Thurrock Flexible Generation Plant

Environmental Statement Volume 6
Appendix 7.2: Geoarchaeological Deposit Model Report

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Environmental Impact Assessment

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Appendix 7.2

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Summary

This appendix presents the results geo-archaeological deposit modelling and interpretation of evidence from intrusive site investigations, which informs the assessment impacts in Volume 3, Chapter 7 of the Environmental Statement.

THURROCK FLEXIBLE GENERATION PLANT, TILBURY, SOUTH ESSEX

Geoarchaeological Deposit Model Report

NGR: TQ 6630 7660

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1. NON-TECHNICAL SUMMARY

A programme of geoarchaeological fieldwork and deposit modelling was carried out at the Thurrock FGP site to: (1) clarify the nature of the sub-surface stratigraphy across the site; (2) enhance our understanding of the nature, depth, extent 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, up to three distinct horizons of peat are identified, towards the base, middle and top of the sequence. Each sequence has the potential to provide information on past environmental change, sea level change and human activity, through the preservation of biological remains.

Of particular importance on this site is a mixture of deposits recorded on the western part of the site indicative of a large former channel. This is a very unusual sequence for the site, the Tilbury area and more widely within the Lower Thames Valley, and raises various questions including: (1) what was its former size and orientation; (2) when was it formed, and when did it cease being active, and (3) how does this apparent channel relate to evidence for channel activity recorded in LIDAR imagery.

As a consequence of the findings from the present investigation, the Thurrock FGP site is considered of potential regional significance. Further borehole sequences are clearly required to: (1) elucidate questions relating to the apparent channel identified in FGP-BH1; (2) to complete coverage of the deposit model for the site, and (3) to obtain sequences for palaeoenvironmental investigation as outlined above. Six further boreholes are recommended. The method of coring will need to be carefully considered to maximise recovery of the samples in a mixture of different sediments. A GPR survey may also help to elucidate some of the questions relating to the size and location of the channel. Following completion of these investigations a subsequent program of palaeoenvironmental works can be determined.

2. INTRODUCTION

2.1 Site context

This report summarises the findings arising out of the geoarchaeological fieldwork and deposit modelling undertaken by Quaternary Scientific (University of Reading) in connection with the proposed development of land at Thurrock FGP, Tilbury, South Essex (National Grid Reference: centred on TQ 6630 7660; Figures 1-3). Quaternary Scientific were commissioned by RPS Planning to undertake the geoarchaeological investigations. The site is divided into a number of development areas; the works documented here apply only to the Main Development Site (Area A – Figures 2 & 3). The site is situated on the River Thames floodplain, to the north of the present course of the river and south-east of Fort Road (Figure 1). The British Geological Survey (BGS) (http://mapapps.bgs.ac.uk/geologyofbritain/home.html) show the site underlain by Cretaceous Seaford and Newhaven Chalk Formation bedrock, and describes the Alluvium overlying it as 'Clay, Silty, Peaty, Sandy'. 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 (known as Tilbury I to V), whilst periods of alluvial deposition (known as Thames I to V) represent inundation caused by increased RSL rise. At The World's End, Tilbury (Figure 1), Devoy dated these five peat horizons as follows:

Tilbury I	9450-8750 to 9000-8400 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	7350-6800 to 4550-3950 cal BP	*ca*. -6.50m to -5.30m OD
Tilbury IV	3640-3300 to 3370-3000 cal BP	*ca*. -2.00m to -1.90m OD
Tilbury V	Undated	*ca*. -0.70m OD

Subsequent work at Tilbury Fort (Batchelor, 2009), London Distribution Park (Batchelor et al., 2014; in prep) and most recently Tilbury 2 (Young & Batchelor, 2016; Batchelor et al., 2019) have identified an undulating Shepperton Gravel surface overlain by Alluvium with up to three distinct peat horizons, approximately equivalent in date to Devoy's Tilbury II, III and between IV and V. However, the range of different elevations and ages of these peat horizons suggests that formation was diachronous and in some cases, highly localised.

2.2 Geoarchaeological, palaeoenvironmental and archaeological significance

Nearby sites 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 alluvial units represent periods of changing 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 its location, the site 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 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 Thurrock FGP 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.

The alluvial and organic-rich sediments (in particular peat) 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: Tilbury 2 (Batchelor et al., 2019), London Distribution Park (Batchelor *et al*., 2014; in prep), Tilbury Fort (Batchelor, 2009), Tilbury Docks (Spurrell, 1889) and The World's End (Devoy, 1979) (see Figure 1). At nearby sites such as London Distribution Park/Tilbury North (Batchelor *et al*., 2014) and Tilbury Fort (Batchelor, 2009), 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, 2016). 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 Thurrock FGP 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).

2.3 Aims & Objectives

On the basis of the geoarchaeological, palaeoenvironmental and archaeological potential of the site, investigation of the Thurrock FGP site is required. The following research aims are proposed:

1. To clarify 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 investigate whether the sequences contain any artefact or ecofact evidence for prehistoric or historic human activity;
4. To investigate whether the sequences contain any evidence for natural and/or anthropogenic changes to the landscape (wetland and dryland);
5. To produce new RSL index points, contributing to wider investigations of relative sea level change from the Tilbury area.

A program of geotechnical site investigation works is planned on the Main Development Site, incorporating 6 boreholes, 6 window samples and 10 CPT samples (Figures 2 & 3). These investigations will be subject to geoarchaeological monitoring, the results of which will be used to begin addressing the first two of these aims. The following objectives are proposed for this exercise:

1. To monitor selected geotechnical interventions across the site (the six boreholes)
2. To use the stratigraphic data from all locations, and existing records to produce a deposit model of the major depositional units across the site
3. To make recommendations for any further geoarchaeological, palaeoenvironmental and archaeological investigation

Aims 3 to 5 will be addressed through laboratory-based assessment/analysis, the potential for which will be confirmed after achieving these objectives.

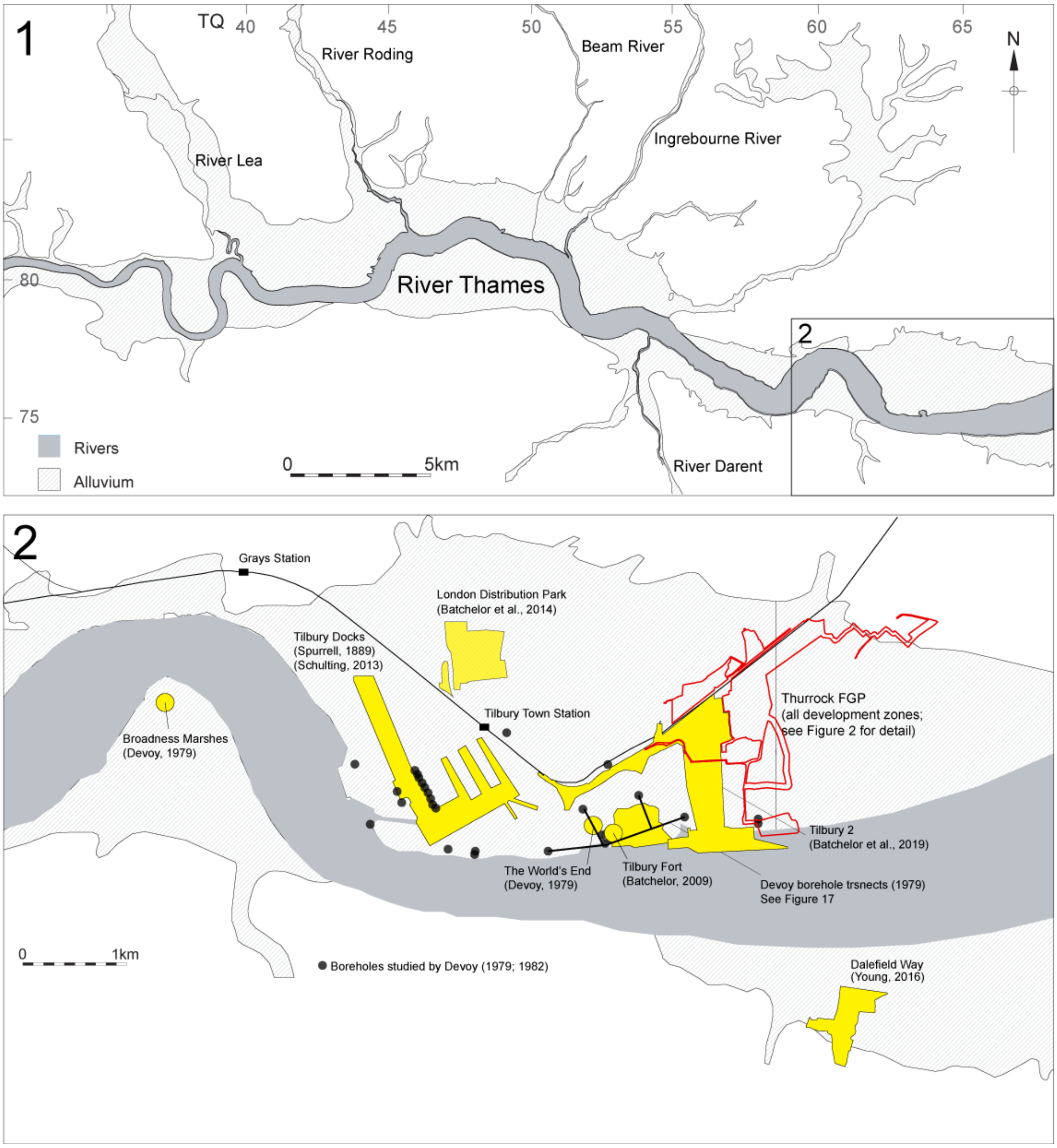

Figure 1: Location of the Tilbury 2 site, Tilbury, South Essex site and other sites of geoarchaeological and palaeoenvironmental interest, showing the extent of the floodplain alluvium.

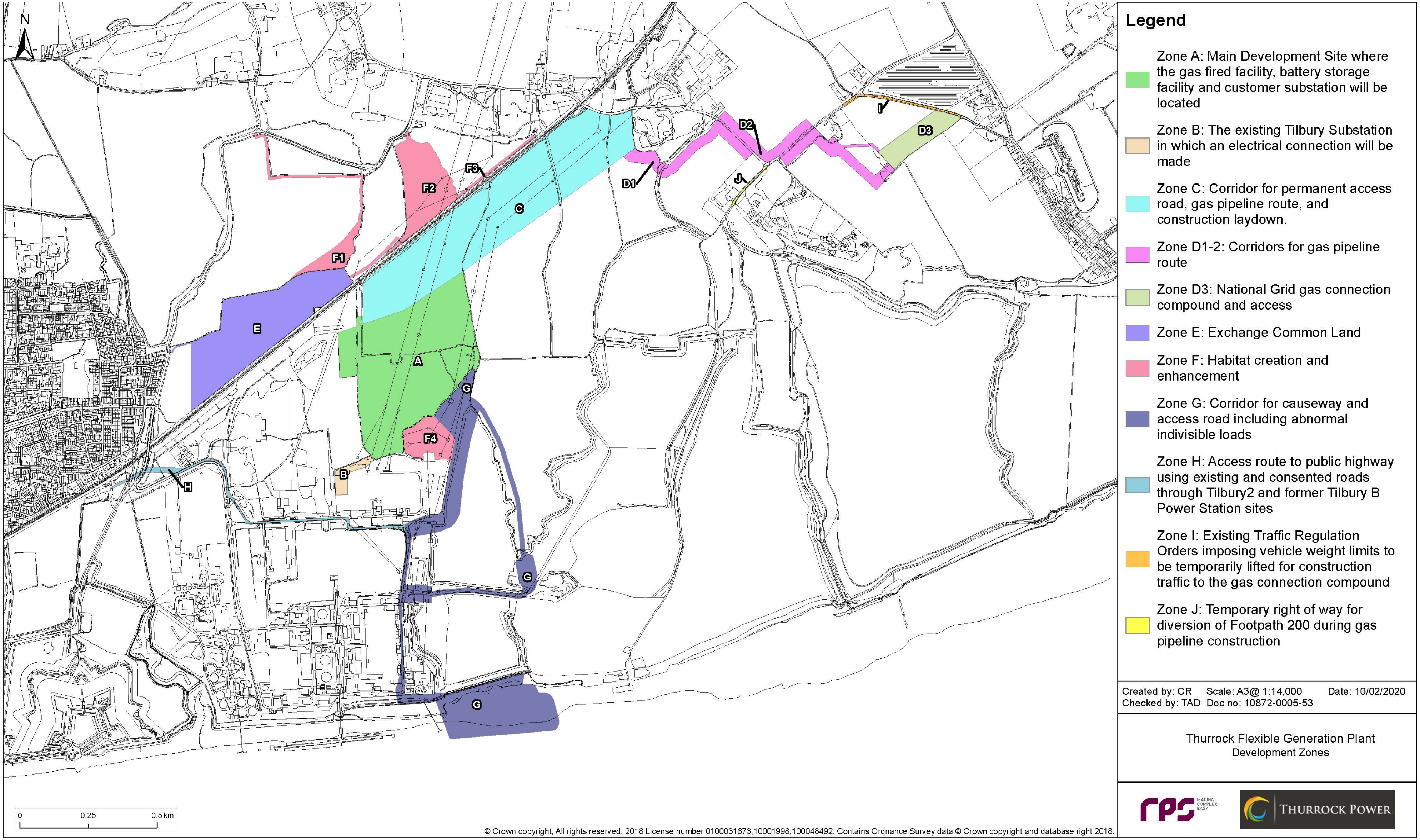

Figure 2: Thurrock Flexible Generation Plant Development Zones. All works outlined here relate only to the Main Development Site (A) (modified from RPS, 2019)

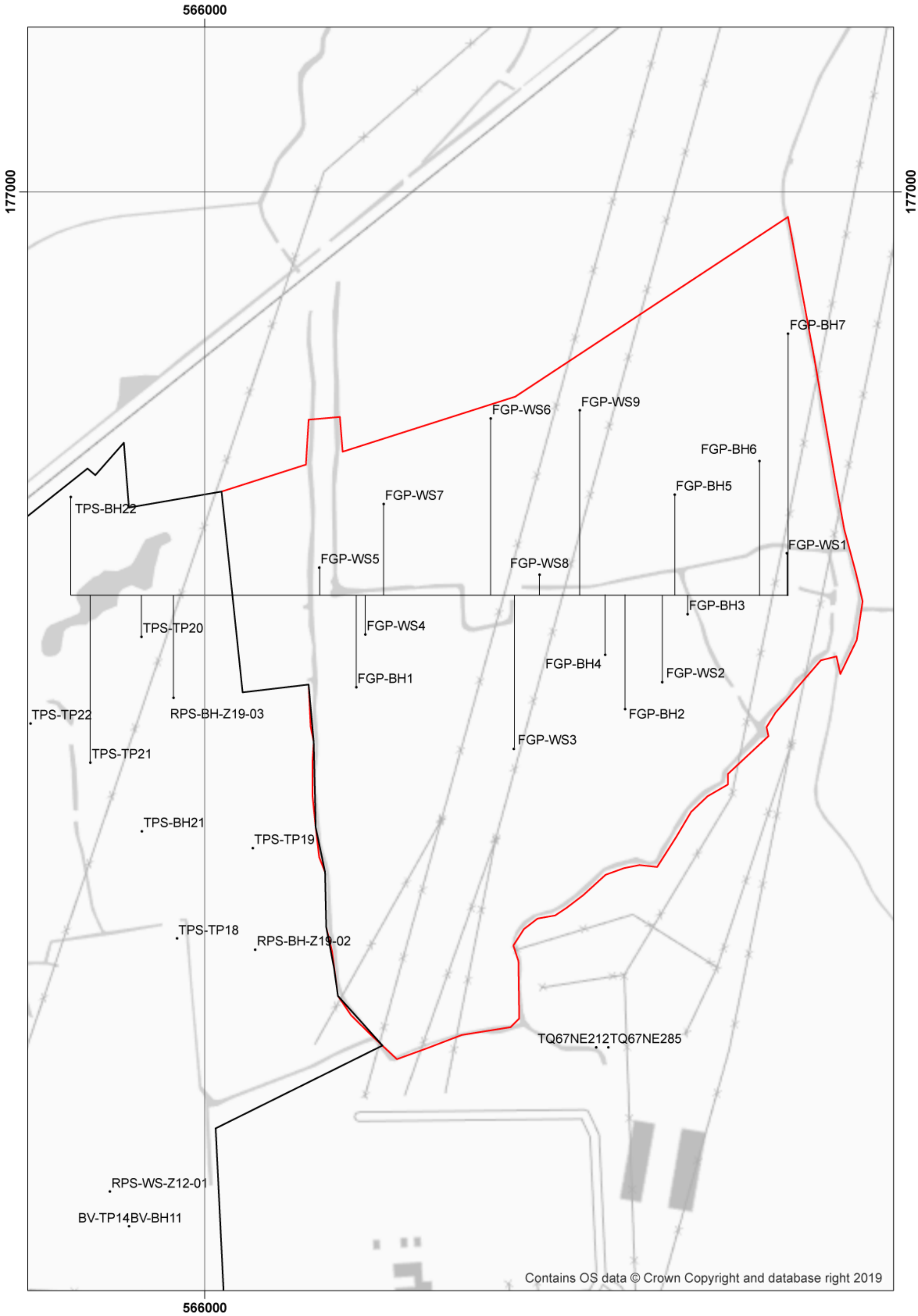

Figure 3: Location of geotechnical site investigations (cable percussion boreholes and window samples only)

3.1 Field investigations

A total of seven cable percussion boreholes (FGP-BH1 to BH7) and nine window samples (FGP-WS1 to WS9) were put down at the site by Terra Consult in September 2019, and monitored by Quaternary Scientific. Spatial co-ordinates for each borehole were obtained using a Leica Differential GPS (Table 1). Ten cone penetration tests were also undertaken, but these did not provide a sufficiently reliable means of estimating the depths between major stratigraphic units and thus were not included.

Table 1: Spatial co-ordinates for the geoarchaeological boreholes

Geotechnical intervention	Easting	Northing	Elevation
FGP-BH1	566123.8	176594.7	1.543
FGP-BH2	566343.8	176576.8	1.358
FGP-BH3	566394.7	176654.5	1.29
FGP-BH4	566327.4	176621.2	1.406
FGP-BH5	566384.1	176752.4	1.224
FGP-BH6	566453.7	176779.8	1.37
FGP-BH7	566477	176884	1.322
FGP-WS1	566475.9	176704.2	1.531
FGP-WS2	566373.8	176598.9	1.327
FGP-WS3	566252.4	176544.2	1.562
FGP-WS4	566131.1	176637.9	1.772
FGP-WS5	566093.3	176692.6	1.272
FGP-WS6	566233.7	176814.7	1.262
FGP-WS7	566146.2	176744.7	1.675
FGP-WS8	566273.7	176686.7	1.532
FGP-WS9	566306.7	176821.1	1.226

Field-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 2-16 and Figure 4.

3.2 Deposit modelling

The deposit model incorporates the sixteen new records from the site, and over 250 records from the neighbouring Tilbury 2 (Batchelor et al., 2019) and 116 BGS archive boreholes (http://mapapps.bgs.ac.uk/geologyofbritain/home.html). A west-east borehole transect traversing the Thurrock FGP and part of the neighbouring Tilbury 2 site is displayed in Figure 4. Sedimentary units from the boreholes were classified into eight groupings: (1) Bedrock, (2) Gravel, (3) Lower Alluvium. (4) Lower Peat, (5) Middle Peat, (6) Upper Peat, (7) Upper Alluvium and (8) Top Soil / 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 Bedrock (Figures 5 & 6) Gravel (Figures 7 & 8), Lower Alluvium (Figure 9), Lower (Figure 10), Middle (Figure 13) and Upper Peat (Figure 16) and the Upper Alluvium (Figure 19 & 20). Thickness of the Lower (Figure 11 & 12), Middle (Figure 14 & 15) and Upper Peat (Figure 17 & 18), the combined Holocene alluvial sequence (Figure 21 & 22), and the Made Ground (Figure 23) 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 north and south-western areas of the site, where no 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, Total Alluvium and Top Soil / 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.

3. RESULTS OF THE FIELD INVESTIGATIONS & LITHOSTRATIGRAPHIC DESCRIPTIONS

The lithostratigraphic descriptions are displayed in Tables 2 to 16, and west-east profile of sequences also incorporating boreholes from the Tilbury 2 site is displayed in Figure 4.

The geotechnical investigations provided an opportunity to gain a good understanding of the sedimentary sequences. However, due to the nature of the work and need to undertake frequent geotechnical testing, the sequences observed from both types of coring had their limitations. The samples seen from the cable percussion boreholes were discontinuous and depths are (in places) coarsely estimated. Furthermore, at depths below 10m, water was frequently added to aid drilling, which resulted in the material brought to the surface as 'slop'. Overall, this meant that the thickness and elevation of the peat and organic-rich units may be misrepresented or missing entirely especially if very thin. The window samples provided a far more accurate means of recording the sedimentary sequence to their maximum depth of 5m bgl, but at the Thurrock FGP site, the samples were simply pushed out of the coring device onto plastic, reducing the normally high level of detail and accuracy that can be obtained. These limitations should be born in mind in the following sections.

4.1 Borehole FGP-BH1

The surface of the bedrock Chalk was recorded at -18.16m OD (19.70m bgl). This was overlain by coarse flint gravels representative of the Shepperton Gravel terrace to -13.46m OD (15.00m bgl). Resting on the gravel surface is a mixture of deposits including fine to coarse grain deposits (including gravels up to 5cm in diameter) and Peat to -9.66m OD (11.20m bgl); above this to 0.44m OD (1.10m bgl) are finally laminated silty clay and sand with occasional plant remains (sedges and reeds) and Mollusca to 0.44m OD (1.10m bgl). This mixture of sediments are interpreted as Channel Fill deposits, the significance of which is outlined section 4.8.

The surface of the Channel Fill deposits is overlain by a 0.1m thick unit of well humified unidentifiable peat between 0.54 and 0.44m OD (0.5-1.0m bgl). Due to the elevation of this peat, it probably correlates most closely with the Upper Peat recorded on the neighbouring Tilbury 2.

The Upper Peat is overlain by 0.5m of grey to brown silty clay with traces of chalk, Mollusca and Iron staining, referred to here as the upper most part of the Upper Alluvium. The surface of the Upper Alluvium (1.04m OD) is capped by a further 0.5m of Top Soil.

4.2 Borehole FGP-BH2

The surface of the bedrock Chalk was recorded at -17.64m OD (19.00m bgl). This was overlain by coarse flint gravels representative of the Shepperton Gravel terrace to -14.64m OD (16.10m bgl). This surface is overlain by fine-grained occasionally laminated mineral-rich deposits dominated by silt and clay with occasional sand, sedge / reed remains. and Mollusca remains to 1.26m OD (0.10m bgl) capped by 0.10m of Top Soil. 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 (at least) two distinct levels:

1. A 1.2m thick horizon of well humified unidentified peat with traces of herbaceous plant remains (sedges / reeds) was recorded between -4.64 and -5.84m OD (6.00 to 7.20m bgl). Due to the elevation and position of this peat, it is considered representative of the Middle Peat recorded on the neighbouring Tilbury 2 site.
2. A 0.1m thick unit of well humified unidentifiable peat between 0.06 and -0.04m OD (1.3-1.4m bgl). Due to the elevation of this peat, it probably correlates most closely with the Upper Peat recorded on the neighbouring Tilbury 2.

4.3 Borehole FGP-BH3

The surface of the bedrock Chalk was recorded at -19.01m OD (20.30m bgl). This was overlain by coarse flint gravels representative of the Shepperton Gravel terrace to -13.71m OD (15.00m bgl). This surface is overlain by fine-grained occasionally laminated mineral-rich deposits dominated by silt and clay with occasional sand, sedge / reed remains to 0.99m OD (0.30m bgl) capped by 0.30m of Top Soil. 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 (at least) three distinct levels:

1. A 0.5m thick horizon of silty sandy peat with traces of detrital plant remains is recorded immediately above the Shepperton Gravel surface between -13.21 and -13.71m OD (14.50 to 15.00m bgl). This unit is within the elevation and position previously ascribed to the Lower Peat on the Tilbury 2 site.
2. A 1.7m thick horizon of well humified unidentified and herbaceous peat with frequent sedge / reed remains was recorded between -4.51 and -6.21m OD (5.80 to 7.50m bgl). Due to the elevation and position of this peat, it is considered representative of the Middle Peat recorded on the neighbouring Tilbury 2 site.
3. A 0.3m thick unit of well humified unidentifiable clayey peat with herbaceous plant remains between -0.21 and -0.51m OD (1.5-1.8m bgl). Due to the elevation of this peat, it probably correlates most closely with the Upper Peat recorded on the neighbouring Tilbury 2.

4.4 Borehole FGP-BH4

The surface of the bedrock Chalk was recorded at -18.09m OD (19.50m bgl). This was overlain by coarse flint gravels representative of the Shepperton Gravel terrace to -14.59m OD (16.00m bgl). This surface is overlain by fine-grained occasionally laminated mineral-rich deposits dominated by silt and clay with occasional sand, sedge / reed remains to 1.31m OD (0.10m bgl) capped by 0.1m of Top Soil. 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 (at least) two distinct levels:

1. A 1.7m thick horizon of well humified unidentified and herbaceous peat with frequent sedge / reed remains and traces of wood was recorded between -4.09 and -5.79m OD (5.50 to 7.20m bgl). Due to the elevation and position of this peat, it is considered representative of the Middle Peat recorded on the neighbouring Tilbury 2 site.

2. A 0.45m thick unit of well humified unidentifiable herbaceous and unidentifiable peat was recorded between -0.09 and -0.54m OD (1.5-1.95m bgl). Due to the elevation of this peat, it probably correlates most closely with the Upper Peat recorded on the neighbouring Tilbury 2.

4.5 Borehole FGP-BH5

The surface of the bedrock Chalk was recorded at -17.78m OD (19.10m bgl). This was overlain by coarse flint gravels representative of the Shepperton Gravel terrace to -13.28m OD (14.50m bgl). This surface is overlain by fine-grained occasionally laminated mineral-rich deposits dominated by silt and clay with occasional sand, sedge / reed remains to 0.92m OD (0.30m bgl) capped by 0.30m of Top Soil. 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 (at least) three distinct levels:

1. A 0.5m thick horizon of unidentifiable peat with silty clay is recorded immediately above the Shepperton Gravel surface, separated by 2.8m of silty clay with frequent plant remains from a 0.2m thick horizon of highly humified herbaceous and unidentifiable peat. The lowermost peaty unit is recorded between -12.78 and -13.28m OD (14.00 to 14.50m bgl), and the second is at -9.78 to -9.98m OD (11.00 to 11.20m bgl). Both of these units are within the elevation and position previously ascribed to the Lower Peat on the Tilbury 2 site.
2. A 1.0m thick horizon of moderately humified unidentifiable, herbaceous and wood peat was recorded between -4.58 and -5.58m OD (4.58 to 5.58m bgl), underlain by a 0.4m thick organic silt with traces of sand, Mollusca and seeds to -5.98m OD (7.2m bgl). Due to the elevation and position of these two units, they are considered representative of the Middle Peat recorded on the neighbouring Tilbury 2 site.
3. A 0.2m thick unit of well humified unidentifiable peat with herbaceous plant remains was recorded between -0.08 and -0.28m OD (1.3-1.5m bgl). Due to the elevation of this peat, it probably correlates most closely with the Upper Peat recorded on the neighbouring Tilbury 2.

4.6 Borehole FGP-BH6

The surface of the bedrock Chalk was recorded at -17.63m OD (19.00m bgl). This was overlain by coarse flint gravels representative of the Shepperton Gravel terrace to -11.13m OD (12.50m bgl). This surface is overlain by fine-grained occasionally laminated mineral-rich deposits dominated by silt and clay with occasional sand, sedge / reed remains to 0.97m OD (1.37m bgl) capped by 0.40m of Top Soil. 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 (at least) three distinct levels:

1. A 0.3m thick horizon of unidentifiable and herbaceous peat is recorded 1.3m above the Shepperton Gravel surface, between -9.83 to -10.13m OD (11.20 to 11.50m bgl). This unit is within the elevation and position previously ascribed to the Lower Peat on the Tilbury 2 site.
2. A 1.5m thick horizon of moderately humified unidentifiable and herbaceous peat was recorded between -4.13 and -5.63m OD (5.50 to 7.00m bgl). Due its elevation and position this peat is considered representative of the Middle Peat recorded on the neighbouring Tilbury 2 site.

3. A 0.1m thick unit of well humified unidentifiable peat was recorded between 0.27 and 0.17m OD (1.1-1.2m bgl). Due to the elevation of this peat, it probably correlates most closely with the Upper Peat recorded on the neighbouring Tilbury 2.

4.7 Borehole FGP-BH7

The surface of the bedrock Chalk was recorded at -17.18m OD (18.50m bgl). This was overlain by coarse flint gravels representative of the Shepperton Gravel terrace to -12.18m OD (13.50m bgl). This surface is overlain by fine-grained occasionally laminated mineral-rich deposits dominated by silt and clay with occasional sand, sedge / reed remains to 1.22m OD (0.10m bgl) capped by 0.10m of Top Soil. These mineral rich layers are equivalent to the Lower and Upper Alluvium are separated by a 1.0m thick horizon of well humified unidentifiable, herbaceous and wood peat overlain by sandy peat is recorded 0.7m above the Shepperton Gravel surface, between -10.48 to -11.48m OD (11.80 to 12.80m bgl). These units are within the elevation and position previously ascribed to the Lower Peat on the Tilbury 2 site.

4.7 Window samples FGP-WS1 to WS9

Each of the window samples reached to 5m bgl and recorded a similar sequence of fine-grained occasionally laminated mineral-rich deposits dominated by silt and clay with occasional sand, sedge / reed remains, capped by up to 0.4m of Top Soil. Within FGP-WS2, WS3, WS4, WS5 and WS8, a thin (generally up to 10cm thick) horizon of well-humified predominantly unidentifiable peat was recorded. These units are within the elevation and position previously ascribed to the Lower Peat on the Tilbury 2 site.

Also of note were traces of brick in the uppermost part of the Upper Alluvium in FGP-WS4; this was the only definitive anthropogenic material recorded within any of the borehole or window sample sequences.

Table 2: Lithostratigraphic description of FGP-BH1, Thurrock FGP

Depth (m bgl)	Depth (m OD)	Lithostratigraphic description	Stratigraphic unit
0 to 0.50	1.54 to 1.04	Top soil	TOP SOIL
0.50 to 1.00	1.04 to 0.54	10YR 5/3 to 10YR 5/1; As3, Ag1; Brown becoming grey silty clay with traces of chalk and Mollusca. Unidentifiable well humified peat lense recorded around 1m bgl	UPPER ALLUVIUM
1.00 to 1.10	0.54 to 0.44	10YR 2/1; Sh4, Th+; Humo 4; Black well humified unidentifiable peat with traces of herbaceous plant remains	UPPER PEAT
1.10 to 11.20	0.44 to -9.66	10YR 5/1; Ga2, Ag1, As1; Grey frequently laminated silty clay and sand with occasional herbaceous plant remains (sedges/reeds), and Mollusca	CHANNEL FILL
11.20 to 13.30	-9.66 to -11.76	10YR 4/1; Ga2, Gg2; Dark grey sandy flint gravel. Gravel sub-rounded to angular and <5cm in size	
13.30 to 13.70	-11.76 to -12.16	10YR 2/1; Sh3, Th1; Humo 2; Black moderately humified unidentifiable peat and herbaceous peat	
13.70 to 14.20	-12.16 to -12.66	10YR 4/1; Ga2, Gg2; Dark grey sandy flint gravel. Gravel sub-rounded to angular and <5cm in size	
14.20 to 15.00	-12.66 to -13.46	10YR 5/1; As2, Ga2; Grey silty sand	
15.00 to 19.70	-13.46 to -18.16	10YR 4/1; Ga2, Gg2; Dark grey sandy flint gravel. Gravel sub-rounded to sub-angular and frequently >5cm in size (cobbles measuring 20cm recorded)	SHEPPERTON GRAVEL
>19.70	< -18.16	Chalk bedrock	CHALK

Table 3: Lithostratigraphic description of FGP-BH2, Thurrock FGP

Depth (m bgl)	Depth (m OD)	Lithostratigraphic description	Stratigraphic unit
0 to 0.10	1.36 to 1.26	Top soil	TOP SOIL
0.10 to 1.30	1.26 to 0.06	10YR 5/3 to 10YR 5/1; As2, Ag2; Brown becoming grey silty clay with traces of sand, plant remains and iron staining	UPPER ALLUVIUM
1.30 to 1.40	0.06 to -0.04	10YR 2/1; Sh4, Th+; Humo 4; Black well humified unidentifiable peat with traces of herbaceous plant remains	UPPER PEAT
1.40 to 6.00	-0.04 to -4.64	10YR 5/1; As2, Ag2, Th+; Grey silty clay with traces of herbaceous plant remains (sedges/reeds)	UPPER ALLUVIUM
6.00 to 7.20	-4.64 to -5.84	10YR 2/1 to 10YR 3/3; Sh2-3, Th1-2[2]; Humo 3; Black to very dark brown compacted well-humified unidentifiable and herbaceous peat with horizontally bedded sedges/reeds.	MIDDLE PEAT
7.20 to 9.00	-5.84 to -7.64	10YR 5/1; As3, Ag1; Grey silty clay	LOWER ALLUVIUM
9.00 to 16.10*	-7.64 to -14.74	10YR 5/1; Ag2, Ga2; Grey silty sand; increasing sand with depth	
16.10 to 19.00*	-14.74 to -17.64	10YR 4/1; Ga2, Gg2; Dark grey sandy flint gravel. Gravel sub-rounded to sub-angular and frequently >5cm in size (cobbles measuring 10cm recorded)	SHEPPERTON GRAVEL
>19.00	< -17.64	Chalk bedrock	CHALK

Table 4: Lithostratigraphic description of FGP-BH3, Thurrock FGP

Depth (m bgl)	Depth (m OD)	Lithostratigraphic description	Stratigraphic unit
0 to 0.30	1.29 to 0.99	Top soil	TOP SOIL
0.30 to 1.00	0.99 to 0.29	10YR 5/3 to 10YR 5/1; As2, Ag2; Brown becoming grey silty clay with rootlets and iron staining	UPPER ALLUVIUM
1.00 to 1.50	0.29 to -0.21	10YR 5/1; As2, Ag2; Grey silty clay with frequent vertical roots, infilled with yellow-white precipitate	
1.50 to 1.80	-0.21 to -0.51	10YR 3/3; Sh2, As1, Th1; Humo 3; Very dark brown well-humified clayey unidentifiable and herbaceous peat; frequent sedge/reed remains	UPPER PEAT
1.80 to 5.50	-0.51 to -4.21	10YR 5/1; As2, Ag2, Th+; Grey very soft silty clay with traces of herbaceous plant remains (sedges/reeds)	UPPER ALLUVIUM
5.50 to 5.80	-4.21 to -4.51	10YR 5/1; As2, Ag1, Th1; Grey silty clay with herbaceous plant remains (sedges/reeds)	
5.80 to 7.50	-4.51 to -6.21	10YR 4/3 to 10YR 3/3; Sh2-3, Th1-2^2, Tl+; Humo 3-4; Brown to very dark brown well-humified unidentifiable and herbaceous peat with traces of wood	MIDDLE PEAT
7.50 to 14.50*	-6.21 to -13.21	10YR 5/1; Ag2, As2; Grey silty clay	LOWER ALLUVIUM
14.50 to 15.00*	-13.21 to -13.71	10YR 3/1; Ga2, Ag1, Sh1, Th+; Very dark grey organic-rich silty sand with traces of detrital plant remains	LOWER PEAT
15.00 to 20.30	-13.71 to -19.01	10YR 4/1; Ga2, Gg2; Dark grey sandy flint gravel. Gravel sub-rounded to sub-angular and frequently >5cm in size (cobbles measuring 10cm recorded)	SHEPPERTON GRAVEL
>20.30	< -19.01	Chalk bedrock	CHALK

Table 4: Lithostratigraphic description of FGP-BH4, Thurrock FGP

Depth (m bgl)	Depth (m OD)	Lithostratigraphic description	Stratigraphic unit
0 to 0.10	1.41 to 1.31	Top soil	TOP SOIL
0.10 to 0.90	1.31 to 0.51	10YR 3/3; As2, Ag2; Brown stiff silty clay with rooting and iron-staining	UPPER ALLUVIUM
0.90 to 1.50	0.51 to -0.09	10YR 5/1; As2, Ag2, Th+; Grey silty clay with traces of detrital plant remains	
1.50 to 1.95	-0.09 to -0.54	10YR 2/1; Sh3, Th1; Humo 4; Black very well-humified unidentifiable and herbaceous peat	UPPER PEAT
1.95 to 5.50	-0.54 to -4.09	10YR 5/1; As2, Ag2, Th+; Grey soft silty clay with traces of herbaceous plant remains (sedges/reeds)	UPPER ALLUVIUM
5.50 to 7.20	-4.09 to -5.79	10YR 4/3; Sh2, Th^{2}2 to Sh3, Th^{2}1, Tl+; Humo 3; Dark brown well-humified herbaceous and unidentifiable peat with traces of wood	MIDDLE PEAT
7.20 to 12.00	-5.79 to -10.59	10YR 5/1; Ag2, As2; Grey silty clay	LOWER ALLUVIUM
12.00 to 14.00	-10.59 to -12.59	10YR 5/1; Ag2, Ga2; Grey silty sand	
14.00 to 16.00	-12.59 to -14.59	10YR 5/1; Ga4, Gg+; Grey sand with traces of fine angular gravel	
16.00 to 19.50	-14.59 to -18.09	10YR 4/1; Ga2, Gg2; Dark grey sandy flint gravel. Gravel sub-rounded to sub-angular and frequently >5cm in size (cobbles measuring 10cm recorded)	SHEPPERTON GRAVEL
>19.50	> -18.09	Chalk bedrock	CHALK

Table 5: Lithostratigraphic description of FGP-BH5, Thurrock FGP

Depth (m bgl)	Depth (m OD)	Lithostratigraphic description	Stratigraphic unit
0 to 0.30	1.22 to 0.92	Top soil	TOP SOIL
0.30 to 1.30	0.92 to -0.08	10YR 5/1 to 10YR 5/3; As2, Ag2, Gg+; Grey to brown stiff silty clay with rooting, chalk and iron-staining and traces of gravel	UPPER ALLUVIUM
1.30 to 1.50	-0.08 to -0.28	10YR 2/1; Sh3, Th1; Humo 4; Black very well-humified unidentifiable and herbaceous peat	UPPER PEAT
1.50 to 5.50	-0.28 to -4.28	10YR 5/1; As3, Ag1, Th+; Grey soft silty clay with traces of herbaceous plant remains (sedges/reeds)	UPPER ALLUVIUM
5.50 to 5.80	-4.28 to -4.58	10YR 3/1; As3, Ag1, Th+; Dark grey soft silty clay with traces of herbaceous plant remains (sedges/reeds)	
5.80 to 6.80	-4.58 to -5.58	10YR 4/3; Sh2, Th^{2}1, Tl^{2}1; Humo 3; Very dark brown well-humified herbaceous and unidentifiable peat with large pieces of 'rubberised' wood between 6.5 and 6.8m bgl	MIDDLE PEAT
6.80 to 7.20	-5.58 to -5.98	5Y 5/4; Sh2 Ag2, Ga+; Olive organic silt with traces of sand, Mollusca and seeds	
7.20 to 11.00	-5.98 to -9.78	10YR 5/1; As3, Ag1, Th+; Grey soft silty clay with traces of herbaceous plant remains (sedges/reeds)	LOWER ALLUVIUM
11.00 to 11.20	-9.78 to -9.98	10YR 2/1; Sh3, Th1; Humo 4; Black highly humifed herbaceous and unidentifiable peat; insect remain noted	LOWER PEAT
11.20 to 14.00	-9.98 to -12.78	10YR 5/1; As2, Ag1, Dh1, Ga+; Grey silty clay with frequent herbaceous plant remains (sedges/reeds) and traces of sand	LOWER ALLUVIUM
14.00 to 14.50	-12.78 to -13.28	10YR 3/1; Sh2, As1, Ag1, Th+, Tl+; Very dark grey organic-rich silty clay with traces of herbaceous and twig remains	LOWER PEAT
14.50 to 19.00	-13.28 to -17.78	10YR 4/1; Ga2, Gg2; Dark grey sandy flint gravel. Gravel sub-rounded to sub-angular and frequently >5cm in size (cobbles measuring 10cm recorded)	SHEPPERTON GRAVEL
>19.00	< -17.78	Chalk bedrock	CHALK

Table 6: Lithostratigraphic description of FGP-BH6, Thurrock FGP

Depth (m bgl)	Depth (m OD)	Lithostratigraphic description	Stratigraphic unit
0 to 0.40	1.37 to 0.97	Top soil	TOP SOIL
0.40 to 1.10	0.97 to 0.27	10YR 5/2; As2, Ag2, Gg+; Greyish brown stiff silty clay with rooting, iron-staining and traces of Mollusca	UPPER ALLUVIUM
1.10 to 1.20	0.27 to 0.17	10YR 2/1; Sh4, Tl+; Humo 4; Black very well-humified unidentifiable peat with traces of herbaceous remains and modern rooting	UPPER PEAT
1.20 to 5.50	0.17 to -4.13	10YR 5/1; As3, Ag1, Th+, Ga+; Grey soft silty clay with traces of herbaceous plant remains (sedges/reeds) and occasional sand. Yellowish white residue infills vertical rooting in upper part of the unit	UPPER ALLUVIUM
5.50 to 7.00	-4.13 to -5.63	10YR 4/3; Sh3, Th^{2}1, Tl+; Humo 3; Very dark brown well-humified herbaceous and unidentifiable peat with occasional fragments of wood	MIDDLE PEAT
7.00 to 10.00	-5.63 to -8.63	10YR 5/1; As2, Ag1, Th1; Grey soft silty clay with herbaceous plant remains (sedges/reeds)	LOWER ALLUVIUM

10.00 to 11.20	-8.63 to -9.83	10YR 5/1; As2, Ag1, Ga1, Th+; Grey soft sandy silty clay with traces of herbaceous plant remains (sedges/reeds)	
11.20 to 11.50	-9.83 to -10.13	10YR 2/1; Sh3, T11, Th+; Humo 4; Black highly humifed wood and unidentifiable peat; insect remain noted	LOWER PEAT
11.50 to 12.00	-10.13 to -10.63	10YR 5/1; As2, Ag2, Dh+; Grey silty clay with frequent herbaceous plant remains (sedges/reeds)	LOWER ALLUVIUM
12.00 to 12.50	-10.63 to -11.13	10YR 3/1; As2, Ag1, Ga1, Sh+; Very dark grey silty sandy clay with traces of organic remains	
12.50 to 19.00	-11.13 to -17.63	10YR 4/1; Ga2, Gg2; Dark grey sandy flint gravel. Gravel sub-rounded to sub-angular and frequently >5cm in size (cobbles measuring 10cm recorded)	SHEPPERTON GRAVEL
>19.00	< -17.63	Chalk bedrock	CHALK

Table 7: Lithostratigraphic description of FGP-BH7, Thurrock FGP

Depth (m bgl)	Depth (m OD)	Lithostratigraphic description	Stratigraphic unit
0 to 0.10	1.32 to 1.22	Top soil	TOP SOIL
0.10 to 1.50	1.22 to -0.18	10YR 5/2; As2, Ag2, Ga+; Greyish brown stiff silty clay with occasional lenses of sand (bedding?) rooting, iron-staining	UPPER ALLUVIUM
1.50 to 6.00	-0.18 to -4.68	10YR 2/1; As2, Ag1, Ga1, Th+; Grey soft silty clay and sand (bedded) with traces of herbaceous plant remains (sedges/reeds).	
6.00 to 7.50	-4.68 to -6.18	10YR 5/1; As3, Th1, Sh+; Grey soft silty clay with herbaceous plant remains (sedges/reeds) and occasional organic remains	
7.50 to 8.50	-6.18 to -7.18	10YR 5/1; As3, Ag1, Th+; Grey soft silty clay with traces of herbaceous plant remains (sedges/reeds)	LOWER ALLUVIUM
8.50 to 10.50	-7.18 to -9.18	10YR 2/1; As2, Ag1, Ga1, Th+; Grey soft silty clay and sand (bedded) with traces of herbaceous plant remains (sedges/reeds).	
10.50 to 11.80	-9.18 to -10.48	10YR 5/1; Ga4; Grey sand	
11.80 to 12.00	-10.48 to -10.68	10YR 3/1; Ga2, Sh1, Ag1; Very dark grey organic-rich silty sand	LOWER PEAT
12.00 to 12.80	-10.68 to -11.48	10YR 2/1; T1^{2}2 Sh1, Th1; Humo 3; Black highly humifed wood, herbaceous and unidentifiable peat, with frequent fragments of wood	
12.80 to 13.50	-11.48 to -12.18	10YR 4/1; Ga2, Ag1, Sh1; Dark grey organic-rich silty sand	LOWER ALLUVIUM
13.50 to 18.50	-12.18 to -17.18	10YR 4/1; Ga2, Gg2; Dark grey sandy flint gravel. Gravel sub-rounded to sub-angular and frequently >5cm in size (cobbles measuring 10cm recorded)	SHEPPERTON GRAVEL
>18.50	< -17.18	Chalk bedrock	CHALK

Table 8: Lithostratigraphic description of FGP-WS1, Thurrock FGP

Depth (m bgl)	Depth (m OD)	Lithostratigraphic description	Stratigraphic unit
0 to 0.40	1.53 to 1.13	Top soil	TOP SOIL
0.40 to 1.80	1.13 to -0.27	10YR 5/2; As2, Ag2, Ga+; Greyish brown stiff silty clay	UPPER ALLUVIUM
1.80 to 5.00	-0.27 to -3.47	10YR 5/1; As3, Ag1; Grey soft silty clay	

Table 9: Lithostratigraphic description of FGP-WS2, Thurrock FGP

Depth (m bgl)	Depth (m OD)	Lithostratigraphic description	Stratigraphic unit
0 to 0.40	1.33 to 0.93	Top soil	TOP SOIL
0.40 to 1.30	0.93 to 0.03	10YR 5/1 to 10YR 5/3; As2, Ag2; Brown becoming grey stiff silty clay with rooting, iron-staining and traces of Mollusca	UPPER ALLUVIUM
1.30 to 1.50	0.03 to -0.17	10YR 2/1; Sh4, Tl+; Humo 4; Black very well-humified unidentifiable peat with traces of wood remains and modern rooting	UPPER PEAT
1.50 to 5.00	-0.17 to -3.67	10YR 2/1; As2, Ag1, Th+; Grey soft silty clay and sand with traces of herbaceous plant remains (sedges/reeds).	UPPER ALLUVIUM

Table 10: Lithostratigraphic description of FGP-WS3, Thurrock FGP

Depth (m bgl)	Depth (m OD)	Lithostratigraphic description	Stratigraphic unit
0 to 0.40	1.56 to 1.16	Top soil	TOP SOIL
0.40 to 0.95	1.16 to 0.61	10YR 5/1 to 10YR 5/3; As2, Ag2; Brown becoming grey stiff silty clay with rooting and iron-staining	UPPER ALLUVIUM
0.95 to 1.00	0.61 to 0.56	10YR 2/1; Sh4, Tl+; Humo 4; Black very well-humified unidentifiable peat with traces of wood remains and modern rooting	UPPER PEAT
1.00 to 1.50	0.56 to 0.06	10YR 5/1; As3, Ag1, Th+; Grey soft silty clay with traces of herbaceous plant remains (sedges/reeds). Yellowish white residue infills vertical rooting in upper part of the unit	UPPER ALLUVIUM
1.50 to 5.00	0.06 to -3.44	10YR 4/1; Ga2, Ag2, Th+; Dark grey silty sand (sometimes banded, sometimes pure sand) with traces of herbaceous plant remains (sedges/reeds)	

Table 11: Lithostratigraphic description of FGP-WS4, Thurrock FGP

Depth (m bgl)	Depth (m OD)	Lithostratigraphic description	Stratigraphic unit
0 to 0.40	1.77 to 1.37	Top soil	TOP SOIL
0.40 to 0.70	1.37 to 1.07	10YR 5/1; As2, Ag2; Grey silty clay with traces of brick cement and frequent rooting	UPPER ALLUVIUM
0.70 to 1.00	1.07 to 0.77	10YR 5/2; As2, Ag2; Greyish brown stiff silty clay with frequent rooting and iron-staining	
1.00 to 1.50	0.77 to 0.27	10YR 5/1; As3, Ag1, Th+; Grey silty clay with traces of herbaceous plant remains (sedges/reeds). Yellowish white residue infills vertical rooting in upper part of the unit; becomes softer below 1.20m bgl	
1.50 to 1.60	0.27 to 0.17	10YR 2/1; Sh4; Humo 4; Black very well-humified unidentifiable peat with modern rooting	UPPER PEAT
1.60 to 2.00	0.17 to -0.23	10YR 5/1; As3, Ag1, Th+; Grey soft silty clay with traces of herbaceous plant remains (sedges/reeds)	UPPER ALLUVIUM
2.00 to 5.00	-0.23 to -3.23	10YR 5/1; As3, Ag1, Th+, Ga+; Grey soft silty clay with traces of herbaceous plant remains (sedges/reeds); becoming increasingly silty sandy	

Table 12: Lithostratigraphic description of FGP-WS5, Thurrock FGP

Depth (m bgl)	Depth (m OD)	Lithostratigraphic description	Stratigraphic unit
0 to 0.30	1.27 to 0.97	Top soil	TOP SOIL
0.30 to 0.50	0.97 to 0.77	Gravel	
0.50 to 1.00	0.77 to 0.27	10YR 5/2; As2, Ag2; Greyish brown stiff silty clay with frequent rooting and iron-staining	UPPER ALLUVIUM
1.00 to 1.10	0.27 to 0.17	10YR 2/1; Sh4; Humo 4; Black very well-humified unidentifiable peat with modern rooting	UPPER PEAT
1.10 to 5.00	0.17 to -3.73	10YR 5/1; As3, Ag1, Th+; Grey soft silty clay with traces of herbaceous plant remains (sedges/reeds)	UPPER ALLUVIUM

Table 13: Lithostratigraphic description of FGP-WS6, Thurrock FGP

Depth (m bgl)	Depth (m OD)	Lithostratigraphic description	Stratigraphic unit
0 to 0.20	1.26 to 1.06	Top soil	TOP SOIL
0.20 to 1.00	1.06 to 0.26	10YR 5/2; As2, Ag2, Ga+; Greyish brown dry & stiff silty clay with occasional sand lenses, frequent rooting and iron and manganese-staining and chalk fragments	UPPER ALLUVIUM
1.00 to 2.00	0.26 to -0.74	10YR 5/3; As2, Ag2, Ga1; Brown silty clay with sand (possible bedding)	
2.00 to 5.00	-0.74 to -3.74	10YR 5/1; As3, Ag1, Th+, Ga+; Grey soft silty clay with traces of herbaceous plant remains (sedges/reeds) and sand	

Table 14: Lithostratigraphic description of FGP-WS7, Thurrock FGP

Depth (m bgl)	Depth (m OD)	Lithostratigraphic description	Stratigraphic unit
0 to 0.20	1.68 to 1.48	Top soil	TOP SOIL
0.20 to 1.20	1.48 to 0.48	10YR 5/2; As2, Ag2, Ga+; Greyish brown dry & stiff silty clay with occasional sand lenses, frequent rooting and iron and manganese-staining and chalk fragments	UPPER ALLUVIUM
1.20 to 1.40	0.48 to 0.28	10YR 5/1; As3, Ag1; Grey silty clay. Yellowish white residue infills vertical rooting	
1.40 to 1.50	0.28 to 0.18	10YR 5/3; As2, Ag2; Brown silty clay with iron staining/panning	
1.50 to 5.00	0.18 to -3.32	10YR 5/1; As2, Ag1, Ga1; Grey soft silty sandy clay	

Table 15: Lithostratigraphic description of FGP-WS8, Thurrock FGP

Depth (m bgl)	Depth (m OD)	Lithostratigraphic description	Stratigraphic unit
0 to 0.20	1.53 to 1.33	Top soil	TOP SOIL
0.20 to 0.98	1.33 to 0.55	10YR 4/2; As3, Ag1; Dark brownish grey silty clay with iron staining, brick fragments and frequent rooting	UPPER ALLUVIUM
0.98 to 1.00	0.55 to 0.53	10YR 2/1; Sh4; Humo 4; Black very well-humified unidentifiable peat with modern rooting	UPPER PEAT
1.00 to 2.00	0.53 to -0.47	10YR 5/1; As2, Ag2, Th+, Ga+; Grey soft silty clay with traces of herbaceous plant remains (sedges/reeds) and sand	UPPER ALLUVIUM
2.00 to 5.00	-0.47 to -3.47	10YR 5/1; As2, Ag1, Ga1; Grey soft silty sandy clay (possible bedding)	

Table 16: Lithostratigraphic description of FGP-WS9, Thurrock FGP

Depth (m bgl)	Depth (m OD)	Lithostratigraphic description	Stratigraphic unit
0 to 0.20	1.23 to 1.03	Top soil	TOP SOIL
0.20 to 0.50	1.03 to 0.73	10YR 5/2; As2, Ag2; Greyish brown stiff silty clay with frequent rooting and iron-staining	
0.50 to 1.00	0.73 to 0.23	10YR 6/2; As2, Ag1, Ga1; Pale greyish brown desiccated silty sandy clay with frequent iron and manganese-staining, rootlets and chalk; possible bedding?	UPPER ALLUVIUM
1.00 to 5.00	0.23 to -3.77	10YR 5/1; As3, Ag1, Th+; Grey soft silty clay with traces of herbaceous plant remains (sedges/reeds)	

4. RESULTS, INTERPRETATION AND DISCUSSION OF THE DEPOSIT MODELLING

The deposit model for the site incorporates the sixteen new records from the site, and over 250 records from the neighbouring Tilbury 2 (Batchelor et al., 2019) and 116 BGS archive boreholes (http://mapapps.bgs.ac.uk/geologyofbritain/home.html). 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 23. Figure 4 is a two-dimensional north-south transect of selected boreholes/test pits across the site; Figures 5 to 23 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 24.

The results of the deposit modelling indicate that the number and spread of the logs is sufficient to permit modelling with a moderate level of certainty across the site, but there are voids towards the north-west and southwest.

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
Channel Fill – only present on the western part of the site
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
Bedrock Chalk – widely present but not reached in all boreholes/window samples

4.1 Bedrock Chalk

The bedrock Chalk was present in all boreholes that penetrated to the base of the Pleistocene deposits. Across the site itself (Figures 4 & 5), the surface of the Chalk is relatively level at around -18m OD. More widely, across the Tilbury 2 site and beyond (Figure 6), the surface is a little more variable, ranging between approximately -16 and -18m OD, with lower elevations of -20 to -22m OD recorded towards the River Thames.

4.2 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.

Across the site (Figures 4 & 7), the surface of the Gravel generally lies at between *ca*. -14 and -12m OD, with the surface generally rising in a north-eastward direction, perhaps reflecting its location closer towards the edge of the present day floodplain. More widely across the Tilbury 2 site and beyond (Figure 8), the surface of the Gravel is generally higher towards the north and west, generally lying between approximately -9.5 and -12.5m OD. It falls in a south-easterly direction to between -12.5 and -15m OD. Within the channel of the Thames, the Gravel surface falls further to between *ca*. -15 and -17m OD, Devoy (1979) produced a north-south transect of boreholes immediately to the west of Tilbury Fort (Figure 24), indicating that (similarly to the topography across the Thurrock FGP and Tilbury 2 sites) the Gravel surface becomes progressively deeper towards the modern course of the Thames, (recorded at between *ca*. -13 and -15m OD).

The topography of the Shepperton Gravel undulates across the wider modelled area, but generally falls in the direction of the present day River Thames as would be expected. However, the Gravel surface appears generally lower towards the east. Whether this represents the position of a former north-south aligned channel, mid channel bar, widening of the former Thames, or some other feature is however unclear, due to an absence of boreholes beyond the confines of the site. The Gravel surface could however be considered to be higher than anticipated along the route of the Infrastructure Corridor; particularly as it also follows a south-west trajectory towards the Thames.

4.3 Lower Alluvium

The Lower Alluvium rests directly on the Shepperton Gravel and was recorded in the majority of records from the eastern part of the site (Figures 4 & 9). As previously highlighted, due to the nature of the geotechnical works, determination of the composition of the Lower Alluvium was limited. However, where possible, the deposits are described as predominantly silty or clayey, tending to become increasingly sandy downward in most sequences. It also frequently contains detrital wood or plant remains, with occasional peat lenses and Mollusca remains. The surface of the Lower Alluvium (Figure 9) rests around variable, but generally lies around -6m OD. More widely, the surface of the Lower Alluvium is more variable, generally lying at between *ca*. -3m and -8m 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).

4.4 Lower Peat

Recorded either directly overlying the Shepperton Gravel or within the Lower Alluvium in the majority of boreholes on the eastern part of the site are units of organic-rich sediment and/or peat. This horizon was consistently between 0.5 and 1m in thickness; up to 3m is recorded in borehole FGP-BH5 but this represents two horizons separated by 2.8m of Lower Alluvial deposits (Figure 11). The upper surface of the Lower Peat rests between -10 and -13m OD. Across the Tilbury 2 site, this horizon was generally between 0.5 and 2.5m in thickness (Figure 12), 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. Again, greater thicknesses ordinarily represented multiple units separated by substantial thicknesses of Lower Alluvial sediment.

Thus, 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. 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.

Radiocarbon dating of the Lower Peat on the Tilbury 2 (Batchelor et al., 2019) and London Distribution Park (Batchelor et al., in prep) site provides determinations generally ranging between 8000 and 7000 years ago (late Mesolithic) (Figure 25), correlating most closely correlate to Devoy's Tilbury II peat as recorded at the Worlds's End (Figure 25).

4.5 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 eastern part of the site and the surrounding area. The Middle Peat lies at elevations of between *ca*. -4.10 and -6.20m OD, and is generally present in thicknesses of between 1.0 and 1.7m (Figures 14). More widely (Figure 15), the thickness of this unit is highly variable, 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, the Middle Peat is definitely absent in FGP-BH1, FGP-BH7 and select geoarchaeological specific boreholes on the Tilbury 2 site.

The surface of the Middle Peat (where recorded) is relatively even between -4.1 and -4.6m OD (Figure 13). The geoarchaeological boreholes confirm that the Middle Peat is almost solely composed of herbaceous remains with wood less common. This is indicative of a transition towards semi-terrestrial (marshy) conditions, supporting the growth of saltmarsh and/or sedge fen/reed swamp.

Radiocarbon dating of the Middle Peat on the Tilbury 2 (Batchelor et al., 2019) and London Distribution Park (Batchelor et al., in prep) site provides determinations generally ranging between 6500 and 3500 cal BP (Mesolithic-Neolithic transition to Bronze Age), correlating most closely correlate to Devoy's Tilbury III peat as recorded at the Worlds's End (Figure 25).

4.6 Upper Alluvium

The Upper Alluvium rests on the Middle Peat, or on the occasional instances where this was not present, the Lower Alluvium (e.g. FGP-BH7), 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. The deposits of the Upper Alluvium are described as predominantly silty or clayey which are very occasionally organic-rich. The surface of the Alluvium is relatively even across the site (Figure 19) and wider area (Figure 20), generally lying at between 0 and 1m OD; lower elevations are recorded towards the centre of the Tilbury 2 site, predominantly as a consequence of development and thicker horizons of Made Ground.

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).

4.7 Upper Peat

A thin horizon of peat was recorded within the Upper Alluvium in six of the seven boreholes and five of the nine window samples from the Thurrock FGP site. It is generally less than 0.3m thick (often only 0.1m thick) and rests between -1 and 1m OD (Figures 16 and 17). On the neighbouring Tilbury 2 site, the Upper Peat was much more localised in comparison to the Middle and Lower Peats, and was present in thickness of up to 1m (Figure 18). Due to the location of the units close to the surface (normally around 1m bgl), it is possible that in some of the locations, the peat has been removed by ploughing. This unit is indicative of a localised transition towards semi-terrestrial (marshy) conditions, supporting the growth of sedge fen/reed swamp communities.

Radiocarbon determinations on the Upper Peat at Tilbury 2 (Batchelor et al., 2019) and London Distribution Park (Batchelor et al., in prep), returned ages between 2150 and 3000 cal BP (Iron Age). In terms of elevation, this correlates with Devoy's Tilbury IV peat, but accumulated over a 1000 years later (3680-3270 to 3370-3000 cal BP).

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*. 13 and 15m across the site (Figure 21) and between 12 and 16m across the wider Tilbury 2 area (Figure 22).

Greater thicknesses 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.

4.8 Channel Fill

Perhaps the most striking feature recorded during the monitoring was the sequence in FGP-BH1. Here, a mixture of fine to coarse grain deposits (including gravels up to 5cm in diameter) and Peat were recorded above the Shepperton Gravel surface to -9.66m OD (11.20m bgl). Recorded over this were finally laminated silty clay and sand with occasional plant remains (sedges and reeds) and Mollusca to 0.44m OD (1.10m bgl), followed by a normal sequence of Upper Peat, Upper Alluvium and Top Soil. No Lower or Middle Peat units were recorded.

This mixture of sediments between the Shepperton Gravel surface and Upper Peat is somewhat unusual. Whilst the Lower and/or Middle Peat is absent in other boreholes (e.g. FGP-BH7), no other sequence on the site contains thick units of gravel, nor is it recorded on other sites across the Tilbury area, and is uncommon in the Lower Thames Valley as a whole. It is suggestive of a large former channel traversing this part of the Thurrock FGP site, of (at least at times) high energy flow. Its orientation and size are unknown, but on the basis that it is not replicated in other boreholes more distally to the west or east, is most likely orientated on a north-south trajectory. This would also be a logical orientation on the basis of a depression in the natural topography beyond the edge of the floodplain to the north (and thus possible origin of the channel), and position of the Thames towards the south.

It is hypothesised that the channel was active sometime between the accumulation of the Middle and Upper Peats. The Middle Peat formed widely across the Tilbury area so it seems likely that the channel cut through deposits of dating to this period (i.e. during the Bronze Age). And the presence of the Upper Peat in the sequence, suggests that the channel ceased being active sometime before its formation (i.e. before the Iron Age). However, the possibility that the channel was active throughout from the cessation of Shepperton Gravel deposition to the accumulation of the Upper Peat cannot be discounted at this stage.

It is also of note from LIDAR imagery that the FGP-BH1 is located on an undulating surface which flattens out to the west and east, and is perhaps the result of former channel activity (Figure 26). Overall the surface is raised in the area. It is only possible to postulate here, but it is possible that the surface is higher here the channel fill gravel deposits are less compressible than the Alluvial and Peat deposits recorded elsewhere. Any former channel system would also have a greater amount of overbank deposition, which may also have resulted in thicker deposits in the area of the channel itself.

4.9 Top Soil / Made Ground

On the site, the thickness of the Top Soil generally ranges between 0.1 and 0.5m in thickness (Figure 23. Across the wider area, a similar thickness of Top Soil is recorded, with greater thicknesses of Made Ground up to 3m thick in the area of the Power Station.

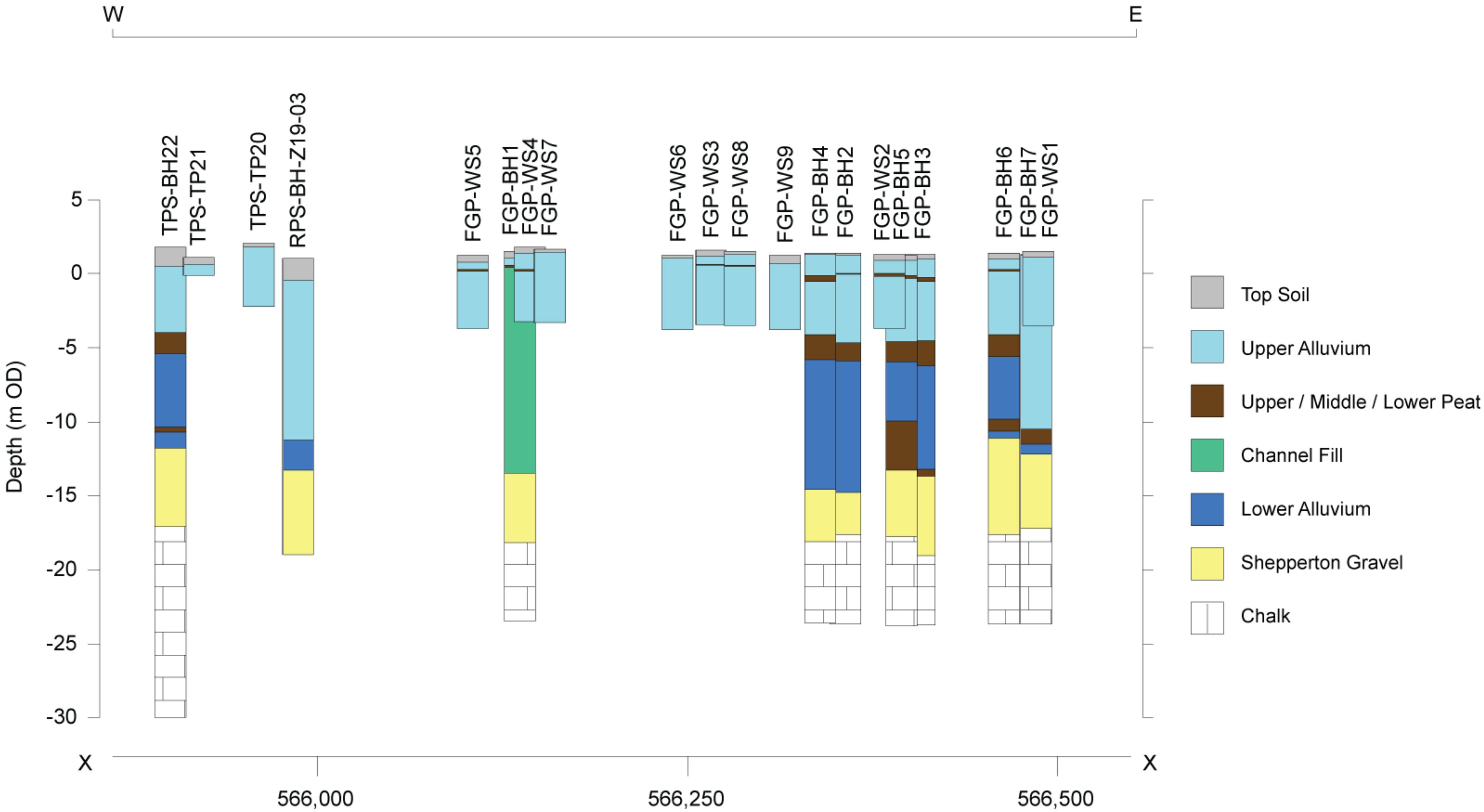

Figure 4: West-east transect of sequences across the Thurrock FGP and neighbouring Tilbury 2 site

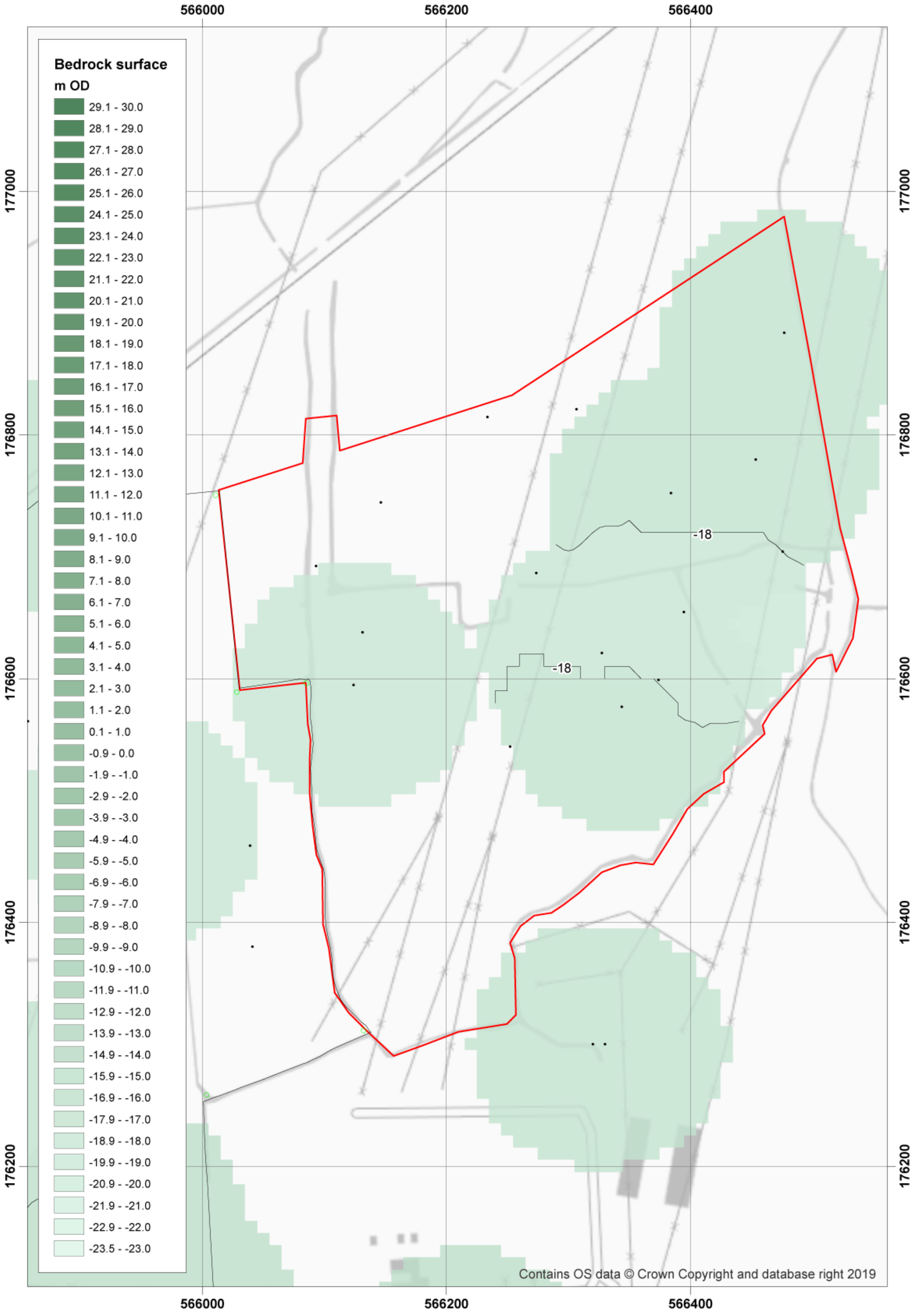

Figure 5: Surface of the Bedrock Chalk (m OD)

Figure 6: Wider surface of the Bedrock Chalk (m OD)

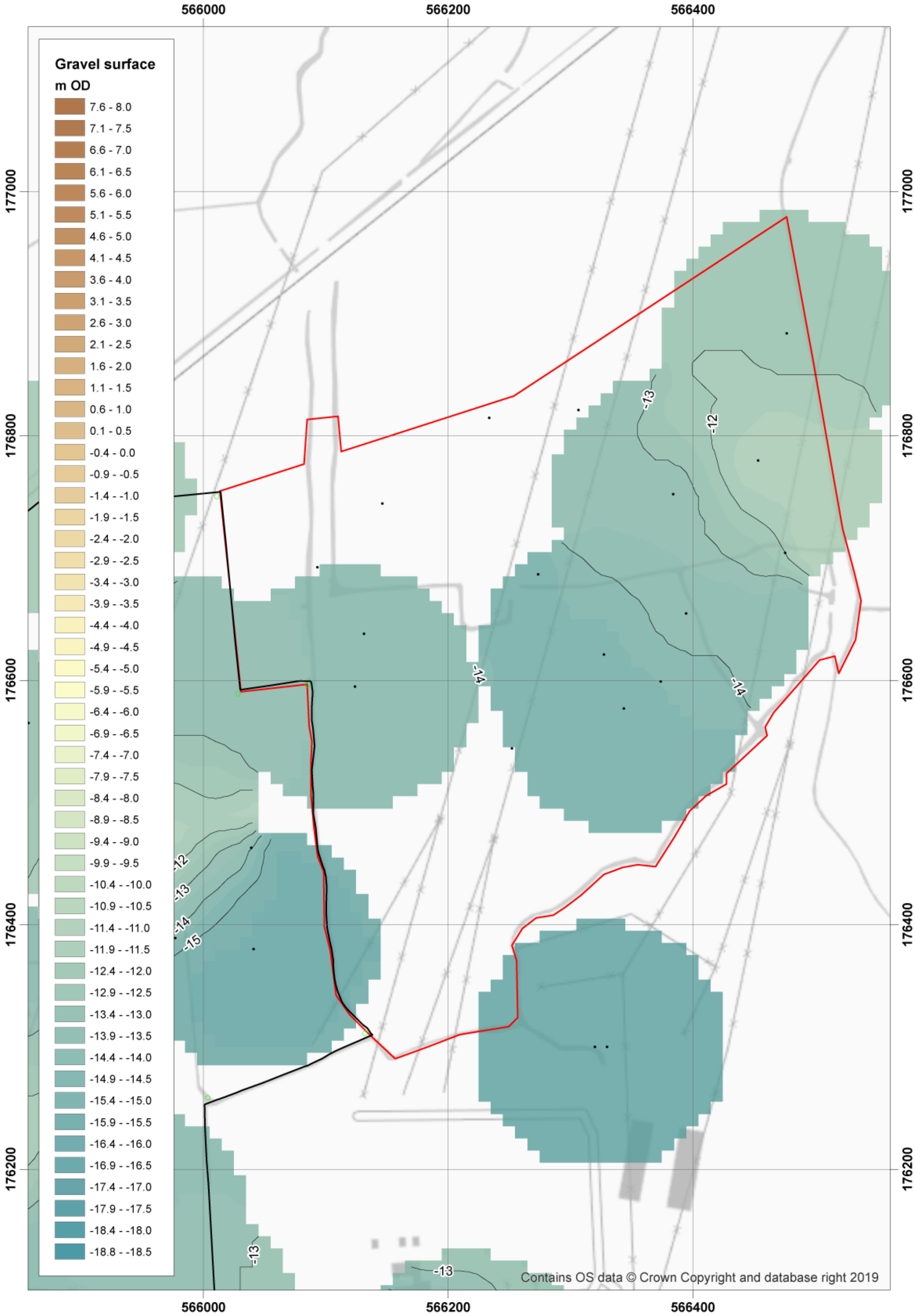

Figure 7: Surface of the Shepperton Gravel (m OD)

Figure 8: Wider surface of the Shepperton Gravel (m OD)

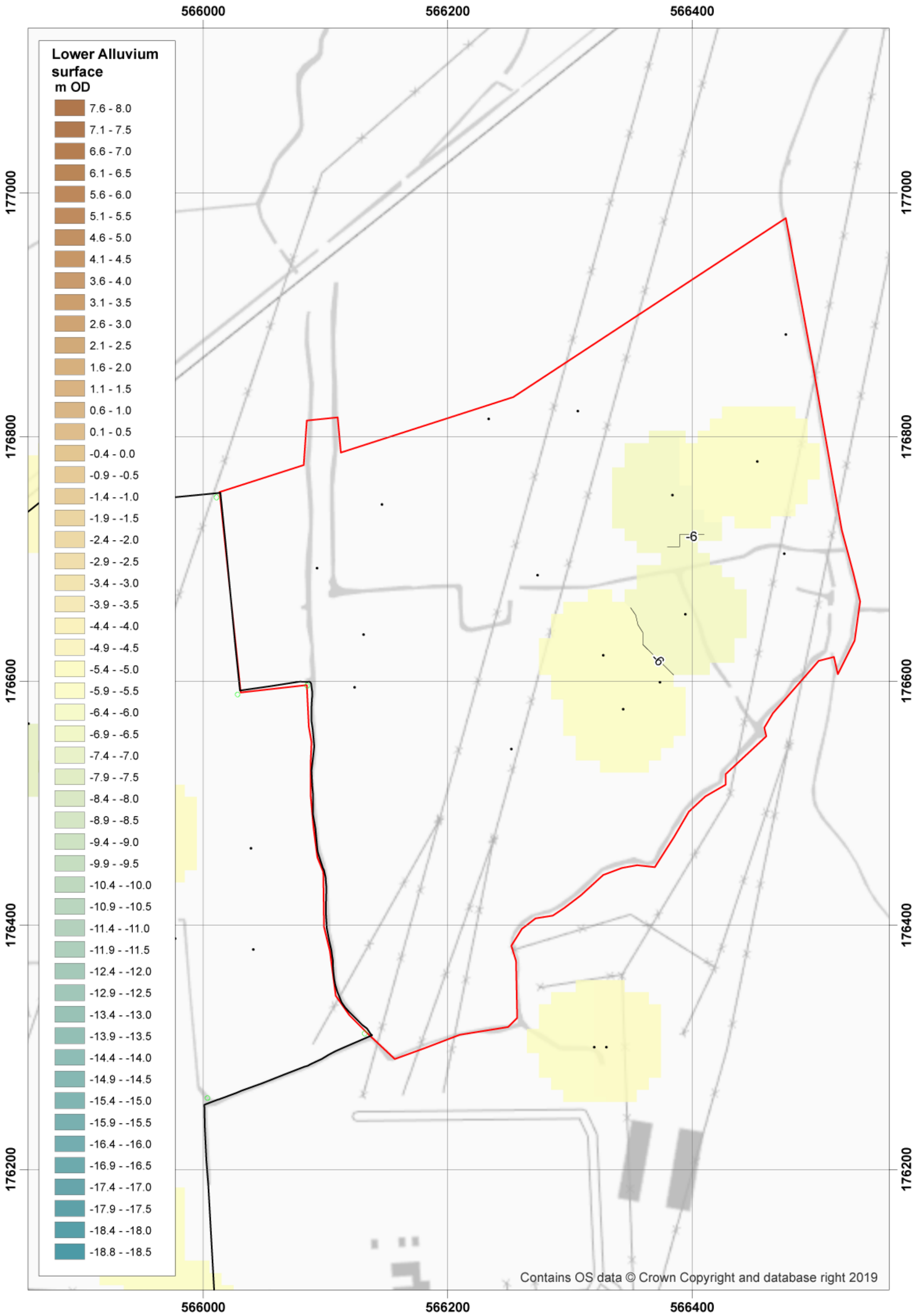

Figure 9: Surface of the Lower Alluvium (m OD)

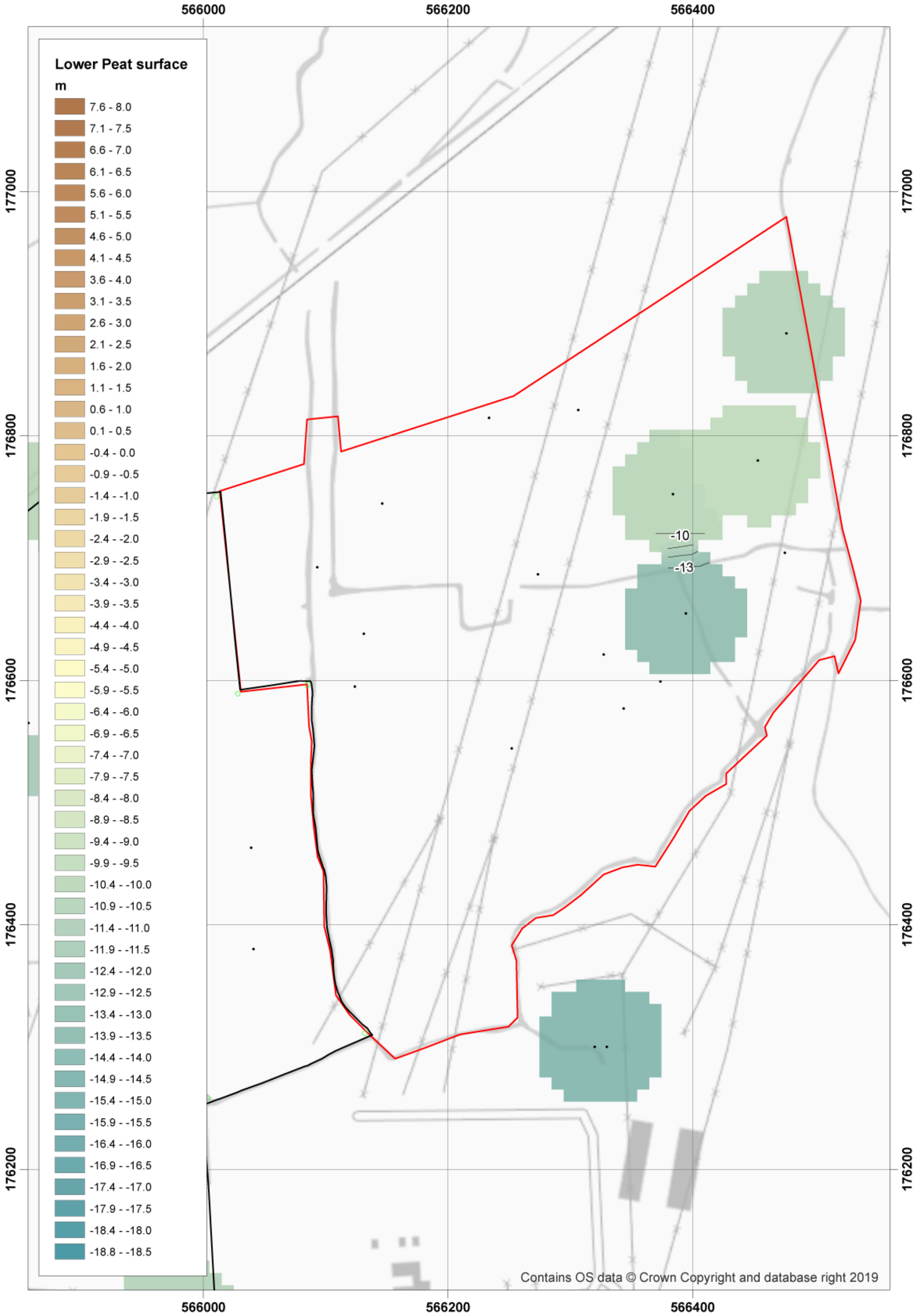

Figure 10: Surface of the Lower Peat (m OD)

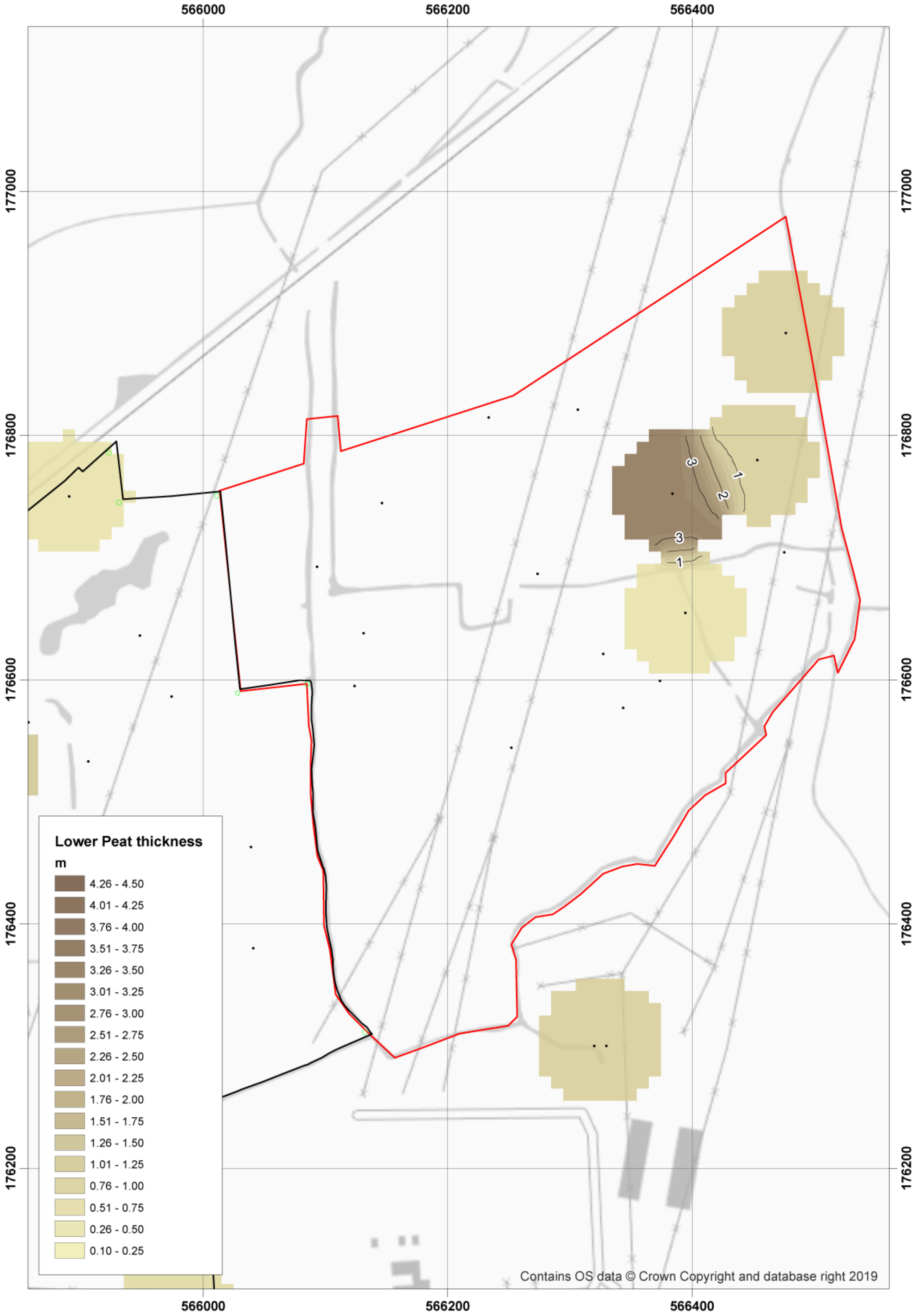

Figure 11: Thickness of the Lower Peat (m)

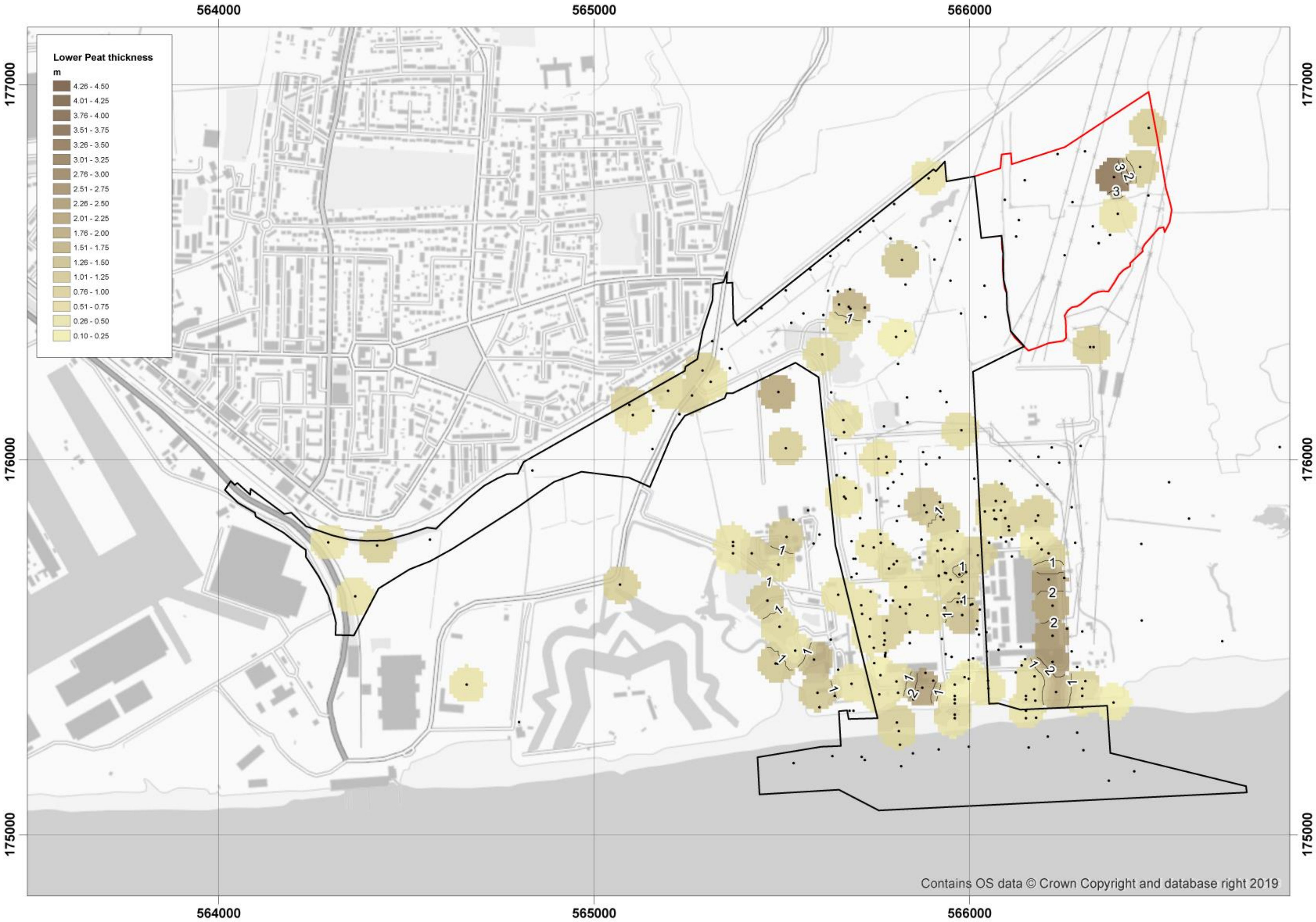

Figure 12: Wider thickness of the Lower Peat (m OD)

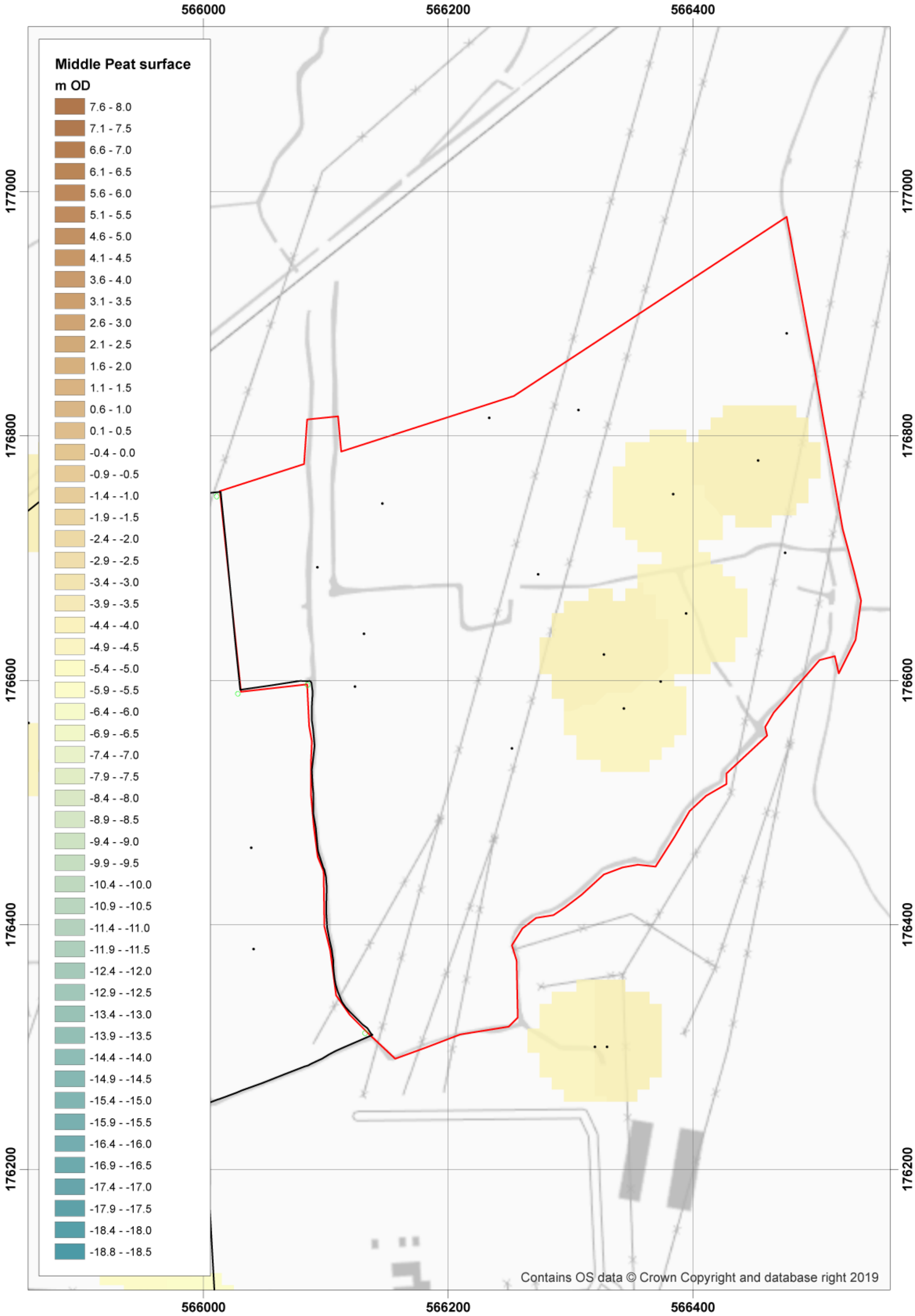

Figure 13: Surface of the Middle Peat (m OD)

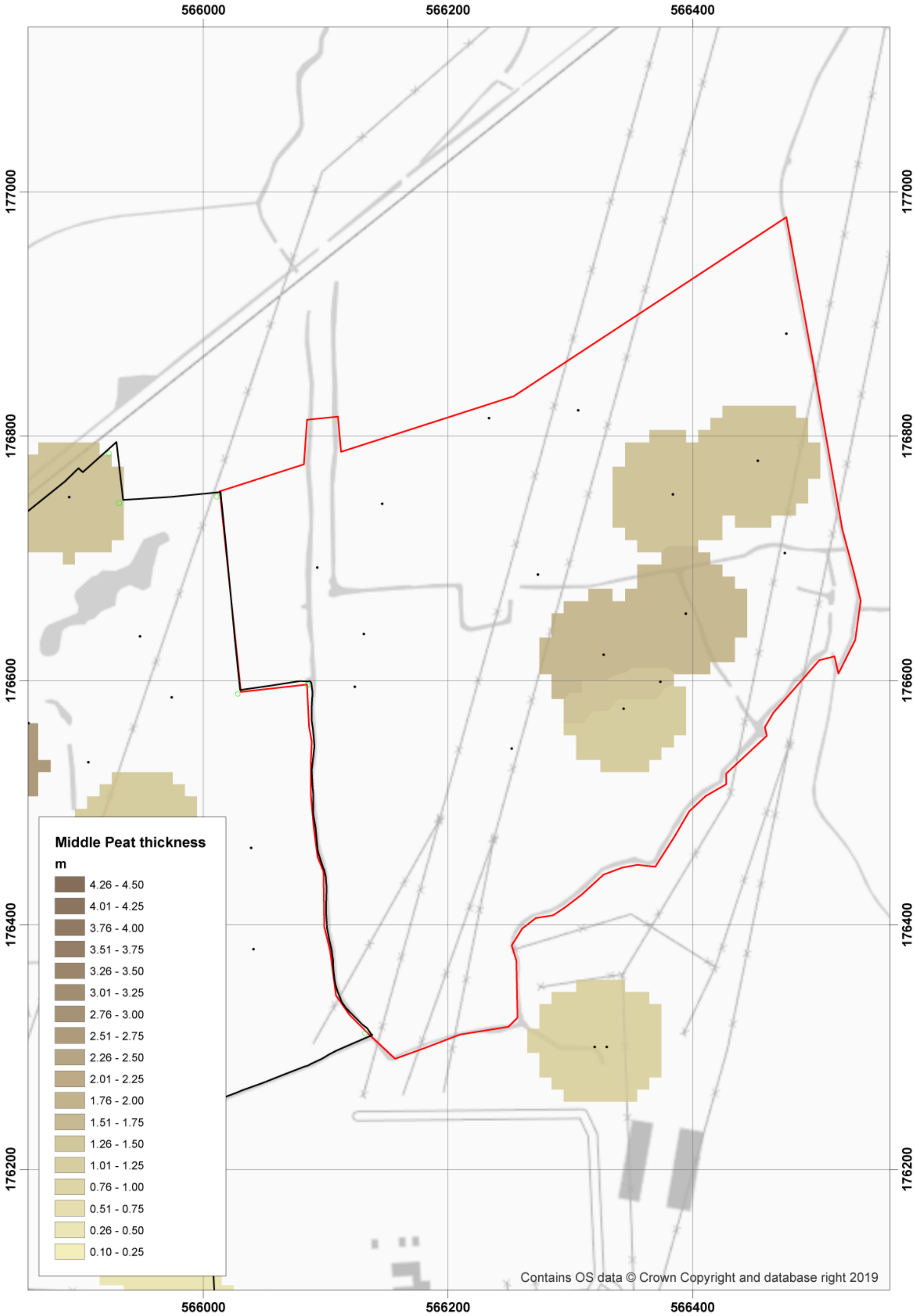

Figure 14: Thickness of the Middle Peat (m)

Figure 15: Wider thickness of the Middle Peat (m)

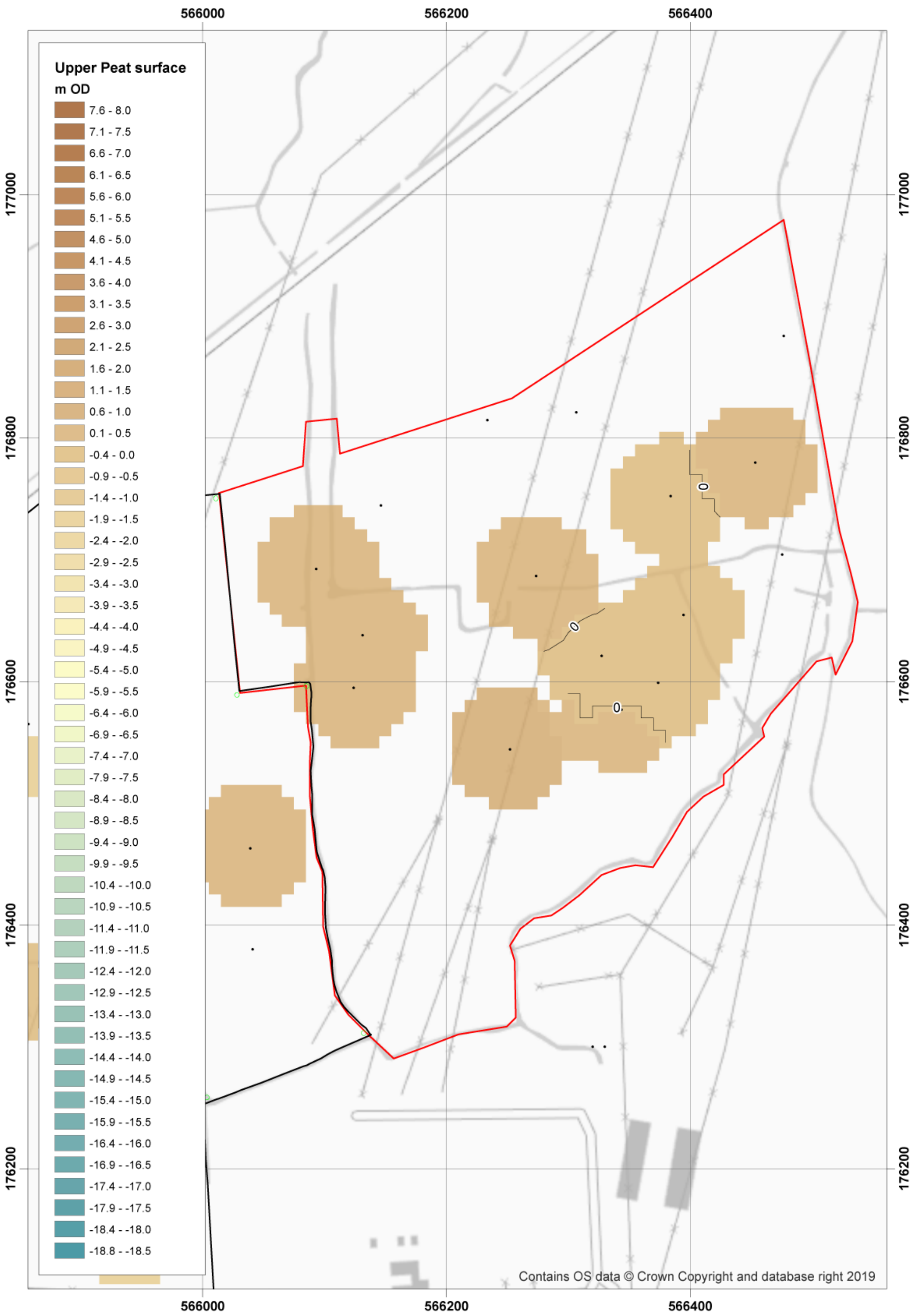

Figure 16: Surface of the Upper Peat (m OD)

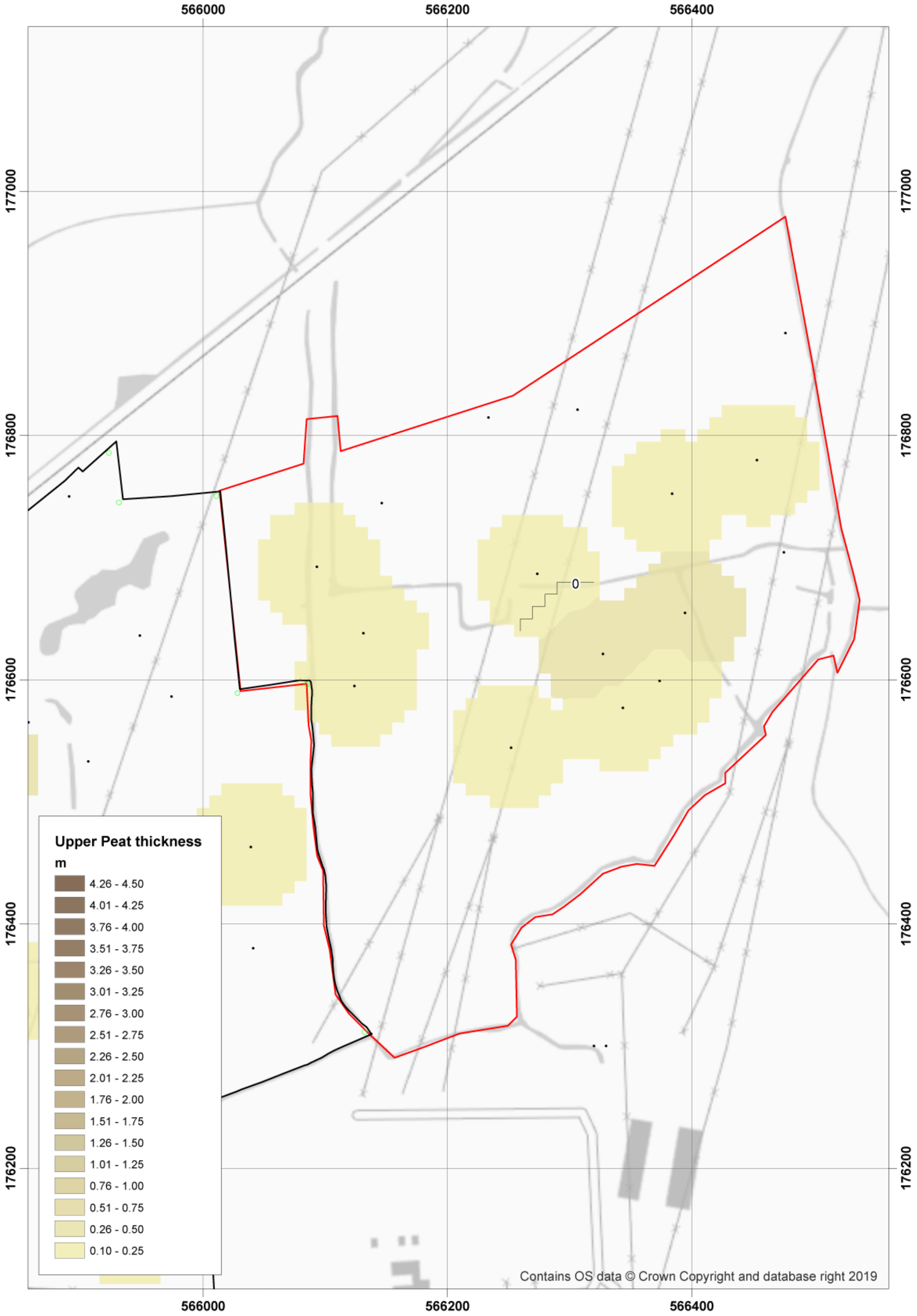

Figure 17: Thickness of the Upper Peat (m)

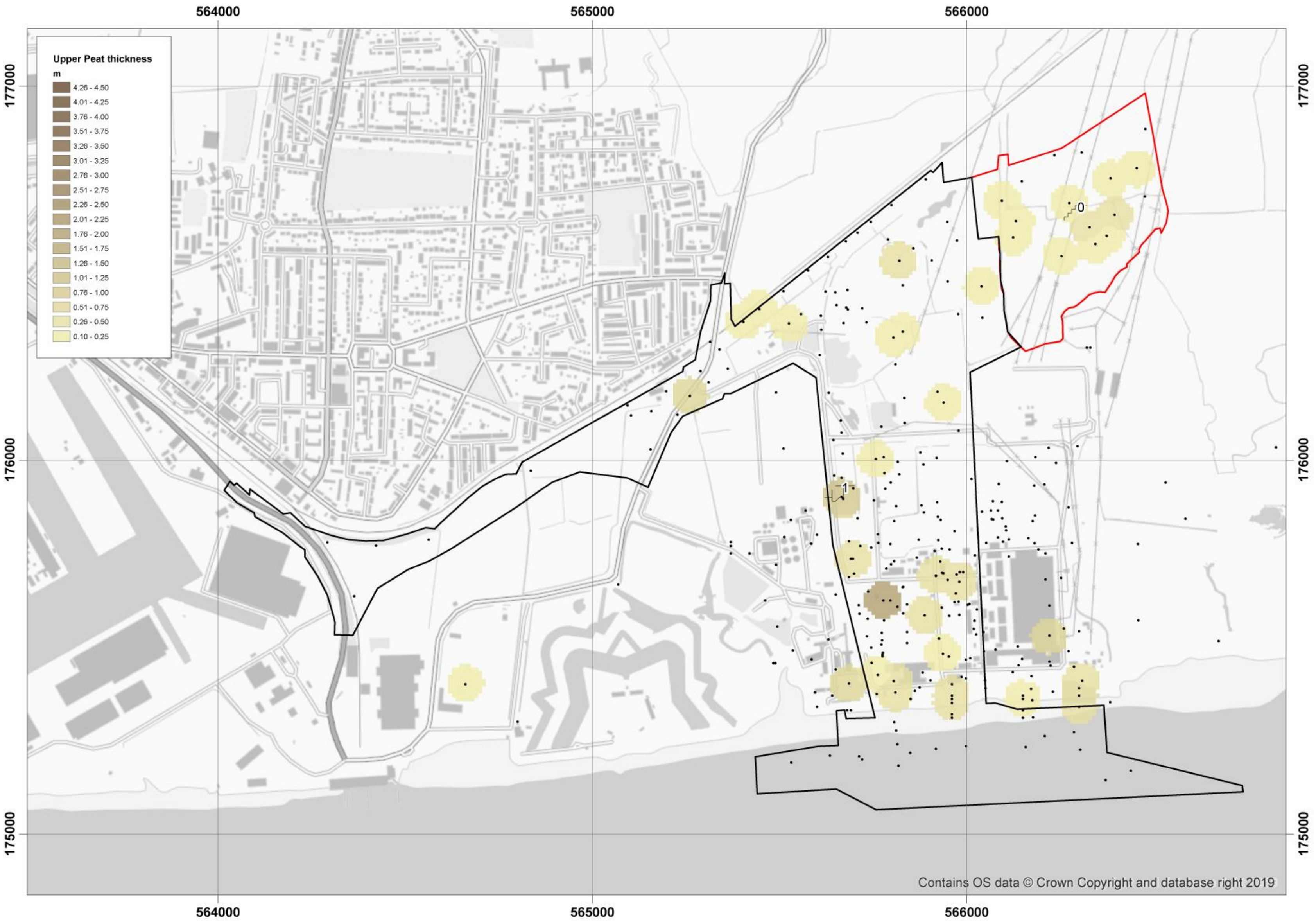

Figure 18: Wider thickness of the Upper Peat (m)

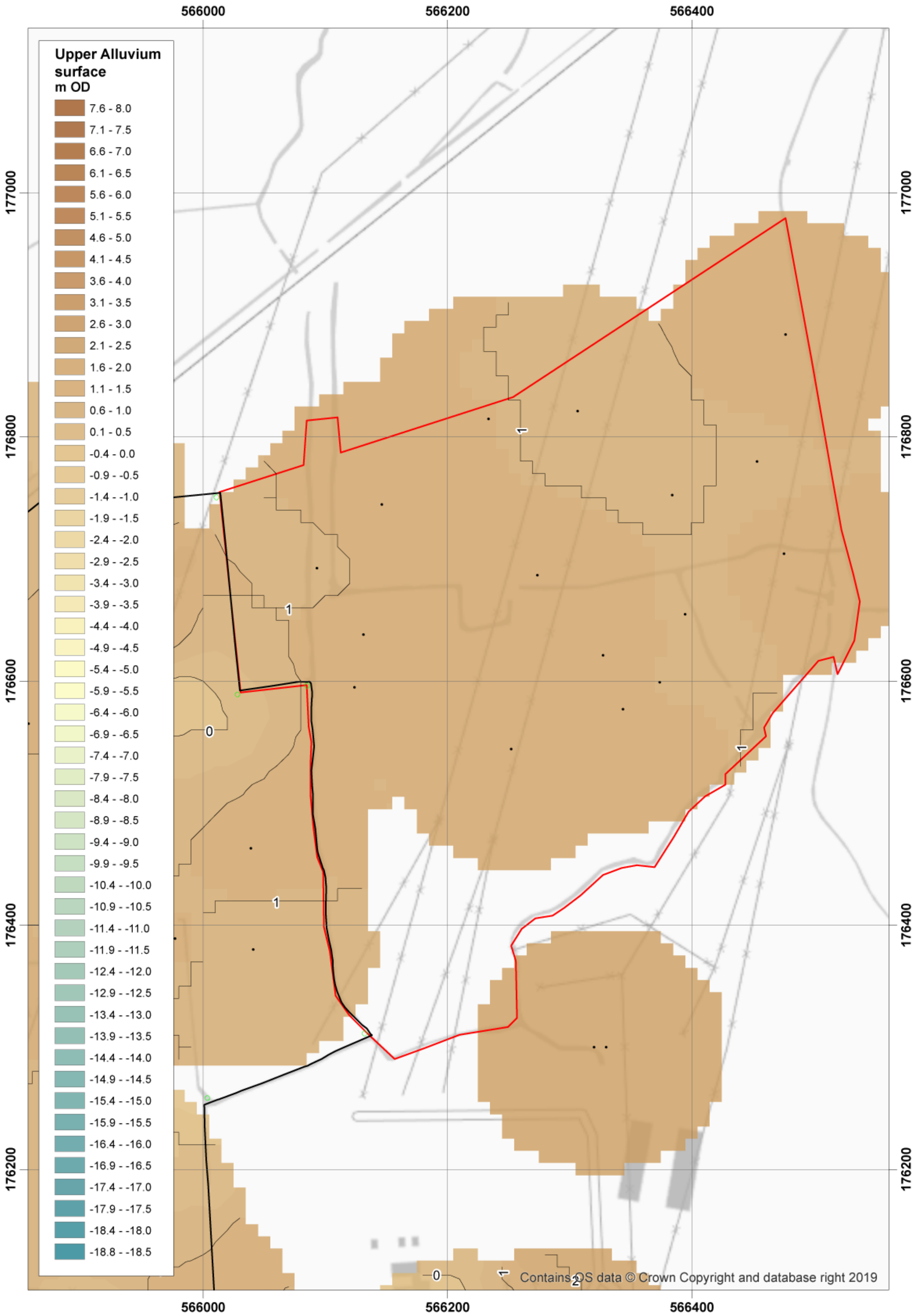

Figure 19: Surface of the Upper Alluvium (m)

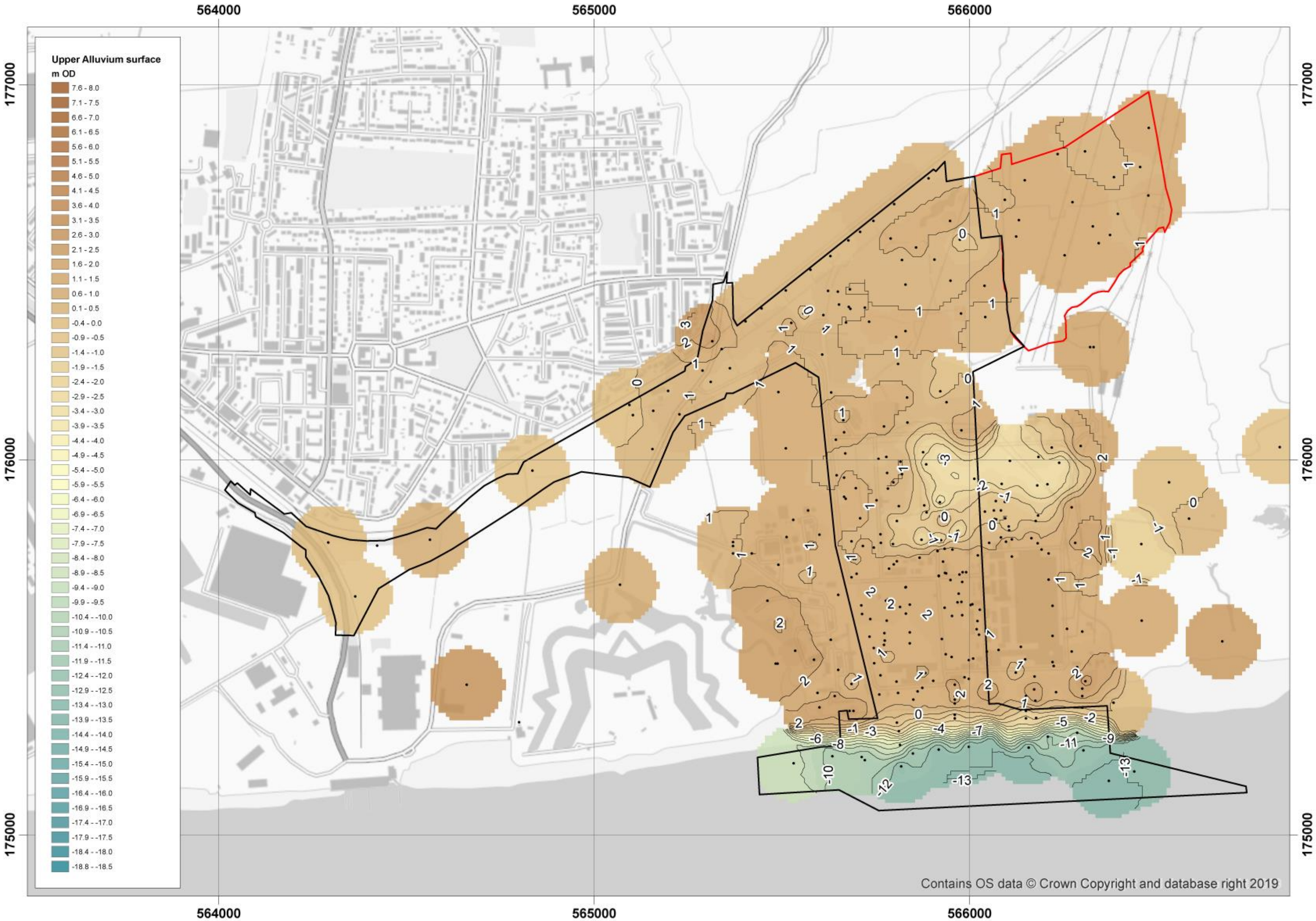

Figure 20: Wider surface of the Upper Alluvium (m)

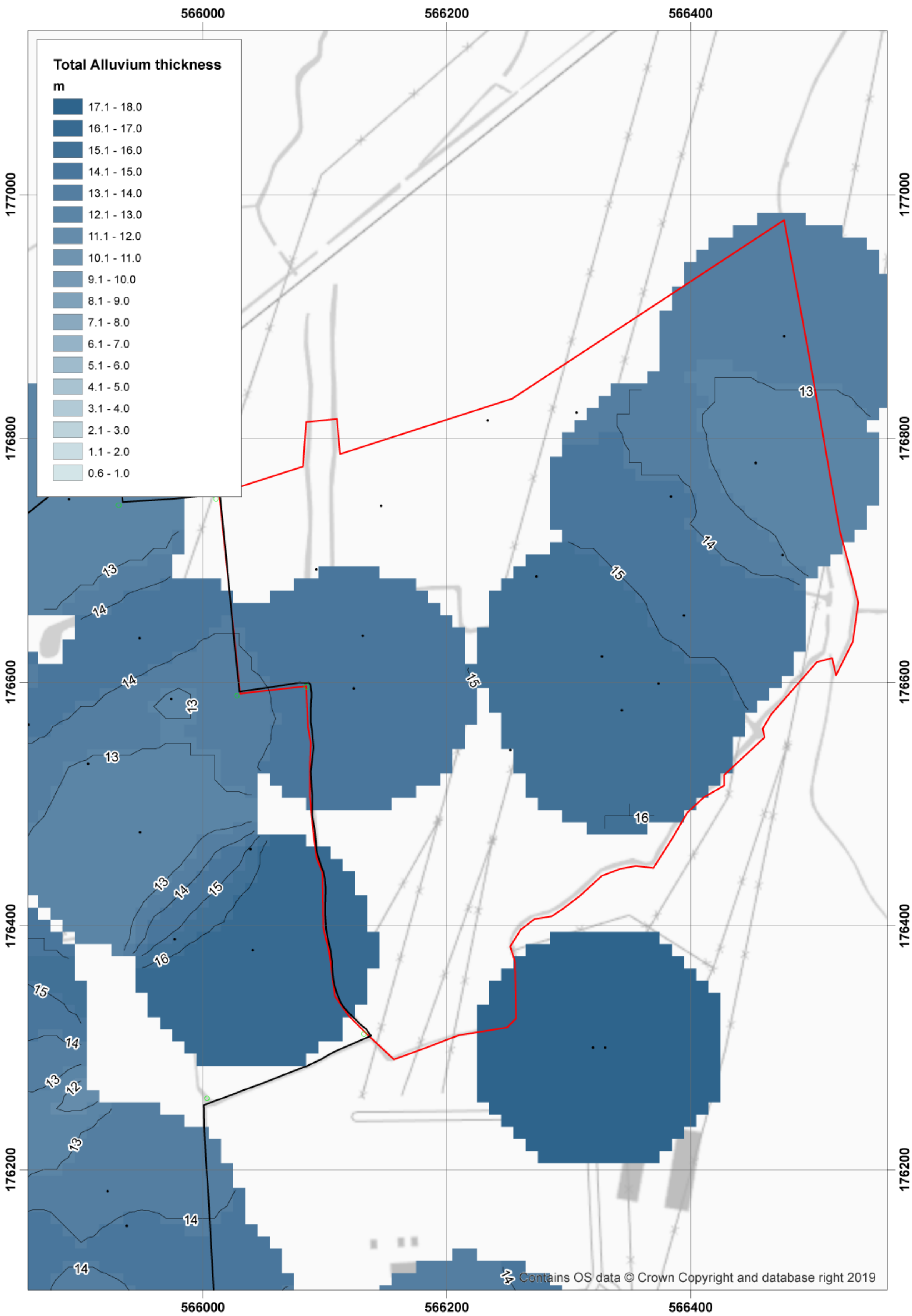

Figure 21: Thickness of the Holocene alluvial sequence (Lower Alluvium, Peat horizons and Upper Alluvium) (m)

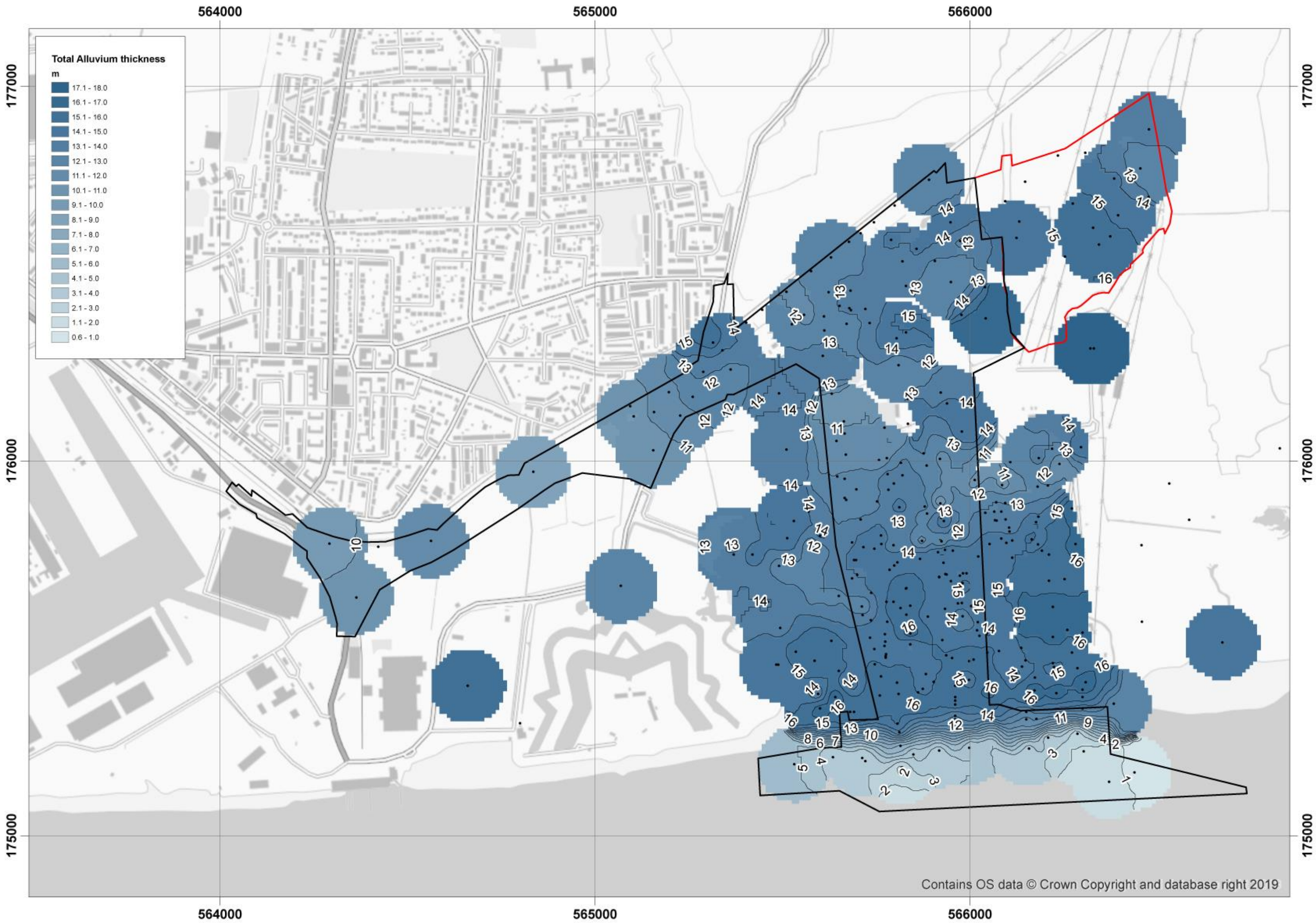

Figure 22: Wider thickness of the Holocene alluvial sequence (Lower Alluvium, Peat horizons and Upper Alluvium) (m)

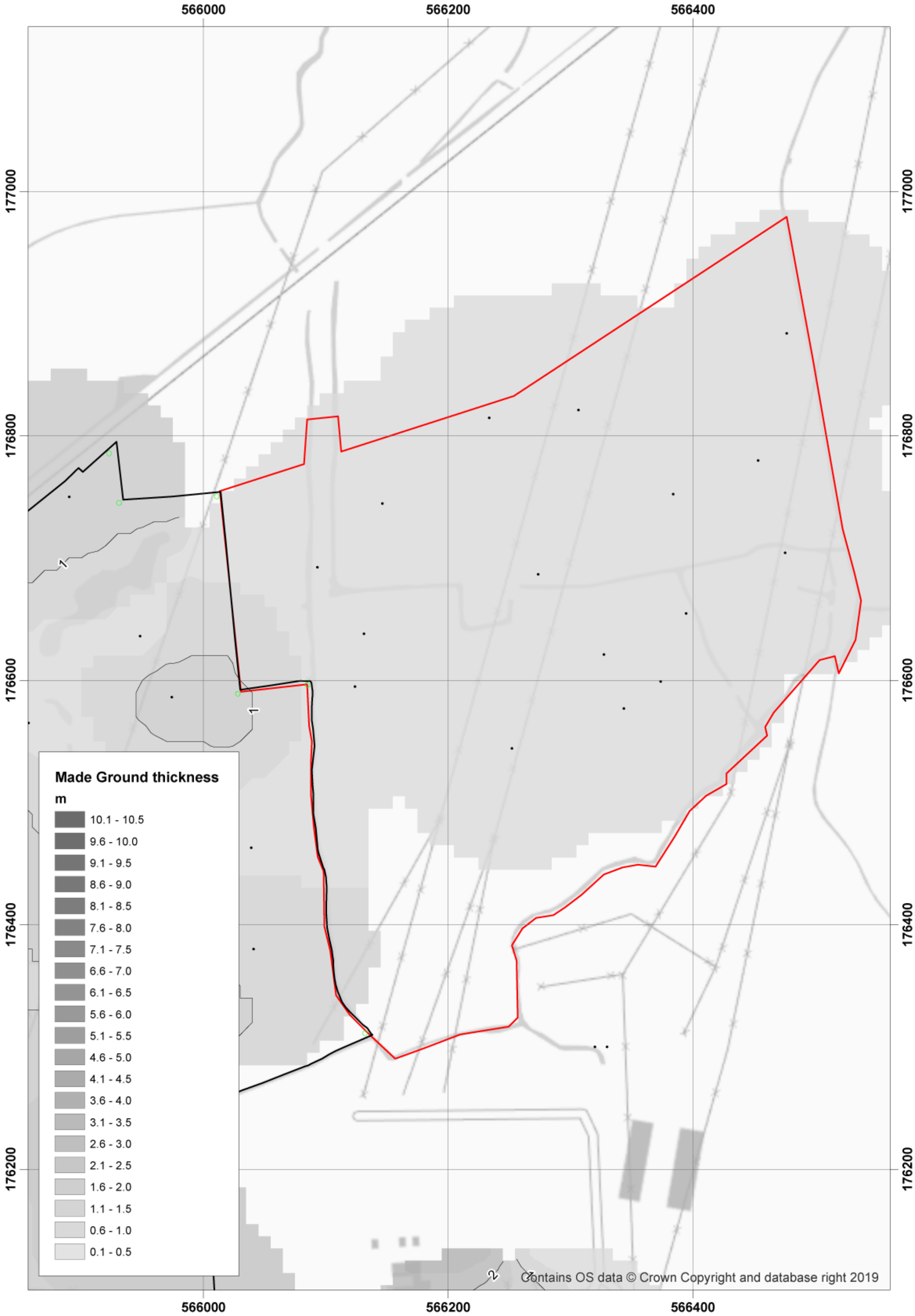

Figure 23: Thickness of Made Ground (m)

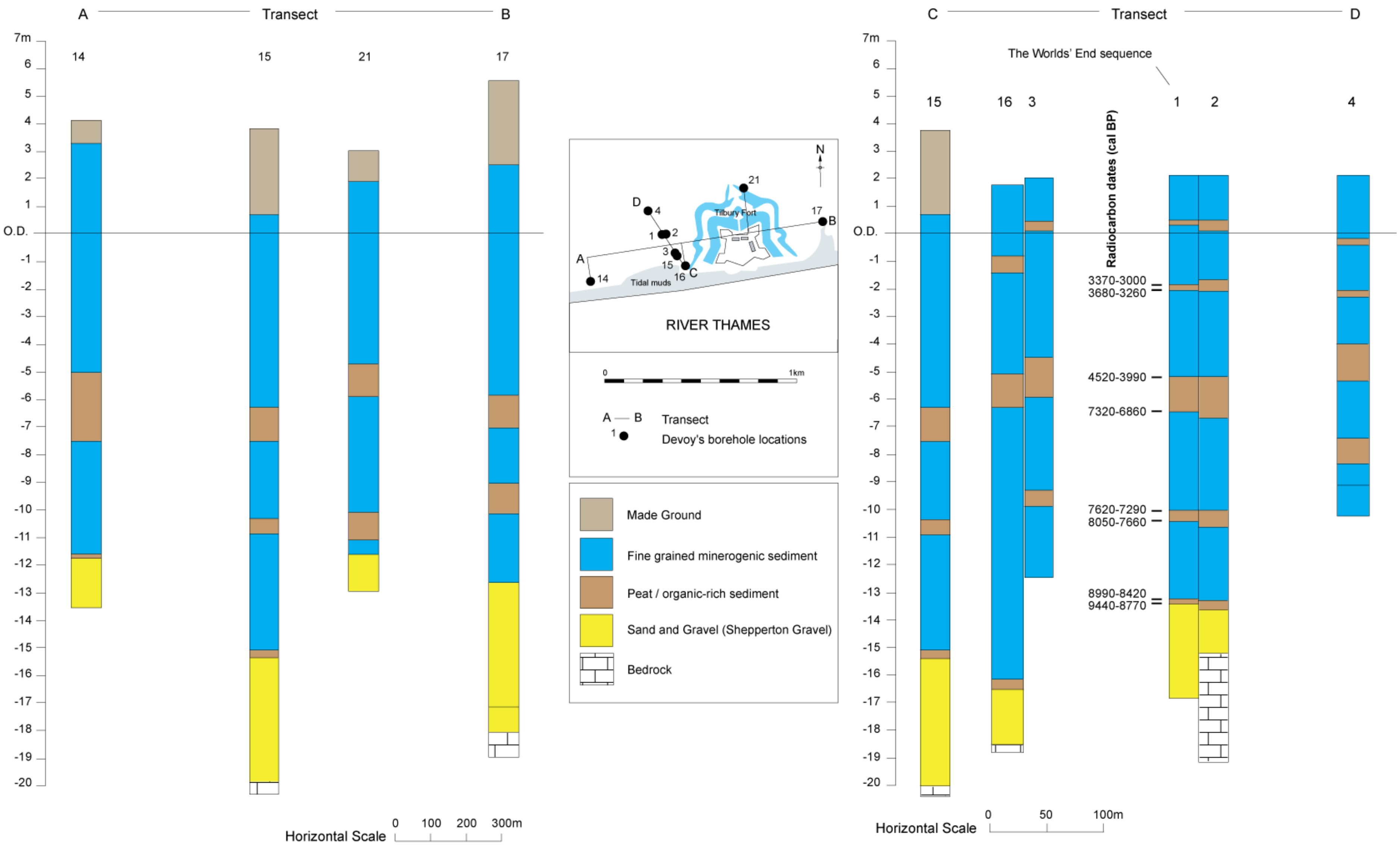

Figure 24: Devoy borehole transects (1979)

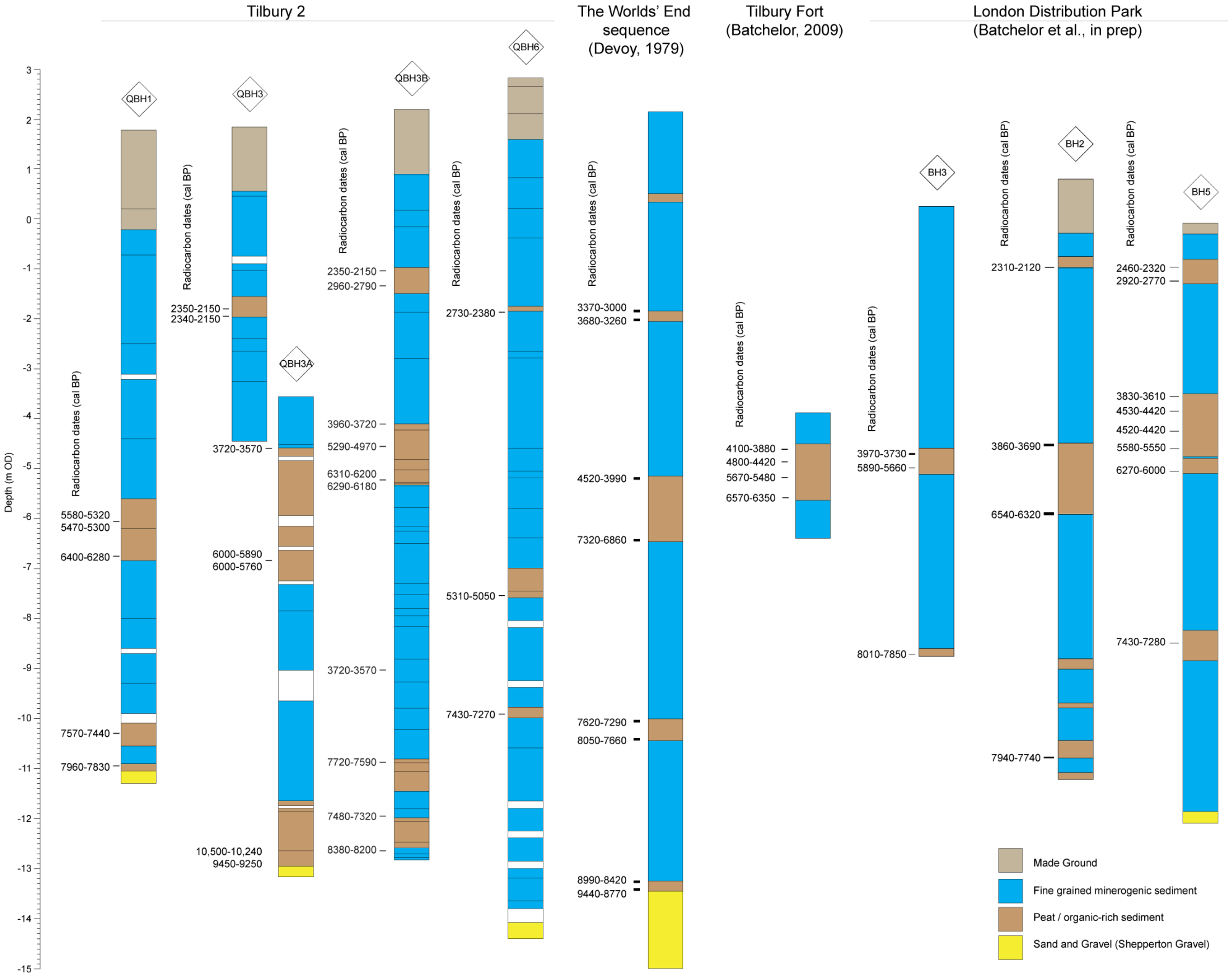

Figure 25: Radiocarbon dated sequences in the Tilbury area

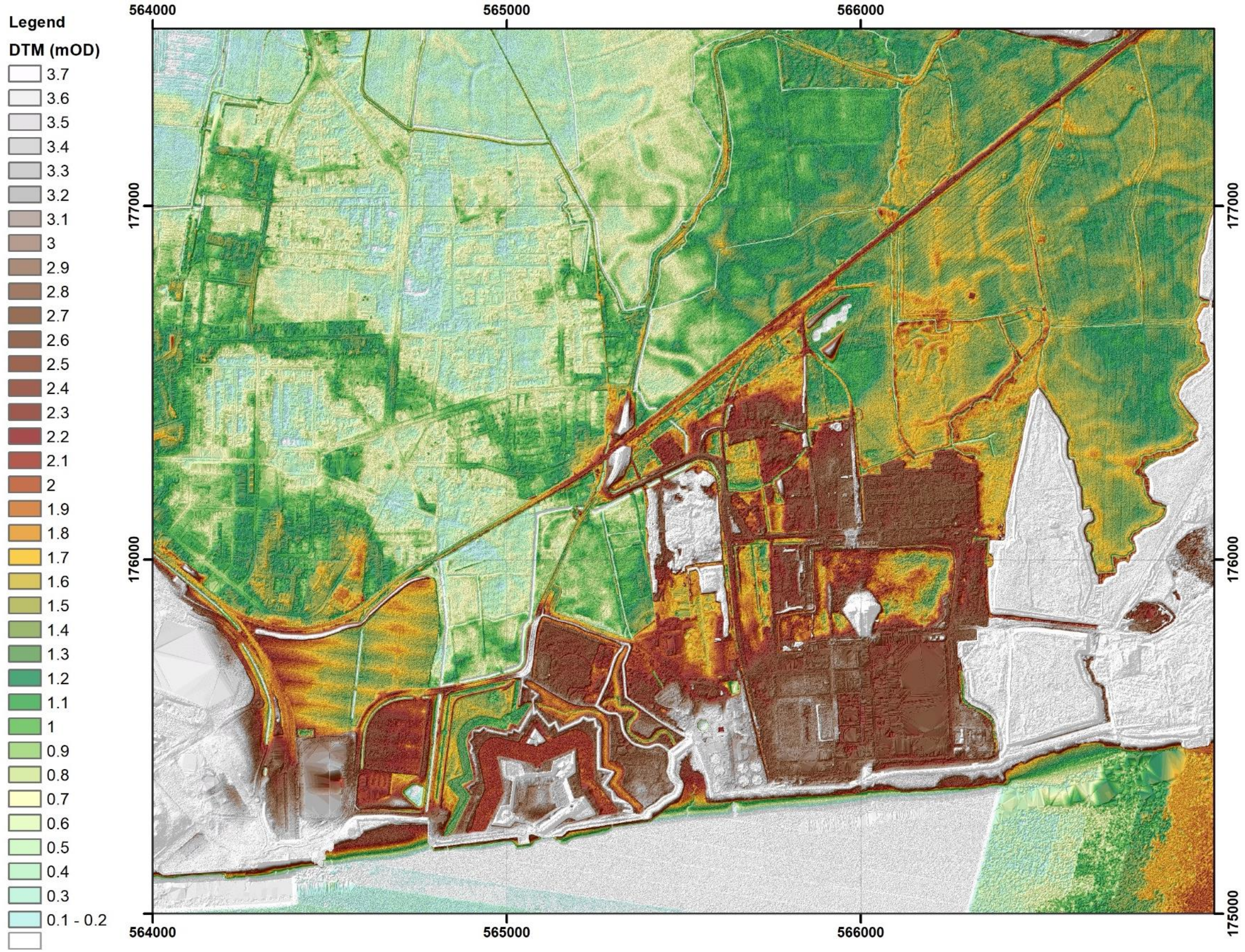

Figure 26: Lidar 0.25m Digital Terrain Model (Environment Agency, 2019)

5. CONCLUSIONS & RECOMMENDATIONS

The findings from the fieldwork and deposit modelling have enhanced knowledge and understanding of the sedimentary history in this area of Tilbury. Up to three distinct peat horizons broadly equivalent in depth (and most likely age) to those recorded at other sites in the Tilbury area have been identified within the Holocene alluvial sequence, 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.

Of particular importance on this site are the mixture of deposits recorded on the western part of the site indicative of a former channel. As outlined in section 4.8, this is a very unusual sequence for the site, the Tilbury area and more widely within the Lower Thames Valley, and raises various questions including: (1) what was its former size and orientation; (2) when was it formed, and when did it cease being active, and (3) how does this apparent channel relate to evidence for channel activity recorded in LIDAR imagery (Figure 26).

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. Significantly, the peat and any soil horizons from the site also 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 Thurrock FGP site is considered of potential regional significance. Further borehole sequences are clearly required to: (1) elucidate questions relating to the apparent channel identified in FGP-BH1; (2) to complete coverage of the deposit model for the site, and (3) to obtain sequences for palaeoenvironmental investigation as outlined above. Six further boreholes are recommended, with a transect of three sequences orientated west-east on the western part of the site adjacent to FGP-BH1, two more should be placed to the north-west and south-west of the site, and a final borehole in the location of FGP-BH5 to collect the peat and organic-rich sediment with Mollusca and seeds identified in that location. The method of coring will need to be carefully considered to maximise recovery of the samples in a mixture of different sediments. A GPR survey may also help to elucidate some of the questions relating to the size and location of the channel. Attempts should also be made to obtain borehole records resulting from recent geotechnical works undertaken by the Highways Agency in preparation for the Tilbury Tunnel. Following completion of these investigations a subsequent program of palaeoenvironmental works can be determined.

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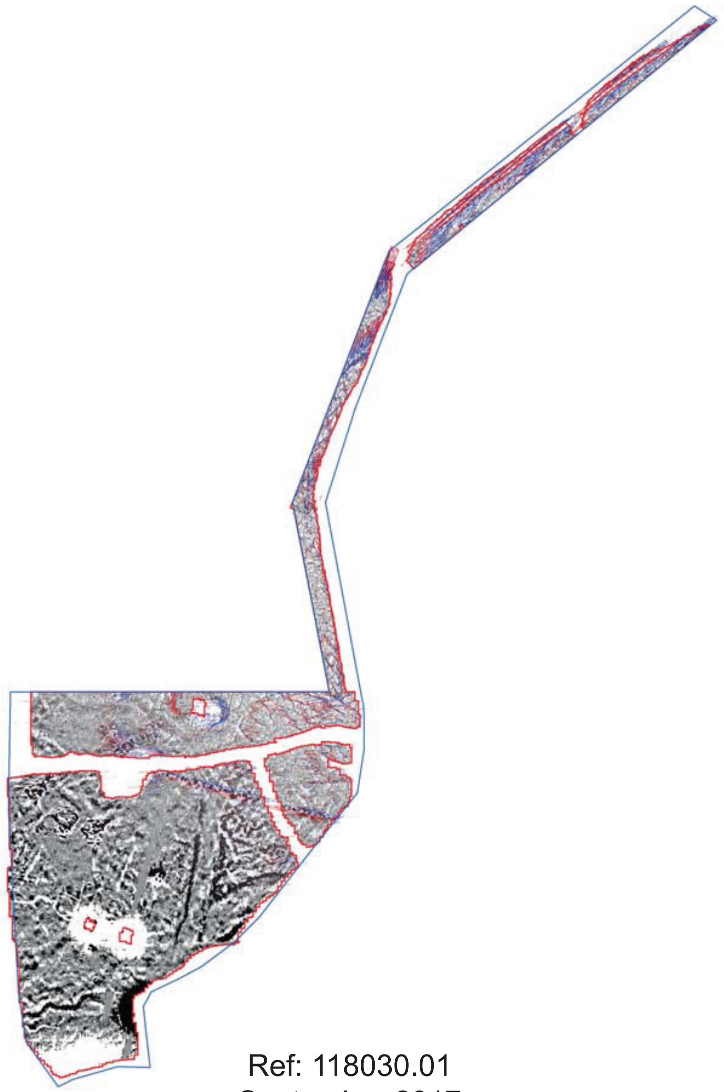
Land adjacent to Tilbury Substation
Tilbury, Essex

Detailed Gradiometer Survey Report



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County	Essex
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Summary

A detailed gradiometer survey was conducted over land adjacent to Tilbury Substation, Tilbury, Essex (centred on NGR 566194 176616). The project was commissioned by Statera Energy Ltd. with the aim of establishing the presence, or otherwise, and nature of detectable archaeological features in support of a planning application for the development of the site as an extension of the power station infrastructure to the south.

The Site comprises arable fields located to the east of Tilbury with a designated survey area covering approximately 17.3 ha. The geophysical survey was undertaken between 21st August 2017 and 25th August 2017. The detailed gradiometer survey has demonstrated the presence of several strong rectilinear anomalies that could be archaeological in origin.

The anomalies identified as being of probable archaeological interest are linear and rectilinear in plan. These anomalies are interpreted tentatively as possible archaeology as due to the high prevalence of geological responses across the survey area, and it is not clear whether the anomalies themselves are geological in origin.

Additionally, this archaeological investigation has detected several modern services traversing the Site along with several areas of increased magnetic response and possible evidence of irrigation or drainage.

Acknowledgements

Wessex Archaeology would like to thank Statera Energy for commissioning the geophysical survey. The assistance of Kirsty Cassie is gratefully acknowledged in this regard.

Land adjacent to Tilbury Substation, Tilbury, Essex

Detailed Gradiometer Survey Report

1 INTRODUCTION

1.1 Project background

1.1.1 Wessex Archaeology was commissioned by Statera Energy to carry out a geophysical survey at land north of Tilbury Substation, Tilbury, Essex (hereafter "the Site", centred on NGR 566194 176616) (**Figure 1**). The survey forms part of an ongoing programme of archaeological investigation being undertaken in support of a planning application for the development of the Site as an extension of the power station infrastructure to the south.

1.2 Scope of document

1.2.1 This report presents a brief description of the methodology, followed by the detailed survey results and the archaeological interpretation of the geophysical data.

1.3 The Site

1.3.1 The Site is located immediately north of Tilbury Substation and 2.15 km east of Tilbury in Essex (**Figure 1**).

1.3.2 The survey comprises a larger southern area of approximately 14 ha currently utilised for pasture and arable cultivation, and a linear northern area of approximately 3 ha across arable fields and along the edge of an access track. The Site is bounded by Tilbury Substation to the south, and arable land to the east, west and north. The railway between Tilbury and Linford forms the northwestern boundary to the site.

1.3.3 The Site is relatively flat, lying at approximately 1m OD across the survey area.

1.3.4 Several overhead cables traverse across and around the periphery of the Site. Two parallel sets cross the centre of survey area, and a third set traverses the south-eastern corner. The northern, linear portion of the survey area may be impacted by the continuation of the overhead cables to the south. Three pylons relating to the overhead cables are present on Site within the survey area, and several others around the periphery.

1.3.5 The solid bedrock geology comprises Seaford and Newhaven Chalk Formations. These are overlain by superficial deposits of alluvium (BGS online).

1.3.6 The soils underlying the Site are likely to consist of pelo-alluvial gley soils of the 813f (Wallasea 1) association (SSEW 1983). Soils derived from such geological parent material have been shown to produce magnetic contrasts acceptable for the detection of archaeological remains through magnetometer survey.

2 ARCHAEOLOGICAL BACKGROUND

2.1 Introduction

2.1.1 A summary of the archaeological and historical background follows to outline the baseline for the survival of buried archaeological remains within the vicinity of the Site, using information available from the Essex Historic Environment Record (EHER) and the National Heritage List for England (NHLE). The following is a background summarising the findings.

2.2 Summary of the known archaeological resource

2.2.1 Within the Site, there are two historical assets noted within the EHER. The site itself is historically recorded as within the West Tilbury Marshes and the southern portion referred to as Walton Common.

2.2.2 There are no World Heritage Sites, Scheduled Monuments, Registered Parks and Gardens, Conservation Areas, Historic Battlefields, or Listed Buildings identified within the Site.

2.2.3 A Neolithic arrowhead (Monument Number 413484) was retrieved in 1973, a Roman lamp was uncovered in Thurrock in 1910 (Monument Number 413495), and a Roman burial was uncovered in West Tilbury with associated finds (Monument Number 413490).

2.2.4 Tilbury Fort is situated approximately 1.4km to the south-west of southern boundary of the survey area. While this is outside the wider study area of the historic and archaeological background, the Fort has been in use as a naval defensive structure since the 16th Century and much later in the 20th Century as an anti-aircraft placement during WWII. This may be relevant when considering the recorded data concerning anti-glider ditches noted within the survey area.

2.2.5 Th Site appears to have been predominantly occupied by arable farm and marsh land during the post-medieval period, and later in the mid-20th Century by anti-invasion structures. The archaeological potential for this period is considered moderate to high.

2.2.6 A large proportion of the wider area is covered by an area of known anti-glider ditches noted to be to the south-east of Bowater's Farm and north-east of Tilbury Power Station, forming part a network of aerial defence during WWII (MEX39674). Immediately north of the southern portion of the Site, a linear series of oyster beds is noted on historic aerial photographs from 1953 and 1955 (MEX39665).

2.2.7 Previous archaeological works undertaken in the wider study area include an archaeological watching brief by Oxford Archaeology (2006) that uncovered post-medieval remains of a farm building known to have occupied the site, comprising a wall and a fence. Further works were undertaken in Stanford Le Hope that uncovered no archaeological features or deposits.

2.2.8 No further evidence of any prehistoric, Romano-British, Saxon or medieval activity is recorded within the Site, although the absence of recorded evidence is likely to reflect the limited number of archaeological investigations undertaken in the vicinity.

3 METHODOLOGY

3.1 Introduction

3.1.1 The geophysical survey was undertaken by Wessex Archaeology's in-house geophysics team between 21st August and 25th August 2017. Field conditions at the time of the survey were good throughout the period of fieldwork. An overall coverage of 14.2 ha was achieved, with any reduction the result of overgrown hedgerows bisecting the site along with other obstructions, which at the time of the survey included several pylons, pieces of farm machinery and the access track.

3.2 Aims and objectives

3.2.1 The aims of the survey comprise the following:

- to conduct a detailed survey covering as much of the specified area as possible, allowing for artificial obstructions;

- to clarify the presence/absence and extent of any buried archaeological remains within the site; and
- to determine the general nature of the remains present.

3.3 Fieldwork methodology

3.3.1 Individual survey grid nodes were established at 30m x 30m intervals using a Leica Viva RTK GNSS instrument, which is precise to approximately 0.02 m and therefore exceeds Historic England recommendations (2008).

3.3.2 The detailed gradiometer survey was conducted using a Bartington Grad601-2 fluxgate gradiometer instrument, which has a vertical separation of 1m between the fluxgate sensors and 1m horizontal separation between sensor housings. Data were collected at 0.25m intervals along transects spaced 1m apart with an effective sensitivity of 0.03nT, in accordance with Historic England guidelines (Historic England 2008). Data were collected in the zigzag method.

3.4 Data processing

3.4.1 Data from the survey were subject to minimal correction processes. These comprise a Zero Median Traverse function (±5nT thresholds) to correct for any variation between the two Bartington sensors used, and a de-step function to account for variations in traverse position due to varying ground cover and topography. These two steps were applied throughout the survey area, with no further interpolation applied.

3.4.2 Further details of the geophysical and survey equipment, methods and processing are described in **Appendix 1**.

4 GEOPHYSICAL SURVEY RESULTS AND INTERPRETATION

4.1 Introduction

4.1.1 The detailed gradiometer survey has identified magnetic anomalies across the Site, along with weaker anomalies of likely geological origin and a large amount of high magnitude, ferrous anomalies. Results are presented as a series of greyscale plots, XY plots and archaeological interpretations at a scale of 1:2,000 (**Figures 2, 3, 5** and **6**). The data are displayed at -2 nT (white) to +3 nT (black) for the greyscale image and ±25nT at 25nT per cm for the XY trace plots.

4.1.2 The interpretation of the datasets highlights the presence of potential archaeological anomalies, ferrous/burnt, or fired objects, and magnetic trends (**Figures 4** and **7**). Full definitions of the interpretation terms used in this report are provided in **Appendix 2**.

4.1.3 Numerous ferrous anomalies are visible throughout the dataset. These are presumed to be modern in provenance and are not referred to, unless considered relevant to the archaeological interpretation.

4.1.4 It should be noted that small, weakly magnetised features may produce responses that are below the detection threshold of magnetometers. It may therefore be the case that more archaeological features may be present than have been identified through this survey.

4.1.5 Gradiometer survey may not detect all services present on Site. This report and accompanying illustrations should not be used as the sole source for service locations and appropriate equipment (e.g. CAT and Genny) should be used to confirm the location of buried services before any trenches are opened on Site.

4.2 Gradiometer survey results and interpretation

4.2.1 The geophysical survey has identified several features that are tentatively considered to be anthropogenic in origin and therefore, an interpretation of possible archaeology has been ascribed. These are predominantly located in the southern portion of the site, and comprise linear, curvilinear and rectilinear anomalies. Further anomalies likely to be geological or modern in origin have also been identified and interpreted as such in associated figures.

4.2.2 Towards the south-easternmost portion of the survey area (**Figure 7**), two parallel, moderate/high magnitude linear anomalies **4000** and **4001** have been identified aligned roughly north to south approximately 25m apart. **4000** is a more complete linear response, measuring approximately 180m long by 4.5m wide. **4001** is more fragmented and unclear against a much more variable magnetic background, measuring approximately 160m long by 5m wide. In addition, curvilinear anomaly **4002** can be seen branching to the north-east and curving round to the east from the approximate middle of **4001**. This anomaly is of a similar magnitude (+2 to +8 nT) and size to **4000** and **4001**. These anomalies have been interpreted as possibly archaeological in origin as due to their increased magnitude and alignment; they could be indicative of ditch-like features cut into the natural geology. It is considered possible that these anomalies may relate to WWII anti-glider ditches, although this interpretation is made less confident due to the strong magnetic background.

4.2.3 Several smaller and more discrete linear anomalies surround the anomalies at **4000**, **4001** and **4002**, appearing to intersect or form right angles with the parallel anomalies and therefore also tentatively considered to be archaeological in origin, as they may form part of the same network of ditch-like features, perhaps relating to anti-glider ditches.

4.2.4 Across the western portion of the southern area, several further linear and rectilinear anomalies **4003** to **4007** have been identified, with several smaller, discrete linear anomalies present. The responses are generally negative, measuring approximately 3m to 5m wide and of varying length. Their notable negative response against the background magnetic response and their form in plan suggest that these anomalies may be archaeological in origin. Their form and collinearity are consistent with enclosures or a network of ditches, perhaps relating to anti-invasion defences.

4.2.5 Towards the north-western extent of the southern area, several areas of increased magnetic response are noted (**4008**, **4009** and **4010**). Within these regions, several linear and rectilinear anomalies have been identified. The interpretation of these anomalies is uncertain, as it is not clear whether these responses are the result of modern dumps of debris or arise from more formalised features. The change in magnetic texture and apparent rectilinear form in plan suggest that they may be archaeological in origin, and it is possible that they relate to WWII emplacements.

4.2.6 Immediately north of the anomalies at **4008 – 4010**, a single linear anomaly on a north-west to south-east alignment has been identified (**4011**). This anomaly is typical of a ditch, with a weak positive response measuring approximately 35m long by approximately 2.5m wide against a locally low magnetic background. The anomaly is positioned to the north of an area of increased magnetic response and it may form part of a rectilinear feature with the anomalies at **4009**.

4.2.7 Several roughly linear anomalies **4012** can be seen near the southwesternmost extent of the survey area. These anomalies lie on a similar E-W alignment as the linear anomalies at **4004** and to the immediate west of **4009**. Due to their form and magnitude, the anomalies are considered to be of possible archaeological interest, perhaps also relating to the anti-glider ditches in the area. However, these anomalies are also consistent with infilled water management ditches of unknown date, as they appear to all connect with a water course to the west of the survey area.

4.2.8 Several linear and rectilinear anomalies have been identified in the northern portion of the larger southern area. **4013** is a negative linear anomaly of possible archaeological interest, although its location at the corner of the survey makes interpretation less definitive. Similarly, rectilinear anomaly **4014** is fragmented and lies at the edge of the survey area.

4.2.9 Several areas of increased magnetic response can be seen within the linear portion of the survey area (**Figure 4**), some of which are substantially stronger than others. Due to a lack of wider context and no clear form or consistency throughout the anomalies, they are interpreted as likely to be geological in origin and possibly relating to infilled former watercourses. Sinuous anomaly **4015** may be a canalised watercourse, although it is difficult to present a more definitive interpretation given the limited width of the survey area.

4.2.10 Several high magnitude, linear anomalies have been identified. Primarily, these are in the southern portion and the very north of the Site at **4016**, **4017**, and **4018** (**Figure 4**). The anomalies are typical of modern services, such as pipes. Similar responses **4019**, **4020** and **4021** can be seen across the northern portion of the larger area (**Figure 7**).

4.2.11 Several large high magnitude responses have been identified across the southern portion of the survey area. Several of these **4022**, **4023** and **4024** are associated with the pylons present in the field. Several linear bands of magnetic disturbance can be seen across the survey area, such as at **4025**, **4026**, **4027** and **4028**, due to interference from overhead cables. Anomalies at **4029** and **4030** along the southern boundary of the survey relate to the Tilbury Substation infrastructure immediately adjacent to the field boundary.

5 DISCUSSION

5.1.1 The detailed gradiometer survey has been successful in detecting a small number of anomalies perhaps more likely to be of archaeological interest, which are largely confined to the southern part of the survey area. These anomalies are linear, rectilinear and curvilinear in form, and could be indicative of anti-glider ditches as well as associated infrastructure dating from WWII.

5.1.2 Many anomalies have been identified as being of possible archaeological interest due to their form in plan, although the limited evidence from archaeological investigations and finds in the surrounding area makes their interpretation less conclusive; many of the responses could conceivably be of either natural or anthropogenic origins. Any future intrusive investigation, such as archaeological trial trenches, would provide direct information on the archaeological nature, or otherwise, of these anomalies and a dynamic review of the geophysical interpretation during this phase of investigation may provide a greater understanding of the surrounding anomalies of uncertain provenance.

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Cartographic and documentary sources

Ordnance Survey 1983 *Soil Survey of England and Wales. Sheet 6, Soils of South East England*. Southampton.

Online resources

British Geological Survey *Geology of Britain Viewer* (accessed September 2017) http://mapapps.bgs.ac.uk/geologyofbritain/home.html

Old Maps (accessed September 2017) https://www.old-maps.co.uk

APPENDICES

Appendix 1: Survey Equipment and Data Processing

Survey methods and equipment

The magnetic data for this project was acquired using a Bartington 601-2 dual magnetic gradiometer system. This instrument has two sensor assemblies fixed horizontally 1m apart allowing two traverses to be recorded simultaneously. Each sensor contains two fluxgate magnetometers arranged vertically with a 1m separation, and measures the difference between the vertical components of the total magnetic field within each sensor array. This arrangement of magnetometers suppresses any diurnal or low frequency effects.

The gradiometers have an effective resolution of 0.03nT over a ±100nT range, and measurements from each sensor are logged at intervals of 0.25m. All of the data are stored on an integrated data logger for subsequent post-processing and analysis.

Wessex Archaeology undertakes two types of magnetic surveys: scanning and detail. Both types depend upon the establishment of an accurate 20m or 30m site grid, which is achieved using a Leica Viva RTK GNSS instrument and then extended using tapes. The Leica Viva system receives corrections from a network of reference stations operated by the Ordnance Survey and Leica Geosystems, allowing positions to be determined with a precision of 0.02m in real-time and therefore exceed the level of accuracy recommended by Historic England (English Heritage 2008) for geophysical surveys.

Scanning surveys consist of recording data at 0.25m intervals along transects spaced 10m apart, acquiring a minimum of 80 data points per transect. Due to the relatively coarse transect interval, scanning surveys should only be expected to detect extended regions of archaeological anomalies, when there is a greater likelihood of distinguishing such responses from the background magnetic field.

The detailed surveys consist of 20m x 20m or 30m x 30m grids, and data are collected at 0.25m intervals along traverses spaced 1m apart. These strategies give 1600 or 3600 measurements per 20m or 30m grid respectively, and are the recommended methodologies for archaeological surveys of this type (English Heritage 2008).

Data may be collected with a higher sample density where complex archaeological anomalies are encountered, to aid the detection and characterisation of small and ephemeral features. Data may be collected at up to 0.125m intervals along traverses spaced up to 0.25m apart, resulting in a maximum of 28800 readings per 30m grid, exceeding that recommended by Historic England (English Heritage 2008) for characterisation surveys.

Post-processing

The magnetic data collected during the detail survey are downloaded from the Bartington system for processing and analysis using both commercial and in-house software. This software allows for both the data and the images to be processed in order to enhance the results for analysis; however, it should be noted that minimal data processing is conducted so as not to distort the anomalies.

As the scanning data are not as closely distributed as with detailed survey, they are georeferenced using the GPS information and interpolated to highlight similar anomalies in adjacent transects. Directional trends may be removed before interpolation to produce more easily understood images.

Typical data and image processing steps may include:

- Destripe – Applying a zero mean traverse in order to remove differences caused by directional effects inherent in the magnetometer;
- Destagger – Shifting each traverse longitudinally by a number of readings. This corrects for operator errors and is used to enhance linear features;
- Despike – Filtering isolated data points that exceed the mean by a specified amount to reduce the appearance of dominant anomalous readings (generally only used for earth resistance data)

Typical displays of the data used during processing and analysis:

- XY Plot – Presents the data as a trace or graph line for each traverse. Each traverse is displaced down the image to produce a stacked profile effect. This type of image is useful as it shows the full range of individual anomalies.
- Greyscale – Presents the data in plan using a greyscale to indicate the relative strength of the signal at each measurement point. These plots can be produced in colour to highlight certain features but generally greyscale plots are used during analysis of the data.

Appendix 2: Geophysical Interpretation

The interpretation methodology used by Wessex Archaeology separates the anomalies into four main categories: archaeological, modern, agricultural, and uncertain origin/geological.

The archaeological category is used for features when the form, nature and pattern of the anomaly are indicative of archaeological material. Further sources of information such as aerial photographs may also have been incorporated in providing the final interpretation. This category is further sub-divided into three groups, implying a decreasing level of confidence:

- Archaeology – used when there is a clear geophysical response and anthropogenic pattern.
- Possible archaeology – used for features which give a response but which form no discernible pattern or trend.

The modern category is used for anomalies that are presumed to be relatively modern in date:

- Ferrous – used for responses caused by ferrous material. These anomalies are likely to be of modern origin.
- Modern service – used for responses considered relating to cables and pipes; most are composed of ferrous/ceramic material although services made from non-magnetic material can sometimes be observed.

The agricultural category is used for the following:

- Former field boundaries – used for ditch sections that correspond to the position of boundaries marked on earlier mapping.
- Ridge and furrow – used for broad and diffuse linear anomalies that are considered to indicate areas of former ridge and furrow.
- Ploughing – used for well-defined narrow linear responses, usually aligned parallel to existing field boundaries.
- Drainage – used to define the course of ceramic field drains that are visible in the data as a series of repeating bipolar (black and white) responses.

The uncertain origin/geological category is used for features when the form, nature and pattern of the anomaly are not sufficient to warrant a classification as an archaeological feature. This category is further sub-divided into:

- Increased magnetic response – used for areas dominated by indistinct anomalies which may have some archaeological potential.
- Trend – used for low amplitude or indistinct linear anomalies.
- Superficial geology – used for diffuse edged spreads considered to relate to shallow geological deposits. They can be distinguished as areas of positive, negative, or broad bipolar (positive and negative) anomalies.

Appendix 3: OASIS form

Project Details:

Project name	Land adjacent to Tilbury Substation, Tilbury, Essex				
Type of project	Detailed gradiometer survey (Field evaluation)				
Project description	A detailed gradiometer survey was conducted over land adjacent to Tilbury Substation, Tilbury, Essex (centred on NGR 566194 176616). The project had the aim of establishing the presence, or otherwise, and nature of detectable archaeological features in support of a planning application for the development of the site as an extension of the power station infrastructure to the south. The Site comprises arable fields covering approximately 17.3 ha located to the east of Tilbury. The geophysical survey was undertaken between 21st August 2017 and 25th August 2017, and has demonstrated the presence of several anomalies of possible archaeological origin. Several linear and rectilinear anomalies have been interpreted tentatively as possible archaeology due to the known presence of WWII anti-invasion defences and other emplacements nearby. Other anomalies are more clearly geological in origin. Several modern services can be seen, along with several areas of increased magnetic response and possible evidence of drainage.				
Project dates	**Start:** 21-08-2017		**End:** 25-08-2017		
Previous work	Not Known				
Future work	Not Known				
Project Code:	118030	**HER event no.**	N/A	**OASIS form ID:**	wessexar1-296552
		NMR no.	N/A		
		SM no.	N/A		
Planning Application Ref.					
Site Status					
Land use	Pasture/Hay/Silage				
Monument type		**Period**			

Project Location:

Site Address	Tilbury Power Station, East Tilbury, Essex			**Postcode**	RM18 8UJ
County	Essex	**District**	Tilbury / Thurrock	**Parish**	Tilbury
Study Area	17.3 ha	**Height OD**	1 m aOD	**NGR**	566194 176616

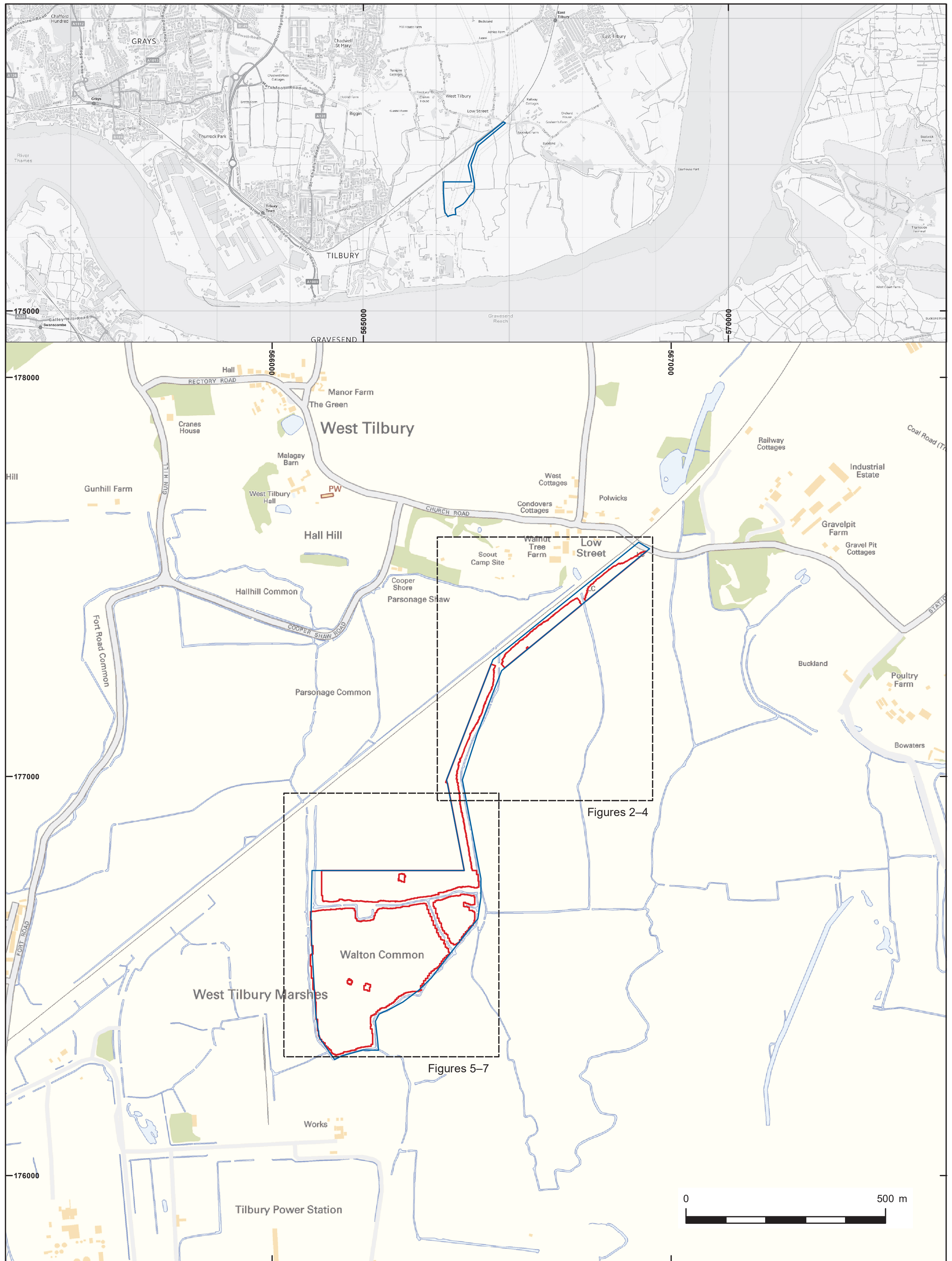
Project Creators:

Name of Organisation	Wessex Archaeology		
Project brief originator	Statera Energy Ltd.	**Project design originator**	

Project Manager	Ben Urmston	**Project Supervisor**	PV
Sponsor or funding body		**Type of Sponsor**	

Project Archive and Bibliography:

Physical archive	N/A	**Digital Archive**	Geophysics, survey and report	**Paper Archive**	N/A
Report title	Land Adjacent to Tilbury Substation, Tilbury, Essex			**Date**	2017
Author	Wessex Archaeology	**Description**	Unpublished report	**Report ref.**	118030.01



Coordinate system:
OSGB36 (OSTN15/OSGM15)

Site boundary
Detailed survey extents

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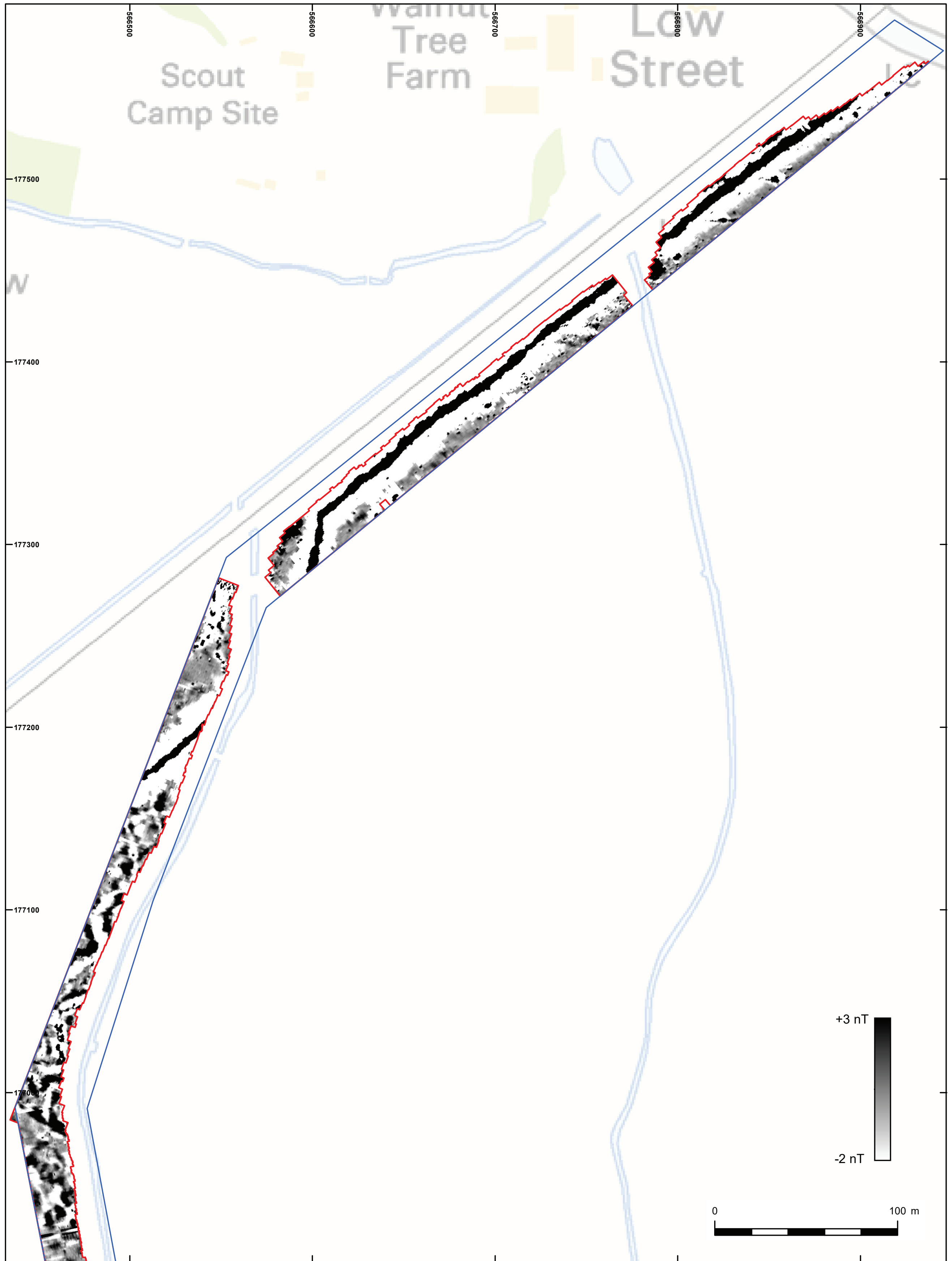
Site location

Figure 1



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Site boundary

Detailed survey extents

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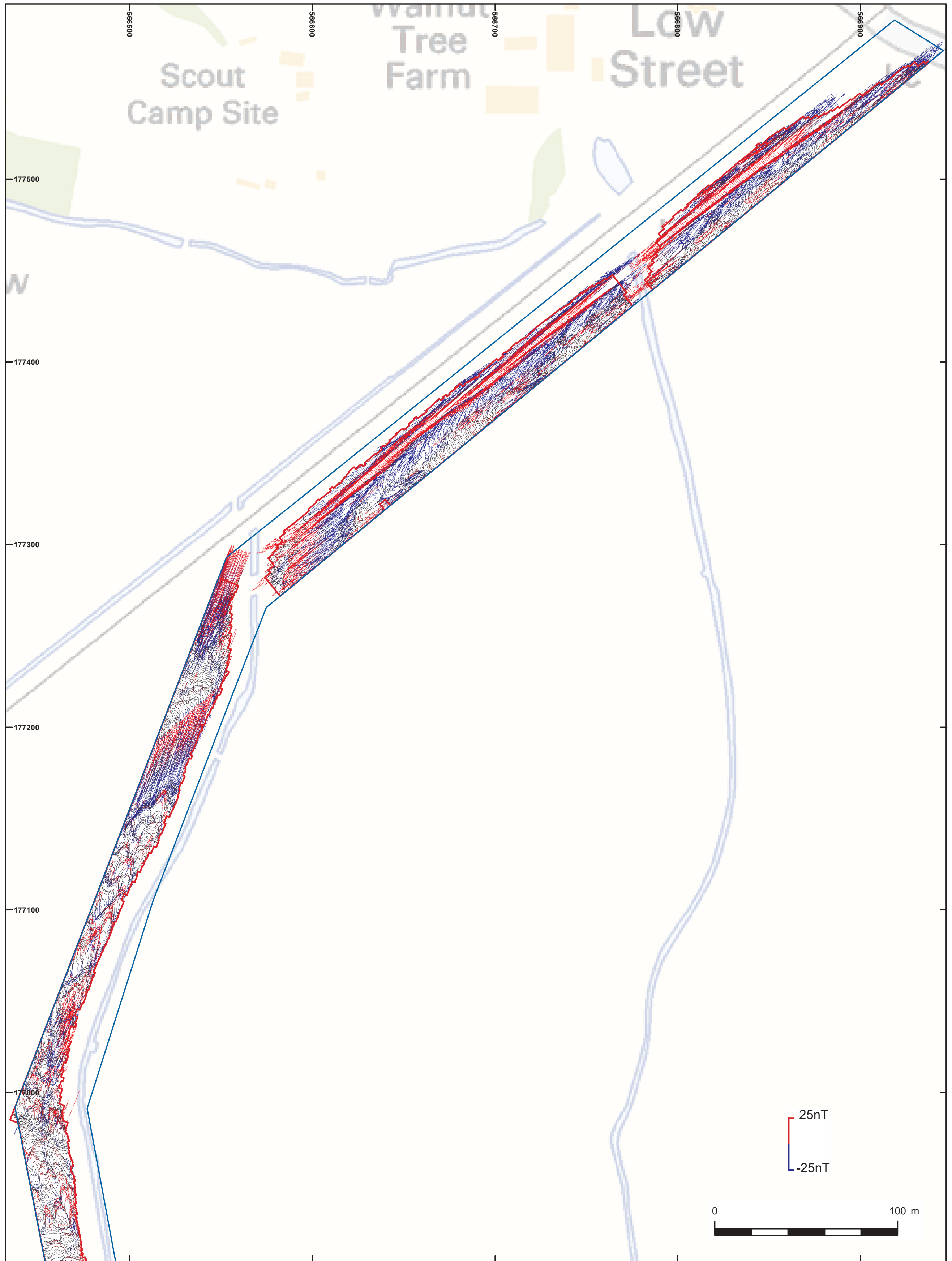
Greyscale plot of north end of site

Figure 2



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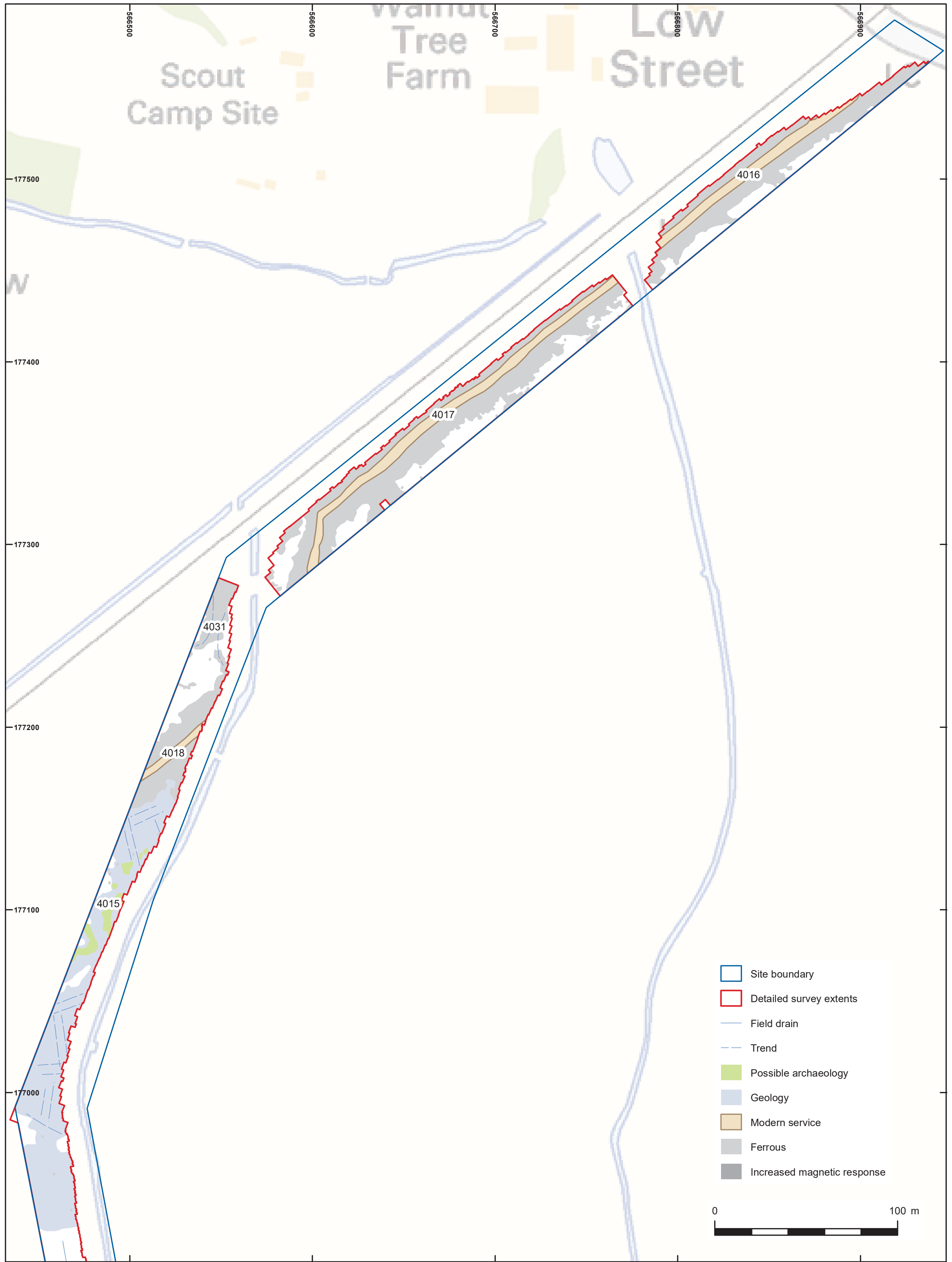
XY Trace plot of north end of site

Figure 3



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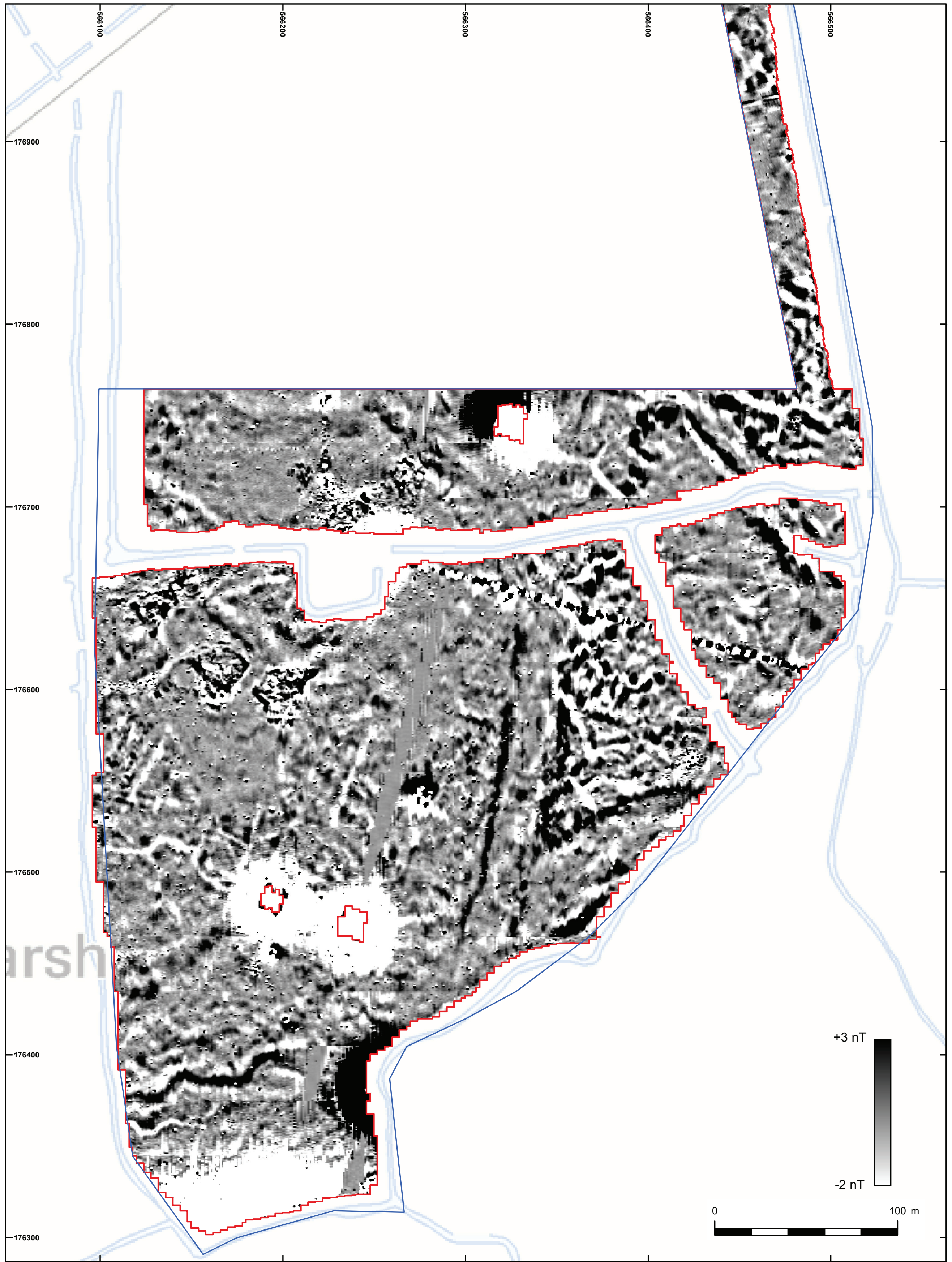
Scale:	1:2000 at A3	Illustrator:	WAF
Path:	X:\PROJECTS\118030\GIS\FigsMXD\2017_09_20_Geophys		

Archaeological interpretation of north end of site

Figure 4



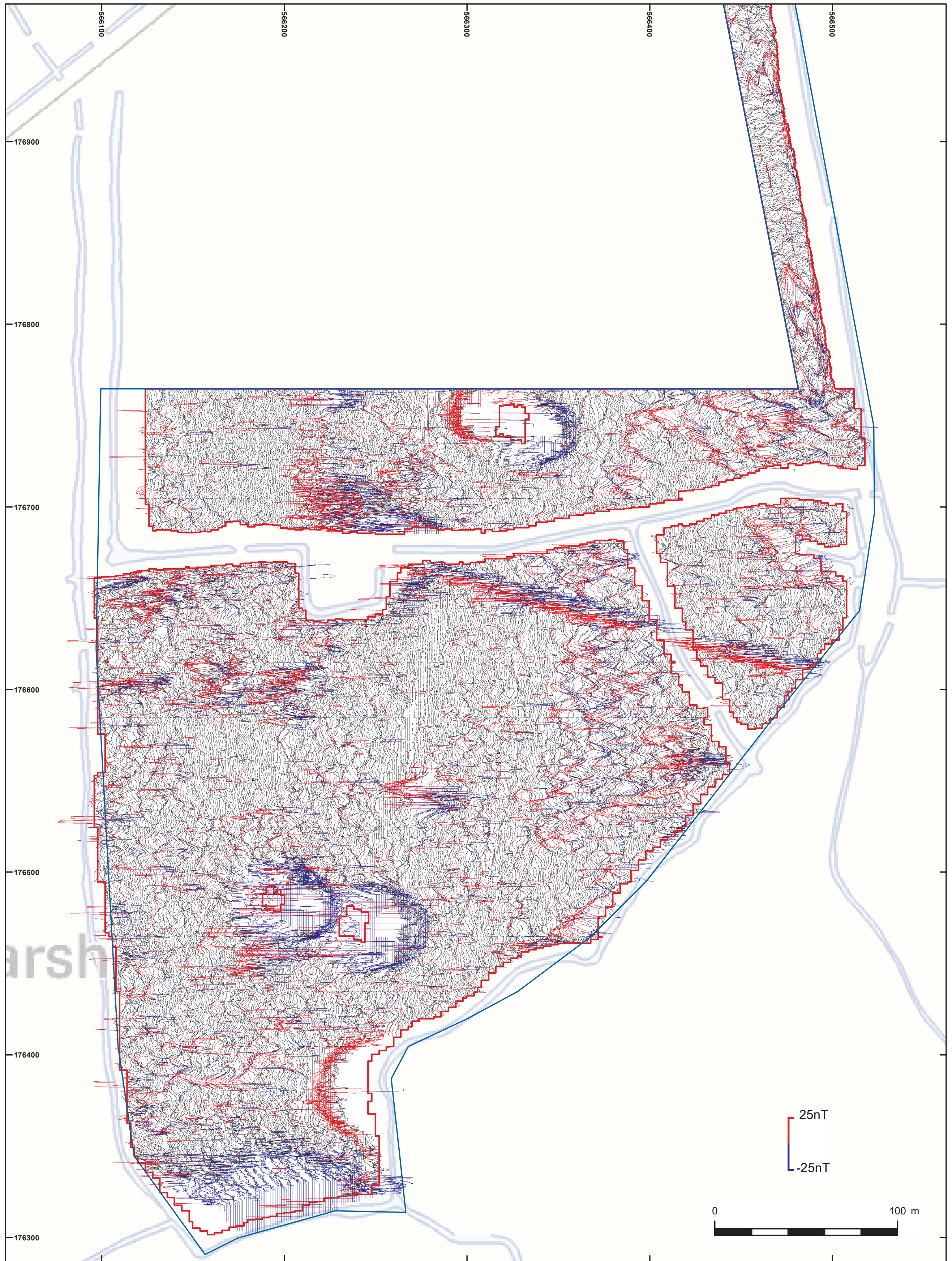
Coordinate system:
OSGB36 (OSTN15/OSGM15)

Site boundary
Detailed survey extents

Date:	20/09/2017	Revision Number:	0
Scale:	1:2000 at A3	Illustrator:	WAF
Path:	X:\PROJECTS\118030\GIS\FigsMXD\2017_09_20_Geophys		

Greyscale plot of south end of site

Figure 5



Coordinate system:
OSGB36 (OSTN15/OSGM15)

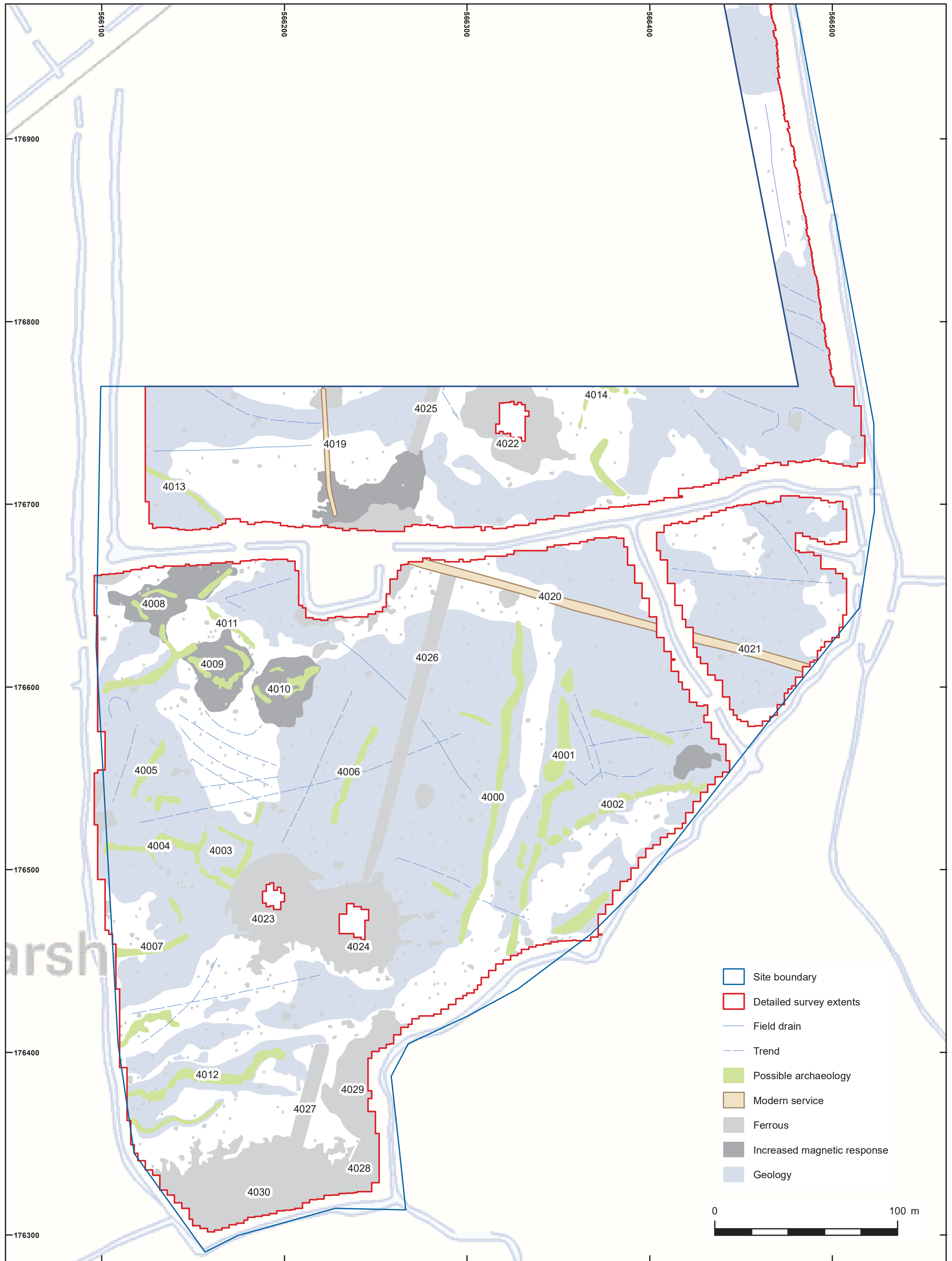
Site boundary

Detailed survey extents

Date:	20/09/2017	Revision Number:	0
Scale:	1:2000 at A3	Illustrator:	WAF
Path:	X:\PROJECTS\118030\GIS\FigsMXD\2017_09_20_Geophys		

XY Trace plot of south end of site

Figure 6



Coordinate system:
OSGB36 (OSTN15/OSGM15)

Date:	20/09/2017	Revision Number:	0
Scale:	1:2000 at A3	Illustrator:	WAF
Path:	X:\PROJECTS\118030\GIS\FigsMXD\2017_09_20_Geophys		

XY Trace plot of south end of site

Figure 6

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