Land at Northfleet Embankment West
Gravesham, Kent

Palaeolithic Archaeological and Geoarchaeological Excavation

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Summary

Wessex Archaeology (WA) was commissioned by RPS, to undertake a Palaeolithic archaeological and geoarchaeological excavation on several parcels of land located across the Northfleet Embankment West site within the former Northfleet Cement Works, Gravesham, Kent. The investigation area is centred on NGR TQ 61931 7473.

The Palaeolithic archaeological and geoarchaeological excavations form part of a staged approach to mitigate against potential development impacts on the Palaeolithic resource. The work follows on from an archaeological Desk Based Assessment (CgMs 2008), Palaeolithic archaeological field evaluation (WA 2009), and a site wide Heritage Management Plan (RPS 2020) and archaeological monitoring of GI works (WA 2020a).

The Site has been divided into 8 areas of differing Palaeolithic archaeological and geoarchaeological potential/significance (WA 2009; 2020a). Priorities for further archaeological and geoarchaeological work to mitigate against the potential impact of the development on the Palaeolithic archaeological and geoarchaeological resource in the different areas have been outlined (WA 2020a). This document reports on Palaeolithic archaeological and geoarchaeological excavations in four areas, Areas 2 – 4, and Area 8. The report outlines the significance of the Palaeolithic archaeology present in in these areas and provides an update on the archaeological and geoarchaeological potential of Quaternary deposits in all areas of the Site.

The Palaeolithic archaeological and geoarchaeological excavations demonstrated that Pleistocene deposits are present within Area 2 – 4, and Area 8, beneath variable depths of made ground. These deposits principally belong to a terrace of the River Thames. Although mapped by the BGS as part of the Boyn Hill/Orsett Heath terrace (430 – 350 Ka), these investigations have demonstrated that these largely belong to a later terrace; likely the Lynch Hill/Corbets Tey terrace (350 – 280 Ka).

These investigations have established the stratigraphic sequence for Quaternary deposits in the areas investigated and refined those present across the Site. Additional GI data (ERM 2018) suggests that deposits of the Boyn Hill/Orsett Heath terrace (430 – 350 Ka). may be present in a restricted are in the northern part of Area 8. These deposits (?Phase I) may be equivalent with those from which historic artefact and faunal finds were made from south of the current investigation areas (Spurrell 1883).

These excavations have established that the stratigraphic sequence for the postulated Lynch Hill/Corbets Tey terrace deposits comprise basal chalky solifluction and fluvial sands and gravels with a high chalk component (Phase II and III). These sediments are in the southern part of the Site (Areas 2 and 3). They reflect solifluction and relatively high energy fluvial deposition under cold conditions by a braided river. These are overlain by fluvial sands and gravels (Phase IV), with a much lower chalk component, which are in turn overlain by horizontal and cross bedded fluvial sands (Phase V); these fluvial sands have produced tentative, minimum OSL estimates of MIS 8 to MIS 7 (300 – 191 Ka). The transition to the fluvial sands likely reflects a change from a braided river system to a period of infilling and of hollows and cut-off channels and a shift towards anatomising channel patterns with stable channels; this may also reflect a change to more temperate conditions.

Palaeolithic lithic artefacts have been recovered in low densities from throughout this fluvial sequence, except for the Phase V fluvial sands. The artefacts are undiagnostic flakes. The lithic artefacts from the basal chalky solifluction and fluvial sandy gravels (Phase III) include a small number of unabraded but edge damaged flakes. Their condition demonstrates that they are contemporary with the deposits and, although not *in situ*, are not significantly reworked. They reflect contemporary human activity during cool conditions likely late in a glacial or early in the subsequent interglacial. If the deposits do belong to the Lynch Hill/Corbets Tey terrace, they may reflect evidence for human activity late in MIS 10 or during MIS 9 (365 – 300 Ka). Palaeolithic archaeology of this

date is relatively rare in the Lower Thames, particularly south of the modern river. This archaeology is considered to have moderate-high significance in relation to national and regional research questions. The presence of minimally disturbed artefacts, albeit in low numbers, demonstrates that the Phase III deposits elsewhere may contain *in-situ*, potentially nationally significant, archaeology.

Other lithic artefacts from the fluvial sequence (Phase III-IV) exhibit varying degrees of fluvial abrasion. They may reflect reworking of material within the terrace, and/or material reworked from earlier terrace deposits. This reworked material is considered to have moderate significance in relation to national and regional research questions.

The investigations have confirmed that the paleoenvironmental of these deposits is generally low, although the lower chalky units do sporadically preserve molluscs and mammal bones. A small number of terrestrial molluscs and rodent teeth were recovered from a sample taken from chalky solifluction gravels. Given the small number of molluscs and rodent teeth preserved in the one productive sample (<5 of each), the potential for further analysis is limited.

The investigations have demonstrated that historic artefact and faunal finds from south of the investigation areas (Spurrell 1883) likely derive from earlier deposits of the Boyn Hill/Orsett Heath terrace (430 – 350 Ka). Additional GI data from the norther part of Area 8 indicates that these earlier terrace deposits (?Phase I) may be present in this area.

Colluvial deposits (Phase VII), which once likely overlay the fluvial deposits across the Site, have almost entirely been removed by previous impacts. However, these colluvial deposits are preserved with a very restricted area within the construction of a chalk slurry back wall (Area 3). The age of these deposits is unknown; they may include late Pleistocene and/or Holocene units. Neolithic artefacts, including a broken leaf shaped arrowhead and keeled blade core, were recovered from made ground in interventions in the same area of the site. These may be intrusive to the site; however, they could have originated from within similar colluvial deposits or features cut into such deposits.

Quaternary deposits have largely been removed from the northern part of the site by quarrying (Area 6). Additional GI data has clarified that potential fluvial deposits recorded beneath made ground in a restricted area in the north of the site (Area 7) are likely to be alluvial deposits overlying fluvial sands and gravels. The age of the fluvial sands and gravels (Phase VI) is unknown; however, their basal heights indicate that they predate the Shepperton Gravel of the Thames (17 – 11.7 Ka). Based on their basal height they are tentatively correlated with the East Tilbury Marshes terrace (123 – 11.7 Ka). The lithological description of these deposits suggests that their geoarchaeological potential is low, although the East Tilbury Marshes terrace as a whole has potential to include units associated with late Middle and Upper Palaeolithic archaeology.

The alluvial deposits (Phase VIII) are likely to be principally Holocene in age. They are coarse gained, gravelly sediments and therefore are likely to have low geoarchaeological potential. Holocene alluvial deposits have the broad potential to contain or mask Holocene archaeology.

Based on the results of these investigations, and consideration of the development proposals – including proposed landscaping of the site – recommendations regarding possible requirements for, and methods of, any further archaeological and geoarchaeological investigations in all 8 areas of the site are provided.

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Wessex Archaeology would like to thank Richard von Kalinowski-Meager of RPS for commissioning the Palaeolithic archaeological and geoarchaeological excavations. Wessex Archaeology is also grateful for the advice of Casper Johnson, Senior Archaeological Officer for KCC who monitored the project who monitored the watching brief on behalf of the LPA.

The fieldwork was directed by Dr Andrew Shaw and Jon Dobbie, with the assistance of Charlotte Porter, Elliot Gribbin, Jamie Kelsey and Elisha Meadows. This report was written by Dr Andrew Shaw with contributions from Jon Dobbie. Illustrations were prepared by Kitty Foster. The project was managed by Rob De'Athe on behalf of Wessex Archaeology.

Land at Northfleet Embankment West, Gravesham, Kent

Palaeolithic Archaeological and Geoarchaeological Excavation

1 INTRODUCTION

1.1 Project and planning background

1.1.1 Wessex Archaeology (WA) was commissioned by RPS ('the client'), to undertake a Palaeolithic archaeological and geoarchaeological excavation on several parcels of land located across the Northfleet Embankment West site located within the former Northfleet Cement Works, Gravesham, Kent (hereafter 'the Site'). The investigation area is centred on NGR TQ 61931 7473 (**Figure 1**).

1.1.2 The proposed development comprises the construction of residential and commercial properties, an open playing field and a Heritage Park, along with associated ground works.

1.1.3 Outline planning permission (EDC/16/0004) has been granted, subject to conditions. Condition 20 relates to Palaeolithic archaeological and geoarchaeological work.

20. No development, including earthworks, shall take place on any particular phase of the development until the applicant, or their agents or successors in title, has secured the implementation of a programme of archaeological interpretation work, covering the land/buildings/structures in that phase, and to include a programme of Palaeolithic archaeological work. These works shall be carried out in accordance with a written specification and timetable which has been submitted to and approved in writing by the Local Planning Authority.

Reason: To ensure that features of archaeological interest are properly examined and recorded, in accordance with adopted Gravesham Local Plan Core Strategy Policies CS09 and CS20.

1.1.4 Overall development proposals consist of:

- Residential development in the western area of the Site, following ground regrading. This regrading will involve cut and fill involving infilling areas to the north and cutting down of areas to the south, in order to create a smooth gradient northward towards the river;
- An open playing field and Heritage Park in the eastern part of the Site, to be created with elements of cut and fill, and
- Additionally, the two areas of former quarry to the southwest and southeast of the High Street are to be developed for employment purposes.

1.1.5 The Site lies within an Area of Archaeological Potential, associated with Pleistocene deposits with Palaeolithic archaeological and geoarchaeological potential (RPS 2020). This potential has been demonstrated by the results of previous Palaeolithic evaluation in the south west of the Site (WA 2009).

1.1.6 The Palaeolithic evaluation demonstrated the presence of Pleistocene fluvial deposits containing Palaeolithic archaeology beneath a variable thickness of made ground. The distribution of these deposits was refined through archaeological monitoring of GI works (WA 2020a). The combined datasets demonstrate that Pleistocene deposits are primarily present in the southern part of the Site and largely absent from the northern part of the Site.

1.1.7 The results of the Palaeolithic evaluation, when considered in relation to development proposals, demonstrate that further work is required to fulfil Condition 20 of outline planning permission and to mitigate against the impact of the development on the Palaeolithic archaeological and geoarchaeological resource.

1.1.8 These Palaeolithic archaeological and geoarchaeological excavation works form part of a staged approach to mitigating against potential development impacts on the Palaeolithic resource. The work follows on from an archaeological Desk Based Assessment (CgMs 2008), Palaeolithic archaeological field evaluation (WA 2009), and a site wide Heritage Management Plan (RPS 2020) and archaeological monitoring of GI works (WA 2020a).

1.1.9 All works were undertaken in accordance with a written scheme of investigation (WSI) which detailed the aims, objectives, methodologies and standards to be employed to undertake the evaluation (WA 2020b). The County Archaeologist for Kent County Council (KCC) approved the WSI, on behalf of the Local Planning Authority (LPA), prior to fieldwork commencing.

1.1.10 The excavation was undertaken between 9th November and 4th December 2020. It comprised the excavation, investigation and recording of 3 stepped trenches, 17 test pits and 3 sections.

1.2 Scope of the report

1.2.1 The purpose of this report is to provide a detailed description of the results of the Palaeolithic archaeological and geoarchaeological excavation, to interpret the results within a local, regional or wider geoarchaeological context and assess whether the aims of the excavation have been met.

1.2.2 The presented results will provide further information on the archaeological and geoarchaeological resource that may be impacted by the proposed development and facilitate an informed decision with regard to the requirement for, and methods of, any further mitigation works (preservation by record).

1.3 Location, topography and geology

1.3.1 The Site is located within the former Northfleet Cement Works at Northfleet, Kent (**Figure 1**). It is situated on the south bank of the River Thames and on the eastern side of the Ebbsfleet Valley. The Site is surrounded by previously quarried land, and much of the Site itself was previously quarried.

1.3.2 The natural ground surface reaches c. 30m above Ordnance Datum (aOD) at the southern boundary of the Site. Ground levels within the Site are often substantially lower than they would otherwise have been prior to quarrying (despite substantial backfilling), but generally the ground within the Site slopes down northward to c. 5m aOD.

1.3.3 The Northfleet Cement Works were set up as the Knight, Bevan and Sturge Works in the 1850s. These works were reconfigured in 1905 and rebuilt twice, in 1926 and then 1958, before parts were incorporated within the new Northfleet Works, constructed between 1969 and 1970. Cement production ceased at the Site in 2008 and the buildings demolished.

1.3.4 The Site currently consists of open grassed areas that are within and adjacent to former chalk quarry workings, and areas of concrete hard standing where the now demolished cement works buildings once stood.

1.3.5 According to the British Geological Survey mapping (BGS online viewer), the bedrock geology underling the Site consists of Upper Cretaceous deposits of the Seaford Chalk Formation (89.8 – 86.3 MA). At the highest, southernmost part of the Site, this is overlain by Thanet Sand (59.2 – 56.0 MA).

1.3.6 Overlying superficial deposits are only recorded along the southern edge and within the western part of the Site (**Figure 1**). These consist of Pleistocene deposits of the Boyn Hill/Orsett Heath terrace (430 – 350 Ka) of the Thames terrace sequence. It should be noted, however, that the results of previous Palaeolithic archaeological evaluation (WA 2009) suggests that these terrace deposits belong to an unmapped outcrop of the younger Lynch Hill/Corbets Tey terrace (350 – 280 Ka).

2 GEOARCHAEOLOGICAL, ARCHAEOLOGICAL AND HISTORICAL BACKGROUND

2.1 Introduction

2.1.1 The geoarchaeological, archaeological, and historical background was assessed in a prior Written Scheme of Investigation (WA 2020b), Palaeolithic archaeological monitoring of GI works report (WA 2020a), site wide Heritage Management Plan (RPS 2020) and Palaeolithic archaeological field evaluation report (WA 2009), The relevant information on the local Pleistocene geoarchaeological and Palaeolithic archaeological resource is summarized below. Additional sources of information are referenced as appropriate.

2.2 Previous investigations within the Site

Northfleet Cement Works, Kent, Archaeological (Palaeolithic Test Pit) Evaluation Report (WA 2009)

2.2.1 In 2009 ten Palaeolithic archaeological and geoarchaeological test pits were excavated in the south west of the Site (**Figure 2**). These demonstrated the presence of Pleistocene deposits preserved beneath a variable thickness of made ground. Although generally heavily truncated by quarrying activity, the full sequence of these deposits was shown to be present within the southern-most part of the evaluation area. The heights above OD of these fluvial deposits suggest that they belong to the Lynch Hill/Corbets Tey terrace of the Thames. These deposits were demonstrated to have Palaeolithic archaeological potential and produced seven typo-technologically undiagnostic flakes. The condition of these artefacts ranged from quite fresh to well-abraded, indicating the potential of the terrace deposits to contain minimally transported and more extensively derived Palaeolithic archaeology. No palaeoenvironmental evidence was recovered. No direct dating evidence was recovered; however, sand units with OSL dating potential were noted.

Land at Northfleet Embankment West, Gravesham, Kent, Palaeolithic Archaeological Monitoring of Ground Investigation (GI) Works (WA 2020a)

2.2.2 In 2020 six GI trial pits in areas with known Palaeolithic archaeological potential were subject to direct archaeological monitoring, whilst the descriptions of the deposits and draft GI logs for a further eight GI trial pits and nineteen cable percussion borehole logs were made available for review by a Palaeolithic archaeological and geoarchaeological specialist (**Figure 2**).

2.2.3 Quaternary deposits were present in two trial pits subject to direct archaeological monitoring. These deposits consisted of fluvial sands and gravels and equate with those that have previous produced Palaeolithic archaeology (WA 2009). No additional archaeological evidence was recovered during archaeological monitoring and no deposits preserving significant paleoenvironment material were encountered.

2.2.4 Review of the GI data enabled the lateral and vertical extent of Quaternary deposits in the Site to be refined and allowed previously defined areas of Palaeolithic potential (WA 2009) to be updated and augmented (WA 2020a).

2.3 Pleistocene geoarchaeological context

2.3.1 The Pleistocene fluvial deposits within the Site belong to the Lower Thames terrace sequence. The Lower Thames terraces (**Table 1**) constitute one of the most complete geological records of the last 500,000 years, within which internationally significant Palaeolithic archaeological records are preserved, along with associated geoarchaeological evidence of palaeoenvironmental and landscape change.

Table 1 Chronostratigraphic framework for Lower Thames terraces with the Boyn Hill/Orsett Heath and Lynch Hill/Corbets Tey terraces highlighted (based on Bridgland 2006).

Terrace	Units	Climate	Ages	MIS
Shepperton	Tilbury Alluvial Deposits	Warm	Holocene	1
	Shepperton Gravel	Cold	Devensian	2
East Tilbury Marshes	East Tilbury Marshes Upper Gravel	Cold	Devensian	5d-2
	Trafalgar Square deposits	Warm	Ipswichian	5e
	East Tilbury Marshes Upper Gravel	Cold		6
Taplow/Mucking	Mucking Upper Gravel	Cold		6
	Aveley Silts and Sands	Warm		7
	Mucking Lower Gravel	Cold		8
Lynch Hill/Corbets Tey	Corbets Tey Upper Gravel	Cold		8
	Purfleet Silts and Sands	Warm		9
	Corbets Tey Lower Gravel	Cold		10
Boyn Hill/Orsett Heath	Orsett Heath Upper Gravel	Cold		10
	Swanscombe interglacial deposits	Warm	Hoxnian	11
	Orsett Heath Lower Gravel	Cold	Late Anglian	12
Plateau gravels		?	?pre-Anglian	>12

2.3.2 The Pleistocene fluvial deposits within the Site are mapped by the BGS as the Boyn Hill/Orsett Heath terrace of the River Thames. However, previous investigations (WA 2009; 2020a) demonstrated that these deposits are at a lower basal elevation than other Boyn Hill/Orsett Heath deposits the area; a tentative correlation with the younger Lynch Hill/Corbets Tey terrace was therefore suggested (see **Table 1**).

2.3.3 The Boyn Hill/Orsett Heath terrace has been shown to be present intermittently along the south side of the Lower Thames from Dartford Heath through Dartford, Stone, Greenhithe and Swanscombe to Northfleet. The Boyn Hill/Orsett Heath terrace incorporates sands and gravels generally reflecting deposition under cold climatic conditions and interglacial sediments, which are generally finer grained. It is currently thought to have aggraded between MIS 12 and MIS 10 (430 – 350 Ka).

2.3.4 The Lynch Hill/Corbets Tey terrace is poorly represented within BGS mapping on the south bank of the Lower Thames and is absent in area of the Site (BGS online viewer). However, this lack may be a reflective of inaccuracies in the mapping, rather than a genuine absence. In addition to evidence from the current Site (WA 2009; 2020a), a lower level, post-Boyn Hill fluvial deposits that have been identified at the north side of New Craylands Lane (Wenban-Smith 1999), located 2.4 km west of the current Site.

2.3.5 In order to assess Palaeolithic archaeological and geoarchaeological potential, ten test pits have previously been excavated within the Site (WA 2009; Figure 2). These demonstrated that Pleistocene deposits were preserved beneath a variable thickness of made ground. Although truncated by quarrying activity, the full sequence of these deposits was shown to be present within the southern-most part of the Site. The Pleistocene sequence encountered is summarized in **Table 2**.

Table 2 Sediment groups recorded during previous Palaeolithic evaluation (WA 2009)

Sediment Group	Period	Deposit	Description	Interpretive notes	Test pits
M	19^{th} – 20^{th} C	Modern made ground	Very variable across site; includes very compacted chalk-silt and cement-making waste; major deposits of bricks, concrete, ironwork and sand; well-compacted ash and clinker	Mostly waste from cement works	All TPs — especially 1-5, 7
IV	Pleistocene (late Middle)	Clayey /silty sand	Firm reddish-brown clay-silty sand with trails dipping downslope to N of fine flint and chalk pebbles	Probably colluvial slopewash	Sec 1
III	Pleistocene (late Middle)	Sand	Variably soft/firm brownish-yellow VF-M sand	Probably fluvial	9, 10, Sec 1
II	Pleistocene (late Middle)	Sandy /chalky gravel	Soft and loose, horizontally bedded flint gravel in sandy matrix; also contains chalk pebbles at certain horizons	Fluvial	5, 6, 8, 9-10, Sec 1
I	Pleistocene (late Middle)	Chalk diamict	Coarse chalk pebbles in cream/very pale brown chalk silt matrix	Hardly seen; probably grades rapidly down into Chalk bedrock	6, 8
C	Cretaceous	Chalk	Solid dry white crumbly Upper Chalk with bands of flint nodules	Cretaceous bedrock	None — but proved in geotechnical investigations

2.3.6 Sediment Groups II and, likely, III are Pleistocene fluvial deposits. They were found between 12 m and 17 m aOD. As deposits of the Boyn Hill/Orsett Heath terrace are found above 25 m aOD in the area, the fluvial deposits in the Site are likely to belong to a younger terrace.

Correlation with Lynch Hill/Corbets Tey terrace has been suggested (WA 2009). No direct dating evidence was recovered during the evaluation; however, sand units (Sediment Group III) with OSL dating potential were recorded.

2.3.7 No palaeoenvironmental evidence was recovered during the evaluation; however, deposits within Sediment Group III contained a chalk clast component which could provide calcareous conditions suitable for the preservation of more robust faunal elements (WA 2009). Additionally, Spurrell (1883: 102) recovered mammalian faunal remains including straight-tusked elephant, rhinoceros and deer from a small quarry that was located within the current Site boundary (**Figure 1**).

2.4 Palaeolithic Archaeological Context

2.4.1 Boyn Hill/Orsett Heath deposits found between Dartford Heath and Northfleet have produced internationally significant Lower Palaeolithic hominin remains, archaeology and associated palaeoenvironmental datasets.

2.4.2 At Barnfield Pit, Swanscombe, located 2.4 km west of the Site, an early human fossil skull, extensive Lower Palaeolithic archaeological assemblages and wide-ranging environmental datasets have been recovered from these sediments (Conway et al. 1996).

2.4.3 The Barnfield Pit Middle Pleistocene and Lower Palaeolithic sequence is in summarized in **Table 3**.

Table 3 Summary of Barnfield Pit Lower Palaeolithic sequence

Phase	Stratigraphic Unit	Marine Isotope Stage	Date (Ka)	Palaeolithic Archaeology
III	Upper Gravel	11-?8	?375-300	Associated with Palaeolithic archaeology, but poorly provenanced material
	Upper Loam			
II	Upper Middle Gravel	11	?400-375	Assemblages containing frequent handaxes, often pointed in form. Hominin skull fragments attributed to junction between Upper and Lower Middle Gravel. Abundant environmental evidence but thought to be largely associated with Lower Middle Gravel
	Lower Middle Gravel			
I	Lower Loam	11	425-400	Core, flake and flake tool assemblages generally lacking handaxes (Clactonian), associated with extensive environmental datasets, minimal disturbed archaeology preserved within Lower loam associated with land surfaces

2.4.4 Deposits of Lynch Hill/Corbets Tey terrace in the Lower Thames, are associated nationally and internationally significant late Lower and early Middle Palaeolithic archaeological assemblages and associated palaeoenvironmental evidence. This is particularly the case on the north bank of the Thames around Greys (Wymer 1985, Bridgland 1994) and Purfleet (Schreve et al. 2002, Scott 2011, Bridgland et al. 2013). The purported absence of the

Lynch Hill/Corbets Tey terrace within the area of the Site has meant that such contemporary evidence is poorly documented in this area south of the Thames (see **section 2.3.4**).

2.4.5 Within the Site itself, a Palaeolithic handaxe and several flakes in fresh condition were found by Spurrell (1883: 102; Figure 1) along with a range of fossil animal remains (see **section 2.3.7**).

2.4.6 The Palaeolithic archaeological potential of extant Pleistocene fluvial deposits within the Site has been demonstrated by the recovery of seven flint flakes during a previous Palaeolithic test pitting evaluation (WA 2009). These were all recovered from Sediment Group II – sandy/chalky fluvial gravel (**Table 2**). The flakes ranged in condition from quite fresh to well-abraded, demonstrating the potential for minimally to more extensively derived Palaeolithic archaeology to be preserved within the Pleistocene deposits in the evaluation area.

2.5 Areas of Palaeolithic potential and priorities for excavation

2.5.1 Based on the results of previous Palaeolithic evaluation and archaeological monitoring of GI works (WA 2009; 2020a), the Site has been divided in areas of differing Palaeolithic archaeological and geoarchaeological potential/significance. These areas are illustrated in **Figure 2** and summarised in **Table 4**.

2.5.2 Priorities for further archaeological and geoarchaeological work in different areas are outlined in **Table 4**. As outlined in the WSI (WA 2020b), these priorities have been assigned based on results the of previous Palaeolithic evaluation and archaeological monitoring of GI works (WA 2009; 2020a) and proposed development impacts.

Table 4 Areas of Palaeolithic potential

Area	Nature of evidence	Depth of Made Ground overlying Pleistocene deposits	Approx. max depth of proposed cut	Palaeolithic potential/ significance	Priorities for further works
1-a 1-b 1-c	Undisturbed original, pre-quarrying sediment sequence preserved under roads and footpaths	Minimal made ground	0.00m	Moderate	• None required as there are no proposed development impacts in these areas
2	Minimally backfilled, full preservation of artefact-bearing gravel, and the lower part of overlying sand. Basal sand also recorded in GI	0.60-1.60m	1.50m	Moderate	• Record sequence and lateral changes • Sieve larger samples for artefacts • Carry out OSL dating on upper sand and any other suitable units encountered • Sample for palaeoenviro. remains, if present

3	Partly backfilled in places (e.g. "Chimney Green" open space), but mostly minimal made ground, and with substantial thickness of artefact-bearing gravel	0.30-2.00m	4.00m	Moderate	• Record sequence and lateral changes • Sieve larger samples for artefacts • Carry out OSL dating on any suitable units encountered • Sample for palaeoenviro. remains, if present
4	Backfilled with made ground to depth of up to c. 3 m, but with preservation underneath of substantial thickness of artefact-bearing gravel	1.80-2.80m+	5.00m	Moderate (at medium depth)	• Record sequence and lateral changes • Sieve larger samples for artefacts • Sample for palaeoenviro. remains, if present
5	Backfilled with made ground to depth of c. 5 m, but with possible preservation in places underneath of lower parts of artefact-bearing gravel. Basal sand recorded in GI	3.00m+	6.50m	Moderate (at great depth)	• Depth of made ground precludes predevelopment investigation of Pleistocene deposits • Based on assessment of the results of mitigation works in adjacent areas, and consideration of the depth of development impacts in specific parts of this area, a targeted watching brief during ground works may be considered
6	Substantially quarried and backfilled; likely most, if not all, Quaternary deposits removed	6.00-12.00m	10.00m	Low	• None required as previous impacts have largely or entirely removed Quaternary deposits in this area
7	Isolated occurrence of sands and gravels; possibly redeposited	?2.50-6.00m	0.00m	Unknown	• None required as there are currently no proposed development impacts for this area

8	LiDAR data suggests original ground surface is present. GI data is only available for southern part of zone, which indicates +4.00m of mage ground present in this part of area. Unknown whether accessible Quaternary deposits are preserved in norther part of area	4.00+ in southern part of area; unknown in northern part of area	TBC	Unknown	• Assess whether intact Pleistocene deposits are present in the northern part of area • Recover a representative sample of any archaeological evidence from Pleistocene deposits, if present • Sample for palaeoenviro. remains from Pleistocene deposits, if present

2.5.3 An integrated strategy of Palaeolithic archaeological and geoarchaeological investigation designed to mitigate against potential impacts on the Palaeolithic resources in each area of Palaeolithic potential is outlined in the WSI (WA 2020b). This is summarized by area below.

Areas 1-a, 1-b and 1-c

2.5.4 These areas are located under roads and footpaths and will not be impacted on by development proposals. Therefore, no mitigation works in these areas are required.

Area 2

2.5.5 Pleistocene deposits known to preserve Palaeolithic archaeology may be 0.75 mbgl and extend beyond 2.30 mbgl in this area (WA 2009). Deposits with known dating potential are found below 0.75 m below ground level. These will be impacted on by the proposed development.

2.5.6 Mitigation works in this area are required to recover Palaeolithic archaeology through systematic sieving of deposits; recording in detail associated Pleistocene deposits; assessment of whether deposits with palaeoenvironmental potential are present (and where present sampling such deposits); and the recovery of Optically Stimulated Luminescence (OSL) samples for dating. These works are reported on in this report.

Area 3

2.5.7 Pleistocene deposits known to preserve Palaeolithic archaeology may be 0.65 mbgl in this area and continue to at least 3.30 mbgl (WA 2009). These deposits will be impacted by the proposed development, except in Chimney Green open space where no significant development impacts are proposed.

2.5.8 Mitigation works in areas impacted on are required to recover Palaeolithic archaeology through systematic sieving of deposits; recording in detail associated Pleistocene deposits; assessment of whether deposits with environmental potential are present (and where present sampling such deposits); and the recovery of OSL samples for dating. These works are reported on in this report.

Area 4

2.5.9 GI monitoring has shown that Pleistocene deposits broadly equivalent to those in Areas 2 and 3 are found beneath at least 1.80 m of made ground in this area (WA 2020a). These deposits will be impacted on and have not previously been archaeologically investigated.

2.5.10 Mitigation works in this area are aimed at recovering Palaeolithic archaeology through systematic sieving of deposits and palaeoenvironmental datasets, should they be present. These works are reported on in this report.

Area 5

2.5.11 GI monitoring has shown that Pleistocene deposits broadly equivalent to those in Areas 2 and 3 are generally found beneath at least 4.00 – 5.00 m of made ground (WA 2020a). These deposits may potentially be impacted on by development in places, but their depth precludes pre-development investigation works in this area.

Area 6

2.5.12 GI monitoring suggests Pleistocene deposits are absent from this zone (WA2020a) and no mitigation is required.

Area 7

2.5.13 GI monitoring suggests Pleistocene deposits of unknown potential could be present in this area (WA2020a). However, as there are currently no proposed development impacts for this area, no mitigation is required.

Area 8

2.5.14 Based on LiDAR data, it has been suggested the original, pre-quarrying ground surface may be present in this area (RPS 2020). No previous archaeological works have been carried out in this area.

2.5.15 Ground investigation works (ERM 2018) have, however, demonstrated that at least 4.00m of made ground is present in the southern part of Area 8. It is currently unknown what deposits are present in the northern part of the area

2.5.16 To assess whether intact Pleistocene stratigraphy is present in the northern part of this area, and to recover Palaeolithic archaeological and Pleistocene palaeoenvironmental remains, test pitting is required. The results of this test pitting are reported on in this report.

3 AIMS AND OBJECTIVES

3.1 Aims

3.1.1 The aims (or purpose) of the Palaeolithic archaeological and geoarchaeological excavation, in compliance the CIfA's *Standard and guidance for an archaeological excavation* (CIfA 2014a), Kent County Council's (KCC) *Manual of Specification Part B Specification for Detailed Evaluation of Quaternary Deposits and Palaeolithic Potential* and *Manual of Specification Part B Mitigation – Specification for Detailed Palaeolithic Excavation*, were:

- to establish with a high degree of confidence the nature, character, distribution, extent and depth of Pleistocene deposits within the investigation areas;
- to establish with a high degree of confidence the nature, character and distribution of the Palaeolithic archaeological and geoarchaeological resource within the investigation areas;
- to recover, and place within secure chronological, taphonomic and behavioural context, Palaeolithic archaeological and palaeoenvironmental evidence present within the investigation areas;

- to investigate the spatial distribution of Palaeolithic artefacts within the main stratigraphic horizons identified during previous evaluation, consider whether they are evenly dispersed through them, or whether they are present in spatial concentrations and if so at what scale, and

- to provide a detailed record of Palaeolithic archaeological and geoarchaeological resource as a basis for future study and interpretation.

3.2 Objectives

3.2.1 To achieve the above aims, the objectives of the Palaeolithic excavation were:

- to record the Pleistocene deposits, present within the investigation areas, identify lateral and vertical changes, and provide a detailed assessment of associated depositional processes;

- to recover stratigraphically secure Palaeolithic lithic assemblages, through systematic artefact sampling and sieving;

- to obtain OSL dating samples from suitable deposits;

- to take paleoenvironmental samples from suitable deposits, if present, and

- to relate the results of the mitigation works to regional and national research themes and priorities.

4 CONTRIBUTION TO RESEARCH AGENDAS

4.1 Introduction

4.1.1 Assessment of the archaeological and geoarchaeological potential of Pleistocene deposits present in the Site demonstrates that they have Palaeolithic archaeological and geoarchaeological potential. Specifically, they may preserve evidence which can contribute to the national and regional research themes and priorities outline below.

4.2 Research and Conservation Framework for the British Palaeolithic (EH 2008a)

Hominin Environments and Climate Drivers:

- What effect did Pleistocene climate change have upon British environments and faunal communities?

- How much of Pleistocene time saw the presence of hominins in Britain or on the adjacent continental shelf?

- What were the specific environmental and climatic tolerances of hominins in Britain?

- How did hominin subsistence, technical and social strategies respond to climate change over the long-term?

Hominin Demographies: The Palaeoecology of Hominin Colonisation and Settlement Processes:

- How did Pleistocene faunal communities change over time, and what was the pattern of human interaction with and impact on these?

- What were the biological relationships between British Pleistocene populations and those of neighbouring regions?

4.3 South-East Research Framework: The Early Palaeolithic in the South-East (KCC 2019)

Fluvial deposits:

- 5 - How disturbed/transported are Palaeolithic remains in fluvial contexts?
- 6 - Are there levels or geographic/topographic zones within deposits that are more likely to be richer in Palaeolithic artefactual remains?
- 7 - Improved mapping, longitudinal correlation and dating of terrace systems within major river valley and tributary systems
- 8 - Are there correlations of terrace units between basins/systems?
- 9 - What is the relationship of terrace formation with tectonic uplift, climate change and marine isotope stage (MIS) framework?
- 10 – Can characterisation of occupation (technological/typological change, presence/density of occupation) in specific terrace units be combined into a regional/basin picture?
- 12 - Modelling of fluvial deposit zones/types more likely to contain undisturbed or minimally disturbed remains and biological remains

5 METHODS

5.1 Introduction

5.1.1 All works were undertaken in accordance with the detailed methods set out within the WSI (WA 2020b) and in general compliance with the standards outlined in relevant CIfA and Historic England guidance (CIfA 2014a, HE 2015a). Any significant variations to the proposed methods were agreed in consultation with the Senior Archaeological Officer to KCC and the client, prior to being implemented. The methods employed are summarised below.

5.2 Fieldwork methods

Trenches

5.2.1 Trenches were dug in stages and stepped to allow direct recording of continuous sedimentary sequences, sampling for palaeoenvironmental evidence and dating evidence, and for samples to taken and sieved for artefacts along their length and throughout the accessible Pleistocene sequence.

5.2.2 The locations of the trenches are illustrated in **Figure 2.** As outlined in the WSI (WA 2020b), the trenches were located and orientated based on the results of the prior evaluation (WA 2009) to investigate areas where archaeology was recorded and where different sets of deposits are located (including those suitable for OSL dating). The trenches were orientated to encompass broadly the same groups of deposits in both trenches. An illustrative plan and cross-section of the trenches (longitudinal and transverse) is provided in **Figure 3**.

5.2.3 Trench 100 (Area 3) had a maximum dimension of 30.00 x 7.00 m (**Plates 1 – 2**). Due on-site constraints, and following agreement with the County Archaeologist for KCC, Trench 101 (Area 2) was split into two separate trenches (Tr101 and Tr102) with maximum dimensions of 12.50 x 6.50 m and 13.50 x 7.500 m (**Plates 3 – 6**). These trenches respected the original coordinates and orientation as close as reasonably possible. An additional test pit (TP28) was also added to further determine the extent of the deposits in Area 2.

5.2.4 Each stepped trench was be excavated by a 20 tonne 360º mechanical excavator equipped with a toothless bucket. Machine excavation was under the constant supervision and instruction of geoarchaeological specialist with experience of recording and interpreting Pleistocene sediments and identifying Palaeolithic artefacts.

5.2.5 The upper cut of each trench was machine excavated in level spits of approximately 50 – 100 mm. Steps were cut at the ends of each trench to facilitate safe ingress and egress.

5.2.6 Once the initial upper cut of the trench was complete to a depth of approximately 1.20m, at least one long section was photographed, drawn and, the deposits sampled for paleoenvironmental evidence and OSL dating.

5.2.7 On completion the upper cut, each trench was widened and, where appropriate, the sections battered back prior to the excavation of the lower cut to an approximate depth of 1.20 m. Once the lower cut of the trench was complete, at least one long section was photographed, drawn and the deposits sampled for paleoenvironmental evidence and OSL dating.

5.2.8 Samples of at least 200 litres were taken at regular intervals along each cut of each trench throughout Quaternary deposits and respecting stratigraphic boundaries. These samples were sieved on site through a 10 mm mesh to investigate whether artefacts and/or macro mammalian faunal remains were present. If the sediments encountered were not suitable for dry-sieving (i.e. too clayey), deposits were carefully investigated by hand (using archaeological trowels) for any geoarchaeological evidence.

5.2.9 The degree of truncation of deposits were recorded in all trenches. All Quaternary deposits were recorded. Deposits with the potential to preserve archaeology post-dating that associated with the Pleistocene terrace deposits present, were highlighted and the potential assessed.

Test Pits

5.2.10 As outlined in the WSI (WA 2020b), test pits were distributed to investigate areas where GI data (WA 2020) suggested that deposits with archaeological and geoarchaeological potential were present, and which were between where such deposits were identified during evaluation (WA 2009). The locations of the test pits are illustrated in **Figure 2**. An additional test pit was excavated in Area 2 (TP28; see above). Furthermore, in agreement with the Senior Archaeological Officer for KCC, one test pit (TP27) was replaced by cleaning sampling and recording of a recently exposed section (Sec31) through Pleistocene fluvial deposits.

5.2.11 The test pits were excavated using a 20 tonne 360º mechanical excavator with a toothless bucket. Machine excavation was under the constant supervision and instruction of a recognised geoarchaeological specialist with experience of recording and interpreting Pleistocene sediments and identifying Palaeolithic artefacts, who recorded and numbered the sequence of sedimentary units as excavation progresses, following standard descriptive practices. The textural characteristics (grain-size, consolidation, colour, material and sedimentary structures) of sedimentary units were recorded, and the shape and nature of their lithostratigraphic contacts (dip, conformity and overall geometry). Machine excavation proceeded in level spits of approximately 50 – 100 mm, respecting the interface between sedimentary units, until either the solid geology was exposed, or further excavation became impractical.

5.2.12 Test pits were entered at the maximum safe depth (usually c. 1.20 m, but less if loose sands/gravel are present) to record the upper stratigraphy. After excavation had progressed beyond this depth, recording took place without entering the test pit. However, it was occasionally necessary to widen and step out the upper part of a test pit to allow direct access to its lower part for controlled sediment sampling.

5.2.13 Excavated material from the different Pleistocene stratigraphic horizons was screened by the monitoring geoarchaeologist to investigate whether artefacts and/or macro mammalian faunal remains were present. Where appropriate, at least 200 litre sediment samples of the deposits were taken at appropriate intervals in stratigraphic succession and sieved on site through a 10 mm mesh to investigate whether artefacts and/or macro mammalian faunal remains were present. If the sediments encountered were not suitable for dry-sieving (i.e. too clayey), deposits were carefully investigated by hand (using archaeological trowels) for any geoarchaeological evidence.

5.2.14 The degree of truncation of deposits was recorded in all test pits. All Quaternary deposits were recorded. Deposits with the potential to preserve archaeology post-dating that associated with the Pleistocene terrace deposits were highlighted and their potential assessed.

Sections

5.2.15 Three upstanding sections through Pleistocene deposits were identified within the Site during excavation works. In consultation with the Senior Archaeological Officer for KCC these sections were cleaned, sampled and recorded. Two (Sec29 and 30) are additional to the investigations outlined in the WSI (WA 2020b), whilst a third (Sect. 31) replaces a test pit (TP27).

5.2.16 All three sections were cleaned by hand. The deposits exposed in each section were investigated by a recognised Palaeolithic specialist with experience of recording and interpreting Pleistocene sediments, who recorded and numbered the sequence of sedimentary units following standard descriptive practices. The textural characteristics (grain-size, consolidation, colour, material and sedimentary structures) of sedimentary units will be recorded, and the shape and nature of their lithostratigraphic contacts (dip, conformity and overall geometry).

5.3 Sampling and dating

5.3.1 Appropriate strategies for the recovery, processing and assessment of artefacts and environmental samples were in line with those detailed in the WSI (Wessex Archaeology 2020b). The treatment of artefacts and environmental remains was in general accordance with: *Guidance for the collection, documentation, conservation and research of archaeological materials* (CIfA 2014b) and *Environmental Archaeology: A Guide to the Theory and Practice of Methods, from Sampling and Recovery to Post-excavation* (EH 2011).

5.3.2 The potential for deposits to preserve paleoenvironmental evidence was assessed for each Quaternary sediment unit. If deposits suitable for palaeoenvironmental sampling were encountered, appropriate samples were taken following the methodologies outlined in the WSI (WA 2020b).

5.3.3 Provision was made for palaeoenvironmental assessment of samples taken from Quaternary deposits and reporting on the results. This enabled the potential of samples taken to be established and informed recommendations made for any further processing and/or specialist analysis required.

5.3.4 Consideration was given to the suitability of any sediment units for optically stimulated luminescence dating (OSL). Where suitable deposits were encountered and accessible, samples were taken, and selected samples processed. Samples for OSL dating were taken following Wessex Archaeology's in-house guidance, which adheres to the principles outlined in Historic England's Luminescence Dating: Guidelines on using luminescence dating in archaeology (EH 2008b).

5.4 Recording

5.4.1 All deposits exposed in trenches, test pits and sections were recorded using Wessex Archaeology's pro forma recording system.

5.4.2 Descriptions include information such as:

- Depth
- Texture
- Composition
- Colour
- Inclusions
- Structure
- Shape and nature of contacts between deposits

5.4.3 Interpretations for deposits include, where possible, probable depositional environments and formation processes.

5.4.4 A full photographic record was made using digital cameras equipped with an image sensor of not less than 10 megapixels. Digital images have been subject to managed quality control and curation processes, which has embedded appropriate metadata within the image and will ensure long term accessibility of the image set.

5.5 Deposit modelling

5.5.1 A previous deposit model for the Site has been produced (WA 2020a). This has been updated utilising the data from these investigations and additional GI data provided by the client (ERM 2018).

5.5.2 To create the deposit model for the Site, 126 deposit records were reviewed (**Figure 4**).

5.5.3 The different lithologies were entered into industry standard software (Rockworks ™ v17.0) and assigned to a stratigraphic unit.

5.5.4 Three representative transects mapping the subsurface topography beneath the Site have been produced (**Figures 5 –-12**).

5.6 Monitoring

5.6.1 The Senior Archaeological Officer to KCC, on behalf of the LPA, monitored the excavation through regular site visits. Any variations to the WSI, if required to better address the project aims, were agreed in advance with both the client and the Senior Archaeological Officer to KCC.

6 RESULTS

6.1 Introduction

6.1.1 The results of the archaeological and geoarchaeological excavation are outlined. The stratigraphic, archaeological and dating evidence is reviewed, and palaeoenvironmental potential of the deposits discussed.

6.2 Stratigraphic evidence

6.2.1 The stratigraphy present in 3 trial trenches, 17 test pits and 3 sections are listed and summarized below. The specific lithologies and stratigraphic succession encountered in each intervention are outlined in **Appendix 1**.

6.2.2 The generalised stratigraphic sequence preserved across the five areas investigated (Areas 2 – 4, and Area 8; see **Figure 2**) Site comprises:

- Made ground (Recent)
- Colluvial deposits (Holocene and/or Pleistocene)
- Fluvial sand and gravel (Middle Pleistocene)
  - Fluvial sand
  - Sandy flint gravel
  - Sandy flint and chalk gravel
  - Fluvial and soliflucted sand and gravel
- Chalky solifluction gravel (Middle Pleistocene)
- Brecciated chalk (Cretaceous)
- Bedrock chalk (Cretaceous)

Chalk and brecciated chalk

6.2.3 Chalk bedrock is present across Areas 2 – 4 and Area 8, the upper parts of which is often brecciated with light greyish brown clays infilling fractures (**Plates 7 – 10**). The brecciated chalk reflects chalk fractured through freeze-thaw and clays the associated downward movement of sediments from the overlying unit.

Chalky solifluction gravel

6.2.4 These solifluction deposits overlay chalk bedrock and are principally recorded at the base of the Pleistocene sequences in Areas 2 and 3 (**Plates 7 – 9**).

6.2.5 The chalky solifluction gravel consists of poorly sorted, fine to coarse chalk gravel with occasional flint clasts in sandy chalky silt matrix. The upper units are matrix supported, whilst it becomes clast supported with depth. In some instances, coarse stratification is apparent. These sediments have been reworked down-slope by solifluction processes; they reflect periglacial seasonal and perennial freeze-thaw processes.

Fluvial and soliflucted sand and gravel

6.2.6 Separate stratigraphic phases are apparent within fluvial sand and gravel present in Areas 2 – 4, and Area 8. The earliest phases are fluvial sands and chalky gravels interstratified with soliflucted sediments; these are present in the southern-most parts of Areas 2 and 3 (e.g., Tr100, TP14 and TP28).

6.2.7 The fluvial sediments consist of fine to medium sub-angular to sub-rounded flint and chalk clasts in light brownish yellow fine to medium sand matrix; they exhibit sub-horizontal and crossed bedding structures. The soliflucted sediments are generally structureless, chalky gravels within a light greyish yellow silt and coarse sand matrix. The gravel component is poorly sorted and contains angular, sub-angular, sub-rounded and rounded flint clasts (including Paleogene marine pebbles), and angular and sub-angular, blocky chalk clasts. In areas close to the chalk bedrock, soliflucted material can occur in lobes interstratified between fluvial sands and gravel (**Plate 8 – 7**).

6.2.8 The fluvial deposits reflect high energy deposition by a braided river, likely under cold climatic conditions. These fluvial sediments are located towards the southern lateral margin of the terrace where the chalk bedrock rises. Close to the edge of terrace, where they are close to the chalk, the fluvial deposits are interstratified with soliflucted material which has moved down-slope, again likely in a cold climate.

Sandy flint and chalk gravel

6.2.9 In the north of Area 2 (e.g., Tr 101 and 102) the lowermost fluvial deposits consist of light greyish yellow to light reddish yellow gravelly sand and matrix supported sandy gravel. The deposits are sub-horizontally bedded and the gravels, and comprise fine to coarse sub-angular, sub-rounded, rounded flint clasts, and sub-rounded and rounded chalk clasts, which are moderately sorted (**Plate 9**).

6.2.10 These sands and gravels are the lateral equivalent of the interstratified fluvial and soliflucted sediments identified in the southern part of Areas 2 and 3.

Sandy flint gravel

6.2.11 In Areas 2 and 3 it is possible to define a clear stratigraphic separation between the lower, chalky fluvial sand and gravel and overlying, principally flint dominated, sand and gravel. The lower chalkier gravel appears to be absent from Area 8.

6.2.12 The upper fluvial sand and gravel consists of light brownish red gravelly sand and matrix supported sandy gravel (**Plate 10**). The gravel principally consists of fine to coarse sub-angular and sub-rounded flint clasts; it tends to be moderately well sorted. The deposits are sub-horizontally bedded and include clayey sand and more gravelly lenses.

Fluvial sand

6.2.13 Sub-horizontally and cross bedded reddish-brown silty fine sands and light-yellow fine to medium sand units overlie sandy flint gravel in Areas 2 – 4 and Area 8 (**Plates 11 – 12**). In all cases the upper units of this sand have been truncated by previous impacts. Data from these investigations and GI suggest that, if previously present, the fluvial sand has been entirely removed by recent truncation in the northern part of Area 4 (e.g. TP17) and across Area 5.

6.2.14 The fluvial sand includes laminated sand units and silty clay lenses. In Area 8 the sand is interbedded with gravelly layers (**Plate 12**). These fluvial sands are characteristic of bars located within a meandering river system; they potentially reflect a transition to more temperate conditions.

Colluvial deposits

6.2.15 Across nearly all the Site the upper part of the fluvial sequence is truncated and overlain by varying depths of made ground. However, a concrete chalk slurry back wall in Area 3 has been broken through revealing that the construction involved cutting down deposits either side and revetting the faces with concrete. This has preserved Quaternary sediments in the core of the wall (**Plate 13**).

6.2.16 The two sections revealed by the breach in the wall demonstrate that colluvial deposits are present overlying the truncated surface of the underlying fluvial sand (**Plate 14**). The colluvial sediments are heavily rooted and bioturbated. Stratigraphy is apparent within these colluvial deposits, indicating that they may reflect several phases of deposition during the Pleistocene and/or Holocene. They consist of clayey sand and sandy silt units; the latter may include an aeolian component. Some units are gravelly, and incorporate sub-rounded, sub-angular and angular chalk and flint, including glauconitic flint pebbles originating from Palaeogene marine deposits. This gravel component will be derived from underlying Pleistocene fluvial gravels, whilst the marine clasts may derive directly from upslope Thanet Sand outcrops. The sediments all reflect material reworked down-slope through colluvial processes.

Made ground

6.2.17 Variable thicknesses of made ground are present across Ares 2 – 4 and Area 8, which truncates the underlying Pleistocene deposits. The made ground includes backfill and construction debris from the chalk works. In places it includes redeposited chalk, Pleistocene fluvial gravel, colluvial sediments and likely Holocene alluvial sediments.

6.3 Deposit modelling outputs

6.3.1 The deposit modelling comprised a series of modelled outputs consisting of 8 cross-sections along transects through the deposits within the Site (**Figures 5** – **12**). These incorporate data from current and previous archaeological investigations (WA 2009; 2020a), and all available GI (WA2020a, ERM 2018).

6.3.2 The cross-sections are two-dimensional vertical displays of the deposit records along lines drawn across the Site, modelling the possible make-up of the deposits between individual deposit records. This was achieved using Rockworks to interpolate the upper and lower surface of stratigraphic units, creating a grid model which was sliced along the path of the drawn transect, then overlaying that vertical slice of the model with interventions located along the lines of the transects.

6.3.3 Cross-sections 1 and 2 (**Figures 5** – **6**) are south to north orientated transects through the Quaternary deposits in the western part of the Site (Areas 3, 5 and 6). They demonstrate that Pleistocene fluvial deposits with basal heights of the are found at 17.00 maOD to 9.00 maOD are present beneath varying depth of made ground in Areas 3 and 5, with made ground increasing to the north (up to 5.00 m in Area 5); in Area 3 the chalk bedrock rises to abut these deposits. These Pleistocene deposits have been entirely removed by quarrying activity in the northern part of the Site (Area 6); the northern-most limit of these is in the vicinity of TP28. Additional GI data (ERM 2018) records fluvial deposits at the southern boundary of the Site in Area 1c (TP220). Although, the base of the deposits in Area 1c are not recorded, they appear to be at a higher elevation than those in Areas 3 and 5, and may reflect a higher, earlier terrace. Fluvial sand overlies fluvial sand and gravel in Area 3; it is not found north of TP215 (Area 3) and is absent from Area 5. The upper part of the Pleistocene fluvial sequence has been truncated by previous impacts across Areas 3 and 5; a small remnant of colluvial deposits overlying the Pleistocene fluvial sequence is present in Area 3, within the construction of the wall of a chalk slurry back.

6.3.4 Cross-sections 3 and 4 (**Figures 7** – **8**) provide south to north transects through the deposits in the west-central part of the Site (Areas 2, 4 and 6). Pleistocene fluvial sand and gravel is present across Areas 2 and 4, overlain by made ground. The fluvial deposits do not extend beyond MBH16 (Area 4) and have been entirely removed from this point north, including across Area 6. The base of the fluvial sequence along this transect is found between c. 12.5 maOD and 11 maOD. Made ground depths increase from south to north (from 0.80 m in Area 2 to up to 2.80 m in Area 5). Within Area 2 and southern-most part of Area 4 fluvial sand overlies the fluvial sand and gravel; this sand has been entirely truncated north of MBH18 (Area 5). Beyond the northern boundary of the Site alluvial sediments are present beneath made ground.

6.3.5 Cross-sections 5 and 6 (**Figures 9** – **10**) provide west to east transects through deposits in the southern part of the Site (Area 2, 3 and 8). It demonstrates that the Pleistocene fluvial deposits in Areas 2, 3 and 8 likely belong to a single, altitudinally consistent terrace aggregation and that the complementary stratigraphy is present in these areas. In all three areas fluvial sands and gravels are overlain by fluvial sand, however, chalk and flint fluvial gravel and extensive basal chalky solifluction deposits have only been identified in the south west part of the Site (Areas 2 and 3). The most extensive sequences of fluvial sands are preserved in Areas 2 and 8; they are significantly less extensive in Area 3. The comparative lack of fluvial sand in Area 3 is at least partly due to previous quarrying. However, these sands may have been comparatively thin in Area 3 prior to quarrying; Sec1, 29 and 30 demonstrate that they were truncated and overlain by colluvial deposits. Similar colluvial deposits would have been present in other areas of the Site prior to quarrying but have been entirely removed.

6.3.6 Cross-section 7 (**Figure 11**) runs south to north along a transect through deposits in the western part of the Site (Areas 8, 6 and 7). The transect demonstrates that Pleistocene fluvial deposits are preserved within Area 8, beneath a varying depth of made ground; the depth of made ground increases significantly towards the south to more than 4.00 m. In the southern-most part of the area fluvial deposits are sporadically recorded in additional GI records (ERM 2018) beneath made ground which appear to at a higher elevation (TP220) than those found further north. These may belong to a separate, earlier terrace, although basal heights would be required to conform this.

6.3.7 In the northern-most part of Area 8 Quaternary deposits are absent, having been removed by previous impacts. Across much of the area north of Area 8 Quaternary deposits have been removed by quarrying. However, deposits may be preserved in one limited area (Area 7) where possible fluvial deposits have been identified (WA2020a). Additional GI data from the Site suggests that these possible fluvial deposits in Area 7 are alluvium overlying fluvial sand and gravel; the basal heights of the deposits clearly demonstrate they belong to a chronologically distinct set of deposits than those located further south. This separation is supported by Cross-section 8 (**Figure 12**); this an east to west transect through deposits at the northern boundary of the Site, which demonstrates that alluvial deposits overlying fluvial sand and gravel is sporadically present at analogous heights in this area.

6.4 Artefactual evidence

Introduction

6.4.1 Extensive sieving of samples taken from throughout the Pleistocene sediments was carried out to assess for the presence of Palaeolithic artefacts. This is summarised in **Table 5.** A total 29,000 litres of Pleistocene deposits were sieved.

Table 5 Volume of sediments sieved by stratigraphic unit

Stratigraphic unit	Volume of sediments sieved (litres)
Chalky solifluction gravel	1600
Fluvial and soliflucted sand and gravel	7200
Fluvial sandy flint and chalk gravel	4500
Fluvial sandy flint gravel	12800
Fluvial sand	3800
Total	29900

6.4.2 Twenty-four lithics were retained for post-excavation assessment. Of these, 13 retain evidence of conchoidal fracture but do retain features which unequivocally reflect anthropogenic manufacture. This reflects the elevated number of clasts within the deposits sampled which exhibit natural frost and starch fractures, and natural factures resulting from clast collision within fluvial gravel.

Table 6 Summary of lithic artefacts

Stratigraphic unit	Number of artefacts	Condition of artefacts	Typo-technological age attribution
Chalky solifluction gravel	0	-	-
Fluvial and soliflucted sand and gravel	2	Unabraded to moderately abraded; moderately to heavily edge damaged	Palaeolithic
Fluvial sandy flint and chalk gravel	2	Unabraded to lightly abraded; moderately edge damaged	Palaeolithic
Fluvial sandy flint gravel	5	Lightly to heavily abraded; moderately to heavily edge damaged	Palaeolithic
Disturbed fluvial sand (?redeposited)	1	Fresh	Modern
Made ground	3	Unabraded; lightly to moderately edge damaged	Neolithic

6.4.3 The results of typo-technological assessment of the 13 pieces considered to reflect human manufacture are outline in **Appendix 2** and summarised in **Table 6**.

Results

6.4.4 Palaeolithic lithic artefacts were recovered in small numbers from the *Fluvial and soliflucted sand and gravel*, the *Fluvial sandy flint and chalk gravel* and the *Fluvial sandy flint gravel* in Areas 2, 3 and 8. The artefacts are flakes, one of which exhibits likely retouch. They are typologically undiagnostic but would all fit within Lower or Middle Palaeolithic lithic assemblages.

6.4.5 The Palaeolithic artefacts exhibit a range of conditions states, from unabraded but edge damaged, to heavily abraded and edge damaged. Notably, the three fresher, unabraded pieces all come from the lower *Fluvial sandy flint and chalk gravel*, and the interstratified *Fluvial and soliflucted sand and gravel*. These fresher pieces are reflective of human activity which is contemporary with these deposits.

6.4.6 The artefacts from the *Fluvial sandy flint gravel* all exhibit a degree of fluvial abrasion. Two are heavily abraded and are likely to be significantly reworked, possibly from earlier terrace deposits. The third piece is only lightly abraded and may reflect human activity which is broadly contemporary with the terrace deposits.

6.4.7 In addition to the Palaeolithic artefacts from the Pleistocene fluvial deposits, three lithic artefacts were recovered from made ground. These were recovered from two test pits (TP12 and TP 14) in Area 3, two from within a modern feature infilled with gravelly clayey sand containing brick, and redeposited, topsoil, chalk and gravel (**Plate 15**); this feature which may be associated with the construction of a slurry back wall. The artefacts include a broken leaf shaped arrowhead of Neolithic date and an exhausted keeled blade core which is also of likely Neolithic date. The third piece is a blade which, although undiagnostic, would similarly fit within a Neolithic lithic assemblage.

6.4.8 A modern galletting flake produced with a metal hammer and with mortar adhering to it was recovered from disturbed and possibly redeposited fluvial sand in Area 4.

Discussion

6.4.9 The density of lithic artefacts recovered from the Pleistocene deposits is low. The small number of artefacts recovered are all undiagnostic flakes but are likely to be Lower and/or Middle Palaeolithic in date. Unabraded but edge damaged artefacts were recovered from basal fluvial and soliflucted deposits in Areas 2 and 3. The only artefact recovered during previous evaluation (WA 2009) which is minimally abraded, but similarly edge damaged (a flake), was obtained from same chalky gravel context in Area 3. These artefacts likely reflect human activity which is broadly contemporary with the basal solifluction and fluvial deposits, and which occurred during cool conditions, potentially late in a glacial, or early in an interglacial period. Such a scenario is reminiscent of that at nearby early Middle Palaeolithic sites in the Ebbsfleet Valley (Scott 2011, Scott et al. 2011).

6.4.10 Low numbers of lithic artefacts were also recovered from the stratigraphically younger, generally high energy, fluvial deposits. These pieces reflect varying degrees of reworking within coarse fluvial deposits. They complement and add the small number of abraded flakes recovered from similar contexts during evaluation (WA 2009). Such artefacts may include material reworked within the terrace and/or material reworked from earlier terrace deposits.

6.4.11 Three artefacts were recovered from made ground, all of which may be Neolithic. Both the interventions from which these were recovered (TP12 and 13) are located within Area 3, in proximity to where colluvial deposits are preserved within a slurry back wall (Sec1, 29 and 30; **Figure 2**). It is possible that these artefacts originate from similar, now removed colluvial deposits. Later prehistoric lithics are found within historic Palaeolithic artefact collections from nearby Sites in the Ebbsfleet Valley (Scott 2011), which may originate from similar deposits which overlay the earlier Pleistocene sequences.

6.5 Dating evidence

Introduction

6.5.1 Six sediment samples were submitted for Optical Stimulated Luminescence (OSL) dating. The samples were all taken from *Fluvial sand* in Areas 2, 3 and 8 (**Table 7**). The location of the deposits sampled is illustrated in **Figure 2**.

Table 7 OSL dating samples

Sample number	Area	Trench/ test pit	Context number	Stratigraphic unit
9	2	Tr102	10207	*Fluvial sand*
7	2	Tr102	10209	*Fluvial sand*
61	3	Tr100	10015	*Fluvial sand*
71	3	TP14	1403	*Fluvial sand*
106	8	Sec31	3102	*Fluvial sand*
108	8	Sec31	3103	*Fluvial sand*

6.5.2 Full methodological details are given in **Appendix 3**.

6.5.3 Diagnostics were used to estimate the influence of laboratory and environmental factors on the results as a means of testing the analytical validity of the OSL age (**Appendix 3**). Based on these five age estimates have been accepted without caveats (**Table 8**), the sixth is accepted as a minimum age estimate due to significant feldspar contamination. Full details on the limitations of the OSL dating are presented in **Appendix 3**.

Table 8 OSL age estimates (Blue indicates samples with accepted age estimates, red, age estimates with caveats).

Sample number	Context number	Stratigraphic unit	Lab code	Total D_r (Gy. Ka^{-1})	D_e (Gy)	Age (ka)	Age (MIS)
9	10207	*Fluvial sand*	GL20094	1.21 ± 0.10	539.0 ± 60.1	444 ± 61 (57)	MIS 13/12
7	10209	*Fluvial sand*	GL20093	0.52 ± 0.05	280.3 ± 16.1	543 ± 64 (59)	MIS 14/13
61	10015	*Fluvial sand*	GL20095	0.86 ± 0.07	229.9 ± 26.3	268 ± 38 (35)	MIS 8/7
71	1403	*Fluvial sand*	GL20096	0.26 ± 0.03	129.0 ± 7.6	493 ± 62 (58)	MIS 13/12
106	3102	*Fluvial sand*	GL20097	0.48 ± 0.05	122.1 ± 8.5	257 ± 34 (33)	MIS 8/7
108	3103	*Fluvial sand*	GL20098	1.71 ± 0.02	406.5 ± 43.9	238 ± 31 (29)	MIS 8/7

Results

6.5.4 Five of the OSL ages estimates have been accepted without caveats. The sixth (GL20097) is accepted as a minimum age estimate due to significant feldspar contamination.

6.5.5 The OSL estimates from the *Fluvial Sands* have provided a range of estimates from MIS 13/14 to MIS 8/7. This broad range of dates from the same stratigraphic unit and highly variable D_e values, indicates that these ages should be treated with a high degree of caution. Three of the estimates have provided age ranges from MIS 14 to MIS 12 (563–424 Ka). These do not fit within the Site and local terrace stratigraphy of the River Thames; they are clearly too old.

6.5.6 Three samples (including GL20097) have produced age estimates within MIS 8 to MIS 7 (300 – 191 Ka). These dates could be accommodated with the Site and local Thames terrace stratigraphy. However, these age estimates should also be treated with caution, and are all considered here to be minimum age estimates.

Conclusions

6.5.7 Six OSL samples from the *Fluvial Sands* have produced dates ranging from MIS 13/14 to MIS 8/7. Three age estimates are clearly too old. The remaining three, one of which is caveated as a minimum age estimate, have produced ages with MIS 8/7. These three samples are considered to provide a minimum age estimate for the *Fluvial Sands*, indicated deposition during or prior to MIS 8/7.

6.6 Palaeoenvironmental evidence

Introduction

6.6.1 The palaeoenvironmental potential of the Quaternary deposits encountered during excavations was generally low and no environmental remains were recovered during on-site sieving. Five bulk samples were taken for off-site palaeoenvironmental assessment. Full results of this assessment are presented in **Appendix 4**.

Aims and Methods

6.6.2 The purpose of this assessment is to determine the potential of selected deposits to preserve paleoenvironmental evidence suitable for addressing project aims and to provide data valuable for wider research frameworks. The nature of this assessment follows recommendations by Historic England (Campbell et al. 2011).

6.6.3 The size of the bulk sediment samples varied between 2 and 19 litres, and on average was around 12 litres. The samples were processed by wet-sieving on a 0.5 mm size mesh for 4 samples and a 0.063 mm mesh for one sample. The coarse fractions (>4 mm) were sorted by eye and discarded. The grid method was used to split large residues into smaller residue subsamples when appropriate. The fine residue fractions were scanned using a stereo incident light microscopy (Leica MS5 microscope) at magnifications of up to x40 for the identification of environmental remains. The preservation and nature of environmental remains such as terrestrial molluscs and animal bone was recorded. Abundance of remains is qualitatively quantified (A*** = exceptional, A** = 100+, A* = 30-99, A = >10, B = 9-5, C = <5) as an estimation of the minimum number of individuals and not the number of remains per taxa. Mollusc nomenclature follows Anderson (2005).

Results

6.6.4 The fine residues from the bulk sediment samples ranged from 143 ml to 5200 ml (**Appendix 4**). Paleoenvironmental evidence was sparse. One sample (23) taken from

Chalky solifluction gravel (2803) preserved small numbers of terrestrial molluscs (*Vallonia* sp. and *Limax* sp.), and several rodent teeth. All other samples were barren except for fossilised remains (foraminifera, ostracods, and marine shell fragments) reworked from pre-Quaternary deposits (Chalk and Thanet Sand)

Discussion and recommendations

6.6.5 The results of the paleoenvironmental assessment provide further evidence that the Pleistocene deposits present within the Site have generally low paleoenvironmental potential, but that the lower-most chalky units do have greater potential to sporadically preserve evidence, including molluscs and mammal bones.

6.6.6 Given the small number of molluscs and rodent teeth preserved in the one productive sample, the potential for further analysis of this sample is limited.

7 DISCUSSION

7.1 Introduction

7.1.1 The excavation has fulfilled the aims and objectives outlined in the WSI (WA 2020b). It has established the nature, character, distribution, extent and depth of Pleistocene deposits within each investigation area and refined understanding of Quaternary deposits present across the Site. It has also established the nature, character and distribution of the Palaeolithic archaeological and geoarchaeological resource within each investigation area and established the spatial distribution of Palaeolithic artefacts within the main stratigraphic horizons identified during previous evaluation (WA 2009). OSL samples suitable for dating the deposits were obtained; the results are discussed below.

7.2 Pleistocene deposits

7.2.1 Pleistocene deposits are present beneath varying depths of made ground in Areas 1a-c, 2, 3, 4, 5 and 8. They have been removed by previous quarrying activity from Area 6. GI data from the Site suggests that isolated Quaternary deposits are preserved in Area 7 (WA 2020a), whilst additional GI provided by the client (ERM 2018) has established that these are likely to Holocene alluvium, overlying basal Pleistocene sands and gravels belonging to a later phase of fluvial deposition than those in other areas of the Site.

7.2.2 The results of these investigations have enabled an updated Quaternary stratigraphy for the Site to be produced (**Table 9**).

Table 9 Quaternary sequence within the Site

Phase	Stratigraphic Unit	Thames terrace	Areas	Date	Archaeology	Paleoenvironmental potential
MG	Made ground	-	All areas	Modern	-	-
VIII	Alluvial deposits	Tilbury alluvial deposits	7	Holocene (<11.7 Ka)	None known	Low

VII	Colluvial deposits	-	3	Later Pleistocene-Holocene	None known. Poss. potential for Neolithic material	Low
VI	Fluvial sand and gravel	?East Tilbury Marshes	7	Late Pleistocene (?17-11.7 Ka)	None known	Low
V	Fluvial sand	?Lynch Hill/Corbets Tey	2-4	Late Middle Pleistocene (?350 – 280 Ka)	None known	Low
IV	Sandy flint gravel	?Lynch Hill/Corbets Tey	2-5, 8	Late Middle Pleistocene (?350 – 280 Ka)	Low density fluvially reworked Palaeolithic artefacts	Low
IIIb	Sandy flint and chalk gravel	?Lynch Hill/Corbets Tey	2-3	Late Middle Pleistocene (?350 – 280 Ka)	Low density minimally reworked, contemporary Palaeolithic artefacts	Low
IIIa	Fluvial and soliflucted sand and gravel	?Lynch Hill/Corbets Tey	2-3	Late Middle Pleistocene (?350 – 280 Ka)	Low density minimally reworked, contemporary Palaeolithic artefacts; low density fluvial reworked Palaeolithic artefacts	May sporadically preserve mammal bones and molluscs
II	Chalky Solifluction Gravels	?Lynch Hill/Corbets Tey	2-3	Late Middle Pleistocene (?350 – 280 Ka)	None known	Sporadically preserves mammal bones and molluscs
?I	Fluvial sand and Gravel	?Boyn Hill/Orsett Heath	8	Middle Pleistocene (?430 – 350 Ka).	?Lower Paleolithic artefacts (Spurrell 1883)	?Mammalian fauna (Spurrell 1883)

Ch	Chalk; upper units brecciated in places	-	All areas	89.8 – 86.3 MA	-	-

7.2.11 The Quaternary deposits within the Site principally belong to terraces of River Thames. Potentially the earliest terrace deposits are located within the northern part of Area 8 (?Phase I). GI data (ERM 2018) suggests that fluvial sands and gravels are sporadically present beneath made ground fluvial deposits which appear to be at a higher elevation than those found elsewhere in the Site, and may therefore be earlier in date If so, these sediments likely belong to the Boyn Hill/Orsett Heath terrace (430 – 350 Ka).

7.2.12 The principal terrace deposits (Phase II-V) post-date the Boyn Hill/Orsett Heath terrace. The fact that these deposits are not part of the Boyn Hill/Orsett Heath terrace (as mapped by the BGS) is demonstrated by both the basal heights of the terrace deposits in the Site (17.0 – 9.0 maOD) and the fact that the southern lateral edge of these terrace deposits is located up against chalk bedrock in Areas 2 and 3; this provides clear spatial separation between this terrace and deposits of the Boyn Hill/Orsett Heath terrace located further to the south.

7.2.13 The Phase II-V sediments may belong to the Lynch Hill/Corbets Tey terrace of the River Thames, which would suggest an MIS 10-9-8 (350 – 280 Ka) date (Bridgland 2006). OSL estimates on sediments within the *Fluvial sand* (Phase IV) have produced tentative, minimum OSL estimates of MIS 8 to MIS 7 (300 – 191 Ka), which broadly support this correlation.

7.2.14 The earliest units of this terrace (Phase II and III) consist of chalky solifluction gravels and fluvial sandy flint and chalk gravel, which are interstratified in places. These sediments have only been identified in Areas 2 and 3 in the south of the Site, banked up against chalk bedrock. They reflect solifluction and relatively high energy fluvial deposition under cold conditions by a braided river.

7.2.15 The Phase II and III deposits are post-dated by fluvial sands and flint gravels with a much lower chalk content (Phase IV), which are overlain cross bedded fluvial sands (Phase V). The fluvial sands likely suggest a transition from a braided river system to a period of infilling and of hollows and cut-off channels and a shift towards anatomising channel patterns with stable channels; this may indicate more temperate conditions.

7.2.16 The postulated Lynch Hill/Corbet Tey terrace deposits are post-dated by colluvial deposits (Phase VII) which unconformably overlie them. These have been almost entirely removed from the Site and are only preserved within a slurry back wall in Area 3 (Sec1, 29 and 30). These deposits reflect material deposited downslope through rain-wash, sheetwash and/or slow continuous downslope creep. These deposits are undated but could include later Pleistocene and/or Holocene sediments.

7.2.17 Previous quarrying removed almost all Quaternary deposits from the northern part of the Site (Area 6), towards the modern River Thames. However, an isolated occurrence of possible extant Quaternary deposits beneath >2m of made ground is present (Area 7). Additional GI data (ERM 2018) has established that this is likely to be fluvial sand and gravel overlain by alluvium (Phase VI and VIII). Much of the alluvial sediments is likely to be Holocene in age (<11.7 Ka).

7.2.18 The age of the underlying fluvial sand and gravel is more difficult to determine. The basal height of the sands and gravel (-2.00 maOD) clearly demonstrate that they post-date the postulated Lynch Hill/Corbets Tey deposits in the southern part of the Site. There is a lack of historic borehole data (BGS online viewer) along the modern Thames foreshore in the immediate vicinity of the Site; however, the basal heights of the sand and gravel are at a considerably higher elevation that the youngest Pleistocene deposits of the Thames sequence – the Shepperton Gravel – upstream on the Swanscombe Peninsula and downstream in the Gravesend area. This would suggest that these fluvial gravels belong to either the Taplow/Mucking or East Tilbury Marshes terrace (see **Figure 1**). Based on comparison of basal heights of the terrace deposits in the wider area, attribution to the East Tilbury Marshes terrace (MIS 5e – 2; 123 – 11.7 Ka) may be preferable. The lower part of the deposits identified as alluvium may include finer grainer Pleistocene deposits of this terrace.

7.3 Palaeolithic archaeology and geoarchaeological evidence

7.3.1 Extensive artefact sieving has demonstrated that, except for the *Fluvial Sand* (Phase IV), the postulated Lynch Hill/Corbets Tey deposits (Phases II-IV) all contain Palaeolithic artefacts, albeit in low densities. All artefacts are undiagnostic but fit within Lower/Middle Palaeolithic assemblages.

7.3.2 The basal chalky solifluction and fluvial sandy gravels (Phase III) in Areas 2 and 3 have produced a small assemblage of unabraded but edge damaged flakes. Their condition demonstrates that they are contemporary with the deposits and, although not *in situ*, are not significantly reworked. This suggests contemporary human activity during cool conditions, likely late in a glacial or early in the subsequent interglacial. Such a scenario is reminiscent of that at early Middle Palaeolithic sites in the Ebbsfleet Valley, most notably Bakers Hole, where hominin activity focussed on a flint raw material source providing by solifluction deposits at the base of a fluvial sequence either late in the MIS 8 glacial or early in the subsequent MIS 7 interglacial (260 – 220 Ka; Scott 2011, Scott et al. 2011); these deposits would be equivalent with the Taplow/Mucking terrace of the River Thames.

7.3.3 The Phase II-V deposits in the Site are correlated with the Lynch Hill/Corbets Tey terrace of the Thames; tentative OSL age estimates suggest a minimum age of MIS 8/7 (300 – 191 Ka) for these deposits. This would be broadly supportive of correlation with the Lynch/Hilll Corbets Tey terrace. Correlation with the Lynch Hill/Corbets Tey terrace, suggests that human activity dates to early in the terrace formation, which may imply a late MIS 10 or MIS 9 date (365 – 300 Ka) and reflect late Lower/early middle Palaeolithic activity. Evidence for archaeology of this date is relatively rare in the Lower Thames, particularly south of the modern river.

7.3.4 Artefacts also occur in low densities within the subsequent fluvial sands and gravels (Phase IV). These reflect varying degrees of reworking and may include material reworked from deposits associated with activity contemporary with the terrace and/or material reworked from earlier deposits, principally units of the Boyn Hill/Orsett Heath terrace, which occur south of the Site.

7.3.5 The paleoenvironmental potential of the postulated Lynch Hill/Corbets Tey deposits within the Site has been shown to be generally low, although the lower chalky deposits in Areas 2 and 3 sporadically preserve terrestrial molluscs and mammal bones.

7.3.6 Historically a Palaeolithic handaxe and several flakes in fresh condition were found by Spurrell (1883: 102; Figure 1), along with a range of fossil animal remains, including straight-tusked elephant, rhinoceros and deer, from fluvial deposits located south of the current investigation areas. Spurrell describes this material as ‘ at *100 (ft) O.D*., in the gravel under the river loams which cover the little tongue of high land lying a quarter of a mile west of Northfleet Church.’ This suggests that these deposits were at 30.50 maOD, whilst the highest the postulated Lynch Hill/Corbets Tey deposits reach in the current investigation areas is c. 19.0 maOD. This suggests the deposits from which Spurrell recovered artefacts and fauna were at a considerably higher elevation and belong to an earlier terrace, likely the Boyn Hill/Orsett Heath terrace. Additional GI data records fluvial deposits (?Phase I) with a truncated surface at 24.0 m aOD in the southern part of Area 8, at the southern limit of the Site (TP220); these may belong to this earlier terrace.

7.3.7 Later fluvial sands and gravels (Phase VI) are potentially present at depth in a restricted zone in the north of the Site (Area 7). The specific age of these deposits is unknown, but they may belong to the East Tilbury Marshes terrace (MIS 5e-2; 123-11.7 Ka) of the River Thames. Based on the descriptions in GI logs, the geoarchaeological potential of these deposits may be limited (coarse likely generally high energy deposits), however, the East Tilbury Marshes terrace as a whole has broad potential to contain late Middle and early Upper Palaeolithic archaeological material, along with Ipswichian (MIS 5e; 123-110,000 Ka) and/or Devensian (MIS 5d-2; 110-11,700 Ka) palaeoenvironmental datasets. Specifically, the East Tilbury Marshes Member is known to contain Ipswichian (MIS 5e) deposits associated with a wide range of paleoenvironmental dataset, including key nationally important faunal assemblages (Franks 1960, Preece 1999).

7.4 Post-Palaeolithic archaeology

7.4.1 Across almost the entirety of the Site the upper part of the Pleistocene sequence has been truncated and is overlain by made ground; any Holocene deposits that may once have existed having been removed. The potential for post-Palaeolithic archaeology to be present is therefore generally very low across the Site. Colluvial deposits (Phase VII) are preserved within the construction of a chalk slurry back wall in Area 3, however. The age of these deposits is unknown (they are too rooted for OSL dating), but they could include Holocene sediments.

7.4.2 Three later prehistoric lithic artefacts, including a broken Neolithic leaf shaped arrowhead and a likely Neolithic keeled blade core, were recovered from made ground. These originate from test pits located in the vicinity of the colluvial deposits within the slurry back wall. The origin of this material is unknown; it may be redeposited as part of sediments from within the Site or have been brought in amongst imported material. If the former, these artefacts may originate from the colluvial sequence that previously existed within the Site, or from features cut into these deposits.

7.4.3 The potential fluvial deposits in Area 7 are overlain gravelly alluvial deposits (Phase VIII). These are likely to be principally Holocene in age but could contain units that are part of the underlying terrace deposits. These minerogenic, coarse deposits have low geoarchaeological potential, but could potentially contain or mask Holocene archaeology.

7.5 Summary of archaeological potential and significance

7.5.1 Based on the results of the Palaeolithic archaeological and geoarchaeological excavation, the potential of the deposits to preserve archaeological and geoarchaeological evidence has been updated. In addition, the significance of the archaeological and geoarchaeological evidence recovered is considered.

7.5.2 The ‘potential’ rating assigned to deposits in each area represents a measure of probability. This has been determined via the application of professional judgement, informed by the evidence from the Site itself and equivalent deposits in the surrounding study area. 'Potential' is expressed on a four-point scale, assigned in accordance with the following criteria:

- **High** Situations where archaeological and/or geoarchaeological datasets (including palaeoenvironmental material) are known or strongly suspected to be present and likely to be well preserved and have high chronostratigraphic integrity.

- **Moderate** Includes cases where there are grounds for believing that archaeological and/or geoarchaeological datasets (including palaeoenvironmental material) may be present, but for which conclusive evidence is not currently available. This category is also applied in situations in which assets are likely to be present which have reasonable chronostratigraphic integrity.

- **Low** Includes situations where archaeological and/or geoarchaeological datasets (including palaeoenvironmental material) may be present but are likely to have low chronostratigraphic integrity

- **Very Low** Circumstances where the available information indicates that assets are unlikely to be present, or that their state of preservation and/or chronostratigraphic integrity is liable to be severely compromised.

- **Unknown** Cases where currently available information does not provide sufficient evidence on which to provide an informed assessment with regard to the potential for assets to be present.

7.5.3 The relative '*Significance'* of known and potential assets has been determined in accordance with the criteria set out in **Table 10.**

Table 10 Generic schema for classifying the significance of archaeological/ geoarchaeological assets (based on HE 2015b)

Significance	Categories
Very High	World Heritage Sites (including nominated sites) Assets of recognised international importance Assets that contribute to international research objectives
High	Scheduled Monuments Non-designated assets of national importance Assets that contribute to national research agendas
Moderate	Assets that contribute to regional research objectives
Low	Assets compromised by poor preservation and/or poor contextual associations Assets with importance to local interest groups
Negligible	Little or no archaeological or geoarchaeological interest
Unknown	The importance of the asset has not been ascertained from available evidence

7.5.4 The potential of the deposits in each area, and the significance of archaeological and geoarchaeological evidence present in each area is summarised in **Table 11**.

Table 11 Updated areas of archaeological potential

Area	Deposits present	Potential	Significance
1-a 1-b 1-c	Undisturbed original, pre-quarrying sediment sequence preserved under roads and footpaths	Unknown	Unknown
2	Phase IV-V Phase II-III	Moderate Moderate	Moderate Moderate-high (but could be higher elsewhere)
3	Phase VII (slurry back wall) Phase IV-V Phase II-III	Unknown Moderate Moderate	Unknown Moderate Moderate-high (but could be higher elsewhere)
4	Phase IV-V	Moderate	Moderate
5	?Phase IV	?Moderate	?Moderate
6	None	None	-
7	Phase VI Phase VIII	Unknown Unknown	Unknown Unknown
8	?Phase I Phase IV-V	Unknown Moderate	Unknown Moderate

7.5.5 Archaeology has been recovered from two phases of the Quaternary sequence in the Site (Phase III-IV), all of which are broadly correlated with the Lynch Hill/Corbets Tey terrace. The archaeology comprises lithic artefacts, which occur in low densities. The material is undiagnostic, but their context demonstrates a Lower/Middle Palaeolithic date. The condition of lithics subdivides between fluvially abraded and edge damaged material reflecting varying degrees of reworking in high energy fluvial deposits, and unabraded and edge damaged artefacts which are less reworked. The latter has only been recovered from chalky solifluction and fluvial deposits at the base of the sequence (Phase II-III).

7.5.6 The condition of less reworked material from Phase III-IV sediments demonstrates that this archaeology is contemporary with these deposits but is not *in-situ*. These deposits are assigned to Lynch Hill/Corbets Tey terrace of the Thames. The stratigraphic position of this archaeology, at the base of the terrace sequence, may indicate a late MIS 10 or MIS 9 date (365 – 300 Ka). If so, the material would represent relatively rare evidence for late Lower/early Middle Palaeolithic activity in the Lower Thames. Given the low density of artefacts and their taphonomy, this evidence principally contributes to our understanding of regional and national research questions relating to occupation history and, potentially, landscape-use practices and environmental tolerances (see **section 4**) and is considered to have moderate-high significance. However, the presence of minimally disturbed artefacts, albeit in low numbers, demonstrates that the Phase I and II deposits elsewhere have the potential to contain *in-situ* with greater, potentially national, significance.

7.5.7 The fluvially reworked artefacts from the Phase III-IV may include material that is contemporary with the terrace deposits, or reworked from an earlier terrace, likely the Boyn Hill/Orsett Heath terrace. This material potentially adds to understanding of broad settlement density in the Lower Thames during the period over which the terrace deposits accumulated. Such evidence been used as a proxy for changing settlement densities and demographics during the Lower and Middle Palaeolithic in Britain (Ashton and Lewis 2002). This reworked material is therefore considered to have moderate significance.

8 CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

8.1.1 The Palaeolithic archaeological and geoarchaeological excavations demonstrated that Pleistocene deposits are present within Area 2 – 4, and Area 8 of the Site, beneath a variable depth of made ground. These deposits belong to a terrace of the River Thames. Although mapped by the BGS as part of the Boyn Hill/Orsett Heath terrace (430 – 350 Ka) by the BGS, these investigations have demonstrated that they principally belong to a later terrace. They are suggested to belong to the Lynch Hill/Corbets Tey terrace (350 – 280 Ka).

8.1.2 Additional GI data (ERM 2018) suggests that deposits of the Boyn Hill/Orsett Heath terrace (430 – 350 Ka). may be present in a restricted are in the northern part of Area 8. These deposits may be equivalent with those from which historic artefact and faunal finds were made from south of the current investigation areas (Spurrell 1883).

8.1.3 These excavations have established that the stratigraphic sequence for the postulated Lynch Hill/Corbets Tey terrace deposits comprise basal chalky solifluction and fluvial sands and gravels with a high chalk component (Phase II and III). These sediments are present in the southern part of the Site (Areas 2 and 3), where it is banked up against chalk bedrock. They reflect solifluction and relatively high energy fluvial deposition under cold conditions by a braided river. These are overlain by fluvial sands and gravels (Phase IV), with a much lower chalk component, which are in turn overlain by horizontal and cross bedded fluvial sands (Phase V); these deposits are found in Areas 2 – 5. The transition to the fluvial sands likely reflects a change from a braided river system to a period of infilling and of hollows and cut-off channels and a shift towards anatomising channel patterns with stable channels; this may also reflect a change to more temperate conditions.

8.1.4 Palaeolithic lithic artefacts have been recovered in low densities from throughout this fluvial sequence, except for the Phase V fluvial sands. The archaeology consists of undiagnostic flakes whose techno-typological characteristics and context demonstrate are Lower/Meddle Palaeolithic.

8.1.5 The lithic artefacts from the basal chalky solifluction and fluvial sandy gravels (Phase III) include a small number of unabraded but edge damaged flakes. Their condition demonstrates that they are contemporary with the deposits and, although not *in situ*, are not significantly reworked. This suggests contemporary human activity during cool conditions likely late in a glacial or early in the subsequent interglacial. If the deposits do belong to the Lynch Hill/Corbets Tey terrace, the stratigraphic evidence suggest that this may reflect evidence for human activity late in MIS 10 or during MIS 9 (365 – 300 Ka). Palaeolithic archaeology of this date is relatively rare in the Lower Thames, particularly south of the modern river. This archaeology is considered to have moderate-high significance in relation to national and regional research questions. The presence of minimally disturbed artefacts, albeit in low numbers, demonstrates that the Phase III deposits elsewhere have the potential to contain *in-situ* highly and nationally significant archaeology.

8.1.6 Lithic artefacts from elsewhere in the fluvial sequence (Phase IV) exhibit varying degrees of fluvial abrasion. They may reflect reworking of material within the terrace, and/or material reworked from earlier terrace deposits. This reworked material is therefore considered to have moderate significance in relation to national and regional research questions.

8.1.7 The investigations have confirmed that the paleoenvironmental of these deposits is generally low, although the lower chalky units do sporadically preserve molluscs and mammal bones. A small number of terrestrial molluscs and rodent teeth were recovered from a sample taken from chalky solifluction gravels. Given the small number of molluscs and rodent teeth preserved in the one productive sample, the potential for further analysis is limited.

8.1.8 Colluvial deposits (Phase VII), which once overlay the fluvial deposits within the Site, have almost entirely been removed. However, these deposits are preserved within a very restricted area within the construction of a chalk slurry back wall (Area 3). The age of these deposits is unknown; they may include late Pleistocene and/or Holocene units. Neolithic artefacts, including a broken leaf shaped arrowhead and keeled blade core, were recovered from made ground in interventions in the same area of the Site. These may be intrusive to the Site; however, they could have originated from within similar colluvial deposits or features cut into such deposits.

8.1.9 Quaternary deposits have largely been removed from the northern part of the Site by quarrying (Area 6). Additional GI data has clarified that potential fluvial deposits recorded beneath made ground in a restricted area in the north of the Site (Area 7), likely consists of alluvial deposits overlying fluvial sands and gravels. The age of the fluvial sands and gravels (Phase VI) is unknown; however, their basal heights indicate that they predate the Shepperton Gravel of the Thames (17 – 11.7 Ka). Based on their basal height they are tentatively correlated with the East Tilbury Marshes terrace (123 – 11.7 Ka). The lithological description of these deposits suggests that their geoarchaeological potential is low, although the East Tilbury Marshes terrace as a whole has potential to include units associated with late Middle and Upper Palaeolithic archaeology.

8.1.10 The alluvial deposits (Phase VIII) are likely to be principally Holocene in age. They are coarse gained gravelly sediments and therefore are likely to have low geoarchaeological potential. Holocene alluvial deposits have the broad potential to contain or mask Holocene archaeology.

8.2 Recommendations

8.2.1 Archaeological and geoarchaeological excavation has provided a detailed record of Palaeolithic archaeological and geoarchaeological resource in the areas investigated. It has also enabled the archaeological and geoarchaeological potential of Quaternary deposits across the Site to be refined. Based on the results of these investigations, and consideration of the development proposals, including proposed landscaping of the Site (**Figures 12** – **13** and **Appendix 5**), recommendations regarding potential requirements for, and methods of, any further archaeological and geoarchaeological investigations are provided. These are summarized in **Table 12**.

Table 12 Updated areas of archaeological potential and possible requirements for further archaeological/geoarchaeological work

Area	Deposits present	Depth of deposits (mbgl)	Approx. max depth of proposed cut (m)	Potential	Significance	Possible requirements for further work
1-a 1-b 1-c	Undisturbed original, pre-quarrying sediment sequence preserved under roads and footpaths Pleistocene fluvial deposits proved in 1-c	Unknown	0.00	Unknown	Unknown	None
2	Phase IV-V Phase II-III		1.50	Moderate Moderate	Moderate Moderate-high (but could be higher elsewhere)	None None
3	Phase VII (slurry back wall) Phase IV-V Phase II-III		4.00	Unknown Moderate Moderate	Unknown Moderate Moderate-high (but could be higher elsewhere)	Targeted WB None None
4	Phase IV-V	1.80-2.80+	5.00	Moderate	Moderate	None
5	?Phase IV	3.00+	6.50	?Moderate	?Moderate	Limited WB to establish details of Pleistocene strat. and potential of deposits
6	None	6.00-12.00	10.00	None	-	None
7	Phase VI Phase VIII	2.50	0.00	Unknown arch., low gearch. Unknown arch., low geoarch.	Unknown Unknown	None None

8 (North)	Phase IV-V	0.60-4.00+	Unknown	Moderate	Moderate	None
8 (South)	?Phase I	2.00-4.00+	None - piling for foundation	Unknown, possibly high	Unknown, possibly high	Test pitting or targeted WB if Pleistocene deposits to be impacted on

Areas 1-a, 1-b and 1c

8.2.2 There are no proposed development impacts in these areas and no further work is likely to be required. It should be highlighted that terraces deposits (likely the Boyn Hill/Orsett Heath terrace) broadly equivalent to those which historically produced Lower Palaeolithic artefacts and faunal remains (Spurrell 1883) may be present in Area 1-c; this should be taken into consideration in any subsequent development is proposed in this area.

Area 2

8.2.3 Archaeological and geoarchaeological excavations have made detailed records of the Pleistocene deposits present in this area. Extensive sieving of deposits has recovered low density Palaeolithic archaeology from fluvial sands and gravels. The upper fluvial sands and gravel in this area (Phase IV) are associated with low density archaeology which exhibits varying degrees of fluvial reworking, which of moderate significance in relation to national and regional research questions and priorities. The lower fluvial sands and gravels (Phase III) have produced a small number of unabraded, but edge damaged are contemporary with the deposits and, although not *in* situ, are not significantly reworked. These deposits have been extensively investigated in this area and a small number of artefacts of moderate-high significance to national and regional research questions and priorities have been recovered. However, their presence indicates that these Phase II deposits elsewhere have potential to preserve minimally disturbed archaeology of higher, national significance.

8.2.4 Proposed development impacts in this area include landscaping involving cuts which will have a maximum impact depth of 1.50m (**Figure 13** and **Appendix 5**). This will likely impact of Phase IV deposits. As Phase I-II deposits are generally located >3 mbgl in this area (**Figures 5** – **6**), these deposits will not be significantly impacted on by landscaping. Given the extensive investigations carried out in this area, no further archaeological or geoarchaeological works are likely to be required.

Area 3

8.2.5 Archaeological and geoarchaeological excavations have made a detailed record of the Pleistocene deposits present in this area. Extensive sieving of deposits has recovered low density Palaeolithic archaeology from solifluction deposits and fluvial sands and gravels. The lower solifluction deposits and fluvial sands and gravels (Phase III) have produced a small number of unabraded, but edge damaged artefacts which are contemporary with the deposits and, although not *in* situ, are not significantly reworked. These small number of artefacts are of moderate-high significance to national and regional research questions and priorities. However, their presence indicates that these lower deposits elsewhere have potential to preserve minimally disturbed archaeology of higher, national significance. These lower chalky deposits have also been shown to sporadically preserve mammal bones and molluscs. The upper fluvial sands and gravel in this area (Phase IV) are associated with low density archaeology which exhibits varying degrees of fluvial reworking, which are of moderate significance in relation to national and regional research questions and priorities

8.2.6 Proposed development impacts in this area are of variable depth (**Figure 13** and **Appendix 5**) but include landscaping cuts which will have a maximum impact depth of 4.00m. This will likely impact on Phase II-V deposits (**Figures 7** – **8**). Given the extensive investigations carried out in this area, no further archaeological or geoarchaeological works are likely to be required.

8.2.7 Additionally, the investigations have demonstrated that colluvial deposits containing units of possible later Pleistocene and/or Holocene date are preserved within the core of a slurry back wall (Sec 1 and Sec 29-30; see **Figure 2**). The archaeological potential of these deposits is unknown; they have low geoarchaeological potential. Neolithic artefacts were recovered from within made ground in vicinity of these colluvial deposits. The original context of these artefacts is unknown but could potentially have been similar colluvial deposits or features cut into them. Construction proposals will necessitate the removal of this wall and the deposits (**Figures 12** – **13** and **Appendix 5)**. The removal of this wall may require an archaeological watching brief and the controlled stripping of these remnant colluvial deposits.

Area 4

8.2.8 Archaeological and geoarchaeological excavations have made a detailed record of the Pleistocene deposits present in this area. Extensive sieving of deposits has recovered low density fluvially reworked Palaeolithic archaeology from fluvial sands and gravels (Phase IV), and which have low paleoenvironmental potential (Phase IV and V).

8.2.9 Proposed development impacts in this area include landscaping cuts which will have a maximum impact depth of up to 5.00m (**Figure 13** and **Appendix 5**). Pleistocene deposits are generally found at +2.00 mbgl in this area (**Figures 7** – **8**). As these deposits have been extensively investigated and shown to preserve low density reworked artefacts of moderate significance in relation to national and regional research questions and priorities, no further work is likely to be required.

Area 5

8.2.10 GI data has demonstrated the southerly continuation of Pleistocene fluvial deposits investigated in Area 3 in this area of the Site. They are located beneath a considerable depth of made ground (>3 m). The GI descriptions are not sufficient to establish with certainly which phases of the Pleistocene sequence are present. Proposed landscaping in this area will impact to up to 6.50 mbgl (**Figure 13** and **Appendix 5**) and will impact on the Pleistocene deposits. A limited watching brief may therefore be required during construction to establish the Pleistocene fluvial sequence in this area and to mitigate against the presence of any deposits with significant archaeological and/or geoarchaeological potential.

Area 6

8.2.11 Any Quaternary deposits which may once have been present in this area have been removed from this area. Consequently, no further archaeological or geoarchaeological work will be required.

Area 7

8.2.12 Additional GI indicates that the possible occurrence of fluvial deposits beneath >2.00 m of made ground in this area are likely reflect local preservations of Holocene alluvial deposits which overlie fluvial sands and gravels, which are tentatively equated with the East Tilbury Marshes terrace of the River Thames. The archaeological potential of these deposits is unknown; lithological descriptions suggests that their geoarchaeological potential is low. No construction impacts are proposed for this area and, consequently, no further archaeological or geoarchaeological work is likely to be required. The presence of these deposits should be considered in any subsequent development proposals in this area.

Area 8 – North

8.2.13 These investigations have demonstrated that Quaternary deposits have been removed from the northern-most part of the area. Further south, Pleistocene fluvial sands and gravels are present that correlate with Phase IV and V of the site stratigraphy. The Phase IV deposits contain low density, fluvially reworked Palaeolithic artefacts, which are of regional significance in relation to national and regional research questions and priorities.

8.2.14 The fluvial deposits in Area 8 – North are preserved beneath a variable sequence of made ground, which ranges from 0.60 m in the north to >4.00 m in the south. Proposed landscaping impacts in this area are currently unknown. Investigations in the northern part of the area has established that Quaternary deposits are either absent or have produced low density reworked artefacts of moderate significance in relation to national and regional research questions and priorities. No further work is therefore likely to be required within the northern part of Area 8.

Area 8 – South

8.2.15 Additional GI data (ERM 2018) indicates that earlier Pleistocene terrace deposits are sporadically present in this part of Area 8 beneath made ground. Where present, the Pleistocene deposits are beneath at least 2.00 m of made ground; these may belong to the Boyn Hill/Orsett Heath terrace (?Phase I) and be equivalent with deposits with have historically produced Lower Palaeolithic artefacts and mammalian fauna (Spurrell 1883).

8.2.16 Development impacts in this part of Area 8 are likely to be limited to piling for house foundations. Given the potential for Pleistocene terrace deposits to be present, which are earlier in date to those elsewhere in the Site and which may be equivalent to those which have historically produced Lower Palaeolithic artefacts and fauna (Spurrell 1883), further work may be required. The need and scope for this further work is dependent on extent and location of specific impacts. GI data indicates >4.00m of made ground is present in area of proposed housing (TP219), with extant Pleistocene deposits located further to the west (TP220; see Figures 11 and 14). Should development impacts (pile caps, ground beams, services etc) include the area where GI data indicates Pleistocene deposits are present, targeted purposive test pitting with artefact sieving and or a targeted watching brief may be required. Should development impacts be restricted to impact only the made ground, further work may not be required.

9 ARCHIVE STORAGE AND CURATION

9.1 Museum

9.1.1 The archive resulting from the watching brief is currently held at the offices of Wessex Archaeology in Salisbury. Dartford Museum has agreed in principle to accept the archive on completion of the project, under site code **232991**. Deposition of any finds with the museum will only be carried out with the full written agreement of the landowner to transfer title of all finds to the museum.

9.2 Preparation of the archive

9.2.1 The archive, which includes paper records, graphics, artefacts, ecofacts and digital data, will be prepared following the standard conditions for the acceptance of excavated archaeological material by Dartford Museum, and in general following nationally recommended guidelines (SMA 1995; CIfA 2014c; Brown 2011; ADS 2013).

9.2.2 All archive elements are marked with the site code **232991**, and a full index will be prepared. The physical archive currently comprises the following:

- 01 cardboard boxes or airtight plastic boxes of artefacts and ecofacts, ordered by material type;
- 02 files/document cases of paper records and A3/A4 graphics;

9.3 Selection policy

9.3.1 Wessex Archaeology follows national guidelines on selection and retention (SMA 1993; Brown 2011, section 4). In accordance with these, and any specific guidance prepared by the museum, a process of selection and retention will be followed so that only those artefacts or ecofacts that are considered to have potential for future study will be retained. The selection policy will be agreed with the museum and is fully documented in the project archive.

9.4 Security copy

9.4.1 In line with current best practice (e.g., Brown 2011), on completion of the project a security copy of the written records will be prepared, in the form of a digital PDF/A file. PDF/A is an ISO-standardised version of the Portable Document Format (PDF) designed for the digital preservation of electronic documents through omission of features ill-suited to long-term archiving.

9.5 OASIS

An OASIS online record) has been initiated, with key fields and a .pdf version of the final report submitted. Subject to any contractual requirements on confidentiality, copies of the OASIS record will be integrated into the relevant local and national records and published through the Archaeology Data Service ArchSearch catalogue.

10 COPYRIGHT

10.1 Archive and report copyright

10.1.1 The full copyright of the written/illustrative/digital archive relating to the project will be retained by Wessex Archaeology under the *Copyright, Designs and Patents Act* 1988 with all rights reserved. The client will be licenced to use each report for the purposes that it was produced in relation to the project as described in the specification. The museum, however, will be granted an exclusive licence for the use of the archive for educational purposes, including academic research, providing that such use conforms to the *Copyright and Related Rights Regulations* 2003. In some instances, certain regional museums may require absolute transfer of copyright, rather than a licence; this should be dealt with on a case-by-case basis.

10.1.2 Information relating to the project will be deposited with the Historic Environment Record (HER) where it can be freely copied without reference to Wessex Archaeology for the purposes of archaeological research or development control within the planning process.

10.2 Third party data copyright

10.2.1 This document and the project archive may contain material that is non-Wessex Archaeology copyright (e.g., Ordnance Survey, British Geological Survey, Crown Copyright), or the intellectual property of third parties, which Wessex Archaeology are able to provide for limited reproduction under the terms of our own copyright licences, but for

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APPENDICES

Appendix 1 Trench, test pit and section logs

The stratigraphic succession encountered in each intervention are outlined below. Heights are given in metres above OD.

NGR coordinates and OD heights taken at one corner of each test pit; depth bgl = below ground level

Trench No 100		**Length 30m**	**Width 7m**	**Depth 4.60 m**
Easting 561877.83		**Northing 174626.25**		**m OD 15.71**
Context Number	**Fill Of/Filled With**	**Interpretative Category**	**Description**	**Depth BGL**
10001		Modern soil profile	Formed on chalk slurry. Grey-black gritty clay loam overlying light grey clay. **Sharp, sub-horizontal contact**	0.00-0.40
10002		Material infilling modern root cavities/tree throw	Dark brownish red medium to coarse gravelly sand. Frequent fine to coarse sub-angular and sub-rounded flint clasts (<200m); includes Tertiary pebbles. Clayey towards base. **Sharp, undulating contact**	0.20-0.50
10003		Material infilling modern root cavities	Fine to coarse subangular and sub-rounded medium to coarse flint gravel (<200mm). Dark reddish brown coarse to very coarse sand matrix. Clast supported. Structureless. **Abrupt, undulating contact**	0.20-0.50
10004		Soliflucted and fluvial gravel	Medium to very coarse clast supported chalk gravel (<600mm). Coarsely interbedded with angular, sub-angular and sub-rounded clast supported, moderately sorted flint gravel (including Tertiary pebbles) in mid reddish-brown fine to medium sand matrix. Sub-horizontally bedded. **Abrupt, sub-horizontal contact**	0.20-0.70
10005		Fluvial sand and gravel	Light reddish brown gravelly medium to coarse slightly clayey sand. Frequent fine to medium sub-angular and sub-rounded flint clasts (<50mm). Weakly cross bedded. Rooted. **Abrupt, sub-horizontal contact**	0.20-0.45

10006		Fluvial sand and gravel	Dark to mid reddish brown gravelly medium sand and clayey sand. Frequent fine to coarse sub-angular and sub-rounded flint clasts. Gravel is moderately sorted, Moderately frequent sand lenses. Rooted. **Abrupt, 45º southerly dipping contact**	0.40-0.90
10007		Soliflucted and fluvial gravel.	Medium to coarse chalk and flint gravel (<200m). Moderately sorted. Light brownish yellow fine sand matrix. Clast supported. Coarsely sub-horizontally bedded. Part of same unit as (10011). **Abrupt, 45º northerly dipping contact.**	1.80-2.20
10008		Fluvial sand and gravel	Medium to very coarse sub-angular and sub-rounded flint gravel (<300m). Poorly sorted. Dark brownish red sandy clay matrix. Sand is medium to coarse. Clast supported. Moderately frequent fine to medium dark brownish red clay sand lenses. **Abrupt, 30 º southerly dipping contact**	0.30-1.10
10009		Fluvial sand and gravel	Fine to very coarse sub-angular to sub-rounded flint and chalk gravel (<400mm). Moderately sorted. Light reddish yellow fine slightly clayey sand matrix. Clast supported. sub-horizontally bedded. Equivalent of (10014).	0.40-1.90
10010		Soliflucted and fluvial gravel	Fine to very coarse sub-angular and sub-rounded flint and chalk gravel. (<300mm). Poorly sorted. Light greyish yellow clayey sand matrix. Matrix supported, becoming clast supported with depth. Increasingly chalky with depth. Coarsely sub-horizontally bedded. **Abrupt, sub-horizontal contact**	0.30-1.20

10011		Solifluction gravel	Solifluction gravel. Medium to very coarse chalk gravel. Light brownish red coarse sandy silt matrix. Clast supported. Part of same unit as (10011). **Diffuse, 20^{o} northerly dipping contact**	1.60-2.60
10012		Brecciated chalk	Brecciated chalk. Very coarse angular and blocky chalk gravel (<300m). Light brownish red very coarse sandy silt matrix. Clast supported. **Sharp, sub-horizontal contact**	2.60-3.90
10013		Chalk bedrock	Blocky chalk.	3.90-4.60+
10214		Fluvial sand and gravel	Fine to very coarse sub-angular and sub-rounded flint gravel (2mm-400mm). Moderately sorted. Light reddish-brown fine to medium-coarse sand matrix. Clast supported. Sub-horizontally bedded. Loose. Equivalent of (10009). **Sharp, 35^{o} northerly dipping contact**	0.80-2.30
10215		Fluvial sand and gravel	Mid greyish brown gravelly medium sand. <30% fine to coarse sub-angular, sub-rounded and rounded flint clasts. Moderate to well sorted. Horizontally bedded with fine sand layers. Loose. **Abrupt, sub-horizontal contact**	2.50-4.30
10216		Fluvial sand	Light yellow medium sand. Clast free. Sand lens in top of (10009).	0.60-0.90

Trench No 101		Length 12.50 m	Width 6.50 m	Depth 5.10 m
Easting 561995.06		Northing 174538.15	m OD 19.31	
Context Number	**Fill Of/Filled With**	**Interpretative Category**	**Description**	**Depth BGL**
10101		Made ground	Mixed lithologies. Includes brick and concrete.	0.00-1.80
10102		Uncategorised	Colluvial. Light reddish brown fine sandy clay. Occasional fine to medium sub-rounded Tertiary flint clasts (≤80 mm). Occasional chalk flecks. Structureless. Moderately consolidated. **Sharp, sub-horizontal contact**	1.80-2.00
10103		Fluvial sand	Fine light greyish yellow sand. Very occasional fine to medium sub-angular and sub-rounded flint clasts. Cross bedded. Loose. **Diffuse contact**	2.00-2.40
10104		Fluvial sand	Medium to coarse gravelly sand. Frequent fine medium sub-angular and sub-rounded flint clasts. Cross bedded. Loose. Very frequent heavily commuted shell fragments. Cross bedded. **Abrupt, sub-horizontal contact**	2.40-2.80
10105		Fluvial sand	Light greyish yellow fine slightly clayey sand. Very occasional fine to coarse sub-angular and sub-rounded flint clasts. Sub-horizontally bedded. Occasional gravelly beds containing fine to medium sub-angular to sub-rounded flint clasts (≤50mm). **Abrupt sub-horizontal contact**	2.80-3.30
10106		Fluvial gravelly sand	Light brownish reddish slightly clayey gravelly sand. Frequent fine to coarse sub-angular to sub-rounded, fine to coarse flint clasts (<≤180 mm). Gravel is moderately sorted. Sub-horizontally bedded. Clayey sand and sandy gravel beds and lenses. Gravelly beds and lenses include chalky gravel units. Loose. **Abrupt, sub-horizontal contact**	3.30-4.10

10107		Fluvial sand and gravel	Fine to very coarse sub-angular and sub-rounded flint and chalk gravel (≤<200mm) in a light reddish yellow fine to medium sand matrix. Matrix supported. Moderately sorted (20-60mm). Sub-horizontally bedded. Increasingly gravelly to the north. Loose.	4.10-5.10+
10108		?Colluvial clay	Mid reddish-brown silty clay. Very occasional fine to medium sub-angular and sub-rounded flint clasts (≤50mm). Structureless. Rooted, with large root cavities infilled with dark grey silty clay.	1.30-2.10

Trench No 102	Length 13.5m	Width 7.5m	Depth 4.50 m	
Easting 562001.78		Northing 174575.76	m OD 17.64	
Context Number	**Fill Of/Filled With**	**Interpretative Category**	**Description**	**Depth BGL**
10201		Made ground	Mixed lithologies. Includes brick and concrete. Overlain by tarmac. **Sharp, sub-horizontal contact**	0.00-1.20
10202		?Disturbed fluvial deposits	Mid reddish-brown sandy clay. Upper 0.40m includes mid reddish brown gravelly sandy clay with frequent angular, sub-angular and sub-rounded fine to medium (5mm to 35mm) flint clasts, including sub-rounded Tertiary flint pebbles. Roughly circular with gravelly material forming halo when viewed in plan. Heavily rooted. **Sharp contact, near vertical in places**	0.70-4.40+
10203		Fluvial sand	Light greyish yellow and mid reddish-brown fine sand. Sub-horizontally and cross bedded. Clayey sand beds. Clast free. Rooted. **Abrupt, sub-horizontal contact**	0.80-1.10
10204		Fluvial clay	Mid reddish-brown clay. Clast free. Forms sub-horizontal bed between (10203) and (10204). **Abrupt, sub-horizontal contact**	1.10-1.25
10205		Fluvial sand	Light greyish yellow and mid reddish-brown fine to medium sand. Sub-horizontally and cross bedded. Clast free. **Abrupt, sub-horizontal contact**	1.20-1.60
10206		Fluvial sand	Light greyish yellow fine sand. Clast free. Sub-horizontally bedded. **Abrupt, sub-horizontal contact**	1.60-1.80

10207		Fluvial sand	Mid reddish brown and light greyish yellow fine sand. Sub-horizontally laminated. Clayey sand laminations. Extremely occasional fine to medium (3-30mm) sub-angular and sub-rounded flint clasts, including sub-rounded Tertiary flint pebbles. **Abrupt, 20º southerly dipping contact**	1.80-2.20
10208		Fluvial sand	Light greyish yellow and mid reddish-brown fine to medium sand. Sub-horizontally and cross bedded. Sub-horizontal and cross laminations. Mid reddish-brown silty clay lenses. Clast free. **Abrupt. 20º southerly dipping contact**	2.20-2.50
10209		Fluvial sand	Light greyish yellow and mid reddish-brown fine to medium sand. Sub-horizontally and cross bedded. Sub-horizontal and crossed laminations. Clast free. **Abrupt. sub-horizontal contact**	2.50-2.60
10210		Fluvial sand	Light greyish yellow and mid reddish-brown fine sand. Sub-horizontally and cross bedded. Clayey sand beds. Clast free. **Abrupt, 20º southerly dipping contact**	1.60-1.90
10211		Fluvial sand	Light reddish brown clayey fine . Clast free. Structureless.	1.90-2.30
10212		Fluvial sand	Dark reddish brown clayey fine sand. Clast free. Structureless.	2.30-2.60
10213		Fluvial sand and gravel	Fine to medium sub-angular flint gravel (5-25mm). Moderately sorted. Light greyish yellow and dark reddish-brown sand matrix. Clast supported. Sub-horizontally bedded. **Sharp, 40º northerly dipping contact**	2.60-3.40

10214		Fluvial sand and gravel	Light greyish yellow medium to coarse sandy gravel / gravelly sand. 50% fine to very coarse (10-100mm) sub-angular, sub-rounded and rounded flint clasts. Moderately sorted. <1% fine to coarse (5-70mm) sub-rounded and rounded chalk clasts. Poorly sorted. **Sharp, 40º northerly dipping contact**	3.40-4.40+
10215		Fluvial sand and gravel	Mid greyish brown gravelly medium sand. <30% fine to coarse sub-angular, sub-rounded and rounded flint clasts. Moderate to well sorted. Horizontally bedded with fine sand layers. Loose. **Abrupt, sub-horizontal contact**	2.50-4.30
10216		Fluvial sand and gravel	Light greyish white gravelly coarse sand. <40% fine to very coarse (10-100mm) sub-angular, sub-rounded, rounded flint clasts. Moderately sorted. <10% fine to coarse (10-60mm) sub-rounded and rounded chalk clasts. Moderately sorted. Structureless. Loose.	4.3-4.50+

Site Code: 232991	**Site Name:** Northfleet Embankment West	**Test Pit ID:** TP11
Coordinates (NGR) X: 561856.56	**Coordinates (NGR) Y:** 174694.52	**Level (top):** 15.29 m aOD
Length: 4 m	**Width:** 2.20 m	**Depth:** 4.10 m

Context Number	Description	Interpretation	Depth m BGL	Depth m aOD	Samples
1101	Dark greyish brown silty clay. <10% fine to coarse (10-70mm) angular and sub-angular flint clasts. Modern brick, plastic, iron. Structureless. Heavily rooted. Poorly consolidated. **Sharp horizontal contact**	Modern soil profile	0.00-0.40	15.29-14.89	-
1102	Dark blackish brown clayey silt. Plastic, iron, brick etc. Poorly consolidated. **Sharp 'v' shaped linear feature, east-west running contact**	Made ground	0.40-1.30	14.89-13.99	-
1103	Mid coarse sandy clay. <5% angular, sub-angular and sub-rounded flint clasts, occasional tarmac/clinker. Poorly sorted. Structureless. Heavily rooted. Well consolidated. **Sharp horizontal contact**	Made ground	0.40-2.50	14.89-11.89	-
1104	Dark brownish grey clayey silt. <1% fine to coarse (10-70mm) angular and sub-angular flint clasts. Poorly sorted. Brick and iron waste. **Abrupt undulating contact**	Made ground	2.50-3.30	11.89-11.09	-
1105	Light yellowish red gravelly coarse sand. Fine to coarse (5-90mm) sub-angular, sub-rounded and rounded flint clasts. Poorly consolidated.	?Disturbed fluvial sand and gravel	3.30-4.10+	11.09-10.29	66

Site Code: 232991	**Site Name:** Northfleet Embankment West	**Test Pit ID:** TP12
Coordinates (NGR) X: 561869.49	**Coordinates (NGR) Y:** 174661.57	**Level (top):** 15.57 m aOD
Length: 4 m	**Width:** 2.20 m	**Depth:** 4.40 m

Context Number	**Description**	**Interpretation**	**Depth m BGL**	**Depth m aOD**	**Samples**
1201	Dark greyish brown clayey silt. <1% fine to medium (5-50mm) sub-angular and angular flint clasts. Modern brick, iron and plastic. Heavily rooted. Structureless. Poorly consolidated. **Sharp horizontal contact**	Modern soil profile	0.00-0.30	15.57-15.27	-
1202	Mid-dark reddish brown silty fine sand. <5% fine to coarse (10-70mm) angular, sub-angular, sub-rounded and rounded flint clasts. Poorly sorted. Modern CBM, slag, coal. Heavily rooted. **Sharp horizontal contact**	Made ground	0.30-2.60	15.27-12.97	-
1203	Light reddish yellow gravelly coarse sand. <30% fine to coarse (5-100mm) sub-angular, sub-rounded and rounded flint clasts, well sorted. Bedded with fine sand layers. Very poorly consolidated. Loose. **Sharp undulating contact**	Fluvial sands and gravels	2.60-3.20	12.97-12.37	65
1204	Light reddish white fine sandy chalky silt. <30% fine to coarse sub-rounded chalk inclusions poorly sorted. Structureless. Poorly consolidated. **Diffuse undulating contact**	Solifluction gravel	3.20-3.80	12.37-11.77	-
1205	Brecciated chalk.	Brecciated chalk	3.80-4.40+	11.77-11.17	-

Site Code: 232991	**Site Name:** Northfleet Embankment West	**Test Pit ID:** TP13
Coordinates (NGR) X: 561860.45	**Coordinates (NGR) Y:** 174633.83	**Level (top):** 15.70 m aOD
Length: 4 m	**Width:** 2.20 m	**Depth:** 3.50 m

Context Number	Description	Interpretation	Depth m BGL	Depth m aOD	Samples
1301	Dark brownish grey clayey silt. Modern rubble, brick, iron etc. Heavy rooting. Structureless. Moderately consolidated. **Sharp sub-horizontal contact**	Modern soil profile	0.00-0.35	15.70-15.35	-
1302	Dark reddish grey gravelly clayey medium sand. Tip lines bedded with redeposited chalk, gravel and topsoil, brick. Poorly consolidated. **Sharp southerly dipping contact**	Made ground	0.35-1.20	15.35-14.50	-
1303	Mid yellowish red gravelly coarse sand. <10% fine to coarse (5-70mm) sub-angular, sub-rounded and rounded flint clasts. Poorly sorted. Structureless. Poorly consolidated. Rooted **Sharp undulating contact**	Fluvial sands and gravel	0.70-1.80	14.50-13.40	64
1304	Light brownish grey silt. Fine to coarse (5-100mm) <40% angular chalk clasts. <1% fine to coarse angular and nodular flint clasts **Diffuse undulating contact**	Soliflucted chalk	1.80-2.80	13.40-12.40	-
1305	Brecciated chalk	Brecciated chalk	2.80-3.30	12.40-11.90	-
1306	Structural chalk.	Structural chalk.	3.30-3.50+	11.90-11.70	-

Site Code: 232991	**Site Name:** Northfleet Embankment West	**Test Pit ID:** TP14
Coordinates (NGR) X: 561874.1682	**Coordinates (NGR) Y:** 174640.0198	**Level (top):** 15.85 m aOD
Length: 4 m	**Width:** 2.20 m	**Depth:** 4.30 m

Context Number	Description	Interpretation	Depth m BGL	Depth m aOD	Samples
1401	Dark greyish brown fine sandy clay. <5% fine to coarse angular, sub-angular and sub-rounded flint clasts, poorly sorted. Heavily rooted. Poorly consolidated. **Sharp horizontal contact**	Modern soil profile	0.00-0.20	15.85-	-
1402	Dark greyish black silty clay. Tarmac. **Sharp horizontal contact**	Made ground	0.20-0.50		-
1403	Light reddish yellow fine to medium sand. Clast free. Poorly consolidated. Finely laminated. Light rooting. **Sharp 45° southerly dipping contact**	Fluvial sand	0.50-1.20		-
1404	Mid yellowish red gravelly medium sand. <10% fine to medium (5-30mm) sub-angular, sub-rounded and rounded flint clasts. Moderately sorted. Structureless. Poorly consolidated. Light rooting. **Sharp 45° southerly dipping contact**	Fluvial sand and gravel	0.50-1.60		67,68,69
1405	Light greyish white silty chalky gravelly coarse sand. <40% fine to coarse (5-70mm) angular, sub-angular, sub-rounded and rounded flint clasts. Poorly sorted. <20% fine to medium (5-40mm) angular and sub-angular chalk clasts. Poorly sorted. Structureless. Poorly consolidated	Solifluction gravel	0.50-2.10		70
1406	Light greyish yellow gravelly fine to medium sand. <40% fine to coarse (5-160mm) sub-angular, sub-rounded, rounded and nodular flint clasts. Well sorted. Bedded with medium sand layers. **Sharp 45° southerly dipping contact**	Fluvial sand and gravel	2.10-2.90		71,72,73, 74,75

1407	Chalk gravel. <60% coarse angular chalk clasts. Poorly sorted. Light brownish white silt matrix. Structureless. Well consolidated. **Diffuse undulating contact**	Solifluction gravel	2.90-3.80		-
1408	Brecciated chalk.	Brecciated chalk	3.80-4.30		-

Site Code: 232991	**Site Name:** Northfleet Embankment West	**Test Pit ID:** TP15
Coordinates (NGR) X: 561943.02	**Coordinates (NGR) Y:** 174645.36	**Level (top):** 14.24 m aOD
Length: 4 m	**Width:** 2.20 m	**Depth:** 3.70 m

Context Number	**Description**	**Interpretation**	**Depth m BGL**	**Depth m aOD**	**Samples**
1501	Dark greyish brown clayey silt. <5% fine to coarse angular, sub-angular and sub-rounded flint clasts. Slurry material at base. Structureless. Heavily rooted. **Sharp horizontal contact**	Modern soil profile	0.00-0.40		-
1502	Light greyish red silty clay. Brick, iron, chalk rubble. Cut into fluvial gravels. **Sharp sub-horizontal to 45° contact**	Made ground	0.40-1.20		-
1503	Mid yellowish red gravelly coarse sand. <40% fine to coarse (5-70mm) sub-angular, sub-rounded and rounded flint clasts. Well sorted. Horizontally bedded with fine sand layers. Poorly consolidated.	Fluvial sand and gravel	0.40-2.60		80, 81, 82, 83, 84,
1504	Light brownish white silty chalk. <60% coarse angular chalk clasts. Poorly sorted. Structureless. Well consolidated. **Diffuse undulating contact**	Solifluction gravel	2.60-3.10		-
1505	Brecciated chalk.	Brecciated chalk	3.10-3.70_		-

Site Code: 232991		**Site Name:** Northfleet Embankment West		**Test Pit ID:** TP16	
Coordinates (NGR) X: 561963.4313		**Coordinates (NGR) Y:** 174646.6711		**Level (top):** 14.0679m aOD	
Length: 4 m		**Width:** 2.20 m		**Depth:** 4.10 m	
Context Number	**Description**	**Interpretation**	**Depth m BGL**	**Depth m aOD**	**Samples**
1601	Dark greyish brown clayey silt. <5% fine to coarse angular, sub-angular and sub-rounded flint clasts. Poorly sorted. Chalk slurry material at base. Structureless. Heavily rooted. **Sharp horizontal contact**	Topsoil	0.00-0.30		-
1602	Light yellowish brown clayey silty fine sand. <1% fine to medium (5-40mm) sub-rounded and rounded flint clasts. Poorly sorted. Structureless. Poorly consolidated. Moderately rooted. **Sharp sub-horizontal contact; gradually dipping to north**	Made ground	0.30-1.10		-
1603	Light brownish yellow clayey silty fine sand. <1% fine to medium (5-40mm) sub-angular, sub-rounded and rounded flint clasts. Poorly sorted. <1% fine chalk flecks. <2% fine manganese flecks. Structureless. Poorly consolidated. **Sharp sub-horizontal contact; gradually dipping to north**	Made ground	1.10-2.40		-
1604	Dark greyish brown clayey fine sandy silt. Very common brick fragments, iron slag and coal. <10% angular flint clasts. Poorly sorted. Structureless. Poorly consolidated. **Sharp sub-horizontal contact; gradually dipping to north**	Made ground	2.40-3.90		-
1605	Brecciated chalk	Brecciated chalk	3.90-4.10		-

Site Code: 232991	**Site Name:** Northfleet Embankment West	**Test Pit ID:** TP17
Coordinates (NGR) X: 561993.92	**Coordinates (NGR) Y:** 174685.81	**Level (top):** 18.59 m aOD
Length: 3.80 m	**Width:** 2.20 m	**Depth:** 4.70 m

Context Number	**Description**	**Interpretation**	**Depth m BGL**	**Depth m aOD**	**Samples**
1701	Made ground with brick, hardcore, concrete and iron. Heavily rooting. **Sharp sub-horizontal contact**	Made ground	0.00-3.40		-
1702	Gravel with brick, iron and chalk rubble. Sharp sub-horizontal contact	Made ground	3.40-4.10		-
1703	Mid brownish red gravelly coarse sand. <40% fine to coarse (5-80mm) sub-angular, sub-rounded and rounded flint clasts. Moderately sorted. Horizontally bedded with fine sand layers. Poorly consolidated.	Fluvial sand and gravel	4.10-4.70		49, 50, 51

Site Code: 232991	Site Name: Northfleet Embankment West	Test Pit ID: TP18
Coordinates (NGR) X: 561991.60	**Coordinates (NGR) Y:** 174645.87	**Level (top):** 19.05 m aOD
Length: 4 m	**Width:** 2.20 m	**Depth:** 4.30 m

Context Number	Description	Interpretation	Depth m BGL	Depth m aOD	Samples
1801	Made ground with brick, tarmac, wood, redeposited chalk rubble and iron. **Sharp sub-horizontal contact**	Made ground	0.00-1.60		-
1802	Mid brownish red clayey gravelly coarse sand. <20% fine to coarse (5-80mm) sub-angular, sub-rounded and rounded flint clasts. Poorly sorted. Moderately consolidated. Structureless. **Sharp undulating contact**	?Redeposited	1.60-2.20		40,41
1803	Mid brownish red silty clayey medium sand. <5% sub-angular, sub-rounded and rounded flint clasts. Poorly sorted. Structureless. Well consolidated. **Sharp sub horizontal contact**	Fluvial sand	2.20-3.20		42,43,44
1804	Mid-light brownish red gravelly coarse sand. <40% fine to coarse (5-100mm) angular, sub-angular, sub-rounded and rounded flint clasts. Well sorted. Horizontally bedded with clayey fine sand layers. Poorly consolidated.	Fluvial sand and gravel	3.20-4.30+		45,46,47, 48

Site Code: 232991	**Site Name:** Northfleet Embankment West	**Test Pit ID:** TP19
Coordinates (NGR) X: 562008.56	**Coordinates (NGR) Y:** 174646.48	**Level (top):** 19.37 m aOD
Length: 3.50 m	**Width:** 2.20 m	**Depth:** 4.30 m

Context Number	Description	Interpretation	Depth m BGL	Depth m aOD	Samples
1901	Made ground with tarmac, brick, redeposited chalk rubble, iron and redeposited gravel.	Made ground	0.00-4.30+		-

Site Code: 232991		**Site Name:** Northfleet Embankment West		**Test Pit ID:** TP20	
Coordinates (NGR) X: 562003.55		**Coordinates (NGR) Y:** 174620.46		**Level (top):** 20.01 m aOD	
Length: 3.50 m		**Width:** 2.20 m		**Depth:** 2.30 m	
Context Number	**Description**	**Interpretation**	**Depth m BGL**	**Depth m aOD**	**Samples**
2001	Made ground. Brick, tarmac, hardcore redeposited chalk dust and plastic.	Made ground	0.00-2.30+		-

Site Code: 232991	**Site Name:** Northfleet Embankment West	**Test Pit ID:** TP21
Coordinates (NGR) X: 561995.64	**Coordinates (NGR) Y:** 174589.76	**Level (top):** 19.37 m aOD
Length: 3.70 m	**Width:** 2.20 m	**Depth:** 4.20 m

Context Number	**Description**	**Interpretation**	**Depth m BGL**	**Depth m aOD**	**Samples**
2101	Made ground. Hardcore, brick and iron. Sharp horizontal contact	Made ground	0.00-1.60		-
2102	Light reddish yellow gravelly medium sand. <20% fine to coarse (5-80mm) sub-angular, sub-rounded and rounded flint clasts. Moderately-well sorted. Horizontally bedded with coarse sand layers. Poorly consolidated. **Sharp horizontal contact**	Fluvial sand and gravel	1.60-3.40		27,28,29, 30,31,32, 33
2103	Light greyish yellow gravelly coarse sand. <40% fine to coarse (5-70mm) sub-angular, sub-rounded and rounded flint clasts. <20% fine to coarse (5-40mm) sub-rounded and rounded chalk clasts. Moderately sorted. No apparent bedding. Poorly consolidated.	Fluvial sand and gravel	3.40-4.20+		35,36,37, 38,39

Site Code: 232991	**Site Name:** Northfleet Embankment West	**Test Pit ID:** TP22
Coordinates (NGR) X: 562158.19	**Coordinates (NGR) Y:** 174657.96	**Level (top):** 14.03 m aOD
Length: 4 m	**Width:** 2.20 m	**Depth:** 4.20 m

Context Number	**Description**	**Interpretation**	**Depth m BGL**	**Depth m aOD**	**Samples**
2201	Dark greyish brown and reddish-brown clayey sand. Brick, tarmac etc.	Made ground	0.00-0.45		
2202	Dark brownish black silty clay. Brick, clinker and iron. Well consolidated.	Made ground	0.45-1.00		-
2203	Light greyish white silty chalk. <60% fine to coarse (5-80mm) angular chalk clasts. Poorly sorted. Rooted Poorly consolidated.	?Redeposited chalk	1.00-4.00		
2204	Structural chalk.	Chalk bedrock	4.00-4.20+		-

<table>
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232991</td><td colspan="2">Site Name:
Northfleet Embankment West</td><td colspan="2">Test Pit ID:
TP23</td></tr>
<tr><td colspan="2">Coordinates (NGR) X:
562167.56</td><td colspan="2">Coordinates (NGR) Y:
174649.47</td><td colspan="2">Level (top):
14.06 m aOD</td></tr>
<tr><td colspan="2">Length:
4 m</td><td colspan="2">Width:
2.20 m</td><td colspan="2">Depth:
4.40 m</td></tr>
<tr><td>Context Number</td><td>Description</td><td>Interpretation</td><td>Depth m BGL</td><td>Depth m aOD</td><td>Samples</td></tr>
<tr><td>2301</td><td>Tarmac over hard standing. Brick, clinker, chalk rubble and coal.

Sharp horizontal contact</td><td>Made ground</td><td>0.00-0.70</td><td></td><td></td></tr>
<tr><td>2302</td><td>Dark greyish brown silty clay. <10% fine to coarse angular and sub-angular flint. Poorly sorted. Brick, iron, clinker and chalk.

Sharp, northerly dipping contact</td><td>Made ground</td><td>0.70-1.90</td><td></td><td></td></tr>
<tr><td>2303</td><td>Light greyish yellow silty chalk. Occasional coarse (50-200mm) flint nodules.

Abrupt sub-horizontal contact</td><td>Weathered chalk</td><td>1.90-3.70</td><td></td><td>-</td></tr>
<tr><td>2304</td><td>Structural chalk.</td><td>Chalk bedrock</td><td>3.70-4.40+</td><td></td><td>-</td></tr>
</table>

Site Code: 232991		**Site Name:** Northfleet Embankment West		**Test Pit ID:** TP24	
Coordinates (NGR) X: 562151.44		**Coordinates (NGR) Y:** 174634.92		**Level (top):** 15.40 m aOD	
Length: 4 m		**Width:** 2.20 m		**Depth:** 3.70 m	
Context Number	**Description**	**Interpretation**	**Depth m BGL**	**Depth m aOD**	**Samples**
2401	Redeposited building rubble. Possible cellar. Clinker, brick, iron, tile and plastic. **Sharp horizontal contact**	Made ground	0.00-1.20		-
2402	Light bluish grey clay. Mixed with redeposited soil, brick, clinker and iron. **Sharp horizontal contact**	Made ground	1.20-1.70		-
2403	Mid brownish red gravelly coarse sand. <40% fine to coarse (5-180mm) sub-angular, sub-rounded and rounded flint clasts. Moderately sorted. Sub-horizontally bedded. Alternating gravelly and coarse sand layers. Poorly consolidated. Light rooting. **Sharp 20° westerly dipping contact**	Fluvial sands and gravels	1.70-2.40		102,103
2404	?Soliflucted chalk.	?Solifluction gravel	2.40-2.60		-
2405	Structural chalk	Chalk bedrock	2.60-3.70+		-

Site Code: 232991		Site Name: Northfleet Embankment West		Test Pit ID: TP25	
Coordinates (NGR) X: 562151.54		**Coordinates (NGR) Y:** 174615.29		**Level (top):** 16.18 m aOD	
Length: 3.50 m		**Width:** 2.20 m		**Depth:** 4.85 m	
Context Number	**Description**	**Interpretation**	**Depth m BGL**	**Depth m aOD**	**Samples**
2501	Concrete over brick rubble. Well consolidated. **Sharp horizontal contact**	Made ground	0.00-0.50		-
2502	Light reddish yellow gravelly medium to coarse sand. <40% fine to coarse (5-60mm) sub-angular, sub-rounded and rounded flint clasts. Well sorted. Horizontally bedded. Poorly consolidated. **Diffuse undulating contact**	Fluvial sand and gravels	0.50-3.10		89, 90, 91, 92, 93,
2503	Mid reddish yellow gravelly coarse sand. <30% fine to coarse (5-120mm) angular, sub-angular, sub-rounded, rounded and nodular flint clasts. Moderately sorted. Horizontally bedded with fine sand layers. Poorly consolidated. **Sharp undulating contact**	Fluvial sands and gravels.	3.10-4.75		98, 99, 100,101
2504	Structural chalk	Chalk bedrock	4.75-4.85+		-

Site Code: 232991	**Site Name:** Northfleet Embankment West	**Test Pit ID:** TP26
Coordinates (NGR) X: 562171.09	**Coordinates (NGR) Y:** 174626.99	**Level (top):** 15.44 m aOD
Length: 4 m	**Width:** 2.20 m	**Depth:** 3.70 m

Context Number	Description	Interpretation	Depth m BGL	Depth m aOD	Samples
2601	Dark brownish black silty modern rubble. Brick, clinker, concrete, iron and plastic rubble. **Sharp horizontal contact**	Made ground	0.00-0.70		-
2602	Dark brownish grey fine sandy clay. <5% (5-40mm) sub-angular, sub-rounded and rounded flint clasts. Brick, iron, redeposited chalk and clinker. **Sharp horizontal contact**	Made ground	0.70-1.20		-
2603	Mid brownish-blue silty clay mixed in with redeposited soil. **Sharp horizontal contact**	Made ground	1.20-1.80		
2604	Mid brownish red gravelly medium to coarse sand. <40% fine to coarse (5-250mm) angular, sub-angular, sub-rounded, rounded and nodular flint clasts. Moderately sorted. Sub-horizontally bedded, dipping to northeast. Poorly consolidated. **Sharp 45° north easterly dipping contact**	Fluvial sands and gravels.	1.80-3.20		104, 105
2605	Chalk gravel in light reddish white fine sandy silt matrix. Frequent nodular flint clasts. **Diffuse undulating contact**	Solifluction gravel	2.60-3.20		-
2606	Structural chalk	Chalk bedrock	3.20-3.70+		-

Site Code: 232991	**Site Name:** Northfleet Embankment West	**Test Pit ID:** TP28
Coordinates (NGR) X: 561973.16	**Coordinates (NGR) Y:** 174531.26	**Level (top):** 19.75 m aOD
Length: 4 m	**Width:** 2.10 m	**Depth:** 4.30 m

Context Number	**Description**	**Interpretation**	**Depth m BGL**	**Depth m aOD**	**Samples**
2801	Made ground. Brick, tarmac, iron and rubble. **Diffuse sub-horizontal contact**	Made ground	0.00-0.70		-
2802	Light greyish yellow clayey silty fine sand with patches of fine sandy clay. <1% fine to coarse (5-100mm) sub-rounded, rounded and nodular flint clasts. Occasional medium rounded chalk clasts concentrated towards base. Poorly sorted. Finely laminated. Poorly consolidated. **Sharp sub-horizontal contact**	?Fluvial sands	0.70-1.40		15
2803	Angular chalk clasts with occasional coarse flint nodules. Very well consolidated. **Sharp sub-horizontal contact**	Solifluction gravel	1.40-1.80		23
2804	Mid reddish brown silty gravelly medium sand. <15% fine to coarse (5-80mm) sub-angular, sub-rounded and rounded flint clasts. Very occasional angular medium chalk clasts. Moderately sorted. No apparent bedding. Poorly consolidated **Sharp northerly dipping contact**	Fluvial sand and gravel	1.40-2.70		16, 17, 18, 19
2805	Mid greyish brown silty gravelly medium sand. 20% fine to coarse angular, sub-angular and sub-rounded flint clasts. Fine to coarse sub-angular and angular chalk clasts. Poorly sorted. Sub-horizontally bedded with silty medium sand (dipping to north). Becoming chalkier towards base. Moderately consolidated. **Abrupt northerly dipping contact**	Soliflucted and fluvial sand and gravel	2.70-3.75		20, 21, 22, 24, 25
2806	Coarse nodular flint clasts. Well consolidated. Dips towards north of test pit.	Brecciated chalk	3.75-4.30+		-

Site Code: 232991	**Site Name:** Northfleet Embankment West	**Test Pit ID:** Sec29
Coordinates (NGR) X: 561868.5280	**Coordinates (NGR) Y:** 174637.1883	**Level (top):** 16.0635
Length:	**Width:**	**Depth:** 2.20 m

Context Number	**Description**	**Interpretation**	**Depth m BGL**	**Depth m aOD**	**Samples**
2901	Dark greyish brown fine sandy silt. <1% fine to medium (5-30mm) rounded, sub-rounded and sub-angular flint clasts. <1% chalk flecks. Poorly sorted. Structureless. Poorly consolidated. **Sharp sub-horizontal contact**	Modern soil profile	0.00-1.21		-
2902	Mid reddish brown fine sandy clay. <1% chalk flecks. . Structureless. Well consolidated. Heavily rooted. **Sharp unconformable sub-horizontal contact**	Colluvial clay (Head)	1.21-1.74		-
2903	Light reddish yellow slightly clayey fine sand. No apparent inclusions. Structureless? Poorly consolidated. **Sharp northly dipping contact**	Fluvial sand	1.74-2.20		-
2904	Fine to medium angular, sub-angular and sub-rounded gravel in a mid-brownish-red coarse sand matrix. Moderately sorted. Coarsely stratified. Deposit dipping to north.	Fluvial gravel	1.74-2.20+		-

Site Code: 232991	**Site Name:** Northfleet Embankment West		**Test Pit ID:** Sec30		
Coordinates (NGR) X: 561864.5450	**Coordinates (NGR) Y:** 174640.3006		**Level (top):** 16.1972		
Length: 2.10 m	**Width:**		**Depth:** 1.70 m		
Context Number	**Description**	**Interpretation**	**Depth m BGL**	**Depth m aOD**	**Samples**
3001	Mid brownish red clayey sand. Sand is fine. Moderately frequent fine to coarse (≤50 mm) sub-rounded, sub-angular and angular flint clasts, including glauconitic Tertiary flint pebbles. Structureless. Heavily rooted. **Abrupt 10º northerly dipping contact**	Colluvial sand (Head)	0.00-1.20		-
3002	Light reddish yellow gravelly clayey silty sand. Sand is fine. Gravel is fine to medium (≤25mm) sub-rounded, sub-angular and angular chalk and flint, including glauconitic Tertiary flint pebbles. Structureless. Heavily rooted. **Abrupt 10º northerly dipping contact**	Colluvial gravelly sand (Head)	0.80-1.40		-
3003	Mid brownish red fine to medium slightly silty sand. Occasional fine to medium sub-angular and sub-rounded flint clasts (≤30mm). Occasional lenses of calcareous sandy silts reworked from (3004) **Abrupt 10° northerly dipping contact**	Colluvial sand (Head)	0.90-1.70+		-
3004	Light reddish-brown sandy silt. Sand is fine. Very frequent fine light greyish yellow fine sandy clayey silt laminations and lenses. Clast free.	Colluvial silt (head); possibly with aeolian component	1.40-1.70+		-

Site Code: 232991	**Site Name:** Northfleet Embankment West	**Test Pit ID:** Sec31
Coordinates (NGR) X: 562154.2915	**Coordinates (NGR) Y:** 174579.7230	**Level (top):** 16.7330
Length: 5 m	**Width:**	**Depth:** 2.86 m

Context Number	**Description**	**Interpretation**	**Depth m BGL**	**Depth m aOD**	**Samples**
3101	Made ground.	Made ground	0.00-0.26		-
3102	Light brownish clayey fine sandy silt. Horizontally bedded with gravelly coarse sand <30% fine to medium (5-50mm) angular, sub-angular, sub-rounded and rounded flint clasts. Moderately sorted. Interbedded with medium to coarse sand layers. Poorly consolidated. Moderate rooting. **Sharp 10° north easterly dipping contact.**	Fluvial sand	0.26-2.36		106, 107
3103	Light greyish yellow medium sand. <1% fine to medium (5-20mm) sub-rounded and rounded flint clasts. Poorly sorted. Finely laminated. Poorly consolidated.	Fluvial sand	2.00-2.86+		108

Appendix 2 Lithic artefacts data

Appendix 2 Lithic artefacts data

Artefact number	Area	Trench / Test Pit	Context	Sample number	Stratigraphic unit	Length (mm)	Width (mm)	Thickness (mm)	Abrasion (mm)	Patination	Edge damage	Staining	Techno-typological description
1	3	Tr100	10004	55	Soliflucted and fluvial gravel	38.9	45.3	5.0	None	None	Moderate	None	Hard hammer flake
2	3	Tr100	10010	56	Soliflucted and fluvial gravel	35.2	33.6	10.3	Moderate	Light	Heavy	None	Hard hammer flake removed from a flake
3	3	Tr100	Spoil heap	-	Fluvial sandy flint gravel	69.3	46.4	23.2	Heavy	Moderate	Heavy	Moderate	Hard hammer flake
4	2	Tr101	10107	4	Fluvial sandy flint and chalk gravel	62.2	40.5	11.7	None	None	Moderate	None	Flake with lateral break; indeterminate hammer mode
5	2	Tr101	10107	4	Fluvial sandy flint and chalk gravel	45.5	37.0	9.8	Light	None	Moderate	None	Flake; indeterminate hammer mode
6	2	Tr102	10215	13	Fluvial sandy flint gravel	53.3	20.0	12.7	Moderate	Light	Heavy	None	Probable hard hammer flake
7	3	TP14	1404	72	Fluvial sandy flint gravel	52.2	52.6	23.0	Heavy	None	Heavy	None	Hard hammer flake with probable concave abrupt retouch at the distal end forming a borer
8	8	TP25	2502	89	Fluvial sandy flint gravel	65.4	56.7	12.2	Light	Light	Heavy	Light	Hard hammer flake
9	3	TP13	1302	-	Made ground	28.7	24.4	3.9	None	Light	Light	Light	Broken leaf shaped arrowhead

10	3	TP13	1302	-	Made ground	42.7	17	7.2	None	Light	Moderate	None	Blade
11	3	TP12	1202	-	Made ground	57.5	40.7	33.3	None	Light	Moderate	None	Keeled blade core; exhausted
12	4	TP18	1802	42	Disturbed fluvial sand (?redeposited)	81.1	64.7	21.3	None	None	Light	None	Galletting flake with adhering mortar

Appendix 3 OSL dating

University of Gloucestershire

Luminescence dating laboratory

Optical dating of sediments: Northfleet excavations, UK

to

Dr Claire Mellett & Dr Andrew Shaw
Wessex Archaeology

Analysis & Reporting, Prof. P.S. Toms
Sample, Preparation & Measurement, Dr J.C. Wood
26 March 2021

Contents

Scope of Report

This is a standard report of the Luminescence dating laboratory, University of Gloucestershire. In large part, the document summarises the processes, diagnostics and data drawn upon to deliver Table 1. A conclusion on the analytical validity of each sample's optical age estimate is expressed in Table 2; where there are caveats, the reader is directed to the relevant section of the report that explains the issue further in general terms.

Field Code	Lab Code	Overburden (m)	Grain size (μm)	Moisture content (%)	Ge γ-spectrometry (*ex situ*)			β D_r (Gy.ka^{-1})	γ D_r (Gy.ka^{-1})	Cosmic D_r (Gy.ka^{-1})	Preheat (°C for 10s)	Low Dose Repeat Ratio	High Dose Repeat Ratio	Post-IR OSL Ratio
					K (%)	Th (ppm)	U (ppm)							
7 (10209)	GL20093	1.20	180-250	3 ± 1	0.21 ± 0.04	1.46 ± 0.27	0.24 ± 0.08	0.20 ± 0.05	0.14 ± 0.05	0.17 ± 0.02	180	1.00 ± 0.04	1.03 ± 0.04	1.00 ± 0.04
9 (10207)	GL20094	1.65	180-250	12 ± 3	0.89 ± 0.07	3.85 ± 0.37	0.44 ± 0.09	0.67 ± 0.08	0.39 ± 0.07	0.16 ± 0.02	200	1.01 ± 0.04	1.00 ± 0.04	1.00 ± 0.04
106 (3102)	GL20095	1.10	180-250	4 ± 1	0.58 ± 0.06	1.75 ± 0.31	0.17 ± 0.08	0.45 ± 0.07	0.23 ± 0.06	0.17 ± 0.02	200	0.98 ± 0.05	1.02 ± 0.05	1.03 ± 0.05
108 (303)	GL20096	2.40	180-250	3 ± 1	0.00 ± 0.00	1.27 ± 0.25	0.16 ± 0.08	0.05 ± 0.03	0.08 ± 0.03	0.14 ± 0.01	220	1.01 ± 0.05	0.98 ± 0.04	0.98 ± 0.04
61 (10015)	GL20097	0.70	180-250	3 ± 1	0.22 ± 0.04	0.83 ± 0.29	0.13 ± 0.09	0.19 ± 0.05	0.10 ± 0.05	0.19 ± 0.02	240	1.01 ± 0.06	0.99 ± 0.05	0.93 ± 0.05
71 (1403)	GL20098	0.70	125-180	10 ± 3	1.27 ± 0.09	4.21 ± 0.40	0.80 ± 0.10	0.99 ± 0.11	0.53 ± 0.09	0.19 ± 0.02	200	0.99 ± 0.05	1.01 ± 0.04	1.00 ± 0.04

Field Code	Lab Code	Total D_r (Gy.ka^{-1})	D_e (Gy)	Age (ka)
7 (10209)	GL20093	0.52 ± 0.05	280.3 ± 16.1	543 ± 64 (59)
9 (10207)	GL20094	1.21 ± 0.10	539.0 ± 60.1	444 ± 61 (57)
106 (3102)	GL20095	0.86 ± 0.07	229.9 ± 26.3	268 ± 38 (35)
108 (303)	GL20096	0.26 ± 0.03	129.0 ± 7.6	493 ± 62 (58)
61 (10015)	GL20097	0.48 ± 0.05	122.1 ± 8.5	257 ± 34 (33)
71 (1403)	GL20098	1.71 ± 0.02	406.5 ± 43.9	238 ± 31 (29)

Table 1 D_r, D_e and Age data of submitted samples located at c. 51°N, 0°E, 10m. Age estimates expressed relative to year of sampling. Uncertainties in age are quoted at 1σ confidence, are based on analytical errors and reflect combined systematic and experimental variability and (in parenthesis) experimental variability alone (see 6.0). **Blue** indicates samples with accepted age estimates, **red**, age estimates with caveats (see Table 2).

Generic considerations	Field Code	Lab Code	Sample specific considerations
Absence of *in situ* γ spectrometry data (see section 4.0)	7 (10209)	GL20093	None
	9 (10207)	GL20094	None
	106 (3102)	GL20095	None
	108 (303)	GL20096	None
	61 (10015)	GL20097	Significant feldspar contamination (see section 3.1.1, Table 1 and Fig. 1) Accept as minimum age estimate
	71 (1403	GL20098	None

Table 2 Analytical validity of sample suite age estimates and caveats for consideration

1.0 Mechanisms and principles

Upon exposure to ionising radiation, electrons within the crystal lattice of insulating minerals are displaced from their atomic orbits. Whilst this dislocation is momentary for most electrons, a portion of charge is redistributed to meta-stable sites (traps) within the crystal lattice. In the absence of significant optical and thermal stimuli, this charge can be stored for extensive periods. The quantity of charge relocation and storage relates to the magnitude and period of irradiation. When the lattice is optically or thermally stimulated, charge is evicted from traps and may return to a vacant orbit position (hole). Upon recombination with a hole, an electron's energy can be dissipated in the form of light generating crystal luminescence providing a measure of dose absorption.

Herein, quartz is segregated for dating. The utility of this minerogenic dosimeter lies in the stability of its datable signal over the mid to late Quaternary period, predicted through isothermal decay studies (e.g. Smith *et al*., 1990; retention lifetime 630 Ma at 20°C) and evidenced by optical age estimates concordant with independent chronological controls (e.g. Murray and Olley, 2002). This stability is in contrast to the anomalous fading of comparable signals commonly observed for other ubiquitous sedimentary minerals such as feldspar and zircon (Wintle, 1973; Templer, 1985; Spooner, 1993)

Optical age estimates of sedimentation (Huntley *et al*., 1985) are premised upon reduction of the minerogenic time dependent signal (Optically Stimulated Luminescence, OSL) to zero through exposure to sunlight and, once buried, signal reformulation by absorption of litho- and cosmogenic radiation. The signal accumulated post burial acts as a dosimeter recording total dose absorption, converting to a chronometer by estimating the rate of dose absorption quantified through the assay of radioactivity in the surrounding lithology and streaming from the cosmos.

$$\text{Age} = \frac{\text{Mean Equivalent Dose } (D_e, \text{ Gy})}{\text{Mean Dose Rate } (D_{r}, \text{ Gy.ka}^{-1})}$$

Aitken (1998) and Bøtter-Jensen *et al*. (2003) offer a detailed review of optical dating.

2.0 Sample Preparation

Six sediment samples were collected within opaque tubing and submitted for Optical dating. To preclude optical erosion of the datable signal prior to measurement, all samples were opened and prepared under controlled laboratory illumination provided by Encapsulite RB-10 (red) filters. To isolate that material potentially exposed to daylight during sampling, sediment located within 20 mm of each tube-end was removed.

The remaining sample was dried and then sieved. The fine sand fraction was segregated and subjected to acid and alkaline digestion (10% HCl, 15% H_2O_2) to attain removal of carbonate and organic components respectively. A further acid digestion in HF (40%, 60 mins) was used to etch the outer 10-15 μm layer affected by α radiation and degrade each samples' feldspar content. During HF treatment, continuous magnetic stirring was used to effect isotropic etching of grains. 10% HCl was then added to remove acid soluble fluorides. Each sample was dried, resieved and quartz isolated from the remaining heavy mineral fraction using a sodium polytungstate density separation at 2.68g.cm^{-3}. Twelve 6 mm multi-grain aliquots (*c*. 3-6 mg) of quartz from each sample were then mounted on stainless steel cups for determination of D_e values.

All drying was conducted at 40°C to prevent thermal erosion of the signal. All acids and alkalis were Analar grade. All dilutions (removing toxic-corrosive and non-minerogenic luminescence-bearing substances) were conducted with distilled water to prevent signal contamination by extraneous particles.

3.0 Acquisition and accuracy of D_e value

All minerals naturally exhibit marked inter-sample variability in luminescence per unit dose (sensitivity). Therefore, the estimation of D_e acquired since burial requires calibration of the natural signal using known amounts of laboratory dose. D_e values were quantified using a single-aliquot regenerative-dose (SAR) protocol (Murray and Wintle 2000; 2003) facilitated by a Freiberg Instruments Lexsyg Smart irradiation-stimulation-detection system (Richter *et al*., 2015). Within this apparatus, optical signal stimulation is provided by an assembly of blue laser diodes, filtered to 445±3 nm conveying 80 $mW.cm^{-2}$ using a 3 mm Schott GG420 and HC448/20 positioned in front of each laser diode. Infrared (IR) stimulation, provided by IR laser diodes stimulating at 850±3nm filtered by 3 mm RG 715 and delivering ~200 $mW.cm^{-2}$, was used to indicate the presence of contaminant feldspars (Hütt *et al*., 1988). Stimulated photon emissions from quartz aliquots are in the ultraviolet (UV) range. These were divided from stimulating photons by 2.5 mm Hoya U-340 and 1mm NG4 glass filters, and a Delta BP 365/50 interference filter, then detected by a Hamamatsu UV-VIS (300-650 nm) bi-alkaline cathode photomultiplier. Aliquot irradiation was conducted using a 1.85 GBq $^{90}Sr/^{90}Y$ β source calibrated for multi-grain aliquots of 125-180 and 180-250 μm quartz against the 'Hotspot 800' ^{60}Co γ source located at the National Physical Laboratory (NPL), UK.

SAR by definition evaluates D_e through measuring the natural signal (Fig. 1) of a single aliquot and then regenerating that aliquot's signal by using known laboratory doses to enable calibration. For each aliquot, five different regenerative-doses were administered so as to image dose response. D_e values for each aliquot were then interpolated, and associated counting and fitting errors calculated, by way of exponential plus linear regression (Fig. 1). Weighted (geometric) mean D_e values were calculated from 12 aliquots using the central age model outlined by Galbraith *et al*. (1999) and are quoted at 1σ confidence (Table 1). The accuracy with which D_e equates to total absorbed dose and that dose absorbed since burial was assessed. The former can be considered a function of laboratory factors, the latter, one of environmental issues. Diagnostics were deployed to estimate the influence of these factors and criteria instituted to optimise the accuracy of D_e values.

3.1 Laboratory Factors

3.1.1 Feldspar contamination

The propensity of feldspar signals to fade and underestimate age, coupled with their higher sensitivity relative to quartz makes it imperative to quantify feldspar contamination. At room temperature, feldspars generate a signal (IRSL; Fig. 1) upon exposure to IR whereas quartz does not. The signal from feldspars contributing to OSL can be depleted by prior exposure to IR. For all aliquots the contribution of any remaining feldspars was estimated from the OSL IR depletion ratio (Duller, 2003). The influence of IR depletion on the OSL signal can be illustrated by comparing the regenerated post-IR OSL D_e with the applied regenerative-dose. If the addition to OSL by feldspars is insignificant, then the repeat dose ratio of OSL to post-IR OSL should be statistically consistent with unity (Table 1). If any aliquots do not fulfil this criterion, then the sample age estimate should be accepted tentatively. The source of feldspar contamination is rarely rooted in sample preparation; it predominantly results from the occurrence of feldspars as inclusions within quartz.

3.1.2 Preheating

Preheating aliquots between irradiation and optical stimulation is necessary to ensure comparability between natural and laboratory-induced signals. However, the multiple irradiation and preheating steps that are required to define single-aliquot regenerative-dose response leads to signal sensitisation, rendering calibration of the natural signal inaccurate. The SAR protocol (Murray and Wintle, 2000; 2003) enables this sensitisation to be monitored and corrected using a test dose, here set at 5 Gy preheated to 160°C for 10s, to track signal sensitivity between irradiation-preheat steps. However, the accuracy of sensitisation correction for both natural and laboratory signals can be preheat dependent.

The Dose Recovery test was used to assess the optimal preheat temperature for accurate correction and calibration of the time dependent signal. Dose Recovery (Fig. 2) attempts to quantify the combined effects of thermal transfer and sensitisation on the natural signal, using a precise lab dose to simulate natural dose. The ratio between the applied dose and recovered D_e value should be statistically concordant with unity. For this diagnostic, 6 aliquots were each assigned a 10 s preheat between 140°C and 240°C.

That preheat treatment fulfilling the criterion of accuracy within the Dose Recovery test was selected to generate the final D_e value from a further 12 aliquots. Further thermal treatments, prescribed by Murray and Wintle (2000; 2003), were applied to optimise accuracy and precision. Optical stimulation occurred at 105°C in order to minimise effects associated with photo-transferred thermoluminescence and maximise signal to noise ratios. Inter-cycle optical stimulation was conducted at 240°C to minimise recuperation.

3.1.3 Irradiation

For all samples having D_e values in excess of 100 Gy, matters of signal saturation and laboratory irradiation effects are of concern. With regards the former, the rate of signal accumulation generally adheres to a saturating exponential form and it is this that limits the precision and accuracy of D_e values for samples having absorbed large doses. For such samples, the functional range of D_e interpolation by SAR has been verified up to 600 Gy by Pawley *et al*. (2010). Age estimates based on D_e values exceeding this value should be accepted tentatively.

3.1.4 Internal consistency

Abanico plots (Dietze *et al*., 2016) are used to illustrate inter-aliquot D_e variability (Fig. 3). D_e values are standardised relative to the central D_e value for natural signals and are described as overdispersed when >5% lie beyond $\pm$ 2σ of the standardising value; resulting from a heterogeneous absorption of burial dose and/or response to the SAR protocol. For multi-grain aliquots, overdispersion of natural signals does not necessarily imply inaccuracy. However where overdispersion is observed for regenerated signals, the efficacy of sensitivity correction may be problematic. Murray and Wintle (2000; 2003) suggest repeat dose ratios (Table 1) offer a measure of SAR protocol success, whereby ratios ranging across 0.9-1.1 represent effective sensitivity correction. However, this variation of repeat dose ratios in the high-dose region can have a significant impact on D_e interpolation.

3.2 Environmental factors

3.2.1 Incomplete zeroing

Post-burial OSL signals residual of pre-burial dose absorption can result where pre-burial sunlight exposure is limited in spectrum, intensity and/or period, leading to age overestimation. This effect is particularly acute for material eroded and redeposited sub-aqueously (Olley *et al*., 1998, 1999; Wallinga, 2002) and exposed to a burial dose of <20 Gy (e.g. Olley *et al*., 2004), has some influence in sub-aerial contexts but is rarely of consequence where aerial transport has occurred. Within single-aliquot regenerative-dose optical dating there are two diagnostics of partial resetting (or bleaching); signal analysis (Agersnap-Larsen *et al*., 2000; Bailey *et al*., 2003) and inter-aliquot D_e distribution studies (Murray *et al*., 1995).

Within this study, signal analysis was used to quantify the change in D_e value with respect to optical stimulation time for multi-grain aliquots. This exploits the existence of traps within minerogenic dosimeters that bleach with different efficiency for a given wavelength of light to verify partial bleaching. D_e (t) plots (Fig. 4; Bailey *et al*., 2003) are constructed from separate integrals of signal decay as laboratory optical stimulation progresses. A statistically significant increase in natural D_e (t) is indicative of partial bleaching assuming three conditions are fulfilled. Firstly, that a statistically significant increase in D_e (t) is observed when partial bleaching is simulated within the laboratory. Secondly, that there is no significant rise in D_e (t) when full bleaching is simulated. Finally, there should be no significant augmentation in D_e (t) when zero dose is simulated. Where partial bleaching is detected, the age derived from the sample should be considered a maximum estimate only. However, the utility of signal analysis is strongly dependent upon a samples pre-burial experience of sunlight's spectrum and its residual to post-burial signal ratio. Given in the majority of cases, the spectral exposure history of a deposit is uncertain, the absence of an increase in natural D_e (t) does not necessarily testify to the absence of partial bleaching.

Where requested and feasible, the insensitivities of multi-grain single-aliquot signal analysis may be circumvented by inter-aliquot D_e distribution studies. This analysis uses aliquots of single sand grains to quantify inter-grain D_e distribution. At present, it is contended that asymmetric inter-grain D_e distributions are symptomatic of partial bleaching and/or pedoturbation (Murray *et al*., 1995; Olley *et al*., 1999; Olley *et al*., 2004; Bateman *et al*., 2003). For partial bleaching at least, it is further contended that the D_e acquired during burial is located in the minimum region of such ranges. The mean and breadth of this minimum region is the subject of current debate, as it is additionally influenced by heterogeneity in microdosimetry, variable inter-grain response to SAR and residual to post-burial signal ratios.

3.2.2 Turbation

As noted in section 3.1.1, the accuracy of sedimentation ages can further be controlled by post-burial trans-strata grain movements forced by pedo- or cryoturbation. Berger (2003) contends pedogenesis prompts a reduction in the apparent sedimentation age of parent material through bioturbation and illuviation of younger material from above and/or by biological recycling and resetting of the datable signal of surface material. Berger (2003) proposes that the chronological products of this remobilisation are A-horizon age estimates reflecting the cessation of pedogenic activity, Bc/C-horizon ages delimiting the maximum age for the initiation of pedogenesis with estimates obtained from Bt-horizons providing an intermediate age 'close to the age of cessation of soil development'. Singhvi et al. (2001), in contrast, suggest that B and C-horizons closely approximate the age of the parent material, the A-horizon, that of the 'soil forming episode'. Recent analyses of inter-aliquot D_e distributions have reinforced this complexity of interpreting burial age from pedoturbated deposits (Lombard *et al*., 2011; Gliganic *et al*., 2015; Jacobs *et al*., 2008; Bateman *et al*., 2007; Gliganic *et al*., 2016). At present there is no definitive post-sampling mechanism for the direct detection of and correction for post-burial sediment remobilisation. However, intervals of palaeosol evolution can be delimited by a maximum age derived from parent material and a minimum age obtained from a unit overlying the palaeosol. Inaccuracy forced by cryoturbation may be bidirectional, heaving older material upwards or drawing younger material downwards into the level to be dated. Cryogenic deformation of matrix-supported material is, typically, visible; sampling of such cryogenically-disturbed sediments can be avoided.

4.0 Acquisition and accuracy of D_r value

Lithogenic D_r values were defined through measurement of U, Th and K radionuclide concentration and conversion of these quantities into β and γ D_r values (Table 1). β contributions were estimated from sub-samples by laboratory-based γ spectrometry using an Ortec GEM-S high purity Ge coaxial detector system, calibrated using certified reference materials supplied by CANMET. γ dose rates can be estimated from *in situ* NaI gamma spectrometry or, where direct measurements are unavailable as in the present case, from laboratory-based Ge γ spectrometry. *In situ* measurements reduce uncertainty relating to potential heterogeneity in the γ dose field surrounding each sample. The level of U disequilibrium was estimated by laboratory-based Ge γ spectrometry. Estimates of radionuclide concentration were converted into D_r values (Adamiec and Aitken, 1998), accounting for D_r modulation forced by grain size (Mejdahl, 1979) and present moisture content (Zimmerman, 1971). Cosmogenic D_r values were calculated on the basis of sample depth, geographical position and matrix density (Prescott and Hutton, 1994).

The spatiotemporal validity of D_r values can be considered a function of five variables. Firstly, age estimates devoid of *in situ* γ spectrometry data should be accepted tentatively if the sampled unit is heterogeneous in texture or if the sample is located within 300 mm of strata consisting of differing texture and/or mineralogy. However, where samples are obtained throughout a vertical profile, consistent values of γ D_r based solely on laboratory measurements may evidence the homogeneity of the γ field and hence accuracy of γ D_r values. Secondly, disequilibrium can force temporal instability in U and Th emissions. The impact of this infrequent phenomenon (Olley *et al*., 1996) upon age estimates is usually insignificant given their associated margins of error. However, for samples where this effect is pronounced (>50% disequilibrium between ^{238}U and ^{226}Ra; Fig. 5), the resulting age estimates should be accepted tentatively. Thirdly, pedogenically-induced variations in matrix composition of B and C-horizons, such as radionuclide and/or mineral remobilisation, may alter the rate of energy emission and/or absorption. If D_r is invariant through a dated profile and samples encompass primary parent material, then element mobility is likely limited in effect. Fourthly, spatiotemporal detractions from present moisture content are difficult to assess directly, requiring knowledge of the magnitude and timing of differing contents. However, the maximum influence of moisture content variations can be delimited by recalculating D_r for minimum (zero) and maximum (saturation) content. Finally, temporal alteration in the thickness of overburden alters cosmic D_r values. Cosmic D_r often forms a negligible portion of total D_r. It is possible to quantify the maximum influence of overburden flux by recalculating D_r for minimum (zero) and maximum (surface sample) cosmic D_r.

5.0 Estimation of Age

Ages reported in Table 1 provide an estimate of sediment burial period based on mean D_e and D_r values and their associated analytical uncertainties. Uncertainty in age estimates is reported as a product of systematic and experimental errors, with the magnitude of experimental errors alone shown in parenthesis (Table 1). Cumulative frequency plots indicate the inter-aliquot variability in age (Fig. 6). The maximum influence of temporal variations in D_r forced by minima-maxima in moisture content and overburden thickness is also illustrated in Fig. 6. Where uncertainty in these parameters exists this age range may prove instructive, however the combined extremes represented should not be construed as preferred age estimates. The analytical validity of each sample is presented in Table 2.

6.0 Analytical uncertainty

All errors are based upon analytical uncertainty and quoted at 1σ confidence. Error calculations account for the propagation of systematic and/or experimental (random) errors associated with D_e and D_r values.

For D_e values, systematic errors are confined to laboratory β source calibration. Uncertainty in this respect is that combined from the delivery of the calibrating γ dose (1.2%; NPL, pers. comm.), the conversion of this dose for SiO_2 using the respective mass energy-absorption coefficient (2%; Hubbell, 1982) and experimental error, totalling 3.5%. Mass attenuation and bremsstrahlung losses during γ dose delivery are considered negligible. Experimental errors relate to D_e interpolation using sensitisation corrected dose responses. Natural and regenerated sensitisation corrected dose points (S_i) were quantified by,

$$S_i = (D_i - x.L_i) / (d_i - x.L_i) \quad \textbf{Eq.1}$$

where D_i = Natural or regenerated OSL, initial 0.2 s
L_i = Background natural or regenerated OSL, final 5 s
d_i = Test dose OSL, initial 0.2 s
x = Scaling factor, 0.08

The error on each signal parameter is based on counting statistics, reflected by the square-root of measured values. The propagation of these errors within Eq. 1 generating σS_i follows the general formula given in Eq. 2. σS_i were then used to define fitting and interpolation errors within exponential plus linear regressions.

For D_r values, systematic errors accommodate uncertainty in radionuclide conversion factors (5%), β attenuation coefficients (5%), matrix density (0.20 g.cm^{-3}), vertical thickness of sampled section (specific to sample collection device), saturation moisture content (3%), moisture content attenuation (2%) and burial moisture content (25% relative, unless direct evidence exists of the magnitude and period of differing content). Experimental errors are associated with radionuclide quantification for each sample by Ge gamma spectrometry.

The propagation of these errors through to age calculation was quantified using the expression,

$$\sigma y\ (\delta y/\delta x) = (\Sigma\ ((\delta y/\delta x_n).\sigma x_n)^2)^{1/2} \qquad \textbf{Eq. 2}$$

where y is a value equivalent to that function comprising terms x_n and where σy and σx_n are associated uncertainties.

Errors on age estimates are presented as combined systematic and experimental errors and experimental errors alone. The former (combined) error should be considered when comparing luminescence ages herein with independent chronometric controls. The latter assumes systematic errors are common to luminescence age estimates generated by means identical to those detailed herein and enable direct comparison with those estimates.

Fig. 1 Signal Calibration

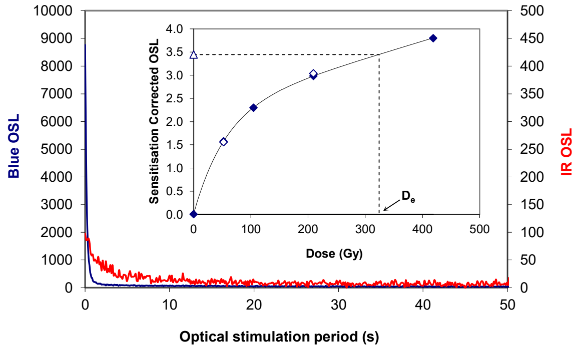


Fig. 1 Signal Calibration Natural blue and laboratory-induced infrared (IR) OSL signals. Detectable IR signal decays are diagnostic of feldspar contamination. Inset, the natural blue OSL signal (open triangle) of each aliquot is calibrated against known laboratory doses to yield equivalent dose (D_e) values. Repeats of low and high doses (open diamonds) illustrate the success of sensitivity correction.

Fig. 2 Dose Recovery The acquisition of D_e values is necessarily predicated upon thermal treatment of aliquots succeeding environmental and laboratory irradiation. The Dose Recovery test quantifies the combined effects of thermal transfer and sensitisation on the natural signal using a precise lab dose to simulate natural dose. Based on this an appropriate thermal treatment is selected to generate the final D_e value.

Fig. 3 Inter-aliquot D_e distribution Abanico plot of inter-aliquot statistical concordance in D_e values derived from **natural** irradiation. Discordant data (those points lying beyond **±2 standardised ln D_e**) reflect heterogeneous dose absorption and/or inaccuracies in calibration.

Fig. 4 Signal Analysis Statistically significant increase in **natural** D_e value with signal stimulation period is indicative of a partially-bleached signal, provided a significant increase in D_e results from **simulated partial bleaching** followed by insignificant adjustment in D_e for simulated **zero** and **full bleach** conditions. Ages from such samples are considered maximum estimates. In the absence of a significant rise in D_e with stimulation time, simulated partial bleaching and zero/full bleach tests are not assessed.

Fig. 5 U Activity Statistical concordance (equilibrium) in the activities of the daughter radioisotope ^{226}Ra with its parent ^{238}U may signify the temporal stability of D_r emissions from these chains. Significant differences (disequilibrium; >50%) in activity indicate addition or removal of isotopes creating a time-dependent shift in D_r values and increased uncertainty in the accuracy of age estimates. A 20% disequilibrium marker is also shown.

Fig. 6 Age Range The Cumulative frequency plot indicates the inter-aliquot variability in age. It also shows the **mean age range**; an estimate of sediment burial period based on mean D_e and D_r values with associated analytical uncertainties. The **maximum influence** of temporal variations in D_r forced by minima-maxima variation in moisture content and overburden thickness is outlined and may prove instructive where there is uncertainty in these parameters. However the combined extremes represented should not be construed as preferred age estimates.

Fig. 2 Dose Recovery

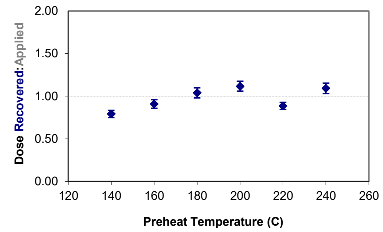


Fig. 3 Inter-aliquot D_e distribution

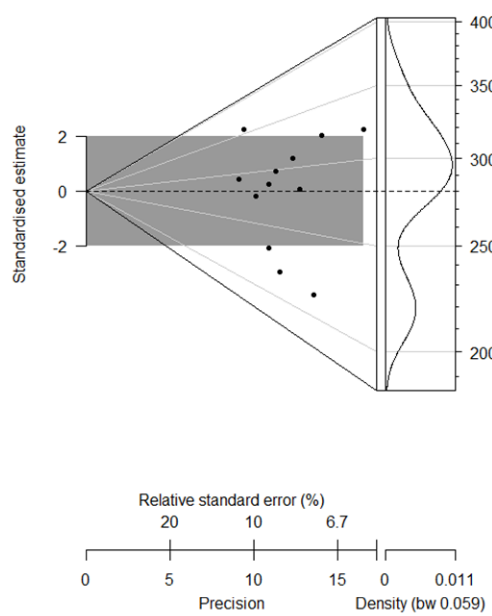


Fig. 4 Signal Analysis

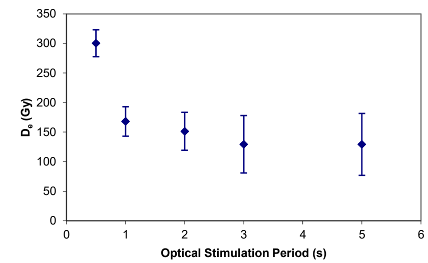


Fig. 5 U Decay Activity

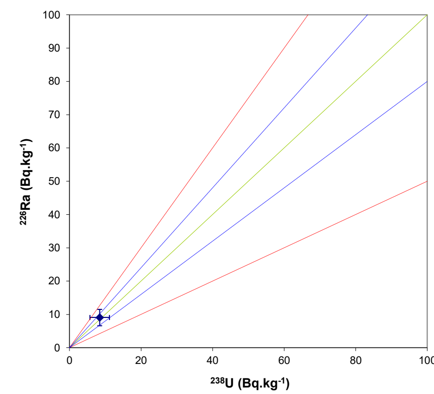
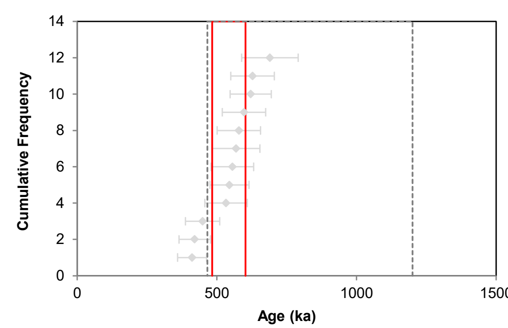


Fig. 6 Age Range



Sample: GL20093

Fig. 1 Signal Calibration

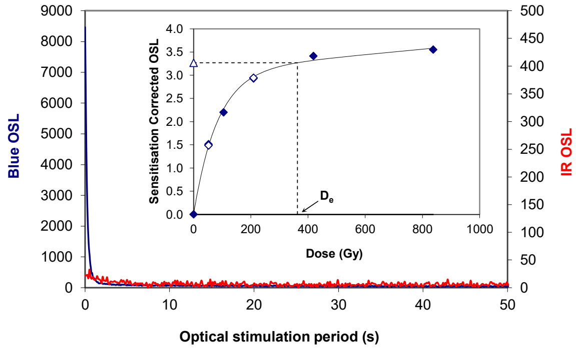


Fig. 2 Dose Recovery

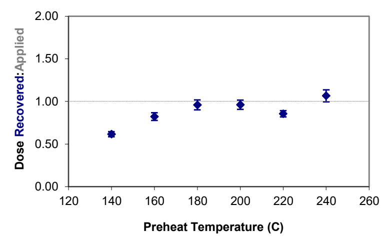


Fig. 4 Signal Analysis

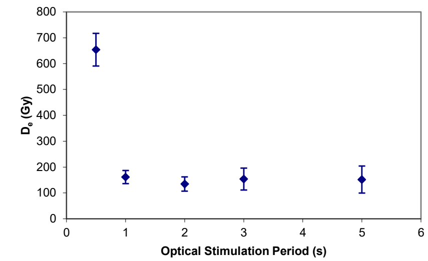


Fig. 3 Inter-aliquot D_e distribution

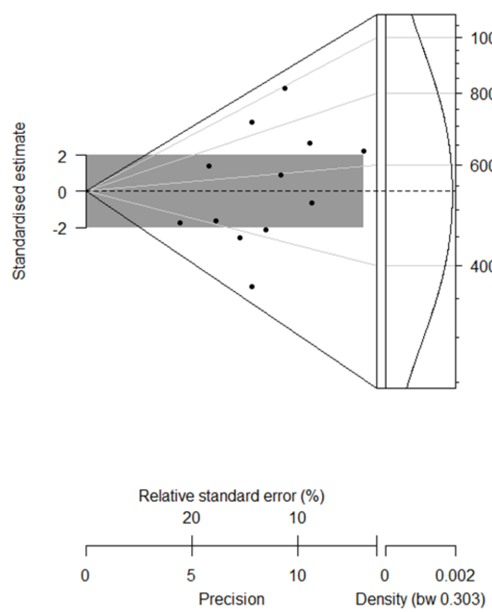


Fig. 5 U Decay Activity

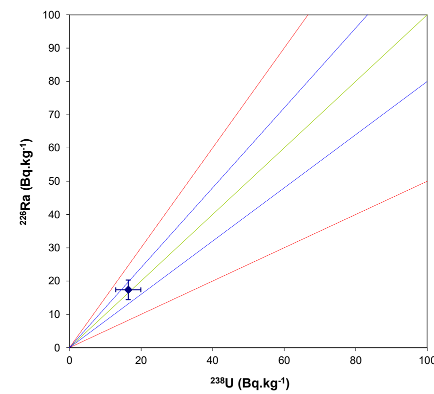


Fig. 6 Age Range

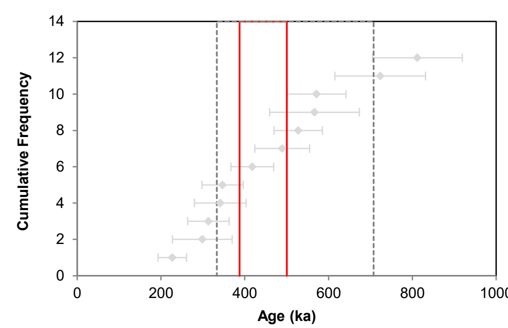


Fig. 1 Signal Calibration Natural blue and laboratory-induced infrared (IR) OSL signals. Detectable IR signal decays are diagnostic of feldspar contamination. Inset, the natural blue OSL signal (open triangle) of each aliquot is calibrated against known laboratory doses to yield equivalent dose (D_e) values. Repeats of low and high doses (open diamonds) illustrate the success of sensitivity correction.

Fig. 2 Dose Recovery The acquisition of D_e values is necessarily predicated upon thermal treatment of aliquots succeeding environmental and laboratory irradiation. The Dose Recovery test quantifies the combined effects of thermal transfer and sensitisation on the natural signal using a precise lab dose to simulate natural dose. Based on this an appropriate thermal treatment is selected to generate the final D_e value.

Fig. 3 Inter-aliquot D_e distribution Abanico plot of inter-aliquot statistical concordance in D_e values derived from **natural** irradiation. Discordant data (those points lying beyond **±2 standardised ln D_e**) reflect heterogeneous dose absorption and/or inaccuracies in calibration.

Fig. 4 Signal Analysis Statistically significant increase in **natural** D_e value with signal stimulation period is indicative of a partially-bleached signal, provided a significant increase in D_e results from **simulated partial bleaching** followed by insignificant adjustment in D_e for simulated **zero** and **full bleach** conditions. Ages from such samples are considered maximum estimates. In the absence of a significant rise in D_e with stimulation time, simulated partial bleaching and zero/full bleach tests are not assessed.

Fig. 5 U Activity Statistical concordance (equilibrium) in the activities of the daughter radioisotope ^{226}Ra with its parent ^{238}U may signify the temporal stability of D_r emissions from these chains. Significant differences (disequilibrium; >50%) in activity indicate addition or removal of isotopes creating a time-dependent shift in D_r values and increased uncertainty in the accuracy of age estimates. A 20% disequilibrium marker is also shown.

Fig. 6 Age Range The Cumulative frequency plot indicates the inter-aliquot variability in age. It also shows the **mean age range**; an estimate of sediment burial period based on mean D_e and D_r values with associated analytical uncertainties. The **maximum influence** of temporal variations in D_r forced by minima-maxima variation in moisture content and overburden thickness is outlined and may prove instructive where there is uncertainty in these parameters. However the combined extremes represented should not be construed as preferred age estimates.

Sample: GL20094

Fig. 1 Signal Calibration

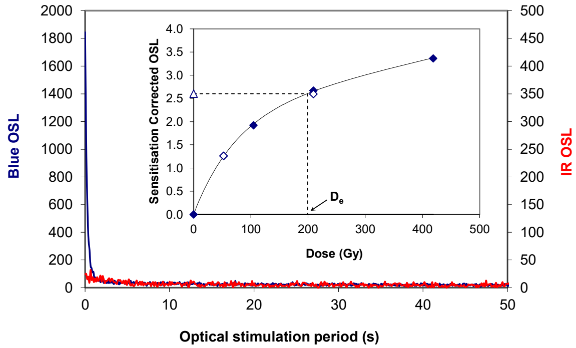


Fig. 2 Dose Recovery

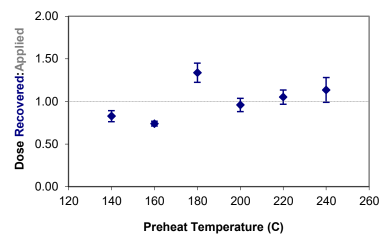


Fig. 4 Signal Analysis

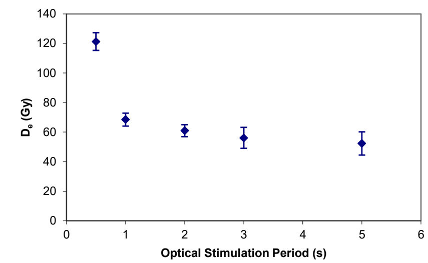


Fig. 3 Inter-aliquot D_e distribution

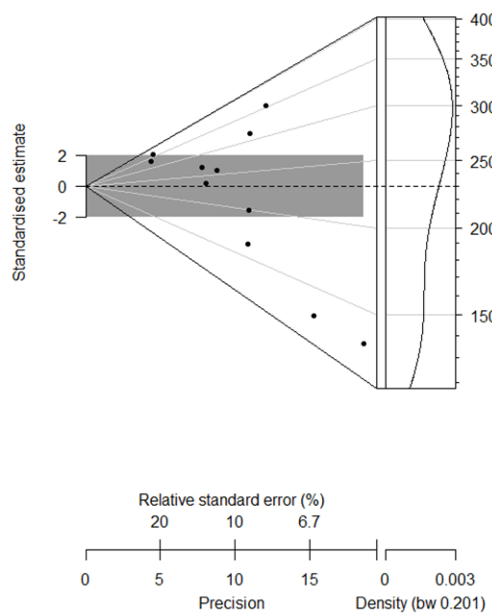


Fig. 5 U Decay Activity

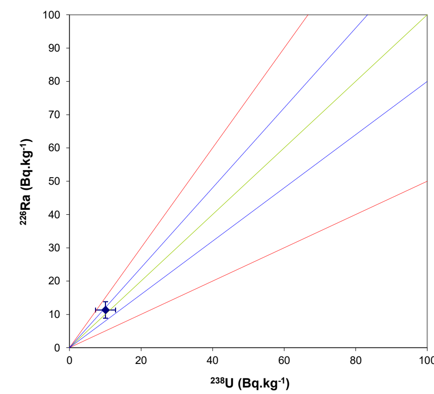


Fig. 6 Age Range

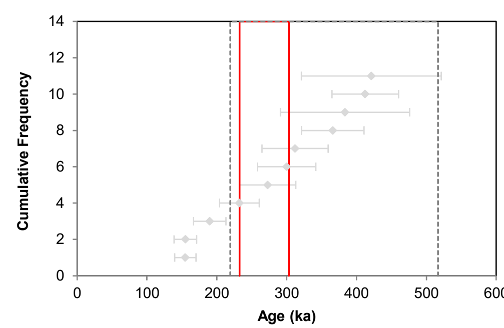


Fig. 1 Signal Calibration Natural blue and laboratory-induced infrared (IR) OSL signals. Detectable IR signal decays are diagnostic of feldspar contamination. Inset, the natural blue OSL signal (open triangle) of each aliquot is calibrated against known laboratory doses to yield equivalent dose (D_e) values. Repeats of low and high doses (open diamonds) illustrate the success of sensitivity correction.

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Sample: GL20095

Fig. 1 Signal Calibration

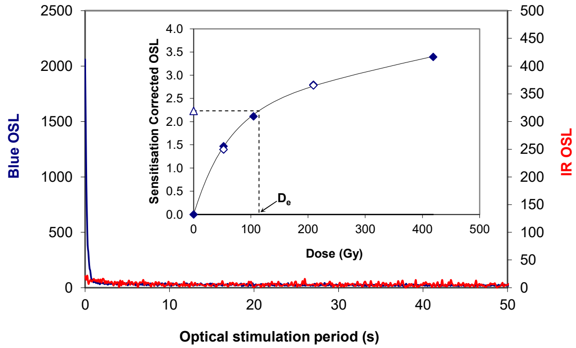

Fig. 1 Signal Calibration Natural blue and laboratory-induced infrared (IR) OSL signals. Detectable IR signal decays are diagnostic of feldspar contamination. Inset, the natural blue OSL signal (open triangle) of each aliquot is calibrated against known laboratory doses to yield equivalent dose (D_e) values. Repeats of low and high doses (open diamonds) illustrate the success of sensitivity correction.

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Fig. 2 Dose Recovery

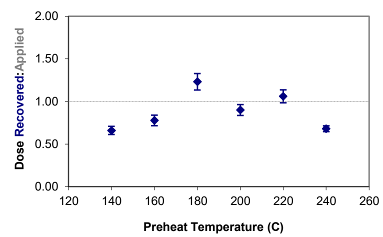
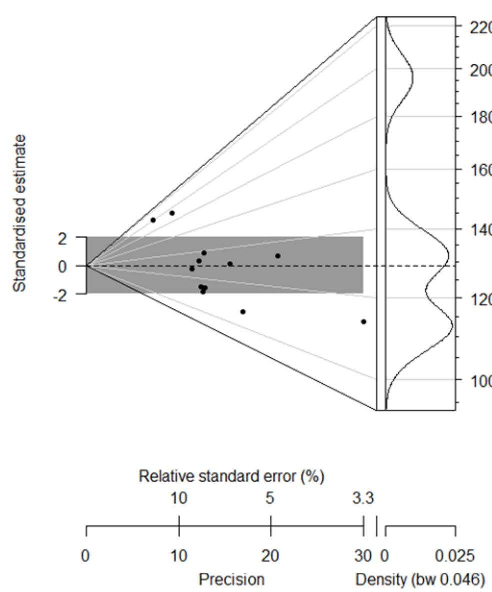


Fig. 3 Inter-aliquot D_e distribution



Sample: GL20096

Fig. 4 Signal Analysis

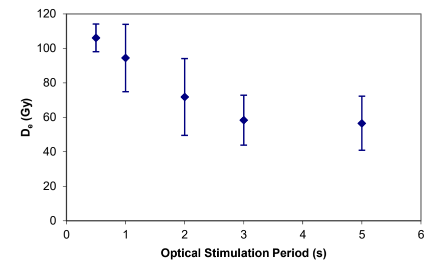


Fig. 5 U Decay Activity

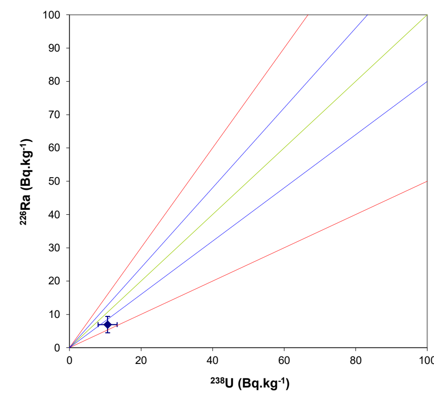


Fig. 6 Age Range

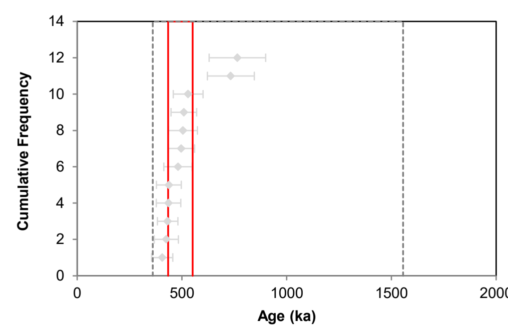


Fig. 1 Signal Calibration

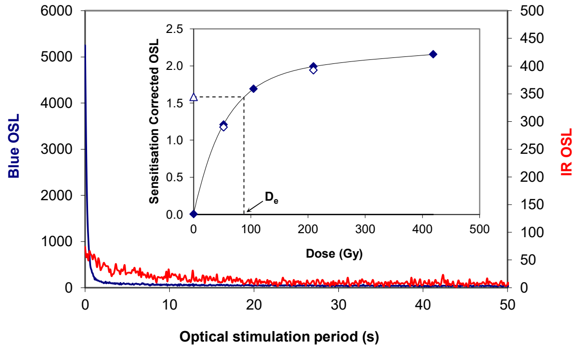


Fig. 2 Dose Recovery

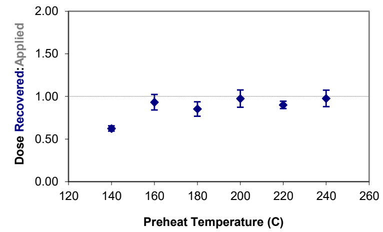


Fig. 4 Signal Analysis

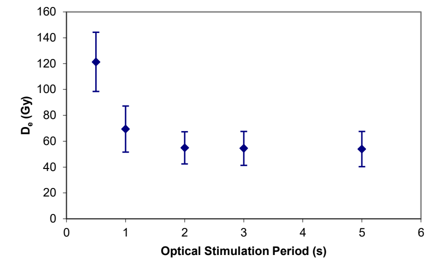


Fig. 3 Inter-aliquot D_e distribution

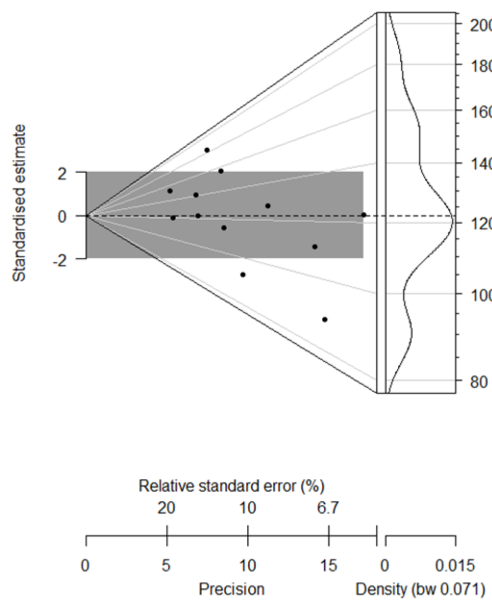


Fig. 5 U Decay Activity

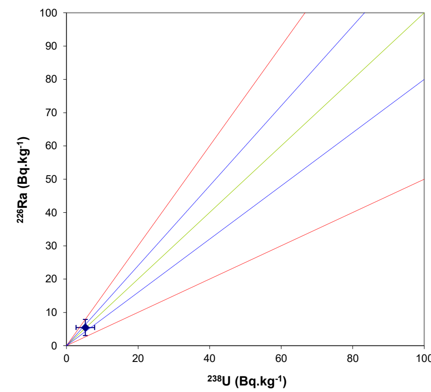
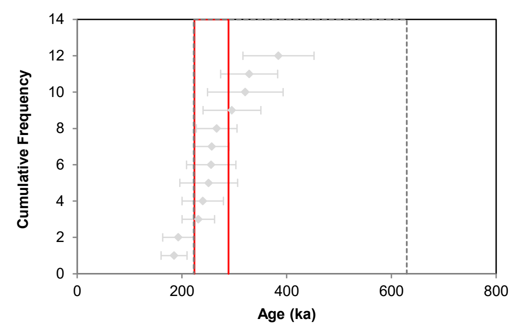


Fig. 6 Age Range



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Sample: GL20097

Fig. 1 Signal Calibration

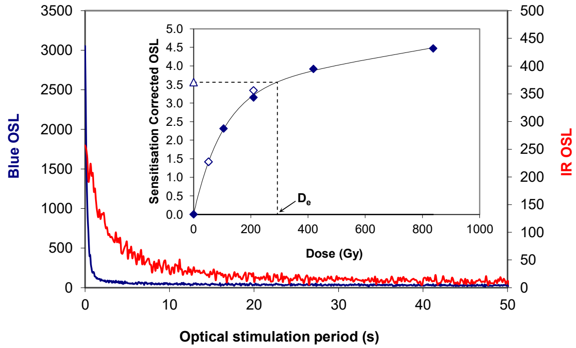


Fig. 2 Dose Recovery

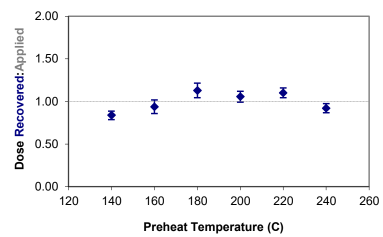


Fig. 4 Signal Analysis

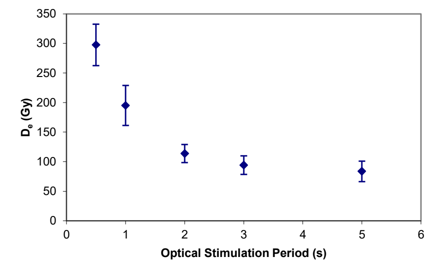


Fig. 3 Inter-aliquot D_e distribution

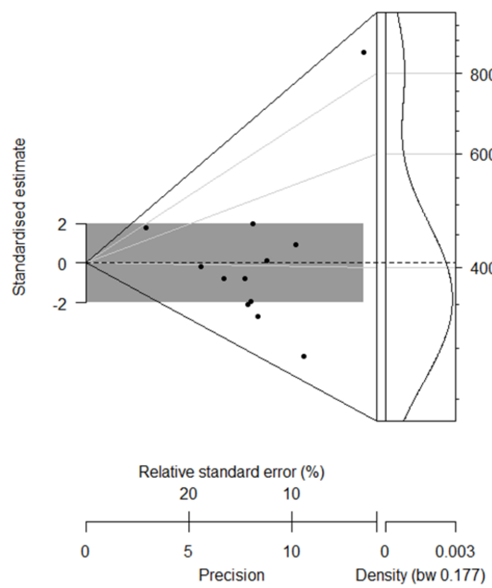


Fig. 5 U Decay Activity

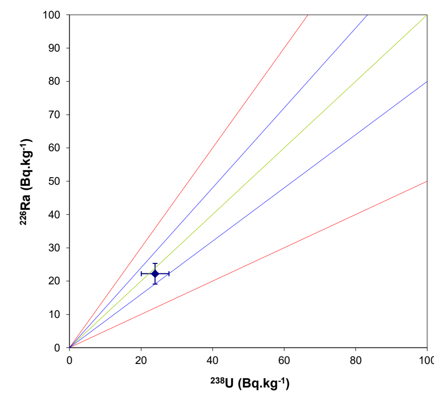
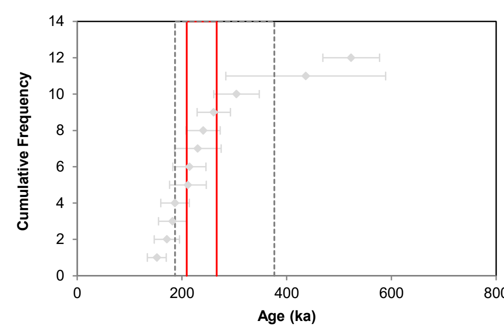


Fig. 6 Age Range



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Sample: GL20098

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Appendix 4: Palaeoenvironmental assessment data

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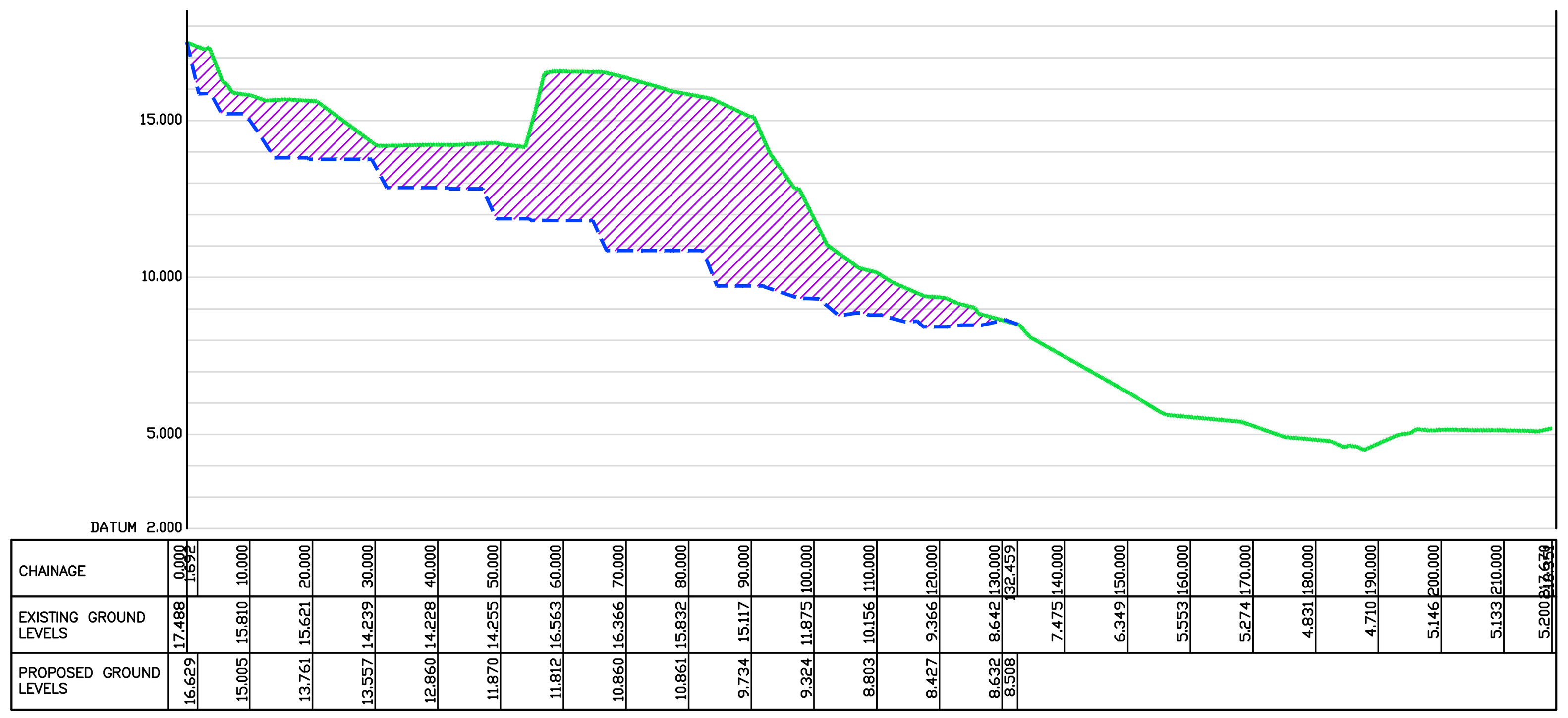
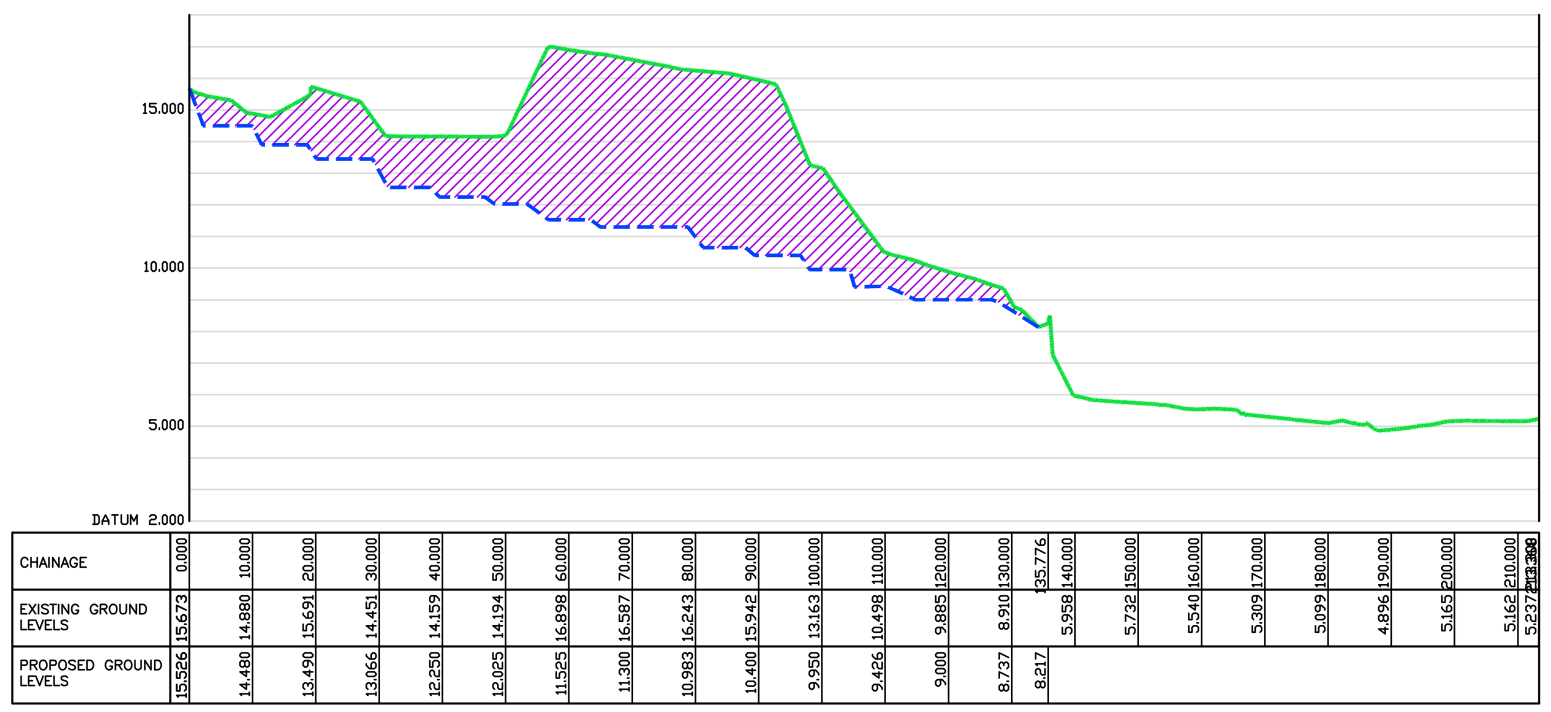
								Invertebrates		Vertebrates	
Sample no.	**Context no.**	**Stratigraphic unit**	**Sample volume (l)**	**Mesh size**	**Residue volume (ml)**	**Sub-sample**	**Wood charcoal**	**Insects**	**Molluscs + Crustaceans**		**Comments**
5	10104	Fluvial sand	19	4, 0.5mm	5200	10%	-	-	Moll-m (fossil) (A***)		
11	10208	Fluvial sand; clay silt lense	2	0.5, 0.25, 0.125, 0.063mm	143 = 30% of total sample (0.5l dry residue fine sieved)	-	-	-	-	-	
23	2803	Chalky solifluction gravel	8	4, 0.5mm	500	-	-	-	Moll-t (C - *Limax* sp., *Vallonia* sp.)	Sab (C - rodent teeth)	
62	10007	Soliflucted and fluvial sand and gravel	15	4, 0.5mm	2000	25%	-	-	Foraminifera (B), Ostracods (C) fossil	-	
63	10012	Soliflucted and fluvial sand and gravel	17	4, 0.5mm	1800	25%	-	-	-	-	

Key: Scale of abundance: A** = 100+, A* = 30-99, A = >10, B = 9-5, C = <5; Moll-t = terrestrial molluscs, Sab/f/c = small animal

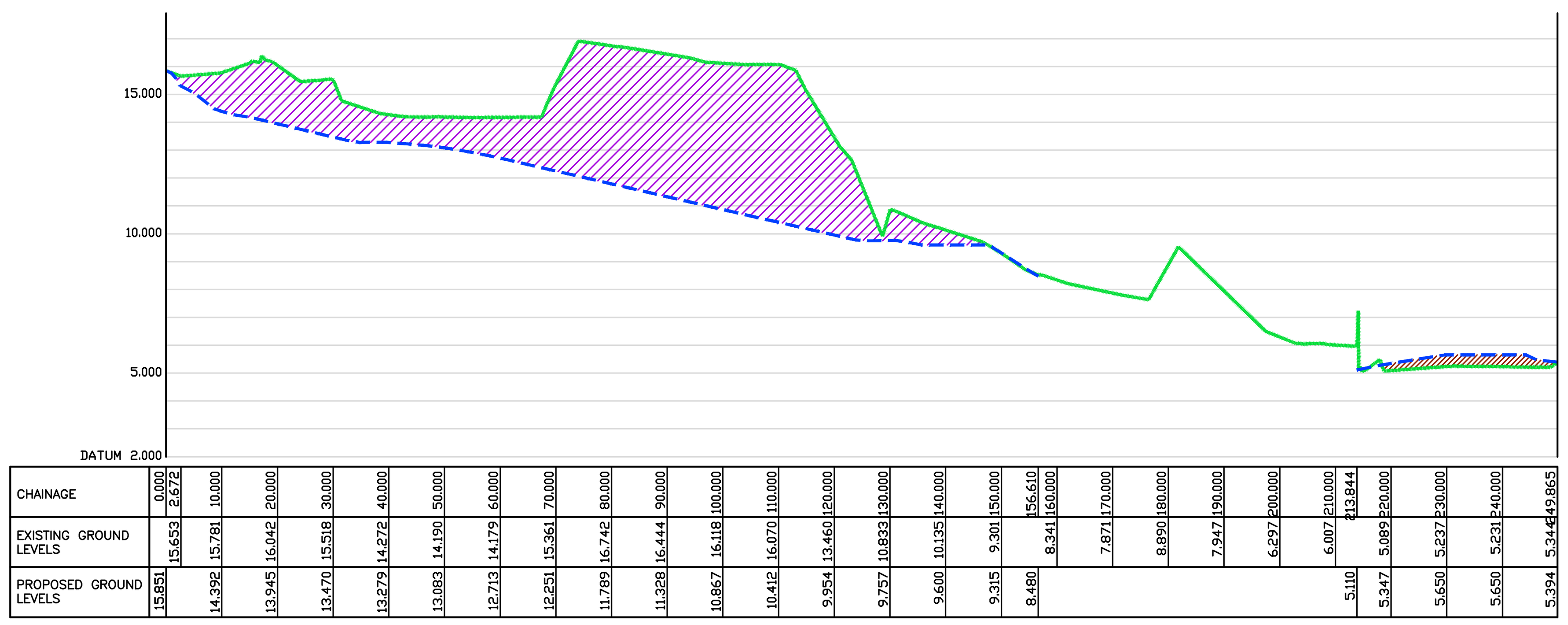
Appendix 5: Proposed cut and fill cross-sections



XSECTION 2



XSECTION 3



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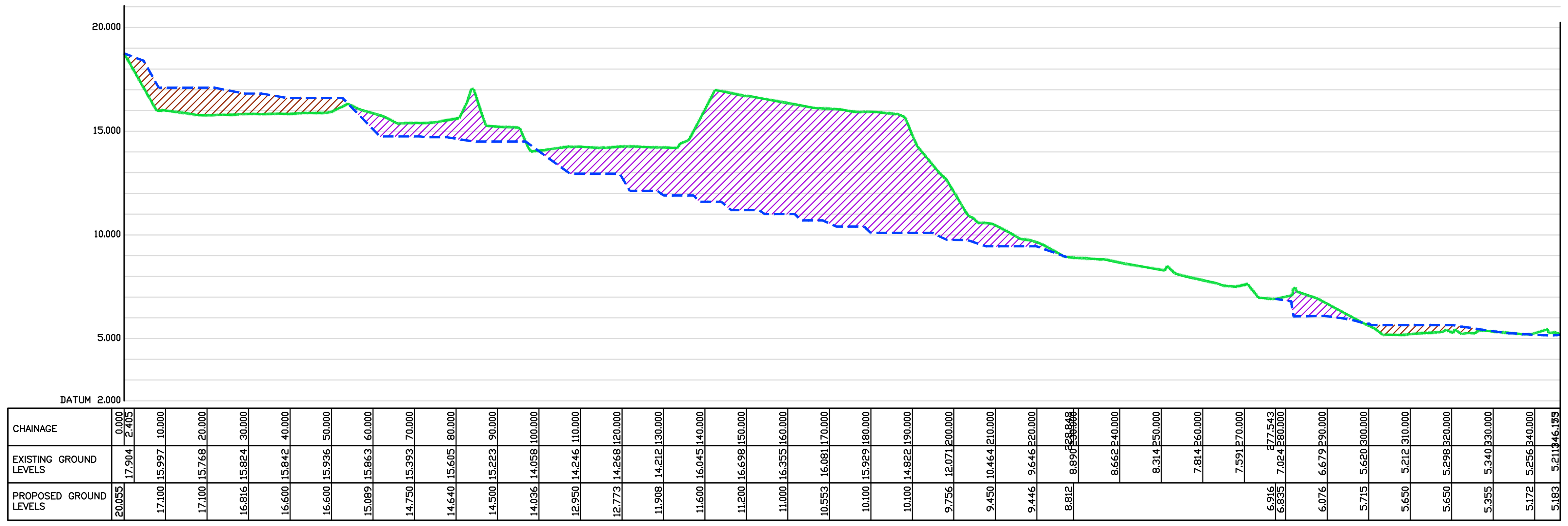

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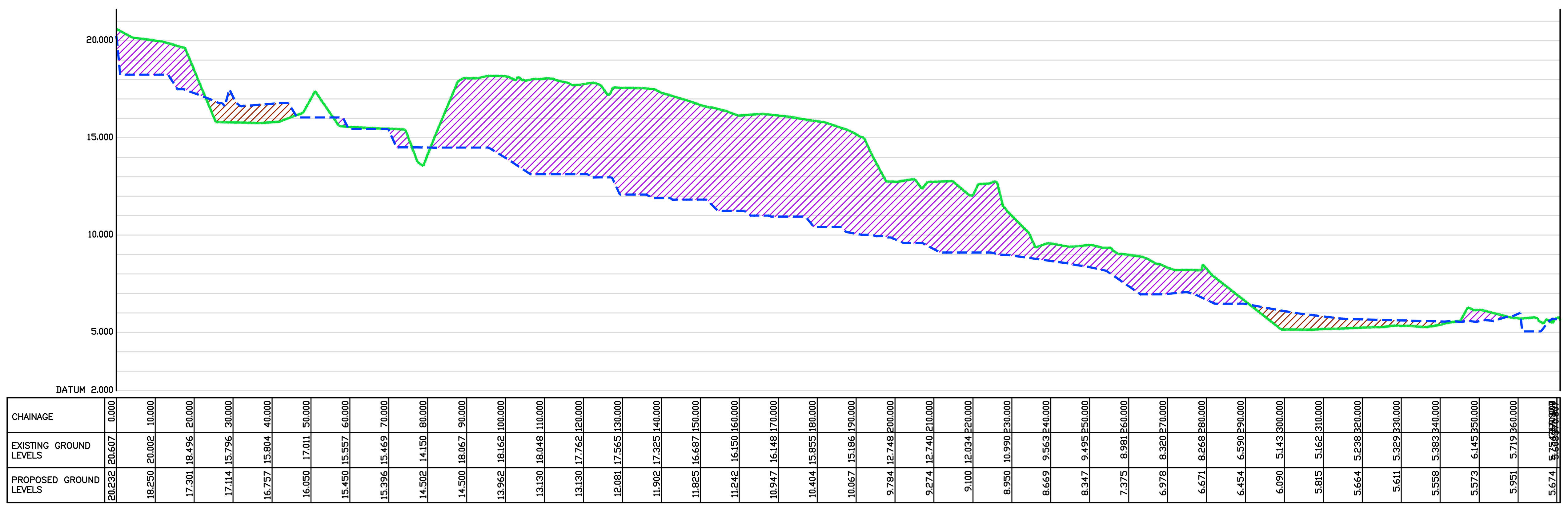

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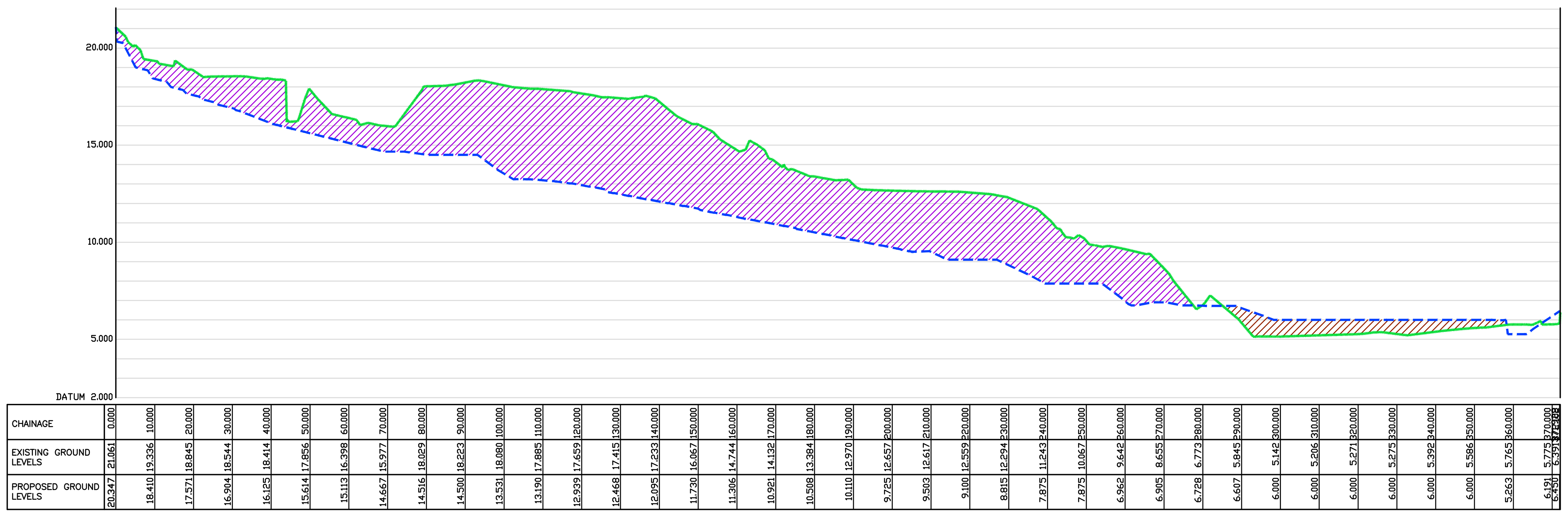

XSECTION 7

GENERAL NOTES

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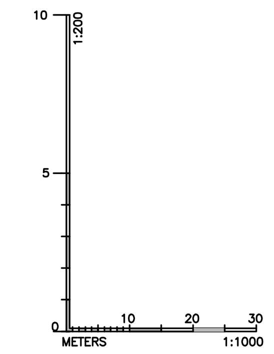

EXISTING GROUND LEVELS

PROPOSED LEVELS

PROPOSED CUT VOLUME

PROPOSED FILL VOLUME

LATEST REVISIONS ARE 'TAGGED' WITH THIS INDICATOR. HOWEVER, ALL USERS OF THIS DRAWING MUST SATISFY THEMSELVES OF ALL REVISIONS TO ANY PREVIOUS ISSUES, BY COMPARISON OF THIS DRAWING AGAINST OTHER ISSUES, AS IT CANNOT BE GUARANTEED THAT EVERY ITEM OF REVISION HAS BEEN 'TAGGED'.

Rev	Date	Description	Drawn & Checked	Checked
G				
F				
E				
D				
C				
B				
A	03.07.19	LONGSCTION ADDED	JCU	SCO

Revisions

Date	26.03.19	FIRST ISSUE	RPI	SCO

Project

NORTHFLEET EMBANKMENT WEST

Title

CUT AND FILL
CROSS SECTIONS
SHEET 1 OF 3

Client

BELLWAY HOMES

RLT

RLT Engineering Consultants Ltd
Civil and Structural Consulting Engineers
2 St Peter's Court
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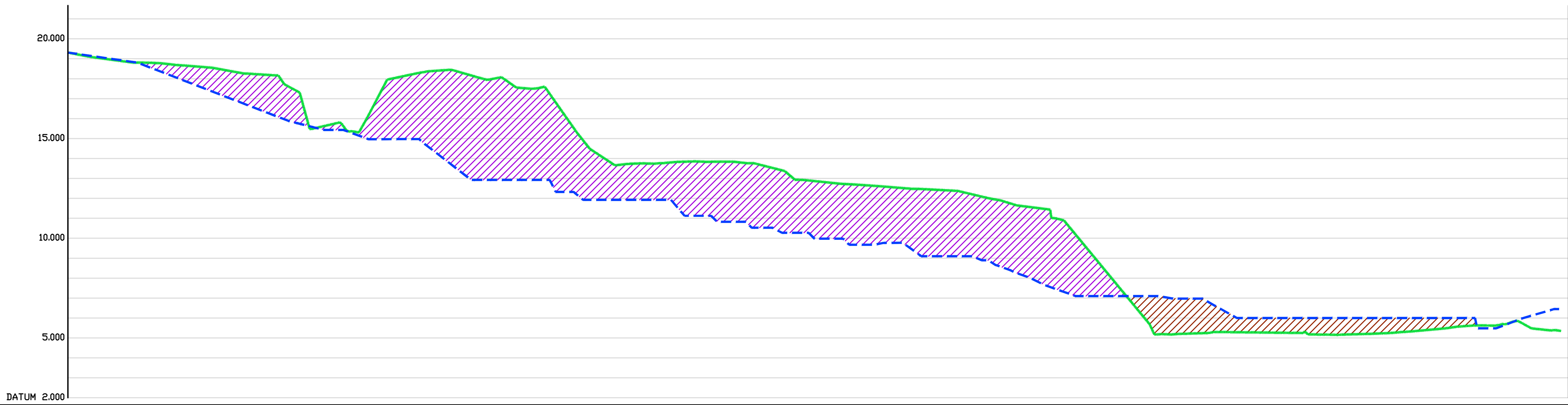
E: email@rltengcon.co.uk

QMS ISO 9001 REGISTERED

SAFEMARK

Dwg No. 1803/05/1001 | Scales: AS SHOWN @ A1 | Rev: A



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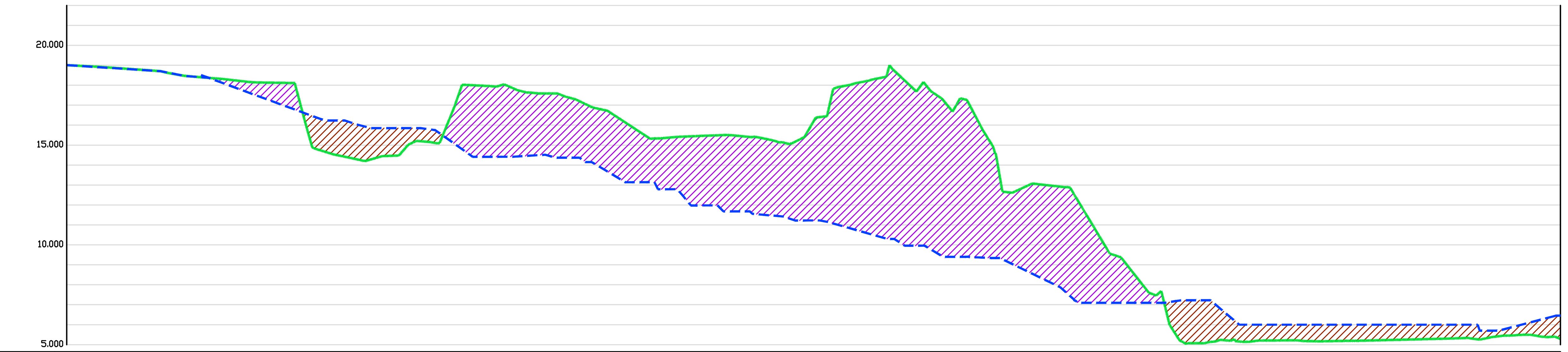
EXISTING GROUND LEVELS		19.161	18.979	18.804	18.651	18.413	18.194	15.951	15.394	17.923	18.364	18.232	17.904	17.486	14.716	13.718	13.780	13.833	13.772	13.339	12.811	12.659	12.507	12.408	12.053	11.597	10.855	8.432	6.009	5.209	5.294	5.271	5.273	5.170	5.233	5.381	5.587	5.695	5.417	[illegible]	
PROPOSED GROUND LEVELS	20.674		19.381	18.610	17.838	17.067	16.295	15.648	15.365	14.968	14.650	13.104	12.925	12.925	11.925	11.925	11.925	11.125	10.825	10.275	9.975	9.675	9.689	9.100	8.896	8.108	7.296	7.100	7.100	6.971	6.360	6.000	6.000	6.000	6.000	6.000	6.000	5.616	6.285	6.450	

XSECTION 8



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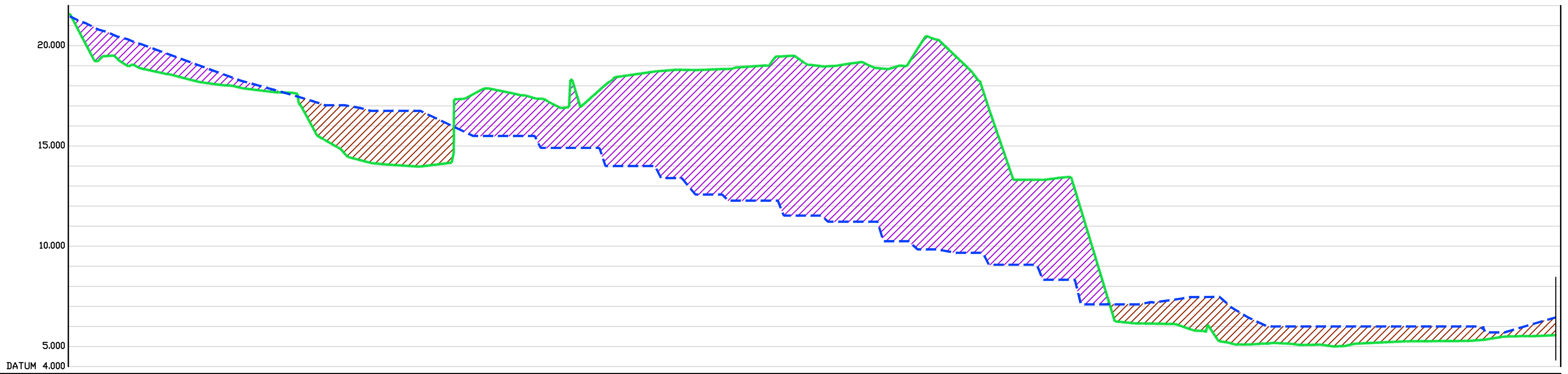
EXISTING GROUND LEVELS		18.932	18.897	18.757	18.462	18.293	18.132	15.974	14.404	14.454	15.172	18.016	18.010	17.586	17.055	16.132	15.259	15.469	15.479	15.198	16.434	18.190	18.234	17.162	15.609	12.895	12.888	10.008	7.997	5.091	5.223	5.206	5.181	5.187	5.224	5.273	5.326	5.449	5.393	5.335	
PROPOSED GROUND LEVELS	21.022		20.295	19.510	18.779	18.044	17.307	16.574	16.212	15.850	15.814	14.663	14.416	14.512	14.354	13.137	12.789	11.977	11.680	11.395	11.175	10.619	9.960	9.490	9.298	8.743	7.693	7.100	7.100	7.220	6.449	6.000	6.000	6.000	6.000	6.000	6.000	5.761	6.287	6.450	

XSECTION 9



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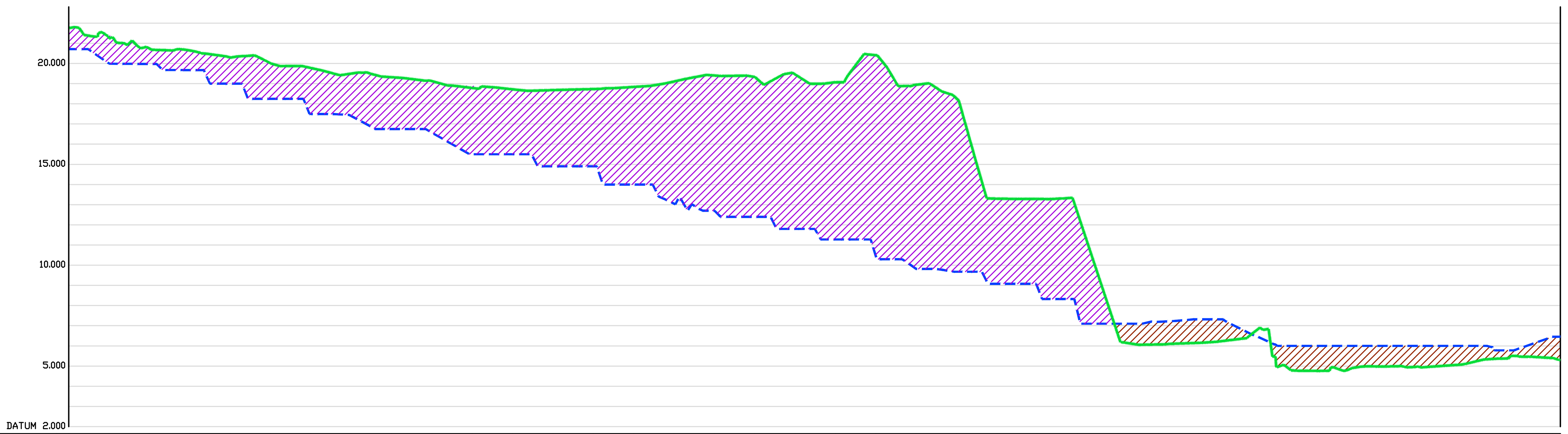
EXISTING GROUND LEVELS	21.581		19.490	18.784	18.323	18.012	17.716	16.262	14.435	14.065	14.029	17.480	17.656	17.169	17.356	18.533	18.774	18.810	18.961	19.492	18.981	18.981	19.306	19.702	16.555	13.313	13.422	6.818	6.139	5.836	5.146	5.175	5.083	5.108	5.226	5.265	5.291	5.502	5.555	5.552	
PROPOSED GROUND LEVELS	21.464		20.653	19.940	19.207	18.473	17.870	17.292	16.990	16.750	16.533	15.585	15.500	14.900	14.900	14.000	13.400	12.575	12.275	11.525	11.225	11.225	10.148	9.717	9.075	9.075	8.325	7.100	7.205	7.465	6.932	6.000	6.000	6.000	6.000	6.000	6.000	5.819	6.495	6.450	

XSECTION 10



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EXISTING GROUND LEVELS	21.761	21.238	20.742	20.643	20.296	20.010	19.776	19.497	19.318	19.127	18.785	18.718	18.680	18.731	18.837	19.106	19.403	19.331	19.457	19.072	20.408	18.943	18.266	13.298	13.283	12.587	6.553	6.072	6.150	6.340	4.987	4.763	4.964	5.003	5.003	5.293	5.465	5.323	
PROPOSED GROUND LEVELS	20.714	19.998	19.975	19.671	19.000	18.250	17.497	17.395	16.750	16.570	15.500	15.500	14.900	14.900	14.000	13.051	12.700	12.400	11.800	11.275	10.454	9.815	9.675	9.075	8.939	7.671	7.100	7.194	7.315	6.887	6.000	6.000	6.000	6.000	6.000	6.000	5.912	6.450	

XSECTION 11

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GENERAL NOTES

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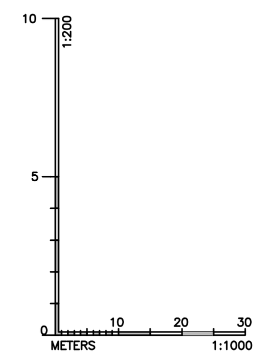

EXISTING GROUND LEVELS	green solid line
PROPOSED LEVELS	blue dashed line
PROPOSED CUT VOLUME	purple hatch
PROPOSED FILL VOLUME	brown hatch

LATEST REVISIONS ARE "TAGGED" WITH THIS INDICATOR. HOWEVER, ALL USERS OF THIS DRAWING MUST SATISFY THEMSELVES OF ALL REVISIONS TO ANY PREVIOUS ISSUES, BY COMPARISON OF THIS DRAWING AGAINST OTHER ISSUES, AS IT CANNOT BE GUARANTEED THAT EVERY ITEM OF REVISION HAS BEEN "TAGGED".

Rev	Date	Description	Drawn & Checked	Checked
G				
F				
E				
D				
C				
B				
A	03.07.19	LONGSECTIONS UPDATED	JCU	SCO

Revisions

Date	26.03.19	FIRST ISSUE	RPI	SCO

Project

NORTHFLEET EMBANKMENT WEST

Title

CUT AND FILL CROSS SECTIONS SHEET 2 OF 3

Client

BELLWAY HOMES

RLT ENGINEERING CONSULTANTS LTD
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CO1 1WD
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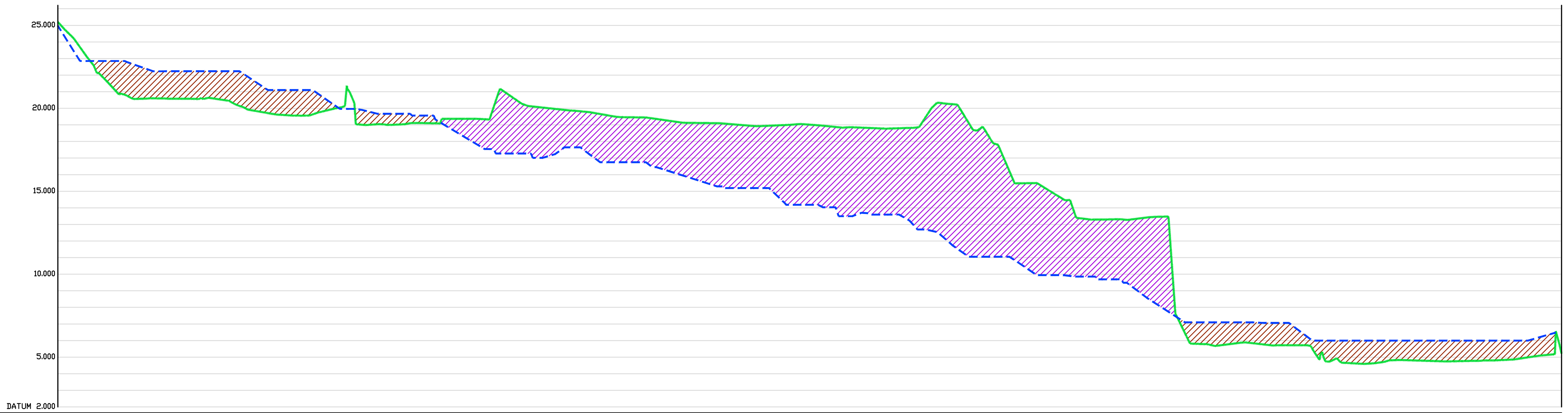

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20.000	20.824	22.850
30.000	20.596	22.232
40.000	20.572	22.234
50.000	20.499	22.236
60.000	19.825	21.537
70.000	19.572	21.100
80.000	19.820	20.656
90.000	19.034	19.956
100.000	19.002	19.672
110.000	19.108	19.563
120.000	19.367	18.576
130.000	19.315	17.542
140.000	20.261	17.273
150.000	19.960	17.258
160.000	19.771	17.255
170.000	19.465	16.750
180.000	19.368	16.454
190.000	19.122	15.842
200.000	19.091	15.292
210.000	18.930	15.192
220.000	18.997	14.186
230.000	18.962	14.096
240.000	18.853	13.538
250.000	18.775	13.594
260.000	19.000	12.694
270.000	20.241	11.687
280.000	18.489	11.054
290.000	15.479	10.624
300.000	14.887	9.944
310.000	13.324	9.856
320.000	13.314	9.692
330.000	13.444	8.345
340.000	6.312	7.100
350.000	5.705	7.100
360.000	5.841	7.100
370.000	5.717	7.065
380.000	4.902	6.000
390.000	4.632	6.000
400.000	4.731	6.000
410.000	4.795	6.000
420.000	4.748	6.000
430.000	4.799	6.000
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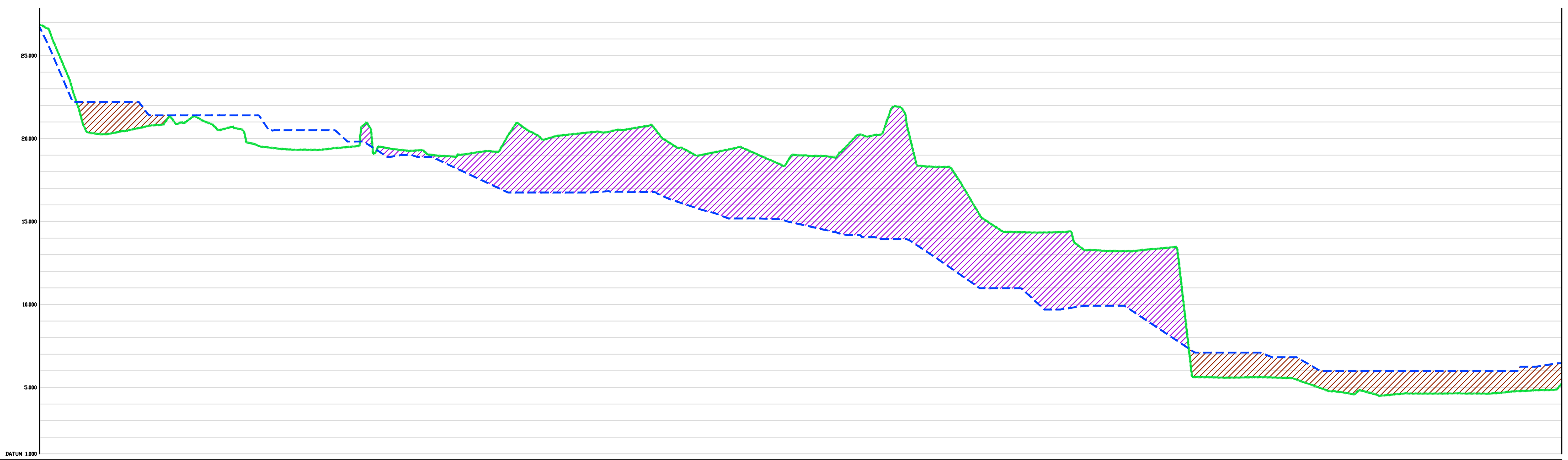
XSECTION 12



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30.000	20.639	22.171
40.000	21.164	21.400
50.000	21.005	21.400
60.000	20.592	21.400
70.000	19.435	20.488
80.000	19.328	20.500
90.000	19.438	20.324
100.000	20.174	19.508
110.000	19.285	19.009
120.000	18.970	18.721
130.000	19.111	17.787
140.000	19.789	16.852
150.000	20.204	16.750
160.000	20.250	16.750
170.000	20.360	16.808
180.000	20.660	16.768
190.000	19.718	16.334
200.000	19.034	15.678
210.000	19.442	15.183
220.000	18.716	15.162
230.000	18.982	14.793
240.000	18.842	14.343
250.000	20.139	14.053
260.000	21.751	13.950
270.000	18.296	12.821
280.000	16.503	11.435
290.000	14.421	10.975
300.000	14.335	10.199
310.000	14.394	9.774
320.000	13.246	9.925
330.000	13.225	9.505
340.000	13.422	8.174
350.000	5.620	7.100
360.000	5.594	7.100
370.000	5.609	6.928
380.000	5.380	6.674
390.000	4.771	6.000
400.000	4.715	6.000
410.000	4.613	6.000
420.000	4.632	6.000
430.000	4.634	6.000
440.000	4.676	6.000
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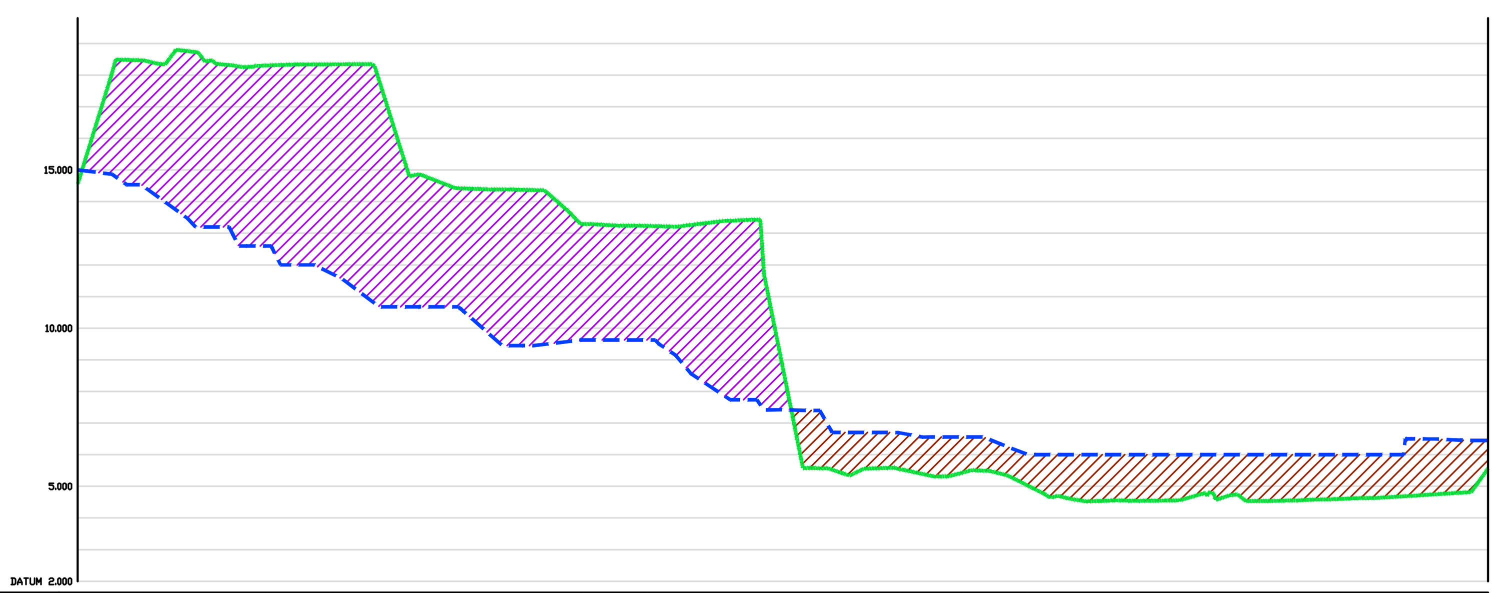
458.635	5.232	

XSECTION 13



CHAINAGE	EXISTING GROUND LEVELS	PROPOSED GROUND LEVELS
0.000	14.565	15.000
10.000	18.467	14.537
20.000	18.458	13.200
30.000	18.306	12.600
40.000	18.341	11.740
50.000	16.340	10.675
60.000	14.425	10.675
70.000	14.376	9.446
80.000	13.295	9.625
90.000	13.233	9.625
100.000	13.337	8.156
110.000	10.222	7.419
120.000	5.478	6.704
130.000	5.539	6.689
140.000	5.440	6.563
150.000	5.046	6.020
160.000	4.529	6.000
170.000	4.548	6.000
180.000	4.574	6.000
190.000	4.542	6.000
200.000	4.606	6.000
210.000	4.691	6.501
220.000	4.815	6.451
221.917	5.260	6.450
223.003		

XSECTION 14

GENERAL NOTES

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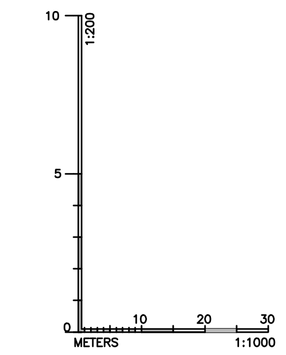

EXISTING GROUND LEVELS
PROPOSED LEVELS
PROPOSED CUT VOLUME
PROPOSED FILL VOLUME

LATEST REVISIONS ARE "TAGGED" WITH THIS INDICATOR. HOWEVER, ALL USERS OF THIS DRAWING MUST SATISFY THEMSELVES OF ALL REVISIONS TO ANY PREVIOUS ISSUES, BY COMPARISON OF THIS DRAWING AGAINST OTHER ISSUES, AS IT CANNOT BE GUARANTEED THAT EVERY ITEM OF REVISION HAS BEEN "TAGGED".

Rev	Date	Description	Drawn	Checked
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F				
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B				
A	03.07.19	LONGSECTIONS UPDATED	JCU	SCO

Revisions

Date	26.03.19	FIRST ISSUE	RPI	SCO

Project

NORTHFLEET EMBANKMENT WEST

Title

CUT AND FILL CROSS SECTIONS SHEET 3 OF 3

Client

BELLWAY HOMES

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2 St Peter's Court
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E: email@rltengcon.co.uk

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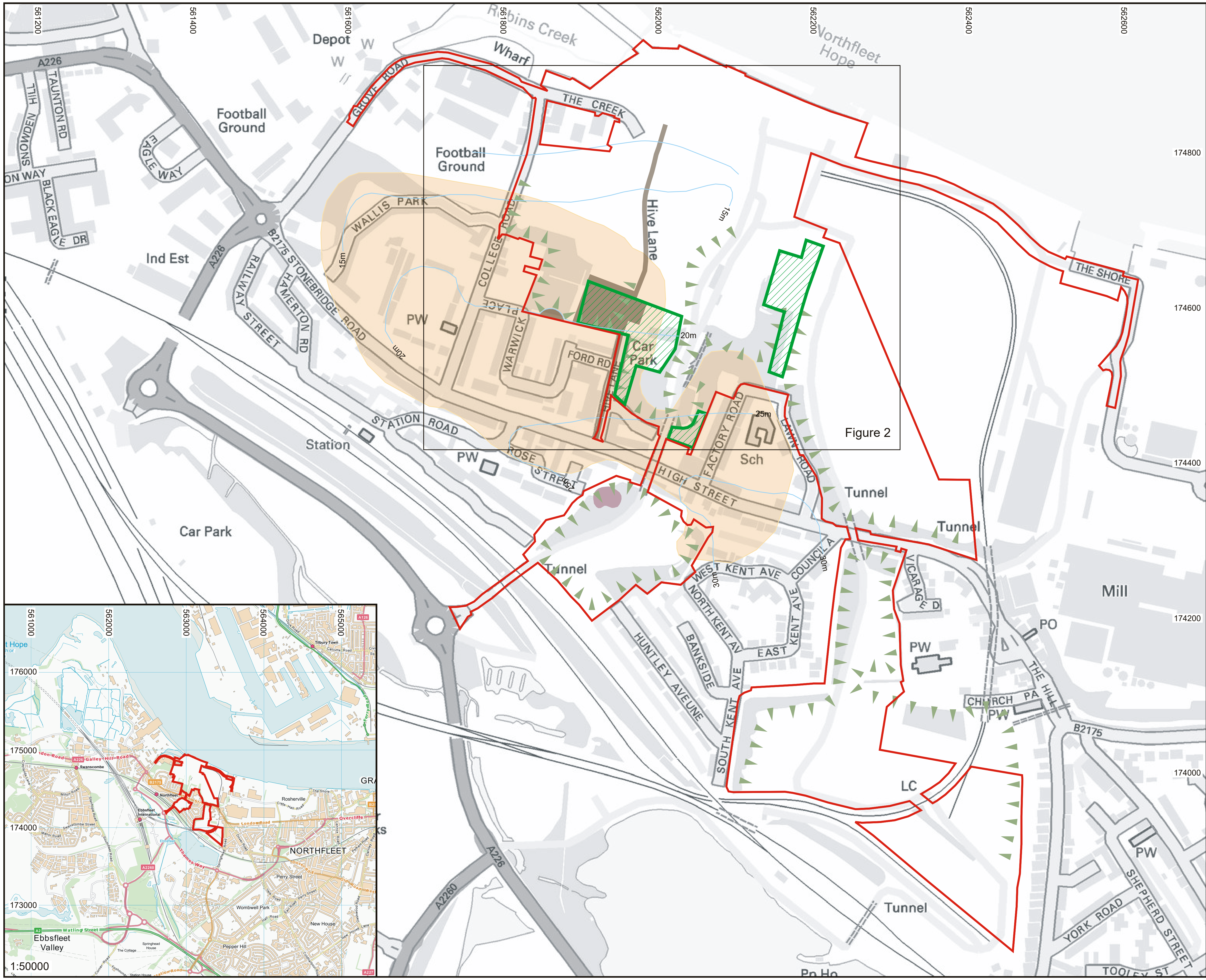


Site outline

Areas with potential to retain original ground level (based on LiDAR and historic mapping)

? Unquarried/less deeply extracted

Visible quarry face

Extent of Boyn Hill/Orsett Heath terrace mapped by BGS

Palaeolithic finds (Spurrell 1883)

Revision Number:	0
Illustrator:	RG/KJF
Date:	11/02/2021
Scale:	Main illustration 1:5000 @ A3
Path:	R:\PROJECTS\232991\

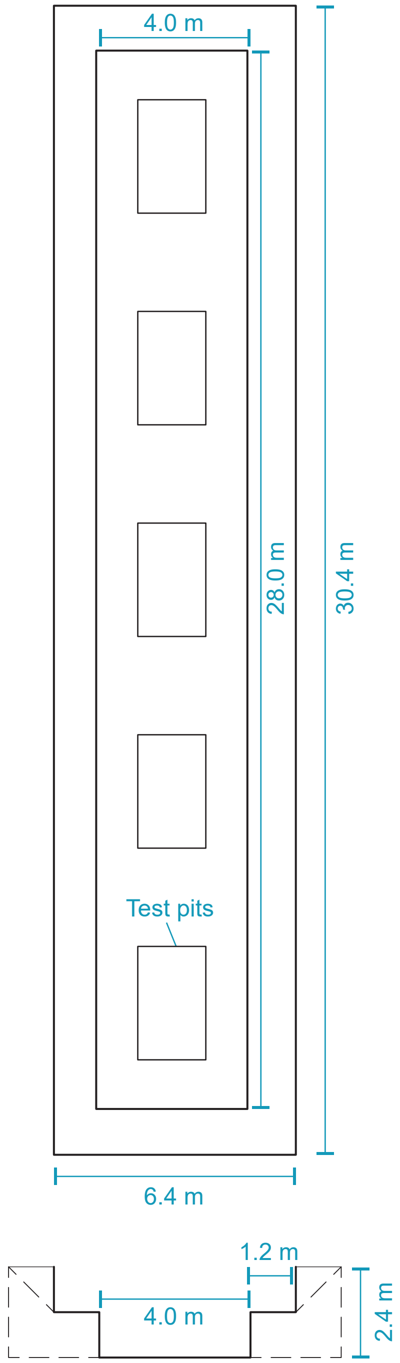
Graphics_Office\Rep figs\Geoarch\2021_02_05

Site location

Figure 1

Site plan

Figure 2



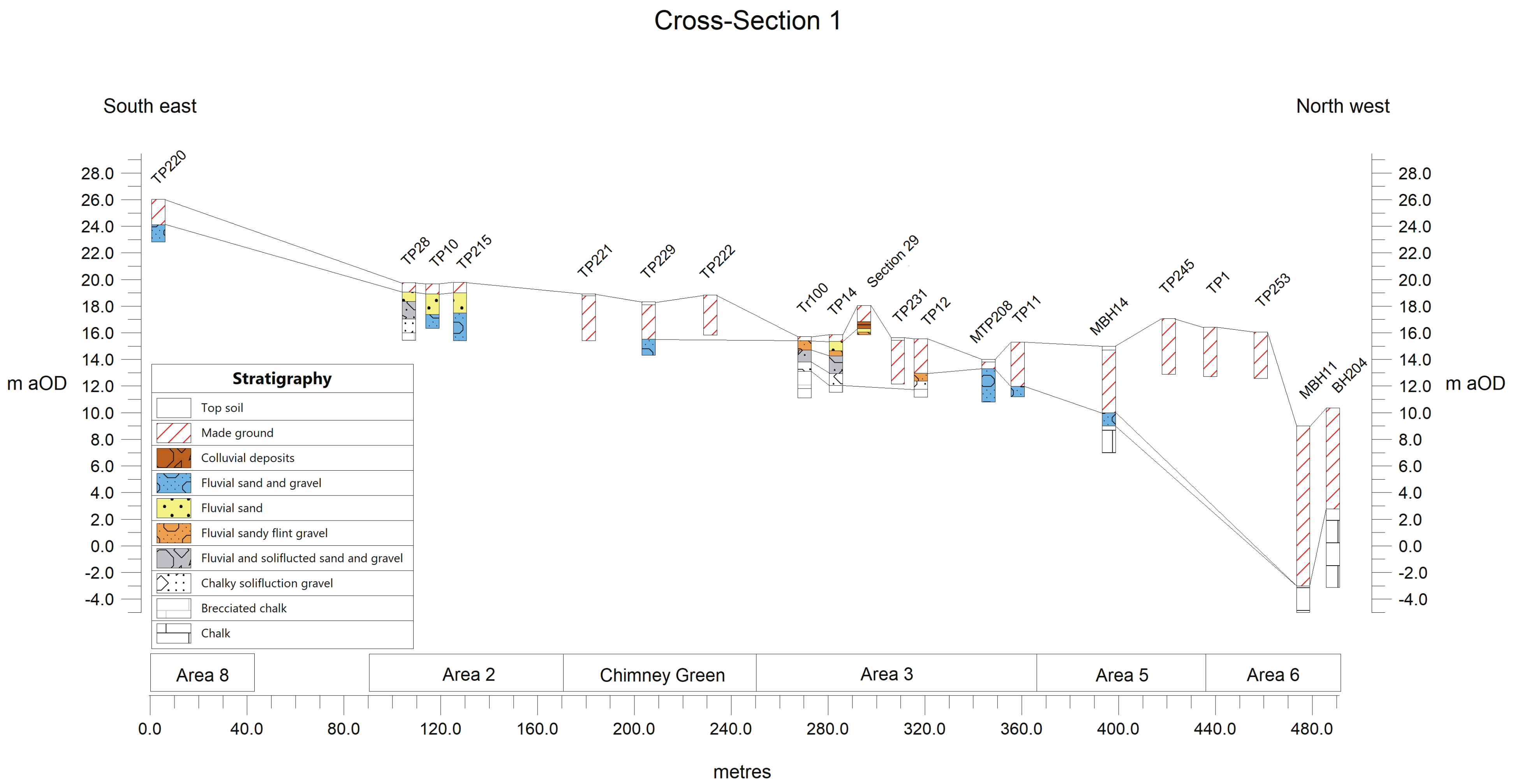
Date:	11/02/2021	Revision Number:	0
Scale:	1:200 @ A4	Illustrator:	KJF
Path:	R:\PROJECTS\232991\Graphics_Office\Rep figs\Geoarch\2021_02_05		

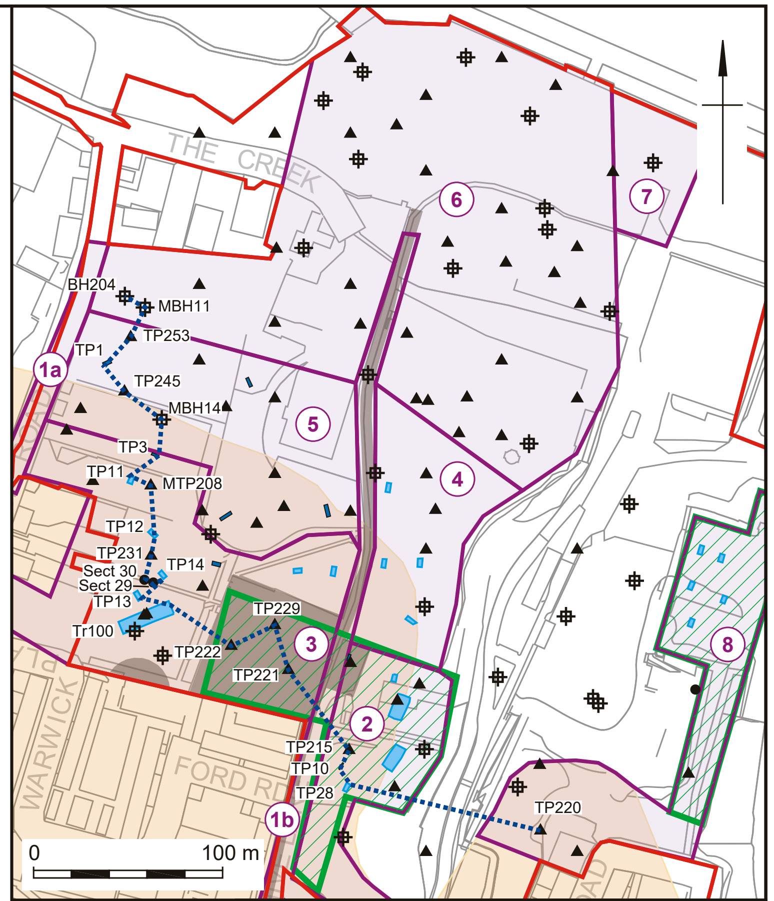
Schematic plan and cross section of trenches

Figure 3

Site plan, including all GI with interventions used in cross-sections labelled

Figure 4





Site outline

Areas with potential to retain original ground level (based on LiDAR and historic mapping)

? Unquarried/less deeply extracted

Extent of Boyn Hill/Orsett Heath terrace mapped by BGS

Areas of Palaeolithic potential

WA 2020 trench/test pit

WA 2009 test pits

GI trial pit

Borehole

Section location

Cross-section location

Revision Number:	0
Illustrator:	KJF
Date:	11/02/2021
Scale:	Location inset 1:4000 @ A3
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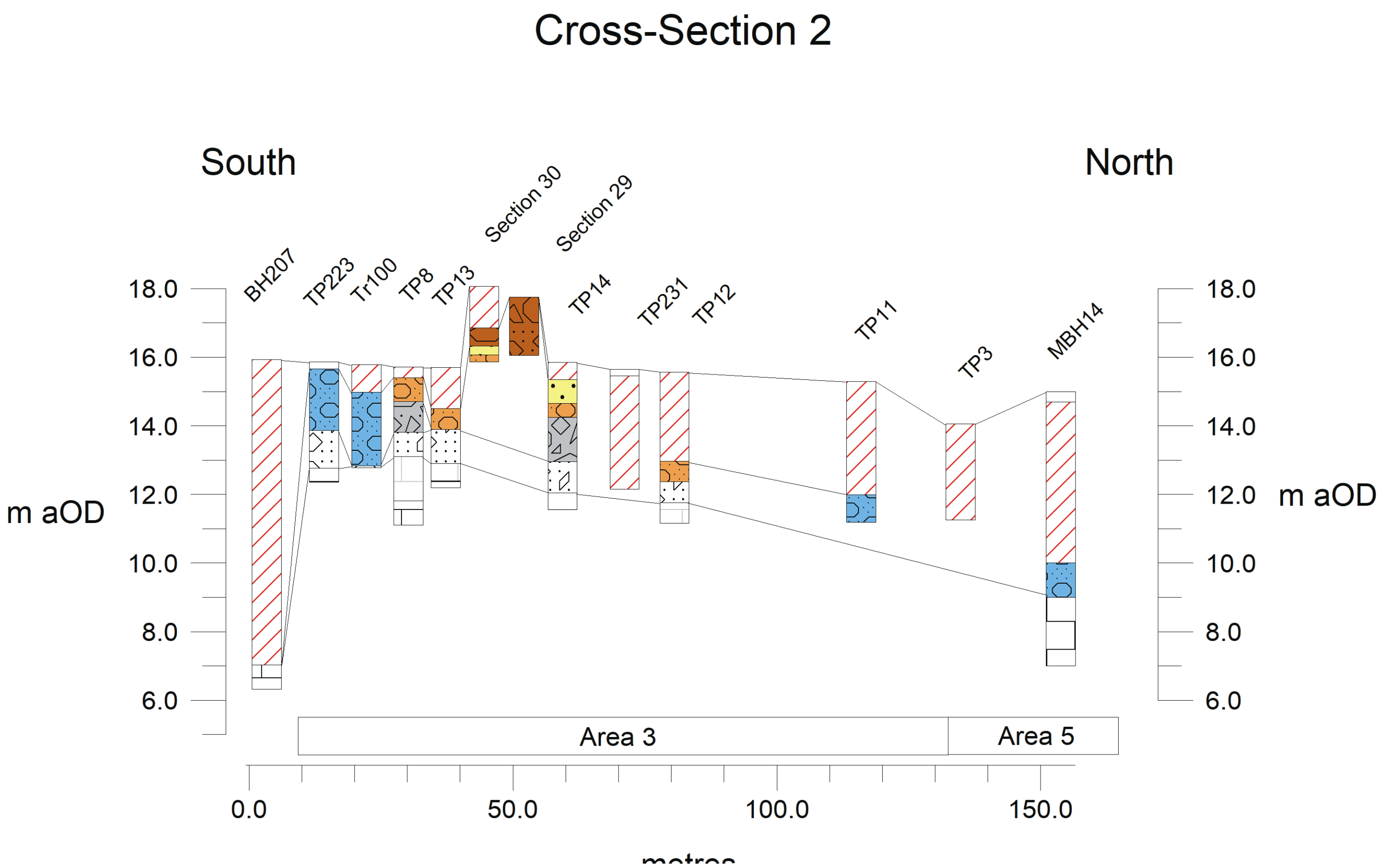
Graphics_Office\Rep figs\Georarch\2021_02_05

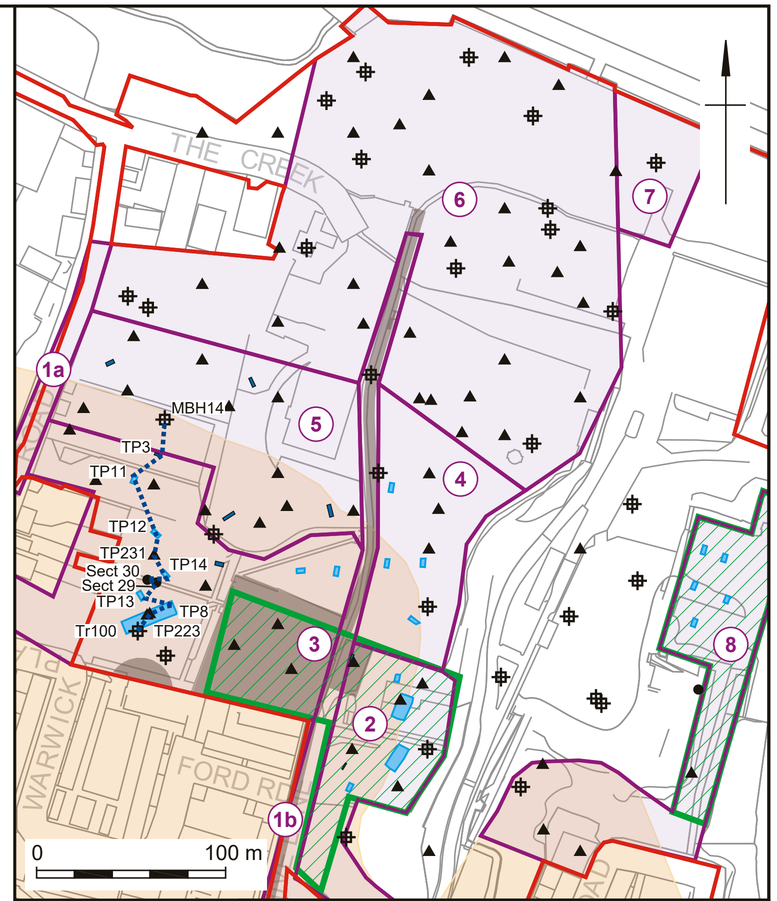
Georchaeological cross-section 1

Figure 5



Stratigraphy

- Made ground
- Colluvial deposits
- Fluvial sand and gravel
- Fluvial sand
- Fluvial sandy flint gravel
- Fluvial sandy flint and chalk gravel
- Fluvial and soliflucted sand and gravel
- Chalky solifluction gravel
- Brecciated chalk
- Chalk



- Site outline
- Areas with potential to retain original ground level (based on LiDAR and historic mapping)
- ? Unquarried/less deeply extracted
- Extent of Boyn Hill/Orsett Heath terrace mapped by BGS
- Areas of Palaeolithic potential
- WA 2020 trench/test pit
- WA 2009 test pits
- GI trial pit
- Borehole
- Section location
- Cross-section location

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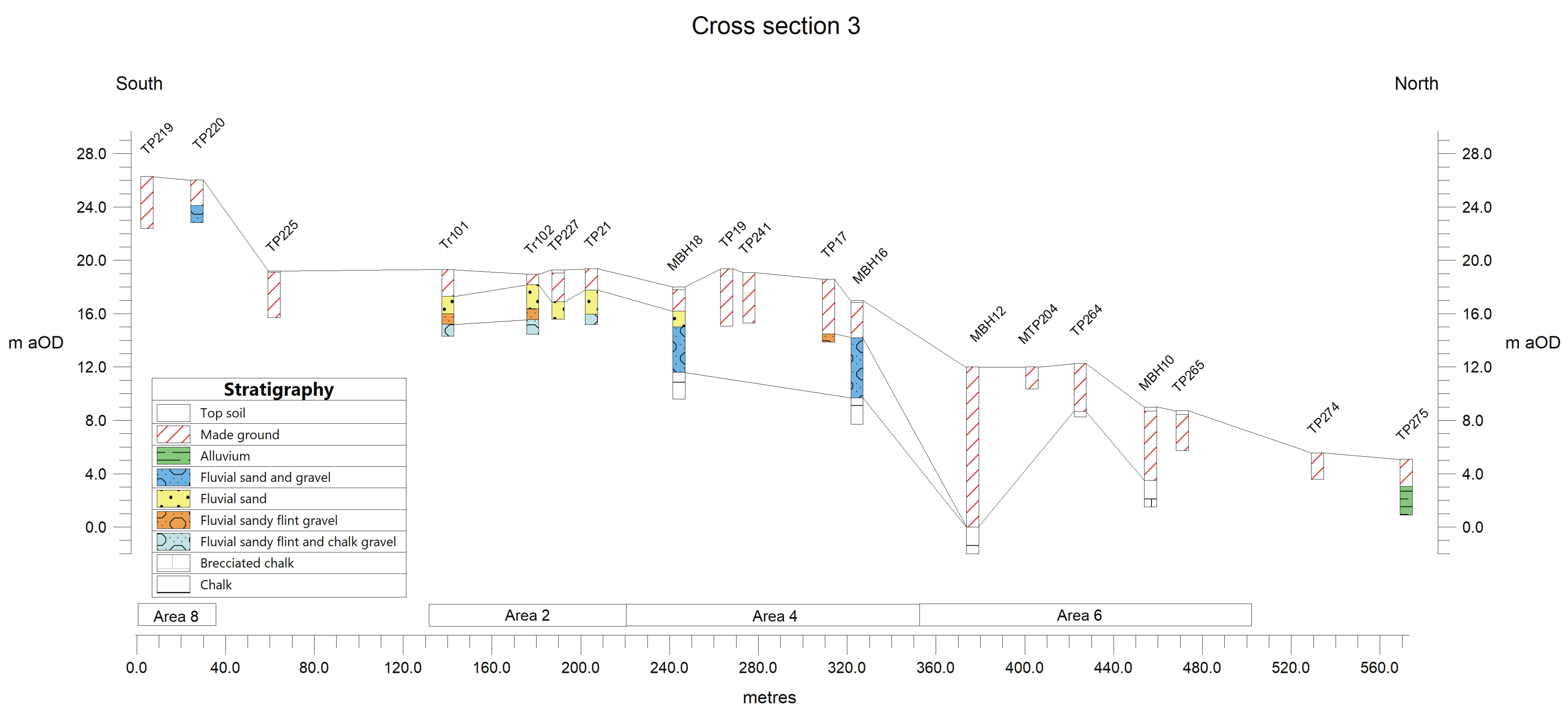
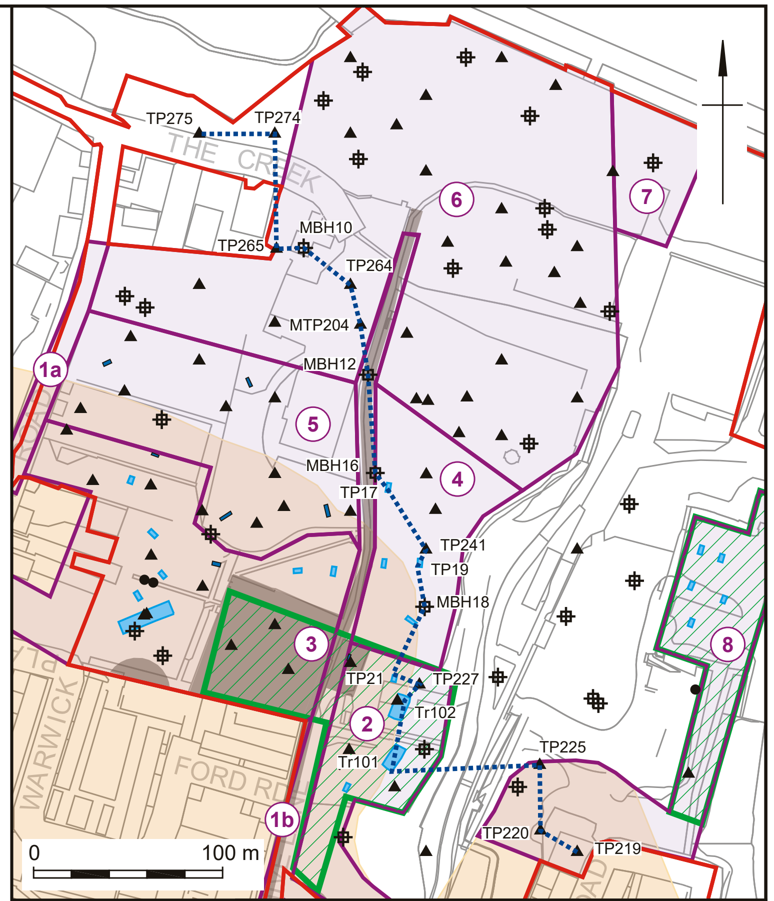
Georchaeological cross-section 2 — Figure 6





Site outline

Areas with potential to retain original ground level (based on LiDAR and historic mapping)

? Unquarried/less deeply extracted

Extent of Boyn Hill/Orsett Heath terrace mapped by BGS

Areas of Palaeolithic potential

WA 2020 trench/test pit

WA 2009 test pits

GI trial pit

Borehole

Section location

Cross-section location

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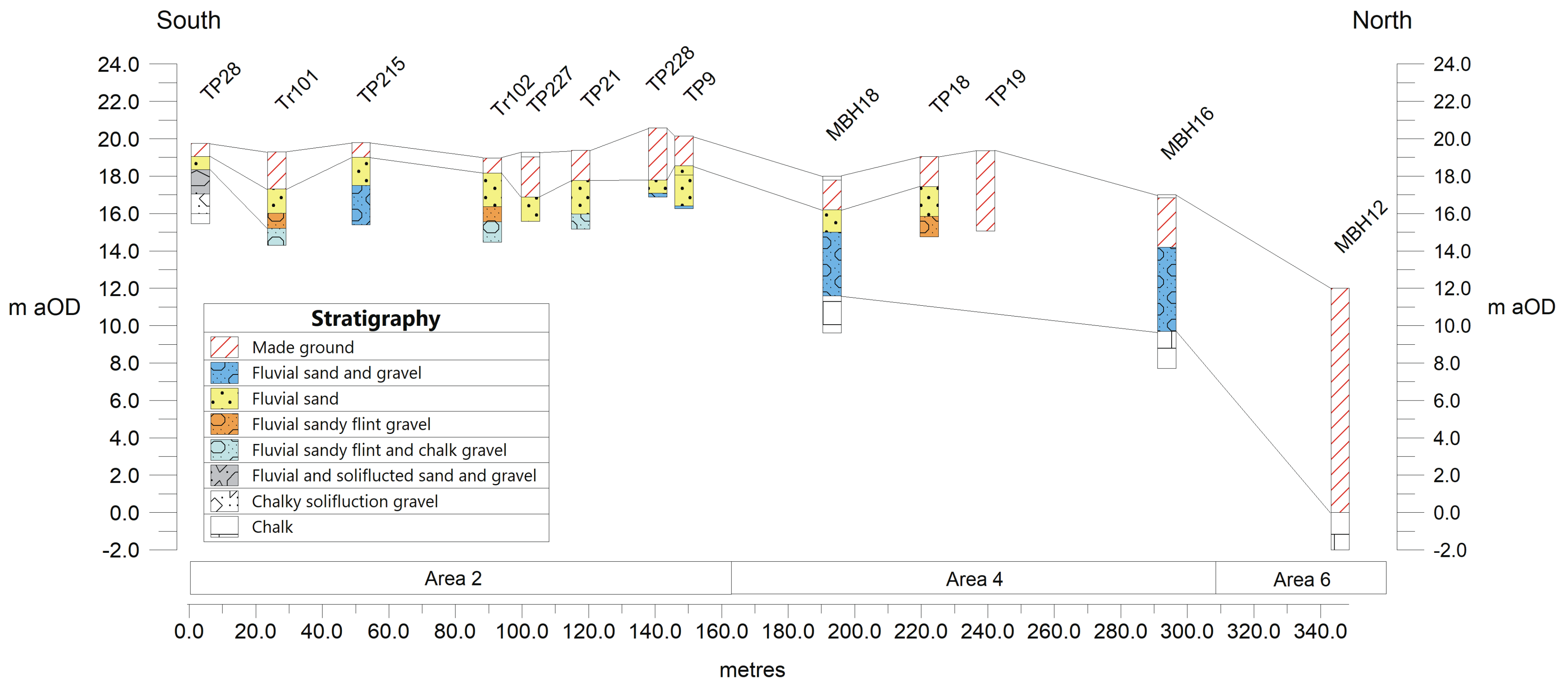
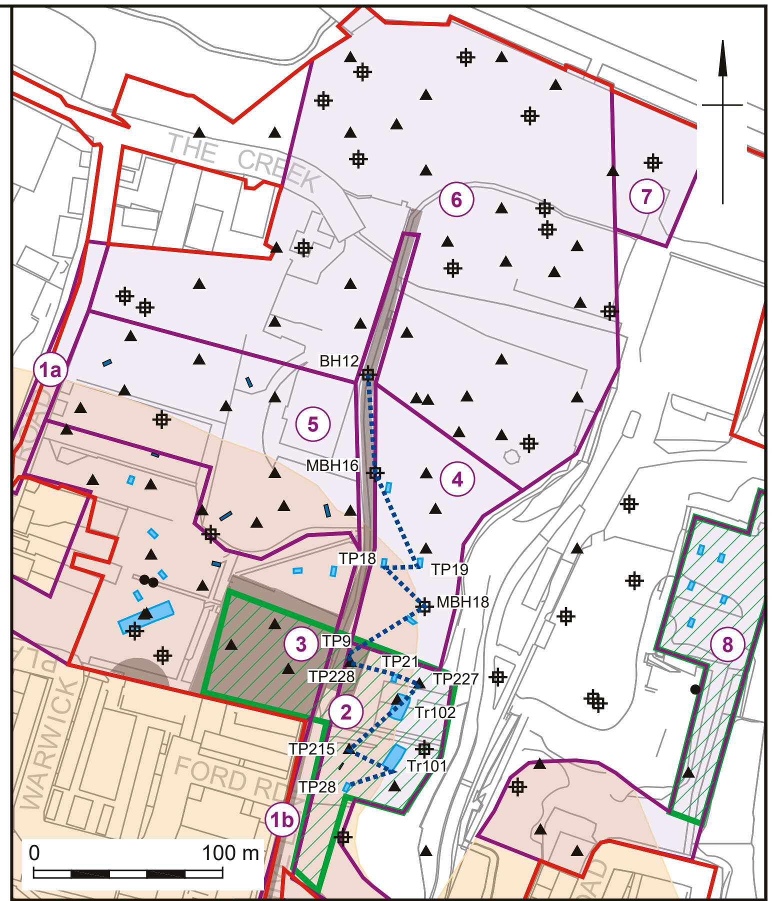
Geoarchaeological cross-section 3

Figure 7

Cross-Section 4





Site outline

Areas with potential to retain original ground level (based on LiDAR and historic mapping)

? Unquarried/less deeply extracted

Extent of Boyn Hill/Orsett Heath terrace mapped by BGS

Areas of Palaeolithic potential

WA 2020 trench/test pit

WA 2009 test pits

GI trial pit

Borehole

Section location

Cross-section location

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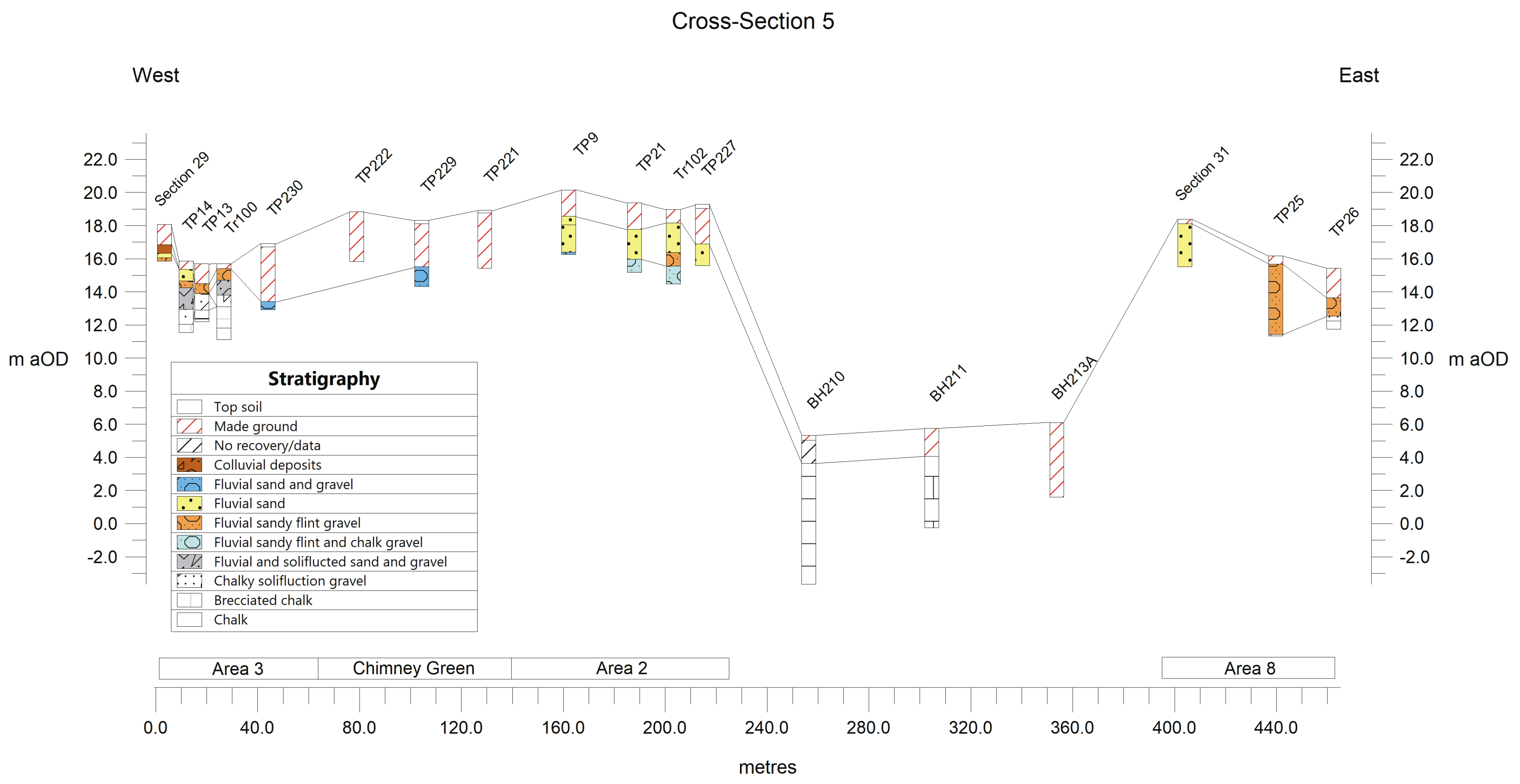

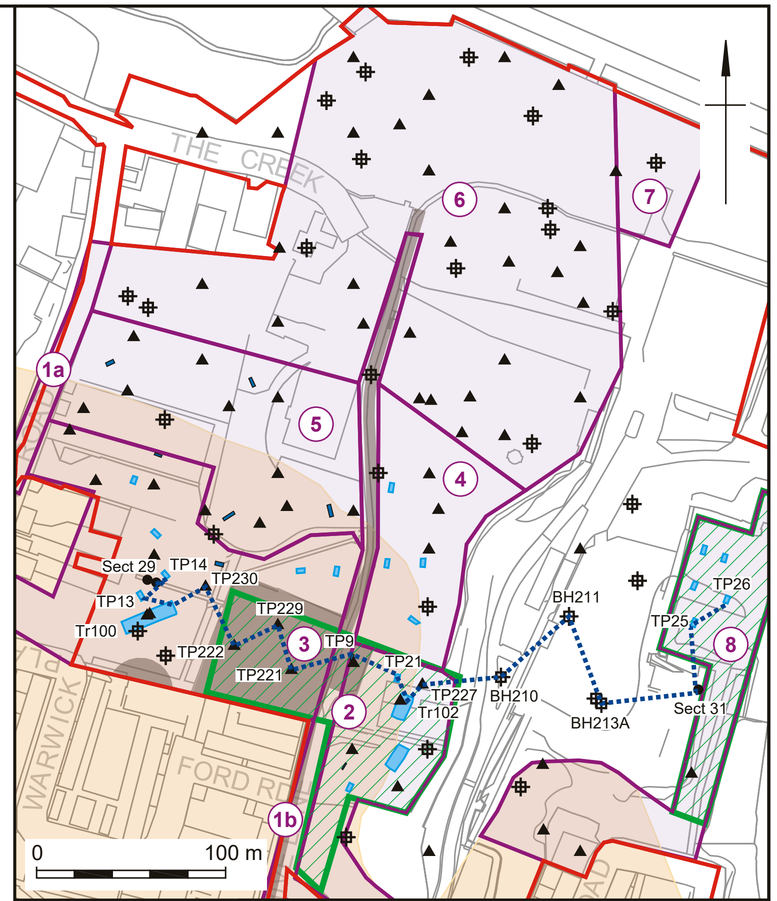

Site outline

Areas with potential to retain original ground level (based on LiDAR and historic mapping)

? Unquarried/less deeply extracted

Extent of Boyn Hill/Orsett Heath terrace mapped by BGS

Areas of Palaeolithic potential

WA 2020 trench/test pit

WA 2009 test pits

GI trial pit

Borehole

Section location

Cross-section location

Base plan supplied by client © BPTW.

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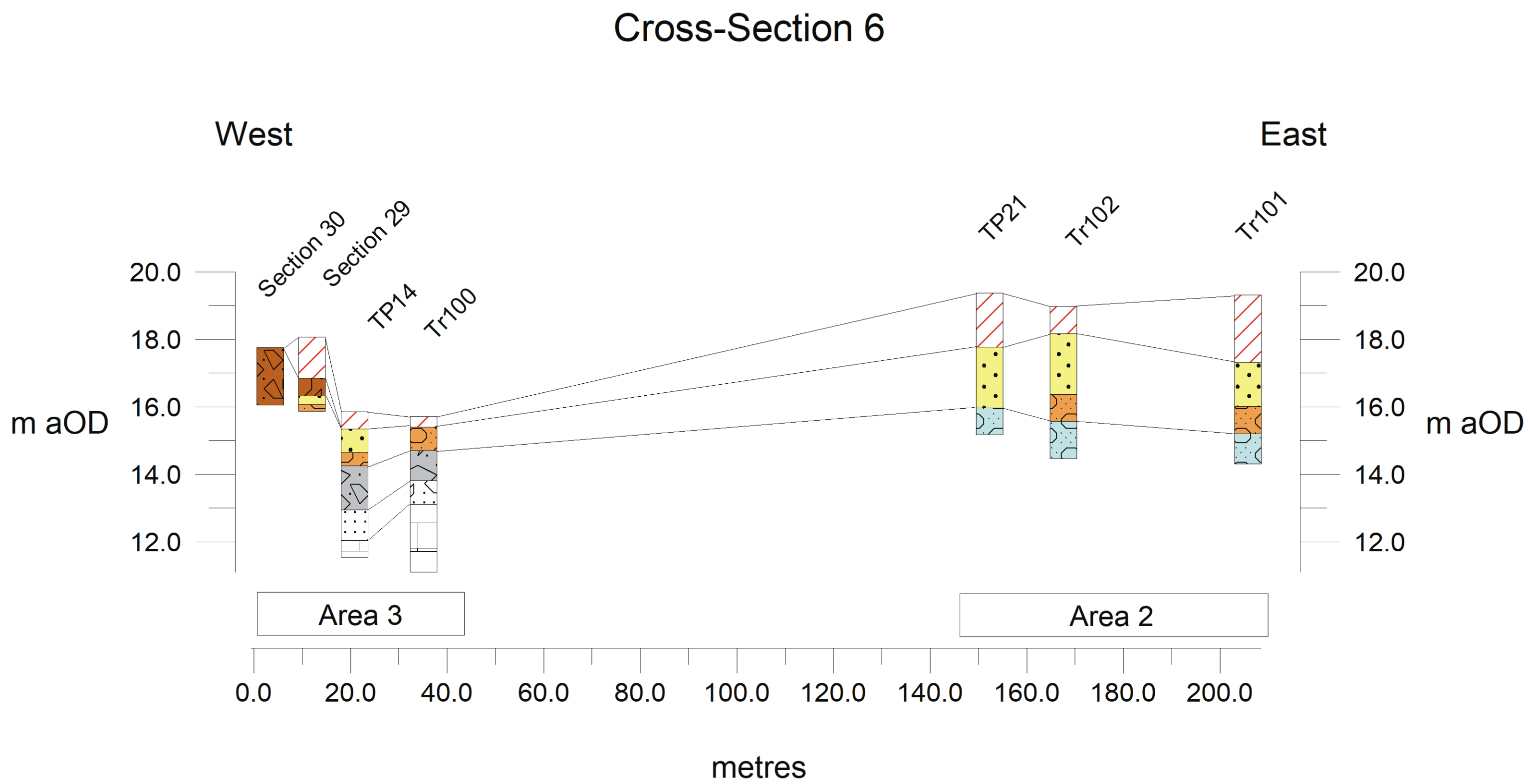
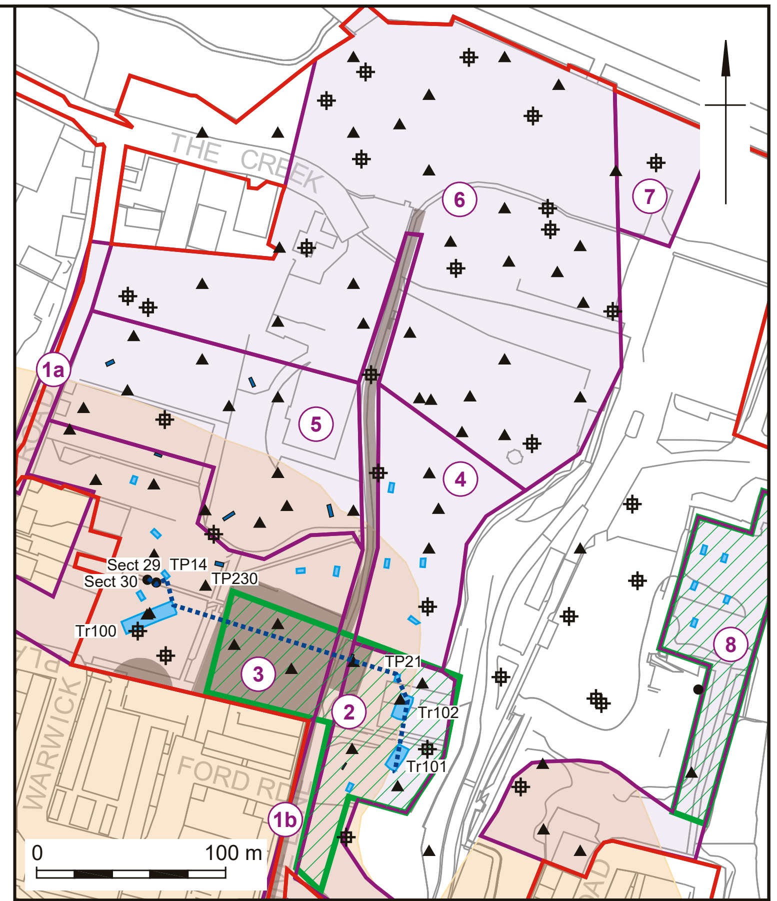
Georchaeological cross-section 5

Figure 9



Stratigraphy
Top soil
Made ground
Colluvial deposits
Fluvial sand
Fluvial sandy flint gravel
Fluvial sandy flint and chalk gravel
Fluvial and soliflucted sand and gravel
Chalky solifluction gravel
Brecciated chalk
Chalk



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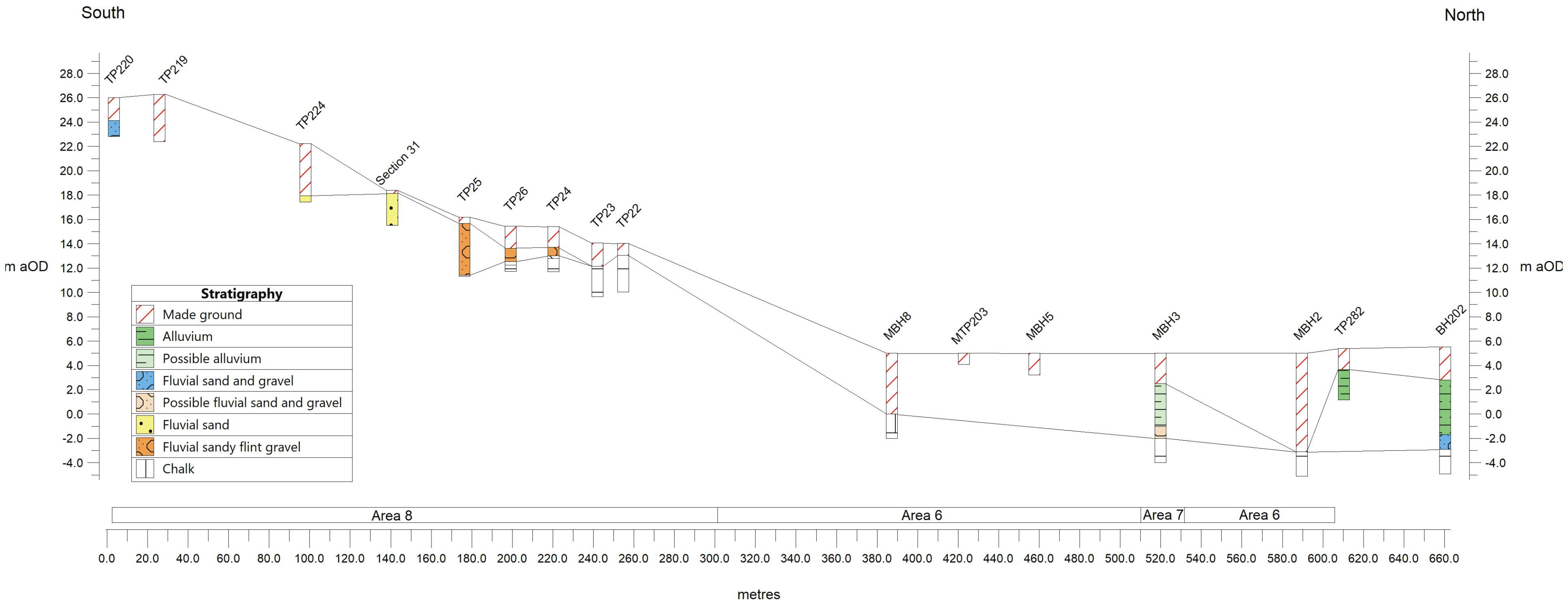
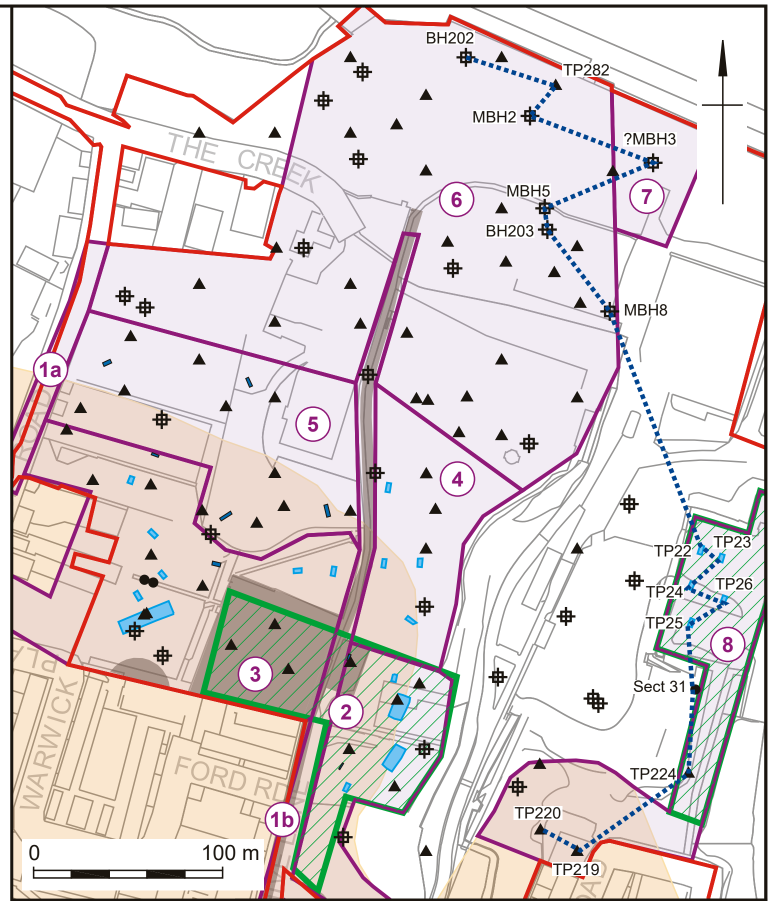
Cross-Section 7





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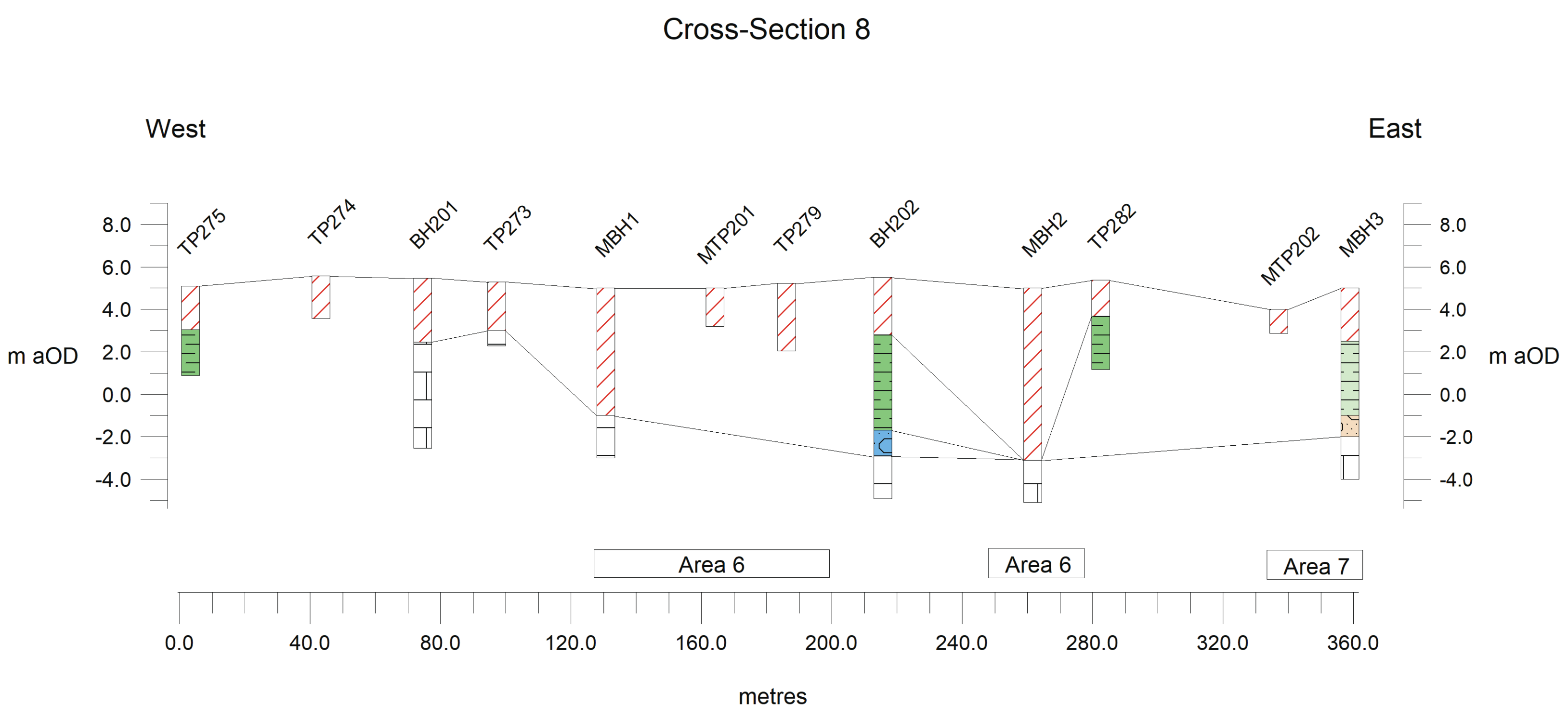

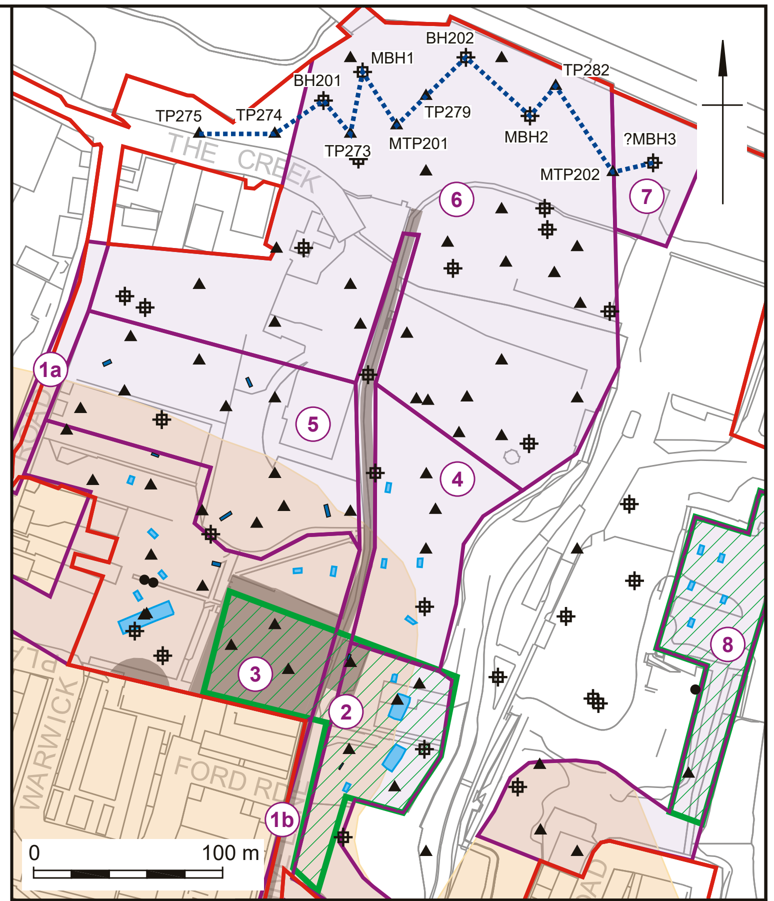

Stratigraphy
Made ground
Alluvium
Possible alluvium
Fluvial sand and gravel
Possible fluvial sand and gravel
Chalk

Site outline
Areas with potential to retain original ground level (based on LiDAR and historic mapping)
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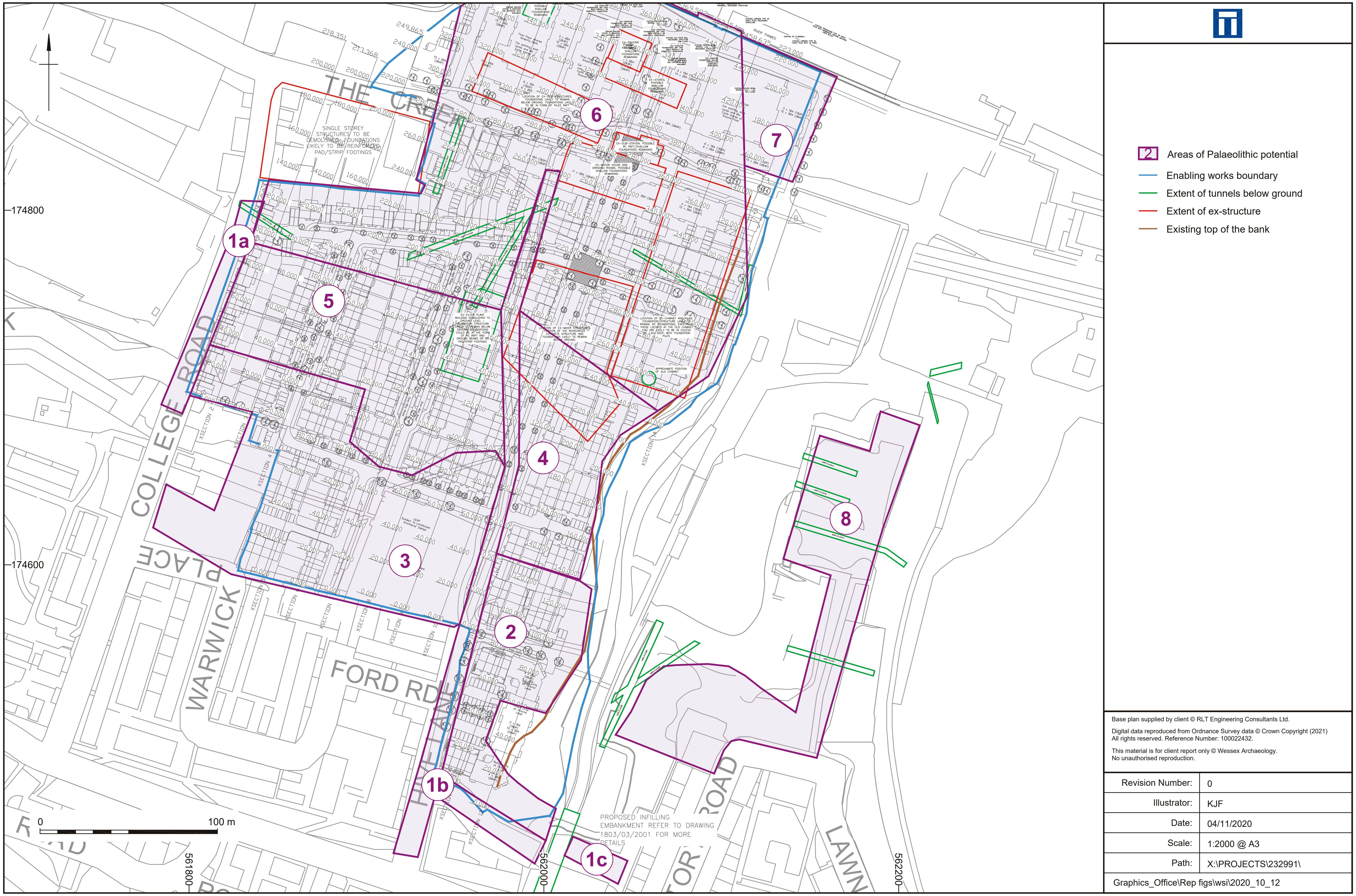
Georchaeological cross-section 8

Development proposals

Figure 13



Proposed cut and fill cross-section locations

Figure 14

Plate 1: Tr100 – south facing section

Plate 2: Tr100 – south facing section

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Plate 3: Tr101 – south east facing section

Plate 4: Tr101 – south east facing section

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Plate 5: Tr102 – north west facing section

Plate 6: Tr102 – north west facing section

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Plate 7: TP15 south east facing section – made ground overlying sandy flint gravel, chalky solifluction gravel and brecciated chalk

Plate 8: TP14 north east facing section – made ground overlying fluvial sand, sandy flint gravel, interdigitated fluvial and solifluction gravels and brecciated chalk

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Plate 9: Tr100 south east facing section, northern end of trench – sandy flint and chalk gravel overlying, chalky solifluction gravel, brecciated chalk and chalk bedrock

Plate 10: TP25 south east facing section – made ground overlying sandy flint gravel and bedrock chalk

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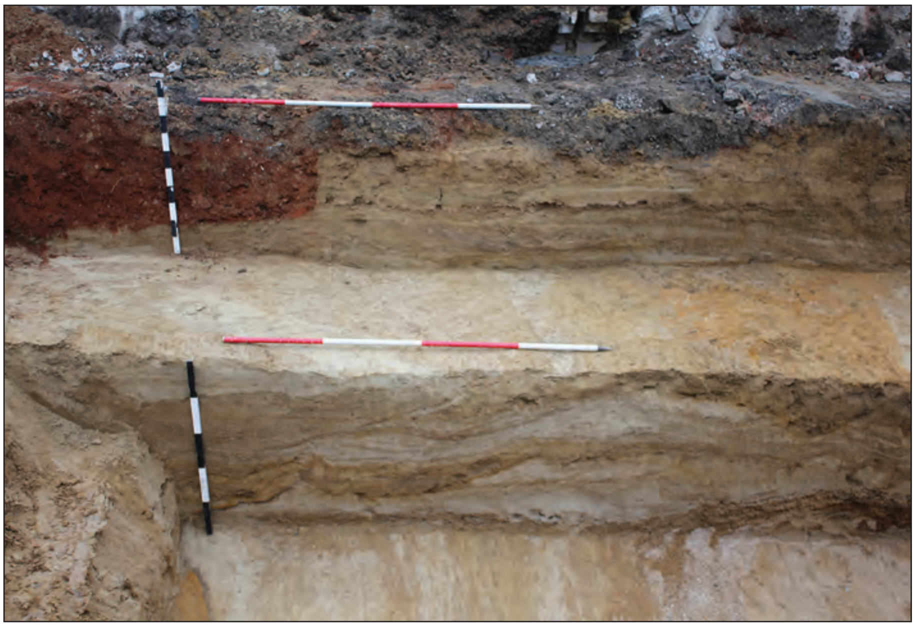

Plate 11: Tr102 west facing section, northern end of trench – made ground, overlying fluvial sand

Plate 12: Sec 31 north west facing section, northern end of trench – made ground, overlying fluvial sand

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Plate 13: Breach in concrete wall of chalk slurry back, Sec 29, Area 3

Plate 14: Sec 29, west facing section – modern soil profile overlying colluvial sand clay, fluvial sand and gravel

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Plate 15: TP11, south west facing section, modern feature cut through made ground

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