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CENTRAL WINCHESTER REGENERATION PROJECT: GEOARCHAEOLOGICAL AND HYDROGEOLOGICAL DESK-BASED ASSESSMENT

Prepared for Winchester City Council

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SUMMARY

This desk-based assessment marks the first stage of works on the Winchester City Council funded Central Winchester Regeneration (CWR) geoarchaeological and hydrogeology project. Stratigraphic data were extracted from a RockWorks database maintained by ARCA for an area comprising the CWR site and a surrounding buffer of 50m. Ninety-eight records were so obtained, and these then used in the RockWorks software to produce an outline deposit model. This latter comprised of five stratigraphic units (SU) and four sub-units. Resources for the future production of a hydrogeological model for the site were also researched.

The deposit model is considered to be of variable reliability as a consequence of the uneven spatial distribution of the database records and the depth to which previous geoarchaeological and archaeological investigations have proceeded. The model is likely to have moderate accuracy for the top 3m of the western part of the CWR site, but is unreliable for other areas (in particular east of Tanner Street) and at greater depths. Nevertheless, the model provides some useful indicators of the stratigraphy:

- *The geological basement is of the Lewes Nodular Chalk Formation (SU1) which subcrops at 7.1–12.6m below ground level (bgl). This Cretaceous unit (i.e. 93.9 to 86.3 million years ago) has no archaeological potential.*
- *The Lewes Nodular Chalk Formation is overlain by gravels of River Terrace Deposits 1 (SU3), which are between 1.67 and 6.25m thick and have a surface at 2.7–7.5m bgl. SU3 is a Late Pleistocene deposit (130,000–11,700 years ago) has an unknown archaeological potential.*
- *Alluvium (i.e. deposits forming in moving water during the last 11,700 years) overlie the gravels and extend to <1m bgl in some locations. Four separate sub-units are recognised and comprise (from bottom to top) sands, silts and clays (SU4a); peat (SU4b); tufa (SU4c) and silts and clays (SU4d). The first three of these likely date to the period 8290–4500 BC and the last to 170 BC–AD 1014, while the distribution of each reflects former channel and floodplain configurations of the River Itchen. All sub-units have a high potential to provide useful information on previous human environments, while SU4d also has a high archaeological potential.*
- *Archaeological strata (SU5) overlie the alluvium of SU4 across the whole CWR study area and comprises 60–70% of surface area at 2m below ground surface and >70% at 1m. By definition, SU5 is of high archaeological potential, while biological remains reported from the lower part of the unit in previous investigations indicate there is a high potential to recover remains of palaeoenvironmental significance.*
- *Made ground (SU6) dating from the last 200 years overlies the archaeological strata to variable depths. By definition, SU6 has a low archaeological and palaeoenvironmental potential.*

The present hydrological dataset is unsystematic in nature and does not provide a good basis on which to predict archaeological preservation.

1. INTRODUCTION

1.1 Background

1.1.1 This document is a geoarchaeological and hydrogeological desk-based assessment (DBA) of the Central Winchester Regeneration (CWR) site (Figure 1). In turn the DBA is the first stage of a geoarchaeological and hydrogeological study (henceforth collectively the 'geoarchaeological project') that will eventually comprise fieldwork (test pits and boreholes), assessment of the samples recovered and hydrological monitoring for at least a year (Winchester City Council 2020). The remit of the present DBA accords with the brief provided by Winchester City Council (2020) and an interim written scheme of investigation (iWSI) (Wilkinson et al. 2020). The DBA has been compiled and written in accordance with Chartered Institute of Archaeologists (CIfA) (2014) and Historic England (2015) guidance.

1.1.2 The geoarchaeological project as a whole is tasked with providing an early assessment of the archaeological and palaeoenvironmental potential of sub-surface strata of the CWR study area (Winchester City Council 2020, 1). By undertaking such a study Winchester City Council's intention is to make clear the archaeological 'risk' of developing the area (for potential developers) and to establish a baseline dataset which can be used by that organisation in future decision making (Winchester City Council 2020, 3–4). The purpose of this DBA is to provide baseline information on the stratigraphy and hydrological status of the CWR study area on the basis of data presently in the public domain or held by Winchester City Council (WCC) and ARCA[1].

1.2 The CWR study area and prior geoarchaeological study

1.2.1 The CWR site (henceforth 'study area') is intended for redevelopment for commercial, residential, retail and cultural purposes. It is situated in central Winchester, between 95 and 385 m west of the present channel of the River Itchen and 120 to 340 m north of the Cathedral (Figure 1). It comprises 4.9 ha of land centred on NGR SU 48384 29484 which lies between c. +35 and +37 m OD. The study area includes Winchester's bus station, several car parks as well as retail premises, while several of the buildings are presently unused.

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1.2.2 The British Geological Survey (BGS) map the study area as lying on rock of the Lewes Nodular Chalk Formation, a Late Cretaceous (Turonian—Coniacian) carbonate-rich limestone forming in a marine environment and dating from 93.9 to 86.3 million years ago (BGS 2020a). The Chalk is overlain in the western part of the site (i.e. west of Middle Brook Street) by Quaternary (i.e. the last 2.4 million years) River Terrace Deposits 1 strata and in the eastern part by Alluvium (BGS 2020b).

[1] ARCA is the geoarchaeological consultancy of the University of Winchester (see www.ARCAuk.com)

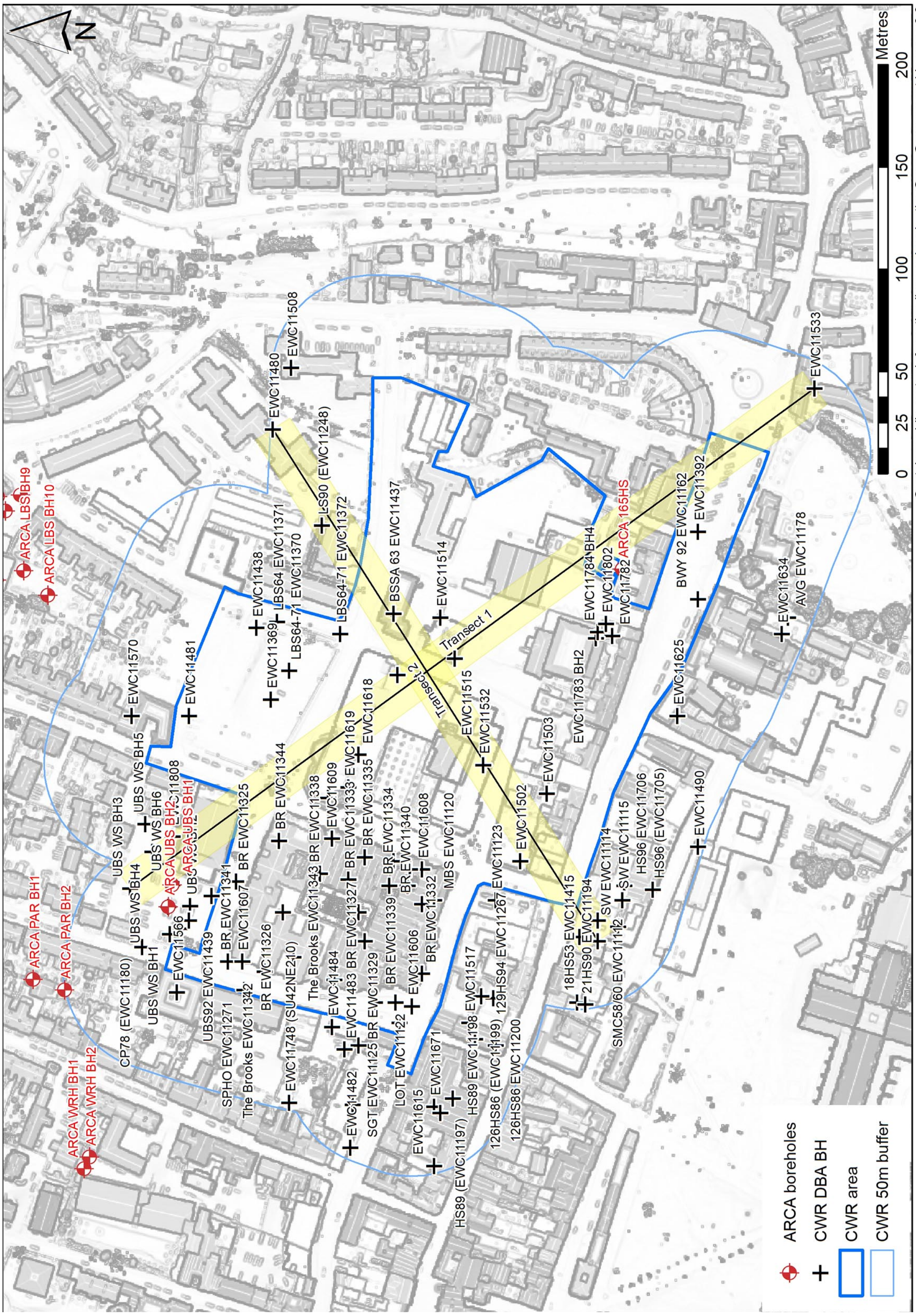

Figure 1. Location of the Central Winchester Regeneration site (with a 50m buffer) plotted against a 1m resolution LiDaR-derived slope model and showing the position of (a) datapoints used in the deposit modelling exercise and (b) the transects of composite cross sections (Figure 2 and Figure 3)

1.3 Aims, themes and objectives of the proposed works

1.3.1 The geoarchaeological project is tasked with addressing the following *aims* (Winchester City Council 2020, 4):

1.3.1.1 'To define and understand the deposit characteristics and hydrogeological context of the CWR site and the vulnerability of waterlogged deposits of archaeological interest to changes in the water environment';

1.3.1.2 'To provide a preliminary assessment of the state of preservation of waterlogged organic deposits, their extent and the artefacts/ecofacts that they contain';

1.3.1.3 'To provide detailed baseline information about the existing water environment of the CWR site and likely state of preservation of buried archaeological remains, against which the implications of future development proposals can be assessed and evaluation strategies developed'.

The present DBA provides background information that begins to address all three aims. To that end data compiled during the present phase of work are considered against aims 1.3.1.1–1.3.1.3 in Section 5 below.

1.3.2 Research themes incorporated within the geoarchaeological project include the investigation of the Late Glacial (i.e. c. 20,000–11,700 BP) and Early Holocene (11,700–6550 BP, i.e. 9650–4500 BC) topography and palaeoenvironment, as well as the following from Ottaway's (2017b, 62–67) desk-based assessment:

1.3.2.1 Iron Age activity in the CWR (NB: floodplain alluvium of Iron Age date was encountered in a borehole at 165 High Street [Wilkinson and Grant 2019]);

1.3.2.2 The degree to which the CWR site is occupied by Roman buildings (as manifested by demolition debris and occupation deposits) and/or open ground (i.e. 'alluvium');

1.3.2.3 The palaeoenvironment of Roman, Anglo-Saxon and medieval Winchester;

1.3.2.4 The distribution of 'Dark Earth' (which has not previously been noted in borehole strata in and around the CWR site);

1.3.2.5 How much of the area was occupied by Anglo-Saxon and medieval dwellings (as manifested by demolition debris and occupation deposits containing artefacts of these periods).

These themes cannot be examined as part of the current DBA given the present lack of a detailed chronological information associated with stratigraphic data from the CWR study area.

1.3.3 The aims outlined in Section 1.3 will be resolved during the course of the geoarchaeological project by meeting the following *objectives* (Winchester City Council 2020, 4–5):

1.3.3.1 'To provide a predictive model of the Quaternary deposit sequence';

1.3.3.2 'To obtain data on the significance, date, character, quality, survival and extent of archaeological and palaeoenvironmental deposits within the CWR site';

1.3.3.3 'To assess the likely state of preservation and vulnerability of organic and potentially waterlogged deposits';

1.3.3.4 'To develop, test and refine, through field tests and acquisition of new data, a hydrogeological conceptual model of the water environment'.

This DBA reviews data that contribute to achieving Objectives 1.3.3.1 and 1.3.3.2.

2. METHODOLOGY

2.1 Stratigraphy

2.1.1 The cross sections and deposit models presented in Section 3 have been compiled from ARCA's stratigraphic database of central Winchester. The latter resides within the geological utilities program, RockWorks (RockWare 2020) and presently contains 544 records (as of 1 August 2020). The contents of the database have been accrued incrementally since 2007 and comprise:

- Records from 16 geoarchaeological boreholes studies conducted by ARCA;
- Geotechnical records held by the BGS (2020b)
- Digitised 'type sequences' derived from section drawings and context sheets from the Winchester Museums Service archive (Payne 2014)
- Stratigraphic records from investigations conducted by other archaeological contractors (e.g. Wessex Archaeology, Oxford Archaeology) since 2000 and harvested from their reports.

2.1.2 The RockWorks database contains lithostratigraphic (formal descriptions of sediment layers), magnetic susceptibility (for boreholes drilled by ARCA using its Atlas Cobra TT/Eijkelkamp core sampling equipment) and chronometric (AMS ^{14}C dates) data. In addition, a table ('Stratigraphy' in RockWorks parlance) within the relational database groups each lithostratigraphic unit into interpretational groups as follows:

Stratigraphic unit (SU)	Component strata
1	Chalk, weathered chalk (Lewes Nodular Chalk Formation on the CWR site)
2	'Clay-with-flints', matrix-supported gravel, silts and clays, diamicts (not present on the CWR site)
3	Clast-supported gravel, matrix-supported gravel, sand/silt/clay, weathered chalk (Pleistocene gravels – River Terrace Deposits 1 on the CWR site)
4a	Sands, silts and clays, matrix-supported gravel alluvium
4b	Peat and organic mud
4c	Tufaceous deposits and marl
4d	Sand, silts and clay alluvium
5	Diamicts, structural deposits, peat, silts and clays. All containing artefacts (archaeological deposits)
6	Diamicts, structural deposits, 'overburden' (Made ground)

2.1.3 Using ArcGIS (v10.4), a buffer of 50m was placed around the CWR study area (Figure 1), and that polygon used to extract records from the ARCA stratigraphic database. Ninety-eight records were obtained as a result, three of which (from the Upper Brook Street car park [two boreholes] and 165 High Street [one borehole]) are ARCA geoarchaeological records[2].

2.1.4 The deposit modelling reported in Section 3 was carried out using an algorithm, nearest neighbour and maximum distance parameters informed by previous experiments carried out on the ARCA stratigraphic database. These latter

[2] NB: although stratigraphic data from the Silver Hill geotechnical investigations reside within the ARCA stratigraphic database (Stastney et al. 2014), these have been excluded from the present analyses given ownership concerns.

demonstrate that root mean square (RMS) error does not vary significantly as the number of data points (i.e. records) used in the interpolation are increased (5, 10 and 15 points were modelled). Therefore, in order to produce the interpolations used in the composite cross sections (Figure 2 and Figure 3) and deposits models (Figure 4 and Figure 5), the following parameters were employed:

- A kriging algorithm (most appropriate for data points that are not regularly spaced);
- Each pixel modelled on the basis of the 5 nearest data points;
- A 40m distance limit (i.e. a given pixel will be modelled only on the basis of 5 data points [or less] within 40m);
- The 98 selected records from the study area and the 50m buffer (Section 2.1.3) are the sole basis of the models.

2.2 Hydrogeology

2.2.1 A Tier 1 hydrogeology model is included in Ottaway's (2017b) desk-based assessment. It was originally intended that the following additional sources would be examined during the present phase of works to assess their potential to augment the Tier 1 model and contribute to the Tier 2 hydrogeology model to be developed following groundwater monitoring studies (see Wilkinson et al. 2020, section 4.4, 26–27):

- *National River Flow Archive (Environment Agency):*
- o Flow gauge at Easton;
- *Environment Agency groundwater monitoring:*
- o Station recording data at Harestock;
- *MetOffice Precipitation and temperature (MIDAS) data:*
- o Weather station at Harestock;

And the following archive held by the University of Winchester:

- Precipitation, temperature and evaporation data collected at hourly intervals at a weather station on the University Centre building, Sparkford Road, University of Winchester.

2.2.2 However, of the datasets listed in Section 2.2.1 only the National River Flow Archive and the University of Winchester weather station data could be accessed for a time frame greater than 28 days. Therefore in the case of the National River Flow Archive and the University of Winchester weather station, data from 1 January 2017 to as close to present as possible[3], were downloaded from the relevant server in ASCII format and incorporated within a multi-worksheet Excel file. The latter software was then employed to (a) reduce the resolution of the data to a weekly time frame (i.e. that to be employed in the initial groundwater monitoring study within the CWR study area), and (b) plot the graph shown in Section 4 (Figure 6).

2.2.3 Rainfall data from the Harestock monitoring station for the last 28 days can be obtained from the Department for Environment, Food and Rural Affairs (DEFRA 2020) data store. Therefore, during the course of the monitoring works, these rainfall data will be downloaded on a weekly basis[4]. Likewise, groundwater data from the Environment Agency's Harestock station, which are

[3] 30 September 2019 in the case of the National River Flow Archive, 14 February 2020 for the University of Winchester weather station.
[4] Using the following command: http://environment.data.gov.uk/flood-monitoring/id/measures/E12580-rainfall-tipping_bucket_raingauge-t-15_min-mm/readings.csv?parameter=rainfall&since=2020-08-17T00:00:00Z&_limit=672

also available as a 28-day archive will be similarly downloaded during monitoring[5]. Finally, data recording the flow of the River Itchen from the Environment Agency's monitoring station at Sewards Bridge, Titchbourne (the closest upstream flow gauge location to Winchester) will also be obtained from the Environment Agency's website while hydrological monitoring is ongoing[6].

[5] Using the following command https://environment.data.gov.uk/flood-monitoring/id/measures/E12760-level-groundwater-i-15_min-mAOD/readings?since=2020-09-17T00:00:00Z&_limit=672
[6] From https://environment.data.gov.uk/hydrology/id/measures/152201001-flow-m-86400-m3s-qualified.

3. STRATIGRAPHY

3.1 Reliability of the modelled data

3.1.1 As pointed out in Section 2.1.4, both deposit models and composite cross sections include interpolated data. These latter, however, are of variable quality depending on (a) the planar location, and (b) the depth of the interpolated point. Where such a point is close to the surface, i.e. within the depth range encompassed by an archaeological trench (NB: >50% of the records from the CWR study area and its 50m buffer have been digitised from archaeological records), and close to positions of existing records, it is likely that the point is modelled reliably. However, the potential for modelling error increases proportionally the further away from existing stratigraphic records a modelled point is and the greater the sub-surface depth that is being interpolated.

3.1.2 A good illustration of the variable reliability of the modelling at different locations and depths is revealed in the composite cross section shown in Figure 2. This figure combines known subcrop data from 12 records within 20m either side of the transect line (those named at the top of the figure and shown in the shaded 'Transect 1' area of Figure 1) with a vertical slice through the deposit model along the transect line. It is clear in this figure that modelled Made ground (SU6), archaeological stratigraphy (SU5) and to a certain extent the upper part of the alluvium (SU4d) correlates reasonably well with the bounding surface of these strata in the 12 records. Indeed, correspondence of the modelled and real data is particularly in the north-western part of the transect, where there are many records. However, the correlation between the modelled and actual subcrop becomes less close as the transect progress further south-east and as the sub-surface depth increases. This latter is because of the paucity of records in the eastern part of the CWR study area (see Figure 1) and product of the few records that extend to the geological substrate. In respect of the last, it is worth noting that only 6 of the 12 stratigraphic records shown in Figure 2 extend to the base of the Holocene sediment stack and just 2 record the SU3 River terrace 1-SU1 Lewes Nodular Chalk contact.

3.1.3 In summary, the deposit models shown in Figure 4 and Figure 5 and the interpolated cross sections of Figure 2 and Figure 3 (albeit not the actual stratigraphic records in the latter) should not be taken at face value and read uncritically. The modelled data from the near surface (c. 0–3m below ground level [bgl]) and from the western part of the CWR study area (particularly The Brooks and Middle Brook Street) can be considered as a reasonable approximation of reality. However, the number of existing stratigraphic records decreases significantly east of Middle Brook Street, while there are only 12 records covering the 40% of the CWR study area and 50m buffer east of Tanner Street. Therefore, the correspondence of the stratigraphic models with the real near surface subcrop is likely to be poor for the area between Middle Brook Street and Tanner Street, and exceedingly poor east of the latter. Moreover, the modelled subcrop of alluvial (SU4), River terrace 1 (SU3) and Lewes Nodular Chalk (SU1) strata will be a poor to very poor reflection of reality over the whole study area given that <50% of records extend below archaeological strata (SU2).

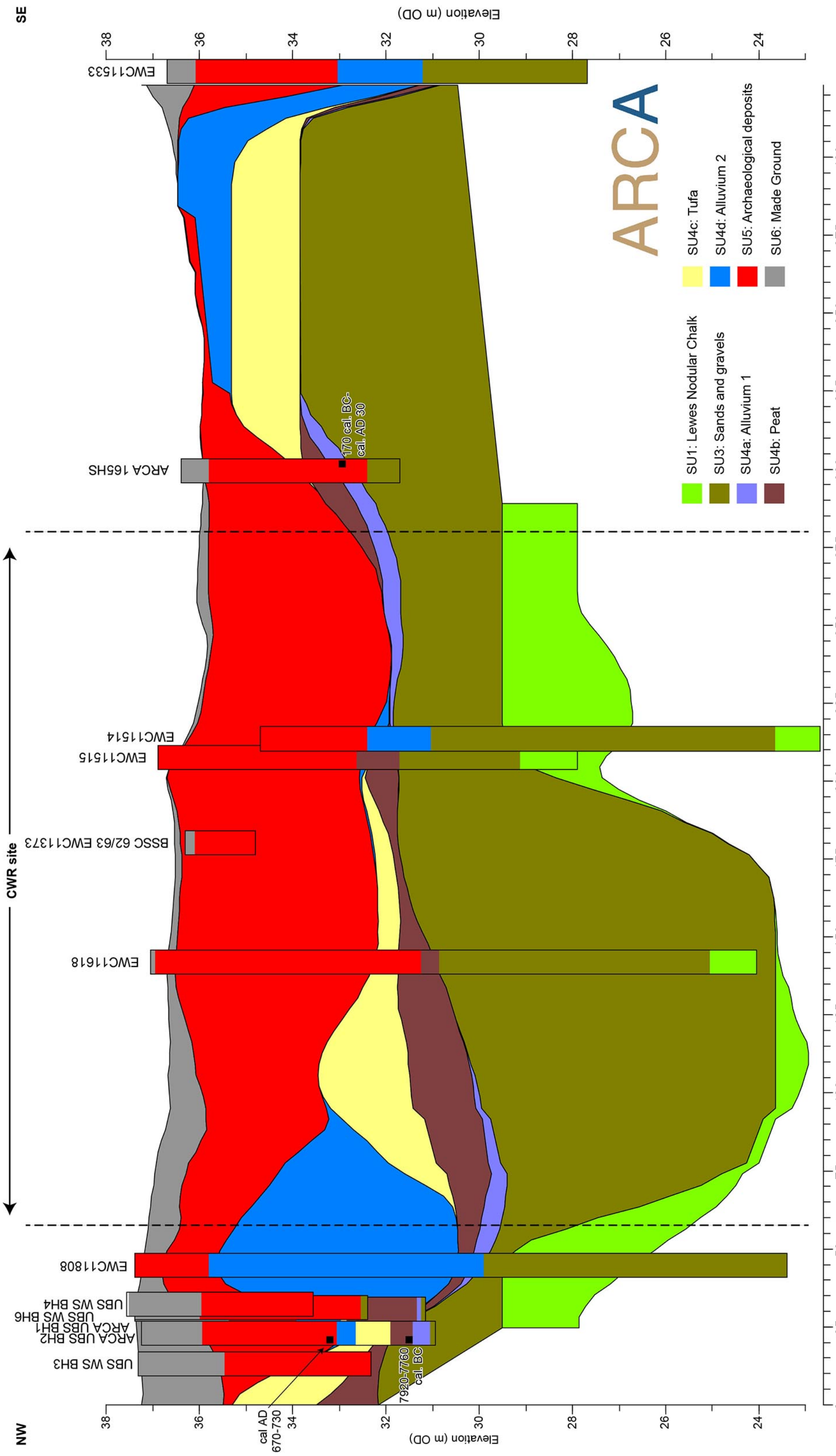

Figure 2. Transect 1 (*sensu* Figure 1): North-west to south-east composite cross section through records adjacent to and within the Central Winchester Regeneration site as generated from the ARCA stratigraphic database

3.1.4 Taking the caveats outlined above into account, the subcrop and properties of the SU set out in Section 2.1.2 are considered in the sub-sections below. Discussion is from the base of the stack upwards and on the basis of both the demonstrable and predicted subcrop of the SUs in the composite cross sections (Figure 2 and Figure 3) and deposit models (Figure 4 and Figure 5).

3.2 SU1: Lewes Nodular Chalk Formation

3.2.1 'Chalk', presumably of the Lewes Nodular Chalk Formation, was recorded in 24 of the 98 records from the CWR study area. All such records are geotechnical boreholes, but only one (immediately west of the King Alfred statue on The Broadway) was investigated geoarchaeologically (Wilkinson 2006). At the latter location, soliflucted/cryoturbation Chalk extended down from 9.72m bgl to the solid Chalk subcrop at 19.85m bgl (Wilkinson 2006).

3.2.2 The upper bounding surface of the Chalk is between 7.1m bgl (+28.9m OD) at EWC 11570 and 12.6m bgl (+24.1m OD) at EWC 11619 (Figure 4). Moreover, the modelled surface of the Chalk suggests that its subcrop is deeper in the north and west of the CWR study area than in the south and east, albeit that a single borehole north of the Middle Brook Street car park (EWC 11570) indicates a higher elevation than elsewhere in the north (Figure 4).

3.3 SU2: Clay-with-flints and Head

3.3.2 Neither composite cross sections nor deposits models suggest that there are Clay-with-flint or Head subcrops within the CWR study area.

3.4 SU3 River Terrace Deposits 1

3.4.1 Sands and gravels attributable to River Terrace Deposits 1 of the BGS (2020a) have an upper bounding surface across the study area at between 2.74m bgl (+33.84m OD) in SMC 58/60 EWC 11113 and 7.5m bgl (+29.89m OD) at EWC 11808 (Figure 4), while the thickness of the subcrop varies between 1.67m at EWC 11784 BH4 to 6.25m at EWC 11606. Further, River Terrace Deposits 1 were encountered in every record in which Chalk was found, indicating that the Pleistocene fluvial terrace extends beneath the entire CWR study area. Records beyond the study area suggests that the terrace butts against the Chalk subcrop approximately along the line of Parchment Street and is not therefore found west of this line.

3.4.2 The cross sections do not indicate any particular pattern in the variation of the thickness of the gravel deposits, which might for example suggest the presence of Pleistocene channels (Figure 2 and Figure 3). However, the deposit model suggests that the upper contact of River Terrace Deposits 1 is lower in the west of the study area (<+31m OD) than in the east (>+31m OD) (Figure 4). These data *may* support the hypothesis that a former Holocene channel of the Itchen (i.e. cutting into the gravels) passes north to south through the CWR study area and approximately along the axis of Middle Brook Street.

3.4.3 As with the Chalk, River Terrace 1 has only been geoarchaeologically observed once in the CWR study area, also immediately west of the King Alfred statue. Here a 5.32m thickness of clast- and matrix-supported gravels of cobble to granular flint were found within a medium to coarse sand matrix (Wilkinson 2006). Fine-grained (i.e. silt/clay) and Pleistocene fossils were not encountered.

3.5 SU4 Alluvium

3.5.1 As set out in Section 2.1.2 above, alluvial strata subcropping within the CWR study area are conveniently split into four stratigraphic sub-units: SU4a sands, silts and clays subcropping beneath peat or tufa; SU4b peat; SU4c tufa; and SU4d sands, silts and clays subcropping above tufa and or peat, or occurring where SU4b and SU4c are not found (see Section 2.1.2).

3.5.2 Although the alluvium of SU4 subcrops across the whole study area with an upper contact of <1m to c. 2.5m bgl (+36.2–+32.0m OD) and with a thickness of 0.5–3.0m, the individual sub-units are not universally present. The ands, silts and clays of SU4d have the most discontinuous subcrop, although this is mostly a product of the definition of the SU (i.e. it can only occur where peat and/or tufa also subcrop). Such alluvium is found irregularly throughout the CWR study area, and must be of Mesolithic age in the north-western area given a ^{14}C date of 7920–7760 cal. BC (GU27838) from overlying peat at ARCA UBS2 in the Upper Brook Street car park (Figure 2) (Wilkinson and Batchelor 2012).

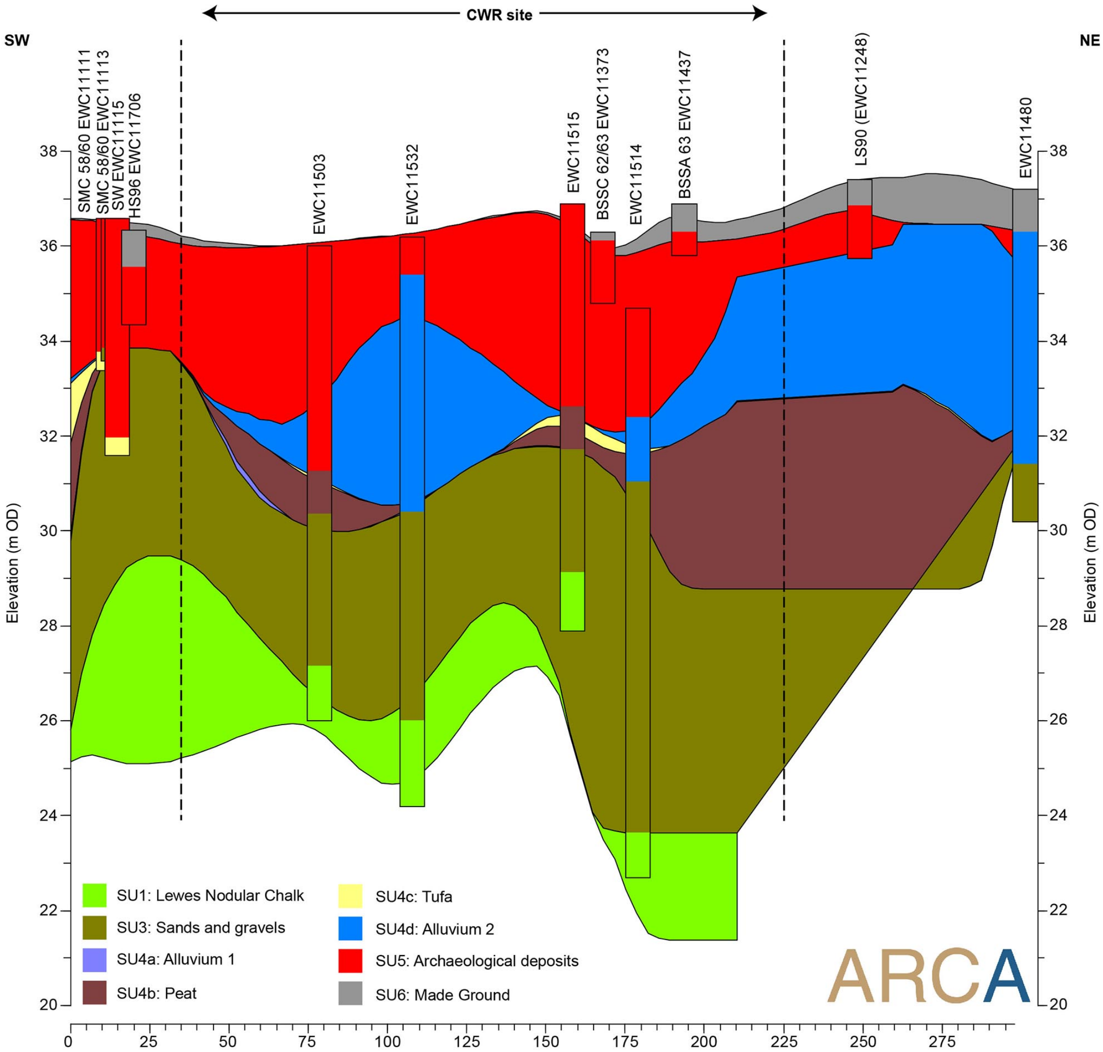

Figure 3. Transect 2 (*sensu* Figure 1): South-west to north-east composite cross section through records adjacent to and within the Central Winchester Regeneration site as generated from the ARCA stratigraphic database.

3.5.3 The peat of SU4b has an upper contact between 3.05m bgl (+32.62m OD) at EWC 11490 and 5.72m bgl (+31.39m OD) at UBS WS BH5 (Figure 4), and varies in thickness between 0.17m (also UBS WS BH5) and 2.44m (EWC 11490). Further, the composite cross sections (Figure 2 and Figure 3) and the deposit model (Figure 4 and Figure 5) suggests that the peat subcrop is not continuous, and rather the stratigraphic sub-unit sits within a number of channel-like features (these latter, probably former oxbow lakes). Given this irregular subcrop in a series of small basins across the Itchen floodplain, it is unsurprising that the chronology of the peat is highly varied (i.e. basins have filled up at different times as channels are abandoned). There are no ^{14}C dates on the peat within the CWR study area for the very good reason that the peat has not been seen in geoarchaeological studies within the area[7]. However, as noted above the peat is dated to 7920–7760 cal. BC in the Upper Brook Street car park. North-east of the study area in Lower Brook Street, peat is AMS ^{14}C dated between 9120–8670 (SUERC 62360) and 5470–5300 cal. BC (SUERC 62361) in BH14 (Watson 2015), while further north-east still a peat subcrop is dated to 4690–4330 cal. BC (HAR-4242) on Winnall Moors (Waton 1982). To the south-west at Pilgrim's School, peat in a similar stratigraphic position to that in the CWR study area is AMS ^{14}C dated between 6230–6050 (OxA 17233) and 4340–4060 cal. BC (17231) (Champness et al. 2012). Collectively these ^{14}C data suggest that the peat is a Mesolithic phenomenon, but also that there are no spatio-temporal trends in subcrop (e.g. the oldest peats occur both west and east of the study area). Palynological studies carried out of the peat suggest that deciduous woodland communities (hazel and alder in the valley and oak and broad-leaved lime on the valley sides) dominated the Mesolithic vegetation (Waton 1982, Champness et al. 2012, Wilkinson and Batchelor 2012, Watson 2015).

3.5.4 Unlike the peat of SU4b which is distributed irregularly and discontinuously, the SU4c tufa mostly subcrops in the western part of the CWR study area (i.e. west of Tanner Street) (Figure 4).The upper bounding surface of the tufa occurs between 1.32m bgl (+35.31m OD) at FG82 EWC 11193 and 4.63m bgl (+31.95m OD) at SW EWC 11115 (Figure 4), and varies in thickness between 0.1 and 2.5m (Figure 5). Although never dated (by ^{14}C or other means), the tufa must have formed after the peat in any given locality, while it also predates the upper alluvium (SU4d), which as discussed below, has associated Iron Age and later ^{14}C dates. At Bossington in the Test valley, a 1.25m-thick tufa sequence has been dated on biostratigraphic grounds and by ^{14}C to the period 8500–5500 BC (Davies and Griffith 2005), and it is possible that the Winchester tufa also developed during this same interval. If so, the peat and tufa would have formed coevally in different parts of the floodplain.

[7] Peat was recovered, recorded and dated during the Silver Hill geotechnical works (Stastney et al. 2014), but as noted above, those records cannot be employed in this report.

Figure 4. Modelled surfaces of stratigraphic units (SU) 1, 3, 4b-c and 5 in the CWR study area and a surrounding 50m buffer

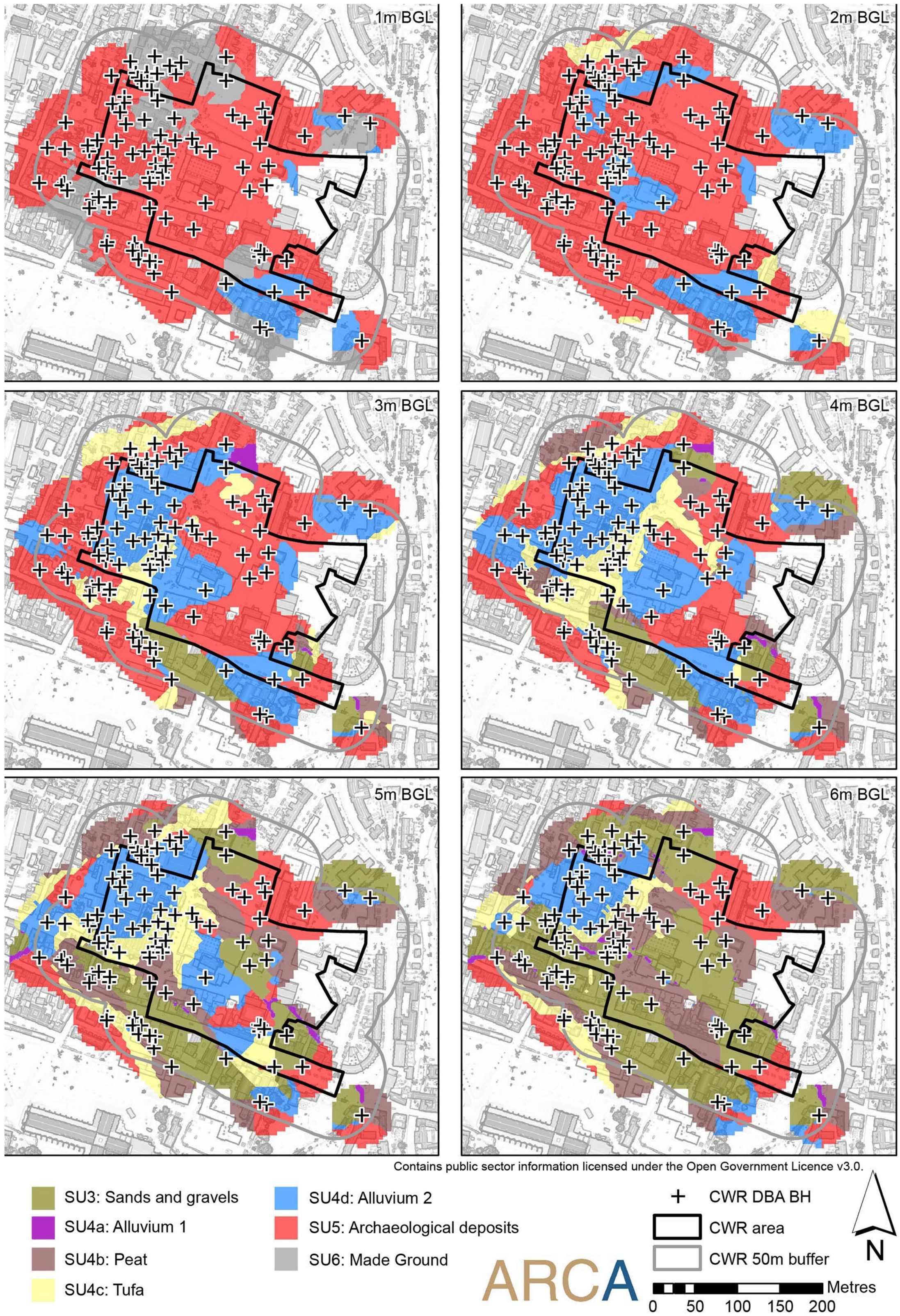

Figure 5. Modelled SU at 1m interval slices through the CWR study area and a surrounding 50m buffer

3.5.5 The upper alluvium of SU4d has an irregular distribution across the study area in both spatial and depth terms (see Figure 5). As has been discussed in Section 3.5.2, this apparent heterogeneity is in part because where there is no peat (SU4b) and tufa (SU4c), and rather mineral fine-grained alluvium is encountered, it is always attributed to SU4d. However, an additional reason for the irregular spatial distribution at shallow depths is that SU4d often contains archaeological artefacts. As a result, some records of SU4d are probably classified as SU5 Archaeological deposits (e.g. ARCA 165HS). Nevertheless, it is clear that SU4d subcrops throughout the CWR study area and at a variety of depths. Where ^{14}C dated, as for example in the Upper Brook Street car park (cal. AD680–880, GU 27837) and in Lower Brook Street (cal. AD 885–1014, SUERC 62366), the alluvium attributable to SU4d was still accreting in the Anglo-Saxon period (Wilkinson and Batchelor 2012, Watson 2015). However, it is likely that deposition of the SU began earlier as indicated by a date of 170 cal. BC–cal. AD 30 (SUERC 85816) from alluvial strata overlying River Terrace Deposits 1 (SU3) gravels at 165 High Street (Wilkinson and Grant 2019). Pollen assessment from SU4d alluvial sediments indicates open environments in which human arable and pastoral activities were taking place (Wilkinson and Batchelor 2012, Watson 2015, Wilkinson and Grant 2019).

3.6 SU5 Archaeological deposits

3.6.1 Archaeological deposits (SU5) are present across the entirety of the CWR study area (Figure 4), albeit as noted in Section 3.5.5 above, SU5 may have been confused with fine-grained alluvium of SU4d. However, it is also the case that, where not recorded in an archaeological section, coarse-grained archaeological deposits might be classified as Made ground (SU6), particularly where archaeologists did not do the recording (i.e. in the case of geotechnical boreholes) and where the age of associated artefacts was not determined. In other words, even though there are plenty of known points from which to interpolate (particularly in the west of the study area), the modelled extent (spatial and vertical) of SU5 is unlikely to be an accurate reflection of the actual distribution of archaeological strata.

3.6.2 Despite the caveats of the previous paragraphs and the few existing stratigraphic data from the eastern part of the study area, it is clear that archaeological deposits dominate the upper 2m of stratigraphy across the CWR study area. As Figure 5 shows, deposit modelling suggests that SU5 covers >70% of the study area at 1m bgl and 60–70% at 2m bgl. The interpolated cross sections show the same phenomenon (Figure 2 and Figure 3), and suggest that archaeological strata are thicker within the CWR study area than the surrounding 50m buffer. However, below 2.5m bgl, SU5 becomes increasingly uncommon (e.g. archaeological strata subcrop below this depth in only one of the records presented in the two cross sections [EWC 11618, Figure 2]), while at 3m bgl, deposit modelling suggests that archaeological deposits subcrop across <30% of the CWR study area (Figure 5). At the latter depth and at 4m bgl (Figure 5) SU5 is modelled as subcropping across a central north-south swathe and as an outlier in the extreme south-east of the study area, while by 5 and 6m bgl, it is modelled only in isolated pockets (particularly in the Middle Brook Street car park in the north of the study area) (Figure 5). Such deep occurrences of archaeological deposits are almost certainly the result of modelling from records that extended down pits and wells.

3.7 SU6 Made ground

3.7.1 Made ground (SU6) is here defined as strata deposited as a direct result of human activity since AD 1800. Consequent on this definition are the difficulties of distinguishing Made ground from SU5 Archaeological deposits that have been discussed in Section 3.6.2 above. As a result, interpolated distributions of Made ground and archaeological deposits can only be considered accurate where the known records on which modelling is based comprise archaeological sections or geoarchaeological boreholes in which diagnostic artefacts have been noted. In the case of the CWR study area, these conditions apply only to the area of The Brooks shopping centre, and elsewhere SU5 and SU6 are best considered collectively.

3.7.2 Made ground is present only within the uppermost 1.5m of stratigraphy (e.g. see Figure 2 and Figure 3) and only appears in the deposit models in the 1m bgl depth slice (Figure 5a). Where modelled at the latter level, SU6 subcrops only in the western part of the CWR study area (in the area of The Brooks shopping centre and northern part of the Lower Brook Street car park) and at the transition of the bus station to The Broadway in the southern margin (Figure 5). However, in reality Made ground deposits are likely to be much more widely distributed, even at 1m bgl depth, than the modelling suggests, not least because of the number of intrusive features that have been dug and backfilled, or simply filled since 1800 (a good example being the former open culverts along the Brook Streets).

4. HYDROGEOLOGY

4.1 The Tier 1 hydrogeological assessment in Ottaway's (2017b, 57–64) archaeological desk-based assessment makes the following key points regarding archaeological preservation and groundwater in the CWR study area:

- Groundwater has likely passed through the Chalk or strata derived from that geological basement and will therefore have a pH >7. The implication is that artefacts and biological materials with a pH >7 will be readily preserved within the study area even when not permanently waterlogged.
- Waterlogged preservation of plant remains and insects in archaeological deposits (SU5 of this report) occurs in fills of pit fills and other 'negative' features that have been cut into the alluvium (SU4 here) and gravel (SU3).
- Where recorded, i.e. on the Urban Archaeological Database (UAD) and/or the Historic Environment Record (HER), groundwater in excavation trenches and other features monitored by archaeologists and/or geotechnical engineers varies between 1.6 and 3.7m bgl (c. +35–+33m OD). Further, there is a suggestion that in bgl terms, groundwater is encountered at a greater depth in the east and the south of the CWR study area than the north and west.
- Given the data above, groundwater flow is suggested as being from a north-west (i.e. from the Upper Brook Street car park and The Brooks) to south-east (i.e. the Broadway) direction.
- In making the above comments, however, Ottaway (2017b, section 7.9, 59) notes that no systematic attempt has been made to monitor ground water in either archaeological or geotechnical situations, while the UAD/HER do not record the seasons in which groundwater observations were made. Nevertheless, where long term excavations allowed, i.e. in The Brooks, the difference between summer and winter groundwater was estimated as 0.80m (Zant 1993, 11–13).
- Groundwater is suggested to be derived from an unconfined aquifer comprising the alluvial (SU4) and gravel strata (SU3).
- There is no suggestion of a perched water table (as would result for example from impermeable strata subcropping high in the sediment stack).
- The present elevation range of the River Itchen at City Mill varies between +35.50 and +35.11m OD. Further, hydrological continuity is suggested between groundwater in the CWR study area and both the present Itchen channel and the channel passing through the CWR site.
- Archaeological data from The Brooks and Lower Brook Street suggest a lower water table in the Roman period than at present. Zant (1993, 11–13) has suggested that the water table was between +33.9 and +33.4m OD on the basis that this was the basal depth of a timber-lined drain. However, a Roman ditch at Lower Brook Street was dug to +32.60m OD and is not thought to have penetrated the water table (Biddle 1975).

4.2 Example monitoring data beyond those considered by Ottaway (2017b, 57–64) are presented in Figure 6. While it should be noted that until the winter of 2019–2020, the University of Winchester weather station data are incomplete, it is nevertheless clear that there is no simple relationship between the magnitude of rainfall and flow in the River Itchen. This difference likely reflects the complexity of groundwater flow. This latter will be investigated in detail during the hydrogeological studies of the next stage of the geoarchaeological project.

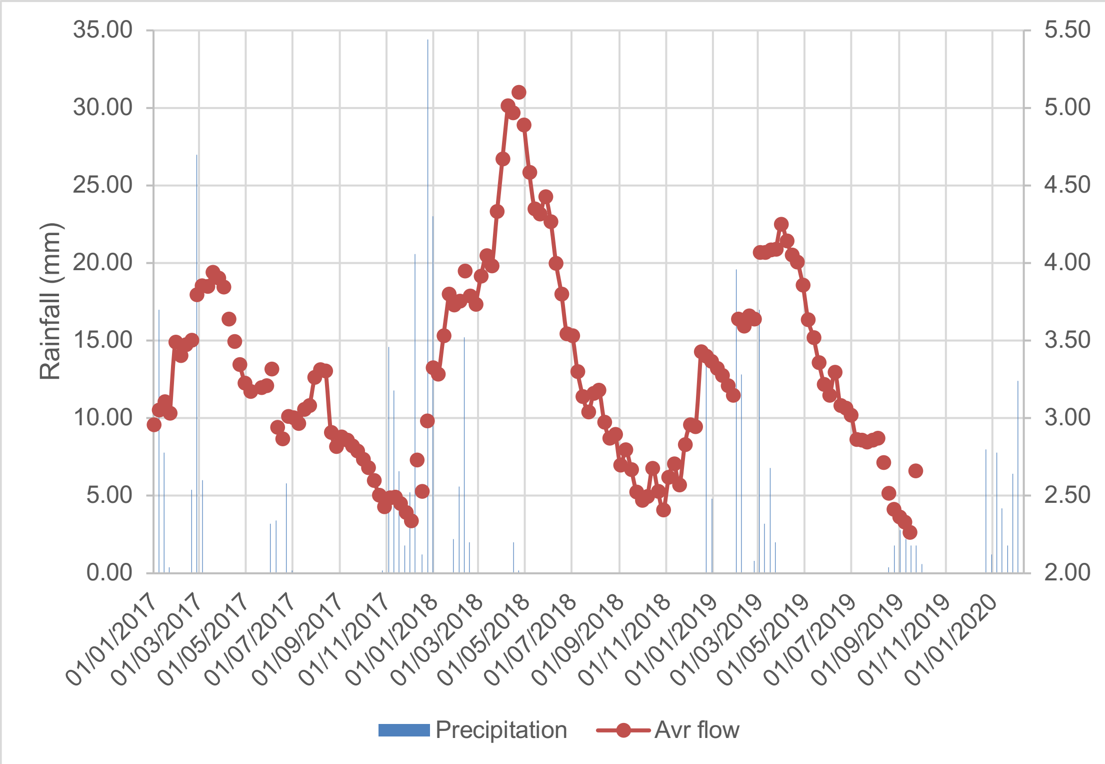

Figure 6. Rainfall measured at the University of Winchester weather station (blue bars) plotted against the flow of the River Itchen at the Environment Agency's Easton monitoring station (red line) (measured in m^3/s)

5. ASSESSMENT

5.0.1 The aims and objectives set for the CWR geoarchaeology and hydrogeology study are reviewed below against the data described in Sections 3 and 4 above

5.1 Depositional context of the site

5.1.1 The CWR study area coincides with all stratigraphic units outlined in Section 2.1.2 other than SU2 Clay-with-flints. This latter unit subcrops on the flanks of the Itchen valley and has been observed west of the site in geoarchaeological boreholes in Staple Gardens (Payne 2010).

5.1.2 The pre-Quaternary geological basement of the CWR study area is formed of Chalk of the Lewes Nodular Chalk Formation (SU1) and which subcrops >7m bgl (<+29m OD). This stratum likely comprises a weathered surface layer (10m-thick on The Broadway [Wilkinson 2006]), which has been sculpted by fluvial processes during the course of the Quaternary. The Lewes Nodular Chalk Formation has no archaeological significance given that it is dated (on biostratigraphic grounds) to 93.9–86.3 million years ago (BGS 2020a), while the earliest human occupation of the British Isles occurred at <1 million years ago (Parfitt et al. 2010).

5.1.3 The Lewes Nodular Chalk Formation is unconformably overlain by a 1.67–6.25m-thickness of sands and gravels of River Terrace Deposits 1 (*sensu* BGS 2020a) (SU3) across the entirety of the CWR study area and at depths below 2.74–7.5m bgl (+33.84–+29.89m OD). However, on the basis of the 40 stratigraphic records containing the River Terrace Deposits 1 stratum, it is unclear whether different thicknesses of sands and gravels reflect the presence of former channel features. River Terrace Deposits 1 strata in the Itchen have not been geologically investigated, but a possible lateral equivalent in the Test valley at the Hunts Farm Sportsground, Romsey has been dated by optically stimulated luminescence to 68.8 ± 11.1 thousand years before present (Bates et al. 2010). Such an age, if applicable River Terrace Deposits 1 in the Itchen would place formation of SU3 in Marine Isotope Stage (MIS) 5a and 4 (see Lisiecki and Raymo 2005), a period when humans are thought to have been absent from Britain (Currant and Jacobi 2001).

5.1.4 Typically, geotechnical contractors describe coarse-grained strata such as River Terrace Deposits 1 in broad terms noting the size, lithology and density of the gravel components, but not the presence of fine-grained strata or of bedding properties. Fine-grained strata within a terrace sequence might represent low energy deposition or even stasis and could therefore have formed a surface on which human activity took place (Wilkinson 2002). Such fine-grained deposits, if present on within River Terrace Deposits 1 in the CWR study area might therefore be of archaeological potential. However, of the 40 records of River Terrace Deposits 1 from the CWR study area and its surrounds, 39 are from geotechnical records in which such fine-grained strata will not have been described, while only 1 has been examined during a geoarchaeological investigation (see Section 3.4.3). Thus, the present lack of good quality lithostratigraphic data and the uncertainty of the present chronology means that SU3 River Terrace Deposits 1 is categorised as having an unknown archaeological potential.

5.1.5 Alluvium of SU4 unconformably overlies River Terrace Deposits 1 across the whole CWR study area at 2.74–7.5m bgl (+34–+29m OD) and extends upwards as far as 1m bgl in some eastern parts of the study area (Figure 5a). More typically, however, the upper contact of SU4 is at 2–4m bgl (Figure 4 and Figure 5). 'Alluvium' is a catch-all term used by the BGS to describe deposits forming as a result of fluvial (i.e. stream) transport during the Holocene, and it therefore encompasses channel sands and gravels (present only in fine beds and laminae within SU4a), tufa forming in shallow channels (SU4c), levee silts and sands (SU4a), floodplain silts and clays (SU4a and SU4d) and backswamp organic muds and peat (SU4c) (BGS 2020b). Several geoarchaeological studies have been conducted in proximity to the CWR site in recent years that characterise the nature of the alluvial subcrop, e.g. at the North Walls-Lower Brook Street intersection, in the Upper Brook Street car park and at 165 High Street (Wilkinson and Batchelor 2012, Watson 2015, Wilkinson and Grant 2019). Available ^{14}C dates from these sites suggest that peat (SU4b) was laid down in the 8290–4500 cal. BC interval (i.e. the Mesolithic), while the floodplain silt/clays (SU4d) have been dated between 170 cal. BC and cal. AD 1014 (Wilkinson and Batchelor 2012, Watson 2015, Wilkinson and Grant 2019). As discussed in Section 3.5.4 the tufa (SU4c) is presently undated, except by association, but probably has a chronology similar to the peat.

5.1.6 Archaeological remains have not been found in SU4a-c, but against this statement should be set the fact that these strata have never been excavated in an archaeological trench or test pit. Where encountered in geoarchaeological boreholes, SU4a–c have been found to be variably fossiliferous, but as discussed further in Section 5.2.2 below, no systematic attempt has been made to assess biological preservation. Presently therefore, SU4a–c have an unknown archaeological potential. However, the same strata have a moderate–high potential for the recovery of proxy biological evidence to reconstruct environments contemporary with human activity. The fine-grained alluvium of SU4d began forming before the foundation of *Venta Belgarum* (i.e. Roman Winchester), but continued to develop in some locations until the Saxo-Norman period. Archaeological artefacts are commonly found in SU4d (e.g. in the Upper Brook Street car park and 165 High Street [Wilkinson 2012, Wilkinson and Grant 2019]), while biological preservation is almost universally good, meaning that the stratum has high archaeological and palaeoenvironmental potentials.

5.1.7 Archaeological deposits (SU5) subcrop across the whole CWR study area and for the most part, extend from within 1m of the present ground surface to 2–3m bgl (Figure 5). SU5 is likely to be formed predominantly of diamicts (poorly sorted sediment of gravel to clay grain size), containing frequent artefacts and structural material, and which are probably strata associated with demolition, levelling and rubbish disposal. Ottaway's (2017a) review of the archaeology of Winchester suggests that the CWR site coincides with residential insula of Roman period, Anglo-Saxon dwellings and medieval tenements. Examples of these latter were explored in detail during Martin Biddle's excavations in Lower Brook Street in 1962–1971 (summarised in Ottaway [2017a]) and in advance of construction of the Brooks shopping centre in the 1980s (Zant 1993). Waterlogged preservation of organic materials was a feature of both these excavations (and indeed others of Roman and early medieval strata within central Winchester), suggesting that well preserved biological materials will be a feature of at least the lower part of SU5 throughout the CWR study area. The archaeological deposits of SU5 therefore have both high archaeological and palaeoenvironmental potentials.

5.1.8 Made ground (SU6) caps the archaeological deposits (SU5), Indeed were the present ground surface to have been modelled in Figure 5, it would show universal coverage of SU6. The Made ground across the CWR study area will be of highly heterogenous properties, comprising concrete and tarmac surfaces, sub-base to support the former and deliberately deposited sediment used to level hollows, infill service trenches etc. As Made ground (*sensu* BGS 2020b), is by definition of strata formed as a result of human activity since AD 1800, it has a low archaeological and palaeoenvironmental potential.

5.2 Vulnerability and preservation of waterlogged deposits/organic remains

5.2.1 Organic materials, i.e. plant remains (e.g. wood, seeds, pollen etc), are protected from oxidation and therefore decay when they are permanently submerged by water (e.g. see Historic England 2016, 2–3). Preservation of such remains is further enhanced where the submerging water contains little free oxygen (the latter contributing to oxidation) (Kibblewhite et al. 2015). On the other hand, decay of organic materials increases in situations where waterlogging is discontinuous (Historic England 2016, 3).

5.2.2 Data examined in this DBA do not enable an informed consideration of the vulnerability of waterlogged remains to decay consequent on construction within the CWR study area. Such a situation is because (a) other than SU4b Peat, it is unclear which SUs in ARCA's deposit database, contain organic materials, and (b) it is presently uncertain where the groundwater table lies within the CWR study and to what extent groundwater level varies on a seasonal basis. In respect of the first, it is known from excavations carried out within the CWR study area (e.g. Lower Brook Street and The Brooks), that waterlogged archaeological materials occur within the SU5 Archaeological deposits, but the elevation at which that preservation commences is less clear[8]. Geoarchaeological investigations have also reported the preservation of organic remains within the tufa (SU4c) and mineral alluvial strata (SU4a and SU4d) (e.g. Wilkinson and Batchelor 2012, Wilkinson and Grant 2019, 2020), Nevertheless, during previous archaeological and geoarchaeological studies within central Winchester, no systematic attempt was made to quantify and assess such biological preservation at a spatial scale greater than a single site.

5.2.3 Following the fieldwork, palaeoenvironmental assessment and hydrological monitoring of next CWR geoarchaeology project stage, suitable data will have been collected which will enable a consideration to be made of the vulnerability of sub-surface organic remains across the CWR study area. Therefore, further consideration of this aim will be postponed until the integrated geoarchaeological report that will complete project Stage 1 (Wilkinson et al. 2020, section 4.5.2, 28–29).

5.3 Baseline hydrogeological data

5.3.1 Cross referencing the informally recorded groundwater data reported by Ottaway (2017, 58–60, Section 4.1 above) with the deposit models of Figures 2–5 suggests that the present water table intersects the lower part of the archaeological deposits (SU5) and the entirety of the underlying strata. Therefore, the present hypothesis remains as articulated by Ottaway (2017, section 7.14, 60), i.e.

'….. pre- Roman deposits, i.e. the Late Glacial and Early Holocene alluvial and fluvial deposits are below the water table, although the

[8] Research in the relevant Hampshire Cultural Trust archives is required to address this question.

extent to which they have been in the past is a complex question. As far as Roman and later deposits accumulating on the 'natural' ground surface are concerned, the data from The Brooks and elsewhere suggests they are not below the water table. However, deposits in pits and other features which penetrate the 'natural' do contain waterlogged deposits with a high level of organic preservation. In the south-eastern part of the Central Winchester site the picture may be a little different in that in some of the boreholes on Broadway the base of 'fine archaeological deposits', possibly Roman in date, appear to have been recorded below the present water table.'

5.3.2 Key questions remain to be answered, however, in order to more fully understand the hydrogeology of the CWR study area and thus the effect of potential groundwater changes on archaeological preservation. These are:

- To what extent does groundwater elevation vary across the site and do elevation changes indicate the direction of groundwater movement?
- Does groundwater intersect with the present (artificial) channel of the Itchen and former channels of the Brook Streets within the CWR study area?
- How does groundwater change seasonally and as a result of individual weather events?
- What are the geochemical properties of the groundwater, do these vary by location or on a temporal basis, and what is the likely effect of such properties on biological (and other archaeological) preservation?

These questions will be addressed during hydrogeological monitoring and testing that will form part of the next phase of works on the CWR geoarchaeology project (Wilkinson et al. 2020, section 4.4, 26–27)

6. RECOMMENDATIONS

6.1 As outlined by both Winchester City Council (2020) in their brief for the CWR geoarchaeological and hydrogeology project, and ARCA's iWSI written as a response (Wilkinson et al. 2020), excavating test pits/drilling geoarchaeological boreholes is to be the next phase of works. The purpose of the boreholes/test pits is to investigate the entirety of the Quaternary stratigraphic sequence in order to develop a more reliable understanding of the sub-surface deposits than has been articulated above. A second, but equally important reason for drilling the boreholes is to prepare the way for the groundwater monitoring study articulated by Wilkinson et al. (2020, section 4.4, 26–27).

6.2 The iWSI indicated that up to 15 testpits/boreholes would be excavated/drilled and that their location would be on the basis of the following criteria (in descending order of priority) (Wilkinson et al. 2020, section 4.1.6, 19–20):

- Areas that are available (those zones outlined in green in
- Figure 7);
- Avoiding areas containing known services (i.e. following a statutory undertakers-related search);
- Avoiding land subject to Highways regulations);
- Areas where present coverage of stratigraphic records is poor (i.e. the 'blank' areas of Figure 1);
- Areas where groundwater data are desirable in order to produce a Tier 2 assessment 'model';
- Areas lacking stratigraphic records with accompanying biostratigraphic assessments.

6.3 Two walkover visits have been made to the CWR study area (17 June and 15 July 2020) by the author and a colleague (Nick Watson), together with officers of WCC (Rachel Robinson, Tracy Matthews and Graeme Todd) and Pre-Construct Archaeology (Paul McCulloch) to review the practicalities of excavating test pits/drilling boreholes at the relevant locations.

6.4

Figure 7 shows the recommended location of test pits/boreholes given the constraints outlined in Section 6.2 and local circumstances revealed by the actions described in Section 6.3. Fourteen sample locations have been proposed, while a fifteenth test pit/borehole is held in reserve for opportunistic sampling.

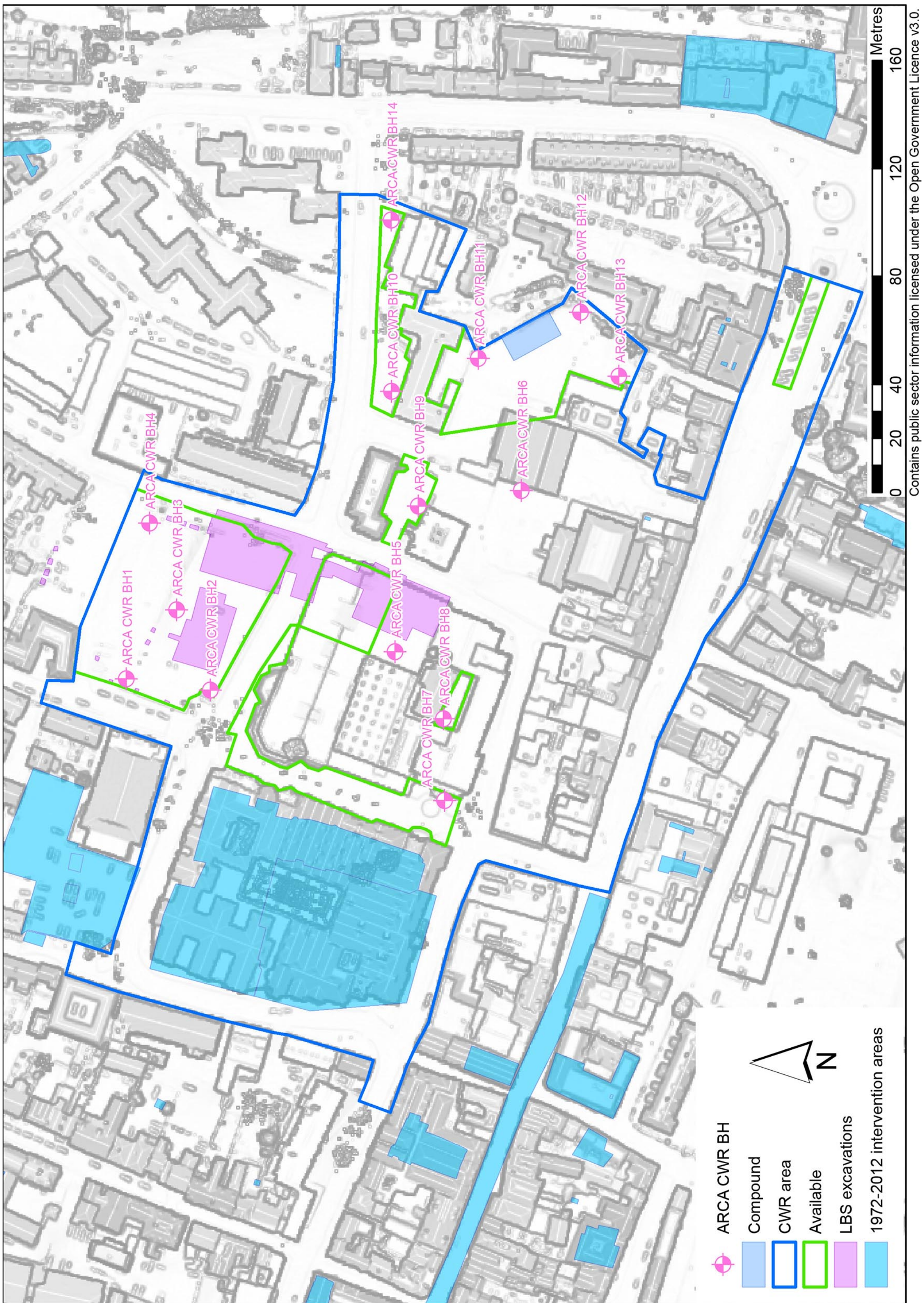

Figure 7. Proposed test pit and borehole locations

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