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Carried out for	London City Airport	Date		Photograph	01 & 02

Photograph No 01

Photograph No 02

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Appendix B Concept Interpretative Report

GEOTECHNICAL INTERPRETATIVE REPORT

CADP Surveys Ground Investigation (Dock) – Phase 2

ISSUE 02

GEOTECHNICAL
INTERPRETATIVE REPORT

CADP Surveys Ground Investigation (Dock) – Phase 2

Prepared for: London City Airport Limited

Concept: 16/2900 - IR 02 04/07/2017

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1 INTRODUCTION

Concept Site Investigations (Concept) has been instructed by London City Airport Ltd to provide a Geotechnical and Geonevironmental Interpretative Report of the site where the proposed airport expansion project known as City Airport Development Programme (CADP) Airfield and Deck Design is to be situated.

The purpose of the report is to discuss the geoenvironmental and geotechnical findings of the site investigation carried out by Concept between 02/11/2016 and 28/02/2017. An interim geotechnical interpretative report was produced in 13/01/2017 which incorporated all site investigation data available by the 16th December 2016.

A geo-environmental appraisal of the site is presented in section 8 of this report. It contains a review of the available historic data and provides an appraisal of the levels of contamination present within the soils and groundwater encountered on site. It then assesses the geo-environmental risks to the development.

A geotechnical appraisal of the site is presented in section 9 of this report. It presents the ground conditions and the geotechnical properties of the soils encountered at the site and makes recommendations on the geotechnical parameters to be used in the design. In addition it provides an appraisal of the factors to be considered during the design of the substructure and assesses the geotechnical risks to the development. Finally it provides preliminary pile design charts for the sizing of the piles.

The proposed geotechnical design options and recommendations summarised in this report relate to details of the proposed development at the time of writing the report. Any substantial changes to the proposed design may require reassessment of the implications of the risks identified and the recommendations given herein.

The recommendations made in this report are based on information contained in the factual site investigation report:

- Concept Site Investigations (2017). Factual Site Investigation Report, CADP Surveys – Ground Investigation (Dock) Phase 2, (16/2900 - FR 00, 06/03/2017).

In addition, this report refers to and takes into account the findings of previous investigations listed in section 4.

This report has been prepared for London City Airport Ltd based on the specific requirements and instructions submitted by TPS on their behalf. Any other party using this information for any other purpose whatsoever does so at their own risk and any duty of care to that party is excluded. In particular, the designers of the substructure elements should satisfy themselves of the suitability of the design parameters given in this report for the needs of their designs. Concept does not accept responsibility for the design of any elements that have incorporated assumptions stated within this report where the responsibility of the design of such elements lies with a third party.

Reasonable skill and care has been exercised in the preparation of this report in accordance with the technical requirements of the brief. Notwithstanding the efforts made by the professional team in undertaking this investigation, it is possible that ground conditions other than those indicated in this report may exist at the site.

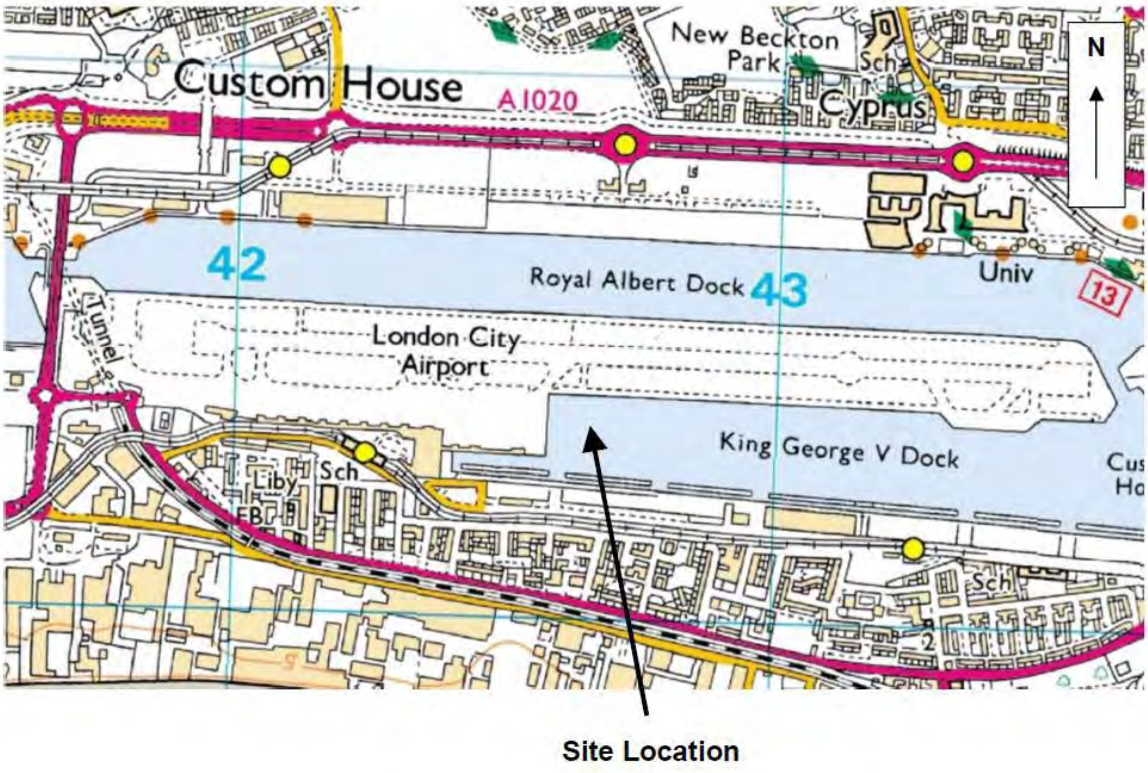
2 THE SITE

London City Airport is a city centre airport that lies within the administrative area of the London Borough of Newham (LBN). It is located between the Royal Albert Dock (30 hectares) and King George V (KGV) Dock (24 hectares), adjacent to the Woolwich Reach and Gallions Reach of the River Thames.

The Airport is approximately 6 miles east of the City of London, approximately 2 miles east of Canary Wharf and 0.5 miles away from the ExCeL Exhibition and Conference Centre. The surrounding area comprises of a mix of residential, industrial and commercial uses.

The area of the Airport proposed for redevelopment under the CADP comprises an approximately 2km long strip and includes land to the south of the King George V Dock and an area to the south and west of the main terminal building. This area comprises (from west to east) a staff car park, a service area adjacent to the main terminal, the terminal forecourt, the short and long stay car parking areas, a disused shed / warehouse, a fuel depot, a steel yard and an area of derelict land.

The site is located at the approximate National Grid Reference TQ 425 804.



Map 1: Site Location (Not to Scale © Crown Copyright reserved)

2.1 Topography

The existing decks located in the dock are flat due to being used as part of the airport (taxiways). Historic The top of the dock silt varies between approximately -5.51mAD and -8.71mAD.

2.2 Proposed Development

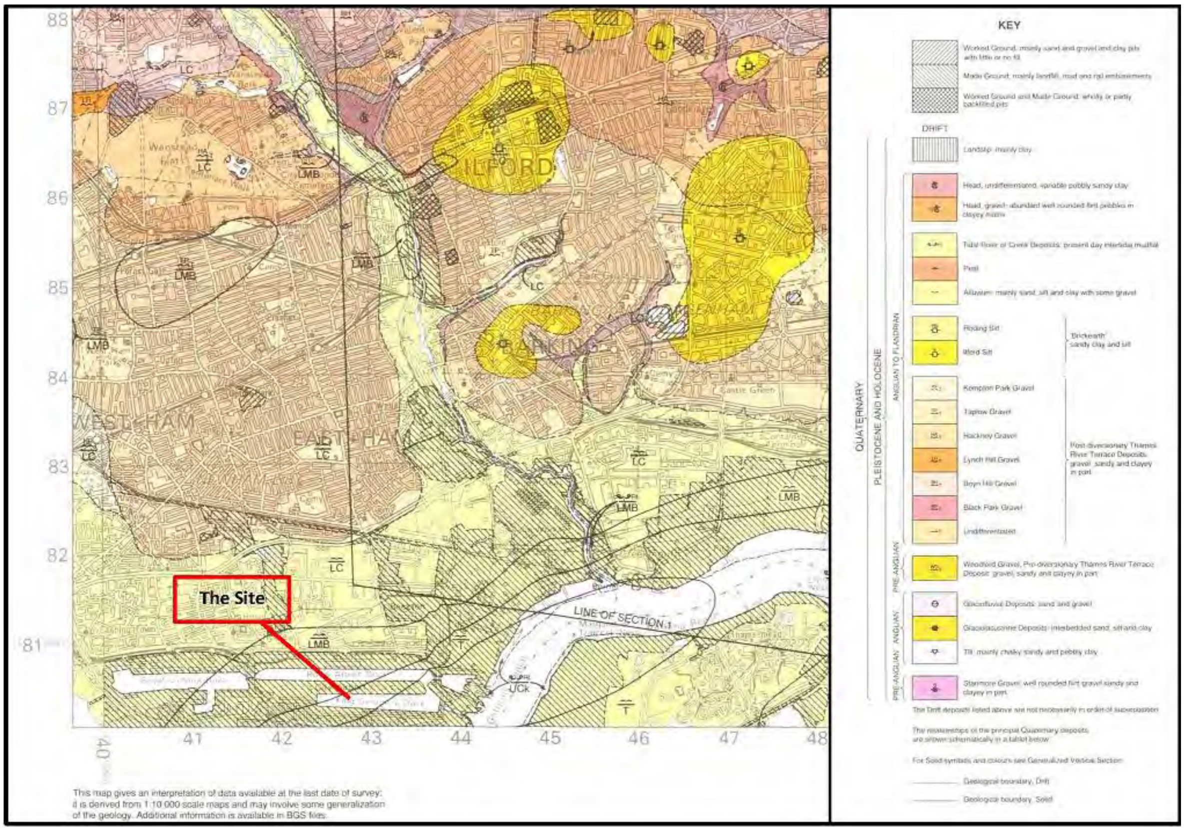
Eight new aircraft stands, an extended taxi-lane and an Eastern Terminal Extension will be largely situated on a 7.4 hectare deck or platform over King George V (KGV) Dock. A plan of the proposed development is reproduced in Figure 2 of this report.

The deck will comprise precast reinforced concrete planks with an in-situ topping spanning onto precast concrete beams. The beams are to be supported by bored concrete piles with steel founded in the Thanet Sand or Chalk beneath the dock bed. The proposed pile layout plan is reproduced in Figure 3 of this report.

3 GEOLOGY

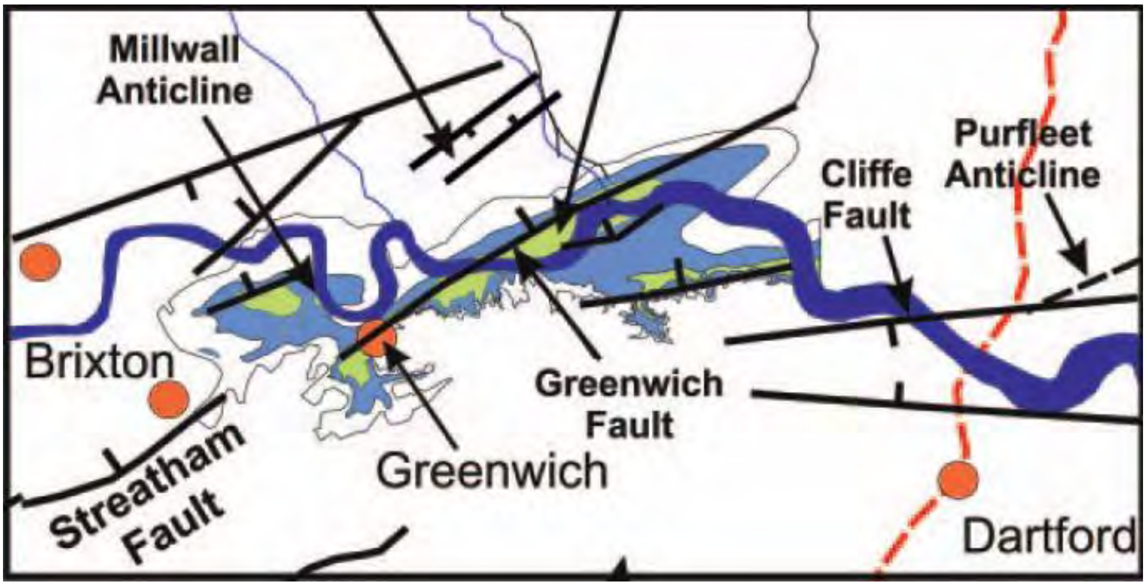
The BGS Geological Survey Sheet 257 Romford (Solid and Drift Edition), Scale 1:50,000 reveals that the site is underlain by Alluvium overlying the Thanet Sand Formation on the west of the dock but rests directly on the Upper Chalk Formation on the east of the dock.

Although the Upper Chalk Formation is undifferentiated on the Survey Sheet a generalised stratigraphic log of the Chalk beneath East London contained in Mortimore et al (2017) indicates that the Chalk underlying the site is part of the Seaford Chalk Formation. The overlying Newhaven Chalk Formation has been removed by sub-Paleogene erosion (together with the upper part of the Seaford Chalk Formation itself).



Map 2: Site Geology (Not to Scale © Copyright reserved)

The site is located in close proximity to the southern edge of the London Basin and broadly crosses the NE–SW strike of the main tectonic features, the Greenwich and Purfleet Anticlines and the Greenwich Fault. Mortimore et al (2011) identified faults in cored boreholes interpreted as an extension of the Greenwich Fault system northeastwards along the northern flank of the Greenwich Anticline.



Map 3: Main tectonic structures present at the area of the site after Mortimore, 2011 (**Not to Scale © Copyright reserved**)

4 HISTORICAL SITE INVESTIGATION REPORTS

A summary of the historical reports reviewed in the preparation of this report is provided in Table 4.1.

Table 4.1: Historical Investigation Reports

Year	Organisation	Description	Purpose	Investigation details
September 2015	RPS	Ground Conditions and Contamination	Assessment of the effects of the proposed CADP relating to ground conditions and contamination	
December 2014	RPS	Phase 2 Environmental Site Investigations	Provides information on ground conditions and the contamination status of soils and groundwater	5no cable percussion boreholes to depths ranging from 20.00m to 25.00m bgl, California bearing ratio (CBR) testing in four locations.
May 2013	RPS	Phase 1 Environmental Risk Assessment	Identifies potential pollutant linkages associated with former and current potentially contaminative land uses across the airport.	
May 2013	TPS	Piling Risk Assessment Report	Risk assessment for piling within the King George V dock.	
April 2013	RPS	City Airport Development Programme London City Airport Phase 2: Environmental Site Investigation	Assesses the potential for ground contamination /pollution	21 window sampler boreholes (WS1 - WS23) to depths of between 0.5m and 5.0m, 13 groundwater/ ground gas monitoring wells and 7 hand dug trial pits to undertake falling head permeability tests.
February 2013	ARCADIS (UK Ltd)	Environmental Site Assessment Report	Assesses whether hydrocarbon contaminants of concern may be present in soil or groundwater and undertakes a risk based evaluation of the findings	
June 2011	Keltbray Environmental	London City Airport Ledger Building Site Investigation10	Assesses the potential for contamination for the proposals to construct additional office space to replace the former Ledger Building	8 probeholes to a depth of 3m using a hand held geoprobe
January 2011	Subadra	Environmental Investigation Report	Determines whether past or current land uses in the area had led to contamination of underlying groundwater and soils	5 boreholes to a depth of 5m and 2 hand-pits to a depth of 1.2m.
May 2008	RPS	London City Airport Aircraft Stands and Car Park – Phase 2 Site Investigation Report7	Identifies potentially contaminative land uses previously occupying the site	7 window sampler boreholes to a depth of 5m bgl; 3 cable percussive boreholes to

Year	Organisation	Description	Purpose	Investigation details
				a depth of 30m bgl; 7 trial pits to depth of 3.8m bgl; and, 10 groundwater / ground gas monitoring wells. 3 rounds of groundwater and ground gas
2007		Pile Test Report		1No Cable Percussion borehole
February 2006	FUGRO	Contaminated Land Survey-Interpretive Report	Provides information on potential issues on land contamination at the western area of the Airport.	8 trial pits
Jan 2001	Soil Mechanics	Factual Report on Ground Investigation Vol 2	Results and data from the ground investigation and lab testing	
Jan 2001	Soil Mechanics	Factual Report on Ground Investigation Vol 1	Results and data from the ground investigation and lab testing	74 trial pits and one borehole (13.10m)
Oct 2001	Soil Mechanics	Factual Report on Ground Investigation Vol 1 – Report Text, Appendices & Exploratory Hole Information	Provides information on the subsurface conditions for design and construction	17 Cable percussion boreholes: 11 Cable percussion boreholes (west 20.10-25.80m) & 6 (east 20.00-20.80m)

5 DESK STUDY REVIEW

A desk study of the site was carried out by RPS in June 2013 the results of which are presented in their Phase 1 Preliminary Environmental Assessment Report but the salient points are summarised below.

5.1 Site History and Environmental Setting

5.1.1 Site History

The OS maps show that prior to 1869 the site comprised predominantly marshland. By c.1898, the Royal Albert Dock had been constructed to the north of the site. A wharf with a number of warehouses had also been constructed adjacent to the dock and two associated dry docks had been constructed to the west. Works were also present on the site and residential properties extended across the southern site boundary. Construction of the King George V Dock with associated warehouses started in 1912 and was formally completed in 1921. A wharf had been constructed to the south of the King George V Dock and was reportedly raised by around 5m with ballast obtained from the dredging of the dock. An associated dry dock was constructed to the west of the King George V Dock. The construction of London City Airport began in 1986 and was opened in November 1987. The site remains predominantly in this form to the present day.

Additional information relating to the current use of the site was discussed in the RPS Phase 1 report which included a car hire centre on the southern boundary road although there are no details regarding fuel storage or refueling arrangements for the vehicles kept there.

A tank farm comprising three above-ground storage tanks (ASTs) each of 70,000l capacity and a fourth AST of 500,000l capacity, operated by BP, was also located within a fenced enclosure in the southwestern area of the Airport. This area was surfaced with brick-block paving and the fuel storage containers were located within a 1m high concrete bund. These AST are understood to be used to store aviation fuel (Jet A-1 kerosene), which it is reported that is delivered at a daily rate of approximately four 38,000 litre loads. The fuel is then transferred to the refueling area via underground pipework.

5.1.2 Geological Setting

From current British Geological Survey (BGS) online data, the Site is underlain by superficial deposits of Alluvium (peaty, sandy, silty clay). The bedrock geology comprises the Lewes Nodular Chalk Formation. It is considered likely that significant depths of Made Ground are present beneath the Site, and that River Terrace Gravels are present below the Alluvium layer.

5.1.3 Hydrogeology

The superficial Alluvium is classified as being a Secondary (undifferentiated) Aquifer. The Lewes Nodular Chalk Formation is classified as a Principal Aquifer. The River Terrace Gravels, Lambeth Group and Thanet Sands are classified as Secondary (A) Aquifers. The Chalk underlying the Thanet Sands is classified as a Principal Aquifer.

The site is not within a Source Protection Zone and there are no licensed groundwater abstractions within 1km radius.

5.1.4 Hydrology

The nearest water body is the King George V Dock, situated to the east of the terminal building. The Royal Albert Dock is present adjacent to the northern boundary of the site and the Royal Victoria Dock is present adjacent to the western boundary of the site. The River Thames is located approximately 460m to the south of the site and flows in an easterly direction.

5.1.5 Landfill / Waste Management Sites

There are Environmental Agency registered landfills recorded within 250m of the site, the nearest is Located 269m to the west but it is unknown the waste it was permitted to accept.

However from the historical maps it would appear that Woolwich Reach, which intersected the south of the site, was infilled in the late 1890’s and there was evidence that a wharf area was constructed c.1912 by raising levels by 5m using dredging from the docks

5.1.6 Radon

The property is not in a Radon Affected Area, as less than 1% of properties are above the action level. In accordance with the BR211 BRE publication, no radon protection measures are considered necessary.

5.1.7 Additional Information and Reports Reviewed by RPS

During the production of their Phase 1 report RPS reviewed previous reports, which were not made available to Concept, and they summarised the data as follows:

1. Factual Report on Ground Investigation, London City Airport – Phase I Airside Improvement Programme by Soil Mechanics Limited, dated January 2001.

   Soil Mechanics were commissioned to carry out an intrusive ground investigation between June and August 2000 across four areas around and on the existing runway facilities of London City Airport and KGV Dock for the Airside Improvement Programme. The purpose of the investigation was to determine subsurface conditions in order to aid the design and construction phases of the proposed works. The areas of investigation were as follows (Area 1 was investigated during a later phase, detailed below): Area 2: Eastern areas of the runway and KGV Dock; 25 trial pits were excavated through the eastern area of the runway. Area 3: Approximately 10m north of the western edge of the KGV Dock; 24 trial pits were excavated in this area. Area 4: Western area of London City Airport; 20 trial pits were excavated and one borehole was drilled in this area. Area 5: Approximately 5m north of the western edge of the existing runway; five trial pits were excavated in this area.

   The investigation comprised a total of 74 trial pits and one borehole. Made Ground encountered in the trial pits typically comprised silty gravelly sand in Area 2 and Area 3, and variable sand, clay and silt in Area 4 and Area 5. The borehole, drilled to a maximum depth of 13.10m in Area 4, encountered Made Ground of red brown clayey gravel and blue grey sandy organic clay underlain by firm grey brown mottled dark grey fissured clay (interpreted as Alluvium), further underlain by grey brown very sandy flint gravel, likely to represent River Terrace Deposits. Groundwater was struck at a depth of 5.80m below ground level, rising to 5.10m after a 20 minute interval.

   Geotechnical testing was carried out on representative soil samples along with testing for a suite of metals and metalloids, asbestos, chloride, pH, semi-volatile organic compounds (SVOC), TPH (total mineral oil) and glycol. No interpretation of the data was presented in the report. However, the results do not indicate that significant contamination was encountered within the Made Ground in these areas of the site. Localised elevated concentrations of metals were detected but metal contamination does not appear to have been widespread. Total TPH was detected within the majority of samples, although no speciated analysis was undertaken. With the exception of occasional occurrences of PAH compounds, the SVOC concentrations were generally below or close to the laboratory limits of detection.

2. Factual Report on Ground Investigation, London City Airport – Phase 2 Airside Improvement Programme by Soil Mechanics Limited, dated October 2001.

Soil Mechanics undertook an additional intrusive ground investigation for the Airside Improvement Programme on behalf of London City Airport Limited between 5th March and 4th May 2001. The investigation comprised the drilling of 17 boreholes through the base of the KGV Dock, in areas known as Area 1 (western half of the dock) and Area 2 (eastern half of the dock). Boreholes were drilled to a maximum depth of 25.80m below the base of the dock.

Ground conditions comprised dark grey silt (Alluvium) underlain by sandy gravel (River Terrace Deposits). Thanet Sand was encountered beneath the River Terrace Deposits in Area 1, but this stratum was absent beneath the eastern area of the dock. Chalk was encountered beneath the Thanet Sand in the western area of the KGV Dock at depths ranging between approximately 15m and 20m below the base of the dock. The Chalk was encountered beneath the River Terrace Deposits at much shallower depth in the eastern area of the dock, at depths ranging between 2m and 3m below the base of the dock.

Depths to water ranged from 9.20m to 12.40m in Area 1 and 10.70m and 11.60m in Area 2m, indicating a relatively consistent groundwater body within the Thanet Sand and Chalk.

As part of the investigation, geotechnical testing was undertaken on a number of samples. However, no laboratory testing for potential contaminants of concern was undertaken.

3. <u>Contaminated Land Survey at London City Airport – Interpretive Report, by FUGRO Engineering Services Ltd, dated February 2006.</u>

FUGRO Engineering Services Ltd was commissioned in February 2006 to carry out an intrusive ground investigation at the Airport. The objective of this investigation was to provide information on potential issues associated with land contamination that could impact the proposed development of a taxiway and parking apron in the far western area of the Airport.

A total of eight trial pits were excavated and chemical analysis, waste acceptance criteria and leachate testing was undertaken on selected soil samples. A degree of hydrocarbon and metal contamination was identified within shallow soils. Groundwater analysis was not undertaken; however, the leachate test results indicated the presence of potentially mobile soil contaminants, including metals and hydrocarbons. It was concluded that the proposed development, which would comprise the excavation of Made Ground to a depth of 2m bgl and replacement with a concrete apron, would provide a suitable form of remediation. However, a further site investigation was recommended in order to delineate the extent of ground contamination.

4. <u>London City Airport Aircraft Stands and Car Park – Phase 2 Site Investigation Report by RPS Health Safety and Environment, Ref: HLEC3237/004R, dated May 2008.</u>

An intrusive ground investigation was carried out by RPS Health Safety and Environment during May 2008 at the Hartmann Road staff car park in the southwest of the Airport and of land to the east of this car park, which comprised a slope with an electricity sub-station. The investigation was undertaken in relation to proposals to redevelop this part of the site into aircraft stands and an underground car park (Note: these proposals were not subsequently pursued by LCY). Several potentially contaminative land uses previously occupied this area of the Airport site, including the composition works and a paint works, referred to above.

The investigation comprised: the drilling of seven window sampler boreholes, advanced to a maximum depth of 5m bgl; three cable percussive boreholes, advanced to a maximum depth of 30m bgl; seven trial pits, excavated to a maximum depth of 3.8m bgl; and, the installation of ten groundwater / ground gas monitoring wells. Three rounds of groundwater and ground gas monitoring were undertaken.

Encountered ground conditions comprised concrete underlain by Made Ground constituting ashy clay, sand and gravel with varying amounts of brick, metal, clinker, pottery and wood to depths of between 1.2m and 3.6m bgl. Alluvium was recorded beneath the Made Ground, underlain by the River Terrace Deposits and Thanet Sand Formation. Visual and olfactory evidence of hydrocarbon contamination was recorded within the Made Ground and Alluvium.

A degree of ground contamination (hydrocarbons and metals) was identified within the Made Ground and shallow natural Alluvium. However, due to the commercial nature of the site, and the extensive hardstanding and building cover of the proposed development, the contamination was not considered to pose a significant risk to future site users due to the absence of an active exposure pathway. No elevated concentrations of contaminants were recorded within groundwater sampled from the Alluvium, River Terrace Deposits or Thanet Sand. This indicated that the contamination had not impacted shallow groundwater and was unlikely to migrate from this area of the site via the groundwater migration pathway.

Ground gas monitoring data was indicative of CIRIA Characteristic Situation 2, whereby basic gas protection measures would need to be installed into future site buildings.

5. <u>Environmental Investigation Report – BP Air Fuel Storage Area, London City Airport, Royal Dock, London by Subadra, dated January 2011.</u>

Subadra was commissioned to carry out an intrusive site investigation during November 2011 and December 2011 at the BP Fuel Storage Area in the west of the London City Airport complex 5m north of Camel Road and the Docklands Light Railway viaduct. The site comprised tanker off-loading facilities and a central bund structure containing four fuel storage tanks. The purpose of the investigation was to determine whether past or current land uses in this area had led to contamination of underlying groundwater and soils.

The report includes a review of two previous reports relating to this area, as follows:

1. Assessment of Environmental Impact at UK Aviation Terminals, September 1993, completed by Land Restoration Systems on behalf of BP; this report included a summary of the history of this area, which was formerly a "composition works" and later a works. The report included anecdotal evidence that remedial works may have been undertaken at the site, required as a result of historical contamination. The remedial works reportedly comprised excavation of soils to a depth of 1m below ground level and placement of an impermeable membrane prior to development of the fuel depot.

2. London City Airport Environmental Compliance Audit, September 2007, completed by Wardell Armstrong LLP on behalf of Air BP; this report detailed the results of an environmental compliance audit completed at the BP Air fuel storage depot and associated air-side fueling station. No intrusive works were completed as part of the investigation. The report mentions that remedial works may have been undertaken in the past.

Subadra carried out some additional research into the possibility that remedial works may have been carried out at the site. The construction engineers confirmed that remedial works were carried out for geotechnical ground improvement purposes in order to provide a suitable founding layer for the fuel tanks. Clay soils from this area were excavated and a geotextile membrane was placed prior to backfilling of the excavation with compacted granular material.

Five direct-push boreholes were drilled to a maximum depth of 5m below ground level and two handpits were excavated to a maximum depth of 1.2m below ground level. Soil and groundwater samples were collected and analysed for a range of contaminants. Ground conditions comprised hardstanding underlain by Made Ground of gravel, concrete and brick fragments, underlain by a layer of Made Ground of soft slightly sandy clay. Beneath the Made Ground, natural clay and peat were encountered (Alluvium). Hydrocarbon odours were noted in soil samples collected from one borehole, with a sheen noted on groundwater at this location. Hydrocarbon odours were also noted in one hand pit. Free phase hydrocarbons were encountered in a second borehole product.

Soil and groundwater analysis indicated that kerosene range hydrocarbons were present in shallow soils and groundwater underlying the north-east of the site. However as this contamination found beneath a thick layer of concrete and block paving, the risk to human receptors was considered to be negligible.

Due to the low permeability of the Alluvium, it was not considered likely that contamination within perched groundwater would migrate from this area of the site.

6. <u>Environmental Investigation Report - BP Air Airside Fuel Loading Area, London City Airport, Royal Dock, London by Subadra, dated January 2011.</u>

On 26th November 2011, Subadra carried out an 'airside' intrusive site investigation 5m to the north of Connaught Road in the western end of the London City Airport complex. The area of investigation comprised a fueling island and fuel loading area for aviation fueling tankers with an underground tank, wasted drum storage and an oil/water interceptor. The investigation was undertaken to establish whether there was any existing diesel contamination in the underlying soils or groundwater prior to the fueling facilities being taken over by London City Airport.

During a walkover of the site, Subadra noted that there was surface hydrocarbon staining in the vicinity of the diesel dispenser, suggesting localised spilling of diesel during refueling. Surface water run-off from the site was reported to discharge into the main Airport drainage systems via a three chambered interceptor.

The investigation comprised the drilling of three direct-push geoprobe boreholes advanced to a maximum depth of 4.8m. One borehole was located on the airside pavement and two were located within the loading bay. Ground conditions comprised hardstanding (block paving underlain by a sand layer and concrete) and Made Ground of compacted concrete and brick in-fill. The Made Ground was underlain by natural soils comprising soft Alluvium with interbedded peat layers. No olfactory or visual signs of contamination were observed.

Soil samples from all three boreholes were analysed for a range of contaminants including Total Petroleum Hydrocarbons, Polycyclic Aromatic Hydrocarbons and Volatile Organic Compounds. Hydrocarbons were only detected within one sample; this was taken from the sand layer between the block paving and concrete hardstanding. Hydrocarbons within this sample were thought to relate to surface diesel spillage that did not appear to have impacted soils beneath the concrete layer.

Groundwater samples were only collected from two of the three boreholes as one monitoring well was dry. The samples were analysed for Total Petroleum Hydrocarbons and Volatile Organic Compounds. 1,2,4-trimethylbenzene was detected within one sample; none of the other hydrocarbon contaminants of concern were detected within the water samples.

Overall it was considered that there was no evidence of significant hydrocarbon contamination within soil or groundwater in this area of the site. Furthermore, the low permeability of the underlying Alluvium was considered likely to restrict migration of any contamination from this area.

7. <u>London City Airport Ledger Building Site Investigation by Keltbray Environmental, dated June 2011.</u>

   Keltbray Environmental undertook an intrusive ground investigation during June 2011 in the southwest of the Airport across the Hartmann Road staff car park, located adjacent to the east of the tank farm and on land to the southwest of the Ledger Building. The investigation was undertaken to assess the potential for contamination to exist in soils in this area in relation to proposals to construct additional office space to replace the former Ledger Building (now demolished).

   A total of eight probeholes were drilled to a maximum depth of 3m below ground level (bgl) using a hand held geoprobe. Beneath a concrete slab, ground conditions were described as sandy, ashy, slightly clayey, gravelly fill with man-made fragments including brick to approximately 1.3m bgl. This Made Ground was underlain by soft to firm, grey clay with occasional black mottling and a slight hydrocarbon odour, interpreted as Alluvium.

   A total of 31 soil samples were collected and analysed for a range of contaminants including total petroleum hydrocarbons (TPH), poly-aromatic hydrocarbons (PAH), metals, inorganics and asbestos. However, an assessment of the analytical results was not included within the report.

8. <u>Environmental Site Assessment Report – BP Northair Fuel Storage and Distribution Areas, London City Airport, Royal Docks, London E16 2PB, ref 807880106, by ARCADIS (UK Ltd), dated February 2013.</u>

   ARCADIS (UK) Ltd was commissioned by Air BP Limited and London City Airport to carry out a desk study and intrusive site investigation for the Landside Jet A1 Fuel Storage Area (Landside Site) and the Airside Fuel Distribution and Storage Area (Airside Site). The objective of the investigation was to assess whether hydrocarbon contaminants of concern may be present in soil or groundwater beneath the site and to undertake a risk based evaluation of the findings. The report makes reference to the investigations carried out by Subadra, summarised above.

The intrusive investigation included the drilling of four boreholes to a maximum depth of 6m at each of the Landside and Airside sites. Ground conditions comprised Made Ground to a depth of 2.4m bgl, underlain by silty clayey sand (Alluvium). Analysis for potential hydrocarbon contaminants was completed on soil and groundwater samples and the results were screened against generic assessment criteria derived by ARCADIS for the protection of human health and controlled waters.

None of the measured concentrations exceeded the generic assessment criteria for the protection of human health. However a number of the measured concentrations exceeded the generic assessment criteria for the protection of controlled waters. It was concluded that further assessment of the risks to controlled waters was required, and this was subsequently carried out by ARCADIS with the findings detailed in the report summarised below.

9. Detailed Quantitative Risk Assessment – London City Airport by Arcadis, dated March 2013.

ARCADIS (UK) Ltd was commissioned by Air BP Limited and London City Airport to carry out a Detailed Quantitative Risk Assessment (DQRA) for the Landside Jet A1 Fuel Storage Area (Landside Site) and the Airside Fuel Distribution and Storage Area (Airside Site) between December 2012 and February 2013. The assessment was carried out to further characterise and evaluate the risks associated with petroleum hydrocarbon-related impacts on the site.

The DQRA was undertaken using CLEA v.1.06, RBCA v. 2.5 and RTW 3.1 in order to provide risk based assessment criteria to determine whether the measured concentrations of contaminants would pose a risk to watercourses or off-site human health receptors. Following comparison of the data to the Site Specific Assessment Criteria, none of the measured concentrations exceeded the criteria for the protection of human health. Although some concentrations measured were in exceedance of the screening criteria for the protection of controlled waters, it was considered that these did not pose an unacceptable risk to water resource receptors.

6 GEOENVIRONMENTAL SITE INVESTIGATIONS POST 2013

Following the completion of the Phase 1 report in 2013 it is understood by Concept prior to the current investigation that other two intrusive site investigations were undertaken first by RPS in 2013 and then Delta –Simons in 2016. The subsequent reports have been made available to Concept and the findings from these which have been summarised below.

1. Phase 2: Environmental Site Investigation for London City Airport reference HLEI24974/001 R Rev 2 by RPS dated April 2013

The site investigation was carried out between 11th and 19th February 2013 and comprised the drilling of twenty one window sampler boreholes (WS1 - WS23) advanced to depths of between 0.5m and 5.0m below ground level (bgl), the installation of thirteen groundwater/ ground gas monitoring wells and the excavation of seven hand dug trial pits to undertake falling head permeability tests.

Made Ground was encountered in all of the boreholes to depths of between 4.7m and >5.0m below ground level. The Made Ground typically consisted of reworked natural materials (Alluvium and River Terrace Deposits) with fragments of anthropogenic material including brick, concrete, ash and clinker. The Made Ground was predominantly granular in nature, although localised pockets of sandy clay (reworked Alluvium) were encountered. Depths to water during monitoring in the boreholes ranged from 1.96m below ground level at the eastern extent of the site to up to 4.22m below ground level in the vicinity of the existing terminal building and groundwater flow appeared to be towards the west.

A total of thirty samples of soil collected from Made Ground were submitted to a laboratory for chemical analysis of a broad range of potential contaminants. None of the determinants tested for were recorded at concentrations in excess of RPS derived screening values for a commercial end to be protective of on-site human health receptors. No significant volatile contamination was detected within groundwater sampled from beneath the site. As such, the risk to site users from contamination present in soils and groundwater beneath the site is considered to be low.

A slight hydrocarbon odour was detected in shallow Made Ground sampled from one borehole (WS4), to the west of the existing terminal building. TPH compounds, predominantly in the range C12-C35 were detected in a sample of this material submitted for analysis. This contamination appears to be localised and a sample taken from deeper within this borehole did not record TPH above the limit of detection. Trace concentrations of hydrocarbons were also detected in a number of other samples of Made Ground across the site. However, these were typically the longer chain, less mobile TPH compounds that, at the measured concentrations, are considered unlikely to pose a significant risk to water resource receptors. The concentrations of other potential contaminants of concern (including PAH and metals) in soils were typically low.

Analysis of groundwater samples detected elevated concentrations of arsenic in borehole WS7 (1300ug/l) with marginally elevated concentrations in borehole WS11 (90ug/l). This contamination appears to be localised and was not detected in down gradient boreholes. No significant soil source of arsenic was detected during the investigation. Copper was detected locally at concentrations marginally in excess of the Environment Agency Environmental Quality Standard (EQS) within a number of groundwater samples collected from the site. The measured concentrations of copper within these boreholes are unlikely to pose a significant risk to the wider groundwater environment. The risk to groundwater from contamination sourced from the site is therefore considered to be low.

Given that the adjacent dock is lined and is not in hydraulic continuity with groundwater beneath the site the risks posed to this receptor are considered to be low. Groundwater flow direction appears to be to the west and the localised contamination detected within groundwater is therefore not considered to pose a risk to the River Thames, located approximately 500m to the south. The risk to surface water receptors is therefore considered to be low.

Falling head permeability tests were undertaken in monitoring wells installed into eight boreholes and all of the seven shallow hand dug trial pits. In three of the boreholes water drained too quickly to perform the tests. In the other tests K values varied from 3.87x10-04 to 9.38x10-06. This is indicative of relatively rapid drainage rates. The levels of contamination detected in soil samples collected from the site are not considered to pose a significant risk to groundwater should infiltration be increased. However, due to the presence of localised arsenic contamination within groundwater in the vicinity of WS7, as a precaution it is recommended that soakaways are located away from this area.

Ground gas monitoring was undertaken on three occasions. Using CIRIA Report C665, the ground gas regime for the site corresponds to Characteristic Situation 1, whereby gas protection measures are not required for new developments. However, as the carbon dioxide concentrations exceeded 5% and methane concentrations exceeded 1%, CIRIA C665 recommends that consideration should be given to increasing the classification to Characteristic Situation 2 where basic specific gas protection measures are required for new buildings.

Waste Acceptance criteria testing was undertaken on samples collected from Made Ground in WS3, WS11, WS13, WS16 and WS19 in the location of five proposed attenuation tanks. Soil collected from WS11 is likely to be suitable for disposal as non-hazardous waste, while soil collected from WS3, WS13, WS16 and WS19 is likely to be suitable for disposal as Inert waste.

2. <u>Factual Ground Investigation Report : Evaluation of Ground Conditions – Airside City Airport Development Programme reference 16-0205.01v2 by Delta-Simons dated July 2016</u>

   Delta-Simons undertook an investigation on a vacant grassed area between taxiways Echo, Kilo, Lima and Mike plus the runway turning circle area and South Dock Road. The site works were carried out between 18th and 28th April 2016 and comprised the drilling of eleven window sampler boreholes advanced to a maximum depth of between 10m below ground level (bgl), with in-situ SPT's at 1.0m intervals to 5m bgl and then every 1.5m thereafter. Seven locations on the taxiway Kilo, South Dock Road and the runway turning circle were selected for the collection of concrete cores. Sixteen TRL Dynamic Cone Penetration probe tests were also undertaken. Twelve soil samples were tested for a standard suite and thirteen samples were subjected to geotechnical analysis.

   Made Ground was encountered in all locations to a maximum depth of 5.10m and generally comprised: Grass/concrete overlying organic, brown, clayey, sandy gravel. Gravel is fine to coarse, angular to sub-angular flint and brick and concrete. Underlying the made ground in all holes was soft blackish brown, slightly gravelly, peaty CLAY with occasional bands of gravel (Alluvium), which extended to the base of the holes except for in the southern area of the site where soft to firm grey CLAY (Alluvium) generally between 6.0m-8.95m bgl below which was brown sandy GRAVEL (Alluvium).

Groundwater strikes were encountered between 2.0m and 8.6m bgl during the drilling.

The SPT values within then made ground ranged from N=3 to 26 but were generally below 5. In the Alluvium the values were generally between N=2 and 4 whilst the underlying CLAY were N= 4 to 6.

At the time of writing the report no laboratory geotechnical testing had been undertaken.

The concrete coring revealed the surfacing ranged in thickness from 177mm to 505mm thick and generally comprised of two layers. The upper layer (53mm to 340mm thick) was not reinforced and was formed from a strong concrete. The underlying layers ranged in strength from strong to very weak.

As the report was factual there was no assessment undertaken of the results obtained from the chemical analysis of the soils samples. Therefore Concept has compared the results against the published LQM S4UL and DEFRA C4SL commercial end use assessment criteria and no exceedances were noted. Although asbestos was identified within some of the made ground samples but no quantification testing was undertaken and therefore the level of risk cannot be fully assessed. Based upon these results the site is, post development, to pose a low risk to human health.

Three water samples were also tested and the results have been compared by Concept against the published EQS screening values, which revealed marginally elevated copper, lead and PAH's plus a significantly elevated zinc value. Although there is some metal contamination within the groundwater as discussed previously due to the site setting and general poor quality of the groundwater due to the long history of industrial use of the area the site is considered to represent a low risk to controlled waters.

7 2017 SITE INVESTIGATION

Concept Site Investigations carried out a ground investigation between 2nd November 2016 and 10th February 2017 & 17th March 2017. The extent and scope of the site investigation was specified by TPS. The locations of the intrusive holes and trial pits are shown in Figure 1 of this report.

The total scope of the investigation carried out was:

- 19 No. Cable Percussion Boreholes to a maximum depth of 37.50m;
- 15 No. Rotary Boreholes to a maximum depth of 45.50m;
- 2 No. Machine Excavated Trial Pits to a maximum depth of 3.50m and 4 No probes to investigate the existing southern dock wall ;
- Menard Pressuremeter Testing;
- Geotechnical & Chemical Testing.

All boreholes took place over the dock (offshore from a pontoon platform in the dock) on the south side of the airport runway with the exception of BH06 (dockside) which took place on land.

The stratigraphy revealed within the boreholes where there was full recovery of sample cores during the ground investigation undertaken at the site confirmed the anticipated geology and was consistent with the previous investigations. Across the former dockside area hard surfacing (concrete/asphalt) was encountered over Made Ground, which generally comprised sandy gravel with some rubble. This rested upon the Alluvium Deposits of CLAY over PEAT below this the River Terrace Deposits of predominantly GRAVEL over SAND were present. This in turn rested on the Thanet Sand Formation as a sequence of SAND over GRAVEL layers that were present in all holes. The Seaford Chalk formation underlies the Thanet Sand.

Within the dock area the depth of water was between 10.6-14.0m with a layer of clayey silt dock sediment at the base apart from in BH14 where it was absent although the River Terrace Deposits were identified to contain a high clay content. The Alluvium was not recorded as being present in any of the boreholes with the sediment resting directly upon the River Terrace Deposits in all boreholes except BH11 where it was not present. Below this, the sequence was the same as the dockside boreholes with Thanet Sand formation not being present in BH28, BH31-BH34 situated in the eastern part of the dock. At these locations the Seaford Chalk Formation underlies the Terrace Gravels.

A brief description of the strata encountered is summarised in Table 7.1:

Table 7.1– Summary of ground conditions on the dockside (BH6)

Stratum	Top (mbgl)	Base (mbgl)	Description
Surfacing	0.00	0.40	Comprises either plain concrete on hardcore or 70mm asphalt over concrete
Made Ground	0.40	7.10	Generally it comprises loose brown very sandy gravel. Gravel comprises angular to well-rounded fine to coarse flint and concrete/brick/ rubble fragments. Sand is fine to coarse. Locally tending with depth to a soft light grey to greenish grey silty gravelly clay..
Alluvium	7.1	11.00	Varying from very soft to soft light grey silty CLAY with occasional dark staining and organic odour becoming a soft dark brown fibrous very clayey PEAT with organic odour frequent wood and plant fragments (<30mm) and dark staining.
River Terrace Deposits	11.0	14.5	A thin upper layer of either medium dense light grey very clayey fine SAND or slightly sandy silty CLAY. Locally resting on a layer of medium dense dark brown yellow angular to well-rounded fine to coarse flint GRAVEL. Underlying this is a medium dense yellow brown very gravelly locally clayey fine to coarse SAND in which the gravel is angular to well-rounded fine to coarse flint.
Thanet Sand Formation	14.5	26.30	The upper layer comprises very dense light grey clayey fine SAND, which contains more clay with depth (Thanet Sand). Underlying this is a layer of dense black angular to subangular fine to coarse rounded flint GRAVEL

Stratum	Top (mbgl)	Base (mbgl)	Description
			(Bullhead Bed).
Seaford Chalk Formation	25.50	30.00+ Extent not proven	White CHALK initially recovered as a silty angular to subangular fine to coarse GRAVEL. Gravel is weak to medium density chalk fragments and black rounded flint. With bands of soft to firm very gravelly SILT

Table 7.2– Summary of ground conditions encountered within the dock

Stratum	Top (mbgl)	Base (mbgl)	Description
Water	0.00	14.00	Water
Dock Sediment	10.60	13.80	Very soft dark grey gravelly clayey SILT with strong hydrocarbon odour, locally contained frequent wood fragments (<200mm) and rare glass fragments and metal Gravel is angular to subangular fine to coarse flint. In BH15 the base layer of the sediment is described as being dark grey sandy angular to subangular fine to coarse flint GRAVEL with strong hydrocarbon odour and rare pieces of metal pipe.
River Terrace Deposits	12.50	16.00	Identified in BH05, BH14 and BH21R. In BH05 there is a 50mm layer of yellowish brown gravelly fine to coarse SAND. Gravel is angular to subangular fine to coarse flint. Below this there is dark grey sandy GRAVEL with strong hydrocarbon odour, which extends to 16m is also noted as being reworked although possibly not to the full depth. In BH14 the layer immediately below the water is identified as dark grey clayey silty angular to well-rounded fine to course flint GRAVEL with rare angular to subrounded flint cobble (<110mm) and strong hydrocarbon odour BH21R describes this stratum as dark grey and yellowish brown slightly clayey very gravelly fine to coarse SAND with strong hydrocarbon odour. Gravel is angular to well-rounded fine to coarse flint.
River Terrace Deposits	12.20	17.50	All other boreholes: Brown/Yellow sandy, locally clayey and silty, angular to well-rounded fine to coarse flint GRAVEL with rare cobbles. Sand is fine to coarse. Rare wood fragments (<120mm). Locally strong hydrocarbon odour.
Thanet Sand Formation	13.70	35.10	Not present in BH28 , BH31 - BH34 In all holes except for BH30 the upper layer comprises light grey silty fine SAND, with localised bands containing clay or coarse gravel and cobbles size flint (Thanet Sand). Underlying this in all holes except for BH14, BH21, BH26 and BH29 there is a thin layer of dense dark grey angular to subangular medium to coarse rounded flint GRAVEL (Bullhead Bed).
Chalk	13.70	45.50+ Extent not proven	White CHALK initially recovered as an extremely weak medium density silty angular to subangular chalk COBBLES. With bands of very gravelly SILT, silty GRAVEL and locally white putty SILT. Gravel is weak to medium density chalk fragments and black rounded flint. Open and infilled fractures encountered in some holes.

8 GEOENVIRONMENTAL SETTING

8.1 Environmental Risk Assessment

8.1.1 Introduction

Following a review of the available data at the time RPS undertook a risk assessment based upon a source, pathway receptor contamination linkages approach when considering the site's environmental setting to determine the existence of "contaminated land" as defined under Part 2A of the Environmental Protection Act 1990. For a risk to exist all three components must be present to facilitate a potential "pollutant Linkage"

- Contamination referring to the source of contamination (hazard);
- Pathway for the contaminant to move/migrate to receptor(s);
- Receptor (target) that could be affected by the contaminant(s).

8.1.2 RPS 2013 Conceptual Model for Development Area

Based upon a review of the site history the following potential sources of contamination detailed below were identified.

For the purposes of the assessment the following criteria was adopted:

- **Low risk** – it is considered unlikely that issues within the category will give rise to significant harm or a liability/cost for the owner of the site.
- **Moderate risk** - it is possible, but not certain that issues within the category will give rise to significant harm or a liability/cost for the owner of the site.
- **High risk** - there is a high potential that issues within the category will give rise to significant harm or a liability/cost for the owner of the site.

8.1.3 On-Site Sources

Within the area of the proposed CADP, potentially contaminative former land uses have included a composition works, a paint works and engineering works. Potential contaminants of concern associated with these land uses include metals, polycyclic aromatic hydrocarbons (PAH), total petroleum hydrocarbons (TPHCWG), solvents and asbestos. A large area in the south of the site, formerly comprising the Woolwich Reach inlet also appears to have been infilled. A wharf was constructed to the south of the King George V Dock and was reportedly raised by around 5m with ballast obtained from the dredging of the dock. Made Ground associated with these and with former construction/demolition activities across the remaining site area may also form a source of contaminants listed above, as well as ground gas.

Historical land uses for the wider Airport include the dry docks, warehouses and engineering works. Potential contaminants of concern associated with these land uses include metals, polycyclic aromatic hydrocarbons (PAH), total petroleum hydrocarbons (TPHCWG), solvents and asbestos. Made Ground associated with former construction/demolition activities across the Airport may also form a source of contaminants listed above, as well as ground gas.

The site has been occupied by London City Airport since the late 1980's / early 1990's. The northern half of the site is occupied by the runway, adjacent to the Royal Albert Dock to the north, with the terminal building in the south west of the site. A tank farm, comprising three above ground 70,000l and one 500,000l jet fuel tanks are present in a fenced off area in the south west of the site. Smaller fuel oil and diesel tanks were also noted on site. A small-scale hazardous waste storage area was observed adjoining the eastern end of the re-fueling area. Several 200l barrels of waste engineering oil, contaminated filters / rags and 'jet slops' were observed upon drip trays and directly onto hardstanding. Surface water in the re-fueling area is understood to drain into a well maintained oil/water interceptor. Potential contaminants of concern associated with the storage of fuel and refueling of planes include PAH and TPHCWG. IBCs containing anti-icing and de-icing agents were noted during the walkover and were reportedly used to keep the runway free of ice.

The area of the proposed CADP comprises a fuel depot, a steel yard, a disused shed/ warehouse and a car hire centre.

Previous intrusive investigations at the Airport have recorded localised elevated concentrations of PAH, metals and TPH in Made Ground and shallow Alluvium. However, widespread significant contamination does not appear to have occurred.

The site is situated in an area with an industrial heritage, with several potentially contaminative land uses in the vicinity of the site, many of which are still active today. These include railways, docks, depots, engineering works, warehouses, industrial estates and a sugar refinery. These land uses potentially represent off site sources of the potential contaminants of concern discussed above.

In view of the above, there is a **MODERATE** likelihood of significant ground contamination being present beneath the site.

8.1.4 Summary of Potential Pathways

Given the presence of total building and hardstanding cover, the potential for current and future site users to be exposed to any ground contamination (if present) through direct contact or ingestion or inhalation of soil or dust is limited. If volatile contaminants are present beneath the site, current and future site users may be at risk via the vapour inhalation pathway.

Made Ground and permeable natural strata underlying the site may allow vertical migration of contamination through the unsaturated zone towards groundwater. Lateral migration of contamination may then occur via groundwater towards off site receptors. Similarly, this pathway could facilitate the on-site migration of contaminants originating from off site. Alluvium underlying Made Ground on site is likely to offer a degree of protection. However, the stratum is variably permeable and may allow the migration of limited groundwater. The adjacent docks are likely to be concrete lined, which is likely to offer a significant level of protection to these receptors.

8.1.5 Receptors

A new western extension, arrivals building, forecourt, hotel and car parking are proposed in the south of the site as part of the new development. Future site users and neighbouring residents are considered to be sensitive human health receptors.

The site is underlain by an Undifferentiated Secondary Aquifer relating to the Alluvium and Secondary (A) Aquifers relating to the River Terrace Deposits and Lambeth Group (where present). The underlying Thanet Sand (where present) and Chalk are Principal Aquifers. These are considered to be sensitive receptors. However, the site and surrounding area have had a significant industrial history and groundwater resources may be of reduced quality as a result.

There are no records of licensed groundwater abstractions within 1km of the Airport and the site does not lie within a groundwater Source Protection Zone.

The nearest surface waters are the Royal Albert, King George V and Royal Victoria Docks present adjacent to the site. However, these are likely to be lined with concrete and are afforded a significant level of protection from contamination beneath the Airport. These lead into the River Thames, which flows from west to east approximately 460m to the south of the site.

8.1.6 Overall Risk

Historically, a number of potentially contaminative land uses have been recorded within the area of the proposed CADP. These include a composition works, a paint works and an engineering works. A landfill comprising a backfilled dry dock is also present in the north west of Airport. Current uses of the proposed CADP include a fuel depot, a steel yard, a disused shed/ warehouse and a car hire centre.

Currently, a number of potentially contaminative land uses and activities are recorded within the wider Airport (including bulk fuel / chemical storage and usage) and in the surrounding area (e.g. railways and industrial land use associated with the docks). Fuel storage at the Airport is well managed and a well maintained oil/water interceptor is present on the site. Furthermore, historically numerous potentially contaminative land use were recorded within the area currently occupied by the Airport and in the surrounding area. As such, there is the potential for a degree of shallow soil and perched groundwater contamination beneath the site. Intrusive investigations undertaken in the wider Airport site have recorded localised elevated concentrations of PAH, metals and TPHCWG in Made Ground and shallow Alluvium. However, widespread significant contamination does not appear to have occurred.

In view of the current and proposed hardstanding and building cover for the proposed area of the CADP, site users will be prevented from coming into contact with contaminated media via the pathways of direct contact and ingestion. If volatile contaminants are present beneath the proposed area of the CADP, site users may be at risk via the vapour inhalation pathway. However, this can be controlled during redevelopment through the placement of a vapour proof membrane. As such, risks to current and future site users are considered to be low due to the absence of a source-pathway-receptor linkage.

The underlying Secondary and Principal Aquifers, the Royal Docks and the nearby River Thames are considered to be potential receptors to any contamination sourced from the site. Although mobile contaminants may be present in shallow soils, groundwater within the variably permeable overlying alluvial deposits will likely be perched within pockets of non-cohesive soils. As such, vertical and lateral migration of this perched, potentially impacted groundwater toward the controlled waters receptors will be restricted. In addition, the site is predominantly surfaced by hardstanding and drainage is well managed, which will restrict infiltration and thereby limit leaching of any contamination. Furthermore, due to the extensive industrial heritage of the site and surrounding area, controlled waters receptors may be of reduced quality. Overall, risks to controlled waters from potential contamination sourced within the proposed CADP are considered to **be low to moderate**.

Therefore post development provided appropriate mitigation measures are incorporated into the proposed development (if required) the risk to on-site human health receptors will be **LOW**. The risk to controlled waters and other off-site receptors is considered to be **LOW to MODERATE.**

8.2 GEOCHEMICAL TESTING

A suite of chemical tests were undertaken upon selected soil samples retrieved from the boreholes and carried out by The Environmental Laboratory Ltd. Copies of the result sheets from these tests are contained in Appendix B but are also summarised in Table 8.2 below. An assessment of these results when compared against the published based on these results is also discussed later in this report.

Table 8.2 – Soil Analysis Results Summary

Determinant	Recorded Concentrations		Number of Samples Tested
	Minimum (mg/kg)	Maximum (mg/kg)	
Asbestos in Soil	Not-detected	Not Detected	33
Arsenic	<1	124	33
Barium	11.8	1280	9
Beryllium	<1	1.9	9
Cadmium	<0.5	9.3	33
Chromium	<5	171	33
Copper	<5	753	33
Lead	<5	1630	33
Mercury	<0.5	47.8	33
Nickel	<5	92.9	33
Selenium	<1	5.4	9
Vanadium	<5	88.8	9
Boron	<0.5	45.4	9
Zinc	<5	3070	33
Water Soluble Sulphate	0.03	0.68	24
Complex Cyanide	<1	2.9	24
Elemental Sulphur	<20	20900	9

Determinant	Recorded Concentrations Minimum (mg/kg)	Maximum (mg/kg)	Number of Samples Tested
Free Cyanide	<1	<1	9
Hexavalent Chromium	<0.8	<0.8	9
Total Cyanide	<1	2.9	9
Acid Neutralisation Capacity	<0.1	<0.1	33
Loss On Ignition (450°C)	0.31	19.4	5
pH	7.7	8.7	5
Soil Organic Matter	<0.1	17	11
Total Organic Carbon	0.07	17	33
Phenol	<1	<1	5
M,P-Cresol	<1	<1	4
O-Cresol	<1	<1	4
3,4-Dimethylphenol	<1	<1	4
2,3-Dimethylphenol	<1	<1	4
2,3,5-trimethylphenol	<1	<1	4
Total Monohydric Phenols	<5	<6	4
Naphthalene	<0.1	12.8	27
Acenaphthylene	<0.1	24.2	33
Acenaphthene	<0.1	15.8	33
Fluorene	<0.1	24.1	33
Phenanthrene	<0.1	71.2	33
Anthracene	<0.1	21.2	33
Fluoranthene	<0.1	130	33
Pyrene	<0.1	104	33
Benzo(a)anthracene	<0.1	77.2	33
Chrysene	<0.1	83.4	33
Benzo (b) fluoranthene	<0.1	58.3	33
Benzo(k)fluoranthene	<0.1	65.7	33
Benzo (a) pyrene	<0.1	91.8	33
Indeno (1,2,3-cd) pyrene	<0.1	56	33
Dibenzo(a,h)anthracene	<0.1	17.1	33
Benzo[g,h,i]perylene	<0.1	46.2	33
Total PAH(16)	<0.4	890	33
Total PAH (Including Coronene)	<2	906	33
Benzene	<0.01	0.306	5
Toluene	<0.01	0.218	19
Ethylbenzene	<0.01	0.151	19
Xylenes	<0.01	0.369	19
MTBE	<0.01	0.0999	19
Total BTEX	<0.01	1.04	19
>C5-C6 Aliphatic	<0.01	0.76	5
>C6-C8 Aliphatic	<0.01	0.22	33
>C8-C10 Aliphatic	<1	<1	33
>C10-C12 Aliphatic	<1	29.5	33
>C12-C16 Aliphatic	<1	345	33
>C16-C21 Aliphatic	<1	1060	33
>C21-C35 Aliphatic	<1	3520	33
>C35-C40 Aliphatic	<1	493	33
>C5-C7 Aromatic	<0.01	0.31	33
>C7-C8 Aromatic	<0.01	0.22	33
>C8-C10 Aromatic	<1	<1	33
>C10-C12 Aromatic	<1	50	33
>C12-C16 Aromatic	<1	469	33
>C16-C21 Aromatic	<1	1130	33
>C21-C35 Aromatic	<1	3160	33
>C35-C40 Aromatic	<1	517	33
Total (>C5-C40) Ali/Aro	<1	10100	33
Mineral Oil	<5	7220	33
PCB 28	<0.01	<0.01	5

Determinant	Recorded Concentrations		Number of Samples Tested
	Minimum (mg/kg)	Maximum (mg/kg)	
PCB 52	<0.01	0.06	7
PCB 101	<0.01	0.04	7
PCB 118	<0.01	0.05	7
PCB 153	<0.01	0.04	7
PCB 138	<0.01	0.04	7
PCB 180	<0.01	0.04	7
PCB (Total of 7 Congeners)	<0.03	0.28	7
VOC determinants tested were below limit of detection except for:			
Heptane	<0.01	0.0939	17
Octane	<0.01	0.124	17
Nonane	<0.01	0.0212	17
Benzene	<0.01	0.306	17
Toluene	<0.01	0.218	17
Ethylbenzene	<0.01	0.151	17
m+p-xylene	<0.01	0.251	17
o-xylene	<0.01	0.118	17
cis-1,2-dichloroethene	<0.01	0.0303	17
Chloroform	<0.01	0.0454	17
Tetrachloromethane	<0.01	0.0182	17
1,1,1-Trichloroethane	<0.01	0.0242	17
Tetrachloroethylene	<0.01	0.0273	17
1,1,1,2-Tetrachloroethane	<0.01	0.0151	17
1,1,2,2-Tetrachloroetha	<0.01	0.0333	17
Bromodichloromethane	<0.01	0.0303	17
Methylethylbenzene	<0.01	0.0242	17
1,1-Dichloro-1-propene	<0.01	0.0273	17
2,2-Dichloropropane	<0.01	0.0151	17
Bromochloromethane	<0.01	0.0424	17
1,2-Dichloroethane	<0.01	0.0333	17
Dibromomethane	<0.01	0.0121	17
1,2-Dichloropropane	<0.01	0.0182	17
cis-1,3-Dichloro-1-propene	<0.01	0.0151	17
1,1,2-Trichloroethane	<0.01	0.0212	17
Dibromochloromethane	<0.01	0.0121	17
Propylbenzene	<0.01	0.0244	17
2-Chlorotoluene	<0.01	0.0212	17
1,2,4-Trimethylbenzene	<0.01	0.0242	17
4-Chlorotoluene	<0.01	0.0121	17
t-butylbenzene	<0.01	0.0151	17
1,3,5-Trimethylbenzene	<0.01	0.0787	17
1-methylpropylbenzene	<0.01	0.0121	17
o-cymene	<0.01	0.0454	17
Butylbenzene	<0.01	0.0151	17
1,2-Dibromo-3-chloropropane	<0.01	0.0151	17
Hexachlorobutadiene	<0.01	0.0111	17
Naphthalene	<0.01	0.194	17
1,2,4-Trichlorobenzene	<0.01	0.0189	17
Bromoform	<0.01	0.0333	17
SVOC determinants tested were below the limit of detection except for			

Determinant	Recorded Concentrations		Number of Samples Tested
	Minimum (mg/kg)	Maximum (mg/kg)	
Phenol	<0.01	0.04	17
2-Methylphenol	<0.01	0.02	17
3 and 4-methylphenol	<0.01	0.04	17
Naphthalene	<0.01	1.01	17
2-Methylnaphthalene	<0.01	0.9	17
1-Methylnaphthalene	<0.01	1.12	17
Acenaphthylene	<0.01	0.96	17
Acenaphthene	<0.01	1.03	17
Dibenzofuran	<0.01	0.43	17
Fluorene	<0.01	1.32	17
Phenanthrene	<0.01	7.79	17
Anthracene	<0.01	2.45	17
Fluoranthene	<0.01	12.6	17
Pyrene	<0.01	10.6	17
Butyl benzyl phthalate	<0.01	0.01	17
Benzo(a)anthracene	<0.01	4.41	17
Chrysene	<0.01	6.76	17
Benzo(b)fluoranthene	<0.01	4.77	17
Benzo(k)fluoranthene	<0.01	4.22	17
Benzo(a)pyrene	<0.01	6.69	17
Indeno(1,2,3-cd)pyrene	<0.01	3.31	17
Dibenz(ah)anthracene	<0.01	1.42	17
Benzo[g,h,i]perylene	<0.01	3.96	17
1,12-Bis(2-nitrophenoxy)dodecane	0.28	0.28	1
1-Eicosene	0.86	0.86	1
10,18-Bisnorabieta-5,7,9(10),11,13-pentaene	0.29	5.9	3
11,13-Dimethyl-12-tetradecen-1-ol acetate	4.41	4.41	1
13-Methyl-Z-14-nonacosene	0.07	0.07	1
13-Tetradecen-1-ol acetate	1.36	1.36	1
17-Pentatriacontene	1.63	1.63	1
2,6,10,14,18,22-Tetracosahexaene, 2,6,10,15,19,23-hexamethyl-, (all-E)-	9.83	15.99	2
2-Dodecen-1-yl(-)succinic anhydride	8.97	8.97	1
2-Ethylhexyl mercaptoacetate	3.78	3.78	1
2-Methyl-Z-4-tetradecene	1.28	1.28	1
28-Nor-17.alpha.(H)-hopane	0.5	0.5	1
3,13-Dihydroxy-5,8,11,18,23-pentaoxa-1,15-diazabicyclo[13.5.5]pentacosane	0.21	0.22	2
Cyclohexane, 2-butyl-1,1,3-trimethyl-	0.27	0.27	1
Cyclopentane, (4-octyldodecyl)-	2.71	2.71	1
Cyclotetradecane, 1,7,11-trimethyl-4-(1-methylethyl)-	3.43	3.43	1
Cyclotriacontane	6.61	6.61	1
D-Homoandrostane, (5.alpha.,13.alpha.)-	10.74	10.74	1
Eicosane	0.64	3.01	2
Hexadecane, 1-chloro-	3.58	3.58	1
Hexadecane, 2,6,10,14-tetramethyl-	7.18	7.18	1
Naphthalene, 1,6,7-trimethyl-	1.39	1.39	1
Octadecane, 1-chloro-	2.32	2.32	1
Pentadec-7-ene, 7-bromomethyl-	10.2	10.2	1

Determinant	Recorded Concentrations		Number of Samples Tested
	Minimum (mg/kg)	Maximum (mg/kg)	
Pentadecane, 2,6,10,14-tetramethyl-	9.71	9.71	1
Pyridine-3-carboxamide, oxime, N-(2-trifluoromethylphenyl)-	0.22	0.22	1
Squalene	4.52	4.98	2
Tricosane	2.76	2.76	1
Undecane, 3,6-dimethyl-	1.17	1.17	1
m,p'-DDD	0.38	0.38	1
trans-2,3-Epoxydecane	3.54	3.54	1

Selected soil samples were also subjected to leachate testing by The Environmental Laboratory Ltd. The results are presented in the factual investigation report and are also summarised in Table 8.3 below. An assessment of these results when compared against the published based on these results is also discussed later in this report.

Table 8.3 – Leachate Analysis Results Summary

Determinant	Recorded Concentrations		Number of Samples Tested
	Minimum (µg/l)	Maximum (µg/l)	
Arsenic	<5	26	9
Cadmium	<1	<1	9
Chromium	<5	<5	9
Copper	<5	<5	9
Lead	<5	<5	9
Mercury	<0.1	0.3	9
Nickel	<5	<5	9
Selenium	<5	<5	9
Zinc	<5	8	9
Boron	11	82	3
Complex cyanide	<5	<5	6
Hexavalent chromium	<100	100	9
Free Cyanide	<5	<5	6
Total Cyanide	<5	<5	6
Ammoniacal Nitrogen as N	200	800	3
Total Monohydric Phenols	<5	<5	3
pH	7.3	8.3	6
Naphthalene	<0.05	0.11	9
Acenaphthylene	<0.01	0.02	9
Acenaphthene	<0.01	0.12	9
Fluorene	<0.01	0.16	9
Phenanthrene	<0.03	0.62	9
Anthracene	<0.01	0.08	9
Fluoranthene	<0.02	0.08	9
Pyrene	<0.01	0.05	9
Benzo (a) anthracene	<0.01	0.06	9
Chrysene	<0.01	0.05	9
Benzo (b) fluoranthene	<0.01	0.08	9
Benzo (k) fluoranthene	<0.01	0.06	9
Benzo (a) pyrene	<0.01	0.05	9
Indeno (1,2,3-cd) pyrene	<0.01	0.03	9
Dibenzo(a,h)anthracene	<0.01	<0.01	9
Benzo(ghi)perylene	<0.01	0.04	9
Total PAH(16)	0.17	1.12	9
Benzene	<1	<1	9
Toluene	<1	<1	9
Ethylbenzene	<1	<1	9

Determinant	Recorded Concentrations		Number of Samples Tested
	Minimum (µg/l)	Maximum (µg/l)	
Xylenes	<1	<1	9
MTBE	<1	<1	6
>C5-C6 Aliphatic	<1	<1	3
>C6-C8 Aliphatic	<1	<1	3
>C8-C10 Aliphatic	<5	<5	3
>C10-C12 Aliphatic	<5	<5	3
>C12-C16 Aliphatic	<5	<5	3
>C16-C21 Aliphatic	<5	<5	3
>C21-C35 Aliphatic	<5	7.3	3
>C35-C40 Aliphatic	<5	<5	3
Total (>C5-C40) Aliphatic	<5	7.3	3
>C5-C7 Aromatic	<1	<1	3
>C7-C8 Aromatic	<1	<1	3
>C8-C10 Aromatic	<5	<5	3
>C10-C12 Aromatic	<5	<5	3
>C12-C16 Aromatic	<5	7.1	3
>C16-C21 Aromatic	<5	<5	3
>C21-C35 Aromatic	5.2	11.2	3
>C35-C40 Aromatic	<5	<5	3
Total (>C5-C40) Aromatic	5.8	12.3	3
Total (>C5-C40) Ali/Aro	11.2	13.1	3

As the majority of the boreholes were located within the dock area, which were not fitted with standpipes, no post installation gas or groundwater monitoring was carried.

8.3 Environmental Assessment

8.3.1 General

As discussed earlier the assessment of the potential impacts arising from contaminated land is based upon considerations of pollution linkages between contamination sources and sensitive receptors. The UK framework for the assessment of contaminated land endorses the principle of risk assessment and a suitable for use approach to contaminated land. Remedial action is only required if there are unacceptable risks to human health or the environment, taking into account the use of the land and its environmental setting.

The methodology of risk assessment is normally set out in terms of significant pollutant linkages within a source-pathway-receptor model of the site. All three of these elements must be present for a site, or area of a site, to be determined to be contaminated.

A preliminary conceptual site model (CSM) as presented in the Phase 1 Environmental Risk Assessment report produced by RPS, which has included within Section 4 of this report. The preliminary CSM identified and described the sources of potential contamination and provided a qualitative assessment of the risk posed. This was then further developed with the data obtained from their site investigation, which as summarised in Section 7 concluded that there were no elevated concentrations, based upon the commercial end use, that pose a risk to human health. Also although there were some locally elevated metals recorded within the groundwater due to the site setting and the proposed hardcover it is considered o pose a low risk to controlled waters. The gas monitoring revealed that a Characteristic Situation 2, passive gas protection measures, should be included within new properties. The data from the later Delta-Simons site investigation has been reviewed by Concept and no elevated concentrations of the determinants tested were above the target level, however asbestos was identified within some of the samples. Therefore this pose a potential risk to future construction workers and occupiers if exposed but quantification testing is required to fully assess the level of risk posed.

The exposure model is in line with the Statutory Guidance to Part 2A of the Environmental Protection Act 1990, also known as a "potential pollution linkages" in the Model Procedures of CLR11 (DEFRA and Environment Agency, 2004).

8.3.2 Human Health

The human health risk assessment process is based upon a tiered system of risk estimation. It aims to identify significant risks that may require further investigation, be considered for remediation or indicate potential legal or financial liability. A tiered approach has been adopted within the UK risk assessment framework providing a series of steps, after each of which decisions are taken on whether or not more sophisticated assessment is required. By doing so a pragmatic approach to the assessment of human health risk is maintained.

8.3.3 Assessment of Averaging Areas/Zones Following Ground Investigation Works

On some sites that have complex, varied past uses or proposed end uses the site can be divided into zones based on the historical usages or proposed end use and these zones can be further divided into averaging areas. These averaging areas can be used to assess different soil types revealed or different potential exposure pathways etc. for the purposes of accurately modelling the site conditions. Each averaging area can be considered independently of each other for human health exposure assessment.

On the London City Airport site area investigated by Concept as a number of the boreholes were located within the dock based on professional judgement, it has been decided to split the site into two zones, which have been further divided into two averaging areas each, as detailed below

- Zone 1 – Dockside –
    - Area 1 : made ground
    - Area 2 : natural soils – however no samples were collected from this strata as part of the Concept investigations.
- Zone 2 Within the Dock:
    - Area 3 : dock sediment
    - Area 4 : natural soils

8.3.4 Tier 1 Risk Assessment

Where chemical test data records contaminant concentrations that are on or beneath the laboratory detection limits these have been excluded from further assessment. This is based upon the conclusion that the determinant in question, if actually present, will be at such low concentrations that it does not represent a potential source. This forms the basis for the Tier 1 risk assessment and based upon the chemical test data recovered during the works, as detailed previously in Table 4 in Section 8 a number of the determinants tested for in the soils can be removed from further consideration.

Tables 8.4 and 8.5 below details the determinants that require further consideration for Zone 1 and Zone 2 respectively, which have been sub-divided into their respective averaging areas. Any averaging areas that have been shown to contain determinants with recorded concentrations below the limit of detection these have been highlighted in yellow and removed from the data set for any further assessment as they have passed the Tier 1 risk assessment.

Table 8.4 – Zone 1 Determinants on the Dockside failing the Tier 1 Assessment in their Averaging Areas

Determinant	Made ground	
	Min (mg/kg)	Max (mg/kg)
Arsenic	1	44.5
Barium		
Beryllium		
Cadmium	0.5	0.7
Chromium	5	49.2
Copper	5	60.9
Lead	5	462
Mercury	0.5	1.7
Nickel	5	41.2
Selenium	0	0
Vanadium	0	0
Boron	<0.5	4.2
Zinc	5	875
Water Soluble Sulphate	0.03	0.14
Complex Cyanide		
Elemental Sulphur		
Total Cyanide	1	1.6
Loss On Ignition (450°C)	0.4	0.4
pH	7.8	7.8
Soil Organic Matter	0.1	5.5
Total Organic Carbon	0.07	0.07
Naphthalene	<0.1	<0.1
Acenaphthylene	<0.1	<0.1
Acenaphthene	<0.1	<0.1
Fluorene	<0.1	<0.1
Phenanthrene	<0.1	0.3
Anthracene	<0.1	<0.1
Fluoranthene	<0.1	0.7
Pyrene	<0.1	0.4
Benzo(a)anthracene	<0.1	0.4
Chrysene	<0.1	0.5
Benzo (b) fluoranthene	<0.1	0.4
Benzo(k)fluoranthene	<0.1	0.6
Benzo (a) pyrene	<0.1	0.4
Indeno (1,2,3-cd) pyrene	<0.1	0.3
Dibenzo(a,h)anthracene	<0.1	<0.1
Benzo[g,h,i]perylene	<0.1	0.3
Total PAH(16)	<0.4	4
Total PAH (Including Coronene)	2	2
Benzene	<0.01	<0.01
Toluene	<0.01	<0.01
Ethylbenzene	<0.01	<0.01

Determinant	Made ground	
	Min (mg/kg)	Max (mg/kg)
Xylenes	<0.01	<0.01
MTBE	<0.01	<0.01
Total BTEX	<0.01	<0.01
>C5-C6 Aliphatic	<0.01	<0.01
>C6-C8 Aliphatic	<0.01	<0.01
>C10-C12 Aliphatic	<1	<1
>C12-C16 Aliphatic	<1	<1
>C16-C21 Aliphatic	<1	9.9
>C21-C35 Aliphatic	<1	53.1
>C35-C40 Aliphatic	<1	7.3
>C5-C7 Aromatic	<0.01	<0.01
>C7-C8 Aromatic	<0.01	<0.01
>C10-C12 Aromatic	<1	<1
>C12-C16 Aromatic	<1	<1
>C16-C21 Aromatic	<1	5.6
>C21-C35 Aromatic	<1	49.7
>C35-C40 Aromatic	<1	17.6
Total (>C5-C40) Ali/Aro	<1	138
Mineral Oil	<5	<5
PCB 52		
PCB 101		
PCB 118		
PCB 153		
PCB 138		
PCB 180		
PCB (Total of 7 Congeners)	<0.03	<0.03
Heptane	<0.01	
Octane	<0.01	
Nonane	<0.01	
Benzene	<0.01	
Toluene	<0.01	
Ethylbenzene	<0.01	
m+p-xylene	<0.01	
o-xylene	<0.01	
cis-1,2-dichloroethene	<0.01	
Chloroform	<0.01	
Tetrachloromethane	<0.01	
1,1,1-Trichloroethane	<0.01	
Tetrachloroethylene	<0.01	
1,1,1,2-Tetrachloroethane	<0.01	
1,1,2,2-Tetrachloroetha	<0.01	
Bromodichloromethane	<0.01	
Methylethylbenzene	<0.01	
1,1-Dichloro-1-propene	<0.01	
2,2-Dichloropropane	<0.01	
Bromochloromethane	<0.01	
1,2-Dichloroethane	<0.01	
Dibromomethane	<0.01	
1,2-Dichloropropane	<0.01	
cis-1,3-Dichloro-1-propene	<0.01	
1,1,2-Trichloroethane	<0.01	
Dibromochloromethane	<0.01	
Propylbenzene	<0.01	
2-Chlorotoluene	<0.01	
1,2,4-Trimethylbenzene	<0.01	
4-Chlorotoluene	<0.01	
t-butylbenzene	<0.01	
1,3,5-Trimethylbenzene	<0.01	
1-methylpropylbenzene	<0.01	

Determinant	Made ground	
	Min (mg/kg)	Max (mg/kg)
o-cymene	<0.01	
Butylbenzene	<0.01	
1,2-Dibromo-3-chloropropane	<0.01	
Hexachlorobutadiene	<0.01	
Naphthalene	<0.01	
1,2,4-Trichlorobenzene	<0.01	
Bromoform	<0.01	
Phenol	<0.01	
2-Methylphenol	<0.01	
3 and 4-methylphenol	<0.01	
Naphthalene	<0.01	
2-Methylnaphthalene	<0.01	
1-Methylnaphthalene	<0.01	
Acenaphthylene	<0.01	
Acenaphthene	<0.01	
Dibenzofuran	<0.01	
Fluorene	<0.01	
Phenanthrene	<0.01	
Anthracene	<0.01	
Fluoranthene	<0.01	
Pyrene	<0.01	
Butyl benzyl phthalate	<0.01	
Benzo(a)anthracene	<0.01	
Chrysene	<0.01	
Benzo(b)fluoranthene	<0.01	
Benzo(k)fluoranthene	<0.01	
Benzo(a)pyrene	<0.01	
Indeno(1,2,3-cd)pyrene	<0.01	
Dibenz(ah)anthracene	<0.01	
Benzo[g,h,i]perylene	<0.01	

Table 8.5 – Zone 2 Determinants within the Dock failing the Tier 1 Assessment in their Averaging Areas

Determinant	Dock Sediment		Natural Soils	
	Min (mg/kg)	Max (mg/kg)	Min (mg/kg)	Max (mg/kg)
Arsenic	6.4	124	2.3	116
Barium	147	616	11.8	1280
Beryllium	1.6	1.9	<1	1.9
Cadmium	<0.5	9.3	<0.5	5
Chromium	24.6	171	13.7	90.2
Copper	11.9	753	5	512
Lead	17.9	1630	5	969
Mercury	0.5	47.8	<0.5	31.8
Nickel	11.8	92.9	5.2	59.3
Selenium	1.6	5.4	<1	3.5
Vanadium	71.7	88.8	<5	81.4
Boron	36.5	45.4	<0.5	33.2
Zinc	31.4	3070	14	2030
Water Soluble Sulphate	<0.08	0.68	0.05	0.13
Complex Cyanide	2.3	2.9	<1	2.8
Elemental Sulphur	2070	20900	<20	9940
Total Cyanide	<1	2.9	<1	2.8
Loss On Ignition (450°C)	7.33	19.4	0.31	0.82
pH	7.7	8.1	8.1	8.7
Soil Organic Matter	0.6	17	0.1	14
Total Organic Carbon	3.8	17	0.07	0.08
Naphthalene	<0.1	12.8	<0.1	3.7

Determinant	Dock Sediment		Natural Soils	
	Min (mg/kg)	Max (mg/kg)	Min (mg/kg)	Max (mg/kg)
Arsenic	6.4	124	2.3	116
Barium	147	616	11.8	1280
Beryllium	1.6	1.9	<1	1.9
Acenaphthylene	<0.1	24.2	<0.1	6.3
Acenaphthene	<0.1	15.8	<0.1	4
Fluorene	<0.1	24.1	<0.1	4.5
Phenanthrene	<0.1	71.2	<0.1	9.6
Anthracene	<0.1	21.2	<0.1	2.9
Fluoranthene	0.1	130	<0.1	16.5
Pyrene	0.2	104	<0.1	13.7
Benzo(a)anthracene	<0.1	77.2	<0.1	10.1
Chrysene	0.2	83.4	<0.1	14.5
Benzo (b) fluoranthene	<0.1	58.3	<0.1	8
Benzo(k)fluoranthene	<0.1	65.7	<0.1	10.9
Benzo (a) pyrene	<0.1	91.8	<0.1	12.7
Indeno (1,2,3-cd) pyrene	<0.1	56	<0.1	14.1
Dibenzo(a,h)anthracene	<0.1	17.1	<0.1	3.9
Benzo[g,h,i]perylene	<0.1	46.2	<0.1	12.8
Total PAH(16)	1.3	890	<0.4	149
Total PAH (Including Coronene)	23	906	<2	4
Benzene	<0.010	0.306	<0.010	<65.5
Toluene	<0.010	218	<0.010	28
Ethylbenzene	<0.010	151	<0.010	28
Xylenes	<0.010	369	<0.010	74.4
MTBE	<0.010	99.9	<0.010	23
Total BTEX	0.12	1.04	<0.01	<0.01
>C5-C6 Aliphatic	<0.01	0.76	0.01	0.15
>C6-C8 Aliphatic	<0.01	0.22	<0.01	0.04
>C10-C12 Aliphatic	<1	29.5	<1	<1
>C12-C16 Aliphatic	<1	345	<1	5.7
>C16-C21 Aliphatic	<1	1060	<1	75
>C21-C35 Aliphatic	<1	3520	<1	313
>C35-C40 Aliphatic	<1	493	<1	43.4
>C5-C7 Aromatic	<0.01	0.31	<0.01	0.07
>C7-C8 Aromatic	<0.01	0.22	<0.01	0.1
>C10-C12 Aromatic	<1	50	<1	<1
>C12-C16 Aromatic	<1	469	<1	60.7
>C16-C21 Aromatic	<1	1130	<1	160
>C21-C35 Aromatic	<1	3160	<1	475
>C35-C40 Aromatic	<1	517	<1	76.2
Total (>C5-C40) Ali/Aro	<1	10100	1.4	1200
Mineral Oil	<5	7220	9	24
PCB 52	0.05	0.06	<0.01	<0.01
PCB 101	0.03	0.04	<0.01	<0.01
PCB 118	0.02	0.05	<0.01	<0.01
PCB 153	0.02	0.04	<0.01	<0.01
PCB 138	0.02	0.04	<0.01	<0.01
PCB 180	0.01	0.04	<0.01	<0.01
PCB (Total of 7 Congeners)	<0.03	0.28	<0.03	<0.03
Heptane	<0.01	0.0939	<0.01	0.0348
Octane	<0.01	0.124	<0.01	<0.01
Nonane	<0.01	0.0212	<0.01	<0.01
Benzene	<0.01	0.306	<0.01	<0.01
Toluene	<0.01	0.218	<0.01	<0.01
Ethylbenzene	<0.01	0.151	<0.01	<0.01
m+p-xylene	<0.01	0.251	<0.01	<0.01
o-xylene	<0.01	0.118	<0.01	<0.01
cis-1,2-dichloroethene	<0.01	0.0303	<0.01	<0.01
Chloroform	<0.01	0.0454	<0.01	<0.01

Determinant	Dock Sediment		Natural Soils	
	Min (mg/kg)	Max (mg/kg)	Min (mg/kg)	Max (mg/kg)
Arsenic	6.4	124	2.3	116
Barium	147	616	11.8	1280
Beryllium	1.6	1.9	<1	1.9
Tetrachloromethane	<0.01	0.0182	<0.01	<0.01
1,1,1-Trichloroethane	<0.01	0.024.2	<0.01	<0.01
Tetrachloroethylene	<0.01	0.0273	<0.01	<0.01
1,1,1,2-Tetrachloroethane	<0.01	0.0151	<0.01	<0.01
1,1,2,2-Tetrachloroetha	<0.01	0.0333	<0.01	<0.01
Bromodichloromethane	<0.01	0.0303	<0.01	<0.01
Methylethylbenzene	<0.01	0.0242	<0.01	<0.01
1,1-Dichloro-1-propene	<0.01	0.0273	<0.01	<0.01
2,2-Dichloropropane	<0.01	0.0151	<0.01	<0.01
Bromochloromethane	<0.01	0.0424	<0.01	<0.01
1,2-Dichloroethane	<0.01	0.0333	<0.01	<0.01
Dibromomethane	<0.01	0.0121	<0.01	<0.01
1,2-Dichloropropane	<0.01	0.0182	<0.01	<0.01
cis-1,3-Dichloro-1-propene	<0.01	0.0151	<0.01	<0.01
1,1,2-Trichloroethane	<0.01	0.0212	<0.01	<0.01
Dibromochloromethane	<0.01	0.0121	<0.01	<0.01
Propylbenzene	<0.01	0.0244	<0.01	<0.01
2-Chlorotoluene	<0.01	0.0212	<0.01	<0.01
1,2,4-Trimethylbenzene	<0.01	0.0242	<0.01	<0.01
4-Chlorotoluene	<0.01	0.0121	<0.01	<0.01
t-butylbenzene	<0.01	0.0151	<0.01	<0.01
1,3,5-Trimethylbenzene	<0.01	0.0787	<0.01	<0.01
1-methylpropylbenzene	<0.01	0.0121	<0.01	<0.01
o-cymene	<0.01	0.0454	<0.01	<0.01
Butylbenzene	<0.01	0.0151	<0.01	<0.01
1,2-Dibromo-3-chloropropane	<0.01	0.0151	<0.01	<0.01
Hexachlorobutadiene	<0.01	0.0111	<0.01	<0.01
Naphthalene	<0.01	0.194	<0.01	<0.01
1,2,4-Trichlorobenzene	<0.01	0.0189	<0.01	<0.01
Bromoform	<0.01	0.0333	<0.01	<0.01
Phenol	<0.01	0.04	<0.01	<0.01
2-Methylphenol	<0.01	0.02	<0.01	<0.01
3 and 4-methylphenol	<0.01	0.04	<0.01	<0.01
Naphthalene	<0.01	1.01	<0.01	0.07
2-Methylnaphthalene	<0.01	0.9	<0.01	0.02
1-Methylnaphthalene	<0.01	1.12	<0.01	0.03
Acenaphthylene	<0.01	0.96	<0.01	0.02
Acenaphthene	<0.01	1.03	<0.01	0.06
Dibenzofuran	<0.01	0.43	<0.01	0.02
Fluorene	<0.01	1.32	<0.01	0.03
Phenanthrene	0.02	7.79	<0.01	0.33
Anthracene	<0.01	2.45	<0.01	0.08
Fluoranthene	0.05	12.6	<0.01	0.49
Pyrene	0.05	10.6	<0.01	0.47
Butyl benzyl phthalate	<0.01	<0.01	<0.01	<0.01
Benzo(a)anthracene	0.02	4.41	<0.01	0.014
Chrysene	0.03	6.76	<0.01	0.23
Benzo(b)fluoranthene	<0.01	4.77	<0.01	0.18
Benzo(k)fluoranthene	0.02	4.22	<0.01	0.16
Benzo(a)pyrene	0.03	6.69	<0.01	0.17
Indeno(1,2,3-cd)pyrene	<0.01	3.31	<0.01	0.09
Dibenz(ah)anthracene	<0.01	1.42	<0.01	0.03
Benzo[g,h,i]perylene	0.02	3.96	<0.01	0.11
1,12-Bis(2-nitrophenoxy)dodecane	0.28	0.28		
1-Eicosene	0.86	0.86		
10,18-Bisnorabieta-5,7,9(10),11,13-	5.9	5.9	0.29	0.57

Determinant	Dock Sediment		Natural Soils	
	Min (mg/kg)	Max (mg/kg)	Min (mg/kg)	Max (mg/kg)
Arsenic	6.4	124	2.3	116
Barium	147	616	11.8	1280
Beryllium	1.6	1.9	<1	1.9
pentaene				
11,13-Dimethyl-12-tetradecen-1-ol acetate	4.41	4.41		
13-Methyl-Z-14-nonacosene	0.07	0.07		
13-Tetradecen-1-ol acetate	1.36	1.36		
17-Pentatriacontene	1.63	1.63		
2,6,10,14,18,22-Tetracosahexaene, 2,6,10,15,19,23-hexamethyl-, (all-E)-			9.83	15.99
2-Dodecen-1-yl(-)succinic anhydride	8.97	8.97		
2-Ethylhexyl mercaptoacetate			3.78	3.78
2-Methyl-Z-4-tetradecene	1.28	1.28		
28-Nor-17.alpha.(H)-hopane	0.5	0.5		
3,13-Dihydroxy-5,8,11,18,23-pentaoxa-1,15-diazabicyclo[13.5.5]pentacosane	0.22	0.22	0.21	0.21
Cyclohexane, 2-butyl-1,1,3-trimethyl-	0.27	0.27		
Cyclopentane, (4-octyldodecyl)-	2.71	2.71		
Cyclotetradecane, 1,7,11-trimethyl-4-(1-methylethyl)-	3.43	3.43		
Cyclotriacontane	6.61	6.61		
D-Homoandrostane, (5.alpha.,13.alpha.)-	10.74	10.74		
Eicosane	0.64	0.64	3.01	3.01
Hexadecane, 1-chloro-	3.58	3.58		
Hexadecane, 2,6,10,14-tetramethyl-	7.18	7.18		
Naphthalene, 1,6,7-trimethyl-	1.39	1.39		
Octadecane, 1-chloro-	2.32	2.32		
Pentadec-7-ene, 7-bromomethyl-	10.2	10.2		
Pentadecane, 2,6,10,14-tetramethyl-	9.71	9.71		
Pyridine-3-carboxamide, oxime, N-(2-trifluoromethylphenyl)-	0.22	0.22		
Squalene	4.98	4.98	4.52	4.52
Tricosane			2.76	2.76
Undecane, 3,6-dimethyl-	1.17	1.17		
m,p'-DDD	0	0	0.38	0.38
trans-2,3-Epoxydecane	3.54	3.54		

In addition to those determinants with below detection limit values that have been removed from table 8.5 above following determinants have also not been assessed further with regard to human health as justified below

- Organic Matter and Total Organic Carbon
- pH
- Water soluble sulphate
- Total PAH
- Total TPH aliphatic and aromatic values and Mineral Oils
- Total and complex cyanide
- Elemental Sulphur
- Loss on ignition

Organic Matter, Total Organic Carbon and pH do not pose any identified human health based risks under normal circumstances.

Research on sulphate toxicology has revealed the major health effect with sulphate ingestion is laxative action. In general, the toxicity of sulphate alone is not considered to pose a significant risk to human health and has therefore been excluded from the exposure assessment.

Total PAH, TPH (aliphatic and aromatic) and Mineral Oil values have not been considered as, in accordance with current best practice, the individual species have been assessed in accordance with their differing toxicological properties.

Total and Complex Cyanide have not been considered as analytical test results are also available for the same samples for free cyanide, which were below the limit of detection. Free cyanide consists of HCN and CN (the highly toxic forms), whereas the total cyanide test procedure reports all forms of free and metal bound cyanides, including the non-toxic and stable iron cyanides. Iron-complexed cyanides, dominated by the ferrocyanide ion, comprise over 97% of total cyanides in either weathered or unweathered soils.

A search for toxicity data for elemental sulphur has been unsuccessful. This has included the DEFRA/EA sources, WHO Environmental Health Criteria documents, Risk Assessment Information System (RAIS) database and the USEPA IRIS database. A Holly Industries material safety data sheet identifies that sulphur is essentially non-toxic either through ingestion, inhalation, skin or eye contact. Irritant effects have been reported when sulphur is in dust form. As a result of these searches, elemental sulphur has not been considered as a determinant that is potentially hazardous to human health.

Sulphide (S2-) is chemical compound containing sulphur and one other element and a form of sulphur and is defined as a although specific sulphide species can be hazardous including hydrogen sulphide (H2S) and carbon disulphide (CS2) in isolation sulphide is not recognised to be a determinant that is potentially hazardous to human health.

Loss on ignition is a result that is considered for disposal purposes and therefore has not been considered in this section of the report.

8.3.5 Tier 2 Risk Assessment

The Tier 2 risk assessment utilises published and authoritative generic assessment criteria to determine the likelihood of harm being caused to human health. For the London City Airport site the proposed redevelopment will be for an arrivals building, forecourt, hotel and car parking it will hard covered and. therefore it has been deemed appropriate to compare the recorded concentrations against the Commercial end use published assessment criteria.

Tables 8.6, 8.7 and 8.8 below compares the determinants with concentrations above the limit of detection determined previously in Tables 8.4 and 8.5 for each averaging area directly against, where available, the adopted published generic assessment criteria. The source of the assessment criteria has also been included and any identified failures highlighted in blue

Table 8.6 –Tier 2 Assessment for Zone 1 - Made Ground

Determinant	Made ground		Assessment Value (mg/kg)	No failures	Source
	Min (mg/kg)	Max (mg/kg)			
Arsenic	1	44.5	640	NONE	LQM
Cadmium	0.5	0.7	190	NONE	LQM
Chromium	5	49.2	8600	NONE	LQM
Copper	5	60.9	68000	NONE	LQM
Lead	5	462	2330	NONE	C4SL
Mercury	0.5	1.7	1100	NONE	LQM
Nickel	5	41.2	980	NONE	LQM
Selenium	0	0	12000	NONE	LQM
Vanadium	0	0	9000	NONE	LQM
Boron	<0.5	4.2	24000	NONE	LQM
Zinc	5	875	730000	NONE	LQM
Phenanthrene	<0.1	0.3	22000	NONE	LQM
Fluoranthene	<0.1	0.7	23000	NONE	LQM
Pyrene	<0.1	0.4	54000	NONE	LQM
Benzo(a)anthracene	<0.1	0.4	170	NONE	LQM
Chrysene	<0.1	0.5	350	NONE	LQM
Benzo (b) fluoranthene	<0.1	0.4	44	NONE	LQM
Benzo(k)fluoranthene	<0.1	0.6	1200	NONE	LQM
Benzo (a) pyrene	<0.1	0.4	35	NONE	LQM
Indeno (1,2,3-cd) pyrene	<0.1	0.3	500	NONE	LQM
Benzo[g,h,i]perylene	<0.1	0.3	3900	NONE	LQM
>C16-C21 Aliphatic	<1	9.9	1600000	NONE	LQM
>C21-C35 Aliphatic	<1	53.1			
>C35-C40 Aliphatic	<1	7.3	1600000	NONE	LQM
>C16-C21 Aromatic	<1	5.6	28000	NONE	LQM
>C21-C35 Aromatic	<1	49.7	28000	NONE	LQM
>C35-C40 Aromatic	<1	17.6	28000	NONE	LQM

Key: LQM = LQM/CIEH Suitable 4 Use Levels (S4UL) published 2015
C4SL = Category 4 Screening Levels Defra published 2014

As can be seen from the table above none of the determinants tested were present at concentrations in excess of the adopted assessment criteria. Therefore the made ground is not considered to pose a risk to human health and therefore no remedial measures are proposed. However although no asbestos was identified within the samples collected during the Concept investigations the Delta-Simons 2016 investigation did identify asbestos fibres within some of their made ground samples. As no quantification testing was undertaken it has not been possible to quantity the level of risk. Therefore during the construction works suitable protection measures need to be incorporated within the method statements to reduce the risk of fibre release when the made ground is disturbed.

Table 8.7 –Tier 2 Assessment for Zone 2 – Dock Sediment Samples

Determinant	Dock Sediment		Assessment Value (mg/kg)	No failures	Source
	Min (mg/kg)	Max (mg/kg)			
Arsenic	6.4	124	640	NONE	LQM
Barium	147	616	22000	NONE	EIC
Beryllium	1.6	1.9	12	NONE	LQM
Cadmium	<0.5	9.3	190	NONE	LQM
Chromium	24.6	171	8600	NONE	LQM
Copper	11.9	753	68000	NONE	LQM
Lead	17.9	1630	2330	NONE	C4SL
Mercury	0.5	47.8	1100	NONE	LQM

Determinant	Dock Sediment		Assessment Value (mg/kg)	No failures	Source
	Min (mg/kg)	Max (mg/kg)			
Nickel	11.8	92.9	980	NONE	LQM
Selenium	1.6	5.4	12000	NONE	LQM
Vanadium	71.7	88.8	9000	NONE	LQM
Boron	36.5	45.4	24000	NONE	LQM
Zinc	31.4	3070	73000	NONE	LQM
Naphthalene	<0.1	12.8	190	NONE	LQM
Acenaphthylene	<0.1	24.2	83000	NONE	LQM
Acenaphthene	<0.1	15.8	84000	NONE	LQM
Fluorene	<0.1	24.1	63000	NONE	LQM
Phenanthrene	<0.1	71.2	22000	NONE	LQM
Anthracene	<0.1	21.2	520000	NONE	LQM
Fluoranthene	0.1	130	23000	NONE	LQM
Pyrene	0.2	104	54000	NONE	LQM
Benzo(a)anthracene	<0.1	77.2	170	NONE	LQM
Chrysene	0.2	83.4	350	NONE	LQM
Benzo (b) fluoranthene	<0.1	58.3	44	1 from 9	LQM
Benzo(k)fluoranthene	<0.1	65.7	1200	NONE	LQM
Benzo (a) pyrene	<0.1	91.8	35	1 from 9	LQM
Indeno (1,2,3-cd) pyrene	<0.1	56	500	NONE	LQM
Dibenzo(a,h)anthracene	<0.1	17.1	3.5	1 from 9	LQM
Benzo[g,h,i]perylene	<0.1	46.2	3900	NONE	LQM
Benzene	<0.010	0.306	27000	NONE	LQM
Toluene	<0.010	218	56000000	NONE	LQM
Ethylbenzene	<0.010	151	5700000	NONE	LQM
Xylenes	<0.010	369	5900000	NONE	LQM
MTBE	<0.010	0.0999	79000	NONE	EIC
>C5-C6 Aliphatic	<0.01	0.76	3200	NONE	LQM
>C6-C8 Aliphatic	<0.01	0.22	7800	NONE	LQM
>C10-C12 Aliphatic	<1	29.5	9700	NONE	LQM
>C12-C16 Aliphatic	<1	345	59000	NONE	LQM
>C16-C21 Aliphatic	<1	1060	1600000	NONE	LQM
>C21-C35 Aliphatic	<1	3520			
>C35-C40 Aliphatic	<1	493	1600000	NONE	LQM
>C5-C7 Aromatic	<0.01	0.31	260000	NONE	LQM
>C7-C8 Aromatic	<0.01	0.22	56000	NONE	LQM
>C10-C12 Aromatic	<1	50	16000	NONE	LQM
>C12-C16 Aromatic	<1	469	36000	NONE	LQM
>C16-C21 Aromatic	<1	1130	28000	NONE	LQM
>C21-C35 Aromatic	<1	3160	28000	NONE	LQM
>C35-C40 Aromatic	<1	517	28000	NONE	LQM
PCB 52	0.05	0.06			
PCB 101	0.03	0.04			
PCB 118	0.02	0.05			
PCB 153	0.02	0.04			
PCB 138	0.02	0.04			
PCB 180	0.01	0.04			
PCB (Total of 7 Congeners)	<0.03	0.28	0.24	1 from 3	PoHH
Heptane	<0.01	0.0939			
Octane	<0.01	0.124			
Nonane	<0.01	0.0212			
Benzene	<0.01	0.306	27	NONE	C4SL
Toluene	<0.01	0.218	870	NONE	EIC
Ethylbenzene	<0.01	0.151	520	NONE	EIC
m+p-xylene	<0.01	0.251	630	NONE	EIC
o-xylene	<0.01	0.118	480	NONE	EIC
cis-1,2-dichloroethene	<0.01	0.0303	14	NONE	EIC
Chloroform	<0.01	0.0454			
Tetrachloromethane	<0.01	0.0182			

Determinant	Dock Sediment		Assessment Value (mg/kg)	No failures	Source
	Min (mg/kg)	Max (mg/kg)			
1,1,1-Trichloroethane	<0.01	0.024.2	700	NONE	EIC
Tetrachloroethylene	<0.01	0.0273	130	NONE	EIC
1,1,1,2-Tetrachloroethane	<0.01	0.0151	120	NONE	EIC
1,1,2,2-Tetrachloroethane	<0.01	0.0333	290	NONE	EIC
Bromodichloromethane	<0.01	0.0303	2.1	NONE	EIC
Methylethylbenzene	<0.01	0.0242			
1,1-Dichloro-1-propene	<0.01	0.0273			
2,2-Dichloropropane	<0.01	0.0151			
Bromochloromethane	<0.01	0.0424			
1,2-Dichloroethane	<0.01	0.0333	0.71	NONE	EIC
Dibromomethane	<0.01	0.0121			
1,2-Dichloropropane	<0.01	0.0182			
cis-1,3-Dichloro-1-propene	<0.01	0.0151			
1,1,2-Trichloroethane	<0.01	0.0212	94	NONE	EIC
Dibromochloromethane	<0.01	0.0121			
Propylbenzene	<0.01	0.0244			
2-Chlorotoluene	<0.01	0.0212			
1,2,4-Trimethylbenzene	<0.01	0.0242	42	NONE	EIC
4-Chlorotoluene	<0.01	0.0121			
t-butylbenzene	<0.01	0.0151			
1,3,5-Trimethylbenzene	<0.01	0.0787			
1-methylpropylbenzene	<0.01	0.0121			
o-cymene	<0.01	0.0454			
Butylbenzene	<0.01	0.0151			
1,2-Dibromo-3-chloropropane	<0.01	0.0151			
Hexachlorobutadiene	<0.01	0.0111	32	NONE	EIC
Naphthalene	<0.01	0.194			
1,2,4-Trichlorobenzene	<0.01	0.0189			
Bromoform	<0.01	0.0333			
Phenol	<0.01	0.04	3200	NONE	EIC
2-Methylphenol	<0.01	0.02			
3 and 4-methylphenol	<0.01	0.04			
Naphthalene	<0.01	1.01	190	NONE	LQM for soil
2-Methylnaphthalene	<0.01	0.9			
1-Methylnaphthalene	<0.01	1.12			
Acenaphthylene	<0.01	0.96	83000	NONE	LQM for soil
Acenaphthene	<0.01	1.03	84000	NONE	LQM for soil
Dibenzofuran	<0.01	0.43			
Fluorene	<0.01	1.32	63000	NONE	LQM for soil
Phenanthrene	0.02	7.79	22000	NONE	LQM for soil
Anthracene	<0.01	2.45	520000	NONE	LQM for soil
Fluoranthene	0.05	12.6	23000	NONE	LQM for soil
Pyrene	0.05	10.6	54000	NONE	LQM for soil
Benzo(a)anthracene	0.02	4.41	170	NONE	LQM for soil
Chrysene	0.03	6.76	350	NONE	LQM for soil
Benzo(b)fluoranthene	<0.01	4.77	44	NONE	LQM for soil
Benzo(k)fluoranthene	0.02	4.22	1200	NONE	LQM for soil
Benzo(a)pyrene	0.03	6.69	35	NONE	LQM for soil
Indeno(1,2,3-cd)pyrene	<0.01	3.31	500	NONE	LQM for soil
Dibenz(ah)anthracene	<0.01	1.42	3.5	NONE	LQM for soil
Benzo[g,h,i]perylene	0.02	3.96	3900	NONE	LQM for soil
1,12-Bis(2-nitrophenoxy)dodecane	0.28	0.28			
1-Eicosene	0.86	0.86			
10,18-Bisnorabieta-5,7,9(10),11,13-pentaene	5.9	5.9			

Determinant	Dock Sediment		Assessment Value (mg/kg)	No failures	Source
	Min (mg/kg)	Max (mg/kg)			
11,13-Dimethyl-12-tetradecen-1-ol acetate	4.41	4.41			
13-Methyl-Z-14-nonacosene	0.07	0.07			
13-Tetradecen-1-ol acetate	1.36	1.36			
17-Pentatriacontene	1.63	1.63			
2-Dodecen-1-yl(-)succinic anhydride	8.97	8.97			
2-Methyl-Z-4-tetradecene	1.28	1.28			
28-Nor-17.alpha.(H)-hopane	0.5	0.5			
3,13-Dihydroxy-5,8,11,18,23-pentaoxa-1,15-diazabicyclo[13.5.5]pentacosane	0.22	0.22			
Cyclohexane, 2-butyl-1,1,3-trimethyl-	0.27	0.27			
Cyclopentane, (4-octyldodecyl)-	2.71	2.71			
Cyclotetradecane, 1,7,11-trimethyl-4-(1-methylethyl)-	3.43	3.43			
Cyclotriacontane	6.61	6.61			
D-Homoandrostane, (5.alpha.,13.alpha.)-	10.74	10.74			
Eicosane	0.64	0.64			
Hexadecane, 1-chloro-	3.58	3.58			
Hexadecane, 2,6,10,14-tetramethyl-	7.18	7.18			
Naphthalene, 1,6,7-trimethyl-	1.39	1.39			
Octadecane, 1-chloro-	2.32	2.32			
Pentadec-7-ene, 7-bromomethyl-	10.2	10.2			
Pentadecane, 2,6,10,14-tetramethyl-	9.71	9.71			
Pyridine-3-carboxamide, oxime, N-(2-trifluoromethylphenyl)-	0.22	0.22			
Squalene	4.98	4.98			
Tricosane					
Undecane, 3,6-dimethyl-	1.17	1.17			
trans-2,3-Epoxydecane	3.54	3.54			

Key: LQM = LQM/CIEH Suitable 4 Use Levels (S4UL) published 2015

C4SL = Category 4 Screening Levels Defra published 2014

EIC = Environmental Industry Commission 2010 list of derived GAC's

PoHH = Protection of Human Health SGV published 2009

LQM/CIEH = For VOC and SVOC determinants the LQM/CIEH 2009 SGV's have adopted

Table 8.7 above it can be seen that the sediment at the base of the dock contains localised elevated PAHs and a very marginally elevated PCB level. From a review of the results the elevated PAH's were all within the sample collected from BH3, which was located in the south-western corner of the dock, at 11.70m below water level (bwl), which was from a 2m thick layer described as "very soft dark grey SILT with strong hydrocarbon odour" with a VOC field reading of 19ppm.

The marginally elevated PCB was identified within BH31 located in the north-eastern section of the dock at 12m bwl within a 0.5m thick layer described as "soft dark to light grey SILT with strong hydrocarbon odour and rare glass fragments (<85mm)".

Generally when a determinant is shown to be at concentrations in excess of the Tier 2 published assessment criteria the risk assessment progresses to Tier 3 with statistical analysis of the data set and site specific risk assessment. However as there are only localised exceedances, which are significantly above the other results, these are likely to be shown to be statistical outliers from the data set and therefore should be removed from further assessment. With regard to undertaking a site specific risk assessment as the sediment is below 11.5m and 12m of water the current and future users of the airport and general public cannot come into contact with it. Therefore as there is no pathway these sediments have not been deemed not to pose a significant risk to human health and therefore do not require remedial protection measures.

Table 8.8 –Tier 2 Assessment for Zone 2 – Dock Natural Samples

Determinant	Dock Sediment		Assessment Value (mg/kg)	No failures	Source
	Min (mg/kg)	Max (mg/kg)			
Arsenic	2.3	116	640	NONE	LQM
Barium	11.8	1280	22000	NONE	EIC
Beryllium	<1	1.9	12	NONE	LQM
Cadmium	<0.5	5	190	NONE	LQM
Chromium	13.7	90.2	8600	NONE	LQM
Copper	5	512	68000	NONE	LQM
Lead	5	969	2330	NONE	C4SL
Mercury	<0.5	31.8	1100	NONE	LQM
Nickel	5.2	59.3	980	NONE	LQM
Selenium	<1	3.5	12000	NONE	LQM
Vanadium	<5	81.4	9000	NONE	LQM
Boron	<0.5	33.2	24000	NONE	LQM
Zinc	14	2030	73000	NONE	LQM
Naphthalene	<0.1	3.7	190	NONE	LQM
Acenaphthylene	<0.1	6.3	83000	NONE	LQM
Acenaphthene	<0.1	4	84000	NONE	LQM
Fluorene	<0.1	4.5	63000	NONE	LQM
Phenanthrene	<0.1	9.6	22000	NONE	LQM
Anthracene	<0.1	2.9	520000	NONE	LQM
Fluoranthene	<0.1	16.5	23000	NONE	LQM
Pyrene	<0.1	13.7	54000	NONE	LQM
Benzo(a)anthracene	<0.1	10.1	170	NONE	LQM
Chrysene	<0.1	14.5	350	NONE	LQM
Benzo (b) fluoranthene	<0.1	8	44	NONE	LQM
Benzo(k)fluoranthene	<0.1	10.9	1200	NONE	LQM
Benzo (a) pyrene	<0.1	12.7	35	NONE	LQM
Indeno (1,2,3-cd) pyrene	<0.1	14.1	500	NONE	LQM
Dibenzo(a,h)anthracene	<0.1	3.9	3.5	NONE	LQM
Benzo[g,h,i]perylene	<0.1	12.8	3900	NONE	LQM
Benzene	<0.010	0.0655	27000	NONE	LQM
Toluene	<0.010	0.028	56000000	NONE	LQM
Ethylbenzene	<0.010	0.028	5700000	NONE	LQM
Xylenes	<0.010	0.0744	5900000	NONE	LQM
MTBE	<0.010	0.023	7900	NONE	EIC
>C5-C6 Aliphatic	0.01	0.15	3200	NONE	LQM
>C6-C8 Aliphatic	<0.01	0.04	7800	NONE	LQM
>C12-C16 Aliphatic	<1	5.7	59000	NONE	LQM

Determinant	Dock Sediment		Assessment Value (mg/kg)	No failures	Source
	Min (mg/kg)	Max (mg/kg)			
>C16-C21 Aliphatic	<1	75	1600000	NONE	LQM
>C21-C35 Aliphatic	<1	313			
>C35-C40 Aliphatic	<1	43.4	1600000	NONE	LQM
>C5-C7 Aromatic	<0.01	0.07	260000	NONE	LQM
>C7-C8 Aromatic	<0.01	0.1	56000	NONE	LQM
>C12-C16 Aromatic	<1	60.7	36000	NONE	LQM
>C16-C21 Aromatic	<1	160	28000	NONE	LQM
>C21-C35 Aromatic	<1	475	28000	NONE	LQM
>C35-C40 Aromatic	<1	76.2	28000	NONE	LQM
Heptane	<0.01	0.0348			
Naphthalene	<0.01	0.07	190	NONE	LQM for soil
2-Methylnaphthalene	<0.01	0.02			
1-Methylnaphthalene	<0.01	0.03			
Acenaphthylene	<0.01	0.02	83000	NONE	LQM for soil
Acenaphthene	<0.01	0.06	84000	NONE	LQM for soil
Dibenzofuran	<0.01	0.02			
Fluorene	<0.01	0.03	63000	NONE	LQM for soil
Phenanthrene	<0.01	0.33	22000	NONE	LQM for soil
Anthracene	<0.01	0.08	520000	NONE	LQM for soil
Fluoranthene	<0.01	0.49	23000	NONE	LQM for soil
Pyrene	<0.01	0.47	54000	NONE	LQM for soil
Benzo(a)anthracene	<0.01	0.014	170	NONE	LQM for soil
Chrysene	<0.01	0.23	350	NONE	LQM for soil
Benzo(b)fluoranthene	<0.01	0.18	44	NONE	LQM for soil
Benzo(k)fluoranthene	<0.01	0.16	1200	NONE	LQM for soil
Benzo(a)pyrene	<0.01	0.17	35	NONE	LQM for soil
Indeno(1,2,3-cd)pyrene	<0.01	0.09	500	NONE	LQM for soil
Dibenz(ah)anthracene	<0.01	0.03	3.5	NONE	LQM for soil
Benzo[g,h,i]perylene	<0.01	0.11	3900	NONE	LQM for soil
1-Eicosene					
10,18-Bisnorabieta-5,7,9(10),11,13-pentaene	0.29	0.57			
2,6,10,14,18,22-Tetracosahexaene, 2,6,10,15,19,23-hexamethyl-, (all-E)-	9.83	15.99			
2-Ethylhexyl mercaptoacetate	3.78	3.78			
3,13-Dihydroxy-5,8,11,18,23-pentaoxa-1,15-diazabicyclo[13.5.5]pentacosane	0.21	0.21			
Eicosane	3.01	3.01			
Squalene	4.52	4.52			
Tricosane	2.76	2.76			
m,p'-DDD	0.38	0.38			

Key: LQM = LQM/CIEH Suitable 4 Use Levels (S4UL) published 2015

C4SL = Category 4 Screening Levels Defra published 2014

EIC = Environmental Industry Commission 2010 list of derived GAC's

PoHH = Protection of Human Health SGV published 2009

LQM/CIEH = For VOC and SVOC determinants the LQM/CIEH 2009 SGV's have adopted

From the table above it can be seen that none of the determinants tested within the natural soils were present at concentrations in excess of the adopted assessment criteria. Therefore the natural soils are not considered to pose a risk to human health and therefore no remedial measures are proposed

8.3.6 Controlled Waters

No groundwater samples were tested as part of the Concept site investigation but nine selected samples were submitted for leachate analysis the results of which are summarised in Table 8.3.

The recorded values for the determinants have been compared to UK Drinking Water Standards (DWS) and freshwater Environmental Quality Standards (EQS) for freshwater and saltwater as the River Thames is tidal. For EQS assessment where the hardness of the water is critical the groundwater in the London area has been considered to be hard (201-300mg/l Calcium Carbonate) based upon the published DEFRA groundwater hardness map.

The results of this assessment are summarised in Table 8.9 below with any exceedances highlighted in red.

Table 8.9 – Assessment of Groundwater Results

Determinant	Recorded Concentrations		Number of Samples Tested	Assessment Criteria		
	Minimum (μg/l)	Maximum (μg/l)		UKDWS	EQS (freshwater)	EQS (saltwater)
Arsenic	<5	26	9	10	**50**	**25**
Cadmium	<1	<1	9	5	5	5
Chromium	<5	<5	9	50	50	15
Copper	<5	<5	9	2000	10	5
Lead	<5	<5	9	10	20	25
Mercury	<0.1	0.3	9	1	1	0.3
Nickel	<5	<5	9	20	200	30
Selenium	<5	<5	9	10		
Zinc	<5	8	9	5000	75	40
Boron	11	82	3	1000	2000	7000
Complex cyanide	<5	<5	6			
Hexavalent chromium	<100	100	9			
Free Cyanide	<5	<5	6		5	5
Total Cyanide	<5	<5	6	50		
Ammoniacal Nitrogen as N	200	800	3		15	21
Total Monohydric Phenols	<5	<5	3	**0.5**	30	30
pH	7.3	8.3	6		6-9	7-8.5
Naphthalene	<0.05	0.11	9		10	5
Acenaphthylene	<0.01	0.02	9			
Acenaphthene	<0.01	0.12	9			
Fluorene	<0.01	0.16	9			
Phenanthrene	<0.03	0.62	9			
Anthracene	<0.01	0.08	9			
Fluoranthene	<0.02	0.08	9			
Pyrene	<0.01	0.05	9			
Benzo (a) anthracene	<0.01	0.06	9			
Chrysene	<0.01	0.05	9			
Benzo (b) fluoranthene	<0.01	0.08	9			
Benzo (k) fluoranthene	<0.01	0.06	9			
Benzo (a) pyrene	<0.01	0.05	9	**0.01**		
Indeno (1,2,3-cd) pyrene	<0.01	0.03	9			
Dibenzo(a,h)anthracene	<0.01	<0.01	9			

Determinant	Recorded Concentrations		Number of Samples Tested	Assessment Criteria		
	Minimum (µg/l)	Maximum (µg/l)		UKDWS	EQS (freshwater)	EQS (saltwater)
Benzo(ghi)perylene	<0.01	0.04	9			
Total PAH(16)	0.17	1.12	9	**0.1**		
Benzene	<1	<1	9	1	30	30
Toluene	<1	<1	9		50	40
Ethylbenzene	<1	<1	9		20	20
Xylenes	<1	<1	9		30	30
MTBE	<1	<1	6		5	
>C5-C6 Aliphatic	<1	<1	3			
>C6-C8 Aliphatic	<1	<1	3			
>C8-C10 Aliphatic	<5	<5	3			
>C10-C12 Aliphatic	<5	<5	3			
>C12-C16 Aliphatic	<5	<5	3			
>C16-C21 Aliphatic	<5	<5	3			
>C21-C35 Aliphatic	<5	7.3	3			
>C35-C40 Aliphatic	<5	<5	3			
Total (>C5-C40) Aliphatic	<5	7.3	3			
>C5-C7 Aromatic	<1	<1	3			
>C7-C8 Aromatic	<1	<1	3			
>C8-C10 Aromatic	<5	<5	3			
>C10-C12 Aromatic	<5	<5	3			
>C12-C16 Aromatic	<5	7.1	3			
>C16-C21 Aromatic	<5	<5	3			
>C21-C35 Aromatic	5.2	11.2	3			
>C35-C40 Aromatic	<5	<5	3			
Total (>C5-C40) Aromatic	5.8	12.3	3			
Total (>C5-C40) Ali/Aro	11.2	13.1	3	**10**	50	

From the previous table it can be seen that the leachates from the dock silt contains widespread elevated hydrocarbons (PAH and TPH) and possibly phenols (DWS<LoD) when compared against the UK Drinking Water Standards. When compared against the EQS levels for freshwater localised arsenic exceedances were present. These results are consistent with the observations during the drilling of the boreholes that identified hydrocarbon odours below the dock and the RPS 2013 investigation that noted hydrocarbon in the made ground and their groundwater samples recorded elevated metals.

However the site is not within a source protection zone for drinking water therefore the dock and the River Thames are the two identified controlled water receptors. However the dock is unlikely to be in continuous continuity with the underlying groundwater at depth within the Chalk as it would have been lined when constructed. With regard to the River Thames the groundwater flow direction has been determined by RPS to be in a westerly direction which would make the Thames a distance of 500m from the site. Also the industrial past use of the area would have seriously impacted upon the general groundwater quality in the area. Therefore risk to controlled waters from the contamination identified on the site is considered to be low and no remedial measures are proposed.

8.3.7 Ground Gas

Although there are no registered landfills within a 250m radius of the site from the historic plans it would appear that during the construction of the dock in the early 1900's an inlet from the Thames was backfilled to the south of the site. Also the boreholes revealed PEAT and sediment within the base of the dock, which was shown to have an organic content of 17% and LOI of 19.4%.

No gas monitoring was undertaken as part of the Concept investigations but the results obtained by RPS were assessed at the time and they concluded that:

> *"Ground gas monitoring was undertaken on three occasions. Using CIRIA Report C665, the ground gas regime for the site corresponds to Characteristic Situation 1, whereby gas protection measures are not required for new developments. However, as the carbon dioxide concentrations exceeded 5% and methane concentrations exceeded 1%, CIRIA C665 recommends that consideration should be given to increasing the classification to Characteristic Situation 2 where basic specific gas protection measures are required for new buildings."*

Based upon this assessment the classification to CS2 (low risk), which would require:

a) Reinforced concrete cast in situ floor slab (suspended, non-suspended or raft) with at least 1200g DPM9
b) Beam and block or pre-cast concrete slab and minimum 2000g DPM/reinforced gas membrane
c) Possibly underfloor venting or pressurisation in combination with a) and b) depending on us all joints and penetrations sealed.

This is also in accordance with the recommendations of CL:aire RB17 "A pragmatic approach to ground gas risk assessment", which states that an organic content between 1-1.5% (max recorded organic matter = 2%) within made ground < 5m thick should be considered as a situation CS2

Therefore based upon the available data it is considered that passive gas protection measures will be required to be incorporated within the new buildings. Full details of which will need to be agreed with London Borough of Newham Environmental Health/Building Control.

8.3.8 Flora and Fauna

Any soft landscaping or planting within the proposed development will require the import of a suitable growth medium. Therefore the potential impact on plant growth of the geochemistry within the made ground and natural soils have not been considered further in this report.

8.3.9 Building Materials and Services

Recorded pH values and water soluble sulphate concentrations recorded by the chemical testing were revealed with values of between 7.7 to 8.7 units and 0.03-0.68g/l (SO4) respectively.

When compared the maximum values against the BRE Special Digest 1 (2005) assessment levels, this indicates a DS2 design mix concrete should be suitable for buried structures.

Contaminants in the ground can pose a risk to potable water supply by permeating plastic water supply pipes. Therefore in order to fulfil their statutory obligation, UK water supply companies require robust evidence from developers to demonstrate either that the ground in which new plastic supply pipes will be laid is free from specific contaminants, or that the proposed remedial strategy will mitigate any existing risk. If these requirements cannot be demonstrated to the satisfaction of the relevant water company, it becomes necessary to specify an alternative pipe material on the whole development or specific zones.

In 2010, UK Water Industry Research (UKWIR) published Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites (Report Ref. No. 10/WM/03/21). This report reviewed previously published industry guidelines and threshold concentrations adopted by individual water supply companies. The focus of the UKWIR research project was to develop clear and concise procedures, which provide consistency in the pipe selection decision process. It was intended to provide guidance that can be used to ensure compliance with current regulations and to prevent water supply pipe failing prematurely due to the presence of contamination.

Report 10/WM/03/21 concluded that in most circumstances only organic contaminants pose a potential risk to plastic pipe materials and Table 3.1 of the report provides threshold concentrations for PE and PVC pipes for the organic contaminants of concern.

The potential risks to water supply pipes have therefore been assessed against the threshold concentrations for PE and PVC pipe specified in Table 3.1 of Report 10/WM/03/21, which have been adopted as the GAC's for this project. Table 8.10 below summaries the results

Table 8.10 Assessment of Results against WRAS Criteria

Determinant	WRAS criteria		Recorded Concentrations	
	PE pipe	PVC pipe	Minimum	Maximum
VOC	0.5	**0.125**	∑=<0.01	∑=2.2
BTEX + MTBE	0.1	**0.03**	<0.01	1.04
SVOCs	2	**1.4**	<0.01	∑=162.68
Phenols	2	**0.4**	<1	<1
Cresols and chlorinated phenols	2	**0.04**	<1	<1
Mineral Oils C11-C20	**10**	Suitable	<1	2423
Mineral Oils C21-C40	**500**	Suitable	<10	4906

Notes:

VOC & SVOC is a sum of the individual determinants tested

Mineral Oils C11-C20 is a combination of TPH alipatics and aromatic ranges C10 to C21

Mineral Oils C21-C40 is a combination of TPH alipatics and aromatic ranges C21 to C35

The results presented within Table 8.10 indicate that, based on the available chemical test results both PE and PVC pipes are unsuitable however as the samples with the elevated concentrations were from the sediment within the dock water pipes would not be located there as they would be on the dockside. Therefore further liaison should be undertaken with the Local Water Authority to determine their requirements for buried water mains.

8.4 Data Evaluation

8.4.1 Soil Assessment

8.4.1.1 General

Thirty three samples (8No of made ground, 9No of dock sediment and 16No from the underlying natural soils) were analysed for a range of potential contaminants including asbestos screen, metals, other inorganics, asbestos and hydrocarbons. An additional nine samples (3No made ground, 2No of dock sediment and 4No natural soils) were also tested for leachate.

8.4.1.2 Metal and Metalloids

None of the samples tested contained by Concept contained any determinants at concentrations above the adopted commercial end use assessment criteria. Also none of the samples tested by RPS in 2013 or Delta-Simons in 2016 contained elevated concentrations. Therefore no remedial measures are proposed for the development.

The leachate samples collected by Concept and RPS water samples identified some localised elevate metal concentrations when compared against the EQS target levels for freshwater. However due to the site setting these are not considered to pose a risk to controlled waters so no remedial measures are proposed.

8.4.1.3 Non-metallic inorganic Compounds

As above none of the investigations undertaken identified any elevated concentrations when compared against the adopted commercial end use assessment criteria. However although no Asbestos was identified within any of the Concept samples tested during the Delta-Simons investigation fibres were recorded within the made ground. Therefore, although there was no quantification testing on the samples it has to be considered the made ground has the potential to pose a risk to human health. However the samples taken by Delta-Simons were from below the concrete service roads and taxiways it is not considered to currently pose a risk. Also post development as the made ground will be below hard surfacing or capped in soft landscaped areas it will not represent a risk.

Therefore during the development construction phase the working methods should incorporate appropriate protection measures. Also ground workers should be vigilant during all excavations and should any asbestos be identified works should cease until appropriate measures can be implement to protect site operatives and the general public.

8.4.1.4 Hydrocarbons

The results of the contamination testing did not identify any hydrocarbons at concentrations that are considered to pose a risk to human health based upon the commercial end use. Plus the leachable PAH's and TPH above the UK Drinking Water Standards are not considered to pose a risk as the site is not within a source protection zone. Therefore no remedial measures are proposed.

8.4.2 Ground Gas

The site is not within an area affected by radon but carbon dioxide and methane was recorded at concentrations by RPS in 2013 it is recommended that gas characteristic situation CS2 passive gas protection measures should be incorporated within the new building.

8.5 Risk Assessment & Recommendations

8.5.1 Introduction

A preliminary risk assessment of the proposed development land use has been undertaken based on the information currently available on the site. The risk characterisations provided below has been assessed qualitatively using the CIRIA 552 guidance which reports a range of risk levels from low to very low.

8.5.2 Risks to human health during development

During the construction of the new arrivals building, forecourt, hotel and car park a potential pollutant linkage would exists for construction workers (direct contact/ingestion, inhalation) and neighbours (from inhalation of dust emissions). Asbestos was identified within the made ground during the Delta-Simons investigations so the risk to construction workers and neighbouring site users is considered **MEDIUM** however following the implementation of appropriate working methods and the use of P.P.E the risk of exposure will be reduce thereby lowering the overall risk to **LOW**.

The docks area of London was heavily bombed during the war and therefore it is recommended that a watching brief for the identification of unexpected ordnance is included in the principal contractor risk assessment and all the site workers should be adequately induction.

In addition general precautionary methods should be taken to limit direct exposure to soils and dust during the development. This should include the use of appropriate PPE based on the findings of this site investigation and dust control during earthworks. Dust suppression will also mitigate the risks of fugitive dust emissions impacting on neighbouring sites.

8.5.3 Risks to human health after development

Following the construction of the extension to the airport the majority of the site will be under hardcover therefore the risk to the end users is considered to be **VERY LOW**.

8.5.4 Risks to groundwater

Although some elevated leachate levels were recorded within the sediment in the dock and the ground water was shown to have localised metal contamination based upon the sites environmental setting the risks to controlled waters is considered to be **LOW**.

8.5.5 Risk from ground gases and vapours

The gas monitoring undertaken by RPS has identified a carbon dioxide and methane levels that will are considered to pose a **MODERATE** risk to future occupiers. However the inclusion of passive gas protection measures (CS2) will address this issue and reduce the assessment to **LOW** risk.

8.6 Waste Disposal

8.6.1 Introduction

For the construction of the new apart-hotel and the basement to the existing public house it will be necessary to remove the surplus material, which will comprise made ground and natural soils. Therefore an assessment of the waste categorisation has been undertaken to comply with the various legislation and guidance related to waste. All material removed from site must be adequately described by reference to the appropriate codes in the List of Waste regulations.

Following the implementation of the Landfill Regulations 2002 which introduced the use of waste acceptance criteria testing for hazardous waste classification on the 16th July 2005 when hazardous waste is intended for disposal at a suitably licensed landfill site it is necessary for the producer (i.e. the developer or their consultant on their behalf) to identify among other general information the following:

- the European Waste Catalogue (EWC) code for the waste;
- the relevant hazard code (H1 to H14)
- the landfill class where the waste may be accepted.

The EWC codes for all wastes are listed in "Consolidated European Waste Catalogue" of the "Environment Agency Hazardous Waste: Interpretation of the definition and classification of hazardous waste".

8.6.2 European Waste Catalogue (EWC) Codes

Based on the chemical analysis results for the soils on the site it is anticipated that most suitable EWC codes based upon the currently available information will be:

17.05.03 – Hazardous soils

17 05 04 – Non-hazardous soils

17.05.05 – Hazardous dredging spoil

17 05 06 – Non-hazardous dredging spoil

Table 8.11: EWC Codes and Description – Construction and Demolition Waste

Number	Description
17	Construction and Demolition Waste (including Excavated Soils from Contaminated Sites)
05	Soil (including excavated from contaminated sites), stones and dredging
03	Soil and stones containing dangerous substances
04	Soil and stones other than those mentioned in 17 05 03
05	Dredging spoil containing dangerous substances
06	Dredging spoil other than those mentioned in 17 05 05

8.6.3 European Waste Catalogue (EWC) Codes

In addition to the category code hazardous soils also have to be coded in terms of their relative hazard codes as detailed upon Table 8.12 below:

Table 8.12: Hazard Codes

Hazard code	Description

Hazard code	Description
HP1	Explosive
HP2	Oxidising
HP3A	Highly Flammable
HP3B	Flammable
HP4	Irritant
HP5	Harmful
HP6	Toxic
HP7	Carcinogenic
HP8	Corrosive
HP9	Infectious
HP10	Teratogenic
HP11	Mutagenic
HP12	Substances which release toxic gases when in contact with air or acid
HP13	Substances capable of yielding another substance after disposal
HP14	Ecotoxic

8.6.4 Soil Waste Classification

As discussed above prior to disposal it is necessary to classify soils within one of the following categories:

- Inert Waste
- Non-hazardous Waste
- Hazardous Waste

Within the Environment Agency document "Environmental Permitting Regulations: Inert Waste Guidance" based upon the landfill Directive inert waste is defined as:

"….waste that does not undergo any significant physical, chemical or biological transformations. Inert waste will not dissolve burn or otherwise physically or chemically react, biodegrade or adversely affect other matter with which it comes into contact in a way likely to give rise to environmental pollution or harm human health. The total leachability and pollutant content of the waste and the ecotoxicity of the leachate must be insignificant, and in particular not endanger the quality of surface water and/or groundwater."

Hazardous waste is defined by Article 1 of "Commission Decision 2000/532/EC" as amended by 2001/118/EC, 2001/119/EC and 2001/573/EC of the "Hazardous Waste Directive" and is based upon the total concentrations of the individual determinants when compared against the associated EWC limit values.

Non-hazardous waste is the classification for all other material that is not shown to be inert or hazardous. However within this classification there is a sub group that is described as "inactive non hazardous waste" and if the soils are classified in this group although they attract a higher disposal rate they are not subject to the higher rate of landfill tax which is discussed later in this section.

For the determination of whether the soils revealed on the site are hazardous the chemical analysis results obtained have been assessed using the HazWasteOnline computer program. Table 8.13 below summaries this assessment with additional comments and considerations used to determine the most likely waste classification. Also the results of the Waste Acceptance Criteria (WAC) testing undertaken upon a selected five samples has been included within the table to assist with the assessment of the waste classification for the soils.

Table 8.13 – Summary of Soil Waste Classification

Exploratory Hole		Soil Type	Initial Classification	Comments	Likely Classification
Ref	Depth				
BH3	11.7	Dock Sediment	Hazardous	Hazardous codes HP3, HP7 & HP11 due to the TPH value of 7320mg/kg and HP 14 due to zinc, copper and lead levels. Also the WAC testing confirmed the soils to be hazardous due to LOI and TOC percentages	Hazardous
	12.7	Natural Soils	Hazardous	Hazardous codes HP3, HP7 & HP11 due to the TPH level (1,200mg/kg) plus HP14 due to zinc and copper	Hazardous
	13.7	Natural Soils	Non-hazardous	Natural soils - with the agreement of the receiving landfill should be considered to be inert. Also the WAC result for the samples from 11.5 confirmed the determinants are at concentrations below the inert threshold criteria	Inert
	14.7	Natural Soils	Non-hazardous		Inert
	15.7	Natural Soils	Non-hazardous		Inert
	16.7	Natural Soils	Non-hazardous		Inert
BH34	11.5	Dock Sediment	Non-hazardous	Due to the low levels recorded within the sediment it could be classified as “inactive non-hazardous waste, which would not attract the higher rate of landfill tax. The WAC testing for this sample has confirmed the levels are within the non-hazardous thresholds.	Inactive Non-hazardous
	13.7	Natural Soils	Non-hazardous	Natural soils - with the agreement of the receiving landfill should be considered to be inert	Inert
	14.1	Natural Soils	Non-hazardous		Inert
BH31	12.0	Dock Sediment	Non-hazardous	Hazardous codes HP3, HP7 & HP11 due to the TPH level (5620mg/kg) plus HP14 due to zinc	Hazardous
	12.5	Natural Soils	Non-hazardous	Natural soils - with the agreement of the receiving landfill should be considered to be inert	Inert
	13.5	Natural Soils	Non-hazardous		Inert
BH17	11.9	Dock Sediment	Non-hazardous	Due to the low levels recorded within the sediment it could be classified as “inactive non-hazardous waste, which would not attract the higher rate of landfill tax. The WAC testing for the sample from BH34 has confirmed the levels to be in the non-hazardous range	Inactive Non-hazardous
	13.9	Natural Soils	Non-hazardous	Natural soils - with the agreement of the receiving landfill should be considered to be inert	Inert
BH28	12	Dock Sediment	Hazardous	Hazardous codes HP3, Hp7 &, HP11 due to the TPH level (10,100mg/kg) plus HP14 due to zinc	Hazardous

Exploratory Hole Ref	Exploratory Hole Depth	Soil Type	Initial Classification	Comments	Likely Classification
	13.5	Natural Soils	Non-hazardous	Natural soils - with the agreement of the receiving landfill should be considered to be inert. Also the WAC result for the samples from 11.5 confirmed the determinants are at concentrations below the inert threshold criteria	Inert
BH25	11.9	Dock Sediment	Non-hazardous	Due to the low levels recorded within the sediment it could be classified as "inactive non-hazardous waste, which would not attract the higher rate of landfill tax. The WAC testing for the sample from BH34 has confirmed the levels to be in the non-hazardous range	Inactive Non-hazardous
	13.7	Natural Soils	Non-hazardous	Natural soils - with the agreement of the receiving landfill should be considered to be inert	Inert
BH10	12.5	Dock Sediment	Non-hazardous	Due to the low levels recorded within the sediment it could be classified as "inactive non-hazardous waste, which would not attract the higher rate of landfill tax. The WAC testing for the sample from BH34 has confirmed the levels to be in the non-hazardous range	Inactive Non-hazardous
	13.5	Natural Soils	Non-hazardous	Natural soils - with the agreement of the receiving landfill should be considered to be inert	Inert
BH06	0.6	Made Ground	Non-hazardous	Due to the very low levels recorded within the sediment it could be classified as "inactive non-hazardous waste, which would not attract the higher rate of landfill tax. Although it is possible that following discussions with the receiving landfill it could be reclassified as inert which the WAC testing for the sample 1.0m confirmed the levels were below the inert thresholds	Inactive Non-hazardous
	1.0	Made Ground	Non-hazardous		Inactive Non-hazardous
	2.5	Made Ground	Non-hazardous		Inactive Non-hazardous
	4.1	Made Ground	Non-hazardous		Inactive Non-hazardous
	5.7	Made Ground	Non-hazardous		Inactive Non-hazardous
BH25R	13.9	Natural Soils	Non-hazardous	Natural soils - with the agreement of the receiving landfill should be considered to be inert	Inert
BH24	12	Dock Sediment	Hazardous	Hazardous codes HP3, Hp7 &, HP11 due to the TPH level (2700mg/kg) plus HP14 due to zinc and copper	Hazardous
	13	Natural Soils	Non-hazardous	Natural soils - with the agreement of the receiving landfill should be considered to be inert	Inert

Exploratory Hole Ref	Exploratory Hole Depth	Soil Type	Initial Classification	Comments	Likely Classification
BH21	13.1	Dock Sediment	Non-hazardous	Due to the low levels recorded within the sediment it could be classified as "inactive non-hazardous waste, which would not attract the higher rate of landfill tax. The WAC testing for the sample from BH34 has confirmed the levels to be in the non-hazardous range	Inactive Non-hazardous
	13.8	Natural Soils	Non-hazardous	Natural soils - with the agreement of the receiving landfill should be considered to be inert	Inert
BH01	1.5	Made Ground	Non-hazardous	Due to the low levels recorded within the made ground it would be classified as "inactive non-hazardous waste, which would not attract the higher rate of landfill tax. Although it is possible that following discussions with the receiving landfill it could be reclassified as inert based upon the WAC results for BH06.	Inactive Non-hazardous
TP02	1.6	Made Ground	Non-hazardous		Inactive Non-hazardous
BH02	1.2	Made Ground	Non-hazardous		Inactive Non-Hazardous

Apart from the near surface natural ground below the base of the dock, which has been shown to be hazardous due to the hydrocarbons within it, the deeper natural soils, as discussed in the table above, following liaison with the receiving landfill facility should be classify as inert waste for disposal purposes.

The made ground has been shown to contain low levels of the determinants tested and therefore should be classified as inactive non-hazardous waste. However depending upon the landfill's license and independent classification due identified concentrations and the WAC results for the made ground within BH06 it may be possible to get agreement to reclassify some of the made ground as inert. However if this is not possible then as inactive waste does not attract the higher level of landfill tax, which currently (2016/17) is set at £84.40/tonne, there would not be a significant difference in the rates charged. It should also be noted that if asbestos is identified within the made ground then quantification testing will be required to determine its classification although at a minimum it we need to be disposed of at a facility licensed to acceptable it and depending upon the upon the asbestos content (>0.1%) it may be classified as Hazardous Waste.

The sediment within the dock has been shown the hazardous, due mainly due to hydrocarbons, and non-hazardous based upon the available WAC results. However landfills are not permitted to accept wet/slurry type waste and therefore if dredging required off-site disposal at a landfill then it will require dewatering prior to removal.

An alternative to disposal at a landfill could be to dispose of the soils, if accepted, at a licensed treatment facility, which would remove the requirement to classify the soils. However generally these facilities treat elevated hydrocarbons and not metals therefore it would be necessary to forward the results to any proposed facilities for them to confirm their acceptance.

Regardless of the destination appropriate documentation should be retained, and be available for inspection, that demonstrates the nature of the material disposed of including chemical analysis where appropriate.

8.7 Recommendations

- This report should be forwarded to the Regulators for their review and approval of the conclusions and recommendations;
- Liaison with the Local Water Authority to determine the specification for buried water supply pipework;
- The available chemical testing data should be forward to the proposed receiving landfill/treatment facility for confirmation of the waste classifications although further testing may be required before these can be confirmed;
- Due to the potential for as yet unidentified contamination to be present on site we would recommend all site works are inducted in the recognition of potentially contaminated soils.

9 GEOTECHNICAL SETTING

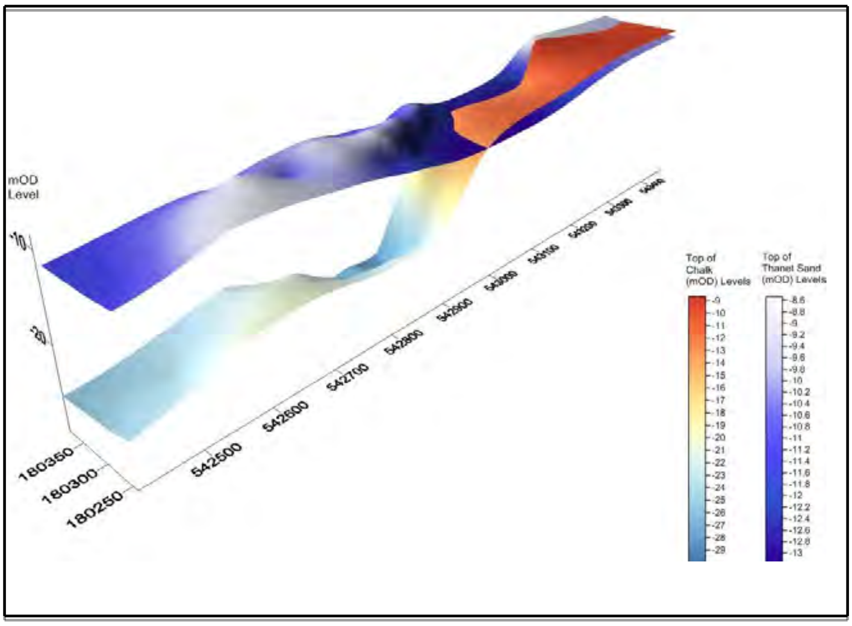
9.1 Stratigraphy

The stratigraphy obtained from the boreholes generally confirms the geological map and the findings of the previous investigations carried out at this site.

A summary of the stratigraphical succession encountered are provided in Tables 9.1 to 9.3. The site is zoned into three areas, the landside where deep Made Ground was encountered, the west dock where Thanet Sand is present and the East Dock where the chalk directly underlies the Terrace Gravels. It should be noted that some variations in the presented strata levels should be anticipated as a result of drilling over water.

Contour plots of the thickness of the Thanet Sand and of the elevation of the top of the chalk are presented in Figure 5 and Figure 6 respectively. Geological Sections across the site are shown in Figures 4a to 4g.

Geological section A – A'(Figure 4a) indicates an apparent dislocation of the strata seen across BH23, BH25 and BH28 over a horizontal distance of approximately 150m, with the Bullhead Beds at the base of the Thanet Sand encountered at 31.10m in BH23 and then 22.10m depth in BH25 but absent in BH28 due to erosion. As discussed in Section 3 the site crosses the NE–SW strike of the Greenwich and Purfleet Anticlines and the Greenwich Fault system. The observed dislocation is most likely associated with the Greenwich Fault system. A 3D representation of the variation of the Thanet Sand and Chalk levels across the site is presented below:



Map 4: 3D representation of the variation of the Thanet Sand and Chalk levels across the site

Table 9.1 – Summary of ground conditions at the western end of the dock (BH03, BH05, BH07, BH09, BH10,BH10R, BH11, BH12, BH13, BH14, BH15, BH16, BH17, BH18, BH19, BH21, BH21R, BH22, BH23, BH24, BH25, BH25R, BH26, BH27, BH29[2],BH30[2])

Formation	Average Thickness (m)	Min and Max Reduced Level to top of the unit (mOD)
Dock Silt	0.98	-6.46 to -8.71
River Terrace Deposits	2.41	-6.96 to -9.26
Thanet Sand Formation	12.23	-8.91 to -13.57
Thanet Sand Formation: Bullhead Bed	0.42	-17.79 to -29.99
Chalk Formation	Depth of strata not proven	-13.79 to -28.26

Notes: (1)Due to no recovery in BH03 the top of the Thanet Sands and bottom of the Terrace Gravels was not established (2) Although geographically BH29 and BH30 are in the east of the dock they are included in Table 9.1 as they have similar ground conditions to the boreholes in the west.

Table 9.2 – Summary of ground conditions at the eastern end of the dock (BH28, BH31, BH32, BH33, and BH34)

Formation	Average Thickness (m)	Min and Max Reduced Level to top of the unit (mOD)
Dock Silt	1.27	-5.51 to -7.81
River Terrace Deposits	2.01	-6.01 to -9.31
Chalk Formation	Depth of strata not proven	-8.51 to -13.57

Table 9.3 – Summary of land side ground conditions (BH06)

Formation	Average Thickness (m)	Reduced Level to top of the unit (mOD)
Made Ground	7.10	+5.69
Alluvium	3.90	-3.52
River Terrace Deposits	3.50	-5.32
Thanet Sand Formation	11.70	-8.82
Thanet Sand Formation: Bullhead Bed	0.10	-20.52
Chalk Formation	Depth of strata not proven	-20.62

9.2 Geotechnical Conditions

9.2.1 Hardstanding/Obstructions

Hardstanding was present at BH06 comprising concrete over concrete rubble extending to a maximum depth of 0.4m. No obstructions at depth were encountered in any of the boreholes constructed.

9.2.2 Made Ground

Made Ground was encountered in BH 06 located on the land-side. The Made Ground extended 7.10m below existing ground level to a level of -1.42mOD. The layer comprises layers of soft slightly sandy slightly gravelly silty Clay, slightly clayey very sandy Gravel and gravelly fine to coarse Sand.

Standard Penetration Tests (SPT) in this layer recorded N blow counts between 0 and 8 blows /300mm suggesting the layer to be very loose (Figure 15a).

No laboratory testing was carried out in these strata. Although no specific tests have been carried out, a bulk density of 18kN/m3 can be assumed in the design based on previous experience.

Characteristic design parameters for the layer are shown in Table 9.9a.

9.2.3 Alluvium

An Alluvium layer was encountered underneath the Made Ground in BH06. The Alluvium was encountered between levels -1.42mOD and -5.32mOD. It comprises very soft to soft dark grey Silt with a layer of gravelly fine to coarse Sand.

No laboratory testing was carried out in this stratum. Although no specific tests have been carried out, a bulk density of 18kN/m3 can be assumed in the design based on previous experience.

Standard Penetration Tests (SPT) in this layer recorded 4 no. N blow counts of 0 /300mm suggesting the layer to be very soft (Figure 15a).

Characteristic design parameters for the layer are shown in Table 9.9b.

9.2.4 Dock Silt

The Dock Sediment was encountered in all (20 No) boreholes constructed in the dock. The top of the strata was found between -5.51mOD and -8.71mOD with an average thickness of 1.27m. The Dock Sediment mainly comprised soft to very soft SILT and gravelly SILT. A layer of silty CLAY and Clayey SILT were encountered in borehole BH25R and BH10R. A strong hydrocarbon smell was noted in all boreholes.

The layers of Dock Silt encountered across the site are shown in Table 9.4.

Table 9.4: Dock Silt reduced levels and thickness

Location	Reduced Level of Dock Silt		Thickness (m)
	Top of Strata (mOD)	Bottom of Strata (mOD)	
BH03	-6.73	-8.73	2.00
BH05	-7.22	-7.82	0.60
BH07	-6.86	-7.86	1.00
BH10	-7.46	-8.16	0.70
BH10R	-7.54	-8.14	0.60
BH11	-8.58	-8.88	0.30
BH12	-8.71	-8.91	0.20
BH13	-7.62	-8.12	0.50
BH15	-6.50	-8.65	2.15
BH17	-6.46	-6.96	0.50
BH18	-7.32	-8.32	1.00
BH19	-7.66	-8.91	1.25
BH21	-7.55	-8.85	1.3
BH21R	-6.96	-8.96	2.0
BH22	-8.26	-9.06	0.80
BH23	-7.45	-8.95	1.50
BH24	-7.96	-9.26	1.30
BH25	-7.59	-7.99	0.40
BH25R	-7.89	-8.14	0.25
BH26	-7.59	-8.09	0.50
BH28	-7.21	-8.31	1.10
BH31	-5.51	-6.01	0.50
BH32	-6.59	-7.89	1.30
BH33	-7.81	-9.31	1.50
BH34	-6.55	-8.50	1.95

9.2.4.1 Index properties

No tests have been carried out in this stratum. A bulk density of 18kN/m3 can be assumed in the design based on previous experience.

9.2.4.2 Strength and Stiffness Parameters

A total of 3 no. Standard Penetration Tests (SPT) were carried out in this layer and recorded N blow counts between 0 and 1 blows/ 300mm with the exception of a single test which recorded 37 blows/300m. Review of the borehole log suggests that this is possibly due to flint/wood fragments and should not be taken as representative of this strata.

9.2.5 River Terrace Deposits

River Terrace Deposits (RTD) were encountered in all boreholes below the Made Ground (landside) and the Dock Silt (dock side). The reduced levels and thickness of the layer are presented in Table 9.5.

The layer comprises dark brown to grey sandy to very sandy GRAVEL to sandy silty GRAVEL with rare flint cobbles and rare wood particles. Bands of Yellowish brown gravelly fine to course SAND are noted in BH06 and BH10R.

A hydrocarbon odour is noted in BH05, BH10, BH10R, BH11, BH14, BH15, BH17, BH19, BH21, BH21R, BH22, BH23, BH24, BH25R, BH26, BH28, BH31, BH32, BH33 and BH34.

Table 9.5: River Terrace Gravel depth and thickness

Location	Reduced Level of River Terrace Gravel		Thickness (m)
	Top of Strata (mOD)	Bottom of Strata (mOD)	
Land-side Borehole			
BH06	-7.52	-8.82	1.30
Western Area			
BH03	-8.73	Not proven	>
BH05	-7.82	-11.32	3.50
BH07	-7.86	-10.41	2.55
BH10	-8.16	-11.46	3.30
BH10R	-8.14	-11.24	3.10
BH11	-8.88	-9.08	0.20
BH13	-8.12	-10.12	2.00
BH15	-8.65	-9.90	1.25
BH17	-6.96	-9.26	2.30
BH18	-8.32	-9.52	1.20
BH19	-8.91	-10.91	2.00
BH21	-8.85	-10.00	1.15

Location	Reduced Level of River Terrace Gravel		Thickness (m)
	Top of Strata (mOD)	Bottom of Strata (mOD)	
BH21R	-8.96	-11.46	2.50
BH22	-9.06	-12.26	3.20
BH23	-8.95	-9.55	0.60
BH24	-9.26	-12.66	3.40
BH25R	-8.14	-10.04	1.90
BH26	-8.09	-12.49	4.40
BH27	Not Proven		
BH29	Not Proven		
BH30			
Eastern Area			
BH28	-8.31	-12.71	4.40
BH31	-6.01	-8.51	2.50
BH32	-7.89	-9.09	1.20
BH33	-9.31	-9.81	0.50
BH34	-8.50	-10.05	1.55

Note: The base of the Terrace Gravel was not proven in BH03, 16, 27 and 29 due to no recovery during drilling

9.2.5.1 Index Properties

Based on 18 no Particle Size Distribution tests the layer comprises 0% to 8% silt and clay, 6% to 53% sand and 47% to 99% gravel (Figure 12a).

The natural moisture content for this layer ranged between 2% and 22%.

A bulk density of 21kN/m3 can be assumed in the design based on previous experience.

9.2.5.2 Strength and Stiffness Parameters

Standard Penetration Tests (SPT) in this layer recorded N blow counts between 10 and 143 blows/ 300mm suggesting the layer to be medium dense to very dense (Figure 15…)

9.2.6 Thanet Sand Formation

The Thanet Sand formation was encountered in the boreholes located to the west at depths varying between 14.35m bgl and 30.40m bgl, with average thickness of 12.23m. The Thanet Sand is described as light grey silty SAND to clayey SAND with rare flint cobbles.

The Bullhead Bed layer was encountered at the base of the formation varying in thickness between 0.1m and 1.0m. It comprised dark black/grey angular and subangular fine to coarse GRAVEL with rare flint cobbles.

Table 9.6: Thanet Sand depth and thickness

Location	Reduced Level of Thanet Sand		Thickness (m)
	Top of Strata (mOD)	Bottom of Strata (mOD)	
BH03	Not proven	-25.03	>8.80
BH05	-11.32	-24.32	13.00
BH06	-8.82	-20.52	12.00
BH07	-10.41	-24.26	13.85
BH10	-11.46	-23.16	11.70
BH10R	-11.24	-23.04	11.80
BH11	-9.08	-22.08	13.00
BH12	-8.91	-21.01	12.10
BH13	-10.12	-25.12	15.0
BH14	-10.83	-21.83	11.00
BH15	-9.90	-21.40	11.50
BH16	Not proven	-30.09	>15.60
BH17	-9.26	-25.46	16.20
BH18	-9.52	-24.43	14.90
BH19	-10.91	-27.16	16.25
BH21	-10.00	-23.75	13.75
BH21R	-11.46	-22.96	11.50
BH22	-12.26	-28.26	16.00
BH23	-9.55	-26.95	17.40
BH24	-12.66	-24.46	11.80
BH25R	-10.04	-17.84	7.80
BH26	-12.49	-13.79	1.30
BH27	Not proven	-14.02	>0.90
BH29	Not proven	-13.57	>1.50
BH30	-12.77	-12.87	0.10

Note: The top of the Thanet Sand was not proven in BH03, 16, 27 and 29 due to no recovery during drilling.

9.2.6.1 Classification Tests

The natural moisture content for this stratum ranged between 20% and 60% (Figure 7). A bulk density of this layer can be assumed to be 20kN/m^3 in the design according to CIRIA SP95 and BS 8002.

Particle size distribution tests reveal the layer to comprise 4% to 22% clay, 8%-43% silt, 35% to 96% sand and 0.1% to 13.2% gravel. The PSD curves are plotted in Figure 12b.

The gravel content was noted in the samples tested from the boundary between the Thanet Sand and the River Terrace deposits. Gravel content was also noted at the sample from BH25 taken from the bottom of Thanet Sand layer where the layer tends to become slightly gravelly.

The fines (<0.063mm) and clay (<0.002mm) content of the Thanet Sand are plotted in Figures 13 and 14 respectively. An increase in fines and clay content with depth is evident, although high concentrations of fines can be seen at higher levels also. Furthermore, tests carried out in the boreholes closer to the fault line seem to demonstrate higher levels of fines in comparison to the boreholes towards the west end of the site. Maximum values were recorded in BH22 at depth of -26mOD of up to 63% fines and 22% clay.

9.2.6.2 Standard Penetration Tests

The SPT N blowcounts in Thanet Sand are presented in Figure 15f. The N blow counts recorded ranged between 35 and 375 blows/300mm (extrapolated values) suggesting the layer to be dense to very dense.

9.2.6.3 Menard Pressuremeter Testing

Menard Pressuremeter tests were carried out in BH03, BH06, BH17 and BH25R. All pressuremeter tests were carried out in accordance with BS EN ISO 22476-4:2012 Geotechnical investigation and testing: Field testing: Part 4: Ménard pressuremeter test. The data obtained is interpreted following the test with the commercially available software package GEOVISION by APAGEO.

A total of 15No tests were carried out. All tests are deemed satisfactory based on the first section of the curves displaying minimal alteration of the wall except for two tests, BH17 at17.6m depth and BH10R at 19m depth. For these two tests the procedure was terminated due to the volume of liquid injected into the central measuring cell exceeding the specified (ISO 22476-4:2012) 450 cm3 for a short probe within a slotted tube.

Borehole drilling for probe positioning was deemed acceptable by the independent sub-contractor Igeotest.

Extrapolation

In accordance with ISO22476-4:2012 when, during an expansion test, the injected liquid volume is smaller than Vc + 2V1 the limit pressure shall be extrapolated. Two extrapolation methods should be applied to the test results:

- Reciprocal Method
- Double Hyperbolic Method

All pressuremeter tests carried out for this site investigation fulfilled the conditions of obtaining a representative P_{lim}.

Excluded Test Results

Although plots are included in the report to provide a historical record of the test the results should not be included in any design or analysis work.

In accordance with the code when, during an expansion test, the injected liquid volume (VL)is smaller than Vc + 2V1 the limit pressure shall be extrapolated. The final value of the limit pressure is only permitted when the number of pressure holds applied beyond pressure pfM is at least two.

For BH17 at 17.6m depth there were no further pressure holds beyond pfM.

For BH10R at 19m although there were two further pressure holds past pfM the final reading was at the limit of VL = Vc + 2V1

Extended Tests

The tests carried out in BH03 (at depths 23.8m and 26.5m) were extended to include an intermediate cyclic load which allows the Menard Pressuremeter Modulus(Em) to be obtained when the Thanet Sands are loaded/unloaded. A second hyperbolic curve is noted in the graphical results, however, this is for information only. The test results are comparable with all others undertaken on the project and the Em used in the analysis is obtained from the second group of readings.

Detailed results are presented in section 10 of the factual report (Issue 01, Concept, March 2017). A summary of the results of the tests is presented in Table 9.7.

Table 9.7 - Menard Pressuremeter tests details

Location	Depth (mbgl)	p_{lm} (MPa)	E_m elastic (MPa)
BH17	14.80	7.91	101.6
	21.90	5.92	58.1
	26.60	4.33	69.1
BH03	22.30	5.43	51.0
	23.80	5.56	51.8
	26.65	5.96	68.1
BH25R	16.20	2.15	27.3
	19.10	3.13	36.1
BH10R	25.10	4.65	69.9
BH06	15.80	3.78	41.8
	25.40	3.59	48.8
BH21R	15.00	4.79	63.3
	26.60	3.84	49.5

Comparison of the pressuremeter test results with the SPT values at similar depths suggests a good correlation between the two methods of testing. The lower pressuremeter test values were predominately recorded in layers in the Thanet Sand with increased clay and silt content. This is to be anticipated as the material will tend to behave more like clay and therefore demonstrate lower strengths than the sandy parts of the layer.

9.2.7 Chalk

The top of the Chalk was proven in all boreholes. At the western part of the site the layer is overlaid by the Thanet Sands whilst at the eastern part of the site it lies directly beneath the Terrace Gravels.

In the western part of the site the Chalk was encountered between -13.79mOD and -28.26mOD, however, on the eastern part of the site the top of strata was between -8.51mD and -13.57mOD. A contour plot of the top of the Chalk is presented in Figure 6. The depth of this stratum was not proven.

The Chalk is described as extremely weak to medium density in places strong white silty sub-angular to angular chalk cobbles comprising weak to moderately weak, medium density chalk fragments and rare sub-angular rounded flint.

Table 9.8 RQD of the Chalk

Borehole	RQD (%)	Borehole	RQD (%)
BH03	57-63	BH22	32-75
BH06	27-57	BH24	57-63
BH07	57-63	BH25R	20-69
BH10R	53-87	BH27	7-20
BH12	33-57	BH29	15-80
BH16	7-60	BH30	17-62
BH17	15-65	BH32	10-76
BH21R	57-63	BH33	33-63

Table 9.8 shows the RQD of the Chalk. A wide range of RQD between 7% and 87% is noted. The majority of the results however fall into a zone between 40% and 60%. The change of RDQ with depth is shown in Figure 10.

9.2.7.1 *Index Properties*

The natural water content in the tested samples ranged between 20% and 30%. (Figure 8). A bulk density of 20 kN/m3 can be adopted for the chalk (Figure 9). The dry density of the chalk ranged predominantly between 15kN/m3 and 16kN/m3 with no notable increase with depth. (Figure 9).

9.2.7.2 *Strength and Stiffness Parameters*

Standard Penetration Tests (SPT) N-values in the Chalk show N blow counts between 5 and 375 blows/ 300mm. A single SPT result when extrapolated gives an N value of 1000, however, it is considered that this is due to the presence of flint and is not representative of the whole stratum. The SPTs in the western part of the dock where the Chalk was overlain by the Thanet Sand tend to exhibit higher values predominantly ranging between 20 and 55 blows/300mm. There is no notable increase with depth (Figure 15c). In the eastern part of the dock where the Thanet Sand has been eroded, the chalk exhibits lower strengths which tend to linearly increase with depth from 9 blows/300mm at the top to 50 blows/300mm at approximately 8m depth (Figure 15b). A single borehole (BH29) penetrating deeper into the chalk, suggests that the strength of the chalk decreases to approximately 35-40blows/300mm between -28mOD and -41mOD.

The factors influencing the engineering behaviour of the chalk mass are:

- Hardness of the intact chalk
- Bedding/discontinuity spacing and pattern
- Discontinuity aperture

Based on Mortimore et al. 1990 and Matthews et al. 1993, intact dry density scales of chalk suggest that the chalk encountered is of medium density. The chalk in the rotary boreholes was recovered mainly as gravel and cobbles with open or infilled horizontal and subvertical discontinuities. The Chalk encountered at the western part of the site generally appears to be falling within Grade C in accordance to CIRIA C574. Grade D chalk can be potentially encountered at the first top meters of the layer. The chalk to the eastern part of the site has mostly been recovered as gravelly silt suggesting that Grade D chalk may be present in this area.

9.3 GEOTECHNICAL DESIGN PARAMETERS

The recommended geotechnical design parameters are presented in the following tables. Where parameters could not be derived, due to a lack of laboratory tests or appropriate empirical correlations, such parameters have been conservatively assumed for the purposes of preliminary foundation design and are denoted with **

Table 9.9 – Geotechnical Design Parameters

9.9a - Made Ground

Design Parameter	Unit	Value
Bulk Unit weight (γ)	KN/m^3	18**
Angle of friction (ϕ')	Degrees (°)	29**
Modulus of Elasticity (E)	kN/m^2	6,000**

9.9b - Alluvium

Design Parameter	Unit	Value
Bulk Unit weight (γ)	KN/m^3	18**
Dry density	KN/m^3	14 – 15**
Undrained Shear Strength (C_u)	kN/m^2	20**
Modulus of Elasticity (E)	kN/m^2	6,000**

9.9c - River Terrace Deposits

Design Parameter	Unit	Value
Bulk Unit weight (γ)	KN/m^3	21
Angle of friction (ϕ')	Degrees (°)	37
SPT (N)	blows/300mm	35
Modulus of Elasticity (E')	kN/m^2	60,000

9.9d – Thanet Sand

Design Parameter	Unit	Value
Bulk Unit weight (γ)	KN/m^3	20
Angle of friction (ϕ')	Degrees (˚)	33**
Pressuremeter Parameter- P_{lim}	MPa	4MPa
Modulus of Elasticity E'	kN/m^2	250,000**

9.9e - Chalk

Design Parameter	Unit	Value
Bulk Unit weight (γ)	KN/m^3	20
Dry density	KN/m^3	15
SPT	kN/m^2	3z to -25.0mOD 40 from -25.0mOD
Modulus of Elasticity (E')	kN/m^2	300,000**

*Where z is the depth below the top of the Chalk in m

The design water level should be taken at the level of the dock in all areas which is approximately at -4.5mOD.

9.4 FOUNDATION DESIGN RECOMMENDATIONS

9.4.1 Introduction

The proposed development is to provide new aircraft stands, taxiway and terminal facilities. The extension to the aircraft stands and new taxiway will be constructed over the King George V Dock. A layout of the proposed and existing site can be seen in Drawings reproduced in Figures 2 and 3 of this report:

CAOL-004: Overall Plan showing the proposed new 8 stands and new taxi lane link to existing Hold 28 – (Figure 2)

CAOL900: Proposed pile layout for new deck – (Figure 3)

Piling works in the dock formed part of the construction works for the Hold area (2003) and the Eastern Apron Extension (2007-2008). The methodology was to lower a permanent steel casing off a barge down into the dock and then drive into the dock bed. On the Eastern Apron the steel casing was driven just below the top of the Thanet Sand (depth varies - 2.5m to 6.0m below dock bed level). For the Hold area the casing was driven to a constant depth of -13.0m AOD into the Chalk (about 8.0m below dock bed level).

9.4.2 Preliminary Pile Design

The piles will mainly carry the deck and aircraft loads. Based on the Piling Risk Assessment (TPS, 2013) and previous piling carried out successfully in historic construction works at the airport it is expected that a bored pile with a permanent steel casing will be used. TPS concluded in the piling risk assessment (TPS, May 2013) that the use of bored piles will reduce the risk of transferring pollutants from the Dock Silt and/or Dock Water into the natural ground or underlying aquifers. A permanent steel casing will protect the Aquifer located in the upper Sedimentary Deposits and aid in preventing pollutants from the Dock Silt and/or Dock Water entering the natural ground or underlying aquifers.

On the basis of the above and taking into account the variability of the ground conditions across the site the following has been assumed in the preliminary pile design:

Land-Based Piles: Rotary bored pile constructed on using permanent casing to 2.0m into the top of the Thanet Sands. Use of bentonite to maintain stability to pile toe level.

Piles in the east of the dock (founding on chalk): Rotary bored pile constructed using permanent casing to 5.0m into the Chalk.

Piles in the west of the dock (founding on Thanet Sand): Rotary bored pile using permanent casing for the full length of the pile.

Preliminary pile design charts are presented in Figures 16a to 16c and are split into East Area, West Area and Landside respectively. The following sections outline the rationale for the pile calculations.

9.4.3 General Design Assumptions:

The design of the piles has been carried out in accordance to BS EN1997-1, UK National Annex. The safety factors adopted correspond to case B of the Annex which assumes the following:

(a) Pile testing to at least 1% of preliminary/working piles loaded to at least 1.5 the representative load for which they are designed

Or

(b) Settlement is explicitly predicted by a means no less reliable than in (a)

Or

(c) Settlement at the serviceability state is of no concern.

Adopting higher factors of safety will limit the anticipated pile settlements and will not require confirmation of the design assumptions with pile tests. It may however lead to uneconomical designs. Adopting lower factors of safety will be subject to the type and frequency of pile testing proposed. It is prudent to seek agreement for the pile testing proposals with the local building control office. The final design of the piles should be carried out by the piling contractor.

The design lines shown on the charts represent the design resistance. This is dictated in all the results by the geotechnical limit state and in this respect the factors stated in table NA.A1 of the National Annex to BS

N 1990 should be applied when comparing the design resistance to the applied actions (γ= 1 for permanent and γ=1.35/0 for variable unfavourable/ favourable respectively).

9.4.4 Piles Located in the East of the Dock (Founding on Chalk)

9.4.4.1 Skin Friction

The introduction of CIRIA Report PR11 (CIRIA, 1994) was intended to 'extend and advance' the earlier report, PG6ii (CIRIA, 1979), by increasing the range of foundations considered, improving the understanding of the behaviour of chalk and reviewing available plate loading and pile load test data. In regard to bored pile design (CIRIA, 1994) recommends that end bearing capacity should be calculated on the basis of SPT results, however, the shaft capacity should be calculated on the basis of the average vertical effective stress along the shaft, using the following equation:

Average shaft friction $\tau sf = K \times \tan \delta' \times \sigma v' = \sigma \times \sigma v'$

Where:

- K = coefficient of earth pressure ($\sigma h'/\sigma v'$)

  $\sigma v'$ = average vertical effective stress

  $\sigma v'$ = average vertical effective stress

  δ' = effective angle of interface friction

The report concludes that a relationship does exist and assigns values of 0.8 to conventional bored piles. Skin friction within the Dock Silt and Terrace Gravels has not been taken into account as it is expected that a permanent casing will be used within this strata. It is considered that any negative skin friction from the dock bed silt will have a negligible effect onto the piles and it has therefore not been taken into account in the design. Skin friction has been assumed from 4m below the top of the Chalk to the toe pile level. This allows for the permanent casing to be keyed in to the chalk.

9.4.4.2 Base Capacity

After Hobbs (1976) the ultimate end- bearing resistance qu could be expressed as:

$q_u = 240 * N$ kN/m² for N < 30

$q_u = 200 * N$ kN/m² for N > 40

9.4.5 Piles Located in the West of the Dock (Founding on Thanet Sand)

9.4.5.1 Skin Friction

The design is based on effective stress parameters for the design of the piles within the Thanet Sand. No skin friction has been taken into account as the installation method is not known and therefore an inherent risk exists with regard to the contact between the pile and the surrounding ground. It is considered that any negative skin friction from the dock bed silt will have a negligible effect onto the piles and it has therefore not been taken into account in the design.

9.4.5.2 Base Capacity

Ground penetration to at least 1.5 -2.0 x pile diameters within the founding layer is recommended to mobilise the bearing capacity of the layer. A minimum thickness of at least 3.0m should be present below the toe of the piles. For piles founded close to the boundary with the Chalk, consideration should be given to avoid exceedance of the bearing capacity of this layer. In the areas where there is insufficient thickness of the Thanet Sand to achieve the above conditions the piles should be designed for bearing in the Chalk.

Two methods are considered in calculating the base capacity of the piles founded in the Thanet Sand:

1) Derivation of piling capacity based on Nq
2) Derivation of piling capacity based on pressuremeter testing.

The lesser capacity derived from the two methods is adopted in the design.

For the purposes of this design a pressuremeter value of 4MPa has been adopted, which is a moderately conservative value based on the available pressuremeter test results. It should be noted that in areas of the dock where there is high silt and clay content like at the location of BH25R, lower values of 3MPa should be adopted.

9.4.6 Land-based Piles

9.4.6.1 Skin Friction

The design is based on effective stress parameters for the design of the piles within the Thanet Sand. Skin friction within the Made Ground, Alluvium and Terrace Gravels has not been taken into account. It is assumed that a permanent slip-coated liner will be used within the Made Ground and Alluvium layer to avoid the additional loading of the pile by negative skin friction potentially being generated in these layers.

9.4.6.2 Base Capacity

Base Capacity is calculated as for the piles in the West of the Dock. Ground penetration to at least 1.5 -2.0 x pile diameter within the founding layer is recommended to mobilise the bearing capacity of the layer.

9.4.7 Base Grouting

In order to increase pile capacities, base grouting can be adopted. Base grouting of the piles will achieve higher end bearing pressures and will overcome the uncertainties associated with the condition of the base of the bore being drilled under bentonite. The increased clay content of the basal beds of the Thanet Sand formation should be taken into account when designing the base grout.

9.4.8 Lateral Loading

Lateral loading of the piles should be taken into account at detailed design stage to comply with aviation authority guidelines and regulations for relevant runway and taxiway uses.

9.5 Sub-surface Concrete

Concrete to be placed in contact with the soil or groundwater should be designed in accordance with the recommendations of Building Research Establishment Special Digest 1 "Concrete in Aggressive Ground" (2005) taking into account the pH of the soils.

In the Made Ground the soluble sulphate 2:1 values (mg/l SO_4) reported concentrations between 51 mg/l and 166 mg/l. The pH values recorded varied between 8.2 and 8.6.

In the Dock Silt the soluble sulphate 2:1 values (mg/l SO_4) reported concentrations between 350mg/l and 2210 mg/l. The pH values recorded varied between 7.8 and 8.3.

In the Alluvium the soluble sulphate 2:1 values (mg/l SO_4) reported concentrations of 308 mg/l and 406mg/l. The pH values recorded were 7.8 and 8.0.

In the River Terrace Deposits the soluble sulphate 2:1 values (mg/l SO_4) reported concentrations between 54mg/l and 590 mg/l. The pH values recorded varied between 7.9 and 8.9.

In the Thanet Sand the soluble sulphate 2:1 values (mg/l SO_4) reported concentrations between 130mg/l and 820 mg/l. The pH values recorded varied between 7.1 and 8.8.

The soluble sulphate 2:1 values (mg/l SO_4) reported concentrations between 49mg/l and 171mg/l in the Chalk. The pH values recorded varied between 8.2 and 8.7.

Assuming mobile groundwater Table C1 suggests a Design Sulphate Class of DS-2 and an ACEC classification of AC-2 to be adopted for concrete placed in contact with the ground including piling operations within the Thanet Sand. This recommendation assumes that the Dock Silt is removed by dredging prior to construction works commencing. If this is not the case then concrete in contact with Dock Silt would require a Design Sulphate Class of DS-3 and an ACEC classification of AC-3 to be adopted.

9.6 Risk Assessment

The key geotechnical risks that need to be considered during detailed design stage and during the construction of the development are summarised in Table 8.1:

Table 8.1: Key Geotechnical Risks

Key Geotechnical Hazards	Consequences	Risk	Proposed Mitigation	Residual Risk
Deep Layer of Made Ground and alluvium at landside	Deep foundations required for any construction work in this area. Potential risk of unforeseen ground conditions (Made Ground) Uncertainty on the depth of Made Ground and alluvium in this area.	High	Currently the development proposals for this area are not known. It is suggested that once these are known further investigation is considered to assess the variation of the depth of Made Ground and alluvium across the development footprint.	Low
Presence of fault across the site	Variability in ground conditions in the east and west of the site. Borehole depths insufficient for design. Different piling techniques adopted for each side Need to pile in Chalk (EA to be notified) Potential differential settlement across the structure.	Medium	Foundation design to take account varying ground considerations	Low
Instability of permeable Thanet Sand deposits	Collapse of pile bores	High	Support pile shafts during construction using permanent casing	Low
High Fines content in the Thanet Sand below approximately -20mOD.	Reduced pile capacity below this depth	High	Avoid founding piles below -20mOD Design Piles in this area using lower bound parameters below -20mOD Soil arisings should be recorded.	Low
High Fines content in the Thanet Sand adjacent to the fault line	Reduced pile capacity	High	Design piles in this area using lower bound parameters Record soil arisings Carry out pre-construction pile test	Low
High ground water pressures in the Thanet Sands	Reduced pile base capacity	Medium	Use base grouting. Carry out pile tests to confirm design assumptions	Low

Key Geotechnical Hazards	Consequences	Risk	Proposed Mitigation	Residual Risk
Unstable excavations within Made Ground, Alluvium and Terrace Gravel layers.	Collapse of excavation if unsupported.	High	Use embedded retaining walls to support excavation sides for landside structures if excavations are required Case piles through these layers	Low
Negative Skin Friction from the Made Ground and Alluvium loading the piles	Excessive settlements of piles	High	Use appropriately designed slip coated casings	Low/Medium
Variability in the strength of the Chalk between eastern and western areas	Excessive settlement of piles	High	Adopt separate design profiles for the chalk in each area	Low
Piling works in the dock leading to disturbance of contaminated sediment	Temporary effect on quality of dock water	High / Medium	Piling risk assessment Correct disposal procedure	Low/Medium
Transfer of pollutants from the Dock Silt and/or Dock Water into the natural ground or underlying aquifers through the piles	Contamination of the underlying aquifer	High/Medium	Use of permanent casing in the Dock Silt, Terrace Gravels and Thanet Sands	Low/Medium
Compromise of existing dock walls during construction works	Failure of dock wall, flooding	High	Investigation of existing walls and back analysis of design and parameters	Low/Medium
Variable and compressible nature of Made Ground and soft layers	Excessive Settlements	High	Avoid founding on these layers.	Low
Existing piles and other foundation obstructions (land side)	Obstructing the boring of new piles Increase in demolition and piling costs	High	Carry out a desk based study of available substructure information and verify on site by carrying out intrusive surveys.	Low
Accidental Strike of Underground Services	Death/Injury/Damage to third party assets	High	Detailed mapping and surveying of services running under the site. Isolate all services before commencement of works.	Medium to Low
Accidental Detonation of Bombs	Death/Injury/Damage to third party assets	High	UXO risk assessment designates the site as high risk. Adopt magnetometer surveys during piling as per risk assessment recommendations.	Low to Medium
Existing buried foundations in landside/ objects within dock silt	Obstructions during excavation works/piling	High	Investigate the layout of existing foundations during the site investigation phase to enable informed costing of works. Investigate dock bed and clear/dredge	Low to Medium
Ground movements associated with heave, settlement, wall displacements	Impact on adjacent buildings and proposed scheme	High	Establish ground movement prediction models at detailed design stage. Establish movement monitoring regime	Low

10 REFERENCES

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NOTE: Historic Reports reviewed are listed in Section 4 of this report, table 4.1

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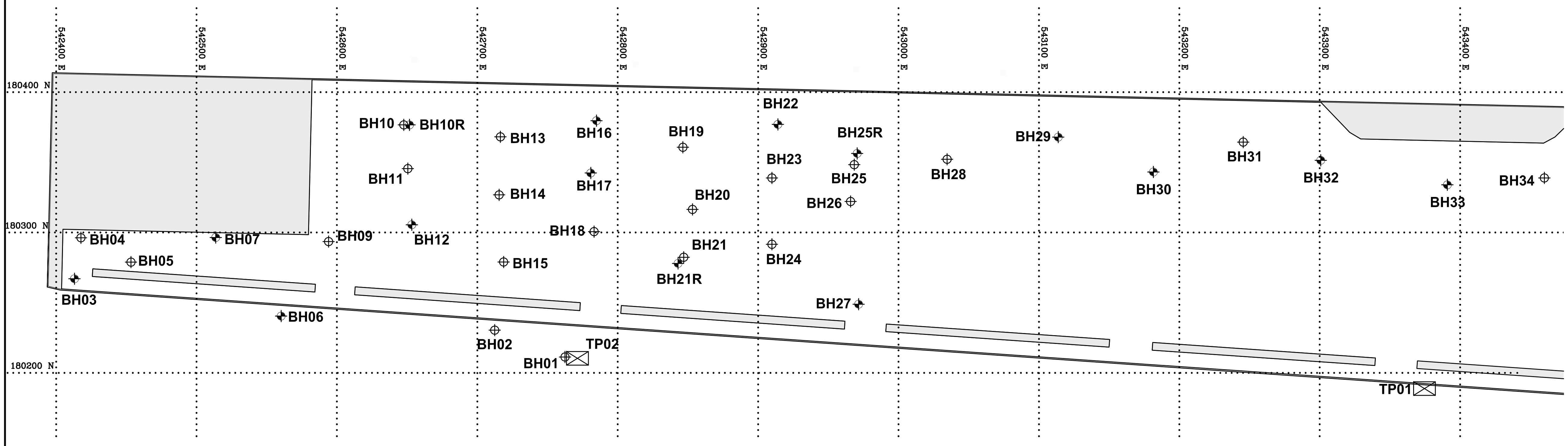
11 FIGURES



NOTES

1. This drawing should not be scaled, only use annotated dimensions.

PointID	HoleDepth	Easting	Northing	Elevation (mOD)	TYPE
BH03	34.60	542413.37	180267.86	4.77	DS/RC
BH04	37.50	542417.70	180296.25	4.89	CP
BH05	33.95	542452.30	180279.08	4.68	CP
BH06	30.80	542560.27	180240.47	5.69	DS/RC
BH07	33.50	542513.76	180296.37	4.95	DS/RC
BH09	32.00	542594.06	180293.69	5.02	CP
BH10	32.50	542647.53	180376.79	4.34	CP
BH10R	32.80	542651.71	180376.70	4.46	DS/RC
BH11	31.50	542650.53	180345.58	4.92	CP
BH12	32.00	542653.37	180305.55	5.29	RC
BH13	34.50	542716.47	180368.24	4.88	CP
BH14	31.50	542716.89	180326.61	4.67	CP
BH15	30.45	542718.78	180279.03	4.10	CP
BH16	39.00	542785.28	180379.68	5.01	RC
BH17	35.90	542780.80	180342.43	5.24	DS/RC
BH18	33.50	542783.21	180300.56	4.18	CP
BH19	36.60	542846.43	180360.76	4.34	CP
BH20	35.50	542853.06	180316.15	4.92	CP
BH21	33.00	542847.09	180282.34	4.25	CP
BH21R	33.50	542842.98	180278.21	4.54	DS/RC
BH22	37.50	542914.01	180377.07	4.44	DS/RC
BH23	36.50	542909.73	180338.93	4.55	CP
BH24	33.00	542909.85	180291.63	3.54	CP
BH25	32.00	542968.45	180348.39	4.31	CP
BH25R	32.00	542970.56	180356.36	4.31	DS/RC
BH26	32.00	542965.95	180322.20	4.41	CP
BH27	33.00	542971.44	180248.90	4.88	RC
BH28	32.00	543034.61	180352.20	4.79	CP
BH29	45.50	543114.06	180367.98	4.93	RC
BH30	33.00	543181.64	180343.20	4.23	DS/RC
BH31	32.00	543245.51	180364.44	6.49	CP
BH32	31.40	543300.74	180351.60	4.61	DS/RC
BH33	32.00	543390.97	180334.13	4.19	DS/RC
BH34	31.50	543459.99	180338.91	4.96	CP
TP01	2.00	543374.64	180188.76	5.44	TP
TP02	3.50	524771.33	180210.40	5.55	TP

KEY

DS/R - Dynamic Sampling / Rotary

CP - Cable Percussion

TP - Trial Pit

No	Revision	Drawn	Checked	Passed	Date

CONCEPT SITE INVESTIGATIONS

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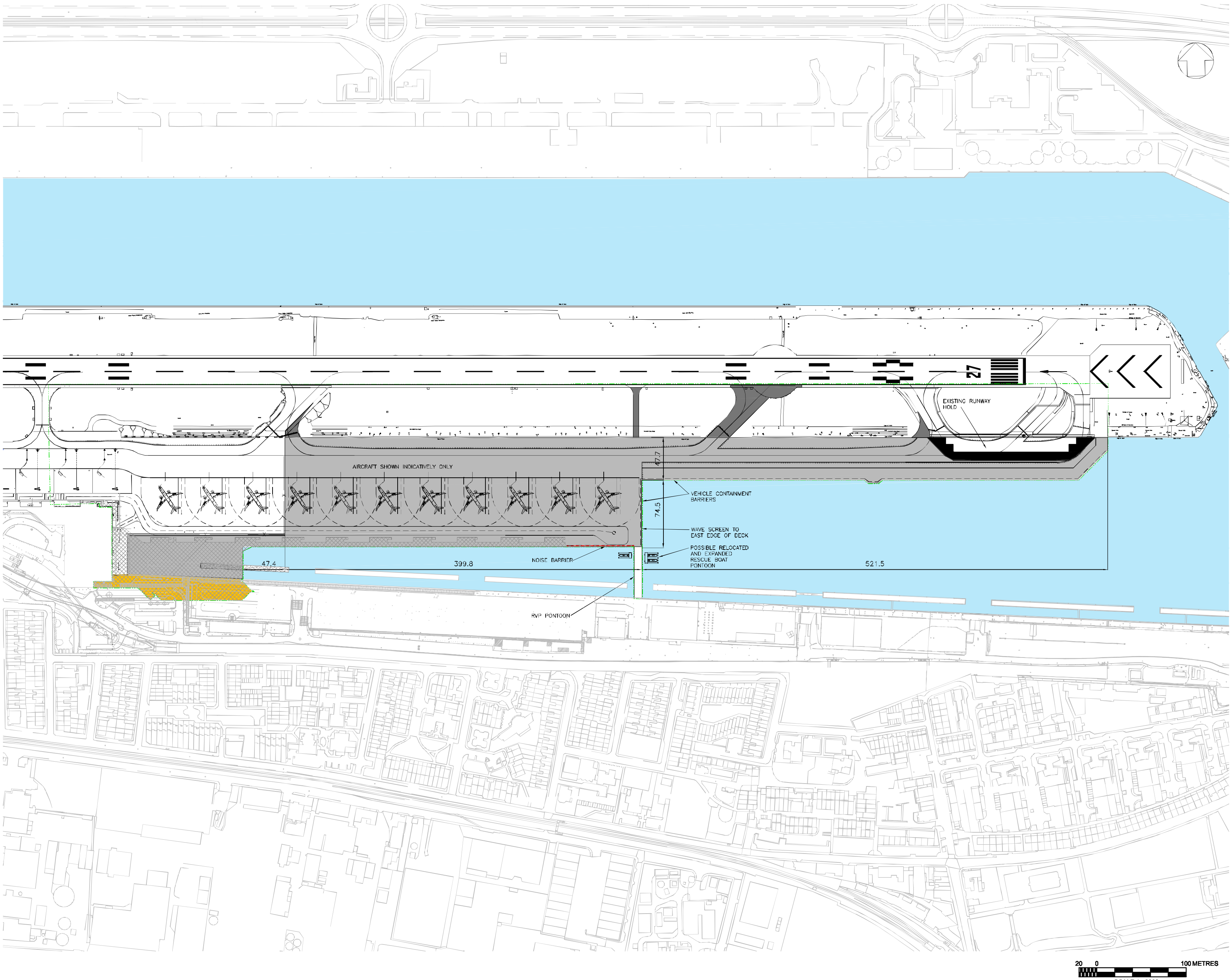
Client:	London City Airport
Project:	CADP Surveys - Ground Investigation (Dock) - Phase 2
Title:	Figure 1 Exploratory Hole Location Plan
Dwg. No:	162900/00
Status:	Issue
Scale:	NTS

Drawn	Checked	Passed	Date
RD/EV	OS	MD	February 17



NOTES:

1. ALL DIMENSIONS IN MILLIMETRES UNLESS STATED OTHERWISE.
2. APRON TO HAVE FLOOD LIGHTING IN ACCORDANCE WITH CAP 168. SEE DRAWING CA1L–521 AND 522.
3. TAXIWAYS TO HAVE AIRFIELD GROUND LIGHTING IN ACCORDANCE WITH CAP 168. TYPICAL DETAILS ON DRAWING CAOD–500.
4. NEW AIRCRAFT STANDS TO BE PROVIDED WITH FIXED ELECTRICAL GROUND POWER.
5. REFER TO 'PROPOSED SURFACE WATER DRAINAGE STRATEGY' FOR AIRFIELD SURFACE WATER CONCEPT.

KEY

- HOLD AREA STRENGTHENING (1864m²)
- NEW RUNWAY LINKS CONSTRUCTED USING TRADITIONAL GROUND BEARING PAVEMENT (3234m²)
- SUSPENDED DECK (75628m²)
- PILED FOUNDATION
- EXPOSED DOCK WATER
- DOLPHINS CUT OFF BELOW WATER LEVEL TO ENABLE DECK CONSTRUCTION
- NEW NOISE BARRIER
- HIGH CONTAINMENT VEHICLE BARRIER
- PLANNING APPLICATION SITE BOUNDARY
- ILLUSTRATIVE BUILDING OUTLINE, REFER TO DESIGN AND ACCESS STATEMENT FOR FURTHER INFORMATION.
- PROPOSAL BOUNDARY – ALL INFORMATION OUTSIDE OF THE PROPOSAL BOUNDARY IS FOR ILLUSTRATION PURPOSES ONLY.

Rev	Revised By	Date	Checked By	Date
C	R.WOOD	04/04/2013	W.HELLYER	04/04/2013
ISSUED FOR PLANNING, REVISED TO LYC COMMENTS				
B	R.WOOD	22/03/2013	W.HELLYER	22/03/2013
ISSUED FOR PLANNING				
A	R.WOOD	11/03/2013	W.HELLYER	11/03/2013
PRELIMINARY PLANNING SET				

For Approval

LondonCityAirport
Royal Docks London E16 2PB

Project
CITY AIRPORT
DEVELOPMENT PROGRAMME

Drawing Title
5.4 KEY ENGINEERING FEATURES

Originating Office
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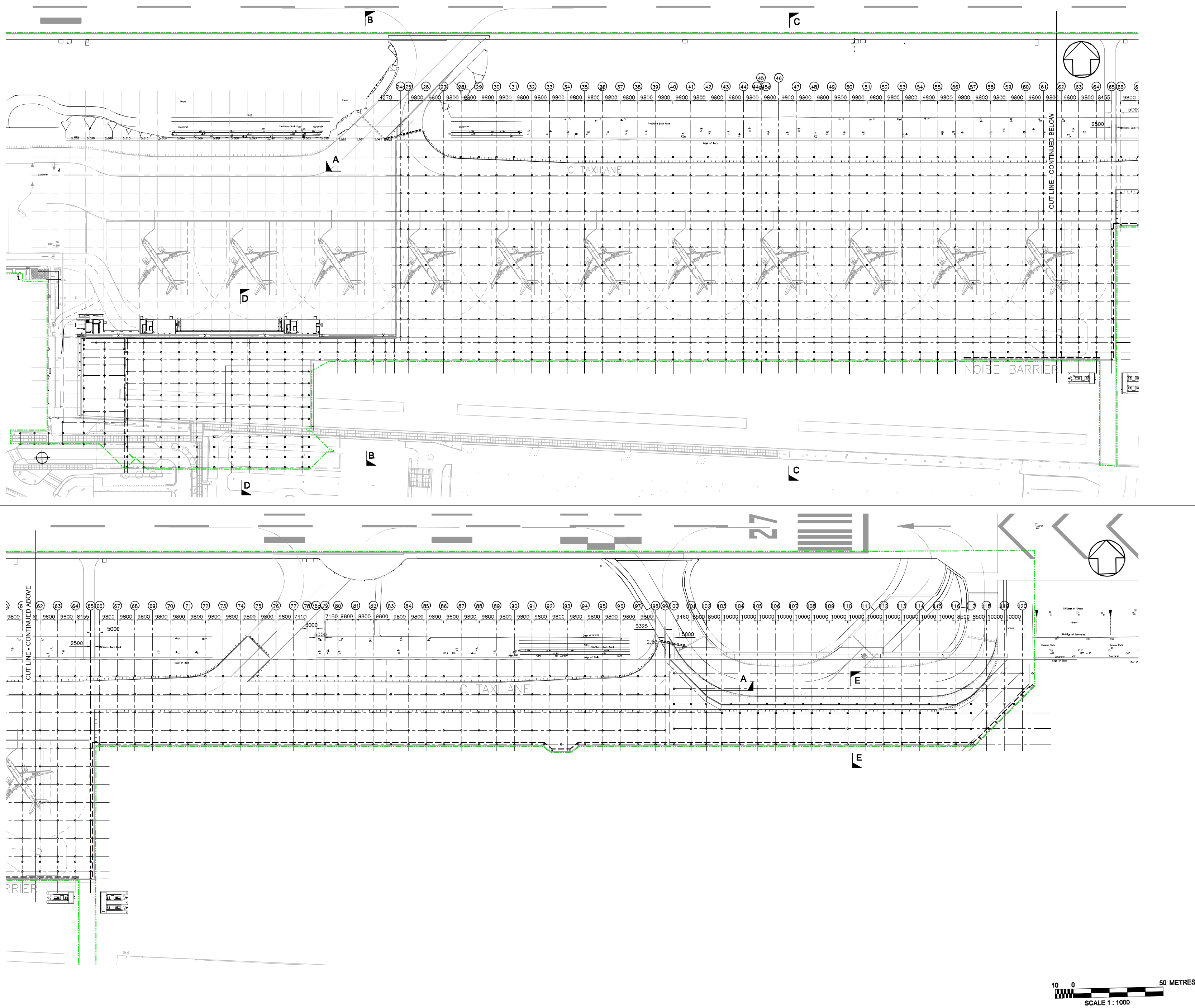
TPS Job Manager R.MOORE

QA System - Checks		Signature	Date
Drawn By:	R.WOOD		12/12/2012
Checked:	W.HELLYER		20/12/2012
Authorised:	R.MOORE		20/12/2012

TPS Project No.	Drawing Status	Scale (at A1)	(at A3)
112406	APPROVAL	1:2000	

Drawing No. Displ Bldg Level Type CISfb Element Code Seq. No. — **CA0L- 004** — Revision **C**

USERNAME ACAD 2010
PLOT SCALE 1=1



NOTES

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE STATED.
2. ALL LEVELS ARE IN METRES ABOVE ORDNANCE SURVEY DATUM.
3. FOR SECTIONS REFER TO Dwg.Nos. CA0L-910, CA0L-911 AND CA0D-921.
4. PILE POSITIONS TO BE ADJUSTED TO SUIT FINAL LOCATION OF ANY BUILDING STRUCTURES ABOVE.

KEY

PROPOSAL BOUNDARY – ALL INFORMATION OUTSIDE OF THE PROPOSAL BOUNDARY IS FOR ILLUSTRATION PURPOSES ONLY.

Rev	Revised By	Date	Checked By	Date
C	R.WOOD	04/04/2013	W.HELLYER	04/04/2013
ISSUED FOR PLANNING, REVISED TO LCY COMMENTS				
B	R.WOOD	22/03/2013	W.HELLYER	22/03/2013
ISSUED FOR PLANNING				
A	R.WOOD	11/03/2013	W.HELLYER	11/03/2013
PRELIMINARY PLANNING SET				

For Approval

LondonCityAirport
Royal Docks London E16 2PB

Project
CITY AIRPORT DEVELOPMENT PROGRAMME

Drawing Title
5.14 PROPOSED DECK STRUCTURE AND FOUNDATIONS GENERAL ARRANGEMENT

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TPS Job Manager: R.MOORE

QA System - Checks		Signature	Date
Drawn By:	R.WOOD		19/02/2013
Checked:	W.HELLYER		11/03/2013
Authorised:	R.MOORE		11/03/2013

TPS Project No.	Drawing Status	Scale (at A1) (at A3)
112406	APPROVAL	1:1000

Drawing No. CA0L-900 — Revision C

USERNAME
PLOT SCALE 1=1
ACAD 2010

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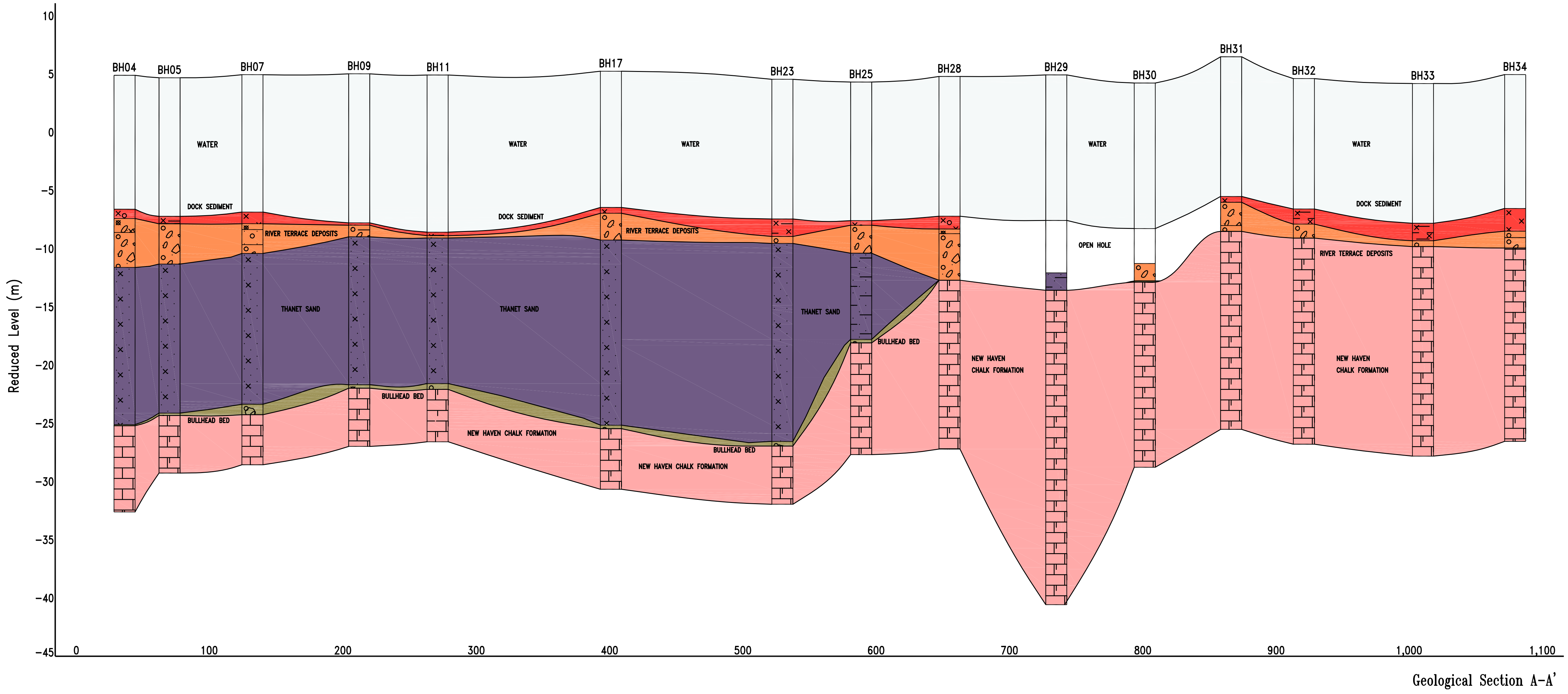
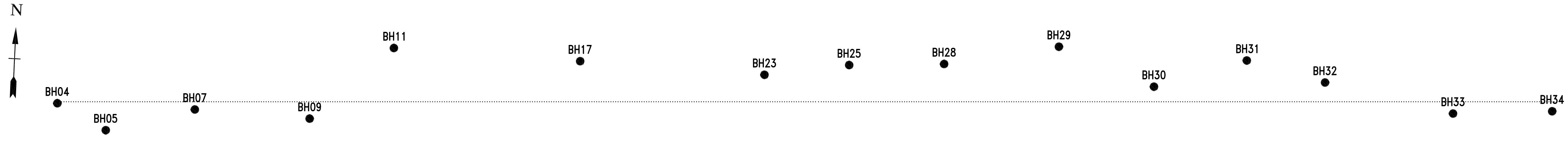


Geological Section A-A'

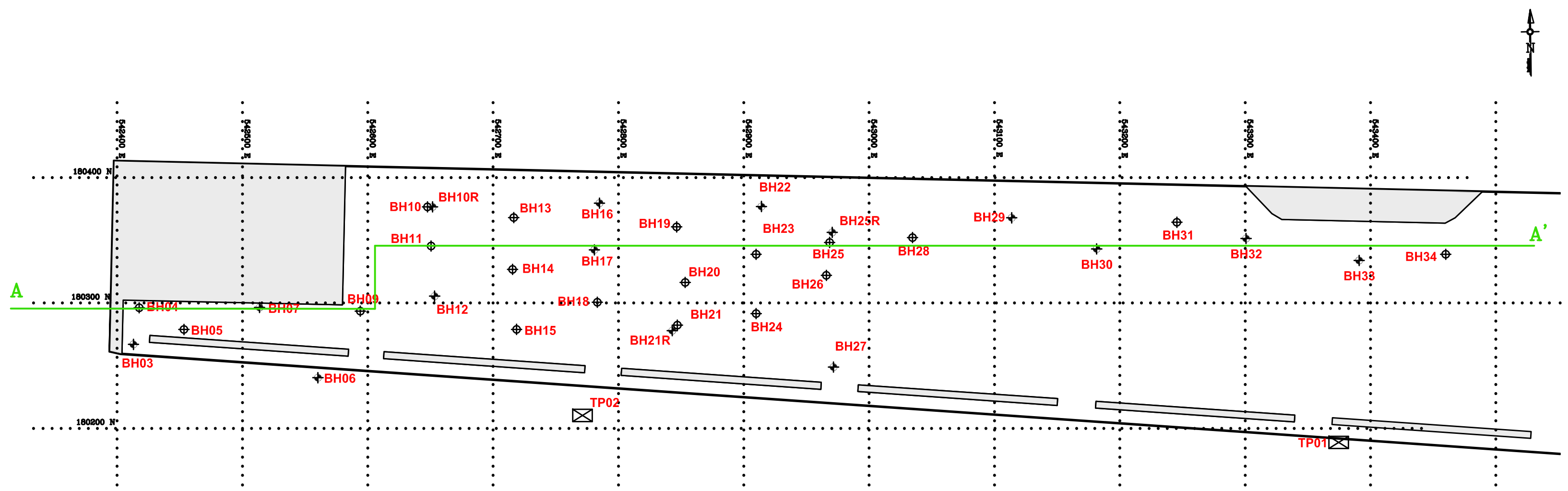


KEY

- River Terrace Deposits
- Bullhead Beds
- Dock Sediment
- Thanet Sand
- Water
- Chalk Formation

LITHOLOGY GRAPHICS

- VOID
- CHALK
- Silty GRAVEL
- SILT
- Silty CLAY
- Clayey SAND
- sandy GRAVEL
- Gravelly SAND
- Silty SAND
- SAND
- clayey sandy GRAVEL
- GRAVEL
- Cobbly GRAVEL
- Gravelly SILT
- Clay/Silt



No	Revision	Drawn	Checked	Passed	Date

CONCEPT SITE INVESTIGATIONS

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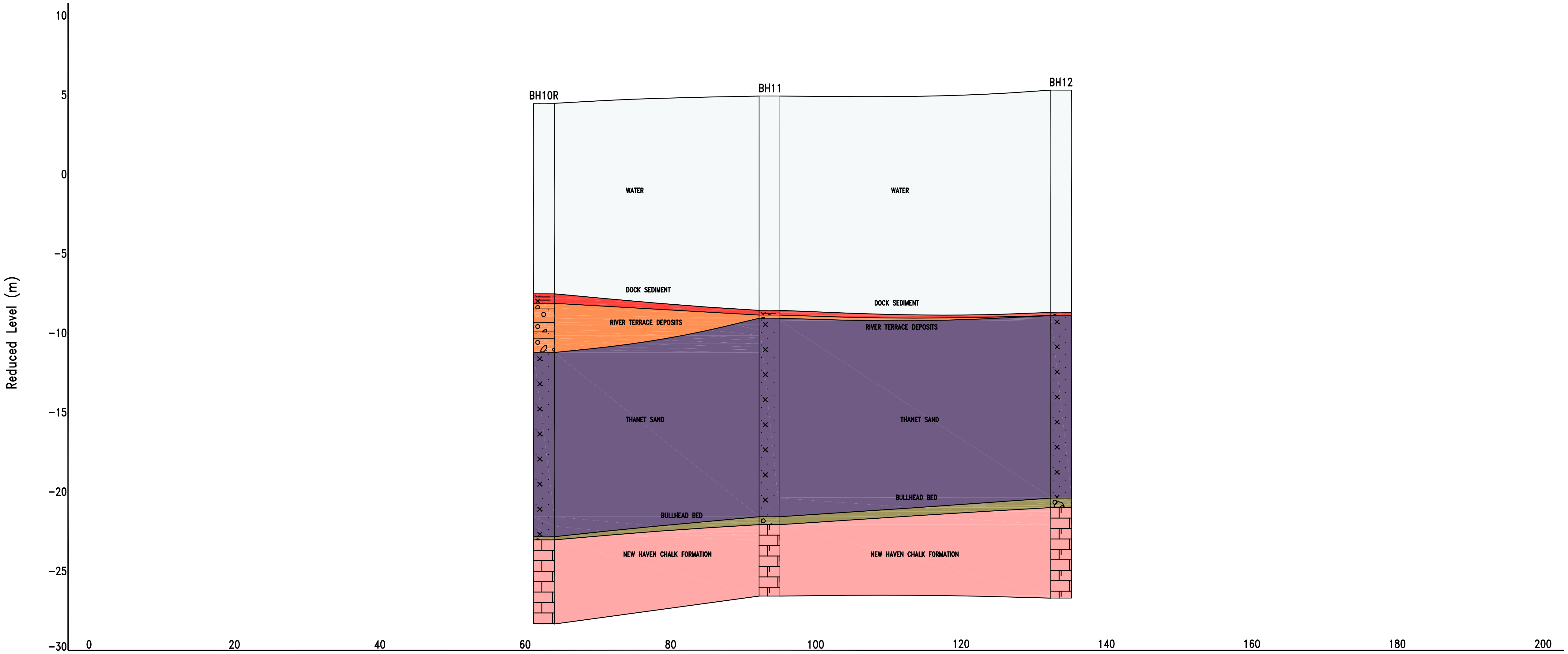
Client:	London City Airport
Project:	CADP Surveys - Ground Investigation (Dock) - Phase 2
Title:	Figure 4a - Geological Section A-A'
Dwg. No:	16200/01
Status:	Issue
Scale:	NTS

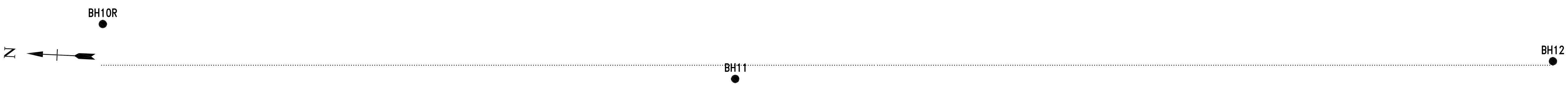
Drawn	Checked	Passed	Date
EV	OS	MD	February 17

NOTES

1. This drawing should not be scaled.



Geological Section B-B'

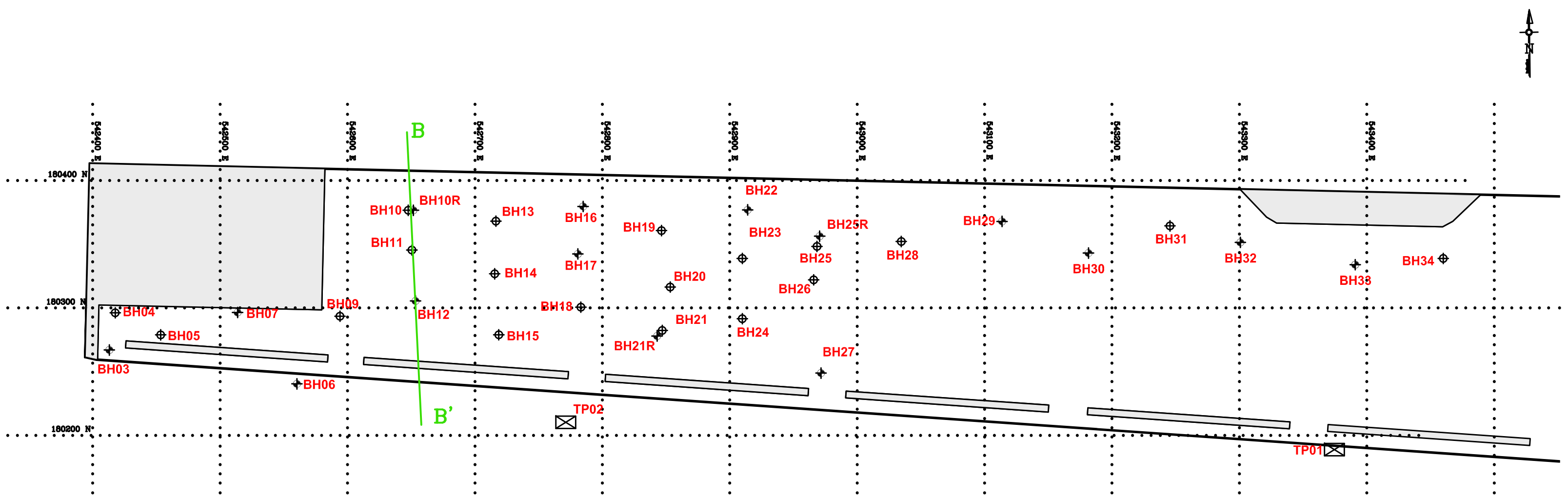


KEY

- River Terrace Deposits
- Bullhead Beds
- Dock Sediment
- Thanet Sand
- Water
- Chalk Formation

LITHOLOGY GRAPHICS

- VOID
- CHALK
- Silty GRAVEL
- SILT
- Silty CLAY
- Clayey SAND
- sandy GRAVEL
- Gravelly SAND
- Silty SAND
- SAND
- clayey sandy GRAVEL
- GRAVEL
- Cobbly GRAVEL
- Gravelly SILT
- Clay/Silt



No	Revision	Drawn	Checked	Passed	Date

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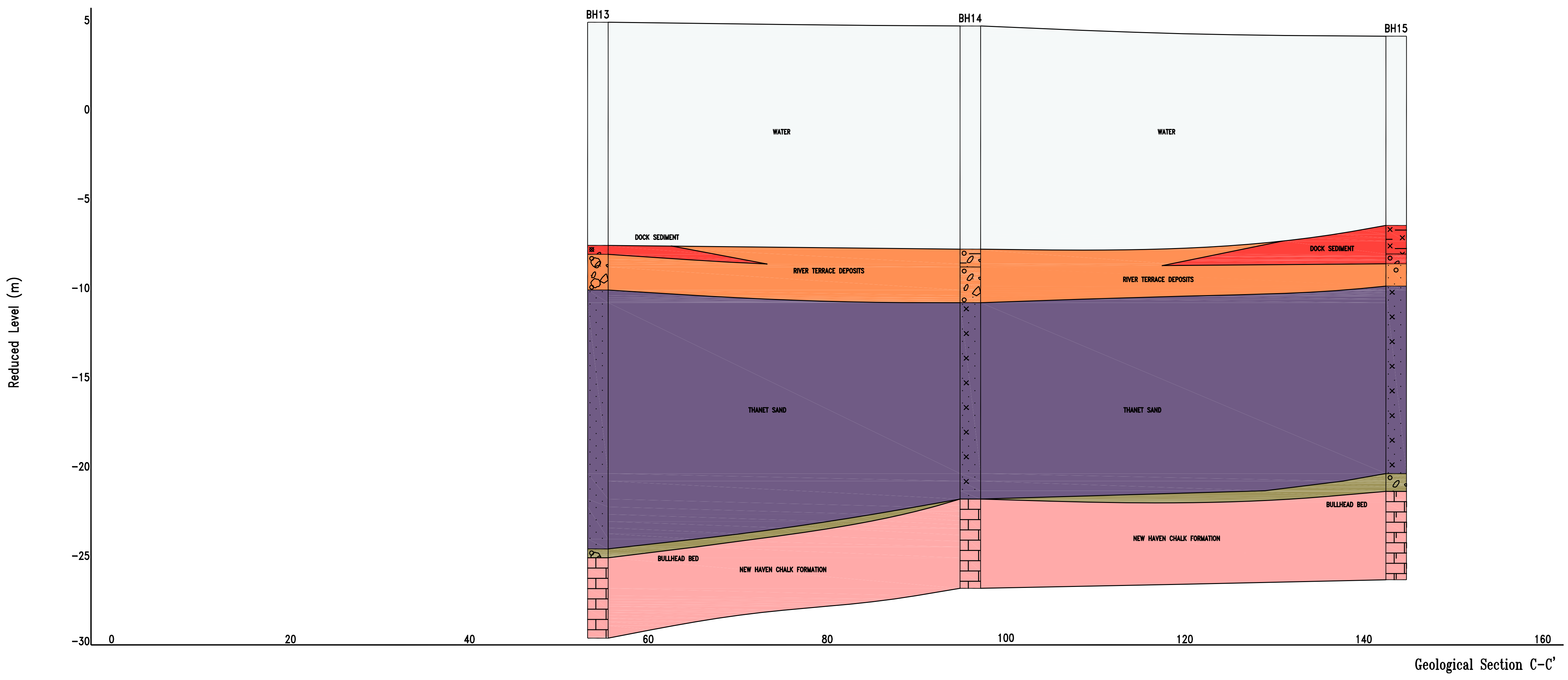
Client:	London City Airport
Project:	CADP Surveys - Ground Investigation (Dock) - Phase 2
Title:	Figure 4b - Geological Section B-B'
Dwg. No:	16200/02
Status:	Issue
Scale:	NTS

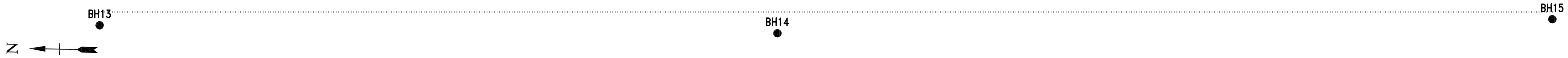
Drawn	Checked	Passed	Date
EV	OS	MD	February 17

NOTES

1. This drawing should not be scaled.



Geological Section C-C'

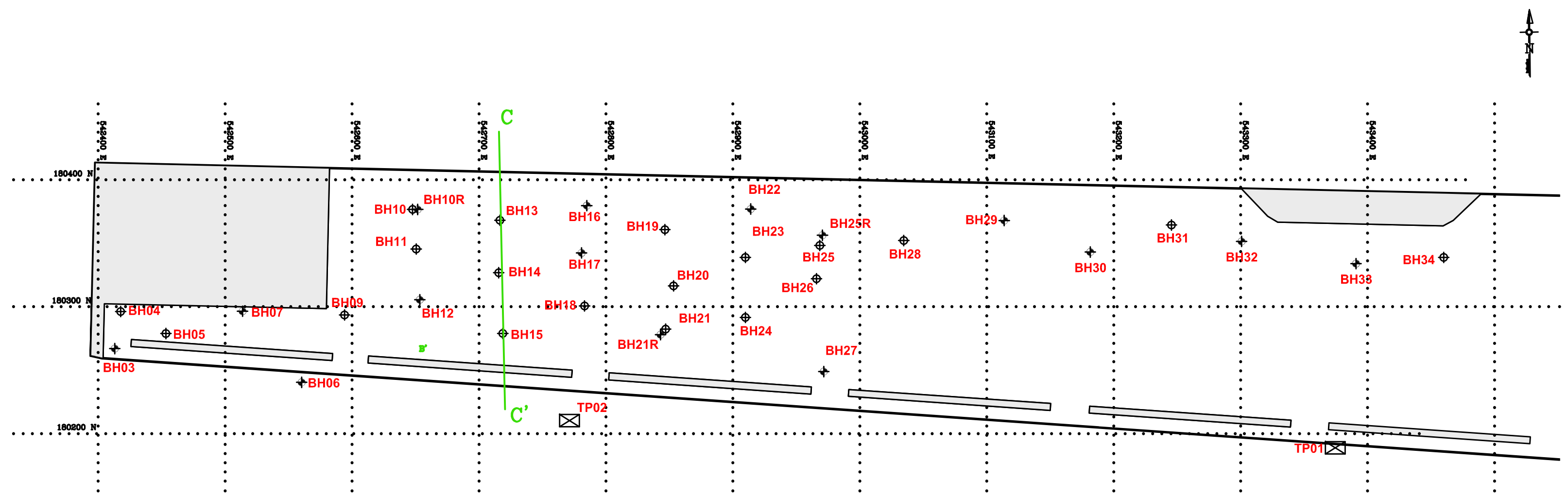


KEY

- River Terrace Deposits
- Bullhead Beds
- Dock Sediment
- Thanet Sand
- Water
- Chalk Formation

LITHOLOGY GRAPHICS

- VOID
- CHALK
- Silty GRAVEL
- SILT
- Silty CLAY
- Clayey SAND
- sandy GRAVEL
- Silty SAND
- SAND
- clayey sandy GRAVEL
- GRAVEL
- Cobbly GRAVEL
- Gravelly SILT



No	Revision	Drawn	Checked	Passed	Date

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Client:	London City Airport
Project:	CADP Surveys - Ground Investigation (Dock) - Phase 2
Title:	Figure 4c - Geological Section C-C'
Dwg. No:	16200/03
Status:	Issue
Scale:	NTS

Drawn	Checked	Passed	Date
EV	OS	MD	February 17