ARCHAEOLOGICAL MONITORING AND DEPOSIT MODEL OF GROUND INVESTIGATIONS GI PACKAGE 30: VICTORIA DOCK PORTAL, CUSTOM HOUSE STATION AND CONNAUGHT TUNNEL WORKSITES

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Annex 1 - Figures

Note to the reader: the major changes in this document from the previous deposit model are to sections 5 (LZ3), 6 (LZ4), and especially 7 (Conclusions).

1 Purpose and Scope

1.1.1 This document updates the previous deposit model undertaken for the Victoria Dock Portal and Custom House station (Crossrail 2010a) with additional geotechnical data received from the Package 30 (Pk 30) ground investigations (Crossrail 2010b). It constitutes a third revision of the deposit model, the first of which was undertaken in 2008 (Crossrail 2008). The additional data comprises a total of 6 borehole and 18 trial pit records. Of these, 9 points fall within the immediate vicinity of the previous model. The majority of the new data points lie within the footprint of the Custom House station.

1.1.2 It is required by the FDC design archaeologists for Victoria Dock Portal and Custom House Station, to contribute to their archaeological mitigation strategies.

2 Introduction

2.1 Deposit model construction and Landscape Zones

2.1.1 In order to create the deposit model the geotechnical data was entered into a digital (Rockworks 2006) database. Each identified lithological unit (gravel, sand silt etc) was given a unique colour and pattern allowing cross correlation of the different sediment and soil types across the site. By examining the relationship of the lithological units (both horizontally and vertical) correlations can be made between soils and sediments, and associations grouped together on a site-wide basis. The grouping of these deposits is based on the lithological descriptions, which define distinct depositional environments, coupled with a wider understanding of the Thames floodplain sequence gained from non-Crossrail archaeological and geoarchaeological investigations undertaken in the surrounding area. Thus a sequence of stratigraphic units, representing certain depositional environments, and/or landforms can be reconstructed both laterally and through time for the site. By this method a series of Landscape Zones (LZs, Fig 5) can be defined which are determined by characteristic types of deposit sequences, made up of one or more of these stratigraphical units.

2.1.2 In addition to this, the study of the underlying gravel topography is essential in defining the major landforms present within the floodplain which may have influenced later sedimentation rates, depositional environments, landscape development and by consequence areas of anthropogenic activity. In the case of the present study area, by plotting the surface of the basal Pleistocene gravels an indication is given of the undulating topography which existed at the beginning of the Early Holocene (*c* 10 000 BP, Fig 2). This is archived by transferring the Rockworks data to Arc GIS v.9 where the Spatial Analyst module is used to generate a surface plot. These basal gravels form the base line for deposits of archaeological interest.

2.1.3 The basal gravels belong to the Shepperton Gravel formation, and were deposited within a cold climate braided river regime between 18 000–15000 BP, during the closing stages of the Devensian Glaciation (Gibbard 1994). This braided river regime consisted of higher relief channel bar macroforms interspersed with lower lying channel threads. As the climate ameliorated at the beginning of the Holocene, the raised gravel bars developed into areas of dry ground, while anatomising and/or multiple threaded channels occupied the lower lying areas. Across the study area the sub-surface gravel topography consists of higher gravel areas to the north and south dissected by an area of low lying channels/estuarine environments on a west to east axis.

2.1.4 In general the new data obtained from Pk 30 has enabled the landscape boundaries between LZ3 and 4 in the direct vicinity of the Custom House Station footprint to be redefined. The deposit characteristics within these zones remain unchanged from the previous model. LZ1 and LZ2 remain unchanged. Although the area of the portal and station footprint only covers LZ3 and 4, the other two zones help to place the site within a wider landscape context.

2.2 Reliability of the model

2.2.1 Along the line of the portal and station itself the spread of geotechnical data is well spaced and numerous giving a good indication on the nature of the deposits and topography likely to be encountered. However, directly to the north and south of the portal the data points are of extremely poor resolution. While this does not directly affect the understanding of the deposit sequences, it does raise questions on the reliability of the surface model, and therefore how the deposits are placed within a wider landscape setting.

2.2.2 This is most pertinent to LZ2 and LZ3. LZ2 represents an area of lower lying topography, which from the extrapolation of the data points is predicted to cover the majority of the area directly to the south of the portal footprint. This is merely a prediction and therefore the boundaries that exist between this zone and LZ4 and LZ3 should be regarded with caution. In essence this effects how 'marginal' the area of the portal footprint is to areas of major channel activity to the south.

2.2.3 Another point of caution is the relationship between the gravel islands represented by LZ3 and the raised gravel topography of LZ1. The surface model suggests that two major 'eyot' features exist at the western and eastern end of the portal. The predictive surface model extrapolated this as potentially linking to the higher ground of LZ1 further to the north, essentially forming a peninsular of land rather than an isolated island feature as predicted from previous data (Crossrail 2008). This may have an impact on how accessible these areas were, and therefore the potential for prehistoric occupation and activity.

3 Raised gravel topography (LZ1)

3.1.1 LZ1 covers the north-central part of the area surrounding the Victoria Dock Portal (VDP) and Custom House Station sites, but does not extend to the Crossrail sites. It consists of higher ground with elevations of the Pleistocene gravel surface ranging from *c* 98 to 99m ATD. The boundaries of the zone remain unchanged from the previous deposit model. This high ground probably relates to the very beginning of the incline up towards the high ground of the second mid Devensian 'Kempton Park' terrace to the north. In borehole ARC/cfn99ev (south–north transect; Fig 4), fine-grained silts and clays probably relate to Late Prehistoric (i.e. Iron Age) alluviation and may seal cut features which extend down into the surface of the basal sands and gravels.

3.1.2 Previous work undertaken at Freemasons underpass further to the north did uncover evidence of Neolithic to Bronze Age activity cutting into the basal sand and gravel deposits, sealed by minerogenic alluviation (D Goodburn, MOLA, *pers comm.*). Bronze Age flint scatters have also been recorded from excavations at Fords Park Road, occurring within soil horizons sealed by minerogenic alluvium (Eastbury and Ruddy, 2009).

3.1.3 These areas of higher dry ground are also likely to be dissected by palaeochannels. Excavations at Crediton Road, Butchers Road and Vandome Close have revealed organic deposits and fibrous woody peats. The organic deposits were found to be infilling abandoned channels and possible lake and pool features, while the woody peat accumulated within a wet alder carr floodplain woodland environment (*ibid*).

3.1.4 This landscape zone has a **high potential for Mesolithic to Roman dry land activity and occupation**. These are most likely to be found cutting into the basal sands and gravels sealed below minerogenic alluvium. Peats and organic deposits are also likely to survive across this zone and could preserve a range of palaeoenvironmental proxy indicators suitable for past landscape reconstruction. The peat deposits may also preserve timber structures constructed to access and traverse the wetlands. Evidence of such a Bronze Age structure, thought to be a bridge (D. Goodburn *pers comm*.), was found within the peat deposits excavated at Freemasons underpass.

4 Deeper channel areas/estuarine environments (LZ2)

4.1.1 LZ2 comprises the central east–west section of the study area, and is characterised by generally low-lying land (Fig 2). The revised deposit model places the northern boundary of this zone slightly further to the south of the portal footprint than previously mapped. In general this zone is characterised by an underlying gravel topography which occurs at *c* 97–93.5m ATD. Recent work undertaken at the water sports centre towards the western end of the Victoria Dock basin has aided in characterising the overlying sediments (Halsey, *in prep*).

4.1.2 The basal gravels are often found to be overlain by well-sorted moderately coarse sands, which indicate fluvial deposition within a relatively high energy, stable flowing channel. These sands have also been noted to contain lenses of eroded rip up clasts of peat. This would suggest that the sands are likely to be of a Late Glacial to possibly mid Holocene date, with the zone itself falling into a part of the floodplain prone to erosion and significant levels of fluvial activity.

4.1.3 This may be due to the presence of the River Lea slightly further to the west. The channel sediments in the vicinity of the study area could be associated with a former course of the Lea rather than the Thames, with the erosion being caused by flow turbulence where the two rivers meet a confluence.

4.1.4 At the water sports centre these well sorted sands were found to be overlain by finely laminated clays, silts and fine sands. Similar deposits have been reported in other geotechnical interventions undertaken across the zone. These laminated deposits represent a transition to slack water deposition and are most probably associated with the formation of mudflat/saltmarsh environments inundated regularly by tidal waters. By the Bronze Age the tidal head is thought to have reached as far as the Custom House stretch of the Thames (Sidell, *et al* 2000). It's likely that by this period the whole zone formed an estuarine environment marginal and transitional to the peat deposits and alder carr woodland forming on the slightly drier interfluves within Landscape Zone 4.

4.1.5 Occasional lenses of peat are recorded within this zone, but these are far less extensive and deep than those recorded within LZ4. These peat deposits probably represent short periods of floodplain stabilisation, where subtle changes in local hydrology and topography impeded regular tidal inundation and thus allowed vegetated waterlogged horizons to develop. Such periods appear to have been short lived. Sharp boundaries between these peats and the overlying minerogenic sediments points to renewed tidal inundation and erosion of the peat horizons.

4.1.6 The upper-most minerogenic deposits are markedly different to the laminated clays and silts. These deposits show evidence of pedogenesis in the form of a blocky ped structure, occasional rooting and mottles of manganese and iron oxides. This transition is gradual up through the sequence. These deposits are indicative of semi-terrestrial accretionary floodplain soils, which underwent less frequent inundation than the underlying laminated clays and silts. This change in depositional environments is related to aggradation and the raising of the floodplain surface. As tidal inundation continued sedimentation gradually raised the floodplain surface above the level where regular inundation could occur and thus a gradual transition occurred from tidal mudflats to semi terrestrial grassland floodplain.

4.1.7 Overall this zone has **no potential for occupation**, but does provide a useful resource in determining the evolution of the fluvial system and identifying the allogenic and autogenic factors (i.e. changes to climate, sediment supply and hydrology) influencing floodplain development, particularly with reference to the upstream influence of Relative Sea Level rise (RSL) and the migration of the tidal head. These sediments do, however, have **good potential for palaeoenvironmental and topographic evidence**: they will preserve molluscs, ostracods, diatoms and foraminifera which can be utilised to reconstruct the fluvial depositional environments and identity the transition from freshwater to brackish river systems. Although the organic content of these sediments is generally low, detrital plant remains can be preserved and used to reconstruct the vegetational communities and palaeoecology of the saltmarsh. These organic remains can also potentially provide material to radiocarbon date the sediments thus providing a chronology for understanding the changes in river morphology.

4.1.8 These channel areas would have provided an important means of access and transport across the landscape, and are therefore of significance in understanding the wider prehistoric landscape and how it was utilised. The potential for artefactual material is generally low, although there is **some potential for prehistoric to Roman archaeological remains** in the form of boats, and subsistence equipment related to fishing and the exploitation of the Thames floodplain.

5 Sand and gravel ‘islands’ (LZ3)

5.1.1 This zone constitutes areas of relatively high gravels and sands which exist as possible ‘eyots’ within the wetland landscape represented by LZ4. The additional data has aided in revising these areas across the Custom House Station footprint. The parts of LZ3 towards the Victoria Dock Portal footprint remain unchanged.

5.1.2 The previous model identified an extensive area of raised gravel towards the station, which was initially thought to be comprised of two separate entities. As discussed previously (Section 2.2) the predicted plot of the Early Holocene topography extrapolates this island as forming a peninsular of high ground linking northwards to LZ1. The data set from Pk 30 has reduced the area of LZ1 across the station footprint. This area now appears as a large area to the north, with a thin peninsula of land extending towards the south (Fig 2 and Fig 5). It is also possible that the data points which map this area form isolated areas of high gravel rather than a connected zone of elevated surface topography. These gravel high points may simply be reflecting the upper surface of small scale gravel bar features, rather than a continuous surface.

5.1.3 The surface elevation of these sand and gravel 'islands' ranges from c 98–99m ATD. At the beginning of the Holocene (early Mesolithic) it is likely that the Thames river level was significantly lower than that of the present day, possibly up to 15m lower (Bates and Whittaker 2004). However, during the course of the early to mid Holocene (*c* 10 000–6000 BP), rapidly rising sea levels (related to the unlocking of polar ice) caused the Thames to rise to approximately 97m ATD by the Mesolithic/Neolithic transition (*ibid*). Given the elevation of the sand and gravel in LZ3, these areas of high ground would have remained above river levels throughout the Mesolithic period, and possibly through at least the early part of the Neolithic, and would have been attractive areas of the floodplain for carrying out subsistence activities such as hunting and fishing. It is possible that makeshift camps would have been constructed on some of the larger islands, which might have served as a base from where such activities took place.

5.1.4 Depending on the elevation and the position of these sand and gravel islands within the floodplain, there is also potential for these areas of high ground to have remained dry land during the Neolithic and Bronze Age periods. To the south of the study area, a gravel island with an upper surface lying at approximately 99m ATD is likely contiguous with the large area of LZ3 in the south central region of the study area. At Fort Street, 100m to the south of the study area, a timber trackway of Neolithic age was found associated with this gravel high, at an elevation of 99m ATD (Wessex Archaeology 2000). This trackway was thought to have been used to link areas of high ground which were separated by lower-lying, wet and marshy areas not easily accessible to prehistoric people traversing the Thames floodplain.

5.1.5 Peats and humic silts often directly overlie the Pleistocene gravels and sands, and testify to further rises in the Thames during the later Holocene (later prehistoric/historic periods; Bronze Age to Roman periods). The formation of the peats is related to continued increase in river levels due to the upstream migration of the tidal head. Previously terrestrial land surfaces across the gravel and sand islands became waterlogged, impeding drainage and hence supporting peat development.

5.1.6 These peats are sealed by minerogenic clays and silts, which are often reported to display gleyed characteristics and a blocky ped structure. These deposits are similar to those recorded in the upper part of the sequence in LZ2. This transition from peat formation to minerogenic sedimentation results from the increase in river levels outstripping the rate of peat formation. The waterlogged peat horizons became regularly inundated by tidal flood waters which impeded vegetational development and eventually resulted in the formation of mudflat and salt marsh environments. As with LZ2 this continued sedimentation raised and flattened the irregular floodplain surface. The flooding became less frequent allowing semi-terrestrial grassland floodplain soils to develop. The formation of these alluvial sediments is usually found to have begun in the Iron Age, with a transition to alluvial floodplain soils beginning in the Roman/Medieval period.

5.1.7 This zone should be considered to have **moderate potential for dry land activity and occupation from the Mesolithic period possibly through to the Bronze Age**. The Mesolithic occupation may take the form of ephemeral scatters of flint and bone representing tool manufacture and a range of subsistence activities. Later Neolithic and Bronze Age activity may also take the form of artefact scatters although definable cut features may also occur cutting through the basal sand and gravel deposits. The overlying organic deposits and peats will preserve pollen and plant macro fossils to a high degree, allowing reconstruction of the sites past landscape and palaeoecology.

6 Early Holocene channels and wetland deposits (LZ4)

6.1.1 LZ4 is essentially the transitional environment between the higher ground of the sand and gravel islands (as well as the higher ground to the north), and the network of channels and estuarine environments towards the south. This landscape zone is characterised by thick, well-developed peats which testify to an increase in wetland vegetation at the margins of the channels and mudflat environments. The additional borehole data in this revision of the deposit model has aided in refining the deposit characteristics of this zone within the area of the station footprint.

6.1.2 Of particular interest within this zone is a number of calcareous channel sediments reported to occur above the floodplain Pleistocene gravels (see WS26 and WS31, Fig 3). These deposits are noted to consist of occasionally finely laminated, clays and silts with calcareous 'tufa' like inclusions and occasional reed and plant stem fragments. It is likely that these deposits represent early Holocene freshwater channels flowing off the higher ground to the north. These fine grained sediments appear to be representing the lower-lying threads of the preceding Late Devensian braidplain. The mention of calcareous 'tufa' like inclusions is particularly interesting and provides a possible chronology to the deposition.

6.1.3 Tufa forms as a result of calcareous-rich waters evaporating, leaving calcareous clasts around roots and plants stems. This requires a warm, wet, climate which has only existed during the period of the Holocene known as the Climatic Optimum (Parker and Chambers, 1997). This event occurred at approximately 7000 BP. Tufa rich sediments are often encountered within floodplain deposits and provide a useful chronological marker. If this material is indeed tufa, then LZ4 potentially contains a long sequence of organic deposits which stretches across almost the entire Holocene.

6.1.4 Above these channel deposits are thick units of peat. The peats are described as woody and fibrous although drier humified bands and lenses of organic clays also occur. The peats probably began to form in the Late Mesolithic/Early Neolithic period when the Early Holocene channel threads became abandoned and began to infill. The peat primarily formed in alder carr floodplain woodland although sedges and ferns would have developed in more open areas. Pollen evidence from other sites on this stretch of the Thames has shown that the alder carr woodland not only consisted of alder, but also oak, elm, ash and lime (Sidell *et al* 2000).

6.1.5 The Pk 30 data shows that the eastern end of the station footprint lies very close to the interface of LZ4 and 2. The majority of the 'peat' units within this area were described as predominately organic clays, with fibrous peaty inclusions increasing with depth. This is more indicative of a grass sedge fen environment, rather than a densely wooded floodplain. Such environments can be expected to occur in a transitional zone between the floodplain woodland and the open channel areas represented by LZ2.

6.1.6 This wetland landscape not only consisted of dense woodland vegetation and sedge fen, but also contained ephemeral pools of standing water and possible flowing channels as evidenced by the organic clays. Boreholes WS26 and CH100 (Fig 3) recorded thick deposits of silts and clays above the peat which may represent either a channel contemporary with the peat formation, or later Historic channels which cut through the peat horizon. CH100 was observed to contain rip up clasts (see Glossary) of peat within the minerogenic channel deposits, pointing to erosion of the peat beds.

6.1.7 The new data from Pk 30 has also enabled a projection of one of these channel courses to be tentatively made. Just to the south of CH100, the previous deposit model identified similar channel deposits within borehole B30 (see Fig 3; Crossrail 2010b). By extrapolating between these two boreholes, the channel may be following the 98–98.5m ATD contour of the Early Holocene surface topography (Fig 2). Whatever the true course, this feature evidently cuts across the station footprint.

6.1.8 The previous deposit model discussed the possibility of Mesolithic soils occurring directly over the gravel and sand islands within LZ3. These soils were noted within boreholes CH22 (Fig 3) and BWC96-BH8 (Fig 4) and consisted of humic clays and silts. However, the additional boreholes show that a possible humic clay horizon exists across LZ4 (Fig 3, boreholes WS32 and WS28). This appears at a fairly consistent level of *c* 99m ATD. Given the elevation these humic deposits are likely to be Bronze Age in date, and represent a phase of peat humification (i.e. drier episodes), rather than forming Mesolithic soil horizons. Humic organic soil horizons generally form within well vegetated land surfaces with high moisture content. The gravel high points within LZ4 were probably not well enough vegetated or waterlogged for such well developed soil horizons to form during the Mesolithic. Any Early Holocene soil horizons which formed above the gravel and sand surface are likely to be very ephemeral, and possible not even discernible as an archaeological context. Later peat formation and alluviation can often mask these ephemeral soils, and only by using soil micromorphological techniques can such horizons be identified.

6.1.9 Overall LZ4 has **high potential for palaeoenvironmental evidence**. The organic deposits and peats will preserve pollen and plant macro fossils which can be used to reconstruct the past landscape and palaeoecology of the site. Given the possibility of Climatic Optimum tufaceous deposits at the base of the sequence, these wetland deposits could contain a palaeoenvironmental record with extremely good levels of chronological resolution (i.e. deep sequences which accrued over long time periods; on average the floodplain deposits within this zone measure up to 4m in depth). The interspersed channel and pool deposits within these wetlands will also preserve molluscs, ostracods and diatoms which can reconstruct the hydrology and nature of the fluvial features. It should be noted that the majority of the floodplain sequence across this zone appears complete and relatively untruncated. A number of boreholes (WS26 and B280) recorded humic horizons above the upper alluvium which was interpreted as possible Post-Medieval soil horizons.

6.1.10 Although this semi-terrestrial wooded wetland landscape would have been accessible to past prehistoric populations, the waterlogged nature of the ground would have made any form of settled occupation untenable. However, these wetlands would have provided a rich subsistence resource, with fish, waterfowl and large ungulates in abundance. LZ4 has a **moderate potential of timber structures** such as trackways, bridges, jetties and wharfs constructed to access and traverse the wetter areas of the wetlands.

7 Conclusions

7.1.1 The additional data from GI Package 30 has produced a revised deposit model which significantly alters the landscape zone boundaries within the vicinity of the Custom House station footprint. The previous model suggested that LZ3 (higher gravel areas) existed as a fairly large area of land across the central and western parts of the station footprint. The new model suggests that the areas of high gravel could be fairly discrete, and consideration should be given as to whether these areas form a continuous surface of raised topography, or simply small scale gravel bar features. These areas of raised gravel may have formed larger ‘eyots’ within the wetland landscape and have moderate potential for Mesolithic, and possibly Bronze Age, activity and (temporary) occupation.

7.1.2 LZ4’s (early Holocene wetland) characteristics remain as before, although a possible prehistoric channel has been identified running across the Custom House Station footprint within the wetland peat deposits. These wetland and channel deposits have moderate potential for timber structures such as trackways and platforms.

7.1.3 These revisions from interpretation of the new data should be of material use to the design archaeologists in focusing mitigation measures at Custom House Station. The model for Victoria Dock Portal is unchanged.

8 References and glossary of terms

8.1 References

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8.2 Glossary

BP	Years before present, conventionally taken to be 1950
Braidplain	The active extent of a braided river, which consists of multiple channel threads, separated by raised in-channel bars
Bronze Age	*c* 2000–650 BC
DDBA	Detailed desk-based assessment(s)
Devensian	Geological era from 70,000 to 10,000 BP
Eyot	A small island (in this work, one within the existing or former courses of the Thames or its tributaries)
Holocene	Geological era from 10,000 BP to the present day

Interfluves	A ridge or area of higher drier ground separating two or more channels which belong to the same drainage/catchment system
Iron Age	*c* 650 BC–AD 43
Late Glacial	The period following the Last Glacial Maximum and lasting until the climatic warming at the start of the Holocene. In Britain this period is subdivided into a warm ‘interstadial’ episode the Windermere Interstadial, followed by a renewed cold (‘stadial’) episode, in which local ice advances occurred (the Loch Lomond Stadial).
Last Glacial Maximum	The last major cold stage of the Devensian Glaciation known as the Dimlington Stadial which reached its peak at *c* 20 000–18 000 BP
m OD	Metres above Ordnance Datum (Newlyn). To obtain Tunnel Datum heights (m TD) add 100m to OD heights.
m TD	Tunnel Datum (Crossrail project datum, same as LUL datum, see above)
Mesolithic	*c* 12,000–4000 BC
Neolithic	*c* 4000–2000 BC
Palaeochannel	Deposits representing a former stream channel
Ped	A unit of soil structure
Pedogenesis	Soil formation
Pleistocene	Geological era from 2,000,000 to 10,000 BP, characterised by fluctuating cold (Glacial) and warm (Interglacial) climatic cycles
Post-medieval	AD 1485 to present
Rip up clasts	Clasts (lumps etc) of eroded material
Roman (Romano-British)	AD 43–*c* 410
Saxon (early-medieval)	AD 410–1066
TBM	Tunnel boring machine.

Annex 1 – Figures

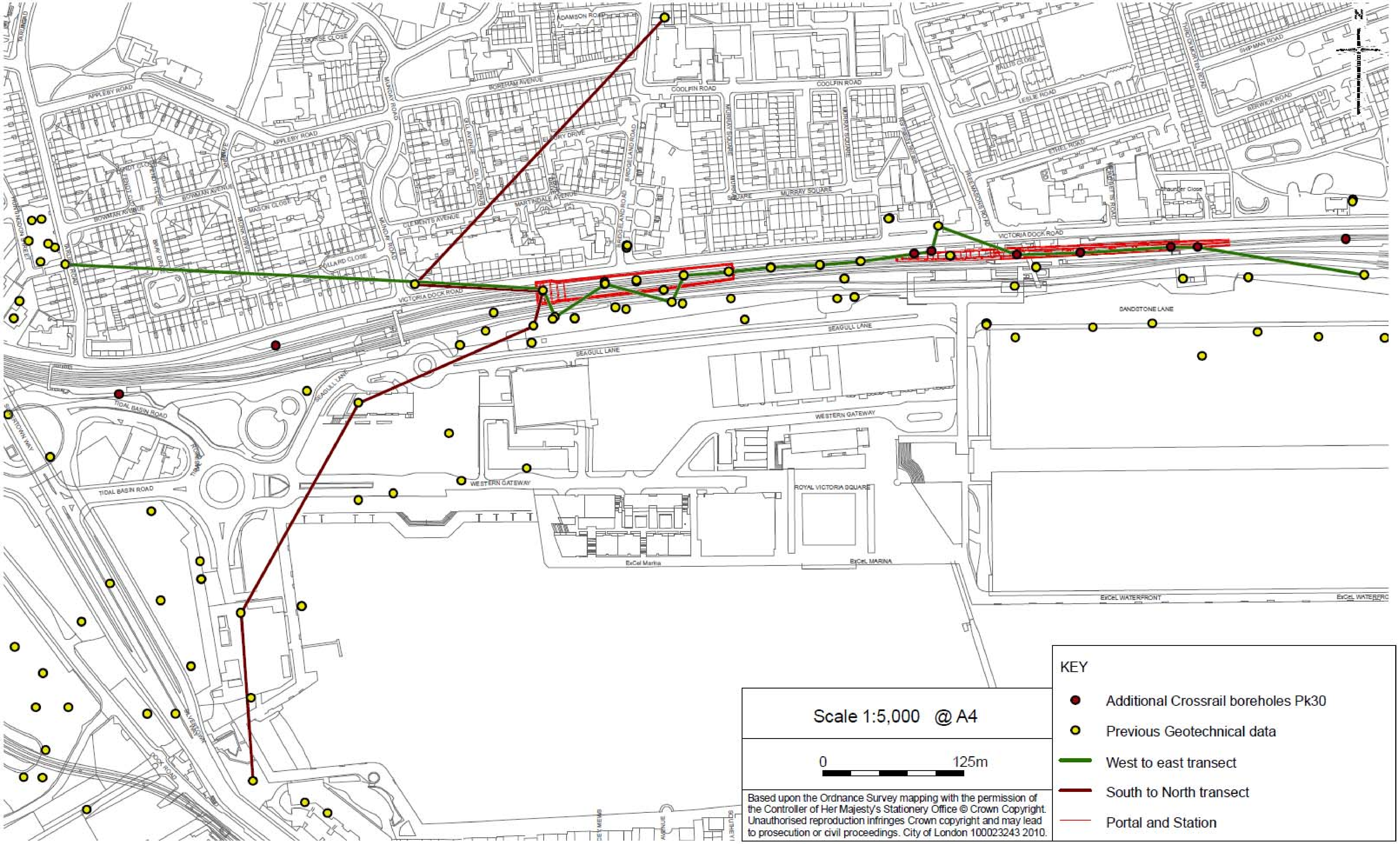

Fig 1: Location of geotechnical data and borehole transects

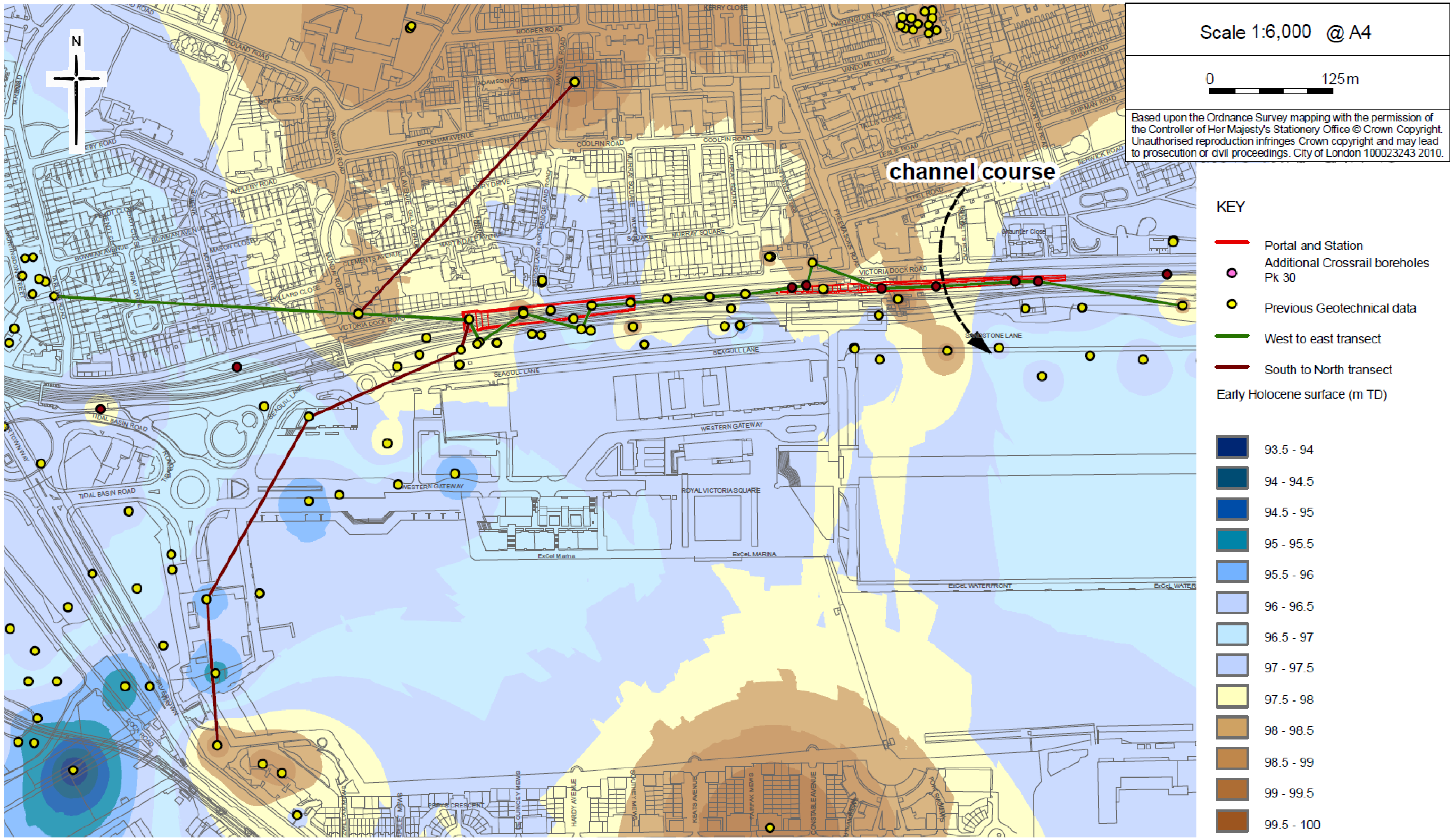

Fig 2: Buried topography of the Early Holocene

Victoria Dock portal West to East transect

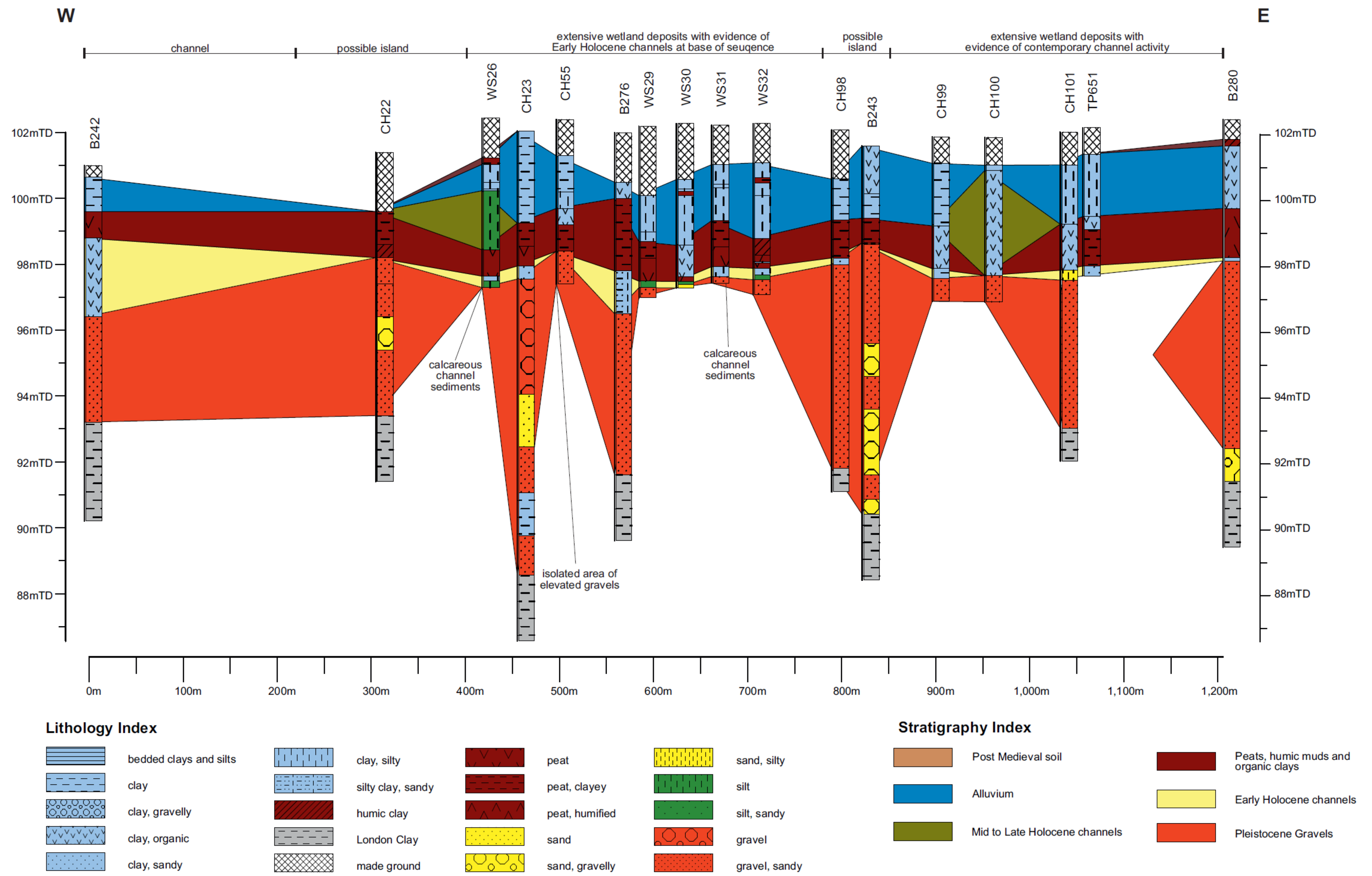

Fig 3: West to east transect across the site

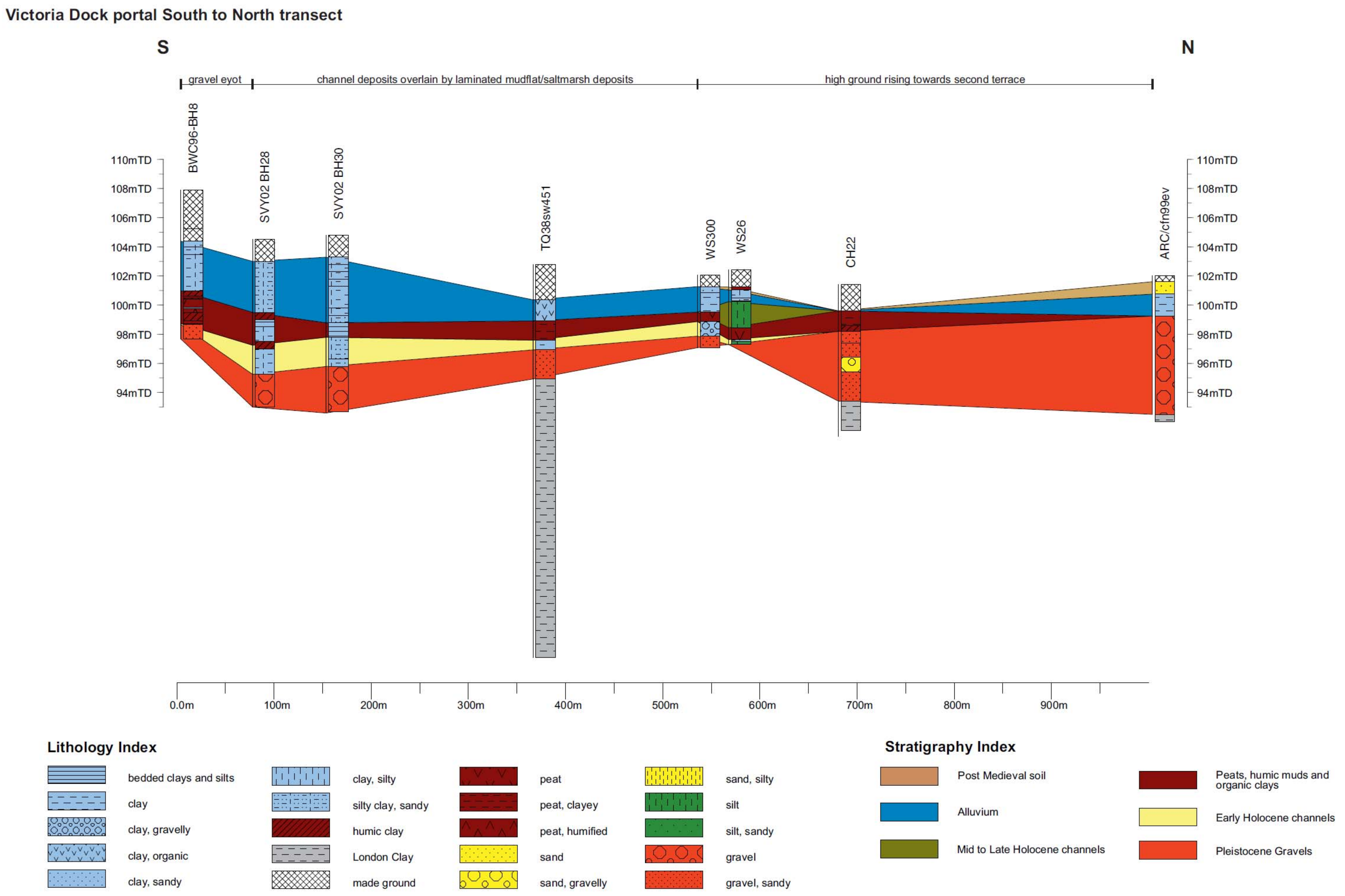

Fig 4: South to north transect across the site

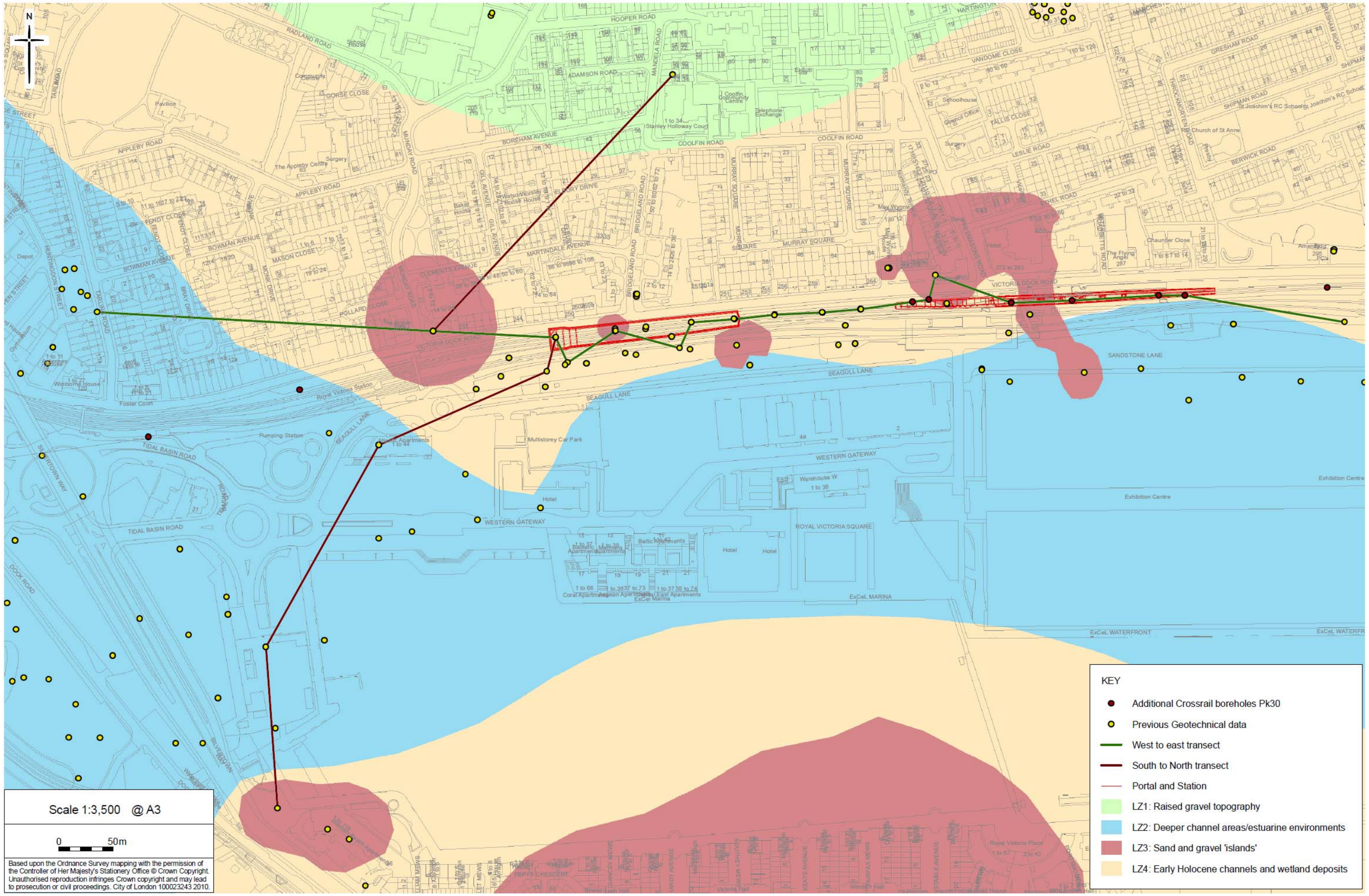

Fig 5: Landscape Zones