C263 ARCHAEOLOGY LATE EAST

Geoarchaeological Borehole Evaluation and Deposit Model Update North Woolwich Portal – XSV11

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Non technical summary

This report presents the results of a geoarchaeological borehole evaluation carried out by the Museum of London Archaeology (MOLA) on the site of North Woolwich Portal, London E16, in the London Borough of Newham. This report was commissioned from MOLA by Crossrail Ltd.

The results of the three evaluation boreholes were used with additional geotechnical data to update a previous deposit model undertaken for the site. The deposit model identified high areas of Pleistocene gravels and Early Holocene sands forming islands within a low lying channel floodplain. These dry island areas have the potential for Mesolithic activity. During the Early Holocene former deep channel threads became abandoned, becoming infilled with silts and peat deposits. Subsequently, river levels continued to rise over the Late Mesolithic to Bronze Age periods, resulting in transgression and regression episodes, which waterlogged these drier island areas allowing for dense wetland vegetation to develop. As further inundation occurred, thick alluvial deposits formed, levelling out the terrain, with any former depressions in the floodplain area silting up. Woodland became increasingly waterlogged and died off, leaving the landscape as an open salt marsh environment.

The results from the borehole evaluation and updated deposit model will contribute to the archaeological mitigation design for the portal excavation and associated works.

Because of the potential for Mesolithic archaeology, and for associated deep organic sequences preserving significant palaeoenvironmental data, the results from North Woolwich Portal are assessed as being of regional and local significance.

These results will be used by the C263 design archaeologist to revise and finalise the mitigation strategy for the site.

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1 Introduction

This document presents the results of a geoarchaeological borehole survey and updated deposit model for the North Woolwich Portal site. The site work is recorded under site code XSV11. The co–ordinates for the site are NGR 542749,179975 (centre of site). The borehole survey was designed to assess the potential for the survival of archaeological and palaeoenvironmental remains. The fieldwork was carried out on 3rd August 2011.

The requirements for the geoarchaeological borehole survey work were set out in the C263 Archaeology Late East Method Statement, Watching Briefs, Non Listed Building recording and Geoarchaeological Borehole Survey–Victoria Dock Portal and North Woolwich Portal, July 2011, document number C263–MLA–X–RGN–CRG07–50003, Revision 3.1.

2 Planning background

The legislative and planning framework in which all archaeological work took place was summarised in the Method Statement, which formed the project design for the evaluation (Crossrail July 2011).

3 Origin and scope of the report

This report has been commissioned from Museum of London Archaeology (MOLA) by Crossrail Ltd. The report has been prepared within the terms of the relevant standard specified by the Institute for Archaeologists (IFA, 2001). It considers the significance of the fieldwork results (in local, regional or national terms) and makes appropriate recommendations for any further action, commensurate with the results.

4 Previous work relevant to archaeology of site

The principal previous Crossrail studies are as follows:

- Crossrail, Environmental Statement, February 2005;
- Crossrail, 2005, Assessment of Archaeology Impacts, Technical Report, Part 4 of 6, South–East Route Section, 1E0318–E2E00–00001
- Crossrail, 2008a, Archaeological Monitoring of Ground Investigations, Borehole Package 11, Limehouse to North Woolwich
- Crossrail/MoLAS, 2008b, Geoarchaeological Deposit Model: North Woolwich Portal. January 2008
- Crossrail/MDC4, 2008d, WSI Victoria Dock Portal and Custom House Station, Document Number: CR–SD–PRW–X–IS–00002
- Crossrail, 2010a, North Woolwich Portal, Site–Specific Archaeological Written Scheme of Investigation, v 6.0, Document Number: CR–SD–PRW–X–IS–00006

- Crossrail, 2010b, Archaeological Monitoring of Ground Investigations, Borehole Package 19

- Crossrail C263 Archaeology Late East Method Statement, Watching Briefs, Non Listed Building recording and Geoarchaeological Borehole Survey–Victoria Dock Portal and North Woolwich Portal July 2011

All on–site archaeological work was carried out in accordance with the following documents:

C263 Archaeology Late East Method Statement, Watching Briefs, Non Listed Building recording and Geoarchaeological Borehole Survey–Victoria Dock Portal and North Woolwich Portal, July 2011, document number C263–MLA–X–RGN–CRG07–50003, Revision 3.1.

5 Geology and topography of site

The site lies on the reclaimed alluvial floodplain of the River Thames, approximately 700m to the north of the present Thames. Overlying London Clay are the floodplain sands and gravels deposited during the Pleistocene approximately 18,000 to 10,000 years BP (Before Present), during which time the Thames was a fast flowing braided river, formed of interconnected channels interspersed with higher sand and gravel bars. These floodplain gravels form the 'Holocene Template' on which Mesolithic activity would have taken place. The areas around channels and lakes provided resources attracting a hunter–gatherer population. During the early Holocene, sea levels rose and lower lying areas were inundated. By the time of the Mesolithic/Neolithic transition at approximately 4000BP, the level of the Thames is likely to have risen to approximately 97m ATD. From the Late Neolithic, the braided channels gradually silted up, and peat began to develop across former channel threads and across waterlogged areas.

As river levels continued to rise during the Bronze Age period, extensive peat deposits indicative of alder wet floodplain woodland began to develop. By the Early Iron Age, the rate of sea level rise outstripped peat formation causing intertidal muds and salt marsh environments to accumulate across the surface of the alder carr peats. Inundation continued, until the medieval period, when drainage channels and revetments were constructed to reclaim the salt marsh.

6 Research objectives and aims

The overall objectives of the evaluation are to assess the level of preservation and significance of archaeological and/or palaeoenvironmental remains, revise the landscapes zones determined by the previous geoarchaeological deposit model, and recover core samples suitable for off site palaeoenvironmental work. All work was undertaken within the overall research framework for London archaeology (*Museum of London, 2002*).

Specifically, the evaluation has the potential to recover:

- Peat and alluvial deposits preserving a wide range of proxy palaeoenvironmental indicators (i.e. pollen, diatoms, plant macro fossils) that can be utilised to reconstruct past landscape, palaeoecology, hydrology, geomorphology and past landforms.
- Prehistoric structural timber remains such as trackways, fish traps and revetments possibly occurring within the thick peat deposits
- Mesolithic to Neolithic dryland activity horizons above gravel high points, consisting of ephemeral scatters of animal bone and lithic material.
- Evidence of floodplain stabilisation and soil formation of a Roman to Medieval date within the upper minerogenic alluvium, and associated archaeology consisting of pits, ditches etc

7 Geoarchaeological borehole evaluation

7.1 Methodology

All on–site geoarchaeological work was carried out in accordance with the C263 Archaeology Late East Method Statement, Watching Briefs, Non Listed Building recording and Geoarchaeological Borehole Survey–Victoria Dock Portal and North Woolwich Portal, July 2011, document number C263–MLA–X–RGN–CRG07–50003, Revision 3.1, and the Museum of London *Archaeological Site Manual 3rd edition* (1994).

The site finds and records can be found under the site code XSV11 in the MOLA archive. They will be stored there pending a future decision over the longer–term archive deposition and public access process for the wider Crossrail scheme. Three boreholes (BH1–3) located along an east/west transect across the site were supervised and recorded by a MOLA geoarchaeologist (Figure 1).

Starter pits were hand excavated down to 1.2m bGL (below ground level) and then bored by a terrier rig to varying depths. The geoarchaeologist recorded the sequence of made ground and alluvial deposits from ground level to the surface of Pleistocene gravels. A written and drawn record of all archaeological deposits encountered was made in accordance with the principles set out in the Museum of London site recording manual (MoL 1994), and also according to standard geoarchaeological criteria. All the core samples were retained.

7.2 Results

The interpreted results of the monitoring are tabulated below.

BH1 (NWP_EVAL_BH1 on Figure 1)					
Location				North Woolwich Portal	
OS National grid coordinates				542627.457; 180016.092	
Surface Level				2.56m OD (102.56m ATD)	
Natural observed				–0.04m OD (99.06m ATD)	
Top (m)	**Base (m)**	**Top (m OD)**	**Base (m OD)**	**Description**	**Interpretation**
0	0.6	2.56	1.96	Grey aggregate ROADSTONE. Sharp horizontal contact with unit below.	Consolidation fill
0.6	0.8	1.96	1.76	Orange SAND & GRAVEL. Grades into unit below.	Consolidation fill
0.8	2.55	1.76	0.01	Light brown becoming black fine sand (MADE GROUND). Grades into unit below.	Consolidation fill
2.55	2.6	0.01	–0.04	Spongy black ORGANICS. Sharp horizontal contact with unit below.	Turf line
2.6	2.85	–0.04	–0.29	Soft, brown organic becoming dark grey laminated SILTY CLAY with manganese staining. Grades into unit below.	Soil profile developed from historic alluvial deposits
2.85	4	–0.29	–1.44	Light brownish grey SILTY CLAY. Sharp contact with unit below.	Estuarine muds
4	4.2	–1.44	–1.64	Firm black fine sand. Sharp contact with unit below.	Estuarine muds
4.2	4.3	–1.64	–1.74	Very soft brown SILTY CLAY. Sharp contact with unit below.	Estuarine muds
4.3	4.65	–1.74	–2.09	Firm black fine sand with occasional organic fragments near base of unit. Sharp contact with unit below.	Potential early to mid Holocene sands with later soil formation.
4.65	8.45	–2.09	–5.89	Very soft, brown SILTY CLAY (hole collapse, unknown depth, probed to 8.45mbgl)	Collapsed hole so possible backfill

BH2 (NWP_EVAL_BH1 on Figure 1)					
Location				North Woolwich Portal	
OS National grid coordinates				542722.739; 179994.318	
Surface Level				2.23m OD (102.23m ATD)	
Natural observed				0.93m OD	
Top (m)	**Base (m)**	**Top (m OD)**	**Base (m OD)**	**Description**	**Interpretation**
0	0.8	2.23	1.43	Grey aggregate ROADSTONE. Sharp horizontal contact with unit below.	Consolidation fill
0.8	1.3	1.43	0.93	Light brown fine SAND. Sharp horizontal contact with unit below.	Consolidation fill
1.3	1.35	0.93	0.88	Spongy dark brown ORGANICS. Sharp horizontal contact with unit below.	Turf line
1.35	1.6	0.88	0.63	Soft, brown organic becoming dark grey laminated SILTY CLAY with manganese staining. Grades into unit below.	Soil profile developed from historic alluvial deposits
1.6	3.55	0.63	–1.32	Grey, soft, plastic, sticky SILTY CLAY becoming grey and firmer with depth. Grades into unit below.	Estuarine muds
3.55	3.75	–1.32	–1.52	Mid brownish grey, soft, ORGANIC SILTY CLAY. Grades into unit below.	Estuarine muds flooding peat surface.
3.75	5.8	–1.52	–3.57	Dark brown clayey fibrous PEAT with moderately frequent wood fragments. Sharp horizontal contact with unit below.	Channel marginal wetland and channel silting up
5.8	6.8	–3.57	–4.57	Dark grey medium SAND (hole collapse, unknown depth)	Early to mid Holocene channel bars

BH3 (NWP_EVAL_BH1on Figure 1)					
Location				North Woolwich Portal	
OS National grid coordinates				542894.157;179958.372	
Surface Level				2.02m OD (102.02m ATD)	
Natural observed				1.27m OD	
Top (m)	**Base (m)**	**Top (m OD)**	**Base (m OD)**	**Description**	**Interpretation**
0	0.6	2.02	1.42	Grey aggregate ROADSTONE. Sharp horizontal contact with unit below.	Consolidation fill
0.6	0.75	1.42	1.27	Light brown fine SAND , some clay. Sharp horizontal contact with unit below.	Consolidation fill
0.75	1.5	1.27	0.52	Dark grey, firm, CLAY SILT with oxidised root channels, manganese staining and fine sand component. Blocky at top with $CaCO_3$ concretions at base of unit. Grades into unit below.	Soil profile developed from historic alluvial deposits
1.5	1.9	0.52	0.12	Greyish blue becoming light green plastic, sticky clay. Grades into unit below.	Estuarine muds
1.9	2.4	0.12	–0.38	Mid brownish grey, soft, plastic ORGANIC CLAY. Grades into unit below.	Estuarine muds flooding peat surface.
2.4	2.55	–0.38	–0.53	Dark brown clayey PEAT. Sharp horizontal contact with unit below.	Channel marginal wetland
2.55	2.75	–0.53	–0.73	Mid brownish grey, soft, plastic ORGANIC CLAY. Grades into unit below.	Channel marginal wetland overbank floodplain deposit
2.75	3.5	–0.73	–1.48	Dark brown clayey fibrous PEAT with moderately frequent wood fragments. Sharp horizontal contact with unit below.	Channel marginal wetland
3.5	3.85	–1.48	–1.83	Mid brownish grey, soft, plastic ORGANIC CLAY. Grades into unit below.	Channel marginal wetland overbank floodplain deposit
3.85	4.8	–1.83	–2.78	Dark brown clayey fibrous PEAT with moderately frequent wood fragments.	Channel marginal wetland

				Sharp horizontal contact with unit below.	
4.8	5	–2.78	–2.98	Grey clast supported GRAVEL granular to 30mm subrounded to angular, with coarse sand matrix (unknown depth)	River terrace

8 Revised deposit model

8.1 Methodology

The lithostratigraphy of the evaluation boreholes along with other geotechnical and archaeological site information were entered into the geoarchaeological Rockworks (2006) database. Sediments were then interpreted and a basic stratigraphy created. This included a 'Early Holocene surface' stratigraphy layer interpreted from the top of the sand or gravel. Spot heights from this layer were exported to ARCGIS (10) and used to model a surface (Figure 2). The surface plot is an inverse distance weighted (IDW) plan created within ArcMap 10 spatial analyst. IDW is a deterministic (rather than geostatistical) method that assumes points close to one another are more alike than those further away. Default settings were generally used with a cell size of 1 and a power value of 2. This study of the underlying gravel topography is essential in defining the major landforms present within the floodplain that 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 that existed at the beginning of the Early Holocene (*c* 10 000 BP).

Each identified lithological unit within a sediment sequence (gravel, sand silt etc) was given a unique colour and pattern allowing cross correlation of the different sediment and soil types across the site, as shown in the transect (Figure 3). 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 (facies, see Figure 3). 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 (facies), representing certain depositional environments, and/or landforms can be reconstructed both laterally and through time for the site.

In order to discuss the archaeological and palaeoenvironmental potential, the site has been divided into Landscape Zones where similar sequences of deposits exist and thus are likely to have similar potential for archaeological and palaeoenvironmental remains. The distribution of these Landscape Zones (LZ's) is illustrated on Figure 4.

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8.2 The Stratigraphic Sequence

8.2.1 Pleistocene gravels (facies 1)

The basal gravels are part of the Shepperton Gravel formation, and were deposited within a cold climate braided river regime between 18 000–15000 BP, in the final stages of the Devensian Glaciation (Gibbard 1994). The braided river regime consisted of higher relief channel bar macroforms interspersed with lower lying channel threads. As climatic amelioration began in the early Holocene, these higher relief gravel bars developed into areas of dry ground, while anatomising and/or multiple threaded channels occupied the lower lying areas.

The surface of this facies is present in the early Holocene topographic plot (Figure 2). Across the wider context of the North Woolwich Portal the sub–surface gravel topography consists of a low lying channels/estuarine environment segmented by higher gravel areas (islands) to the west (e.g. ETAP_BH1, Figure 3) and centre (e.g. NWP_EVAL_BH3, Figure 3), and with additional smaller island areas to the east (Figure 2).

Areas above approximately –4m OD are thought to denote areas of high ground that remained dry for most of the early Holocene and potentially later. Areas below –4m OD are thought to denote the deeper channel areas. Across the transect (Figure 3) the elevation of the surface of this facies is between 0.0m OD (100m ATD) and –6.5m OD (93.5m ATD). Within the area of the Portal and worksite the surface is recorded around –3m OD (97m ATD, see NWP_EVAL_BH3 in Figure 3) to the east, but could drop down to –6m OD (94m ATD) to the west. Within the western part of the site the surface is likely to be around –3m OD (97m ATD), but drops off to –5m OD (95m ATD) to the east entering the deeper channel areas.

8.2.2 Early Holocene sand (facies 2)

To the centre and east of the transect (Figure 3) sands and sandy silts were recorded overlying the Pleistocene gravels, between c –1m OD (99m ATD) and c –5m OD (95m ATD). Deposits such as these most likely formed during the early Holocene when high water flux present at the end of the Devensian glaciations had abated, leading to a reduction in the size of the particles that the river could entrain. However, medium to coarse sand, still available in the fluvial system, was still being transported along the river and was being deposited and banked up against gravel highs. Early Holocene channels would have deposited these sands forming point and mid–channel bars within the network of anastomosing channels.

Theses sands would have banked up against the higher gravel areas to the west and centre of the wider landscape (Figure 2). Wooded dry land surfaces could have formed across the surface of these deposits. The elevation of the sands suggests that these dry land surfaces would have only been exposed during the early Prehistoric and then inundated as a result of relative sea level rise and the ponding back of inland rivers during the Late Mesolithic or Early Neolithic Within the Portal Area, the surface of these units may exist from –1m OD (99m ATD) to –3.5m OD (96.5m ATD).

8.2.3 Early Holocene channel sediments (facies 3)

This facies includes sandy silts, sandy peats, and clayey peats. These deposits exist from c –1.5m OD (98.5m ATD) to c –6.5m OD (93.5m ATD). These deposits were subject to gleying or showed a high organic content preserved in waterlogged conditions. The low elevation and therefore early deposition of these deposits indicate the silting up or stagnation of the earlier deeper channels to the west and east, as indicated by the early Holocene topography (Figure 2), and potentially later shallower higher channels to the centre of the transect (Figure 3).

It is suggested that the borehole locations where these deposits are thickest are where this process occurred to a greater degree and was therefore closer to a channel. To the west of the Portal the surface of these deposits occur from c –1.5m OD (98.5m ATD). The surface of these deposits drops to c –3m OD (97m ATD) in the east of this impact area. The silty clay deposit to the base of BH1 (see section 7.2 and Figure 3) could be a very deep channel deposit but it appears out of character for the immediate vicinity. The borehole logs suggest (see section 7.2) it is backfill or re–drilling as a result of the borehole process.

8.2.4 Peat and humic muds (facies 4)

Facies 4 consists of a series of alternating layers of peats or organic clays and silts. These deposits occur between c –5m OD (95m ATD) to c –1m OD (101m ATD) and measure over 4m at the thickest extent. The organic peats and especially the woody peat (DLA03_PH2_ARC4 and XRAIL_NW15R, Figure 3), indicate a return to a more stable, albeit now wetland, environment. Previous work by Devoy (1979, 1982) across the lower and middle Thames suggested that this alternating sequence of peats and clays relates to a series of marine transgression and regression events dating from the Early Mesolithic to the medieval period. More recent work has been done in the area, which shows that the peat is (despite lenses of clay) predominantly a thick build up representing the wet woodland (alder carr) of the Mesolithic to Bronze Age. More recent work by Bates and Whittaker, revised the regional model for the Lower Thames Valley and proposed the need for more site specific environmental studies on archaeological sites (Bates and Whittaker 2004). The previous assumption based on Devoys work was that once we have one sequence we know the whole story for a region. A recent article (Yendell 2011) demonstrates that this assumption is incorrect as lithologically similar sequences within a kilometre of each other can show very different environments and pressures on landscape change, and therefore human occupation activity and artefact preservation.

This rise and fall in river levels and marine transgression and regression episodes are thought to relate to relative sea level rise, combined with isostatic rebound, which has resulted in the down warping of south east England since the ice sheets retreated from northern Britain at the end of the Devensian glaciation. However, a number of local factors are likely to also have affected the river levels, including sediment input, soil stability and erosion, and changes to the hydrology of the river itself. This facies could be of a Mesolithic to Bronze Age date.

At Devoy's Woolwich site, the gravel surface which existed at c –5 m OD was found to be overlain by a peat deposit (Tilbury II) that was radiocarbon dated to *c* 6755 BP (i.e. the Late Mesolithic). Within the east of the Portal, the gravel surface is recorded around –3m OD (97m ATD, see NWP_EVAL_BH3 in Figure 3). However, it may drop to –6m OD (94m ATD) to the west of the TWB Portal Excavation and the GWB worksite. The gravel surface in the east of the impact areas is likely to have supported a dry landsurface until later and therefore, the overlying peat will likely be later than Late Mesolithic peat at Woolwich. However, if the gravel deposits exist at –6m OD (94m ATD) in the west of the impact areas then Mesolithic peat deposits may survive. The peat deposits are recorded from c 0m OD (100m ATD) in the east of the site, where they are up 3m thick and from c –1.5m OD (98.5m ATD) in the centre of the site. Further to the east, well developed woody peats, over 2m in thickness, are likely from c –1m OD (99m ATD). Facies 4 deposits do not appear to survive in the west of the Portal as the Early Holocene banked sands deposits (facies 2) rise up and the peats thin out.

8.2.5 Holocene alluvium (facies 5)

On the whole the facies 5 sediments are occasionally organic, silty clays. They are recorded from c –2m OD (98m ATD) to 2.5m OD (102.5m ATD) and signify a freshwater to brackish estuarine mudflat environment. Following a rise in RSL during the Bronze

Age, the floodplain landscape changed dramatically as it became inundated by rising river levels (Devoy 1977; 1979; 1980; 1982; 2000; Sidell et al 2000; Wilkinson et al 2000). This inundation can roughly be associated with Devoy's (1979) Thames IV estuarine expansion event, which was identified at Woolwich from *c* 2600 BC or later, around the Middle Bronze Age (Cal BC 1870–1840 (Cal BP 3820–3790), Cal BC 1820–1790 (Cal BP 3770–3740), Cal BC 1780–1520 (Cal BP 3730–3470) (BETA 272865)) at Canning Town (Yendell 2011).

As inundation occurred, woodland became waterlogged and died off, and the landscape would have become much more open, with an expansion in herbs and grasses to match the reduction in local alder woodland. The accumulation of this facies led to the terrain levelling out with any former depressions in the floodplain silting up. Soil erosion associated with increased agricultural activity would have greatly increased the sediment transported into the river system and in turn added to this. On the northern margins of the meandering River Thames, water meadows formed that would have been prone to episodic overbank flooding. The deposited fine–grained sediment would have gradually built up as an accretionary floodplain soils. This sequence of events is likely to be associated with Bates and Whittaker's stage 5 of the lower Thames Valley evolution (Bates and Whittaker 2004). From the Bronze Age to the medieval period indirect evidence of human agricultural activity is likely to be preserved within these deposits.

Within the Portal area the surface of this facies lies from 1m OD (101m ATD) to the east, appearing to drop away to the west as it approaches a deep area of truncation infilled with redeposited alluvium in PKG19_WS4 (Figure 3). The deposits appear thickest in the west (up to 1m), just before the area of truncation and shallower in the east, c 0.5m thick. The thick deposits within Trial_Pit_TP673 may relate to Ham Creek, a tidal creek previously suggested to be in the area (Crossrail 2011).

8.3 Archaeological Potential

8.3.1 Reliability of the model

The landscape zones are presented in Figure 4. Along the line of the Portal area 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, and to the immediate west of the excavation area the data points are of poor resolution. While this does not directly affect the interpretation 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.

This is most pertinent to the relationship of LZ1 to that of LZ2 and LZ3. LZ1 represents an area of lower lying topography, which from the extrapolation of the data points is predicted to cover the majority of the west of the Portal area. This is merely a prediction and therefore the boundaries that exist between this zone and LZ2 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 east and west and how much of the site lies on the higher drier island (LZ2).

8.3.2 LZ1

LZ1 occupies the majority of the modelled area, and is typified by low–lying land, most likely associated with a network of braided channels flowing across this area of the Thames floodplain from the late Pleistocene/early Holocene to historic periods. Within

LZ1 there is reasonable 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. In addition, this landscape zone is important for investigating the changing behaviour of fluvial systems during significant changes in climate regime (i.e. glacial – interglacial transitional periods). Such information is not only important in its own right, but if associated with evidence for human activity, allows for the clarification of the interaction between past human populations, the landscape features and the climate.

At present, the River Thames is a single channel meandering river, situated directly to the south of the site. However, just after the last glaciation, the Thames existed as a network of smaller interconnected channels surrounded by a wide expanse of marshland, and higher, drier sand and gravel bars. These channels migrated back and forth across the Thames floodplain, alternating between active, flowing channels, and isolated channels prone to sediment infilling. During this period the landscape zone would have been relatively inaccessible by humans except by water craft and would have formed a formidable barrier against travelling the floodplain.

These channels were active at the beginning of the Holocene (Early Mesolithic) and could have been easily exploited by humans for food resources. Later in the Holocene, probably from the Late Neolithic up until historic times, these channels silted up, and peat formation was initiated. Peat formation would have been induced by slowly rising river levels, causing this landscape zone to change to a predominantly marshland environment. By this time the Thames floodplain would have been dominated by a single–thread meandering channel, similar to today and fed by creeks draining the marshland and later mudflats. The thick deposits within Trial_Pit_TP673 have previously suggested the presence of such a tidal creek. This has been supported by historical maps of the area, which have shown Ham Creek to be in the vicinity (Crossrail 2011).

The humic muds and peats infilling these relict channels are highly conducive to the preservation of organic material, and so these sediments have high potential for containing palaeoenvironmental material, such as molluscs, insects and pollen, all of which can be examined in order to reconstruct the developing environment in which past human populations existed.

River valleys would have been targeted during prehistoric periods by hunter–gatherer–fisher groups in particular, for the diverse food resources. Such activity was often focused in marginal areas adjacent to the stream channels themselves. Thus there is also potential for evidence of wetland activity from the Mesolithic onwards to be found in this landscape zone. Such evidence might include organic artefacts and structures associated with river crossings, fish traps and boats. The western half of the Portal falls within this landscape zone and deposits of archaeological interest could lie from c 0m OD (100m ATD).

8.3.3 LZ2

Areas of higher, drier ground exist in the western and central areas, with small areas to the east of the study area. Such sand and gravel islands are important in our understanding of the exploitation of the Thames floodplain over the course of the prehistoric period as they are likely to have remained higher and drier above the marshy environment of the channel marginal area (LZ3) and low lying channel plain (LZ1). High dry areas could have good potential for evidence of dry–land prehistoric and later human activity.

The deposit sequence of LZ2 consists of gravel and sand islands that have a surface elevation rising from –4m OD (96m ATD). The level of the River Thames would have been notably lower at the beginning of the Holocene (Early Mesolithic), possibly up to 15m lower (Bates and Whittaker 2004). However, rapidly rising sea levels (related to the unlocking of polar ice) over the course of the Early to Mid Holocene, caused the Thames to rise to c 13m OD (97m ATD) by the Mesolithic/Neolithic transition (Bates and Whittaker 2004).

The high ground to the west of the transect (Figure 3) has a surface elevation of c 0m OD (100m ATD) and, as a result, is likely to have remained as high, dry ground throughout much of prehistory. This would have been an attractive area of the Thames floodplain in which subsistence activities such as hunting and fishing could have been carried out. It is probable that temporary camps would have been constructed on larger islands, to serve as a base from where such activities took place.

Towards the centre, and with additional smaller areas to the east, of the study area are island zones at a lower elevation than recorded to the west, from c –4m OD (96m ATD) to –1m OD (99m ATD). Based on estimates of rising river levels during the early part of the Holocene it is suggested that these lower islands would have probably been inundated by the end of the Mesolithic period (10,000–6,000 BP) (Bates and Whittaker 2004). The eastern half of the Portal area lies within the zone of the central island. Over the course of the Mesolithic period, hunter–gatherer–fisher populations could have employed such dry land to carry out subsistence activities such as hunting, stone tool manufacture and food processing. Soils may have formed on these surfaces, prior to inundation and wetland formation as a result of rising sea/river levels, and these buried land–surfaces have the potential for the accumulation and preservation of archaeological material, such as lithic scatters – the bi–product of the manufacture of stone tools. Mesolithic ephemeral soils have been frequently recorded in this part of the Thames floodplain (eg Lam and Corcoran 2002; Morley 2003).

Dependent on the elevation of these lower islands within the floodplain and the local hydrological conditions, there is the potential for these areas of high ground to have remained dry–land up to and including the Neolithic and Bronze Age periods. A timber trackway of Neolithic age was found c 1km to the west of the site associated with a gravel island, which had an upper surface lying at c –1m OD (99m ATD) (Wessex Archaeology 2000). It was proposed that this trackway linked areas of high ground which were separated by lower lying, wet and marshy areas not easily accessible to prehistoric people exploiting the resources of the Thames floodplain.

8.3.4 LZ3

LZ3 characterises the intermediary zone between the higher dry islands of LZ2, and the low lying channel braidplain (LZ1). Well–developed woody peats indicating long term wetland vegetation at the margins of the main channel network dominate this landscape zone. LZ3 has reasonable to good potential for the recovery of prehistoric wetland archaeological remains in particular timber structures (e.g. Bronze Age timber trackways or platforms), and high potential for the recovery of well preserved palaeoenvironmental remains.

Much of the peat found in this landscape zone is highly woody and fibrous and shows that moisture–tolerant vegetation existed at the margins of the Thames floodplain (and associated smaller marginal braidplains), primarily as alder–carr vegetation assemblages, most likely with a ground flora of sedges and ferns. Boreholes DLA03_PH2_ARC4 and XRAIL_NW15R (Figure 3) contained thick woody and fibrous peat directly overlying sandy sediments, indicating that well–stabilised wetland vegetation was developing in the margins of the Thames floodplain. Less developed woodlands of oak, elm, ash and lime trees were probably also colonizing these channel proximal areas (Morley 2003).

The environment of LZ3 would have been largely inaccessible to prehistoric people hunting, fishing and foraging along the margins of the Thames floodplain, due to the potentially impenetrable density of the vegetation and the bogginess of the ground surface.

8.3.5 Comparison to previous model

The previous deposit model (Crossrail/MOLA 2008b) is broadly similar to the updated deposit model presented here (Figure 4). The main changes involve extensions of areas that previously existed with only one or two new additions. To the west of the deposit model area the higher drier ground of LZ2 extends further to the north and south than in the previous model. There is a lack of data points in this area and the extent to which LZ2 does exist to the north and south is somewhat uncertain. As a result of the extension of LZ2 in the west, the area of marginal wetland (LZ3) bordering it has also altered, becoming slightly wider and more north south aligned.

To the middle of the deposit model, in the area of the Portal, the greater number of points showing higher drier ground (LZ2) have extended the boundary of the central island further north and south, and widened it from c 100m to c 200m. Once again the north and south extension is somewhat uncertain due to the lack of data points further to the north and south. The northern and southern limits of the island may lie somewhere within the proposed central LZ2 area or may lie outside of the deposit model area as a whole. In addition to the enlargement of the central island the associated marginal wetland (LZ3) around it has also increased slightly. These changes have resulted in more of the Portal area laying within the higher island zone (LZ2) and the marginal wetland area (LZ3).

To the east and within the main channel area of LZ1 are three smaller island areas. The smallest, to the north west, was not highlighted on the previous model and constitutes a small c 50m wide area of higher ground (LZ2) surrounded by marginal wetland (LZ3). The southern island was present on the previous deposit model but has been extended eastwards by new borehole data and is now c. 200m east to west when it was previously c 100m. It is also surrounded by and area of marginal wetland (LZ3). The eastern most of the smaller islands has been reduced in size with much of its previous area now being considered to have more of a marginal wetland potential (LZ3) than dry land potential (LZ2). The island area has reduced from over 250m in width previously, to under 150m in the present model.

9 Realisation of original research aims

- *Peat and alluvial deposits preserving a wide range of proxy palaeoenvironmental indicators (i.e. pollen, diatoms, plant macro fossils) that can be utilised to reconstruct past landscape, palaeoecology, hydrology, geomorphology and past landforms.*

Organic and minerogenic deposits of palaeoenvironmental interest exist within the Portal area, from c 1m OD (101m ATD) at its surface down to 3.5m OD (96.5m ATD) at the deepest recorded. There is unconfirmed potential that the depth to which the deposits survive may be deeper to the west of the site than recorded above. The deposits show well developed woody peats up to 3m in thickness survive within the site area. These types of deposit have a high potential for preservation of significant palaeoenvironmental remains.

- *Prehistoric structural timber remains such as trackways, fish traps and revetments possibly occurring within the thick peat deposits*

Timber structures are unlikely to be identified in boreholes or window samples. However, peat deposits, up to 3m thick, were identified in the east of Portal area from c 0.0m OD (100m ATD), and may survive in the west of these areas as the gravels (facies 1) and the overlying sands (facies 2) thin out. The thick well developed peats on the channel margins (LZ3), to the centre and west of the Portal site, and the thinner potentially late prehistoric peats overlying the central low islands (LZ2), to the east of the Portal site, indicate environments where such structures would have been utilised and later preserved.

- *Mesolithic to Neolithic dryland activity horizons above gravel high points, consisting of ephemeral scatters of animal bone and lithic material.*

Scatters of animal bone and lithic material are unlikely to be identified in boreholes or window samples. However, good potential for Mesolithic to Neolithic dryland activity exists on the top of the sand and gravel island in the east of the Portal area and the. The surface of these deposits is recorded within the site from c –3.5 m OD (96.5m ATD) to –1m OD (99m ATD). The overlying peats and organic clays indicate that any lithic material or other artefacts may be well preserved.

- *Evidence of floodplain stabilisation and soil formation of a Roman to Medieval date within the upper minerogenic alluvium, and associated archaeology consisting of pits, ditches etc*

Archaeological features such as pits and ditches are unlikely to be identified in boreholes or window samples. However, evidence of floodplain stabilisation and soil formation of a Roman to Medieval date may exist within the upper alluvium from c 1m OD (101m ATD) across the Portal area except to the very western limit where localised truncation may be expected.

10 Statement of potential archaeology

The evaluation has shown that there is good potential for the survival of Mesolithic artefacts (e.g. flint scatters) within the LZ2 area to the east of the site; timber structures associated with prehistoric to historic exploitation of wetlands within LZ2 and LZ3 over much of the site, and high potential for the preservation of significant palaeoenvironmental remains with the deep peat deposits in LZ3 and LZ1 to the west and far east of the site.

The archaeological remains are assessed as of local significance in terms of the development of this part of London, increasing to regional significance in the case of understanding the relationship between human interaction and the landscape development of the east London Thames from the Mesolithic to the Historic periods.

11 Recommendations for appropriate mitigation strategy

The results of the evaluation and deposit model should be used to target any archaeological trench evaluation required, and inform on the level of watching brief required during the ground works.

12 Publication and dissemination proposals

The evaluation results will be disseminated via this report; the supporting site archive of finds and records (including digital data) and by incorporation into the wider predictive deposit modelling for the Crossrail scheme. Any publication proposals will be considered in the wider context of archaeological potential and results within the scheme.

13 Archive deposition

The site archive containing original records and finds will be stored temporarily with MOLA pending a future decision over the longer–term archive deposition and public access process for the wider Crossrail project.

14 Acknowledgements

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16 NMR OASIS archaeological report form

16.1 OASIS ID: molas1–112825

Project details

Project name	C263 ARCHAEOLOGY LATE EAST, Geoarchaeological Borehole Evaluation and Deposit Model Update, North Woolwich Portal – XSV1
Short description of the project	The results of the three evaluation boreholes were used to update previous deposit modelling broadly confirm anticipated findings. High areas of Pleistocene gravels and early Holocene sand form dry land islands with a low lying channel floodplain. These dry island areas have the potential for Mesolithic activity. Channel routes migrated and silted up in these deeper channel areas during the early Holocene. Subsequently, river levels continued to rise over the Late Mesolithic to Bronze Age, resulting in transgression and regression episodes, which waterlogged these drier island areas allowing for dense wetland vegetation to develop. As further inundation occurred, thick clay alluvial deposits formed, levelling out the terrain, with any former depressions in the flood plain area silting up. Woodland became increasingly waterlogged and died off, and the landscape would have become much more open. Because of the potential for Mesolithic archaeology, related to hunter–gatherer–fisher activities centred on the gravel island and exploiting the nearby resource rich wetland of the channel marginal zones, and for associated deep organic sequences preserving significant palaeoenvironmental data concerning the development of the River Thames in east London, the results from North Woolwich Portal are assessed as being of regional significance.
Project dates	Start: 03–08–2011 End: 28–10–2011
Previous/future work	No / Yes
Any associated project reference codes	XSV1 – Sitecode
Type of project	Field evaluation

Site status	None
Current Land use	Transport and Utilities 1 – Highways and road transport
Monument type	BTCLSN Mesolithic

Project location

Country	England
Site location	GREATER LONDON NEWHAM WEST HAM North Woolwich Portal
Postcode	E16
Study area	25000.00 Square metres
Site coordinates	TQ 542749 179975 50.9401774987 0.196100853530 50 56 24 N 000 11 45 E Point
Height OD / Depth	Min: –6.00m Max: 1.00m

Project creators

Name of Organisation	MOLA
Project brief originator	Crossrail
Project design originator	Crossrail
Project director/manager	David Divers

Project supervisor	Virgil Yendell
Type of sponsor/funding body	Crossrail Ltd
Name of sponsor/funding body	Crossrail Ltd

Project archives

Physical Archive Exists?	No
Digital Archive recipient	LAARC
Digital Media available	'Database','GIS'
Paper Archive Exists?	No

Project bibliography 1

Publication type	Grey literature (unpublished document/manuscript)
Title	C263 ARCHAEOLOGY LATE EAST, Geoarchaeological Borehole Evaluation and Deposit Model Update, North Woolwich Portal – XSV11
Author(s)/Editor(s)	Yendell, V

Date	2011
Issuer or publisher	MOLA
Place of issue or publication	London
Description	This report presents the results of a geoarchaeological borehole evaluation carried out by the Museum of London Archaeology (MOLA) on the site of North Woolwich Portal, London E16, in the London Borough of Newham. This report was commissioned from MOLA by Crossrail Ltd.

Entered by	Virgil Yendelll (vyendell@mola.org.uk)
Entered on	28 October 2011

17 Glossary

bGL	below ground level (depth/level)
Bronze Age	*c* 2000–650 BC
Holocene	Geological era from 10,000 BP to the present day
Iron Age	*c* 650 BC–AD 43
m OD	Metres above Ordnance Datum (Newlyn). To obtain Tunnel Datum heights (m TD) add 100m to OD heights.
Mesolithic	*c* 12,000–4000 BC
Neolithic	*c* 4000–2000 BC
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
Roman (Romano–British)	AD 43–*c* 410

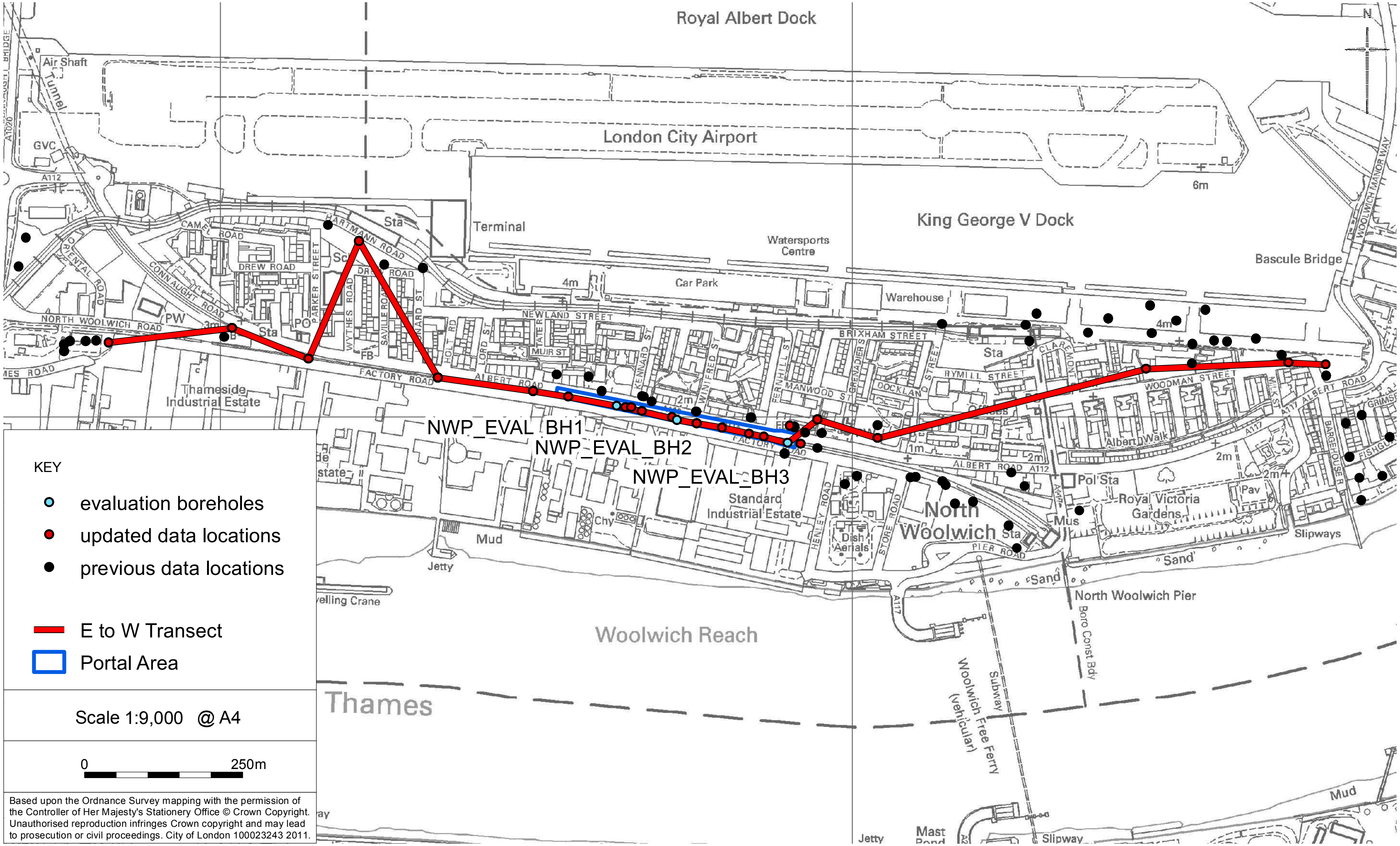


Fig 1 Location of geotechnical data and borehole transects

North Woolwich portal deposit model update © MOLA 2011

MULTI1051GEO11#01

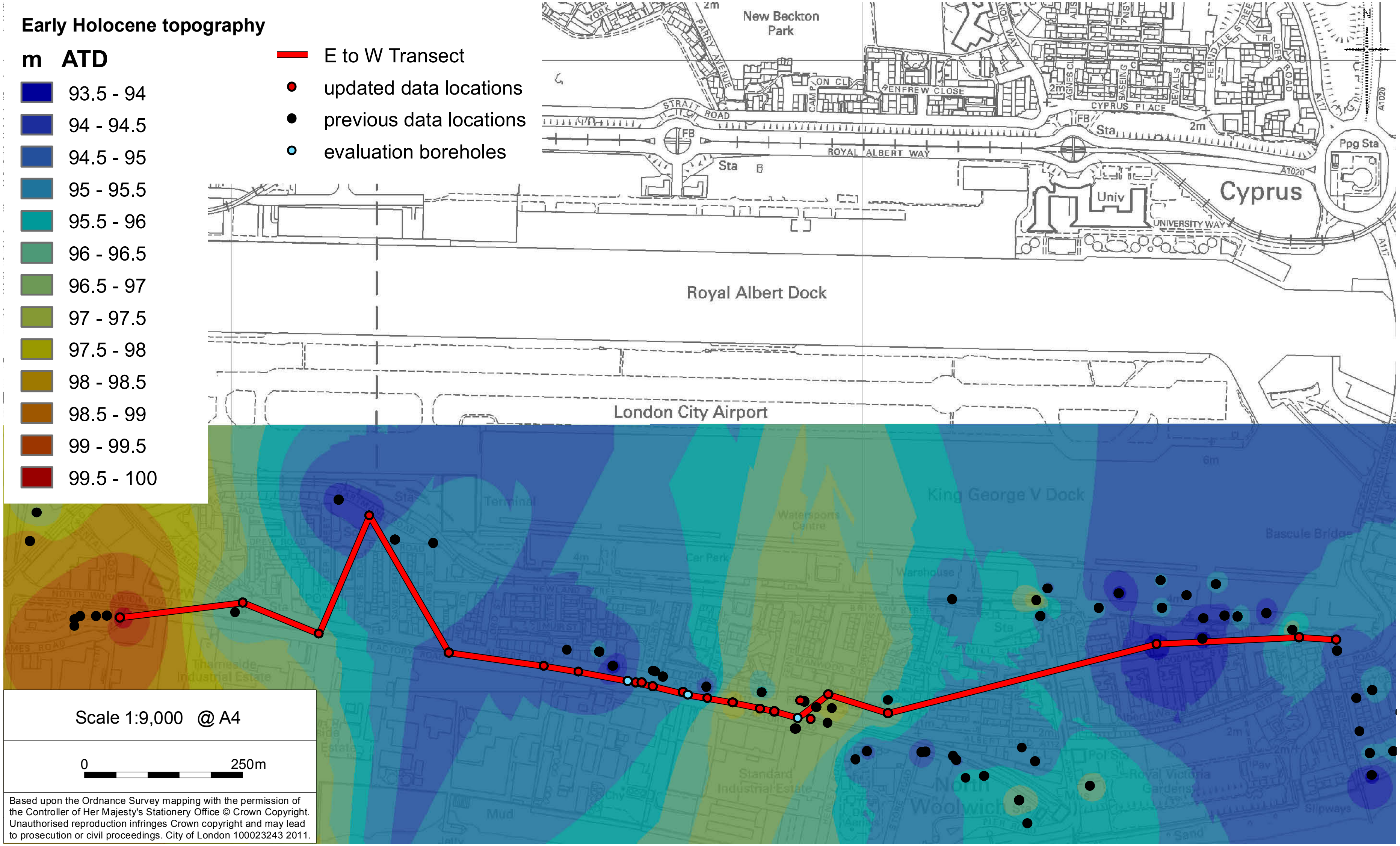
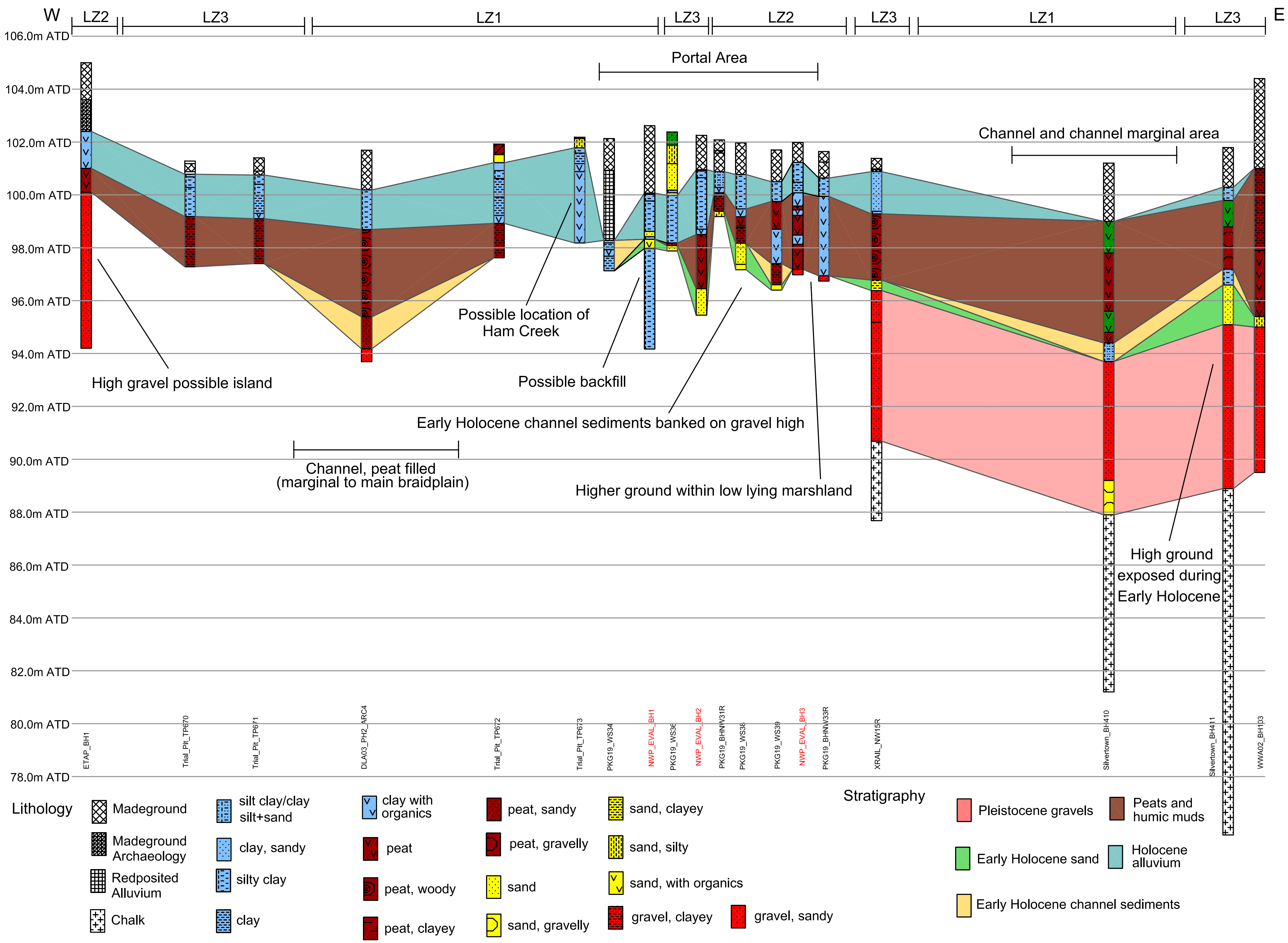


Fig 2 Buried topography of the Early Holocene

MULTI1051GEO11#02

North Woolwich portal deposit model update © MOLA 2011



MULTI1051GEO11#03

Fig 3 West to east transect across the site

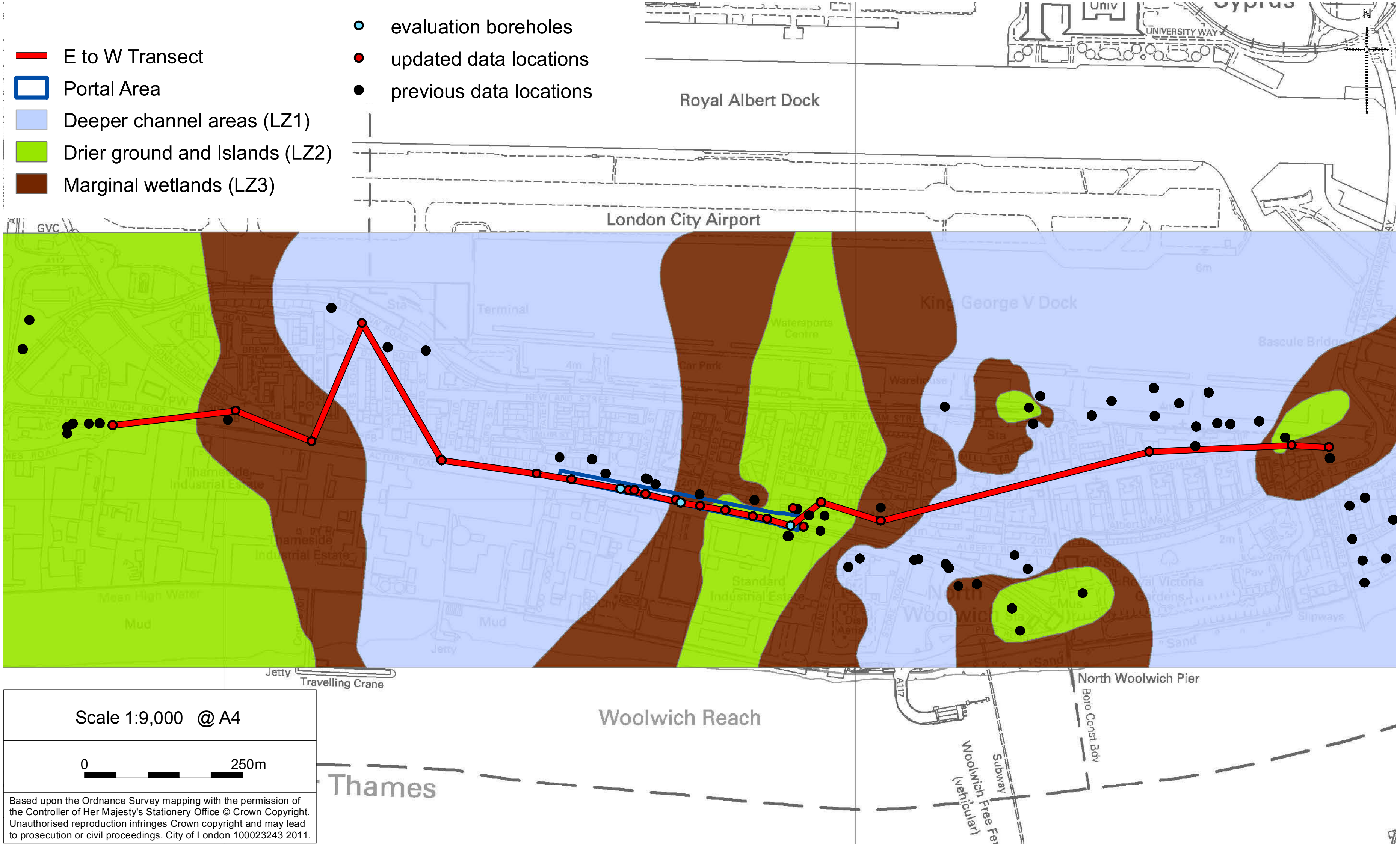


Fig 4 Landscape zones

MULTI1051GEO11#04

North Woolwich portal deposit model update © MOLA 2011