

Appendix 6F

Geoarchaeology Desk-Based Assessment and Preliminary Deposit Modelling

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Glossary

Term	Description
Bathymetric	The study of the underwater depth of water bodies (including seas, lakes, and rivers).
BP	Abbreviation of Before Present, used in radiocarbon dating
Chronostratigraphy	The application of time to sequences of rock layers to understand their ages.
Geoarchaeology	The application of earth science principles and techniques to the understanding of the archaeological record.
GDBA	Geoarchaeological Desk-Based Assessment.
Glacio-eustatic sea level shifts	Global sea-level changes resulting from changes in the volume of terrestrial glacial ice.
Glacio-isostatic	The reactionary movement of land masses following the removal of glacial ice.
Interstadial	A period of less cold climate during a glacial period, seeing the reduction of ice volume and the retreat of glaciers.
Ka	Abbreviation of thousand years ago.
Kettle Hole	A depression formed by the melting of a sediment-locked block of isolated ice left behind by a retreating glacier.
Lacustrine	Pertaining to lakes.
NCA	National Character Area- a modern geographical subdivision of England based on a combination of features, including landscape, geology, and economic activity.
NWWS	North West Wetlands Survey.
Palustrine	Inland freshwater wetland, dominated by vegetation.
RSL	Abbreviation of Relative Sea Level.
Stadial	A period of cold climate during a glacial period seeing the accumulation of ice and the advance of glaciers.

Executive Summary

Purpose of this report

This document is a Geoarchaeological Desk Based Assessment (GDBA), which aims to assess the geoarchaeological potential of the landscape within the HyNet North West Hydrogen Pipeline Project (henceforth, the Project). This assessment aims to provide a high-level baseline review, broadly characterising the topography, bedrock geology and associated superficial sediment sequences likely to be encountered across the scheme, examining regional models of landscape evolution, LiDAR data, geological mapping and the distribution of historical borehole data. Overall, the assessment aims to provide an initial qualitative evaluation of geoarchaeological, and palaeoenvironmental potential, with specific reference to depositional environments which may conceal and preserve archaeological sites in waterlogged conditions. The GDBA was prepared to inform the scope of planned geophysical survey, other archaeological evaluation, and form the basis of a detailed deposit model.

The GDBA also incorporates the results of project specific geotechnical interventions (boreholes and test pits) carried out in 2022, some of which were the subject of on-site monitoring by a geoarchaeologist. Those works enabled some deposit modelling, which is also included here.

For the purposes of assessment, the approximately 100km route of the Project was divided up into its four major components (the North, South, East, and West Corridors) emanating from a Central Hub, plus several spurs, the largest being the Runcorn and Warrington Spurs. These components have been sub-divided into Geoarchaeological Character Zones (GCZs) that have been categorised as part of this assessment. The geoarchaeological potential and significance of each zone has been described, with an attribution of low, medium, or high potential.

Zones with highest potential are typically low-lying or on the margins of several landforms or geologies. They generally contain deposits associated with tidal flats, peat, alluvium, and river terraces within existing and former floodplains. Away from the main river valleys, high geoarchaeological and palaeoenvironmental potential can often be attributed to peat deposits accumulated within former glacial hollows, and to aeolian sands, which have the potential to seal buried land surfaces. Zones considered to have more limited geoarchaeological potential tend to be dominated by outcrops of bedrock, glacial sands and gravel, and till, albeit that some such regions can still retain deeply stratified land surfaces and organic deposits, especially where associated with certain geomorphological traits, such as water courses.

The GDBA considers the extent and quality of existing British Geological Survey (BGS) borehole data as a means of constructing deposit models. It has highlighted that there are significant gaps in the geoarchaeological and palaeoenvironmental knowledge of the area within and immediately around the Draft Order Limits.

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Introduction

Project Background

Oxford Archaeology (OA) North was commissioned by WSP UK (WSP; formerly Wood Group UK Ltd), working on behalf of Cadent Gas Ltd, to undertake a programme of geoarchaeological work on the route of the proposed Hynet North West Hydrogen Pipeline Project (henceforth, the 'Project'). The work comprised Geoarchaeological Desk-Based Assessment (GDBA), a watching brief of geotechnical investigation (GI) in winter 2022, and preliminary deposit modelling where sufficient data was available.

The Project includes the construction, and operation and eventual decommissioning of approximately 100km of new pipeline to distribute hydrogen to industry in the North West. A number of Hydrogen Above Ground Installations (HAGIs), including Block Valve Installations (BVIs) are required to control the flow and pressure of hydrogen at key points along the proposed pipeline.

The Project connects the Hydrogen Production Plant (HPP) at the Stanlow site, as the source of hydrogen, for onward distribution to the network. The pipeline transports hydrogen to the Central Hub at the centre of the network, which then serves as the connection and onward distribution point to the North, East and South corridors, which would extend to St. Helens, Partington and Northwich respectively. Branching off from each main corridor would be pipeline spurs connecting hydrogen customers to the main pipeline. Infrastructure has also been included which supports the potential blending of hydrogen with methane in the existing gas network. The Project would also link to underground hydrogen storage facilities in Cheshire used to balance supply and demand through the network.

The Project crosses a landscape that is archaeologically rich, topographically diverse, and also dynamic, straddling several river valleys, their confluences, and the geologically and historically significant lower Mersey valley and estuary.

Geoarchaeology investigates geology, sediments, soils, flora, and fauna, providing a framework for understanding human occupation, exploitation, adaptation, and modification of past environments and landscapes at multiple spatial and chronological scales (Historic England 2015). The GDBA is the first element of a multi-stage approach to characterise the deposits traversed by the Project, especially those that might seal previously unidentified archaeological remains. As such, the GDBA presents an initial qualitative review of the available data and provides a preliminary framework for identifying and understanding the burial environments that have the potential to preserve a range of archaeological and palaeoenvironmental remains.

Particular foci of geoarchaeological interest will be existing and former lakes, river courses, valleys, floodplains and estuaries, but also areas that are low-lying, poorly drained, or where sediments might accumulate. Wetlands, in both inland and coastal zones, are important archives of archaeological and palaeoenvironmental records – these are historic landscapes, that hold evidence for environmental and climate change, as well as providing environmental settings for human activities (Historic England 2021). Palaeochannels are also recognised as a potential focus for human activity. Many areas of particular geoarchaeological interest are those where buried Pleistocene and Holocene deposits, land surfaces, and archaeological remains may be well preserved, particularly when associated with peat, organic-rich alluvium, and colluvium. Moreover, many such locations are known foci for former human activity (Fitch and Gaffney 2011), with ecotonal zones (marginal areas that straddle several topographic and geological zones) being particularly attractive. An initial understanding of these lithostratigraphic data will be based largely on published studies (for example, the *North West Wetlands Survey*), existing British Geological Survey (BGS) borehole records, and an assessment of superficial deposits mapped by the BGS across the Project.

The results of the GDBA are presented according to the different corridors and spurs that represent the components of the Project. These are described in **Section 0**.

Location

The Project lies in the North West of England where it traverses the counties of Cheshire, Merseyside, and Greater Manchester, and enters six local authorities: Cheshire West and Chester, Cheshire East, Halton, Warrington, St Helens, and Trafford (**Figure 1**). The majority of the Project crosses three National Character Areas (NCA); the Lancashire Coal Measures NCA (Natural England 2013a), the Mersey Valley NCA (Natural England 2013b), and the Shropshire, Cheshire, and Staffordshire Plain NCA (Natural England 2014a). In addition, a small section of the route traverses the lower eastern flanks of the Cheshire Sandstone Ridge NCA (Natural England 2014b). Measuring some 125km in total, the Project comprises four main corridors (North, West, South, and East) radiating from a Central Hub situated just to the north-east of Bartington, Cheshire (SJ 598377; **Figure 2**). In addition, there are several smaller spurs forming offshoots from these main corridors.

The Central Hub

The Central Hub lies immediately to the north-east of Bartington, Cheshire, where it will encompass the Central Hub Hydrogen Above Ground Installation (HAGI). The Hub occupies an essentially rural area of the Shropshire, Cheshire, and Staffordshire Plain NCA that slopes gently southward to the Trent and Mersey Canal (just inside the Project) and the River Weaver (just beyond the Project).

North Corridor and Warrington and St Helens Spurs

The North Corridor extends broadly due north from the Central Hub, crossing first the Bridgewater Canal and then the Manchester Ship Canal at Higher Walton and Moore. The route then heads in a more north-westerly direction, crossing the River Mersey between Cuerdley and Penketh. From Sutton Manor, the route takes a more northerly direction, culminating roughly 1km south-east of St Helens. The route of the North Corridor passes through the three main NCAs relevant to the project.

The Warrington Spur splits from the North Corridor at Higher Walton. It extends to the east, passing through the built-up areas of Wilderspool and Westy, generally on the south bank of the River Mersey and always on the north side of the Manchester Ship Canal. The St Helens Spur and Clock Face Spur both lead from the Clock Face HAGI.

West Corridor and Runcorn/Rocksavage Spur

The West Corridor of the Draft Order Limits would start at the Hydrogen Production Plant HAGI (HPP HAGI) at Stanlow with the pipeline running north-east to the Rocksavage HAGI and then south-east to the Central Hub HAGI. The Runcorn Spur crosses the Weaver Navigation and extends roughly 2km between the Runcorn HAGI and Weston. The route of the West Corridor passes through the Shropshire, Cheshire, and Staffordshire Plain NCA and the Mersey Valley NCA.

South Corridor

The South Corridor largely traverses agricultural land. Heading due south, it crosses the River Weaver/Weaver Navigation at Dutton Locks, just to the south of Bartington, and then the Handforth Brook, to the west of Weaverham. From Gorstage it follows a more south-easterly direction, and again crosses the Weaver in the vicinity of Moulton. From there it heads east to the Hydrogen Storage Facility at Whatcroft, crossing on the way the River Dane, the Trent and Mersey Canal, and the Puddinglake Brook. The route of the South Corridor lies within the Shropshire, Cheshire, and Staffordshire Plain NCA.

East Corridor and Warburton and Partington Spurs

The East Corridor extends in a north-easterly direction, culminating at the Pilkington HAGI, and continuing for a little way as the Partington Spur in an industrial area of Carrington, on the south-western outskirts of Manchester. Otherwise, the landscape traversed is overwhelmingly rural, and the route crosses the Whitley Brook, the Gale Brook, the Crowley Brook, the Bridgewater Canal, the Agden Brook, the River Bollin, the Old Bollin (just to the north of which lies the short Warburton Spur and HAGI), the Caldwell Brook, and the Red Brook. Much of the route of the East corridor passes through the Shropshire, Cheshire, and Staffordshire Plain NCA. Its most easterly end, however, traverses the Mersey Valley NCA.

National Character Areas

The Lancashire Coal Measures

The Lancashire Coal Measures NCA is characterised by farmland, scattered urban centres, and former and current extraction industries (Natural England 2013a). Although much of the NCA is underlain by coal measures, the solid geology of the area of the Project is dominated by Triassic sandstone. The landscape within the Lancashire Coal Measures NCA comprises gentle hills and valleys, with elevation ranging from 179m OD at Billinge Hill, to 11m OD towards the lowlands of the Mersey Valley (**Section 0**). Large deposits of peat have accumulated in depressions and basins in many of the lower and flatter areas. Much of the peat in the area has been subjected to peat cutting and agricultural improvement since the 12th century, leaving black peaty soils and a network of drainage ditches. Remnants of some lowland raised mires have survived, however, such as the Sites of Special Scientific Interest (SSSI) at Red Moss (Horwich, Greater Manchester) and Highfield Moss (Wigan; Natural England 2013a).

The Mersey Valley

The Mersey Valley NCA covers the wide low-lying valley, estuary, and tributaries of the River Mersey, which extends from the mosslands west of Manchester to the wide estuary with intertidal mudflats, salt-marshes and low exposed cliffs to the west (Natural England 2013b). The area has an average elevation of 23m OD, which rises to 144m OD towards the Cheshire Sandstone Ridge. The Mersey becomes estuarine between Warrington and Runcorn, where tidal influence increases and there is a transition between freshwater and marine habitats. The area either side of the river and estuary is a focus for industrial development and urban areas and has a dense network of communication routes. High-quality arable and pastoral farmland exists away from these developed areas.

The underlying geology comprises Triassic Sandstone, with extensive areas of drift geology and marine and freshwater alluvium, which are bordered in places by blown sand. The Mersey Valley is significant for its concentration of lowland fens and raised bogs, which developed in hollows during the early part of the Post-Glacial period. While much of this peat has been lost to 20th century development and agricultural improvement, remnants have survived and form the internationally recognised Manchester Mosses Special Areas of Conservation (SAC). To the west of Manchester, these include the extensive area of Chat Moss, just to the north of the Project, and Carrington Moss, which is traversed by the East Corridor. Prehistoric settlement has been located close to the River Mersey, its tributaries, and on minor promontories (Natural England 2013b). Very few prehistoric finds have been recovered from the Manchester Moss complex, which may partly be explained by the very early development and subsequent spread of these boggy areas roughly 7000 years ago. Any evidence for earlier prehistoric activity is likely to be buried by considerable depths of peat, which, at its deepest, reach up to 7m (Howard-Davies *et al* 1988). Subsequent settlement appears to have avoided these large areas of peat land (*ibid*; Natural England 2013b).

The Shropshire, Cheshire, and Staffordshire Plain

The Shropshire, Cheshire, and Staffordshire Plain NCA is a flat and gently undulating plain dominated by thick glacial deposits of sands and boulder clay; there are numerous glacial landforms, with ponds and meres developing in natural depressions. Subsequent colonisation of vegetation during the Post-Glacial period has created large areas of bog, which make up the nationally important Midlands Meres and Mosses complex, several having been designated SSSI and National Nature Reserve (NNR) status. The low-lying plain, which ranges in elevation from between 20 to 50m OD, is punctuated by a series of low, but prominent Triassic sandstone ridges, including the Cheshire Sandstone Ridge, which have been the foci for Iron Age settlement (Natural England 2014a&b, and below).

Although relatively flat, the area is a watershed for several major rivers and their tributaries, including the Rivers Dane, Weaver, and Gowy, which meander northwards to the River Mersey. The floodplains of many of these rivers have created rich grazing land, with alluvial marshes and hay meadows. There are well-defined examples of historic land use, including medieval dispersed settlement, ridge and furrow agricultural earthworks, and moated houses. Today, the plain is scattered with regularly spaced large farmsteads, dispersed hamlets, market towns, and larger settlements, and there are numerous feeder reservoirs and canals (Natural England 2014). The area is nationally important for its sources of inland silica sand and salt, and has a rich history of salt extraction, which dates back to the Roman period; most notably those at Nantwich and Middlewich (Philpott 2008).

The Cheshire Sandstone Ridge

The Cheshire Sandstone Ridge NCA appears as a group of small, but prominent hills, which rise sharply from the surrounding lowlands of the Shropshire, Cheshire and Staffordshire NCA, and the Mersey Valley NCA to the north-west. Elevation ranges from 4m OD, where it joins the lowlands, to 227m OD at Raw Head in the Peckforton Hills. The Sandstone Ridge is made up of Triassic Sandstone and conglomerate of the Sherwood Sandstone Group, whilst thick layers of Glacial Till and Glaciofluvial sands and gravels cover the lower slopes. The relatively high elevation and outlook provided by the ridge means that it has been the focus for several prehistoric sites and defensive fortifications. The Sandstone Trail, which stretches from Frodsham in the north, to Whitchurch in the south, follows a route which used to link the many Iron-Age hill forts prevalent on the ridge. The NCA is sparsely populated and comprises a dispersed settlement pattern of farmland, villages, and hamlets. Place-name evidence indicates the presence of former deer parks, and remnants of a vast Royal Hunting Forest still survives at Delamere in the north. The ridge has many designated nature conservation sites, including Bickerton Hill SSSI, which contains the largest area of surviving lowland heath in Cheshire.

Archaeological Background

The archaeological resource on the Project, both known, and potential, is vast, and is considered thoroughly in the Archaeological Desk Based Assessment (**Appendix 6A**). It is not proposed to duplicate elements of that very detailed document. Rather, the following sections are abstracted from the *Archaeology DBA* and provide a brief summary pertinent to the present GDBA. It utilises the same abbreviations as the *Archaeology DBA* to ease cross-referencing with that document (for example, the prefixes HCH and HGM refer to Historic Landscape Characterisation Areas in Cheshire and Greater Manchester, respectively, whilst the prefixes MCH, MGM, and MME represent specific sites on the Cheshire, Greater Manchester, and Merseyside Historic Environment Records, respectively; those prefixed NHLE are Scheduled Monuments appearing on the National Heritage List for England). As such, there is a focus on the potential prehistoric, Roman, and early medieval remains. Evidence of medieval, post-medieval, and industrial-period activity is so copious as to defy meaningful summary.

The earliest remains identified on, or near the Project are of Mesolithic date, and were found along the West Corridor, around the Mersey Estuary. They include flint artefacts from peat deposits on the tidal flats of Helsby Marsh, in the vicinity of Elton, at the far western end of the corridor (HCH3913; RSK 2017). Bronze-Age material has been recovered from the same deposits (*ibid*). A flint scatter, thought to be of Mesolithic date, was identified by fieldwalking at Sutton Weaver, near Frodsham (MCH8107, HCH1169), with another, undated, scatter at Sutton Hall Golf Club (MCH8062). A little to the east, on the North Corridor at Daresbury, fieldwork has uncovered lithic scatters thought to represent Neolithic or Bronze-Age activity (L-P Archaeology 2021) from an area of higher ground overlooking the confluence of the Keckwith Brook and the Mersey (HCH12990). Further to the east, a stone axe was found near Antrobus (MCH8431, HCH1358), between the Whitley and Gale Brooks on the East Corridor. North of the Mersey, undated lithics have been identified at Lea Green, which is bounded by the Pendlebury Brook (MME14814, HCH 18766), near the Warrington end of the North Corridor. Located 1km to the north of the Draft Order Limits of the South Corridor as it skirts around Bostock Green, a significant Mesolithic site was identified in association with peat deposits at Church Moss, Davenham Manchester University Archaeological Unit (1995a; 1995b).

Further activity more firmly attributed to the Bronze Age takes the form of barrows, burials, and chance finds of bronze artefacts, with the latter potentially deposited in watery places rather than casually discarded. On the West Corridor there are possible round barrows overlooking the lower reaches of the River Weaver at Sutton Weaver (MCH8218 and MCH8219; HCH1169), and to the west of Aston (MCH16127; HCH1226). Occupying a similar vantage point to the north, a Bronze-Age inhumation vessel (MCH5995) was found on the site of the Rocksavage Power Station (Runcorn Spur). Higher up the Mersey Valley, an isolated Bronze-Age burial was discovered close to Louchers Lane, Warrington (MCH8568) whilst to the south of the town, a Bronze-Age axe was found within or near the old channel of the Mersey (MCH8806, HCH12871; HCH12876). Further east, there is a scheduled bowl barrow at Antrobus (NHLE 1011166, HCH1285), whilst on the South Corridor, a Bronze-Age axe was found in ploughsoil at Weaverham

(HCH1609), close to the meandering River Weaver. Further south, between the River Weaver, the River Dane, and the Peckmill Brook in the area of Davenham, several Bronze-Age sites have been identified. They comprise a possible sword tip recovered from Easton House (MCH9037, HCH582), and a bowl barrow (NHLE 1011123) located on top of a glacial mound around 160m north-east of Moultonbank Farm.

There is widespread evidence of late prehistoric and Romano-British native settlement and field systems, much in the form of cropmarks identified from aerial photographs and satellite imagery. Few have been investigated or dated, and their sparse representation along parts of the Project, including much of the East Corridor, may be an artefact of visibility as much as absence. For instance, there are a few cropmarks around Dunham Massey, in the Bollin Valley (MGM9071 within HGM5738; OA North 2016), whilst a Roman hoard found close to the Agden Brook suggests that settlement was more extensive than present evidence indicates (MCH7468). On the West Corridor there are numerous examples in the lower reaches of the Weaver Valley. These comprise cropmarks at Sutton Weaver (HCH1169), to the east of Sutton (HCH1225); and to the west (MCH24439; MCH24439, HCH1226), north (MCH8401, HCH1235), north-east (HCH21248), and east (HCH1247) of Aston. Further east, field systems have been identified in the vicinity of the confluence of the Longacre Brook (HCH1191) and at Dutton Hall, between the Longacre Brook and the Dean Brook, another tributary of the River Weaver. Higher up the Weaver Valley, in the South Corridor, there are cropmark sites around Bartington and Acton, stretching to the banks of the Weaver (MCH24437, HCH1275; HCH1578; HCH1526; HCH1581).

A little to the north, as the North Corridor passes between the Whitley and Keckwith Brooks as it heads to the Mersey, there are potential settlements and field systems as the valley descends from around Preston on the Hill (HCH13009; MCH24432, HCH1195), Hallamhall Farm (HCH13017), around Walton (HCH13263; HCH13259; HCH13246; HCH13258; HCH13229), Daresbury Hall (HCH12974), Daresbury (HCH12967; HCH12961; HCH12990), to Moore (HCH13245; HCH12938), and a rectangular enclosure between the Mersey and Manchester Ship Canal (MCH8890, HCH13123).

On the north bank of the Mersey there are further cropmarks around the Fiddler's Ferry Power Station (MCH24609, HCH13081; HCH13082; HCH13083) and stretching up the north side of the valley to the M62 corridor at Sutton Manor (HCH13111; HCH13080; HCH13069; HCH13065; 12954; 12890; 12880; 12871; 12867; 12865; 12858; 4876; 4766) and Lea Green (where several enclosure ditches were investigated but remain undated; MME15547; OA North 2007).

The North West of England was an area of significant Roman military and administrative infrastructure, with forts at Chester and Manchester and significant civilian industrial settlement, most notably at Wilderspool (NHLE 1006769) on the north bank of the Mersey (Warrington Spur; HCH12864, HCH12865). Several roads connect the forts and settlements in the region. That from Chester to Wilderspool (Route 701; MCH1449 now the modern A56) is crossed by the North Corridor between Daresbury and Walton. Indeed, Roman concrete, possibly associate with a villa (MCH6070), was found at Daresbury. A section of that road was identified at Sutton Weaver in 1808, alongside a possible Roman arch (MCH7729; West

Corridor). The East Corridor crosses the route of the North Cheshire Ridge Roman Road (MCH9506; now the modern A50) between High Legh and Sworton Heath (HCH9445; HCH9429; HCH9408), whilst a putative route of the Cotebrook to Cuddington Roman road (MCH8018) is crossed by the South Corridor at Weaverham (HCH1726). At Hartford, the South Corridor also crosses that part of Watling Street that passes between Chester and Nantwich before heading to Manchester (HCH1606; HCH64); Nevell and Fielding 2005; Newman 2016, 30).

Evidence for Early Medieval activity is primarily provided by place names and references in Domesday Book, together with a few chance finds. One such find of particular note was made in southern Warrington, during construction works in the 1930s: a logboat of possible early medieval date was found in a silted-up creek which flowed to the River Mersey through former marshland (MCH8766, HCH13376).

Aims, Objectives, And Methodology

Research Context

A firm basis for research on many archaeological projects is provided by the Regional Research Frameworks initiative devised by Historic England and the Association of Local Government Officers. In the case of the Project, some key research themes are provided by the *North West England Regional Research Framework*, available online (NWERRF; Research Frameworks 2022a). Previous studies, such as the North West Wetland Surveys (NWS; Cowell and Innes 1994; Hall *et al* 1995; Leah *et al* 1997) are also important for directing research. Geoarchaeology has the potential to contribute to a wide range of themes but, in particular to further those associated with the context of human societies – the environment, the location and nature of activity, and how these inter-relate and change over time. Significantly, geoarchaeological investigations can highlight areas of potential for buried archaeology and palaeoenvironmental resources, which is especially important in coastal areas and on floodplains. At their most broad, these themes can be applied to every period of human history, not just within the North West of England, but across the country (and no doubt, more widely). They are articulated particularly well in the *East Midlands Historic Environment Framework* (EMHERF; Cooper 2006 reproduced in Research Frameworks 2022b), from which the following overarching themes have been selected as being very relevant to the North West of England with its significant river corridors, coastal areas, and diverse topography and ecology:

- *Pleistocene and Holocene climatic change (as evidenced, for example, by palaeochannel deposits);*
- *changes in sea level, the configuration of sea and land, the drainage network and the spatial extent of wetlands;*
- *the impact of [and relationship with] human activity upon soil development and geomorphic processes (notably alluviation, colluviation and aeolian deposition);*
- *exploitation and settlement of diverse ecological zones (including study of the pivotal highland-lowland contrast); and*
- *the role of rivers as movement corridors.*

In addition, and particularly pertinent, is Howard's assertion that understanding the long-term landscape evolution and the development of models that place the sedimentary deposits within a securely dated chronostratigraphic framework is a prerequisite for any archaeological project (Howard 2022, in Research Frameworks 2022b). The NWERRF (Research Frameworks 2022a) presents selected research questions that are of particular relevance to the present geoarchaeological project (**Table 6F 0.1**).

Table 6F 0.1 Research Questions abstracted from the NWERRF (Research Frameworks 2022a)

Theme	Period	Research Question
General	Prehistory	<i>“PH02: How effective has the North West Wetland Surveys been as a planning and research tool?”</i> Considers importance of wetland/wetland edge areas and lithic deposits occurring in topsoil (i.e. areas of peat shrinkage, where previously sealed sand ridges and ‘islands’ continue to be exposed, <i>sensu</i> Leah <i>et al</i> 1997).
		<i>“PH04: How can we enhance existing datasets for prehistory of the region?”</i> Considers role of field survey from all topographic and geological zones; to assess the continuity in settlement in relation to geography; importance of palaeochannels and riverbanks for Mesolithic assemblages; and palaeochannels and wetlands for votive deposits.
		<i>“PH07: How can we use commercial projects to target the identification and exploration of burnt mounds”</i> . The NWWS clearly showed that burnt mounds tend to be focused around fen-type environments and small peat basins rather than blanket bogs, raised mires and open water meres (lakes).
Improving Methodological Approaches	Overarching multi-period	<i>“GS18: For the Prehistory, Roman and Early Medieval periods how can we identify genuine settlement patterns versus false or skewed data?”</i>
		<i>“GS21: How can we expand our understanding of late Holocene peat sequences?”</i>
		<i>“GS24: How do we ensure topographic; geology and geomorphology information is used appropriately to protect favoured locations for rural sites?”</i>
Environment:	Prehistory	<i>“PH17: How can a programme of sampling and investigation help to characterise landscape use of wetlands during the prehistoric period?”</i>
		<i>“PH20: How can we improve methods for evaluating areas of upland peat?”</i>

Theme	Period	Research Question
	Roman	<i>“R07: What is our understanding of river navigability and potential port development?”</i>
	Post-Medieval	<i>“PM06: How can archaeology inform our understanding of climatic events (such as the Little Ice Age) and river/estuarine silting during this period?”</i> <i>“PM08- How does coastal exploitation during the Post-Medieval period affect the wider environment and climate?”</i>
Land Use and Environment	Overarching multi-period	<i>“GS39: How did people exploit coastal and marine resources and did this change through time?”</i>
Settlement and Land use	Prehistory	<i>“PH23: How can we identify previously unknown prehistoric sites?”</i>
		<i>“PH25: How can we better understand the distribution of prehistoric archaeology?”</i> Considers development of landscape studies for the investigation of prehistoric settlement location by using Historic Landscape Characterisation (HLC) data, synthesising disparate data sets, and using Historic Environment Records (HER).
		<i>PH27: How did people exploit different parts of the wider landscapes when they moved around?”</i> Considers use of geophysical surveys along with LiDAR to identify topographical and structural changes to sites.
		<i>“PH29: What activities were undertaken during the Palaeolithic in the North West?”</i> Notes a need for targeted examination of possible palaeolithic deposits, especially in Cheshire and Merseyside.
	Early Medieval	<i>“EM14: How can we identify changes in landscape use related to climate change?”</i> Considers integrating palaeoecological and archaeological data to investigate how peoples use of the landscape altered it and try to distinguish changes relating to climate from changes related to humans.

Theme	Period	Research Question
		<i>“EM17- What evidence is there for landscape change in the early Medieval period?”</i> Considers targeting river basins and valley bottoms to investigate erosion sequences potentially associated with cultivation, clearance, or soil disturbance. Undertaken in conjunction with investigations of peat deposits for climatic indicators, and changes in settlement and land use.
	Late Medieval	<i>“LM02: What is our understanding of late medieval land reclamation, water management and exploitation of natural resources?”</i> <i>“LM09: How can the analysis of peat and documentary evidence enhance our knowledge of the Right of Turbury?”</i>
	Post-Medieval	<i>“PM09: How did ecological changes linked to agricultural improvement impact upon the wider landscape?”</i> Of most value when closely linked to the documentary and topographical study of landscape and settlement.
Trade, Exchange and Interaction	Roman	<i>“R29: How can a systematic survey of the coastline help to identify formal and informal ports?”</i> a systematic survey of coastal, estuarine, and river environments to assess the surviving resource and the potential for Romano-British buried land surfaces and structures.
Military Activity	Roman	<i>“R12: How can coastal and estuarine changes be understood through analysis of coastal defences?”</i>
Transport and Infrastructure	Post-Medieval	<i>“PM42: How can archaeological investigations inform our understanding of the development of transport and infrastructure in the early Post-Medieval period?”</i> Specifically mentions eighteenth and 19 th century docks, but presumably could include canals

Note: Whilst many of these research questions are beyond the scope of the present GDBA, they do have relevance to later stages of the Project and thus bear some consideration at this stage.

Further research themes and priorities can be discussed with the curatorial bodies responsible for the areas traversed by Project.

Aims of the Geoarchaeological Work

The Geoarchaeological programme is an iterative, multi-stage process and, as such, has several very basic aims:

- i. to identify areas (e.g. wetland ecotonal zones) considered to have high potential to preserve archaeological remains stratified within sediment sequences based on palaeotopography and to consider associated environments of deposition and taphonomy;
- ii. to provide baseline data which may contextualise future detailed deposit modelling. This will be based on Ground Investigation (GI) data and will contribute to a more detailed understanding, both locally and more regionally, of sediment sequences and geomorphological features and their archaeological potential;
- iii. beyond predicting the potential location of buried archaeological remains during evaluation, this GDBA is intended to provide the baseline data that will be used to inform further survey and develop an integrated archaeological and palaeoenvironmental landscape model for the duration of the project;
- iv. to record primary data in the field and laboratory during GI works that can be fed into deposit models and improve an understanding of the geoarchaeological resource;
- v. to enhance the deposit model throughout a staged programme of archaeological works, culminating in a detailed understanding of cultural and natural landscape relationships; and
- vi. in the longer term, to contribute to a better understanding of the value of geoarchaeological work in the regional planning process.

Within the parameters of the geoarchaeological works, those aims are addressed through the following objectives, which are to:

- review published geoarchaeological and significant palaeoenvironmental data relevant to the Project;
- provide mapped geological and superficial data relevant to the Project, to characterise the sediments;
- examine topographical and LiDAR data to identify features such as palaeochannels and gravel/bedrock islands;
- assess availability of BGS borehole/trial pit interventions that could be used to construct a geoarchaeological model. This initial desk-based visual assessment will be able to identify whether there are any high- to medium-priority zones where the data are of sufficient quality and density to be incorporated into a more detailed sub-surface deposit model alongside borehole data from previous infrastructure projects as well as project related GI data when they become available;
- highlight any geoarchaeologically significant zones or deposits, in order to target superficial deposits in areas that may hold potential for recovery of

archaeological remains and could be prioritized during a future watching brief on GI works;

- highlight areas of uncertainty that lack lithostratigraphic data (either superficial mapping and/or BGS GI data) and LiDAR data, and to make recommendations that would result in greater data coverage, in order to develop a more comprehensive deposit model;
- undertake a geoarchaeological watching brief of selected GI works and, where appropriate, examine and record sediment samples from those investigations in the laboratory; and
- produce deposit models where data is sufficient to do so.

Methodology

Desk-based Assessment

The GDBA comprised a review and integration of various forms of readily available information from within and immediately around the Draft Order Limits. Although the GDBA is primarily concerned with the deposits encountered directly within the Project boundaries and associated buffer zone, relevant geoarchaeological and palaeoenvironmental work from outside of the Draft Order Limits was also considered.

The glacial chronostratigraphic profile of the region, through the Pleistocene and into the early Holocene, was reviewed to provide a framework for the various processes that have shaped the landscape seen today and, consequently, the setting for past human activity (presented in **Section 3**). Depositional changes associated with fluctuations in sea level of the neighbouring west coast were also considered, given these processes would have had a bearing not only on the type of landscapes and environments accessible to past populations, but also on how these landscapes became subsequently buried.

The main database for survey of the superficial and bedrock geology is largely based on BGS (2022) mapping, with some localised detail available from the NWWS volumes. Historical BGS borehole data occur across the Project; however, the distribution is generally patchy, often sparse, and much of the data are denoted as confidential. The location of these are shown on appropriate maps. The quality of these data vary, and include records taken for deep geological exploration, which subsequently bypass the superficial deposits, or records for which no height above Ordnance Datum (or Mean Sea Level) is given, which renders them unsuitable for deposit modelling. A representative selection of the boreholes with publicly available information inside the Draft Order Limits, or within 500m of it, have been assessed, and those of stratigraphic value for production of a future deposit model are mentioned as appropriate through this report. Topographical maps and LiDAR images have been scrutinised, where available, to identify features of interest, and others that could mask or seal potentially important archaeology, including preliminary identification of possible topographic highs as well as palaeochannels.

The review of geoarchaeological and palaeoenvironmental studies relevant to the Project included reference to published data and information sourced from grey literature. Limited and localised geoarchaeological data are also available from some previous developer-led infrastructure investigations that have been undertaken within the vicinity of the Project. A search of the local Historic Environment Records (HER) indicates that most of the sites relevant to the Project come from Cheshire. Investigations at Ince Marshes (West Corridor; (ECH 5447 and ECH 6863), and Wilderspool, near Warrington (Warrington Spur; (ECH 5669) led to detailed palaeoenvironmental analyses carried out by specialists (Huntley 2020).

The assessment considered the geoarchaeological potential of each of the main components of the Project, in each case sub-dividing them into a series of discrete Geoarchaeological Character Zones (GCZ). The GCZ are generally defined by topographic features and/or major changes in drift geology so as to remain distinct and meaningful. As such, they vary in size and significance. Any significant areas where existing borehole data are of sufficient quality and density to be incorporated into a more detailed sub-surface deposit model are highlighted, as are any potentially significant areas with a lack of lithostratigraphic data.

Watching Brief on Geotechnical Ground Investigation

A programme of geotechnical ground investigation (GI), comprising deep cable percussion boreholes, shallow window sample boreholes, and test pits commenced in winter 2022. The proposed schedule of works was reviewed and interventions falling within areas considered of high geoarchaeological potential, specifically related to outcrops of peat, Shirdley Hill Sand, and tidal flat deposits adjacent to the Mersey, were prioritised for on-site monitoring by a geoarchaeologist in order to supplement the standard geotechnical records with additional lithological detail. However, due to issues with the programme of works, site access and ecological constraints, only a proportion of the proposed work was carried out in 2022, and of those it was not possible to monitor all priority interventions detailed in **Section 5** (Fig 21).

Preliminary Deposit Modelling

Two areas of the route were currently considered to have sufficient BGS data in which to produce preliminary stratigraphic profiles (Transects 1-8, Figs 14-20). This includes the reclaimed marsh around Frodsham (West Corridor) and the Mersey Crossing (North Corridor). The lithological data from the BGS records was digitised into a spreadsheet and imported into geological modelling software (Rockworks20) for the purposes of stratigraphic correlation.

The results of preliminary modelling have been integrated into the geoarchaeological assessment below (**Section 4**) and includes reference to a small amount of additional data currently available from project specific geotechnical interventions. It is noted both the locations of the geotechnical interventions and transects, particularly at the Mersey Crossing appear offset due to subsequent changes in the route alignment.

Geological and Chronostratigraphic Framework

Geological Background: Solid Geology

BGS mapping (1:625,000 and 1:50,000) indicates that the predominant bedrock of the Central Hub and North Corridor, on the Cheshire Plain and surrounding the River Mersey, comprises Triassic sedimentary rocks dominated by Bollin Mudstone, with outcrops of Tarporley Siltstone, Helsby Sandstone, and Wilmslow Sandstone in the area of the Mersey crossing (**Figures 3a-6a**). Roughly 1.5km north of the Mersey, the bedrock is dominated by further Triassic sandstone deposits comprising the Chester Sandstone and Kinnerton Sandstone Formations. Towards the northern end of the North Corridor, from Sutton Manor, the route passes through Carboniferous sedimentary rocks of the Etruria Formation (comprising mudstone, sandstone, and conglomerate), and the Pennine Middle Coal Measures Formation (interbedded bands of mudstone, siltstone, and sandstone).

The underlying geology of the West Corridor is predominantly Bollin Mudstone, with outcrops of Tarporley Siltstone west of Paddock Moor (**Figures 3a, 7a, and 8a**). Small pockets of Helsby Sandstone, Wilmslow Sandstone, and more extensive beds of the Chester Sandstone and Kinnerton Sandstone Formations underlay the Runcorn Spur, which ends at Weston.

BGS mapping (1:50,000) of the South Corridor indicates that roughly two thirds of this route comprises Bollin Mudstone (**Figures 3a, 9a, and 10a**). Following an eastern turn near Moulton, the route then traverses Triassic rocks of the Northwich Halite Member (Halite stone and mudstone) and the Sidmouth Mudstone Formation.

Roughly two thirds of the underlying bedrock of the East Corridor comprises Bollin Mudstone Member, with the final third, from High Legh, crossing outcrops of Tarporley Siltstone, Helsby Sandstone, rocks of the Northwich Halite Member, and Wilmslow Sandstone Formation (**Figures 3a, 11a, 12a, and 13a**).

Geological Background: Superficial Deposits

Chronostratigraphy and Glaciations

The Pleistocene glacial history of the UK is complex, with the advance and retreat of several ice sheets. The climate oscillated between colder (glacial) and warmer (interglacial) stages. Warmer episodes occurring during glacial episodes are classified as 'interstadials', with intervening severe cold episodes termed as 'stadials'. Within this framework, more localised records of Devensian ice expansion and subsequent retreat do exist, which, in the North West of England, includes the Early Devensian Chelford Interstadial. This is characterised by organic-rich channel deposits exposed at Farm Wood and Oakwood Quarries, near Chelford, Cheshire and Uranium/Thorium dated to 86 +/- 26k Before Present

(BP). Similarly, oxygen isotope evidence from the Irish Sea basin places the Devensian Last Glacial Maximum (LGM) limit at c 38ka, rather than the traditional date of 18ka (Delaney 2003; Chiverrell *et al* 2004). Detailed mapping of geological and lithostraphic data of lowland Lancashire as part of the BRITICE-CHRONO project indicates that deglaciation of the last ice sheet was complete after 18.6-17.3ka BP (Chiverrell *et al* 2016). To provide context, **Table 6F 0.1** presents the main UK chronostratigraphic units alongside the main archaeological periods for Britain.

Table 6F 0.1 Generalised correlation of British Pleistocene and Holocene stratigraphy

Epoch	Archaeology	Chronostratigraphy		
		Stage	Age In Years Cal Bp	Marine Isotope Stage (Mis)
Holocene	Early Mesolithic to post-medieval.	Holocene Interglacial.	11.7k	1
Late Pleistocene	Upper Palaeolithic.	Loch Lomond Stadial, (Lateglacial).	12.9-11.7k	2-5d
		Windermere Interstadial (Lateglacial).	15-12.9k	
		Devensian glaciation.		
		Dimlington Stadial (Lateglacial Maximum (LGM)).	26-15k	
	Later Middle Palaeolithic.	Upton Warren Interstadial.	c 43 – 40k	
		Early Devensian Chelford Interstadial.	C 112-60k	
		Early Devensian.	c 110 - 60k	
		Ipswichian Interglacial.	230-115k	5e
Middle Pleistocene	Early Middle Palaeolithic.	Wolstonian 'Complex'.	374-230k	6-10
		Hoxnian Interglacial	424-374k	11

Epoch	Archaeology	Chronostratigraphy		
		Stage	Age In Years Cal Bp	Marine Isotope Stage (Mis)
		Anglian Glaciation.	478-424k	12
	Lower Palaeolithic.	Cromerian 'Complex'.	750-478k	13-19

Notes: after Hosfield *et al* 2017; Gibbard and Hughes 2021.

Although the solid geology of the area forms the main relief of low sandstone ridges and hills, much of the landscape seen today was created by events associated with the last ice age, the Devensian, which covered the whole of the Lancashire-Cheshire plain with thick ice sheets (Chiverrell *et al* 2004; Innes and Tomlinson 2008). The erosional processes and subsequent deposition of predominantly clay glacial tills formed the basis for all subsequent sedimentation, creating a landscape of undulating plains and low hills, which butt up against existing ridges of solid sandstone rock (Cowell and Innes 1994).

Sea Level Change in the Liverpool Bay Area

Records of early Pleistocene changes in sea level from the UK are relatively few, partly due to successive glaciations obliterating earlier deposits (Long and Roberts 1997). Marine deposits along the coast of historic Lancashire, however, do record successive glacio-eustatic and glacio-isostatic sea level shifts since the Late Devensian, which have led to the suggestion that a land bridge existed between Britain and Ireland (Chiverrell *et al* 2004). A detailed study of Liverpool Bay, incorporating a range of datasets including 3D and 2D seismic data, bathymetric data, and borehole records, suggests that much of the area, though low-lying, was above water during the Late Palaeolithic period (Fitch and Gaffney 2011). Much of that landscape would have been a result of processes associated with the previous Devensian glaciation, which left a series of deeply incised channels, large, braided river systems, and kettle holes, which were likely to have developed into major lakes. The data suggests that several of these river systems follow similar routes to modern rivers, such as the Rivers Mersey and Dee, which would have provided important navigation routes for prehistoric people.

The Early Mesolithic coast would have lain well to the west of the current North Wirral and Lancashire coastlines. By approximately 9,000 BC, the sea level had risen to 37m below modern OD (Research Frameworks 2022a). The amelioration in climate during this period would have encouraged the colonisation of mixed deciduous woodland, which would have replaced previous tundra-like conditions. Subsequent sea-level rise, however, would have shifted the coastline further into the Bay, the lowest areas developing into a mosaic of fens, reed swamps, and salt marshes. By approximately 7,500 BC sea level had risen significantly, but was still 18m below

current levels, providing a large area of land linking Wales and North West England (*ibid*). The final inundation of the Bay proceeded relatively rapidly, reaching -7m OD by 7000 BP and more slowly thereafter (Chiverrell et al 2004; Tooley 1978) during which time an extensive inter-tidal zone developed (Fitch and Gaffney 2011).

Investigations to model the Holocene evolution of the Mersey Estuary by the BGS between 2000 and 2003 involved coring the tidal flat deposits at Ince Banks, an extensive saltmarsh located on the southern shore of the inner Mersey estuary traversed by the West Corridor (**Figure 2**). Several radiocarbon dates were obtained from peat sequences from these cores, which, in association with isotopic evidence and palaeoenvironmental analysis of pollen, foraminifera and diatoms, permitted the Holocene evolution of the area to be reconstructed (Wilson 2004).

The data suggest that rising water table levels coupled with ponding of riverine water may have developed as a response to rising relative sea level (RSL), resulting in deposition of freshwater peats. The peats have been dated at Helsby Marsh, to the early part of the Late Mesolithic Period, at 7350 +/- 60 ¹⁴C yr BP (Wilson 2004). As sea level continued to rise, an expansion of sub-tidal and intertidal zones reached as far inland as Helsby Marsh, approximately 2km inland of the estuary, organic sediments from which have been dated from 6800 +/- 50 ¹⁴C yr BP (*ibid*).

Marine conditions persisted at Helsby Marsh for 860 ¹⁴C years, during which time RSL rose by approximately 1.13m. As the regional rate of sea-level rise slowed in the mid-Holocene, freshwater peat deposits expanded over former sub-tidal and intertidal surfaces, during the later Mesolithic Period, at 5940 +/- 40 ¹⁴C yr BP. Terrestrial and semi-terrestrial conditions existed at Helsby Marsh for approximately 2700 ¹⁴C yr BP. An increase in sediment influx into the estuary is recorded from about 4000 ¹⁴C yr BP. This greater availability of sediment together with low rates of RSL rise, may have encouraged and maintained development of tidal flats from the later Bronze Age, from around 3220 +/- 40 ¹⁴C yr BP (*ibid*).

The results concluded that the Holocene evolution of the Inner Mersey Estuary generally follows the tripartite pattern of estuary evolution common to other estuaries in the UK, which show early Holocene expansion followed by mid-Holocene contraction of the coastal zone driven by changes in the rate of regional RSL rise. This is then followed by the re-establishment of lower intertidal conditions, probably due to an increase in terrigenous sediment influx triggered by catchment disturbance during the late Holocene (*ibid*).

Superficial Deposits

BGS mapping (1:625,000 and 1:50,000) indicates a range of superficial deposits within the Draft Order Limits (**Figures 3b-13b**). The key deposits are summarised below, along with their geoarchaeological and archaeological significance.

Tidal Flat Deposits (Holocene): Comprising clay, silt, and sand, these sedimentary deposits are shallow marine in origin, forming beaches and bars in a coastal setting. They have the potential to seal waterlogged archaeology and palaeoenvironmental remains, including proxy data associated with Holocene climate and sea-level change. They may also seal former land surfaces dated to the Late Glacial and early Post-Glacial Period.

Alluvium (Holocene): Described as clay, silt, sand, and gravel, with peat in places, these sedimentary deposits are fluvial in origin and reflect the channels, floodplains, and levees of a river or (if in a coastal setting) an estuary. Floodplain deposits and palaeochannels (former water courses) are key contexts for the preservation of waterlogged archaeology and palaeoenvironmental remains, including records of Holocene sea-level change (if in a coastal setting). They may seal former land surfaces dated to the Late Glacial and early Post-Glacial Period. Marginal areas adjacent to floodplains, and 'islands' of better-drained ground within floodplains and next to water courses are known to be a foci for former activity (e.g. PH04 (Research Frameworks 2022a); **Table 6F 0.1**).

Peat (Late Devensian/Holocene): Peat deposits are key strata for the preservation of waterlogged archaeology and palaeoenvironmental remains. They may also seal former land surfaces and lake deposits dated to the Late Glacial and early Post-Glacial Period. Lacustrine and palustrine in origin, they comprise organic material, forming beds and lenses within lagoons, bogs, mosses, and swamps. Named mosses within and close to the Draft Order Limits of the Project include Whitley Reed, Sink Moss (both in Cheshire), and Carrington Moss (Greater Manchester).

Shirdley Hill Sand Formation (probably late Devensian): The Shirdley Hill Sand formation are aeolian (wind-blown) deposits, forming lenses, beds, and locally, dunes. They are thought to have accumulated during the last glacial period under dry and lightly vegetated tundra conditions. Although very little work has been carried out on the Mersey Valley and Cheshire Shirdley Hill Sands, investigations in West Lancashire suggest that the sand, which is fluvio-glacial in origin, was first deposited c 9000-8200 BC, towards the end of the Devensian glaciation and redistributed by wind during the early to mid-Holocene (Cowell and Innes 1994). They are often interspersed with outcrops of bedrock, boulder clay, and peat, creating diverse ecotonal landscape. Moreover, they have the potential to seal Late Glacial and early prehistoric archaeology and palaeoenvironmental remains.

River Terrace Deposits: River terrace deposits are key contexts for archaeological and geoarchaeological investigation. They represent fluviially deposited sand and gravel, and reflect the channels, floodplains and levees of a river or estuary (if in a coastal setting). Although most Early/Middle Pleistocene River Terrace Deposits in the North West of England were likely to have been scoured out by the direct action of the Devensian ice sheet, there is scope for the recovery of Late Pleistocene terraces, and subsequently Upper Palaeolithic cultural material. Up until now most Upper Palaeolithic sites in the region have come mainly from caves and rock-shelters, but hardly any open-air sites, which the NWERRF has described as ‘troubling’, (Research Frameworks 2022a).

Glaciofluvial Deposits (Devensian): Comprising sand and gravel, these sedimentary deposits are glacio-fluvial in origin, and form beds, channels, plains, and fans associated with meltwater. Glacio-fluvial sands and gravels have generally little geoarchaeological potential but may contain archaeology eroded and redeposited from Palaeolithic contexts. They may also seal deeply stratified deposits of archaeological and palaeoenvironmental potential.

Till, Diamicton (Devensian): Unsorted sediment with gravel in a fine mud matrix. These sedimentary deposits are glaciogenic in origin, created by the action of ice and meltwater. Although the tills themselves have limited geoarchaeological potential, they may seal deeply stratified deposits of archaeological and geoarchaeological potential.

Geoarchaeological Assessment

Introduction

To provide a framework with which to present the geoarchaeological potential of the Project, the route was divided into a series of Geoarchaeological Character Zones (GCZ). Working on the same principle of Historic Landscape Characterisation (HLC), the GCZ are largely defined by the nature of surface geology, topography, and the likelihood for the preservation of buried land surfaces, archaeology, and palaeoenvironmental data.

The North Corridor and Warrington and St Helens Spurs

North Corridor

The North Corridor is divided into five GCZs, labelled North Corridor 1 (NC1) to NC5, from south to north. It is the longest and the most diverse of the corridors.

GCZ NC1: NC1 includes the Central Hub and stretches for some 5km to Newton Lane, just to the south-west of Hatton. With the exception of a localised spread of Devensian Glaciofluvial sheet in the south-east corner of the Central Hub, the southern-most 3km of the route lies on outcrops of bedrock (Bollin Mudstone; **Figures 3a and 3b**). Nonetheless, the presence of ponds (probably former marl pits) in the surrounding fields, suggests that there are local variations in the upper geological strata. From Higher Lane, Dutton, the more northerly part of NC1 lies on Devensian Till (Diamicton; **Figure 3b**), with the interface between the strata broadly followed by a course of a tributary of the Whitley Brook. With the possible exception of that ecotonal area, NC1 generally has little geoarchaeological potential.

GCZ NC2: NC2 is a 3.5km-long section of the North Corridor that runs north from Newton Lane, past Hatton and up towards the A56 near Higher Walton. It predominantly crosses higher ground that skirts either side of the valley of a brook that passes through Row's and Mort's Woods (**Figures 3c and 4c**). Although boulder clay is the predominant drift geology, the Helsby Sandstone Formation outcrops nearby to the west, whilst an outcrop of Bollin Mudstone is also present within the southern part of the zone. These, and several narrow outcrops of the Tarporley Siltstone Formation within the valley itself, follow a north/south trend. A further outcrop of the Wilmslow Sandstone Formation occurs just south of Higher Walton. Although GCZ NC2 has no obvious burial environments, its location on raised ground overlooking extant water courses could be considered ecotonal and is highlighted as having medium geoarchaeological potential.

GCZ NC3: At Higher Walton the topography dips into the Mersey Valley, elevation falling from some 70m to as little as 20m OD (SJ 614788; **Figures 4b and 4c**). The Till gives way to extensive deposits of Shirdley Hill Sand that flank the southern sides of the valley between Norton and Grappenhall. These deposits of wind-blown sand have potential for concealing Pleistocene deposits on the valley sides. For the upper slopes, the nearest BGS boreholes are located some 700m outside of the Draft Order Limits and contain either no stratigraphic information or are of limited value; BGS SJ58NE1119 recorded 'drift and Pleistocene drift to 55ft (16.8m)'. There is no mention of the depths of the sands. Recent project specific geotechnical boreholes, however, provide some additional data, illustrated in Transect 1 (BH060, BH329, BH300, and BH330, **Figure 15**). Here where ground levels range from c 26-16m OD, patchy and variable deposits of orange brown fine to medium sand, sometimes gravelly, overlie stiff reddish brown clayey Till. The thickness of sand extends to 2.1m in BH060 and 1.3m in BH300 but is almost absent in BH329. In BH330 further north at a lower elevation of 7.9m OD the sand extends to 3.9m directly over bedrock.

For lower elevations, there are data for an east/west line of BGS boreholes following the route of the Manchester Ship Canal and passing across the centre of GCZ NC3. Several boreholes (e.g. BGS SJ58NE1408, SJ58NE1403, and SJ58NE1399), with elevations of between roughly 14m and 18m OD, record 0.5 to 1m of sandy clay, silty sand, or topsoil overlying 1.60 to 3m depths of sand. The borehole distribution in this area may provide a broad transect showing the transition between Shirdley Hill Sand of GCZ NC3 and Tidal Flat Deposits of GCZ WS1 (Warrington Spur, Section 4.3), as illustrated in Transect 3 preliminary modelling that also incorporates two project specific geotechnical boreholes, BH300 and BH338 (**Figure 16**).

Although not visible on BGS 1:50,000 superficial mapping, the western arm of the North Corridor at this location crosses an area south of the Manchester Ship Canal recorded by Natural England (2022) as comprising an area of peat. No previous borehole data is available inside or immediately around the Draft Order Limits at this location; however, those nearest (e.g. BGS SJ 58SE1305 and SJ 58SE1124) record topsoil directly over sand, or sand and gravel, which, in turn, overlies stiff clay and sandstone. Given the location, that sand could be fluvial as opposed to wind-blown; nevertheless, there is the potential to recover buried land surfaces or organic-rich deposits at relatively shallow depths. It is important to bear in mind, however, that the area is now heavily industrialised. This zone is considered to have medium geoarchaeological potential.

GCZ NC4: This very short zone (**Figure 4b**) is essentially defined by Tidal Flat Deposits either side of the River Mersey. Several boreholes record localised peat deposits either within the zone itself or close nearby, including BGS SJ58NE1122 (no OD data), located right in the centre of the Manchester Ship Canal, which refers to a layer of peat roughly 1m thick underlying just 0.6m of sand. Similarly, borehole SJ58NE1 (no OD data), located quite centrally in the large area of Shirdley Hill Sand on the south-east side of the Mersey in this zone, records two black peaty soils intercalated with blue clay and sand; the upper layer being at just 0.84m depth. Another borehole, SJ58NE136 (2.76m OD), situated near to the course of the present-day river just southwest of the North Corridor crossing, describes

nearly 9m of sand and gravel sealing 0.6m of fibrous peat. Lying directly on gravel, this peat could represent a time when the landscape was initially flooded due to rising sea level. The results of preliminary deposit modelling for GCZ NC4 is based on the limited BGS borehole distribution, but also incorporates more recent project specific geotechnical boreholes and is presented in Transect 1 (**Figure 15**)

Transect 1 includes borehole SJ58NE136 containing peat at depth, however the remaining boreholes appear to comprise significant thicknesses of wholly minerogenic sediments characteristic of Tidal Flat Deposits in c 8-10m in depth, the lowest elevations where deposits directly overlie bedrock, appear to occur adjacent to the current river channel (eg boreholes SJ58NE137 and SJ58NE136). The sediments appear to largely comprise sandy deposits with gravelly facies, particularly towards the base of the sequences, although silt and clay was recorded in borehole SJ58NE134. In BH067 the deposits are described as laminated sands, with a thin lens of soft dark brownish grey organic clay at 3.9-4.0m depth. This may coincide with the edge of a large E-W palaeochannel shown on the LiDAR (**Figure 4c**).

On the north side of the Mersey, the slopes rising from the river are an ecotonal zone, whilst the lower reaches could have some potential for the preservation of waterlogged sites and palaeochannels. For example, a possible basal peat is recorded at 1.5m depth in a borehole (BGS SJ58NW623) just south of the Fiddlers Ferry Power Station. However, that borehole also bears witness to contamination associated with local industries, with the top 0.7m described as a 'chemical deposit'. That may suggest that some deposits, especially organic remains, close to areas of current and former industry may have been compromised in terms of their value. Transect 1 (**Figure 15**) and Transect 2 (**Figure 16**) illustrate the general sequences north of the river based on limited borehole data. Sandy Tidal Flat or alluvial deposits with gravel facies similar to those recorded on the south bank are present immediately adjacent to the current river channel at c 6m OD, reaching a depth of 13.41m over bedrock in borehole SJ58NE38 (Transect 2, **Figure 16**). In BH069 at 21.46m OD, a significant thickness (c 17m) of made-up ground is present (Transect 1, **Figure 15**). However, below this the natural sequences from 4.46m OD appear intact and indicate a thinning of alluvial sand against a rapid rise in the elevation of the underlying Glaciofluvial (sand and gravel) and clayey Till deposits. To the northwest in geotechnical borehole BH070 at 8.16m OD, no alluvial deposits are noted.

HLC data for the area nearest the river record the presence of ancient field systems, which are likely to represent land improvement via drainage (**Figure 4c**). Being so close to the river, the area has probably long been prone to flooding. The character of this zone fulfils many of the criteria highlighted by the research agenda (e.g. PH02 and PH04; Research Frameworks 2022a) as being prime locations for the recovery of buried land surfaces, archaeological sites and material culture. Moreover, the complex alluvial sequence with interleaved peat deposits has palaeoenvironmental potential, including possible evidence for sea level markers. This zone is considered to have high geoarchaeological potential.

GCZ NC5: GCZ NC5 is the longest of the GCZs and stretches from just north of the St Helen's Canal at Cuerdley in the Mersey Valley, to the northern end of the Project at St Helens (**Figures 4a-5c**). The southern end of NC5 sees an abrupt transition from the River Mersey Tidal Flat Deposits of NC4 to the Devensian Till that typifies the drift geology of NC5 (**Figure 4b**). Areas of Shirdley Hill Sand within this part of the Project is considered under NC5a and NC5b (**Section 0**). The land rises relatively gently, reaching an altitude of 60m OD towards St Helens (**Figures 4c and 5c**).

As the Project moves north across the boulder clay, it traverses several minor waterways, most of which have been formalised as field boundaries. The most significant of these, between Cuerdley and Penketh, is an unnamed tributary of the Penketh Brook, which is associated with a tongue of alluvium, suggesting a localised ecotonal zone. Another arm of the brook lies some 750m to the north, and it would appear that both channels flow between several small pockets of Shirdley Hill Sand recorded south-east of Bold Heath on the appropriately named Sandy Lane (GCZ NC5b; SJ 532892; **Figure 4b**). Trial pits through the largest pocket (e.g. BGS SJ58NW290/291/292) at c 20.35m OD, record a sequence of sandy silty clays to a depth of 3m. Borehole BGS SJ58NE25 (c 18m OD), just outside the area of Shirdley Hill Sand, however, records a sequence of boulder clays and loose sands to a depth of 9m, whereupon it hits red Sandstone. The correspondence of outcrops of Shirdley Hill Sand with Wilmslow Sandstone Formation is noticeable here. This interleaving of sand and boulder clay is interesting, as it suggests that these deposits have the potential to seal Palaeolithic land surfaces and chronostratigraphic data for the Devensian period. Moreover, the juxtaposition of the sandy areas and the brooks may represent an attractive ecotonal zone.

There are no significant areas of geoarchaeological interest north of the Wilmslow Sandstone Formation and the pockets of Shirdley Hill Sands; the rest of the North Corridor extending across extensive deposits of Devensian Till (**Figure 5b**). Between Rainhill and the Lea Green Industrial Estate the route crosses several small drainage courses and tributaries of the Pendlebury Brook on at least three occasions. None are associated with alluvium and, whilst some stretches would appear to have been straightened, others meander more naturally.

One further area of interest (GCZ NC5c) occurs at Thatto Heath (SJ 505931), near where the Project narrows and makes a right-angled turn to the east as it follows Elton Head Road (**Figures 5b and 5c**). There, the lower ground remains undeveloped and numerous boreholes in the locale (e.g. BGS SJ 49SE139, SJ 49SE137, and SJ49SE142/143) record up to 0.50m of very peaty topsoil overlying sandy clay to depths of between 0.80m and 3.60m. Although there are no records of peat deposits in this location, the area is obviously prone to waterlogging and the accumulation of organic deposits. Given that black peaty clay is recorded as sealing weathered sandstone at just 0.35m depth in one location (BGS SJ 49SE143), there is the potential for the presence of former land surfaces quite near the modern surface of areas outside modern development.

St Helens Spur

The final stretch of the North Corridor follows existing infrastructure into St Helens.

Although BGS mapping shows a stretch of alluvium likely to have been associated with a now lost tributary of the Hardshaw Brook where the route terminates, it mainly lies under a modern roundabout, and some degree of disturbance is highly likely (**Figure 5b**). Indeed, two boreholes (BGS SJ 59SW263/264) in this location record depths of between 4 and 7.5m of made ground overlying gravelly clay and Boulder Clay (Pennine Middle Coal Measures Formation).

Warrington Spur

Two GCZ were attributed to the area traversed by the Warrington Spur (WS). From west to east these are GCZ WS1 and GCZ WS2 (**Figures 6a-c**). The spur is complex topographically (especially the western part), with areas of floodplain, marsh, and ponding, as well as areas of 19th century field systems (HLC). Some, such as the area to the north of the Runcorn and Latchford Canal, show clear signs of intensive artificial drainage. The Mersey meanders along the northern edge of the zone, whilst infrastructure has a significant influence, with the Manchester Ship Canal forming the southern edge of the Draft Order Limits of the western part of the spur, which is further cut across by the railway. There is intense industrial development at the Baronet Works, Walton, whilst much of the eastern part of the spur passes through the streets of Wilderspool and Westy.

GCZ WS1: the first stretch of Warrington Spur lies between Higher Walton and Wilderspool and is generally underlain by Tidal Flat Deposits (**Figure 6b**). Very few BGS borehole data are available in the Draft Order Limits closest to the River Mersey. Two boreholes at elevations of 7m OD (BGS SJ 58NE115 and SJ 68NW894) record clay with organic pockets between 3.40 and 4m depth, which are sealed by clay, sand, and made ground. Boreholes located further north towards Warrington Bank Quay, and along its north eastern bank (**Figure 6b**), record river deposits of silts, sands and alluvial clays. This relatively undeveloped area of floodplain within the loop of a large meander can be considered to have moderate geoarchaeological potential. Several other boreholes describe sand, gravel, and red clay to depths of between 4 and 6m, which seal red Sandstone (Helsby Sandstone Formation). Being this close to the river it is possible that any deposits of interest may have been scoured out.

BGS SJ 68NW34/A (no OD), north of the River Mersey inside the southern loop of this large meander record a much less dynamic environment of clay, organic clay, and peat. Indeed, 'brown bog' intercalated with alluvial clay is recorded between 2.4 and 5.1m below ground level (bgl) in two test pits. Perhaps significantly, bog and timber are recorded at 2.7m bgl in test pit 2. Boreholes south of the river (e.g. BGS SJ 68NW685/894, and 1155) at this point show increased disturbance from development, and record between 1.6 and 2.3m of made ground overlying clay. This made ground is also illustrated in Transect 3 (**Figure 16**). Further east, where Draft Order Limits follows infrastructure in Wilderspool, between 0.7m and 8.70m of made ground seals sand and laminated sand and clay (e.g. BGS SJ 68NW773/774/769 and 790).

Development-led work at Wilderspool include geotechnical investigations carried out prior to the construction of the new Mersey Crossing (ECH4163). Although palaeoenvironmental assessment of deposits recovered through a series of boreholes revealed poor pollen and plant macrofossil preservation, a walkover survey revealed several features, which will be subject to further archaeological mitigation should the project go ahead (Gifford and Partners 2004). A Watching Brief prior to development less than 500m to the east, at Greenalls Complex (ECH5669), revealed a sequence of sandy silt, which sealed an extensive layer of peat overlying sandy clay. There was evidence for Bronze Age and Roman activity, and a Roman soil horizon c 1.5m thick was encountered sealing the peat. Trench 11 revealed a buried organic layer with preserved grass (Poaceae) remains and an extension of a Roman cobbled surface with evidence of Roman industrial activity, including bog iron (L-P Archaeology 2013).

Depending upon the trench, the peat varied in thickness, from 0.70-0.80m to thinner bands intercalated with clays and silts. A small test pit was excavated in an area of 'peat extraction' to create a vertical section to take samples for the assessment of pollen, plant macrofossils, and beetles. In her review of development-led palaeoenvironmental work in Cheshire, Huntley (2020) questioned the location of the test pit, given that c 3m of peat lay to the east (or south) of the test pit, but within the Draft Order Limits.

Nevertheless, two bulk samples were taken for radiocarbon assay from the top and bottom of the peat layer revealed in the test pit, which indicated a Middle Bronze Age date for its development. The sample from the top of the peat was undatable due to petrochemical contamination (Huntley 2020). Two samples were processed and assessed for insect and plant macrofossils; these contained small and poorly preserved assemblages of dung beetles and plant macrofossils, which may indicate damp meadows and grazing livestock.

Six samples were assessed for pollen and, given that total counts of total land pollen (TLP) grains were low, no further work was recommended. The pollen assemblages varied little through the sequence and indicated a local alder carr environment with wet grassland and areas of disturbance, and cereal cultivation taking place in the wider landscape.

Although there are obvious preservation/contamination issues with some of the deposits in the area, the presence of deep sequences of intercalated peat and clay, coupled with nearby evidence for Bronze Age and Roman activity means that much of GCZ WS1 has high geoarchaeological potential.

GCZ WS2: The eastern stretch of Warrington Spur follows the route of existing infrastructure situated primarily on Glaciofluvial Deposits. It is likely that the area has undergone significant disturbance and had low geoarchaeological potential (**Figure 6b**).

West Corridor and Runcorn/Rocksavage Spur

West Corridor

The West Corridor (WC) is divided into six GCZ, labelled WC1-WC6 from east to west (**Figures 3a-c, 7a-c, and 8a-c**). Preliminary deposit modelling has been carried out across WC4, WC5 and WC6 (Transects 4-8, **Figures 18-20**).

GCZ WC1: The easternmost GCZ, measures just 600m from the edge of the Central Hub at Northwich Road, to the eastern edge of the Weaver Valley. BGS superficial geology mapping (1:50,000) shows this initial stretch to be situated on Devensian Glaciofluvial Sheet Deposits (**Figure 3b**). This zone generally has little geoarchaeological potential, but it is notable that it occupies a narrow, perhaps ecotonal, zone overlooking the Weaver (and also the Trent and Mersey Canal, which may have utilised a natural water course). Moreover, just outside the Draft Order Limits, several palaeochannels are visible on satellite and LiDAR imagery (**Figure 3c**).

GCZ WC2: This 750m-long zone is characterised by alluvial floodplain deposits of a former meander of the River Weaver and its confluence with the Longacre Brook, which flows across the Project from the north (**Figure 3b**). Elevation drops quite significantly, from 50-60m OD to less than 10m OD, with the eastern flanks of the river valley showing quite a marked incline. LiDAR mapping provides tentative evidence for palaeochannels on the alluvium north of the river (**Figure 3c**). There are no BGS borehole data. Given that such locations can be foci for former human activity and have the potential for sealing and preserving buried archaeological and palaeoenvironmental remains, this zone is considered to have high geoarchaeological potential.

GCZ WC3: West of the Weaver, GCZ WC3 extends for some 5km to Sutton Dock on the Weaver Navigation, across first an outcrop of Bollin Mudstone, a small pocket of Devensian Till, and then for much of that distance, a large area of Devensian Glaciofluvial Deposits (**Figures 3b and 7b**). Although very few existing BGS borehole data are available, two interventions record roughly 0.30m of topsoil overlying over 7m of sand and silty clay, or sand and gravel (BGS SJ 57NE10 and 11). HLC data indicate that much of this in this gently undulating zone has undergone late post-medieval and 20th century agricultural improvement, although an area of ancient field systems survives at the western end (HLC 12752). Overall, this zone generally has little geoarchaeological potential.

GCZ WC4: This zone extends for some 2.5km, from Sutton Dock to Brook Furlong, on the north side of Frodsham (**Figure 7a**). The eastern end of the zone crosses the Weaver Navigation and the meandering old Weaver in quick succession, as well as several unnamed brooks and a seemingly manmade channel on the island between the two major watercourses. West of the old Weaver, the low-lying 19th century field systems are drained by a network of straight-sided dykes. These cut across various palaeochannels, perhaps vestiges of an estuarine creek system, visible on satellite and LiDAR imagery (**Figure 7c**). Ostensibly, the drift geology within the zone is Tidal Flat Deposits, with the transition to alluvium within the Weaver Valley just to the south-east of the Project (**Figure 7b**). However, a small

cluster of boreholes that crosses the Weaver Navigation, indicates a highly dynamic riverine environment characterised by up to 5m depth of silty clay or sand overlying sand and gravel, and up to 27m depths of alluvial clay, often with organic remains. Of note were the records for borehole BGS SJ 57NW37, which was terminated at 9m depth due to hitting a hard wood obstruction. It is possible the Navigation Channel follows the course of a former channel, or back-channel, of the River Weaver (**Figure 7c**). Transect 5 (**Figure 19**) provides an overview of the character of the sequences broadly following the line of the Weaver Navigation from a limited number of boreholes. The sequences are dominated by minerogenic deposition of sand and silt clay, although a soft grey peaty clay was recorded in BGS SJ57NW248 at a depth of 7.62-9.14m.

At Clifton, North of the Weaver Navigation Channel, LiDAR mapping indicates the presence of a possible small embayment (GCZ WC4b; **Figure 7c**). Several boreholes following the route of the M56, just to the south-east, record significant depths of organic-rich sand and clay, and peat (Transect 4, **Figure 18**). Borehole BGS SJ 57NW252 (6.57m OD), for example, records 1.2m of made ground which seals silt and clay deposits to 6.5m depth, which overlie roughly 2m depth of peat. Intercalated layers of peat and silt or clay then continue to 14.35m depth, whereupon it reaches compact gravel. Eastwards on the inland edge, BGS SJ57NW255 (7.87m OD) contained a significant thickness (5.79m) of peat over intercalated organic alluvium and peat to 14.33m, beneath 4.57m of made ground. The Holocene sediment stack thins in BGS SJ57NW256 against the rise of the underlying Pleistocene deposits, but still contains 2.29m of peat and represents a significant ecotonal zone. HLC data indicates that much of this area has been the focus for 20th century industrial development, which could well be responsible for the observations of made ground.

Although very few ground investigation data are available for much of the western end of GCZ WC4, there are two lines of boreholes close to the route of the M56 where it passes to the north-east of Frodsham (**Figure 7b**). The data indicate a complex sequence of peaty clays with degraded wood, sand, and sand and gravel. Of note in BGS SJ57NW245 is a layer of fine gravel with pieces of charred wood at 4.5m depth. Notwithstanding the localised effects of modern development, GCZ WC4 is considered to have high geoarchaeological potential for buried former land surfaces, riverside activities, wetland remains and palaeoenvironmental deposits.

GCZ WC5: This zone continues south-westward for 4.5km along the Tidal Flat Deposits of Frodsham, Helsby, and Ince Marshes towards Elton (**Figures 7b and 8b**). Much of the area has been subject to 19th century agricultural improvement, with many of the straight dykes feeding into the Hoolpool Gutter (to the north) and the Hornsmill Brook (to the west), the sinuous forms of which bespeak natural channels. Traces of other watercourses can be seen as palaeochannels on satellite and LiDAR imagery (**Figures 7c and 8c**). This stretch of floodplain has seen many ground investigations, including two transects (BGS SJ57NW15/A to H and SJ 47NE9/A to N), which, from east to west, show a change from deep sequences of clay, including alluvial blue-grey clay, to clay overlying significant deposits of peat (over 4m depth), which, in turn, overlie sand, or mudstone of the Tarporley Sandstone Formation. Many other boreholes in the area show a similar sequence and with the surface of much of this peat being recorded at relatively shallow depths of

between 0.2 and 3m (Transects 4, 6, 7 and 8, **Figures 18-20**). A limited number of boreholes show a second and third layer of peat of between 0.4 and 0.9m thickness.

Development-led investigations by RSK Ltd at Ince Marshes (SJ 459767) in 2010 (RSK 2012; 2017; ECH 5447 and ECH 6863) involved geotechnical investigations and a watching brief, which identified two layers of peat across the site at depths of between 3-6m and 10-11m bgl. A detailed programme of palaeoenvironmental investigation ensued, which comprised radiocarbon dating and palynological and plant macrofossil analysis of the two peat layers. (RSK 2012). Palynological and macrofossil data taken from the lower peat, dated to the Early Post-Glacial Period, indicated a transition from wet peaty soils with bog moss (*Sphagnum*), reed swamp and birch (*Betula*)/willow (*Salix*)/juniper (*Juniperus*) scrub, to localised areas of sedge fen, and the regional introduction and spread of pine and hazel, and then oak and elm. Significantly, willow/poplar (*Salix/Populus*) charcoal was recovered some depth below the top of this lower peat, which was dated to 7520 to 7300 cal BC (8340 ± 50 BP, Beta-297207), which, being unlikely to burn by natural fires, is likely to signify local anthropogenic activity (*ibid*). Although there was no direct evidence for marine influence, an increase in the number of indeterminate pollen grains and erosion indicators, coupled with a change from peat to silty clay, suggested a change in environmental conditions possibly caused by a rise in RSL.

Palaeoenvironmental evidence from the upper peat layer, dated to 4840 to 4690 cal BC, indicated the local development of alder (*Alnus*) fen carr and later heathland, with mixed deciduous woodland of oak (*Quercus*), hazel (*Corylus*), elm (*Ulmus*), lime (*Tilia*), ash (*Fraxinus*), and birch (*Betula*) on the surrounding drier slopes. This peat layer contained frequent evidence of localised burning. Evidence for cultivation, including cereal pollen, was recorded at 1.42m depth and, although the date from this level was spurious, the evidence suggested arable farming was likely to have been taking place in the area, possibly during the Late Neolithic Period/Early Bronze Age (*ibid*). Evidence for possible livestock grazing of wet meadows or open woodland was indicated towards the top of the sequence, which is dated to 1000 to 840 cal BC (Beta-297295). Increased marine influences, including the presence of foraminifera, were recorded at 1.26m depth, however peat development ceased following the deposition of a thick layer of silty sandy clay.

The surface of the upper peat was also observed and mapped during an archaeological watching brief and was exposed very close to the surface in a couple of areas. No archaeological remains were identified.

Collectively, the borehole data, existing palaeoenvironmental evidence, and sea-level data from Ince Marshes (**Section 3.2.5**) means the area has excellent potential for geoarchaeological modelling, and for providing detailed information on stratigraphic and vegetation changes in relation to relative sea level, sediment load, and human occupation and land use. It should be noted that all the sedimentary facies, not just peat layers, may contain important palaeoenvironmental data. Overall, GCZ WC5 is considered to have high geoarchaeological potential.

GCZ WC6: The final 2.5km stretch of the West Corridor lies in an area dominated by Devensian Till (**Figure 8b**), which forms a low promontory on which the settlement of Elton has been established (**Figure 8c**). To the east is the Peckmill Brook, whilst the western boundary is defined by an unnamed brook, mostly canalised, but in places following a more natural meandering course and associated with a narrow strip of alluvium. Although this low promontory barely rises above the surrounding floodplain today, several borehole records from investigations on the Till, such as BGS SJ 57NW 15/A (the most westerly borehole of one of the transects mentioned in **Section 0**), show a marked transition from alluvial clay and peat to shallow topsoil sitting straight onto bedrock. A small 'island' of Till is also present just north-east of Elton (GCZ WC6b; **Figure 8b**). Such areas, comprising marginal zones and slight rises adjacent to floodplains, marshes, and river channels, would have been prime locations for prehistoric habitation and resource utilisation. Subsequently this zone, especially in areas away from present-day settlement and industry, is considered to have high geoarchaeological potential.

Runcorn Spur

GCZ RS1: This single zone covers the northerly offshoot of the West Corridor, the Runcorn Spur, which leaves Tidal Flat Deposits on the north side of the Weaver Navigation and extends onto higher ground towards Weston (**Figures 7a and 7b**). BGS mapping (1:50,000) of the solid and superficial geology of this area shows it is dominated by an outcrop of Bollin Mudstone and Tarporley Siltstone Formation, with Devensian Till. Data from several boreholes, which follow the route of the A557 where it crosses Runcorn Spur (e.g. BGS SJ58SW2204/2227/2240, at c 61m OD), record 0.25m of topsoil, which lies directly onto marl (Tarporley Siltstone Formation). Although existing borehole data are absent north of the A557, a lack of superficial geology means this zone could have little geoarchaeological potential, other than as an ecotonal zone on the edge of wetland areas.

South Corridor

Emanating from the Central Hub, the South Corridor (SC) has been divided into nine GCZ, numbered from SC1 to SC9, from north to south.

GCZ SC1: The northernmost GCZ covers the short distance between Bartington and the north-eastern edge of the Weaver Valley. BGS superficial geology mapping (1:50,000) shows this initial stretch to be situated on deposits of Devensian Till and Devensian Glaciofluvial Sheet Deposits (**Figure 3b**). This zone generally has little geoarchaeological potential, but it is notable that it occupies a possible ecotonal zone overlooking the Weaver to south (and possibly a natural precursor to the Trent and Mersey Canal to the north). Outside the Draft Order Limits, the same zone contains several palaeochannels visible on satellite and LiDAR imagery (**Figure 3c**).

GCZ SC2: Elevation dips quite steeply towards the River Weaver (**Figure 3c**), where the route crosses alluvial deposits just south-west of Bartington (SJ 601764; **Figure 9b**). A single borehole north of the river, and just inside the Draft Order Limits, BGS SJ57NE16 (8.97m aOD), records 0.30m of topsoil overlying 1.40m of clay with organic deposits, which seals sand and gravel of up to 5m depth. Several boreholes south of the river (e.g. BGS SJ57NE17/18/131) record a similar sequence, with varying depths of organic clay and/or alluvial sand and gravel, with the alluvial deposits in BGS SJ57NE131 being sealed by c 2m of made ground. Of note is the record for Medieval Townsfields (HCH1575) on the alluvium south of the river. Given the potential for the recovery of buried archaeology and deposits of palaeoenvironmental interest this zone is considered to have medium geoarchaeological potential.

GCZ SC3: South of the River Weaver the land rises gently, where the South Corridor extends across further deposits of Devensian Till and small pockets of Glaciofluvial Sheet Deposits as far as Gorstage (**Figure 9b**). Other than where the route crosses a small stretch of alluvium and neighbouring Glaciofluvial Deposits associated with an ecotonal zone around the Cliff/Grange Brook (GCZ SC3b), this zone is considered to have little geoarchaeological potential.

GCZ SC4: Around Bryn and Gorstage (SJ 600716), Devensian Till gives way to a landscape dominated by Glaciofluvial Deposits (**Figure 9b**). Here, the South Corridor follows low-lying ground where several small water courses, associated with what appears to be a former river valley, are located (**Figure 9c**). Pockets of peat have developed in hollows and/or areas of impeded drainage, including one (SJ 619707), which is adjacent to the Draft Order Limits (**Figure 9b**). Other than BGS SJ 67SW134, which records 0.6m of topsoil overlying 25m of sand, borehole coverage is absent. Although much of this zone is likely to be free draining, it is possible that areas of peat, other than those recorded by BGS, are present. Being a former river valley comprising Glaciofluvial Deposits, the area does have potential for the recovery of redeposited Palaeolithic material. In addition, areas of peat have potential for sealing former land surfaces and material culture; the peat itself providing an important resource for palaeoenvironmental reconstruction. Given this, GCZ SC4 is considered to have high geoarchaeological potential.

GCZ SC5: The South Corridor returns to higher ground dominated by Devensian Till (**Figures 9b and 9c**). Although this zone is considered to have little geoarchaeological potential, HLC records indicate areas of ancient field systems and ancient woodland where the land slopes down to the River Weaver on the eastern edge of Vale Royal Park. The corridor overlooks a steep slope down to the Rookery Pool and associated brook. The parts of the zone lying closest to the small dendritic tributaries of the Weaver might also be considered ecotonal zones of slightly higher potential.

GCZ SC6 and SC7: East of the River Weaver the South Corridor returns to higher ground of Devensian Till and Glaciofluvial Deposits (**Figure 10b**), continuing for about 2km to the River Dane. Although no areas of peat are recorded by the BGS or Natural England in the area, it should be noted that an important prehistoric site was discovered in advance of the A533 bypass at Church Moss, Davenham (SJ 663698; ECH3679 and ECH 3446), situated roughly 700m north of the Draft Order Limits. Ground investigations by Manchester University Archaeological Unit

(1995a and b) included recording and modelling of an area of peat, coupled with an archaeological evaluation, which revealed a potential Mesolithic settlement situated on the margins of the mere. Collected pine (*Pinus*) timbers showed evidence for working and burning, whilst other organic remains included birch bark, willow and hazel wood, and hazelnuts. Based on the mapped data, other than a small stretch of alluvium associated with Peckmill Brook, west of Bostock Green, much of GCZ SC7 is situated on glacial Till. Consequently, much of this zone is considered to have little geoarchaeological potential. Significant sites 'invisible' to high-level mapping, however, may be present, which, as the name of the above-mentioned site suggests, may be identified by place name evidence.

GCZ SC8: This zone denotes where the South Corridor crosses the floodplain of the River Dane. BGS superficial mapping indicates an area of alluvium and, significantly, outcrops of River Terrace Deposits (**Figure 10b**). The area is devoid of existing borehole data. Given that both alluvium and River Terrace Deposits are both key contexts for archaeological and geoarchaeological investigations, this zone is considered as having high geoarchaeological potential.

GCZ SC9: East of the alluvium and river terraces of the River Dane, the superficial geology once more returns to Devensian Till. Other than a small stretch of alluvium associated with Puddinglake Brook, just to the east of Whatcroft and close to where the South Corridor terminates (**Figure 10b**), this zone is considered to have little geoarchaeological potential.

East Corridor and Warburton and Partington Spurs

The East Corridor (EC) has been divided into four GCZ, labelled GCZ EC1 to EC4, from west to east (**Figures 3a-c and 11a-13c**).

GCZ EC1: On leaving the Central Hub the East Corridor extends for some 5km to Antrobus, crossing exposures of Bollin Mudstone, Devensian Till, and Glaciofluvial Deposits (**Figures 3ac, and 11a-c**). The land rises steadily, reaching elevations of 80m OD at Higher Whitley (SJ 618799; **Figure 11c**). This zone has little geoarchaeological potential, other than where the route crosses a small stretch of alluvium along the Whitley Brook between the Central Hub and the A49 Tarporley Road (GCZ EC1b; **Figures 3a-c**). Not only does the alluvium have the potential to seal earlier deposits, but the outcropping Bollin Mudstone on either side could be considered an ecotonal zone.

GCZ EC2: Roughly 1 km north of Antrobus (SJ 643797) the route crosses the Arley/Gale Brook. In addition to alluvial deposits, significant deposits of peat have developed here, which form a large expanse of mossland incorporating Stretton Moss, Appleton Moss, and Whitley Reed (Leah *et al* 1997). Whitley Reed (SJ 645819), the largest of the mosses, covers an area of c 300 acres, and in 1963 was recorded as comprising 8 to 10 feet (2.4 – 3m) of pure peat (*ibid*). Although the NWWs did not carry out any detailed stratigraphic investigations in the area, they estimate that the effects of drainage and cultivation on the Stretton/Appleton Mosses means that only a thin layer of peat survives. It is likely, however, that due to differences in land management, over 1m depths of peat survive at Whitley Reed (*ibid*). Although BGS superficial mapping suggests the route of the East

Corridor bypasses the largest area of what remains of Whitley Reed (**Figure 11b**), it does traverse the southern flanks of a possible remnant pocket further to the east.

Roughly 1.5km to the east again, the East Corridor extends across another area of peat just north of the M6, known as Sink Moss (**Figure 12b**; Leah *et al* 1997). Although land restrictions prevented the NWWS from carrying out any detailed investigations here, borehole data south-east of the Draft Order Limits record 0.45/50m of topsoil or up to 1m of made ground overlying Glacial Till. BGS SJ 68SE63, situated furthest away from the M6, describes 0.30m of topsoil overlying just 0.35m of silty sandy peat, which sits on Till. It is likely that much of this peat, especially in the peripheral area, has been lost, either to peat cutting or through post-medieval/20th century drainage and agriculture. Indeed, as well as the Crowley Brook, the route also traverses numerous unnamed streams that have been incorporated into field boundaries or formalised as drainage features. What remains is likely to represent a very valuable palaeoenvironmental resource. Moreover, given that the NWWS (Leah *et al* 1997) and NWERRF (PH02; Research Frameworks 2022a) identified buried land surfaces underlying peat as prime locations for the discovery of lithic sites, the area should be considered as having high geoarchaeological potential. Although existing findspots of prehistoric artefacts are entirely absent from the Appleton/Stretton mosses, two probable late prehistoric/Romano-British enclosures (SMR 2062/1 and 2) have been identified 1km east of Sink Moss, at Leigh Oaks Farm. A further two enclosures may also lie on its north-western fringes, near to Badger's Croft Farm, which, perhaps significantly, in addition to Roman pottery, has also produced early prehistoric finds, including an assemblage of struck flint and chert, and a hammer stone (*ibid*).

GCZ EC3: West of Sink Moss, the route crosses a short stretch of Devensian Till that has been heavily drained through a network of dyked field boundaries (**Figures 12a-c**). This might imply that this area had been former mossland, and thus this short section might have some moderate geoarchaeological potential for degraded peat and earlier remains. Alternatively, it could be considered an ecotonal zone. The Till gives way to an outcrop of Bollin Mudstone a little west of High Legh (SJ 699841). Again, this seemingly naturally well-drained raised area may have been attractive to settlement, but arguably has little geoarchaeological potential in terms of deeply sealed deposits. North-east of Beechtree Lane, Sworton Heath, the route enters another area of Till that dips relatively steeply in the direction of Broomedge and Bollington in the bollin Valley. This zone is considered to have low geoarchaeological potential.

GCZ EC4: This GCZ represents the north-eastern end of the East Corridor, an area that encompasses the Bollin Valley, as well as the Agden, Caldwell, Red, and Sinderland Brooks, terminating in the Mersey Valley between Partington and Carrington. At the western end of the zone, the land gradually slopes down towards the floodplain of the River Bollin (**Figure 12c**), crossing an area of Shirdley Hill Sand (and the Bridgewater Canal), which, in turn changes to Glaciofluvial Deposits, and then to alluvium on the floodplain of the River Bollin (**Figure 12b**). Of note is the presence of River Terrace Deposits south of the river.

Borehole coverage is sparse. Data from several interventions on the Shirdley Hill Sand record roughly 3m of sand overlying firm silty clay, possibly of the Northwich Halite Member. One of two existing boreholes in the alluvium (BGS SJ 78NW63) records intercalated sand and clay, with a 1m-thick deposit of peat at 2.5 depth. The sequence is broadly mirrored on the north side of the Bollin, the route traversing Glaciofluvial Deposits (including an unnamed stream) and then significant areas of Shirdley Hill Sand north of the River Bollin (**Figure 13b**), where, at about 20m OD, elevation remains relatively low lying (**Figure 13c**). Existing borehole data on this northern deposit of Shirdley Hill Sand indicate varying depths of material. For example, BGS SJ78NW55, in the north, records up to nearly 5m of sand. Whereas BGS SJ78NW83, in the south, records just 1m. It is possible, therefore, that buried prehistoric land surfaces may lie quite near the surface in places.

BGS superficial mapping (1:50,000) shows two small areas of peat in this location, including one to the west, which is situated on the sand and associated with substantial artificial drainage. The data is slightly at odds with Natural England's Peaty Soils Location Geoportal however (Natural England 2022), which maps a large, lozenge-shaped area of the peat (centred at SJ 736 889), which is traversed by the East Corridor on its western side. It is possible that the small pocket of peat just south of Black Moss Lane (SJ 745 888) represents the vestiges of a much larger area (Wood 2022b). If the peat in this area has undergone severe erosion, then prehistoric land surfaces could be exposed. In addition, if further pockets of peat do survive, then these would represent an important palaeoenvironmental archive.

The East Corridor follows the north/south trajectory of Caldwell Brook, which flows between two areas of Shirdley Hill Sand. It then crosses a small deposit of alluvium associated with the Sinderland Brook (**Figure 13b**). Less than 500m north of the Sinderland Brook, and close to the East Corridor's northern terminus, the route extends across the south-west corner of Carrington Moss (SJ 740915), part of the internationally recognised Manchester Moss complex. Survey work carried out as part of the NWWs project in 1992-3 suggested that the moss formerly covered an area approximately 3km by 2km, which formed in a shallow basin on the terrace of the south bank of the River Mersey. Since the publication of the Ordnance Survey First Edition map up to 150ha of the Moss has been destroyed, primarily by industrial development along its northern and western edges, leaving an area of 325ha of peat with depths of more than 0.3m (Hall *et al* 1995). Based on the characteristics observed in similar mire systems, it is likely that modern agricultural activity, accompanied by a series of straight modern dykes, had also removed up to 2m of its surface depth. Given the relative shallowness of the peat and intensity of agriculture and development affecting the moss, Hall *et al* (1995) suggest that the quality of the site as a palaeoenvironmental archive was seriously threatened.

Although no palynological work was carried out as part of the NWWs, 22 cores in five transects were taken and described. The results are consistent with existing BGS borehole data, which record peat depths of between 2m and 3.5m towards the centre of the moss, which overlie Glaciofluvial sand and sand and gravel deposits (*ibid*). BGS superficial mapping (1:50,000), however, indicates nearby deposits of Shirdley Hill Sand, which, to the north, look to be sealed by the peat (**Figure 13b**).

Peat stratigraphy shows a succession from fen-carr woodland to ombrotrophic *Eriophorum/Calluna*-dominated, and then, a much wetter, *Sphagnum*-dominated bog. Burnt vegetation in the lower part of the sequence points to low-level fire disturbance, which largely ceases after the transition to wetter conditions (*ibid*).

Although no radiocarbon dates are available for the start of peat development, Hall *et al* (1995) suggest that initiation is likely to have been at some point during the Neolithic period, c 4000-3000 cal BC. No archaeological sites or artefacts were recovered through field walking, but it is possible that Mesolithic sites may lie buried underneath the peat. If wasting of the peats has continued at a similar rate to that at nearby Chat Moss, then it is likely that pre-Neolithic contexts have been exposed on a wide scale. Establishing the nature of buried land surfaces is important, given that earliest site found at Chat Moss, following peat extraction, was at Nook Farm (SJ 790 979), which comprised a Mesolithic flint scatter situated on a small sandy knoll underlying the peat. Similarly, a Neolithic flint scatter and charred remains, also from Nook Farm, was situated on a broad ridge or 'island' of glaciofluvial sand (Hall *et al* 1995).

Zone GCZ EC4 covers a relatively large stretch of the East Corridor and contains several key geoarchaeological deposits, which have potential for sealing former land surfaces, early material remains, and wetland archaeology, and for containing significant palaeoenvironmental sites. Much of this zone is therefore considered to have high geoarchaeological potential.

Monitoring of Geotechnical Ground Investigation

A programme of geotechnical ground investigation (GI), comprising deep cable percussion boreholes, shallow window sample boreholes, and test pits commenced in winter 2022. The proposed schedule of works was reviewed and interventions falling within areas considered of high geoarchaeological potential, specifically related to outcrops of peat, the Shirdley Hill Sand Formation, and tidal flat deposits adjacent to the Mersey, were prioritised for on-site monitoring by a geoarchaeologist in order to supplement the standard geotechnical records with additional lithological detail. **Table 6F 0.1** provides a summary of the schedule of the planned 139 intrusive interventions, 85 of which were prioritised for monitoring.

However, only 54 of the proposed interventions were carried out in 2022, and of those only 22 were considered a priority for monitoring (**Figure 21**). Unfortunately, due to issues with the programme of works and site access it was not possible to monitor the majority of the priority interventions. Four interventions not on the original schedule were opportunistically monitored (ATP24, BH120, BH318, and BH322). A detailed inventory of the interventions is presented in **Table 6F 0.2** and **Table 6F 0.3**. Several of the priority interventions in the vicinity of the River Mersey along the North Corridor have been included in the modelled Transects 1 and 3 (**Figures 15 and 16**) with information derived from the engineer's logs. For the remainder the sparse distribution and shallow nature of some of the sequences was insufficient to produce meaningful transects. Although the window sample boreholes from the East Corridor were inspected at the geotechnical lab following fieldwork, this was after subsampling for geotechnical purposes. Consequently, no intact cores were observed, the remaining comprising a very small number of tubs of disturbed sediment of limited interpretive value. No significant deposits of peat were recorded at these locations in the engineer's logs.

Table 6F 0.1 Summary of geotechnical interventions

Type	No. of scheduled GI	No. of scheduled GI prioritised for monitoring	No. of GI, excavated (2022)	No. of GI prioritised for monitoring, excavated (2022)	No. GI monitored on-site (2022)
BH	74	35	34	12	5
TP	31	18	13	4	2
TT	4	4			
WS	30	28	7	6	5*
Total	139	85	54	22	12

Notes: BH = deep cable percussion borehole; TP = test pit, TT = trial trench; WS = shallow window sample boreholes; * disturbed samples observed in lab

Table 6F 0.2 Summary of geotechnical interventions

GCZ	Intervention	Type	Status	Drift Geology (BGS)	Easting	Northing	m OD	Total depth (m)	Transect
North Corridor									
GCZ NC3	BH060	BH		SHSF	359084.969	384775.998	26.29	10.00	1
GCZ NC3	BH061	BH		SHSF	359086.953	384803.974	25.91	10.20	
GCZ NC3	BH063	BH	M	SHSF	358980.815	385586.072	13.44	40.50	
GCZ NC3	BH300	BH		SHSF	358325.004	385128.990	15.71	15.00	1, 3
GCZ NC3	BH301	BH		SHSF	358390.078	385049.038	16.42	10.00	
GCZ NC3	BH329	BH		SHSF	358487.007	384740.991	23.01	15.00	1
GCZ NC3	BH330	BH		SHSF	357613.955	385189.981	7.90	26.00	1
GCZ NC3	WS10	WS	Lab	SHSF	359090.930	384912.992	26.51	3.39	
GCZ NC4	BH066	BH		Tidal Flat	356245.018	386002.026	5.37	40.00	1
GCZ NC4	BH067	BH		Tidal Flat	356117.819	386020.936	5.57	40.00	1
GCZ NC4	BH069	BH	M	Tidal Flat	355737.970	386101.020	21.46	28.32	1

GCZ	Intervention	Type	Status	Drift Geology (BGS)	Easting	Northing	m OD	Total depth (m)	Transect
GCZ NC4	ATP23	TP		Tidal Flat	356809.998	385864.033	6.17	2.50	1
GCZ NC5	ATP24*	TP	M	Till	355017.981	386385.961	11.98	2.30	1
West Corridor									
GCZ WC3	BH120*	BH	M	Glacio-fluvial	353857.063	379181.046	20.70	29.20	
GCZ WC4B	BH332*	BH	M	Tidal Flat	353403.166	378848.004	5.83	8.50	
South Corridor									
GCZ SC6	BH318*	BH	M	Till	364667.030	369647.013	33.47	40.00	
East Corridor									
GCZ EC2	ATP41	TP		Peat/Till	365998.998	381548.939	59.03	3.00	
GCZ EC2	ATP43	TP		Peat	368144.469	383272.594			
GCZ EC2	WS32	WS		Alluvium	364975.990	381081.956	58.71	3.45	
GCZ EC2	WS33	WS	Lab	Alluvium	365122.967	381044.019	58.32	3.45	

GCZ	Intervention	Type	Status	Drift Geology (BGS)	Easting	Northing	m OD	Total depth (m)	Transect
GCZ EC2	WS34	WS	Lab	Peat/Till	366336.031	381693.972	59.70	4.35	
GCZ EC2	WS35	WS	Lab	Peat	367751.992	382822.975	51.94	3.13	
GCZ EC2	WS37	WS	Lab	Peat/Till	368394.001	383415.012	53.47	3.00	
GCZ EC4	BH106	BH		SHSF	372281.030	388603.954	23.43	11.00	
GCZ EC4	BH114	BH		SHSF	372153.009	388551.967	25.20	10.00	
GCZ EC4	TP20	TP	M	SHSF	372213.976	388637.999	23.82	3.00	

Notes: SHSF = Shirdley Hill Sand Formation, M= monitored on-site, Lab = disturbed samples observed in lab, shaded entries, * observed intervention not on original priority schedule

Table 6F 0.3 Detailed descriptions of geotechnical interventions of geoarchaeological priority and monitoring carried out in 2022

Intervention	Top (m)	Base (m)	Lithology	Facies
ATP23	0.00	0.40	Brown, slightly clayey, organic , fine to coarse SAND.	TOPSOIL
ATP23	0.40	0.90	Orangish brown, slightly clayey, silty, fine and medium SAND.	SHSF
ATP23	0.90	1.10	Firm, reddish brown mottled light grey, slightly gravelly, sandy CLAY. Gravel is subangular to rounded, fine to coarse including sandstone and siltstone.	BEDROCK
ATP23	1.10	2.50	Reddish brown mottled light grey, slightly clayey, slightly silty, fine and medium SAND occasionally weakly cemented highly weathered sandstone. (CLASS E) [WILMSLOW FORMATION]	BEDROCK
ATP24	0.00	0.40	Dark brown, slightly gravelly, very clayey, fine to coarse SAND. Gravel is angular to rounded, fine to coarse including quartz and limestone.	TOPSOIL
ATP24	0.40	1.80	Brown, very silty, very clayey, fine to coarse SAND with occasional fine gavel.	GLACIAL TILL
ATP24	1.80	2.30	Light greyish brown, slightly gravelly, slightly silty, fine to coarse SAND. Gravel is subangular to rounded, fine to coarse including sandstone, siltstone, mudstone and limestone.	GLACIOFLUVIAL
ATP41	0.00	0.35	Dark brown, slightly gravelly, clayey, sandy SILT, with frequent grey and brown roots (up to 4mm). Gravel is subangular to subrounded, fine to coarse including sandstone, siltstone and limestone and quartzite. Rare subangular fragments (up to 5mm) of brick.	TOPSOIL

Intervention	Top (m)	Base (m)	Lithology	Facies
ATP41	0.35	1.20	Firm, reddish brown, locally mottled light bluish grey and yellow brown, slightly silty, slightly gravelly, sandy CLAY with low cobble and content. Gravel is subangular to rounded, fine to coarse including sandstone, siltstone, limestone, mudstone and rare lignite. Cobbles are subrounded including quartzite. Rare laminae (2mm) of light grey silt.	GLACIAL TILL
ATP41	1.20	3.00	Stiff, locally fissured, dark reddish brown, locally mottled light bluish grey, slightly silty, slightly gravelly, sandy CLAY, with a low cobble content. Gravel is subangular to rounded, fine to coarse including mudstone, siltstone, quartz and sandstone. Cobbles are subangular, up to 70mm, of quartzite. Fissures are closely spaced, undulating, smooth, with orange brown staining (<1mm). Occasional, black, subangular lignite fragments (up to 5mm). Rare, off white shell fragments (up to 5mm).	GLACIOFLUVIAL
BH060	0.00	0.40	Grass over dark brown becoming black, fine and medium SAND with frequent roots and rootlets (<2mm).	TOPSOIL
BH060	0.40	2.10	Loose, brown and dark reddish brown, fine and medium SAND.	SHSF
BH060	2.10	3.30	Firm, orangish brown, slightly gravelly, sandy CLAY with rare fragments (up to 5mm) of black organic matter. Gravel is subangular to rounded, fine and medium including quartz, siltstone and mudstone.	GLACIAL TILL
BH060	3.30	3.90	Stiff, reddish brown, slightly gravelly, very sandy CLAY. Gravel is angular to subrounded fine and medium including mudstone and siltstone.	GLACIAL TILL

Intervention	Top (m)	Base (m)	Lithology	Facies
BH060	3.90	4.50	Reddish brown, slightly gravelly, clayey, fine and medium SAND. Gravel is angular to subrounded, fine to coarse including mudstone, siltstone and sandstone. (CLASS E) [WILMSLOW SANDSTONE FORMATION]	BEDROCK
BH061	0.00	0.40	Dark grey to black, slightly silty, fine and medium sand.	TOPSOIL
BH061	0.40	2.20	Brown mottled greyish brown, fine and medium SAND.	SHSF
BH061	2.20	3.16	Soft, grey, silty CLAY with occasional sand and gravel. Gravel is subrounded to rounded, fine including quartzite and siltstone. Slight organic odour.	ALLUVIUM
BH061	3.16	4.45	Light reddish brown, slightly gravelly, very clayey, fine and medium SAND. Gravel is subrounded to rounded, fine to coarse including quartzite. (CLASS E) [WILMSLOW SANDSTONE FORMATION]	BEDROCK
BH063	0.00	0.30	Dark greyish brown, slightly gravelly, slightly clayey, silty, fine and medium SAND with occasional rootlets.	TOPSOIL
BH063	0.30	1.20	Dark brown mottled brown, fine and medium SAND.	SHSF
BH063	1.20	2.20	Medium dense, yellowish brown, fine and medium SAND.	SHSF
BH063	2.20	2.70	Dense, light brown, slightly gravelly, slightly silty, fine and medium SAND. Gravel is subrounded, fine and medium of mixed lithologies.	SHSF
BH063	2.70	3.10	Reddish brown, slightly silty, fine and medium SAND. (CLASS E) [HELSBY SANDSTONE FORMATION]	BEDROCK
BH066	0.00	0.35	Soft, greyish brown, slightly sandy, clayey SILT.	TOPSOIL

Intervention	Top (m)	Base (m)	Lithology	Facies
BH066	0.35	0.80	Firm to stiff, grey brown, slightly sandy, silty CLAY.	TIDAL FLAT DEPOSITS
BH066	0.80	1.20	Firm to stiff, thinly laminated, light brown and reddish grey, slightly sandy SILT.	TIDAL FLAT DEPOSITS
BH066	1.20	2.50	Loose, light yellowish brown, mottled brown, clayey, very silty, fine SAND, with rare fragments (up to 5mm) of dark brown, decaying, organic matter.	TIDAL FLAT DEPOSITS
BH066	2.50	3.75	Loose, grey, silty, fine SAND, with a slight organic odour.	TIDAL FLAT DEPOSITS
BH066	3.75	5.40	Loose, brownish grey, slightly clayey, silty, fine and medium SAND with occasional fragments (up to 5mm) of black organic matter.	TIDAL FLAT DEPOSITS
BH066	5.40	8.00	Medium dense to very dense, brownish grey, fine and medium SAND, with rare fragments (up to 3mm) of black organic matter.	TIDAL FLAT DEPOSITS
BH066	8.00	8.60	Very dense, reddish brown, gravelly, fine and medium SAND. Gravel is angular to subrounded, fine to coarse, including siltstone, sandstone, quartzite and granite. (CLASS E) [WILMSLOW SANDSTONE FORMATION]	BEDROCK
BH067	0.00	0.40	Dark grey, sandy, clayey SILT with frequent rootlets up to 3mm diameter.	TOPSOIL
BH067	0.40	0.80	Firm, light brownish grey, slightly sandy, silty CLAY.	TIDAL FLAT DEPOSITS
BH067	0.80	1.20	Light brownish grey orangish mottled, silty, fine SAND with clay laminations.	TIDAL FLAT DEPOSITS
BH067	1.20	2.65	Loose, greyish brown, stained orangish brown, silty, fine SAND, with very closely and closely spaced, thick laminations of soft, brown clay.	TIDAL FLAT DEPOSITS

Intervention	Top (m)	Base (m)	Lithology	Facies
BH067	2.65	4.00	Loose, brownish grey, silty, fine SAND, with occasional lenses (up to 20mm) of soft, brown, silty clay.	TIDAL FLAT DEPOSITS
BH067	4.00	8.00	Loose, brown, silty, fine and medium SAND, with closely and medium spaced thick laminations of soft, grey clay.	TIDAL FLAT DEPOSITS
BH067	8.00	8.60	Very dense, brownish grey, medium SAND.	TIDAL FLAT DEPOSITS
BH067	8.60	9.00	Brownish red, fine and medium SAND. [WILMSLOW SANDSTONE FORMATION]	BEDROCK
BH069	0.00	0.10	MADE GROUND: Grass over dark greyish brown, slightly sandy SILT with frequent rootlets.	MADE GROUND
BH069	0.10	1.20	MADE GROUND: Grey SILT and fine SAND. (PULVERISED FUEL ASH)	MADE GROUND
BH069	1.20	17.00	MADE GROUND: Very stiff, dark grey, sandy SILT. (PULVERISED FUEL ASH)	MADE GROUND
BH069	17.00	17.30	Firm to stiff, grey mottled brown, slightly sandy clayey SILT.	TIDAL FLAT DEPOSITS
BH069	17.30	21.00	Medium dense, grey, clayey, very silty, fine SAND.	TIDAL FLAT DEPOSITS
BH069	21.00	24.30	Dense, brown, gravelly, medium and coarse SAND. Gravel is subangular to subrounded, fine to coarse including sandstone, mudstone, granite and metamorphic lithologies.	GLACIOFLUVIAL
BH069	24.30	24.80	Brown, very sandy, angular to subangular, medium and coarse GRAVEL including sandstone, mudstone, granite and metamorphic lithologies. With medium cobble content.	GLACIOFLUVIAL

Intervention	Top (m)	Base (m)	Lithology	Facies
BH069	24.80	27.20	Very stiff, locally thinly laminated, reddish brown, slightly sandy, slightly gravelly CLAY, with rare, rounded pockets (up to 20mm) of fine, brown sand. Gravel is subangular to subrounded, fine to coarse, including quartzite, mudstone and siltstone.	GLACIAL TILL
BH069	27.20	28.32	Very dense, orangish brown, slightly gravelly, fine and medium SAND. Gravel is subangular to subrounded, fine to coarse including mudstone, sandstone and metamorphic lithologies.	GLACIOFLUVIAL
BH106	0.00	0.60	MADE GROUND: Dark brown, slightly gravelly, silty, organic, fine to coarse SAND. Gravel is subangular to subrounded, fine to coarse including sandstone, siltstone, mudstone, slate and glass fragments.	MADE GROUND
BH106	0.60	1.00	Light brown, silty, fine to coarse SAND.	SHSF
BH106	1.00	1.30	Firm, brown, locally mottled light grey, slightly sandy CLAY.	ALLUVIUM
BH106	1.30	7.00	Medium dense, brown, slightly clayey, very silty, fine and medium SAND.	ALLUVIUM
BH106	7.00	10.10	Firm, thinly to thickly laminated, brown silty CLAY.	ALLUVIUM
BH106	10.10	11.00	Brown, silty, fine and medium SAND.	ALLUVIUM
BH114	0.00	0.40	Dark greyish brown, very silty, fine SAND with rare gravel. Gravel is subrounded to rounded, fine and medium including sandstone.	TOPSOIL
BH114	0.40	3.00	Brownish orange, slightly silty, fine SAND.	SHSF
BH114	3.00	3.50	Loose, brown, very silty, fine SAND.	ALLUVIUM
BH114	3.50	10.00	Firm, brown, silty CLAY with frequent bands of brown, fine sand.	ALLUVIUM

Intervention	Top (m)	Base (m)	Lithology	Facies
BH120	0.00	0.40	Grass over soft, dark brown, slightly sandy, slightly gravelly, clayey SILT with occasional rootlets.	TOPSOIL
BH120	0.40	2.80	Firm, orangish brown, slightly silty, slightly sandy, slightly gravelly CLAY. Gravel is subrounded to rounded, fine and medium including sandstone and mudstone.	GLACIAL TILL
BH120	2.80	5.40	Stiff, brown, slightly silty, slightly gravelly, sandy CLAY. Gravel is subrounded to rounded, medium and coarse including sandstone, siltstone and mudstone.	GLACIAL TILL
BH120	5.40	6.10	Extremely weak, reddish brown and light grey MUDSTONE, recovered as sandy, clayey, very silty, angular to subangular, fine to coarse gravel. (Grade III) [BOLLIN MUDSTONE MEMBER]	BEDROCK
BH300	0.00	0.40	Dark, brown, fine and medium SAND with frequent roots and rootlets.	TOPSOIL
BH300	0.40	1.30	Light orangish brown, slightly silty, fine and medium grained SAND.	SHSF
BH300	1.30	2.10	Soft, reddish brown locally mottled light grey, slightly gravelly, sandy CLAY with occasional black organic fragments (up to 3mm). Gravel is subangular to subrounded, fine to coarse including quartz and sandstone.	GLACIAL TILL
BH300	2.10	3.10	Very dense, reddish brown, gravelly, clayey, fine and medium SAND, with occasional pockets (up to 4mm) of greenish grey silt. (CLASS E) [WILMSLOW SANDSTONE FORMATION]	BEDROCK
BH301	0.00	0.30	Grass over dark brown, fine and medium SAND with frequent roots and rootlets (<2mm).	TOPSOIL

Intervention	Top (m)	Base (m)	Lithology	Facies
BH301	0.30	0.80	Brown, fine and medium SAND.	SHSF
BH301	0.80	1.00	Brown, slightly gravelly, fine to coarse SAND with rare cobbles. Gravel is angular to subrounded, fine to coarse including sandstone. Cobbles are angular including sandstone.	SHSF
BH301	1.00	5.10	Medium dense, reddish brown, slightly clayey, silty, fine and medium SAND. (CLASS E) [WILMSLOW SANDSTONE FORMATION]	BEDROCK
BH318	0.00	0.40	Grass over soft, dark greyish brown, silty CLAY with frequent rootlets.	TOPSOIL
BH318	0.40	0.70	Firm, reddish brown, grey mottled yellowish brown, slightly silty, slightly gravelly, sandy CLAY with occasional rootlets and root traces. Gravel is angular, fine, and includes chert and quartzite.	GLACIAL TILL
BH318	0.70	1.20	Firm becoming stiff, reddish brown mottled light grey, slightly sandy, slightly gravelly CLAY. Gravel is angular to well rounded, fine and medium including sandstone, siltstone, occasional chert and quartzite.	GLACIAL TILL
BH318	1.20	3.20	Stiff, light brown locally mottled light grey, slightly silty, slightly gravelly, sandy CLAY. Gravel is angular to subrounded, fine to coarse including mudstone, siltstone, sandstone and quartzite.	GLACIAL TILL
BH318	3.20	6.90	Very stiff, brown, sandy, gravelly CLAY with low cobble content. Gravel is angular to subrounded, fine to coarse including mudstone, siltstone, sandstone, quartzite and chert. Cobbles are subrounded of quartzite.	GLACIAL TILL
BH318	6.90	9.55	Very stiff, reddish brown, silty CLAY with up to 30 percent angular	BEDROCK

Intervention	Top (m)	Base (m)	Lithology	Facies
			lithorelicts (up to 25mm) of extremely and very weak mudstone. Occasional fragments (up to 15mm) of light greyish white, crystalline gypsum. (GRADE III) [BOLLIN MUDSTONE MEMBER]	
BH329	0.00	0.50	Crop over. dark brown, fine and medium SAND with occasional rootlets.	TOPSOIL
BH329	0.50	0.60	Orangish brown, fine and medium SAND.	SHSF
BH329	0.60	1.20	Firm locally soft, orangish brown brown mottled grey, slightly sandy, slightly gravelly CLAY. Gravel is subangular to subrounded, fine and medium including sandstone.	GLACIAL TILL
BH329	1.20	4.00	Stiff, reddish brown, slightly gravelly, sandy CLAY, with occasional fragments (up to 10mm) of back organic matter. Gravel is subangular to rounded, fine to coarse including mudstone, siltstone and quartz.	GLACIAL TILL
BH329	4.00	6.60	Very dense, reddish brown, fine and medium SAND, with up to 15 percent subangular lithorelicts (up to 10mm) of extremely weak sandstone. (CLASS E) [WILMSLOW SANDSTONE FORMATION]	BEDROCK
BH330	0.00	0.10	Grass over dark brown, fine and medium SAND.	TOPSOIL
BH330	0.10	0.80	Dark brown, clayey, fine to coarse SAND with roots (up to 3mm).	SHSF
BH330	0.80	1.20	Light brown yellow, slightly gravelly, slightly clayey, silty, fine to coarse SAND. Gravel is subangular to subrounded, fine to coarse including sandstone, quartz and siltstone.	SHSF
BH330	1.20	3.90	Medium dense, locally dense, light brown, fine and medium SAND.	SHSF

Intervention	Top (m)	Base (m)	Lithology	Facies
BH330	3.90	4.60	Very dense, thinly laminated (3 to 10 degrees) reddish brown, silty, fine SAND. (CLASS E) [WILMSLOW SANDSTONE FORMATION]	BEDROCK
BH332	0.00	0.20	Dark greyish brown, slightly sandy, slightly gravelly CLAY with frequent rootlets up to 3mm diameter. Gravel is subangular to subrounded, fine to coarse including sandstone and mudstone.	TOPSOIL
BH332	0.20	0.50	Firm, grey and brown, slightly silty, sandy locally very sandy CLAY.	TIDAL FLAT DEPOSITS
BH332	0.50	1.00	Light grey, slightly silty, fine and medium SAND.	TIDAL FLAT DEPOSITS
BH332	1.00	1.20	Brown, slightly gravelly, slightly silty, fine and medium SAND. Gravel is subangular to subrounded, fine and medium including mudstone, sandstone and metamorphic lithologies.	TIDAL FLAT DEPOSITS
BH332	1.20	1.80	Medium dense, greyish brown, silty, fine and medium SAND.	TIDAL FLAT DEPOSITS
BH332	1.80	2.00	Soft, grey, slightly sandy SILT with slight organic odour.	TIDAL FLAT DEPOSITS
BH332	2.00	2.66	Medium dense, greyish brown, slightly gravelly, fine and medium rarely coarse SAND. Gravel is subangular to subrounded, fine and medium including sandstone.	TIDAL FLAT DEPOSITS
BH332	2.66	3.00	Greyish brown, gravelly, fine and medium SAND. Gravel is rounded, tabular, medium and coarse including quartzite, siltstone and sandstone.	TIDAL FLAT DEPOSITS
BH332	3.00	8.50	Grey, fine and medium SAND.	TIDAL FLAT DEPOSITS
TP20	0.00	0.80	MADE GROUND: Dark brown, gravelly, slightly clayey, silty, organic, fine and medium SAND. Gravel is	MADE GROUND

Intervention	Top (m)	Base (m)	Lithology	Facies
			subangular to subrounded, fine to coarse including cinder.	
TP20	0.80	2.70	Light brown, fine to coarse SAND.	SHSF
TP20	2.70	3.00	Firm, reddish brown, silty, slightly sandy, slightly gravelly CLAY. Gravel is subangular to subrounded, fine and medium including lignite.	GLACIAL TILL
WS10	0.00	0.70	Dark brown, silty, organic, fine to coarse SAND.	TOPSOIL
WS10	0.70	2.35	Loose, brown mottled orange brown, fine and medium SAND.	SHSF
WS10	2.35	3.30	Soft becoming firm, reddish brown, slightly silty, slightly gravelly, sandy CLAY. Gravel is subangular to subrounded, fine to coarse, including sandstone and siltstone. (CLASS E) [WILMSLOW SANDSTONE FORMATION]	BEDROCK
WS32	0.00	0.33	Grass over soft, dark brown, slightly sandy CLAY with occasional rootlets.	TOPSOIL
WS32	0.33	2.40	Grey mottled orangish brown, slightly clayey, silty, fine to coarse SAND.	ALLUVIUM
WS32	2.40	3.20	Soft, reddish brown, slightly sandy CLAY. (GRADE IVb) [BOLLIN MUDSTONE MEMBER]	BEDROCK
WS33	0.00	0.30	Grass over soft, dark brown, slightly sandy CLAY with occasional rootlets.	TOPSOIL
WS33	0.30	1.40	Grey mottled light yellowish brown, clayey, silty, fine and medium SAND with occasional fine gravel.	ALLUVIUM
WS33	1.40	2.70	Soft, greyish brown, silty, slightly sandy CLAY with rare decomposed plant fragments (roots).	ALLUVIUM
WS33	2.70	3.00	Reddish brown, fine to coarse SAND. (GRADE IVb) [BOLLIN MUDSTONE MEMBER]	BEDROCK

Intervention	Top (m)	Base (m)	Lithology	Facies
WS34	0.00	0.60	Grass over soft, dark greyish brown, slightly sandy CLAY.	TOPSOIL
WS34	0.60	1.70	Soft, reddish brown, slightly silty, slightly gravelly, sandy CLAY. Gravel is subangular to subrounded, fine to coarse including siltstone.	GLACIAL TILL
WS34	1.70	3.80	Firm, reddish brown, slightly silty, slightly gravelly, sandy CLAY. Gravel is very angular to subrounded, fine and medium including quartz and siltstone.	GLACIAL TILL
WS34	3.80	3.90	Firm, reddish brown, slightly sandy, gravelly CLAY. Gravel is very angular to subrounded, fine and medium including mudstone. Multicoloured (GRADE IVb) [BOLLIN MUDSTONE MEMBER]	BEDROCK
WS35	0.00	0.30	Dark brown, slightly sandy, clayey SILT with rare gravel and frequent rootlets. Gravel is subrounded to rounded, fine and medium including quartz and siltstone.	TOPSOIL
WS35	0.30	1.00	Firm, light brownish grey, slightly sandy, slightly gravelly, silty CLAY with rare lenses of grey, very silty, fine sand and rare partially decomposed plant matter.	GLACIAL TILL
WS35	1.00	2.60	Firm, reddish brown, slightly silty, slightly gravelly, sandy CLAY with rare partially decomposed plant matter. Gravel is angular to subrounded, fine to coarse including mudstone.	GLACIAL TILL
WS35	2.60	3.13	Extremely weak, grey and brown MUDSTONE recovered as clayey, angular, fine to coarse gravel. (Grade IVa) [BOLLIN MUDSTONE MEMBER]	BEDROCK
WS37	0.00	0.30	Soft, dark brown, slightly sandy, slightly gravelly SILT with frequent	TOPSOIL

Intervention	Top (m)	Base (m)	Lithology	Facies
			rootlets. Gravel is subangular to rounded, fine and medium including sandstone, mudstone and quartz.	
WS37	0.30	0.45	Light brown and light grey, slightly gravelly, very silty, fine SAND. Gravel is subrounded to rounded, fine to coarse including sandstone and siltstone.	GLACIAL TILL
WS37	0.45	2.00	Firm, brown mottled light grey, slightly silty, slightly sandy, slightly gravelly CLAY with occasional partially decomposed plant matter and rare lenses of sandy silt (2-30mm thick). Gravel is subrounded to rounded, fine and medium including sandstone and siltstone.	GLACIAL TILL
WS37	2.00	2.55	Firm, reddish brown locally mottled bluish grey, slightly sandy, silty CLAY, with up to 10 percent subrounded lithorelicts (up to 10mm) of very weak mudstone and siltstone. (GRADE IVa) [BOLLIN MUDSTONE MEMBER]	BEDROCK

Geoarchaeological Potential

Introduction

The Project traverses a considerable transect across a landscape that is both diverse and complex in its geomorphology, sediment history, and geoarchaeological potential. This chapter integrates the data presented in the previous chapters to consider the geoarchaeological potential within the Project. That potential is expressed in terms of:

- the possible presence of archaeological remains that may lie sealed by, or within, sedimentary facies; and
- areas with good stratigraphic sequences that could contribute to a deposit model (either in the case of existing BGS data, or where GI works could be undertaken).

The data are considered first in general and within the broad context of the Project (**Table 6F 0.1**), then more specifically for each of the five main regions traversed by the Project (**Table 6F 0.2**).

Potential of the Sedimentary Facies

This section considers and summarises the broad potential for encountering archaeological remains within the various environments and sedimentological sequences that are often found at numerous locations along the Project. The deposits are summarised in **Table 6F 0.1**, with a more detailed commentary in **Sections 6.3. – 6.8**.

Table 6F 0.1 **Summary of facies types and inferred general archaeological potential**

Sediment Unit	Environment of Deposition	Archaeological Potential
Topsoil	Modern agricultural ploughsoil.	Could contain redeposited pottery or lithic material brought to the surface through ploughing and sub-surface disturbance.
Colluvium	Potential Modern and Ancient soil movement associated with agriculture and vegetation clearance (hillwash/ploughwash). Soil creep, slope/sheet wash, rill, and gully erosion. Low to moderate energy erosion and deposition.	Potential to contain redeposited pottery and lithic material from historic and prehistoric activities on higher ground/slopes and to seal land surfaces, historic and prehistoric archaeology.

Sediment Unit	Environment of Deposition	Archaeological Potential
Tidal Flat Deposits	Holocene sedimentation of sands, silts and clays in coastal settings. Mudflats, sandflats, saltmarsh and tidal creeks. Moderate to high energy erosion and deposition.	Has the potential to seal <i>in-situ</i> historic and pre-historic archaeology in waterlogged conditions. May preserve evidence of former saltmarsh and creek systems, and earlier freshwater environments at depth (see below). Seasonal activity (e.g. timber structures and fish traps, evidence of salt-making)
Alluvium/ Fluvial Deposits	Holocene alluviation associated with overbank flooding and migrating river/stream channels, backwater areas. Low to high energy erosion and deposition.	Has the potential to seal <i>in-situ</i> historic and prehistoric (former dryland?) archaeology in waterlogged conditions, although reworking and erosion may be associated with coarse-grained channel facies (sands and gravels). Timber structures may be preserved, particularly at the margins of channels or marginal ecotonal zones adjacent to buried islands or at floodplain edges.
Peat/ Organic Alluvium	Periods of stabilisation or channel migration that result in encroachment of vegetation. Low energy deposition.	<i>In-situ</i> prehistoric potential in waterlogged conditions (organic preservation – timber structures). High potential for palaeoenvironmental reconstruction.
Pleistocene/ Holocene Aeolian and riverine deposits	Aeolian coversands/riverine alluvial sand, silt, and clay deposits, undifferentiated. Named deposits, e.g. Shirdley Hill Sand.	Palaeolithic and/or prehistoric potential. May seal land surfaces.
Pleistocene glaciofluvial deposits; river terrace sands	Undifferentiated Pleistocene sands and gravels.	Palaeolithic potential. Reworked artefacts.
Pleistocene Till	Deposits of sands and gravels deposited by and underneath glaciers.	None. Rarely may mask underlying Paleolithic archaeology.

Sediment Unit	Environment of Deposition	Archaeological Potential
Bedrock	Geological strata (predominantly mudstones of early Jurassic – late Triassic age in west, with middle and upper Jurassic clays and limestones further east, followed eastwards by Chalk of Cretaceous age.	None.

Tidal Flat Deposits

BGS mapping of the superficial deposits has recorded accumulations of Tidal Flat Deposits alongside the Mersey Estuary, and alluvial and organic deposits in many of the large river valleys, such as the River Weaver and Bollin. These are characterised by accumulations of clays, silts, and sands, often with an organic component, with peat accumulating in areas or during periods when minerogenic deposition is reduced. Sites within the lower reaches of river valley systems are complex because both fluvial and estuarine processes may have influenced deposition and erosion. Thus, sedimentary sequences in Tidal Flat Deposits and stretches of alluvium near to the Mersey Estuary, such as those at Frodsham, Helsby, and Ince Marshes, and the mouth of the River Weaver, are likely to reflect changes in Holocene relative sea level. As such, they are areas that may have fluctuated in terms of suitability for human exploitation, but they almost certainly have the potential to contain significant archives for sea level and palaeoenvironmental reconstruction.

Floodplain and River Terrace Deposits

Floodplain deposits within the main river valleys of the Weaver and Bollin are also key contexts for the preservation of palaeoenvironmental remains and, given marginal areas adjacent to floodplains and water courses are known foci for human habitation, have the potential for concealing and preserving buried land surfaces and wetland archaeology. Further, river terrace deposits, although not specifically mapped as such across the Project, may represent, in subdued topography, potential topographic highs, subtle ridges, or sand islands that may have been attractive to prehistoric people. Not only could be sealed by alluvium, some such 'islands' may not have been recognised amidst the more expansive alluvial deposits. The presence of former floodplains and river terrace deposits in several locations means that there is also some potential for the recovery of Upper Palaeolithic cultural material, which, up until now, has mostly come from caves and rock-shelters.

Peat Deposits

Away from the river valleys, the Draft Order Limits contain several significant peat deposits, notably along the route of the East Corridor, such as Whitley Reed, Sink Moss (both in Cheshire), and Carrington Moss (Greater Manchester). Having developed in glacial hollows, they have the potential to seal former land surfaces and lake deposits dated to the late glacial and early post-glacial period. Evidence from the NWWs suggests many of these peatlands have undergone significant degradation, which means any remaining peat represents a very valuable palaeoenvironmental resource. The study also highlighted the potential for the recovery of exposed sites, especially on the periphery of the peat, and on elevated areas underlying the peat.

The effects of development upon fragile subsurface deposits such as peat may be direct or indirect and could be of long- and short-term duration. Peat deposits close to the surface could be adversely impacted from works associated with the Project. Impacts, such as excavation and compaction (from heavy vehicle movement) could impact negatively on subsurface strata and the potential archaeological remains contained within.

Dewatering could result in peat desiccation and consequent destruction. Any changes to drainage would affect the buried environments of waterlogged deposits. Waterlogged peat deposits considered to have high archaeological and palaeoenvironmental potential near the Draft Order Limits of the Project should be assessed according to Historic England guidelines (2016) *Preserving archaeological remains*, Appendix 3: *Water environment assessment techniques*.

Shirdley Hill Sand

Of particular interest are the deposits of the Shirdley Hill Sand Formation, which are believed to have accumulated during the last glacial period under dry and lightly vegetated tundra conditions and have the potential to seal late glacial and early post-glacial archaeology and sites for palaeoenvironmental reconstruction. Further, there is a possibility that such deposits may become reactivated by exposure and erosion in later periods. Although studies of these sands have been carried out in West Lancashire, such as those at Sefton (Cowell *et al* 1994) the equivalent deposits in Cheshire have seen no geoarchaeological investigations.

Till and Glaciofluvial Deposits

Large areas of the Project are situated on Devensian Till and Glaciofluvial Deposits. Although these superficial deposits are considered generally to have little geoarchaeological potential, they may rarely contain deeply stratified archaeology and palaeoenvironmental sites and artefacts redeposited from Palaeolithic contexts.

Communications and Ecotonal Zones

Human communities were often drawn to watercourses, springs, and wetland-edge environments (ecotonal zones). Deposits can seal buried land surfaces associated with well-preserved archaeological features, structures or *in-situ* artefact assemblages, and areas of higher ground or islands could have been favoured for settlement.

The region covered by the Project includes areas that lie outside, and on the edges of, the main drainage pattern. Areas such as this were often used as communication routes between lower-lying and higher ground. Within them, deposit sequences and archaeological sites could have been protected from the effects of fluvial erosion and well-preserved remains do not necessarily have to be buried at great depths to survive.

Existing BGS Data

Existing BGS borehole data is largely inadequate for most of the areas highlighted as having high geoarchaeological potential. Many of the interventions are historical and of limited use in construction of a deposit model. The records often lack altitudinal data and have been sited to focus on bedrock geology rather than superficial deposits. In many cases, the spread of boreholes is too far apart to produce a meaningful deposit model representative of the subsurface deposits. There are, however, several areas where BGS borehole coverage is reasonable and would provide sufficient data to supplement new data acquired from future GI investigations. These include the numerous boreholes located in the Tidal Flat Deposits of Frodsham, Helsby, and Ince Marshes, and to a lesser extent those crossing the River Mersey. Preliminary cross sections (Transects 1-8, **Figures 15-19**) have been produced in these areas for this report, supplemented by a small number of project specific geotechnical boreholes. These cross sections maybe enhanced and added too as more data becomes available from further geotechnical investigations planned for the Project.

Summary of Potential and Significance

The potential of the Geoarchaeological Character Zones discussed in **Section 4** is briefly summarised in **Table 6F 0.2** and illustrated on **Figure 22**. This is differentiated into zones of high-, medium-, or low potential, based on the extent and nature of the deposits found within the GCZ. It should be noted that this potential is often specific to discrete regions of these zones (e.g. palaeochannels, valley systems, mires, etc), rather than the GCZ in its entirety.

Deposits of geoarchaeological potential reflect sediment accumulations that could be considered for further work, for example, targeted ground investigation or geoarchaeological survey across key sequences. Deposits of palaeoenvironmental potential are more likely to contain organic sediments that may hold prime data for establishing chronological and vegetational histories. Assessment also takes into consideration the potential for these zones to have acted as foci for past human activity and for the evidence of such activity to be

preserved. For example, early human occupation is often associated with watercourses, fens, and wetland-edge (ecotonal) environments, and that areas of higher ground, including river levees, terraces, and islands or promontories within and adjacent to wetlands were prime locations for human habitation. That is not to say that archaeological sites and artefacts will not be found elsewhere, but in geoarchaeology, emphasis is placed on the geomorphology of landscapes and superficial deposits where former land surfaces and archaeological and palaeoenvironmental remains are likely to be buried/survive.

On this basis, zones containing estuarine, river valley, mire (peat), and aeolian deposits will have high potential. Zones with geomorphological features that might have attracted former occupation, such as watersheds or palaeochannels, but with limited burial environments, are considered to have medium potential. Zones with neither of the above tend to comprise outcrops of bedrock, till, or glaciofluvial deposits with only limited depths of topsoil.

In terms of assigning a general level of significance to the overall geoarchaeological potential of each zone – which is in line with the standard approach for non-designated heritage assets in a standard archaeological DBA, this is more difficult when dealing with swathes of landscape with a heterogeneous mix of environments and undated sediment sequences where group value can often raise the overall significance. However, despite this, it is clear there are some sequences present along the route that have the potential to produce some significant results of regional, and perhaps national importance, related to the earlier prehistoric landscape and occupation preserved in waterlogged conditions (Late Upper Palaeolithic (LUP) and Mesolithic). These sequences can occur at relatively shallow burial depths and thus may be more vulnerable to direct and indirect construction impact, more so than some of the more deeply buried organic sequences across the Mersey valley and estuary. These potentially significant sequences include the discrete localities of the peat mosses, particularly those mapped along, and in the vicinity of, the East Corridor. Also of potential high significance are the swathes of Shirdley Hill Sand which may bury or contain intercalated buried soil horizons and rare evidence of earlier prehistoric LUP occupation.

In terms of the Holocene sediment sequences associated with the larger tracts of alluvial floodplain and estuarine tidal flats with intercalated organic and peat deposits, the potential may be considered of medium significance on a regional basis due to group value for reconstruction of past landscape, climate, vegetation patterns and sea-level change. Associated ecotonal environments may preserve archaeological remains of all periods, particularly within shallow conflated sequences fringing the floodplain margins. Although the route crosses these edge environments at several locations, the footprint tends to be restricted, mainly traversing valley sequences on a perpendicular alignment. The route rarely runs parallel and along the floodplain edge for sustained distances (eg. at Frodsham). Zones with isolated or minor tracts of alluvium associated with streams are considered to be of lower significance, as are zones dominated by till and fluvioglacial deposits where Holocene superficial deposits are thin or entirely absent through weathering and erosion.

Table 6F 0.2 Summary of geoarchaeological potential

Geological Character Zone (GCZ)	BGS GI data	Surface Geology	Geoarchaeological potential		Significance
GCZ NC (North Corridor) 1	Poor	Bollin Mudstone, Till, Glaciofluvial Deposits.	Low	Slightly higher potential around the Whitley Brook.	Low
GCZ NC2	Poor	Bollin Mudstone, Till.	Medium	Possible ecotonal zone overlooking brook through Row's and Mort's Woods.	Low
GCZ NC3	Fair	Shirdley Hill Sand.	Medium	Possible peat deposits in vicinity of Manchester Ship Canal.	High
GCZ NC4	Poor	Tidal Flat Deposits. (Shirdley Hill Sand)	High	Mersey Valley. Complex sequences, including peats at various, sometimes shallow, depths. Ecotonal zones further up the valley sides.	Medium
GCZ NC5	Fair	Till.	Medium	Slightly higher potential around the Penketh Brook, including alluvium; and around the Pendlebury Brook.	Low
GCZ NC5a	Poor	Shirdley Hill Sand	Medium		High
GCZ NC5b	Poor	Till, Shirdley Hill Sand, Alluvium.	High	Interleaved sands and boulder clays with potential to seal land surfaces. Ecotonal zone.	High
GCZ NC5c	Good	Till.	Medium	Peaty soils and organic deposits.	Low
GCZ WS (Warrington Spur) 1	Fair	Tidal Flat Deposits.	High	Some interleaved organic deposits, including thick layers of peat. Evidence for Bronze Age and Roman activity nearby.	Medium
GCZ WS2	Fair	Glaciofluvial Deposits.	Low	Modern disturbance and infrastructure.	Low

Geological Character Zone (GCZ)	BGS GI data	Surface Geology	Geoarchaeological potential		Significance
GCZ WC (West Corridor)1	Poor	Glaciofluvial Deposits.	Medium	Deep-buried deposits not expected but occupies a potential ecotonal zone with palaeochannels.	Low
GCZ WC2	Poor	Alluvium.	High	Palaeochannels and potential for buried deposits.	Medium
GCZ WC3	Poor	Bollin Mudstone, Till, Glaciofluvial Deposits.	Low	Mostly Glaciofluvial deposits	Low
GCZ WC4	Fair/good	Tidal Flat Deposits.	High	Dynamic riverine/estuarine environment with alluvial sequences and palaeochannels, buried remains.	Medium
GCZ WC4b	Poor	Tidal Flat Deposits.	High	Records of thick organic deposits, including peat, c 6m below ground level (bgl).	Medium
GCZ WC5	Good	Tidal Flat Deposits.	High	Buried deposits (including one or more thick peat layers encountered 0.2-3m bgl); palaeochannels and extant natural watercourses.	Medium
GCZ WC6	Fair	Till.	High	Ecotonal zone, water courses and buried organic deposits.	Low
GCZ RS (Runcorn Spur) 1	Poor	Bollin Mudstone, Till, Tarporley Siltstone.	Low	Possible ecotonal zone on edge of wetland areas.	Low
GCZ SC (South Corridor) 1	Poor	Till, Glaciofluvial Deposits.	Low	Possible ecotonal zone with nearby palaeochannels.	Low
GCZ SC2	Fair	Alluvium.	Medium	Buried organic clays, but low potential for land surfaces.	Medium
GCZ SC3	Poor	Till, Glaciofluvial Deposits.	Low	Slightly higher potential and possible ecotonal zone around Cliff/Grange Brook.	Low

Geological Character Zone (GCZ)	BGS GI data	Surface Geology	Geoarchaeological potential		Significance
GCZ SC4	Poor	Glaciofluvial Deposits, Peat.	High	Former valley, buried surfaces, intermittent peat deposits (mosses), extant minor water courses.	High
GCZ SC5	Poor	Till.	Medium	Records of ancient field systems and woodland. Possible ecotonal zones overlooking brooks.	Medium
GCZ SC6	Poor	Alluvium, Glaciofluvial Deposits.	High	River Weaver valley and flood plain, watercourses. Potential for buried surfaces, including peat/organics across north of zone, less so to southeast	Medium
GCZ SC7	Poor	Till, Glaciofluvial Deposits.	Medium	Slightly higher potential around the Peckmill Brook. Place name evidence may indicate areas of peat/mires, such as Black Moss, Davenham, which is associated with possible Mesolithic activity.	High
GCZ SC8	Poor	Alluvium, River Terrace Deposits.	High	River Dane valley and floodplain, with potential for buried deposits and settlement on terraces.	Medium
GCZ SC9	Poor	Till.	Low	Slightly higher potential around the Puddinglake Brook.	Low
GCZ EC (East Corridor) 1	Poor	Bollin Mudstone, Till, Glaciofluvial Deposits.	Low		Low
GCZ EC1b	Poor	Bollin Mudstone, alluvium.	Medium	Possible ecotonal zone on outcrops around the Whitley Brook, alluvium from which could seal deposits.	Low
GCZ EC2	Poor	Till, Alluvium, Peat, Glaciofluvial Deposits.	High	Extant watercourses, surface mosses (extant and reduced), ecotonal zones.	High
GCZ EC3	Poor	Till, Bollin Mudstone.	Medium	Ecotonal zones, possible former mossland.	High

Geological Character Zone (GCZ)	BGS GI data	Surface Geology	Geoarchaeological potential			Significance
GCZ EC4	Poor	Till, Shirdley Hill Sand, Glaciofluvial Deposits, River Terrace Deposits, Peat.	High	Bollin Valley and flood plain, extant watercourse, buried deposits, ecotonal zones, attractive locations, surface, buried and former peat, potential for shallow buried land surfaces		High

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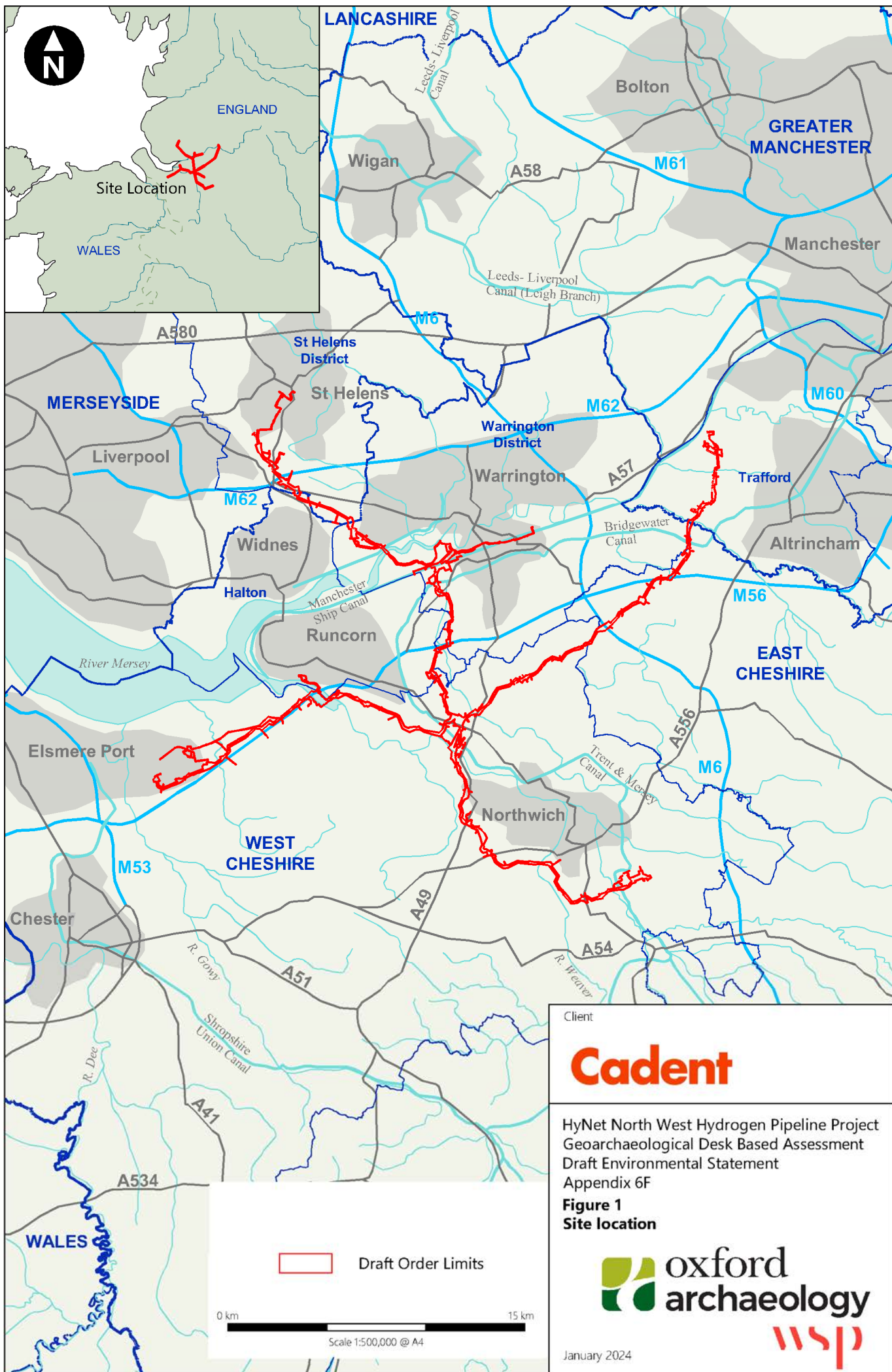
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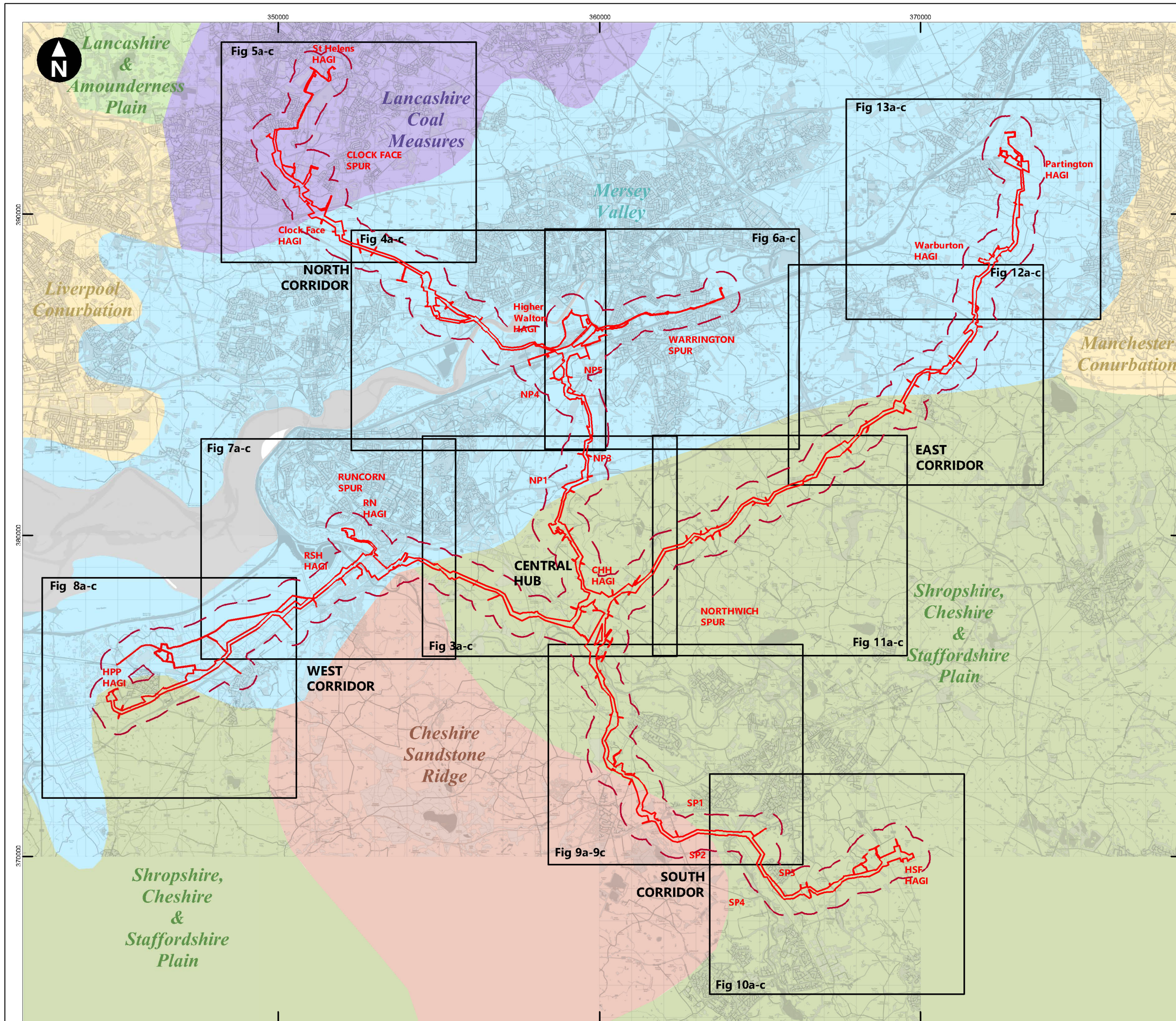
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Annex 6F1 (Figures)



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Key

- Draft Order Limits
- 500m Buffer June 2024

0 km 60 km

Scale 1:125,000 @ A3

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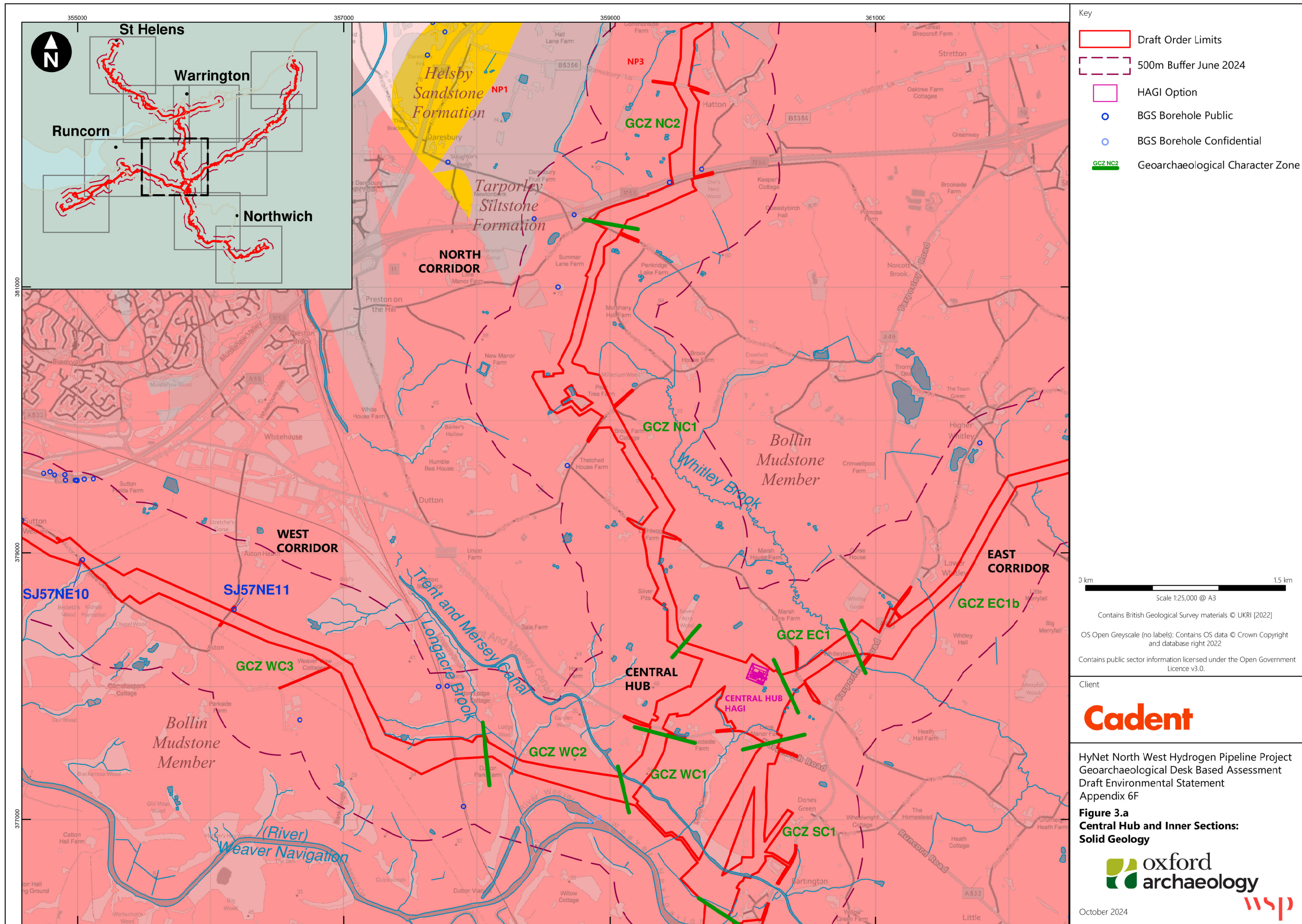
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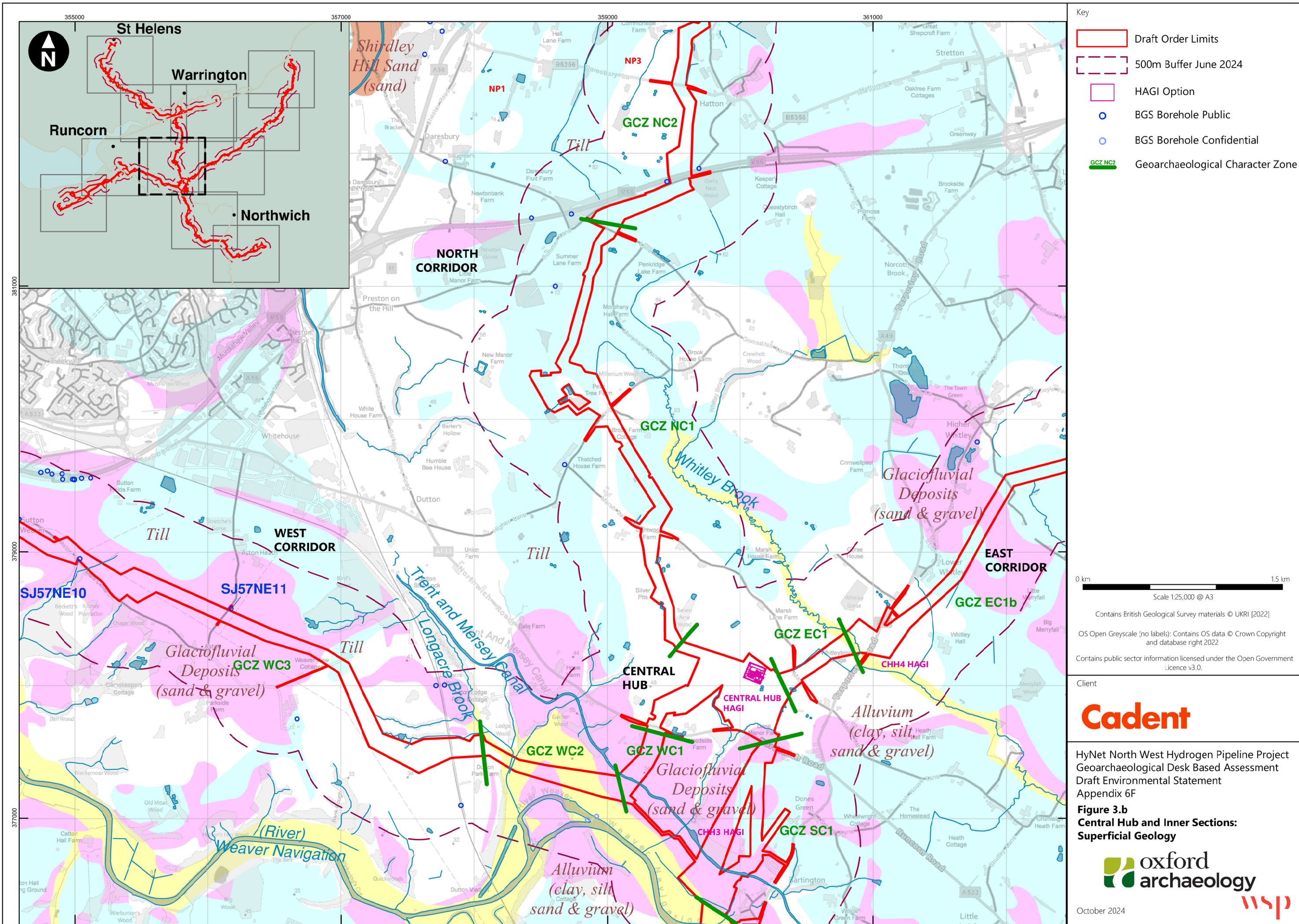
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Location of detail figures, showing National Character Areas (from Natural England)

oxford archaeology

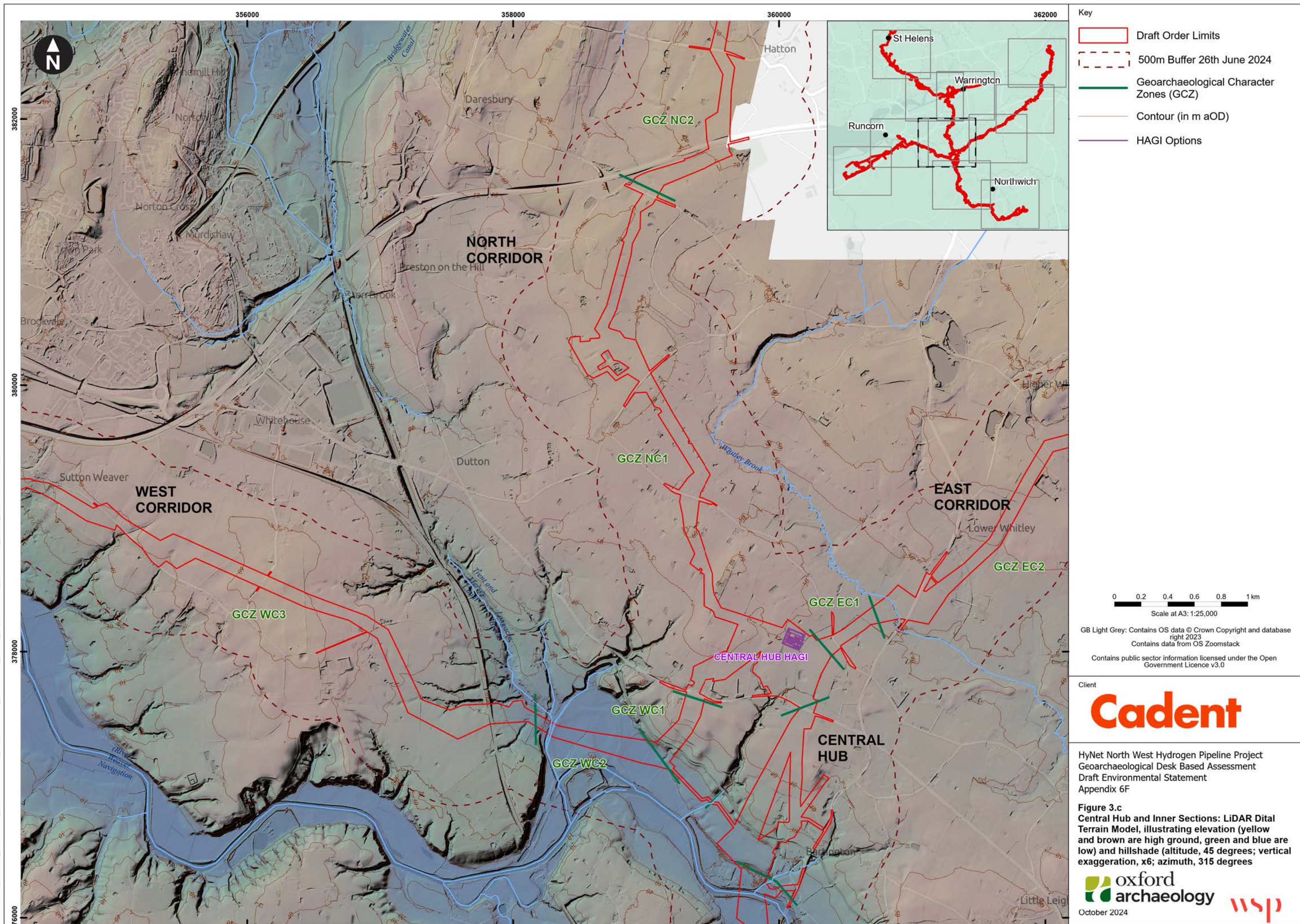
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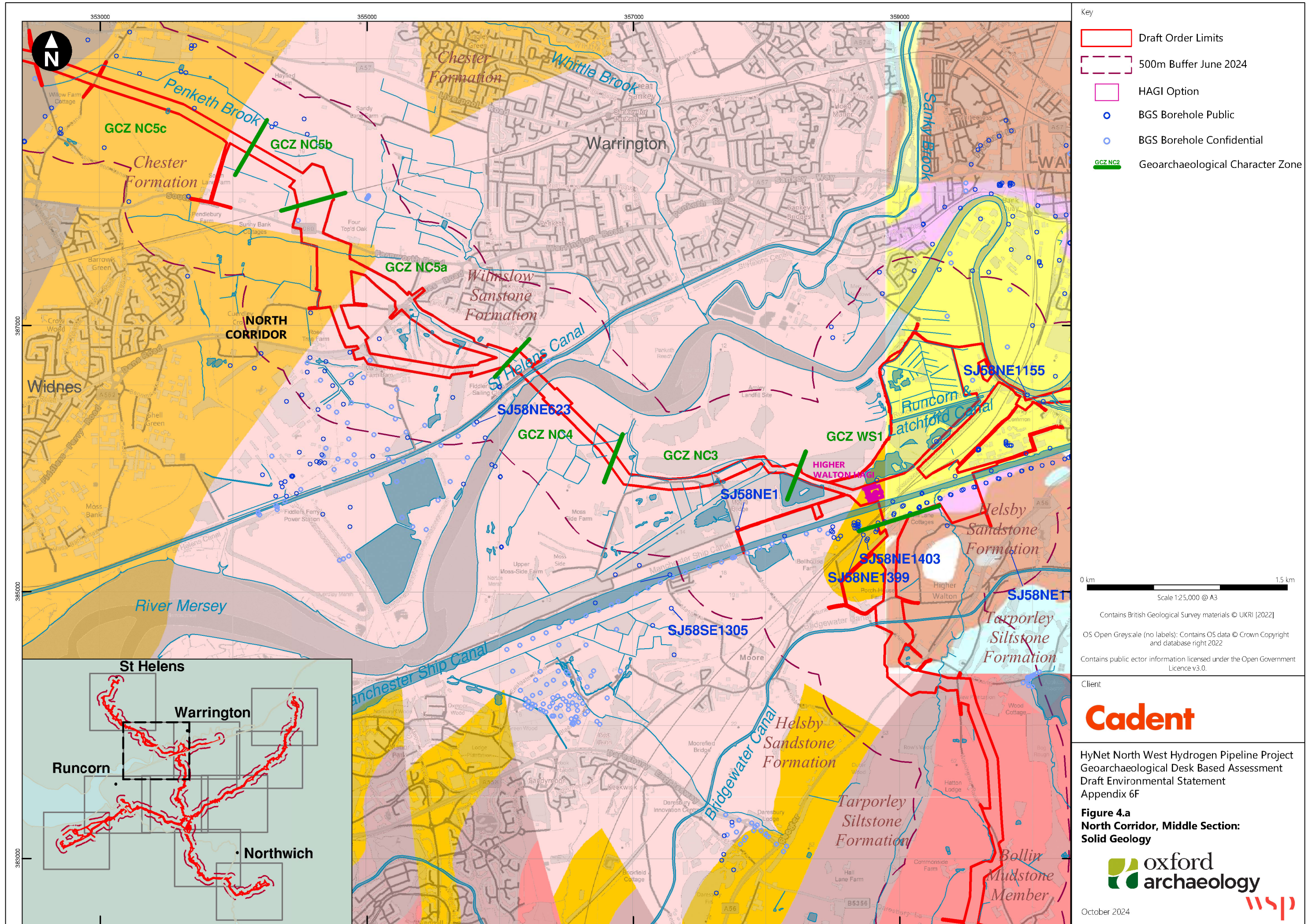
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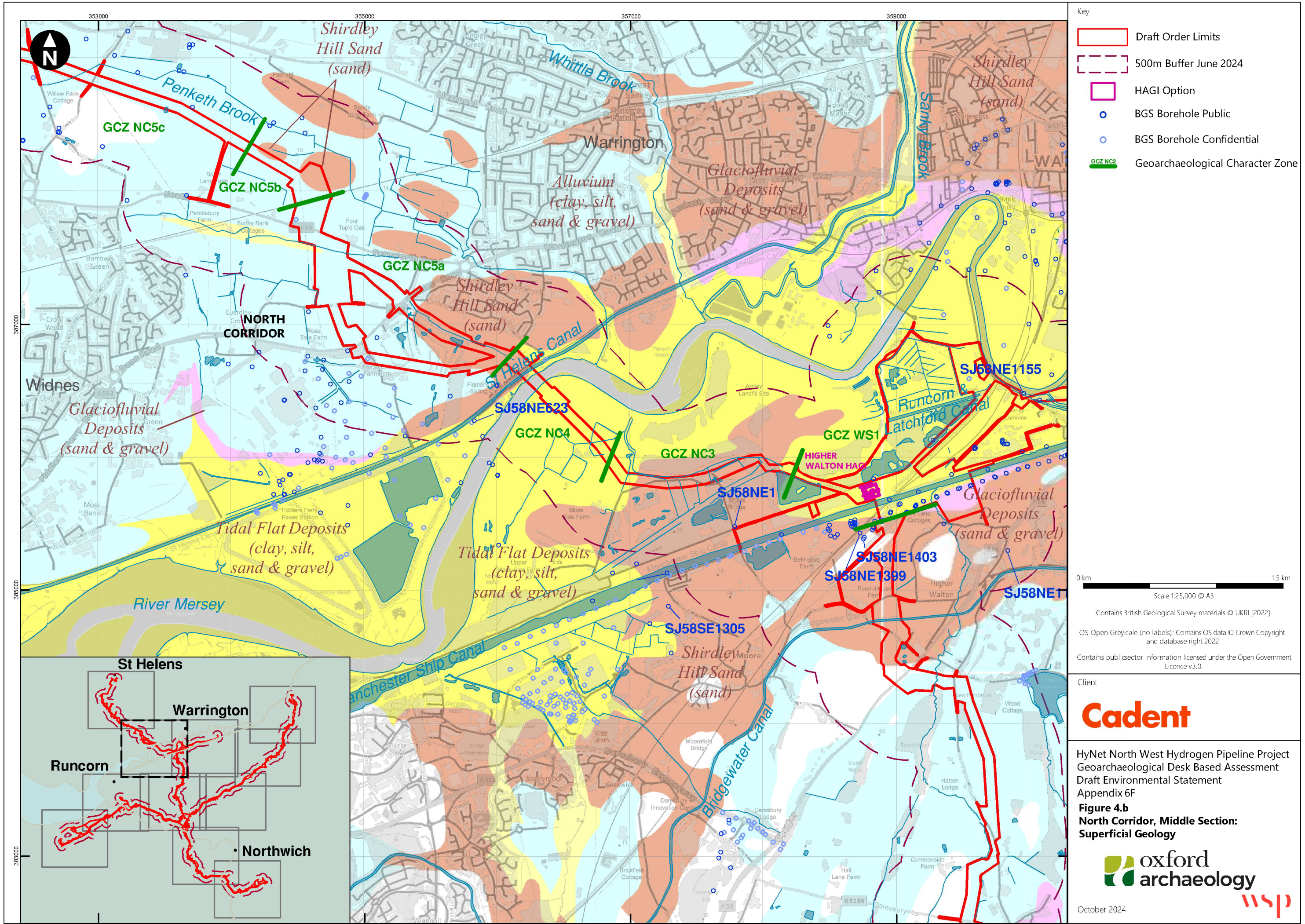


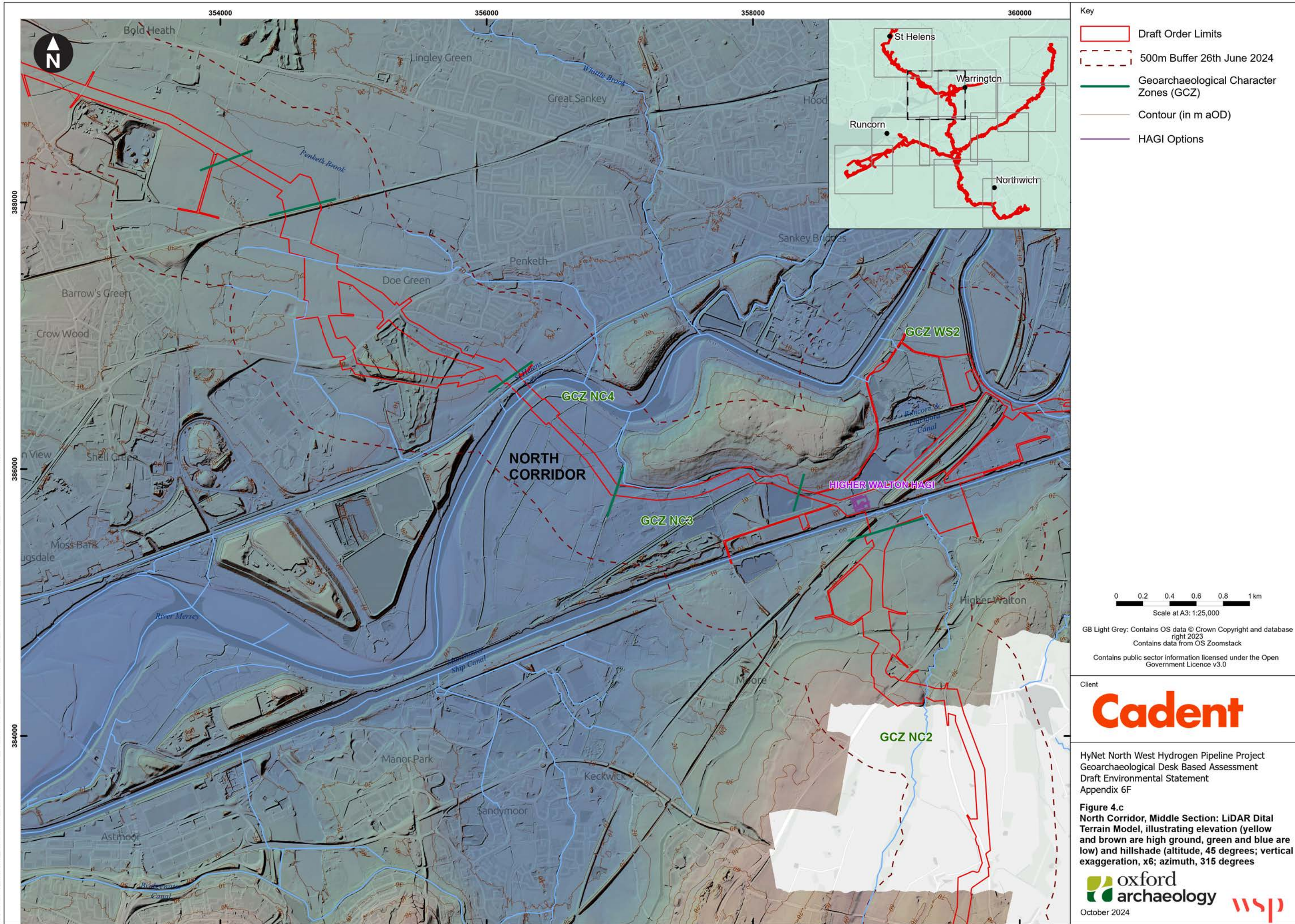


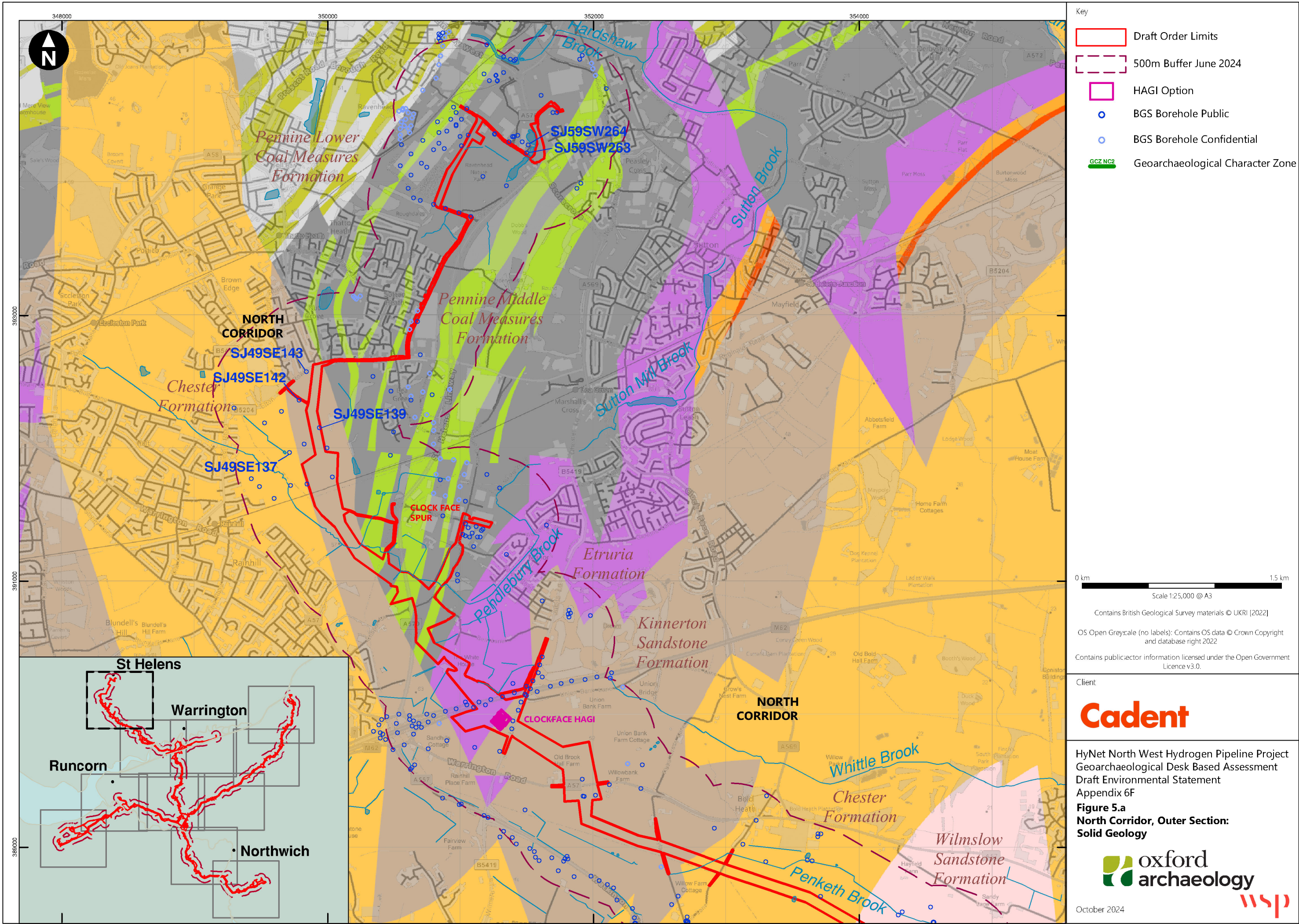
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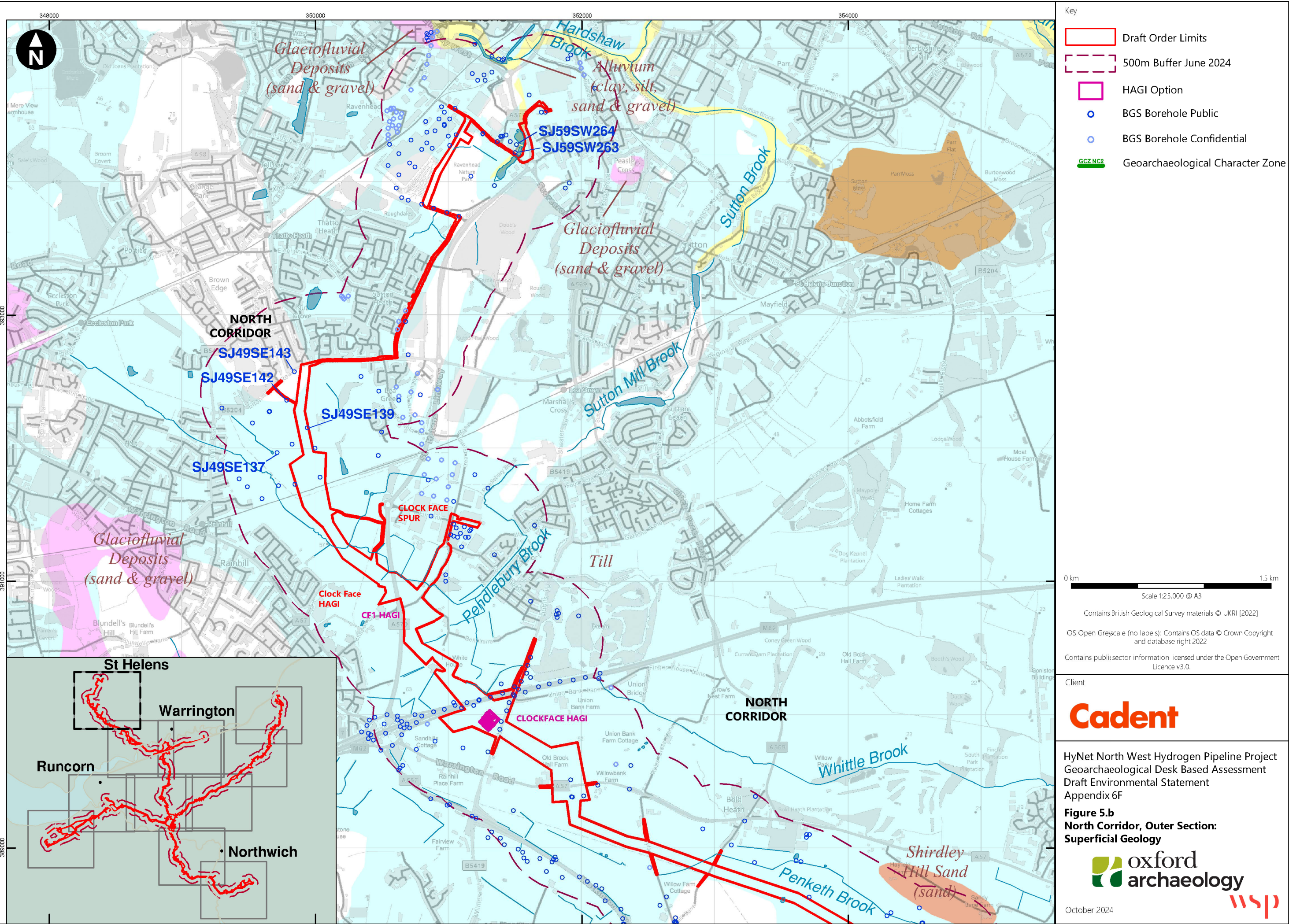


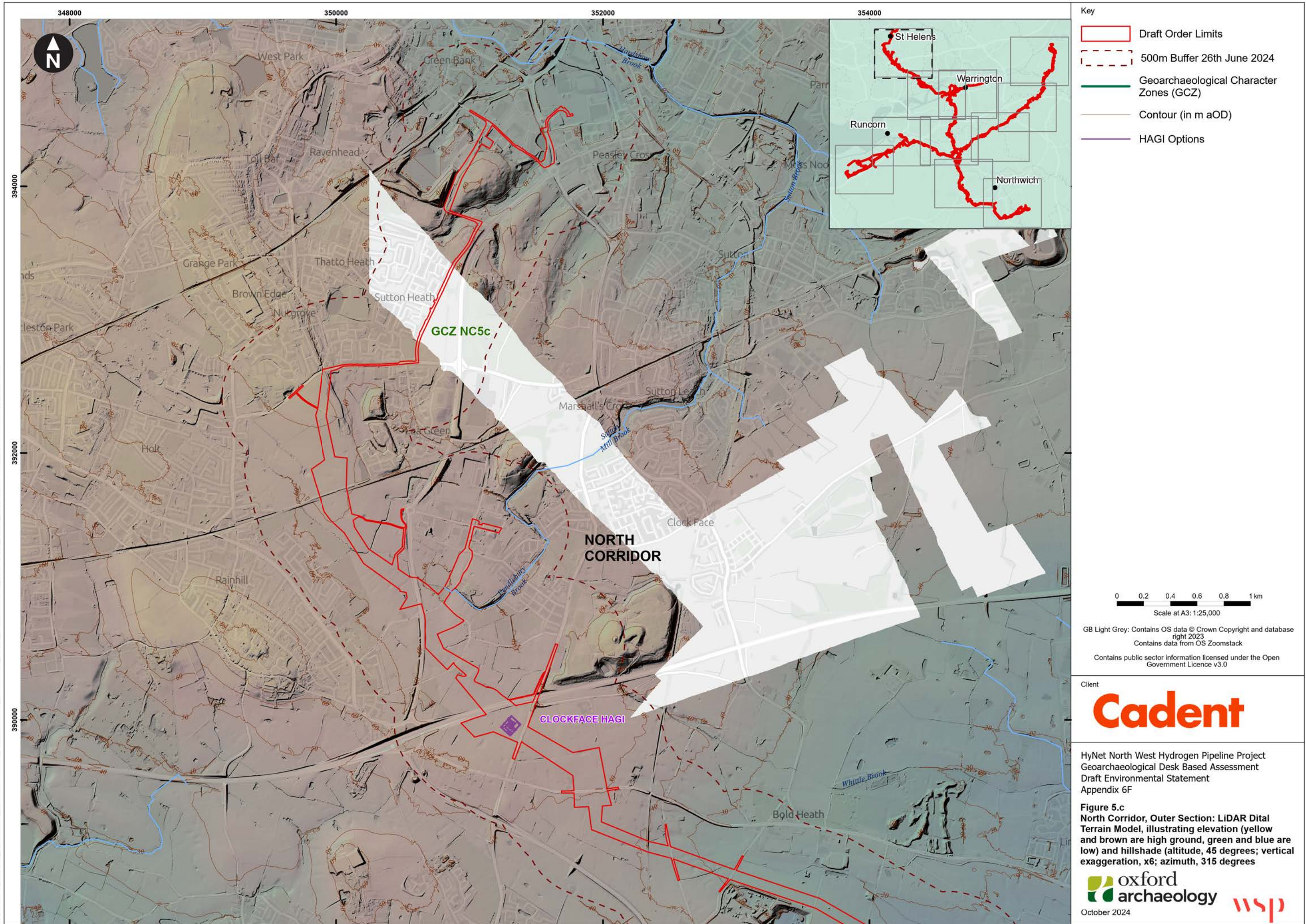


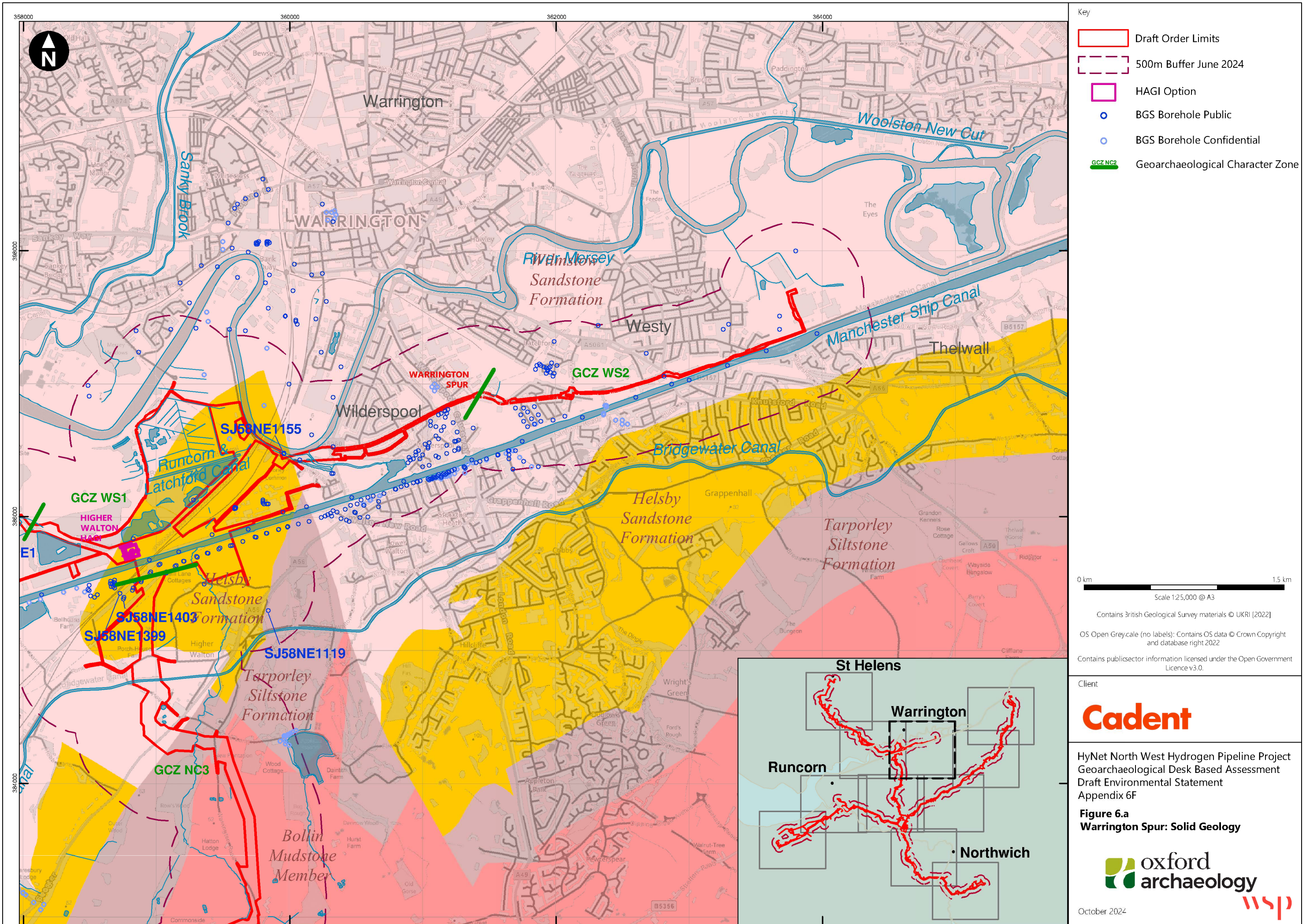


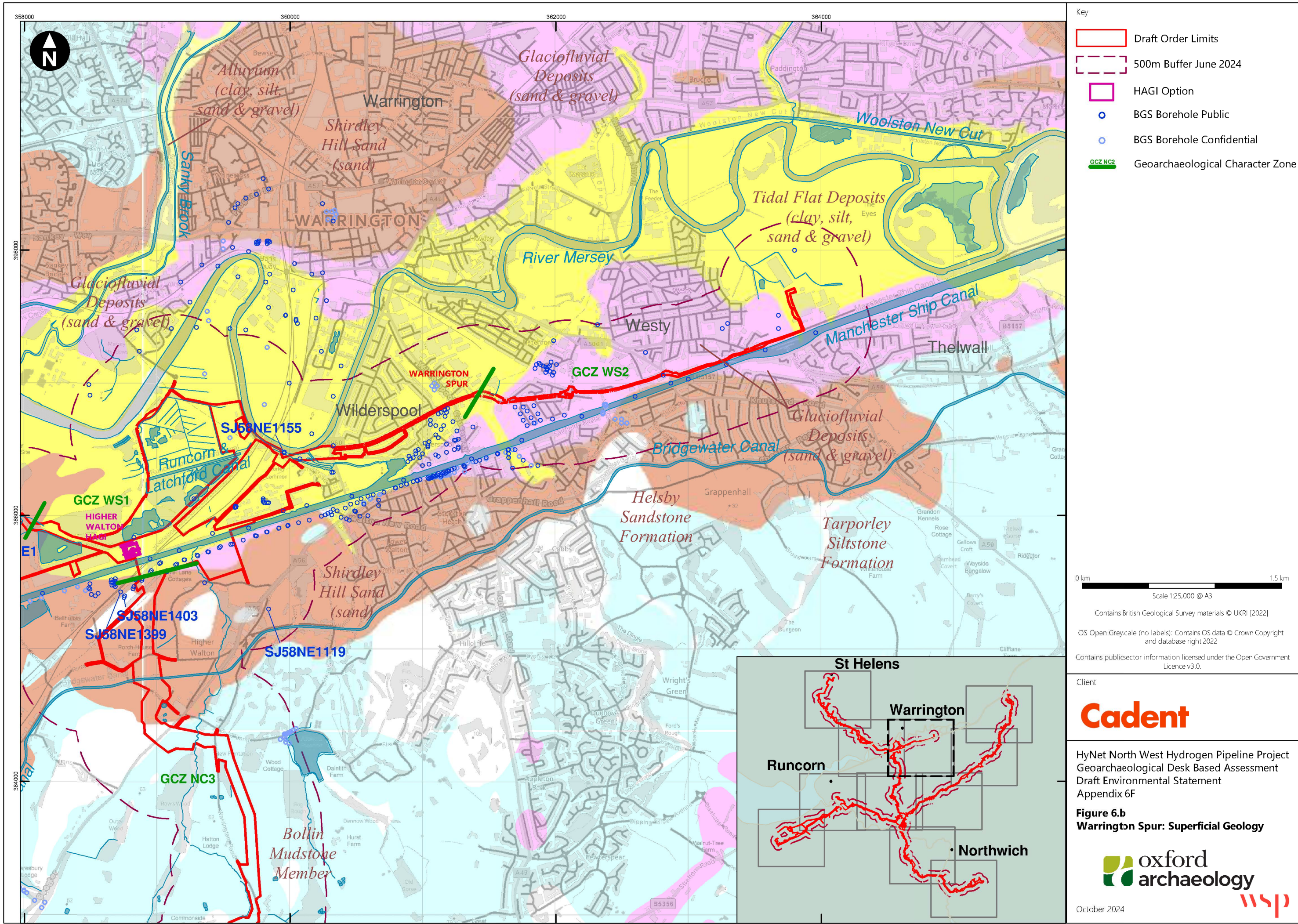




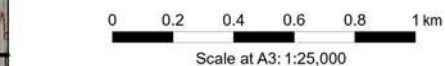
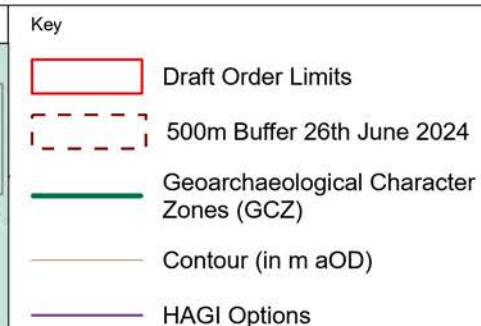
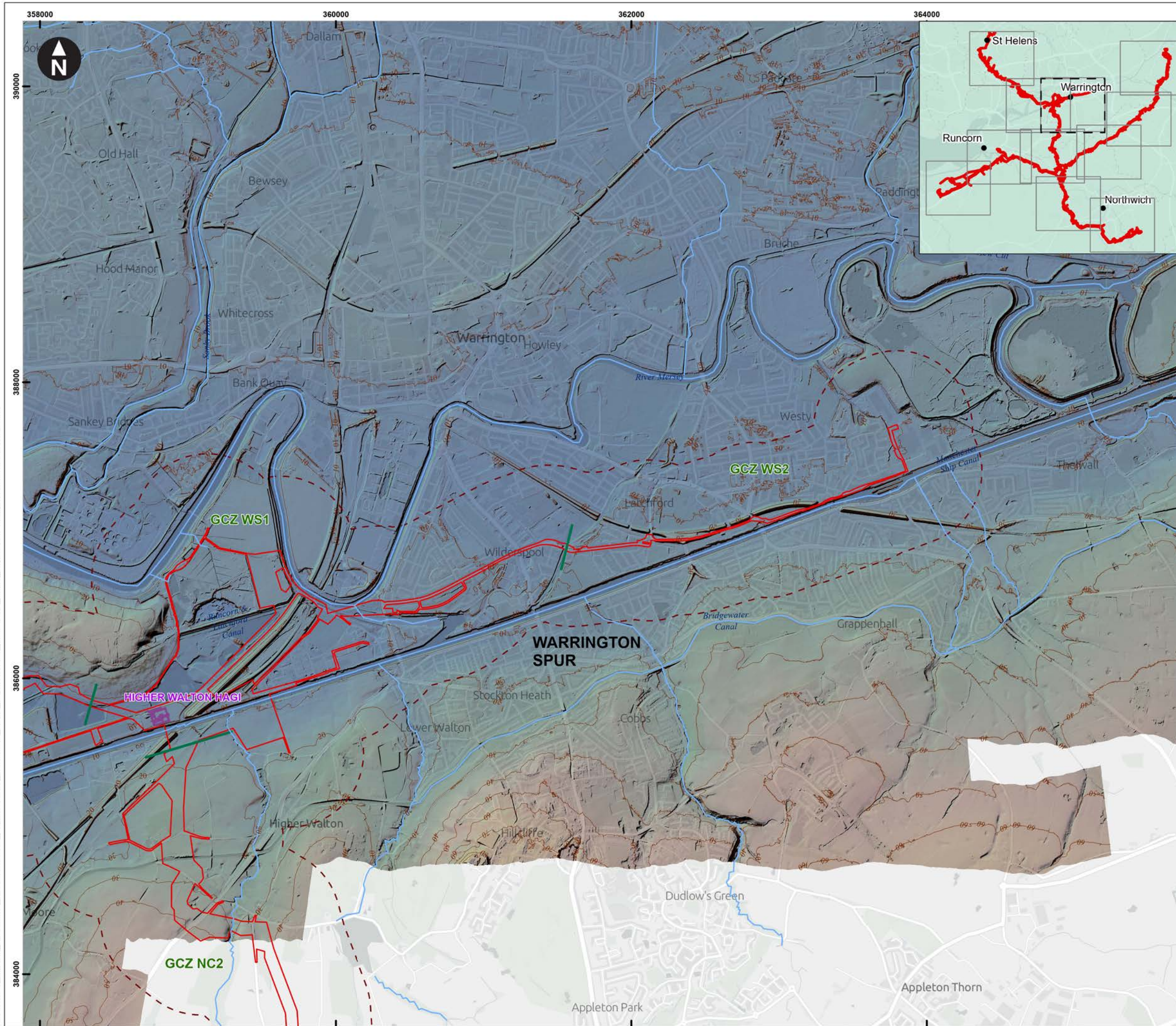








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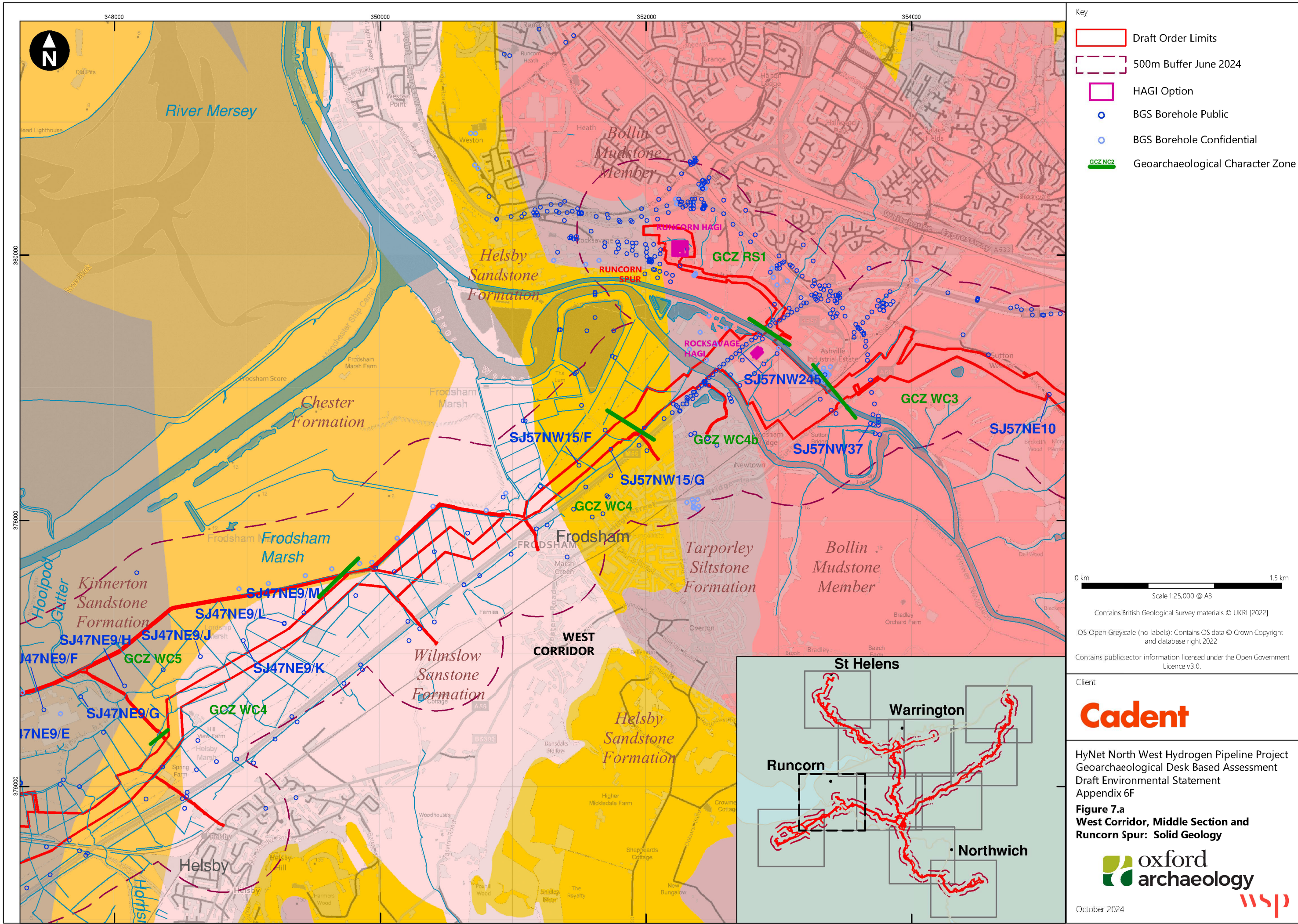
Figure 6.c
Warrington Spur: LiDAR Dital
Terrain Model, illustrating elevation (yellow
and brown are high ground, green and blue are
low) and hillshade (altitude, 45 degrees; vertical
exaggeration, x6; azimuth, 315 degrees

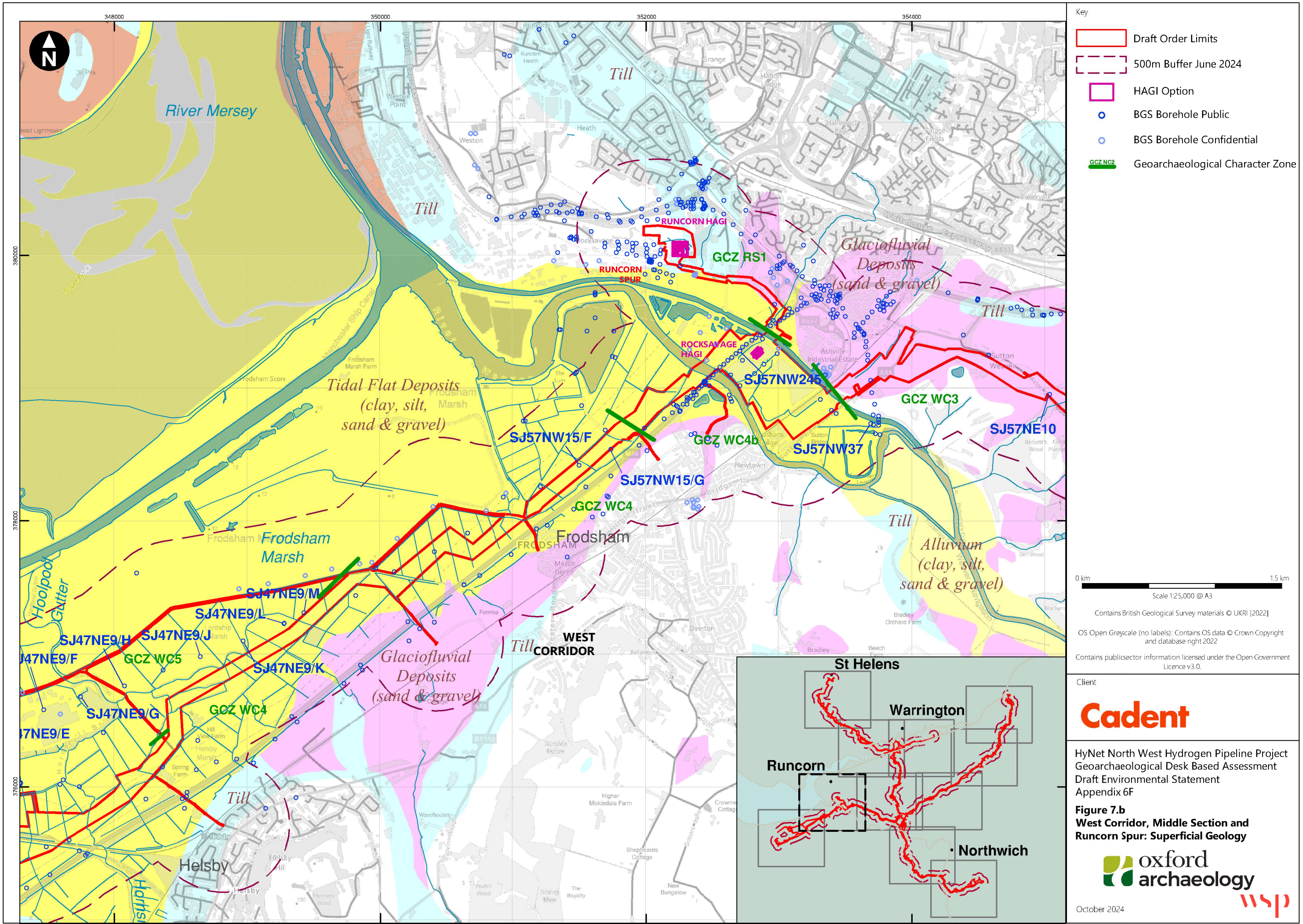
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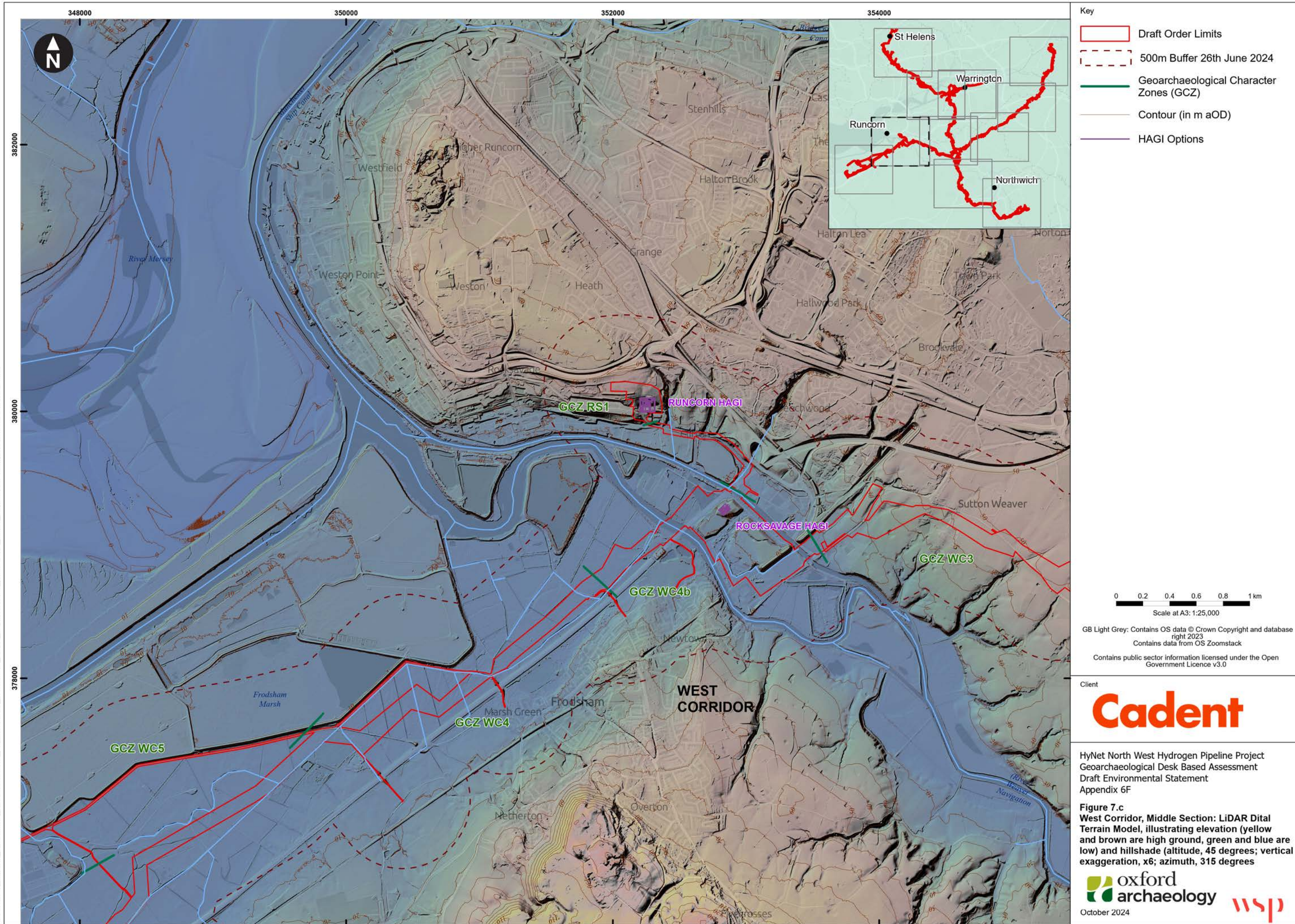
October 2024

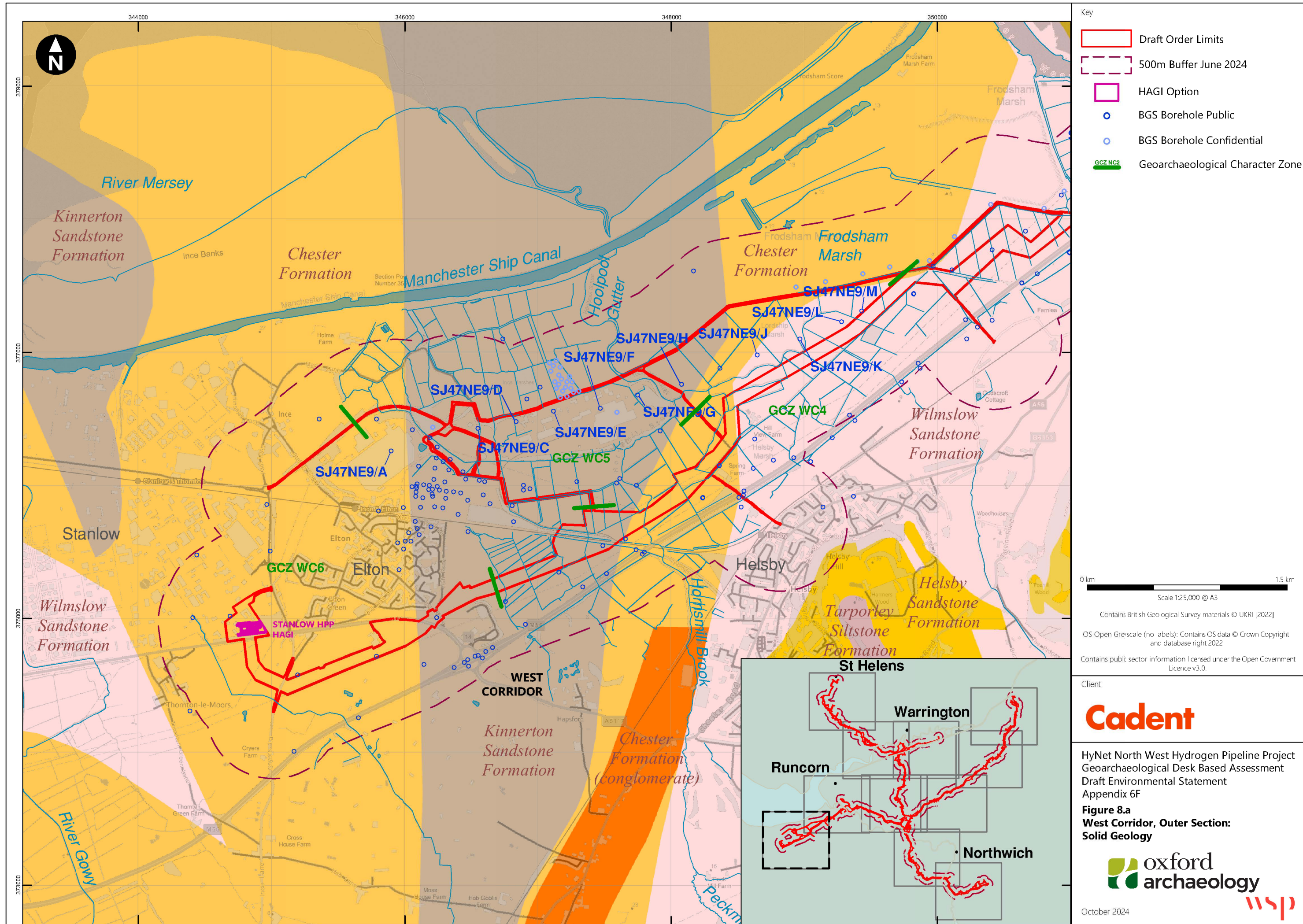
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-  Draft Order Limits
-  500m Buffer June 2024
-  HAGI Option
-  BGS Borehole Public
-  BGS Borehole Confidential
-  Geoarchaeological Character Zone



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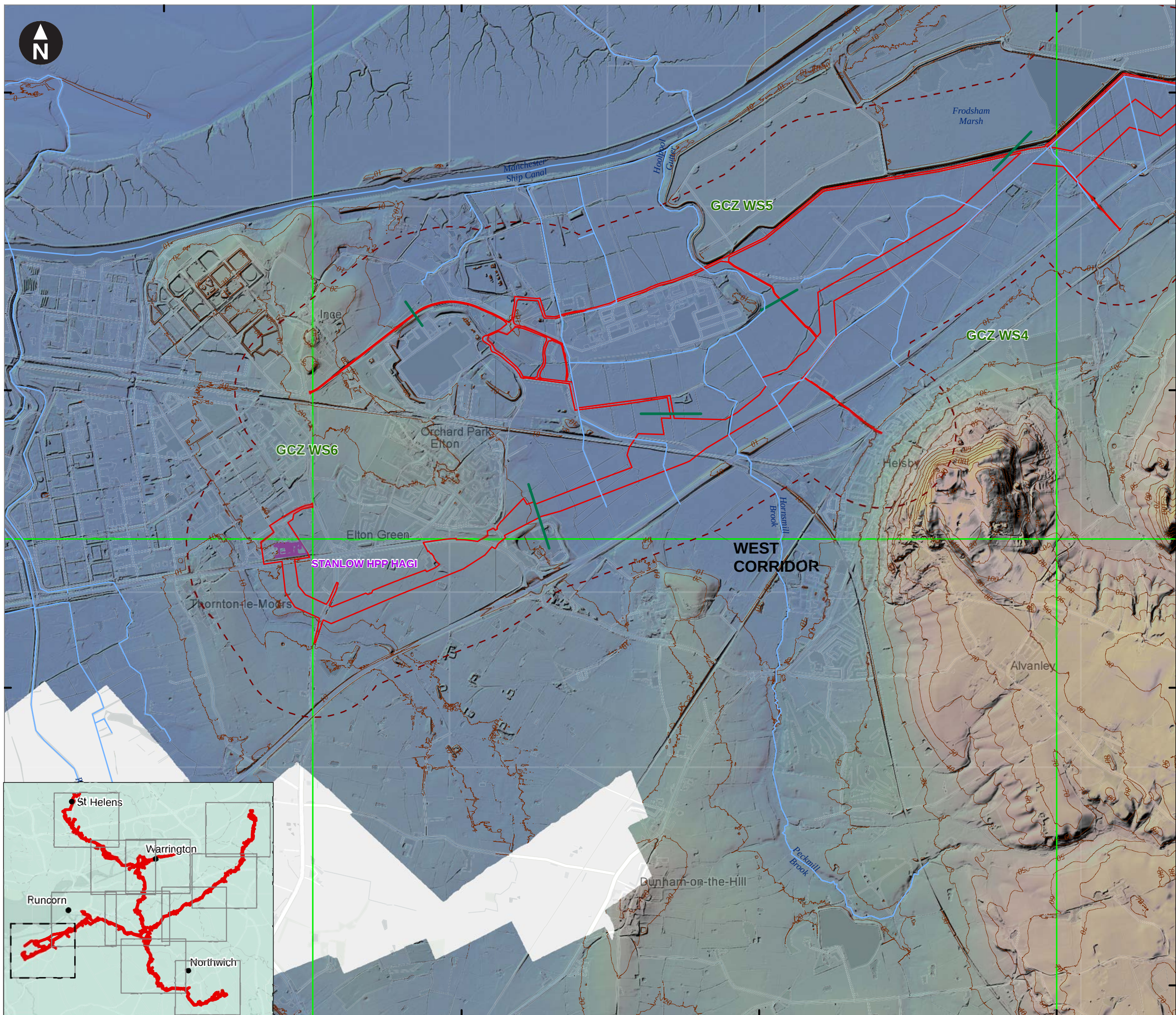
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Figure 8.b
West Corridor, Outer Section:
Superficial Geology



October 2024

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- Key
- Draft Order Limits
 - 500m Buffer 26th June 2024
 - Geoarchaeological Character Zones (GCZ)
 - Contour (in m aOD)
 - HAGI Options

0 0.2 0.4 0.6 0.8 1 km
Scale at A3: 1:25,000

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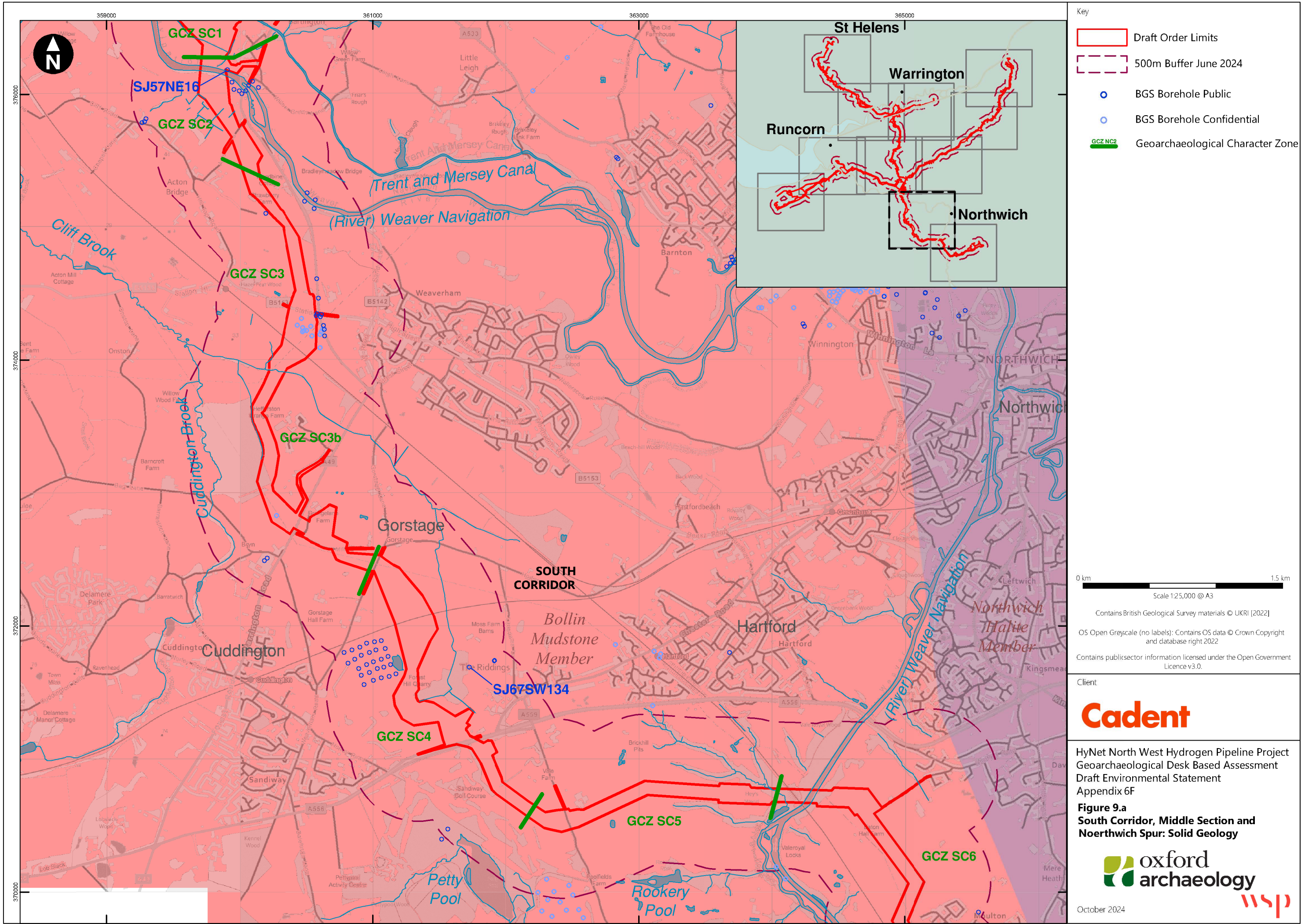
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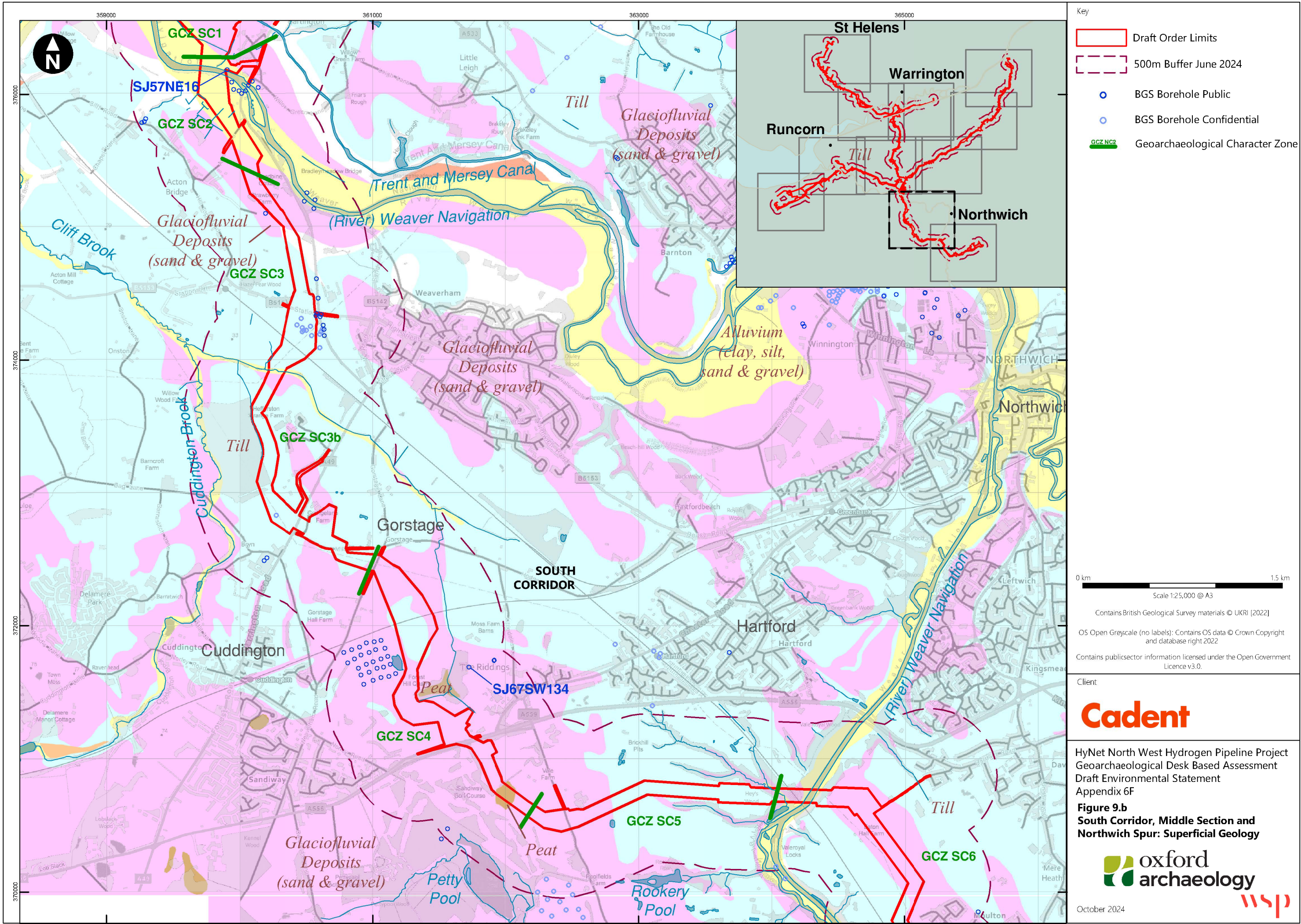
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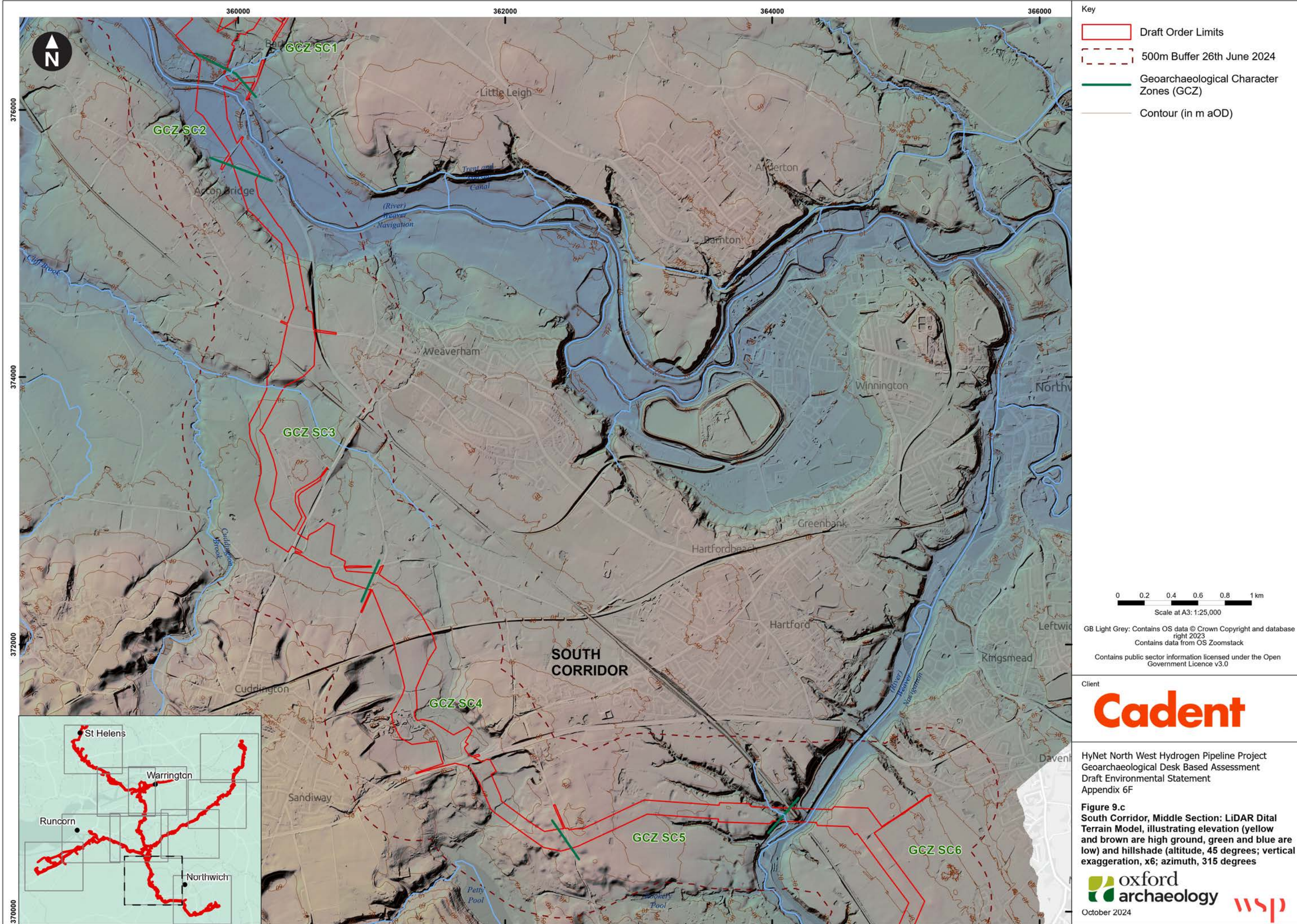
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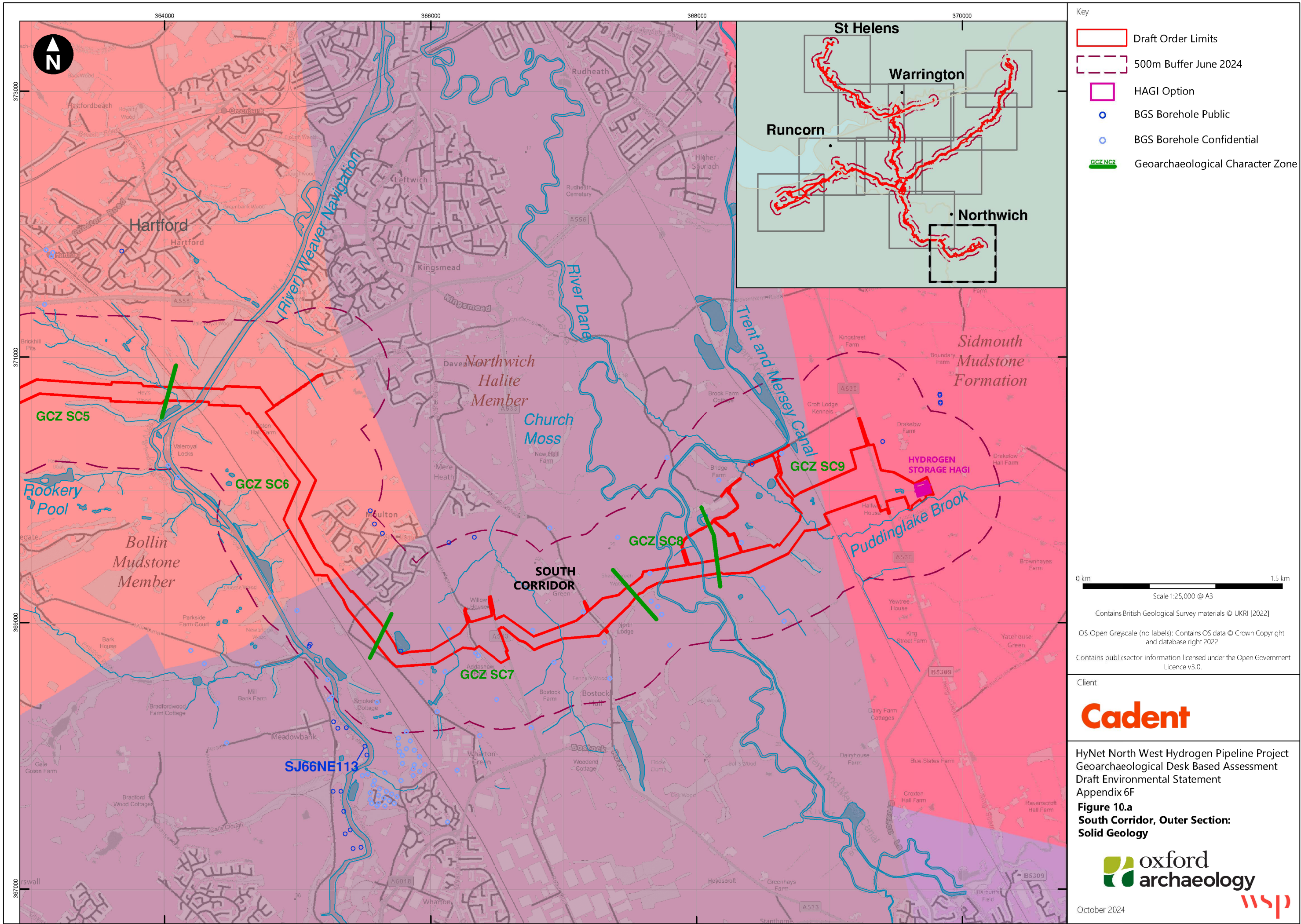
Figure 8.c
West Corridor, Outer Section: LiDAR Dital Terrain Model, illustrating elevation (yellow and brown are high ground, green and blue are low) and hillshade (altitude, 45 degrees; vertical exaggeration, x6; azimuth, 315 degrees)

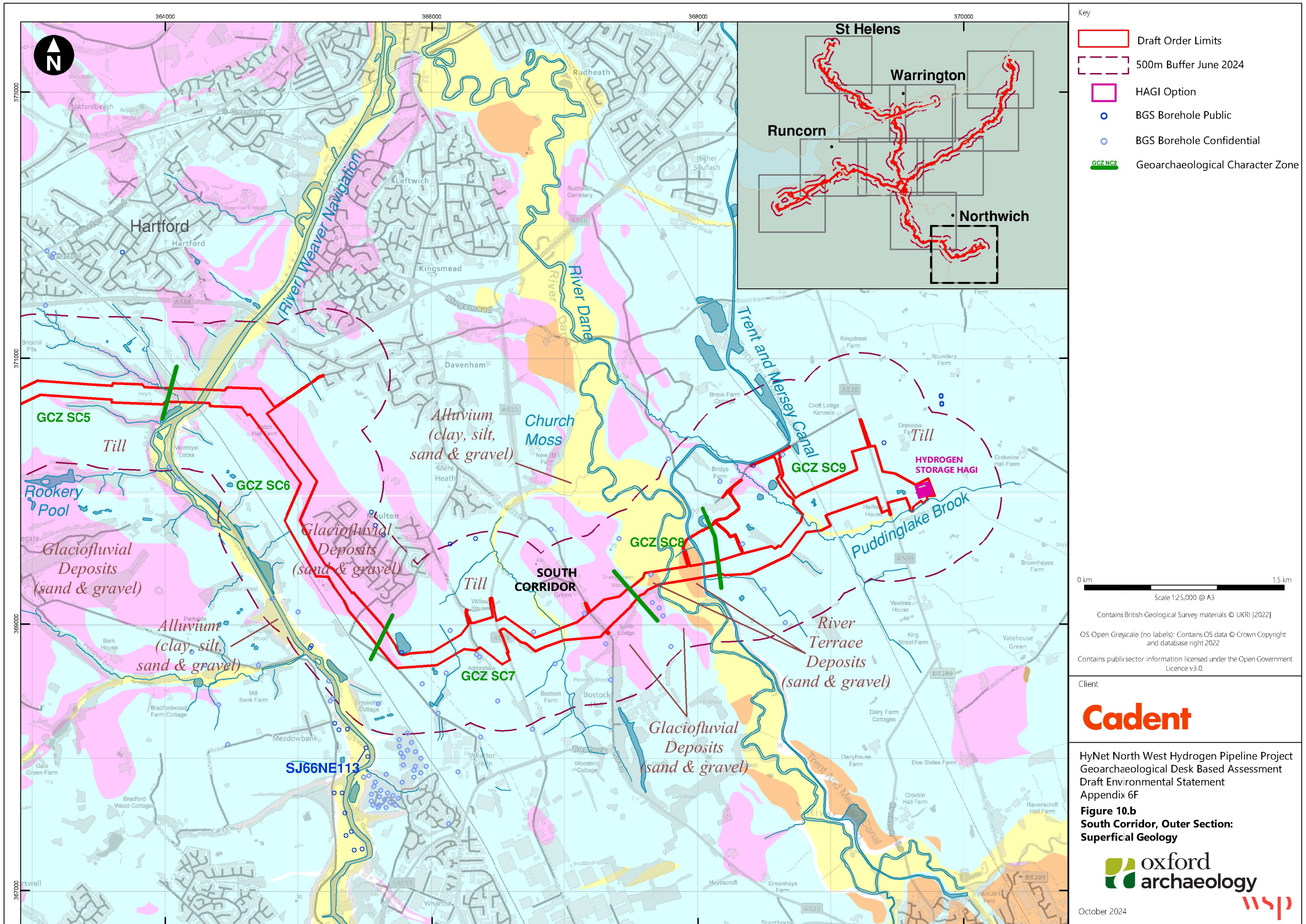




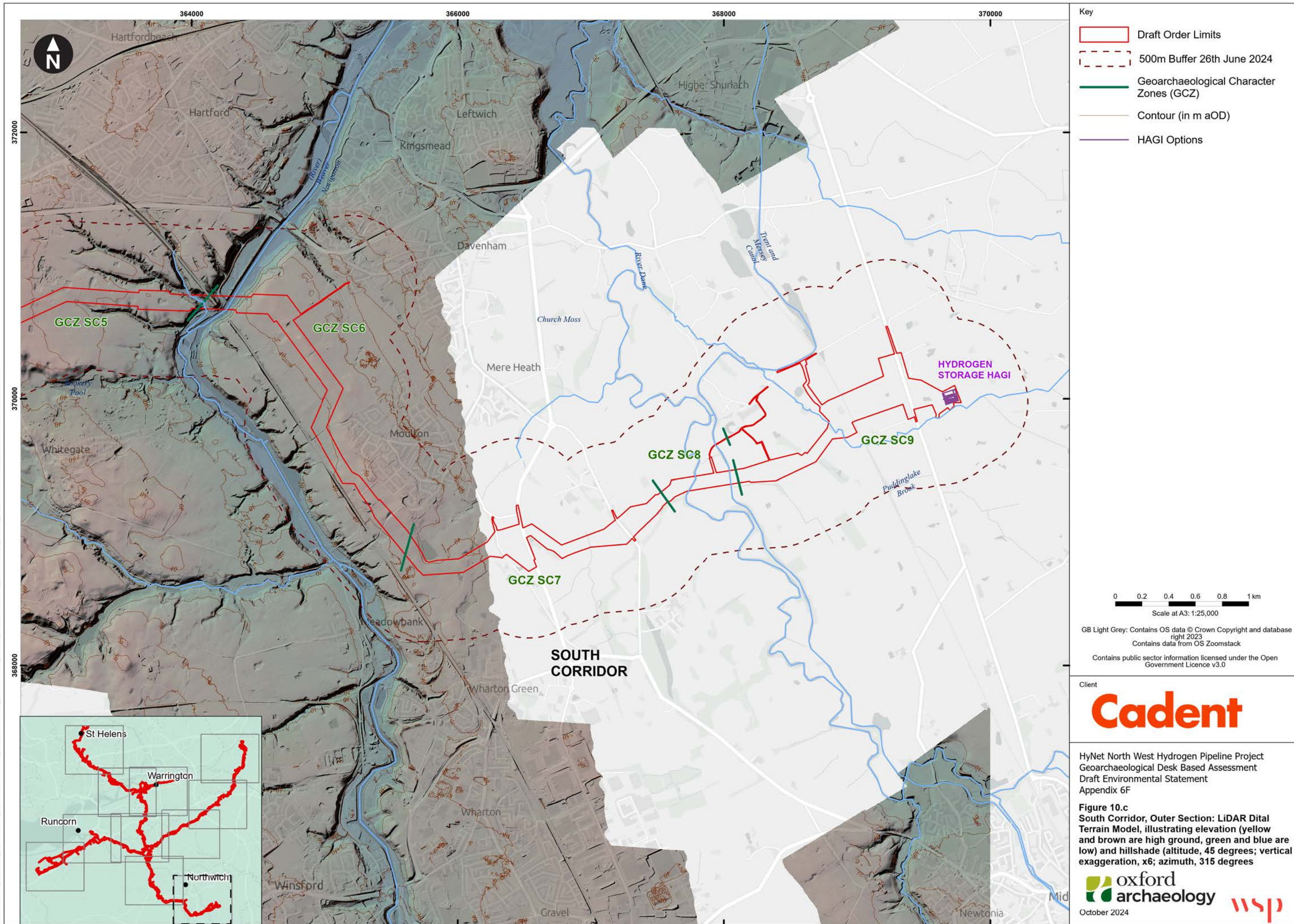
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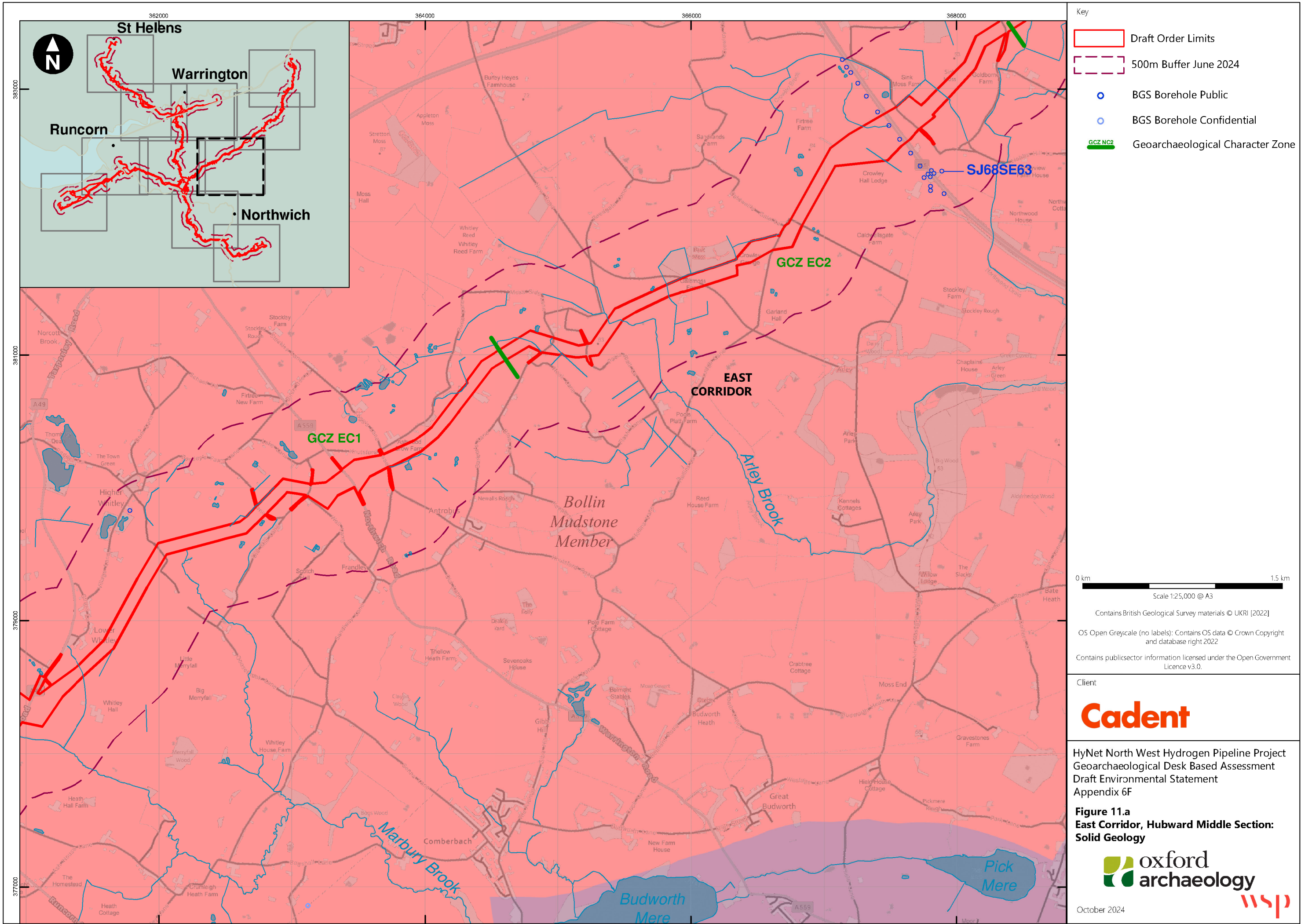


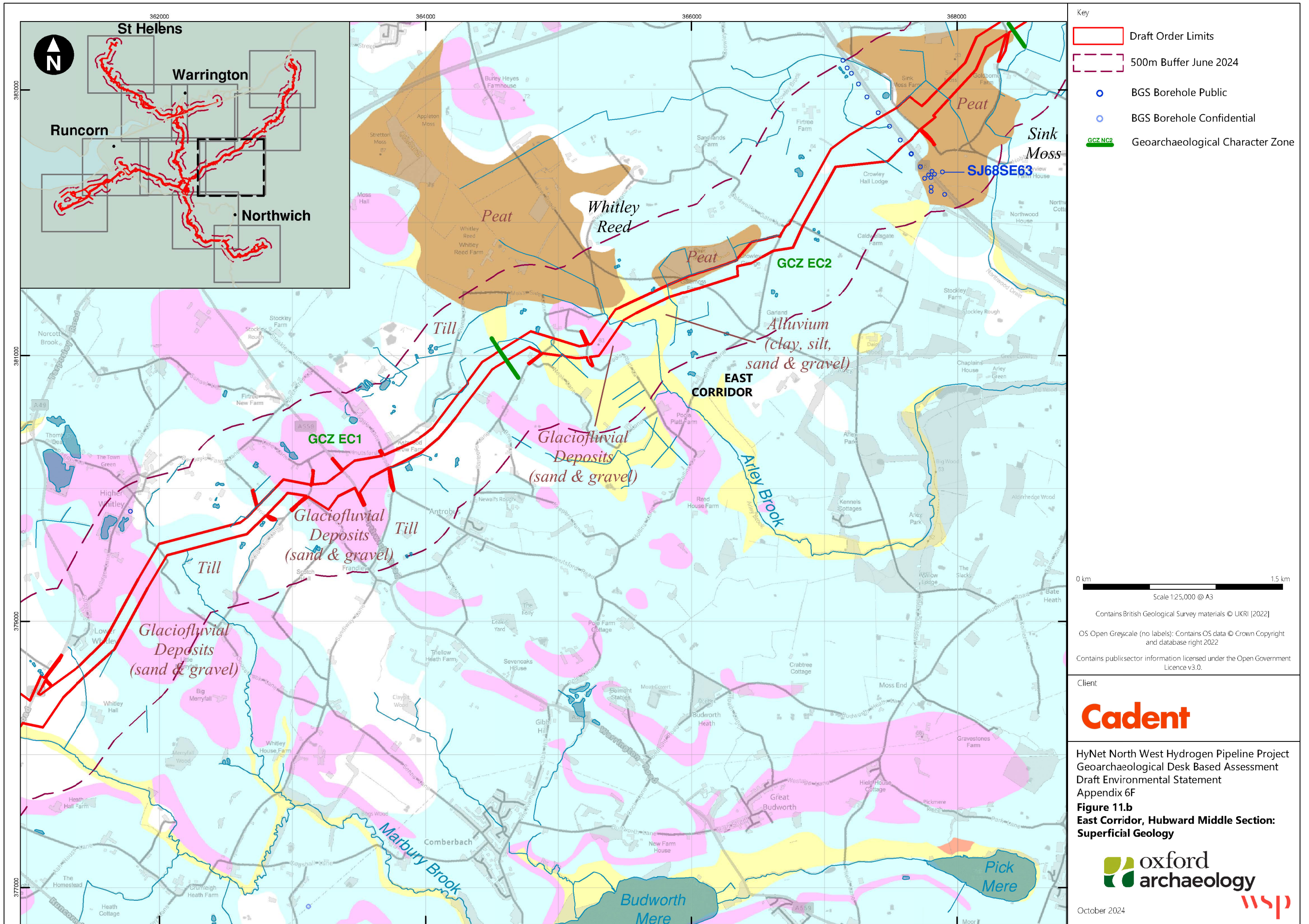




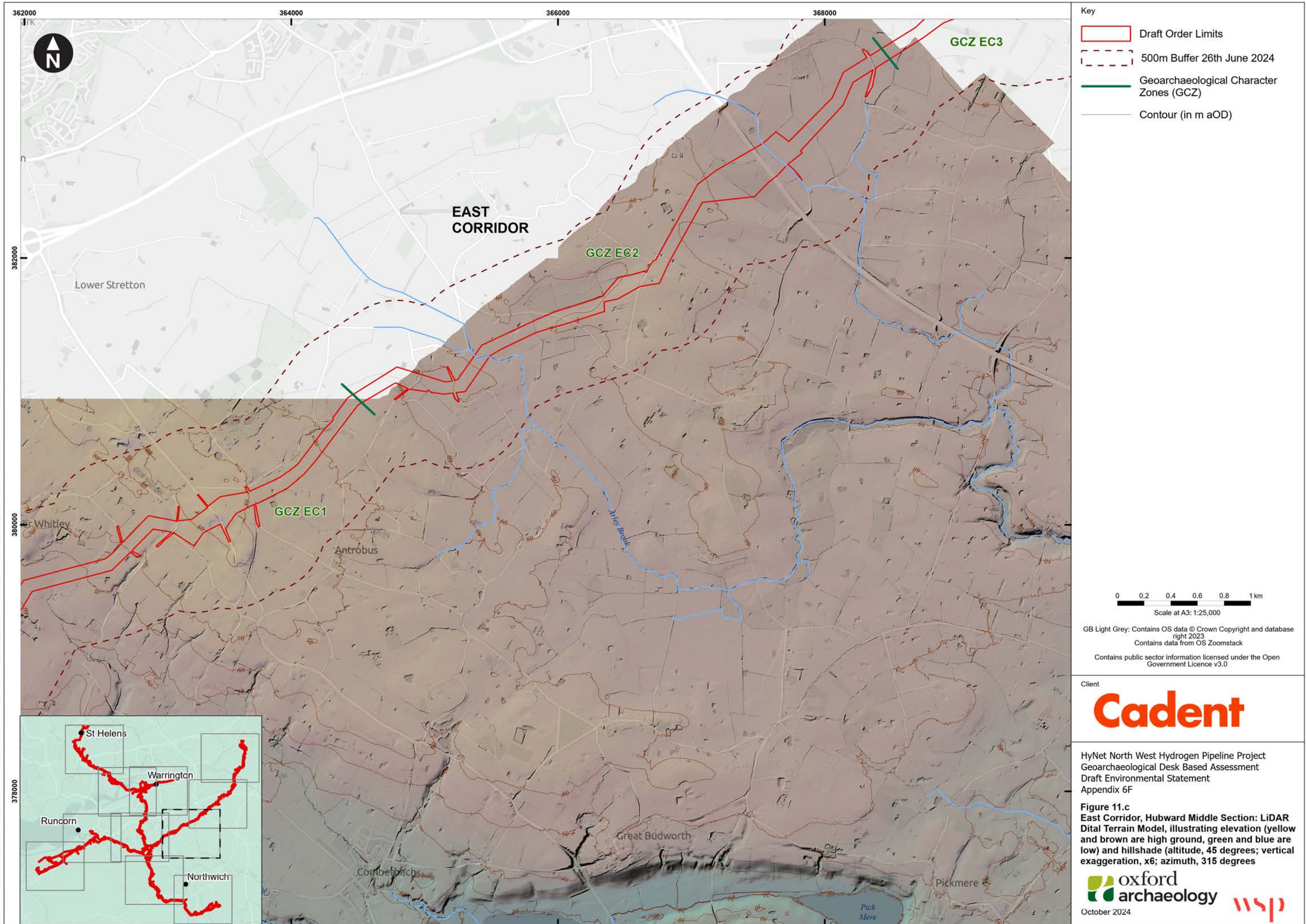
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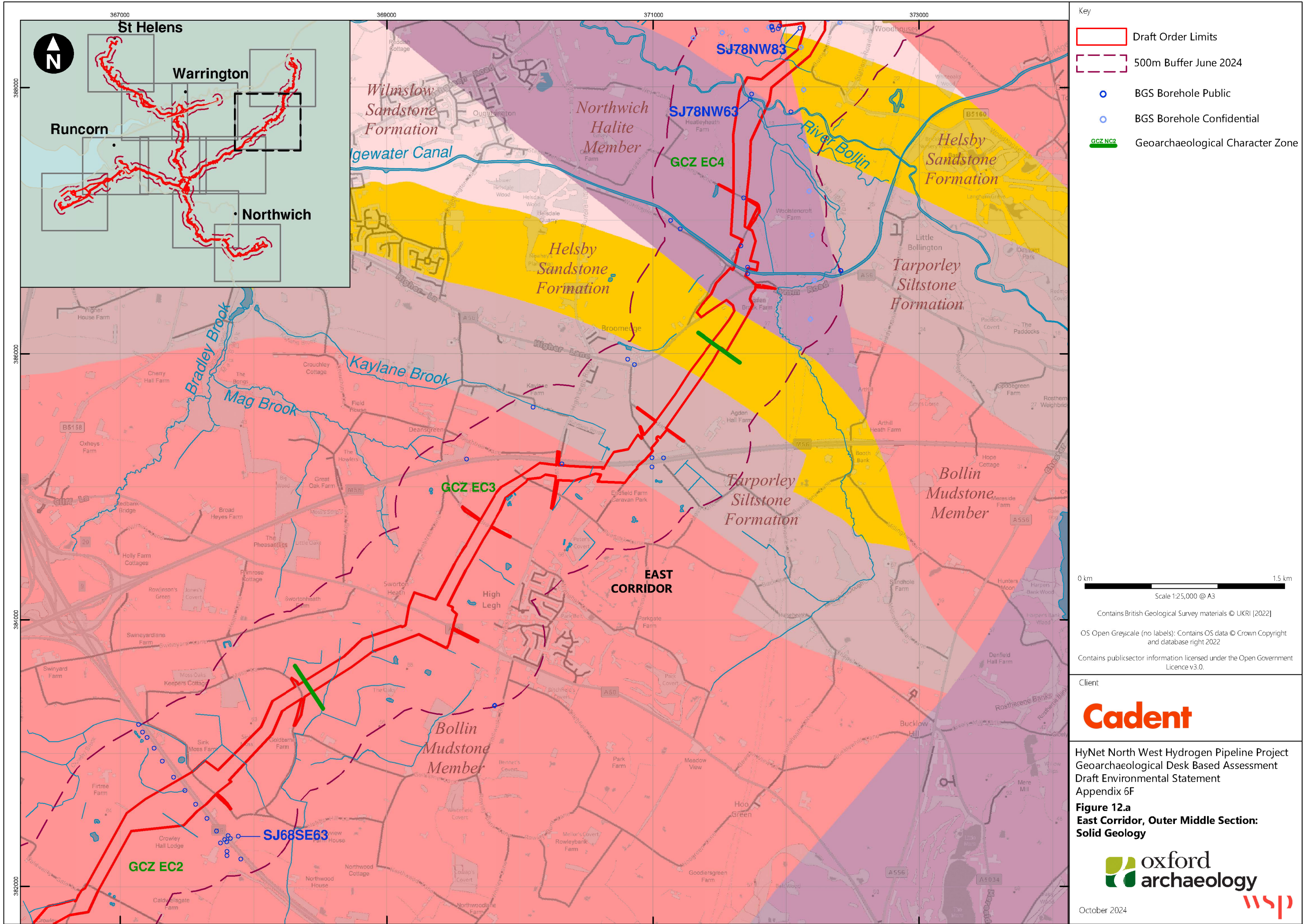


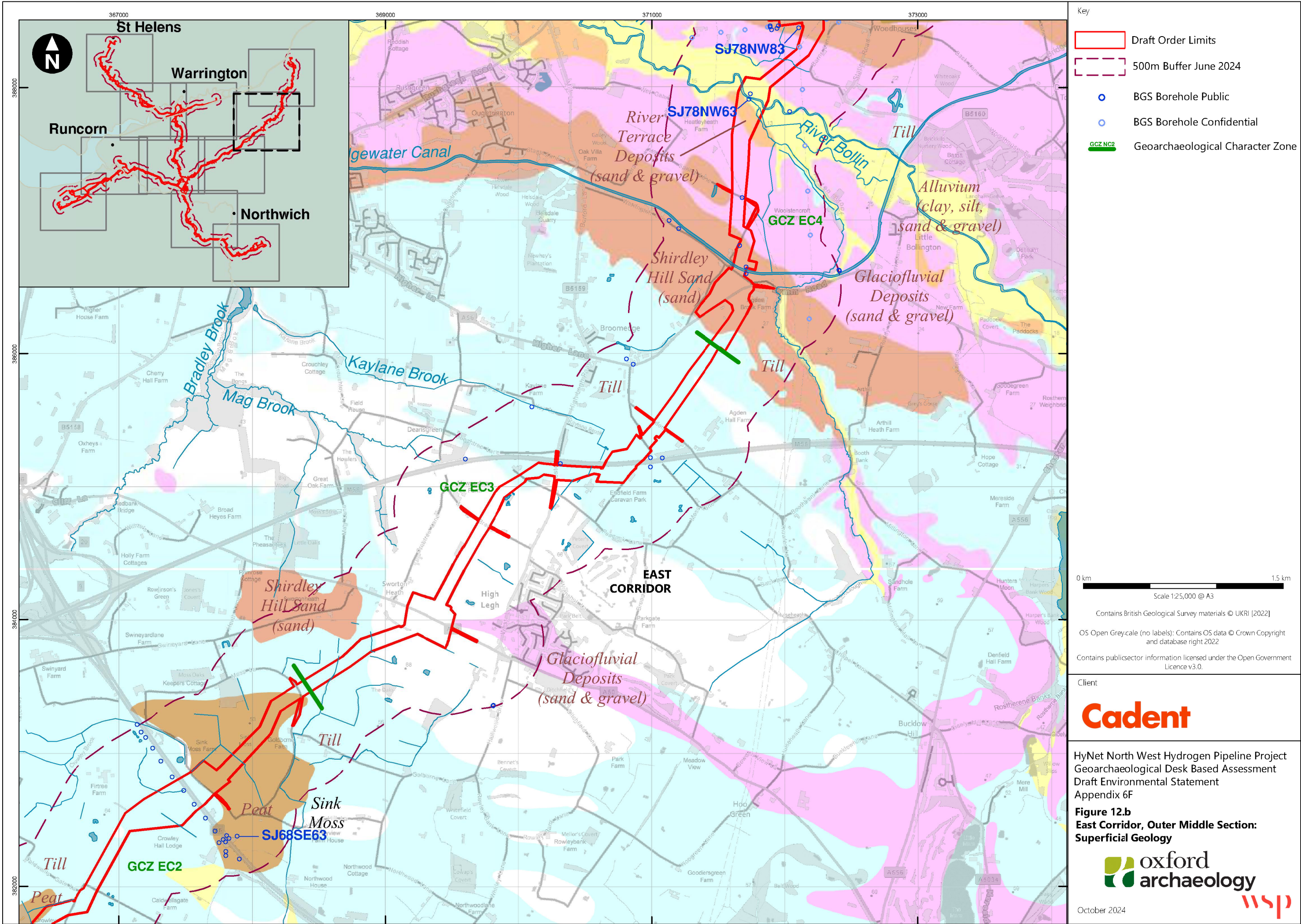




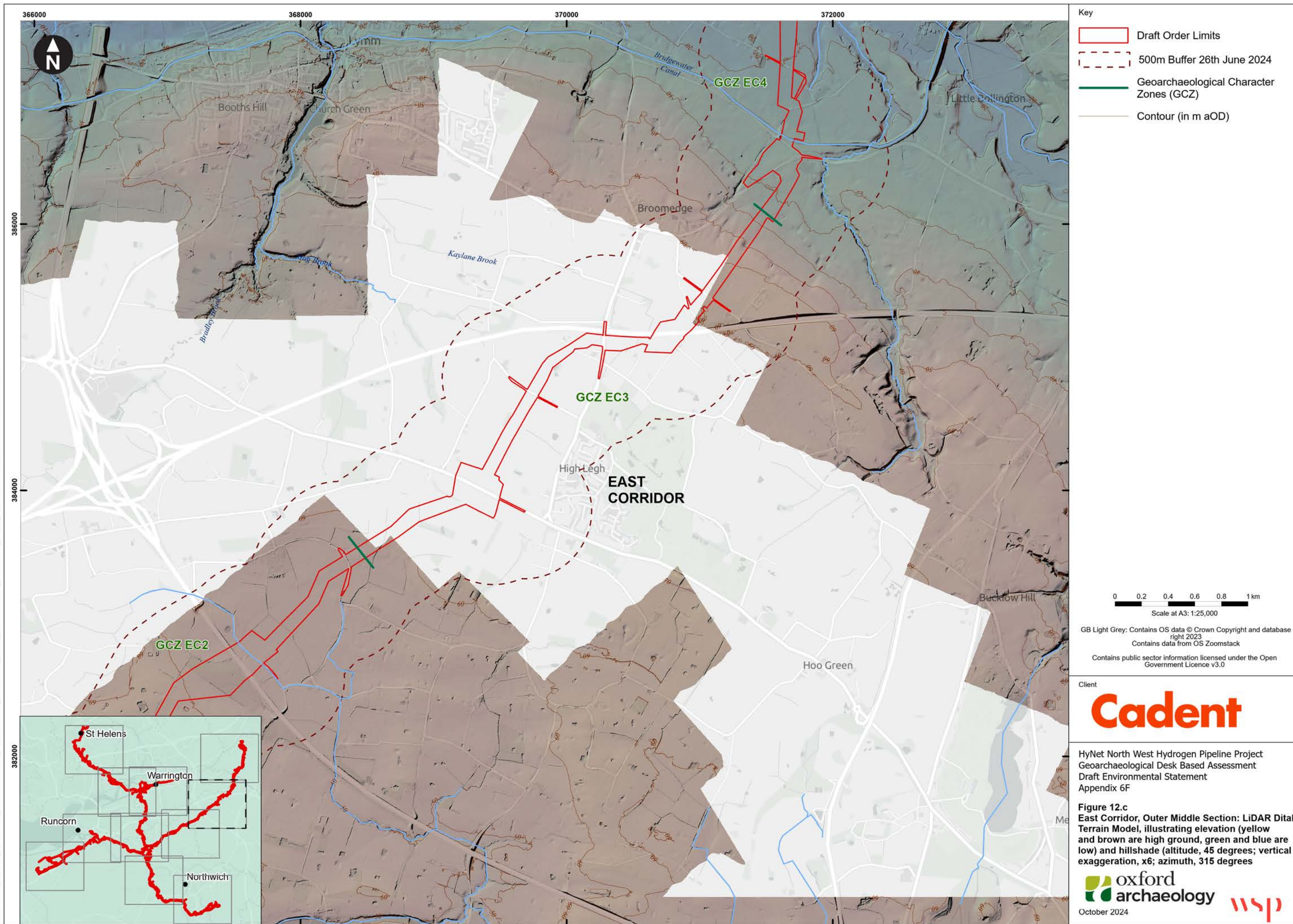
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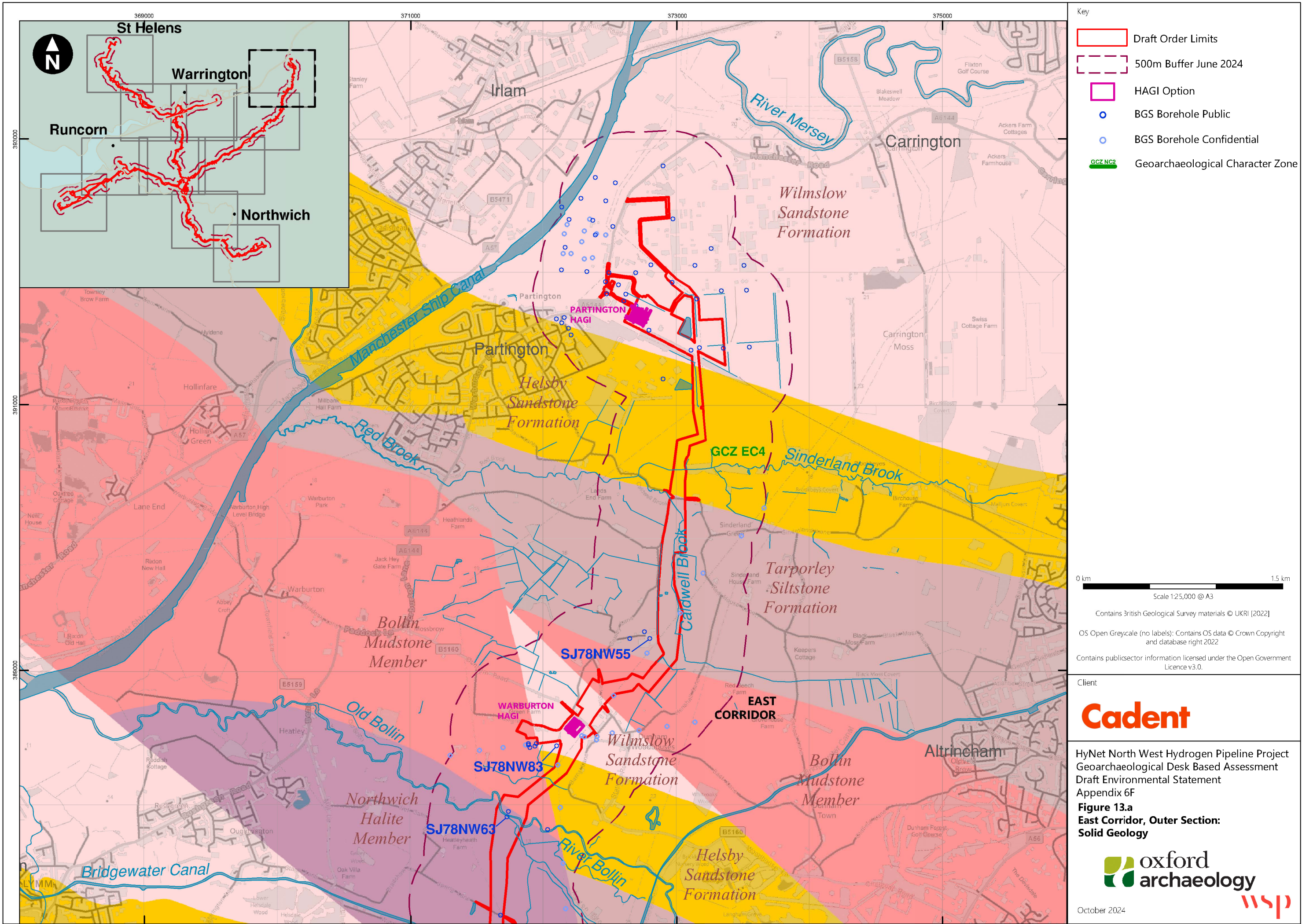


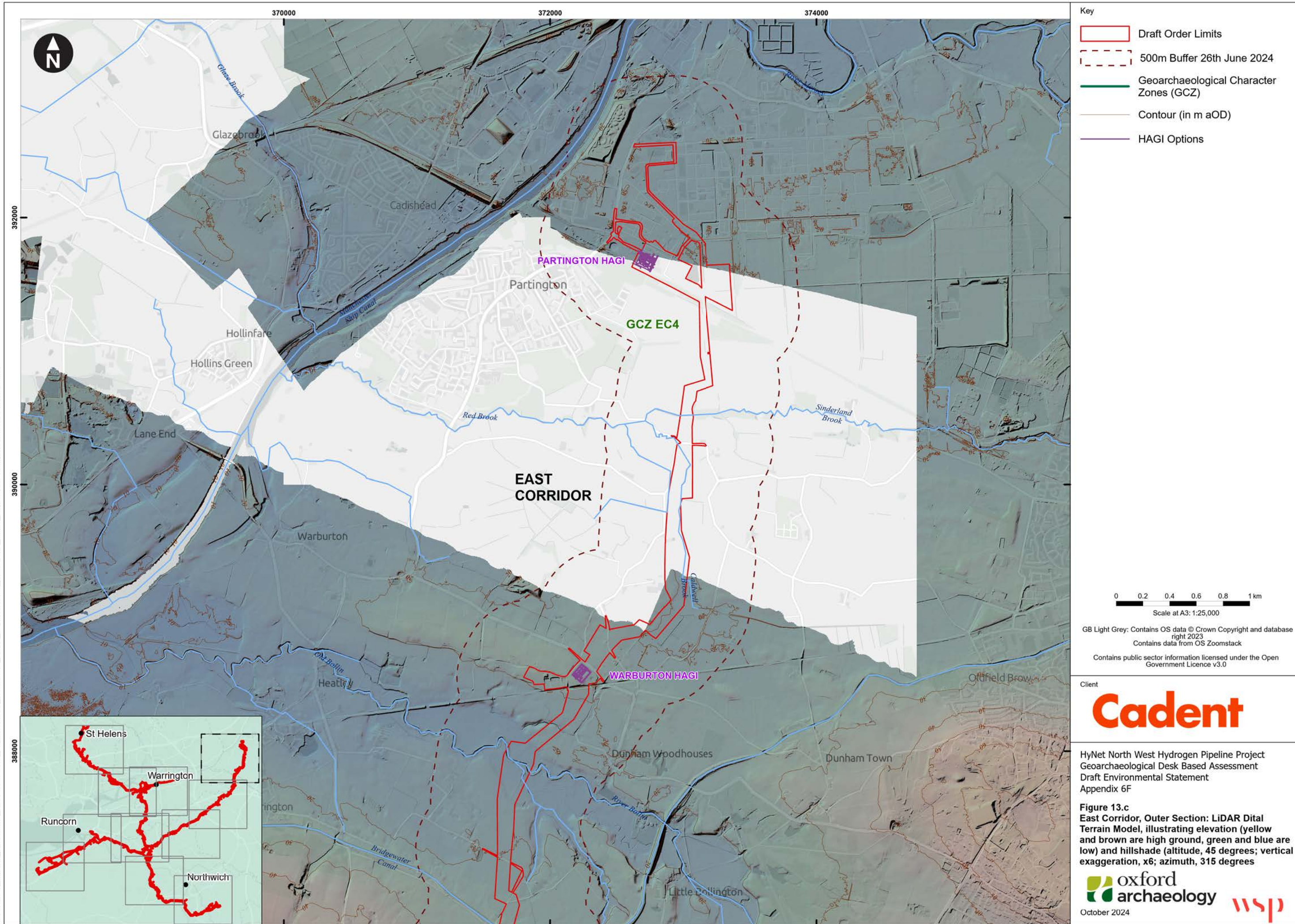




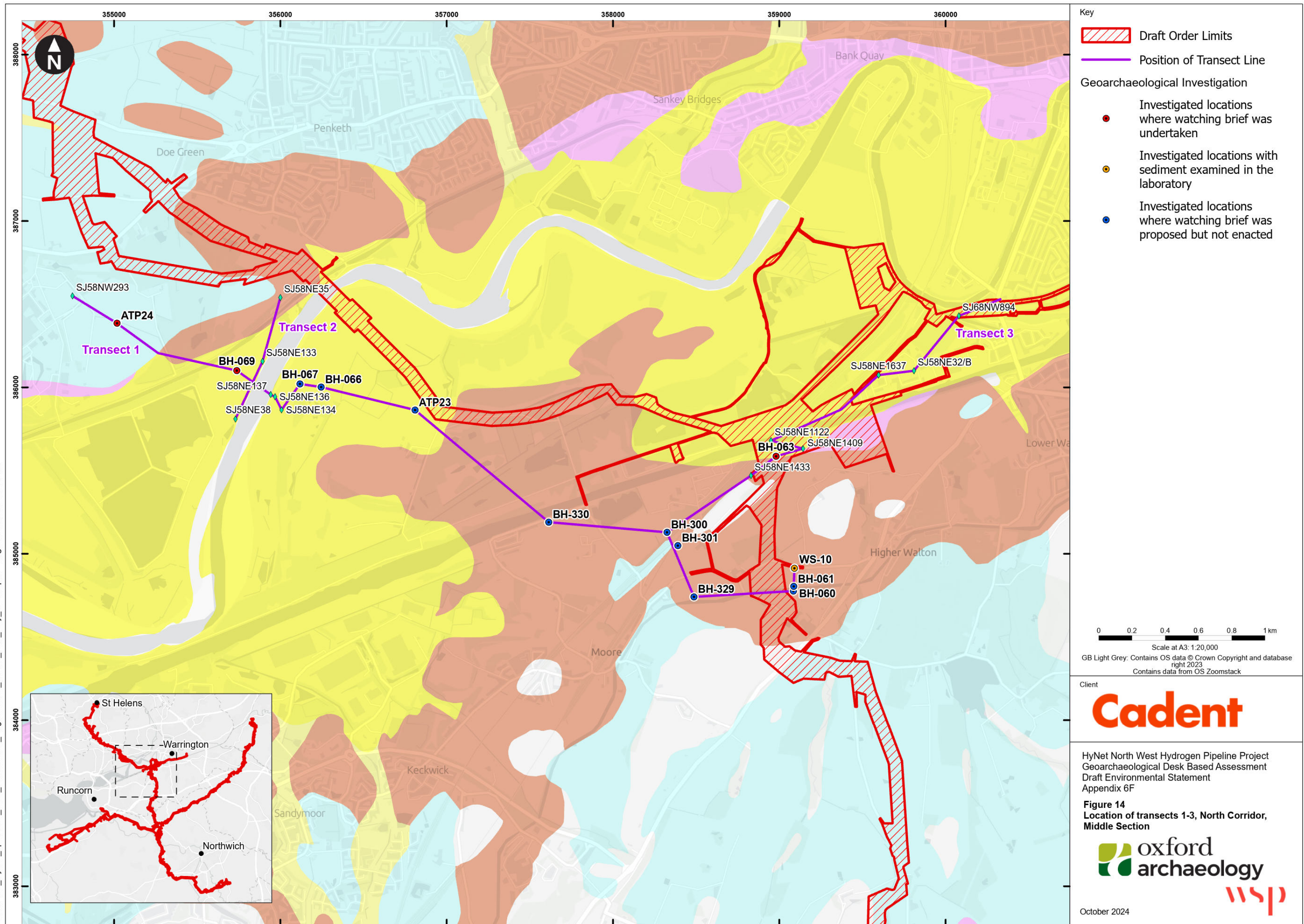
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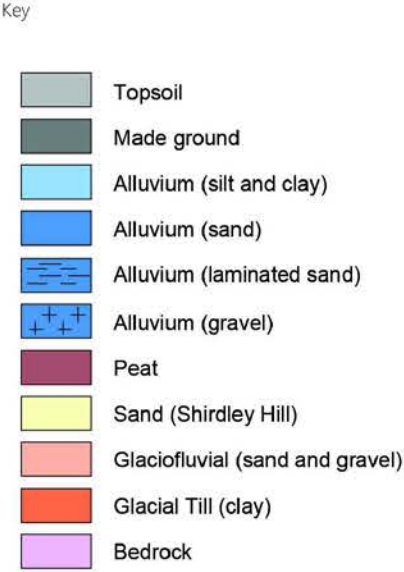






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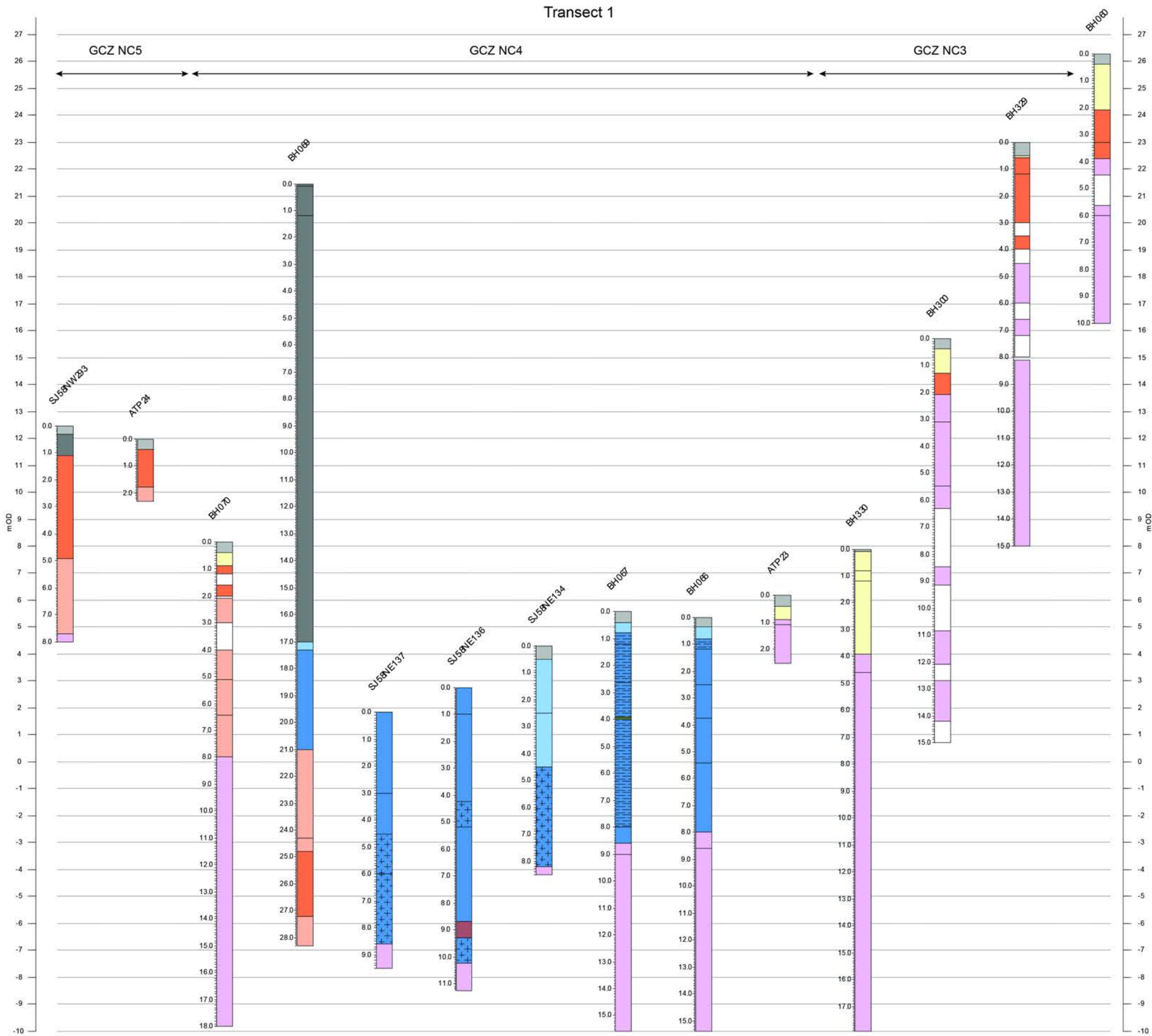
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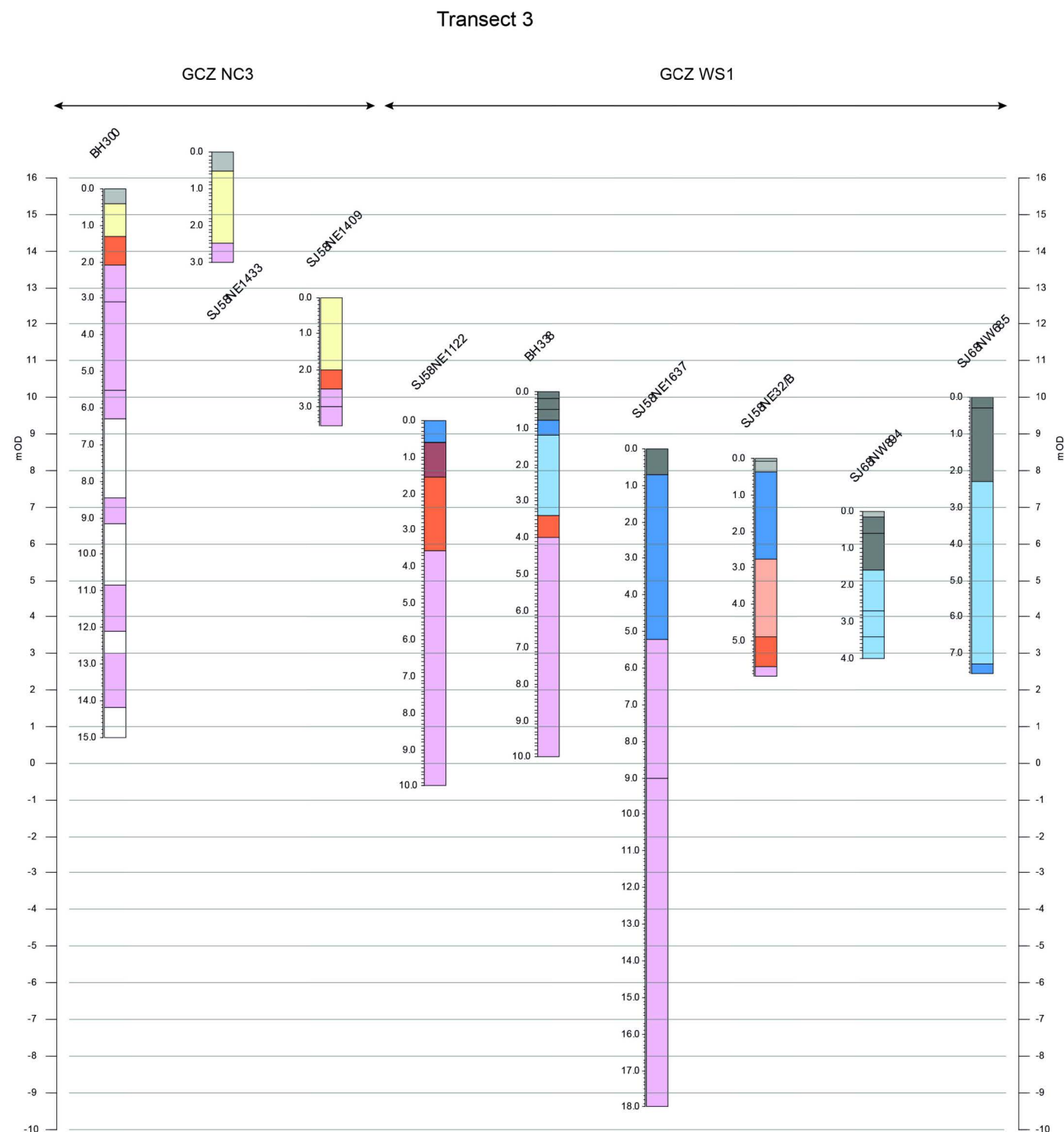
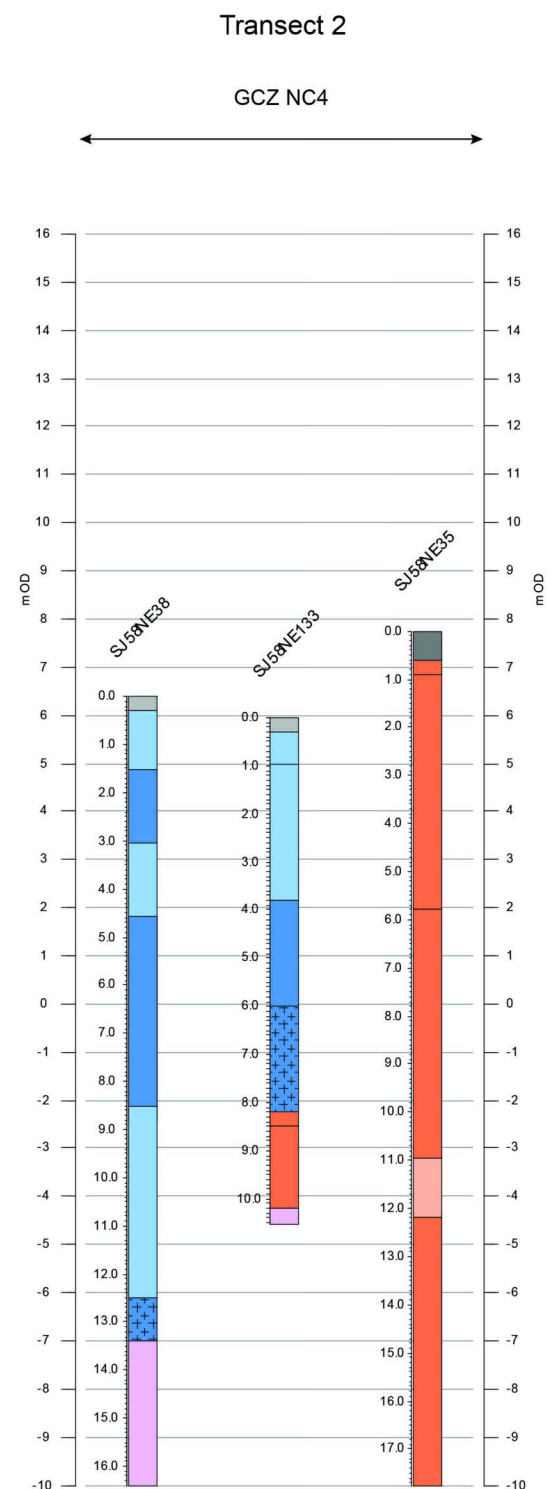
Figure 15
Transect 1 borehole profiles

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August 2024





Key

- Topsoil
- Made ground
- Alluvium (silt and clay)
- Alluvium (sand)
- Alluvium (gravel)
- Peat
- Sand (Shirdley Hill)
- Glaciofluvial (sand and gravel)
- Glacial Till (clay)
- Bedrock

Client

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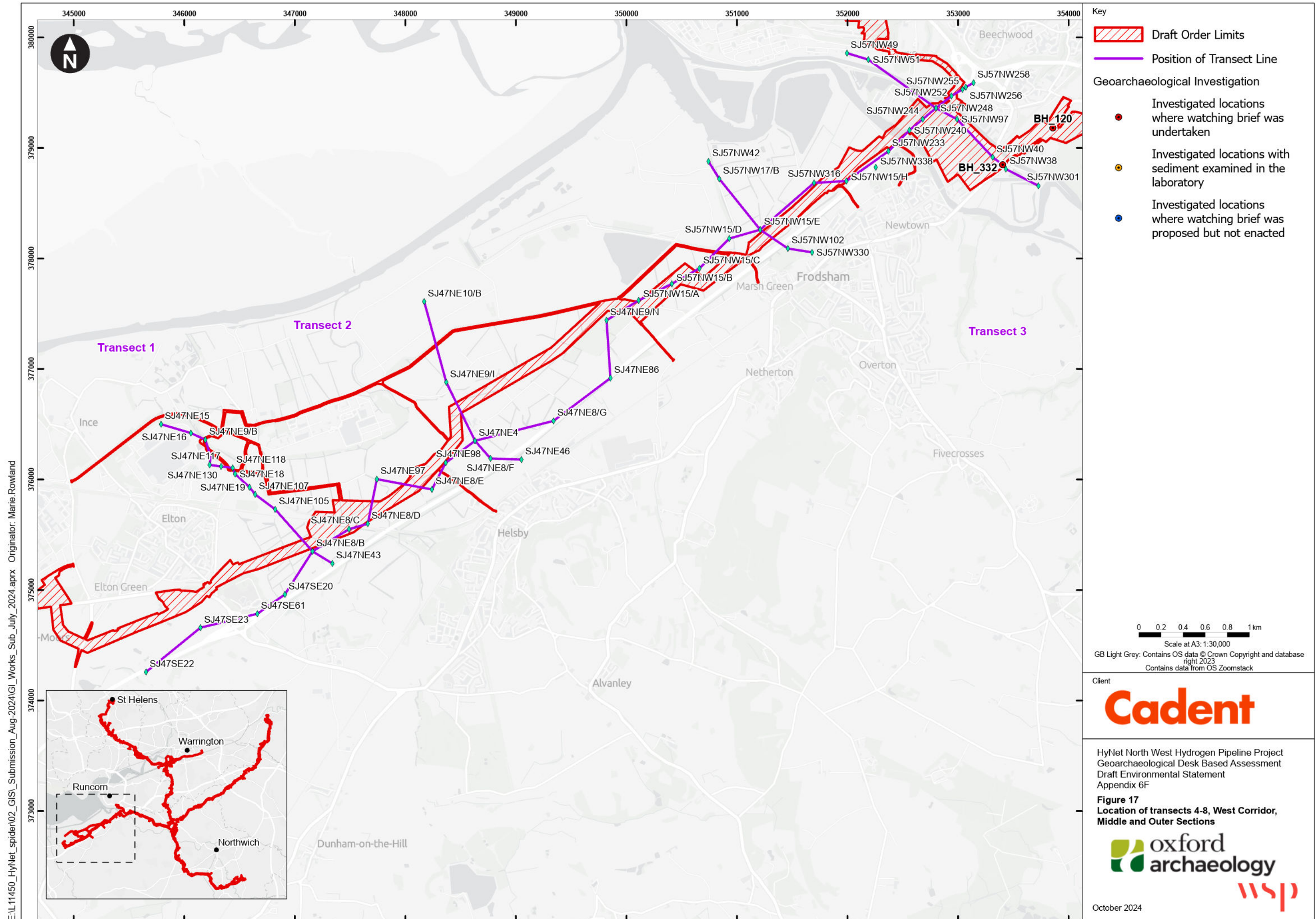
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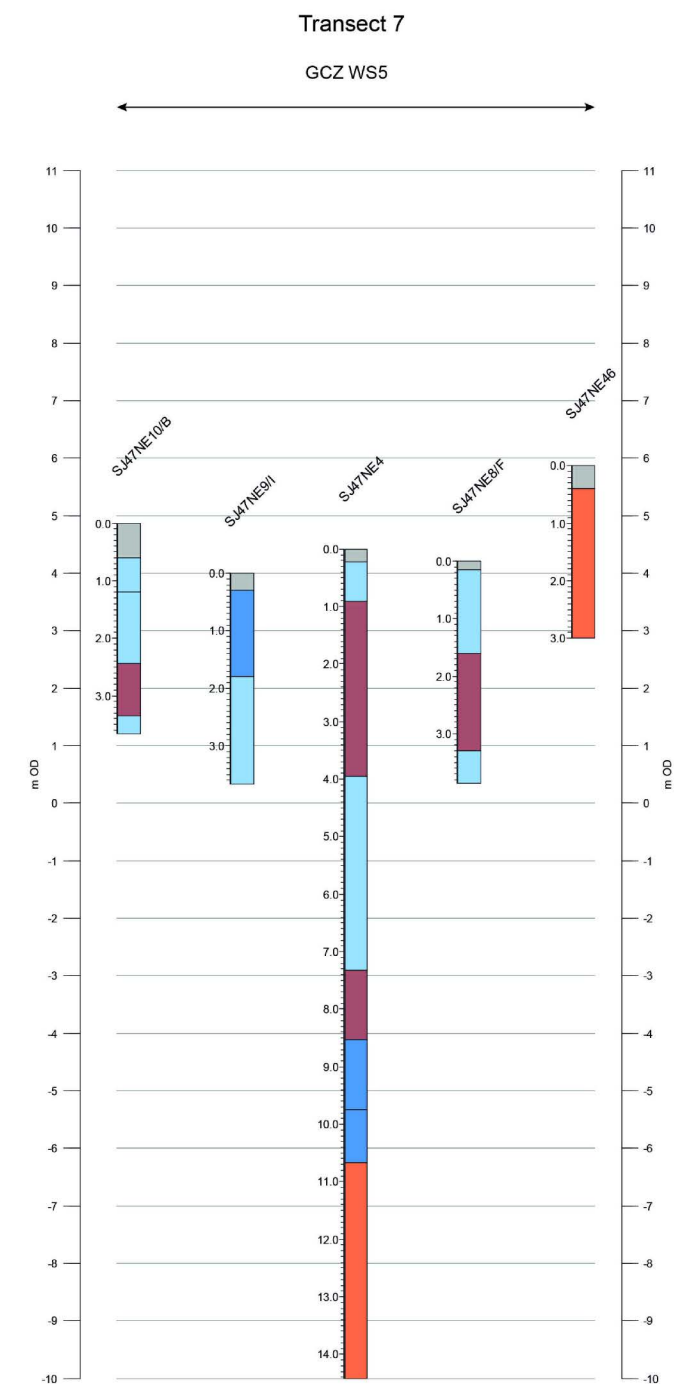
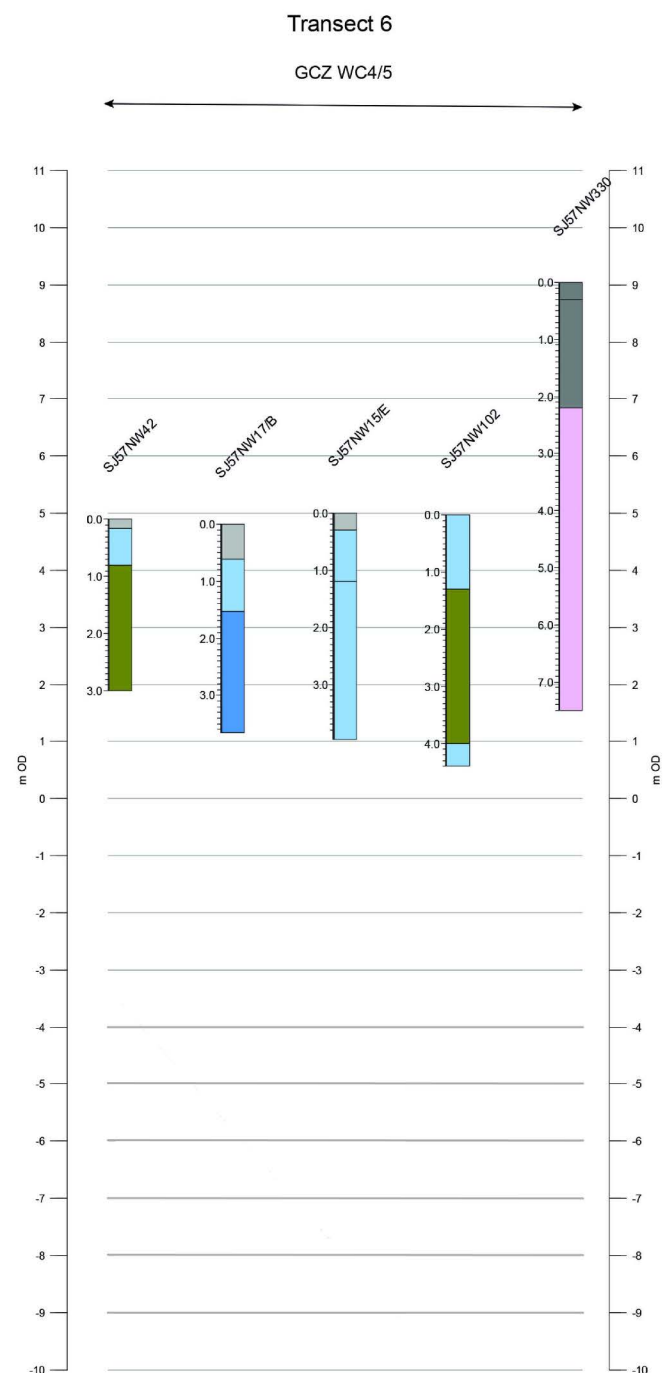
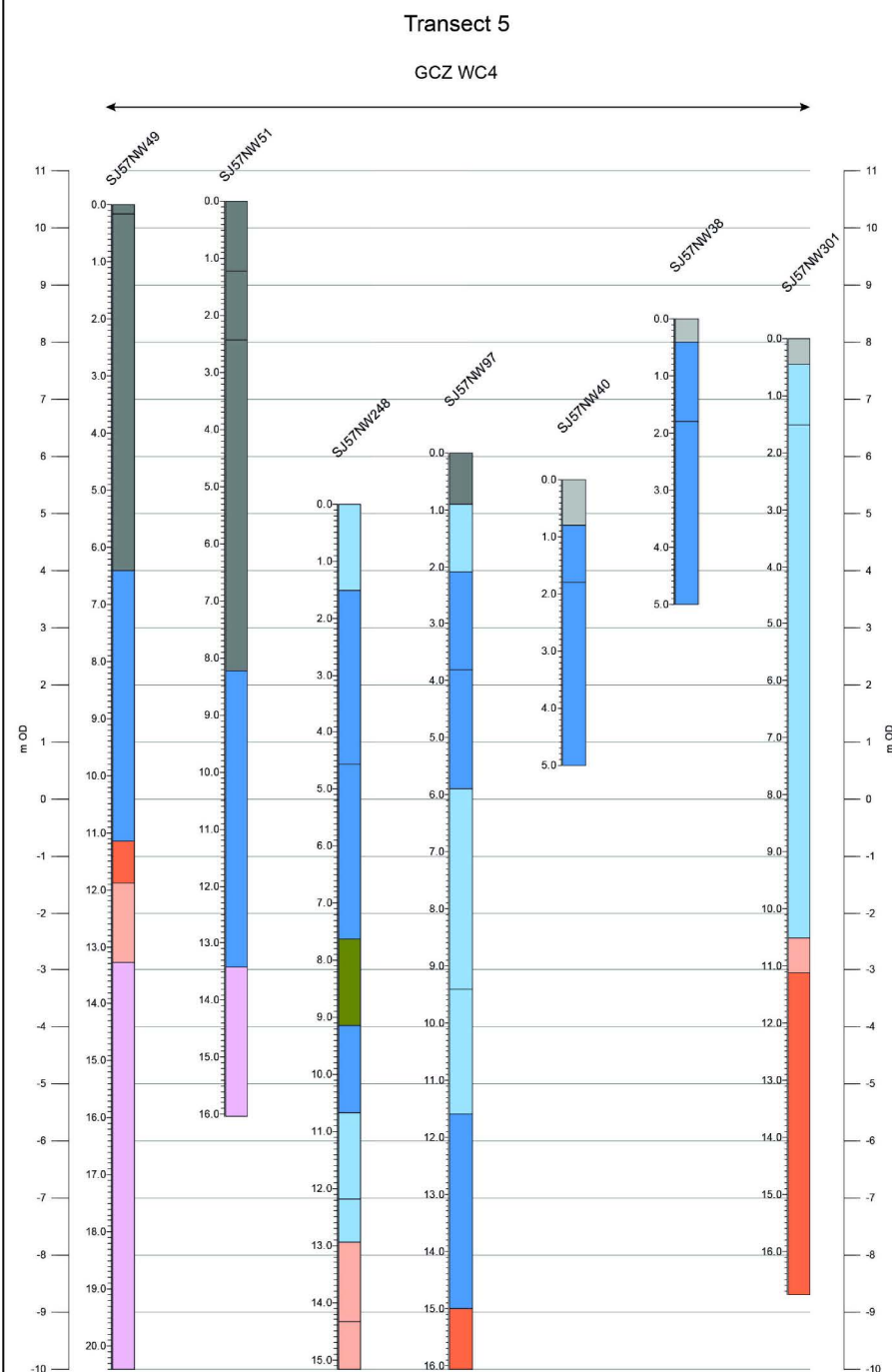
Figure 16
Transects 2 and 3 borehole profiles

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archaeology

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Key



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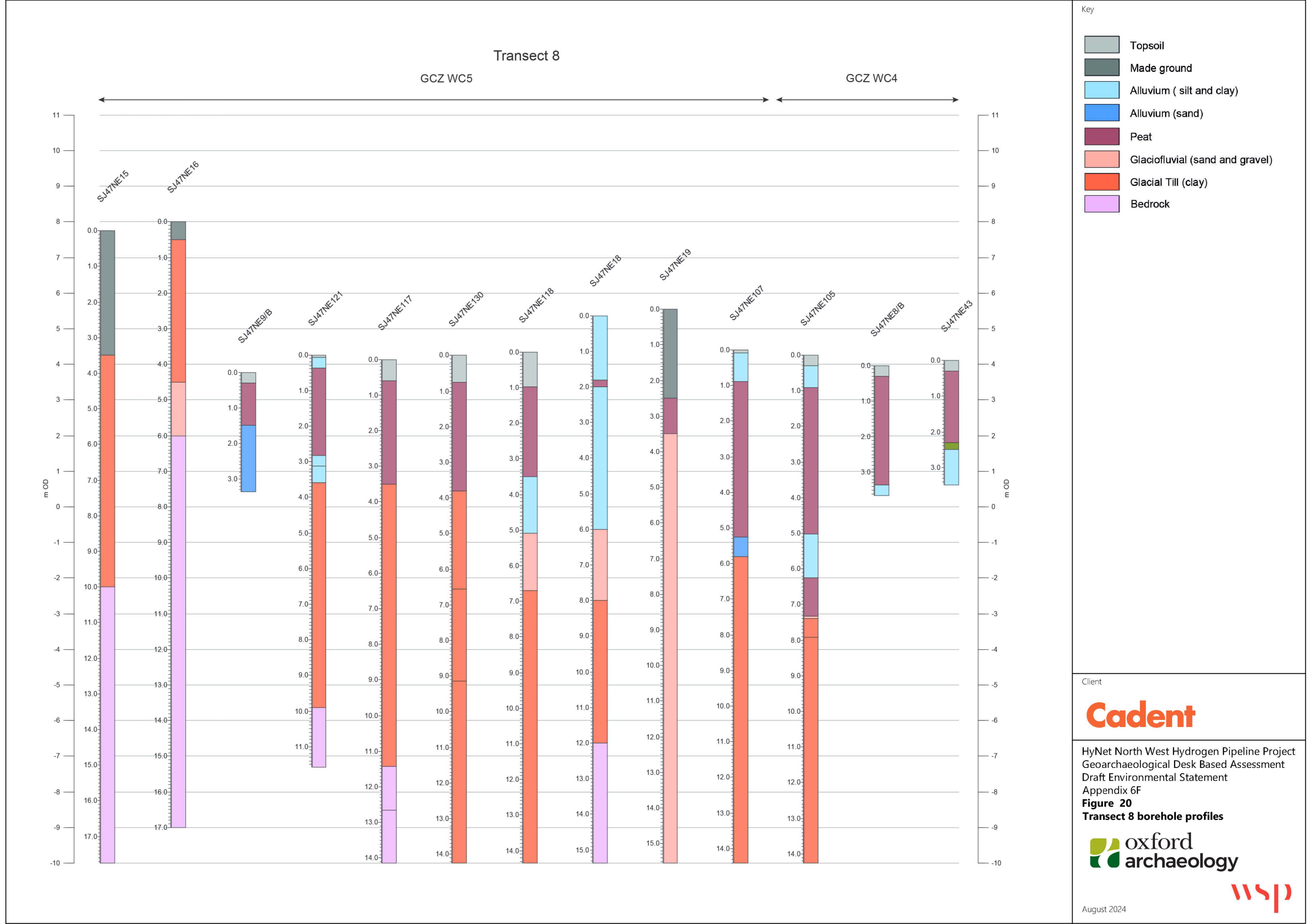
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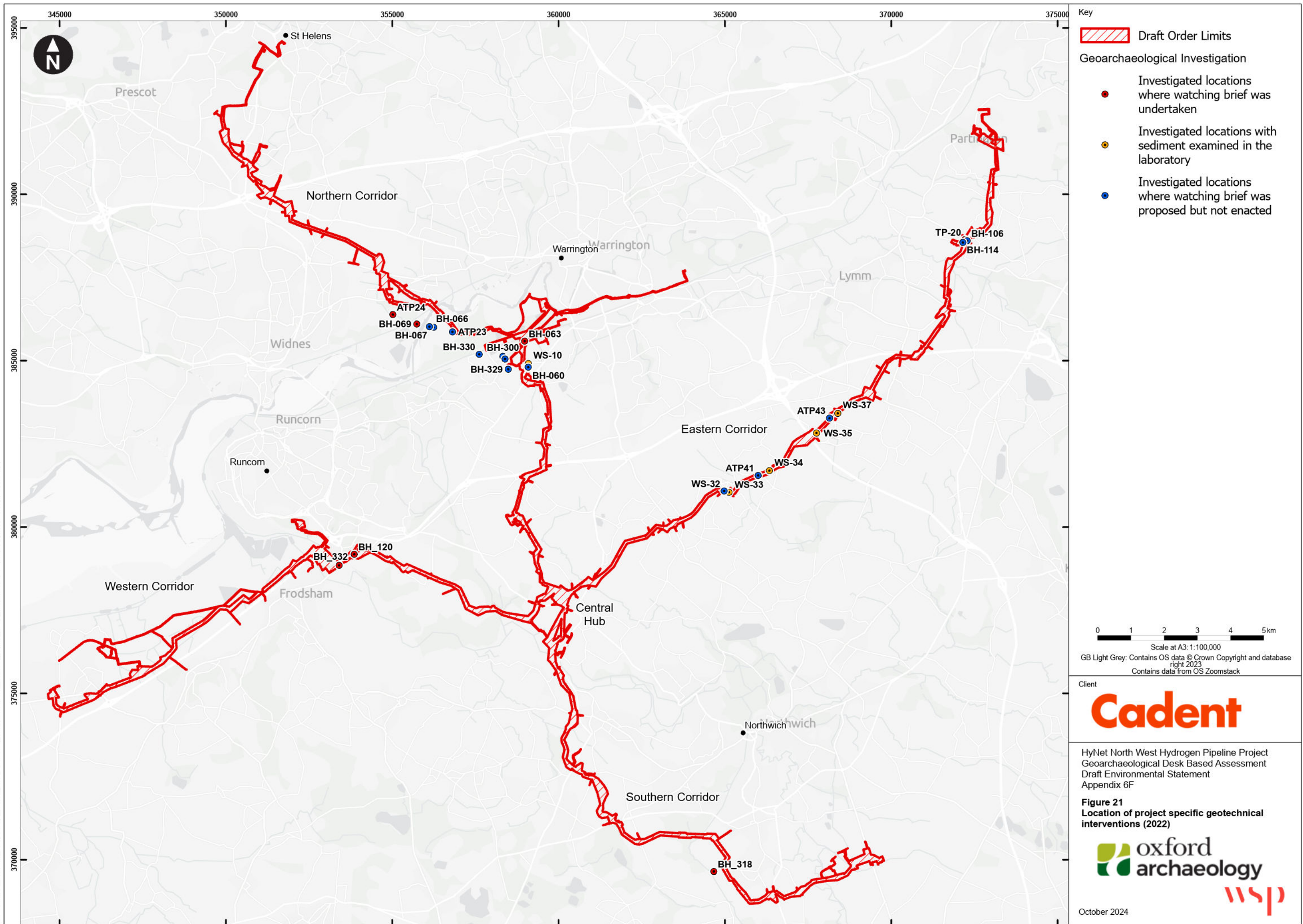
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Figure 19
Transects 5-7 borehole profiles

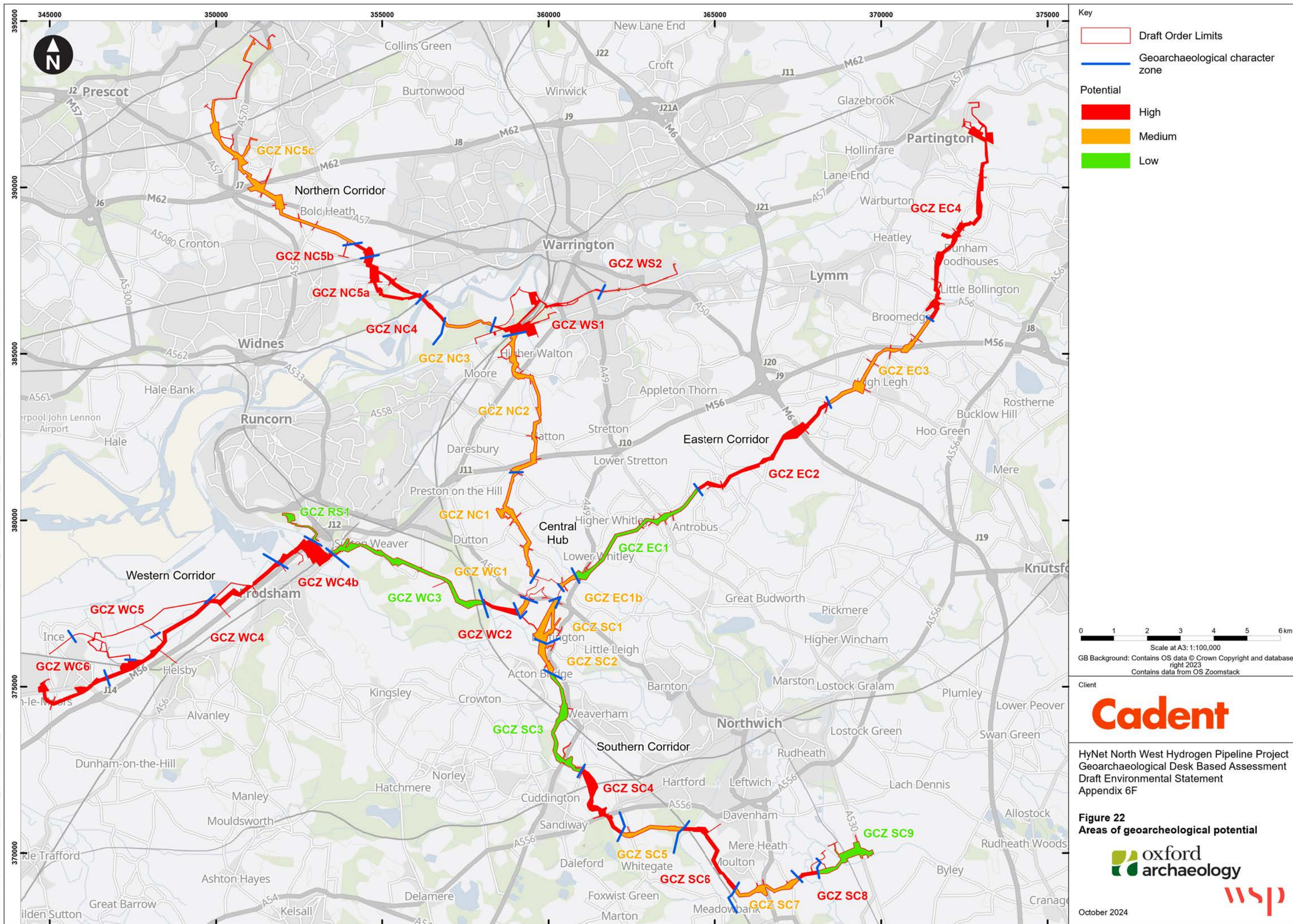


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