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Gwent Levels Archaeological Deposit Model

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CVJV/AAR
3rd Floor
Longross Court,
47 Newport Road,
Cardiff
CF24 0AD

Geoarchaeological Deposit Modelling Report

Prepared for:
RPS Planning & Development
20 Western Avenue
Milton Park,
Abingdon
Oxfordshire, OX14 4SH.
United Kingdom

On behalf of:
The Welsh Government

Prepared by:
Wessex Archaeology
Portway House
Old Sarum Park
Salisbury
Wiltshire
SP4 6EB

www.wessexarch.co.uk

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Geoarchaeological Deposit Modelling Report

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Summary

Wessex Archaeology were commissioned by RPS Planning and Development to produce a deposit model of subsurface sediments along the proposed route of the section of new motorway south of Newport. This is one of a range of different methods being employed in order to inform archaeological evaluation strategy.

The modelling was a desk-based exercise undertaken by interpretation, modelling and reporting upon existing data, which comprised around 1250 sediment sequence records; predominantly Site Investigation and British Geological Survey borehole logs, along with a smaller number of sequences from past archaeological coring works.

Extensive alluvial deposits up to 18m deep were mapped along the route, and model outputs were created showing alluvial thicknesses and underlying topography at various scales.

In addition, a review of recent work on changes in relative sea-level in the area allowed an rough guide to sea levels over time to be produced. This has been used in conjunction with the Digital Elevation Models of the underlying geological surfaces to model a series of approximate palaeo-coastlines at various points from the start of the Neolithic onwards.

It is anticipated that these results will assist in the development of a mitigation strategy to address the potential effects of the Scheme on buried archaeological remains within the Gwent Levels.

Geoarchaeological Deposit Modelling Report

1 INTRODUCTION

1.1 Project Background

1.1.1 Wessex Archaeology (WA) has been commissioned by RPS Planning and Development to produce a deposit model of subsurface sediments along the proposed route of the M4CaN scheme, as one of a range of different methods being used to develop an appropriate mitigation strategy that will address the potential effects of the Scheme on buried archaeological remains within the Gwent Levels.

1.1.2 The modelling is a desk-based exercise undertaken by interpretation, modelling and reporting upon existing data, which comprises around 1250 sediment sequence records; predominantly Site Investigation and British Geological Survey borehole logs, along with a smaller number of sequences from past archaeological coring works.

1.2 Scope of document

1.2.1 The purpose of this report is to present the results of deposit modelling, in order to characterise the route in terms of depths and types of deposit present.

1.2.2 This report is not intended to be a thorough examination of the geoarchaeological potential of the area, but a practical tool for informing more detailed investigation; in this inputting into an appropriate mitigation strategy alongside a number of other methods.

1.2.3 In format and content it conforms with current best practice and to the guidance outlined in *Management of Research Projects in the Historic Environment* (MoRPHE) (English Heritage 2006) and *Geoarchaeology. Using Earth Sciences to Understand the Archaeological Record* (English Heritage 2004).

1.3 Outline geology and topography

1.3.1 The bedrock geology at the eastern extents of the Scheme are recorded as primarily Mercia Mudstone and Black Rock Limestone formations with variable overlying River Terrace deposits and Alluvium deposits of sand and gravels. The western extents are recorded largely as St Maughans formation sandstones with overlying River Terrace and Alluvium sand and gravel deposits as well as small areas of Diamicton Till (BGS).

2 GEOARCHAEOLOGICAL BACKGROUND

2.1.1 In order to put the Site in its geoarchaeological context, the broad sedimentary architecture of the area is summarised below (after Brown 2005).

2.1.2 Underlying the area of the Gwent Levels of southeast Wales is a deep sedimentary sequence, consisting of a series of alternating estuarine alluvial silt and peat deposits up to 15m in depth, and extending over some 840 km^2 of intertidal zone and now reclaimed and drained former wetland.

2.1.3 These deposits have accumulated over the last 8000 years as a result of an upward, but fluctuating trend in sea-level rise following the end of the last glaciation. Estuarine silts are laid down on saltmarshes and mudflats during periods of sea-level-rise, whilst peats represent stable or falling sea-levels, within which a succession of plant communities can become established.

The Wentlooge Formation

2.1.4 Named after the intertidal sediment exposures on the Wentlooge Levels, southeast Wales, the Wentlooge Formation - sub-divided into lower, middle and upper Wentlooge - represents the principal sedimentary deposit within the Severn Estuary, covering all but the last 2000 years of deposition.

2.1.5 Classification of the Wentlooge sequence is based largely on research into the sedimentary sequence in the Severn Estuary by John Allen (e.g., Allen 1987, 1990, 1997), upon which these descriptions are partially based.

2.1.6 <u>The lower Wentlooge</u> Formation, usually only exposed at lowest tides, consists of several metres of estuarine clayey-silts, grading from pale greenish grey to blue-grey in colour. Networks of tidal creeks, latterly infilled and present as palaeochannels, are widely distributed across the exposed Levels. Lower Wentlooge sediments are not typically deposited to the same extent within the interior of the levels.

2.1.7 <u>The middle Wentlooge</u> is characterised by a series of intercalating estuarine alluvial silt and peat deposits of varying date. The earliest basal peats have been radiocarbon dated to the Mesolithic, in the first half of the 6th Millennium BC (at Porlock on the north Somerset coast, Jennings *et al* 1998), whilst the latest peat formation (on the Welsh side of the Severn Levels) has been dated to the Late Bronze and Iron Ages (e.g. Barland's Farm and Vurlong Reen, Walker *et al* 1998; and Greenmoor Arch, Locock 1999b)

2.1.8 The exact sequence of silts and peats varies between individual sites, reflecting complex patterns of relative sea-level rise, involving multiple phases of marine transgression and regression. The overall thickness of peat units also varies, from thin peats of only a few centimetres thick, to reed, wood and succeeding raised mire peats between 2 to 4m deep.

2.1.9 For reasons that are not fully understood, the peat deposits of the Gwent Levels attain a greater maximum thickness than those occurring on either the Avon or North Somerset Levels.

2.1.10 <u>The upper Wentlooge</u> witnessed a return to the deposition of estuarine clayey-silts, dating to the Iron Age and Romano-British periods. It represents a period of rapid sediment accumulation, with between 3-5m of sediment accumulating between the 3rd century BC and the 2nd century AD, ceasing in some areas with the Romano-British drainage of the Levels (Bell 1999).

3 AIMS AND OBJECTIVES

3.1.1 The aims of this study were to:

- Model the interpreted data across that part of the Gwent Levels traversed by the section of new motorway
- Model the interpreted data across the scheme area
- Identify areas with increased or reduced potential for archaeological activity, particularly at shallower depths
- Provide ground-truthing data to increase the accuracy of remote sensing surveys, including ERT/ Lund survey

3.1.2 In order to achieve these aims, the following objectives were identified:

- Obtain Site Investigation and British Geological Society data
- Interpret the logs geoarchaeologically and enter into Rockworks database
- Pass data to the ERT survey team for groundtruthing;
- Model the results using Rockworks and GIS
- Create outputs at a suitable scale to inform evaluation
- Report

4 METHODOLOGY

4.1 Deposit modelling

4.1.1 Deposit records entered into Rockworks consisted of 1251 borehole and test pit records from within around 1km the area of the route (e.g. **Figure 1**). This is an unusually wide catchment, but given that the vast majority of datapoints fell within the scheme area itself, the number of outlying points was relatively small except within built-up areas.

4.1.2 The data were a combination of BGS records (available online), Site Investigation logs from geotechnical works, and a smaller number of previous archaeological borehole logs. In order to create the deposit models, the individual logs or records were examined by a geoarchaeologist, and judgements made as to the nature of the layers recorded. This was entered as lithological data into a digital (Rockworks 15) database.

4.1.3 Model outputs suitable to the nature of the results were then produced using GIS software in combination with Rockworks. These outputs consist of Digital Elevation Models (DEMs) and thickness models, showing primarily the underlying geological topography, the thickness of Holocene alluvial deposits and the surface of sands and gravels underlying the Holocene alluvial clays, silts and peats.

4.1.4 The coarser more minerogenic deposits that make up the sands and gravels, is comprised of deposits both Pleistocene and early Holocene in origin. For simplicity in the modelling here, all have been grouped together and referred to as River Terrace Deposits Undifferentiated (RTDU).

4.2 Palaeo sea levels

4.2.1 From contour information provided from the modelled surface of the RTDU, figures were produced that displayed potential former sea levels in the form of the possible extent of past coastlines. The former coastlines were reconstructed from linking contours at -2m OD for approximately 3000 yr BP, -4m OD for approximately 4-5000yr BP and -6m OD for approximately 6000yr BP.

5 RESULTS

5.1 Data coverage

5.1.1 Although data coverage was generally plentiful and widespread along the route of the new section of motorway, individual datapoints were too widely dispersed to be able to identify features at an archaeological site scale; i.e. to identify the topographic highs and lows in the basal Pleistocene topography – typically a few tens to hundreds of metres in scale – which often highlights an area of relatively drier land within wetlands which would have an increased potential of prehistoric archaeological activity.

5.1.2 It was therefore not possible to achieve some of the project aims using the available dataset. The data is however extremely well suited for providing a landscape-scale model.

5.2 Geoarchaeological units identified

5.2.1 The deposits recorded along the route of the new section of motorway can be grouped into the following broader classifications:

- **Made ground** – Defined as the upper-most sediments that contain evidence of human disturbance, such as ploughing, or anthropogenic deposition, such as iron slag deposits.
- **Peat** – Accumulation of partially decayed vegetation matter. This is the result of both freshwater fen and ombrotrophic (raised mire) peat formation. Non-planar and non-continuous.
- **Alluvium** – Sediments deposited by riverine or marine deposition; comprised primarily of silts and clays.
- **Sand and Gravel** – Found in a number of areas overlying the basal geology. The nature of the sediments is variable, ranging from sands and gravels to sandy / gravely clays. Sediments are categorised as sand and / or gravel where these form the major component of the sediment matrix. These sediments may be Pleistocene fluvial or Head deposits, or reworked sediments laid down in the Holocene.
- **Glacially derived deposits** - these include Fluvio-glacial deposits and Diamicton which are found on the higher ground at the west end of the scheme.
- **Geology** – varying from primarily Mercia Mudstone and Black Rock Limestone formations in the east of the Scheme, to sandstones of the St Maughans formation at the western extents.

5.2.2 Of these units, aspects of the distribution of the most significant with reference to specific datapoints and thicknesses are discussed below.

Thickness and depth of Peat

5.2.3 Along the proposed route of new section of motorway across the Gwent Levels, the most extensive peat deposits can be found within the Caldicot Levels; deposits reaching up to 6.2m in thickness (SH BHM3A). Peat is also present within the Wentlooge Levels (SH SBHE06 CP; <2.3m thick) and the Level of Mendalgief (ST38NW87; <2.0m thick).

5.2.4 The areas of thickest peat are found south of Llandevenny (SH BHM3A; 6.2m) and north west of Grangefield (borehole ST38NE12; 4.12m). North of Pye Corner (borehole SH SBHH05 CP) there is an additional thick peat deposit of 4.35m, though this occurs as four distinct peat layers intercalated by estuarine alluvium.

5.2.5 Peat occurrence on the Caldicott Level is found to be largely continuous between west of Pye Corner (SH BHH1) and south of Llandevenny (SH BHM3). Research at Llandevenny, on the northern edge of the proposed route, by Brown (2005; ST 41258665) located a thick peat 5.5m thick that contained a detailed palaeoenvironmental record and late Mesolithic / early Neolithic occupation site, stratified at the wetland-dryland interface. This site is significant as it has provided evidence for unbroken occupation over this period and is associated with well-preserved organic remains which were utilised in the study to understand settlement mobility, seasonality and subsistence. The thick peat from borehole SH BHM3A (6.2m), just south of this study, may provide a more detailed palaeoenvironmental record in addition to similar archaeological remains.

Within the Gwent Levels, peat in the Wentlooge area is limited, with the thickest deposits found east of Whitecross Farm (SH SBHE06 CP, 2.3m, and SH SBHE07 CP, 2.0m). In the remainder of the area peat deposits are limited, not exceeding 1.5m. Although sporadic, peat is concentrated between SH SBHD01 CP and SH SBHF01 CP. In a number of borehole logs from along the new section of motorway there were peat fragments noted within estuarine alluvium. Peat is found to be present at ground level in boreholes south of Llandevenny, gradually deepening towards Greenmoor Farm (Borehole SH BHL5; 4.4m below ground level (bgl)). Peat between Greenmoor Farm and Pye Corner ranges between 2.5m (SH SBHH05 CP) and 13.5m (SH SBHJ05), the deepest peats being located north of Whitson Court.

5.2.6 Peat in the Wentlooge area is shallowest south of Tyn-y-brwyn (SH SBHD03 CP; 1.65m bgl), with an additional shallow peat to the east of Whitecross Farm on the west bank of the Ebbe River (SH SBHF01 CP; 2.95m bgl). It should be noted that although there is an apparent relationship between shallow peats and settlement locations (e.g. Llandevenny, Brown 2005), this distribution may be the result of the ease with which excavation can occur in shallower deposits. Preserved settlement sites are likely to also be found within some deeper peats as humans appear to have been highly mobile across the Gwent Levels throughout prehistory.

Thickness of Alluvium

5.2.7 Alluvium is found to occur almost continuously along the route of the new section of motorway on the Gwent Levels, running from east of junction 29 of the M4 (b SH BHC3) to east of Llandevenny (SH SBHM02 RC). Alluvium thickness is greatest between the area of the Level of Mendalgief (Custom House, Alexandra Docks) and Pye Corner to the east of the River Usk (SH BHG1; 18.2m), ranging between 18.2 and 9.65m. Average alluvial thickness for the whole Gwent Levels is just under 7m.

Total thickness of Peat and Alluvium

5.2.8 When peat and alluvium thicknesses are combined, the deepest deposits are located between the Level of Mendalgief (Custom House, Alexandra Docks) and north of Whitson Court near Goldcliffe (between 18.2 and 9.8m). Deposits either side of this zone gradually thin towards the margins of the Gwent Levels.

Occurrence of underlying sand and gravel

5.2.9 Basal deposits of sands and / or gravels have predominantly been recorded between Custom House, Alexandra Docks and south of Tyn-y-brwyn, with the thickest deposits south of Tyn-y-brwyn (SH SBHD05 RC and SH SBHD06 RC; 11.4m), and east of Duffryn (SH SBHF03 RC; 7.8m).

5.2.10 Deposits are also located in the area east of Pye Corner (up to 4.45m; SH BHG6), with small patches south of Tatton Farm (SH BHI1; 4.59m), south of Llandevenny (borehole SH BHM3A; 3.9m) and thick deposits north of Magor (SH SBHN02 RC; 11.1m).

5.2.11 Although no attempt has been made in this work to categorise or sub-divide Pleistocene sands and gravels, previous work (including from deposits beneath the Llanwern steel mill) suggests that some of these date back to well before the last glaciation, with Andrews *et al* (1984) summarising that in the Ipswichian period (MIS 5e; c. 124–119 kya) the Severn Estuary would have been flanked by gravel beaches.

5.3 Deposit modelling

5.3.1 For practical purposes, the most significant factor in appreciating the archaeological potential of the Gwent Levels is understanding the thickness and extent of alluvial deposits, which may both cover and contain archaeological sites of many periods, from Late Glacial onwards.

5.3.2 To this end the units identified have been grouped into two overarching stratigraphic units: *Holocene* (which, along with the extensive alluvial and peat deposits of the Levels actually includes some deposits of probable Pleistocene age, and might more properly be described as 'Drift') and *Geology*.

5.3.3 The large-scale results of modelling are presented in **Figures 1** and **2**, with more detailed views of each geoarchaeological character area (discussed below) in **Figures 3**-**16.**

5.3.4 Subsequent to the modelling of the thickness of the Holocene deposits and the upper surface of the bedrock geology the Holocene deposits were further divided. The upper surface of the sands and gravels beneath the later Holocene alluvial silts, clays and peats were then modelled in order to provide a DEM of the sands and gravels together with any areas of bedrock where the later Holocene deposits directly overlay it, this was then referred to as the RTDU DEM.

5.4 Geoarchaeological character areas

5.4.1 The project area has been subdivided into seven 'geoarchaeological character areas', based primarily on the thickness of Holocene deposits present and the underlying geological topography. Deposits referred to "as mapped" indicates the information was provided by the British geological Society (BGS) via their on line mapping facility (www.bgs.ac.uk/geoindex).

Area A

5.4.2 Area A (**Figures 3** & **4**) is located at the western end of the new section of motorway measuring approximately 4km in length from just west of Junction 29 on the M4 to just south of Imperial Park. The underlying bedrock geology is mapped as Devonian Lower Old Red Sandstone of the St Maughans Formation. The upper surface of the bedrock was modelled as ranging from 35m OD in the west rising to a maximum of 95m OD just to the south of Penylan Farm in the north of the centre of Area A before sloping down to 5m OD at the eastern end of the area to the south of Imperial Park.

5.4.3 The bedrock in Area A was overlain by superficial deposits mapped as glacial till in the west, river terrace deposits in the east with a thin band of alluvial deposits running north – north-west to south-south-east along the western edge of Imperial Park. The depth of Holocene deposits across Area A ranged from up to 10m in depth at the east end of Area A decreasing to approximately 1m in the vicinity of Gwaunshonbrown Farm.

Area B

5.4.4 Area B (**Figures 5** & **6**) was located between the south end of Imperial Park and the River Usk, measuring approximately 5km in length. The bedrock was mapped as Mercia Mudstone. The upper surface of the bedrock was modelled as ranging from approximately 5m OD at the west end close to Coedcernyw sloping down to -5m to the east, then rising slightly to 0m OD by Whitecross Farm before falling back to -5m OD. The bedrock then rises once more up to 5m OD at Alexandra Docks before dropping to over -5m OD by the channel of the River Usk. A small but deeper area of bedrock over -10m OD immediately to the east of the River Usk may be related to the proximity of a tidal pill entering the channel at that point.

5.4.5 The bedrock was overlain by Tidal Flat Deposits over the entirety of Area B, with thicknesses that ranged from 6m in the west to 16m in thickness in the east with one area of 6m thick deposits located over the higher area of bedrock identified near Alexandra Docks.

Area C

5.4.6 Area C (**Figures 7** & **8**) covered the part of the route than ran east from the River Usk to the west side of the Solutia Nature Reserve. This area was approximately 1000m in length and relatively short so as to encompass a raised area of the Mercia Mudstone bedrock (5m OD compared to -5m OD either side with a relatively thin (5m in thickness) covering of Tidal Flat Deposits.

Area D

5.4.7 Area D (**Figures 9** & **10**) measured approximately 3km in length and covered the route from Solutia Nature Reserve in the west to Bowlease Common in the east. The bedrock was mapped as Mercia Mudstone and ranged in depth from 0m OD in the vicinity of Pye Corner falling to -5m OD by Tatton Farm before rising to 5m OD just to the east of Bowlease Common. The bedrock falls briefly to -5m OD just to the north east of Moor Barn before rising to 5m OD once more. The bedrock was mapped as being overlain by Tidal Flat deposits that ranged in thickness from 12m over much of the area but decreased to around 5m over the raised area of bedrock immediately to the west of Bowlease Common. Where the upper surface of the bedrock fell briefly just to the north east of Moor Barn the thickness of the Holocene deposits also increased up to 12.5m in thickness before decreasing at the east end of the area where the bedrock rose up to 5m OD.

Area E

5.4.8 Area E (**Figures 11** & **12**) measured approximately 4.5km in length and covered the route from Bowlease Common in the west to Llandevenny in the east. The bedrock was mapped as Mercia Mudstone and from the modelled surface was fairly uniform across the area and ranged in depth from 0 – 5m OD. With the higher areas at 5m OD located at the western end of Area E and in the centre of the area in the vicinity of New Cut Reen.

5.4.9 The bedrock was mapped as being overlain by Tidal Flat Deposits that were modelled as ranging from 9.5m to 3.5m in thickness. The thickness of the Holocene deposits varied in relation to the height of the underlying bedrock. Where the bedrock was at its highest at the west end and in the centre the deposits were modelled as up to 3.5m in thickness, which increased to up to 9.5m in thickness between the west end and the higher bedrock around new Cut Reen. Moving east from New Cut Reen the thickness of the deposits increase up to 9.5m again before slowly decreasing to 7m in thickness at the east end of Area E.

Area F

5.4.10 Area F (**Figures 13** & **14**) measured approximately 730m in length and was positioned to cover a northeast to southwest slope in the bedrock to the west of Magor. The geology was mapped as Tintern Sandstone Formation the upper surface of which was modelled at 0m OD in the southwest rising to 20m OD in the northeast.

5.4.11 The bedrock was mapped as being overlain by Tidal Flat Deposits in the south modelled in thickness from 3.5 to 5.5m with higher parts of Area F in the northeast overlain by River Terrace Deposits. The Holocene deposits overlying the bedrock in the northeast of the area are modelled as up to 3m in thickness.

Area G

5.4.12 Area G (**Figures 15** & **16**) measured approximately 3750m in length and covered the route from the west of Magor to east of Junction 23 on the M4. The bedrock was quite varied across Area G and was mapped as Tintern Sandstone Formation in the west, and then moving east was mapped as Merica Mudstone, Avon Group Mudstone and Limestone, Carboniferous Blackrock Limestone and Carboniferous Llanelly Formation Limestone. The upper surface of the bedrock was modelled as ranging from 25m OD in the west, falling to 10m OD where the St Brides Brook crossed the route before rising to 40m OD in the vicinity of Knollbury in the centre then falling once more to 5m at the east end.

5.4.13 The bedrock was mapped as being overlain by River Terrace deposits at the west and east end with alluvium and head deposits along the line of the St Brides Brook. The Holocene deposits mapped in the thickness model indicates that they are up to 2.5m in thickness at the west end, up to 3m in the vicinity of St Brides Brook, decreasing to 1.5m near Knollbury before steadily increasing up to 6m at the east end.

5.5 Comparison with EM31/ERT results

Western Array

5.5.1 The Western Array (**Figure 17**), one of three areas investigated by geophysical methods (Bates & Bates 2015, see Appendix 8.6 of this ES) was located within Area B. The EM data was mapped by use of colour coordinated values, low conductivity (high resistance) is represented by cool colours such as blues and greens and high conductivity (low resistance) is represented by hot colours such as oranges and reds.

5.5.2 The EM results indicate that deposits with the highest conductivity are to be found at the east end of the route of the new motorway within Area B with decreasing conductivity to the west. When compared to the Holocene deposit thickness model the thickness of deposits covered by the area of the EM survey ranged from approximately 10m to 13.5m with the area of highest conductivity in the east overlying a deeper section of the deposits at up to 13.5m.

5.5.3 As with the EM data the ERT results show the deposits as having a lower resistance (higher conductivity) to the east and a slightly increased resistance to the west reflecting a change from more minerogenic sediments in the east to more organic dominated sediments in the west. There were no obvious palaeochannels identified in this area.

5.5.4 The bedrock DEM shows the upper surface as being fairly uniform across the area of the western Array at mostly -5m OD rising to 0m OD at the west end and towards the east end. The fairly regular height of the bedrock across the area of the Western array indicates that it is changes in the minerogenic content within the Holocene deposits driving the changes in conductivity and hence resistance. The EM results from the east end of the array show sinuous features of high conductivity within the deposits likely indicating the clay rich fills of palaeochannels within the relatively lower conductivity of the minerogenic sediments of the estuarine alluvium.

Central Array

5.5.5 The Central Array (**Figure 18**) was located across Area D, where a number of discrete changes within the geophysical data with particularly clear boundaries from the middle of the Central Array indicated areas of low conductivity (cool colours). These areas of low conductivity are interpreted as palaeochannels and are likely to be recent due to their geophysical signature in comparison with other channels to the east.

5.5.6 The ERT results indicated that the base of the Holocene sequence was at approximately 10m below the marsh surface and that this was consistent across the array with little evidence of palaeochannels extending to depth with one exception approximately 950m to the east of Tatton Farm

5.5.7 EM data from the western end of the central array indicates a zone of low conductivity that corresponds with a zone of higher resistance recorded in the ERT results. These are probably coarse sediments which together with the EM results are interpreted as lying in a small channel complex that developed within marshland.

5.5.8 The upper surface of the bedrock under the central collection of EM results ranged from -5m OD to 0m OD at the eastern end with the thickness of the Holocene deposits decreasing from approximately 13m in the west to 7m in the east. Overall the large area of increased conductivity and low resistivity at the eastern end mirrors the rising bedrock and decreasing thickness of Holocene deposits. Over the remainder of the array the areas of contrasting conductivity and resistivity which cannot be assigned to changes within the surface height of the bedrock are most probably down to variations within the minerogenic content of the Holocene deposits and from former channels that cut through them.

Eastern Array

5.5.9 The eastern Array (**Figure 19**) was located across Area E and F where EM data showed a clear distinction between areas of low conductivity mapped around the lines of two ERT transects in the east and areas of higher conductivity mapped in the west. A similar pattern was also noted in the ERT results across the rest of the array. When compared to the Holocene thickness model, areas of high conductivity at the west end were located over deposits that ranged from 4m in the west to 9.5m in the centre of the array. Though some decrease in conductivity was noticed over the thicker deposits, this was marginal. At the east end a marked decrease in conductivity and rise in resistance coincided with a rise in the upper surface of the bedrock from 0m OD to 5m OD. Whereas at the west end a rise in the upper surface of the bedrock from 0m OD to 5m OD coincided with an increase in conductivity and decrease in resistance. This contrast in results when everything else is fairly equal including a decrease in the thickness of Holocene deposits at both locations indicates that the deposits at the west end with the greater conductivity are more minerogenic when compared to those in the east. With sinuous features evident in the data these areas of higher conductivity probably relate to the fills of palaeochannels.

5.6 Sea level change and palaeo-coastlines

Sea level change over time

5.6.1 Some work is available on changing sea levels in the Severn Estuary (Allen 1990, 2005, Hewlett & Birnie 1996, Heyworth 1978, Heyworth & Kidson 1982, Hill *et al.* 2007) though recent work appears to be limited. The limited work available has made it problematic in identifying past sea levels on a localised scale, although it is still possible to make some general observations.

5.6.2 Probably the best resource is a recent thesis (Elliott 2015) reconstructing sea-level change in Bridgwater Bay, though within it there was criticism of some of the earlier sea level curves representative of changing sea level height over time. The criticism was mainly aimed at the “smoothed” curves as they may be misleading and mask past fluctuations and oscillations over relatively short periods of time (decades or centuries) as well as any events restricted to specific localities that have been masked by their smoothing out when superimposed on to a regional scale.

5.6.3 In order to obtain a rough estimation of past sea levels over time for the area of the scheme, a number of the sea level curves from the works mentioned above were examined in order to produce a very general guide of sea level height (mOD) against time (1000 yr increments), below:

- 2000 BP = -1/-2m OD
- 3000 BP = - 2m OD
- 4000 BP = - 3/-4m OD
- 5000 BP = - 4/-5m OD
- 6000 BP = - 5/-6m OD
- 7000 BP = - 8/-10m OD
- 8000 BP = - 15m OD
- 9000 BP = -20/-25m OD

Palaeo-coastlines

5.6.4 This approximate sea level data can - when applied to the Digital Elevation Model of the River Terrace Deposits and underlying geology – provide a rough guide to the limits of former coastlines and raised areas within the underlying topography which would have remained relatively dry within the surrounding estuarine conditions.

5.6.5 From an examination of contour data from the modelled RTDU together with the broad brush estimations of past sea level heights, three palaeo coastlines were reconstructed: -2m OD for an approximation of the 3000yr BP coastline (**Figure 20**), -4m OD for the 4-5000yr BP coastline (**Figure 21**) and -6m OD for a the 6000yr BP coastline (**Figure 22**).

5.6.6 Reconstructions of previous coastlines from earlier sea levels (>7000BP) have not been produced for two reasons: firstly, the modelling suggested that these coastlines were well to the south of the study area (i.e. the curves in combination with the modelled data suggest that prior to the start of the Neolithic, the whole scheme area was above sea level); and secondly, the point data used was overwhelmingly located within the scheme footprint, making any extrapolation southwards extremely unreliable.

5.6.7 Moving from west to east the -2m OD (c. 3000 BP; **Figure 20**) palaeo-coastline intersects the study area to the south of Imperial Park. The coastline is not smooth here and crosses in and out of the study area a number of times perhaps as a result of depressions or gullies within the sands and gravels. From Alexandra Docks the -2m OD coastline moves to the north of the study area and doesn’t cross it again till just below Llandevenny.

5.6.8 The -4m OD (c.4-5000 BP; **Figure 21**) palaeo-coastline intersected the study area just to the west of Alexandra Docks, then remained to the north of it before crossing it between Greenmoor Farm and Llandevenny.

5.6.9 The -6m OD (c.6000 BP; **Figure 22**) palaeo-coastline lies in parallel with the modern coastline to the west of the mouth of the River Usk before turning inland to cross the study area at Alexandra Docks to the west of the River. To the east of the river it then crosses the study area again forming an embayment as a result of the river valley. The coastline then crosses the study area once more to the north of the Solutia Nature Reserve briefly staying to the north of the study area before crossing it for the last time at Bowlease Common.

5.6.10 All three of the palaeo-coastlines form the outline of a bay at different levels and times that stretches from the Wentlooge Levels to the Caldicott levels with the coastline bisected on its western side by minor depressions and the River Usk, the result of water draining of the higher land to the north.

6 COPYRIGHT

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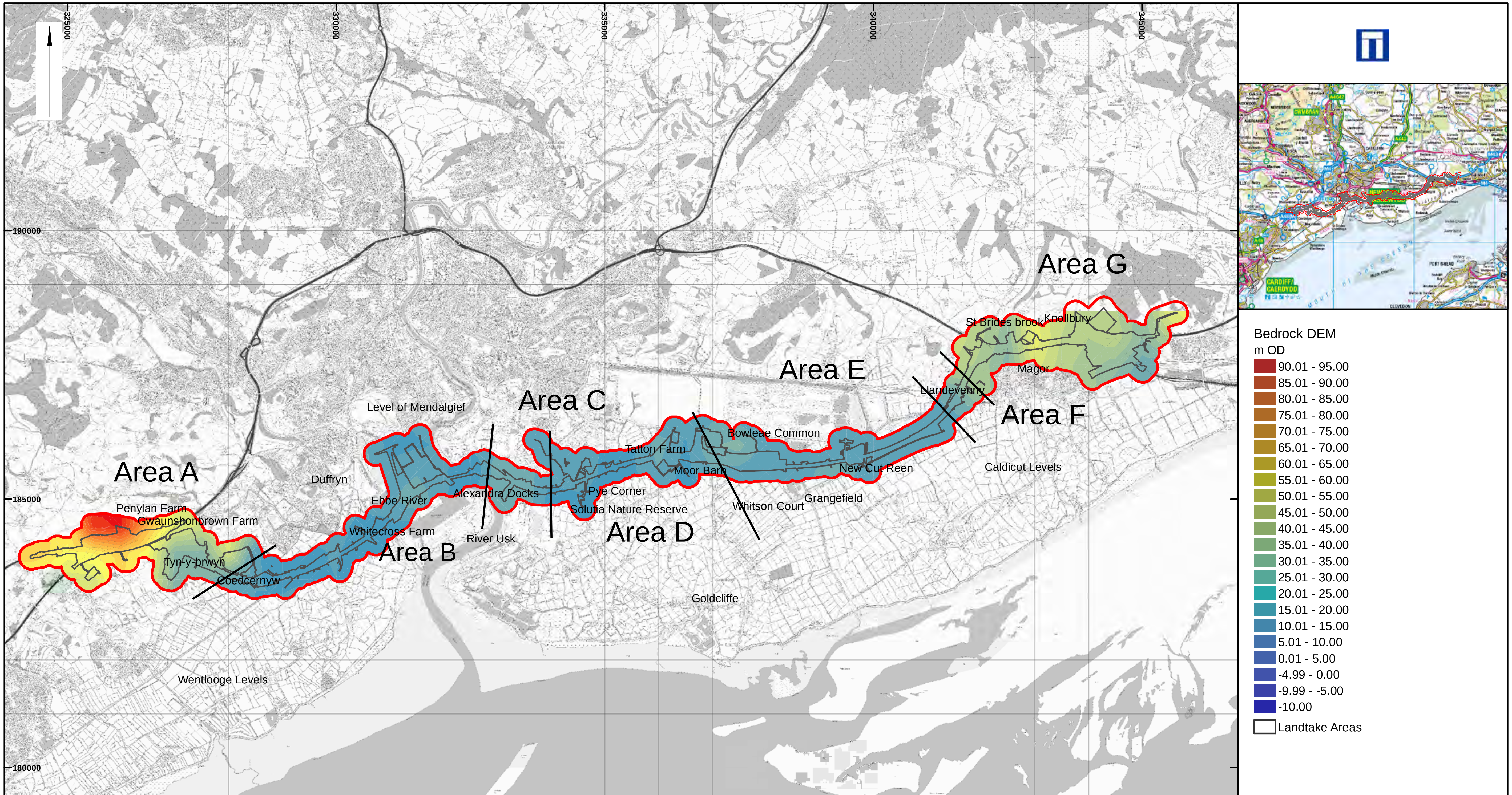

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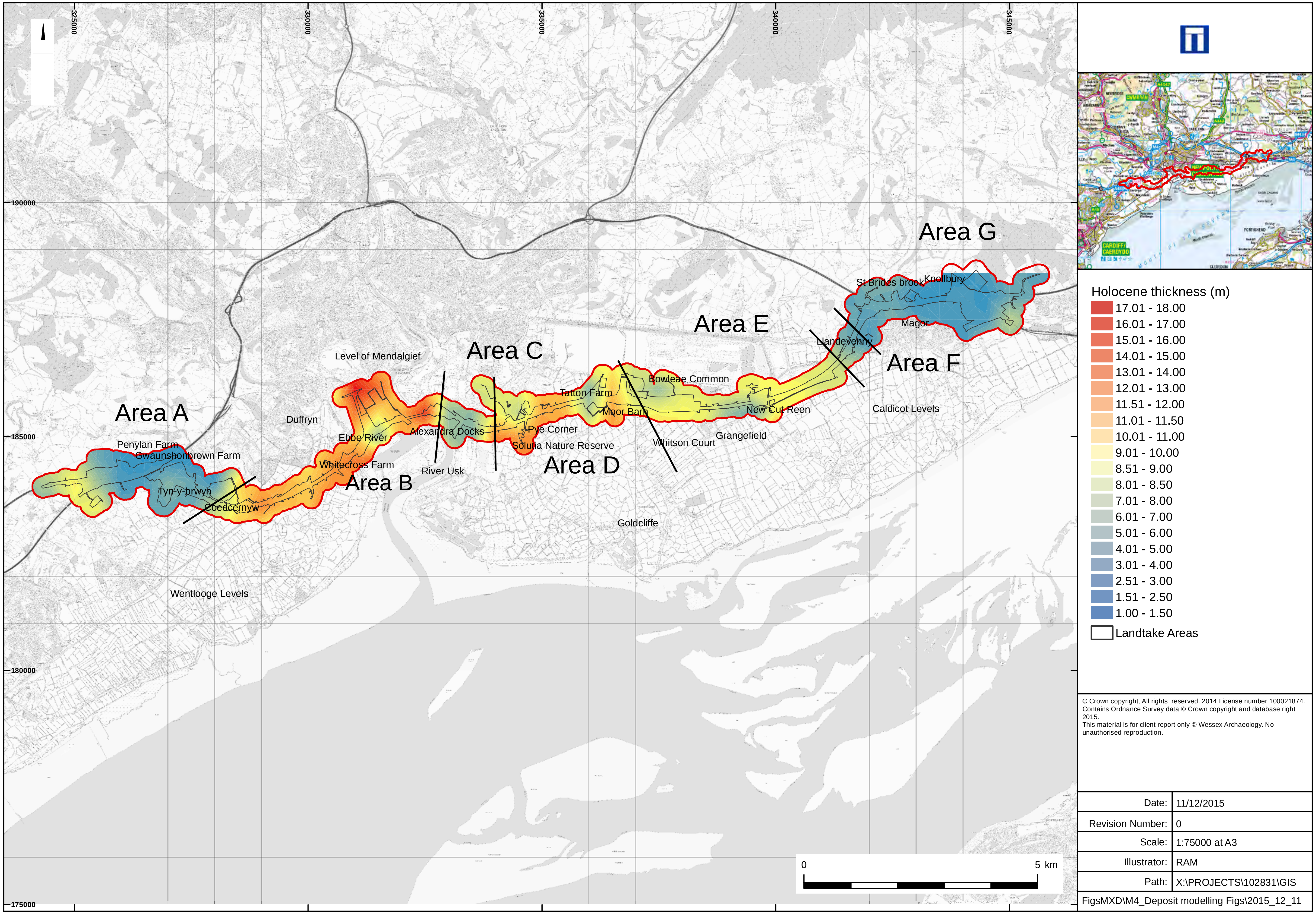
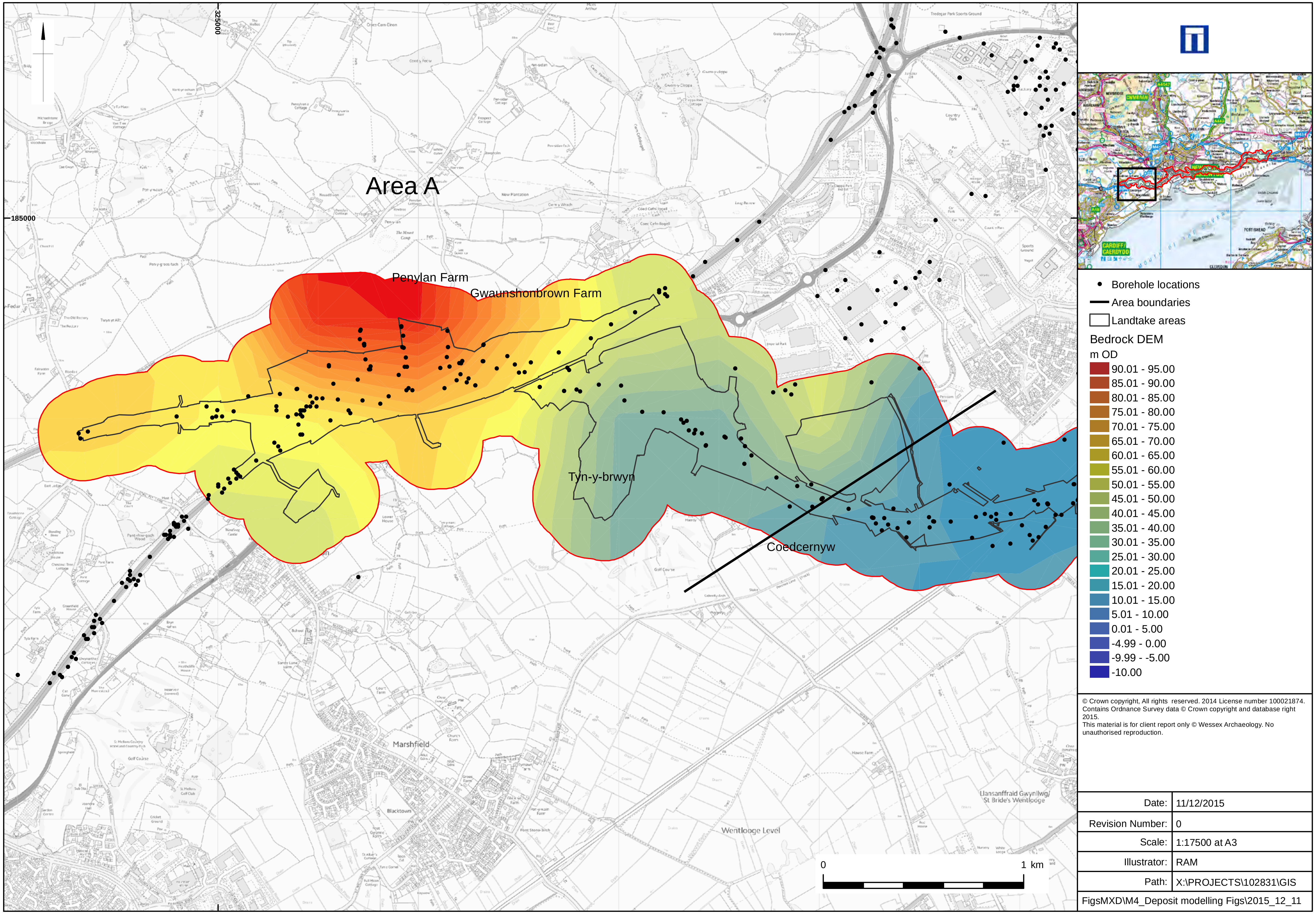
Scheme-wide Bedrock DEM

Figure 1



Scheme-wide Holocene thickness model

Figure 2



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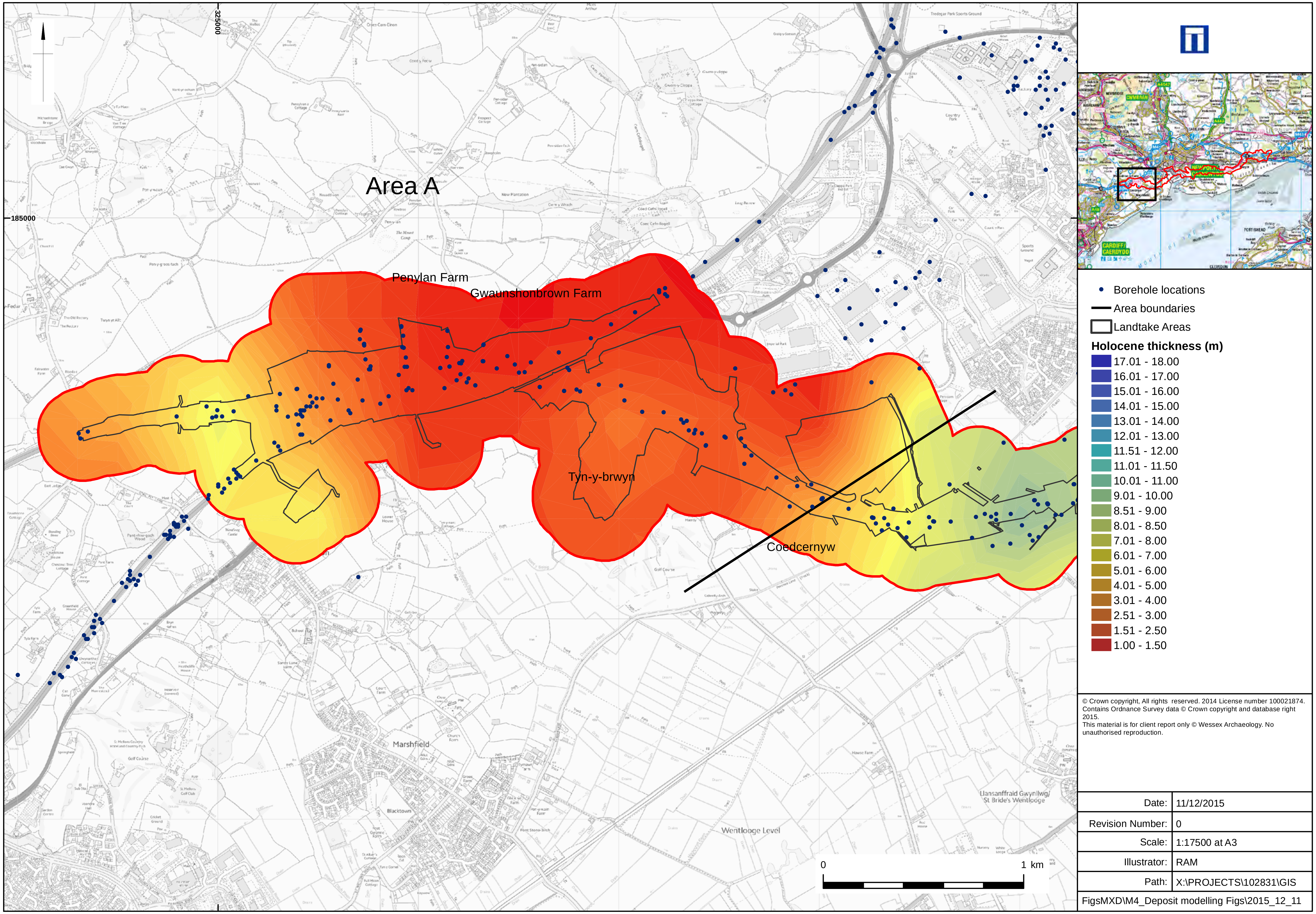
Area A: Bedrock DEM

Figure 3



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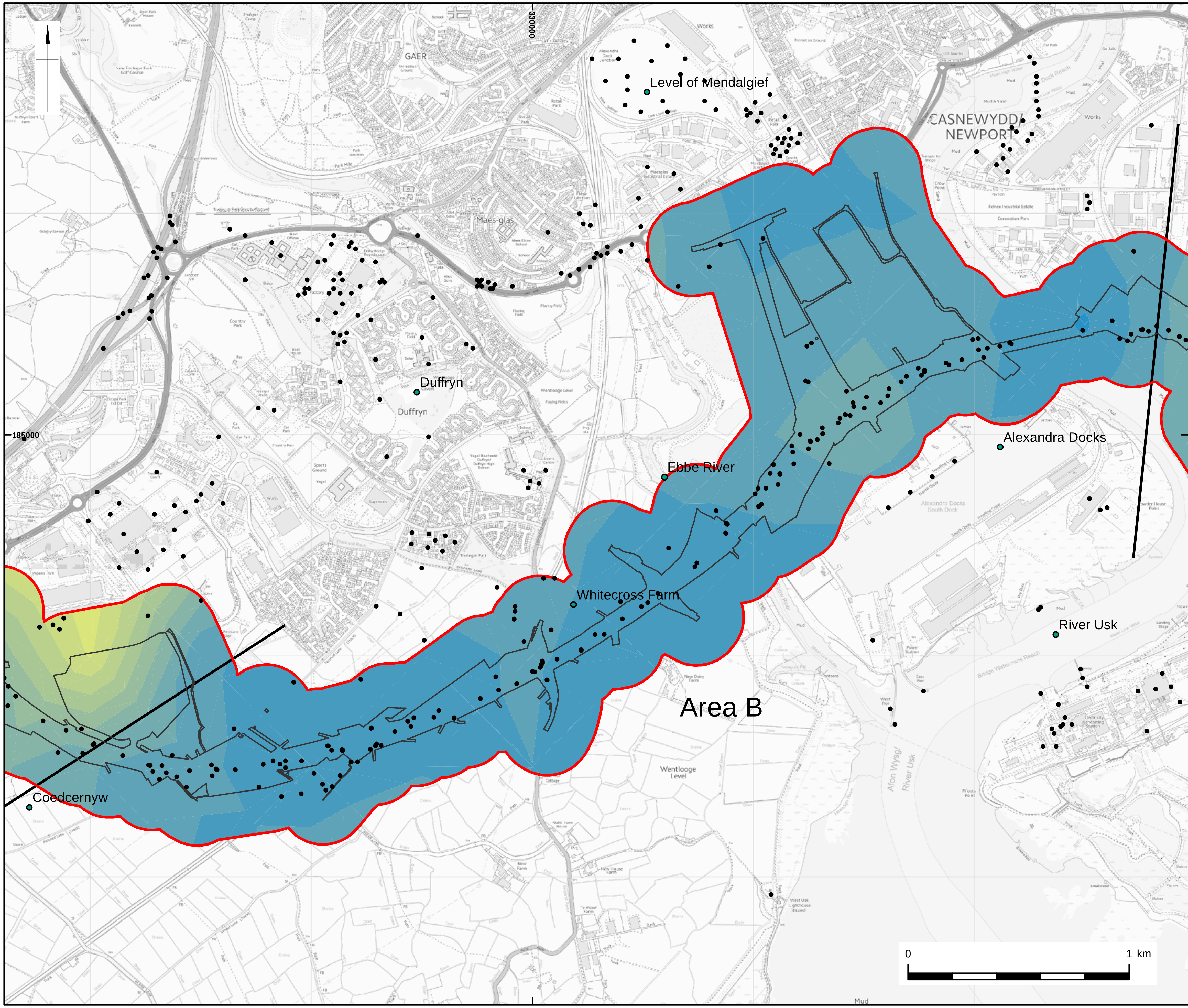
Area A: Holocene thickness model

Figure 4



Borehole locations
Area boundaries
Landtake Areas

Bedrock DEM
m OD
90.01 - 95.00
85.01 - 90.00
80.01 - 85.00
75.01 - 80.00
70.01 - 75.00
65.01 - 70.00
60.01 - 65.00
55.01 - 60.00
50.01 - 55.00
45.01 - 50.00
40.01 - 45.00
35.01 - 40.00
30.01 - 35.00
25.01 - 30.00
20.01 - 25.00
15.01 - 20.00
10.01 - 15.00
5.01 - 10.00
0.01 - 5.00
-4.99 - 0.00
-9.99 - -5.00
-10.00

Date:	11/12/2015
Revision Number:	0
Scale:	1:17500 at A3
Illustrator:	RAM
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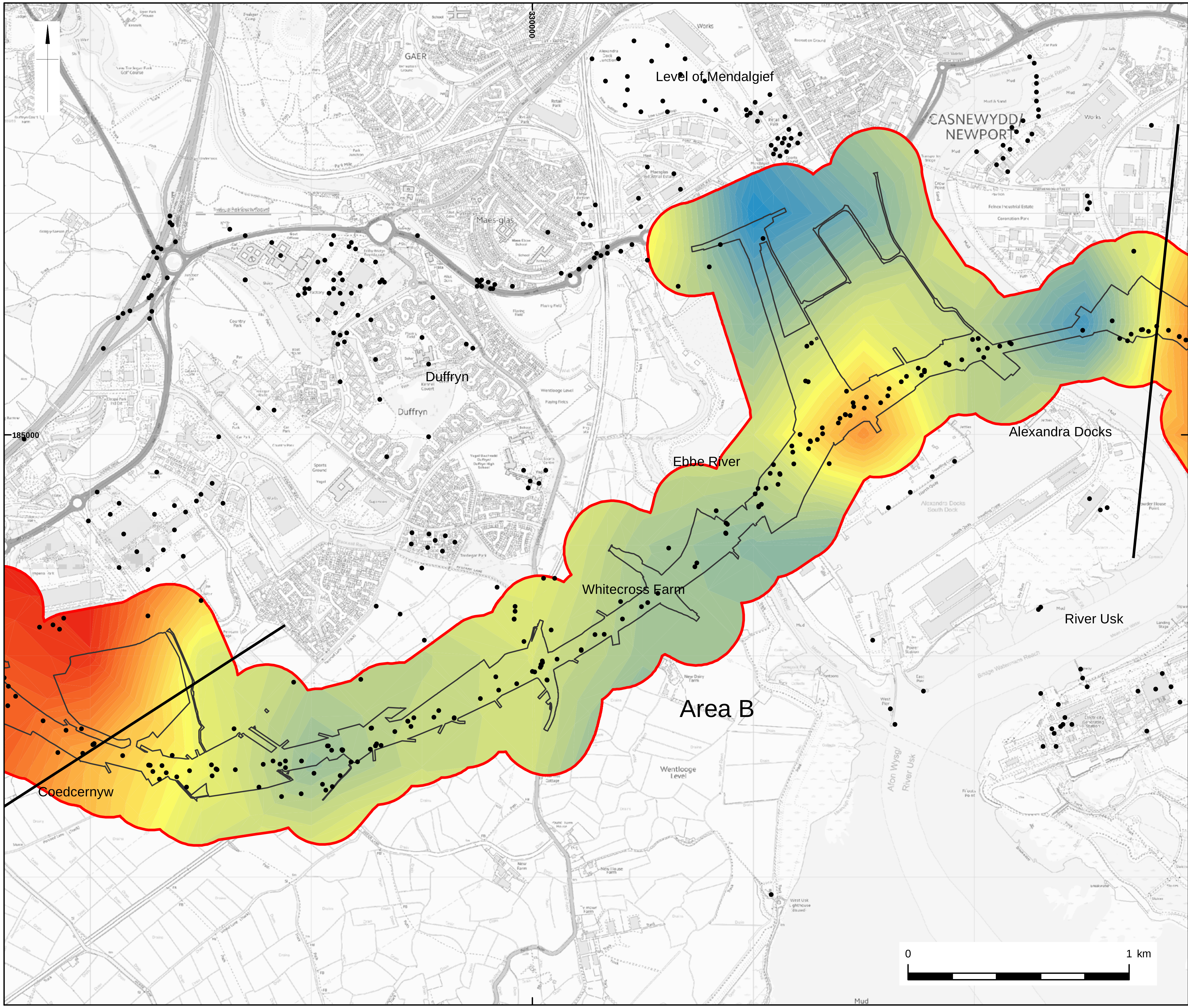
FigsMXD\M4_Deposit modelling Figs\2015_12_11

Area B: Bedrock DEM

Figure 5



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Revision Number:	0
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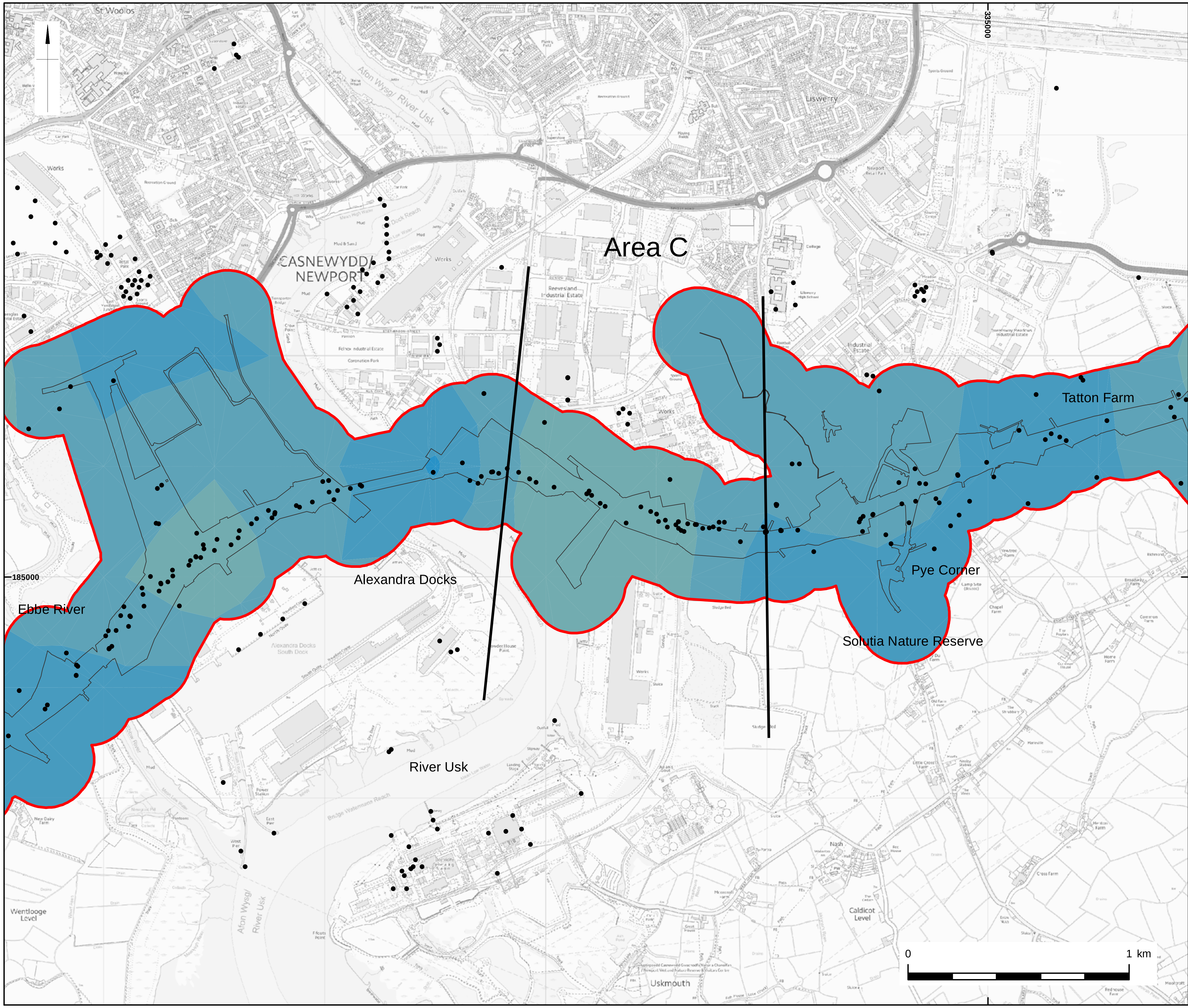
Area B: Holocene thickness model

Figure 6



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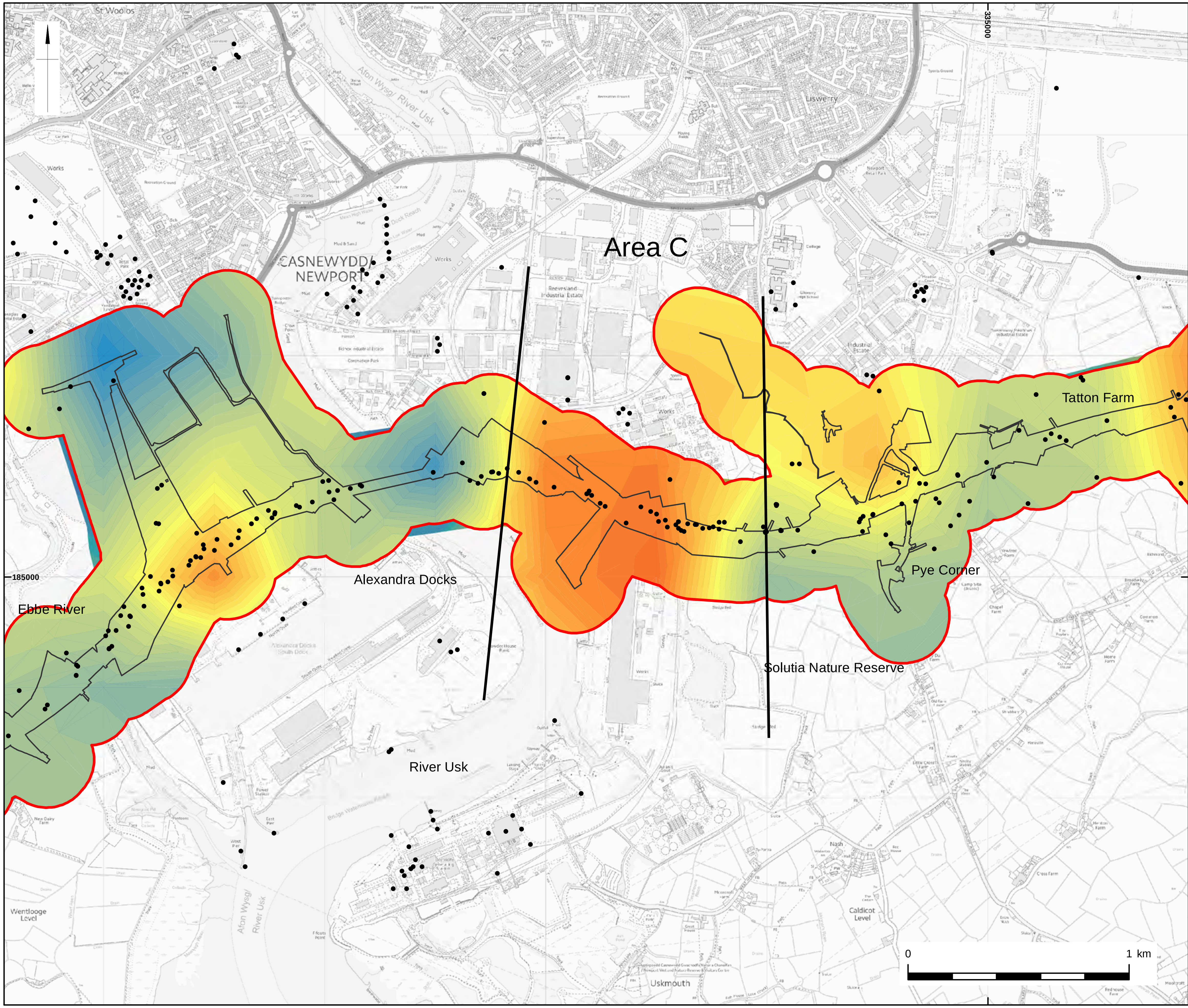
Area C: Bedrock DEM



- Borehole locations
- Area boundaries
- Landtake Areas

Holocene thickness (m)

- 17.01 - 18.00
- 16.01 - 17.00
- 15.01 - 16.00
- 14.01 - 15.00
- 13.01 - 14.00
- 12.01 - 13.00
- 11.51 - 12.00
- 11.01 - 11.50
- 10.01 - 11.00
- 9.01 - 10.00
- 8.51 - 9.00
- 8.01 - 8.50
- 7.01 - 8.00
- 6.01 - 7.00
- 5.01 - 6.00
- 4.01 - 5.00
- 3.01 - 4.00
- 2.51 - 3.00
- 1.51 - 2.50
- 1.00 - 1.50

Date:	11/12/2015
Revision Number:	0
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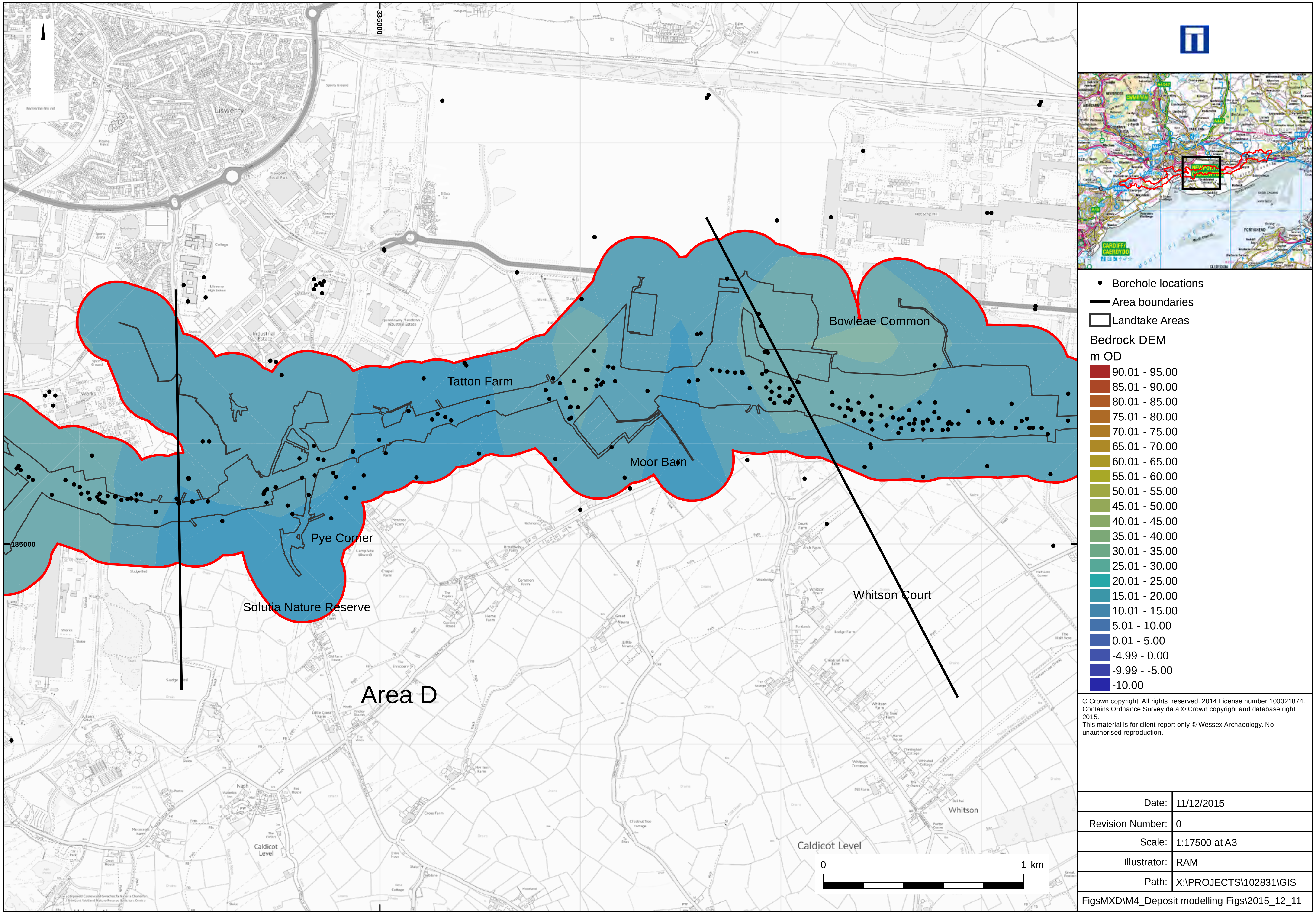
Area C: Holocene thickness model

Figure 8



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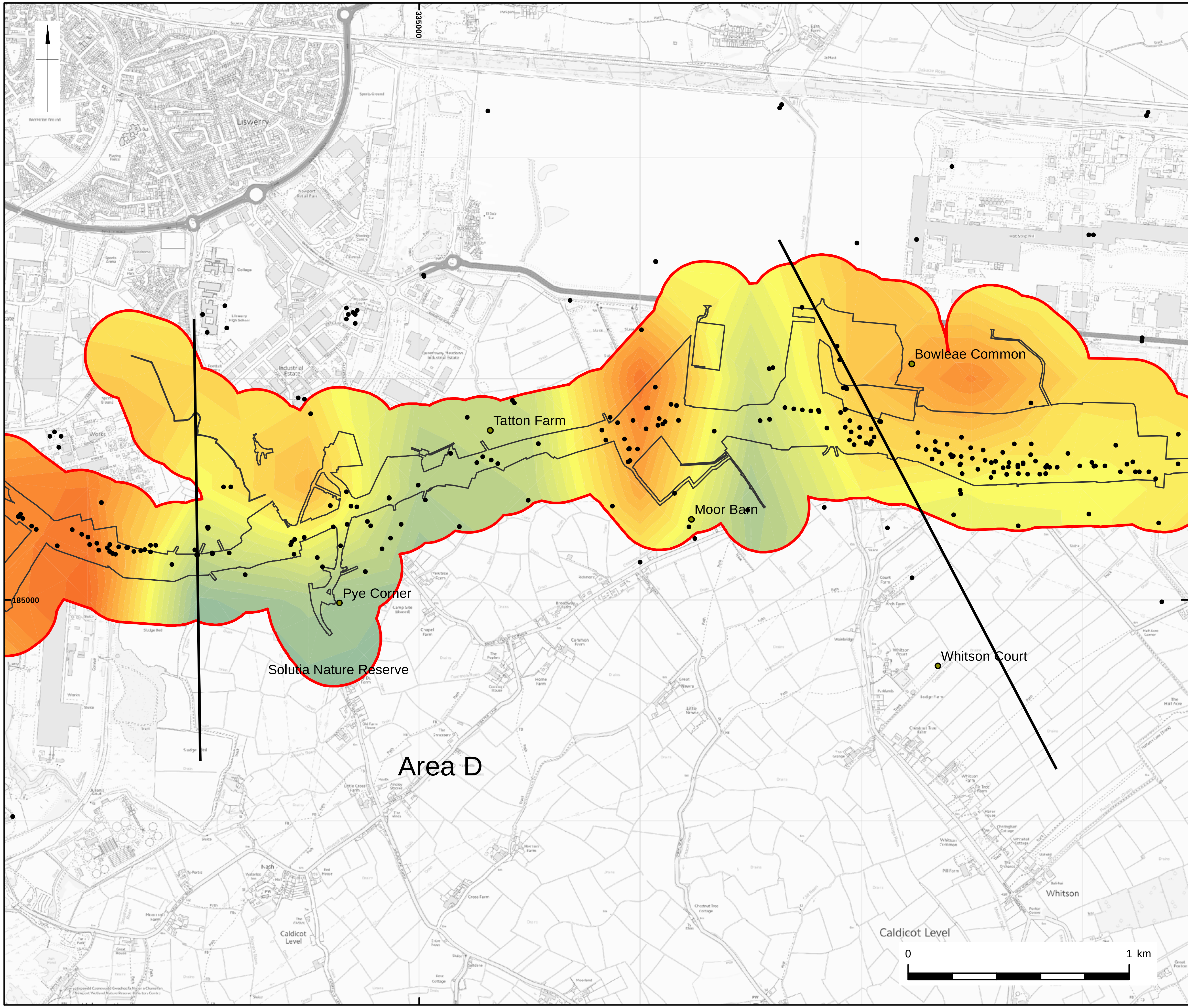
Area D: Bedrock DEM

Figure 9



- Borehole locations
- Area boundaries
- Landtake Areas

Holocene thickness (m)

- 17.01 - 18.00
- 16.01 - 17.00
- 15.01 - 16.00
- 14.01 - 15.00
- 13.01 - 14.00
- 12.01 - 13.00
- 11.51 - 12.00
- 11.01 - 11.50
- 10.01 - 11.00
- 9.01 - 10.00
- 8.51 - 9.00
- 8.01 - 8.50
- 7.01 - 8.00
- 6.01 - 7.00
- 5.01 - 6.00
- 4.01 - 5.00
- 3.01 - 4.00
- 2.51 - 3.00
- 1.51 - 2.50
- 1.00 - 1.50

Date:	11/12/2015
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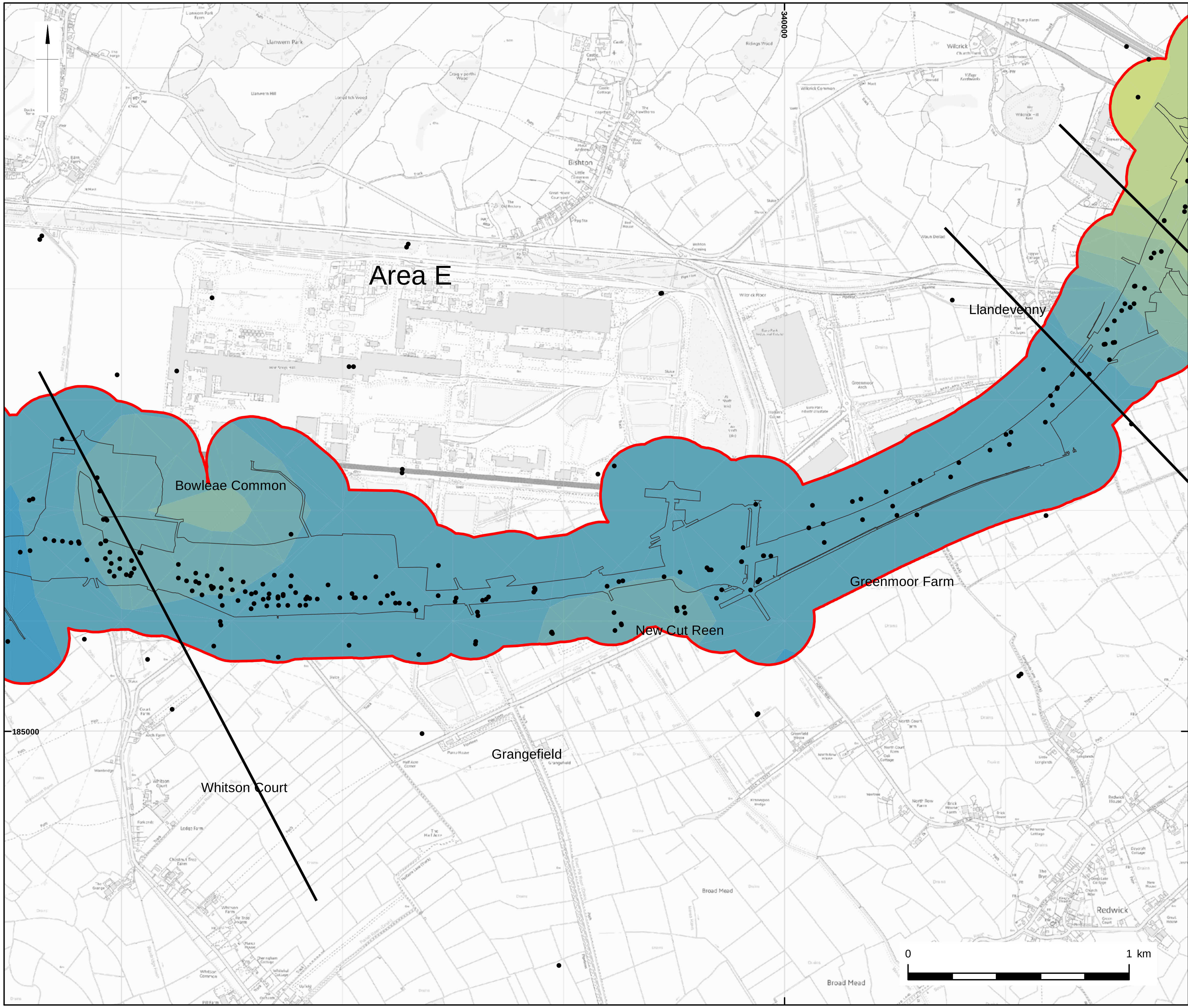
Area D: Holocene thickness model D

Figure 10



Borehole locations
Area boundaries
Landtake Areas

Bedrock DEM
m OD

- 90.01 - 95.00
- 85.01 - 90.00
- 80.01 - 85.00
- 75.01 - 80.00
- 70.01 - 75.00
- 65.01 - 70.00
- 60.01 - 65.00
- 55.01 - 60.00
- 50.01 - 55.00
- 45.01 - 50.00
- 40.01 - 45.00
- 35.01 - 40.00
- 30.01 - 35.00
- 25.01 - 30.00
- 20.01 - 25.00
- 15.01 - 20.00
- 10.01 - 15.00
- 5.01 - 10.00
- 0.01 - 5.00
- -4.99 - 0.00
- -9.99 - -5.00
- -10.00

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Revision Number:	0
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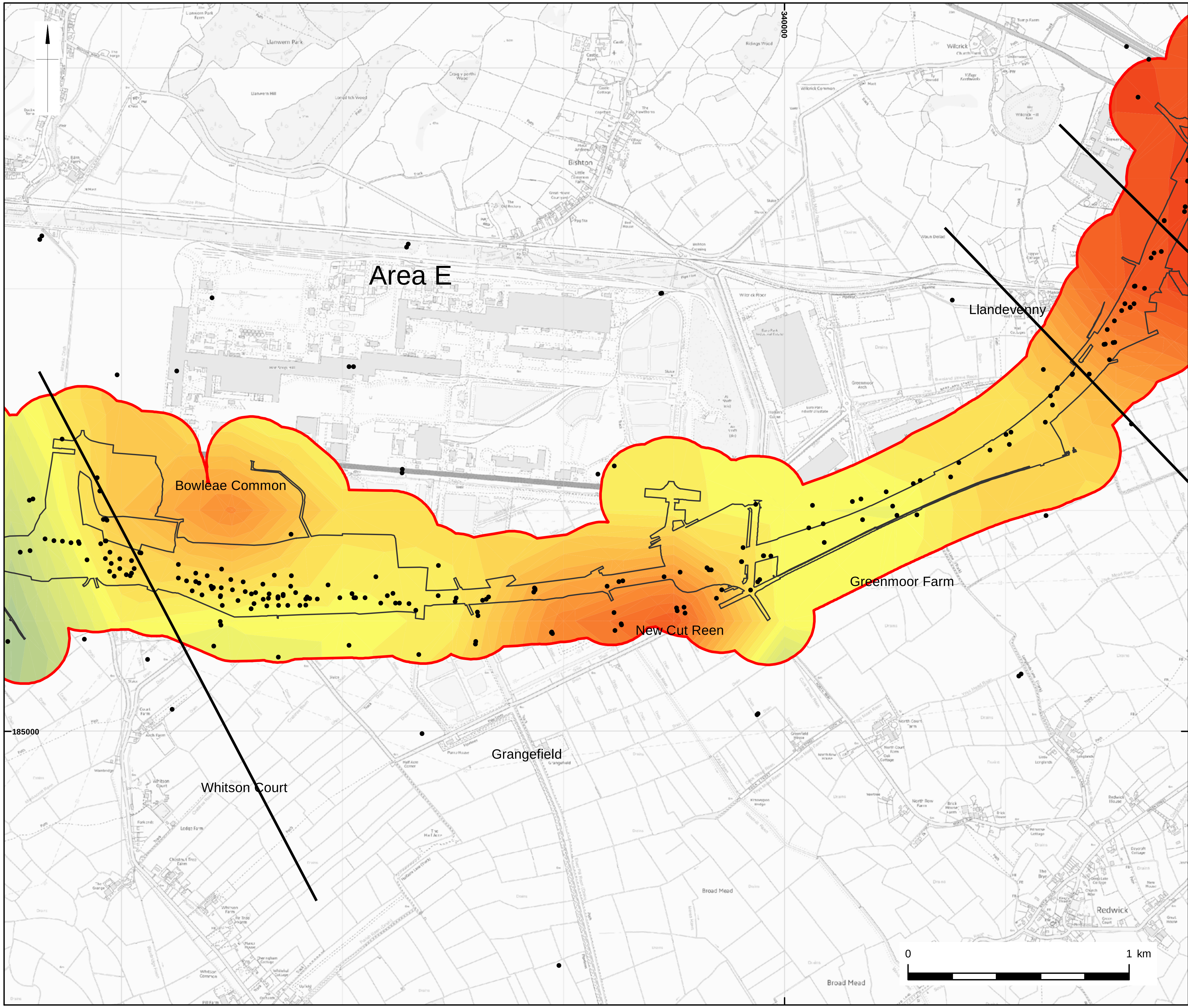
Area E: Bedrock DEM

Figure 11



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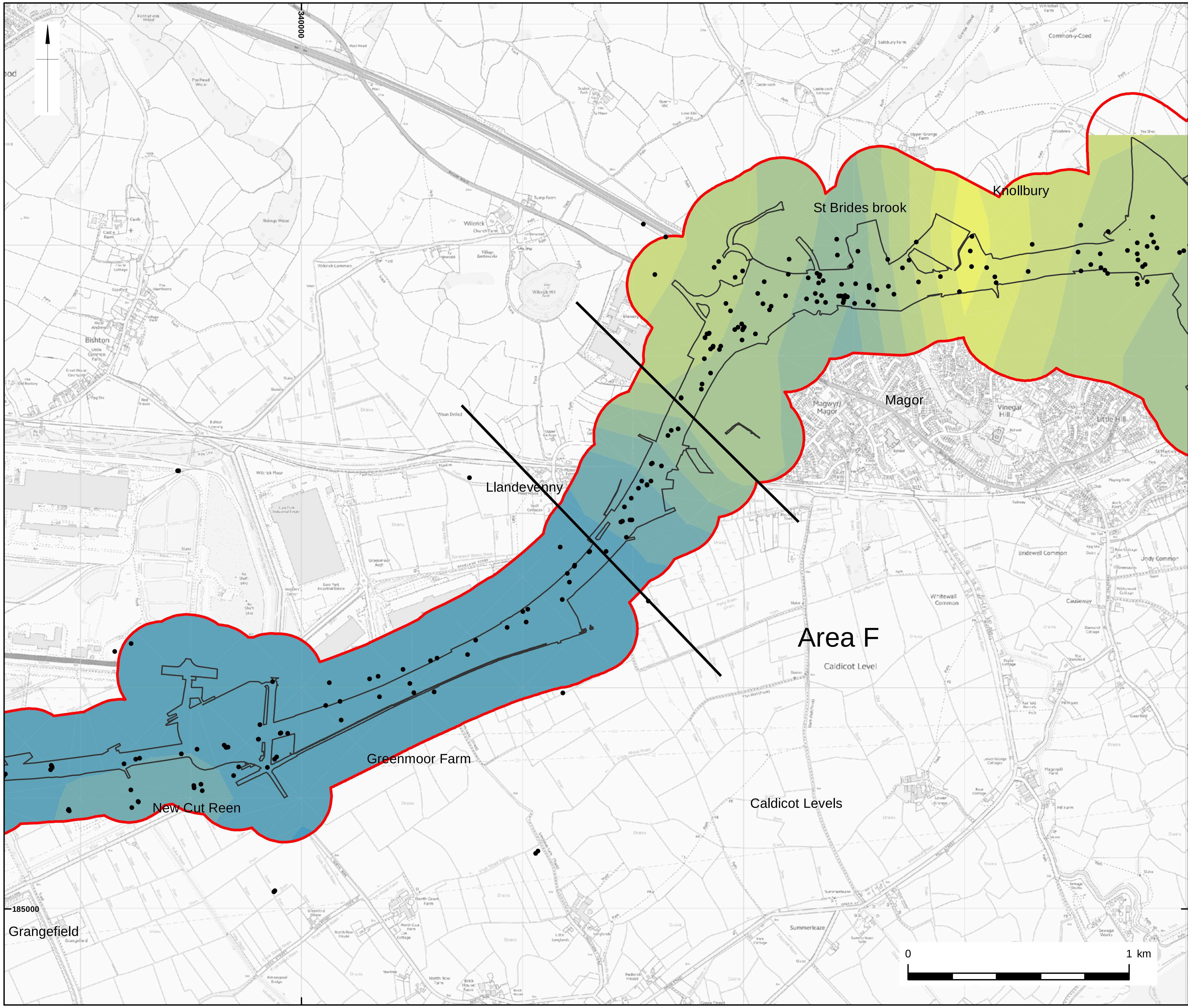
Area E: Holocene thickness model

Figure 12



Borehole locations

Area boundaries

Bedrock DEM
m OD

- 90.01 - 95.00
- 85.01 - 90.00
- 80.01 - 85.00
- 75.01 - 80.00
- 70.01 - 75.00
- 65.01 - 70.00
- 60.01 - 65.00
- 55.01 - 60.00
- 50.01 - 55.00
- 45.01 - 50.00
- 40.01 - 45.00
- 35.01 - 40.00
- 30.01 - 35.00
- 25.01 - 30.00
- 20.01 - 25.00
- 15.01 - 20.00
- 10.01 - 15.00
- 5.01 - 10.00
- 0.01 - 5.00
- -4.99 - 0.00
- -9.99 - -5.00
- -10.00

Date:	11/12/2015
Revision Number:	0
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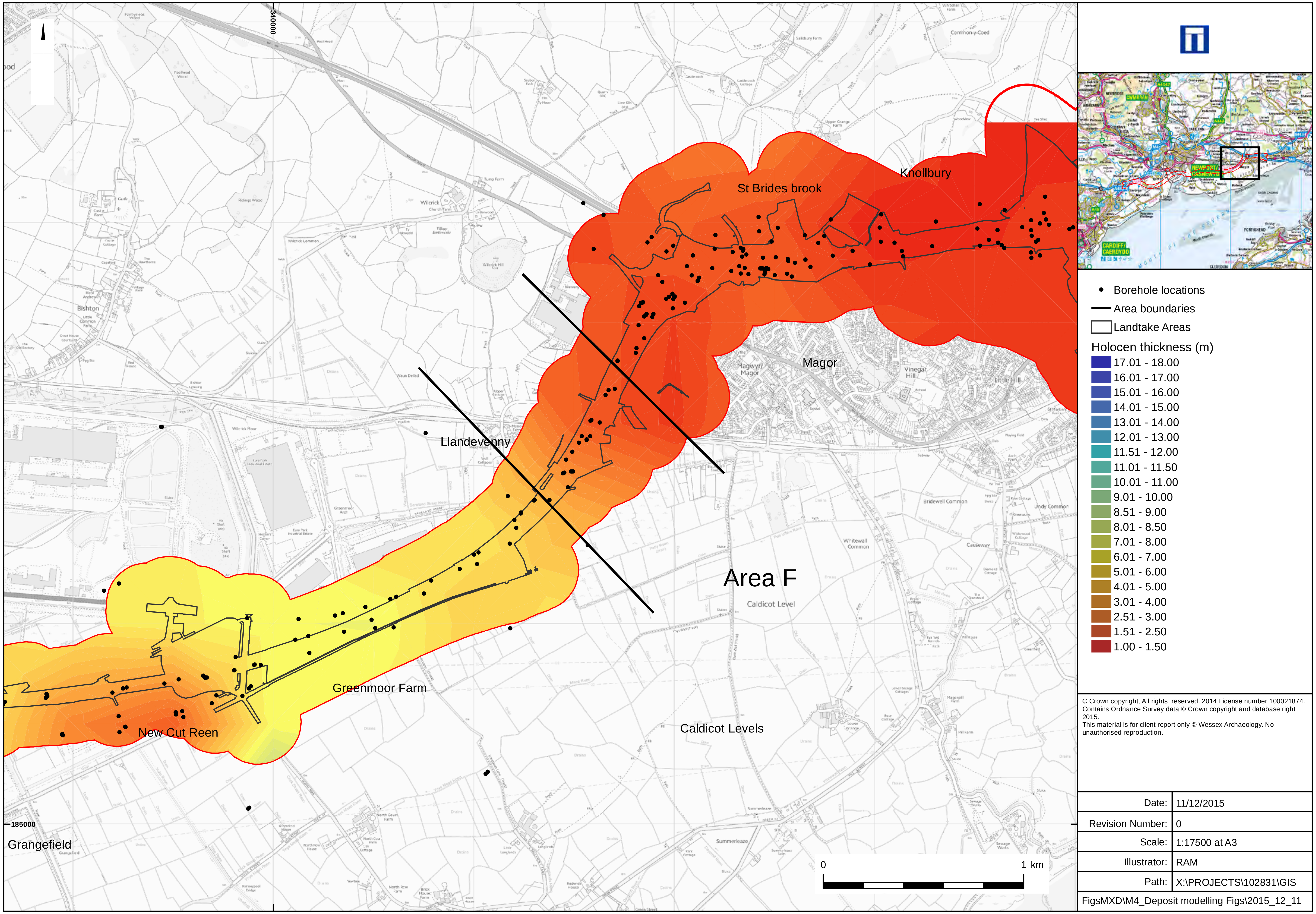
FigsMXD\M4_Deposit modelling Figs\2015_12_11

Area F: Bedrock DEM



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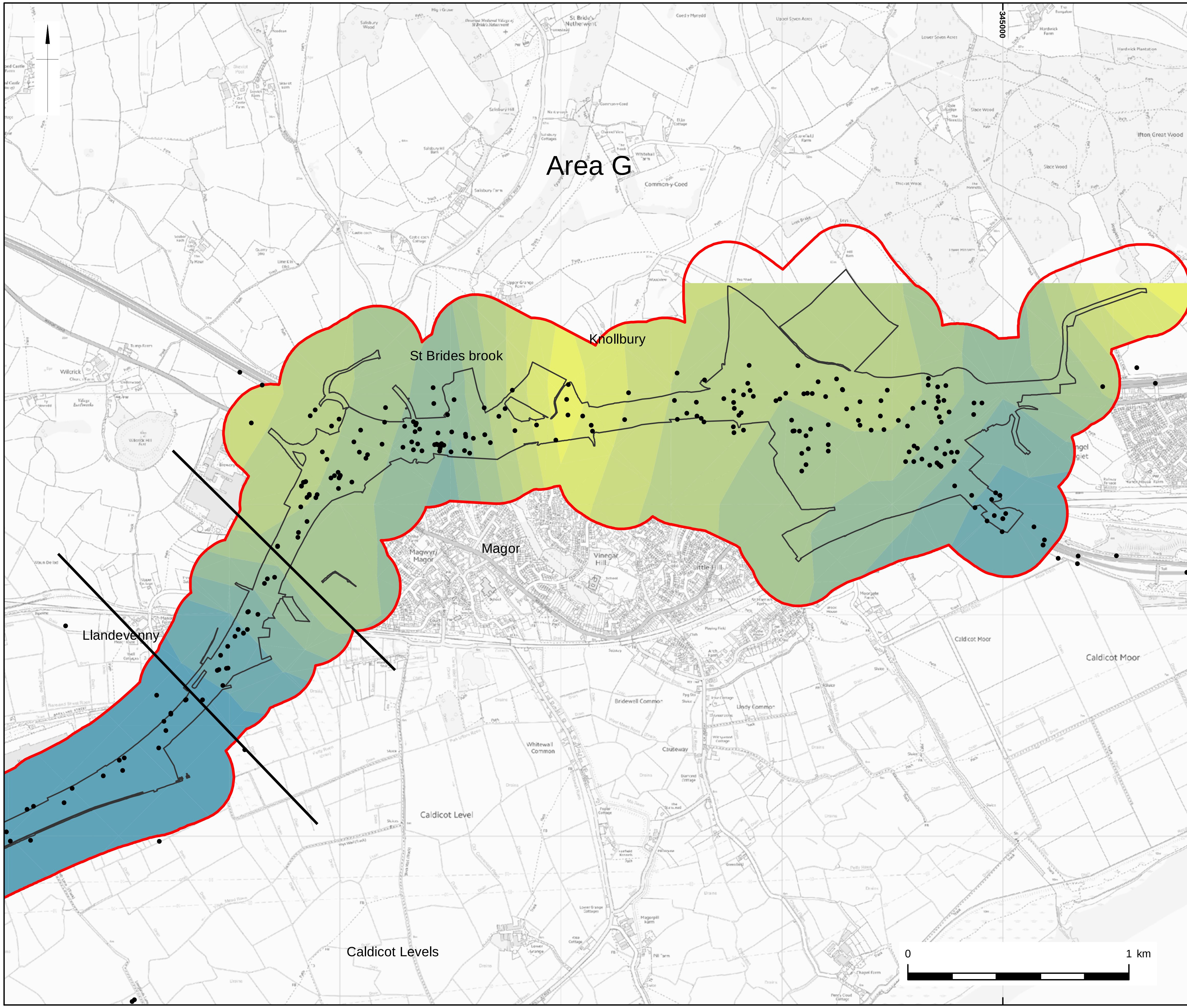
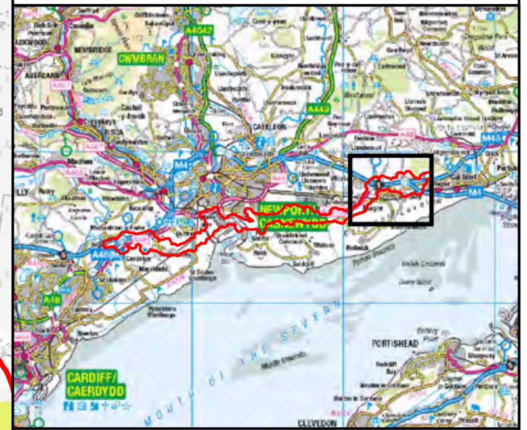
Area F: Holocene thickness model





- Borehole locations
- Area boundaries

Bedrock DEM m OD

- 90.01 - 95.00
- 85.01 - 90.00
- 80.01 - 85.00
- 75.01 - 80.00
- 70.01 - 75.00
- 65.01 - 70.00
- 60.01 - 65.00
- 55.01 - 60.00
- 50.01 - 55.00
- 45.01 - 50.00
- 40.01 - 45.00
- 35.01 - 40.00
- 30.01 - 35.00
- 25.01 - 30.00
- 20.01 - 25.00
- 15.01 - 20.00
- 10.01 - 15.00
- 5.01 - 10.00
- 0.01 - 5.00
- -4.99 - 0.00
- -9.99 - -5.00
- -10.00

Date:	11/12/2015
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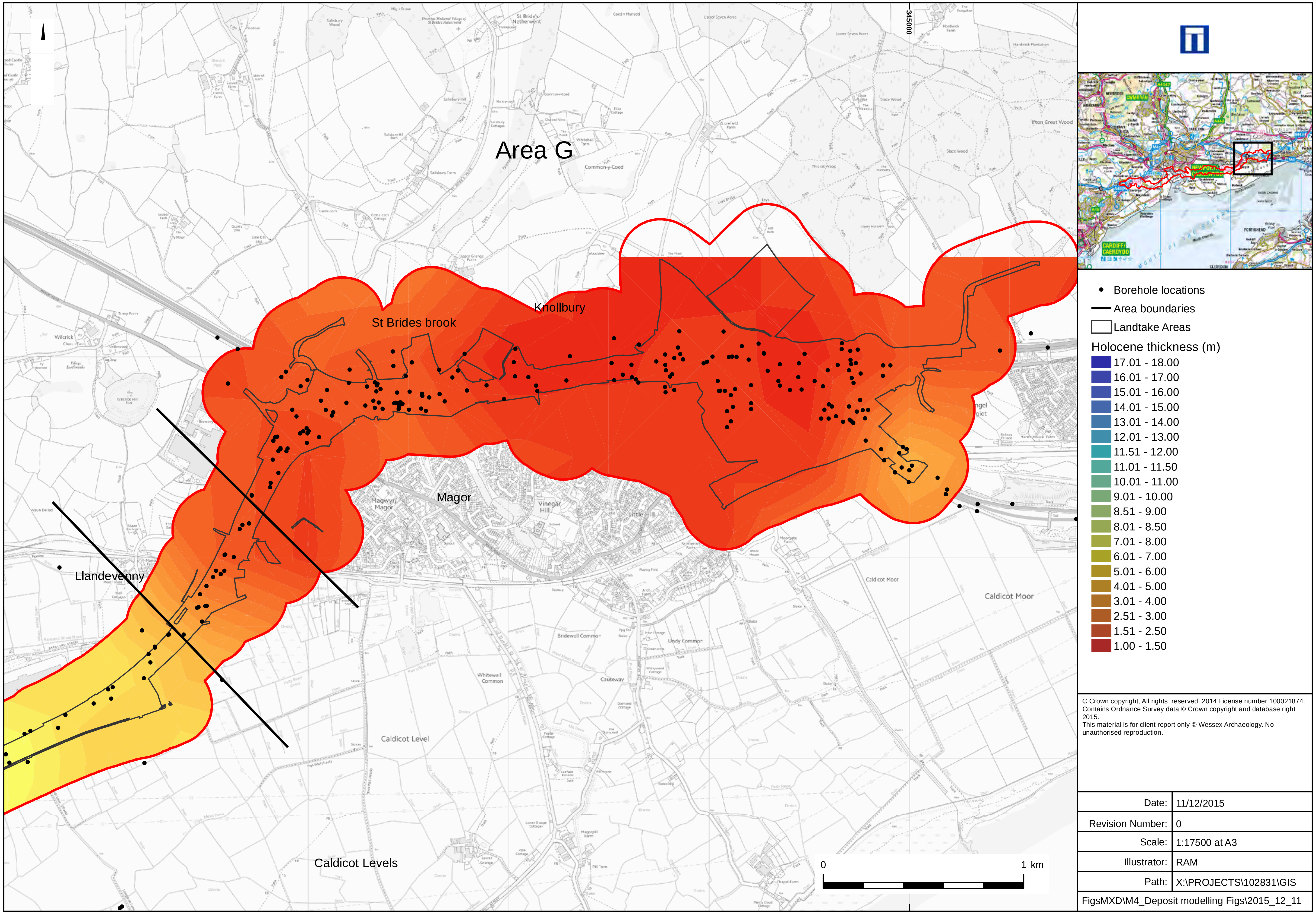

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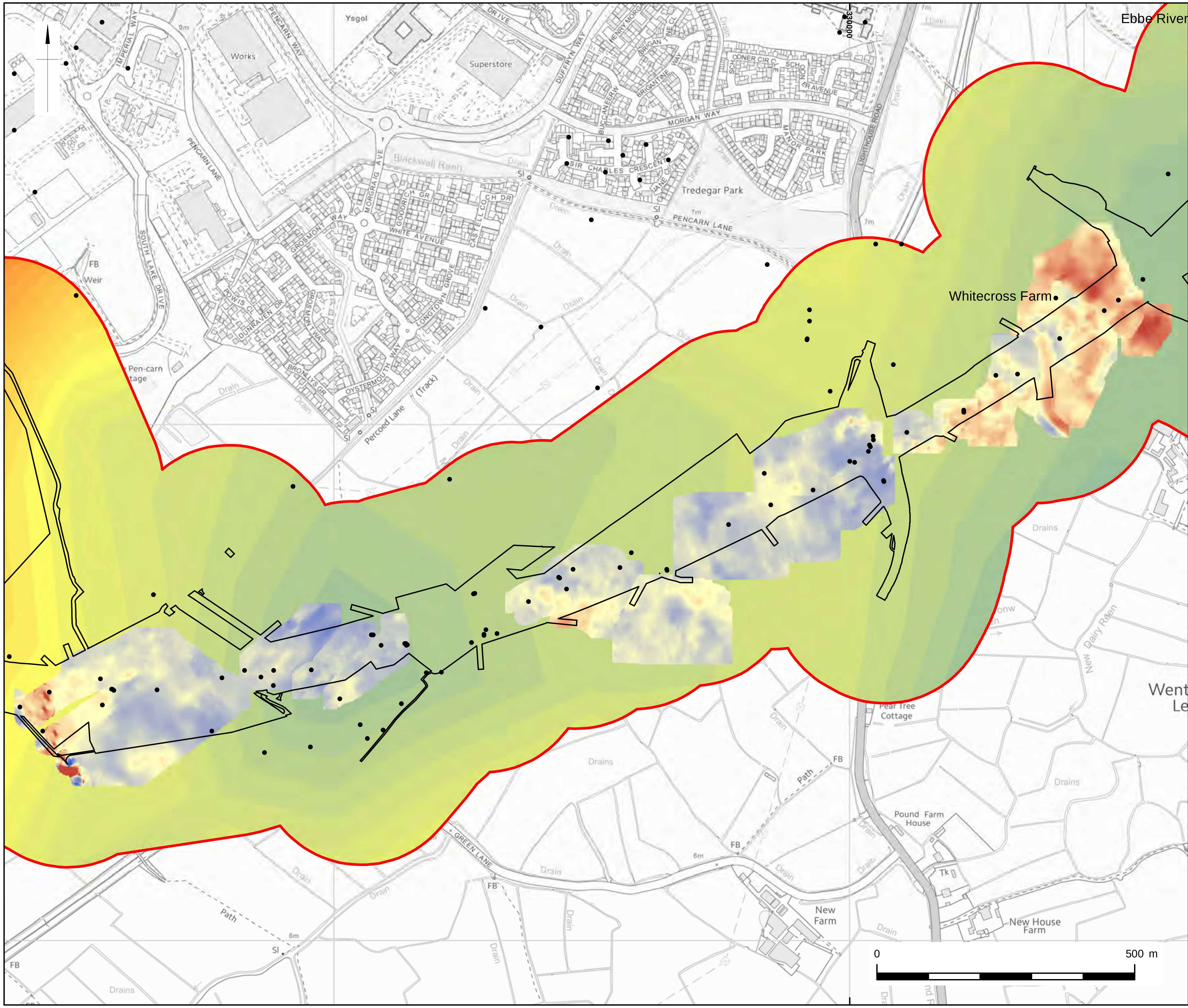
FigsMXD\M4_Deposit modelling Figs\2015_12_11

Area G: Holocene thickness model

Figure 16



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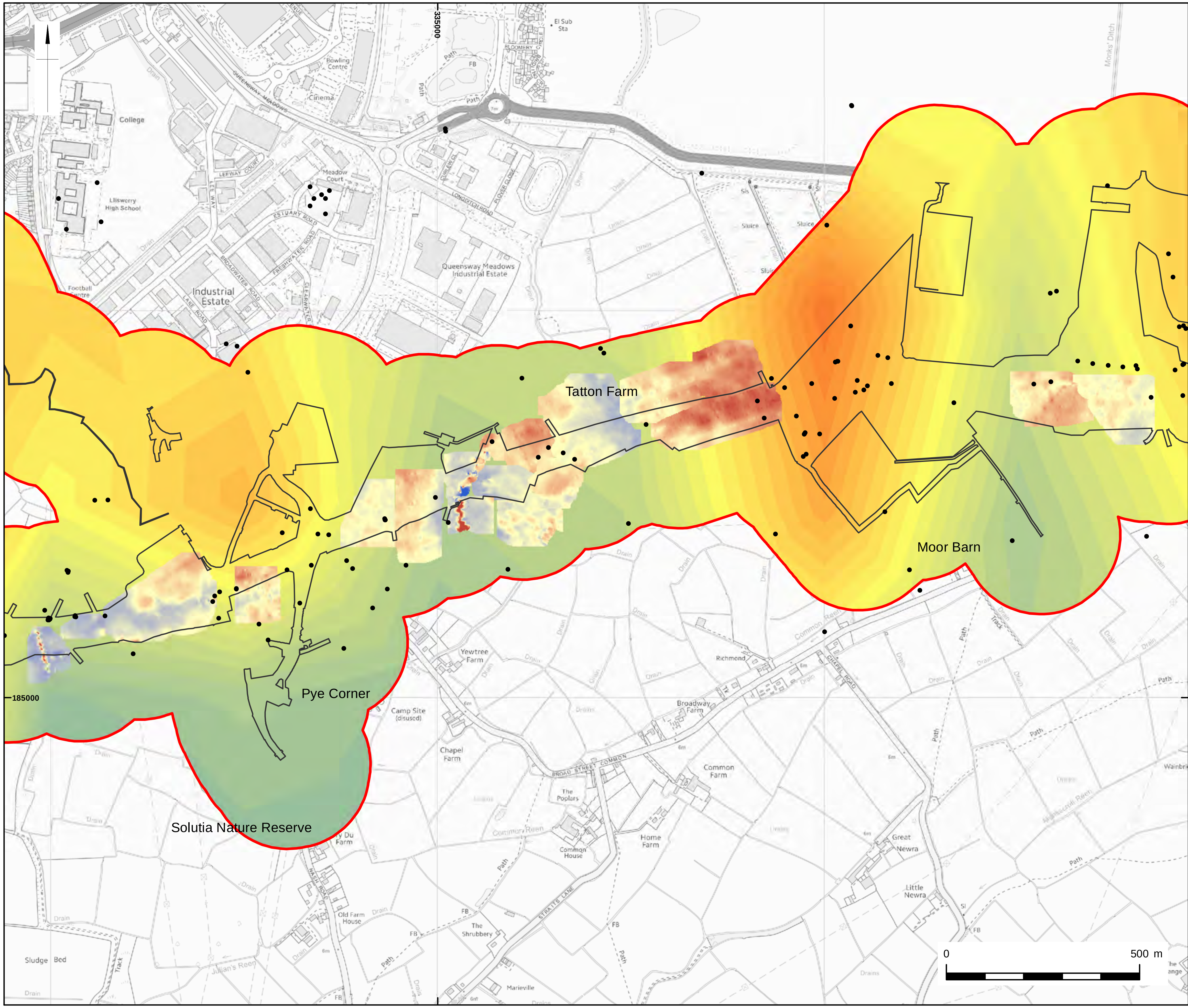
FigsMXD\M4_Deposit modelling Figs\2015_12_11

Comparison of modelling and geophysical survey results: Area B (west)

Figure 17



- Borehole locations
- Landtake Areas

EM31 Survey

High : 508.852

Low : -17.3279

Holocene thickness (m)

- 17.01 - 18.00
- 16.01 - 17.00
- 15.01 - 16.00
- 14.01 - 15.00
- 13.01 - 14.00
- 12.01 - 13.00
- 11.51 - 12.00
- 11.01 - 11.50
- 10.01 - 11.00
- 9.01 - 10.00
- 8.51 - 9.00
- 8.01 - 8.50
- 7.01 - 8.00
- 6.01 - 7.00
- 5.01 - 6.00
- 4.01 - 5.00
- 3.01 - 4.00
- 2.51 - 3.00
- 1.51 - 2.50
- 1.00 - 1.50

EM31 results kindly supplied by M and C Bates (Bates & Bates 2015)

Date:	11/12/2015
Revision Number:	0
Scale:	1:10000 at A3
Illustrator:	RAM
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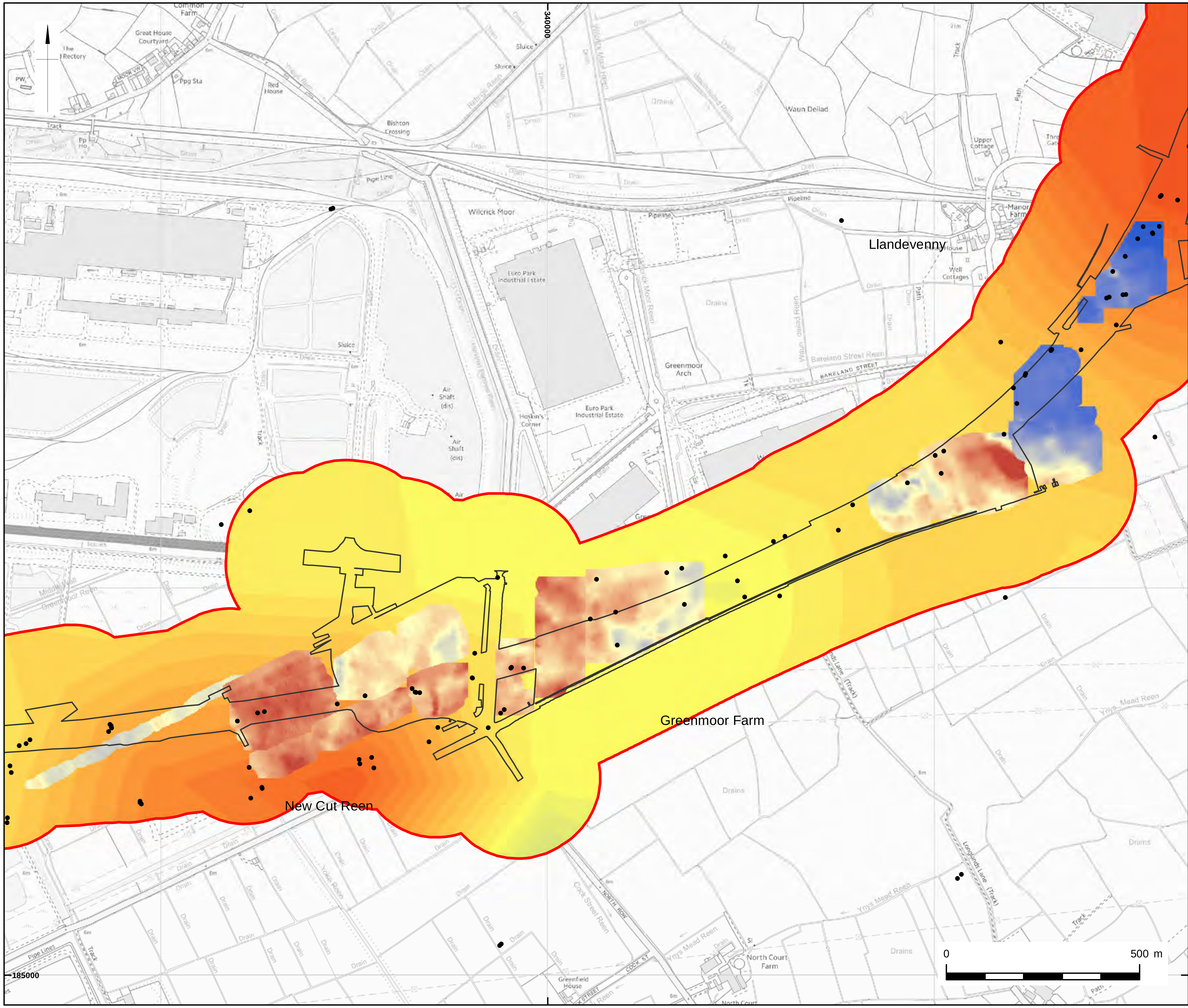
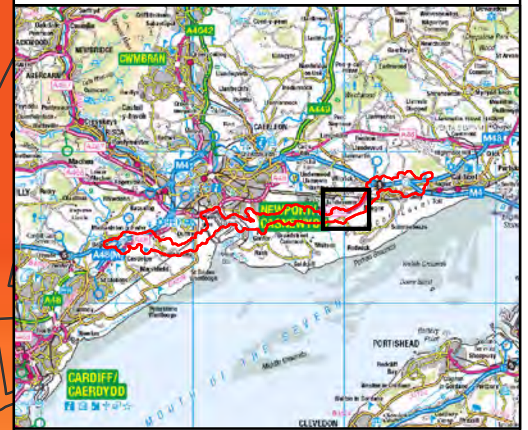
FigsMXD\M4_Deposit modelling Figs\2015_12_11

Comparison of modelling and geophysical survey results: Area D

Figure 18





- Borehole locations
- Landtake Areas

EM31 Survey

High : 508.852

Low : -17.3279

Holocene thickness (m)

- 17.01 - 18.00
- 16.01 - 17.00
- 15.01 - 16.00
- 14.01 - 15.00
- 13.01 - 14.00
- 12.01 - 13.00
- 11.51 - 12.00
- 11.01 - 11.50
- 10.01 - 11.00
- 9.01 - 10.00
- 8.51 - 9.00
- 8.01 - 8.50
- 7.01 - 8.00
- 6.01 - 7.00
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- 2.51 - 3.00
- 1.51 - 2.50
- 1.00 - 1.50

EM31 results kindly supplied by M and C Bates (Bates & Bates 2015)

Date:	11/12/2015
Revision Number:	0
Scale:	1:10000 at A3
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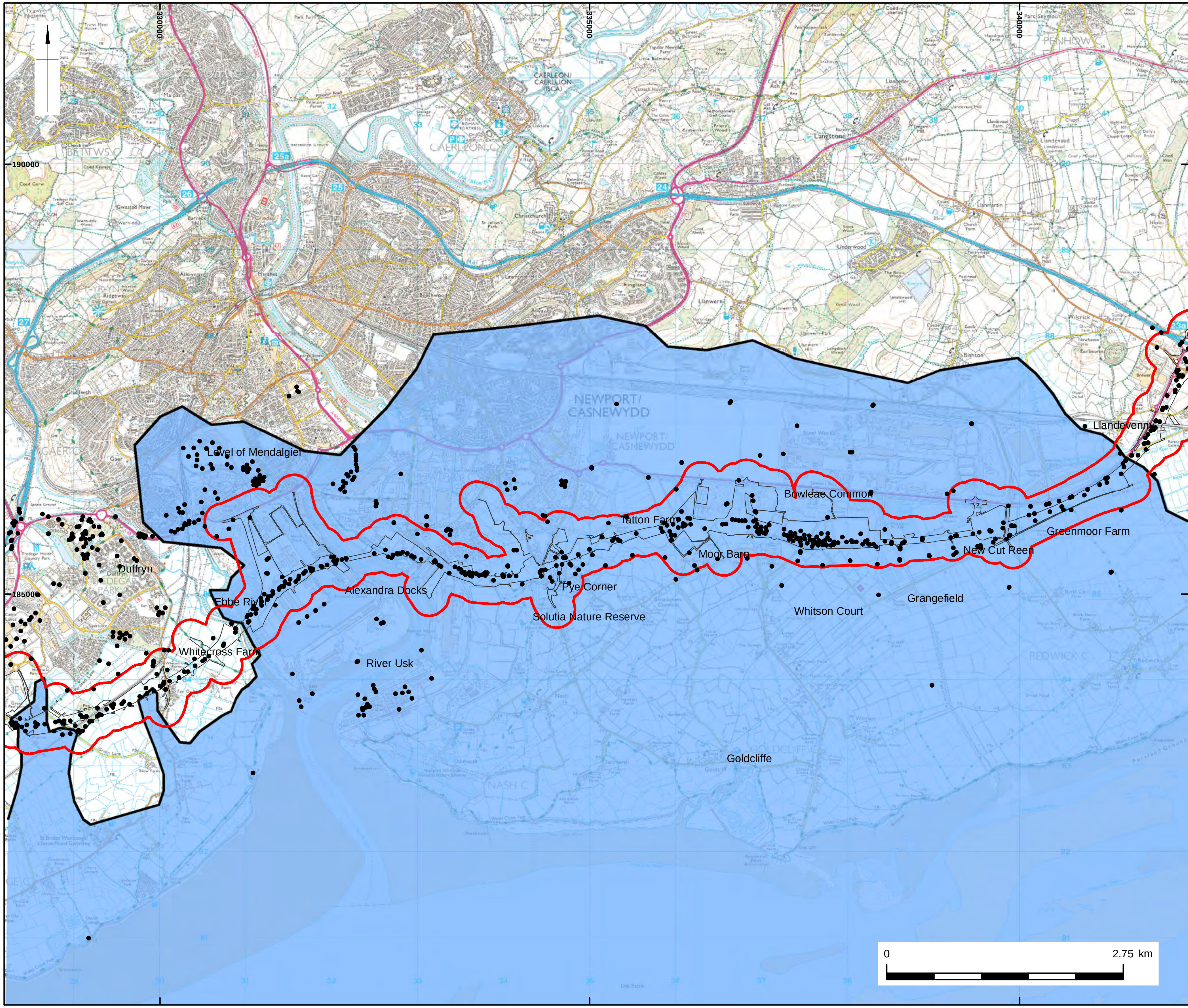
FigsMXD\M4_Deposit modelling Figs\2015_12_11

Comparison of modelling and geophysical survey results: Area E (east)

Figure 19



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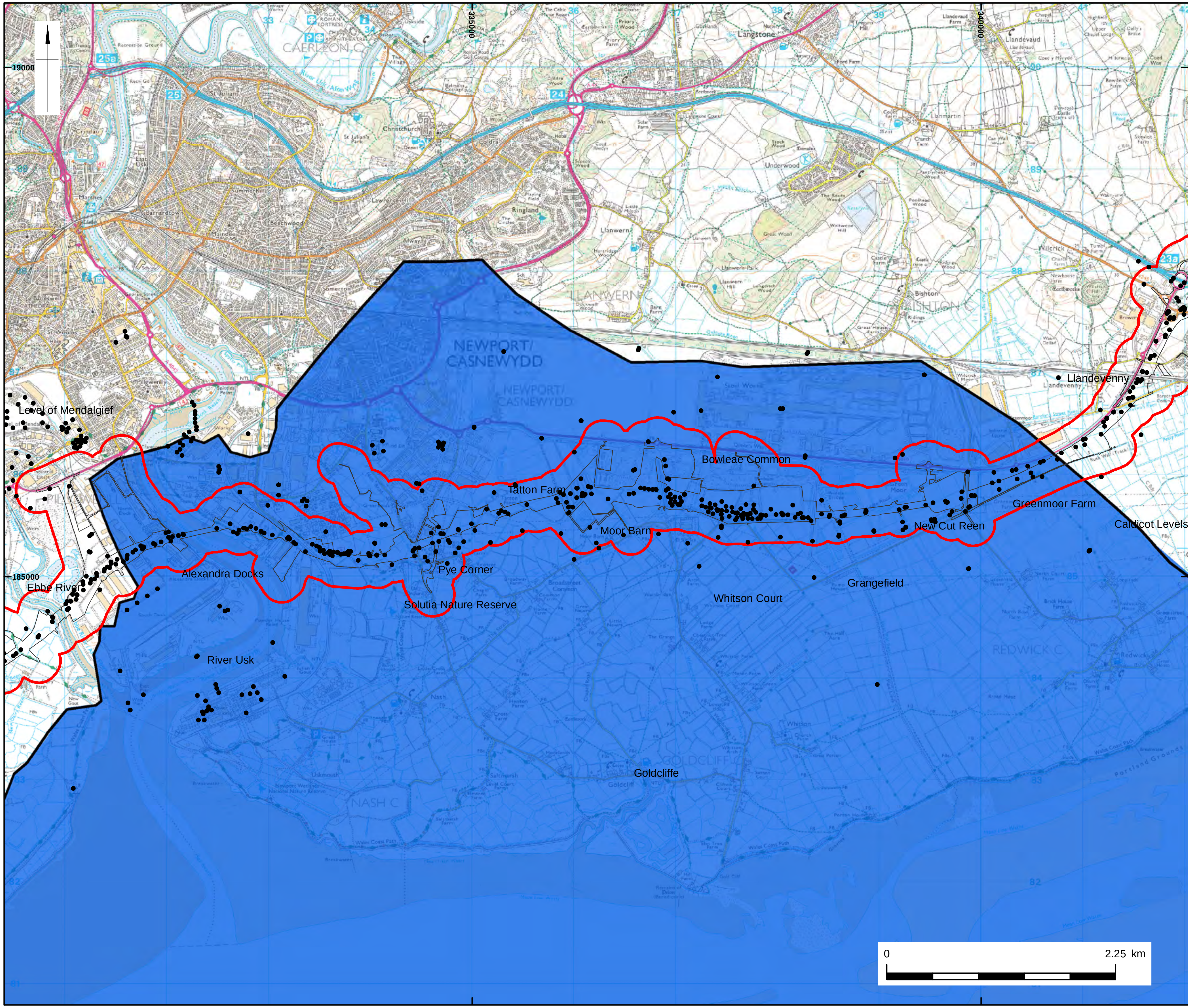
FigsMXD\M4_Deposit modelling Figs\2015_12_11

Figure 20

Late Bronze Age palaeo-coastline



- Borehole locations
- Landtake Areas
- Heritage study area
- -4mOD (4-5000 yr BP)

Date:	11/12/2015
Revision Number:	0
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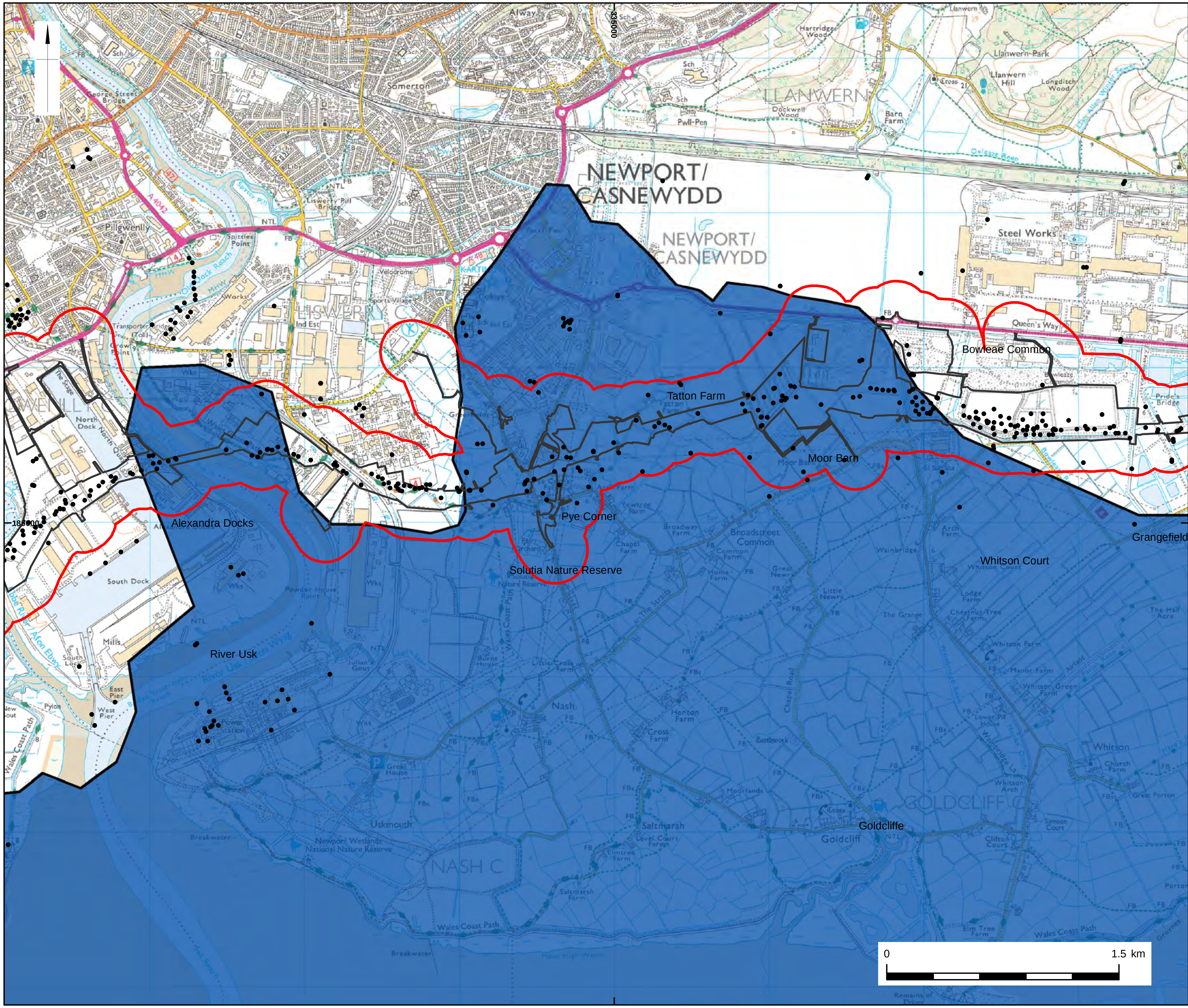
FigsMXD\M4_Deposit modelling Figs\2015_12_11

Later Neolithic to Bronze Age palaeo-coastline

Figure 21



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Revision Number:	0
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FigsMXD\M4_Deposit modelling Figs\2015_12_11

Early Neolithic palaeo-coastline

Figure 22