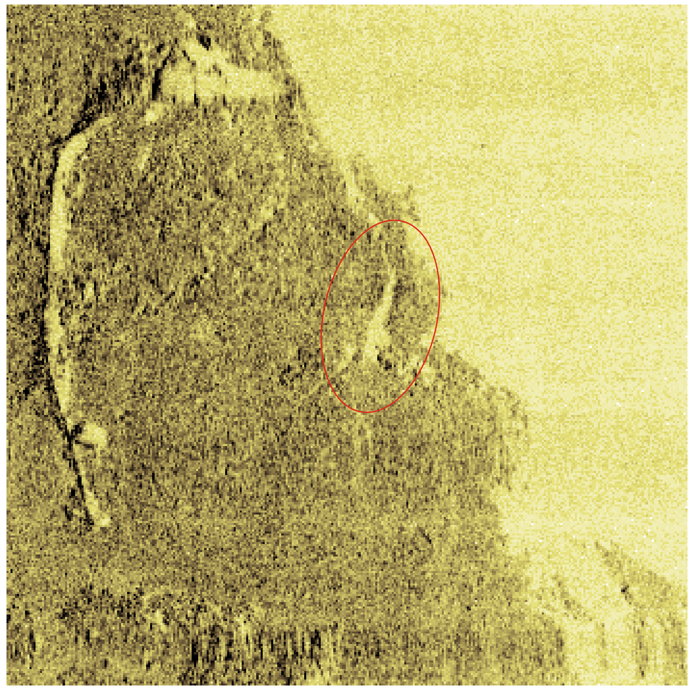
Sidescan sonar image of debris field 7007, 80 m x 30 m x 2 m



Sidescan sonar image of ferrous debris 7000, 1.8 m x 1.4 m x 0.2 m



Magnetic profile of ferrous debris 7000 measuring 108 nT



Sidescan soanr image of bright reflector 7023, 0.8 m x 2.30 m

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Data examples of seabed features

Figure 5

AS 6

Technical Note New Terrestrial Piling

(Atkins August 2017)

Technical note

Project:	Tilbury 2 Development	**To:**	Ian Wright
Subject:	New Terrestrial Piling	**From:**	Adrian Hall
Date:	11 Aug 2017	**cc:**	

Document 170811 Piling strategy (terrestrial) rev-2

An estimate has been provided below on the number of proposed piles for the landside works.

Proposed piles

Estimate for the proposed piles are based on the assumptions detailed in the Bill off Quantities[1].

Table 1 - Schedule of Proposed Terrestrial Piles

Location	Assumptions	No. of piles
Maritime Warehouse and Slab	Warehouse area estimated to be 175m x 75m, scaled from drawing 5153187-ATK-ZZ-XX-DR-ZZ-1000 rev P9. Assume piles are spaced every 2.5m.	2,100
RoRo Terminal workshop/admin/welfare	Workshop area estimated to be 60m x 60m. Assume piles are spaced every 2.5m.	576
Lighting Columns	Assume 5 columns per 100m and 3 rows of columns within each storage area.	240
Conveyor Support Structure	Area of CMAT corridor conveyor taken from latest CAD model (28/07/2017). Assume piles are spaced every 5m.	142
Stone columns to earth embankment to new approach structure to RoRo berth	Number of piles stated in '170802 Piling for Berth Frontage Rev 2' Technical Note and includes the Bankseat, Piled Bents and Abutment.	52
Abutment Piles	Number of piles stated in '170802 Piling for Berth Frontage Rev 2' Technical Note. 14 piles @1.22m diameter. This equates to 83 piles @0.5m diameter	83
Sheet pile wall along earth embankment	14m deep piles, 100m length	
Stone columns under rail track	Length of rail is 5,050m. Assume two piles every 5m under rail.	2,020
CMAT Processing area	Three facilities each with an area of $3,500m^2$. Assume piles are spaced every 2.5m	1,680

1 P:\GBEMC\WGE\Projects\Trans\20161714 POTLL RoRo Terminal Design\7 WIP\TO014 BoQ\RIBA 3 (DCO submission)

Technical note

Location	Assumptions	No. of piles
Fort Road Bridge	Assume 24 piles, with a diameter of 0.75m (Refer to BoQ Rev 1-D2). This equates to 53 piles with a diameter of 0.5m	54
Drainage Culverts	Length total length of drainage culverts is 1,500m (refer to BoQ Rev 1-D2). Culvert width varies from 0.8 to 1.5m. Assume one pile every 5m.	300
Booking Gate	Estimated to be 20 piles	20
Inspection Shed	Estimated to be 15 piles	15
	TOTAL	7,282

We have estimated the percentage of area taken up by piles within the red line DCO boundary.

Area within the red line DCO boundary	This area is taken from the latest CAD model (dated 11/08/2017). This includes the land area only.	810,713m^2
Proposed piled area	Assume each pile has a diameter of 0.5m.	0.196m^2
	Total piles area	1,427m^2
	Percentage area	0.176%

AS 7

Technical Note Berth Frontage Piling

(Atkins August 2017)

Technical note

Project:	Tilbury 2 Development	**To:**	Ian Wright
Subject:	Berth Frontage Piling	**From:**	Steve Osborn
Date:	3 Aug 2017	**cc:**	

Doc 170802 Piling for Berth Frontage Rev 3

Ian,

The following table lists a “worst case” scenario for piling for the berth frontage and associated facilities. Figures 1 to 5 illustrate where the piles are located. Table 1 lists the piles associated with each structure.

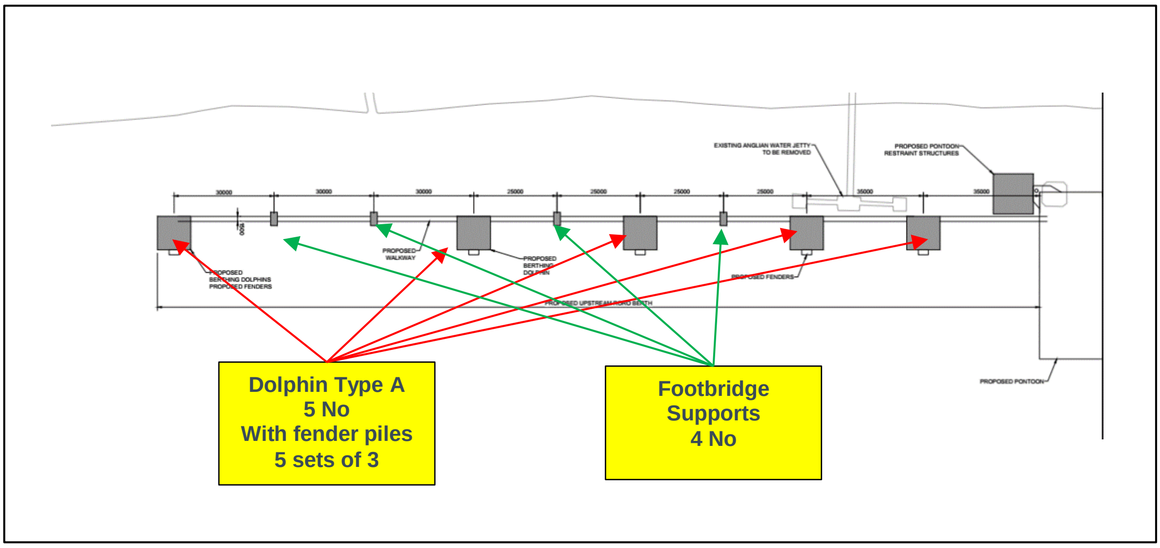

Figure 1. Upstream Berth

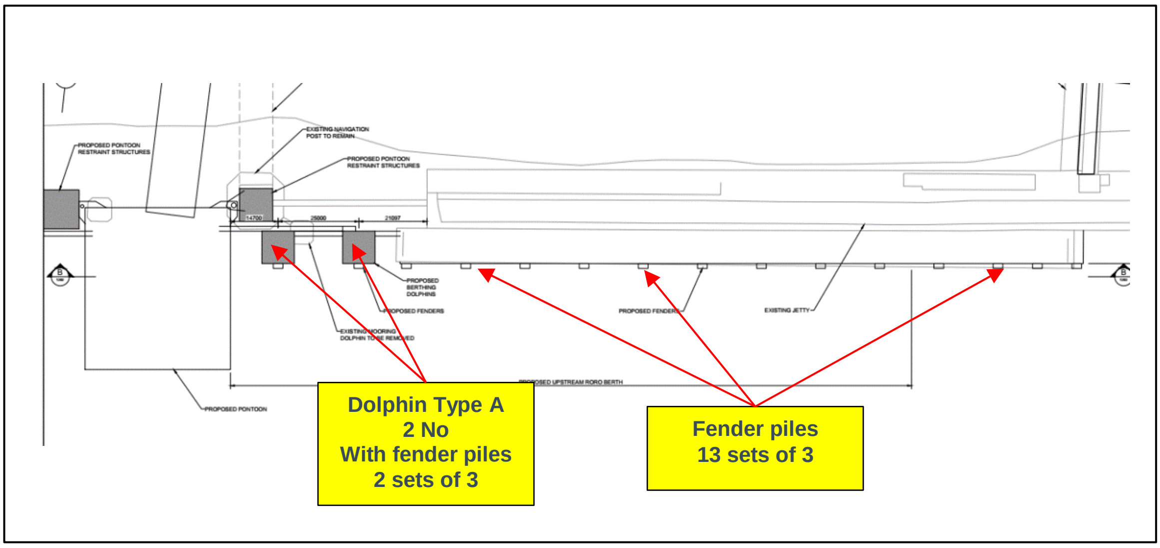

Figure 2. Downstream Berth (Jetty A)

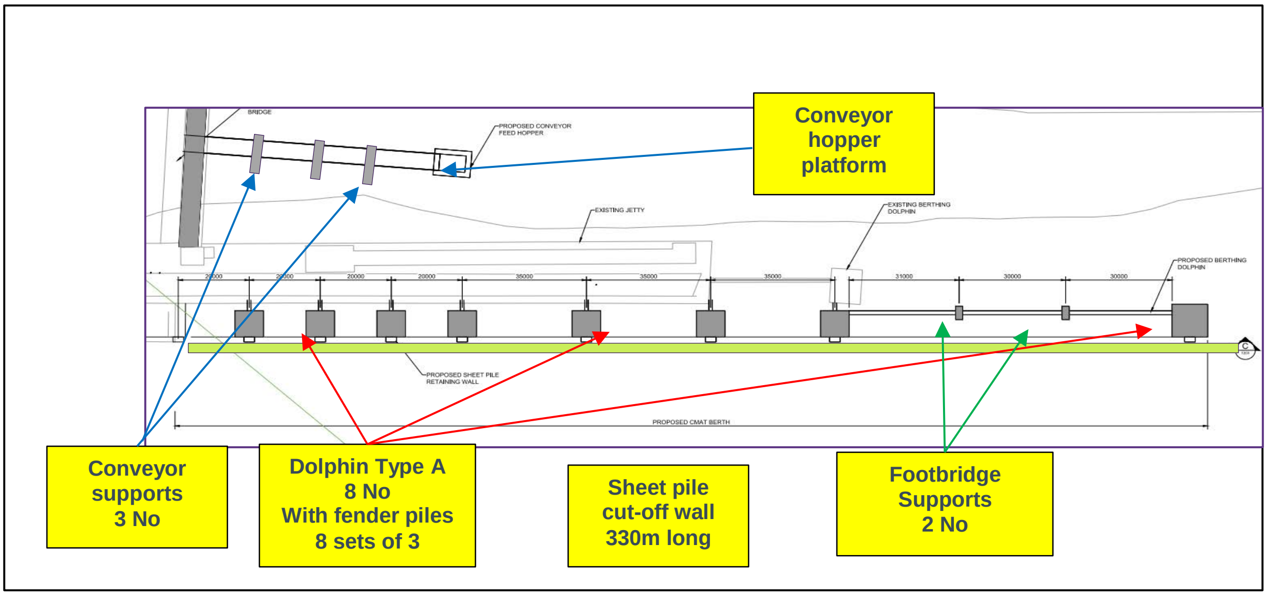

Figure 3. CMAT Berth (Jetty B and beyond)

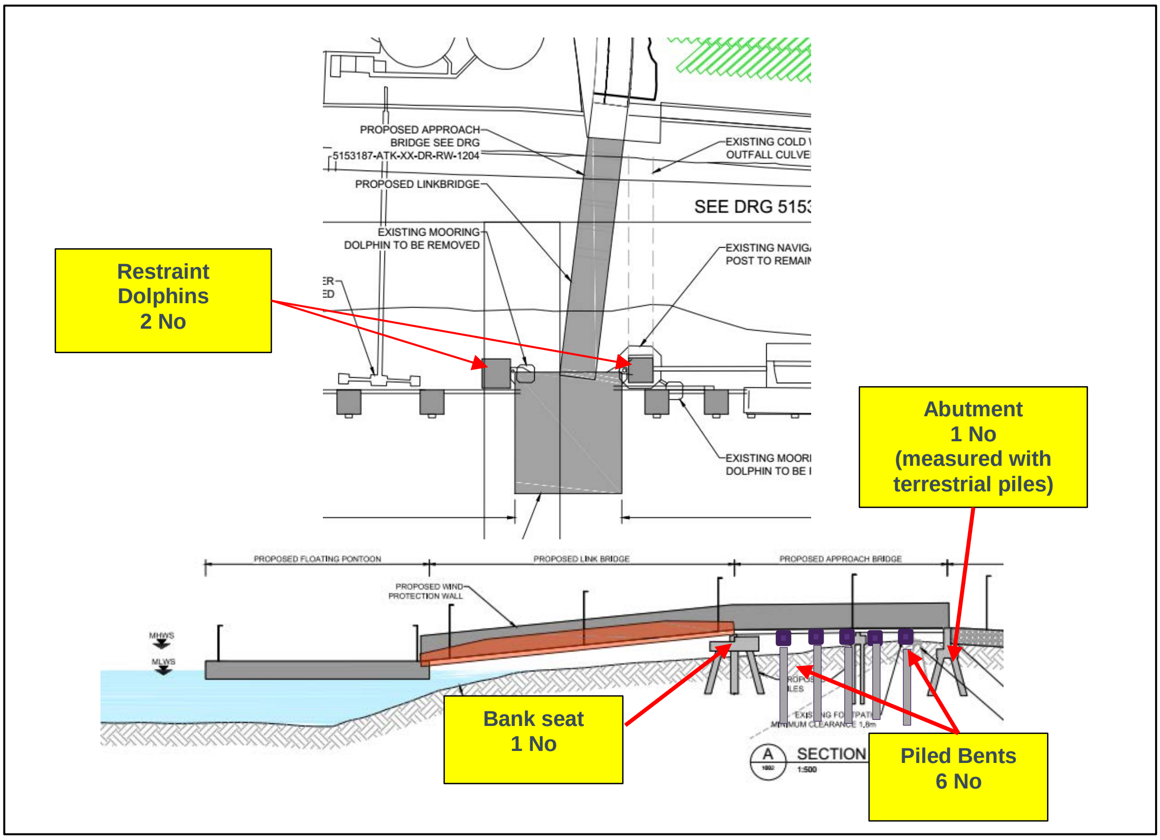

Figure 4. RoRo Pontoon and Approach Bridge

Technical note

Table 1 - Schedule of Piles

Structure	No. of Structures	Multipile Option		Monopile Option	
		Diameter (m)	Numbers	Diameter (m)	Numbers
Upstream Berth					
Dolphin Type A	5	1.22	12 each 60 total	3.5	1 each 5 total
Fenders for Dolphin Type A	5	1.22	3 each 15 total	1.22	3 each 15 total
Footbridge Supports	4	0.914	2 each 8 total	0.914	2 each 8 total
Downstream Berth (Jetty A)					
Dolphin Type A	2	1.22	12 each 24 total	3.5	1 each 2 total
Fenders for Dolphin Type A	2	1.22	3 each 6 total	1.22	3 each 6 total
Fenders for Jetty A	13	1.22	3 each 39 total	1.22	3 each 39 total
CMAT Berth (Jetty B and Beyond)					
Dolphin Type A	8	1.22	12 each 96 total	3.5	1 each 8 total
Fenders for Dolphin Type A	8	1.22	3 each 24 total	1.22	3 each 24 total
Footbridge Supports	2	0.914	2 each 4 total	0.914	2 each 4 total
Conveyor Hopper platform	1	1.22	12 each 12 total	1.22	12 each 12 total
Conveyor supports	3	1.22	3 each 9 total	1.22	3 each 9 total
RoRo Pontoon and Approach Bridge					
Restraint Dolphins	2	1.22	14 each 28 total	3.5	2 each 4 total
Bank Seat	1	1.22	14 each 14 total	1.22	14 each 14 total
Piled Bents	6	1.22	4 each 24 total	1.22	4 each 24 total
Abutment	1	1.22	Measured with terrestrial piles	1.22	Measured with terrestrial piles

Table 2 Steel Sheet Piles

Structure	Length (m)	Height (m)
CMAT Berth (Jetty B and Beyond)		
Steel Sheet Piles	330	25

Technical note

Table 3- Pile plan areas

Structure	No. of Structures	Multipile Option		Monopile Option	
		Dia (m) and No.	Area (m^2)	Dia (m) and No.	Area (m^2)
Upstream Berth					
Dolphin Type A	5	60 x 1.22m	70.1	5 x 3.5m	48.1
Fenders for Dolphin Type A	5	15x1.22m	17.5	15 x 1.22	17.5
Footbridge Supports	4	8 x 0.914m	5.2	8 x 0.914m	5.2
Downstream Berth (Jetty A)					
Dolphin Type A	2	24 x1.22m	28.1	2 x 3.5m	19.2
Fenders for Dolphin Type A	2	6 x 1.22m	7.0	6 x 1.22m	7.0
Fenders for Jetty A	13	39 x 1.22m	45.6	39 x 1.22m	45.6
CMAT Berth (Jetty B and Beyond)					
Dolphin Type A	8	96 x 1.22m	112.2	8 x 3.5m	77.0
Fenders for Dolphin Type A	8	24 x 1.22m	28.1	24 x 1.22m	28.1
Footbridge Supports	2	4 x 0.914m	2.6	4 x 0.914m	2.6
Conveyor Hopper platform	1	12 x 1.22m	14.0	12 x 1.22m	14.0
Conveyor supports	3	9 x1.22m	10.5	9 x 1.22m	10.5
Sheet pile cut-off	1	330m long, 20mm thick	9.9	330m long, 20mm thick	9.9
RoRo Pontoon and Approach Bridge					
Restraint Dolphins	2	28 x 1.22m	32.7	4 x3.5m	38.5
Bank Seat	1	14 x 1.22m	16.4	14 x1.22m	16.4
Piled Bents	6	24 x 1.22m	28.1	24 x 1.22m	28.1
Abutment	1	1.22m	Measured with terrestrial piles	1.22m	Measured with terrestrial piles
Total of piles					
	Sheet pile	N/A	Area 9.9	N/A	Area 9.9
	0.914m diameter	Number 12	Area 7.9	Number 12	Area 7.9
	1.22m diameter	Number 351	Area 410.3	Number 143	Area 167.2
	3.5m diameter	Number Nil	Area Nil	Number 19	Area 182.8
Grand total		**For multipile solution**	**428.1**	**For monopile solution**	**367.7**
Area of DCO Maritime Space			**225,039**		**225,039**
Percentage of area			**0.190%**		**0.163%**