Oriel College, Oxford
Kitchen Project
Geophysical Survey, Archaeological Borehole and Watching Brief Report

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Oriel College, Oxford – Kitchen Project

Geophysical Survey, Archaeological Borehole and Watching Brief Report

Centred on SP 5162 0611

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SUMMARY

In August 2017 Oxford Archaeology (OA) coordinated a geophysical survey (GPR and ERT) of all three college quadrangles, together with a E-W aligned borehole transect, located in the central quadrangle at Oriel College, Oxford. In January 2018 OA conducted a Watching Brief on two small geotechnical pits, TP 3 and TP 4 located to examine the foundations of the structures on the south and east sides of the development area, the boundary wall to Magpie Lane and the north wall of the Chapel respectively. The work was designed to further inform the Planning Authority in regard to the archaeological potential, specifically any evidence pertaining to putative Late Saxon defences for a primary burh, on the site of proposals to create a new basemented kitchen and other facilities at the college.

The GPR did not penetrate to depths below c 1.0m B.G.L and therefore did not give any useful information about the archaeological remains within all three quads. The ERT technique was hampered by interference in the northern quad, but more successful within the central and southern quads, and an eastwards dipping horizon to the natural gravel topography was identified in the southern quad.

The borehole transect in the central quad revealed a complex, sequence of occupation deposits dating to the medieval period. Samples from occupation deposits directly overlying the gravel in two boreholes, produced dates spanning the 12th to 13th centuries at 1165-1265 cal AD and 1225-1300 cal AD. The medieval sequences measured between 1 – 2.2m thick and were highly variable in composition and thickness. It is highly likely that some of these deposits represent the fills of intercutting archaeological features (such as pits, and possibly cellars for buildings) resulting in the truncation of the natural loess and gravel deposits in this area, multiple thin layers may equate to internal floor surfaces, and occupation deposits. No large N-S feature was logged, no deposits, such as limestone or gravel surfaces that may be interpreted as possible roadways and no significant redeposited brickearth or gravel indicating an earthen bank were identified.

Considering this evidence along with previous archaeological work both at Oriel and neighbouring colleges, a c. 10 – 13m wide N – S ditch can be suggested to have run directly below the east ranges of the central and southern quads at Oriel. A parallel extra-mural road would have probably lain beyond the ditch to the east. The suggested alignment of ditch and road does not follow Magpie Lane, however, it does interestingly follow the alignment of the eastern ranges of the central and southern quads of Oriel College, Grove Lane and the eastern college ranges at Corpus Christi (perhaps later echoes of earlier boundaries/land divisions).

An intramural N-S road has been suggested running parallel with the inside line of a probably bank inside the line of the ditch, no evidence of an earthen bank, or a road structure was found within the borehole transect, however evidence from Corpus Christie confirmed a probable Late Saxon road surface in this location, and perhaps this intramural road is similar to the current alignment of Oriel Square and Oriel Street.

1 INTRODUCTION

1.1 Project details

1.1.1 In July 2017 Oxford Archaeology (OA) was commissioned by Allies and Morrison on behalf of Oriel College, Oxford to undertake a geophysical survey of all three college quadrangles, together with a E-W aligned borehole transect, located in the central or southern quadrangle at Oriel College, Oxford.

1.1.2 In January 2018, as part of ongoing consultancy OA conducted a Watching Brief on two small geotechnical pits, TP3 and TP 4 located to examine the foundations of the structures on the south and east sides of the development area, the boundary wall to Magpie Lane and the north wall of the Chapel respectively.

1.1.3 The work was designed to further inform the Planning Authority in regard to proposals to create a new basemented kitchen and other facilities on the site of the existing kitchen, and associated storage rooms, toilets et cetera at Oriel College, Oxford.

1.1.4 The geophysics, borehole and watching brief work follow on from other pre-application work at the site; archaeological desk-based assessment (DBA, OA 2015b) and a trial trench evaluation (OA 2015c).

1.1.5 The DBA and the results of the evaluation were intended to assess the archaeological potential of the site and the likely impact of previous and proposed development on the survival of any archaeological remains. The scope of the 2015 evaluation was limited by on-site constraints (the kitchen supplies the colleges meals and therefore is in constant use), consequently David Radford, Oxford City Archaeologist for the Local Planning Authority requested a further phase of archaeological investigation.

1.1.6 Although the Local Authority did not set a specific brief for the geophysics and borehole work, discussions with David Radford established the aims and scope of work which was detailed in the Written Scheme of Investigation (WSI, OA 2017).

1.1.7 This document reports on the results of the geophysical survey (TigerGeo 2017), summarized below (full report in Appendix D), and the borehole transect.

1.1.8 All work was undertaken in accordance with local and national planning policies.

1.2 Location, topography and geology

1.2.1 The historic centre of Oxford is located at the southern end of a north-south gravel promontory. This raised ground occupies an elevated position above the floodplains of the River Cherwell and the River Thames. The promontory is formed of two terraces; the Summertown-Radley (Second Terrace) Sand and Gravel Member and the Floodplain (First Terrace) Northmoor Sand and Gravel Member. The promontory is surrounded by Alluvium - Clay, Silt, Sand and Gravel associated with the floodplains of the rivers Thames to the west, and Cherwell to the east. The bedrock geology for the centre of Oxford is the Oxford Clay Formation and the West Walton Formation (undifferentiated) - Mudstone formed in the Jurassic Period (British Geological Survey 2015).

1.2.2 Ground level appears to slope gently downwards towards the south west. This is demonstrated by a level of 60.07m OD south of number 4A Merton Street (Poore, Score &

Dodd, 2007) which decreases to 59.4m OD c 57m west-south-west of number 4A at the crossroads of Merton Street and Magpie Lane (just south east of the site).

1.2.3 Oriel College is located south of the High Street in Oxford and is located towards the southern edge of the sand and gravel promontory. As with the wider historic city of Oxford the area under the college is located upon Second Terrace and First Terrace formations as mentioned above. The gravels on this terrace are typically overlain by a 0.3m depth of red brown loessic loam.

2 ARCHAEOLOGICAL AND HISTORICAL BACKGROUND AND POTENTIAL

2.1 Archaeological and historical background

2.1.1 A comprehensive summary of the archaeological and historical background of the site can be found in the DBA (OA, 2015b). This summarised the archaeological potential of the site as follows (full references can be found in the source document):

Prehistoric Periods

2.1.2 There is a low potential for surviving prehistoric remains to be present within the site. Possible Neolithic to Bronze Age ditches were located 150m north east of the site in Logic Lane and Lambrick (2012) notes a number of findspots within Oxford Oriel College Oriel College Kitchen, Oxford City centre which suggests further isolated artefacts may be present within the gravels upon which the Site lies.

Roman Periods

2.1.3 No Roman remains are known to have been found within the Study Area, therefore the site has low potential for Roman remains. Within the wider Oxford City centre Roman building fragments and pottery have been found. However, the focus of Roman activity within Oxford appears to have been a rural settlement in the University Science Area, kiln sites to the east of the historic city centre and villas on the hills surrounding Oxford. Isolated Roman finds may be found as the historic city may have been used for agriculture.

Early Medieval Period

2.1.4 There is some potential for further evidence of the line of the Saxon burh defences of Oxford to exist within the site. It has been suggested that the initial phase of the Saxon defences may have run along or just east of Oriel Street, to the west of the site. To the south-west of the site, an excavation in Corpus Christi quadrangle (Hassall, 1973) revealed a deep north-east/south-west aligned feature, which was interpreted as a ditch possibly forming part of the defensive circuit. However, the trench in which this possible feature was seen was not accessed as it was in excess of 4m deep, and the feature was rapidly recorded prior to backfilling. Additionally, the natural gravel of the second terrace was not encountered - which was interpreted at the time as evidence for the location of the nearby St Frideswide's minster (subsequently Christ Church Cathedral) being on a promontory of the gravel. The potential ditch was seen to "cut through loam" - the origin of which is unclear - and the alignment seems incongruous with the interpretation of the feature as the eastern defensive ditch of the late-Saxon burh. Consequently, the veracity of the interpretation of this undated feature as a late-Saxon defensive ditch is uncertain.

2.1.5 There is also some potential for evidence of Saxon occupation to be found within the area of the site. Within the area studied for the DBA, several excavations have shown evidence of late Saxon activity. The excavations of the Middle Quadrangle of Oriel College in 1941 found rims and body sherds of St Neots type cooking pots, dating to between the 10^{th} century to the mid-11^{th} century (Poore, Score & Dodd, 2007, 214-215). Under the floors of a 16th century tennis court to the east of the site, Saxon and medieval deposits were found. Also three excavations within the area covered in the DBA found rubbish pits and pottery that was dated between the 11th-13th century including a watching brief in St Mary's quadrangle and excavations at 4A Merton Street in 2002.

2.1.6 It is possible that Saxon rubbish pits may survive in situ at depth under the site, depending on how far the 20th century kitchen developments have truncated the area.

Later Medieval Period

2.1.7 The construction of St Martin Hall is likely to have been after 1278 as Salter notes that it was called domus Cestre (heavenly house) in 1275-8 and held by Bogo de Clare at £2 a year. It then appears to have reverted to St Fridswides Priory from 1220 who then sold the land to Oriel College in 1503. The construction of St Martin's Hall may have been between 1279 - 1578 (the date of the Agas map). Therefore, the construction of St Martin's Hall may have truncated earlier medieval tenements on this site as Salter notes ownership of lease of the land to Hen. Simeon in 1220 and 1230 (Salter, 1960, 207). The construction of the medieval Front Quadrangle at Oriel College probably took place during the mid-14th century. Salter notes that the area of land which La Oriele was built on was also called Seneschall Hall (Salter, 1960, 210). The construction of the Front Quadrangle may have truncated earlier medieval tenements that may have previously existed on the site. The location of the medieval Front Quadrangle is likely to have been to the west of the Site, occupying the same footprint as the later Front Quadrangle, however its exact position is unknown.

2.1.8 There is a possibility that medieval rubbish pits and truncated structures may be found underneath the site. This is because archaeological and documentary evidence has been found of 12th-13th century medieval houses within the Study Area (Dodd, 2003, 60-61). Medieval rubbish pits have been found during excavations within the Study Area. A late medieval cellar was found during an evaluation at the Rhodes Building (Wessex Archaeology, 2011); buildings at 4A Merton Street (Poore et al, 2007) dated to between 1200-16th century (and later), and a watching brief at Christ Church between 2005 and 2007 (ref. DBA for reference) found extensive evidence for medieval inns, halls, trades and crafts.

2.1.9 The excavations at the rear of 4A Merton Street (Poore et al 2007) give a good indication of the depth at which medieval pits may survive within the site. Ground level at the Merton Street site sloped gently from 62m OD in the north to 60.1m in the south. A mid-11th to early-13th century pit located in the central area of the site, where ground level was approximately 61m OD, was cut from approximately 57.90m OD, and was 1.4m deep - indicating that the bottom of the feature was approximately 4.5m below the existing ground surface (56.5m OD).

Post-medieval and Early Modern Periods

2.1.10 The construction of Oriel College and Chapel in 1620-42 would have truncated the remains of any medieval buildings and pits to the south and west of the Site. Part of the site, nearest the boundary wall with Magpie Lane began to be built on from the 17th century with low range outbuildings. These outbuildings may have been rebuilt several times within similar footprints.

2.1.11 One area of the site that did not get built on until the 20th century kitchen developments is the area labelled as 'Back Yard' on the 1848 plan of Oriel College. However, a small part of this area may have had a porch attached to the East Range during the 18th

century seen on Taylor's map of 1751. This back yard area is the location on Site that may have been the least truncated as it remained an open yard from the 17th century until the early 20th century. However, this yard area would have also been truncated by the kitchen developments in 1928 and the more modern kitchen extensions to the north.

2.2 Previous Archaeological Works

Proposed Kitchen Extension, Archaeological Evaluation, 2015

2.2.1 The evaluation undertaken in 2015 consisted of two small archaeologically excavated trenches (Trench 1 and 2) and two smaller monitored geotechnical pits (Test Pits 1 and 2).

2.2.2 The upper horizon of the natural gravel terrace, where encountered, was at a relatively consistent elevation at c 58.50m OD, although no *in-situ loess* soils overlay these gravels, but this truncated height was consistent with results from archaeological work in the surrounding area which recorded the gravel at between 58.29m and 58.72m OD.

2.2.3 The gravel had been truncated by negative features (such as pits/ditches/wells etc) probably dating to the 12th-14th century occupation of the site, and perhaps related to medieval tenements pre-dating the construction of the medieval Front Quadrangle of the college in the mid-14th century (re-built in the first half of the 17th century, and now called First Quadrangle).

2.2.4 Of note was a deep negative feature within Trench 2 (full depth recorded by hand-auger only). This feature had removed the *loess* and natural gravel and oxidised Oxford Clay was found at 57.27m OD. The clay was overlain by waterlain (fluvial) organic silt deposits, with the only dating evidence coming from deposits c 1m above these, dating to 12-14th centuries.

2.2.5 The top of the sequence of deposits associated with the 12th-14th century was between 58.76m OD (Trench 1) and 59.25m OD (Trench 2).

2.2.6 A number of structures were revealed which appeared to truncate the 12th-14th century horizon. The earliest of these may relate to a building fronting Merton Street, possibly part of St Martins Hall which preceded the 17th century remodelling.

2.2.7 A second structure was revealed running parallel to the eastern boundary wall of the college along Magpie Lane. Outbuildings are shown in this area of the college on cartographic sources from the 16th century onwards - although the fact that this structure appeared to truncate a deposit which produced 17th century artefactual material would imply that it related to a later phase of construction.

2.2.8 The third structure revealed was the foundation for an extant pillar base which dates from the 17th century re-build of the Front Quadrangle, and a series of rubble rich deposits overlying the foundation are probably contemporary with this phase of construction.

2.2.9 The remaining deposits and structures encountered related to modern reconfigurations of the kitchen area and former back yard to the west of Magpie Lane.

3 PROJECT AIMS

3.1 General

3.1.1 The general aims of the work were to:

i. determine the character of any remains present;
ii. ensure that deposits were removed (where appropriate and practicable) by proper controlled archaeological methods;
iii. determine or estimate the date range of any remains from artefacts or otherwise;
iv. determine the potential of the deposits for significant palaeo-ecological information;

3.2 Specific aims and objectives

3.2.1 The work was designed to try and establish the presence/absence of the putative N-S orientated eastern defences (assumed to take the form of a 'bank and ditch' perhaps with a stone retaining wall) to the earliest phase of the Late Saxon *burh* (c 900 AD). If the defences could be found below the accessible areas of the colleges quads then this would have a direct bearing on understanding the potential archaeology below the current kitchen to the east (an area for which sizable trenched excavation has not been possible).

3.2.2 The results of the geophysical survey should inform the positioning of the borehole transect, so as to ground-truth any anomalies. The geophysical survey could also have the added benefit of providing a broader understanding of the buried archaeological resource below the three Quads, and providing the college with data on the position and alignment of buried services and can readily be incorporated into the colleges site management resource.

4 METHODOLOGY

4.1 Introduction

4.1.1 Geophysical survey was undertaken by TigerGeo (a specialist supplier) and covered all three quads, the initial results informed the exact position of the borehole transect. Borehole drilling and core extraction work was conducted by CC Ground Investigations, using a Terrier Rig, under the supervision of a geoarchaeologist from OA, with small lead-holes archaeologically excavated at each borehole location, prior to drilling, by a trained archaeologist from OA.

4.2 Geophysics

4.2.1 Two types of geophysical survey were undertaken, ground penetrating radar (GPR) to gain 3D modelling of the below ground anomalies, and electrical magnetic tomography (ERT) to gain a broad understanding of the natural topography, and any large archaeological features. The methodology is detailed in Section 5 of TigerGeos full report (Appendix D). The location and coverage of the geophysics work is shown on Figures 2 and 4.

4.3 Borehole survey

4.3.1 The location of the borehole transect is shown on Figure 2. An East-West transect of eleven boreholes (OA02-OA12) was drilled at *c* 2m centres, perpendicular to the projected line of the putative eastern defensive ditch of the suggested primary *burh* within the Central Quad. The majority of the boreholes were located on turf, apart from the far eastern end of the transect which were located within the flagstone perimeter path.

4.3.2 Prior to drilling each borehole location was established using a GPS, ensuring coordinates and levels relative to the National Grid and Ordnance Datum were recorded. Each location was scanned with a Cable Avoidance Tool and a 1.1m deep hand dug inspection pit was excavated to check for services. Two boreholes (OA01 and OA13) were abandoned due to the presence of unmapped services. The sequence of sediments in the inspection pits was recorded by an archaeologist.

4.3.3 The boreholes were drilled from 1.1m below ground level using a Dando Terrier rig. The drilling rig was operated by a specialist sub-contractor suitably qualified in operating this type of equipment (CC Ground Investigations Ltd). Each borehole was cased and drilled to the Oxford Clay or until a maximum depth of 5m was reached. A continuous sequence of core samples (0.125 m in diameter and 1.0 metres in length) were retrieved from each location. The drilling of the boreholes was supervised on site by one of OA's in-house geoarchaeologists.

4.3.4 Cores were transported back to Oxford Archaeology premises where they were extruded, logged and photographed. The deposit sequence observed at each location was recorded and logged using standard sediment terminology and sedimentary proformas. Sediments were described according to Jones et al 1999, and in accordance with HE guidelines for geoarchaeological recording (HE, 2015). This includes information on colour, composition, texture, structure, compaction, erosional contacts, and artefactual and ecofactual inclusions.

4.3.5 Each observed sediment unit was assigned a unique context number. Artefactual material was collected during the logging of the cores, after which alternate boreholes were fully excavated by context for finds retrieval

4.3.6 The lithological data was input into geological modelling software (RockWorks17) for analysis and correlation of deposits into key stratigraphic units in order to produce summary cross-section linked to m OD.

4.3.7 As part of the initial work two radiocarbon dates were submitted to confirm stratigraphic correlations and enhance the chronological framework of the deposit model.

5 RESULTS

5.1 The Geophysical Survey

5.1.1 The results of the Geophysical survey were mixed. The GPR did not penetrate to depths below c 1.0m B.G.L and therefore did not give any useful information about the archaeological remains within the medieval sequence, or truncation affecting the natural gravel horizon (later identified by the borehole work). Useful but limited and basic information on the below ground services within the pathed areas of the quads were identified by the GPR, the same can not be said for the grassed areas.

5.1.2 The ERT technique was hampered by interference in the northern quad, but more illuminating within the central and southern quads. No anomalies were identified that would equate to a large N-S defensive ditch, however, an eastwards dipping horizon to the natural gravel horizon was present in the southern quad. The cause of this eastwards slope is unknown at present and may equally relate to human activity (truncation from large or multiple archaeological features) as to specific trends in the natural topography at the end of the gravel promontory.

5.2 The Borehole Transect

Introduction and presentation

5.2.1 The results of the borehole survey are presented below, and include a description of the stratigraphy with interpretation of the depositional processes. This is followed by a summary of the recovered artefactual assemblages and radiocarbon dating. The detailed lithological descriptions are presented in tabular format in Appendix A, and photographs of the extracted and cleaned core profiles are presented in Appendix B. Figure 3 provides a summary cross-section of correlated sediment units. Table 1 provides details of the borehole locations (which are shown on Figures 2 and 4).

Borehole	Easting	Nothing	GL elevation (m OD)	Total depth (m)
OA02	451612.5	206167.2	61.3	4
OA03	451614.5	206167.3	61.32	4
OA04	451616.5	206167.3	61.34	4.7
OA05	451618.5	206167.4	61.32	5
OA06	451620.5	206167.4	61.3	5
OA07	451622.5	206167.5	61.33	5
OA08A	451624.5	206167.5	61.31	5
OA09A	451626.5	206167.6	61.34	3
OA10	451628.5	206167.6	61.34	5
OA11	451630.5	206167.7	61.46	5
OA12A	451631.8	206167.7	61.38	5

Table 1: Summary of borehole locations

Stratigraphic sequence

5.2.2 The sequence of sediments observed during the investigation can be summarised as follows in order of deposition:

- Oxford Clay (Bedrock)
- Terrace gravel (Pleistocene)
- Occupation deposits (Medieval)
- Occupation deposits (Post-Medieval)
- Topsoil (Modern)

Oxford Clay (Bedrock)

5.2.3 Very stiff homogenous dark bluish grey clay formed a basal unit across the study area and was reached in all of the boreholes with the exception of OA09A that hit an obstruction at a higher depth. The surface of the deposit dropped eastwards from 3.7m BGL in OA02 (57.60m OD) to 4.8m BGL (56.60m OD) in OA12A. This unit was identified as Oxford Clay of Jurassic age.

Terrace gravel (Pleistocene)

5.2.4 Overlying the bedrock was a unit of sandy gravel, frequently described as horizontally bedded, loose brownish yellow to yellow, comprising mostly sub-angular small to large limestone clasts. In OA11 and OA12A, the gravel was clast supported and was notably looser and unbedded. Particularly towards the base of the unit were distinct beds and clasts of bluish grey clay similar to the Oxford Clay which may represent rip-up clasts.

5.2.5 The gravel was recorded in all boreholes and had an average thickness of 1.3m (varying from 1.7m in OA07 to 0.75m in OA03). The top of the gravel was present at an average height of 58.3mOD. The highest elevation was seen in OA02 at 2.2m BGL (59.08m OD), where it was overlain by a disturbed of redeposited orangey brown silty clay that may be a remnant of the capping brickearth that has been truncated elsewhere. The gravel was heavily truncated in OA03-06, but less so in OA07 where the surface lay at 2.75m BGL (58.58m OD). This equates to a drop in elevation of 0.5m eastwards. In OA12A the gravel lay at 3.18m BGL (58.2m OD), equating to a further drop of 0.38m at the eastern end of the transect.

5.2.6 The undulating surface of the unit is a result of later truncation. The upper contact of the gravel unit was generally very abrupt and frequently appeared stained orange brown with Fe oxide. This unit corresponds to the Summertown-Radley Sand and Gravel Member of Pleistocene age and represents an edge of the second terrace.

Occupation deposits (Medieval)

5.2.7 A highly variable sequence of medieval fill or occupation deposits was recorded above the gravel in all boreholes at depths of between 0.9m BGL to 1.2m BGL (60.4m OD to 60.14m OD).

5.2.8 Several contexts were observed within this sequence, the majority having sharp contacts. The variability of the sequences precluded detailed correlation between all boreholes. In general, the deposits were described as dark greyish brown to dark yellowish brown clayey silts with varying amount of rubble material that comprise limestone, crushed mortar and pebbles; some of the deposits had a loamy matrix. The thickness of the sequence reached up to 2m.

5.2.9 Several depositional episodes could be observed across the transect, including dumps of limestone rubble. Most of deposits had well defined, either clear or sharp, contacts, although it is not fully clear which of the contacts represent cut features. Several disturbed loam or soil horizons were noted (eg. in OA02, OA07) that may indicate periods of stability or redeposited garden soils. At the eastern end of the transect a thin layer of dark brown to black humic soil with abundant charcoal fragments was identified overlying the gravel in boreholes OA10 and OA11. Radiocarbon dating of the charcoal suggests a 12^{th}-13^{th} century date (see below). This is consistent with the artefactual material recovered from the other boreholes which included pottery and tile (see below).

Post-medieval deposits

5.2.10 The sequence of post-medieval deposits was very unified across the area and was observed in the inspection pits. At the base a mid-brownish grey clayey silt with gravel inclusions was observed, probably representing a garden soil. This averaged 0.30m in thickness and was recorded at depths of between 0.66m BGL and 1.04m BGL. This was overlain by a layer of mixed lime mortar and limestone rubble, 0.11m to 0.31m thick, becoming thicker towards eastern part of transect. This is likely to represent a construction horizon for the library building to the north.

5.2.11 In some of the inspection pits (OA03, OA04, OA06, OA10) the rubble deposit was overlain by a gravel layer averaging 0.12m in thickness, that was possibly a variation in the composition of the construction debris.

5.2.12 The topmost deposit, directly beneath the top soil was a mid greyish brown silty clay with *c* 30% of sand and gravel inclusions, average 0.30m in thickness and is interpreted as late 17^{th}-18^{th} century garden soil.

Topsoil

5.2.13 Modern topsoil was recorded in the inspection pits located on the lawn area (OA02-OA10) with an average thickness of 0.18m and was described as dark greyish brown humic sandy silt.

5.3 The watching brief results

5.3.1 Two geotechnical Test Pits (TP) were excavated in early January 2018 (TP 3 and TP 4) positioned to examine the nature of the footings and foundations of the boundary wall to Magpie Lane, and the north wall of the Chapel (see Figures 2 and 4).

5.3.2 Both TPs 3 and 4 measured 0.6m x 0.6m, and were excavated to a depth of 0.6m and 1.1m B.G.L respectively. In both TPs 3 and 4 the walls extended to a depth of 0.35m BGL and appeared to be founded on a layer of limestone rubble. The base of the rubble layer was not reached, and proved too difficult to penetrate with a hand auger, therefore no information was obtained regarding the earlier sequences. No artefacts or soil samples were recovered.

5.4 Artefactual material

5.4.1 All the artefacts and ecofacts were recovered solely from the borehole work, either during the hand excavation of the lead-holes, or extracted from the borehole cores during logging work. The reports are short and therefore the specialists full contributions can be found in this section with no need for a supplementary appendix.

Pottery and ceramic building material by John Cotter

5.4.2 A total of 35 sherds of pottery weighing 182g were recovered from 12 contexts relating to the borehole work. Most of the assemblage is of medieval date. All the pottery was examined and spot-dated during the present assessment stage. For each context the total pottery sherd count and weight were recorded on an Excel spreadsheet, followed by the context spot-date which is the date-bracket during which the latest pottery types in the context are estimated to have been produced or were in general circulation. Comments on the presence of datable types were also recorded, usually with mention of vessel form (jugs, bowls etc.) and any other attributes worthy of note (eg. decoration etc.). Fabric codes referred to for the medieval wares are those of the Oxfordshire type series (Mellor 1994) whereas post-medieval codes are those of the Museum of London (MoLA 2014). The range of pottery is described in some detail in the spreadsheet and therefore only summarised below.

5.4.3 The assemblage is mostly in a very fragmentary condition with small but fairly fresh sherds present. Some of these join (within the same context) and may have broken on removal from the ground. Combining both the pottery and ceramic building material (CBM) spot-dates, one can state fairly certainly that none of the contexts here were laid down before the late 12th century, and probably not much before *c* 1225. Most appear to span the 13th-14th century, with possible continuation into the early 15th century (but not definitely). Ordinary domestic pottery types are represented and all typical of the wares commonly found in central Oxford. A few cooking pot sherds in Medieval Oxford ware (OXY, c 1075-1300) represent the earliest type here. As usual in Oxford, the dominant medieval type comprises sherds of glazed Brill/Boarstall ware jugs (OXAM, c 1225-1625) including decorated pieces typical of the 13th-14th centuries.

5.4.4 Context (1001) is clearly different. Taken together, the pottery and clay pipes from this context indicate a deposition date of c 1690-1750. No further work on the assemblage is recommended.

Borehole	Context	Spot-date	No.	Wt (g)	Comments
-	1001	c1680-1800	1	22	Post-med Brill slipware (BRSL) rim from dish with traces of white slip dec int
-	1001	c1650-1800	2	11	1x small bo black-glazed redware (PMBL), cup or jug with v glossy glaze both sides. 1x bo East Wilts ware (OXAQ c 1150-1350) with combed dec
-	1003	c1250-1350	7	37	All smallish body sherds (bos), fairly fresh. 3x green-glazed Brill jug (OXAM) including strip jug. 1x OXAM bo with glaze specks only. 2x OXAQ. 1x Northants shelly ware OXBK
OA03	1304	c1075-1300	9	21	Fresh joining sherds (fresh breaks) Med Oxford ware (OXY) cook pot. Sooted ext

Borehole	Context	Spot-date	No.	Wt (g)	Comments
OA04	1400	c1225-1450	1	2	OXAM glazed jug bo
OA05	1501	c1075-1300	1	3	Fresh bo Med Oxford ware (OXY) cook pot. Sooted ext. Possibly same vessel as in (1304)?
OA07	1706	c1225-1450	4	7	3x small joining bos OXAM jug with orange glaze. 1x small worn scrap yellow glazed OXY pitcher
OA08	1800	c1225-1450	2	46	OXAM incl small bo glazed jug & v worn jug bo with upper handle junction, oval handle section with single row of stabbed pits down the back
OA09	1900	c1250-1450	5	18	3x small bos unglazed OXAM jug (1 vess?) incl bo from jug shoulder with incised horiz groove dec, developed-looking fabric. 1x early Brill OXAW jug/jar lower wall. 1x bo Cotswold-type ware (OXAC)
OA09	1901	c1225-1450	1	6	OXAM bo from jug lower wall with some glaze specks
OA11	11102	c1150-1350	1	4	Fresh bo OXAQ
OA12	11201	c1225-1400	1	5	Fresh bo OXAM jug with glossy mottled green glaze
	TOTAL		**35**	**182**	

Table 2: Pottery spot dates

5.4.5 A total of 19 pieces of CBM weighing 459g were recovered from nine contexts. This was examined and spot-dated during the present assessment stage in a similar way to the pottery and the data recorded on an Excel spreadsheet. As usual, the dating of broken fragments of ceramic building material is an imprecise art and spot-dates derived from them are necessarily broad. The assemblage here is very fragmentary and worn and appears to consist of late 12th- to 14th-century roof tile with nothing definitely later than this. Flat roof tile (peg tile) predominates, although one or two pieces of curved ridge tile were also noted.

Borehole	Context	Spot-date	No.	Wt (g)	Comments
-	1001	13-14C	2	63	Very worn frags medieval orange sandy peg tile, Fabric 3B
-	1003	L12-14C	1	31	Very worn frag medieval pinkish-orange peg tile, Fabric 7B
-	1004	13-14C	3	218	Very worn frags medieval orange sandy peg tile, Fabric 3B. Includes 2 large joining frags from a thick peg tile or ridge tile edge with traces of glaze
OA03	1300	L12-14C	1	34	Very worn frag medieval pinkish-orange peg tile, Fabric 7B
OA03	1304	L12-14C	1	25	Very worn frag medieval pinkish-orange tile edge - probably a ridge tile, Fabric 7B. Thickness = 23mm
OA05	1501	L12-14C	5	57	Worn med peg tile including 1x larger frag from edge of cream-coloured Fab 7A tile and 4 scraps (some joining) pink Fab 7B
OA07	1706	L12-14C	1	18	Very worn scrap medieval pinkish-orange peg tile, Fabric 7B
OA09	1900	L12-14C	3	10	Joining scraps medieval pinkish-orange smooth Fab 7BB peg tile edge
OA11	11102	13-14C	2	3	Joining scraps medieval orange sandy Fab 3B peg tile
	TOTAL		19	459	

Table 3: Ceramic building material spot dates

Clay tobacco pipe by John Cotter

5.4.6 Four pieces of clay pipe weighing 19g were recovered from three contexts. These have not been separately catalogued but are described below.

Context	Spot date	Description
1001	c 1700-1750?	1 piece (2g). Fresh stem fragment (30mm long). Stem bore diam c 2.25mm.
1001	1700-1750?	2 pieces (6g). Fairly fresh stem fragments (up to 30mm long). Stem bore diam c 2.5mm. One burnished.
1003	c 1690-1720	1 piece (11g). Fresh, broken bowl base with broad circular heel and 36mm of stem still attached. Stem bore diam c 2.8mm. Oxford Type C, c 1690-1720 (Oswald 1984, fig. 51C).

Table 4: Clay tobacco pipe

Metal finds by Ian Scott

5.4.7 There are just two metal finds recovered from the cores. A copper alloy lace chape, *c* 25mm in length, from context 1001, was tapered with an overlapped seam with a pin hole. This is probably late medieval or early post medieval (15th- to early 17th-century). A small fragment of slag from context 1501 was too small to be diagnostic.

Animal bone by Lee Broderick

5.4.8 A total of 9 animal bones were recovered from the cores, all associated with contexts dated to the medieval and post-medieval period.

5.4.9 The specimens were generally in moderate condition and it was possible to identify several caprine (sheep – *Ovis aries* and/or goats – *Capra hircus*) specimens as well as one of domestic fowl (*Gallus gallus*). The caprine remains were a fusing proximal ulna, an unfused proximal femur diaphysis and a loose deciduous 4th premolar. All of these suggest an age at death of under 3½ years but it is not possible to ascertain if they were all from the same individual or that they might be representative of the site as a whole given the extremely small size of the assemblage. It was also noted that one of the large mammal specimens, a pelvis, had been sawn through obliquely.

5.4.10 It is impossible to draw any further conclusions from such a small sample but it is recommended that the bones should be included in the full excavation report. If further excavations take place on the site this material should be considered together with any other material recovered but otherwise its retention should not be considered a priority.

Caprine	3
medium mammal	1
large mammal	2
Total Mammal	6
domestic fowl	1
Total Bird	1
Total NISP	7
Total NSP	9

Table 5: Total NISP (Number of Identified SPecimens) and NSP (Number of SPecimens) figures per period

	Butchery marks	Gnawed	Burnt	Ageing data
caprine		1		3
large mammal	1		1	
Total Mammal	1	1	1	3
domestic fowl				1
Total Bird	0	0	0	1
Total	1	1	1	4

Table 6: Non-species data recorded for specimens

Borehole	Context	NSP	Mass (g)
-	1001	2	37
OA05	1501	3	16
OA06	1601	1	3
OA09	1900	1	0
OA09	1902	1	5
OA11	11104	1	2

Table 7: NSP and total mass of specimens per context

5.5 Radiocarbon dating

5.5.1 Two radiocarbon dates were processed from boreholes OA10 and OA11 at Beta Analytic, Florida (certificates can be found in Appendix C). The sample details are presented in Table 8. Both samples, from charcoal extracted from occupation deposits directly overlying Pleistocene gravel, produced dates spanning the 12th to 13th centuries at 1165-1265 cal AD and 1225-1300 cal AD. The position of the samples is noted on Figure 3.

Borehole	Context	Material	Lab code	14C date	δ13C	Calibrated date (95.4%)
OA10	11003	Pomoideae charcoal	Beta-475746	820+/-30BP	-26.0	1165-1265 cal AD
OA11	11104	*Corylus* charcoal	Beta-475746	750+/-30BP	-28.0	1225-1300 cal AD

Table 8: Radiocarbon dates

6 DISCUSSION (FIGURES 3 AND 4) BY BEN FORD

6.1.1 The borehole survey has served well in broadly characterising the sequence of deposits underlying the central quadrangle at Oriel College. The Oxford Clay bedrock was proven in all boreholes apart from OA09. In all cases, where observed, it was overlain by gravel deposits of the Summertown-Radley Terrace, and therefore its' upper horizon represents a natural level untruncated by human activity. The Oxford Clay horizon shows a fall in height from c 57.6m OD in the west (OA02) to c 56.6m OD in the east (OA10 and OA12A). These heights are slightly lower than those observed for the Oxford Clay to the south of the site, at Corpus Christie (OA 2015), which recorded the untruncated clay horizon between 57.7 – 58.2m OD.

6.1.2 In each borehole the Oxford Clay was sterile, with a greyish-blue unoxodised colour, this is in contrast to the oxodised greyish-brown clay (with flecks of charcoal) recorded at 57.27m OD by hand auger in the base of Trench 2 further to the south-west (OA 2015c).

6.1.3 The surface of the gravel was observed in all boreholes, but no *in situ* loess was recorded and therefore the horizon, which mainly undulates between c 58.1 – 58.6m OD with a single eastern high spot at 59.1m OD (OA02,) has been disturbed and truncated by the overlying human activity.

6.1.4 During construction work on the Rhodes building in the NE corner of the north quad truncated gravel was recorded within a lift pit at 58.17m OD (OA, 2017), which concurred with earlier observations by Wessex Archaeology where Test Pit 1 recorded gravel at 59.15m OD (WA, 2011 Section 4.2.2). Of note Test Pit 5 recorded [possible] gravel at 60.72m OD (*ibid.*).

6.1.5 At Corpus Christie archaeological work revealed *in-situ* loess at between 58.8 – 59.1m OD, the loess was 0.3m thick and overlay untruncated gravels (OA 2015, Section 3.1.2). As this site lies to the south of Oriel Square, and the gravel promontory generally falls in height from north to south, it can be suggested that untruncated gravels in the area of the boreholes were perhaps originally at *c* 59.3 – 59.6m OD, and to the southwest around the kitchen could perhaps at *c* 59.1 - 59.3m OD.

6.1.6 Overlying the terrace gravel a complex, sequence of occupation deposits dating to the medieval period were recorded. These sequences measured between 1 – 2.2m thick and are highly variable in composition and thickness, ranging from redeposited loamy soils and dumps of gravel and rubble up to a meter thick, to laminated layers each a few centimeters thick. It is highly likely that some of these deposits represent the fills of intercutting archaeological features, such as pits, and possibly cellars for buildings, resulting in the truncation of the loess and gravel deposits in this area, the multiple thin layers may equate to internal floor surfaces, and occupation deposits. It is worth noting that no deposits, such as limestone surfaces, or gravel surfaces that may be interpreted as possible roadways were identified.

6.1.7 It should be noted that the Terrier Rig hit limestone 'obstructions' at the original locations of boreholes OA08 and 09 – these obstructions probably represent in situ medieval stone structures (e.g. walls).

6.1.8 The artefactual material recovered from these deposits, in addition to two radiocarbon dates suggests the sequence dates from no earlier than the late 12th century.

6.1.9 The horizon between the medieval and Post-medieval deposits sits between 60.0 – 60.4m OD.

The question of the primary *burh* and eastern defences

6.1.10 The antiquarian observation of an earlier limestone wall (below the later medieval defensive wall) turning south within excavations near the Clarendon building, combined with the upward kink of the defensive line eastwards of Catte Street, and the layout of the street system in the historic core of Oxford has led to a theory that the town has a fortified Late Saxon primary *burh* smaller and set within the western half of the well-known walled extents of the Medieval town. The eastern defensive line, thought to comprise an earthen bank with later retaining wall and outer ditch as at Oxford Castle (OA, forthcoming), is suggested to run from the Clarendon observation southwards under the Bodleian Library, the Radcliffe Camera and thence southwards between Magpie Lane (perhaps on the line of an extramural road) and Oriel Street (perhaps an intramural road). If so this would run somewhere below Oriel College.

6.1.11 Figure 4 presents a possible interpretation of the position and orientation of the possible primary *burh* defences south of the High Street, and is based upon reliable, but limited, archaeological evidence that is discussed below.

6.1.12 If the eastwards dip in the gravel horizon identified by the ERT in the southern quad is a result of the natural Second Terrace topography (now masked by the modern townscape), it probably indicates the position at which the southern end of the Oxford gravel promontory divides into a more southerly extent of higher ground to the west (e.g. natural gravel heights within the trenches at Corpus Christie of between 58.5 – 58.8m OD), and lower ground at a similar latitude to the east (e.g. natural gravel/sand heights from recent work at Merton College of 57.1 – 57.3mOD (Ford and Teague, forthcoming)). Therefore, a primary phase of Late Saxon *burh* focused on the higher and more southerly extending ground to the west, would have a defensive advantage offered by this break of slope and lends logical weight to arguments for a north-south defensive line in this area.

6.1.13 The borehole transect did not identify a large, deep feature cutting into the terrace gravels and this was consistent with the results of the geophysical survey (TigerGeo 2017). In addition, observations directly north of the Kitchen at the Rhodes Building recorded possible gravel 60.72m OD in TP5 (WA 2011). Therefore, any large defensive ditch, if present, must lie to the east of Borehole OA12A, the eastern limit of the ERT survey lines (grassed quad areas), and TP5 at the Rhodes Building.

6.1.14 Evaluation work in the Oriel Kitchen area encountered Second Terrace gravels in TP1 and Trench 1 at 58.45m OD which is broadly consistent with the truncated levels from the boreholes in the central quad. Therefore, any large N-S feature must lie to the west of these interventions.

6.1.15 The only location where a deep feature was encountered was in the auger holes in Trench 2 located in the Bar (under the Hall), where natural gravel was absent, and oxodised Oxford Clay was overlain by organic silts, although these were undated. This auger hole may have located the defensive ditch, or an unusually deep feature (deeper than the pits suggested by the borehole profile) such as a well.

6.1.16 A *c* 10 – 13m wide N – S ditch does fit in with the keyhole evidence presented above, and would have run directly below the east ranges of the central and southern quads at Oriel. A parallel extra-mural road would have probably lain beyond the ditch to the east. The suggested alignment of ditch and road does not follow Magpie Lane, however, it does interestingly follow the alignment of the eastern ranges of the central and southern quads of Oriel College, Grove Lane and the eastern college ranges at Corpus Christi (perhaps later echoes of earlier boundaries/land divisions).

6.1.17 An intramural N-S road has been suggested running parallel with the inside line of a probably bank inside the line of the ditch, no evidence of an earthen bank, or a road structure was found within the borehole transect, however the evidence from Trenches 1 and 2 at Corpus Christie (OA, 2015) confirmed a probable Late Saxon road surface in this location, and perhaps this intramural road is similar to the current alignment of Oriel Square and Oriel Street.

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APPENDIX A CORE DESCRIPTIONS

Bore	Top (m)	Base (m)	Context	Lithology
OA01	0	0.16	1000	TOPSOIL
OA01	0.16	0.48	1001	SILTY CLAY
OA01	0.48	0.62	1002	LIME MORTAR
OA01	0.62	1.25	1003	CLAY SILT
OA02	0	0.2	1000	TOPSOIL
OA02	0.2	0.54	1001	SILTY CLAY
OA02	0.54	0.68	1002	LIME MORTAR
OA02	0.68	1.1	1003	CLAY SILT
OA02	1.1	1.15		VOID
OA02	1.15	1.31	1200	CLAYEY SILT
OA02	1.31	1.7	1201	CLAYEY SILT
OA02	1.7	1.93	1202	SILTY CLAY
OA02	1.93	2	1203	CLAYEY SAND
OA02	2	2.1		VOID
OA02	2.1	2.13	1203	CLAYEY SAND
OA02	2.13	2.17	1204	SILTY SAND
OA02	2.17	2.22	1205	CLAYEY SILT
OA02	2.22	3.68	1206	SANDY GRAVEL
OA02	3.68	4	1207	CLAY
OA03	0	0.18	1000	TOPSOIL
OA03	0.18	0.42	1001	SILTY CLAY
OA03	0.42	0.58	1006	GRAVEL
OA03	0.58	0.71	1002	LIME MORTAR
OA03	0.71	1.1	1003	CLAY SILT
OA03	1.1	1.15		VOID
OA03	1.15	1.5	1300	SILTY SAND
OA03	1.5	1.65	1301	SAND
OA03	1.65	1.92	1302	CLAYEY SILT
OA03	1.92	2	1303	SILTY SAND
OA03	2	2.12		VOID
OA03	2.12	2.25	1303	SILTY SAND
OA03	2.25	2.51	1304	SANDY SILT
OA03	2.51	2.56	1305	SAND
OA03	2.56	2.95	1306	SANDY SILT
OA03	2.95	3	1307	SILT
OA03	3	3.13	1308	CLAYEY SILT
OA03	3.13	3.88	1309	SANDY GRAVEL
OA03	3.88	4	1310	CLAY
OA04	0	0.16	1000	TOPSOIL
OA04	0.16	0.45	1001	SILTY CLAY
OA04	0.45	0.57	1006	GRAVEL

OA04	0.57	0.68	1002	LIME MORTAR
OA04	0.68	1.1	1003	CLAY SILT
OA04	1.1	1.2		VOID
OA04	1.2	1.3	1400	SANDY SILT
OA04	1.3	1.46	1401	SANDY SILT
OA04	1.46	1.57	1402	SANDY GRAVEL
OA04	1.57	2	1403	SANDY SILT
OA04	2	2.05		VOID
OA04	2.05	2.21	1403	SANDY SILT
OA04	2.21	2.96	1404	CLAYEY SILT
OA04	2.96	3.95	1405	SANDY GRAVEL
OA04	3.95	4.7	1406	CLAY
OA05	0	0.18	1000	TOPSOIL
OA05	0.18	0.5	1001	SILTY CLAY
OA05	0.5	0.69	1002	LIME MORTAR
OA05	0.69	0.95	1003	CLAY SILT
OA05	0.95	1.1	1004	SILTY CLAY
OA05	1.1	1.37	1500	SANDY SILT
OA05	1.37	3.11	1501	CLAYEY SILT
OA05	3.11	3.2	1502	LIMESTONE RUBBLE
OA05	3.2	4.15	1503	SANDY GRAVEL
OA05	4.15	5	1504	CLAY
OA06	0	0.16	1000	TOPSOIL
OA06	0.16	0.43	1001	SILTY CLAY
OA06	0.43	0.5	1006	GRAVEL
OA06	0.5	0.66	1002	LIME MORTAR
OA06	0.66	0.9	1003	CLAY SILT
OA06	0.9	1.1	1004	SILTY CLAY
OA06	1.1	1.13		VOID
OA06	1.13	1.6	1600	SANDY SILT
OA06	1.6	2	1601	SANDY SILT
OA06	2	2.18	1602	LIMESTONE RUBBLE
OA06	2.18	2.27	1603	SANDY SILT
OA06	2.27	2.75	1604	CLAEY SILT
OA06	2.75	2.98	1605	CLAYEY SILT
OA06	2.98	4.61	1606	SANDY GRAVEL
OA06	4.61	5	1607	CLAY
OA07	0	0.16	1000	TOPSOIL
OA07	0.16	0.52	1001	SILTY CLAY
OA07	0.52	0.67	1002	LIME MORTAR
OA07	0.67	0.98	1003	CLAY SILT
OA07	0.98	1.1	1004	SILTY CLAY
OA07	1.1	1.18		VOID
OA07	1.18	1.24	1700	SANDY SILT

OA07	1.24	1.34	1701	CLAYEY SILT
OA07	1.34	1.44	1702	SANDY SILT
OA07	1.44	1.49	1703	LIMESTONE RUBBLE
OA07	1.49	1.62	1704	CLAYEY SILT
OA07	1.62	1.67	1705	SANDY SILT
OA07	1.67	2	1706	CLAYEY SILT
OA07	2	2.1		VOID
OA07	2.1	2.64	1706	CLAYEY SILT
OA07	2.64	2.67	1707	SILTY CLAY
OA07	2.67	2.75	1708	SILTY CLAY
OA07	2.75	4.45	1709	SANDY GRAVEL
OA07	4.45	5	1710	CLAY
OA08A	0	0.16	1000	TOPSOIL
OA08A	0.16	0.48	1001	SILTY CLAY
OA08A	0.48	0.68	1002	LIME MORTAR
OA08A	0.68	0.94	1003	CLAY SILT
OA08A	0.94	1.1		VOID
OA08A	1.1	1.22	1800	CLAYEY SILT
OA08A	1.22	2	1801	CLAYEY SILT
OA08A	2	2.16		VOID
OA08A	2.16	2.28	1801	CLAYEY SILT
OA08A	2.28	2.46	1802	SILT
OA08A	2.46	2.82	1803	SANDY SILT
OA08A	2.82	3.13	1804	SILTY CLAY
OA08A	3.13	4.66	1805	SANDY GRAVEL
OA08A	4.66	5	1806	CLAY
OA09A	0	0.18	1000	TOPSOIL
OA09A	0.18	0.45	1001	SILTY CLAY
OA09A	0.45	0.68	1002	LIME MORTAR
OA09A	0.68	0.94	1003	CLAY SILT
OA09A	0.94	1.1	1004	SILTY CLAY
OA09A	1.1	1.18		VOID
OA09A	1.18	2	1900	CLAYEY SILT
OA09A	2	2.26		VOID
OA09A	2.26	2.47	1900	CLAYEY SILT
OA09A	2.47	2.53	1901	CLAY
OA09A	2.53	2.84	1902	CLAYEY SILT
OA09A	2.84	3	1903	SANDY GRAVEL
OA10	0	0.18	1000	TOPSOIL
OA10	0.18	0.56	1001	SILTY CLAY
OA10	0.56	0.68	1006	GRAVEL
OA10	0.68	0.86	1002	LIME MORTAR
OA10	0.86	1.1	1003	CLAY SILT
OA10	1.1	1.25		VOID

OA10	1.25	1.95	11000	SILTY CLAY
OA10	1.95	2	11001	LIMESTONE RUBBLE
OA10	2	2.1		VOID
OA10	2.1	2.51	11001	LIMESTONE RUBBLE
OA10	2.51	3	11002	SANDY SILT
OA10	3	3.04		VOID
OA10	3.04	3.19	11003	ORGANIC SILT
OA10	3.19	3.23	11004	SILTY SAND
OA10	3.23	3.5	11005	GRAVELLY
OA10	3.5	3.59	11006	SAND
OA10	3.59	4	11007	SANDY GRAVEL
OA10	4	4.1		VOID
OA10	4.1	4.88	11007	SANDY GRAVEL
OA10	4.88	5	11008	CLAY
OA11	0	0.73	1001	SILTY CLAY
OA11	0.73	1.04	1002	LIME MORTAR
OA11	1.04	1.3	1003	CLAY SILT
OA11	1.3	1.9	11100	SILTY CLAY
OA11	1.9	2	11101	LIMESTONE RUBBLE
OA11	2	2.2		VOID
OA11	2.2	2.62	11101	LIMESTONE RUBBLE
OA11	2.62	3.05	11102	SILTY SAND
OA11	3.05	3.08	11103	SILT
OA11	3.08	3.12	11104	SILT
OA11	3.12	3.22	11105	SILTY CLAY
OA11	3.22	3.32	11106	CLAYEY GRAVEL
OA11	3.32	4.46	11107	SANDY GRAVEL
OA11	4.46	4.74	11108	GRAVEL
OA11	4.47	5	11109	CLAY
OA12A	0	0.18		
OA12A	0.18	0.44		
OA12A	0.44	0.78		
OA12A	0.78	1		
OA12A	1	1.25		
OA12A	1.25	1.52	11200	SILTY CLAY
OA12A	1.52	2	11201	SANDY SILT
OA12A	2	2.18		VOID
OA12A	2.18	2.51	11201	SANDY SILT
OA12A	2.51	3	11202	CLAYEY SILT
OA12A	3	3.18	11203	CLAYEY SILT
OA12A	3.18	4.47	11204	SANDY GRAVEL
OA12A	4.47	4.65	11205	CLAY
OA12A	4.65	4.78	11206	SANDY GRAVEL
OA12A	4.78	5	11207	CLAY

APPENDIX B CORE PHOTOGRAPHS

Borehole OA02.

Borehole OA03.

Borehole OA04.

Borehole OA05..

Borehole OA06.

Borehole OA07.

Borehole OA08A.

Borehole OA09A.

Borehole OA010.

Borehole OA11.

Borehole OA11.

Borehole OA12A.

APPENDIX C RADIOCARBON CERTIFICATES

Beta Analytic
RADIOCARBON DATING

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ISO/IEC 2005:17025-Accredited Testing Laboratory

October 26, 2017

Julia Meen
Oxford Archaeology
Janus House
Oxford, Oxfordshire OX2 0ES
United Kingdom

RE: Radiocarbon Dating Results

Miss Meen,

Enclosed are the radiocarbon dating results for two samples recently sent to us. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable. The Conventional Radiocarbon Ages have all been corrected for total fractionation effects and where applicable, calibration was performed using 2013 calibration databases (cited on the graph pages).

The web directory containing the table of results and PDF download also contains pictures, a cvs spreadsheet download option and a quality assurance report containing expected vs. measured values for 3-5 working standards analyzed simultaneously with your samples.

Reported results are accredited to ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 standards and all chemistry was performed here in our laboratory and counted in our own accelerators here. Since Beta is not a teaching laboratory, only graduates trained to strict protocols of the ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 program participated in the analyses.

As always Conventional Radiocarbon Ages and sigmas are rounded to the nearest 10 years per the conventions of the 1977 International Radiocarbon Conference. When counting statistics produce sigmas lower than +/- 30 years, a conservative +/- 30 BP is cited for the result. The reported d13C values were measured separately in an IRMS (isotope ratio mass spectrometer). They are NOT the AMS d13C which would include fractionation effects from natural, chemistry and AMS induced sources.

When interpreting the results, please consider any communications you may have had with us regarding the samples.

The cost of the analysis was charged to the MASTERCARD card provided. Thank you. As always, if you have any questions or would like to discuss the results, don't hesitate to contact us.

Beta Analytic
RADIOCARBON DATING
Consistent accuracy delivered on time

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REPORT OF RADIOCARBON DATING ANALYSES

Julia Meen — Report Date: October 26, 2017

Oxford Archaeology — Material Received: October 09, 2017

Sample Information and Data	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 475745	**OXOCK17BH1011003A**	**820 +/- 30 BP**	IRMS δ13C: -26.0 o/oo
Submitter Material: Wood charcoal - Pomoideae		**(95.4%) 1164 - 1265 cal AD**	**(786 - 685 cal BP)**

Analyzed Material: Charred material
Pretreatment: (charred material) acid/alkali/acid

Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 90.30 +/- 0.34 pMC
Fraction Modern Carbon: 0.9030 +/- 0.0034
D14C: -97.04 +/- 3.37 o/oo
Δ14C: -104.33 +/- 3.37 o/oo(1950:2017)
Measured Radiocarbon Age: (without d13C correction): 840 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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REPORT OF RADIOCARBON DATING ANALYSES

Julia Meen | Report Date: October 26, 2017

Oxford Archaeology | Material Received: October 09, 2017

Sample Information and Data	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)
Beta - 475746	**OXOCK17BH1111104**	**730 +/- 30 BP** IRMS δ13C: -25.8 o/oo

Submitter Material: Wood charcoal - Corylus avellana | **(95.4%) 1224 - 1298 cal AD (726 - 652 cal BP)**

Analyzed Material: Charred material
Pretreatment: (charred material) acid/alkali/acid

Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 91.31 +/- 0.34 pMC
Fraction Modern Carbon: 0.9131 +/- 0.0034
D14C: -86.87 +/- 3.41 o/oo
Δ14C: -94.24 +/- 3.41 o/oo(1950:2017)
Measured Radiocarbon Age: (without d13C correction): 740 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), “present” = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

BetaCal 3.21

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -26.0 o/oo)

Laboratory number **Beta-475745**

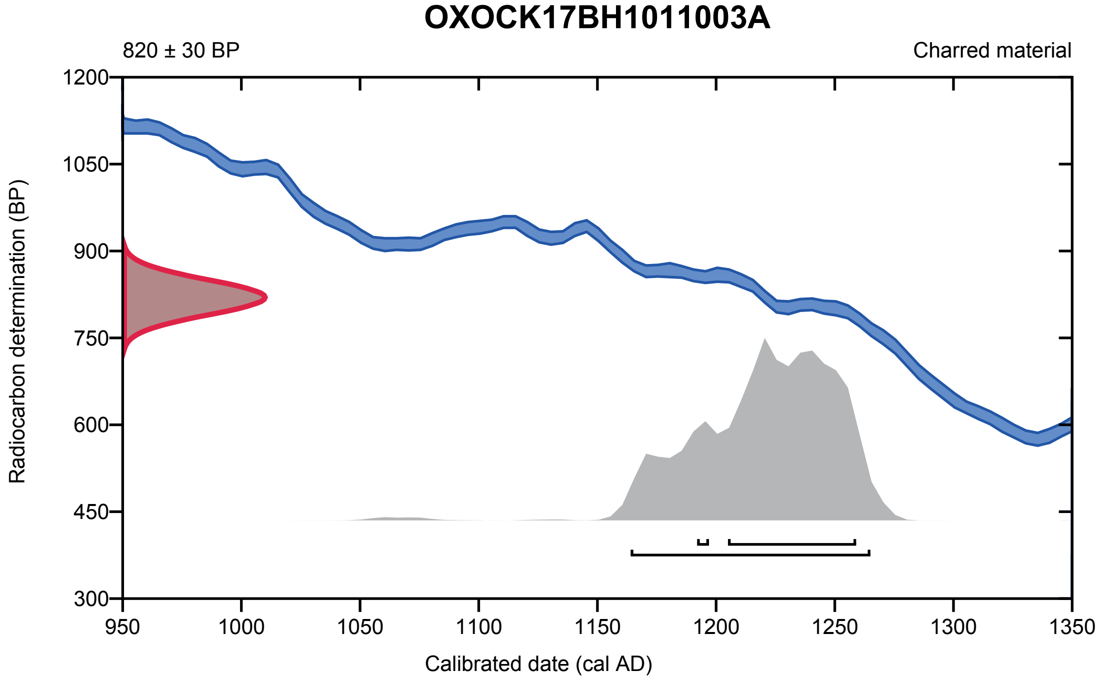
Conventional radiocarbon age **820 ± 30 BP**

95.4% probability

(95.4%)	1164 - 1265 cal AD	(786 - 685 cal BP)

68.2% probability

(64.7%)	1205 - 1259 cal AD	(745 - 691 cal BP)
(3.5%)	1192 - 1197 cal AD	(758 - 753 cal BP)



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -25.8 o/oo)

Laboratory number **Beta-475746**

Conventional radiocarbon age **730 ± 30 BP**

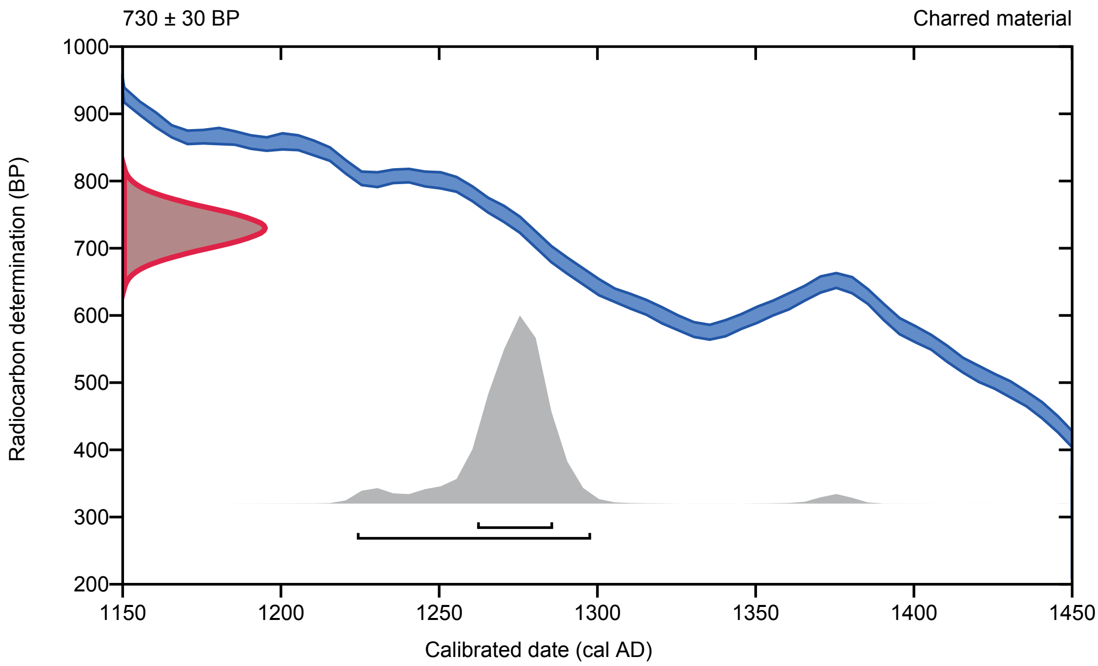
95.4% probability

(95.4%) 1224 - 1298 cal AD (726 - 652 cal BP)

68.2% probability

(68.2%) 1262 - 1286 cal AD (688 - 664 cal BP)

OXOCK17BH1111104



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

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Quality Assurance Report

This report provides the results of reference materials used to validate radiocarbon analyses prior to reporting. Known-value reference materials were analyzed quasi-simultaneously with the unknowns. Results are reported as expected values vs measured values. Reported values are calculated relative to NIST SRM-4990B and corrected for isotopic fractionation. Results are reported using the direct analytical measure percent modern carbon (pMC) with one relative standard deviation. Agreement between expected and measured values is taken as being within 2 sigma agreement (error x 2) to account for total laboratory error.

Report Date: October 27, 2017
Submitter: Miss Julia Meen

QA MEASUREMENTS

Reference 1

Expected Value: 129.41 +/- 0.06 pMC
Measured Value: 129.41 +/- 0.34 pMC
Agreement: Accepted

Reference 2

Expected Value: 0.44 +/- 0.10 pMC
Measured Value: 0.45 +/- 0.03 pMC
Agreement: Accepted

Reference 3

Expected Value: 41.14 +/- 0.10 pMC
Measured Value: 41.21 +/- 0.15 pMC
Agreement: Accepted

COMMENT: All measurements passed acceptance tests.

Validation: Darden Hood

Date: October 27, 2017

APPENDIX D GEOPHYSICAL SURVEY REPORT (TIGERGEO, 2017)

TIGERGEO

Oriel College Quads, Oxford

Geophysical Survey Report
(GPR and ERT - Archaeology)

Version 1.0

Project code: OCQ161

Produced for:

Oxford Archaeology

Authors:

MJ Roseveare, Senior Geophysicist

BSc(Hons) MSc MEAGE FGS MCIfA

REGISTERED · CIfA · ORGANISATION

7th December 2017

Environmental Geophysics – Survey, Research and Consultancy

Oriel College Quads, Oxford

Digital data

Item and version	Sent to	Sent date
CAD – Vector Elements 1.0	Ben Ford	7th December 2017

Audit

Version	Author	Checked	Date
Interim			
1.0	MJ Roseveare	ACK Roseveare	7th December 2017

Project metadata

Project Code	OCQ161
Client	Oxford Archaeology
Fieldwork Dates	1st - 3rd August 2017
Field Personnel	MJ Roseveare, ACK Roseveare, K Cunningham, K Wild, T Collins
Data Processing Personnel	ACK Roseveare, MJ Roseveare
Reporting Personnel	MJ Roseveare
Report Date	7th December 2017
Report Version	1.0

TigerGeo Limited

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Non-Technical Summary

TigerGeo was commissioned by Oxford Archaeology to undertake geophysical survey, namely ground penetrating radar (GPR) and electrical resistivity tomography (ERT) within the courts central to the three quads of Oriel College, Oxford. The purpose was to map any features of archaeological interest that would guide the location of a borehole transect, as well as providing possible cross-sections through the ground into which the Saxon town defensive ditch was expected to have been cut.

Overall the ERT profiles have given an insight towards formation of a ground model for at least the central and southern quads. This includes a fairly accurate model of the depth of material above the natural gravel below the two quads and also how this appears to dip eastwards in the southern one. This in itself has implications for understanding former ground levels contemporary with earlier phases of the college but might also suggest that the palaeotopography has influenced the position of the Saxon town defences. There is no evidence for these within the geophysical data and this would support the suggestion that they were further downhill to the east than previously supposed.

The use of combined resistivity and chargeability during ERT survey has revealed lateral changes in the central quad likely indicative of different land use early in the history of the college, with a boundary implied at the northern extent of the two wings extending from the southern ranges.

Due to conditions within the soil the GPR survey was not successful, with penetration limited to less than 1m and therefore too shallow to image the deeper deposits of archaeological interest. The reason for this is not fully understood but the ERT data suggests unexpected electrical properties likely due to land use and management at this particular site is the cause of the problem. Survey even just a few metres away, outside the college or within its buildings, is likely to produce a better result.

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Drawing	**Title**
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DWG 02	ERT Profile Locations
DWG 03	ERT Profile 1 – Central Quad – Model Resistivity and Chargeability
DWG 04	ERT Profile 2 – Central Quad – Model Resistivity and Chargeability
DWG 05	ERT Profile 3 – Southern Quad – Model Resistivity and Chargeability
DWG 06	ERT Profile 4 – Southern Quad – Model Resistivity and Chargeability
DWG 07	ERT Profile 5 – Northern Quad – Model Resistivity and Chargeability
DWG 08	GPR Area Survey Profile Locations – All Frequencies
DWG 09	GPR Profile 358 – Approximately Coincident with OA Borehole Transect
DWG 10	500 MHz Profile Pick – Location of Reflectors – Central Quad
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DWG 14	Services – Summary – Southern Quad

1 Introduction

TigerGeo was commissioned by Oxford Archaeology to undertake geophysical survey, namely ground penetrating radar (GPR) and electrical resistivity tomography (ERT) within the courts central to the three quads of Oriel College, Oxford. The objective was '*To locate or otherwise the line of the postulated Late Saxon defensive ditch pertaining to the original burh that may run north-south across the central part of the site. If present, it will be sealed below c 1.5m of archaeological and modern deposits (e.g. pits, wells, walls, garden soils etc.) of medieval and later date.*' (Ford, *2016*).

Each court was surveyed at 0.5m line separation using three-frequency GPR and two ERT profiles were undertaken within each, orientated to maximise their length, except within the northern quad where there was space for only one.

Country	England
County	Oxfordshire
Nearest Settlement	Oxford
Central Co-ordinates	451620, 206165

2 Context

2.1 Environment

Soilscapes Classification	Loamy and clayey floodplain soils with naturally high groundwater (20) (nearby)
Superficial 1:50000 BGS	Summertown-Radley Sand and Gravel Member – Sand and Gravel (SURA)
Bedrock 1:50000 BGS	Oxford Clay Formation and West Walton Formation (undifferentiated) – Mudstone (OXWW)
Topography	Flat, with raised area at end of northern quad
Hydrology	Naturally potentially free draining, expected modification with long-term urban usage
Current Land Use	Garden
Historic Land Use	Urban area, possible earlier defensive ditch
Vegetation / Surface	Short grass, flagged paths

The British Geological Survey (BGS) recorded superficial deposits may only be apparent from below 1.0 to 1.5mbgl, buried beneath multiple modified soil strata (Oxford Archaeology, 2015b). The natural soil types are likely to have been significantly modified, due to the long-term urban nature of the site, confirmed by recorded deposits in nearby archaeological test pits and evaluation trenches. The water table was not identified in these excavations.

BGS borehole reference SP50NW439 (the closest one to site, at Bodleian Library approx. 150m to north) can be broadly summarised as various soils and fills within the top 2.6m, sand and gravel below this to 6.0mbgl, at which depth the Oxford Clay is identified. The Oriel College quads are closer to the current river and meadows (to the south). The depths of superficial deposits and depth to bedrock may vary across the three areas.

Oxford Archaeology have reported that *'Sand and gravel (at c 1.5m BGL within test pits) overlying Oxford Clay Formation (at 2.7m depth from test pits). It is possible that waterlogged remains occur at depth of about 2.5m BGL (see Test Pit Report)'* (Ford, *pers. Comm.*). If this is applicable to the courts within the quads, which is debatable, then any remnant of the Saxon Ditch '*sealed below c 1.5m of archaeological and modern deposits*' is expected to exist only within the natural gravels and to have been truncated at shallower depth.

The exact nature of the soils within the quads is not known, however, the antiquity of the surrounding buildings and the degree of landscaping that is evident would suggest significant quantities of reworked and possibly also imported soils and likely building rubble. These are presumably overlaid by garden-type soils supporting the present lawns, however, old illustrations suggest these to be relatively modern innovations compared the history of the site.

The central quad is a late Georgian (c. 1821) creation linking the two earlier complexes of buildings to the north (St. Mary's Hall) and south (Oriel College). A late seventeenth century shows this area to have been gardens with adjacent service structures, the northern wings of Oriel College not existing at this date. After these wings has been built, two grass plats separated them according to an illustration of 1733. The northern quad is also relatively modern, having been formed from an internal courtyard adjacent to St. Mary's (formerly Bedell) Hall. Depictions from the 1700s onwards reveal a variety of changes to its size, shape and character, culminating in its present layout of just a few years age. It is likely therefore that the soils within this quad have been substantially reworked many times and the depictions show a mixture of planted, paved and grass areas at various times.

In contrast the southern quad retains its basic seventeenth century character although again the grass plats are relatively modern, a plat being present in the 1830s but not of the same form as at present. Earlier depictions not surprisingly appear to show paving or some other functional surface.

A range of services within the survey areas is expected and there are apparently no extant service plans (Ford, *pers. comm.*).

2.2 Recent work

A desk-based assessment was prepared for the proposed kitchen extension, to the east of the three quads and the proposed survey area, at Oriel College (Oxford Archaeology, 2015a).

Although the assessment focuses on the proposed kitchen development area, much of the information within is applicable to the wider area. The summary of the assessment states that the surrounding area is dominated by medieval and post-medieval buildings and gardens associated with the eastern Oxford University colleges. It also is states that historical and archaeological evidence *'..........suggests a possibility of the original Saxon Burh defences ....'* in the immediate area and that there is *'....... potential for medieval and post-medieval street front properties and the medieval hall of St Martin's.'*

An archaeological evaluation, comprising the excavation of two trial trenches and the monitoring of two test pits within the proposed kitchen extension, revealed the top of the underlying gravel terrace (Oxford Archaeology, 2015b).

The results suggest that gravel had been truncated by *'.......features probably dating to the 12th-14th century occupation of the site, and perhaps relating to medieval tenements pre-dating the construction of the medieval Front Quadrangle of the college in the mid-14th century .....'*

Later structures were also revealed, dating from the 17th century, and possible associated within the rebuild of the Front Quadrangle of the college at this time. Later deposits and structures were also identified, relating to modern re-configurations of the kitchen area.

Given the architectural context and development of the three quads, the relevance of this work to understanding the soils within them is debatable, not least because previous excavations have all occurred within built up areas of the site. The long-term development and purpose of the courts within the quads, as open areas providing context for buildings, will result in ground of a different geophysical nature.

3 Discussion

3.1 Character & Principal Results

3.1.1 Introduction

The objectives of the survey were twofold: first to prospect for the line of the postulated Saxon ditch and later medieval and post-medieval archaeological features and deposits and second to locate and map known and hitherto unknown service runs that might affect borehole placement. If this ditch survives, it is assumed to exist only within natural gravels, having been truncated during medieval and later developments. Given the lack of intensive development of the site within the quads themselves during the medieval period, whether this assumption is valid is perhaps questionable.

Two complimentary methods were used, 2D electrical resistivity tomography (ERT) and ground penetrating radar (GPR), each exploiting different properties of the subsurface and together maximising the chance of detection of the ditch fill. The methods will allow the complexity of the overburden and the geological context to be examined and thus increase the robustness of the archaeological result.

The ERT survey was to provide geological context and to assist with detection of the ditch fill, which may be deeply buried. It was deployed as a number of discrete profiles (see DWG 02).

The GPR survey was intended to provide a 3D model of the shallower deposits at a high resolution and cannot be expected to penetrate to the same depth as the ERT. However, former urban structures, if these existed, as well as services, could in theory be mapped. Three antenna frequencies were used, the lowest of which (250 MHz) has a theoretical investigation depth of several metres. The service tracking relied more on the mid frequency (500 MHz) GPR data as a compromise between revolution and depth of investigation.

A series of boreholes were excavated by Oxford Archaeology across the central quad following the survey, to sample the archaeological deposits beneath it.

3.1.2 Geolocation

Network RTK GNSS was used throughout for geolocation, with identifiable points with digital plan data provided by the college used to offset that plan onto Ordnance Survey (OS) co-ordinates. Grid set out for geophysical work was achieved using tapes and their positions surveyed with GNSS.

The plan provided by the college was found after comparison with the GNSS data to be inaccurate and distorted relative to OSGB36: to allow it to be used as a base map for this reporting the three quads were separated and offset by an appropriate amount in each case. All geophysical data is accurately on OS co-ordinates but internal inaccuracies of the digital plan will have been retained.

3.1.3 Summary of borehole data from Oxford Archaeology

The report by Oxford Archaeology of their borehole work has not been seen by TigerGeo, apart from a Figure 3 "*Borehole phototransect with dating evidence*". Magdalena Benysek is thanked for sending us her preliminary interpretation of the logs soon after their collection, from which useful material classes provide context for the geophysical work. Twelve holes were bored below the base of hand-dug test pits along a line that roughly coincides with GPR profile 358 in the central quad (see DWGs 02 and 08). Borehole 3 is approximately on the line of our ERT profile 2 and borehole 8 is approximately on the line of ERT profile 1.

The deepest holes reached about 5mbgl and overall, they all show the same stratigraphic framework. The top 1m of ground is post-medieval deposits comprising garden soils and construction or demolition deposits and these overlay between 1.5 and 2 m of medieval deposits directly overlaying the river terrace gravel. The medieval soils seem to be mainly construction or demolition deposits with and without internal soil development, interspersed with occasional buried surface and at the eastern end, the occasional organic layer. Overall, there is about 3 m of stratigraphy of archaeological interest.

3.1.4 Electrical resistivity tomography (ERT) data – Central quad

The inverted (processed model) data for this quad is shown on DWGs 03 and 04.

Overall there are three vertical contexts in the quad, one above 2 – 2.5 mbgl, dipping southwards, with low resistivity (< 120 Ohm m) and high chargeability and one below with much higher resistivity (> 200 Ohm m). Below 4mbgl resistivity again drops to less than 80 Ohm m which is in correspondence with the borehole data for the top of the Oxford Clay and confirmed by a rise in chargeability from less than 5 mV/V to greater than 10 mV/V.

South of about 18 northwards along each profile, i.e. south of a line between the northern gables of the college wings, chargeability within the upper 1m of ground is high (25 mV/V compared with 8 mV/V) and the resistivity is lower. Together these are typical of a clay-like and probably humic soil that is spatially constrained by the college wings. Further south between these wings the high chargeability material dips southwards beneath a higher resistivity and markedly lower chargeability surface material that reaches a maximum depth of about 1 mbgl at the southern end.

There is nothing within either ERT profile to suggest major stratigraphic variation within the gravels that could be indicative of a soil-filled ditch.

There is a favourable comparison between the ERT data and the borehole result. Profile 2 approximately intersects the position of borehole 3 in a region of ground with a uniform resistivity of about 120 Ohm m, typical of the uppermost region within the quad. Below surface soils borehole context [1003], described as a garden soil, is apparent as a raised chargeability (10-13 mV/V) layer extending roughly to 1 mbgl. Below 2mbgl chargeability decreases markedly and this is roughly the region where construction or demolition layers without soil development overlay the natural gravels, the latter normally having low chargeability in an unsaturated state. The ERT data may place the interface slightly shallower than reality but the difference is within the tolerance imposed by the vertical resolution of the method.

Borehole 8A is roughly on the line of profile 1 which shows a broadly similar pattern of resistivity and chargeability variation with depth though less marked than for profile 2. Again, below 2 mbgl chargeability decreases while the resistivity seems to rise slightly, by about 30 – 40 Ohm m, although being near the edge of the model this can only be an approximate figure. This increase in resistivity combined with a decrease in chargeability would be typical of the natural gravel and at a depth comparable with the other profile. Again the interface is modelled to be shallower than is probably real but the presence of construction or demolition debris in the soil above will tend to affect this. Surface resistivity in the region of BH 8A is slightly higher (180 Ohm m compared with 120 Ohm m) but this appears to be localised and may be due to a relatively thick layer of demolition deposits [1801] below 1 mbgl.

The modelled resistivity and chargeability sections are comparable where they cross which increases confidence in the result given they are computed independently.

3.1.5 Electrical resistivity tomography (ERT) data – Southern quad

The inverted (processed model) data for this quad is shown on DWGs 05 and 06.

A high chargeability low resistivity material up to 1.5 m thick is present at surface (below the topsoil) across the western half of the quad, dipping beneath a more resistive material in the northeast quarter, itself about 1.5 m thick. It remains at the surface in the southeast quarter, the more resistive material not being evident here for reasons that are unclear but presumably relate to landscaping. Below these materials is a low chargeability high resistivity material, logically the gravel, extending to more than 3 m depth and dipping eastwards by about 1 in 10 m.

Both profiles show that much of the eastern half of the quad is made ground above natural gravel that dips below 4mbgl. Profile 3 reveals these to be mostly low resistivity can high chargeability materials so likely to be soils and especially within the upper 1.5m of ground. Below this chargeability decreases faster than resistivity increases which might imply a less humic or less clay rich soil at depth. At the eastern end of the profile the model is distorted by what is probably a buries service, giving rise to artificially high chargeability characteristics which have propagated to deeper regions of the model. At the western end of the profile the surface soils are low resistivity and high chargeability and similar to the southern surface soils in the central quad, probably a result of of landscaping. Overall the upper 1 to 1.5m of the ground are a lower resistivity than those in the central quad and may reflect a greater depth of cleaner soils and a lack of construction or demolition debris.

The same basic stratigraphic framework is implied by the second profile 13 m to the north, number 4, which shows the eastwards dip of the gravel and an implied greater depth of fill in this region. Off the gravel, much of the eastern half is dominated by low resistivity and very high chargeability deposits between depths of 1 and 2.5 mbgl. A traditional interpretation of this data could suggest the presence of wet clays, however, this would not be expected here and instead damp humic soils could be an explanation. To what extent there may be distortion from an nearby metallic service, should be exist, is uncertain but the basic trend is the same as within the southern profile but with higher chargeability.

3.1.6 Electrical resistivity tomography (ERT) data – Northern quad

The inverted (processed model) data for this quad,a single profile due to lack of space, is shown on DWG 07.

The profile was collected at a higher resolution (0.5 m electrode spacing) to compensate for the shorter length of array that could be fitted into the courtyard. The model reveals a low resistivity surface layer extending to about 0.5mbgl, perhaps related to recent construction and reseeding works, beneath which the resistivity rises to about 160 – 200 Ohm m, i.e. relatively high compared to the central and southern quads. Chargeability is low at 5 mV/m or less for much of the profile below 0.5 mbgl and in combination with the resistivity a dry clay-free material would be a likely, perhaps actually the natural gravel.

There is little sign of significant variation and no convincing sign of the high chargeability soil found closer to the college buildings. Given the northern quad is within the curtilage of the former St Mary's Hall, an outlier of the college for much of the medieval period, it is perhaps relevant that there is nothing about the ERT result to suggest deep urban stratigraphy at this location. This might suggest truncation of the medieval deposits, perhaps during the construction of the later buildings.

3.1.7 Summary ground model

The three quads are quite different in terms of ground model, although the southern two make good sense as a pair. The northern quad is markedly different and without invoking the possibility of ground truncation and hence natural gravels being close to the surface it is difficult to offer much interpretation.

The southern two quads are more straightforward with natural gravels present at a near constant depth below the central one, possibly slightly shallower to the west. Within the southern quad the gravels continue, dipping more steeply eastwards here than further north, and it is implied that here the ground level may have been significant raised, perhaps during the early post-medieval reconstruction of the college. If so, this has implications for understanding the depth of medieval deposits below the eastern range which might originally have been built upon lower ground than the present level might imply.

In general the southern quad appears to have less of the high resistivity materials apparent in the central quad and confirmed by the boreholes to be related to construction or demolition activities at various dates. Indeed, although these materials may be present within the upper 1 – 1.5 m of this quad, below that any fill may be purely soil and accumulated urban soils. The greater presence of these materials below the central quad may relate to its more varied land use history and its location during the medieval period between the two building complexes.

Of particular interest within the central quad is the spatial correlation between the electrical properties of the ground and the college building, especially the two northern wings. Changes in properties coincident with the northern gables implies the former presence of a land use boundary here that is not evident on contemporary or later illustrations, with significant chemical modification of soils prior to the formation of the quad. An anonymous depiction from 1675 shows gardens and what appear to be service buildings attached to the northern side of the college so these may be a source of this material, e.g. an enriched urban soil resulting from waste disposal and gardening. Later on, formation of the central quad by the addition of the library in the early 1800s and associated landscaping seems to have resulted in a capping layer in the southern part with different electrical properties and sealing the earlier post-medieval or perhaps medieval soils.

Overall, the borehole data suggests the ERT-based ground model, although fairly coarse, is realistic and therefore we can be confident that it provides a meaningful basis for future work.

3.1.8 Ground penetrating radar (GPR) data

GPR survey was undertaken across all three quads at a profile separation of 0.5 m using a three frequency antenna system capable of a depth of investigation, in suitable ground, of several metres. The results were disappointing with penetration limited to about 0.7 m below grass areas and no more than 1.5 m below paved.

This was unexpected given the soils were thought to be well-drained loam over sands and gravels, the more problematic Oxford Clay being deeper than of interest to this study. Publicly available soils data revealed low laying areas as having clay rich loamy flood plain soils but the site is on a gravel ridge above these. Borehole logs in the public domain (BGS 50NW439) suggest gravelly rather than clayey soils in the general vicinity of the site and the test pit report from Oxford Archaeology (Oxford Archaeology, 2015b) state that the gravels are typically overlaid by "*red brown loessic loam*". The same report also notes the presence of silty clay within certain features of archaeological interest but not as a description of the overall soil. Together, these sources do not indicate that GPR penetration would be limited and would suggest a fairly normal median depth of investigation of perhaps 2 mbgl at 500 MHz could be expected.

The response has limited the usefulness of the survey for archaeological purposes, useful data being almost wholly within the uppermost capping deposits associated with landscaping etc. Furthermore, it is not wholly suitable for utility mapping as the detection of these cannot be guaranteed within large parts of the site. Analysis for this purpose was carried out in advance of the borehole work and revealed a number of services within the target area, but has been discontinued for the rest of the site to avoid creating a misleading record. The layout of GPR profiles is shown on DWG 08 and a sample profile, number 358 and roughly coincident with the line of boreholes, is shown on DWG 09.

The challenge here is understanding why the result was different from that expected and this has been researched in some detail, albeit without detailed soil data from Oxford Archaeology's test pits. We can perhaps assume something like the expected silty loessic loam at surface, capping the more variable urban garden and debris-laden soils seen at greater depth in the boreholes.

Examination of the ERT and GPR data from the central quad in combination suggests that if the near surface resistivity greater than 100 Ohm m is typical of the overall ground then it should be overall good for wave propagation at 500 MHz and lower frequencies. However, both profiles within the central quad show surface regions with significantly lower resistivity and within the southern quad surface resistivity of less than 40 Ohm m; it may be no coincidence that here penetration is at its lowest. Low resistivity (high conductivity) soils are electromagnetically lossy due to the collapse of the electrical component of the electromagnetic wave and hence poor for GPR propagation.

The difference between penetration through paved and grassed areas (see DWG 09) may be relevant over and above the usual differences expected through variations in electromagnetic coupling within the 'near field zone' immediately beneath the antenna. To some extent this can be caused by different quantities of moisture within the surface soils, in turn affecting the ability of the antenna to couple with the ground. At this site, over soils assumed to be free draining, moisture alone seems unlikely to account for the difference in response.

Conversation with the University's Estate Services after survey suggested that a clay loam may be beneath the grass, based on observations made at other colleges, but this has not been confirmed here. If this is the case then maybe there would be sufficient clay to raise electrical conductivity and therefore limit penetration. Clayey materials have been used in the past to stabilise landscaping but here the better penetration below paved areas would suggest such material is limited to the grass sward.

Whether or not there is a significant proportion of clay within the surface soils, the maintenance regime of the grass sward is potentially another factor. The lawns are fed four or five times annually with a NPK fertiliser with an elemental ratio of 14:5:10 for applications except during the Autumn when one with a 6:5:10 ratio is used. Accumulating nitrates are known to reduce electrical resistivity although the dynamics of the mechanism in terms of GPR response are not fully understood (Leckebusch, *pers. comm.*). This, in combination with a certain proportion of clay and a not fully dry soil might account for the GPR result seen at this site and would help explain the differences between grass sward and paved areas.

The presence of high chargeability materials close to the surface (e.g. from 1 mbgl in profile 2) may independently confirm that soil chemistry is part of the problem and help explain why the lack of penetration is so marked in an ostensibly dry soil. As already observed, penetration is lowest in the southern quad and here surface materials reach a chargeability of 20 mV/V.

DWGs 10 and 11 show the location of major reflectors below the central and southern quads, dominated in the most part by numerous service trenches and on the west side by large service ducts. The relative paucity of reflections from any source below the grass swards illustrates the problems discussed above.

Where strong reflections exist below the grass areas, they can be correlated (in the central quad) with interfaces between soil and construction or demolition rubble seen in the boreholes.

3.1.9 Archaeology

The failure of the GPR to penetrate below 1mbgl has limited the effectiveness of this technique for mapping features of archaeological interest and hence the ground model suggested by the ERT is of greater importance to the overall result. The possible presence of an eastwards dipping ground level prior to the seventeenth century reconstruction of the college perhaps has interesting implications for understanding the potential for buried archaeology in eastern parts of the site and indeed, the development of the eastern range of buildings.

There are no indications anywhere within the data of possible Anglo-Saxon defensive structures and indeed, the ground model might suggest that they were located further east on what was presumably lower ground.

3.1.10 Services – method

A basic record of service covers and the direction of associated services was made to inform interpretation of the GPR result and to reveal where these may conflict with the boreholes planned by Oxford Archaeology. Due to the reasons already discussed, the GPR data is not here a reliable method for detecting services beneath the grassed areas and this is especially the case for those not made of metal.

All covers were lifted where possible although this was not attempted for sealed, weak or damaged examples. A couple (N35 and N40) of modern covers in the northern quad proved a combination of too heavy and jammed to be lifted by hand. Cover locations were either surveyed in using Network RTK GNSS or where this was not possible plotted by hand onto plans at 1:150. These two inputs are differentiated on the plans (see DWGs 12 to 14).

Considerable complexity was observed with various phases of covers and services evident. Most lay beneath the paved areas and beneath the western sides of the southern and central quads there are major concrete service ducts. Smaller others exist beneath the northern side of the southern quad and the southern side of the northern one.

Disclaimer: This is not a full detection survey but a basic visual reconnaissance and it is not intended to be PAS128 compliant. The complexity of services and evidence of substantial modification requires more intensive survey including electromagnetic and potentially dye-based tracing work before a reliable plan of interconnectivity could be achieved.

No services were seen within the area proposed for borehole investigation. An apparent extra one (Ben Ford, *pers. comm.*) found during test pit excavation in advance of a borehole may have been one already mapped by the GPR and perhaps in the vicinity of BH 8A although the exact location is not known to us.

3.2 Conclusions

Overall the ERT profiles have given an insight towards formation of a ground model for at least the central and southern quads. This includes a fairly accurate model of the depth of material above the natural gravel below the two quads and also how this appears to dip eastwards in the southern one. This in itself has implications for understanding former ground levels contemporary with earlier phases of the college but might also suggest that the palaeotopography has influenced the position of the Saxon town defences. There is no evidence for these within the geophysical data and this would support the suggestion that they were further downhill to the east than previously supposed.

The use of combined resistivity and chargeability during ERT survey has revealed lateral changes in the central quad likely indicative of different land use early in the history of the college, with a boundary implied at the northern extent of the two wings extending from the southern ranges.

3.3 Caveats

Geophysical survey is reliant upon the detection of anomalous values and patterns in physical properties of the ground, e.g. magnetic, electromagnetic, electrical, elastic, density and others. It does not directly detect underground features and structures and therefore the presence or absence of these within a geophysical interpretation is not a direct indicator of presence or absence in the ground. Specific points to consider are:

- some physical properties are time variant or mutually interdependent with others;
- for a buried feature to be detectable it must produce anomalous values of the physical property being measured;
- any anomaly is only as good as its contrast against background textures and noise within the data.

TigerGeo will always attempt to verify the accuracy and integrity of data it uses within a project but at all times its liability is by necessity limited to its own work and does not extend to third party data and information. Where work is undertaken to another party's specification any perceived failure of that specification to attain its objective remains the responsibility of the originator, TigerGeo meanwhile ensuring any possible shortcomings are addressed within the normal constraints upon resources.

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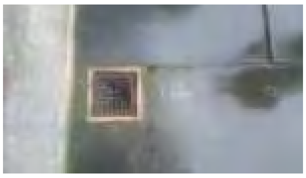
4 Catalogue of Service Covers

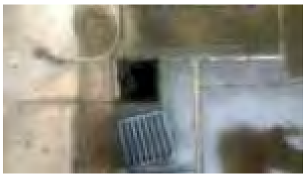
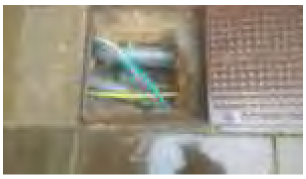
4.1 Southern quad

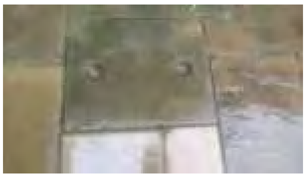
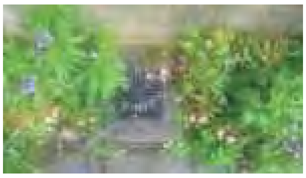
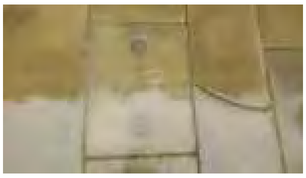
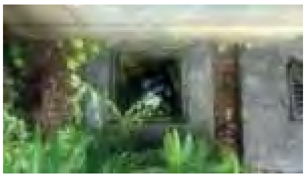
The locations of these are depicted on DWG 14.

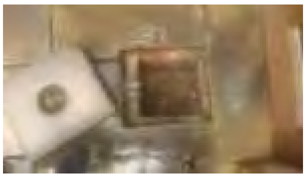
	Designation: S1 Photo orientation: East at top Cover: Grille Lifted: No Function: Drainage
	Designation: S2 Photo orientation: East at top Cover: Grille Lifted: No Function: Gully with blanked mains water riser
	Designation: S3 Photo orientation: North at top Cover: Flagstone Lifted: No – lifting pins rusted out Function: Presumed combined drainage
	Designation: S4 Photo orientation: South at top Cover: Grille Lifted: No Function: Rainwater drainage from roof

	Designation: S5 Photo orientation: North at top Cover: Grille Lifted: No Function: Apparently connected with drainage from roof / combined drainage
	Designation: S6 Photo orientation: North at top Cover: Flagstone Lifted: No – risk of damage to single lifting pin Function: Presumed stop cock over water main
	Designation: S7 Photo orientation: North at top Cover: Gully Lifted: Yes Function: Drainage from roof into combined drainage, pipework apparently parallel to wall
	Designation: S8 Photo orientation: North at top Cover: Grille Lifted: No Function: Drainage from roof
	Designation: S9 Photo orientation: North at top Cover: Grille Lifted: Yes Function: Not a service – reused flagstone

	Designation: S10 Photo orientation: North at top Cover: Flagstone Lifted: No – lifting pins rusted out Function: Presumed combined drainage
	Designation: S11 Photo orientation: North at top Cover: Flagstone Lifted: No – stone already damaged and risk of further Function: Presumed combined drainage
	Designation: S12 Photo orientation: North at top Cover: Grille Lifted: Yes Function: Drainage from roof with shallow additional pipe from west that may be combined drainage
	Designation: S13 Photo orientation: West at top Cover: N/A Lifted: N/A Function: Gas or water supply, retrofitted into masonry beside doorway
	Designation: S14 Photo orientation: North at top Cover: Grille Lifted: No Function: Surface drainage
	Designation: S15 Photo orientation: North at top Cover: Grille Lifted: Yes Function: Uncertain, overlies a gully at a different orientation

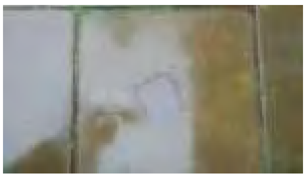
	Designation: S16 Photo orientation: North at top Cover: Cast iron Lifted: Yes Function: Cover over 415V junction, armoured cable passing northwards but vanishing with a couple of meters before duct accessed by S17. It is possible the cable has been deflected onto the floor of the duct
	Designation: S17 Photo orientation: North at top Cover: Cast iron Lifted: Yes Function: Access cover into large concrete duct containing a range of services including several district heating (insulated) pipes, plastic cable ducts, apparently redundant metal ducts and perhaps also a concealed 415V armoured cable. At this point the district heating pipes bend from west to north
	Designation: S18 Photo orientation: North at top Cover: Flagstone Lifted: Yes Function: Not a service – sand beneath
	Designation: S19 Photo orientation: North at top Cover: Grille Lifted: No Function: Surface drainage and gully for drainage from roof
	Designation: S20 Photo orientation: North at top Cover: Grille Lifted: Yes Function: Gully for drainage from roof
	Designation: S21 Photo orientation: North at top Cover: Cast iron Lifted: Yes Function: Retrofitted access into a small concrete duct containing plastic cable ducts, non-ducted cables, a possible plastic water main and district heating pipes running east to west and also southwards, probably to S17

	Designation: S22 Photo orientation: North at top Cover: Flagstone Lifted: No – lifting pins rusted out Function: Presumed combined drainage
	Designation: S23 Photo orientation: Cover: North at top Lifted: No Function: Gully for drainage from roof
	Designation: S24 Photo orientation: North at top Cover: Cast iron Lifted: Yes Function: Access into shallow concrete duct containing district heating pipes turning (with path) from south to east. Also a number of plastic cable ducts and loose cables including probable networking, other signal and perhaps mains power
	Designation: S25 Photo orientation: North at top Cover: Grille Lifted: No Function: Gully for drainage from roof
	Designation: S26 Photo orientation: North at top Cover: Cast iron Lifted: Yes Function: Fire hydrant, water supply from north
	Designation: S27 Photo orientation: North at top Cover: Flagstone Lifted: No – risk of damage Function: Presumed combined drainage
	Designation: S28 Photo orientation: North at top Cover: Grille Lifted: Yes Function: Combined drainage – rainwater from roof and small pipes entering from north (building) and east (S29?)
	Designation: S29 Photo orientation: North at top Cover: Grille Lifted: No Function: Gully for drainage from roof

No photo	Designation: S30 Photo orientation: N/A Cover: Grille Lifted: No Function: Gully for drainage from roof
	Designation: S31 Photo orientation: North at top Cover: Flagstone Lifted: Yes Function: Two stopcocks on water mains, one passing eastwards the other apparently southwards
	Designation: S32 Photo orientation: East Cover: N/A Lifted: N/A Function: Drainage from roof

4.2 Central quad

The locations of these are depicted on DWG 13.

	Designation: M1 Photo orientation: East at top Cover: None Lifted: N/A Function: drainage from roof
	Designation: M2 Photo orientation: North at top Cover: Grille Lifted: No Function: surface water drainage
	Designation: M3 Photo orientation: North at top Cover: Steel plate let into flagstone Lifted: No, not possible Function: Uncertain, maybe stopcock on water main?

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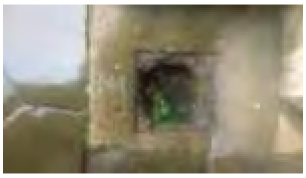
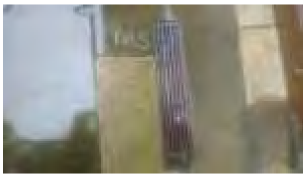
	Designation: M4 Photo orientation: North at top Cover: Grille Lifted: Yes Function: Choked / disused, surface water drainage
	Designation: M5 Photo orientation: North at top Cover: Grille Lifted: Yes Function: Surface water drainage
	Designation: M6 Photo orientation: South Cover: N/A Lifted: N/A Function: Rainwater drainage from roof
	Designation: M7 Photo orientation: North at top Cover: Cast iron Lifted: Yes Function: Combined drainage, inlets from east and southwest (from M8?), outlet apparently to south though channel also goes curves west
	Designation: M8 Photo orientation: North at top Cover: Grille Lifted: No Function: Surface water drainage

	Designation: M9 Photo orientation: North at top Cover: Grille Lifted: Yes Function: Surface water drainage
	Designation: M10 Photo orientation: West Cover: N/A Lifted: N/A Function: Rainwater drainage from roof
	Designation: M11 Photo orientation: North at top Cover: Cast iron Lifted: No, bars rusted out Function: May be combined drainage or alternatively over a well, there being a pump immediately adjacent
No photo	Designation: M12 Photo orientation: N/A Cover: Unseen Lifted: No, within bushes Function: Uncertain, could be rainwater drainage from roof
	Designation: M13 Photo orientation: North at top Cover: Cast iron Lifted: Yes Function: Access into concrete duct containing district heating pipes running north to south plus a 2” water main from the east with a stop cock and connected to a district heating pipe. Loose cables running with pipes north to south
No photo	Designation: M14 Photo orientation: N/A Cover: Grille Lifted: No Function: Rainwater drainage from roof

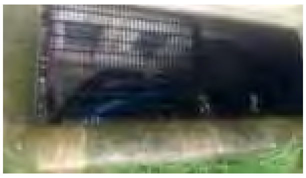
	Designation: M15 Photo orientation: North at top Cover: Steel plate Lifted: Yes Function: Stopcock on end of water main entering from the east
	Designation: M16 Photo orientation: North at top Cover: Cast iron Lifted: Yes Function: Combined drainage, channel aligned north – south, entry from west in southwest corner
	Designation: M17 Photo orientation: North at top Cover: Cast iron Lifted: Yes Function: Entry into concrete duct below path (see also M13) with plastic north – south water main tee'd off westwards, three mains cables, a plastic cable duct entering from the south and turning westwards. At the base of the duct are a number of district heating pipes entering from the south and turning west
	Designation: M18 Photo orientation: North at top Cover: Cast iron Lifted: Yes Function: Combined drainage exiting northwards with north – south channel with two entries from the west and possibly the same from the east (may not be in use). A shallow plastic pipe enters from the southwest
No photo	Designation: M19 Photo orientation: N/A Cover: N/A Lifted: No Function: Drainage, not accessible

No photo	Designation: M20 Photo orientation: N/A Cover: N/A Lifted: No Function: Drainage, not accessible
No photo	Designation: M21 Photo orientation: N/A Cover: Grille Lifted: No Function: Surface water drainage
	Designation: M22 Photo orientation: North at top Cover: Cast iron Lifted: No Function: Access to oil supply for boiler / underground oil tank?
	Designation: M23 Photo orientation: North at top Cover: Cast iron Lifted: No, buried in flower bed Function: Uncertain but probably combined drainage
	Designation: M24 Photo orientation: North at top Cover: Cast iron Lifted: Yes Function: Fire hydrant, water main enters from north
	Designation: M25 Photo orientation: North at top Cover: Steel Lifted: No, lugs rusted out Function: Uncertain, presumed combined drainage

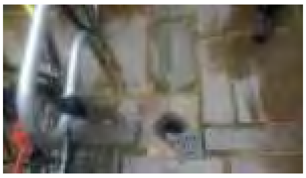
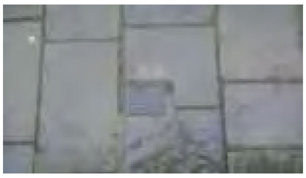
	Designation: M26 Photo orientation: North at top Cover: Cast iron 'Oxford Water' Lifted: Yes Function: Stop cock on water main aligned north - south
	Designation: M27 Photo orientation: North at top Cover: Plastic grille Lifted: Yes Function: Surface water drainage gully

4.3 Northern quad

The locations of these are depicted on DWG 14.

	Designation: N1 Photo orientation: North to top Cover: Grille Lifted: N/A Function: New installation within former basement access of district heating pipes, a plastic water main and various cables. All turn southwards at the west end
	Designation: N2 Photo orientation: North(?) to top Cover: Flagstone in steel frame Lifted: Yes Function: Combined drainage (specifically just sewer?), channel runs approximately east west with an entry from the south and five from the north, one from a shallow plastic soil pipe

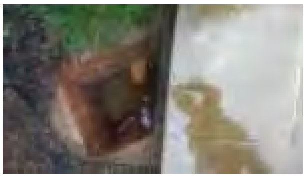
No photo	Designation: N3 Photo orientation: N/A Cover: N/A Lifted: No Function: Drainage
No photo	Designation: N4 Photo orientation: N/A Cover: N/A Lifted: No Function: Drainage
	Designation: N5 Photo orientation: North to top Cover: Flagstone in steel frame Lifted: Yes Function: Combined drainage, channel curves northwest to southwest, entry from east
No photo	Designation: N6 Photo orientation: N/A Cover: N/A Lifted: No Function: Rainwater drainage from roof
	Designation: N7 Photo orientation: North to top Cover: Grille Lifted: No Function: Surface water drainage
No photo	Designation: N8 Photo orientation: N/A Cover: Grille Lifted: No Function: Surface water drainage
	Designation: N9 Photo orientation: Northeast to top Cover: Flagstone in steel frame Lifted: Yes Function: Combined drainage, note recent cover offset relative to chamber beneath, largely blocking access. Deep level channel aligned roughly east to west

No photo	Designation: N10 Photo orientation: N/A Cover: Plastic Lifted: No Function: Rodding eye, aligned north south
	Designation: N11 Photo orientation: North to top Cover: Grille Lifted: Yes Function: Surface drain, formerly (like N26) at the corner of a grass plat. May be disused
	Designation: N12 Photo orientation: North to top Cover: Cast iron Lifted: Yes Function: Four district heating pipes (old style – lagged metal pipework – possible asbestos hazard) enter from the west and turn south
No photo	Designation: N13 Photo orientation: N/A Cover: Lifted: Function: Rainwater drainage from roof
	Designation: N14 Photo orientation: North to top Cover: Cast iron Lifted: No Function: Stop cock on water main?
	Designation: N15 Photo orientation: North to top Cover: Grille Lifted: Yes Function: Surface drainage gully, pipe enters from east, channel orientated east west
No photo	Designation: N16 Photo orientation: N/A Cover: Lifted: No Function: Unknown, close to and likely associated with N17
	Designation: N17 Photo orientation: North to top Cover: Cast iron Lifted: Yes Function: Combined drainage. A shallow plastic soil pipe enters from the west (likely from N22) and another inlet is from the east in the southeast corner. The exit channel is orientated roughly north south. Three more shallow inlets, one plastic, enter form the south.

	Designation: N18 Photo orientation: North to top Cover: Grille Lifted: No Function: Surface water drainage, connects with N17
	Designation: N19 Photo orientation: East to top Cover: N/A Lifted: N/A Function: Vertical pipe, no gully, likely connects with N17 or N18 (and thus with N17)
	Designation: N20 Photo orientation: North to top Cover: Flagstone Lifted: Yes Function: Reused inspection trap / gully, now has a pipe running east west through it that likely connects N22 and N17
	Designation: N21 Photo orientation: East to top Cover: N/A Lifted: N/A Function: Vertical pipe, no gully

	Designation: N22 Photo orientation: North to top Cover: Plastic Lifted: No Function: Inspection cover over likely bend in plastic sewer
	Designation: N23 Photo orientation: North to top Cover: None Lifted: N/A Function: Gully for rainwater drainage off roof
	N24 not used
	Designation: N25 Photo orientation: North to top Cover: Cast iron Lifted: Yes Function: See also N12 which may be connected. District heating pipes (old style – lagged metal pipework – possible asbestos hazard). Some enter from the west and turn north, others run north south and others east west
	Designation: N26 Photo orientation: North to top Cover: Grille Lifted: Yes Function: Surface water drainage at former corner of grass plat
No photo	Designation: N27 Photo orientation: N/A Cover: Lifted: No Function: Gully for drainage

	Designation: N28 Photo orientation: North to top Cover: Cast iron Lifted: No Function: Stop cock on water main? See also N14
	Designation: N29 Photo orientation: North to top Cover: Flagstone Lifted: Yes Function: Re-used flagstone, not a service
	Designation: N30 Photo orientation: North to top Cover: Cast iron Lifted: Yes Function: Stopcock on water main, orientation uncertain, possibly disused
	Designation: N31 Photo orientation: North to top Cover: Flagstone Lifted: Yes Function: Re-used flagstone, not a service

	Designation: N32 Photo orientation: North to top Cover: Cast iron Lifted: Yes Function: Fire hydrant, water main enters from the west
No photo	Designation: N33 Photo orientation: N/A Cover: Grille Lifted: No Function: Surface water drainage
	Designation: N34 Photo orientation: North to top Cover: Cast iron Lifted: Yes Function: Two stop cocks on a water main, pipe runs north south across a second lower down that may feed fire hydrant N32 to the east
	Designation: N35 Photo orientation: North to top Cover: Flagstones in steel frame Lifted: No Function: Presumed to overlay duct or combined drainage
	Designation: N36 Photo orientation: North to top Cover: Cast iron Lifted: Yes Function: Combined drainage, pit partly overlaid by new paving. A plastic soil pipe enters from the north and the exit channel curves southeast from the northeast with a further inlet from the southwest
No photo	Designation: N37 Photo orientation: N/A Cover: N/A Lifted: N/A Function: Pipe - rain water drainage from roof

No photo	Designation: N38 Photo orientation: N/A Cover: N/A Lifted: N/A Function: Pipe - rain water drainage from roof
	Designation: N39 Photo orientation: North to top Cover: Cast iron Lifted: Yes Function: Lead water main beneath
No photo	Designation: N40 Photo orientation: N/A Cover: Flagstones in steel frame Lifted: No Function: Presumed to overlay duct or combined drainage
No photo	Designation: N41 Photo orientation: N/A Cover: Grille Lifted: Yes Function: Surface water drainage

5 Methodology

5.1 Electrical Resistivity Tomography (ERT) Principles

5.1.1 Physical concepts

Electrical resistivity is the specific measure of a material's ability to limit the flow of electric current as different 'standard' materials have different resistivities. It is measured as electrical resistance but the data is converted to resistivity by incorporating the probe geometry into the process.

Within any material a variety of factors affect resistivity, including the chemistry of mineral components, the size and geometry of pore spaces, their degree of interconnection, to what extent they are water filled and whether the surface of the pore spaces are electro-chemically active. The latter reason is why clay has a lower resistivity than most rocks. The degree of hydraulic saturation is also a factor.

The resistivity of a material is expressed as a range, which overlap for different materials and hence a particular resistivity is rarely a definitive identifier of a specific material. For measurements made within soil there are strong temporal variations related to hydraulic properties but for those within deeper deposits these are less marked which means that technique has a strong application with shallow stratigraphic studies. A classic example is measuring the depth to chalk or clay beneath gravel deposits.

No physical variation exists in isolation and the patterns of electrical resistance observed at the surface relate not to individual structural variations but to the combination of all variations within the 3D electrical current path. Those variations with the greatest influence upon the current vector will be most manifest within the resistance measurement. As a consequence, closely spaced structures may not be separately resolved, their depth of burial will affect the result and likewise their penetration into the ground. Given adjacent pairs of structures or fills with opposing resistivity characteristics, only one may be resolved.

In some circumstances a second physical property, induced polarisation, can be measured at the same time. This is the chargeability, loosely the capacitance, of the ground and in conjunction with the resistivity can provide excellent diagnostic potential of individual materials. For example, the low resistivity and high chargeability of clay contrasts with the higher resistivity and low chargeability of sandstone. The figures below are taken from Telford *et al* (1990) and other sources.

Material	Resistivity	Chargeability
Fresh water	5 – 100 Ohm m	0 ms
Dry sand & gravel	50 - > 200 Ohm m	3 – 9 ms
Dry chalk	70 - 140 Ohm m	> 10 ms
Saturated gravel	0 – 50 Ohm m	0 ms
Clay	5 – 50 Ohm m	high
Alluvium	< 100 Ohm m	1 – 4 ms

5.1.2 Instrumentation

ERT instrumentation works by collecting a sequence of measurements across quadrupoles selected from within a long line of probes, for the Syscal Pro this normally being 72. The exact configuration of each quadrupole governs the region below the array to which the measurement is sensitised and also the 2D resolution of this measurement. For example a dipole-dipole array is sensitive to lateral changes while the Wenner is more sensitive to vertical ones. Other arrays allow different proportions of horizontal and vertical sensitivity to be combined and in practice the Wenner Schlumberger array is commonly used. Increased distance between the two potential probes within each quadrupole allows the measurement to be sensitised to increased depths.

By selecting an appropriate array type, the number of quadrupoles and their sequence of deployment it is possible to build a resistivity profile through the ground along the line of the probes. However, this is apparent resistivity and not the actual distribution of resistivity in the ground. To achieve the latter, inversion (see processing, below) is needed, which attempts to develop a physical model that would create the same apparent resistivity profile as the one measured. This inverse problem is non-unique; different physical distributions of material and hence resistivity can create the same apparent resistivity profile.

As will all electrical techniques, strong surface variations will tend to impact upon measurements from greater depth and hence care is needed to reduce contact resistance at each probe. Adverse weather conditions can limit the effectiveness of the technique.

5.2 Electrical Resistivity Tomography (ERT) Survey

5.2.1 Technical equipment

Measured variable	Apparent resistivity / Ohm m, induced polarisation / mV/V
Instrument	IRIS Instruments Syscal Pro
Array	26-32 probes at 1.0 m separation (profiles 1-4) and 0.5 m separation (profile 5) Wenner Schlumberger array
Instrument configuration	0.5s pulse length, IP on
Sensitivity	1 micro-Volt / 0.2%
QA Procedure	Limits upon variation and maximum resistance set within switching sequence, further checks within software upon processing

5.2.2 Monitoring & quality assessment

All data is recorded and hence can be independently assessed. At the start of each measurement sequence the contact resistance between pairs of probes is automatically checked and any pair with a combined resistance greater than 2 KOhm is reset and checked again until the problem is resolved. Once a sequence is running, periodic checks on the instrument is all that is necessary.

More detailed quality assessment is undertaken during processing.

5.3 Electrical Resistivity Tomography (ERT) Data Processing

5.3.1 Procedure

Where necessary single point outliers within the data and the effects of probes making poor electrical contact with the ground are removed. Topographic correction may also be applied which repositions the probes in 3D space and adjusts the measured resistivity values to account for the consequential variations in inter-probe distance.

Data inversion, i.e. construction of a physical model of ground resistivity that will reproduce the actual measured data, is undertaken using Loke's Res2DInv program which is industry standard for this sort of work. This is controlled by a large number of parameters, but the modelling process generally uses the finite element method with block widths equal to the probe spacing and incomplete Gauss-Newton optimisation. Four inversion nodes tend to be used per unit probe spacing and slight suppression of model side blocks when computing the apparent resistivity for comparison with the original measured data may be applied and especially on short profiles. Where strong variations exist, robust constraint of data and model values may be used. The full set of relevant parameters are listed below.

Visual inspection of the model and comparison of the actual measured data with that calculated from the model allow assessment of realism, combined with what else may be known about the site, e.g. the depth of specific soil or rock units that have limited resistivity values. Model sensitivity is also assessed and inspected to determine to what extent the model is limited near its edges and at depth.

Parameter of inversion within RES2DInv	**Value**
Initial damping factor	0.16
Minimum damping factor	0.02
Line search option	2
Convergence limit	5
Minimum change in RMS error	0.4
Number of iterations	5
Vertical to horizontal flatness filter ratio	1
Model for increase in thickness of layers (0=default 10, 1=default 25, 2=user defined)	2
Number of nodes between adjacent electrodes	4
Flatness filter type (include smoothing of model resistivity)	1
Reduce number of topographical datum points?	no
Carry out topography modelling?	no
Type of topography trend removal	1
Type of Jacobian matrix calculation	1
Increase of damping factor with depth	1.05
Type of topographical modelling	0
Robust data constrain?	0
Cut-off factor for data constrain	0.05
Robust model constrain?	0
Cut-off factor for model constrain	0.01
Allow number of model parameters to exceed datum points?	1
Use extended model?	0
Reduce effect of side blocks?	2
Type of mesh	2
Optimise damping factor?	1
Time-lapse inversion constrain	0
Type of time-lapse inversion method	0
Thickness of first layer	0.5
Factor to increase thickness layer with depth	1
Use finite element method	no
Width of blocks	normal
Make sure blocks have the same width	yes
RMS Convergence limit / %	1

Parameter of inversion within RES2DInv	**Value**
Use logarithm of apparent resistivity	yes
IP Damping factor	0.1
Use automatic IP damping factor	no
Limit resistivity values	yes
Upper limit factor (10-50)	50
Lower limit factor (0.02 to 0.1)	0.02
Type of reference resistivity	average
Model refinement	0.5
Combined Combined Marquardt and Occam inversion	no
Type of optimisation method	Gauss-Newton
Convergence limit for Incomplete Gauss-Newton method	0.01
Use data compression with Incomplete Gauss-Newton	no
Use reference model in inversion	no
Damping factor for reference model	0.05
Use fast method to calculate Jacobian matrix	yes
Use higher damping for first layer	no
Extra damping factor for first layer	2.5
Type of finite-element method	Triangular
Factor to increase model depth range (1.0 to 5.0)	1

5.4 Electrical Resistivity Tomography (ERT) Interpretation

5.4.1 Inversion

The data collected is a pseudosection, a 2D sequence of measurements assigned to positions in space based on overall probe array geometry. At this stage it is not a cross section of resistivity distribution within the ground and this has to be generated through 'inversion', iterative forward and backward modelling. The process seeks to reproduce from a model of physical resistivity distribution the same 2D sequence as measured. The process is non-unique: slightly different physical distributions can produce the same pseudo-section and it is up to the interpreter to determine whether the model is realistic. This is partly guided by model sensitivity data provided by the process and partly by prior of knowledge of what is and is not acceptable, e.g. from other sources of stratigraphic data.

Interpretation then proceeds from the modelled resistivity distribution and also the induced polarisation or chargeability distribution if this exists. The resistivity (and chargeability) values are diagnostic of certain material classes, within constraints imposed by hydrology, etc. and from these the profile can be interpreted in terms of stratigraphy.

Parametric control of the inversion process is non-trivial and needs to be matched both to the data collected and the expected physical characteristics of the ground. Variation of these parameters can result in markedly different models and especially in regions of weak physical contrast.

5.5 Ground Penetrating Radar (GPR) Principles

5.5.1 Physical concepts

The strength of a reflection is proportional to the dielectric permittivity contrast between the materials the electromagnetic wave passes through. This property is governed by the electrical and magnetic properties of the material at high frequencies; these are often different from what would be measured by low frequency or passive techniques like electrical resistance or magnetic surveying. The highest contrasts are generally between air and other materials.

Each recorded reflection is the result of an interaction between the wavelength of the wave and the physical dimensions of the object and the strength is a measure of the difference in dielectric permittivity vertically within one quarter of the wavelength. It thus does not respond differently to different materials but to the differences between them, different therefore from electrical methods which respond to the actual materials.

A deposit or material that continually varies internally will continue to produce reflections whereas a uniform material will produce reflections only at its edges. Like light, the high radio frequencies used for radar mean that the beam can be multiply reflected and refracted. For these reasons, a profile of radar data is never a direct model of the distribution of materials in the ground.

Ground that is electrically conductive, so clay-rich or wet, will allow the electrical part of the wave induced in the ground to ebb away, preventing regeneration of the wave and hence its penetration into the ground. Dry ground (including dried-out clay) is therefore much more likely to produce useful results.

Radio waves cannot penetrate metal and any metal structure in the ground will cast a shadow over deeper deposits. In addition, a reverberation is likely to occur between the object, the ground surface and any interfaces in between and these echoes then appear as multiples below (i.e. later in time) the original object. Within voids wave propagation velocity increases to near the speed of light, i.e. significantly faster than within the surrounding ground. This can lead to distortion of the GPR profile, with deeper reflectors below the void appearing much closer to the surface than in reality. Voids also tend to create strong internal reflections due to reverberation at the interface between air and the containing structure.

5.5.2 Instrumentation and configuration

TigerGeo normally uses GPR manufactured by UTSI Electronics, either the GroundVue 3-8 with an array of antennas or the Trivue with three frequencies operating together (250, 500 and 1000 MHz). Both instruments are of pulsed shielded bowtie configuration.

The advantage of using multiple frequencies is that a mix of depth of investigation and resolutions is available, the lower the frequency the greater the penetration. Resolution is dependent upon wavelength (inversely proportional to frequency) so the higher the frequency the greater the resolution. However, a 1000 MHz system will penetrate at most 1m and usually less, whereas a 250 MHz system will normally penetrate 3-4m in 'normal' northern European soils and deeper in sand or peat.

Resolution in this context is primarily vertical, although there is also some lateral loss of resolution as the wavelength increases. Critically, the vertical resolution is limited to one quarter of the wavelength and to discriminate both the upper and lower interfaces of a stratum this needs to be at least one half a wavelength thick. If specific targets are sought, the instrumentation and specifically the wavelength used needs to account for the dimensions of these otherwise the survey will fail.

Depths in radar survey are expressed in terms of the length of time taken for a wave to travel to a reflective interface and to return to the antenna. To convert this time to depth, the velocity of the wave needs to be determined and this can vary throughout the ground, although often a median estimate can be formed and used overall.

Frequency	**Material / RDP**	**Vertical resolution (¼ wavelength)**	**Lateral resolution at 1m depth**
500 MHz	Average soil / 9	0.05 m	0.32 m
1000 MHz	Average soil / 9	0.03 m	0.23 m
500 MHz	Dry sand / 5	0.07 m	0.37 m
250 MHz	Dry sand / 5	0.13 m	0.54 m
500 MHz	Dry loamy soil / 6	0.06 m	0.36 m
500 MHz	Wet loamy soil / 15	0.04 m	0.28 m
250 MHz	Wet loamy soil / 15	0.08 m	0.40 m

Source: http://www.gpr-parameters.ch/parameters.php

5.6 Ground Penetrating Radar (GPR) Survey

5.6.1 Technical equipment

Measured variable	Strength of reflected pulse, unit-less variable
Instrument	UTSI Electronics Trivue
Antennas	250 MHz / 500 MHz / 1000 MHz
Configuration	512 samples / trace, time window = 100 ns (250 MHz), 60 ns (500 MHz) and 20 ns (1000 MHz) no stacking or other filters at acquisition
QA Procedure	Continuous observation, examination of stationary traces and statistical examination of sets of profiles
Spatial resolution	Trace separation 0.015 m, line (profile) separation 0.5 m

5.6.2 Monitoring & quality assessment

The radar system has a wide ranging set of adjustable parameters, including the time window within which reflections are listened for, the gain (variable across the duration of the window), the time after transmission at which the window starts etc. The correct choice of these is governed by the central frequency of the antenna in use (and hence vertical resolution and penetration), ground conditions and the depth of investigation. Ground conditions tend to vary across a site so once an appropriate set up has been generated this is checked at various locations before survey is started and adjusted if necessary.

All data is recorded and hence can be independently assessed.

5.7 Ground Penetrating Radar (GPR) Data Processing

5.7.1 Procedure

Data processing is minimised and limited to what is essential to extract meaning from the data or necessary to correct or enhance certain characteristics to support interpretation. Reflections are recorded relative to time after pulse transmission and hence the depth measure is actually time, not metres. An approximate conversion to depth is possible by applying an average velocity to the wave; this is best calculated from analysis of the data itself. A more detailed model allows for variations in velocity with depth and across the site.

Processing of GPR data is undertaken within Reflex 3D software and proprietary applications and data is visualised within Manifold GIS for 2D, e.g. time (amplitude) slices and Golden Software's Voxler for 3D.

Normal processing includes adjustment of the zero time (ground surface) and suppression of low frequency noise from the antenna (de-wow). These core processes are followed by others depending upon the character of the data, including bandpass filtering to reject external electromagnetic interference, background removal to suppress ringing effects and re-gaining to optimise signal strength throughout useful regions of the profile.

A mixture of manual and automatic picking procedures are then deployed upon the data to extract relevant reflections as vector data in time and space. These are then assembled into a 3D CAD model to support further interpretation.

If the data is to be time-sliced, further processes are required, principally the collapse of hyperbola to point sources (migration) if a constant wave velocity can be assumed, application of a down-trace lowpass filter to reduce random noise, especially in the deeper regions, and finally calculation of a unipolar amplitude envelope for each vertical trace. To support time slice and similar 2D visualisations, as well as visualisation of 3D amplitude distribution, the amplitude envelopes are stacked together and then interpolated in 3D to form a prism. The exact process depends upon the software used.

5.7.2 Processing for this project

Process	Software	Parameters
Time zero correction	Reflex 3D	Zero crossing point of first bipolar return
Dewow	Reflex 3D	Time window 500 MHz: 5 ns 250 MHz: 10 ns
Background removal	Reflex 3D	Whole traverse
Gain (manual, y)	Reflex 3D	500 MHz: 0 ns: -5 dB, 5 ns: 2 dB, 20 ns: 15 dB, 40 ns: 25 dB 250 MHz: 0 ns: 0 dB, 10 ns: 10 dB, 30 ns: 20 dB, 60 ns: 25 dB
Bandpass filter (Butterworth)	Reflex 3D	500 MHz: 0 - 1000 MHz 250 Mz: 0 - 500 MHz
Stacking	Reflex 3D	Method: Running average (3)
Velocity analysis	Reflex 3D	Hyperbola fitting (500 MHz) Northern quad: 0.0920 m/ns Middle quad: 0.0795 m/ns Southern quad: 0.0870 m/ns
Migration	Reflex 3D	fk (Stolt) using the velocity for each quad
Profile picking	Reflex 3D	
3D CAD generation	Proprietary / Manifold	

Velocities were picked on several profiles from all three quads and a median for each quad calculated. The selected points varied from approximately 4 to 22 ns (two way travel time), resulting in calculated depths of between 0.14 and 0.98 m. Notably few hyperbola were below the grass areas, so these picked velocities nearly entirely represent the paved areas.

In order to estimate a relevant velocity for the grass area, an example profile (208) of the 500 MHz data was investigated. This profile was re-gained beyond normal display levels, to show individual positive and negative signal swings, enabling correlation of a weak-ish reflecting interface beneath the grass with one under the paving. At the median velocity for the southern quad (velocity picks of hyperbola almost exclusively from under the paved area) of 0.087 m/ns, this strata lies at 0.34 mbgl (7.82 ns). If the strata under the grass (13.08 ns) is at the same physical level, the velocity for the region above it must be 0.0870 * 7.82 / 13.08 = 0.052 m/ns. This particularly low velocity is indicative of saturated silt or particularly wet soil, rather than damp soils.

5.8 Ground Penetrating Radar (GPR) Interpretation

5.8.1 Introduction

GPR interpretation is rarely undertaken in a contextual vacuum as the technique it is best deployed to seek specific targets rather than as a pure prospecting technique, not least because the data can easily be especially complex within inhomogeneous ground. This being the case, the interpretation process will often concentrate upon the expected targets and sometimes, depending upon the context of the survey, ignore the rest. For stratigraphic studies, recognition of the strata is more important than processing the detail within each unit, whereas for utilities mapping recognition of individual hyperbolic reflections as instances of of a particular service is the primary objective.

In general, three types of reflection are recognisable:

- hyperbolic point reflectors;
- discrete reflections with width;
- interfaces, e.g. surfaces.

Any combination of these can and usually is present and it is this combination that can render GPR particularly complex in some settings, e.g. historic urban centres where services share space with former foundations, filled areas, surfaces and modified natural deposits. For this reason, there are different strands to processing and interpretation to allow specific aspects of the data to be explored. In some circumstances interpretation may proceed entirely from profile data but in others lateral changes and patterning may be more important and sought using amplitude slicing techniques.

Regardless of approach, there is a need to convert time depth to real depth for this a wave velocity needs to be determined. Practically this is done using hyperbola fitting at several locations within the data, generating a series of relative dielectric permittivity (RDP) estimates and hence velocities. From these a median can be computed and used to convert time to depth across the survey, if this is sufficiently small and the velocities constrained within a sufficiently narrow range. If not, then piece-wise conversions need to be applied.

5.8.2 Procedures

Practically interpretation uses two main techniques of data visualisation, profile picking and time (amplitude) slice generation. The first relies upon the identification of individual relevant reflections within the profile data, e.g. hyperbolas or interfaces and digitising them into 3D space for construction of a model. The second combines the profiles into a stack (hence the terms 'pre-stack' and 'post-stack' analysis) by computing an amplitude envelope for each and interpolating laterally. These amplitude slices create pseudo-plans of waveform amplitude at a particular depth, i.e. the spatial variation of dielectric permittivity within the thickness of a slice.

Together, these two approaches normally describe the data set sufficiently well for a wide range of interpretive agendas and are often used together as they tend to reveal quiet different aspects. For archaeological projects, time slices are often good at revealing subtle lateral variations within the soil, whereas for utilities and animal burrows the 3D pick is normally better.

If using time slices the hyperbolic reflections associated with point (and edge) reflectors need to be collapsed as they are artefacts of survey and do not represent the plan form of the reflector itself. For this, a migration process is used and this requires accurate knowledge of the wave velocity to function correctly. Sometimes this and conversion to depth are the same function. This not only reduces the lateral complexity of the data but also recovers some of the resolution along each profile which is otherwise lost through the spreading of the reflection with depth.

Time slices can themselves be processed and viewed, within reason, like other forms of planar data, e.g. electrical conductivity.

5.9 Glossary

Acronym / term	Type	Definition
A	Physical quantity	SI unit Amp of electric current
BGS	Organisation	British Geological Survey
CIfA	Organisation	Chartered Institute for Archaeologists
dB	Physical quantity	Decibel, unit of amplification / attenuation
DRM	Process	Depositional Remanent Magnetisation
EAGE	Organisation	European Association of Geoscientists and Engineers
EGNOS	Technology	European Geostationary Navigation Overlay Service
ERT	Technology	Electrical resistivity tomography
ETRS89	Technology	European Terrestrial Reference System (defined 1989)
ETSI	Organisation	European Telecommunications Standards Institute
EuroGPR	Organisation	European Ground Penetrating Radar Association, the trade body for GPR professionals
G-BASE	Data	British Geological Survey Geochemical Atlas
GeolSoc	Organisation	Geological Society of London, the chartered body for the geological profession
GNSS	Technology	Global Navigation Satellite System
GPR	Technology	Ground penetrating radar
GPS	Technology	Global Positioning System (US)

Acronym / term	Type	Definition
inversion	process	A combination of forward and backward modelling intended to construct a 2D or 3D model of the physical distribution of a variable from data measured on a 1D or 2D surface. It is fundamental to ERT survey
IP	Physical quantity	Induced polarisation (or chargeability) units mV/V or ms
m	Physical quantity	SI unit metres of distance
mbgl	Physical quantity	Metres below ground level
MHz	Physical quantity	SI unit mega-Hertz of frequency
MS	Physical quantity	Magnetic susceptibility, unitless
mS	Physical quantity	SI unit milli-Siemens of electrical conductivity
nT	Physical quantity	SI unit nano-Tesla of magnetic flux density
OFCOM	Organisation	The Office of Communications, the UK radio spectrum regulator
Ohm	Physical quantity	SI unit Ohm of electrical resistance
OS	Organisation	Ordnance Survey of Great Britain
OSGB36	Data	The OS national grid (Great Britain)
OSTN15	Technology	Current coordinate transformation from ETRS89 to OSGB36 co-ordinates
RDP	Physical quantity	Relative Dielectric Permittivity, unitless
RTK	Technology	Real Time Kinematic (correction of GNSS position from a base station)
s	Physical quantity	SI unit seconds of time
TMI	Physical quantity	Total magnetic intensity (measured flux density minus regional flux density)
TRM	Process	Thermo-Remanent Magnetisation
V	Physical quantity	SI unit Volt of electric potential
WGS84	Data	World Geodetic System (defined 1984)

5.10 Selected reference

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5.11 Archiving and dissemination

An archive is maintained for all projects, access to which is permitted for research purposes. Copyright and intellectual property rights are retained by TigerGeo on all material it has produced, the client having full licence to use such material as benefits their project. Where required, digital data and a copy of the report can be archived in a suitable repository, e.g. the Archaeology Data Service, in addition to our own archive.

The archive contains all survey and project data, communications, field notes, reports and other related material including copies of third party data (e.g. CAD mapping, etc.) in digital form. Many are in proprietary formats while report components are available in PDF format.

The client will determine the distribution path for reporting, including to the end client, other contractors, local authority etc., and will determine the timetable for upload of the project report to the OASIS Grey Literature library or supply of report or data to other archiving services, taking into account end client confidentiality.

TigerGeo reserves the right to display data rendered anonymous and un-locatable on its website and in other marketing or research publications.

6 Supporting information

6.1 Standards and quality (archaeology)

TigerGeo is developing an Integrated Management System (IMS) towards ISO certification for ISO9001, ISO14001 and OHSAS18001/ISO45001 and has appointed Alan Ward of Bigfoot Services Limited as our ISO/HSE Technical Advisor. For work within the archaeological sector TigerGeo has been awarded CIfA (Chartered Institute for Archaeologists) Registered Organisation status.

A high standard of client-centred professionalism is maintained in accordance with the requirements of relevant professional bodies including the Geological Society of London (GeolSoc) and the Chartered Institute for Archaeologists (CIfA). Senior members of TigerGeo are professional members of the GeolSoc (FGS), CIfA (MCIfA & ACIfA grades) and other appropriate bodies, including the European Association of Geoscientists and Engineers (EAGE) Near Surface Division (MEAGE) and the Institute of Professional Soil Scientists (MISoilSci).

In addition TigerGeo is a member of EuroGPR and all ground penetrating and other radar work is in accordance with ETSI EG 202 730.

The management team at TigerGeo have over 30 years of combined experience of near surface geophysical project design, survey, interpretation and reporting, based across a wide range of shallow geological contexts. Added to this is the considerable experience of our lead geophysicists in a variety of commercial and academic roles. All geophysical staff have graduate and in many cases also post-graduate relevant qualifications pertaining to environmental geophysics from recognised centres of academic excellence.

During fieldwork there is always a fully qualified (to graduate or post-graduate level) supervisory geophysicist leading a team of other geophysicists and geophysical technicians, all of whom are trained and competent with the equipment they are working with. Data processing and interpretation is carried out by a suitably qualified and experienced geophysicist under the direct supervision and guidance of the Senior Geophysicist. All work is monitored and reviewed throughout by the Senior Geophysicist who will appraise all stages of a project as it progresses.

Data processing and interpretation adheres to the scientific principles of objectiveness and logical consistency. A standard set of approved external sources of information, e.g. from the British Geological Survey, the Ordnance Survey and similar sources of data, in addition to previous TigerGeo projects, guide the interpretive process. Due attention is paid to the technical constraints of method, resolution, contrast and other geophysical factors.

There is a strong culture of internal peer-review within TigerGeo, for example, all reports pass through a process of authorship, technical review and finally proof-reading before release to the client. Technical queries resulting from TigerGeo's work are reviewed by the Senior Geophysicist to ensure uniformity of response prior to implementing any edits, etc.

Work is undertaken in accordance with the high professional standards and technical competence expected by the Geological Society of London and the European Association of Geoscientists and Engineers.

All work for archaeological projects is also conducted in accordance with the following standards and guidance:

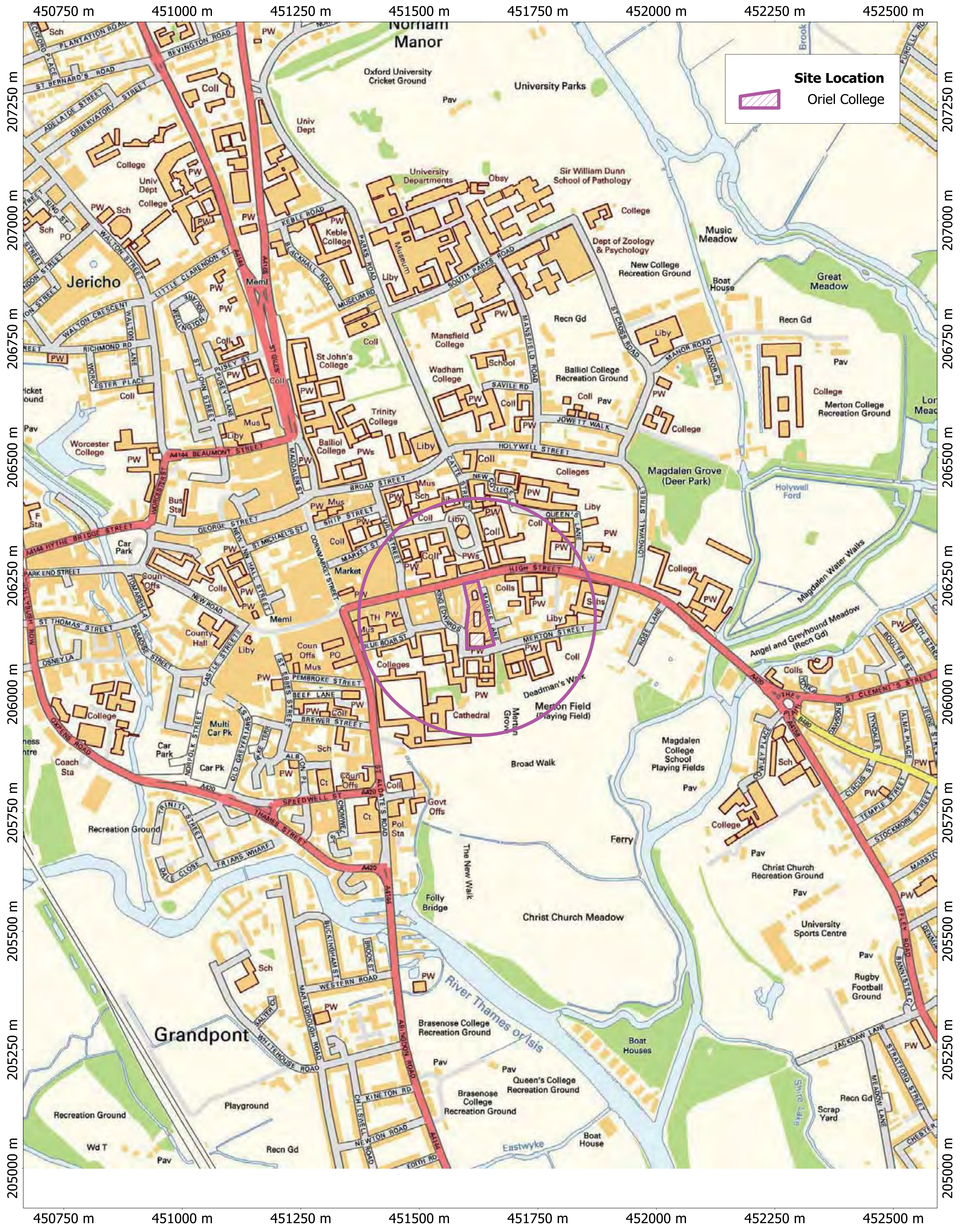
- David et al, "Geophysical Survey in Archaeological Field Evaluation", English Heritage, 2008;
- "Standard and guidance for Archaeological Geophysical survey", Chartered Institute for Archaeologists, 2014 (Updated 2016);

and TigerGeo meets with ease the requirements of English Heritage in their 2008 Guidance "Geophysical Survey in Archaeological Field Evaluation" section 2.8 entitled "Competence of survey personnel".

6.2 Key personnel

Senior Geophysicist (Quality manager)	Martin Roseveare MSc BSc(Hons) MEAGE FGS MCIfA
Martin specialised (MSc) in geophysical prospection for shallow applications and since 1997 has worked in commercial geophysics. Elected a GeolSoc Fellow in 2009 he is now working towards achieving CSci. A member of the European Association of Geoscientists & Engineers, he has served on the EuroGPR and CIfA GeoSIG committees and on the scientific committees of the 10th and 11th Archaeological Prospection conferences. He has reviewed papers for the EAGE Near Surface conference, was a technical reviewer of the Irish NRA geophysical guidance and is a founding member of the ISSGAP soils group. Professional interests include the application of geophysics to agriculture and the environment, e.g. groundwater and geohazards. He is also a software writer and equipment integrator with significant experience of embedded systems.	
Operations Manager (Safety manager)	Anne Roseveare BEng(Hons) DIS MISoilSci
On looking beyond engineering, Anne turned her attention to environmental monitoring and geophysics. She is a Member of the British Society of Soil Science (BSSS) and has specific areas of interest in soil physics & hydrology, agricultural applications and industrial sites. Amongst other contributions to the archaeological geophysics sector over the last 18 years, Anne was the founding Editor of the International Society for Archaeological Prospection (ISAP) and is a founding member of the ISSGAP soils group. Specifications, logistics, safety, data handling & analysis are integral parts of her work, though she is happily distracted by the possibilities of discovering lost cities, hillwalking and good food.	
Archaeological Consultant	Daniel Lewis MA BA(Hons) ACIfA
Daniel studied archaeology at the University of Nottingham and worked in field archaeology for many years, managing urban and rural fieldwork projects in and around Herefordshire. When the desk became more appealing he jumped into the world of consulting, working on small and large multi-discipline projects throughout England and Wales. At the same time, he returned to University, gaining an MA in Historic Environment Conservation. With over 15 years' experience in the heritage sector, Daniel has a diverse portfolio of skills. Here he ensures that geophysical work within the heritage sector is well grounded in the archaeology. His spare time includes much running up mountains.	
Environmental Geophysicist	Kathryn Cunningham BSc(Hons) FGS
Kathryn has been with TigerGeo since its inception and has undertaken over 100 surveys comprising total field magnetometry, twin probe resistivity, electrical resistance tomography, ground penetrating radar and laser-scanning. Her particular role is to ensure all aspects of fieldwork run smoothly, including site-specific paperwork, liaison, internal auditing and risk assessment. In addition she has increasing responsibilities in data processing and interpretation. She graduated with a BSc (Hons) in Applied Geology in 2015 from the University of Plymouth, is a Fellow of the Geological Society and enjoys acrobatics and sunny days.	
Environmental Geophysicist	Jack Wild BSc(Hons) FGS
Down to earth and a Plymouth University graduate in geology Jack entered the world of shallow geophysics with an Atkinson Leapfrog. Happiest when in the field he has undertaken geological projects Europe wide including in Sicily and the Spanish Pyrenees and closer to home has studied much of the Cornish and Devon coast. The mystery of what lies below drives his interest in the collection and interpretation of high quality data - be it from magnetometry or GPR he just cannot resist(ivity)! Jack is a Fellow of the Geological Society.	
Engineering Geophysicist	Toby Collins BSc(Hons)

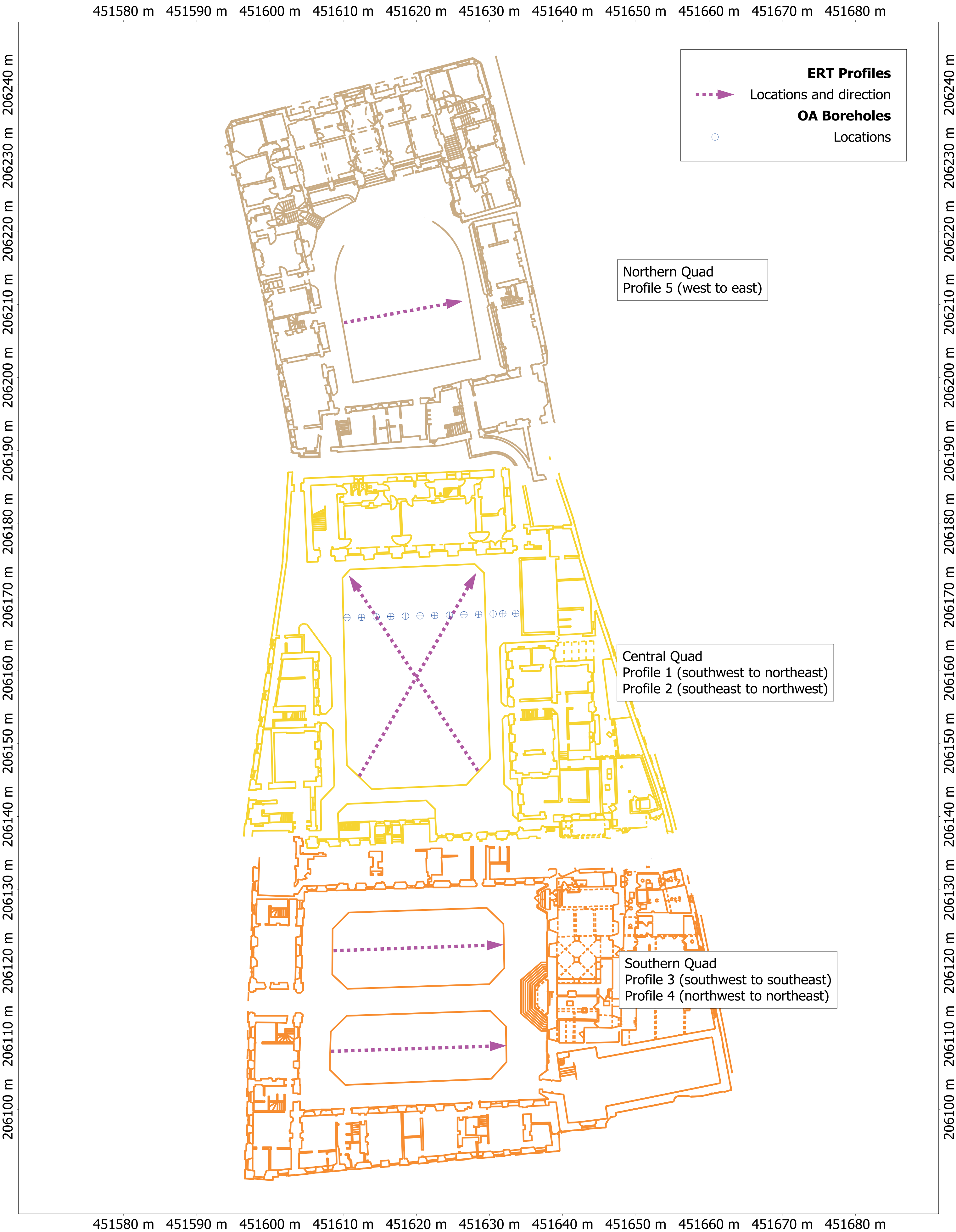
Toby studied a degree in Engineering Geology and Geotechnics at the Camborne School of Mines in Cornwall. Since completing this he has spent eight years working in a range of underground metalliferous mines in Australia as a Geotechnical Engineer. This covered three states and a range of precious and base metal mines. Involving everything from data collection and interpretation through to ground support design and mine sequencing \ scheduling. He has recently returned to the UK to pursue an ongoing career in geotechnics and geophysics. Outside of work he enjoys being outside, whether that be walking in the British uplands or climbing on the Cornish sea cliffs.



OCQ161 Oriel College Quads, Oxford
DWG 01 Site Location

Orthographic Scale: 1:10000 @ A4 Spatial Units: Meter. Do not scale off this drawing - map base approximate

TIGERGEO



OCQ161 Oriel College Quads, Oxford

DWG 02 ERT Profile Locations

Orthographic Scale: 1:650 @ A4 Spatial Units: Meter. Do not scale off this drawing - map base approximate

File: OCQ.map Base Mapping from Oriel College

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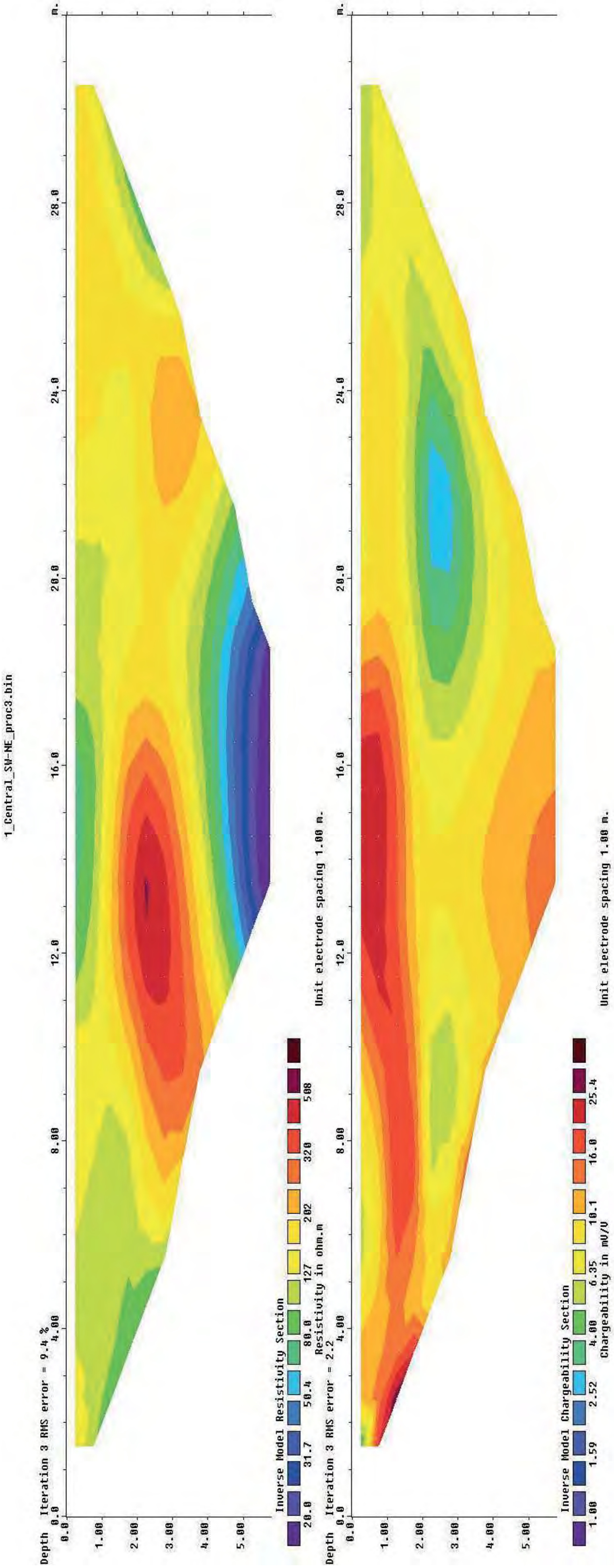

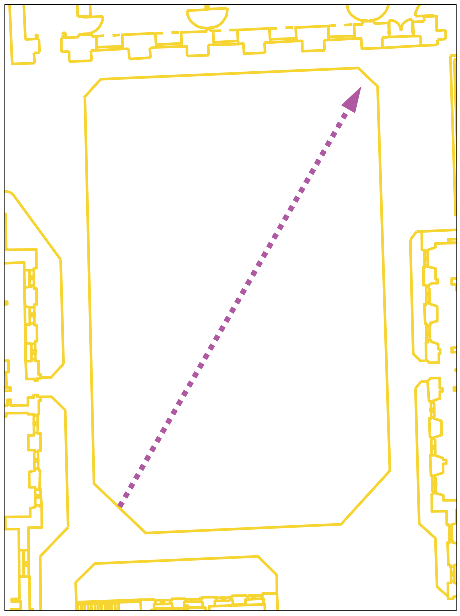

OCQ161 Oriel College Quads, Oxford

DWG 03 ERT Profile 1 - Central Quad - Model Resistivity and Chargeability

Do not scale off this drawing

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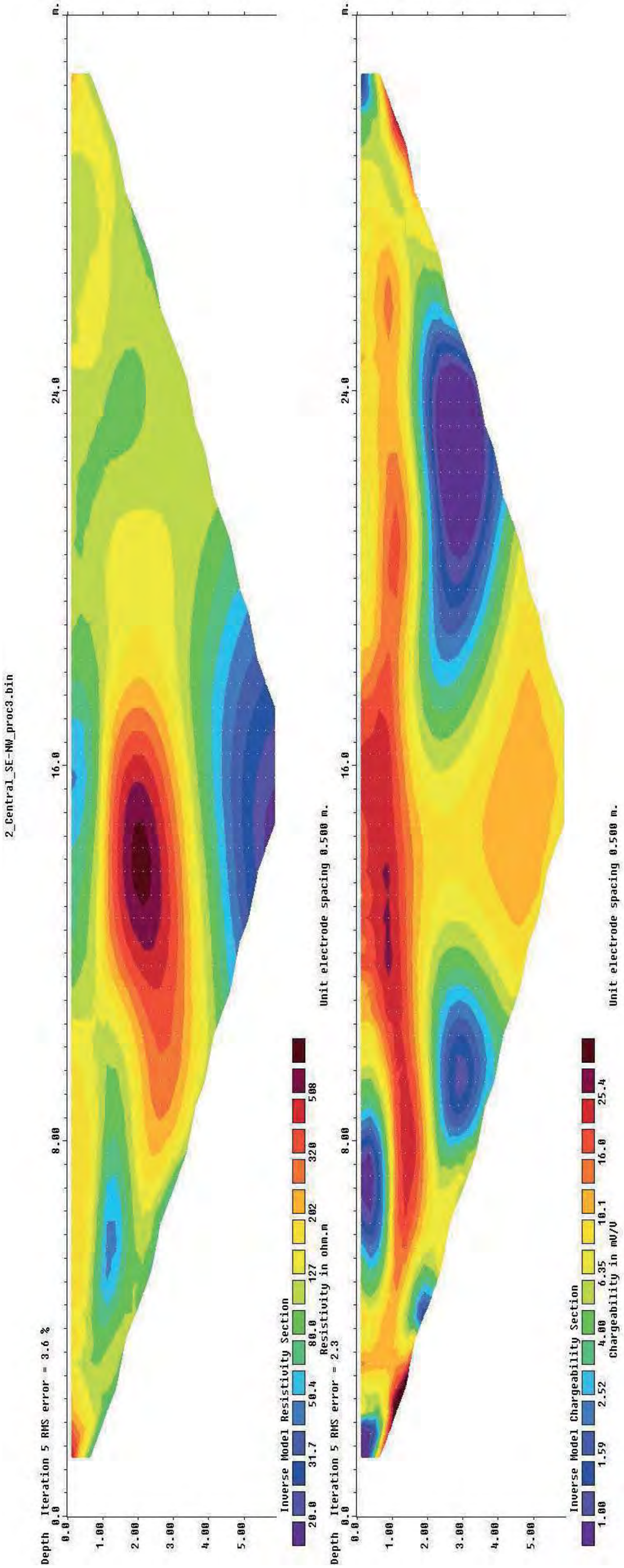

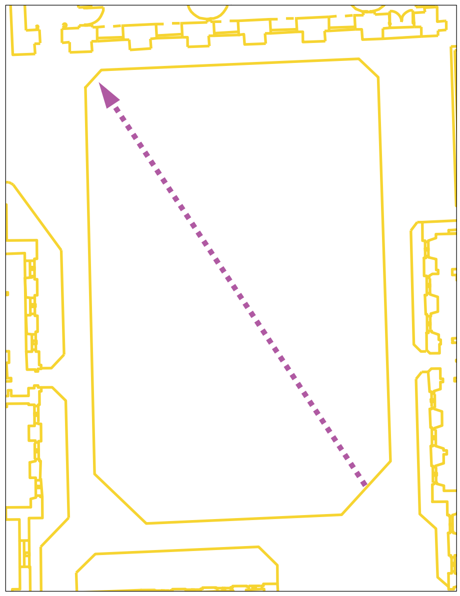

OCQ161 Oriel College Quads, Oxford

DWG 04 ERT Profile 2 - Central Quad - Model Resistivity and Chargeability

Do not scale off this drawing

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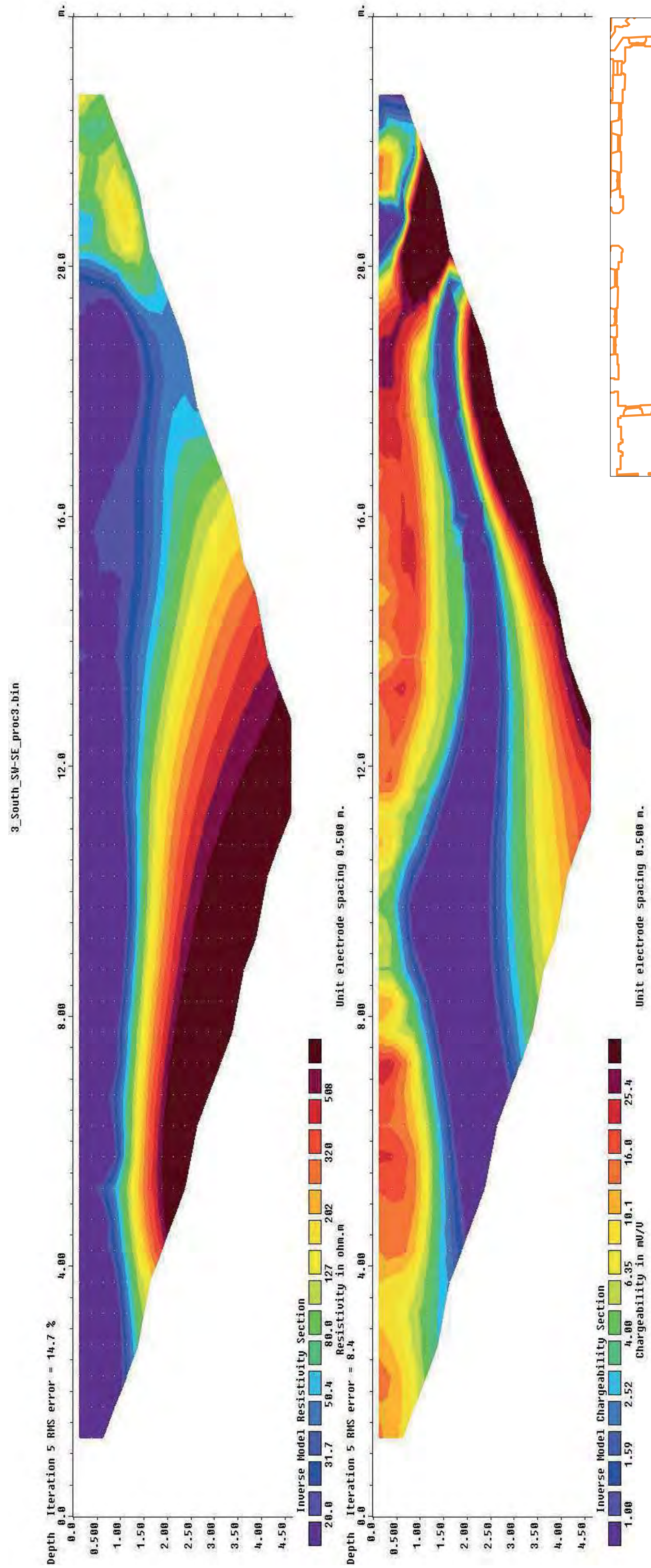

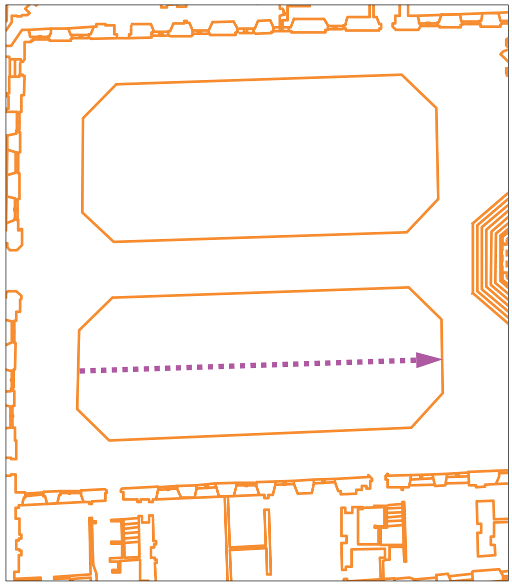

OCQ161 Oriel College Quads, Oxford

DWG 05 ERT Profile 3 - Southern Quad - Model Resistivity and Chargeability

Do not scale off this drawing

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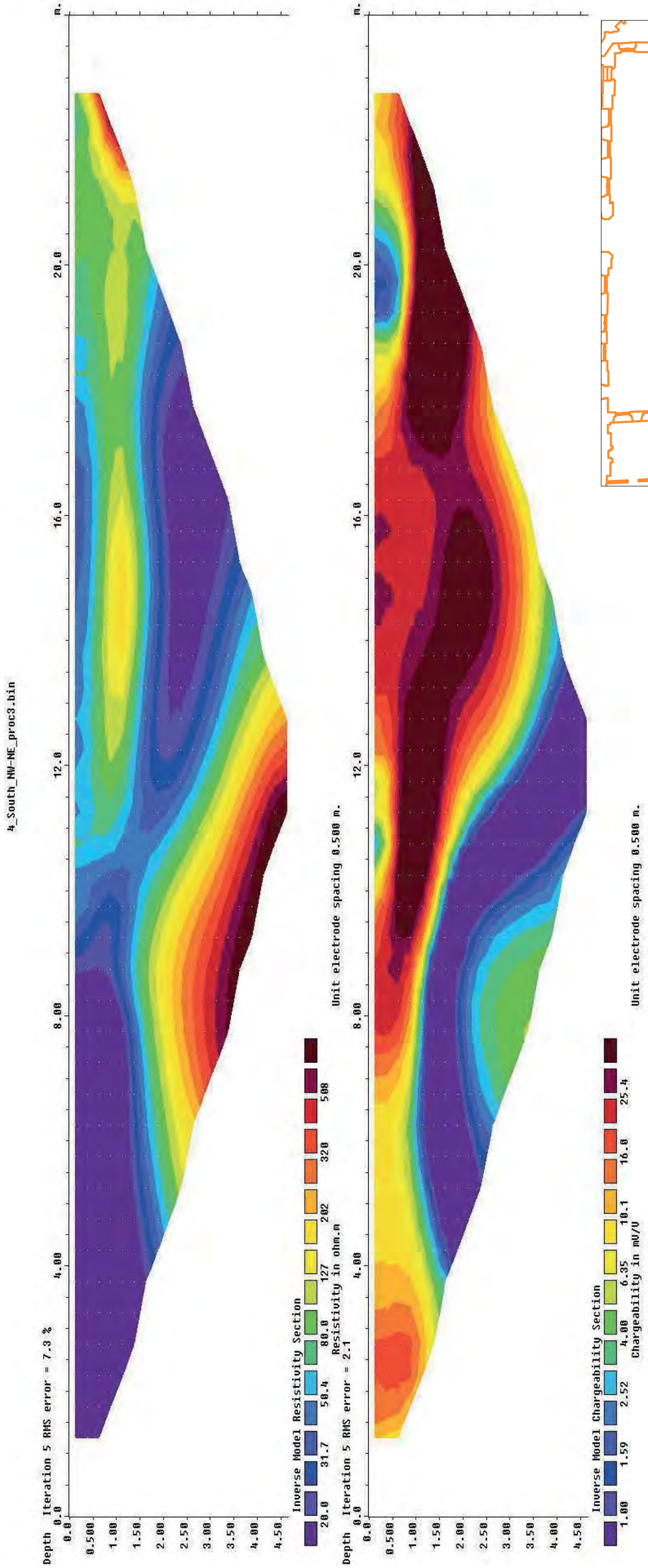

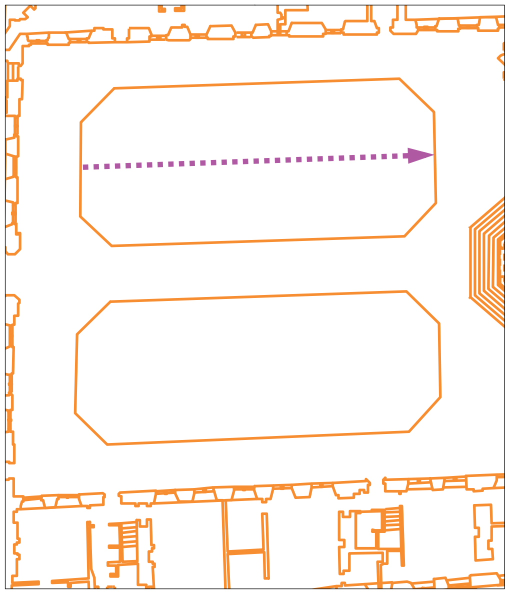

OCQ161 Oriel College Quads, Oxford

DWG 06 ERT Profile 4 - Southern Quad - Model Resistivity and Chargeability

Do not scale off this drawing

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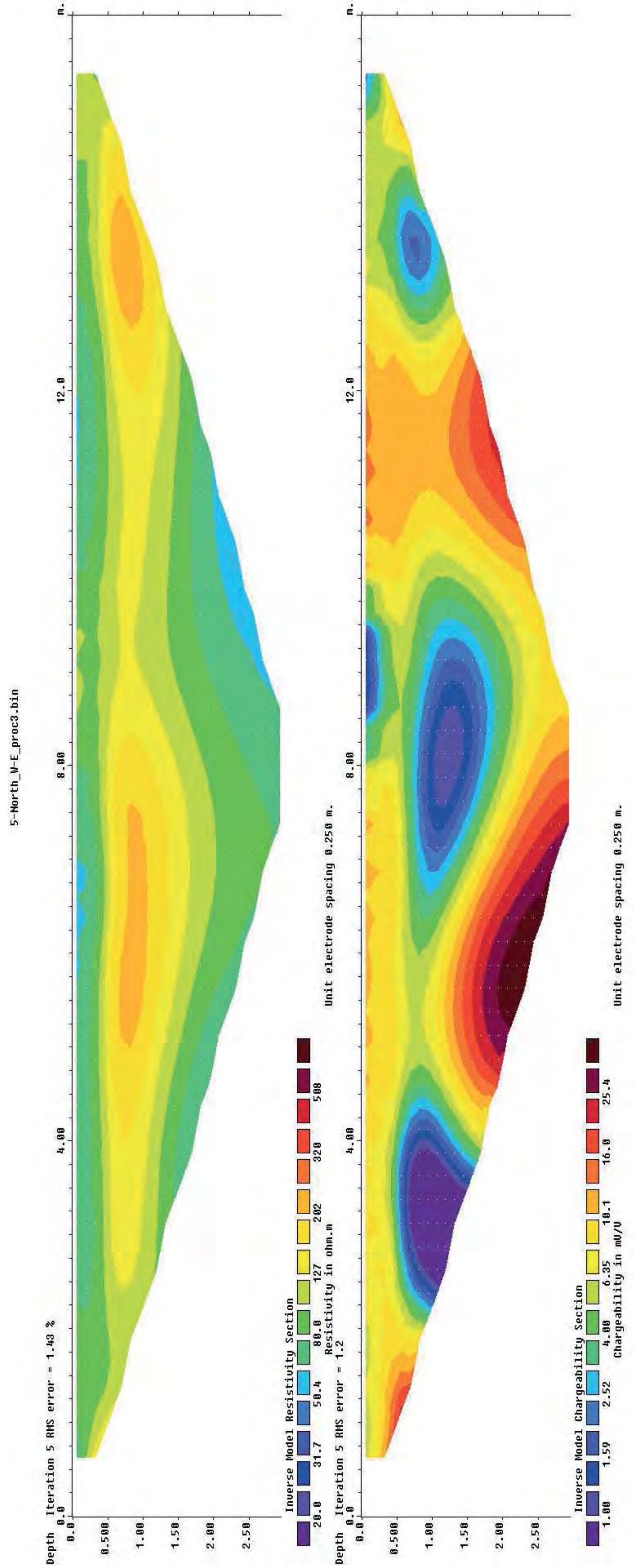
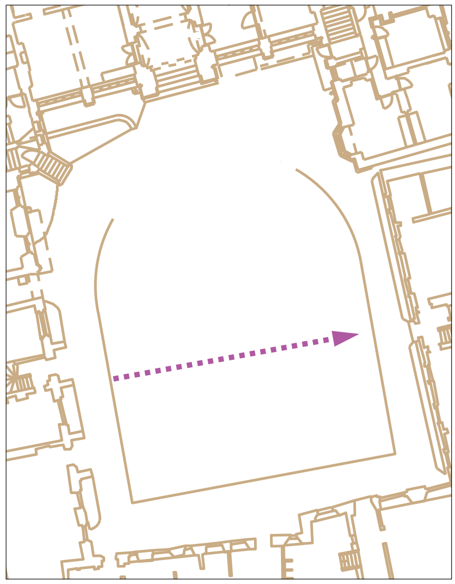


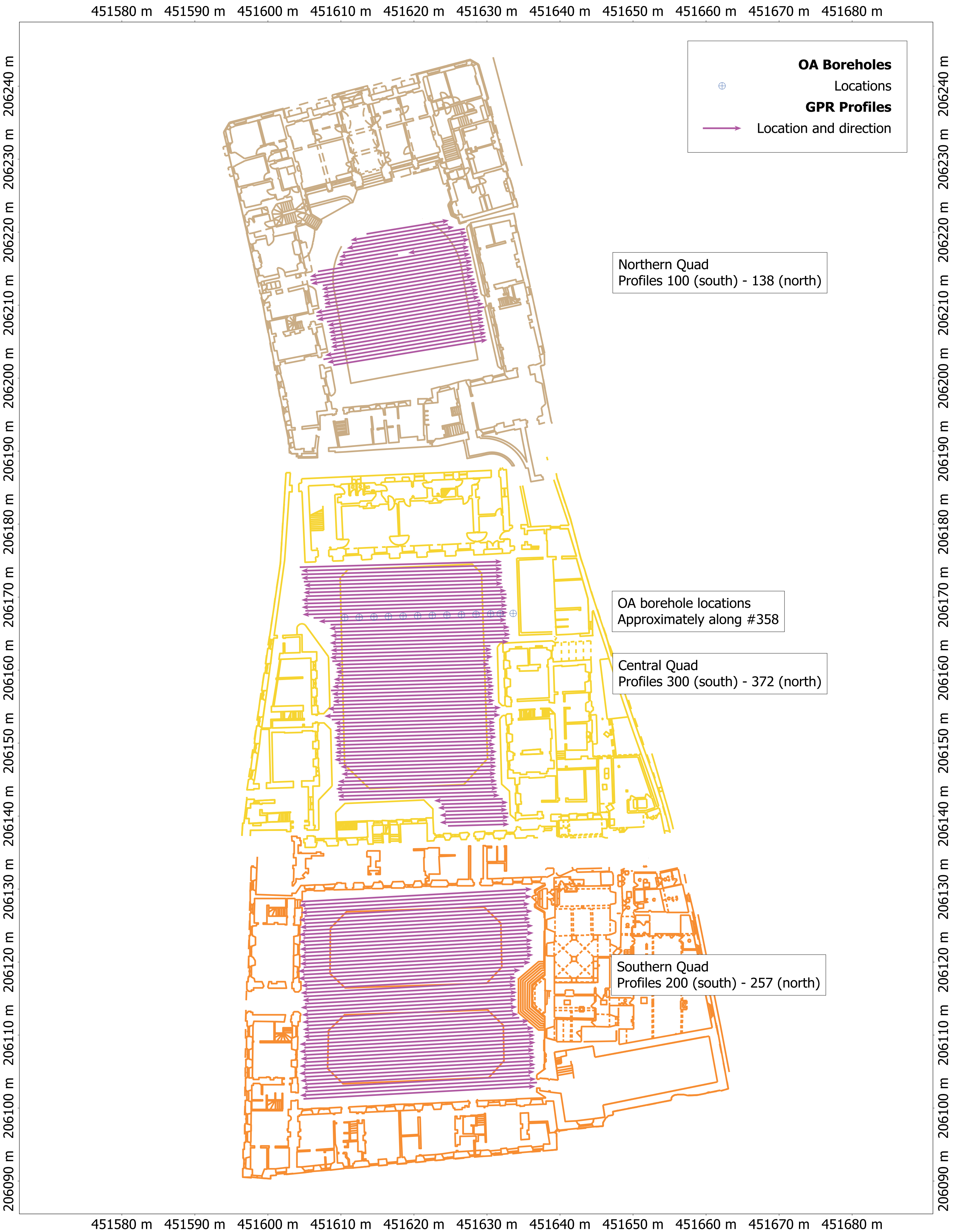


OCQ161 Oriel College Quads, Oxford

DWG 07 ERT Profile 5 - Northern Quad - Model Resistivity and Chargeability

Do not scale off this drawing

TIGERGEO



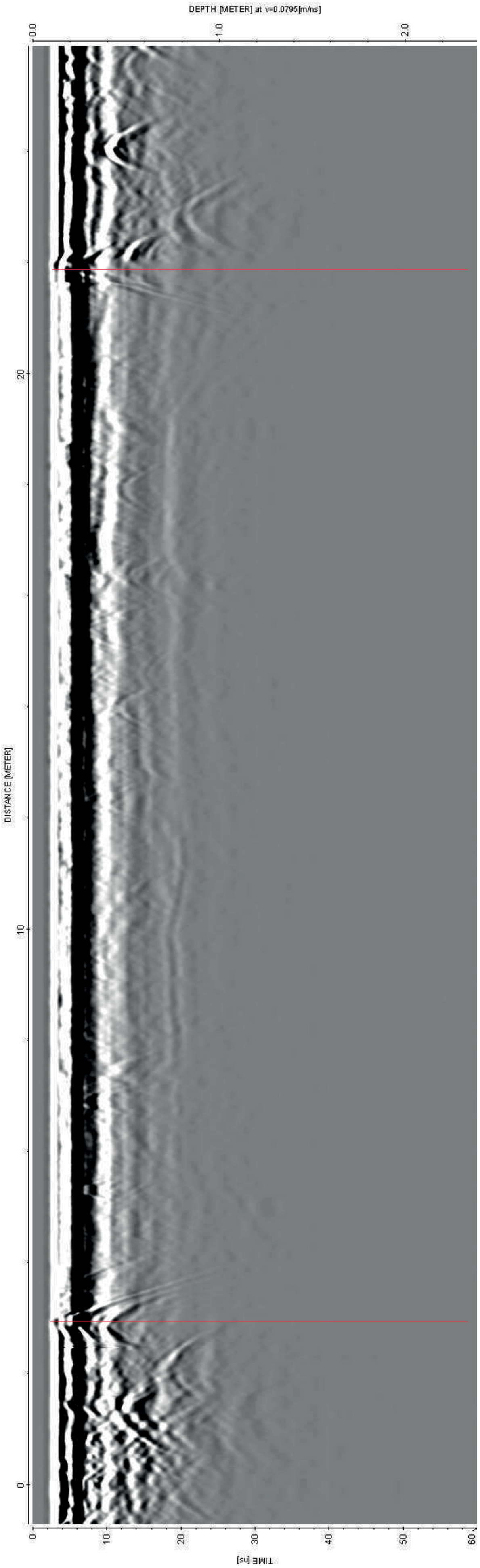
OCQ161 Oriel College Quads, Oxford

DWG 08 GPR Area Survey Profile Locations - All Frequencies

Orthographic Scale: 1:650 @ A4 Spatial Units: Meter. Do not scale off this drawing - map base approximate

File: OCQ.map Base Mapping from Oriel College

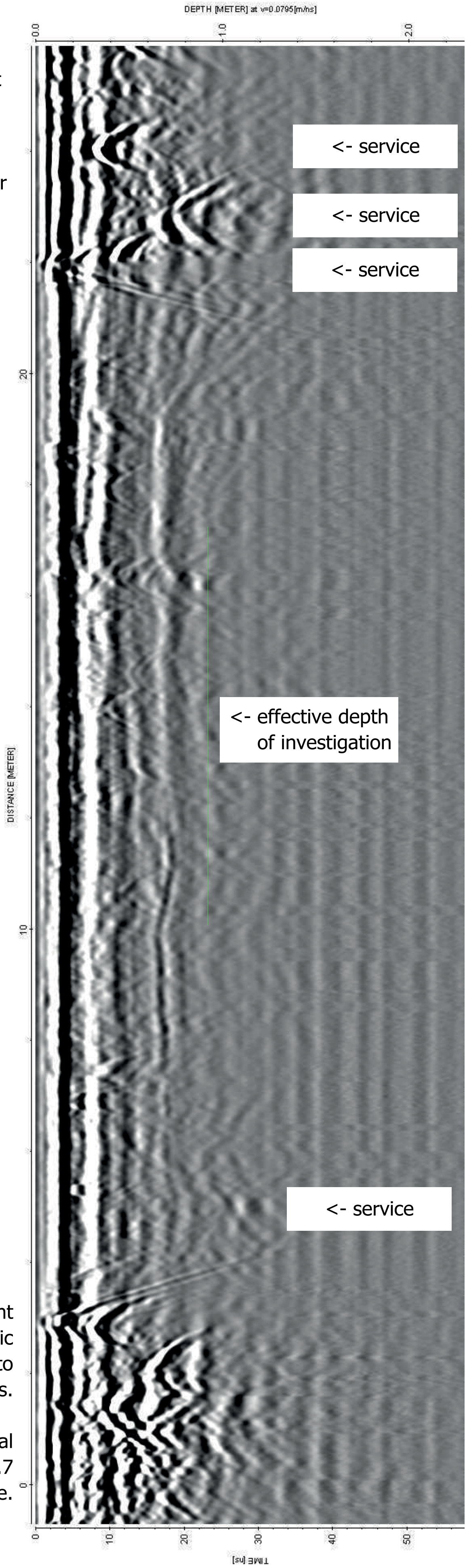
TIGERGEO



RAW DATA - Left
The profile is aligned West to East and the area over grass is edged in red. The change of data character is evident, as is the greater depth of penetration off the grass.

PROCESSED DATA - Right
The same profile after basic processing and regaining to boost deeper reflections.

There is little signal strength below about 0.7 - 1.0m even after this stage.



OCQ161 Oriel College Quads, Oxford
DWG 09 GPR Profile 358 - Approximately Coincident with OA Borehole Transect

Do not scale off this drawing

TIGERGEO

OCQ161 Oriel College Quads, Oxford
DWG 10 500MHz Profile Pick - Location of Reflectors - Central Quad

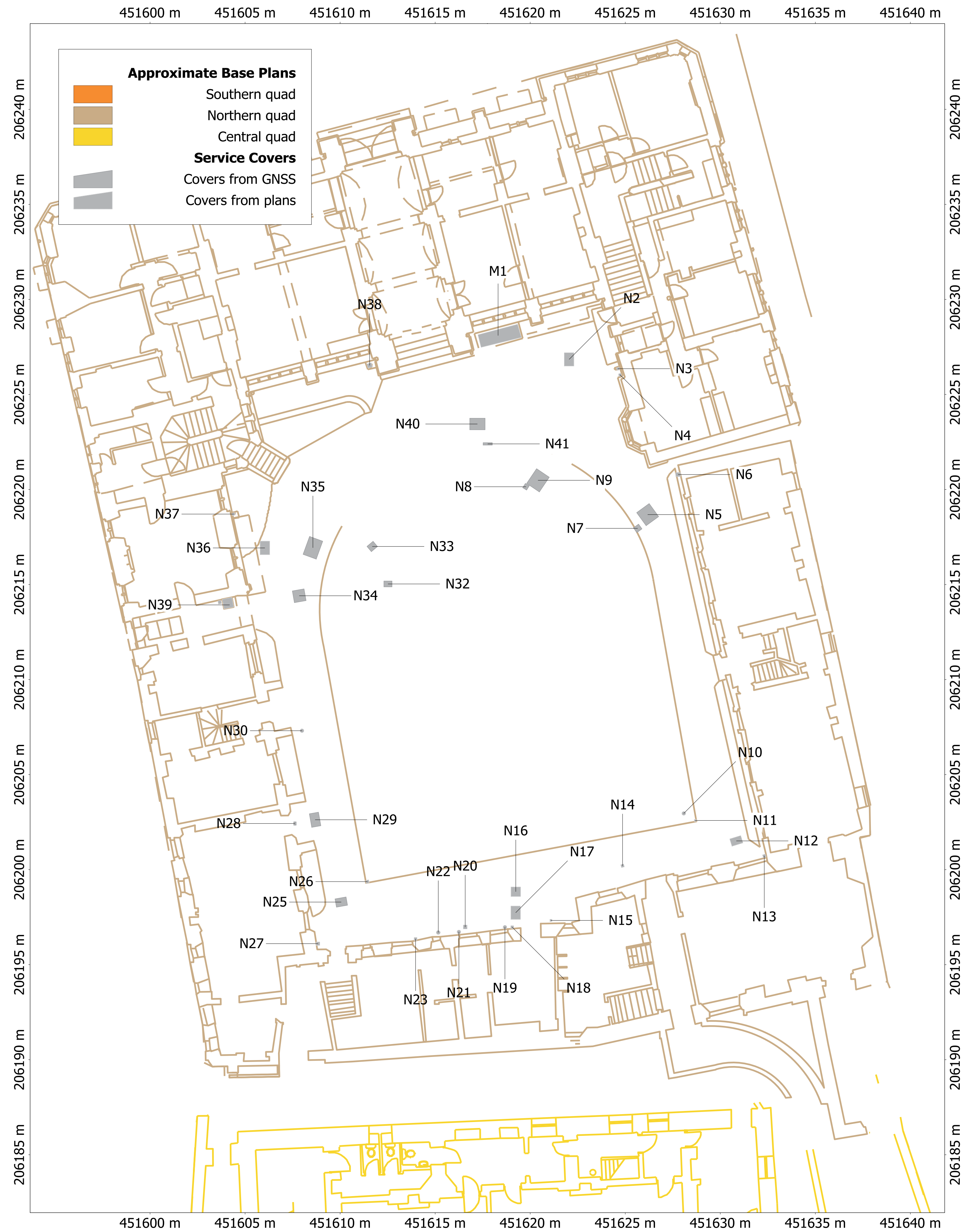
Orthographic Scale: 1:250 @ A4 Spatial Units: Meter. Do not scale off this drawing - map base approximate

TIGERGEO

OCQ161 Oriel College Quads, Oxford
DWG 11 500MHz Profile Pick - Location of Reflectors - Southern Quad

Orthographic Scale: 1:250 @ A4 Spatial Units: Meter. Do not scale off this drawing - map base approximate
File: OCQ.map Base Mapping from Oriel College

TIGERGEO



OCQ161 Oriel College Quads, Oxford

DWG 12 Services - Summary - Northern Quad

Orthographic Scale: 1:250 @ A4 Spatial Units: Meter. Do not scale off this drawing - map base approximate

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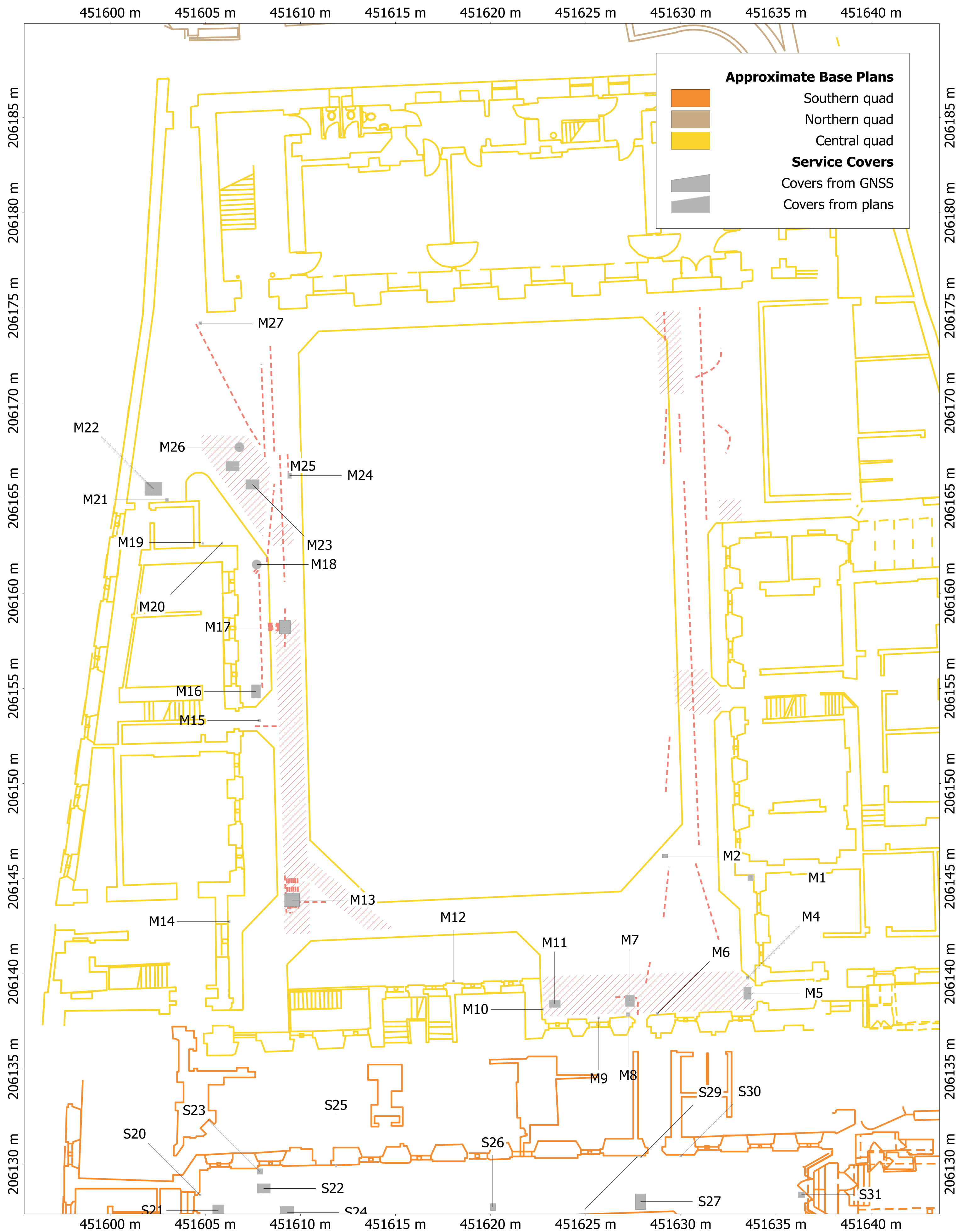

OCQ161 Oriel College Quads, Oxford
DWG 13 Services - Summary - Central Quad

Orthographic Scale: 1:250 @ A4 Spatial Units: Meter. Do not scale off this drawing - map base approximate

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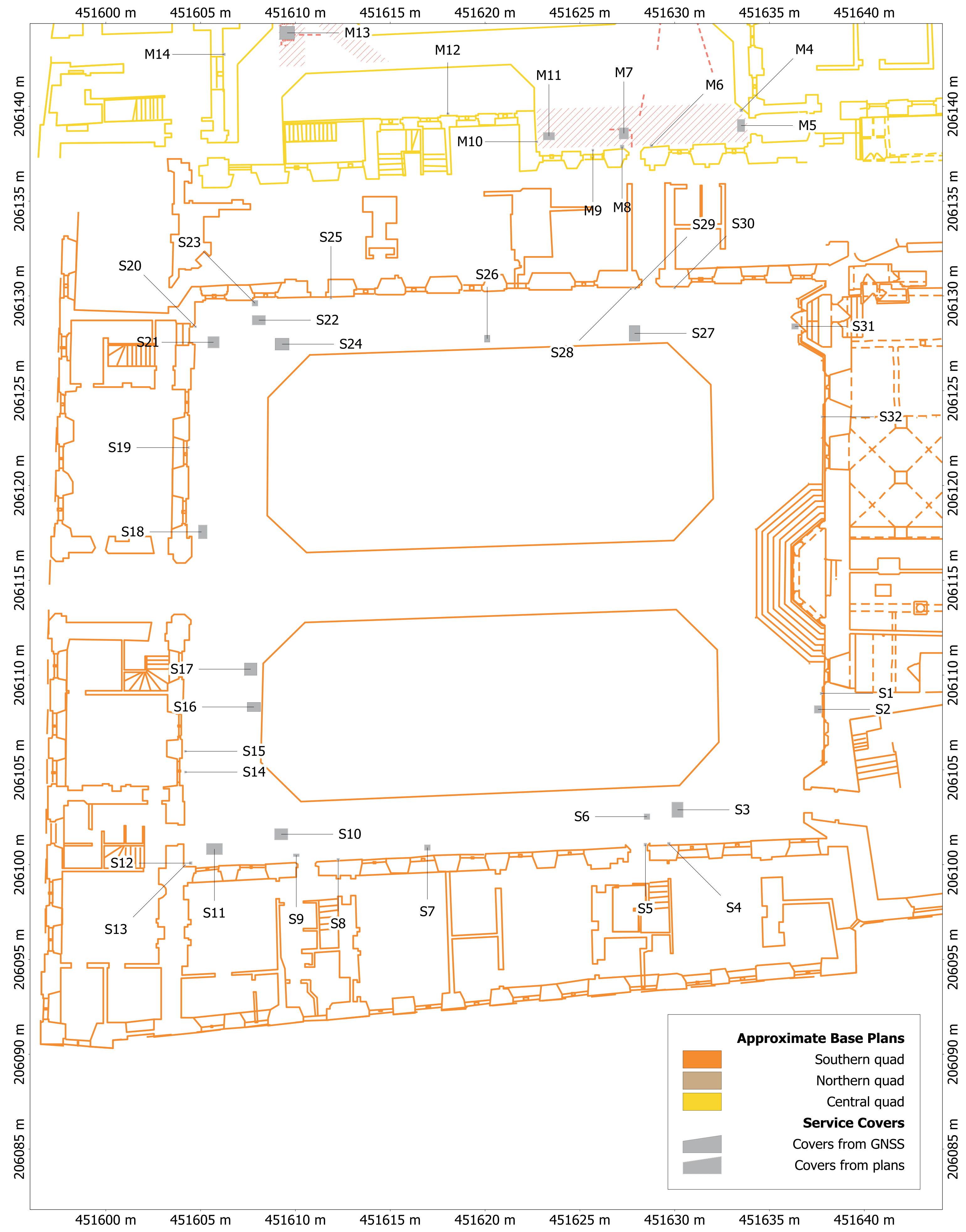

OCQ161 Oriel College Quads, Oxford
DWG 14 Services - Summary - Southern Quad

Orthographic Scale: 1:250 @ A4 Spatial Units: Meter. Do not scale off this drawing - map base approximate
File: OCQ.map Base Mapping from Oriel College

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Figure 1: Site location

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Figure 2: Location of geophysical survey, boreholes, test pits (and previous evaluation)

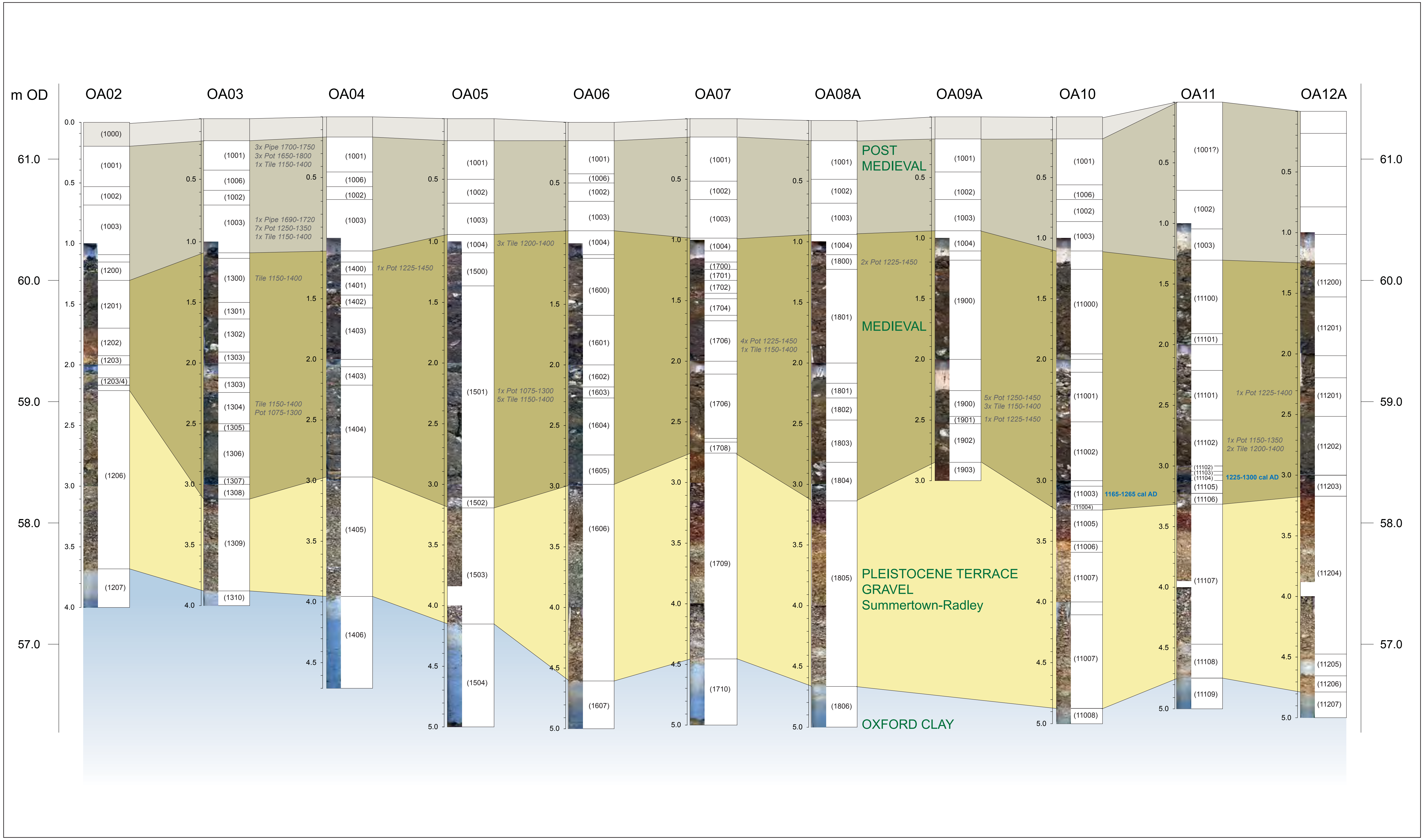
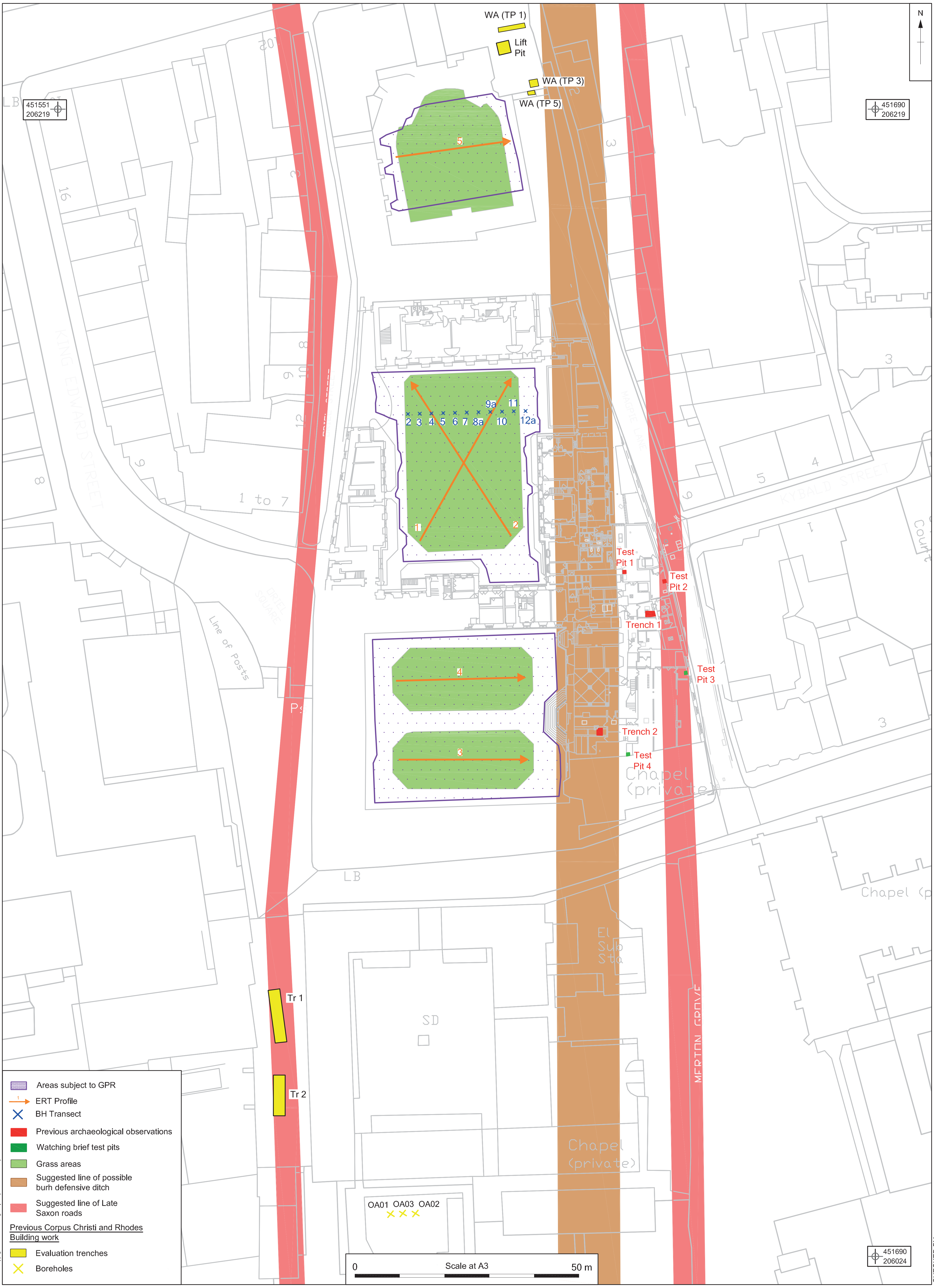


Figure 3: Borehole phototransect with dating evidence



CHECKED BY:

Figure 4: Interpretative plan showing all previous works

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