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CENTRAL WINCHESTER REGENERATION PROJECT: FINAL INTEGRATED GEOARCHAEOLOGICAL REPORT

Prepared for Winchester City Council

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SUMMARY

A geoarchaeological borehole survey was carried out of the Central Winchester Regeneration (CWR) site by ARCA and its partners in August 2020. Thirteen boreholes were drilled (ARCA CWR BH01–13) through the base of 1.2m deep archaeological test pits and to the base of the Quaternary (the last 2.6 million years) sediment stack. Continuous 112mm diameter cores were collected from each and which were later photographed, described and sub-sampled at the University of Winchester. Sub-samples were then assessed for palynology (n = 51), molluscs (n = 15) and plant macroremains (n = 22) while laboratory-based sedimentological and geochemical measurements were made on a further suite of sub-samples (n = 193) and artefacts >20mm identified. Ground water monitoring was carried out of the boreholes at weekly and contamination measurements made at monthly intervals between September 2020 and September 2021.

The stratigraphy of the site was divided into five major and four minor stratigraphic units (SU). These comprise Chalk of the Lewes Nodular Chalk Formation (SU1), which subcrops at between 7.63 and 10.80m below ground level (bgl). This Mesozoic (c. 90 million year old) stratum is overlain by sands and gravels of River Terrace Deposits 1 (SU3), a late Pleistocene stratum (possibly 70,000 years old) which extends upwards to between 4.20 and 6.85m bgl. In turn alluvial deposits (sands and silt [SU4a], peat (SU4b], tufa [SU4c] and silt/clay [SU4d]) continue the sequence until between 4.2 and 2.1m bgl. Although not dated as part of this project, the alluvium likely dates from the Early Holocene (perhaps as early as 8500 BC) through to the Iron Age, and indeed in some parts of the site continued to form even after the foundation of Venta Belgarum. Preservation of biological remains in the alluvium of SU4 is variable, but such sub-fossils might in the future provide useful palaeoenvironmental information to better understand prehistoric and early historic human activity in the area that is now Winchester.

The primary focus of the present project was on archaeological deposits (SU5) which subcrop above the SU4 alluvium and continue the sediment sequence to within 0.50–2.05m of the present ground surface. The thickness of archaeological strata increases from 2–3.5m in the west of the CWR area to >4m in the east (i.e. beneath the present bus station), while the deposits are a heterogenous mixture of poorly sorted gravels to clays with a high artefact concentration, through organic-rich silts and clays to structural remains. Biological preservation is good to moderate in SU5 across the entire CWR site, while the nature of that preservation is dependent of sediment property rather than depth. The SU5 Archaeological strata have high archaeological and palaeoenvironmental significance – locally and nationally. One borehole drilled in Kings Walk passed through 4.6m of alluvial sediments containing artefacts, as well as geochemical and sedimentological evidence of human activity, to reach River Terrace Deposits 1 at >6m bgl. It is highly likely that these Holocene alluvial strata are fills of an artificial channel, possibly that once running along Middle Brook Street.

The hydrogeological monitoring exercise demonstrated that groundwater levels fluctuate in the range 1.5–2.9m bgl, i.e. within the SU5 Archaeological strata. Organic remains were mostly encountered below 1.5m bgl, where they are frequent and well preserved. Groundwater on the site is part of a continuum with that of the underlying Chalk and is therefore unlikely to be affected by construction, except through compartmentalisation. A much greater risk to the archaeological resource as a result of construction and given the proximity of archaeological layers to the ground surface, is likely to be mechanical damage.

1. INTRODUCTION

1.1 This document is the final integrated geoarchaeological report on the stratigraphy revealed in and hydrogeology of 13 boreholes drilled within the Central Winchester Regeneration (CWR) site (Figure 1). Geoarchaeological works on the site are being carried out in stages as set out in a written scheme of investigation (WSI) (Wilkinson et al. 2020), and in accordance with the latter, this document is the fourth report to be produced as part of the project. As such, it follows from a desk-based assessment (DBA) (Wilkinson 2020), and supersedes both a preliminary statement on the borehole stratigraphy (Wilkinson and Watson 2020) and an interim report integrating the stratigraphy and biological preservation (Wilkinson, Batchelor, Watson and Young 2021). The overarching strategy for geoarchaeological and hydrogeological works on the CWR site was set out by Winchester City Council (WCC) (2020) in their brief, while the data reported here complete Part 1 of the project.

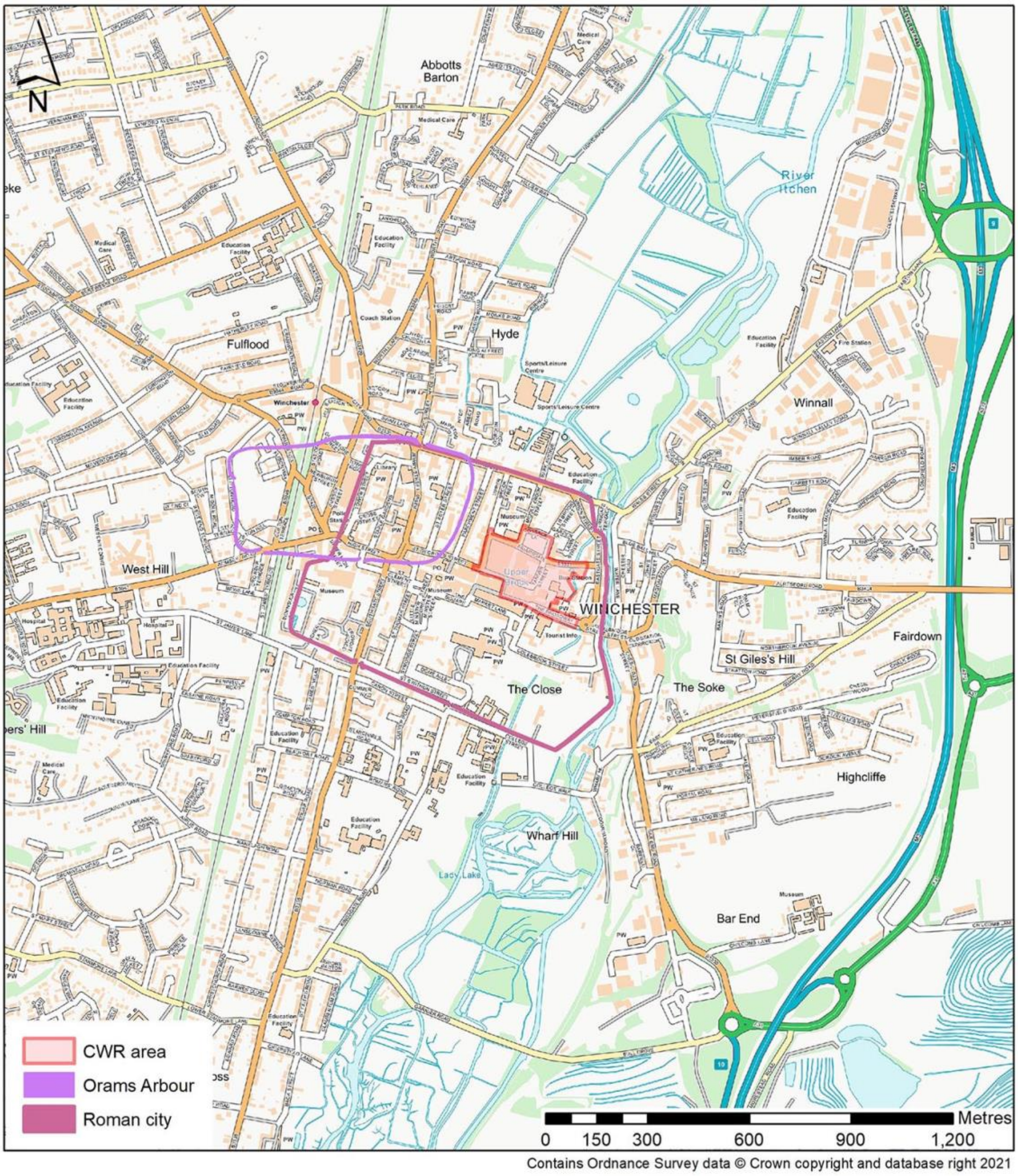


Figure 1. Location of the Central Winchester Regeneration site within Winchester.

1.2 The purpose of this final integrated geoarchaeological report was articulated in ARCA's tender and interim written scheme of investigation (WSI) for the CWR geoarchaeological borehole survey and hydrogeological assessment. As such the primary aims are to (a) present a Tier 2 hydrogeological assessment (*sensu* Historic England 2016) and (b) update (from the interim integrated report [Wilkinson et al. 2021]) the characterisation of the preservational potential and assessment of the archaeological and palaeoenvironmental significance of the sub-surface strata found across the CWR site (Wilkinson et al. 2020, sections 4.5.2, 28 and 4.5.3, 28–29).

1.3 The geoarchaeological data presented in this report have enabled the completion of all objectives of the Written Scheme of Investigation, namely (WCC 2020, 4–5; Wilkinson et al. 2020, sections 3.3, 16):

1. To provide a predictive model of the Quaternary sequence;
2. To obtain data on the significance, date, character, quality, survival and extent of archaeological deposits and palaeoenvironmental proxies within the CWR site;
3. To assess the likely state of preservation and vulnerability of organic and potentially waterlogged deposits;
4. To develop, test and refine, through field tests and acquisition of new data, a hydrogeological conceptual model of the water environment.

1.4 As with the previous geoarchaeological reports produced for the CWR project, the intended audience for the report is officers of Winchester City Council and the Historic England Science Advisor for South-east England (Wilkinson et al. 2020, section 4.2.10, 26).

2. BACKGROUND

2.1 The CWR site is intended for redevelopment for commercial, residential, retail and cultural purposes. It is situated in central Winchester and is located 95–385 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 and lies between c. +35 and +37 m OD. The site includes Winchester's bus station, several car parks as well as retail premises, albeit that some of the buildings are presently unused (Figure 2).

2.2 The British Geological Survey (BGS) map the area as lying on rock of the Lewes Nodular Chalk Formation, a Late Cretaceous (Turonian—Coniacian) carbonate-rich limestone that formed in a marine environment and dates 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). Prior to the present investigation knowledge of the subcrop elevation and thickness of River Terrace Deposits 1 within and around the study area was limited to geoarchaeological reporting of boreholes on the Broadway. This latter suggested that a 5.30m thick body of sands and gravels overlay Chalk at c. 8.30–9.70m below ground level (bgl) (Wilkinson 2006). The chronology of strata mapped as River Terrace Deposits 1 in the Itchen valley has not been determined, but a possible lateral equivalent at the Hunts Farm Sportsground, Romsey has been dated by optically stimulated luminescence to 68.8 ± 11.1 thousand years before present (BP) (Bates et al. 2010).

2.3 '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 (i.e. the last 11,700 years), and it therefore encompasses channel sands and gravels, levee silts and sands, floodplain silts and clays and backswamp organic muds and peat (BGS 2020b). Although geoarchaeological works have been previously undertaken within the CWR site, those data are not presently in the public domain. Rather prior to the prior to the present investigation the nature of Holocene stratigraphy on the CWR site had to be inferred from studies undertaken on the periphery of the study area, for example at 165 High Street, Lower Brook Street and the Upper Brook Street car park (Wilkinson and Batchelor 2012, Watson 2015, Wilkinson and Grant 2019). These suggested that peat strata overlie River Terrace Deposits 1 in the north-eastern part of the CWR site, tufa occupies the same stratigraphic position in the west, while both peat and tufa are overlain by floodplain silts and clays across the entirety of the area. Available ^{14}C dates suggest that the peat in the North Walls and Upper Brook Street area was laid down in the 8290–4500 cal. BC interval (i.e. the Mesolithic), while the floodplain silt/clays formed between cal. AD 760 and 170 cal. BC.

2.4 The same geoarchaeological studies referenced in Section 2.3 demonstrate that 'Alluvium' is overlain by archaeological deposits (Wilkinson and Batchelor 2012, Watson 2015, Wilkinson and Grant 2019). Indeed, archaeological material of Roman and Anglo-Saxon date was also found *within* the silt/clay alluvium in boreholes at the Upper Brook Street car park and 165 High Street (Wilkinson 2012, Wilkinson 2019), suggesting that flooding occurred within the city even after the Roman diversion of the River Itchen east of the walled area (Ottaway 2017a). Other than floodplain alluvium, the archaeological deposits seen in the 165 High Street, Lower Brook Street and Upper Brook Street car park sites are predominantly diamicts (poorly sorted sediment of gravel to clay grain size), containing 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 age, 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). However, opportunities for archaeological excavation have been few elsewhere in the CWR site and it is thus unclear what archaeological structures might lie within such areas.

2.5 Although not indicated on geological maps, the archaeological deposits are overlain across the entire CWR site by Made Ground (*sensu* BGS 2020b), i.e. strata formed as a result of human activity since AD 1800.

3. METHODOLOGY

3.0.1 The methodology adopted largely followed that outlined in ARCA's tender and interim WSI for the CWR site (Wilkinson et al. 2020, section 4.2–4.3, 20–26). The approach taken for sub-sample selection for sedimentological/geochemical study and biostratigraphic assessment was outlined in the interim stratigraphic report (Wilkinson and Watson 2020, section 5, 14–17), while a modified version of the latter text is included as Appendix 3 below.

3.1 Fieldwork

3.1.1 Borehole positions were agreed with Winchester City Council's Archaeologist and Project Manager for the CWR project and were then formally proposed in the DBA (Wilkinson 2020, section 6, 26–27). These locations were subject to CAT scan and a position free of buried services was then selected for test pitting/borehole drilling. The latter position was surveyed using a Leica CG16 (antenna) / CS20 (controller) RTK GPS (Figure 2Figure 2 shows the locations, while the borehole coordinates are given in Appendix 1).

3.1.2 In all locations other than ARCA BH05, ARCA BH05a, ARCA BH07 and ARCA BH08, test pits were excavated by Pre-Construct Archaeology to a depth of 1.15–1.32m below ground level (bgl) and using the methods articulated by Wilkinson et al (2020, section 4.2.3, 20). A test pit could not be dug at BH05 as the location rests on a c. 0.5m thickness of reinforced concrete, while in the case of ARCA BH07 and ARCA BH08, shallower test pits were excavated to the top of (non-reinforced) concrete that could not be penetrated using hand tools. The test pit excavated for ARCA BH14 located services at 0.75m bgl and no suitable alternative location could be found in the immediate surrounds. As a result, a further test pit (termed 'TP15') was positioned in an informal car park at the junction of Eastgate Street and Friarsgate (Figure 2), and excavated to 1.27m bgl. In the case of ARCA BH5a, it was agreed that the sample location would not be test pitted given the absence of high potential archaeological strata from 0.00m to 1.20m depth in adjacent locations[1].

3.1.3 A Pioneer 3 dynamic probe drilling rig operated by Geotechnical Engineering (2020) was used to advance boreholes through the backfilled test pits, recover continuous cores to the top of the Chalk bedrock and install piezometer tubing for groundwater monitoring (Wilkinson et al. 2020, sections 4.2.4–4.2.7, 22–23). Several attempts were made to use a concrete cutting shoe and a rotary drilling technique to advance ARCA BH05 through the reinforced concrete in the Tanner Street car park. However, none were successful, the borehole was abandoned and replaced with ARCA BH05a[1],[2]. Rotary drilling was employed at ARCA BH05a to penetrate the present concrete surface of the bus station car park and then 'pincers' were used to excavate a 0.2m diameter inspection pit to 1.2m bgl. The borehole was then advanced through the base of the inspection pit. As described above, ARCA BH14 was moved from its intended location in the north-eastern part of the former Friarsgate medical centre compound to a location c. 20m to the east. However, despite detailed and extensive CAT scanning in the car park location, a position free of services (including a water main) could not be found. The decision was therefore made not to drill ARCA BH14[1].

[1] As confirmed in email conversations with Winchester City's Archaeologist on 2 and 9 September 2020

[2] These attempts to drill ARCA BH5a lasted half a day and resulted in the destruction of three concrete cutting shoes. The drilling crew reported (verbally) that they had never witnessed such a failure before – such cutting shoes are used to drill through rocks as hard as granites.

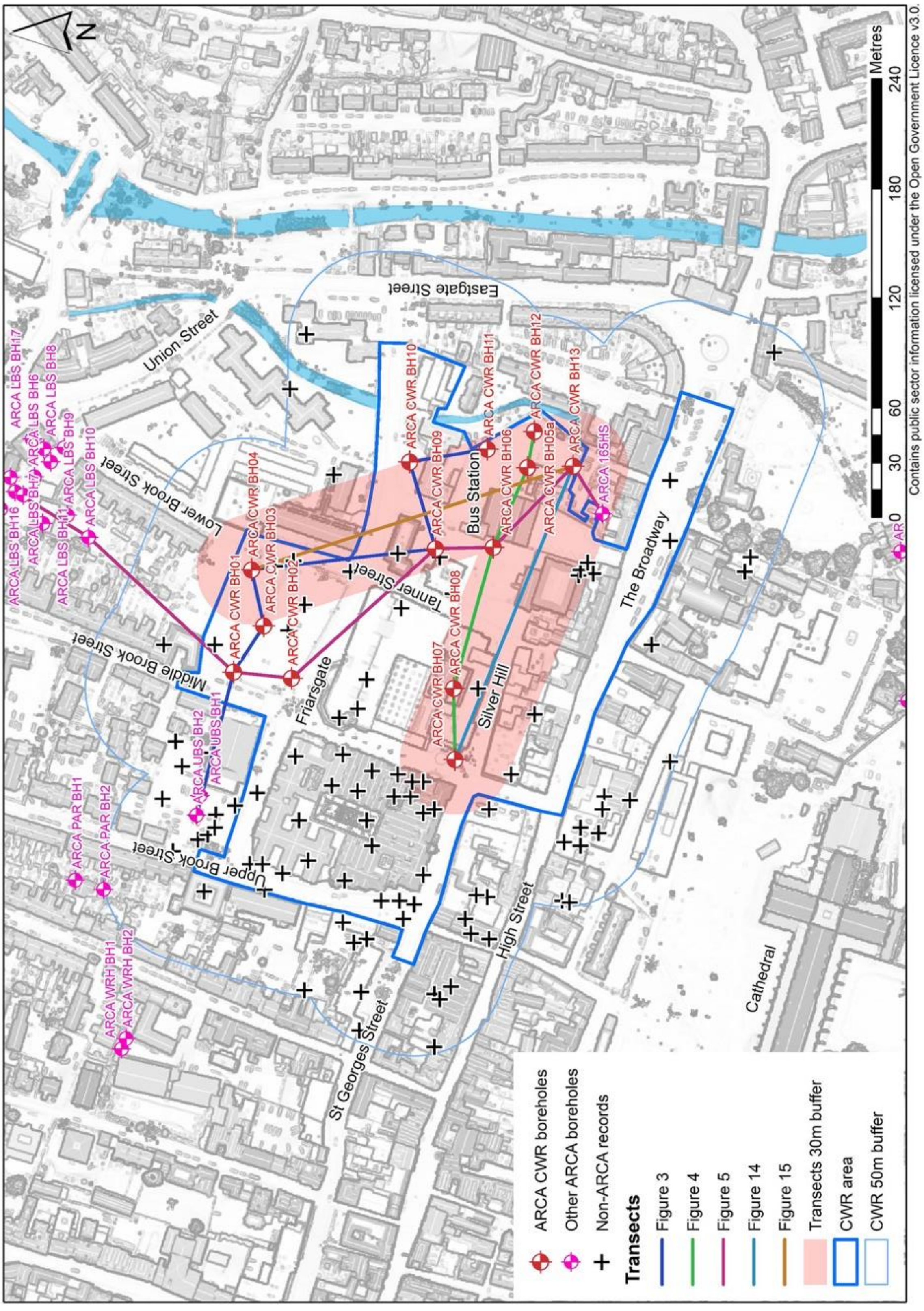


Figure 2. Location of ARCA and other boreholes, and borehole transects discussed in this report

3.1.4 Cores were transferred to the University of Winchester's Medecroft Quarter and were then treated as outlined below.

3.2 Core recording and sub-sampling

3.2.1 In either a laboratory or an open-air setting, core sleaves were cut and the strata so revealed cleaned and photographed. Deposits (lithological units) in the cores were then described using standard geological criteria (i.e. Jones et al. 1999, Munsell Color 2000, Tucker 2011), and directly into an iPad running Excel. Artefacts and bones of >20mm size were extracted during description from the cores and placed in ziplock bags labelled with borehole identification and depth, while sub-samples for laboratory study were collected opportunistically. These latter were of $2cm^3$ for palynology, $4cm^3$ for ^{14}C dating, 10mm (vertical) by 20mm (into the core) for sedimentology and geochemistry and 'bulk samples' measuring 50mm in vertical extent and spanning half the core thickness for microbiological assessment (plant macro remains and non-marine Mollusca) (Table 1). The depth intervals of the sub-samples were recorded in the same Excel spreadsheet as the lithological data.

Table 1. Core sub-samples collected and assessed/measured

Type	Number collected	Number assessed/measured
Palynology	234	51
Plant macrofossils	98	22
Non-marine Mollusca		15
Sedimentology/geochemistry	193	193
AMS ^{14}C dating	37	0
Total	562	281

3.2.2 On completion of description and sub-sampling, the Excel spreadsheet containing the lithological and sample data was imported into an SQLite database for use within the RockWorks 17 geological utilities package (Wilkinson et al. 2020, section 4.3.9, 25–26). The lithological units were then assigned to the same interpretational groups ('Stratigraphy' in RockWorks terminology) as used in the desktop assessment and interim stratigraphic report (Wilkinson 2020; Wilkinson and Watson 2020) (Table 2). RockWorks was then used to produce the composite cross sections of lithology and stratigraphy used in Section 4, and to model the stratigraphy as depth slices in Section 5 below (the algorithms used in the modelling and a justification for them is provided in the geoarchaeological desk-based assessment [Wilkinson 2020]).

3.2.3 Artefacts and bones >20mm recovered from the cores were washed, air dried and then passed to Paul McCulloch (PCA) and Monika Knul (University of Winchester) for study. Given that few artefacts/bones were so recovered, the examination was qualitative[3].

3.2.4 Sub-samples were selected for biostratigraphic assessment on the basis of agreed criteria[4] (in descending order of importance):

[3] The borehole cores were 'excavated' by student volunteers in September 2021 (the cores had dried and degraded in the 12 months since collection), and all artefacts and bones >8mm were recovered in 50mm-thick spits. Study of the remains so extracted will take place as part of a student project, the results of which will be reported to Winchester City Council during the course of 2022.
[4] As agreed with Winchester City Council's archaeologist and the Historic England Science Advisor for South-east England on 3 November 2020.

1. Archaeological (SU5) or alluvial strata containing archaeological artefacts (SU4d) in which waterlogged sub-fossil preservation of biological materials was noted during core description;
2. Representation from as many boreholes as possible;
3. Strata of particular biostratigraphic interest (SU-4c and SU-4b);
4. Alluvial strata (SU4a and SU4d) in which waterlogged sub-fossil preservation of biological materials was noted during core description;
5. Other alluvial strata.

As a result, the samples shown in the final column of Table 1 were assessed/measured (the details of these latter along with further information on selection criteria are included as Appendix 3 below).

Table 2. Stratigraphic designations

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 ('Alluvium 1' below)
4b	Peat and organic mud ('Peat' below)
4c	Tufaceous deposits and marl ('Tufa' below)
4d	Sand, silts and clay alluvium (Alluvium 2' below)
5	Diamicts, structural deposits, peat, silts and clays. All containing artefacts ('Archaeological deposits' below)
6	Diamicts, structural deposits, 'overburden' ('Made ground' below)

3.3 Sedimentology and geochemistry

3.3.1 The 193 sub-samples for sedimentology and geochemistry were initially air dried at 40°C for 72 hours and the weight loss measured as an estimate of field moisture content. The samples were then homogenised using a pestle and mortar, and the resultant powder passed through a 2mm sieve. The coarser residue was discarded and the finer used to fill a 10ml Perspex pot (excess <2mm sediment was placed in a ziplock bag as an archive).

3.3.2 Low frequency magnetic susceptibility measurements were first made on sediment within the 10ml pot using a Bartington MS2C dual frequency sensor and MS2 meter, and using the protocol outlined by Gale and Hoare (1991, 221–226). Next the plastic pot lid was replaced with 6µm Mylar film, and employing the methodology of Glauberman et al. (2020), the samples' geochemical properties measured using a Niton XL3td GOLDD+ portable X-ray fluorescence (pXRF) meter. On completion of the pXRF study, between 1 and 4g of sediment from each Perspex pot was utilised for loss-on-ignition measurement to assess organic carbon content. During this process, sample and crucible mass were measured to three decimal places, while weight loss was determined following combustion at 550°C for four hours.

3.3.3 The calculated percentage of organic carbon was used to select samples for humification measurement (i.e. samples containing >35% of organic carbon were so chosen). Thereafter a sample mass of 0.2g was boiled in an 8% solution of NaOH as described by Payne and Blackford (2008), and humification estimated by photometer reading (at a wavelength of 550nm) of the (300%) diluted filtrate. Finally, pH readings were made by extracting a further 1g of sediment from the 10ml pot, adding that to a beaker containing 20ml of distilled water, mixing and then employing a Hanna HI-98107 pH meter to obtain a pH estimate.

3.4 Palynology

3.4.1 Pollen was extracted from sub-samples as follows: (1) sampling a standard volume of sediment ($1cm^3$); (2) deflocculation of the sample in 1% Sodium pyrophosphate; (3) sieving of the sample to remove coarse mineral and organic fractions (>125µ); (4) acetolysis; (5) removal of finer minerogenic fraction using Sodium polytungstate (specific gravity of $2.0g/cm^3$); (6) mounting of the sample in glycerol jelly. Each stage of the procedure was preceded and followed by thorough sample cleaning in filtered distilled water. Quality control is maintained by periodic checking of residues and assembling sample batches from various depths to test for systematic laboratory effects.

3.4.2 The assessment was carried out to include taxonomic identifications of the main taxa, diversity, abundance and preservation. The assessment consisted of scanning the prepared slides along four transects (10% of the slide), or until 50 total land pollen grains (tree, shrub and herb taxa) were noted. Aquatic and spores were counted in addition, while parasite eggs were also noted. Pollen grains and spores were identified using the University of Reading pollen type collection and the following sources of keys and photographs: Moore et al (1991); Reille (1992).

3.4.3 As outlined in the WSI (Wilkinson et al. 2020, section 4.3.6, 25), all biostratigraphic works for the CWR geoarchaeology project assessed taxonomic diversity, fossil abundance and proxy preservation according to the five-point scale set out in Table 3.

Table 3. Biostratigraphic assessment categories

Score	Diversity	Abundance	Preservation
1	<5 taxa	<10 occurrences	Highly eroded/weathered fossils, only most robust taxa noted
2	6–10 taxa	11–25 occurrences	Highly eroded fossils and fragile taxa present as fragments
3	11–20 taxa	26–75 occurrences	Moderately eroded fossils and fragile taxa present
4	21–30 taxa	76–200 occurrences	Uneroded/weathered fossils and fragile taxa present
5	>30 taxa	>200 occurrences	Uneroded/weathered fossils, fossils are articulated, fragile taxa are present

3.5 Plant macrofossils

3.5.1 The macrofossil extraction process involved the following procedures: (1) measuring the sample volume by water displacement, and (2) processing the sample by wet sieving using 300µm and 1mm mesh sizes. The residues from each sample so-produced was scanned under a stereozoom microscope at x7–45 magnifications, and sorted into the different macrofossil classes. The concentration and preservation of remains was estimated for each class of macrofossil, while preliminary identifications were made of the waterlogged seeds and fruits using modern comparative material and reference atlases (e.g. Martin and Barkley 2000, NIAB 2004, Cappers *et al.* 2006). The nomenclature used follows Stace (2005).

3.5 Non-marine Mollusca

3.5.1 Bulk samples to be assessed for their non-marine molluscan content were processed according to the methodology of Wilkinson and Stevens (2008, 117–119). Samples were initially weighed and then air dried at 40ºC for 72 hours. Weight was then re-measured in a dry state after which samples were placed in 10l buckets and water was added until it just overtopped the sediment. Next, 20ml of 30 vol. H_2O_2 was added, the mixture stirred and left for 24 hours for the reaction to subside. The resultant slurry was wet sieved through a 0.5mm mesh and the residue air dried. The latter was then passed through a nest of sieves and the residues sorted by eye and using a low-power binocular microscope to a size of 1mm. Apical (gastropod) and hinge (bivalves) were removed from the residues, identified to species or genus taxonomic level as appropriate, and quantified. Nomenclature in Section 4.5 follows Welter-Schultes (2012).

3.6 Hydrogeology

3.6.1 A two-week period was allowed to elapse between the completion of the boreholes and the commencement of groundwater monitoring, this to allow for the passing of any disturbance caused by the former to the water table and geochemistry. Thus, the first visit to monitor groundwater levels and collect samples for contamination testing was on 29 September 2020. Subsequent visits were made on a weekly basis to collect groundwater data and at monthly intervals to obtain samples for laboratory contamination testing. Monitoring/sample collection ceased on 15 September 2021. Unfortunately – and despite the best efforts of officers of Winchester City Council – it proved impossible to visit each borehole every week. Vehicles parked over borehole locations in the Lower Brook Street car park (despite cones being placed to block the spaces containing the boreholes) often prevented access, while the Kings Walk shopping area (ARCA BH08) was locked shut during the second Covid-19 lockdown from the end of December 2020 to the beginning of April 2021 and could not be accessed.

3.6.2 During each weekly monitoring visit measurements were taken from each borehole using a Solinst 101 ground water meter (RS Hydro 2020) and water level, temperature and electrical conductivity were all recorded. In addition, during the last visit of each month, 100ml samples of water were collected from each borehole using a bailer. Within 24 hours of sample collection, phosphate, nitrate and dissolved oxygen concentrations of the samples was measured using a Palintest Photometer 7500 and reagents in tablet form (Palintest 2020).

3.6.3 The hydrogeological data described in Section 3.6.1–3.6.2 were incorporated in both and an Excel spreadsheet and the RockWorks database. The former was used to evaluate correlation, and the latter to model and plot groundwater table variation. Hydrogeological data from RockWorks were used to plot models of groundwater elevation (Figure 10 and Figure 11), using the same algorithm and settings described for deposit models in the DBA (Wilkinson 2020).

3.6.4 Rainfall data of 15-minute resolution from the closest Environment Agency weather station at Harestock[5], 3.2 km north-west of the CWR site, were downloaded on a

[5] Station E12580, https://environment.data.gov.uk/flood-monitoring/id/stations/E12580.html.

monthly basis[6]. Measurements of flow in the River Itchen at the Sewards Bridge monitoring station in Alresford[7], 9.4 km north-east and thus upstream of Winchester, were also downloaded at monthly intervals. Data from both sources were stored as Excel spreadsheets, while to facilitate comparison with the hydrological monitoring data collected from the CWR site, the resolution of the rainfall and flow datasets was downgraded to weekly sums (rainfall) and averages (flow).

3.7 Archive

3.7.1 The archive resulting from the Central Winchester Regeneration geoarchaeology project is both material and digital. The material archive comprises artefacts, bones and shells recovered from the borehole cores, and processed and unprocessed samples extracted. The digital archive consists of text, spreadsheet, database and graphical data. The archive has been/will be compiled as required by Chartered Institute for Archaeologists (2014) guidelines.

3.7.2 As was stated in the iWSI the Pioneer 2 borehole cores were discarded 12 months following completion of fieldwork (Wilkinson et al. 2020). However, *contra* the iWSI and as stated in footnote 3, the cores were cut into 5cm-thick slices before disposal and those slices then sieved through an 8mm sieve to recover artefacts, bone and quantifiable mollusc shell. These latter materials are at the time of writing (March 2022) the subject of an undergraduate dissertation project. On completion of that research, the ceramic building material will be discarded, but all other artefacts, bone and shell will be offered to Hampshire Cultural Trust for archiving (including those picked from the cores during description and described in Appendices 7 and 8). If accepted, the archive will be prepared as required by Hampshire Cultural Trust.

3.7.3 The material archive also comprises those samples left unprocessed following the measurements/assessment outlined in Table 1. These samples are presently in climate-controlled storage at the University of Winchester and will remain so for one year following the issuing of this report (i.e. until 10 March 2023) and pending decisions on additional analyses that may be required. Thereafter the samples will be disposed of unless a request is made for their retention (in which case an annual storage fee will apply). Microscope slides made from the assessed palynological samples and flots (stored in water) from the assessed plant macroremain samples are presently stored at the University of Reading. They will be retained until 10 March 2023 to allow for decisions on any further examination that might be required, at which point the plant macroremain flots will be discarded and the pollen slides added to the archive transferred to Hampshire Cultural Trust (if applicable, and discarded if not). Mollusc shells picked from sample residues assessed for that purpose are presently stored (in vials) at the University of Winchester and will be treated as described for pollen slides above in respect of transfer to Hampshire Cultural Trust or discard.

3.7.4 The digital archive comprises:

1. A RockWorks 17 (SQLite) database housing the positional and stratigraphic data of the boreholes (as in Appendices 1–2) and basic hydrogeological data;
2. Photographs of the borehole cores as image files (compressed TIF format);
3. Excel spreadsheets holding the palynological, molluscan and plant macrofossil assessment data (as presented in Appendices 4–6);
4. Excel spreadsheets storing the full hydrogeological monitoring data;

[6] These data are removed from public access after 28 days and do not then reappear as an archive until a year after upload.

[7] Station E12781, https://environment.data.gov.uk/hydrology/station/a3c4766d-b704-4819-913b-0be1d2ed7b3a

5. An Excel spreadsheet storing the sedimentological and geochemical data.

These data will be held in perpetuity at the University of Winchester and (on request) will be made freely available to Winchester City Council and bodies authorised by the latter.

4. RESULTS

4.0.1 The results of the lithostratigraphic descriptions, sedimentological and geochemical measurement and pollen, plant macro-remain and molluscan assessments are set out in separate text sections below. In the case of the lithostratigraphy, the text is a slightly modified version of that previously included in the interim stratigraphic report (Wilkinson and Watson 2020).

4.1 Lithology

Keith Wilkinson and Nick Watson

4.1.0.1 Deposits sampled in the borehole cores are described in reverse stratigraphic order and using the stratigraphic framework set out in ARCA's tender and iWSI, and repeated in the DBA (Wilkinson 2020, section 2.1.2, 8; Wilkinson et al. 2020 section 4.1.1, 18) and subsequent reports (Wilkinson and Watson 2020, Wilkinson et al. 2021).

4.1.0.2 The descriptions are on the basis of three composite cross sections (Figure 3, Figure 4 and Figure 5), plotting ARCA's CWR boreholes and previous ARCA records from the surrounding area. In the cross sections the stratigraphic correlations (i.e. attribution to Stratigraphic Unit [SU], e.g. 'LF-4b Peat) have been made simply by projecting lines between the relevant subcrop contacts in each borehole.

4.1.1 SU1 Lewes Nodular Chalk Formation

4.1.1.1 Chalk of the Lewes Nodular Chalk Formation was found in all ARCA's CWR boreholes at depths of between 7.63m bgl (+29.22m OD) in ARCA CWR BH06 and 10.80m bgl (+25.98m OD) in ARCA CWR BH13. Except for an area of relatively high subcrop (+28.17 to +27.49m OD) in the central part of the site in the area of ARCA CWR BH03, ARCA CWR BH04 and ARCA CWR BH06, there are no obvious trends in the surface elevation of the Lewes Nodular Chalk Formation (Figure 3 and Figure 4).

4.1.1.2 Deposits of the Lewes Nodular Chalk Formation exposed in the borehole cores comprised weathered calcareous detritus and granular to pebble-size flint fragments, while solid Chalk bedrock was not encountered in any of the boreholes.

4.1.2 SU3 River Terrace Deposits 1

4.1.2.1 Sand and gravel strata of River Terrace Deposits 1 was found unconformably overlying deposits of the Lewes Nodular Chalk Formation in all boreholes at depths of between 4.20m bgl (+32.71m OD) in ARCA CWR BH12 and 6.85m bgl (+30.15m OD) in ARCA CWR BH07. The thickness of the sands and gravels varied between 5.54m in ARCA CWR BH13 and 1.95m in ARCA CWR BH08. There are broad trends in the subcrop distribution, namely thinning of the stratum in a westerly direction (Figure 4), and a higher surface in the central and western part of the site (but see Section 4.1.3 below) (Figure 5). Indeed, the thinnest subcrop of River Terrace Deposits 1 broadly coincides with the elevated Chalk subcrop described above in the ARCA CWR BH3 (2.72m), ARCA CWR BH04 (2.71m), ARCA CWR BH06 (2.33m) and ARCA CWR BH08 (1.95m) area.

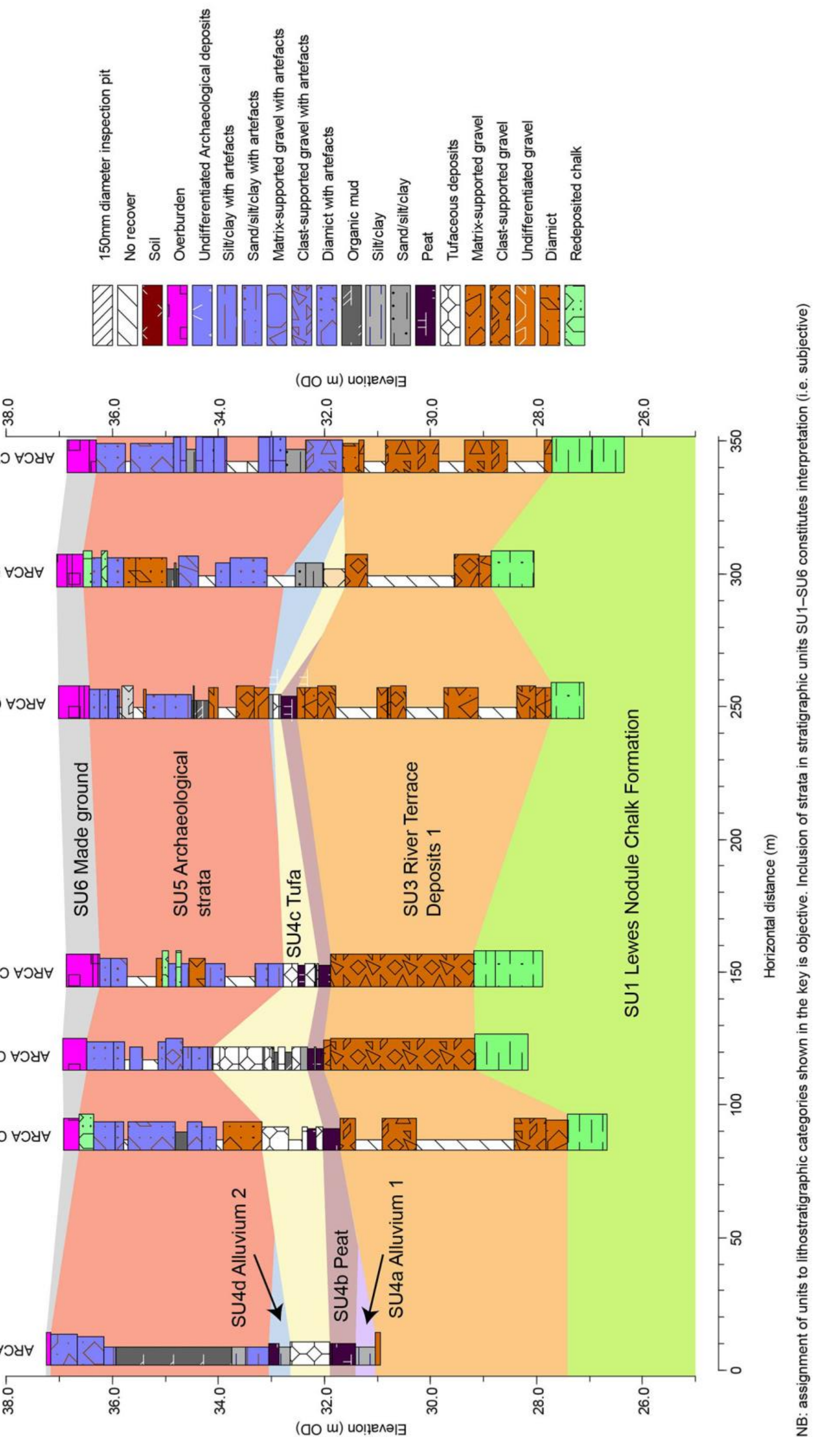
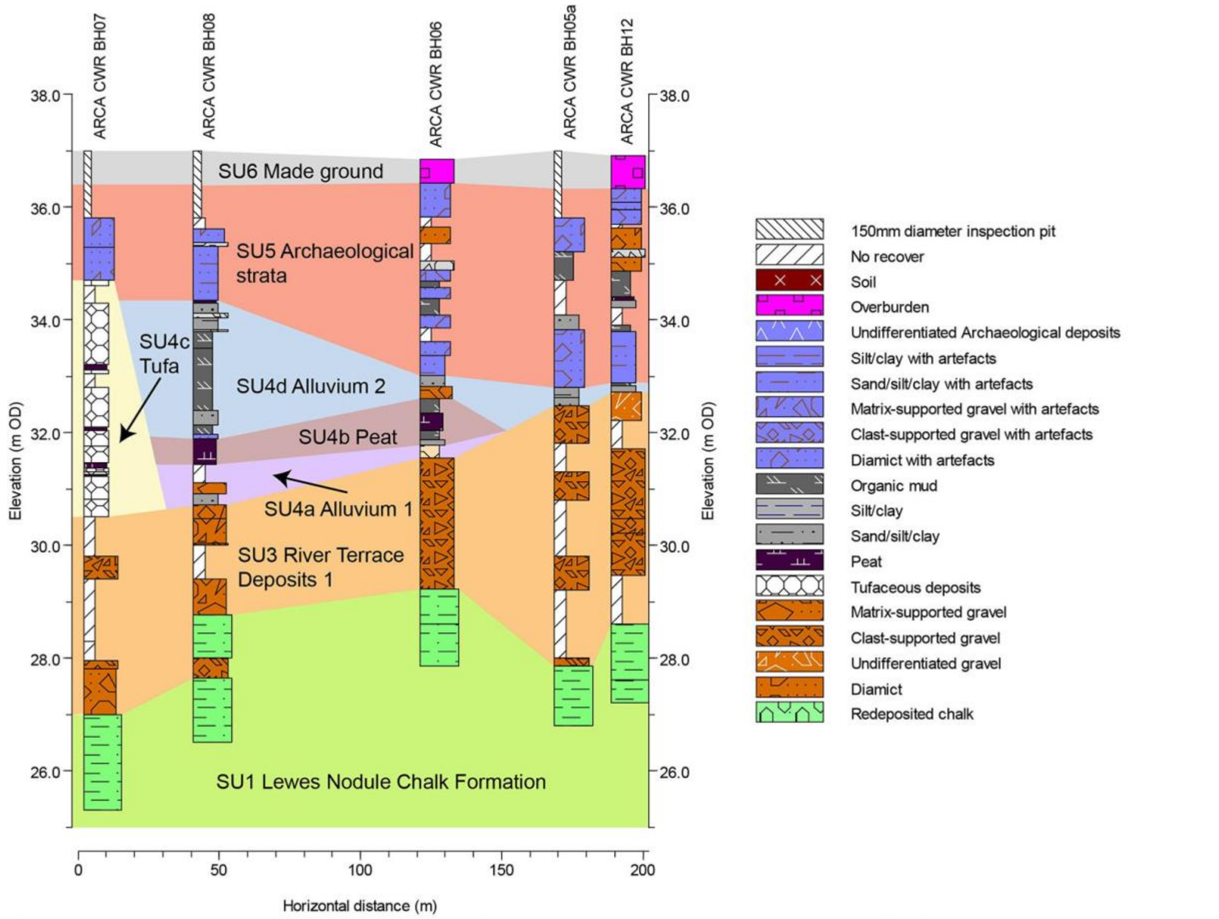


Figure 3. West-north-west to east-south-east composite cross section through ARCA's CWR boreholes in the northern part of the site
Blue transect in Figure 2



NB: assignment of units to lithostratigraphic categories shown in the key is objective. Inclusion of strata in stratigraphic units SU1–SU6 constitutes interpretation (i.e. subjective)

Figure 4. West-north-west to east-south-east composite cross section through ARCA's CWR boreholes in the southern part of the site
Green transect in Figure 2

4.1.2.2 River Terrace Deposits 1 strata encountered in the ARCA CWR boreholes comprised matrix- and clast-supported gravels of flint within a coarse to medium, flint-derived sand matrix. Much of the latter had been flushed out of the cores by water used for lubrication during the drilling operations, while only a single fine-grained bed was found, in ARCA CWR BH08 at 6.08–6.28m bgl (+30.92–+30.72m OD).

4.1.3 SU4 Alluvium

4.1.3.1 As was described in the tender and iWSI (Wilkinson et al. 2020, section 4.1.1, 18), and the DBA (Wilkinson 2020, section 3.5, 14–18), SU4 Alluvium subcrops across the CWR site as four sub-units. Where there is a contact between SU4 and SU3 River Terrace Deposits 1, that boundary is always unconformable. SU4a Sand, silt, clay and matrix-supported gravel ('Alluvium 1') by definition only occurs where either or both SU-4c Peat and SU-4b Tufaceous deposits also subcrop. Further, SU4d Sand, silt and clay ('Alluvium 2') occasionally incorporates archaeological artefacts and where this latter property is noted it implies co-deposition of SU-4d with SU-5 Archaeological strata.

4.1.3.2 The upper surface of the SU4 subcrop varies between 1.69m bgl (+35.31m OD) in ARCA CWR BH08 and 4.50m bgl (+32.56m OD) in ARCA CWR BH10, while the overall thickness of the alluvium is between 4.59m in ARCA CWR BH08 and 0m in

ARCA CWR BH11 and ARCA CWR BH12. In general, SU4 Alluvium thickens towards the west of the CWR site and is either very thin or absent in the east (Figure 3 and Figure 4).

4.1.3.3 Within the overall subcrop distribution set out in 4.3.3.1–4.3.3.2 above are further trends. SU-4b Peat is found in the north-western part of the site, while it thins towards ARCA CWR BH09 in the central area and disappears east of the latter (Figure 3 and Figure 4). Further, SU-4c Tufaceous deposits are found in subcrops of 4.55m (ARCA CWR BH07), 1.79m (ARCA CWR BH03) and 0.66m (ARCA CWR BH04) thickness in the western and north-central part of the site and the stratum then thins south and eastwards towards ARCA CWR BH09 where it subcrops as a 0.11m thick layer (Figure 3 and Figure 4). Tufa is not then found east of ARCA CWR BH09. It is of particular note that peat interdigitates with tufa in ARCA CWR BH07, the first time this phenomenon has been observed in Winchester (Figure 4).

4.1.3.4 SU4d Alluvium 2 is found in variable thicknesses across the whole CWR site. However, as is implied in Section 4.3.3.1 it has not always been possible to separate that sub-stratum from the overlying SU5 Archaeological deposits. Therefore, over parts of the study area, alluvial and archaeological deposition is likely to have occurred simultaneously. Indeed, artefacts were found in SU4d in ARCA CWR BH06 and ARCA CWR BH08 (Appendix 7), demonstrating that the stratum was still developing in the Romano-British and Anglo-Saxon periods. The thickest subcrop of SU4d Alluvium 2 is in ARCA CWR BH08 in which 4.59m of such deposits were encountered. However, <1m of alluvial strata attributable to SU4d subcrop elsewhere, while it is notable that the boreholes drilled in the bus station contain <0.3m of the stratum.

4.1.4 SU5 Archaeological deposits

4.1.4.1 Poorly sorted (diamicts) archaeological deposits (SU5) unconformably overlie SU3 River Terrace Deposits 1 in ARCA CWR BH11 and ARCA CWR BH12, while the archaeological deposits have a conformable contact with SU4 Alluvium in all other boreholes. The archaeological deposits vary in their thickness between 4.68m in ARCA CWR BH11 to 0.00m in ARCA CWR BH08 (although see Section 4.1.3.4 on the latter). Indeed, the thickest subcrop is in the area of the bus station (ARCA CWR BH05a, ARCA CWR BH11–13) and the former Friarsgate medical centre (ARCA CWR BH10) (2.50–4.35 m), while the thinnest deposits are found in the southern part of the Middle Brook Street car park (ARCA CWR BH02–03) and the central part of the CWR site (ARCA CWR BH07, ARCA CWR BH09) (1.11–2.18m) (Figure 3, Figure 4 and Figure 5).

4.1.4.2 Deposits of SU5 are heterogeneous and vary from sediments dominated by clays and silts, but containing moderate gravel sized clasts and artefacts, to well-sorted organic-rich silts and indeed structural materials. Examples of the latter are present in the form of two wooden, waterlogged stakes and multiple horizontal layers of mortar at 2.42–4.13m bgl (+34.43–+32.72m OD) in ARCA CWR BH11 and a wooden pile at 4.09–4.20m bgl (+32.69–+32.58m BGL) in ARCA CWR BH13[8].

[8] The wooden stake was extracted from the core and placed in climate/moisture controlled storage. Although detailed study is beyond the scope of the present project, it is clear that the stake is well preserved, albeit that it suffered mechanical damage during borehole drilling.

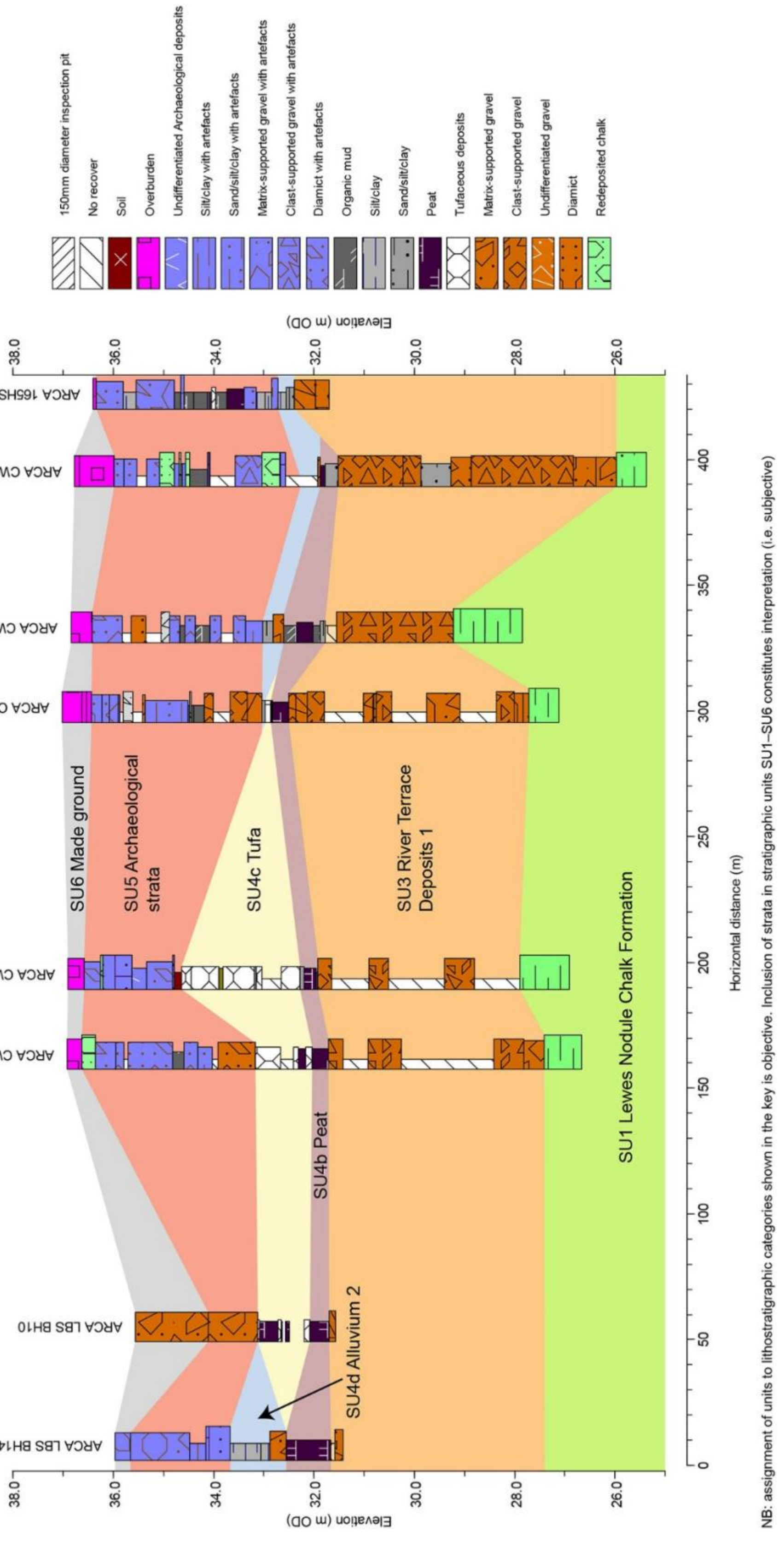


Figure 5. North–south composite cross section through ARCA's CWR, Lower Brook Street (LBS) and 165 High Street boreholes

Purple transect in Figure 2

4.1.4.3 Artefacts (>20mm) recovered from SU5 strata (with the sherds identified in SU4d – see Section 4.1.3.4) are catalogued in Appendix 7. The majority of ceramic finds are of Romano-British date and were retrieved from a depth range spanning 1.75–1.77m bgl in ARCA CWR BH03 to 3.35–3.45m bgl in ARCA CWR BH12. A medieval green-glazed ware sherd was found in ARCA CWR BH13 (3.20m bgl). All the pottery sherds, tile and brick fragments have rounded breaks, suggesting that they became fragmented in antiquity, and are therefore likely to have been reworked (i.e. they probably do not date the strata from which they were recovered).

4.1.5 SU6 Made ground

4.1.5.1 Made ground strata of SU6 were encountered in the archaeological test pits through which the boreholes were advanced and the uppermost cores. Such strata are so defined based on inclusion of materials that were only manufactured and/or used in the 19th to 21st centuries. However, when such materials and indeed older artefacts, are absent, it is difficult to separate SU6 Made ground from SU5 Archaeological deposits. In other words, the inferred thickness of Made ground deposits is best considered a minimum estimate.

4.2 Sedimentology and geochemistry

Keith Wilkinson

4.2.0.1 The sedimentological and geochemical properties of the stratigraphic units are reviewed in reverse order below, i.e. beginning with SU1 Chalk and ending with SU5 Archaeological deposits. Further, in accordance with the primary aims of the project (i.e. to evaluate the preservational potential and archaeological/palaeoenvironmental significance of strata underlying the CWR site – see Sections 1.2–1.3), the main thrust of this section of the report is descriptive so as to define the baseline properties of the strata. Some interpretation of the data is provided with regards the implications for the depositional environment, but that explanation is outline in nature[9].

4.2.0.2 Sedimentological and geochemical data are presented in summary form in Table 4 and Table 5.

4.2.1 SU1 Lewes Nodular Chalk Formation

4.2.1.1 The sedimentological and geochemical properties of the Lewes Nodular Chalk Formation are of geoarchaeological importance given that the unit is the parent material for the overlying superficial deposits. Therefore, deviation in SU3–SU5 from the sedimentological and geochemical baseline of SU1 is likely to reflect depositional conditions (e.g. mechanisms of transport and accretion) and environmental factors (e.g. the amount and nature of vegetation, but also human activity).

4.2.1.2 SU1 is characterised by a slight low frequency magnetic susceptibility (χ^{lf}) (-0.05–2.73 SI units x10^{-8} m^3 kg^{-1}), a relatively low moisture content (this despite the Chalk subcrop lying well below the water table) and only a slight weight loss-on-ignition (0.70–3.19%). This latter parameter indicates low organic carbon content and indeed the small mass that was lost is probably a product of the partial breakdown of calcium carbonate

[9] The sedimentological and geochemical dataset is by an order of magnitude the most extensive ever acquired from Winchester, but given the limited aims/objectives set in the brief and iWSI (WCC 2020, Wilkinson et al. 2020), its full analysis is beyond the remit of the present project.

($CaCO_3$). The unit is highly alkaline as demonstrated by a pH ranging between 9.2 and 9.5.

Table 4. Summary sedimentological data by stratigraphic unit

SU	Samples	Moisture (%)	χ^{lf} SI units x10^{-8} m^3 kg^{-1}	LOI 550 (%)	pH
1	12	16.46±2.04	0.91±0.74	1.62±0.69	9.36±0.13
3	7	17.05±8.52	32.51±56.40	4.76±5.93	8.70±0.72
4a	8	26.64±6.42	26.36±32.67	6.84±3.73	8.90±0.18
4b	24	60.83±14.82	3.01±6.81	48.17±30.45	8.54±0.37
4c	25	49.571±1.54	0.90±1.51	11.79±10.68	8.77±0.31
4d	47	37.89±11.44	35.56±80.98	13.38±17.33	8.82±0.27
5	67	41.45±12.13	73.48±134.81	14.53±9.73	8.64±0.23

NB: SU1 = Lewes Nodule Chalk Formation, SU3 = River Terrace Deposits 1, SU4a = Alluvium 1, SU4b = Peat, SU4c Tufa, SU4d = Alluvium 2, SU5 = Archaeological strata

Table 5. Summary geochemical data by stratigraphic unit

SU	Bal. (%)	Ca (%)	Si (%)	Fe (%)	K (%)	P (%)
1	59.76±1.61	36.70±1.91	2.02±0.64	0.40±0.17	0.27±0.07	0.14±0.06
3	68.90±4.29	21.27±9.39	7.26±5.21	1.09±0.55	0.41±0.28	0.18±0.06
4a	68.08±4.03	21.51±8.14	6.89±3.34	1.19±0.60	0.75±0.40	0.31±0.21
4b	80.04±11.55	14.02±13.77	3.19±4.84	1.09±0.77	0.29±0.36	0.16±0.04
4c	61.65±4.75	36.71±4.91	0.55±0.77	0.47±0.87	0.08±0.07	0.20±0.16
4d	65.74±6.07	27.54±7.83	4.06±2.65	0.93±0.51	0.39±0.23	0.36±0.36
5	67.06±4.85	23.94±4.65	4.67±1.41	1.24±0.55	0.20±0.13	0.57±0.46

NB: SU1 = Lewes Nodule Chalk Formation, SU3 = River Terrace Deposits 1, SU4a = Alluvium 1, SU4b = Peat, SU4c Tufa, SU4d = Alluvium 2, SU5 = Archaeological strata

4.2.1.3 The geochemical properties of SU1 explain the low χ^{lf} and organic carbon content. The unit is characterised by a high proportion of 'Bal.' (this parameter being a sum of all elements with an atomic number of 10 or less – of which carbon [C], oxygen [O] and to a lesser extent, nitrogen [N] and hydrogen [H], are the most important), ranging from 58 to 64% and calcium (Ca), which is found at 34 to 39%. Collectively Ca and Bal are the constituent parts of $CaCO_3$, of which Chalk is >90% composed. The only other element found at >1% is silicon (Si), which is present at 1.2–3.3%, and in the present instance is an indicator of the flint content of the Chalk (flint is >90% Si). All other elements, including those such as iron (Fe) and aluminium (Al), which are common in the Earth's crust, are present as a trace. Further, it is notable that SU1 contains no copper (Cu), zinc (Zn) or lead (Pb), while phosphorous (P) is only present as a trace (0.1–0.2%). $CaCO_3$ has a χ^{lf} of 0 and therefore any slight enhancement of χ^{lf} in SU1 is a product of trace element content.

4.2.2 SU3 River Terrace Deposits 1

4.2.2.1 Given that the grain size of SU3 exceeded 2mm in most of the sampled subcrop, only the rare fine-grained facies (i.e. lenses of sand and silt) could be studied for their sedimentological and geochemical properties. The results of those analyses demonstrate that there is some degree of variation between fine-grained strata in the various boreholes (hence the comparatively large standard deviations in Table 4 and Table 5), while in the case of ARCA CWR BH13, SU3 would appear to have been affected by human activity as demonstrated by low frequency magnetic susceptibility properties.

4.2.2.2 If the two samples of SU3 from ARCA CWR BH13 are excluded, the unit is possessed of low χ^{lf} (1–17 SI units x10^{-8} m^3 kg^{-1}), a comparatively wide ranging (but always alkaline) pH (7.3–9.5) and variable moisture content (8–31%), while weight loss-on-ignition is variable, but mostly low (1–15%). Elevated moisture and loss-on-ignition contents are found in the same samples suggesting that the two relevant samples (in ARCA CWR BH08 and ARCA CWR BH09) contain organic carbon. The two samples from ARCA CWR BH13 have elevated χ^{lf}, i.e. 35–158 SI units x10^{-8} m^3 kg^{-1}, but moisture, loss-on-ignition and indeed geochemical properties are in line with other samples from SU3.

4.2.2.3 The geochemical properties of SU3 reflect the greater importance of Si (3–18%) than in SU1, in turn demonstrating the fact that the gravels of which the unit is composed are of flint and that some of those clasts have weathered to produce <2mm particles. Ca is present at 20–28%, indicating that the sand in most samples is at least partly of Chalk. However, one sample from ARCA CWR BH09 contains only 1% Ca (but 18% Si), suggesting that the sand grains in this sample are flint-derived. 'Bal.' measurements are higher than for SU1 and range from 65 to 78%. The highest two readings coincide with elevated loss-on-ignition percentages and therefore reflect relatively high organic carbon content, while the relatively high 'Bal.' levels elsewhere probably indicate the continued importance of Chalk (i.e. $CaCO_3$), but also of oxides (SiO_2 in flint for example). As with SU1, most other elements are present as a trace, albeit that Fe is found at slightly higher levels than in SU1 (0.7–2.0%). As with SU1, Pb, Cu and Zn are not found in SU3.

4.2.3 SU4a Alluvium 1

4.2.3.1 Other than the three samples from ARCA CWR BH08 (see below), the remaining five samples of SU4a have a low χ^{lf} (1–7 SI units x10^{-8} m^3 kg^{-1}), a relatively high pH (8.8–9.1), a moderate moisture content (18–33%) and a relatively low weight loss-on-ignition (4–7%). These data confirm field description of the unit as a mineral-rich (i.e. inorganic) sand and mud, with low biological content. Such properties suggest that the deposits are a product of in-channel sedimentation.

4.2.3.2 The geochemical properties of SU4a also split as outlined above, i.e. the three samples from ARCA CWR BH08 have distinct trace element properties compared to those from other boreholes. The entire sub-unit - with the exception of one sample from ARCA CWR BH12 - is characterised by Ca contents of 22–25%, while 'Bal.' is present at 65–70% and Si at 4–8%, i.e. a very similar composition to SU3 and indicating a similar derivation. Indeed the single sample from ARCA CWR BH12 has a high proportion of 'Bal.' (77%) and Si (15%) (but only 4% loss-on-ignition), suggesting that it is flint-rich sediment.

4.2.3.3 Whereas the majority of samples from SU4a contain no Pb, Zn and Cu, and P at levels of c 0.2%, those from ARCA CWR BH08 contain the first three elements, while P is present at 0.4–0.7%. The presence of Pb, Zn and Cu, and elevated levels of P are therefore further evidence of human activity during the deposition of the ARCA CWR BH08 SU4a sediments.

4.2.4 SU4b Peat

4.2.4.1 The majority of samples taken from SU4b have a high moisture content (35–79%), a high weight loss-on-ignition (13–83%), a relatively low (compared to other units) pH (7.6–9.0) and low χ^{lf} (-0.8–5.4 SI units x10^{-8} m^3 kg^{-1}). Further, given the high organic contents, a significant proportion (15 of the 24) samples were measured for humification and results of 7–27% returned. These data are as expected given that SU4c is a highly compressed peat in which variable quantities of plant macro-remains were noted during core description. There are, however, anomalies in the sedimentological data such as low weight loss-on-ignition, e.g. ARCA CWR BH01 4.88–4.89m, ARCA CAR BH03 4.76–4.77m, ARCA CWR BH03 4.66–4.67m, ARCA CWR BH06 4.62–4.64m, ARCA CWR BH09 4.16–4.17m and ARCA CWR BH13 4.98–4.99m, and which is likely to have been caused by inclusion in the samples of mineral lenses. These latter might have been incorporated in the marsh in which the peat formed during flood events.

4.2.4.2 Geochemical data from SU4b demonstrate high organic contents in the form of high to very high proportion of 'Bal.' (52–92%). Indeed 'Bal.' and loss-on-ignition values correlate closely (r=0.84), while the proportion of Ca (2–41%) is weakly and inversely correlated with loss-on-ignition (r=-0.55). High Si content in the non-correlating samples (e.g. ARCA CWR BH06 4.93–4.94, 14.9% Si, cf a mean of 3.2%), is the reason why the inverse correlation is not stronger. In other words, Chalk and flint content explain the majority of variation in the geochemistry of SU4b. As with the underlying strata, Cu and Pb are absent from SU4b, Zn is present in a few samples, but at less than 0.01%, while P is present in very low concentrations (0.08–0.18%), even in samples from ARCA CWR BH08 that have magnetic susceptibility evidence for human activity. The geochemistry data therefore confirm those of the sedimentology, i.e. that although in appearance 'organic', SU4b contains lenses of mineral sediment derived from both Chalk and flint. These latter are likely the products of the flooding outlined in Section 4.2.4.1 above.

4.2.5 SU4c Tufa

4.2.5.1 The sedimentological properties in the tufa of SU4c are in part similar to those of SU1 and in others to SU4b. In the first instance this is because like Chalk, tufa is a largely composed of $CaCO_3$, albeit that the latter in Chalk is the product of the compression of marine invertebrate 'shell', while in the case of tufa, $CaCO_3$ is a chemical precipitate. The high $CaCO_3$ content explains the low χ^{lf} (-0.8–5.6 SI units x10^{-8} m^3 kg^{-1}) in SU4c, while the substantially higher (than in SU1) moisture contents (31–66%) are because of a much greater pore space in the tufa compared to the Chalk (this a product of a younger age, shallow subcrop depth and hence subjection to much lesser compressive forces), but also in the case of ARCA CWR BH07 the inclusion of two samples of peat within SU4c (uniquely in ARCA CWR BH07, peat interfingers with tufa). Indeed, the two peat samples from SU4c have the highest weight loss-on-ignition in the sub-unit (35–37%) and if these samples are excluded the range is 2–26%, i.e. below that of SU4b. As with SU1, weight loss-on-ignition is likely to include combusted $CaCO_3$.

4.2.5.2 For the same reasons as set out in Section 4.2.1.3, the geochemical properties of SU4c reflect the carbonate rich environment of deposition. Ca is present at high concentrations (28–43%), higher indeed than SU1, while (if the two peat samples are excluded) 'Bal.' accounts for 56–65%. Si is present at lower concentrations than in SU1 (0–2.7%). In other words, $CaCO_3$ is likely to account for an even greater proportion of SU4c than SU1 because there is so little flint in the former. Cu and Pb are both absent from SU4c, while Zn is found as a minute trace (<0.01%) and the proportion of P is also low (0.11–0.34%). These data suggest that there is no anthropogenic input into SU4c. Indeed, tufa formation is inhibited in environments where pollution and mud deposition pertains, i.e. in situations of intense human habitation. The two peat samples from SU4c in ARCA CWR BH07 have ‘Bal.’ concentrations elevated above those of the rest of the sub-unit (71–76%) and correspondingly reduced proportions of Ca (23–28%),

4.2.6 SU4d Alluvium 2

4.2.6.1 The sedimentological properties of SU4d reflect the heterogenous nature of the sub-unit and the likelihood that the samples from ARCA CWR BH08 formed in a channel that was cut following the foundation of Roman Winchester. Mineral and organic facies are reflected in variable weight loss-on-ignition (2–85%), while the incorporation of anthropogenic detritus results in highly varied χ^{lf} (0–483 SI units x10^{-8} m^3 kg^{-1}). Indeed, three samples have a χ^{lf} of > 100 SI units x10^{-8} m^3 kg^{-1} (ARCA CWR BH02 2.17–2.18m, ARCA CWR BH05a 4.26–4.27m and BH08 1.88–1.89m), suggesting a level of human input in this part of the alluvial stratigraphy similar to that found in SU5 (see below). So far as a background can be established, it would seem that alluvial deposition of SU4d resulted in a moderate, but variable moisture content (10–75%). Moisture variations are, however, only weakly correlated with depth (r=0.37), and indeed all sub-crops of SU4d are below the water table as measured between September 2020 and September 2021 (see Section 5 below). Background χ^{lf} is 0–27 SI units x10^{-8} m^3 kg^{-1}, and where higher than this range is very likely a product of human input (10 of the 42 samples from which χ^{lf} was measured, show such enhancement, while 7 of the former are from ARCA CWR BH08[10]).

4.2.6.2 As highlighted in Section 4.1.3.4 above, deposits originally classified as SU4a–SU4d in ARCA CWR BH08 are a special case as they are highly likely to have been deposited in a channel that post dates the foundation of Venta Belgarum (Roman Winchester). The sedimentological data confirm this hypothesis as the SU4 samples from ARCA CWR BH08 are characterised by elevated χ^{lf} (54–78 SI units x10^{-8} m^3 kg^{-1}), and which is highly likely to be a product of human activity (input of ceramic or otherwise burnt material). Loss-on-ignition values are also higher than elsewhere in the other parts of SU4d (7–79%), while pH is lower (8.6–8.9%). Therefore, given that organic carbon has a zero or negative χ^{lf}, the magnetisation of the organic-rich samples is caused by particular iron minerals rather than quantity of mineral matter. Such magnetic susceptibility enhancement data are likely to reflect anthropogenic additions into the infilling sediments.

4.2.6.3 There is considerable variation in the geochemical properties of SU4d, albeit that with one exception, samples are characterised by moderate proportion of Ca (18–42%) and high ‘Bal.’ (60–88%). These latter data likely reflect high $CaCO_3$ content, but also increased ‘Bal.’ in cases where weight loss-on-ignition is high (r=0.88 for ‘Bal.’ versus weight loss-on-ignition). Si content is variable between 0 and 9.5%, indicating that flint is an irregular constituent of the SU4d alluvium. P is found in higher concentrations in ARCA CWR BH08 (mean = 0.60%) than elsewhere in the sub-unit (mean = 0.23%), while Cu, Pb and Zn are all present in the ARCA CWR BH08 samples, but not in SU4d strata in ARCA CWR BH01–04. It is also the case that Zn is present in ARCA CWR BH08 at higher proportions (0.01–0.06%) than in other SU4d strata (<0.01%), and which taken with the other geochemical data discussed above is further evidence of human input into the SU4d strata in that borehole. The incorporation of Pb and Cu in SU4d strata in ARCA CWR BH06 might also indicate human activity while those

[10] Those others with χ^{lf} of > 27 SI units x10^{-8} m^3 kg^{-1} and not from ARCA CWR BH08 are ARCA CWR BH02 2.17–2.18m, ARCA CWR BH05a 4.26–4.27m and ARCA CWR BH06 3.53–3.54m.

deposits formed (as is supported by the inclusion of ceramic sherds – see Section 4.1.3.4).

4.2.6.4 The sedimentological and geochemical data discussed above suggest that the SU4d strata accumulated in alluvial settings that were characterised by both mineral (e.g. overbank flooding and in-channel accretion) and organic sedimentation (e.g. backswamp, abandoned channel), and for the most part in the absence of human input. However, as previously discussed in Section 4.2.6.2 above, samples from ARCA CWR BH08 are consistent outliers from the background, and suggest human input during deposition. SU4d strata sampled in ARCA CWR BH06 is also likely to have formed following the foundation of Venta Belgarum.

4.2.7 SU5 Archaeological deposits

4.2.7.1 As with the alluvium of SU4d, the Archaeological deposits (SU5) are heterogenous and comprise a mixture of strata ranging from coarse diamicts containing moderate quantities of artefacts to organic-rich silts and clays lacking any obvious cultural inclusions. This mixture of strata is also reflected in a high degree of variability in the sedimentological and geochemical properties of SU5. Nevertheless, the 'average' SU5 sample is characterised by a moderate moisture content (16–76%), which in turn is strongly correlated to weight loss-on-ignition (2–41%) (r=0.89), i.e. organic carbon. There is, however, no correlation between field moisture content (and hence weight loss-on-ignition) and depth (r=-0.01), suggesting that presence of organic material is facies dependent (i.e. the original depositional context) rather than distance from the present ground surface. The lack of a depth/preservation relationship is potentially significant given that the groundwater measurements indicate that the water table moves within SU5 (see Section 5). Still, a note of caution should be introduced, namely that all except two (one from ARCA BH01 and the other from ARCA BH12) of the sub-samples examined for their sedimentological and geochemical properties were taken from below the depth of the September 2020–September 2021 groundwater table (Section 5), i.e. present groundwater elevation is unlikely to be a factor in the field moisture and weight loss-on-ignition measurements reported here.

4.2.7.2 Unsurprisingly given the artefact (and in particular ceramic) content of and burning witnessed in SU5, χ^{lf} is generally high throughout (4–845 SI units x10^{-8} m^3 kg^{-1}). It is on average two to three times higher than in the 'naturally' accreting strata (SU1, SU3, SU4a–SU4c), and significantly elevated above that in the SU4d alluvium (Table 4). It is also notable that there is no correlation between χ^{lf} and weight loss-on-ignition (r=-0.06), demonstrating that organic-rich layers contain artefactual residues (ceramic particles are the most likely reason for elevated χ^{lf}). Particularly high χ^{lf} is associated with ARCA CWR BH09 1.96–2.59m (157–844 SI units x10^{-8} m^3 kg^{-}) and also ARCA CWR BH03 2.50–2.61m (93–476 SI units x10^{-8} m^3 kg^{-}), strata in both cases comprising artefact-rich sands–silts with chalk gravel, but also organic mud.

4.2.7.3 The geochemical properties of SU5 are, despite the heterogeneity of the strata, reasonably consistent. As with other units, 'Bal.' (64–73%) and Ca (17–41%) are the most important components, while Si (4–6%) is present in higher proportion than any other unit excepting SU3. These data confirm that, as in the other units, Chalk, flint and organic matter are the prime constituents of the SU5 sediment, albeit that decomposing lime mortar might be contributing to the high Ca and 'Bal.' contents. However, there are some key differences in the geochemistry of SU5 compared to lower units. P is present as a notably higher proportion in SU5 (0.46–3.37%) than in any other unit and indeed at twice the concentration of the 'natural' strata (SU1, SU3, SU4a-4c). These elevated levels of P are highly likely to reflect faecal, urinary and bone decomposition products forming as residues associated with the disposal of occupation waste. Further, Pb and Zn are present in all sub-samples taken from SU5, while Cu is found in all except eight sub-samples. In particular it is notable that concentrations of Pb are considerably higher (reaching a maximum of 0.73% in ARCA CWR BH05a 1.90–1.91m – i.e. significantly above soil Pb alert levels of several EU states [European Commission 2000]) than the few samples from SU4c containing the element. These data demonstrate that Pb, Zn and Cu in the sedimentary record are associated with human activity and therefore anthropogenic indicators in the central Winchester strata.

4.3 Biostratigraphy

4.3.0.1 In each of the sub-sections below, samples are assessed (and interpreted) in reverse stratigraphic order, i.e. beginning with the lowest stratigraphic units and continuing upwards.

4.3.0.2 The stratigraphic locations of the samples are shown in Figure 20.

4.3.1 Pollen

Rob Batchelor, Quest, University of Reading

4.3.1.1 SU4a Alluvium 1

A single sample was assessed from SU4a, a marl (tufa) in BH06 (5.22–5.23m) and pollen was entirely absent.

4.3.1.2 SU4b Peat

Three samples were assessed from SU4b; a peat in BH04 at 4.78–4.79m bgl; and peat at 5.14–5.15 and 5.38–5.39m bgl in BH08. All three samples contained a minimal abundance and diversity or absence of pollen in a poor to moderate state of preservation. *Tilia*, *Ulmus* and *Alnus* were the only grains recorded. These assemblages are too limited to make any further palaeoenvironmental interpretation.

4.3.1.3 SU4c Tufa

Four samples were assessed from the peat (SU4c) of BH07 and between 5.78–5.79 and 3.80–3.81m bgl. These samples have a high abundance of pollen (in excess of 350 grains per slide), The diversity of these samples is low to moderate (6–10 taxa) but grains are generally in an uneroded state of preservation. These samples are characterised by high values of tree and shrub pollen dominated by *Alnus*, with *Quercus*, *Tilia*, and *Corylus* type. Herbs included a few grains of Cyperaceae with some Poaceae. This assemblage is predominantly indicative of a wetland environment dominated by alder, and dryland occupied by mixed deciduous woodland.

4.3.1.4 SU4d Alluvium 2

Three samples were assessed from SU4d, from a ‘soil’ in BH02 (2.12–2.13m bgl), a sand/silt/clay deposit in BH05A (4.26–4.27m bgl), and a diamict in BH01 (3.74–3.75m bgl).

In the soil sample, the pollen abundance was in the region of 70 occurrences per slide. However, the diversity was very low (4 taxa recorded), and the pollen grains were present in a highly eroded state. The sample also included grains of Lactuceae (dandelions) and Asteraceae (daisies) with single occurrences of *Corylus* type (hazel) and *Tilia* (lime). All of these grains are either more resistant to decay and/or have an easily distinguished morphology, so are likely to represent a biased signal.

In the sand/silt/clay sample, the pollen abundance was in the region of 300 occurrences per slide. The diversity of this sample was moderate (11 taxa recorded), but the grains were often present in a highly eroded state. The sample was characterised by high values of Lactuceae with Poaceae (grasses), and singular occurrences including Asteraceae, *Plantago* type (plantain), *Chenopodium* type (e.g. fat hen), *Ranunculus* type (e.g. buttercup) and *Centaurea nigra* (black knapweed). Tree and shrub taxa were limited to individual grains of *Pinus* (pine) and *Calluna vulgaris* (heather). Again, the dominance of Lactuceae in particular is suggestive of a biased signal, as this grain is particularly resistant to decay. However, the overall assemblage is suggestive of a relatively open environment.

The diamict sample however contained a high abundance of pollen with around 500 occurrences per slide. The diversity of this sample was moderate (12 taxa) and in a moderate state of preservation. This assemblage was characterised by high values of tree and shrub pollen including *Tilia*, *Alnus* (alder), *Quercus* (oak), *Ulmus* (elm) and *Corylus* type. Herbs included a few grains of Poaceae, Cyperaceae (sedges), Asteraceae and *Cirsium* type (thistles). This assemblage is predominantly indicative of a wetland environment dominated by alder, and dryland occupied by mixed deciduous woodland.

4.3.1.5 SU5 Archaeological deposits

A total of 39 samples were assessed predominantly from diamict or sand/silt/clay with artefacts or organic mud deposits in SU5. These originated from BH01 (5 samples), BH03 (2 samples), BH04 (2 samples), BH05A (4 samples), BH06 (2 samples), BH08 (9 samples), BH09 (5 samples), BH10 (3 samples), BH12 (4 samples) and BH13 (3 samples).

BH01

Pollen abundance is generally high in the five samples from BH01, with all containing between 200 and 500 grains per slide. The diversity was variable, however; the sample at 2.65–2.66m bgl for example contained over 21 individual taxa, whilst at 1.85–1.86m bgl there were <5. Preservation was also variable, but tended to improve with increased depth. The assemblages are characterised by high values of herbaceous taxa, dominated by *Cereale* type and Poaceae with Lactuceae, *Asteraceae*, *Chenopodium* type, Rosaceae (rose family), Apiaceae (carrot family), *Sinapis* type (brassica) and other taxa. Tree and shrub taxa were limited to a few grains of *Alnus*, *Quercus*, *Calluna vulgaris* and *Corylus* type. The most notable aspect of the assemblage was the large number of parasite eggs recorded between 2.25–2.26 and 3.23–3.24m bgl. These latter are most likely a result of human activity.

BH03

Pollen abundance is high in both samples from BH03, with each containing >500 grains per slide. Diversity was also consistent with between 11 and 20 taxa recorded in each sample. Preservation was generally moderate to good. The assemblage was very similar to that recorded in BH01, with high values of herbaceous taxa dominated by *Cereale* type and Poaceae with Lactuceae, *Sinapis* type and other isolated taxa. Trees and shrubs consisted mainly of *Corylus* type with isolated occurrences of other trees. High numbers of parasite eggs were recorded.

BH04
Pollen abundance is generally high in both samples from BH04, with each containing 190–500 grains per slide. Diversity and preservation were both moderate and improved with depth. The assemblage was very similar to that recorded in BH01 and BH02, with high values of herbaceous taxa dominated by *Cereale* type and Lactuceae, with *Chenopodium* type. and isolated occurrences of other taxa. Trees and shrubs consisted mainly of *Corylus* type with isolated occurrences of other trees. Parasite eggs were absent.

BH05A
The four samples from BH04 contained a high abundance of pollen containing in the region of 350–600 grains per slide. Diversity varied between <5 and 11–20 different taxa in each sample. The pollen was generally well preserved, except in lowermost sample at 3.71–3.72m in which there were more eroded grains. This assemblage contained high values of herbaceous taxa, this time dominated by Poaceae with *Cereale* type, Lactuceae, Asteraceae, *Plantago* type, *Rumex* undiff (dock/sorrel), *Centaurea nigra*, *Sinapis* type and isolated occurrences of other taxa. Trees and shrubs consisted mainly of *Corylus* type and *Quercus* with isolated occurrences of other taxa.

BH06
Pollen abundance is generally very high in both samples from BH06, with each containing >450 grains per slide. Diversity and preservation were both moderate or high. The assemblages are characterised by high values of herbaceous taxa dominated by *Cereale* type, Poaceae and Lactuceae, with *Chenopodium* type. *Plantago* type, *Asteraceae*, *Ranunculus* type, *Sinapis* type and *Trifolium*/*Vicia* type (clover/vetch) and isolated occurrences of other taxa. Trees and shrubs consisted mainly of *Corylus* type with *Quercus*, *Alnus* and isolated occurrences of other taxa.

BH08
Pollen abundance, diversity and preservation was variable but generally declined with depth through SU5 in BH08. Between 1.82–1.83 and 3.26–3.27m bgl, pollen abundance was generally high, with in the region of 100 to 600 grains per slide. Similarly, the diversity generally ranged from 6 to 20 taxa, and the pollen preservation was moderate. The assemblages are characterised by high values of herbaceous taxa dominated by *Cereale* type, Poaceae and Lactuceae, with *Plantago* type, Asteraceae, *Ranunculus* type, *Centaurea nigra*, *Sinapis* type and isolated occurrences of other taxa. When present, tree and shrub taxa mainly included *Corylus* type and *Quercus*. Parasite eggs were recorded between 2.98–2.99 and 3.98–3.99m bgl.

Below this however, in samples 3.98–3.99 to 5.10–5.11m bgl pollen abundance reduced from 100 to 20 grains per slide. Diversity reduced to <5 taxa per sample, and the grains became increasingly eroded. In these samples, only isolated grains of herbaceous, tree and shrub taxa were recorded.

BH09
Pollen abundance ranged between 50 and 450 grains per slide. Diversity varied between <5 and 11–20 different taxa in each sample. The pollen was generally poorly or moderately preserved. Overall, there was little relationship between depth and pollen abundance, diversity or preservation. Herbaceous taxa dominated each sample, with higher values of Lactuceae and *Cereale* type, together with Poaceae and individual occurrences of other taxa. When present, tree and shrub taxa mainly included *Corylus* type and *Quercus*. A few parasite eggs of *Trichuris* sp. (whipworm) were noted in BH09 (1.73–1.74m bgl), though whether of human or animal origin was not established

BH10
Pollen abundance and diversity was low in the two samples from the uppermost part of SU5, with <50 grains per slide. These predominantly comprised individual grains of tree and shrub taxa. They were preserved in a generally poor state of preservation. The sample at 3.27–3.28m bgl contained a much higher abundance of pollen, but this was also poorly preserved and dominated by Lactuceae and *Sinapis* type; grains that are more resistant to decay and thus be over–represented. Other taxa include Cyperaceae, Poaceae and *Quercus*.

BH12
Pollen abundance was high in the four samples from BH12, with between 200 and >600 grains recorded on each slide. Diversity varied between <5 and 11–20 different taxa in each sample. The pollen preservation improved with depth. The assemblages are characterised by high values of herbaceous taxa, dominated by Lactuceae with Asteraceae, Poaceae, *Plantago* type, *Sinapis* type and limited occurrences of other taxa. Tree and shrub taxa were limited to a few grains of *Quercus* and *Corylus* type. A few parasite eggs were recorded in the uppermost sample.

BH13
Pollen abundance was variable in the three samples from BH13, with between 100 and 350 grains recorded on each slide. Diversity was relatively low, varying between <5 and 10 different taxa in each sample. The pollen was preservation poor. The assemblages are characterised by high values of herbaceous taxa, dominated by Lactuceae with Asteraceae, Poaceae and limited occurrences of other taxa. Tree and shrub taxa were limited to a few grains of *Quercus* and *Corylus* type. A few parasite eggs were recorded in the uppermost sample.

When combined, the assemblages from SU5 are indicative of an open and disturbed environment, with strong evidence of anthropogenic activity as would be expected given the nature and likely age of the deposits. In particular, the assessment provides evidence of cultivation, crop processing, or the disposal of food remains due to the frequent and high values of pollen from cereals and their associated weeds. In addition, whilst not quantified, microcharcoal and fungal spores were frequently present in the SU5 and SU4c deposits providing further evidence of human activities. There is also little doubt that if analysed further[11], the pollen, non–pollen palynomorph and microcharcoal remains would enable a more detailed reconstruction of the spatial and temporal changes in vegetation and different types of human activity.

4.3.2 Plant macro remains

Dan Young, Quest, University of Reading[12]

4.3.2.1 SU4a Alluvium 1

One sample was assessed from Stratigraphic Unit SU4a (BH08, 6.22–6.27m bgl). The plant macroremains (seeds/fruits) in this sample contained a low quantity of seeds of *Carex* sp. (sedge) (Diversity = 1, Abundance = 1, Preservation = 3). This assemblage is too small to make a full palaeoenvironmental interpretation, but sedges are typical of wet or damp environments such as sedge fens and reed swamps. Other macrofossil remains observed in this sample included low to moderate quantities of charcoal,

[11] Further analyses of the bioarchaeological remains is beyond the scope (and funding) of the CWR geoarchaeological project as presently constituted.
[12] Present affiliation: Wessex Archaeology, Portway House, Old Sarum Park, Salisbury, SP4 6EB

waterlogged wood, and fragments of bone and Mollusca (see below for the latter two categories, but beyond noting its presence, waterlogged wood was not examined in detail as part of the geoarchaeological works presented here).

4.3.2.2 SU4b Peat

Two samples were assessed from SU4b (BH08 5.18–5.23 and 5.35–5.40m bgl). No plant macroremains (seeds/fruits) were identified in either of these samples. Other macrofossil remains observed in this sample included low quantities of charcoal in the sample from 5.35–5.40m bgl, high quantities of waterlogged wood and low quantities of insects in the sample from 5.18–5.23m bgl[13].

4.3.2.3 SU4d Alluvium 2

A total of five samples were assessed from Stratigraphic Unit 4d, including one sample from BH06 (3.52–3.57m bgl) and four samples from BH08 (3.35–3.40, 3.65–3.70, 4.00–4.05 and 4.50–4.55m bgl).

BH06
No plant macroremains (seeds/fruits) were identified in the samples from BH06, but other macrofossil remains included moderate to high quantities of charcoal, low quantities of bone and high quantities of mollusc fragments.

BH08
In the four samples from BH08, plant macroremains (seeds/fruits) were generally present in low quantities (Diversity = 1, Abundance = 1) and in poor to moderate states of preservation (Preservation = 1 to 3). The assemblage in these samples included *Sambucus nigra/racemosa* (elder), *Chenopodium* sp. (goosefoot), *Silene*/*Stellaria* sp. (campion/stitchwort), *Ranunculus bulbosus*/*acris*/*repens* (buttercup), *Potentilla* sp. (cinquefoil) and unidentified mosses. This assemblage is small, but in general it is typical of a potentially disturbed, damp and open environment. Other macrofossil remains observed in these samples included high quantities of charcoal and waterlogged wood, and low to moderate quantities of bone, Mollusca and insects.

4.3.2.4 SU5 Archaeological deposits

A total of 14 samples were assessed from SU5, including one sample from BH01 (2.25–2.26m bgl), three samples from BH03 (1.85–1.90, 2.45–2.50 and 2.75–2.80m bgl), two samples from BH04 (2.70–2.75 and 2.85–2.90m bgl), one sample from BH05A (2.07–2.12m bgl), four samples from BH06 (2.20–2.25, 2.47–2.52, 2.67–2.72 and 2.79–2.84m bgl) and three samples from BH09 (1.80–1.85, 2.25–2.30 and 2.65–2.70m bgl).

BH01
In the sample from BH01 the plant macroremains (seeds/fruits) included a number of *Prunus* cf. *avium* (cf. wild cherry) stones (Diversity = 1, Abundance = 2, Preservation = 3). Other macrofossil remains observed in these samples included low quantities of charcoal and waterlogged wood.

BH03

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[13] Specific assessment of insect fossils was not included in ARCA's WSI (Wilkinson et al. 2020), in part because the sediment sample available from the borehole cores is too small to recover quantitatively meaningful assemblages of Coleopteran schlerites (cf. Campbell et al. 2011).

In the samples from BH03, nut shell fragments of *Corylus avellana* (hazel), wild cherry, *Vitis vinifera* (common grape vine), *Carex* sp. (sedge) and *Brassica*/*Sinapis* sp. (mustards) were recorded (Diversity = 1–2, Abundance = 1–2, Preservation = 1–4), although plant macroremains were absent in the sample from 1.85–1.90m bgl. Again, this assemblage is small, but it is typical of a potentially disturbed, damp and open environment with waste/refuse inputs such as hazelnut, wild cherry and common grape vine. Other macrofossil remains observed in these samples included moderate to high quantities of charcoal, fragments of bone and Mollusca (limited to the sample from 1.85–1.90m bgl), and insects.

BH04
The plant macroremains in the samples from BH04 were limited to *Sambucus nigra/racemosa* (elder) and *Chenopodium* sp. (goosefoot) (Diversity = 1, Abundance = 1, Preservation = 1–3). This assemblage is too small to make a palaeoenvironmental interpretation. Other macrofossil remains observed in these samples included high quantities of charcoal, low quantities of bone and Mollusca, and insects in the sample from 2.85–2.90m bgl).

BH05A
Fragments of hazelnut shell, seeds/fruits of elder and sedge and unidentified mosses were recorded in the single sample from BH05A (Diversity = 1, Abundance = 1, Preservation = 1). This assemblage is small, but it is typical of a disturbed, damp and open environment with potential waste/refuse inputs such as hazelnut and elder. Other macrofossil remains observed in these samples included high quantities of charcoal and waterlogged wood.

BH06
In the samples from BH06 fragments of hazelnut shell, seeds of common grape vine, *Rumex*/*Polygonum* sp. (dock/sorrel/knotweed), *Bidens* sp. (e.g. beggarticks), mustards and unidentified mosses were recorded (Diversity = 1–2, Abundance = 1–2, Preservation = 3–4). Again, this assemblage is typical of a disturbed, damp and open environment with potential waste/refuse inputs such as hazelnut and common grape vine. Other macrofossil remains observed in these samples included high quantities of charcoal and waterlogged wood, and low to moderate quantities of bone, Mollusca (present as fragments) and insects.

BH08
Single specimens of dock/sorrel/knotweed and sedge were recorded in the samples from 2.25–2.30 and 1.80–1.85m bgl respectively (Diversity = 1, Abundance = 1, Preservation = 2), with no seeds/fruits recorded in the sample from 2.65–2.70m bgl. Other macrofossil remains observed in these samples included high quantities of charcoal, and low to moderate quantities of bone and Mollusca (present as fragments).

4.3.3 Mollusca

Keith Wilkinson

4.3.3.1 Of the 15 samples that were assessed for their sub–fossil mollusc content, 5 contained no shell. These latter (SU4b: BH06 4.58–4.63m bgl; SU4c: BH03 2.85–2.90m bgl, BH03 3.20–3.25m bgl, BH03 4.20–4.25m bgl, BH09 4.09–4.14m bgl) are not discussed any further.

4.3.3.2 The molluscan data are tabulated in Appendix 6 and reviewed in reverse stratigraphic order below. Samples selected for molluscan assessment were from SU4b Peat (2 samples), SU4c Tufa (7 samples), SU4d Alluvium 2 (3 samples), and SU5

Archaeological deposits (3 samples). As the data presented in Section 4.3.3.1 above make clear, mollusc shell was present in half the samples from SU4b, less than half from SU4c, but in all samples from SU4d and SU5.

4.3.3.3 SU4b Peat

One sample from SU4b contained low quantities of shell. Species diversity was also low, but fragile–shelled taxa (e.g. *Nesovitrea hammonis*) survived intact. These data suggest that the low incidence is not a product of poor preservation, but rather that the marsh in which the SU4b peat formed was not densely occupied by snails. The taxa found are indicative of moving, but vegetated water (*Valvata cristata*, *Planorbis planorbis*), while adjacent terrestrial habitats are likely to have been at least partially open (*Pupilla muscorum*).

4.3.3.4 SU4c Tufa

Only three of the seven assessed samples from SU4c contained mollusc shell. However, the sample residue itself provided a good indication of the environment in which accretion had taken place. This latter because the tufa granules and sands had developed around the stems, seeds and fruits of both aquatic (e.g. reeds and grasses) and terrestrial plants (e.g. *Rubus* sp.), creating identifiable impressions. Tufa fragments were sub–angular in five of the seven samples, suggesting that tufa formation was *in situ* at these locations. The two exceptions were BH03 4.09–4.14m bgl and BH03 4.20–4.25m bgl where tufa granules were rounded, suggesting that tufa had been reworked by fluvial processes.

Where shell was found in SU4c, abundance was low or very low, and diversity very low, albeit that fragile shells (e.g. members of the Zonitidae and *Pisidium* valves) survived in a complete state in two of the samples. As with SU4c, these latter data suggest a low molluscan population density during formation of the stratum rather than poor shell preservation. The mollusc taxa present in the samples suggest shallow, and vegetated water with areas of open mud (*Valvata cristata*, *Galba truncatula*, *Radix peregra*, Succineidae). All fully terrestrial taxa in the SU4c samples are indicative of shade (*Discus rotundatus*, *Oxychilus* sp., *Vitrea* sp.), indicating dense and/or long vegetation on the banks bordering the basin in which the tufa developed.

4.3.3.5 SU4d Alluvium 2

Mollusc shell was present in all three of the samples assessed from SU4d. However, in the case of BH08 3.50–3.55m bgl, shell was entirely comprised of fragments of the marine bivalve, *Mytilus* sp. (i.e. mussel). These shell remnants are clearly refuse from human activity. Indeed, both BH08 3.50–3.55m bgl and BH06 4.40–4.45m bgl contained <2mm fragments of rounded ceramics indicating that (a) deposition must have post–dated the foundation of Venta Belgarum and/or its later manifestations, and (b) deposition was in a fluvial environment in which domestic debris had been deposited/reworked.

Shells in BH06 4.40–4.45m bgl are present in low abundance and diversity, while the absence of fragile-shelled taxa and the frequency of whorl fragments indicates that mechanical damage has taken place. All except one of the shells in the sample are terrestrial and suggest that environments were open (*Vallonia costata*, *Vallonia excentrica*, *Pupilla muscorum*).

Sample BH09 4.01–4.06m bgl contains more shells than any other sample, meaning that abundance is moderate. However, the diversity is low. The assemblage composition is identical to that in BH06 4.40–4.45m bgl, while only one individual of the thin–shelled family, Zonitidae, was recovered. These data again suggest open terrestrial environments, and probably indicate that the ‘floodplain’ on which accretion took place, was dry for much of the year.

4.3.3.6 SU5 Archaeological deposits

Shell noted in the three samples assessed from SU5 was almost entirely of marine origin and was of *Mytilus* sp. (mussel) and *Ostea* sp. (oyster). Bone of mammals and fish was found in all three samples, in the former case mostly in fragmented form. Sub–angular ceramic fragments were also found in all residue size classes. Collectively these data suggest that the SU5 strata include domestic debris, while the sub–angular nature of the latter suggest (*contra* SU4d) that it has not been reworked by fluvial processes.

A single shell of the moving (fresh) water species, *Valvata picinalis*, was found in BH04 2.95–3.00m bgl, suggesting the presence of a nearby watercourse.

4.3.4 Bone

Monika Knul

4.3.4.1 While bone is present throughout SU5 (and SU4d in ARCA CWR BH08), it is mostly as fragments of less than 20mm size and which were not extracted from the borehole cores (but see footnote 3 above). The bone fragments that were picked out are catalogued in Appendix 8.

4.3.4.2 The two bone fragments (a butchered femoral end of a juvenile cow and a metacarpal fragment of a medium-sized mammal) from ARCA CWR BH08 are well preserved and the edges have not been rounded. Despite the channel-fill context, these pieces have the appearance of local discard and reasonably rapid burial.

4.3.4.3 The cow-sized vertebral fragment found from ARCA CWR BH08 has rounded edges and no evidence of cut marks. It has clearly been removed from the rest of the vertebra by mechanical processes that are unlikely to be associated with butchery. It is therefore likely that this bone fragment was not recovered from its primary context of deposition.

5. HYDROGEOLOGY

5.0.1 The text in this section, together with that on the site geology and lithostratigraphy provided above, collectively comprise a Tier 2 hydrogeological assessment (*sensu* Historic England 2016). Key elements of such assessments, namely examinations of archaeological preservation potential and risks to such remains, are included in Sections 6.2 and 6.3 below.

5.1 Water environment baseline

5.1.1 Earlier sections of the report describe the geology of the site, which in broad terms comprises rocks of the White Chalk Group, overlain by 1.95–5.54m of sand and gravel, 0.00–4.55m of silt/clay, peat and tufa and 2.11–5.60m of 'Made ground', this latter an amalgamation of SU5 Archaeological strata and SU6 Made ground. These strata are all relatively porous, thereby allowing the vertical passage of water except in those zones where a localised impermeable layer might exist (e.g. a seam of flint in the Chalk or a tiled or concrete surface in the Archaeological strata and Made ground).

5.1.2 The Chalk of the Wessex and South Downs (of which the Chalk in the CWR study area is a part) is classified as a principal aquifer, reflecting its importance for supplying groundwater and as supporting surface water flow (British Geological Survey 2021). The superficial valley deposits (River terrace deposits and Alluvium of the BGS maps) are categorised as a Secondary A aquifer (British Geological Survey 2021). Further, the principal aquifer is unconfined and the water table within it fluctuates seasonally in response to recharge (British Geological Survey 1979). Recharge is in turn a product of precipitation within the catchment, augmented by seepage from stream channels and overbank flooding (Section 5.2.1), but as noted above, hindered by impermeable layers within the Chalk (Stuart and Smedley 2009).

5.1.3 The groundwater catchment of the Chalk aquifer is partly defined by the topography of impermeable bedrock underlying the White and Grey Chalk Groups, namely the Gault Formation [albeit that the intervening Upper Greensand may not be in hydraulic continuity with the Chalk, i.e. groundwater reservoirs in these two strata might be separate (Stuart and Smedley 2009)]. The Gault Formation has been encountered in five boreholes drilled by the British Geological Survey in the Winchester area at depths of 90–100m bgl (Booth et al. 2008). These represent the highest elevation outcrops of the Gault Formation in the western part of the South Downs. Nevertheless, groundwater flow within the Chalk is thought to approximately follow the present topography, albeit in a subdued form (Allen et al. 2009), meaning in the case of the Winchester area that flow is towards the Itchen from north, east and west (Stuart and Smedley 2009). In addition to re-supply from the principal aquifer, the catchment for groundwater recharge in the superficial valley deposits of the CWR study area is the upstream drainage basin of the River Itchen, which extends 25 km north-eastwards (Figure 6).

5.1.4 As reported in the geoarchaeological DBA (Wilkinson 2020), a Tier 1 hydrogeological assessment was carried out as part of the archaeological DBA (Ottaway 2017b, 58–61). The latter document described the site catchment and hydrology of the CWR study area based on data in existence prior to the present investigation, and makes the following observations:

1. Groundwater has been observed in archaeological excavation trenches and test pits at +33 to +35m OD, i.e. the equivalent of 4.00–2.00m bgl in the CWR area;
2. Groundwater flow appears to be from the north-west to south-east, i.e. towards the channel of the River Itchen;

3. The level of the River Itchen at City Mill varies between +35.11 and +35.50m OD, i.e. 1.4m below the ground level at the east of the Broadway;
4. There is hydraulic continuity across the CWR study area, that continuity stretching to the present channel of the River Itchen east of the site.

Figure 6. Groundwater catchment of the secondary (superficial geology) aquifer upstream of the CWR site

5.2 Groundwater level and flow

5.2.1 Groundwater within the CWR study has its origin in three interrelated sources: the principal (Chalk) aquifer (see Section 5.1.2), flow along the River Itchen (the secondary aquifer) and precipitation falling within the catchment (Figure 6). The contribution of principal aquifer-derived groundwater is difficult to measure, particularly given that there are no publicly available groundwater monitoring data from central Winchester. However, the Harestock Ground Water Level (GWL) monitoring station[14], 3.2 km west-

[14] Station E12760, https://environment.data.gov.uk/flood-monitoring/id/stations/E12760.html

north-west of the CWR measures groundwater in a borehole drilled directly into the Chalk and therefore likely reflects seasonally changing aquifer properties. During the time scale of the September 2020 to September 2021 hydrogeological monitoring exercise in the CWR study area, water level in the Harestock GWL borehole varied between +48.00 and +59.14m OD (c. 50–39m bgl), suggesting a vertical water displacement of c. 11m. In contrast to the uncertainty of the aquifer contribution to site groundwater, hydrological monitoring data from the CWR in combination with rainfall (as measured at the Environment Agency's Harestock weather station) and flow records (from the Environment Agency's Seward's Bridge monitoring station), enable an assessment to be made of the contribution of the secondary aquifer and precipitation.

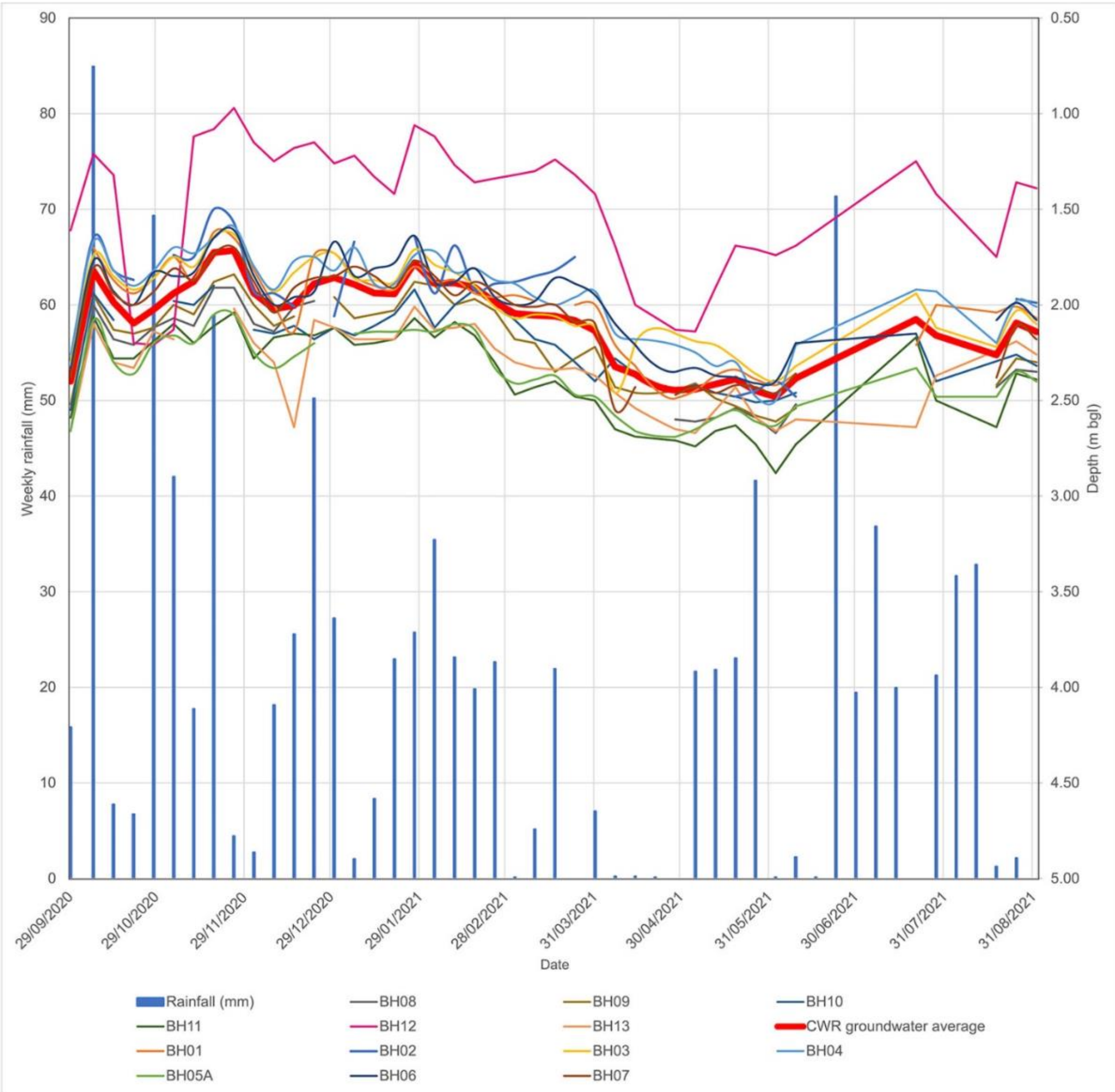

Figure 7. Groundwater variation across the CWR site in September 2020 to September 2021 plotted against rainfall as recorded by the Environment Agency's Harestock rainfall station

5.2.2 A direct comparison of average groundwater variation across all CWR boreholes monitored between September 2020 and September 2021, and weekly rainfall at Harestock suggests that there is only a very weak positive correlation (r=0.3).

However, plotting the data graphically reveals similarities of pattern (Figure 7), namely that:

1. A drop in groundwater elevation from January to May 2021 as the magnitude of high weekly rainfall 'events' decreased;
2. Weeks of high rainfall between September 2020 to March 2021 are reflected in elevated groundwater over the same period;
3. Slight groundwater rise in June–August 2021 following an increase in weekly rainfall in those months.

Despite the last, the relationship between rainfall and groundwater seems to weaken between June and September 2021, although that declining relationship might in part be a product of missing monitoring data (see Section 3.6.1).

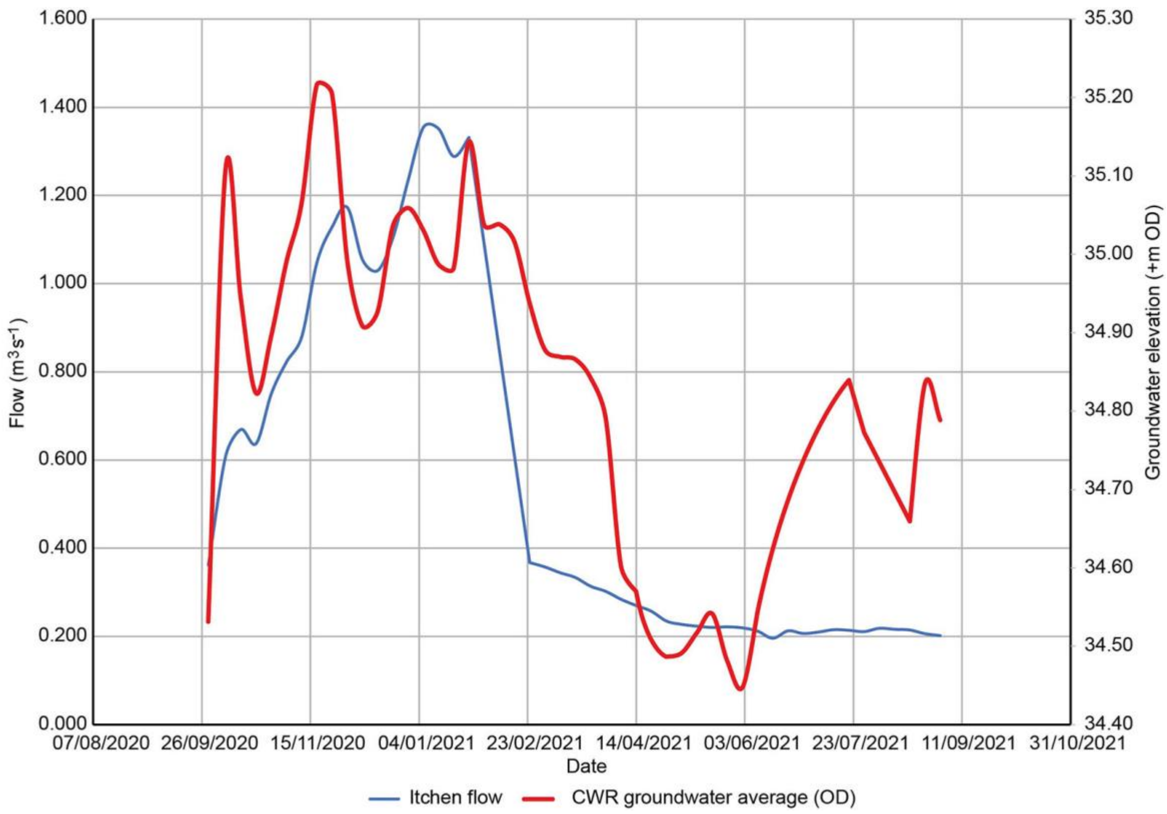

Figure 8. Average groundwater in the CWR study area plotted against flow in the River Itchen as measured at the Seward's Bridge monitoring station, Alresford

5.2.3 The lack of strength in the correlation between groundwater and rainfall is of no great surprise given that not all precipitation infiltrates the soil. Indeed, almost the entirety of the CWR site is covered by tarmac, concrete or other artificial impermeable surfaces, meaning that infiltration is negligible. Rather some precipitation is intercepted by vegetation, while both intercepted and surface water is subject to evapotranspiration. Given that vegetation cover increases from January to reach a maximum in early summer, while temperature rises in the same period, evapotranspiration will correspondingly increase over the same time interval and therefore a declining proportion of precipitation will be incorporated in groundwater as the seasons advance from winter to summer. This same pattern is observed in the rainfall versus groundwater data, i.e. a reducing relationshop between rainfall and groundwater from January to July 2021 (Figure 7).

5.2.4 Average groundwater elevation in the CWR boreholes correlates reasonably strongly with measurements of flow in the River Itchen at Seward's Bridge, Alresford (r=0.77).

Indeed, the respective curves on Figure 8 have a close correspondence between September 2020 and mid-January 2021. However, following a gap in the Seward's Bridge record for the first three weeks of February 2021[15], the latter records very reduced flows (a drop from 1.331 $m^3 s^{-1}$ in the week ending 27 January 2021 to 0.368 $m^3 s^{-1}$ in the week of 24 February 2021) and a declining trend in flow until the end of the monitoring period. As described in Section 5.2.2, groundwater in the CWR study area fell between January and June 2021, i.e. showing a similar trend to flow in the River Itchen. However, the rise and subsequent fluctuation in groundwater in the CWR (although, as noted in Section 5.2.2, partly a product of missing data), is in contrast to the continued low flow (<0.220 $m^3 s^{-1}$) in the River Itchen.

5.2.5 The commonalities in the patterns of groundwater variation in the CWR study area and flow in the River Itchen are likely in a small part to be the result of seepage into the former from the channel of the latter and its tributaries (see Section 5.2.8). However, a much more important reason for the correspondence is because the flow records are reflecting the operation of a similar variable precipitation–evapotranspiration balance (see Section 5.2.3) to that affecting groundwater in the CWR study area. Indeed, it is notable in this respect that rainfall and flow are even more weakly correlated (r=0.2) than rainfall and CWR groundwater (albeit that the Harestock rainfall monitoring station is downstream and therefore outside the catchment, of the Seward's Bridge flow monitoring station).

Table 6. Minimum, maximum and mean groundwater in the CWR boreholes for the period September 2020 to September 2021

BH	High (m bgl)	High date 1	High date 2	Mean (m bgl)	Low (m bgl)	Low date 1	Low date 2
ARCA BH01	1.62	18/11/2020		2.01	2.49	28/04/2021	
ARCA BH02	1.50	18/11/2020		1.93	2.48	19/05/2021	09/06/2021
ARCA BH03	1.63	25/11/2020		2.00	2.46	07/04/2021	
ARCA BH04	1.59	25/11/2020		1.96	2.50	02/06/2021	
ARCA BH05	2.05	18/11/2020	25/11/2020	2.35	2.69	28/04/2021	
ARCA BH06	1.61	25/11/2020		1.99	2.41	26/05/2021	
ARCA BH07	1.70	25/11/2020		2.07	2.55	07/04/2021	
ARCA BH08	1.91	18/11/2020	25/11/2020	2.30	2.67	02/06/2021	
ARCA BH09	1.84	25/11/2020		2.20	2.61	02/06/2021	
ARCA BH10	1.90	18/11/2020		2.21	2.55	29/09/2020	
ARCA BH11	2.04	25/11/2020		2.37	2.88	02/06/2021	
ARCA BH12	0.97	25/11/2020		1.47	2.21	28/10/2020	
ARCA BH13	2.01	27/01/2021		2.33	2.67	05/05/2021	

[15] This break coinciding with a change in the settings of the monitoring equipment used at that station whereby recordings made on a daily basis changed to 15-minute record intervals

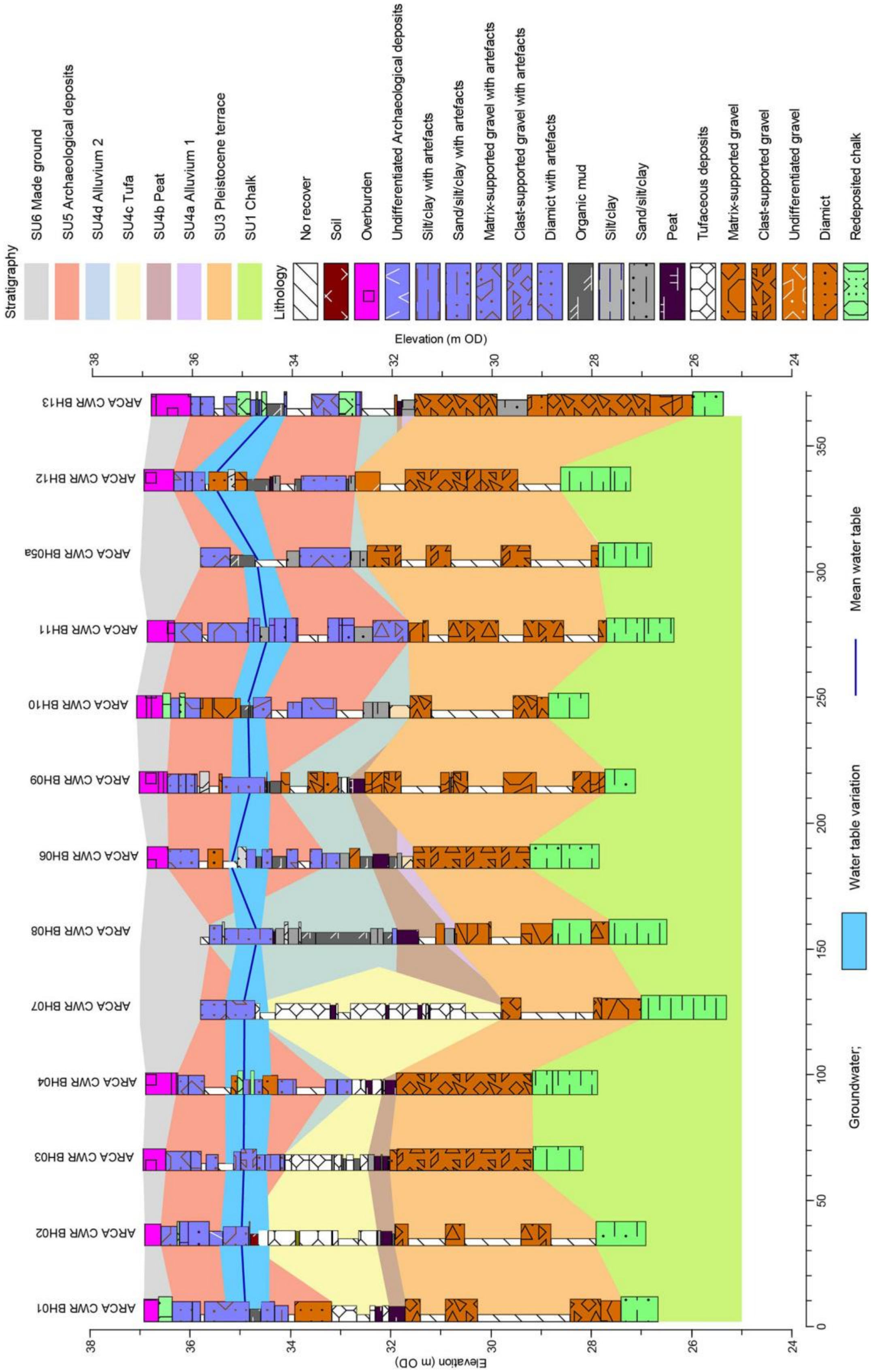

Figure 9. Minimum, maximum and mean groundwater for the period September 2020 to September 2021 plotted against borehole lithology and stratigraphy

Figure 10. Modelled water table of the CWR on 25 November 2020 (maximum water table elevation)

Figure 11. Modelled water table of the CWR on 2 June 2021 (minimum water table elevation)

5.2.6 The hydrological monitoring data collected from the CWR boreholes demonstrate the maximum water table elevation was 0.97m bgl (+35.94m OD) in ARCA BH12 on 25 November 2020 and the minimum at 2.88m bgl (+33.97m OD) in ARCA BH11 on 2 June 2021 (Table 6, Figure 7, Figure 9). These records indicate slightly higher groundwater tables than was suggested in Ottaway's (2017b) Tier 1 hydrogeological assessment (see Section 5.1.4). Figure 7 demonstrates that both the pattern of ground water variation for all boreholes and absolute groundwater level for 12 of the 13 boreholes is similar over the monitoring year. There are, however, minor variations in pattern (e.g. rapid falls on 15 December 2020 in ARCA BH01 and ARCA BH13 and correspondingly large rises in the same boreholes the week after), while groundwater in ARCA BH12 is at a notably higher level than in the other boreholes (see Section 5.2.8).

5.2.7 Figure 9 demonstrates that throughout the monitoring period, and with the exception of ARCA BH08 (and to a lesser extent, ARCA BH02 and ARCA BH07), the groundwater surface sat within the Archaeological strata throughout the monitoring period. As has been previously noted ARCA BH08 is a special case given that it is likely to have been drilled through an artificial stream channel dating from the early historic period (Wilkinson and Watson 2020). In the western and central parts of the site (i.e. the Lower Brook Street car park, Middle Brook Street and Tanner Street), the groundwater surface varied within the basal part of the Archaeological strata. However, in the eastern part of the site (i.e. the bus station car park), that variation was within the middle part of the Archaeological strata (Figure 9).

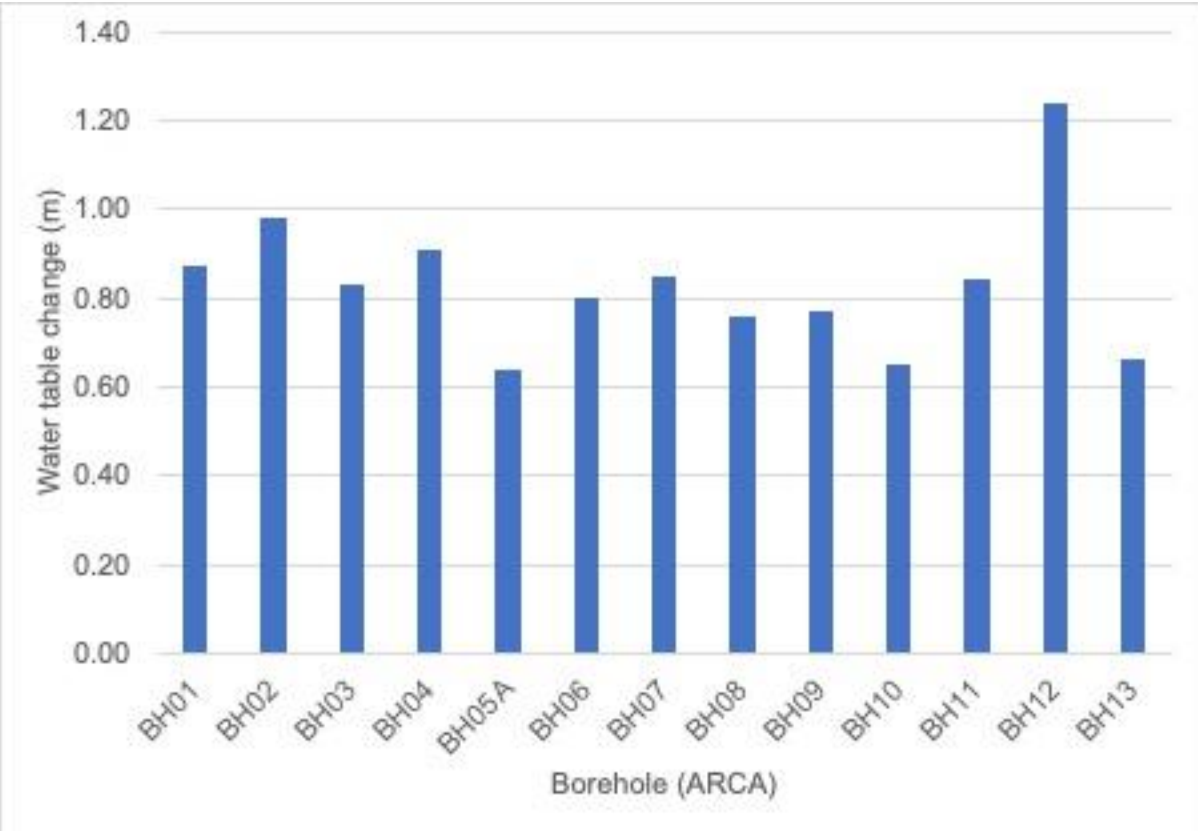

Figure 12. Magnitude of water table variation in the CWR boreholes

5.2.8 The modelled groundwater plotted in Figure 10 and Figure 11 is somewhat skewed by the relatively high elevation records from ARCA BH12. This borehole was drilled c.

10m west of a culverted stream passing south along the eastern boundary of the CWR site and it is highly likely that seepage from the latter has contributed to high groundwater in the former. Evidence in support of such an interpretation are the relatively low groundwater measurements made from the surrounding boreholes (ARCA BH05a, ARCA BH11 and ARCA BH13). Indeed, these latter are 1.05–1.08m lower than the level in ARCA BH12 on 25 November (Figure 10) and 0.89–1.14m lower on 2 June 2021 (Figure 11). Once ARCA BH12 is removed from consideration, a broad pattern of south-eastwards dipping groundwater is revealed, albeit that that drop in elevation is only 0.51m on 25 November 2020 and 0.38m on 2 June 2021 (Figure 10, Figure 11). Given that the distance from ARCA BH01 (in the north-west of the CWR study area) to ARCA BH13 (in the south-east) is 218m, the south-eastwards dip in groundwater was only 0.23% on 25 November 2020 and 0.17% on 2 June 2021.

5.2.9 Water table variation between the highest and lowest recording within a single borehole was to a maximum of 1.24m (in ARCA BH12) and a minimum of 0.64m (in ARCA BH05A), while the mean change (between high and low water table) in all 13 boreholes during the monitoring period was 0.83m (Table 6, Figure 12). With the exception of two boreholes in the bus station car park (ARCA BH11 and ARCA BH12), maximum water table elevation occurred in November 2020 and the minimum in various weeks in the period April to June 2021 (Table 6).

5.3 Groundwater quality

5.3.1 The Groundwater Vulnerability Map for England categorises the River Itchen floodplain of the Central Winchester Redevelopment study area as being of medium to high vulnerability to pollutant discharge at ground level (Environment Agency 2017). Potential sources of contamination include upstream waste water outflow, run off from agricultural (particularly arable) land and unlicenced discharge from commercial and residential settings into the River Itchen and its tributary streams. Additionally, soluble salts and organic pollutants within the stratigraphic column, both that of the CWR site itself and the drainage basin to the north-east might also leach into groundwater.

5.3.2 Comparable baseline data do not exist from the CWR or indeed Winchester, but detailed geochemical measurements of Chalk groundwater were made by the British Geological Survey in 2007–2008 of 27 water samples, including 5 from the Itchen basin upstream of the CWR (Stuart and Smedley 2009). Although the British Geological Survey employed a different method of measuring water chemistry to that used in the present study, a comparison is nevertheless useful (Table 7).

5.3.3 Conductivity measurements reflect mineral content of the groundwater, i.e. higher conductivity indicating greater mineral concentration. The highest conductivity was measured in boreholes in the eastern part of the site with maximum values greater than 800 μS cm^{-1} recorded in ARCA BH05a, ARCA BH06, ARCA BH09-11 and ARCA BH13. However, these same boreholes also had the greatest difference between maxima and minima recordings (>250 μS cm^{-1}). Those boreholes in the west (Lower Brook Street, Middle Brook Street and King's Walk) produced lower maxima (600–700 μS cm^{-1}) as did ARCA BH12, but higher minima (225–550 μS cm^{-1}). These data suggest that dissolved and particulate mineral matter fluctuate in concentration in the eastern part of the site, perhaps as a result of partial groundwater derivation from the river. However, electrical conductivity remains at relatively constant levels in the west suggesting groundwater derived from the Chalk. In the latter location the range is within that previously recorded from Chalk groundwater in Hampshire (466–714 μS cm^{-1}), while the range in boreholes in the eastern part (119–995 μS cm^{-1}) is both lower and in excess of that from elsewhere in Hampshire (Stuart and Smedley 2009).

	BH01	BH02	BH03	BH04	BH05A	BH06	BH07	BH08
Temperature mean	12.3	12.5	12.3	11.2	11.1	11.2	12.0	12.4
Temperature maximum	16.5	16.4	16.8	17.2	18.2	17.6	16.0	16.3
Temperature minimum	9.6	8.7	9.9	6.2	4.6	5.9	5.5	9.1
Conductivity mean	633	579	577	484	688	698	533	544
Conductivity maximum	742	611	618	647	965	995	719	627
Conductivity minimum	501	515	539	272	337	260	179	225
Phosphate mean	1.70	1.30	0.77	2.33	3.54	3.31	0.91	1.14
Phosphate maximum	>4.00	1.80	1.70	>4.00	>4.00	>4.00	1.60	1.55
Phosphate minimum	0.69	0.36	0.31	1.20	0.99	1.55	0.51	0.72
Nitrate mean	5.14	5.07	4.48	4.50	3.73	4.57	5.18	4.05
Nitrate maximum	6.95	6.07	7.30	6.95	8.01	8.54	7.30	5.02
Nitrate minimum	2.20	2.90	2.46	2.64	1.50	1.50	2.29	2.82

	BH09	BH10	BH11	BH12	BH13	Summary	Hampshire
Temperature mean	11.5	11.4	11.8	11.1	11.4	11.7	11.0
Temperature maximum	16.1	14.7	16.5	17.4	16.2	18.2	15.5
Temperature minimum	5.1	8.4	6.0	6.5	8.2	4.6	10.1
Conductivity mean	586	787	568	634	691	617	563
Conductivity maximum	824	867	984	693	891	995	715
Conductivity minimum	119	595	220	578	437	119	466
Phosphate mean	3.33	4.00	2.53	3.16	>4.00	2.55	6.58
Phosphate maximum	>4.00	>4.00	>4.00	>4.00	>4.00	>4.00	12.60
Phosphate minimum	1.20	4.00	1.70	1.85	>4.00	0.31	<0.05
Nitrate mean	4.41	4.37	4.57	4.73	4.54	4.56	6.58
Nitrate maximum	7.39	6.34	9.06	6.86	7.57	9.06	12.6
Nitrate minimum	1.76	2.38	2.29	2.11	1.67	1.50	<0.05

Table 7. Geochemistry of groundwater in the CWR boreholes compared to that from 27 groundwater samples from the Chalk elsewhere in Hampshire (Stuart and Smedley 2009) Units are mg/l, except for conductivity, where the units are μS cm^{-1} and temperature, where the units are ^{o}C

5.3.4 Phosphate (PO_{4-}) concentrations measured in the CWR boreholes range from 0.31mg/l to >4mg/l (the reagent tablets employed to make the measurements meant that higher concentrations could not be further quantified). Given that the maximum PO_{4-} concentration could not be determined, it is impossible to resolve whether the range falls within that of groundwater elsewhere in Hampshire. Possible sources of PO_{4-} in the groundwater are from phosphate minerals in the Chalk bedrock, but also leaching of chemical bi-products of human activity (e.g. urinary and faecal matter, and weathered bone) within the sediment stratigraphy.

5.3.5 The range of measured nitrate concentrations (1.05–9.06 mg/l) falls within the range of those of Chalk-derived groundwater elsewhere in Hampshire (Stuart and Smedley

2009). Moreover, the range is within that of national/European Union drinking water requirements, i.e. <11.3 mg/l.

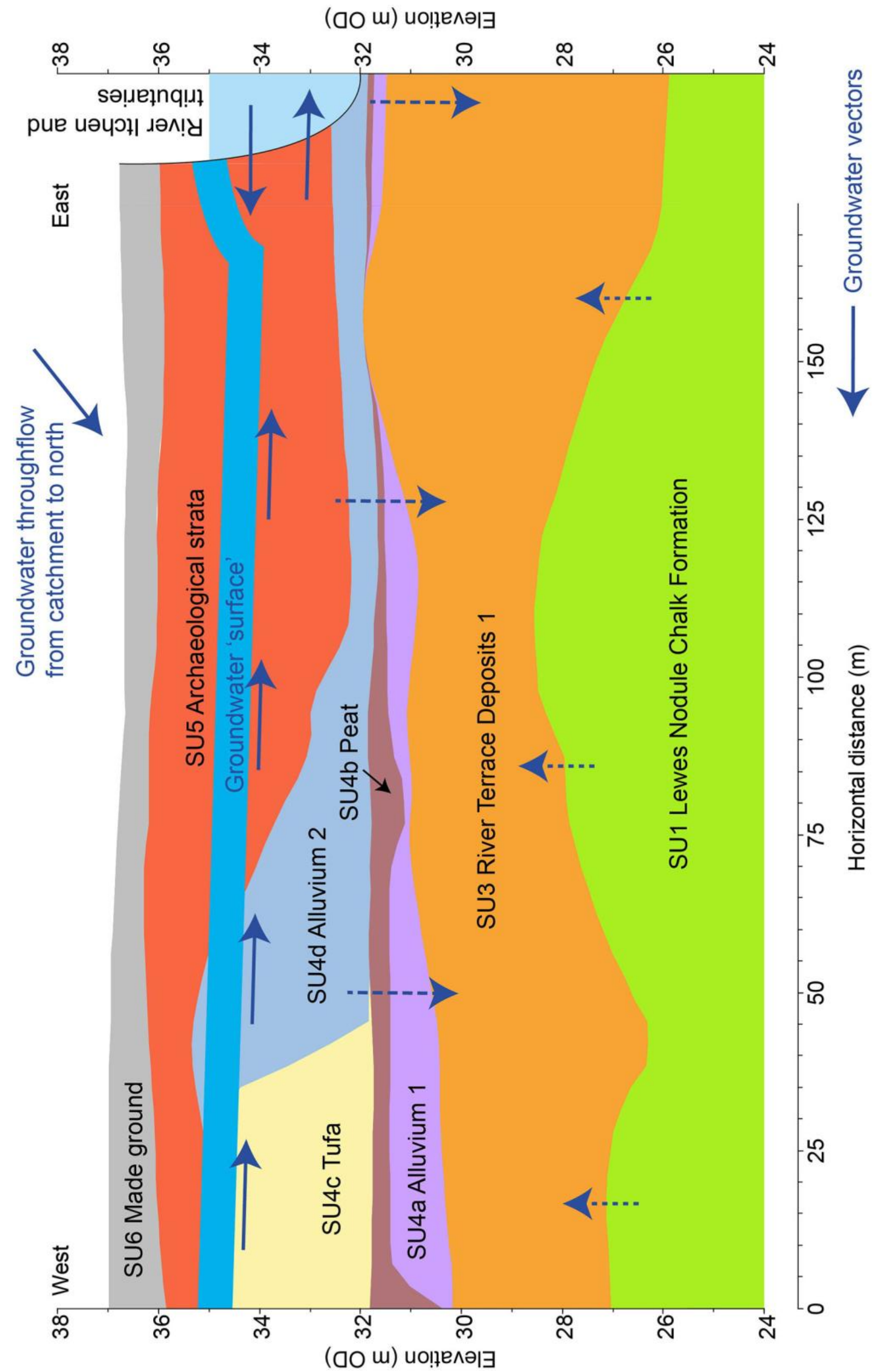

Figure 13. Conceptual groundwater model for the CWR study area (note different horizontal and vertical scales)

5.3.6 Groundwater temperature varied between 4.6ºC in ARCA BH05a on 10 February 2021 to 18.2ºC in the same borehole on 18 August 2021, while the mean temperature from all visits and across all boreholes was 11.7ºC (Table 7).

5.4 Conceptual model

5.4.1 The groundwater of the principal Chalk aquifer is in hydraulic continuity with that of the secondary superficial geology aquifer in the Itchen valley and therefore on the CWR site. Indeed, groundwater from the two aquifers is exchanged. Water moving by gravity from the superficial geology to the principal aquifer passes downwards through pore space rather than along fractures (Stuart and Smedley 2009), while pressure and capillary action moves groundwater in the Chalk upwards and laterally to the alluvial and Made ground strata (some such water entering the fluvial system and thereby maintaining flow along the Itchen). This aquifer connectivity means that groundwater properties of the CWR study area are largely controlled by processes operating at the regional scale, i.e. the basin defined in Figure 6.

5.4.2 The data reviewed in Sections 5.2.1–5.2.5 suggest that groundwater *variation* in the CWR study area is mainly driven by the precipitation–evapotranspiration balance, this determining the volume of water infiltrating the regolith within the site catchment. Seepage from the Itchen and its tributaries (e.g. the culverted stream immediately east of the CWR study area) are likely relatively minor contributors and that mainly restricted to the eastern margins of the study area (as witness in ARCA BH12 – see Section 5.2.8).

5.4.3 Figure 13 presents a model for groundwater exchange within the CWR study area and reflects the discussion of Sections 5.4.1 and 5.4.2.

6. ASSESSMENT

6.0.1 Two of the CWR geoarchaeology project aims as articulated in Section 1.3 are considered in the text below, namely an assessment of the state of preservation and extent of waterlogged organic remains, and the vulnerability of those remains to changes in the water environment (WCC 2020, sections 3.1.1 and 3.1.2, 4). However, before either of these aims can be considered, an account of the modelled sub-surface stratigraphy of the CWR site is necessary as context.

6.0.2 The remaining aims of the brief, i.e defining and understanding deposit characteristics and hydrogeological context, and providing detailed baseline information of the existing water environment against which development proposals can be assessed (WCC 2020, sections 3.1.1 and 3.1.3, 4), have already been addressed in Sections 4 and 5 of the present report.

6.0.3 Although not a requirement of the brief, the final part of this section of the report assesses the archaeological and palaeoenvironmental potential of the strata encountered in the geoarchaeological study.

6.1 Depositional sequence of the CWR site

6.1.1 Figure 14 and Figure 15 plot the stratigraphy of ARCA CWR boreholes and others from within the CWR site. In these cross sections, stratigraphic correlation has been carried out within RockWorks and was achieved by vertically slicing the deposit model (the latter constructed using the algorithm and settings set out in the DBA [Wilkinson 2020, section 2.1.4, 8–9] along a straight line between the first and last boreholes). One change has, however, been made to the model in Figure 15, i.e. curtailing the modelled extent of SU4c Tufa south of ARCA BH09 and replacing the modelled extension with SU4d Alluvium. In addition, Figure 16 and Figure 17 present the stratigraphic data as horizontal slices cut at 1m intervals at Ordnance Datum levels from +36m (c 1m bgl) to +25m OD (c 12m bgl) through the deposit model. These latter figures are updated versions, using the new borehole data acquired for this project, of an illustration employed in the DBA (Wilkinson 2020, figure 5, 17). The significant differences between Figure 16 and the desk-based assessment equivalent demonstrates the improvement in both accuracy and precision of deposit modelling as a result of the 13 new data points, all of which extend to the Chalk bedrock.

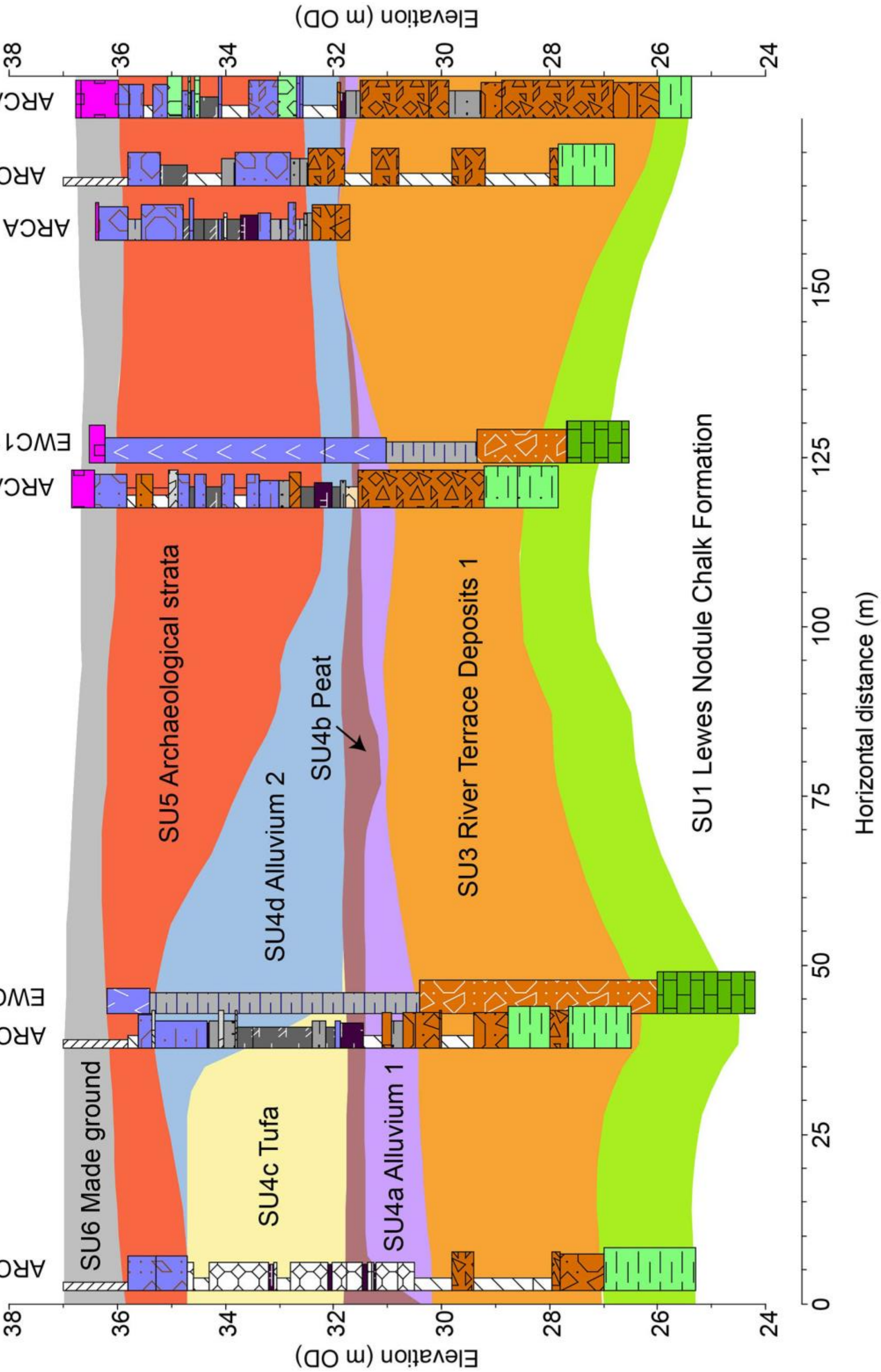

Figure 14. West–north–west to east–south–east composite cross section through the CWR site on the basis of ARCA CWR boreholes and other records in the ARCA stratigraphic database

Lithostratigraphic key as for Figures 3–5. Turquoise transect in Figure 2

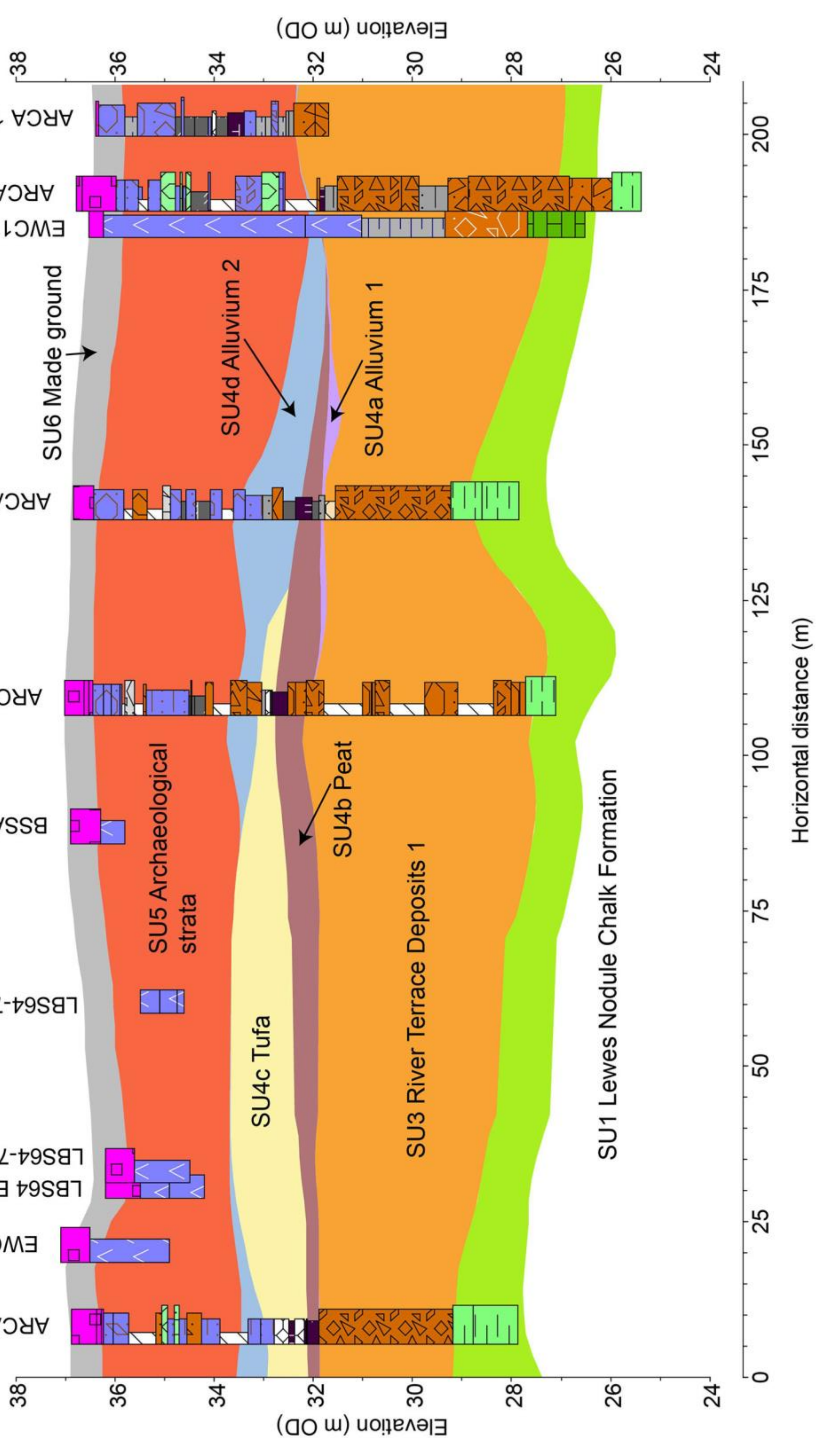

Figure 15. North to south composite cross section through the CWR site on the basis of ARCA CWR boreholes and other records in the ARCA stratigraphic database
Lithostratigraphic key as for Figures 3–5. Brown transect in Figure 2

6.1.2 The west–north–west to east-south-east transect shows that stratigraphic units are horizontally bedded (Figure 14). SU1 Lewes Nodular Chalk Formation has an irregular surface subcrop, and as discussed in Section 4.2.2 above, SU3 River Terrace Deposits 1, thickens to the east, while the elevation of its upper contact drops to the west. The latter feature is likely to be the result of new channel development in the western part of the CWR site. Indeed, this latter channel forms the basin in which SU4a Alluvium 1, SU4b Peat and SU4c Tufa were later deposited. These initial sub-strata of SU4 are likely to be of Middle or Early Holocene date given ^{14}C dates on SU4b elsewhere in central Winchester (see review in Wilkinson [2020, section 3.5.3, 15]) and likely formed in first a channel and later a backswamp/abandoned channel environment. SU4c Tufa occurs only in the west and the central part of the CWR site, but in the former it forms a subcrop of up to 4.55m in thickness in ARCA CWR BH07. Figure 14 clearly shows the vertical extent of the tufa subcrop in the western part of the study area and its 'appearance' from beneath SU5 at c 2.3m bgl. The biostratigraphic data reviewed in Sections 4.3–4.5 suggest that the tufa accreted within a shallow channel in which clean, carbonate-rich waters flowed, while the climate must also have been warm in order for such precipitation to occur. Molluscan and palynological data indicate that the environment beyond the channel was of long vegetation and probably woodland. Thin peat layers found within the tufaceous deposits in ARCA CWR BH07 might represent reworking of stratigraphically earlier SU4b Peat, or more likely episodes when the area was emergent from the channel and during which a floodplain margin marsh developed.

6.1.3 Figure 14 shows and indeed emphasises the significance of a thick (4.55m) subcrop of SU4d in ARCA CWR BH08. This latter borehole is within 25m of ARCA CWR BH07, yet no tufa (SU4c) is present (cf. the 4.19m thickness of tufa in the ARCA CWR BH07). Indeed, sedimentological and geochemical evidence demonstrates that the SU4d deposits in ARCA CWR BH08 (as well as those attributed during lithostratigraphic description to SU4b and SU4c) are associated with magnetic susceptibility and geochemical indicators of human activity and thereby indicate that the deposits are the fill of an artificial channel cut through SU4a–4d and following the foundation of Venta Belgarum. The channel is likely to be that formerly running along Middle Brook Street.

6.1.4 Archaeological deposits of SU5 are present as a tabular layer, which as described in Section 4.1.5 above, thickens to the east, and particularly within the present bus station.

6.1.5 The north to south transect shown in Figure 15 follows similar patterns to those set out in Sections 6.1.2–6.1.4 above. The surface subcrop of the Lewes Nodular Chalk Formation (SU1) drops from north to south, while that of the River Terrace Deposits 1 (SU3) is sub-horizontal. Subcrops of the basal sub-units of SU4 Alluvium (i.e. SU4a–SU4c) thin and disappear from north to south to be replaced by SU4d Alluvium 2, while archaeological deposits (SU5) remain at a relatively constant thickness throughout the transect.

6.1.6 Unlike the deposit model presented in the desk-based assessment (Wilkinson 2020, figure 5, 17), Figure 16 clearly shows SU3 River Terrace Deposits 1 'emerging' at +32m OD (c 5m bgl), and sub-cropping across most of the CWR site by +31m OD (c 6m bgl). There is the possibility that SU3 is of an age that coincided with hominin occupation of Britain (possibly c. 70,000 BP – see Section 2.2) and therefore the unit might have limited Palaeolithic archaeological potential. However, the entirety of the SU3 stratum in the CWR study area appears to reflect deposition in a high energy fluvial environment, i.e. conditions in which people are unlikely to have been present. Indeed, even the fine-grained facies of SU3 observed in the boreholes (a single 100mm thick bed)appeared unfossiliferous (a caveat being that no formal assessment has been carried out of the samples collected).

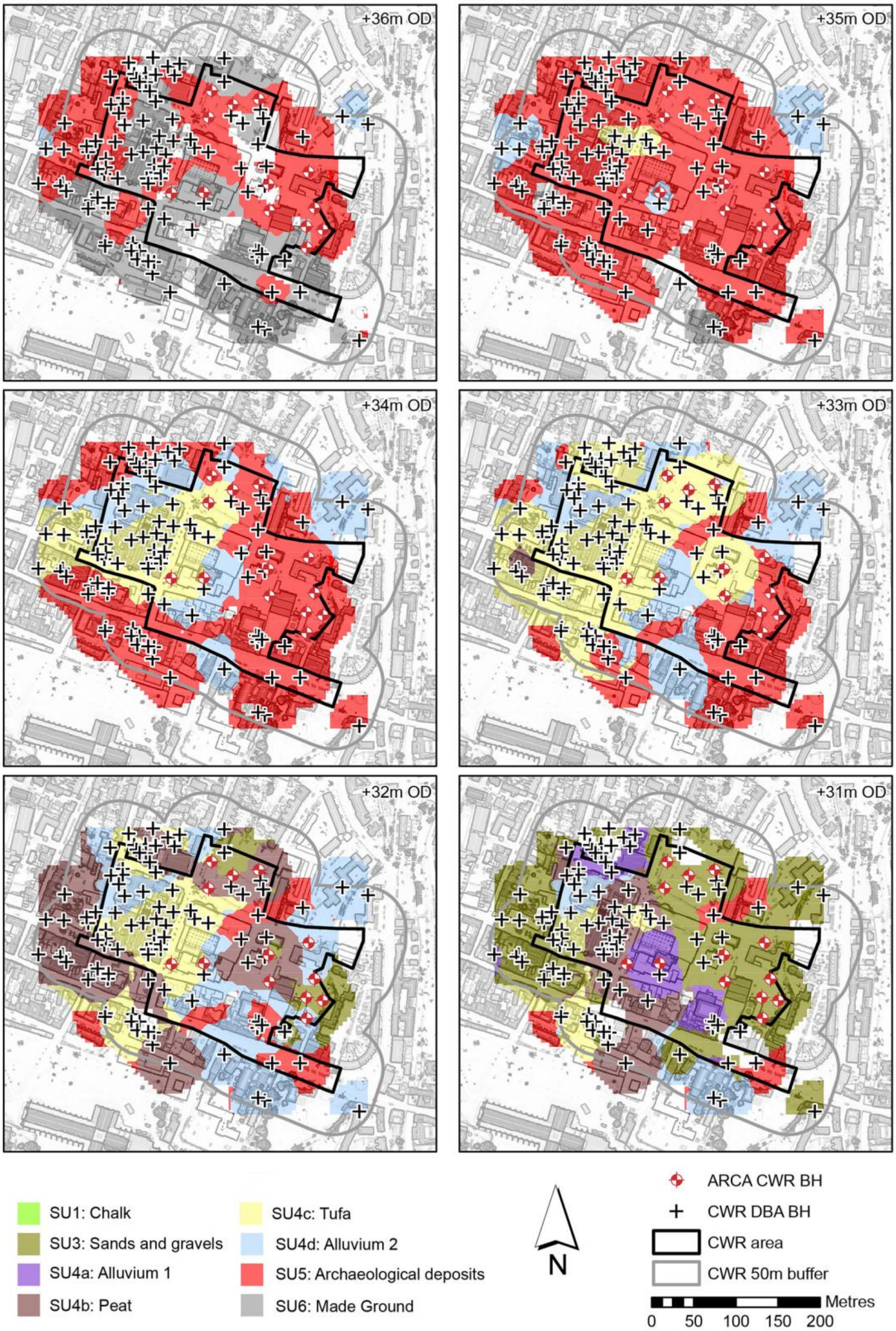

Figure 16. Modelled distribution of stratigraphic units at 1m depth slices (1–6m bgl)
NB: +36m OD is c 1m bgl, +35m OD is c 2m bgl, +34m OD is c 3m bgl, +33m OD is c 4m bgl, +32m OD is c 5m bgl and +31m OD is c 6m bgl

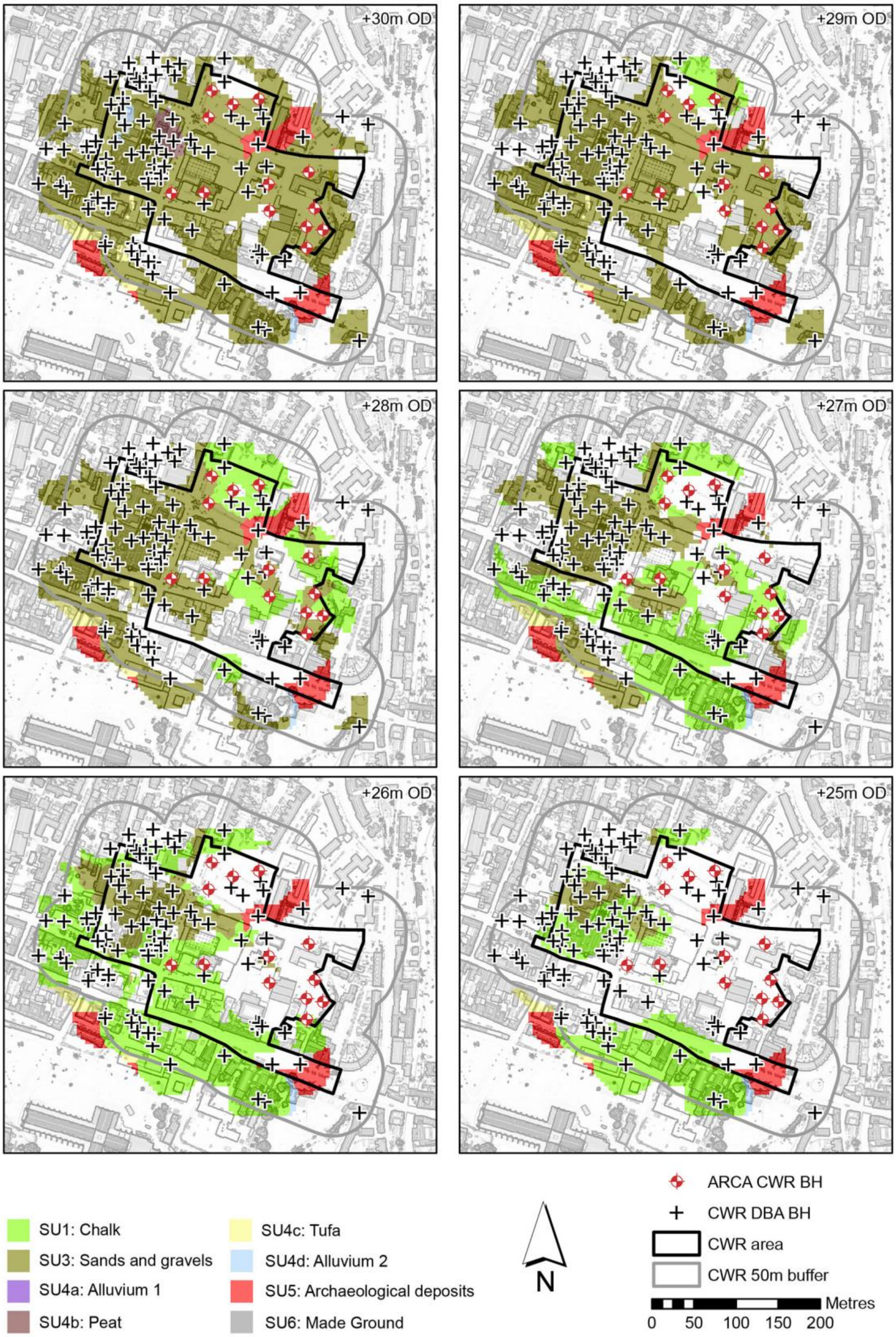

Figure 17. Modelled distribution of stratigraphic units at 1m depth slices (7–12m bgl)
NB: +30m OD is c 7m bgl, +29m OD is c 8m bgl, +28m OD is c 9m bgl, +27m OD is c 10m bgl, +26m OD is c11m bgl and +25m OD is c 12m bgl

6.1.7 The subcrop patterns described in Sections 6.1.2–6.1.6 combined with the sedimentological and geochemical evidence suggest the following changes in depositional environment during the course of the Holocene:

1. The development and infilling of a broadly north–south orientated channel in the western and central area of the CWR site during the Early (i.e. 9700–6236 cal. BC) and/or Middle Holocene (6236–2250 cal. BC)[16];
2. A change in flow regime leading to the development of a shallow channel filled by clean, carbonate charged water in the western part of the CWR during the Middle Holocene (6236–2250 cal. BC);
3. A further alteration to the fluvial regime, probably in the Late Holocene (after 2250 cal. BC)[7], in which the CWR site coincided with the floodplain (and probably [the] channel[s]) of the River Itchen, and on which mineral-rich overbank deposits formed. These latter are likely indicative of soil erosion upstream (i.e. providing a source of the mineral particles) and therefore possibly woodland clearance and agriculture (it is notable that molluscan and plant macroremain assessment of the relevant strata are suggestive of open environments). Geochemical and sedimentological data from alluvium suggests that initial development was before the foundation of Venta Belgarum, but that final accretion in the central part of the CWR site was coincident with human activity in the Roman and Anglo-Saxon periods.
4. A new 4m deep channel passing through the area in which ARCA CWR BH08 was constructed and was infilled by alluvial deposits (but also incorporated anthropogenic artefacts and residues) during the historic period (AD 43 onwards);
5. Accretion of archaeological deposits took place from the Roman period (AD43–410) onwards across the entirety of the CWR site. The thickest of these deposits and those with the greatest quantity of structural material lie beneath the present bus station and its surrounds.

6.2 Preservational potential

6.2.1 In considering preservation, it should be emphasised that (a) biological materials are the main consideration (an implicit emphasis of the brief [Winchester City Council 2020] and the reason why floral and faunal content have been assessed in this report [Wilkinson et al. 2020]), and (b) the focus (as demonstrated by the sample selection criteria of Section 3.2.4 and Appendix 3) is on SU5 Archaeological strata (Wilkinson and Watson 2020, section 5). The reason for the latter is the known archaeological significance of SU5 and the greater potential effect that development is likely to have on near surface compared to lower strata. This greater risk of mechanical damage of the near-surface subcrop of SU5 is combined with groundwater fluctuation within that stratigraphic unit (Section 5.2.7, Figure 9). For these combined reasons 52 of the 73 samples assessed for palynological and plant macroremain purposes were from SU5. As a result, well informed comments can be made with regards to the preservation potential of biological materials within SU5, but too few samples have been examined from lower strata to provide reliable indications of biological survival.

[16] These sub-divisions referring to the Greenlandian (Early Holocene), Northgrippian (Middle Holocene) and Meghalayan (Late Holocene) (Subcommission on Quaternary Stratigraphy 2018)

Figure 18. Preservation of pollen by depth slice
NB: +36m OD is c 1m bgl, +35m OD is c 2m bgl, +34m OD is c 3m bgl, +33m OD is c 4m bgl, +32m OD is c 5m bgl and +31m OD is c 6m bgl

Figure 19. Preservation of plant macroremains and mollusc shell by depth slice

NB: +36m OD is c 1m bgl, +35m OD is c 2m bgl, +34m OD is c 3m bgl, +33m OD is c 4m bgl, +32m OD is c 5m bgl and +31m OD is c 6m bgl

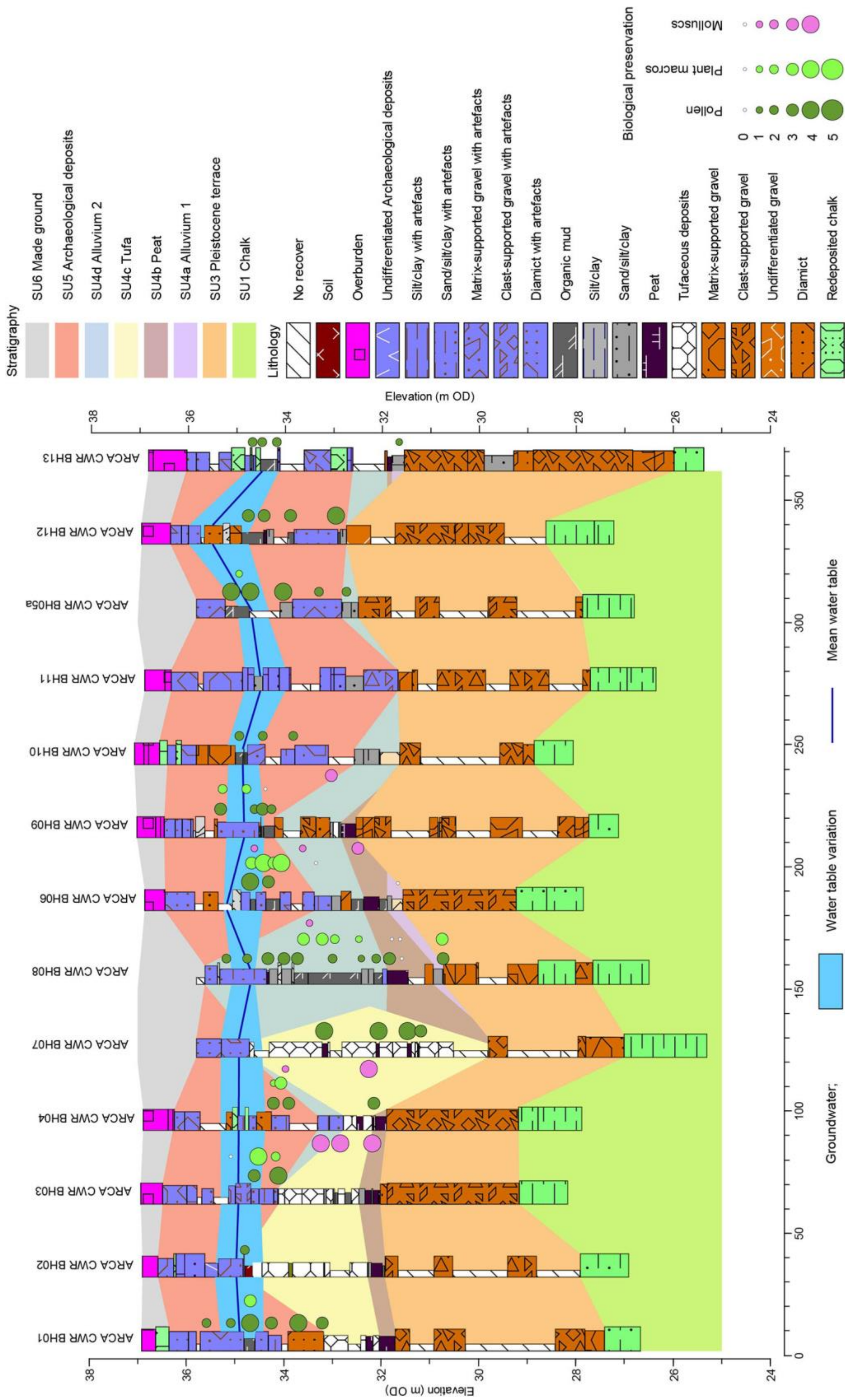

Figure 20. Preservation of pollen, plant macrofossils and mollusc shell plotted against lithostratigraphy and groundwater elevation September 2020–September 2021

6.2.2 Figure 18 and Figure 19 plot assessed preservation of the three categories of biological remains against the depth-sliced deposit model, while Figure 20 cross references biological preservation, lithostratigraphy and groundwater between September 2020 and September 2021. These data demonstrate that preservation of pollen and (to a slightly lesser extent) plant macroremains is consistently high to a depth of +34m OD (c 3m bgl), but would then *appear* to decline. However, the latter impression is entirely a product of the focus of the assessment on SU5, the subcrop of which extends below +34m OD only in the east of the site. The average preservation 'value' for SU5 was 3 (from a possible maximum of 5 – see Table 3) in the case of pollen, indicating that grains of fragile taxa are present, and 2 for plant macroremains. There is, however, considerable variability in the latter and individual preservation assessments in SU5 vary between 0 and 4, but there is only a very slight correlation of better preservation with greater depth (r=0.32) (see Figure 20). These data support suggestions made above with respect to weight loss-on-ignition estimates of organic carbon in SU5 (Section 4.2.7.1), namely that organic content (and by inference, biological preservation) is mainly a factor of the original depositional environment in situations where the subcrop is below present groundwater. Although few samples were examined from stratigraphic units above September 2020–September 2021 groundwater (three pollen and one plant macrofossil sample), there is some indication that preservation is less good than in underlying strata (Figure 20). Nevertheless, as stated above, the overwhelming impression given by Figure 20 is of biological preservation varying by depositional context to a greater extent than position with respect to groundwater.

6.2.3 As implied in Section 6.2.1 above, a reliable assessment of biological preservation in the sub-units of SU4 is difficult to make. The few (four in total) palynological and plant macroremain samples examined from SU4a Alluvium 1 produced variable results, ranging from moderate (a score of 3) to very poor (0) levels of preservation. On the other hand, pollen and plant macroremain assessment of SU4b Peat (four samples from ARCA CWR BH06) indicates uniformly poor preservation of both proxies. Nevertheless, prior palaeoenvironmental assessment of peat in an equivalent stratigraphic position from elsewhere in Winchester suggests variable levels of pollen preservation, i.e. poor in the Upper Brook Street car park (Wilkinson and Batchelor 2012), but good in Lower Brook Street (Watson 2015) and the Cathedral Close (Champness et al. 2012, Wilkinson and Grant 2020). Given that SU4b lies within the present groundwater zone, it is likely that a combination of mechanical factors (e.g. compression) and prior groundwater properties (e.g. a lower water table in the Middle to early Late Holocene) are the major determinants of preservation in that stratum. Further, it should be (re-) emphasised that the four samples assessed as part of the present exercise are an insufficient basis for arguing for an absence of botanical preservation in SU4b in the CWR study area. Indeed, it is of note that peat lenses within the tufa of SU4c, four samples from which were assessed for their palynological content, demonstrated better sub-fossil preservation than any other stratigraphic unit (an average score of 4). Conversely and perhaps counterintuitively given the calcareous nature of the tufa itself, mollusc shell preservation in SU5c is either very good (4) or non-existent (0), again probably as a result of the individual circumstances of tufa growth in particular locations.

6.2.4 Sub-fossil preservation in SU4d is moderate for all categories of biological remain (pollen = 2, plant macrofossil = 2, mollusc shell = 2), but notably less good than in SU5 in the case of pollen and plant macrofossils. Once again, biological preservation is likely associated with facies differences, i.e. better in fine-grained deposits that were probably forming in channel margins and on the floodplains, and less good in coarse-grained channel deposits.

6.3 Vulnerability of organic remains

6.3.1 As Figure 20 *appears* to show, biological preservation in SU5 Archaeological strata appears to be better below present groundwater than above. It is also the case that biological preservation within the zone of fluctuating groundwater (the blue-shaded area in Figure 20) is of similar quality to that permanently within the groundwater zone. A significant caveat, however, is that only four samples (three for pollen and one for plant macroremains) were examined from strata above groundwater elevation, and there was some degree of biological preservation even in these. Nevertheless, many decades of taphonomic research (implicit in Historic England's guidance for environmental archaeology and preservation of archaeological sites [Campbell et al. 2011, Historic England 2016]) leave little doubt that a reduction in groundwater would very likely have an adverse effect on biological remains in the subcrop. The key question for development of the CWR study area then concerns the risk of groundwater change as a result of those engineering works.

6.3.2 The hydrogeological study described in Section 5 demonstrates that groundwater in superficial deposits (SU3–SU6) on the CWR site is hydraulically linked with that of the underlying Chalk bedrock (SU1). Groundwater in the latter most likely extends down to the base of the Grey Chalk, some 190m bgl (Booth et al. 2008). Further, there is no evidence in the data recovered during the drilling of boreholes on the CWR or from their subsequent monitoring for the presence of any perched water table (e.g. that might be punctured by the insertion of piles). As a result, it is considered highly unlikely that engineering works will have a significant impact on the overarching groundwater regime of the CWR study area. However, groundwater might be altered locally, i.e. as a result of compartmentalisation, should development proposals include the construction of cellars and underground car parks, especially if such structures extended to more than 2m bgl.

6.3.3 Local contributions to groundwater are presently negligible as almost the entire CWR study area is presently covered by impermeable surfaces such as concrete and tarmac. Thus, rainfall infiltration into groundwater is inhibited within the CWR site and rather such water is transferred to the drainage system and removed from the study area. In other words, development cannot further downgrade present local groundwater recharge (and might even improve it).

6.3.4 The most significant risk to organic, and indeed all archaeological remains on the CWR site as a result development, is mechanical damage rather than potential changes in groundwater. As Figure 16 shows, deposits of archaeological relevance sub-crop within 1m of the surface over much of the CWR site and within 2m of modern ground level over its entirety. Organic remains were not noted within 1m of the ground surface during the present archaeological and geoarchaeological works, but are found at 1–2m (e.g. in ARCA BH05a), and become increasingly common and well preserved between 2 and 3m bgl (Figure 20). Unless the present ground surface is raised before construction begins and piles are not used, it is certain that construction would extend to the depth of SU5 Archaeological strata and highly likely that deposits containing organic archaeological remains would be affected. Measures would therefore need to be put in place to protect and/or record such material before and during construction,

6.4 Archaeological and palaeoenvironmental significance

6.4.1 The data reviewed above clearly demonstrate that the SU5 Archaeological strata have high archaeological and palaeoenvironmental significance. The former was never in doubt given the location of the CWR in the core of historic Winchester, but the palaeobotanical assessments demonstrate good, albeit variable, waterlogged organic preservation throughout the SU5 stratum. Moreover, the stratigraphic data indicate that archaeological deposits are of considerable thickness over much of the CWR site (e.g. to > 4.20m bgl in the eastern parts [ARCA CWR BH5a, ARCA CWR BH10–13]). It is of note that the botanical remains are indicative of both local and extra local environments, as well as subsistence economies of the former inhabitants of the city, suggesting a high potential to reconstruct all of three of these.

6.4.2 Geochemical analysis demonstrates that copper, zinc and lead only appear in the sedimentological record once Venta Belgarum was founded, while concentrations of phosphorus at least doubles from background levels once urban activities begin. Magnetic susceptibility also increases significantly in the aftermath of historic occupation as ceramic, metallic and other burnt mineral materials become incorporated in the sedimentary record. Collectively these data provide a characterising marker for the Roman and later periods, while the presence of these elements and elevated magnetic susceptibilities in deposits of ARCA CWR BH08 categorised as SU4a, SU4b and SU4d argues for both a historic date for the sediments and the presence of an artificial channel at that location. Similar geochemical data also demonstrate that other alluvium of SU4d (e.g. in ARCA CWR BH06) formed following the foundation of Venta Belgarum. Use of sedimentological and geochemical data in the manner described above is unusual in a UK setting, at least in ‘commercial’ archaeological settings. Nevertheless, in the particular circumstances of central Winchester, the potential of employing such data is clear as a means to determine whether strata were deposited before or after the foundation of the Roman city.

6.4.3 While the archaeological and palaeoenvironmental potential of SU5 on the CWR site is confirmed by the present geoarchaeological investigation, little can be added with regards these potentials for earlier strata. As noted in Section 6.4.2 it is now clear that the upper alluvial layers (parts of SU4d) formed following the foundation of Roman Winchester, that they contain residues of human activity and that biological preservation is good. As a result, palaeoenvironmental and archaeological potential of the upper parts of SU4d is high. However, evidence of human activity in the form of sedimentological or geochemical indicators, or indeed, artefacts was not found lower in SU4d or indeed in any underlying strata. Nevertheless, it is highly likely that the lower part of SU4d is at least partly contemporary with Iron Age activity in the wider area (e.g. in the Orams Arbour enclosure and the St Catherine’s Hill, hillfort), assuming the CWR SU4d strata are the same as those in an equivalent stratigraphic position at 165 High Street. On the latter site alluvial deposits immediately underlying archaeological strata have been dated to 180 cal. BC–cal. AD 30 (Wilkinson and Grant 2019).

5.3.4 Winchester is relatively unusual for a city setting in England in that archaeological deposits resulting from urban activities in the historic period overlie Middle and Early Holocene strata (Bristol would be a further example [Baker et al. 2018]). These latter, while not of demonstrable archaeological potential, are nevertheless of considerable palaeoenvironmental potential. The present geoarchaeological investigation provides no further information – as indicated previously - with regards the former, but there are hints to the latter. The CWR geoarchaeological project has for the first time enabled:

1. Determination of the spatial extent and form of the peat (SU4b) and tufa (SU4c) subcrops, suggesting their confinement within a former channel on the western and northern part of the CWR site and their truncation by later channelling in the east;
2. Collection of a complete sample through the tufa (SU4c) demonstrating tufa–peat interdigitation. These data show that while peat formation pre-dates tufa precipitation, peat continued to form as the tufa accreted;

3. Observation of pre-peat alluvial strata (SU4a) that likely formed early in the Holocene and which might provide proxy palaeoenvironmental data for a period unrepresented in existing records from Winchester.

These new data can be most usefully exploited once a chronological framework is in place, i.e. following a programme of ^{14}C dating (see Section 7.4).

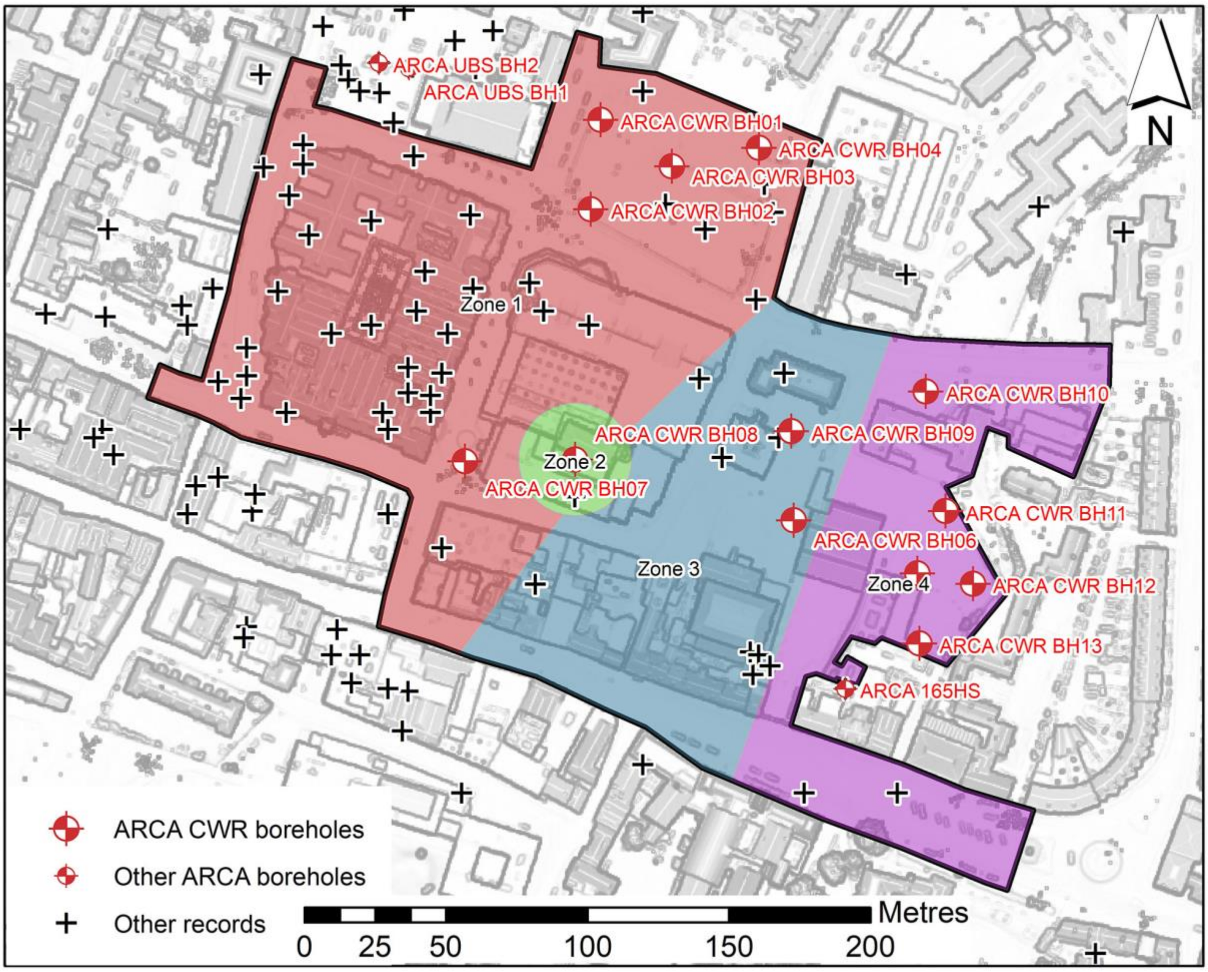

Figure 21. Zonation of the CWR on the basis of stratigraphic characteristics

5.3.5 Figure 21 is an attempt to zone the CWR site by character, depth, thickness and preservation of archaeological and biological remains in the subcrop, While the zone boundaries are not prescriptive (too few data points, i.e. stratigraphic records are available to allow a high resolution characterisation), the zones provide a basis for archaeological response on the basis of development proposals:

Zone 1: Tufa – moderate thicknesses of archaeological strata (to 2.11–3.74m bgl) with moderately preserved biological remains, overlying palaeoenvironmentally significant tufa and peats extending down to between 4.92 and 6.49m bgl. Significant archaeological excavation has taken place within this zone, namely in The Brooks and the Lower Brook Street car park.

Zone 2: Artificial channel – channel infill sequence of historic date with moderately preserved biological remains represented only by ARCA CWR BH08 but probably extending northwards and parallel with Middle Brook Street.

Zone 3: Alluvium – moderate thicknesses of archaeological strata (to 2.83–3.48m bgl) with frequent artefacts (including Anglo-Saxon and Romano-British types) and moderate to well preserved biological remains, overlying minerogenic alluvium (SU4d)

Zone 4: Gravel – thick sequences of archaeological strata (to 4.22–5.20m bgl) containing well preserved biological remains (including structural materials) and resting thin (<0.94m) minerogenic alluvium (SU4d, SU4a) or the Pleistocene fluvial terrace (SU3).

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 The present report completes the Stage 1 geoarchaeological works (*sensu* WCC 2020) of the CWR site. Data acquired demonstrate that 1–4m of archaeological deposits overlie alluvial strata and that the anthropogenic sediments contain well to moderately preserved biological remains. Further, sedimentological and geochemical data indicate evidence of human activity in the top of the underlying alluvial strata. In other words, deposits resulting from floods continued to form even after the foundation of the Roman city. Indeed, sedimentological and geochemical data also confirm observations made during core description and which indicate the presence of an artificial channel beneath King's Walk (sampled in ARCA CWR BH08). Approximately 4.5m of infilling alluvial sediment contains residues of human activity demonstrating that the water course was open during the historic period. Although deeper alluvial strata were described and sampled, they were not the focus of the present study. Nevertheless, biological preservation within several of the relevant strata was found to be suitable for detailed analyses, which if undertaken would allow reconstruction of prehistoric and early historic environments. New phenomena were also observed during the study, most significant of which are the shape of the tufa sub-crop and the partly contemporary relationship of the tufa and peat.

7.2 The hydrogeological works demonstrate that groundwater on the CWR site is in hydraulic continuity with that of the Chalk and is unlikely to be affected by development on the site, albeit that the potential problems posed by local compartmentalisation will have to be considered by planners. Monitoring data suggest that groundwater fluctuates within the archaeological stratigraphy and that good organic preservation is found both in strata coinciding with groundwater, but also in the zone in which groundwater fluctuates. Although monitoring visits were not possible to all borehole sites every week (see Section 3.6.1 for constraints), the data are still considered reliable (even for ARCA CWR BH08 which could not be visited for 15 weeks because of the closure of King's Walk during the second Covid-19 lockdown) given (a) that groundwater monitoring was possible in adjacent locations, and (b) the limited variability of the data (Figure 7). Given the findings summarised above and following discussions with Winchester City Council's Archaeology (Tracy Matthews) and Historic England's Science Advisor for the South-east Region (Jane Corcoran), no further hydrogeological works (i.e. a Tier 3 assessment [*sensu* Historic England 2016] are recommended as part of the present project[17].

7.3 The main risk of construction to organic remains of archaeological significance (and indeed all archaeological artefacts and structures) is considered to be mechanical damage rather than oxidation as a result of groundwater change.

7.4 A basic assessment has been made in Section 6.4 of the archaeological and palaeoenvironmental significance of the deposits beneath the CWR study area revealed in the borehole cores. However, that assessment can be refined if a chronology is obtained for the deposits. Understanding the age of the strata that subcrop on the CWR site would enable their integration within the archaeological framework for Winchester (e.g. as set out by Ottaway [2017a, 2017b]) and therefore aid in understanding their context and therefore importance. It is therefore recommended that a programme of AMS ^{14}C dating is carried out on a selection (n =

[17] The brief had set out the possibility of a Stage 2 geoarchaeological project following on from that reported here (Winchester City Council 2020, section 5.4, 12–13). The Stage 2 project would comprise a Tier 3 (or Tier 2+) hydrogeological assessment and would be undertaken were there to be significant lacunae in the understanding of the groundwater environment and its influence of survival of 'sensitive archaeological deposits' (Winchester City Council 2020, section 5.4.1, 12).

18) of samples taken for this purpose (see Table 1). These chronometric data would then be integrated with the litho- and biostratigraphy and results of an examination of artefacts recovered from the cores (see footnote 3), to provide a more detailed assessment of archaeological significance[18].

7.5 The results of the geoarchaeological project have been made available via the Central Winchester Redevelopment web portal as each report has been completed[19]. Further, a presentation of all except the hydrogeological data took place as part of the Central Winchester Redevelopment Archaeology Day on 6 October 2021. Indeed, a second presentation (including the results of the hydrogeological study) is scheduled as part of an open forum on 16 March 2022. As well as communicating the results of the geoarchaeological project to the residents of Winchester and other interested stakeholders, it is important that results are also disseminated to the wider archaeological and scientific community. Communication to these latter individuals/organisations is particularly relevant given the novel and ground-breaking approach that has been adopted at all stages of the project. It is therefore proposed that the project background, methodology, results, and the interpretations made as a result, are formulated as a scientific paper and published in open access format in a scientific journal.

[18] ARCA submitted to Winchester City Council a proposal for such chronological work on 7 February 2022.

[19] See https://www.winchester.gov.uk/regeneration/central-winchester-regeneration-technical-reports. This report will be placed on that portal on 14 March 2022.

8. ACKNOWLEDGEMENTS

8.1 ARCA would like to thank Rachel Robinson and Tracy Matthews (both of Winchester City Council) for their continuous help throughout the geoarchaeological works reported here. Other officers from Winchester City Council who aided in providing access to borehole locations are also acknowledged and were Jack Burrows and Graeme Todd. Louise Gill (also of Winchester City Council) publicised the project. Keith Wilkinson would also like to thank Tracy Matthews (Winchester City Council) and Jane Corcoran (Historic England) for their constructive comments on an earlier version of this document and discussion of the hydrogeology results.

8.2 The drilling crews (three in total) and Chris Yates of Geotechnical Engineering Ltd are thanked for their efforts during the fieldwork stage. Archaeologists from Pre-Construct Archaeology under the management of Paul McCulloch excavated the archaeological test pits at the majority of sample points before drilling commenced and maintained good humour, despite the paucity of archaeological materials. Dr Paul Lincoln (University of Reading) built the lithostratigraphic database from which the deposit models and cross sections were built. Paul Lincoln also developed the stratigraphic framework that has been employed.

8.3 Fieldwork was supervised for ARCA by Nick Watson. David Ashby surveyed in the boreholes and test pits, described strata exposed in the walls of the latter and undertook the majority of the groundwater monitoring. Borehole cores were recorded and sub-sampled by Nick Watson and Prof Keith Wilkinson, while the latter also carried out the laboratory sedimentological and geochemical measurements. Dr Rob Batchelor (Quest) and Dr Dan Young (formerly of Quest) respectively made the pollen and plant macroremain assessments, while Keith Wilkinson assessed the mollusc shell. Except where indicated otherwise Keith Wilkinson wrote and compiled the present report, and produced the illustrations.

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APPENDIX 1: BOREHOLE LOCATIONS

Bore	Easting	Northing	Elevation
ARCA CWR BH01	448365.100	129589.900	36.915
ARCA CWR BH02	448361.611	129558.200	36.902
ARCA CWR BH03	448390.300	129573.400	36.938
ARCA CWR BH04	448421.000	129580.000	36.879
ARCA CWR BH05a	448477.000	129429.000	37.000
ARCA CWR BH06	448433.300	129447.800	36.848
ARCA CWR BH07	448317.200	129468.700	37.000
ARCA CWR BH08	448356.100	129469.400	37.000
ARCA CWR BH09	448432.500	129479.400	37.014
ARCA CWR BH10	448480.000	129493.500	37.055
ARCA CWR BH11	448487.000	129451.100	36.853
ARCA CWR BH12	448496.700	129425.300	36.910
ARCA CWR BH13	448477.700	129404.000	36.775

APPENDIX 2: LITHOLOGICAL DESCRIPTIONS

Bore	Top	Base	Lithology	Comments
ARCA CWR BH01	1.20	2.10	Diamict with artefacts	2.5 Y 5/2 Greyish brown fine diamict; moist and stiff. Silt/clay matrix with occasional to frequent grains of charcoal, chalk and flint. Rare coarse pebble-size to cobble size chalk and angular flints at the top. Frequent fine pebble-sized charcoal and sub-rounded chalk. Occasional red cbm granules. Occasional medium pebble-sized oyster shell laid horizontally. Occasional medium pebble-sized angular and nodular flints. Generally even distribution of clasts. Sharp angled boundary to:
ARCA CWR BH01	2.10	2.33	Organic mud	7.5 YR 3/3 Dark brown organic material; moist and firm. Poorly humified. Faint, parallel, horizontal laminae. (Fluvially reworked lens within the diamict). Sharp boundary to:
ARCA CWR BH01	2.33	2.60	Diamict with artefacts	2.5 Y 5/2 Greyish brown fine diamict; moist and stiff. Silt/clay matrix with occasional to frequent grains of charcoal, chalk and flint. Frequent fine pebble-sized charcoal and sub-rounded chalk. occasional red cbm granules. Occasional medium pebble-sized oyster shell laid horizontally. Occasional medium pebble-sized angular and nodular flints. Generally even distribution of clasts. Diffuse boundary to:
ARCA CWR BH01	2.60	2.88	Sand/silt/clay with artefacts	7.5 YR 3/3 dark brown silt/clay; wet and loose. Humic, fibrous and gritty. Rare medium pebble-sized flint. Rare, black, cobble-sized cattle leg bone, sawn. Frequent granular and fine pebble-sized, grey, angular mortar fragments composed of fine carbonate nodules and fine flints.
ARCA CWR BH01	2.88	3.00	No recover	Void.
ARCA CWR BH01	3.00	3.74	Diamict	7.5 YR 3/3 dark brown silt/clay; wet and loose. Humic, fibrous and gritty. Rare medium pebble-sized flint. Similar to unit above but more organic and diamict-like. Frequent twigs with bark and lenses of layered fibrous organic material laid at angles. Occasional to frequent tufa granules and flints towards base. Chalk cobble at base. (Archaeological). Sharp boundary to:
ARCA CWR BH01	3.74	4.24	Tufaceous deposits	2.5 Y 5/1 Grey grading to 4/1 at base, tufa. Clayey at top becoming more silty towards base. Frequent granular ooids. Peat particles are frequent towards base. End of core.
ARCA CWR BH01	4.24	4.50	No recover	Void.

Bore	Top	Base	Lithology	Comments
ARCA CWR BH01	4.50	4.60	Tufaceous deposits	2.5 Y 4/1 Dark grey, tufa with frequent peat particles (continuation of unit above). Sharp boundary to:
ARCA CWR BH01	4.60	4.75	Peat	7.5 YR 3/2 Very dark brown peat; dry and firm. Very well humified. Rare granular reed fragments. Diffuse boundary to:
ARCA CWR BH01	4.75	4.88	Tufaceous deposits	2.5 Y 4/1 Dark grey, tufa; moist and firm. Fine grained with a silt/clay matrix and with occasional fine sand-sized peat particles. Occasional granular ooids. Occasional vertical root holes 2mm wide filled with humic matter. Sharp boundary to:
ARCA CWR BH01	4.88	5.20	Peat	7.5 YR 3/2 Very dark brown peat; dry and firm. Well humified. Occasional granular reed fragments and fibres, horizontally matted. (Clay base not apparent). Diffuse boundary to:
ARCA CWR BH01	5.20	5.50	Clast-supported gravel	Flint gravel of granular to medium pebble-sized clasts. Washed out.
ARCA CWR BH01	5.50	6.00	No recover	Void. (Washed out gravels?)
ARCA CWR BH01	6.00	6.65	Clast-supported gravel	Flint gravel very poorly sorted and unstructured. Washed out?
ARCA CWR BH01	6.65	8.50	No recover	Void. (Washed out gravels?)
ARCA CWR BH01	8.50	9.10	Clast-supported gravel	Flint cobbles.
ARCA CWR BH01	9.10	9.50	Matrix-supported gravel	10 YR 8/3 Very pale brown flint gravel; wet and firm. Chalky matrix. Poorly sorted clasts. Matrix-supported. (Solifluction deposit).
ARCA CWR BH01	9.50	10.25	Weathered Chalk	5 Y 7/1 light grey (greenish tinge) diamict; moist and firm to stiff. Granular to medium pebble sized sub-rounded Chalk and rare flint gravel. Matrix-supported. Matrix of fine to coarse sand-sized Chalk particles (sandy texture to matrix but particles crush down). (Solifluction deposit).

Bore	Top	Base	Lithology	Comments
ARCA CWR BH02	1.50	1.56	Undifferentiated Archaeological deposits	continuation of test pit (David)
ARCA CWR BH02	1.56	2.08	Diamict with artefacts	2.5 Y 5/1 Grey coarse diamict; moist and firm. Silt/clay matrix with frequent medium sand-sized mineral grains; frequent medium to coarse sand-sized charcoal and Chalk (limestone too?). Occasional coarse sand-sized red cbm and angular flint. Clasts of granular to medium pebble-sized angular flint, sub-angular cbm and sub-angular Chalk. Rare cobble -sized Chalk (crushed) Rare shell granule. Generally even distribution of clasts; no internal structure. (Archaeological). Sharp boundary to:
ARCA CWR BH02	2.08	2.11	Structural deposits	2.5 Y 6/4 Light yellowish brown silt/clay; moist and firm. Gritty texture tending to a clayey fine gravel. Coarse sand-sized to granular-sized sub-angular to angular flints. (Archaeological construction deposit). Sharp boundary to:
ARCA CWR BH02	2.11	2.26	Soil	2.5 Y 4/2 Dark greyish brown silt/clay; moist and firm with a gritty texture. Frequent coarse-sand-sized to granular-sized charcoal; frequent fine sand-sized to granular-sized tufa particles and rare sub-angular flint particles. Greenish orange oxidation mottles (20%). No clasts larger than granule-size; weakly humic (Soil?). Diffuse boundary to:
ARCA CWR BH02	2.26	2.46	Tufaceous deposits	10 YR 6/3 Light yellowish brown silt/clay; moist and firm. Frequent medium to coarse sand-sized tufa particles and occasionally of granule size. Rare charcoal grain. Gritty texture. Occasional darker stains of oxidation. Diffuse boundary to:
ARCA CWR BH02	2.46	3.00	Tufaceous deposits	10 YR 7/1 Light grey tufa; moist and firm. Very gritty texture. Coarse sand-sized grains, ooids and nodules often with very irregular shapes. General increase in size to granule/fine pebble towards base. Clast-supported throughout but with more silt/clay matrix towards the top.
ARCA CWR BH02	3.00	3.08	Undifferentiated	Slump.
ARCA CWR BH02	3.08	3.72	Tufaceous deposits	10 YR 7/1 Light grey tufa; moist and firm. Very gritty texture. Coarse sand-sized grains with frequent granule and rare fine pebble sized particles: ooids and nodules often with very irregular shapes. Clast-supported throughout but with rare silt/clay matrix. Green and orange oxidation stains. Sharp boundary to:

Bore	Top	Base	Lithology	Comments
ARCA CWR BH02	3.72	3.75	Sand/silt/clay	7.5 YR 3/2 dark brown silt/clay with occasional charcoal granules. Lens /fine bed within tufa.
ARCA CWR BH02	3.75	3.86	Tufaceous deposits	7.5 YR 7/1 Light grey tufa; moist and firm. Very gritty texture. Coarse sand-sized grains with frequent granule and rare fine pebble sized particles: ooids and nodules often with very irregular shapes. Clast-supported throughout but with rare silt/clay matrix. Humic colouration to unit with darker stains (6/1).
ARCA CWR BH02	3.86	4.25	No recover	Void. (loss of tufa?)
ARCA CWR BH02	4.25	4.62	Tufaceous deposits	7.5 YR 7/1 Light grey tufa; moist and firm. Very gritty texture. Coarse sand-sized grains with frequent granule and rare fine pebble sized particles: ooids and nodules often with very irregular shapes. Clast-supported throughout but with rare silt/clay matrix. Humic colouration to unit with darker stains (6/1).
ARCA CWR BH02	4.62	4.71	Sand/silt/clay	2.5 Y 5/1 Grey very fine sand; wet and soft. Silty texture. Occasional, faint, mm size, discontinuous laminations of dark organic particles (peat?) Occasional fine to coarse sand-sized tufa particles. (Incipient precipitation of tufa over peat). Sharp boundary to:
ARCA CWR BH02	4.71	4.94	Peat	10 YR 2.4/1 Black oxidising to 7.5 YR 3/2 Very dark brown peat; dry and stiff. Very well humified with a sharp fracture. No structure, homogenous, no identifiable plant remains. Diffuse boundary to:
ARCA CWR BH02	4.94	4.98	Organic mud	2.5 Y 4/2 Dark greyish brown silt/clay with occasional very fine sand-sized mineral grains. (Alluvium) Sharp boundary to:
ARCA CWR BH02	4.98	5.25	Clast-supported gravel	2.5 Y 6/1 Grey flint gravel. Granular to medium pebble size, angular to sub-angular clasts. Rare very well rounded black flint pebble. Clast-supported. (Fines washed out?)
ARCA CWR BH02	5.25	6.00	No recover	Void
ARCA CWR BH02	6.00	6.38	Clast-supported gravel	2.5 Y 6/1 Grey flint gravel. Granular to medium pebble size, angular to sub-angular clasts. Clast-supported. (Fines washed out?)
ARCA CWR BH02	6.38	7.50	No recover	Void

Bore	Top	Base	Lithology	Comments
ARCA CWR BH02	7.50	8.10	Clast-supported gravel	2.5 Y 6/1 Grey flint gravel. Coarse sand-size to granular size angular flints. Frequent fine to medium size, angular to sub-angular clasts. Clast-supported. 10 YR 8/4 very pale brown muddy matrix retained at the base.
ARCA CWR BH02	8.10	9.00	No recover	Void.
ARCA CWR BH02	9.00	10.00	Weathered Chalk	10 YR 8/4 Very pale brown to 10 YR 8/1 White at the base, clayey flint gravel. Cobble-sized patches of 10 YR5/6 yellowish brown clayey flint gravel. Poorly sorted and matrix-supported. Coarse flint cobble at the base. (Solifluction deposit).
ARCA CWR BH03	1.26	1.50	Sand/silt/clay with artefacts	10 YR 3/2 Very dark greyish brown silt/clay with moderate granular and rare fine pebble-sized sub-round and sub-angular Chalk clasts, occasional bone pebbles and moderate granular-sized charcoal fragments. Clasts are chaotically arranged. Poorly sorted.
ARCA CWR BH03	1.50	1.80	No recover	Void
ARCA CWR BH03	1.80	1.95	Diamict with artefacts	10 YR 3/2 Very dark greyish brown silt/clay and Chalk-derived fine-medium sand. Occasional sub-angular flint pebble. Rare pebble-sized ceramic fragment. Occasional fine pebble sized bone and brick/tile fragments. Poorly sorted. Sharp boundary to:
ARCA CWR BH03	1.95	2.27	Clast-supported gravel with artefacts	Clast and matrix-supported gravel of sub-angular and angular flint pebbles and granules in a silt/clay and fine-medium sand matrix. Reverse bedded, while matrix increases downwards below 2.20m. Sharp boundary to:
ARCA CWR BH03	2.27	2.43	Sand/silt/clay with artefacts	10 YR 3/1 Very dark grey silt/clay with moderate coarse sand and granular sub-angular and sub-rounded Chalk clasts. Occasional pebble sized bone. Occasional pebble and granular sized charcoal. Moderate pebble-sized sub-angular flint. Poorly sorted. Diffuse boundary to:

Bore	Top	Base	Lithology	Comments
ARCA CWR BH03	2.43	2.74	Sand/silt/clay with artefacts	10 YR 2/2 Very dark brown organic silt/clay with occasional Chalk-derived medium-coarse sand. Rare pebble-sized ceramic fragment (tile?) and occasional pebble-sized charcoal/waterlogged plant remain fragment. Thin layer of sub-angular flint pebbles at 2.66-2.70m with matrix as above. Poorly sorted. Diffuse boundary to:
ARCA CWR BH03	2.74	2.82	Sand/silt/clay with artefacts	2.5 Y 4/1 Dark grey silt/clay and Chalk/tufa-derived medium-fine sand. Moderate tufa/chalk sub-angular granules and rare pebble-sized, sub-rounded ceramic fragment. Poorly sorted. Sharp boundary to:
ARCA CWR BH03	2.82	2.83	Organic mud	10 YR 2/2 Very dark brown organic mud/humified peat with occasional Chalk/tufa granule. Poorly sorted. Sharp boundary to:
ARCA CWR BH03	2.83	2.96	Tufaceous deposits	10 YR 6/3 Pale brown tufa gravel of sub-angular tufa granules and fine pebbles in a tufaceous silt-coarse sand matrix. Poorly sorted. Diffuse boundary to:
ARCA CWR BH03	2.96	3.32	Tufaceous deposits	10 YR 3/6 Dark yellowish brown tufa gravel of sub-angular granules and fine pebbles in a tufaceous silt-coarse sand matrix. Poorly sorted. Sharp boundary to:
ARCA CWR BH03	3.32	3.77	Tufaceous deposits	10 YR 7/3 Very pale brown tufa gravel of sub-angular granules and fine pebbles in a tufaceous silt-coarse sand matrix. Poorly sorted. Diffuse boundary to:
ARCA CWR BH03	3.77	3.81	Sand/silt/clay	10 YR 6/2 Light brownish grey silt/clay with occasional coarse sand and granular-sized tufa clasts. Moderately sorted. Diffuse boundary to:
ARCA CWR BH03	3.81	3.95	Tufaceous deposits	10 YR 7/3 Very pale brown tufa gravel of sub-angular granules and fine pebbles in a tufaceous silt-coarse sand matrix. Poorly sorted. Diffuse boundary to:
ARCA CWR BH03	3.95	3.99	Sand/silt/clay	10 YR 6/2 Light brownish grey silt/clay with occasional coarse sand and granular-sized tufa clasts. Moderately sorted. Sharp boundary to:
ARCA CWR BH03	3.99	4.06	Organic mud	10 YR 4/3 Brown silt/clay with moderate wavy, parallel, thin-medium laminae of 10 YR 2/1 Black peat laminae. Occasional coarse sand-sized tufa clasts laid parallel of peat laminae. Moderately sorted within laminae. Sharp boundary to:

Bore	Top	Base	Lithology	Comments
ARCA CWR BH03	4.06	4.19	Tufaceous deposits	10 YR 6/3 Pale brown reverse-bedded tufa gravel of horizontally laid fine beds of tufaceous medium-coarse sands, silts-fine sands and granules/fine pebbles. Moderately sorted within fine beds. Diffuse boundary to:
ARCA CWR BH03	4.19	4.32	Organic mud	10 YR 4/2 Dark greyish brown silt/clay with occasional thin, horizontally-laid beds of 10 YR 4/1 Dark grey organic silt/clay. Moderate granular-size organic mud/peat fragments scattered throughout. Single coarse pebble-sized waterlogged wood fragment at 4.19-4.22m. Moderately sorted. Sharp boundary to:
ARCA CWR BH03	4.32	4.48	Tufaceous deposits	10 YR 6/3 Pale brown reverse-bedded tufa gravel of sub-rounded and sub-angular tufa granules, coarsening upwards to sub-round tufa pebbles in a tufaceous silt-medium sand matrix. Poorly sorted. Sharp boundary to:
ARCA CWR BH03	4.48	4.62	Sand/silt/clay	10 YR 4/2 Dark greyish brown silt/fine sand with moderate coarse sand-sized Chalk/tufa clasts. Moderately sorted. Sharp boundary to:
ARCA CWR BH03	4.62	4.74	Peat	10 YR 2/1 Black compact, highly humified peat. Rare pebble-sized reed plant macrofossils. Diffuse boundary to:
ARCA CWR BH03	4.74	4.78	Sand/silt/clay	10 YR 4/1 Dark grey silt/clay with frequent granular-coarse sand-sized Chalk/tufa clasts. Moderate fine pebble-sized patches of 10 YR 2/1 Black peat. Single wavy, discontinuous thin bed of 10 YR 2/1 Black peat. Poorly sorted. Sharp boundary to:
ARCA CWR BH03	4.78	4.88	Peat	10 YR 2/1 Black compact, highly humified peat. Diffuse boundary to:
ARCA CWR BH03	4.88	4.92	Peat	10 YR 2/2 Very dark brown moderately humified peat.
ARCA CWR BH03	4.92	5.06	Matrix-supported gravel	Matrix-supported gravel of sub-angular and sub-ed flint pebbles in a 10 YR 5/3 Brown silt-fine sand matrix. Occasional fine pebble-sized patches of 10 YR 2/2 Very dark brown peat. Poorly sorted. Diffuse boundary to:
ARCA CWR BH03	5.06	7.78	Clast-supported gravel	Clast and matrix-supported gravel of sub-rounded flint pebbles in a medium to coarse sand (flint-derived) matrix. Gravels are laid in c 0.15m-thick, grain size divided horizontal sets. Poorly sorted. Sharp boundary to:
ARCA CWR BH03	7.78	8.77	Weathered Chalk	2.5 Y 8/2 Pale brown matrix-supported gravel of sub-angular Chalk fine cobbles and pebbles and occasional sub-angular flint pebbled in a Chalk-derived silt/clay matrix. Poorly sorted
ARCA CWR BH04	1.50	1.70	No recover	Void

Bore	Top	Base	Lithology	Comments
ARCA CWR BH04	1.70	1.82	Diamict	10 YR 4/2 Dark greyish brown fine diamict of sub angular flint and sub-rounded and sub-angular Chalk pebbles and granules in a silt/clay matrix. Sharp boundary to:
ARCA CWR BH04	1.82	1.94	Redeposited chalk	10 YR 8/2 Very pale brown matrix-supported Chalk gravel of sub-angular Chalk granules in a Chalk-derived silt/clay matrix. Poorly sorted. Sharp boundary to:
ARCA CWR BH04	1.94	2.08	Sand/silt/clay with artefacts	2.5 Y 5/2 Greyish brown silt/clay with moderate granular-fine pebble size charcoal fragments and moderate (decreasing downwards) sub-rounded and sub-angular Chalk granular clasts. Poorly sorted. Sharp boundary to:
ARCA CWR BH04	2.08	2.17	Redeposited chalk	10 YR 8/2 Very pale brown matrix-supported Chalk gravel of sub-angular Chalk granules in a Chalk-derived silt/clay matrix. Poorly sorted. Sharp boundary to:
ARCA CWR BH04	2.17	2.32	Sand/silt/clay with artefacts	10 YR 5/2 Greyish brown silt/clay, fine to medium sand with moderate granular-sized Chalk granules (decreasing downwards). Sand-size particles are of Chalk. Occasional sub-angular flint pebble. Rare pebble-size decayed waterlogged wood fragment. Poorly sorted. Diffuse boundary to:
ARCA CWR BH04	2.32	2.63	Diamict	10 YR 4/2 Dark greyish brown fine diamict of sub-angular and sub-rounded fine pebble and granular Chalk in a silt/clay and Chalk-derived fine-medium sand matrix. Sharp boundary to:
ARCA CWR BH04	2.63	3.00	Sand/silt/clay with artefacts	10 YR 3/1 Very dark grey organic silt/clay with moderate sub-angular and sub-rounded Chalk granules and medium-coarse sand. Moderate charcoal granules and occasional ceramic and bone fragments (pebble size). Poorly sorted.
ARCA CWR BH04	3.00	3.57	No recover	Void
ARCA CWR BH04	3.57	3.81	Sand/silt/clay with artefacts	10 YR 3/1 Very dark grey silt/clay, fine to medium sand (sands are Chalk-derived) with moderate sub-angular and sub-rounded Chalk granules and occasional sub-rounded and sub-angular flint pebbles. Occasional sub-rounded ceramic granules and fine pebbles at top. Poorly sorted. Diffuse boundary to:

Bore	Top	Base	Lithology	Comments
ARCA CWR BH04	3.81	4.10	Sand/silt/clay with artefacts	10 YR 4/2 Dark greyish brown silt/clay and Chalk-derived fine to medium sand with frequent sub-angular and sub-rounded Chalk granules. Occasional sub-angular and sub-rounded flint pebbles and rare sub-rounded ceramic pebbles and granules. Poorly sorted. Diffuse boundary to:
ARCA CWR BH04	4.10	4.38	Tufaceous deposits	2.5 Y 7/4 Pale brown fine gravel of sub-angular tufa granules in a tufaceaous silt-coarse sand matrix. Poorly sorted. Sharp boundary to:
ARCA CWR BH04	4.38	4.50	Peat	10 YR 2/1 Black moderately humified peat interbedded (fine, discontinuous, wavy) with 7.5 YR 6/3 Light brown tufa gravel of granular tufa in a tufaceous silt to medium sand matrix. Poorly sorted.
ARCA CWR BH04	4.50	4.70	Tufaceous deposits	10 YR 5/2 Greyish brown silt with frequent granular and coarse sand-sized tufa clasts and rare pebble-sized wood fragment. Moderately sorted. Sharp boundary to:
ARCA CWR BH04	4.70	4.73	Peat	10 YR 3/1 Very dark grey moderately humified wood peat with frequent pebble-sized wood fragments. Sharp boundary to:
ARCA CWR BH04	4.73	4.76	Tufaceous deposits	10 YR 5/2 Greyish brown silt with frequent granular and coarse sand-sized tufa clasts. Moderately sorted. Sharp boundary to:
ARCA CWR BH04	4.76	4.99	Peat	10 YR 2/1 Black moderately humified peat with frequent pebble-sized wood fragments at 4.76-4.82m and moderate pebble-sized twiggy plant remains lower down. Sharp boundary to:
ARCA CWR BH04	4.99	7.70	Clast-supported gravel	Clast and matrix-supported gravel of pebble and cobble-sized sub-rounded (mostly) and sub-angular (moderate) flint clasts in a medium sand matrix. Gravel sets evident but poorly preserved due to loss of matrix during drilling. Sharp boundary to:
ARCA CWR BH04	7.70	8.10	Weathered Chalk	10 YR 8/1 White Chalk-derived silt/clay with moderate sub-angular-size Chalk granules and moderate sub-angular and sub-rounded flint granules. Poorly sorted. Diffuse boundary to:
ARCA CWR BH04	8.10	9.00	Weathered Chalk	2.5 Y 7/1 Light grey Chalk-derived silt/clay with frequent sub-angular Chalk granules. Poorly sorted.

Bore	Top	Base	Lithology	Comments
ARCA CWR BH05A	1.20	1.80	Diamict with artefacts	10 YR 5/1 Grey coarse diamict; moist and firm. Granular to coarse pebble-sized sub-rounded Chalk. Granular to coarse pebble-sized angular flint. (60% clasts). Occasional fine pebble-sized oyster shell, charcoal fragments, bone and slate. Occasional grains and granules of red cbm. grey silt/clay matrix with frequent coarse sand-sized Chalk particles. Very gritty texture. Cobble of Chalk at the base. (Archaeological). Sharp boundary to:
ARCA CWR BH05A	1.80	2.30	Organic mud	7.5 YR 2.5/1 Black organic silt/clay; moist and firm. Diamict-like texture of frequent twigs (10mm diameter) horizontally and irregularly bedded. Frequent fibrous organic matter (from bark). Rare mussel valve. Rare black cobble-sized cattle bone fragment. Occasional grains and granules of charcoal. Top 50mm is washed out: fewer organic and silt/clay particles greater proportion of fine mineral grains.
ARCA CWR BH05A	2.30	2.92	No recover	Void.
ARCA CWR BH05A	2.92	3.18	Sand/silt/clay	2.5 Y 3/3 Dark olive brown silt/clay; moist and firm. Slightly silty texture. Homogeneous. Grades to 2.5Y 2.5/1 Black at base. Gradual boundary to:
ARCA CWR BH05A	3.18	4.20	Diamict with artefacts	2.5 Y 2.5/1 Black diamict; moist and firm. Colour grades into 2.5/Y 6/2 Light greyish brown then to 2.5 Y 4/1 Dark grey towards base reflecting changes in humic content but no visible organic matter. Frequent granular to fine pebble-sized angular flints and sub-rounded Chalk. Frequent oyster shell grains and granules (crushed) towards the top. Grains, granules and occasional fine pebble-sized charcoal fragments throughout. Rare grains of red cbm. Coarse pebble-sized Roman roof tile of medieval floor tile (fired twice).
ARCA CWR BH05A	4.20	4.38	Sand/silt/clay	2.5 Y 3/3 Dark olive brown silt/clay; moist and firm. Slightly silty texture. Top 100mm with occasional fine pebble-sized angular flint and sub-rounded Chalk. Fine bed (lense 30mm) of darker silt with very diffuse boundaries at 4.37m. Diffuse boundary to:
ARCA CWR BH05A	4.38	4.53	Sand/silt/clay	2.5 Y 3/3 Dark olive brown silt/clay; moist and firm. Silty texture. Homogeneous. Very well-rounded, black, fine pebble-sized flint dropstone. Oblate fine pebble-sized wood fragment. Sharp boundary to:
ARCA CWR BH05A	4.53	5.20	Clast-supported gravel	Flint gravel. Clast-supported granular to fine pebble-sized flints with minor fraction of 2.5 Y 3/3 dark olive brown silt/clay in top 110mm. (True contact). Coarser flint gravel continues: fine to coarse pebble-sized angular to subangular clasts with rare flint cobbles. (Fines possibly washed out).
ARCA CWR BH05A	5.20	5.70	No recover	Void. (Washed out).

Bore	Top	Base	Lithology	Comments
ARCA CWR BH05A	5.70	6.20	Clast-supported gravel	Very poorly sorted flint gravels. Unstructured. (Washed).
ARCA CWR BH05A	6.20	7.20	No recover	Void. (Washed out).
ARCA CWR BH05A	7.20	7.80	Clast-supported gravel	Very poorly sorted, angular to sub-angular flint gravels. Reverse graded to 7.61m (coarse pebble-sizes at top and coarse sand-sizes at base). At 7.61m 30mm lens of fine pebbles of flint. Normal grading to 7.80m
ARCA CWR BH05A	7.80	9.00	No recover	Void. (Washed out).
ARCA CWR BH05A	9.00	9.15	Clast-supported gravel	Very poorly sorted angular flint gravel with increasing putty chalk content towards base (True contact). Diffuse boundary to:
ARCA CWR BH05A	9.15	10.20	Weathered Chalk	5 Y 7/2 Light grey (greenish tinge) Chalk diamict; moist and firm to stiff. Granular to fine pebble-sized, sub-angular to sub-rounded Chalk clasts (9.5/N) set in a putty Chalk matrix. Matrix-supported. Oxidises white on exposure. (Solifluction deposit).
ARCA CWR BH06	1.20	1.50	Diamict	10 YR 4/1 Dark grey fine diamict of sub-angular Chalk granules and pebbles in a silt/clay matrix. Occasional granular sized charcoal fragments.
ARCA CWR BH06	1.50	1.80	No recover	Void
ARCA CWR BH06	1.80	1.97	Chalk-rich gravel	10 YR 8/2 Very pale brown clast-supported gravel of sub-angular Chalk pebbles to boulders in a Chalk-derived clay-fine sand matrix. Poorly sorted. Sharp boundary to:
ARCA CWR BH06	1.97	2.17	Diamict with artefacts	2.5 Y 3/1 Very dark grey fine diamict of moderate sub-angular Chalk pebbles and granules (decreasing upwards) and moderate pebble-sized oyster shell (increasing upwards). Frequent granular-sized charcoal fragments. Matrix is of silt/clay. Strong petroleum odour. Sharp boundary to:
ARCA CWR BH06	2.17	2.27	Organic mud	10 YR 3/2 Very dark greyish brown organic silt/clay with occasional granular-size fibrous plant remains. Well sorted. Diffuse boundary to:

Bore	Top	Base	Lithology	Comments
ARCA CWR BH06	2.27	2.48	Diamict with artefacts	10 YR 3/1 Very dark grey fine diamict of moderate sub-angular flint pebbles and granules and moderate pebble-sized oyster shell in an organic clay-fine sand matrix. Occasional granular-size plant macro remains, concentrated in around clasts. Diffuse boundary to:
ARCA CWR BH06	2.48	2.77	Organic mud	10 YR 3/2 Very dark greyish brown organic silt/clay with moderate granular-size fibrous plant remains, moderate Chalk-derived coarse sand and granules, occasional granular oyster and rare wood fragments. Poorly sorted. Sharp boundary to:
ARCA CWR BH06	2.77	3.00	Diamict with artefacts	10 YR 2/2 Very dark brown coarse diamict of frequent sub-angular flint, occasional sub-rounded Chalk pebbles and rare sub-rounded ceramic granules in n organic silt/clay matrix
ARCA CWR BH06	3.00	3.24	No recover	Void
ARCA CWR BH06	3.24	3.48	Diamict with artefacts	10 YR 3/2 Very dark greyish brown fine diamict of moderate sub-angular flint pebbles and granules in an organic clay-medium sand matrix. Heterogenous. Sharp boundary to:
ARCA CWR BH06	3.48	3.83	Sand/silt/clay with artefacts	2.5 Y 4/1 Dark grey silt/clay with occasional sub-angular flint fine pebbles and granules, occasional sub-rounded ceramic pebbles and granules and occasional charcoal granules. Gravel content increases upwards. Poorly sorted. Diffuse boundary to:
ARCA CWR BH06	3.83	4.03	Sand/silt/clay	2.5 Y 4/2 Dark greyish brown silt/clay with occasional granular and fine-pebble-size granular-size clasts. Well sorted. Sharp boundary to:
ARCA CWR BH06	4.03	4.24	Matrix-supported gravel	10 YR 6/1 Grey matrix-supported gravel of sub-angular and sub-rounded flint and Chalk/tufa granules and fine pebbles in a calcareous silt/clay matrix. Poorly sorted. Sharp boundary to:
ARCA CWR BH06	4.24	4.50	Organic mud	10 YR 3/1 Very dark grey organic silt/clay with moderate granular and coarse sand-sized flint and Chalk/tufa clasts. Rare boulder-sized sub-angular flint. Moderate granular-sized fibrous plant remains. Poorly sorted.
ARCA CWR BH06	4.50	4.82	Peat	10 YR 2/1 Black moderately humified peat with moderate fine pebble-sized waterlogged wood fragments. Occasional sub-angular flint pebbles. Diffuse boundary to:
ARCA CWR BH06	4.82	4.97	Organic mud	10 YR 2/2 Very dark brown organic mud with moderate pebble-sized fibrous plant macro remains. Well sorted. Diffuse boundary to:

Bore	Top	Base	Lithology	Comments
ARCA CWR BH06	4.97	5.07	Sand/silt/clay	10 YR 4/2 Dark greyish brown silt/clay with rare sub-rounded flint pebbles. Well sorted. Diffuse boundary to:
ARCA CWR BH06	5.07	5.30	Marl	2.5 Y 7/1 Light grey silt/clay marl with occasional granular-fine pebble-sized fibrous plant macroremains (roots). Well sorted. Sharp boundary to:
ARCA CWR BH06	5.30	7.63	Clast-supported gravel	Clast and matrix-supported gravel of sub-angular and sub-rounded flint pebbles to fine boulders in a granular to medium sand matrix. Gravel arranged in sets of 200mm+. Sharp boundary to:
ARCA CWR BH06	7.63	8.25	Weathered Chalk	10 YR 8/1 White Chalk-derived silt/clay with frequent sub-angular flint pebbles and sub-angular Chalk pebbles and granules. Poorly sorted. Diffuse boundary to:
ARCA CWR BH06	8.25	9.00	Weathered Chalk	10 YR 8/1 White Chalk-derived silt/clay with frequent sub-angular Chalk pebbles and granules. Poorly sorted. Diffuse boundary to:
ARCA CWR BH07	1.20	1.72	Diamict with artefacts	10 YR 5/4 Yellowish brown fine diamict; moist and firm. Rare coarse pebble-sized, rounded Chalk. Medium pebble-sized red cbm towards base. Granular sized particles of flint and Chalk form the bulk of the clasts; evenly distributed throughout. Silt/clay matrix with frequent sand-sized grains forming a sandy silt/clay. Patchy colouration of greys and yellowish browns oxidation mottles. (Archaeological). Diffuse boundary to:
ARCA CWR BH07	1.72	2.30	Diamict with artefacts	2.5 Y 5/2 Greyish brown coarse diamict; moist and stiff. Occasional to frequent, angular, granular to pebble-sized flints. Granular to cobble-sized, sub-angular to sub-rounded Chalk. Occasional charcoal and oyster shell granules. Rare fine pebble-sized rib fragment. Rare coarse pebble-sized Roman roof tile. at 1.96m. Sandy textured silt/clay matrix with oxidation mottles at the base. Sharp boundary to:
ARCA CWR BH07	2.30	2.40	Tufaceous deposits	2.5 Y 8/1 White tufa; moist and stiff. Coarse sand-sized particles. Gritty texture. Poorly formed ooids typical of tufa in this borehole. Homogenous. (End of core).
ARCA CWR BH07	2.40	2.70	No recover	Void. (Washed out?).
ARCA CWR BH07	2.70	3.80	Tufaceous deposits	2.5 Y 8/1 White tufa; moist and stiff. Coarse sand-sized particles. Gritty texture. Homogenous. (End of core).
ARCA CWR BH07	3.80	3.90	Peat	7.5 YR 2/1 Black, oxidises to 7.5 YR 3/2 Dark brown, peat; dry and stiff. Very well-humified with a sharp fracture. Oblate wood granule laid horizontally. Sharp boundary to:

Bore	Top	Base	Lithology	Comments
ARCA CWR BH07	3.90	3.95	Tufaceous deposits	2.5 Y 8/1 White tufa; moist and stiff. Coarse sand-sized particles. Homogenous. (End of core).
ARCA CWR BH07	3.95	4.20	No recover	Void. (Washed out?).
ARCA CWR BH07	4.20	4.90	Tufaceous deposits	2.5 Y 6/2 Light brownish grey to 10 YR 4/2 Dark greyish brown 'muddy' tufa; moist and stiff. Coarse sand-sized particles with an occasional granule. Gritty texture. Rare diffuse coarse pebble-sized peat clasts towards top. Peat grains form dark colour and gradually increase towards base. Sharp boundary to:
ARCA CWR BH07	4.90	4.97	Peat	7.5 YR 2/1 Black, oxidises to 7.5 YR 3/2 Dark brown, peat; dry and stiff. Very well-humified with very fine sand-sized tufa grains laid in very fine horizontal laminae. Coarser grains towards top; reverse bedding. Sharp boundary to:
ARCA CWR BH07	4.97	5.24	Tufaceous deposits	7.5 YR 4/2 Brown tufa with horizontal peat laminae. Coarse sand-sized tufa particles with an occasional granule. Gritty texture. Diffuse boundary to:
ARCA CWR BH07	5.24	5.54	Tufaceous deposits	2.5 Y 7/2 Light grey tufa; moist and stiff. Coarse sand-sized tufa particles with an occasional granule. Gritty texture. Occasional to frequent peat grains and rare medium pebble-sized peat clast. Diffuse boundary to:
ARCA CWR BH07	5.54	5.63	Peat	7.5 YR 2/1 Black, oxidises to 7.5 YR 3/2 Dark brown, peat; moist and soft. Very well-humified with very fine sand-sized tufa grains throughout but poorly defined very fine horizontal laminae.. Diffuse boundary to:
ARCA CWR BH07	5.63	5.70	Tufaceous deposits	2.5 Y 4/2 Dark greyish brown 'muddy' tufa. Coarse sand-sized tufa particles with an occasional granule. Gritty texture. Broken up. (End of core).
ARCA CWR BH07	5.70	5.75	Tufaceous deposits	2.5 Y 4/2 Dark greyish brown 'muddy' tufa. Coarse sand-sized tufa particles with an occasional granule. Gritty texture. Diffuse boundary to:
ARCA CWR BH07	5.75	5.78	Peat	7.5 YR 2/1 Black, oxidises to 7.5 YR 3/2 Dark brown, peat; wet and soft. Very well-humified with very fine sand-sized tufa grains throughout. Gradual boundary to:

Bore	Top	Base	Lithology	Comments
ARCA CWR BH07	5.78	6.18	Tufaceous deposits	2.5 Y 5/2 Greyish brown 'muddy' tufa, moist and stiff. Coarse sand-sized tufa particles with an occasional granule. Gritty texture. Grey silt/clay fraction develops towards the base. Sharp boundary to:
ARCA CWR BH07	6.18	6.49	Tufaceous deposits	7.5 YR 5/8 Strong brown to 8/4 Pink with patches and bands of 10 YR 6/3 Pale brown oxidation stained tufa; moist and stiff. Tufa is poorly sorted, fine sand-sized to fine pebble-sized particles. Gritty texture.
ARCA CWR BH07	6.49	7.20	No recover	Void. (Washed out gravels and tufa at boundary: estimate at 6.85m see stratigraphy).
ARCA CWR BH07	7.20	7.60	Clast-supported gravel	10 YR 7/4 Very pale yellow flint gravel. Very poorly sorted and clast-supported. Minor silt/clay fraction giving colour.
ARCA CWR BH07	7.60	8.70	No recover	Void. (Broken liner).
ARCA CWR BH07	8.70	9.05	No recover	Void.
ARCA CWR BH07	9.05	9.20	Clast-supported gravel	Flint gravel. Poorly sorted and clast supported. Silt/clay washed out? Gradual boundary to:
ARCA CWR BH07	9.20	10.00	Matrix-supported gravel	10 YR 8/2 Very pale brown flint gravel; wet and stiff. Poorly sorted and matrix-supported clayey gravel. Sand to medium pebble-sized, angular flint clasts. Rare (5%) and diffuse, orange iron oxide staining. Gradual boundary to:
ARCA CWR BH07	10.00	11.70	Weathered Chalk	2.5 Y 8/1 White Chalk diamict, dry and stiff. Granular to medium pebble-sized, sub-angular to sub-rounded Chalk clasts (9.5/N) set in a putty Chalk matrix. Rare granular to medium pebble-sized, angular flint. (Solifluction deposit).
ARCA CWR BH08	1.20	1.39	No recover	Void
ARCA CWR BH08	1.39	1.64	Diamict with artefacts	10 YR 3/1 Very dark grey fine diamict of frequent sub-angular Chalk pebbles and granules, frequent granular and fine pebble-sized charcoal, moderate granular and pebble-sized sub-angular flint and occasional sub-angular pebble-sized ceramic clasts in a silt clay matrix. Thin charcoal bed at 1.60-1.61m. Sharp boundary to:

Bore	Top	Base	Lithology	Comments
ARCA CWR BH08	1.64	1.69	Chalk-rich gravel	10 YR 8/1 White gravel of sub-angular Chalk granules and fine pebbles in a 7.5 YR 4/4 Brown silt/clay matrix. The matrix is rare between the Chalk clasts, but forms thin beds above and below. Poorly sorted. Sharp boundary to:
ARCA CWR BH08	1.69	2.66	Sand/silt/clay with artefacts	10 YR 3/2 Very dark greyish brown, changing downward to 2.5 Y 4/1 Dark grey silt/clay with moderate sub-angular and sub-rounded Chalk pebbles and granules, moderate granular and fine pebble-size charcoal fragments, occasional pebble-sized bone and occasional pebble-sized oyster shell. Poorly sorted. Diffuse boundary to:
ARCA CWR BH08	2.66	2.70	Peat	Wood fragment.
ARCA CWR BH08	2.70	2.88	Sand/silt/clay	10 YR 4/1 Dark grey silt/clay with occasional coarse sand-sized Chalk and rare granular sub-angular flint clasts. Moderately sorted. Sharp boundary to:
ARCA CWR BH08	2.88	2.96	Chalk-rich gravel	2.5 Y 3/1 Very dark grey clast and matrix-supported gravel of sub-angular Chalk pebbles in a silt/clay matrix. Poorly sorted. Sharp boundary to:
ARCA CWR BH08	2.96	3.17	Sand/silt/clay	10 YR 3/1 Very dark grey silt/clay with moderate granular and occasional fine pebble-sized sub-angular Chalk, and rare pebble-sized oyster shell. Poorly sorted. Sharp boundary to:
ARCA CWR BH08	3.17	3.21	Chalk-rich gravel	10 YR 8/1 White clast-supported gravel of sub-angular Chalk granules and pebbles in a 10 YR 3/1 Very dark grey silt/clay matrix. Poorly sorted. Sharp boundary to:
ARCA CWR BH08	3.21	3.50	Organic mud	10 YR 2/2 Very dark brown organic silt/clay with frequent horizontally-laid pebble sized wood fragments, occasional sub-angular flint pebbled, occasional granular Chalk clasts (in discrete concentrations) and rare cobble-sized bone. Poorly sorted. Diffuse boundary to:
ARCA CWR BH08	3.50	4.60	Organic mud	10 YR 3/1 Very dark grey organic mud with occasional pebble-sized sub-angular flint, occasional pebble-sized waterlogged wood and moderate granular Chalk and flint clasts. Poorly sorted
ARCA CWR BH08	4.60	4.86	Sand/silt/clay	2.5 Y 4/1 Dark grey silt/clay with moderate sub-angular and sub-rounded fine pebble and granular-sized flint and occasional granular-sized Chalk clasts. Poorly sorted. Sharp boundary to:
ARCA CWR BH08	4.86	5.03	Organic mud	10 YR 3/1 Very dark grey organic silt/clay with moderate coarse sand and granular-sized flint and Chalk clasts. Occasional granular charcoal fragments. Poorly sorted. Sharp boundary to:

Bore	Top	Base	Lithology	Comments
ARCA CWR BH08	5.03	5.12	Sand/silt/clay with artefacts	10 YR 4/1 Dark grey silt/clay with moderate granular and coarse sand-sized flint and Chalk clasts. Rare granular ceramic clasts. Poorly sorted. Sharp, diagonal boundary (from 5.07 to 5.14m) to:
ARCA CWR BH08	5.12	5.56	Peat	10 YR 2/1 Black moderately humified peat with moderate pebble-sized waterlogged wood fragments. Single cobble-sized wood fragment filling core from 5.48-5.56m.
ARCA CWR BH08	5.56	5.90	No recover	Void
ARCA CWR BH08	5.90	6.08	Matrix-supported gravel	10 YR 4/2 Dark greyish brown matrix-supported gravel of sub-rounded pebble and granular-sized Chalk and flint clasts in a silt/clay matrix. Poorly sorted. Diffuse boundary to:
ARCA CWR BH08	6.08	6.28	Sand/silt/clay	10 YR 3/1 Very dark grey silt/clay with occasional sub-angular flint granules an d flint-derived coarse sand. Moderately sorted. Sharp boundary to:
ARCA CWR BH08	6.28	6.52	Matrix-supported gravel	10 YR 2/2 Very dark brown clast and matrix-supported gravel of sub-angular and sub-rounded flint pebbles and granules in an organic mud matrix. Sharp boundary to:
ARCA CWR BH08	6.52	6.96	Matrix-supported gravel	10 YR 8/2 Very pale brown matrix-supported gravel of sub-rounded and sub-angular flint pebbles in a Chalk-derived silt/clay, fine-coarse sand and granular matrix. Poorly sorted Sharp boundary to:
ARCA CWR BH08	6.96	7.00	Clast-supported gravel	Clast-supported gravel of sub-rounded and sub-angular flint fine cobbles and pebbled. Poorly sorted
ARCA CWR BH08	7.00	7.60	No recover	Void
ARCA CWR BH08	7.60	8.23	Matrix-supported gravel	10 YR 7/6 Yellow matrix-supported gravel of sub-rounded and sub-angular flint pebbles in a Chalk-derived silt/clay, fine-coarse sand and granular matrix. Poorly sorted. Sharp boundary to:
ARCA CWR BH08	8.23	9.00	Weathered Chalk	2.5 Y 8/2 Pale brown Chalk-derived silt/clay with frequent coarse sand, granular and pebble-sized sub-angular and sub-rounded Chalk. Poorly sorted.

Bore	Top	Base	Lithology	Comments
ARCA CWR BH08	9.00	9.35	Clast-supported gravel	Clast-supported gravel of sub-angular and sub-rounded flint pebbles and granules. Reverse bedded. Poorly sorted (collapse down hole). Sharp boundary to:
ARCA CWR BH08	9.35	10.50	Weathered Chalk	2.5 Y 8/2 Pale brown Chalk-derived silt/clay with frequent coarse sand, granular and pebble-sized sub-angular and sub-rounded Chalk. Poorly sorted.
ARCA CWR BH09	1.20	1.40	Chalk-rich gravel	10 YR 8/2 Very pale brown Chalk marl of sub-angular Chalk pebbles and granules in a compact Chalk mud matrix.
ARCA CWR BH09	1.40	1.59	No recover	Void
ARCA CWR BH09	1.59	1.65	Diamict	10 YR 4/2 Dark greyish brown fine diamict of frequent sub-rounded and sub-angular Chalk granules and coarse sand, occasional sub-angular slate pebbles and occasional sub-angular ceramic fragments in a silt clay matrix. Diffuse boundary:
ARCA CWR BH09	1.65	2.50	Sand/silt/clay with artefacts	10 YR 3/1 Very dark grey silt/clay with moderate sub-rounded and sub-angular Chalk granules, occasional sub-angular flint pebbles, moderate charcoal granules, occasional granular ceramic fragments. Heterogenous. Poorly sorted. Diffuse boundary to:
ARCA CWR BH09	2.50	2.54	Organic mud	10 YR 2/2 Very dark brown organic mud with occasional sub-angular flint granules and coarse sand-sized Chalk. Moderately sorted. Sharp boundary to:
ARCA CWR BH09	2.54	2.56	Chalk-rich gravel	10 YR 7/2 Light grey clast and matrix-supported gravel of sub-angular and sub-rounded Chalk/tufa granules in an organic silt/clay matrix. Poorly sorted. Sharp boundary to:
ARCA CWR BH09	2.56	2.61	Organic mud	10 YR 2/2 Very dark brown organic mud with occasional sub-angular flint granules and coarse sand-sized Chalk. Moderately sorted. Diffuse boundary to:
ARCA CWR BH09	2.61	2.83	Organic mud	10 YR 2/1 Black organic mud with moderate sub-angular flint pebbles and granules. Occasional granular size fibrous plant remains and occasional granular-size ceramic fragments. Poorly sorted. Sharp boundary
ARCA CWR BH09	2.83	3.00	Matrix-supported gravel	10 YR 5/1 Grey clast and matrix-supported gravel of sub-angular flint pebbles and granules in a coarse-sand to clay matrix. Poorly sorted.

Bore	Top	Base	Lithology	Comments
ARCA CWR BH09	3.00	3.35	No recover	Void
ARCA CWR BH09	3.35	3.68	Clast-supported gravel	Clast and matrix-supported gravel of sub-angular and sub-rounded pebbles and granules in medium to coarse sand matrix. Gravels arranged in sets of 100-150mm thickness. Poorly sorted. Diffuse boundary:
ARCA CWR BH09	3.68	3.97	Matrix-supported gravel	10 YR 5/3 Brown matrix-supported gravel of sub-angular flint fine cobbles to granules in a medium sand to clay Chalk/tufa derived matrix. Heterogeneous. Poorly sorted. Sharp boundary to:
ARCA CWR BH09	3.97	4.04	Sand/silt/clay	10 YR 3/3 Dark brown silt/clay with occasional sub-angular pebble-sized flint clasts and moderate granular and coarse sand-sized Chalk/tufa clasts. Poorly sorted. Sharp boundary to:
ARCA CWR BH09	4.04	4.15	Tufaceous deposits	10 YR 5/1 Grey coarse sand/granular gravel derived from tufa. Poorly sorted. Sharp boundary:
ARCA CWR BH09	4.15	4.16	Peat	10 YR 2/1 Black highly humified peat. Sharp boundary to:
ARCA CWR BH09	4.16	4.19	Tufaceous deposits	10 YR 5/1 Grey coarse sand/granular gravel derived from tufa. Poorly sorted. Sharp boundary:
ARCA CWR BH09	4.19	4.50	Peat	10 YR 2/1 Black highly humified peat with moderate fibrous plant remains to fine pebble size.
ARCA CWR BH09	4.50	4.65	Matrix-supported gravel	10 YR 2/1 Black matrix-supported gravel of sub-angular flint pebbles and granules in a peat/organic mud matrix. Poorly sorted. Diffuse boundary to:
ARCA CWR BH09	4.65	4.88	Matrix-supported gravel	10 YR 4/1 Dark grey clast- and matrix-supported gravel of sub-angular and occasional sub-rounded flint pebbles and granules in a organic silt/clay and minerogenic fine to coarse sand matrix. Poorly sorted. Diffuse boundary to:
ARCA CWR BH09	4.88	5.22	Clast-supported gravel	Clast and matrix-supported gravel of sub-angular and sub-rounded flint pebbles and granules in a medium-coarse sand matrix.

Bore	Top	Base	Lithology	Comments
ARCA CWR BH09	5.22	6.00	No recover	Void
ARCA CWR BH09	6.00	6.19	Matrix-supported gravel	Thin discrete beds (30-60mm thick) of medium sands to granules, and matrix-supported fine-pebble and granular gravels. Moderately or poorly sorted depending on bed. Sharp boundary to:
ARCA CWR BH09	6.19	6.21	Sand/silt/clay	2.5 Y 5/3 Light olive brown iron-stained clay to medium sand fine bed. Occasional sub-rounded flint granules. Moderately sorted. Sharp boundary to:
ARCA CWR BH09	6.21	6.26	Matrix-supported gravel	10 YR 7/4 Very pale brown matrix-supported gravel of sub-rounded flint pebbles and granules is a medium to coarse sand matrix. Poorly sorted. Diffuse boundary to:
ARCA CWR BH09	6.26	6.56	Clast-supported gravel	Clast- and matrix-supported gravel of sub-angular and sub-rounded flint fine cobbles, pebbles and granules in a coarse to medium sand matrix. Poorly sorted.
ARCA CWR BH09	6.56	7.26	No recover	Void
ARCA CWR BH09	7.26	7.92	Matrix-supported gravel	Medium normally bedded sets of medium-coarse sands; fine pebbles and granules with a coarse sand matrix, and fine boulder to pebble clast supported gravel. Moderate to poor sorting depending on set.
ARCA CWR BH09	7.92	8.65	No recover	Void
ARCA CWR BH09	8.65	9.00	Clast-supported gravel	Clast-supported gravel of sub-angular and sub-rounded fine cobble to pebble gravel in rare coarse sand matrix. Sharp boundary to:
ARCA CWR BH09	9.00	9.18	Matrix-supported gravel	Clast-and matrix-supported gravel of sub-angular and sub-rounded flint granules and fine pebbles in a coarse sand matrix. Poorly sorted. Sharp boundary to:
ARCA CWR BH09	9.18	9.29	Matrix-supported gravel	10 YR 6/6 Yellowish brown matrix-supported gravel of sub-angular and sub-rounded flint pebbled and granules in a coarse sand matrix. Poorly sorted. Sharp boundary to:

Bore	Top	Base	Lithology	Comments
ARCA CWR BH09	9.29	9.90	Weathered Chalk	2.5 Y 8/2 Pale brown compact Chalk-derived silt/clay with frequent sub-angular Chalk pebbles. Poorly sorted.
ARCA CWR BH10	1.20	1.50	Diamict	2.5 Y 5/1 Grey coarse diamict; wet and firm. Crushed Chalk cobble and occasional fine to medium sized sub-angular flints set in a silt/clay matrix. End of core. (Archaeological).
ARCA CWR BH10	1.50	2.07	Diamict	2.5 Y 5/1 Grey diamict; wet and soft. Granular to medium pebble-sized sub-angular flints and Chalk. Rare angular flint cobble at base. Matrix of silt/clay with occasional medium to coarse sand-sized flint particles. Black charcoal lens of comminuted grains dispersed over 100mm. (Archaeological). Sharp boundary to:
ARCA CWR BH10	2.07	2.22	Organic mud	7.5 YR 3/3 Dark brown organic silt/clay; moist and soft. Frequent fine fibres. Cobble-sized scapula not black. (2.07 to 2.67m distinct set of fine beds with discontinuous, parallel fine laminae, fluvially reworked but not permanently waterlogged [no humic staining to bone] with coarse clast input: archaeological). Sharp boundary to:
ARCA CWR BH10	2.22	2.26	Sand/silt/clay	5 Y 4/3 Olive silt; dryish and soft. Rare carbonate ooid-like granules and occasional very fine grains throughout. Sharp boundary to:
ARCA CWR BH10	2.26	2.30	Organic mud	7.5 YR 4/4 Brown organic silt/clay; moist and soft. Densely packed fine fibres. Sharp boundary to:
ARCA CWR BH10	2.30	2.67	Matrix-supported gravel with artefacts	2.5 Y 7/1 Light grey, grading irregularly and in indistinct bands to 2.5 Y 5/2 Greyish brown, silt/clay; moist and firm. Rare grains and granule of oyster shell; rare, medium pebble-sized, oblate, fragment of wood.
ARCA CWR BH10	2.67	3.00	No recover	Void (probably compression since units appear to be contiguous).
ARCA CWR BH10	3.00	3.28	Sand/silt/clay with artefacts	2.5 Y 3/1 Very dark grey organic silt/clay; wet and soft. Disrupted and broken up through drilling. Occasional medium pebble sized clast of ?organic matter. Rare red cbm granules. Rare coarse pebble sized angular flint. Rare charcoal grains. (Archaeological). Sharp boundary to:

Bore	Top	Base	Lithology	Comments
ARCA CWR BH10	3.28	3.97	Diamict with artefacts	2.5 Y 5/1 Grey coarse diamict; moist and stiff. Occasional medium pebble to cobble-sized angular flints, sub-rounded Chalk, and sub-angular grey limestone clasts. Frequent granular to pebble-sized mortar fragments. Rare red cbm granules; rare granules of oyster shell. Occasional charcoal granules. Matrix of silt/clay with frequent fine to coarse sand-sized mortar grains (tufa?) especially towards top. (Demolition rubble).
ARCA CWR BH10	3.97	4.50	No recover	Void (probably compression).
ARCA CWR BH10	4.50	4.70	Sand/silt/clay	2.5 Y 3/2 Very dark greyish brown silt/clay; wet and soft. Frequent grains, granules and whole medium pebble-sized oyster shell valves. (Distinct shelly bed). Diffuse boundary to:
ARCA CWR BH10	4.70	5.02	Sand/silt/clay	2.5 Y4/2 Dark greyish brown silt/clay; moist and firm. Silty texture, homogeneous. Oblate, horizontal wood cobble at base. Sharp boundary to:
ARCA CWR BH10	5.02	5.04	Sand/silt/clay	10 YR 5/1 Grey fine sand. Very fine to coarse sand-sized grains possible flint. Rare, sub-rounded, medium pebble-sized Chalk. Sharp boundary to:
ARCA CWR BH10	5.04	5.44	Marl	2.5 Y 7/1 Light grey marl; firm and moist. Occasional vertical roots of fine pebble size. Top 20mm is 2.5 Y 3/2 very dark greyish brown: humic cap to unit.
ARCA CWR BH10	5.44	5.87	Clast-supported gravel	Medium to coarse pebble-sized flint gravel.
ARCA CWR BH10	5.87	7.50	No recover	Void. (Fine gravel washed out).
ARCA CWR BH10	7.50	7.97	Clast-supported gravel	Medium to coarse pebble-sized flint gravel. (Fines washed out?). Sharp boundary to:
ARCA CWR BH10	7.97	8.20	Matrix-supported gravel	10 YR 8/1 White fine gravel; moist and stiff. Coarse sand-sized to granular-sized flint gravel set in a putty Chalk matrix. Diffuse boundary to:
ARCA CWR BH10	8.20	9.00	Weathered Chalk	5 Y 7/2 Light grey (greenish tinge) Chalk diamict; firm and moist. Granular to medium pebble-sized, sub-angular to sub-rounded Chalk clasts (9.5/N) set in a putty Chalk matrix. Matrix-supported? (Solifluction deposit).

Bore	Top	Base	Lithology	Comments
ARCA CWR BH11	1.20	2.00	Diamict with artefacts	2.5 Y 5/1 Grey coarse diamict; moist and firm. Occasional to frequent fine to coarse pebble-sized, sub-rounded Chalk. Rare sub-angular fine pebble-sized flint. rare fine pebble-sized vertebra and medium pebble-sized rib fragment. Rare charcoal granules. Matrix of silt/clay with occasional sand-sized Chalk grains. Sharp boundary to;
ARCA CWR BH11	2.00	2.25	Structural deposits	Cobble of carbonate mortar and two flint cobbles. (Structural).
ARCA CWR BH11	2.25	2.42	Sand/silt/clay	2.5 Y 5/2 Greyish brown set of fine beds of fine sand; black silt/clay and a white marl (7mm thick). Mineral set. Deformed by compaction from cobbles above. Boundaries diffuse except for the marl where boundaries are sharp. Fluvially reworked? Probably originally structural. Sharp boundary to:
ARCA CWR BH11	2.42	2.77	Structural deposits	Two vertical stakes each c. 50mm thick, waterlogged, set in 7.5 YR 3/2 Dark brown wet and soft organic mud with frequent granular-sized organic fragments. Rare fine pebble-sized post-medieval brick. Rare fine pebble of angular flint and rare oyster shall granules. Sharp boundary to:
ARCA CWR BH11	2.77	3.00	Structural deposits	2.5 Y 5/1 grey carbonate mortar with a coarse pebble-sized angular fragment of dark grey sandstone. (Structural).
ARCA CWR BH11	3.00	3.40	No recover	Void. (loose silt/clay around stakes washed out)
ARCA CWR BH11	3.40	3.60	No recover	2.5 Y 3/2 Very dark greyish brown silt/clay; wet and loose. (Slump: as above).
ARCA CWR BH11	3.60	3.89	Structural deposits	2.5 Y 5/1 grey carbonate mortar; moist and stiff. Very gritty texture unconsolidated. Rare coarse pebbles of sub-rounded Chalk and rare angular flints all at the base. (Structural). Sharp boundary to:
ARCA CWR BH11	3.89	4.13	Structural deposits	2.5 Y 8/1 White Chalk diamict, moist and stiff. Granular to medium pebble-sized, sub-angular to sub-rounded Chalk set in a putty Chalk matrix. (Structural).
ARCA CWR BH11	4.13	4.50	Sand/silt/clay	2.5 Y 3/2 Very dark greyish brown silt/clay; moist and soft to firm. Silty texture; generally homogeneous. Rare mussel shell valve 50mm long. Rare medium pebble-sized, irregular and diffuse lens of well-humified organic matter of sand-sized to granular sized fibres. (Cf BH10). Sharp boundary to:

Bore	Top	Base	Lithology	Comments
ARCA CWR BH11	4.50	5.20	Clast-supported gravel with artefacts	2.5 Y 6/1 Grey very sandy gravel; moist and stiff. Very poorly and sorted clast-supported. Clasts are angular flints and sub-rounded Chalk. Sand component of very fine flints and occasional red cbm. Rare granules of red cbm too. (Unusual gravel: archaeological)
ARCA CWR BH11	5.20	5.50	Diamict	2.5 Y 6/3 Light yellowish brown diamict (Clayey gravel). Clasts of fine to medium pebble-sized, angular to sub-angular flints. Matrix of silt/clay with frequent sand-sized to granular-sized flints and Chalk. (Unusual unit above the gravels). Sharp boundary to:
ARCA CWR BH11	5.50	5.60	Clast-supported gravel	Poorly sorted flint gravels (Washed out).
ARCA CWR BH11	5.60	6.00	No recover	Void. (Washed out).
ARCA CWR BH11	6.00	7.00	Clast-supported gravel	Flint gravel; poorly sorted. No structure.
ARCA CWR BH11	7.00	7.50	No recover	Void. (Washed out).
ARCA CWR BH11	7.50	8.30	Clast-supported gravel	Flint gravel; poorly sorted. No structure.
ARCA CWR BH11	8.30	9.00	No recover	Void. (Washed out).
ARCA CWR BH11	9.00	9.15	Clast-supported gravel	Flint gravel; poorly sorted. Gradual boundary to
ARCA CWR BH11	9.15	9.91	Weathered Chalk	2.5 Y 7/3 Pale brown Chalk diamict; moist and stiff. Granular to medium pebble-sized Chalk clasts with a minor component of sand to medium pebble-sized angular flints. Putty Chalk matrix. Matrix-supported. (Solifluction deposit).

Bore	Top	Base	Lithology	Comments
ARCA CWR BH11	9.91	10.50	Weathered Chalk	2.5 Y 8/1 White Chalk diamict, moist and stiff. Granular to medium pebble-sized, sub-angular to sub-rounded Chalk clasts (9.5/N) set in a putty Chalk matrix. (Solifluction deposit).
ARCA CWR BH12	1.20	1.28	No recover	Void
ARCA CWR BH12	1.28	1.66	Diamict	10 YR 4/2 Dark greyish brown silt/clay with frequent coarse sand to granular Chalk clasts and moderate pebble to cobble-sized, sub-angular and sub-rounded Chalk clasts. Moderate granular and fine pebble sub-angular flint clasts to 1.35. Poorly sorted. Diffuse boundary to:
ARCA CWR BH12	1.66	1.80	Chalk-rich gravel	10 YR 4/2 Dark greyish brown gravel of sub-rounded and sub-angular Chalk pebbles and granules in a silt/clay matrix. Poorly sorted. Diffuse boundary to:
ARCA CWR BH12	1.80	2.05	Diamict	10 YR 4/1 Dark grey silt/clay with moderate sub-angular and sub-rounded Chalk pebbles and moderate granular-sized charcoal. Poorly sorted. Sharp boundary to:
ARCA CWR BH12	2.05	2.50	Organic mud	10 YR 3/1 Very dark grey organic silt/clay with occasional sub-rounded and sub-angular Chalk pebbles and granules. Occasional granular sized charcoal and occasional granular to pebble-sized marine Mollusca. Single cobble-sized wood fragment at 2.40-2.45m. Poorly sorted. Sharp boundary to:
ARCA CWR BH12	2.50	2.57	Peat	10 YR 3/1 Very dark grey 'peat'. Highly humified and no visible plant macrofossils. Sharp boundary to:
ARCA CWR BH12	2.57	2.70	Sand/silt/clay	10 YR 3/2 Very dark greyish brown silt/clay with rare coarse sand-size Chalk and (terrestrial) Mollusc fragments. Moderately sorted.
ARCA CWR BH12	2.70	3.00	No recover	Void
ARCA CWR BH12	3.00	3.12	Organic mud	10 YR 2/1 Black organic silt/clay with frequent coarse sand and granular-sized Chalk. Moderately sorted. Sharp boundary to:
ARCA CWR BH12	3.12	4.03	Sand/silt/clay with artefacts	10 YR 4/1 Dark grey silt/clay with frequent coarse sand-sized Chalk and moderate granular to pebble-sized sub-angular and sub-rounded Chalk and occasional sub-angular granular flint clasts. Moderate granular charcoal. Single cobble-sized tile fragment (Roman) at 3.35-3.45m. Occasional pebble and granular-sized marine mollusc fragment. Moderately to poorly sorted. Sharp boundary to:
ARCA CWR BH12	4.03	4.08	Organic mud	10 YR 3/1 Very dark grey organic silt/clay with occasional sub-angular and sub-rounded Chalk granules. Sharp boundary to:

Bore	Top	Base	Lithology	Comments
ARCA CWR BH12	4.08	4.20	Sand/silt/clay	10 YR 4/1 Dark grey silt/clay with frequent coarse sand and granular sized Chalk clasts and moderate sub-angular to sub-rounded Chalk pebbles. Poorly sorted.
ARCA CWR BH12	4.20	4.70	Undifferentiated gravel	Coarse flint gravel; coarse pebble to cobble-sized nodular flints. Plastic liner destroyed and fines washed out. Very poor recovery.
ARCA CWR BH12	4.70	5.20	No recover	Void; fines washed out.
ARCA CWR BH12	5.20	6.44	Clast-supported gravel	Sandy flint gravel; normal bedding. Medium to coarse sand-sized to granular-sized angular flints coarsening towards the base.
ARCA CWR BH12	6.44	6.70	Clast-supported gravel	Coarse, clast-supported flint gravel. Angular to sub-angular clasts; occasional, well-rounded pebbles and irregularly rounded nodules.
ARCA CWR BH12	6.70	7.44	Clast-supported gravel	Poorly sorted, clast-supported flint gravel. Fines washed out? Very poor recovery.
ARCA CWR BH12	7.44	8.30	No recover	Void.
ARCA CWR BH12	8.30	9.30	Weathered Chalk	2.5 Y 8/1 White putty Chalk; wet and soft becoming firm. Occasional granular to medium-sized angular flints at the top and decreasing towards the base. Sharp boundary to:
ARCA CWR BH12	9.30	9.70	Weathered Chalk	5 Y 8/1 White Chalk diamict; poorly sorted and matrix-supported. Indurate, dry and sub-rounded Chalk clasts (9.5/N) set in a stiff Chalk putty matrix. (Solifluction deposit).
ARCA CWR BH13	1.20	1.44	No recover	Void. (Compression).
ARCA CWR BH13	1.44	1.70	Diamict with artefacts	10 YR 3/2 Very dark greyish brown fine diamict; wet, structureless and disrupted. Silt/clay matrix with occasional to frequent sand-sized mineral grains and frequent fine sand-sized particles of Chalk. Occasional sand-sized grains of cbm. Occasional granular to fine pebble-sized sub-angular red cbm. occasional fine pebble-sized sub-rounded Chalk. Rare angular flint granules. Rare medium pebble-sized oblate limestone rock fragment. rare slate granules. Diffuse boundary to:

Bore	Top	Base	Lithology	Comments
ARCA CWR BH13	1.70	1.98	Redeposited Chalk	10 YR 7/2 Light grey to 7.5YR 7/2 Pinkish grey at base putty Chalk; moist and firm. Gritty texture from frequent granules of Chalk. Rare medium pebble-sized angular flint. (Archaeological deposit?). Sharp boundary to:
ARCA CWR BH13	1.98	2.09	Sand/silt/clay with artefacts	10 YR 4/2 Dark greyish brown fine sand; wet and poorly sorted. Occasional fine grains and granules of charcoal. Rare grains of red cbm. Coarse pebble-sized oblate lens of charcoal. Coarse pebble-sized lens of pinkish putty Chalk. (Archaeological). Sharp boundary to:
ARCA CWR BH13	2.09	2.12	Redeposited Chalk	9.5/N White putty Chalk with occasional sub-rounded fine pebble-sized Chalk. (Archaeological). Sharp boundary to:
ARCA CWR BH13	2.12	2.15	Sand/silt/clay with artefacts	2.5 Y 4/1 Dark grey, wet silt/clay with frequent fine sand-sized mineral grains and charcoal grains. (Archaeological). Sharp boundary to:
ARCA CWR BH13	2.15	2.21	Sand/silt/clay with artefacts	2.5 Y 6/2 Light brownish grey very fine sand with 50% silt/clay fraction. 'granular' texture like putty Chalk. Occasional charcoal grains. (Archaeological). Sharp boundary to:
ARCA CWR BH13	2.21	2.30	Redeposited Chalk	9.5/N White crushed Chalk set in putty Chalk matrix. Coarse pebble-sized charcoal lens at the top and horizontal coarse pebble-sized rib fragment. (Archaeological). Unit inserted via over-burden pressure into the peat below giving a very irregular sharp boundary:
ARCA CWR BH13	2.30	2.65	Organic mud	7.5 YR 2.5/2 Very dark brown humic silt/clay; moist, firm and homogenous. Rare very fine fibres; like a very well humified peat. Occasional very fine grains of Chalk. Rare fine pebble-sized well round Chalk towards base. (Organic refuse). Deposited on and angular and irregular surface. Sharp boundary to:
ARCA CWR BH13	2.65	2.70	Structural deposits	2.5 Y 8/1 White limestone; coarse pebble-sized, sub-angular to sub-rounded clasts with (crushed) grains and granules (Archaeological).
ARCA CWR BH13	2.70	3.20	No recover	Void.

Bore	Top	Base	Lithology	Comments
ARCA CWR BH13	3.20	3.74	Clast-supported gravel with artefacts	2.5 Y 6/2 Light brownish grey gravel; wet, very poorly sorted and clast supported. Frequent angular limestone (dense, indurate with very fine holes and near conchoidal fracture: building stone). Occasional, medium pebble-sized angular Post-Medieval roof tile. Rare slate granules. Coarse pebble-sized glazed Late Medieval body sherd. Occasional granular to coarse pebble-sized angular flints. (Archaeological). Sharp boundary to
ARCA CWR BH13	3.74	4.09	Redeposited Chalk	9.5/N White Chalk 'diamict'; stiff and dryish. Medium pebble-sized Chalk clast set in a putty Chalk matrix. (Archaeological, structural associated with wood below?). Sharp boundary to:
ARCA CWR BH13	4.09	4.20	Structural deposits	Waterlogged wood. Vertically positioned; fills the core: a pile. (Archaeological). End of core.
ARCA CWR BH13	4.20	4.85	No recover	Void
ARCA CWR BH13	4.85	4.90	Matrix-supported gravel	10 YR 6/1 Grey matrix-supported gravel of sub-rounded Chalk and sub-angular flint pebbles and granules in a medium to coarse sand matrix. Poorly sorted. Sharp boundary to:
ARCA CWR BH13	4.90	5.00	Peat	10 YR 3/1 Very dark grey wood fragment. Sharp boundary to:
ARCA CWR BH13	5.00	5.26	Sand/silt/clay	2.5 Y 4/1 Dark grey silt/clay (compact) with moderate granular and occasional pebble-sized sub-angular flint clasts. Occasional waterlogged plant roots. Poorly sorted. Sharp boundary to:
ARCA CWR BH13	5.26	6.55	Clast-supported gravel	Clast and matrix-supported gravel of sub-angular, trending downwards to sub-rounded flint pebbles and cobbles in a granular flint matrix (sands washed out during drilling). Poorly sorted. Sharp boundary to:
ARCA CWR BH13	6.55	6.90	Clast-supported gravel	Clast-supported gravel of sub-rounded flint pebbles in rare medium to fine sand matrix. Moderately sorted. Sharp boundary to:
ARCA CWR BH13	6.90	7.50	Sand/silt/clay	2.5 Y 7/3 Pale brown normally bedded medium to coarse sand (Chalk-derived), fining up from granular gravel/coarse sand. Granules are of sub-rounded Chalk. Rare sub-angular flint pebbles at top and occasional rounded flint pebbles at base of unit. Moderately sorted. Sharp boundary to:

Bore	Top	Base	Lithology	Comments
ARCA CWR BH13	7.50	7.90	Matrix-supported gravel	Matrix-supported gravel of sub-angular and sub-rounded flint pebbles in a coarse sand (Chalk and flint-derived) matrix. Normally bedded (pebbles denser and larger at base). Sharp boundary to:
ARCA CWR BH13	7.90	9.95	Clast-supported gravel	Clast and matrix-supported gravel of sub-angular, trending downwards to sub-rounded flint pebbles and cobbles in a granular flint matrix (sands washed out during drilling). Poorly sorted. Sharp boundary to:
ARCA CWR BH13	9.95	10.40	Matrix-supported gravel	2.5 Y 7/2 Light grey dense clast and matrix-supported gravel of sub-angular and occasional sub-rounded flint pebbles in a coarse sand, granular and silt/clay matrix, the last increasing with depth. Poorly sorted. Sharp boundary to:
ARCA CWR BH13	10.40	10.80	Matrix-supported gravel	10 Y 7/2 Light grey matrix-supported gravel of sub-angular and sub-rounded flint pebbles in a Chalk-derived silt/clay matrix. Massive. Poorly sorted. Diffuse boundary to:
ARCA CWR BH13	10.80	11.40	Weathered Chalk	10 Y 7/2 Chalk marl of compact silt/clay derived from the Chalk with moderate sub-angular pebble-sized Chalk clasts. Poorly sorted.

APPENDIX 3: CRITERIA FOR SELECTING SUB–SAMPLES FOR MEASUREMENT/ASSESSMENT

A3.1 Table 8 sets out the sub-samples that were assessed for biostratigraphic purposes. Given the purpose of the assessment, i.e. to focus on testing the preservation of organic remains in archaeological relevant deposits across the entirety of the CWR site, samples were selected using the following criteria (in descending order of importance):

6. Archaeological (SU–5) or alluvial strata containing archaeological artefacts (SU–4d) in which waterlogged sub–fossil preservation of biological materials was noted during core description;
7. Representation from as many boreholes as possible;
8. Strata of particular biostratigraphic interest (SU–4c and SU–4b);
9. Alluvial strata (SU–4a and SU–4d) in which waterlogged sub–fossil preservation of biological materials was noted during core description;
10. Other alluvial strata

Table 8. Sub-samples assessed for palynology, plant macrofossils and Mollusca

SU (Stratigraphic Unit): SU5 Archaeological strata; SU4d Alluvium 2; SU4c Tufaceous deposits; SU4b Peat

Borehole	Strata type	SU	Top (m)	Base (m)	Purpose
ARCA CWR BH03	Tufaceous deposits	4c	2.85	2.90	Mollusca
ARCA CWR BH03	Tufaceous deposits	4c	3.20	3.25	Mollusca
ARCA CWR BH03	Tufaceous deposits	4c	3.70	3.75	Mollusca
ARCA CWR BH03	Tufaceous deposits	4c	4.09	4.14	Mollusca
ARCA CWR BH03	Organic mud	4c	4.20	4.25	Mollusca
ARCA CWR BH03	Sand/silt/clay	4b	4.74	4.78	Mollusca
ARCA CWR BH04	Sand/silt/clay with artefacts	5	2.95	3.00	Mollusca
ARCA CWR BH04	Tufaceous deposits	4b	4.65	4.70	Mollusca
ARCA CWR BH06	Diamict with artefacts	5	2.28	2.33	Mollusca
ARCA CWR BH06	Diamict with artefacts	5	3.27	3.32	Mollusca
ARCA CWR BH06	Sand/silt/clay with artefacts	4d	3.52	3.57	Mollusca
ARCA CWR BH06	Organic mud	4d	4.40	4.45	Mollusca
ARCA CWR BH08	Organic mud	4d	3.65	3.70	Mollusca
ARCA CWR BH09	Tufaceous deposits	4c	4.01	4.06	Mollusca
ARCA CWR BH09	Tufaceous deposits	4c	4.09	4.14	Mollusca
ARCA CWR BH01	Organic mud	5	2.25	2.26	Plant macrofossils
ARCA CWR BH03	Diamict with artefacts	5	1.85	1.90	Plant macrofossils
ARCA CWR BH03	Sand/silt/clay with artefacts	5	2.45	2.50	Plant macrofossils
ARCA CWR BH03	Sand/silt/clay with artefacts	5	2.75	2.80	Plant macrofossils
ARCA CWR BH04	Sand/silt/clay with artefacts	5	2.70	2.75	Plant macrofossils
ARCA CWR BH04	Sand/silt/clay with artefacts	5	2.85	2.90	Plant macrofossils

Borehole	Strata type	SU	Top (m)	Base (m)	Purpose
ARCA CWR BH05A	Organic mud	5	2.07	2.12	Plant macrofossils
ARCA CWR BH06	Organic mud	5	2.20	2.25	Plant macrofossils
ARCA CWR BH06	Diamict with artefacts	5	2.47	2.52	Plant macrofossils
ARCA CWR BH06	Organic mud	5	2.67	2.72	Plant macrofossils
ARCA CWR BH06	Diamict with artefacts	5	2.79	2.84	Plant macrofossils
ARCA CWR BH06	Sand/silt/clay with artefacts	4d	3.52	3.57	Plant macrofossils
ARCA CWR BH08	Organic mud	4d	3.35	3.40	Plant macrofossils
ARCA CWR BH08	Organic mud	4d	3.65	3.70	Plant macrofossils
ARCA CWR BH08	Organic mud	4d	4.00	4.05	Plant macrofossils
ARCA CWR BH08	Organic mud	4d	4.50	4.55	Plant macrofossils
ARCA CWR BH08	Peat	4b	5.18	5.23	Plant macrofossils
ARCA CWR BH08	Peat	4b	5.35	5.40	Plant macrofossils
ARCA CWR BH08	Sand/silt/clay	4a	6.22	6.27	Plant macrofossils
ARCA CWR BH09	Sand/silt/clay with artefacts	5	1.80	1.85	Plant macrofossils
ARCA CWR BH09	Sand/silt/clay with artefacts	5	2.25	2.30	Plant macrofossils
ARCA CWR BH09	Organic mud	5	2.65	2.70	Plant macrofossils
ARCA CWR BH01	Diamict with artefacts	5	1.35	1.36	Pollen
ARCA CWR BH01	Diamict with artefacts	5	1.85	1.86	Pollen
ARCA CWR BH01	Organic mud	5	2.25	2.26	Pollen
ARCA CWR BH01	Sand/silt/clay with artefacts	5	2.65	2.66	Pollen
ARCA CWR BH01	Diamict	5	3.23	3.24	Pollen
ARCA CWR BH01	Diamict	4d	3.74	3.75	Pollen
ARCA CWR BH02	Soil	4d	2.12	2.13	Pollen
ARCA CWR BH03	Sand/silt/clay with artefacts	5	2.34	2.35	Pollen
ARCA CWR BH03	Sand/silt/clay with artefacts?	5	2.81	2.82	Pollen
ARCA CWR BH04	Sand/silt/clay with artefacts	5	2.68	2.69	Pollen
ARCA CWR BH04	Sand/silt/clay with artefacts	5	2.98	2.99	Pollen
ARCA CWR BH04	Peat	4b	4.78	4.79	Pollen
ARCA CWR BH05A	Organic mud	5	1.90	1.91	Pollen
ARCA CWR BH05A	Organic mud	5	2.29	2.30	Pollen
ARCA CWR BH05A	Sand/silt/clay	5	2.96	2.97	Pollen
ARCA CWR BH05A	Diamict with artefacts	5	3.70	3.71	Pollen
ARCA CWR BH05A	Sand/silt/clay	4d	4.26	4.27	Pollen
ARCA CWR BH06	Organic mud	5	2.21	2.22	Pollen

Borehole	Strata type	SU	Top (m)	Base (m)	Purpose
ARCA CWR BH06	Organic mud	5	2.72	2.73	Pollen
ARCA CWR BH06	Marl	4a	5.22	5.23	Pollen
ARCA CWR BH07	Peat	4c	3.80	3.81	Pollen
ARCA CWR BH07	Peat	4c	4.97	4.98	Pollen
ARCA CWR BH07	Peat	4c	5.54	5.55	Pollen
ARCA CWR BH07	Peat	4c	5.78	5.79	Pollen
ARCA CWR BH08	Sand/silt/clay with artefacts	5	1.82	1.83	Pollen
ARCA CWR BH08	Sand/silt/clay with artefacts	5	2.22	2.23	Pollen
ARCA CWR BH08	Sand/silt/clay with artefacts	5	2.62	2.63	Pollen
ARCA CWR BH08	Sand/silt/clay	5	2.98	2.99	Pollen
ARCA CWR BH08	Organic mud	5	3.26	3.27	Pollen
ARCA CWR BH08	Organic mud	5	3.98	3.99	Pollen
ARCA CWR BH08	Organic mud	5	4.58	4.59	Pollen
ARCA CWR BH08	Organic mud	5	4.88	4.89	Pollen
ARCA CWR BH08	Sand/silt/clay with artefacts	5	5.10	5.11	Pollen
ARCA CWR BH08	Peat	4b	5.14	5.15	Pollen
ARCA CWR BH08	Peat	4b	5.38	5.39	Pollen
ARCA CWR BH08	Sand/silt/clay	4a	6.24	6.25	Pollen
ARCA CWR BH09	Sand/silt/clay with artefacts	5	1.73	1.74	Pollen
ARCA CWR BH09	Sand/silt/clay with artefacts	5	2.45	2.46	Pollen
ARCA CWR BH09	Organic mud	5	2.58	2.59	Pollen
ARCA CWR BH09	Organic mud	5	2.77	2.78	Pollen
ARCA CWR BH10	Organic mud	5	2.15	2.16	Pollen
ARCA CWR BH10	Matrix–supported gravel with artefacts	5	2.65	2.66	Pollen
ARCA CWR BH10	Sand/silt/clay with artefacts	5	3.27	3.26	Pollen
ARCA CWR BH12	Organic mud	5	2.20	2.21	Pollen
ARCA CWR BH12	Peat	5	2.53	2.54	Pollen
ARCA CWR BH12	Organic mud	5	3.07	3.08	Pollen
ARCA CWR BH12	Sand/silt/clay with artefacts	5	4.03	4.04	Pollen
ARCA CWR BH13	Sand/silt/clay with artefacts	5	2.13	2.14	Pollen
ARCA CWR BH13	Organic mud	5	2.34	2.35	Pollen
ARCA CWR BH13	Organic mud	5	2.64	2.65	Pollen
ARCA CWR BH13	Sand/silt/clay	4a	5.16	5.17	Pollen

A3.2 Table 9 cross references assessed biostratigraphic sub-samples recommended with those suggested in ARCA's tender (Wilkinson et al 2020, section 4.3.5, 24–25). As will be obvious, an additional six (6) palynological samples were assessed beyond those costed in the tender, but eight (8) fewer plant macrofossil sub-samples were examined. The reason for such a 're–deployment' is the quantity and thickness of organic mud strata lacking visible plant macroremains (i.e. where pollen was likely to be preserved, but plant macrofossils not) cf. strata containing visible plant macro remains. Mollusc shell was observed in both the tufa (terrestrial/freshwater) and archaeological strata (marine), but waterlogging is unlikely to contribute to shell preservation. For these reasons, samples for molluscan assessment were focussed on a mixture of tufaceous (mollusc shells have not previously been examined from equivalents of SU4b in Winchester) and Archaeological strata (SU5)

Table 9. Sub–samples proposed for biostratigraphic assessment in Table 8 compared to those costed in ARCA's tender and interim WSI (Wilkinson et al. 2020, section 4.3.5, 24–25)

Sample type	In tender	Proposed for assessment here
Mollusca	15	15
Plant macrofossils	30	22
Pollen	45	51

A3.3 ARCA's tender and iWSI stated that the sedimentological properties of 150 sub-samples would be examined (including 30 humification measurements of organic strata) (Wilkinson et al. 2020, section 4.3.2–4.3.4, 24), while 193 such sub–samples were taken during core description. ARCA undertook magnetic susceptibility (low frequency), pXRF and loss–on–ignition measurements on all 193 collected samples, humification measurements on all 22 sub–samples with a loss–on–ignition (550°C for four hours) of 35% and made pH measurements on 100 samples. Fewer humification samples were measured because such data are meaningless and indeed, misleading, for samples with a low organic carbon content[20]. Moreover, 50 fewer pH measurements were made than anticipated in the tender because of the consistency of the initial 100 results and the minimal variation within SU5 in particular. Further pH measurement was therefore not considered to warrant the additional time that was required.

[20] Loss-on-ignition using the protocol adopted provide a maximum estimate of organic carbon. Indeed, it is highly likely that organic carbon concentrations will have been overestimated and that some geological carbon will have been liberated (from the oxidation of CO_3- anions) (Gale and Hoare 1991, 261.

APPENDIX 4: POLLEN ASSESSMENT DATA

Table A4.1. Pollen assessment data from BH01–BH04

	Borehole	BH01	BH01	BH01	BH01	BH01	BH01	BH02	BH03	BH03	BH04
	SU	5	5	5	5	5	4d	4d	5	5	5
	Top (m)	1.35	1.85	2.25	2.65	3.23	3.74	2.12	2.34	2.81	2.68
	Base (m)	1.36	1.86	2.26	2.66	3.24	3.75	2.13	2.35	2.82	2.69
Latin name	**Common name**										
Trees											
Alnus	alder				2		9				1
Quercus	oak			1	1		4		1		
Pinus	pine						1				
Tilia	lime						12	1	1		
Ulmus	elm						5				
Taxus	yew										
Fraxinus	ash										
Betula	birch					1	1		1	1	
Fagus	beech									1	
Shrubs											
Calluna vulgaris	heather	1				1					
Corylus type	hazel		1			3	11	1	5	2	2
Erica spp.	heath			1							
Hedera	ivy										
Salix	willow										
Lonicera periclymenum	honeysuckle				1						
Herbs											
Cyperaceae	sedge family				1		1				1
Poaceae	grass family	2		5	11	3	2		15	5	
Cereale type	cereals	7	6	18	9	33			23	35	3
Asteraceae	daisy family	2		8	1	4	1	2	3	6	1
Artemisia type	mugwort										1
Lactuceae	dandelion family	24	14	2	3	1	2	3	7	1	6
Plantago type	e.g. plantain										
Chenopodium type	e.g. fat hen				2						2

	Borehole	BH01	BH01	BH01	BH01	BH01	BH01	BH02	BH03	BH03	BH04
	SU	5	5	5	5	5	4d	4d	5	5	5
	Top (m)	1.35	1.85	2.25	2.65	3.23	3.74	2.12	2.34	2.81	2.68
	Base (m)	1.36	1.86	2.26	2.66	3.24	3.75	2.13	2.35	2.82	2.69
Caryophyllaceae	pinks family										
Rosaceae	rose family				1				1		
Potentilla type	cinquefoil										
Rumex undiff.	dock/sorrel				1					1	
Apiaceae	carrot family				2						
Ranunculus type	e.g. buttercup					1					
Cirsium type	thistle						1				
Centaurea nigra	black knapweed				1				1	1	1
Centaura cyanus	cornflower		5	4							
Circeae	nightshade										
Sinapis type	brassica family			4	7				3		1
Filipendula type	meadowsweet										
Malva type	mallow			1	1						
Trifolium/Vicia type	clover / vetch				1						
Sanguisorba minor	burnet										
cf *Primula* type	primrose										
Valeriana type	marsh valerian										
Polygonum type	knotweed										
Aquatics											
Sparganium type	bur-reed										
Spores											
Pteridium type	bracken		3				1				
Filicales	ferns						8				
Polypodium vulgare	polypody fern	1									2
Unknown pollen grains		2		4	10	3			4		
Unidentifiable pollen grains		4	5	3		3	13		4		
Parasite eggs			1	61	145	51			24	140	
Total Land Pollen		36	26	44	45	47	50	7	61	53	19

Borehole	BH01	BH01	BH01	BH01	BH01	BH01	BH02	BH03	BH03	BH04
SU	5	5	5	5	5	4d	4d	5	5	5
Top (m)	1.35	1.85	2.25	2.65	3.23	3.74	2.12	2.34	2.81	2.68
Base (m)	1.36	1.86	2.26	2.66	3.24	3.75	2.13	2.35	2.82	2.69
Total Pollen Concentration (grains/cm3)	22337	15643	436810	68729	116648	124094	1958	24223	58462	18862
Diversity	2	1	3	4	3	3	1	3	3	2
Abundance	5	5	5	5	5	5	3	5	5	4
Preservation	2	2	4	4	3	3	1-2	2-3	4	2-3

Table A4.2. Pollen assessment data from BH05a–BH07

	Borehole	BH05A	BH05A	BH05A	BH05A	BH05A	BH06	BH06	BH06	BH07	BH07
	SU	4d	5	5	5	5	5	5	4a	4c	4c
	Top (m)	4.26	1.9	2.29	2.96	3.7	2.21	2.72	5.22	3.8	4.97
	Base (m)	4.27	1.91	2.3	2.97	3.71	2.22	2.73	5.23	3.81	4.98
Latin name	**Common name**										
Trees											
Alnus	alder		2	1			1	2		12	21
Quercus	oak		1	4	3	1	4	5		7	9
Pinus	pine	1				1					
Tilia	lime									2	2
Ulmus	elm									1	3
Taxus	yew										
Fraxinus	ash										1
Betula	birch		1				2				
Fagus	beech										
Shrubs											
Calluna vulgaris	heather	1	1	7	1		1				
Corylus type	hazel		1		5			6		6	4
Erica spp.	heath										
Hedera	ivy										1
Salix	willow										
Lonicera periclymenum	honeysuckle										
Herbs											
Cyperaceae	sedge family		1	1			1	1		4	3
Poaceae	grass family	7	10	6	26	7	13	3			3
Cereale type	cereals		12	5	7	1	11	7			
Asteraceae	daisy family	1	1	3	2	2	4	1			
Artemisia type	mugwort										

	Borehole	BH05A	BH05A	BH05A	BH05A	BH05A	BH06	BH06	BH06	BH07	BH07
	SU	4d	5	5	5	5	5	5	4a	4c	4c
	Top (m)	4.26	1.9	2.29	2.96	3.7	2.21	2.72	5.22	3.8	4.97
	Base (m)	4.27	1.91	2.3	2.97	3.71	2.22	2.73	5.23	3.81	4.98
Lactuceae	dandelion family	15	1	4	7	35	11	2			
Plantago type	e.g. plantain	1		2		2	3	15			
Chenopodium type	e.g. fat hen	1					2	1			
Caryophyllaceae	pinks family		2		1		1				
Rosaceae	rose family										
Potentilla type	cinquefoil						1				
Rumex undiff.	dock/sorrel		2	1			1				
Apiaceae	carrot family			1							
Ranunculus type	e.g. buttercup	1			1		3			2	
Cirsium type	thistle				2						
Centaurea nigra	black knapweed	1	1		2	6					
Centaura cyanus	cornflower						2	1			
Circeae	nightshade										
Sinapis type	brassica family		1		1		3				
Filipendula type	meadowsweet										
Malva type	mallow										
Trifolium/Vicia type	clover / vetch						2				
Sanguisorba minor	burnet			1			1				
cf *Primula* type	primrose	1									
Valeriana type	marsh valerian										2
Polygonum type	knotweed			1	1						
Aquatics											
Sparganium type	bur-reed									1	
Spores											
Pteridium type	bracken										
Filicales	ferns		1		1					1	

	Borehole	BH05A	BH05A	BH05A	BH05A	BH05A	BH06	BH06	BH06	BH07	BH07
	SU	4d	5	5	5	5	5	5	4a	4c	4c
	Top (m)	4.26	1.9	2.29	2.96	3.7	2.21	2.72	5.22	3.8	4.97
	Base (m)	4.27	1.91	2.3	2.97	3.71	2.22	2.73	5.23	3.81	4.98
Polypodium vulgare	polypody fern	1	1	2				1		2	
Unknown pollen grains		1	5		1	3	1	2			
Unidentifiable pollen grains		5		4	3	1	2	7		5	
Parasite eggs				1			5				
Total Land Pollen		30	37	37	59	55	67	44	0	34	49
Total Pollen Concentration (grains/cm3)		14182	70015	25332	52474	73215	42001	22990	0	168768	162149
Diversity		3	3	1	3	2	4	3	0	2	2
Abundance		5	5	5	5	5	5	5	0	5	5
Preservation		2	3-4	4	3-4	2	3-4	3	0	3-4	3-4

Table A4.3. Pollen assessment data from BH08

	Borehole	BH08	BH08	BH08	BH08	BH08	BH08	BH08	BH08	BH08	BH08
	SU	5	5	5	5	5	5	5	5	5	4b
	Top (m)	1.82	2.22	2.62	2.98	3.26	3.98	4.58	4.88	5.1	5.14
	Base (m)	1.83	2.23	2.63	2.99	3.27	3.99	4.59	4.89	5.11	5.15
Latin name	**Common name**										
Trees											
Alnus	alder						1			2	
Quercus	oak			1	1	2	1				1
Pinus	pine										
Tilia	lime										6
Ulmus	elm										
Taxus	yew										
Fraxinus	ash										
Betula	birch					1					
Fagus	beech										
Shrubs											
Calluna vulgaris	heather										
Corylus type	hazel			1	6		2				
Erica spp.	heath										
Hedera	ivy										
Salix	willow										
Lonicera periclymenum	honeysuckle										
Herbs											
Cyperaceae	sedge family										
Poaceae	grass family	3		36	2	6					
Cereale type	cereals	1	1	2	3	17	1				
Asteraceae	daisy family	1	1	1		3	1				
Artemisia type	mugwort										
Lactuceae	dandelion family	6	10	9	9	5	1		4		
Plantago type	e.g. plantain			4	3	1	1	7			
Chenopodium type	e.g. fat hen					1					

	Borehole	BH08	BH08	BH08	BH08	BH08	BH08	BH08	BH08	BH08	BH08
	SU	5	5	5	5	5	5	5	5	5	4b
	Top (m)	1.82	2.22	2.62	2.98	3.26	3.98	4.58	4.88	5.1	5.14
	Base (m)	1.83	2.23	2.63	2.99	3.27	3.99	4.59	4.89	5.11	5.15
Caryophyllaceae	pinks family										
Rosaceae	rose family										
Potentilla type	cinquefoil					2					
Rumex undiff.	dock/sorrel										
Apiaceae	carrot family		6	1		1					
Ranunculus type	e.g. buttercup			1	1	2					
Cirsium type	thistle					1					
Centaurea nigra	black knapweed		1	1	4	1			1		
Centaura cyanus	cornflower										
Circeae	nightshade										
Sinapis type	brassica family		1		2	5					
Filipendula type	meadowsweet			1							
Malva type	mallow										
Trifolium/Vicia type	clover / vetch				2						
Sanguisorba minor	burnet										
cf *Primula* type	primrose										
Valeriana type	marsh valerian										
Polygonum type	knotweed		1			1					
Aquatics											
Sparganium type	bur-reed										
Spores											
Pteridium type	bracken						1				
Filicales	ferns				1						
Polypodium vulgare	polypody fern				1		1		1		
Unknown pollen grains				4	1						
Unidentifiable pollen grains					2	4					
Parasite eggs					7	26	3				

Borehole	BH08	BH08	BH08	BH08	BH08	BH08	BH08	BH08	BH08	BH08
SU	5	5	5	5	5	5	5	5	5	4b
Top (m)	1.82	2.22	2.62	2.98	3.26	3.98	4.58	4.88	5.1	5.14
Base (m)	1.83	2.23	2.63	2.99	3.27	3.99	4.59	4.89	5.11	5.15
Total Land Pollen	11	21	58	33	49	8	7	5	2	7
Total Pollen Concentration (grains/cm3)	43681	46328	164513	54601	74838	39710	17373	5225	39710	138985
Diversity	1	2	3	3	4	1	1	1	1	1
Abundance	4	5	5	5	5	4	3	3	2	2
Preservation	1-2	2	3	2-3	3	2	1	1-2	1	2-3

Table A4.4. Pollen assessment data from BH09–BH13

	Borehole	BH09	BH09	BH09	BH09	BH10	BH10	BH10	BH12	BH12	BH12	BH12	BH13	B
	SU	5	5	5	5	5	5	5	5	5	5	5	5	
	Top (m)	1.73	2.45	2.58	2.77	2.15	2.65	3.27	2.2	2.53	3.07	4.03	2.13	
	Base (m)	1.74	2.46	2.59	2.78	2.16	2.66	3.26	2.21	2.54	3.08	4.04	2.14	
Latin name	**Common name**													
Trees														
Alnus	alder								1	1				
Quercus	oak		1	3		1		1				1		
Pinus	pine				1			2						
Tilia	lime						1							
Ulmus	elm													
Taxus	yew													
Fraxinus	ash													
Betula	birch		1			1								
Fagus	beech													
Shrubs														
Calluna vulgaris	heather											1		
Corylus type	hazel		1	5		1			5	1			6	
Erica spp.	heath													
Hedera	ivy													
Salix	willow													
Lonicera periclymenum	honeysuckle											1	1	
Herbs														
Cyperaceae	sedge family							2						
Poaceae	grass family	4		4	1			2	3	1	1	11		
Cereale type	cereals	14	1	1			1		4			2		
Asteraceae	daisy family	2		1		1		2		1	1	12		
Artemisia type	mugwort													
Lactuceae	dandelion family	16	6	6	3			27	6	23	12	15	1	
Plantago type	e.g. plantain	1							2	2		11		
Chenopodium type	e.g. fat hen	2								1		1		

	Borehole	BH09	BH09	BH09	BH09	BH10	BH10	BH10	BH12	BH12	BH12	BH12	BH13
	SU	5	5	5	5	5	5	5	5	5	5	5	5
	Top (m)	1.73	2.45	2.58	2.77	2.15	2.65	3.27	2.2	2.53	3.07	4.03	2.13
	Base (m)	1.74	2.46	2.59	2.78	2.16	2.66	3.26	2.21	2.54	3.08	4.04	2.14
Caryophyllaceae	pinks family			1						1		1	
Rosaceae	rose family												
Potentilla type	cinquefoil												
Rumex undiff.	dock/sorrel									1			
Apiaceae	carrot family												1
Ranunculus type	e.g. buttercup								1		1		
Cirsium type	thistle							1				1	
Centaurea nigra	black knapweed			2				1		1		9	2
Centaura cyanus	cornflower	1											
Circeae	nightshade												
Sinapis type	brassica family	3		1			2	10	2	2	5		
Filipendula type	meadowsweet												
Malva type	mallow												
Trifolium/Vicia type	clover / vetch												
Sanguisorba minor	burnet												
cf *Primula* type	primrose												
Valeriana type	marsh valerian												
Polygonum type	knotweed	1						1		1			
Aquatics													
Sparganium type	bur-reed												
Spores													
Pteridium type	bracken	1										1	
Filicales	ferns								2		1		
Polypodium vulgare	polypody fern			1					1				6
Unknown pollen grains		5							2	1		5	
Unidentifiable pollen grains		4		6					2	2	2	1	1
Parasite eggs									8				

Borehole	BH09	BH09	BH09	BH09	BH10	BH10	BH10	BH12	BH12	BH12	BH12	BH13	B
SU	5	5	5	5	5	5	5	5	5	5	5	5	
Top (m)	1.73	2.45	2.58	2.77	2.15	2.65	3.27	2.2	2.53	3.07	4.03	2.13	
Base (m)	1.74	2.46	2.59	2.78	2.16	2.66	3.26	2.21	2.54	3.08	4.04	2.14	
Total Land Pollen	44	10	24	5	4	4	49	24	36	20	66	11	
Total Pollen Concentration (grains/cm3)	174724	33092	95304	11031	5673	4412	15949	47652	714780	33092	262086	9496	79
Diversity	3	1	2	1	1	1	2	2	3	1	3	1	
Abundance	5	4	5	3	3	3	5	5	5	4	5	4	
Preservation	2-3	2	2-3	1-2	2-3	2	2	2-3	3	3	4	2	

APPENDIX 5: PLANT MACROFOSSIL ASSESSMENT DATA

Table A5.1 Plant macroremain assessment data from BH01–BH06

	Borehole	BH01	BH03	BH03	BH03	BH04	BH04	BH05A	BH06	BH06	BH0[illegible]
	SU	5	5	5	5	5	5	5	5	5	5
	Top (m)	2.25	1.85	2.45	2.75	2.70	2.85	2.07	2.20	2.47	2.67
	Base (m)	2.26	1.90	2.50	2.80	2.75	2.90	2.12	2.25	2.52	2.7[illegible]
Latin name	**Common name**										
Trees											
Corylus avellana (nut shell fragment)	hazel				1			2		1	[illegible]
Shrubs											
Prunus cf. *avium*	cf. wild cherry	9		2							
Sambucus nigra/racemosa	elder					3	1	1			
Vitis vinifera	common grape vine			1							[illegible]
Herbs											
Chenopodium sp.	goosefoot						1				
Silene/Stellaria sp.	campion/stitchwort										
Ranunculus bulbosus/acris/repens	buttercup										
Rumex/Polygonum sp.	dock/sorrel/knotweed									2	
Carex sp.	sedge				1			3			
Bidens sp.	e.g. beggarticks										
Brassica/Sinapis sp.	mustards			1						1	[illegible]
Potentilla sp.	cinquefoil										
Others											
Unidentified	-									3	
Indet. seed casing	-										
Unknown cf. Rosaceae	rose family			1							
	Diversity	1	-	2	1	1	1	1	1	2	[illegible]
	Abundance	2	-	2	1	1	1	1	1	2	[illegible]
	Preservation	3	-	4	2	1	3	1	3	4	[illegible]
Other observations (abundance)											
	Charcoal <2mm	1	5	2	2	4	5	3	4	4	[illegible]
	Charcoal 2-4mm	1	-	-	1	2	2	-	1	2	[illegible]

Borehole	BH01	BH03	BH03	BH03	BH04	BH04	BH05A	BH06	BH06	BH0[illegible]
SU	5	5	5	5	5	5	5	5	5	[illegible]
Top (m)	2.25	1.85	2.45	2.75	2.70	2.85	2.07	2.20	2.47	2.6[illegible]
Base (m)	2.26	1.90	2.50	2.80	2.75	2.90	2.12	2.25	2.52	2.7[illegible]
Charcoal >4mm	-	3	4	1	3	3	3	3	4	[illegible]
Waterlogged wood	1	-	-	-	-	-	5	2	4	[illegible]
Bone (fragments)	-	3	1	1	2	1	-	2	1	
Mollusca (fragments)	-	4	-	-	1	3	-	2	-	[illegible]
Insects	-	-	1	2	-	1	-	1	1	[illegible]
Moss	-	-	-	-	-	-	3	1	-	[illegible]

Table A5.1 Plant macroremain assessment data from BH08–BH09

	Borehole	BH08	BH08	BH08	BH08	BH08	BH08	BH08	BH09	BH09
	SU	4d	4d	4d	4d	4b	4b	4a	5	5
	Top (m)	3.35	3.65	4.00	4.50	5.18	5.35	6.22	1.80	2.25
	Base (m)	3.40	3.70	4.05	4.55	5.23	5.40	6.27	1.85	2.30
Latin name	**Common name**									
Trees										
Corylus avellana (nut shell fragment)	hazel									
Shrubs										
Prunus cf. *avium*	cf. wild cherry									
Sambucus nigra/racemosa	elder	1	1	3						
Vitis vinifera	common grape vine									
Herbs										
Chenopodium sp.	goosefoot			1						
Silene/*Stellaria* sp.	campion/stitchwort				1					
Ranunculus bulbosus/acris/repens	buttercup		1							
Rumex/*Polygonum* sp.	dock/sorrel/knotweed									1
Carex sp.	sedge							3	1	
Bidens sp.	e.g. beggarticks									
Brassica/Sinapis sp.	mustards									
Potentilla sp.	cinquefoil	3								
Others										
Unidentified	-									
Indet. seed casing	-		1							
Unknown cf. Rosaceae	rose family									
	Diversity	1	1	1	1	-	-	1	1	1
	Abundance	1	1	1	1	-	-	1	1	1
	Preservation	3	3	2	1	-	-	3	2	2
Other observations (abundance)										
	Charcoal <2mm	5	2	3	3	-	1	3	4	5
	Charcoal 2-4mm	3	3	2	2	-	-	2	-	2
	Charcoal >4mm	3	3	3	3	-	-	2	3	2
	Waterlogged wood	4	5	2	-	4	-	2	-	-
	Bone (fragments)	1	3	1	3	-	-	2	2	2

Borehole	BH08	BH08	BH08	BH08	BH08	BH08	BH08	BH09	BH09
SU	4d	4d	4d	4d	4b	4b	4a	5	5
Top (m)	3.35	3.65	4.00	4.50	5.18	5.35	6.22	1.80	2.25
Base (m)	3.40	3.70	4.05	4.55	5.23	5.40	6.27	1.85	2.30
Mollusca (fragments)	1	1	2	3	-	-	1	1	1
Insects	1	2	-	-	1	-	-	-	-
Moss	-	1	1	-	-	-	-	-	-

APPENDIX 6: MOLLUSCAN ASSESSMENT DATA

Table A6.1 Mollusc assessment data

Taxon	BH03 4.74–4.78m SU4c	BH03 3.70–3.75m SU4c	BH03 4.09–4.14m SU4c	BH04 4.65–4.70m SU4c	BH06 4.40–4.45m SU4d	BH08 3.50–3.55m SU4d	BH09 4.01–4.06m SU4d	BH04 2.95–3.00m SU5	BH06 2.28–2.33m SU5	BH06 3.27–3.32m SU5
Valvata cristata	1			1	1		1			
Valvata piscinalis								1		
Galba truncatula		4	1							
Radix peregra	2			10						
Planorbis planorbis	4									
Succineidae		2		2						
Cochlicopa lubrica							1			
Cochlicopa sp.					1		4			
Pupilla muscorum	2				3		11			
Vallonia costata					3		14			
Vallonia excentrica					3		12			
Discus rotundatus		1								
Vitrea sp.			1							
Oxychilus cellarius		1								
Oxychilus sp.		2								
Nesovirea hammonis	1						1			
Limacidae	1									
Trochulus hispidus					6		33			
Pisidum sp.				12						
Mytilus sp.								+	+	
Ostrea sp.						+		+	+	+
Ceramic					+	+		+	+	
Mammal bone						+		+	+	+
Fish bone								+		
Abundance	2	2	1	2	2	1	4	1	1	1
Diversity	2	1	1	1	2	1	2	1	1	1
Preservation	4	4	4	4	3	1	3	1	1	1

APPENDIX 7: CERAMIC ARTEFACTS FROM BOREHOLE CORES

The following ceramic artefacts were recovered:

Borehole	Depth (m)	Identification	Age
ARCA CWR BH03	1.75–1.77	Pottery sherd. Greyware	Romano-British
ARCA CWR BH03	2.55–2.57	Tile fragment	?
ARCA CWR BH05	2.35	Brick fragment	Roman
ARCA CWR BH06	2.81–2.82	Pottery sherd. Michelmersh ware	Anglo-Saxon (AD 850–1100)
ARCA CWR BH06	3.68–3.70	Pottery sherd. Red coarseware	Romano-British
ARCA CWR BH07	1.96	Roof tile fragment	Roman
ARCA CWR BH08	4.29–3.31	Pottery sherd. Coarseware, red exterior, black interior	Romano-British
ARCA CWR BH11	2.60	Tile fragment	?
ARCA CWR BH12	3.35–3.45	Brick fragment	Roman
ARCA CWR BH13	3.20	Tile fragment	?
ARCA CWR BH13	3.20	Pottery sherd. Green glazed ware	Medieval (AD 13th century)

Identifications by Paul McCulloch

APPENDIX 8: BONES RECOVERED FROM BOREHOLE CORES

The bones extracted from the borehole cores were as follows:

Borehole	Depth (m)	Bone	Taphonomy
ARCA CWR BH04	2.73–2.75	Cow-sized vertebral fragment	Rounded edges
ARCA CWR BH08	3.38–3.44	Fragment of a femoral head of a juvenile (unfused) cow	Two cut marks (one on the shaft and the other on the epiphysis). Sharp edges.
ARCA CWR BH08	6.25–6.27	Fragment of a medium mammal-sized metacarpal including one epiphysis	Sharp edges

Identifications by Monika Knul.

APPENDIX 9: REPORT ON THE ARCHAEOLOGICAL TEST PITS

CENTRAL WINCHESTER REGENERATION PROJECT:
REPORT ON ARCHAEOLOGICAL TEST PITS FOR A GEOARCHAEOLOGICAL INVESTIGATION

Site Code:	**AY715**
Central NGR:	**448431 129483**
Commissioning Client:	**ARCA, University of Winchester**
Written by:	**James Bannister, PCA Winchester**
Managed by:	**Paul McCulloch BA MCIfA, PCA Winchester**

Contractor:	**Pre-Construct Archaeology Limited** **5 Red Deer Court** **Elm Road** **Winchester** **Hampshire**
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July 2021 (REV)

Report Ref: R14442

DOCUMENT VERIFICATION

Site Name: Central Winchester Regeneration scheme

Type of project: Archaeological Test Pit Investigation

Report: R14442

Pre-Construct Archaeology Limited Project Code		K6765
	Name & Title	Date
Written by:	J Bannister	17/11/2020
Graphics by:	D Valk	17/11/2020
Graphics checked:	M Roughley	17/11/2020
Project Manager:	P McCulloch	19/03/2021

Revision No.	Date	Checked	Approved
1	28/07/2021	JB	PCM

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FIGURES

1 ABSTRACT

Pre-Construct Archaeology Ltd (PCA) was appointed by ARCA, University of Winchester, to carry out a programme of preparatory archaeological test-pits in order to facilitate a geoarchaeological borehole investigation and hydrogeological assessment for the Central Winchester Regeneration Project (CWR).

The investigation was undertaken between the 10th of August and the 8th of September 2020 following the methodology detailed in the Methodological Addendum (ARCA 2020), and the Brief for a Geological Borehole Survey and Hydrogeological Assessment (WCC 2020), which was issued by Tracy Matthews, Historic Environment Team Archaeologist at Winchester City Council.

The investigation was carried out over a large part of the Central Winchester Regeneration area in the north eastern part of the historic city of Winchester (Figure 2). The preparatory test pits were formed in Middle Brook Car Park (test pits 1-4), Marks & Spencer's staff car park off Tanner Street (test pit 6), Middle Brook Street (test pit 7), Kings Walk (test pit 8), Coitbury House car park (test pit 9), at three locations on the south side of Friarsgate (test pits 10, 14 & 15) and in Winchester Bus Station (test pits 11-13). Proposed test pit 5 and borehole 5 were not carried out, owing to thick concrete; the relocated borehole 5A, drilled within the bus station car park, was not preceded by a test pit. On site, it was determined that ground conditions meant that preparatory test pits 7 and 8 were not required by ARCA.

The Middle Brook Street car park test pits indicate relatively shallow impacts from modern intrusions, such as foundations of demolished buildings, reaching a maximum of 0.84m BGL (Test Pit 4). Deposits recorded in all four test pits indicate post-medieval garden soil and post structural demolition and clearance or levelling. The survival of these deposits may be taken to indicate the possibility of deeper and potentially significant archaeological deposits at greater depth. As if to demonstrate this, in TP 2, in the south-west corner of the car park, a well-preserved medieval chalk lined water channel was recorded, surviving at a depth of just 0.79m BGL, that may be compared with similar channels recorded on the Lower Brook Street excavations carried out by the Winchester Excavations Committee (Biddle 1968). The shallow depth at which the channel was recorded may be accounted for by the reduction of ground level within the area of car park that resulted from those previous excavations.

The remaining test pits appeared to suggest that the uppermost archaeological deposits, comprising demolition horizons and garden soils of post-medieval date, occur at a depth of between 0.6m and 0.8m BGL in places and in locations that appear to be largely unimpacted by modern intrusions.

2 BACKGROUND

2.1 Introduction

2.1.1 Pre-Construct Archaeology Ltd (PCA) was appointed by ARCA, University of Winchester (hereafter ARCA), to carry out a programme of archaeological test-pits in order to facilitate a geoarchaeological borehole survey and hydrogeological assessment for the Central Winchester Regeneration Project (CWR) (Figure 1).

2.1.2 The investigation was undertaken between the 10th of August and the 8th of September 2020 following the methodology detailed in the *Methodological Addendum* (ARCA 2020), and the *Brief for a Geological Borehole Survey and Hydrogeological Assessment* (WCC 2020), which was issued by the Tracy Matthews, Historic Environment Team Archaeologist at Winchester City Council.

2.2 Test Pit Locations

2.2.1 The investigation was carried out over a large area within the Central Winchester Regeneration area in the north eastern part of the historic city of Winchester (Figure 2). The test pits were proposed in Middle Brook Car Park (test pits 1-4), Marks & Spencer's staff car park off Tanner Street (test pit 6), Middle Brook Street (test pit 7), Kings Walk (test pit 8), Coitbury House car park (test pit 9), at three locations on the south side of Friarsgate (test pits 10, 14 & 15) and in Winchester Bus Station (test pits 11-13).

2.2.2 The location of each test pit was set out by ARCA and excavated by PCA. Modern surfacing was broken out and the pits were then excavated by machine to a depth of 1.2m below ground level and to a depth below modern intrusions, foundations and services. All excavations were monitored by a PCA archaeologist.

2.3 Sampling Strategy

2.3.1 Where encountered and as necessary to meet the aims of the investigation, archaeological deposits and features were sampled to characterise, date them, and establish their extent within the test pits. Sampling included the removal of archaeological deposits and features by hand and stratigraphically by context to the depth that was required for the subsequent geoarchaeological investigations.

2.3.2 On completion archaeological sampling and recording, the pits were handed over to ARCA to conduct the geoarchaeological borehole investigation within the pits.

2.4 Recording

2.4.1 All trenches, structures, deposits, and finds were recorded according to accepted professional standards using PCA's recording system. Sufficient data was recorded to allow the required level of assessment and reporting. Recording was carried out to a sufficiently high standard to provide a full record of the deposits evaluated, including in trenches where no archaeology was identified.

2.4.2 All archaeological contexts were recorded individually on *pro forma* context record sheets, which record stratigraphic relationships for the purpose of preparing a Harris matrix for each pit/trench. A further, more general record of the work, comprising a description and discussion of the archaeology was also maintained.

2.4.3 One section, or two where appropriate, of each test pit were drawn at a scale of 1:10. Significant archaeological features were drawn in plan at a scale of 1:20. A digital photographic record of the work was maintained, forming part of the site archive. The positions of the pits/trenches were located by RTK GPS ±0.015m.

3 RESULTS

3.1 Introduction

3.1.1 The following sections provide a summary of the results of the observations made during the archaeological investigation of the test pits. The summary is based on the site archive, which comprises written, drawn, survey and digital photographic records and indexes. The archive is held at PCA's Winchester office Hampshire Cultural Trust WINCM site code **AY715** and will in due course be deposited with the Hampshire Cultural Trust.

3.1.2 The archaeological evaluation was undertaken following the methodology detailed in the Methodological Addendum (ARCA 2020), and the Brief for a Geological Borehole Survey and Hydrogeological Assessment (WCC 2020), which was approved by the HETA at Winchester City Council.

3.2 Test Pit 1

3.2.1 Test Pit 1 was located in the north-west corner of Middle Brook Street car park (Figure 2). Test Pit 1 measured 1m by 1m and was excavated to a total depth of 1.18m below ground level (BGL); ground surface was recorded at 36.23m above Ordnance Datum (aOD).

3.2.2 Two layers of archaeological interest were revealed (Figure 3A). The earliest deposit uncovered at 1m BGL, comprised a sandy clay (104) containing frequent fragments of degraded chalk, mortar, slate, and flint, and is likely post-medieval in date. This layer, not bottomed, has been interpreted as a post structural clearance layer likely to seal deeper archaeological deposits. Overlying this was a layer of dark silty clay (103) with frequent slate, charcoal, ceramic building material (CBM), and chalk inclusions, recorded at a depth of 0.6m BGL; this has been interpretated as post-medieval garden soil and lay beneath a layer of modern made ground, comprising compact chalk rubble 0.45m thick (105), above which was a sequence of modern deposits capped by asphalt.

3.3 Test Pit 2

3.3.1 Test Pit 2 was located in the south-west corner of Middle Brook Street car park (Figure 2) and measured 1m by 1m and was excavated to a total depth of 1.29m BGL; ground surface was recorded at 36.15m aOD (Figure 4A, B, C). Extending across the base of the test pit, the earliest archaeological feature was a medieval chalk-built water channel (205), the walls of which were revealed at 0.79m BGL (35.36m aOD). The channel base was formed of chalk slabs, overlain by the walls, which were made of large, mortared chalk blocks, together. The channel was 0.51m deep and 0.25m wide and was aligned east-west. The basal slabs were removed to allow access for the geoarchaeological borehole investigation.

3.3.2 The channel was filled by a deposit of silt (201) with abundant CBM, charcoal, mortar, and chalk inclusions. The CBM recovered from fill (201) has been interpretated as late medieval (Appendix 3). The southern channel wall was covered by a thin layer of degraded chalk and mortar (202). Overlying this and covering the channel was a layer of silty clay (206), uncovered at 0.34m BGL, containing frequent fragments of degraded charcoal, mortar, and chalk inclusions. This has been interpreted as a possible post structural clearance or demolition horizon and was sealed by modern made ground.

3.4 Test Pit 3

3.4.1 Test Pit 3 was located in the centre of Middle Brook Street car park (Figure 2) and measured 1m by 1m and was excavated to a total depth of 1.17m BGL; ground surface was recorded at 36.34m aOD. It revealed two layers of archaeological interest (Figure 3B). The earliest deposit was recorded at 0.88m BGL and comprised a silty clay (302), with frequent fragmented slate, chalk and charcoal inclusions and is likely post-medieval in date. This layer has been interpreted as a post structural or demolition horizon. Overlying this was a layer of dark silty clay (301) with frequent CBM, charcoal, slate, and mortar inclusions, recorded at a depth of 0.44m BGL. This has been interpretated as post-medieval garden soil. This layer was sealed by two layers of made ground consisting of bricks and gravel, first uncovered at 0.08m to 0.44m BGL. The asphalt surfacing was 0.06m thick.

3.5 Test Pit 4

3.5.1 Test Pit 4 was located in the north-east corner of Middle Brook Street car park (Figure 2). Test Pit 4 measured 1m by 1m and was excavated to a total depth of 1.32m BGL; ground surface was recorded at 36.29m aOD. It revealed three deposits of archaeological interest (Figure 5A). The earliest deposit was revealed at 1.29m BGL and comprised a silty clay (405) (not visible in the recorded section) with frequent charcoal, gravel, chalk, slate, and mortar inclusions, and is likely to be post-medieval in date. This layer has been interpreted as a post structural or demolition layer. Overlying this was a similar deposit (404), recorded a depth of 1.01m BGL. These deposits were covered by a layer of dark silty clay (403), with frequent chalk and charcoal inclusions and recorded at a depth of 0.84m BGL. This was interpretated as post-medieval garden soil. This layer was sealed by five layers of made ground, consisting of chalk, gravels, and stone, uncovered from 0.12m to 0.84m BGL. The asphalt surfacing was 0.12m thick.

3.6 Borehole 5

3.6.1 Proposed BH 5 was proposed in the centre of Friarsgate car park (Figure 2). No archaeological test pit or borehole was carried out owing to the presence of thick reinforced concrete. An alternative location was selected by ARCA for drilling, 5A, within the bus station car park; this was not preceded by a test pit.

3.7 Test Pit 6

3.7.1 Test Pit 6 was located in the north-east corner of the Marks & Spencer's staff car park (Figure 2). Test Pit 6 measured 1m by 1m and was excavated to a depth of 1.2m BGL; ground surface was recorded at 36.33m aOD. It revealed a layer of archaeological interest at 0.6m BGL comprising a dark silty clay with frequent CBM, slate, charcoal and chalk inclusions (601) (Figure 5B) . This has been interpretated as post-medieval garden soil.

3.7.2 This layer was sealed by a modern brick surface found at 0.44m BGL, which was sealed by six layers of modern made ground topped by asphalt 0.14m thick.

3.8 Borehole 7

3.8.1 Geoarchaeological borehole BH 7 was located at the southern end of Middle Brook Street close to the junction with Silver Hill (Figure 2). Formation of the borehole was not preceded by an archaeological test pit due to a need to avoid tree roots. However, a starter pit for the borehole, monitored by PCA, was taken down 1.2m and revealed modern made ground throughout.

3.9 Borehole 8

3.9.1 Geoarchaeological borehole BH 8 was located within Kings Walk (Figure 2). The location coincided with a thick layer of concrete, beneath two layers of stone paving slabs. No preparatory archaeological test pit was carried out.

3.10 Test Pit 9

3.10.1 Test Pit 9 was located in Coitbury House Car Park (Figure 2). Test Pit 9 measured 1m by 1m and was excavated to a total depth of 1.16m BGL; ground surface was recorded at 36.49m aOD. It revealed four individually distinct but nonetheless similar layers of archaeological interest (Figure 6A). The earliest, at 1.13m BGL, consisted of a grey silty sand (906) with frequent degraded mortar and slate inclusions. Overlying this was another layer of mixed probable demolition or clearance material (905) encountered at 0.87m BGL, consisting of a grey silty clay with frequent small charcoal, chalk, CBM and slate inclusions. Sealing (905) was a further very similar deposit (904) encountered at 0.68m BGL, comprising a sandy clay with degraded mortar, chalk, and charcoal inclusions, beneath a final layer of demolition material (903) encountered at 0.58m BGL and consisting of a silty clay with frequent oyster shell, CBM, slate, and charcoal inclusions. All four layers appear to be post-medieval in date

3.10.2 Layers (902) at 0.5m BGL comprised degraded brick and mortar and is interpretated as modern made ground. This was covered by an additional layer of made ground (901) seen at 0.33m BGL. Sealing this were three layers of made ground consisting of gravel and stone recorded from 0.1m BGL. The asphalt surface was 0.1m thick.

3.11 Test Pit 10

3.11.1 Test Pit 10 was located within a grassed area on the south side of Friarsgate immediately north of the former Friarsgate medical centre (Figure 2). Test Pit 10 measured 1m by 1m, was excavated to a depth of 1.24m BGL; ground surface was recorded at 36.21m aOD. It revealed a sequence of three layers of archaeological interest (Figure 6B). The earliest of these, at 0.95m BGL, consisted of a dark silty clay (1006), with frequent charcoal inclusions and appeared to be organically rich and of post-medieval date. Overlying this was a layer of chalk (1005), uncovered at 0.84m, which lay beneath a layer of dark silty clay (1004) composition found at 0.66m BGL, with frequent CBM, charcoal, and chalk inclusions. This has been interpretated as post-medieval garden soil.

3.11.2 Sealing this were three layers of modern made ground, consisting of compact chalk and two layers of gravels from 0.5m BGL to 0.2m BGL. The topsoil was 0.2m thick.

3.12 Test Pit 11

3.12.1 Test Pit 11 was located within the Bus Station (Figure 2). It measured 1m by 1m and was excavated to a depth of 1.15m BGL ground surface was recorded at 36.33m aOD. A singular layer of archaeological interest was recorded at 0.57m BGL and comprised dark grey silty clay (1102), with frequent small chalk inclusions. This has been interpretated as post-medieval garden soil (Figure 7A). This layer was sealed by modern made ground beneath concrete surfacing 0.15m thick.

3.13 Test Pit 12

3.13.1 Test Pit 12 was located within the Bus Station close to the eastern extent f the investigation area (Figure 2). Test Pit 12 measured 1m by 1m and was excavated to a total depth of 1.21m BGL; ground surface was recorded at 36.24m aOD. It revealed three layers of archaeological interest (Figure 7B). The earliest deposit was a dark grey silty clay (1203) recorded at 0.93m BGL and beneath a similar silty clay (1202) deposit recorded at 0.82m BGL, which, in turn was sealed by dark grey silty clay (1201) at 0.59m BGL. These deposits appear to represent post-medieval garden soil and lay beneath made ground consisting of concrete, asphalt, CBM, slate and sand.

3.14 Test Pit 13

3.14.1 South of Test Pit 12, Test Pit 13 (Figure 2) measured 1m by 1m and was excavated to a total depth of 1.25m BGL; ground surface was recorded at 36.64m aOD It revealed two layers of archaeological interest (Figure 8A). The earliest deposit was encountered at 1m BGL and comprised grey silty clay (1303) with frequent CBM, slate, charcoal, degraded chalk, and mortar inclusions. This was overlain by (1302), of similar composition. Both deposits are interpreted as representing clearance and levelling of post-medieval date and were recorded beneath modern made ground (1301) and modern structural remains.

3.15 Test Pit 14

3.15.1 Test Pit 14 was located at the eastern end of the car park of the former Friarsgate medical centre (Figure 2). Test Pit 14 measured 1m by 1m and was excavated to a total depth of 0.75m BGL; ground surface was recorded at 37.70m aOD. It revealed three service pipes (Figure 8B). No suitable location could be found in which to form a borehole due to the presence of these services. No archaeology was recorded in the test pit nor was a borehole investigation carried out.

3.16 Test Pit 15

3.16.1 In substitution of Test Pit 14, Test Pit 15 was located on open ground at the corner of Eastgate Street and Friarsgate (Figure 2). Test Pit 15 measured 1m by 1m and was excavated to a total depth of 1.27m BGL; ground surface was recorded at 43.95m aOD and revealed two layers of archaeological interest (Figure 8C). The earliest deposit was encountered at 1.24m BGL and consisted of grey sandy clay (1502) with frequent small charcoal, chalk, and CBM inclusions. This lay beneath a similar deposit (1501) recorded at 0.67m BGL. Both deposits are interpreted as representing post-medieval levelling horizons and were sealed by six layers of made modern ground recorded from 0.67m BGL to ground level. A number of services were indicated close to the test pit and in view of these no geoarchaeological borehole was formed.

3.17 Finds and Samples

3.17.1 A very small quantity of finds was recovered from the test pit investigation. Finds included late medieval ceramic building material recovered from archaeological deposits in Test Pit 2 (Appendix 2). No significant archaeological finds were recorded within any other of the test pits.

3.18 Discussion

3.18.1 The investigation aimed to record archaeological resources revealed during the excavation of test pits that were opened in order to facilitate the geoarchaeological investigation carried out by ARCA. A fairly restricted record of archaeological deposits was made but several observations can be suggested. It should be noted that no natural deposits were encountered in any of the test pits.

3.18.2 The Middle Brook Street car park test pits indicate relatively shallow impacts from modern intrusions, such as foundations of demolished buildings, reaching a maximum of 0.84m BGL (Test Pit 4). Deposits recorded in all four test pits indicate post-medieval garden soil and post structural demolition and clearance or levelling. The survival of these deposits may be taken to indicate the possibility of deeper and potentially significant archaeological deposits at greater depth. As if to demonstrate this, in TP 2 a well-preserved medieval chalk lined water channel was recorded, surviving at a depth of just 0.79m BGL, that may be compared similar channels recorded on the Lower Brook Street excavations carried out by the Winchester Excavations Committee (Biddle M. 1968). The shallow depth at which the channel was recorded may be accounted for by the reduction of ground level within the area of car park that resulted from those previous excavations.

3.18.3 The remaining test pits appeared to suggest that the uppermost archaeological deposits, comprising demolition horizons and garden soils of post-medieval date, occur at a depth of between 0.6m and 0.8m BGL in places and in locations that appear to be largely unimpacted by modern intrusions, although within a short distance of probably deeper modern foundation impacts.

4 REFERENCE

ARCA, 2020, Central Winchester Regeneration Project: Geoarchaeological Borehole Survey and Hydrological Assessment: Methodological Addendum.

Biddle, M, 1968, '*Excavations at Winchester 1967. Sixth interim report*', Antiquaries Journal 48 pt 2, 259–63.

WCC, 2020, Central Winchester Regeneration site, Winchester: Brief for a Geoarchaeological Borehole Survey and Hydroarchaeological Assessment.

5 ACKNOWLEDGEMENTS

PCA would like to thank Winchester City Council for facilitating the investigation, in particular Tracy Mathews (Historic Environment Team) and Rachel Robinson (Project Manager), and the ARCA team of Professor Keith Wilkinson, Nick Watson and David Ashby.

The test pit investigation was supervised by James Bannister, assisted by Bart Grden and Sophie Hobday. This report was prepared by James Bannister, with illustrations prepared by Ray Murphy. The project was managed for PCA by Paul McCulloch.

APPENDIX 1: BUILDING MATERIAL

Kevin Hayward
Test Pits Central Winchester Regeneration Project AY715

Introduction and Methods

A review of a small quantity of ceramic building material, fired clay and stone (9 examples 3361g) from the Central Winchester Regeneration Project follows. It all came from the fill (201) of an E-W trending medieval chalk lined drain [205] in Test Pit 2 located in the south-west corner of Middle Brook Street Car Park This review of the ceramic building material, stone and fired clay was undertaken not only to determine the fabric but also to provide a list of spot dates.

The fabric was examined at x20 magnification using a long arm stereomicroscope or hand lens (Gowlland x10). Comparison was made with the fabrics retained from the excavations at North Wales Fire Station and Faberlux Yard (AY437) (Hayward 2018), where each new fabric was prefixed by *FAB* followed by 1. 2 etc; thus *FAB1, FAB.* Stone types were assigned the characteristic 4-digit London coding. Beginning *310;* thus *3105; 3106* etc.

Ceramic Building Material 5 examples 1192g

Roman
No Roman ceramic building material was recorded.

Medieval 5 examples 1192g
Based on form and fabric, all the ceramic building material from the fill (201) of an E-W trending medieval chalk lined drain [205] in Test Pit 2 is medieval in date.

They consist of a mixture of peg tile and higher status items such as a ridge tile associated with a chimney and an abraded floor tile.

Floor Tile 1 example 299g
FAB 1 Thick coarse very sandy fabric
The corner of a 23mm thick patterned floor tile, provides evidence of a high status medieval ecclesiastical flooring belonging to a monastic order, church, or Bishop's residence in the vicinity. It is made from the very common coarse gritty sandy fabric *FAB1,* associated with floor tile manufactured from the Newbury area. Having the characteristic, knife dug stab marks of medieval Wessex floor tiles elsewhere in Winchester (e.g., Hayward 2018) Salisbury or Oxford (Hayward 2015), remnants of a

yellow glazed white slipped petal pattern could be discerned though it was too abraded for any design to be identified. It had been reused in a fine white lime mortar (M2) on its broken fresh edge, though an original pink-white keying mortar (M1) with flecks of red ceramic building material could be identified within the stab marks.

Stab marks were produced to provide an extra bond between the tile and mortar bed. This practice had died out by the 14th century (Roffey) suggesting that the floor tile here dates from the 13th to early 14th century.

Peg Tile

3 examples 774g
FAB15 Coarse sand with thin indistinct yellow silty laminae
Comparable to medieval peg tile fabric *FAB15* from the AY437 excavations (Hayward 2018), three examples were recorded, one with a very small (8mm diameter) square/rhomb shaped nail hole. No glaze was visible though the coarse moulding sand and its thin (10mm), irregularly shape form is typically medieval.

Ridge tile/Chimney Element 1 example 119g
FAB21 Coarse sandy fabric
This knife-trimmed ridge tile is characteristic of apex roof decoration 12th and 14th century buildings of the Wessex region (Hayward 2015) including Winchester (Hayward 2018). Its association with chimneys can be shown here with three knife slits or perforations on the underside, typical of medieval louvres from southern England. The triangular knife cut glazed form and coarse sandy fabric (*FAB21*) are common for Winchester (Hayward 2018)

Late post medieval
No Post-medieval ceramic building material was recorded.

Mortar

Fig. 1 listing of mortar types from AY715

Mortar/Concrete Type	Description	AY715
Type 1 White cream fawn lime mortar	Low density cream lime fawn mortar	Late medieval to early post medieval Reused on 13th-14th

		century floor tile (201) fabric seen at Faberlux Yard AY437
Type 8 Pink mortar fine lime with small (102mm) scattered red ceramic building material inclusions	Pink mortar with small (1-2mm) scattered red ceramic building material inclusions	Medieval 13th to 14th century primary keying mortar for decorated floor tile (201) not seen in Winchester before

A review of the mortar types (Fig. 1) shows that primary medieval pink mortar (Type 8), a recipe not previously identified in Winchester before, was adhered as a keying mortar to the decorative floor tile. This floor tile was found to be reused in a second cream lime fawn mortar (Type 1) common in late medieval to early post medieval Winchester (Hayward 2018).

Stone Petrology and Function 4 examples 2169g

MoL fabric code	Description	Geological Type and source	Use at AY715
3107	Low density very pale green-grey fine glauconitic limestone	Malmstone – Upper Greensand, Lower Cretaceous Farnham Surrey	2 examples 1748g rubble fill (201) of an E-W trending medieval chalk lined drain [205] in Test Pit 2
3115	Dark grey highly fissile slate	North Wales Slate or related West Country rock, Palaeozoic	Roofing material 2 examples 421g fill (201) of an E-W trending medieval chalk lined drain [205] in Test Pit 2

Figure 2 listing of rock types: geological character, form, probable use, date, and distribution from AY715

A review of the stone assemblage from the fill (201) of an E-W trending medieval chalk lined drain [206] n Test Pit 2 identified 2 different rock types (Fig. 2). Large fragments of dumped low density Malmstone are present. This is, a common rubblestone and architectural freestone rock type in medieval Winchester as shown by its very common use from the Faberlux Yard/North Walls Fire Station Excavation AY437 (Hayward 2018) in Window Tracery at the site of the 1258-1538 Greyfriars Priory.

The identification of dark grey North Wales slate in the medieval chalk drain n Winchester should not be seen as at all surprising A plethora of different purple grey-purple, green Cornish (Hayward 2018) and blue South Wales slates (Hayward 2011) were used as roofing material in the City.

Medieval chalk lined drains are common in medieval Winchester and have been identified in earlier excavations at Lower Brook Street.

Distribution

Test Pit 2

Context	Fabric	Form	Size	Date range of material		Latest dated material		Spot date	Spot date with mortar
201	3107; 3115 FAB1; FAB15; FAB21 3101	Malmstone and North Wales slate Roofing; Medieval peg tile, reused Wessex “stabbed” decorative floor tile and ridge tile	9	50	1900	50	1900	1400-1600	Primary pink keying mortar (M1) 1200-1350 reused white lime mortar (M2) 1350-1500+

Analysis of the small (3kg) building material assemblage from the Central Winchester Regeneration Project (AY715) showed it all to be concentrated in Test Pit 2 from a single fill (201) of an E-W trending medieval chalk lined drain [205]. By form and fabric, the stone, ceramic building material and mortar is almost entirely medieval in character, with an example of a high-status decorative Wessex stabbed floor tile (1200-1350) and a 12^{th}-14^{th} century glazed ridge tile with knife cut perforations associated with a chimney at the apex of a roof. Other roofing material including slate and Malmstone associated with window stone moulds in priories. All these materials have been identified in priory excavations such as those from Greyfriars (1258-1538) (Hayward 2018), the material simply dumped or washed into an available chalk culvert

The ridge tile with knife trimmed vents is worthy of illustration should publication be necessary. All stone discarded. All ceramic building material kept.

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Hayward, K.M.J. (2015) *Building Material*. In Douglas, A. (2015) Medieval Craft-Working in Oxford: Excavations at 15-17 Clarendon Centre. Pre-Construct Archaeology Monograph 18; 57-64.

Hayward, K.M.J. (2018). *Building Materials. North Walls Fire Station and Faberlux Yard, Winchester, Hampshire (AY437).* Unpublished Building Materials Report Pre-Construct Archaeology West

APPENDIX 2: OASIS REPORT

OASIS ID: preconst1-406573

Project details

Project name Central Winchester Regeneration Project

The archaeological investigation was carried out prior to geotechnical borehole survey by Geotechnical Engineering Ltd. The investigation covers a large area of the historic city of Winchester, including locations within Middle Brook Car Park, Winchester Bus Station, Friarsgate Car Park, M and S Car Park, Middle Brook Street, Kings Walk, Coitbury Car Park, Saxon Gate, and east of the Saxon Gate development area, where Eastgate Street meets Friarsgate. The location of each test pit was set out by ARCA and excavated by PCA. The tarmac and hard standing was broken out by a breaker and then the pit was excavated by machine to a depth of 1.2m. All excavations were monitored by a PCA archaeologist.

Project dates Start: 10-08-2020 End: 08-09-2020

Previous/future work Yes / Yes

Any associated project reference codes AY715 - Sitecode

Type of project Field evaluation

Site status None

Current Land use Other 3 - Built over

Monument type WATER CHANNEL Medieval

Significant Finds FLOOR TILE Medieval

Significant Finds PEG TILE Medieval

Significant Finds RIDGE TILE Medieval

Methods & techniques "Test Pits"

Development type Not recorded

Development type Large Regeneration Project

Prompt Planning condition

Position in the planning process Pre-application

Project location

Country England

Site location HAMPSHIRE WINCHESTER WINCHESTER Central Winchester Regeneration

Postcode SO23

Study area 0 Square metres

Site coordinates SU 48433 29483 51.062104352012 -1.308779408158 51 03 43 N 001 18 31 W Point

Project creators

Name of Organisation PCA Winchester

Project brief originator Winchester City Council

Project design originator ARCA

Project director/manager Paul McCulloch

Project supervisor James Bannister

Type of sponsor/funding body City Council

Name of sponsor/funding body Winchester City Council

Project archives

Physical Archive recipient Hampshire Cultural Trust

Physical Archive ID WINCM: AY715

Physical Contents "Ceramics"

Digital Archive recipient Hampshire Cultural Trust

Digital Archive ID WINCM: AY715

Digital Contents "none"

Digital Media available "Images raster / digital photography","Spreadsheets","Survey","Text"

Paper Archive recipient Hampshire Cultural Trust

Paper Archive ID WINCM: AY715

Paper Contents "none"

Paper Media available "Context sheet","Diary","Drawing","Plan","Section"

Project bibliography 1

Publication type Grey literature (unpublished document/manuscript)

Title Summary Report On Archaeological Works Accompanying Geotechnical and Geoarchaeological Site Investigation For Central Winchester Regeneration Project

Author(s)/Editor(s) Bannister, J

Other bibliographic details R.14280

Date 2020

Issuer or publisher Pre-Construct Archaeology

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Description Ring bound A4 report, 8 figures.

Entered by james bannister (jbannister@pre-construct.com)

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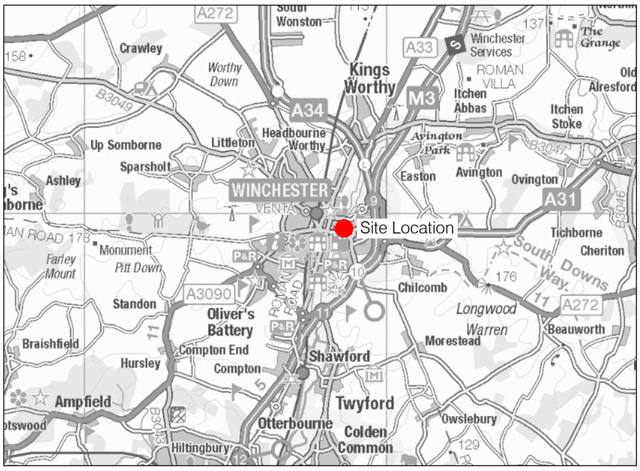


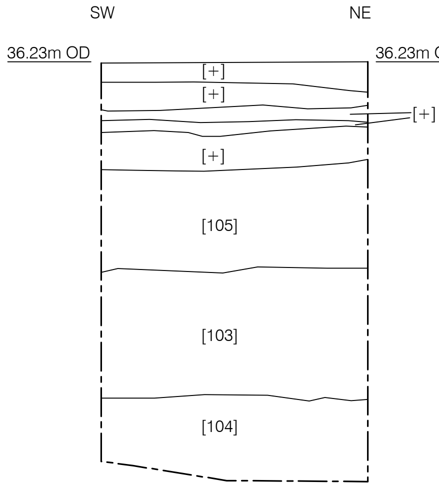
05/10/20 RM

Figure 1
Site Location
1:2,000,000, 1:250,000, 1:20,000 at A4

05/10/20 RM

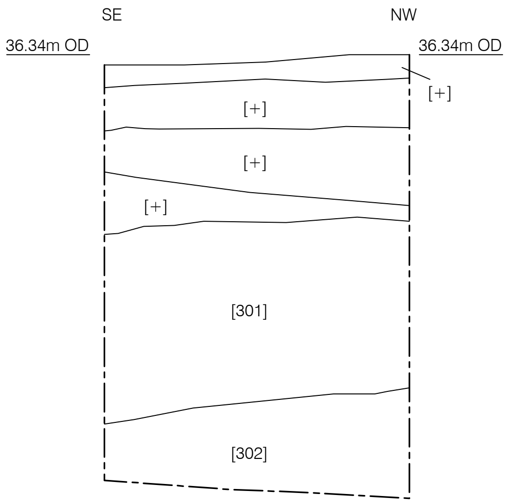
Figure 2
Test Pit Location Plan
1:1,000 at A3

Figure 3A



Section 9A
Test Pit 1
Southeast Facing

Figure 3B

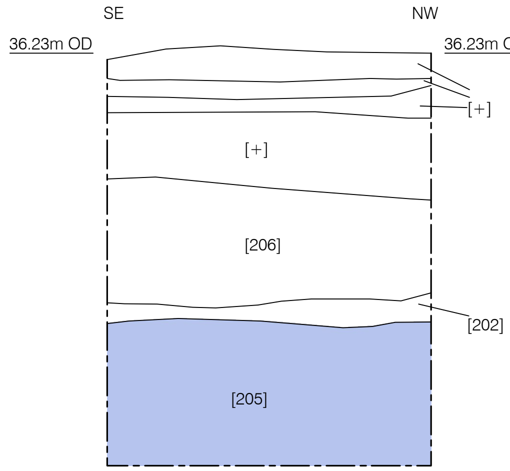


Section 11A
Test Pit 3
Northeast Facing

17/11/20 RM

Figures 3A-B
Sections
1:20 at A4

Figure 4A

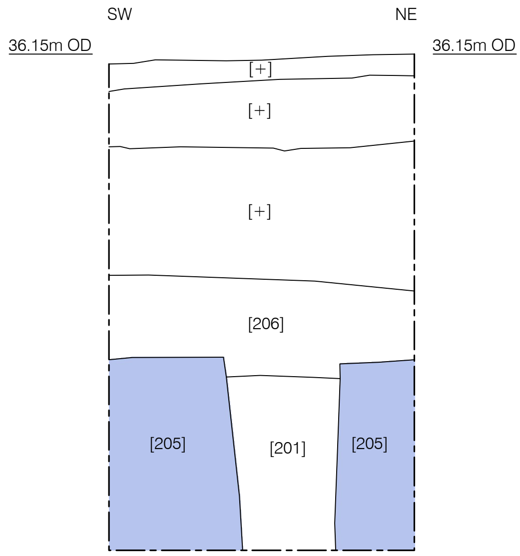


Masonry

0 1m

Section 10A
Test Pit 2
Northeast Facing

Figure 4B



Masonry

0 1m

Section 12A
Test Pit 2
Southeast Facing

Figure 4C

Plan 10C,Test Pit 2

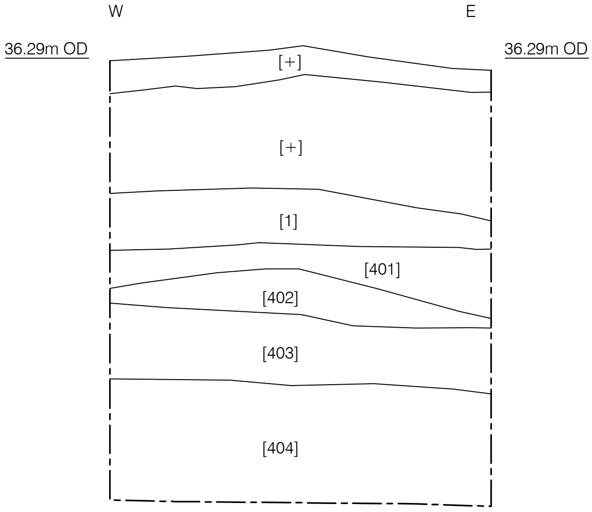
Masonry

0 1m

17/11//20 RM

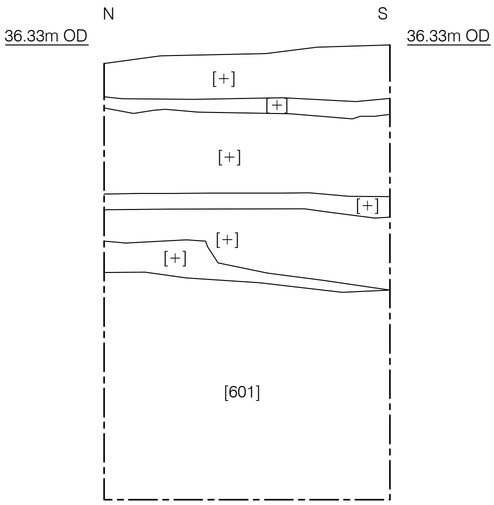
Figures 4A-C
Sections and Plan
1:20 at A4

Figure 5A



Section 8A
Test Pit 4
South Facing

Figure 5B

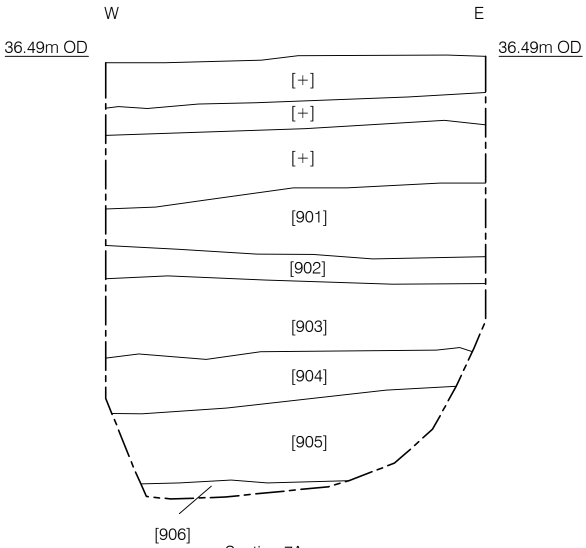


Section 13A
Test Pit 6
West Facing

17/11/20 RM

Figures 5A-B
Sections
1:20 at A4

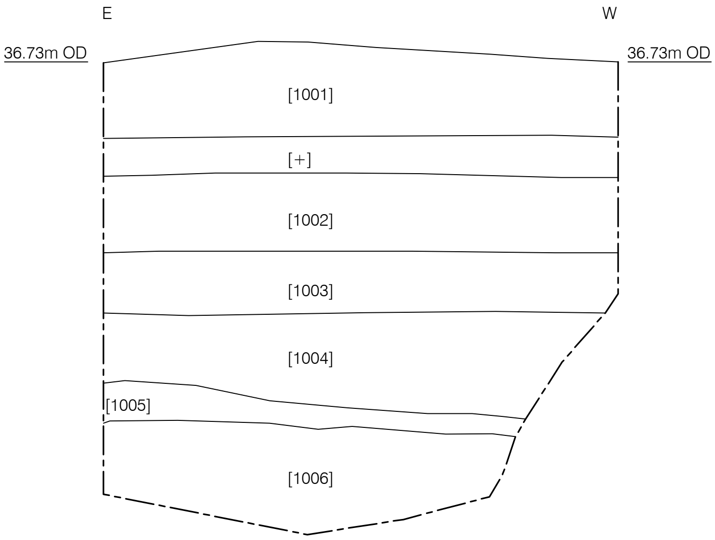
Figure 6A



0 1m

Section 7A
Test Pit 9
South Facing

Figure 6B



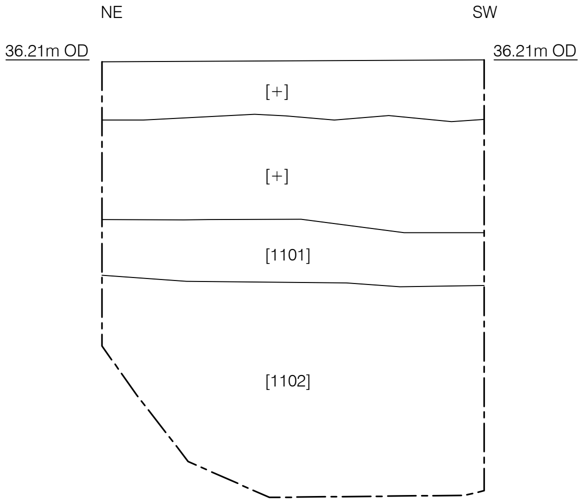
0 1m

Section 5A
Test Pit 10
North Facing

17/11/20 RM

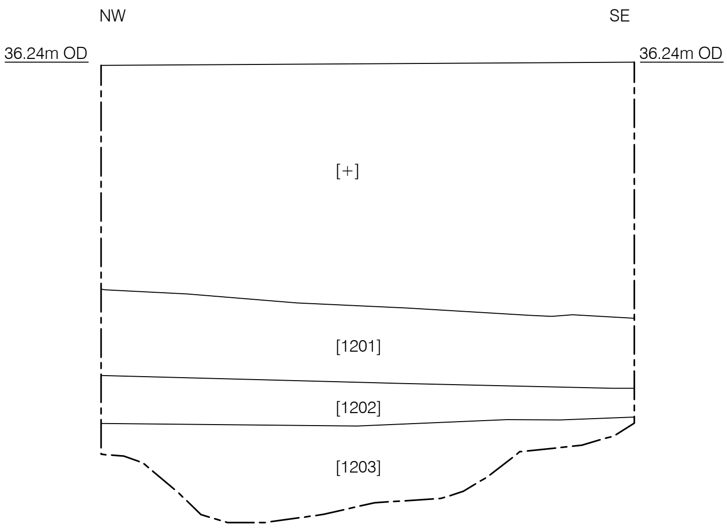
Figures 6A-B
Sections
1:20 at A4

Figure 7A



Section 1A
Test Pit 11
Northwest Facing

Figure 7B

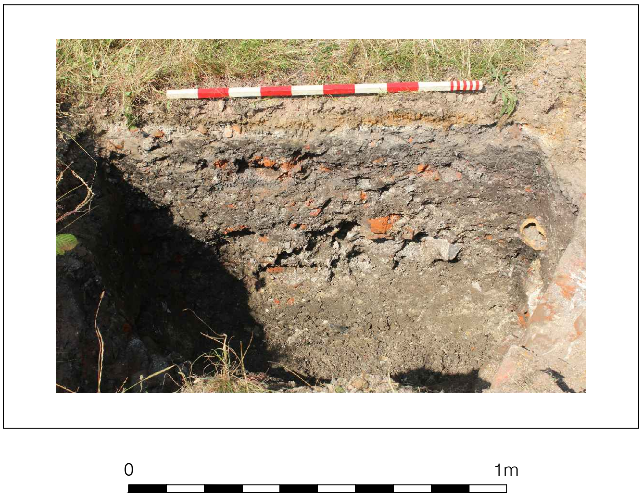


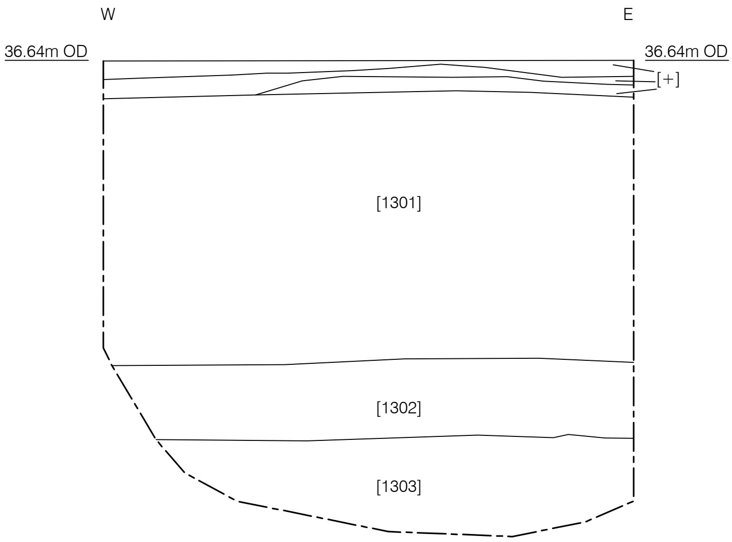
Section 2A
Test Pit 12
Southwest Facing

17/11/20 RM

Figures 7A-B
Sections
1:20 at A4

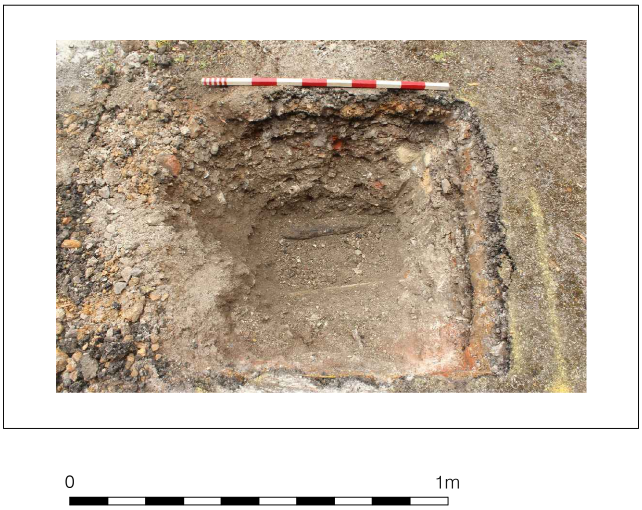
Figure 8A

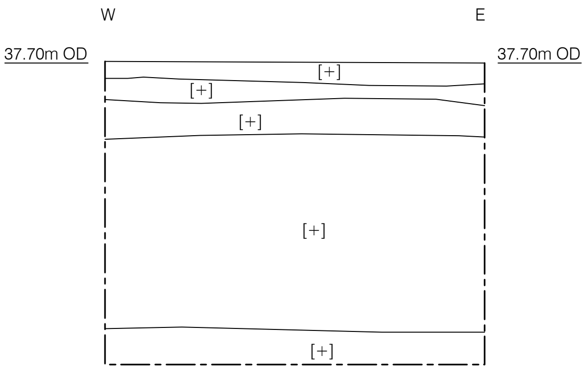




Section 3A
Test Pit 13
South Facing

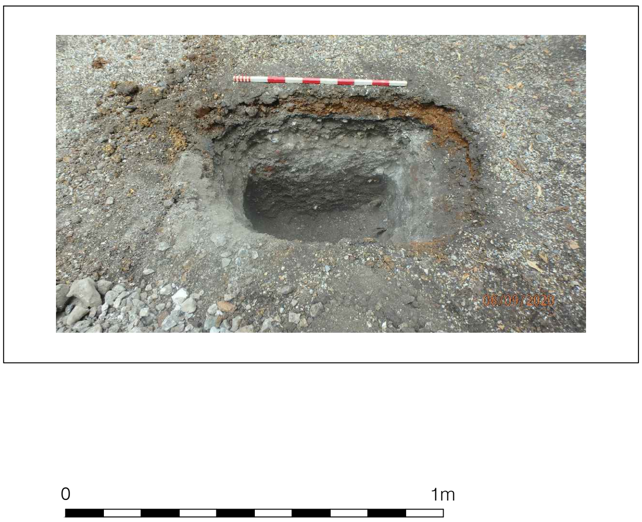
Figure 8B

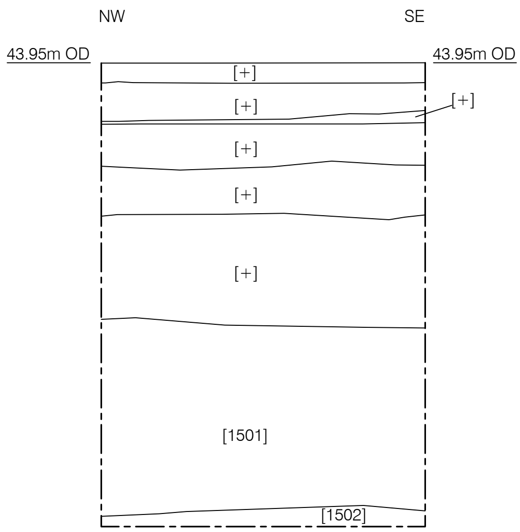




Section 6A
Test Pit 14
South Facing

Figure 8C





Section 14A
Test Pit 15
Northeast Facing

17/11/20 RM

Figures 8A-C
Sections
1:20 at A4