TRANSPORT FOR LONDON

RIVER CROSSINGS: SILVERTOWN TUNNEL

SUPPORTING TECHNICAL DOCUMENTATION

RIVER CROSSINGS:

PHASE 1 CONTAMINATION ASSESSMENT

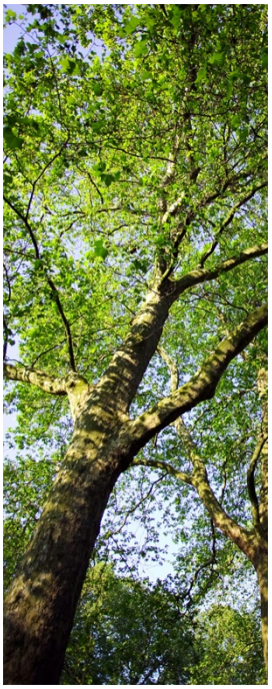
Mott MacDonald

June 2013

This report sets out in detail the assessment of the contamination risks associated with the construction of the proposed Silvertown tunnel scheme and associated highway works.

This report is part of a wider suite of documents which outline our approach to traffic, environmental, optioneering and engineering disciplines, amongst others. We would like to know if you have any comments on our approach to this work. To give us your views, please respond to our consultation at www.tfl.gov.uk/silvertown-tunnel

Please note that consultation on the Silvertown Tunnel is running from October – December 2014.


TfL River Crossings - Phase 1 Contamination Assessment

Silvertown to Greenwich Peninsula

June 2013

Transport for London
320530/MNC/TUN/003

Mott MacDonald

TfL River Crossings - Phase 1 Contamination Assessment

Silvertown to Greenwich Peninsula

June 2013

Transport for London

Mott MacDonald, Mott MacDonald House, 8-10 Sydenham Road, Croydon CR0 2EE, United Kingdom
T +44 (0)20 8774 2000 F +44 (0)20 8681 5706 W www.mottmac.com

Mott MacDonald

Issue and revision record

Standard

Revision	Date	Originator	Checker	Approver	Description
A	12/04/13	M Hogg	D Giordanelli	J Dottridge	Draft issued for client comment
B	24/04/13	M Hogg	D Giordanelli	J Dottridge	Final
C	24/04/13	M Hogg	D Giordanelli	J Dottridge	Final addressing client comments
D	24/06/13	M Hogg	D Giordanelli	J Dottridge	Final addressing client comments

Contents

Executive Summary

Mott MacDonald Limited (MML) was commissioned by Transport for London to undertake a Phase 1 Contaminated Land Risk Assessment of the proposed Silvertown to Greenwich Peninsula River Crossing scheme. The scheme assessed within this report comprises a bored tunnel between North Greenwich Peninsula and the Royal Victoria Docks.

This Phase 1 report provides an assessment of the contamination risks associated with the construction of the proposed tunnel scheme and associated highway works. The assessment considers the geo-environmental setting together with the development history of the area to build-up a picture of the types of contamination that may be expected to be present. An assessment is then made of the potential pollutant linkages that may be present, either currently, at the time of construction, or within the finished scheme.

The superficial geology beneath the study area comprises alluvial deposits overlying River Terrace Deposits. The underlying bedrock geology comprises a thin layer of London Clay, in turn overlying the largely granular Harwich Formation, Lambeth Group, and the Thanet Sand Formation beneath which lies the Chalk. In addition, Made Ground is known to overlie the alluvial deposits across the majority of the study area.

The superficial deposits are classified by the Environment Agency as a Secondary A aquifer. This aquifer is separated from underlying Principal Chalk aquifer by the London Clay which, in the southern (Greenwich) area is locally very thin and may be absent; additionally the Lambeth Group in this area is predominantly granular. Therefore there is likely to be a degree of existing hydraulic continuity between the upper and lower aquifers, at least locally.

The principal contamination sources in the Silvertown area comprise former land uses including rail land (including coal and goods depots), manure works, chemical works, garages and an engineering works as well as those associated with continued use for industrial activities. On the Greenwich Peninsula the principal contamination source relates to the former South Metropolitan Gasworks which dominated this area during between the 1860s and 1980s. A single remaining gas holder is the only above ground remnant of this former facility.

Site wide remediation of the gasworks was undertaken during the late 1990s by British Gas and English Partnerships. It is understood that key sources of contamination, such as tar tanks and known contamination hot spots, were removed, groundwater remediation was undertaken and near surface soils were removed or cleaned prior to landscaping. However, it is understood that contaminated materials remain at depth beneath much of the site.

Additionally, the study area was subject to the heavy bombing during WWII and whilst the site area has undergone extensive redevelopment following WWII, there remains the potential for unexploded ordnance to exist.

Overall the site has been given a MODERATE – HIGH risk rating in the absence of any specific mitigation measures. Specifically the following key points, contaminant linkages and potential mitigation measures should be noted:

- Human uptake pathways. Construction workers are highly likely to encounter contaminated soil, water and vapours/gases during tunnel excavation works and to a lesser extent during redevelopment of new surface highway works (particularly in former gasworks locations where the existing remediation cap is breached). Risks are however easily mitigated using widely used measures (such as site welfare and PPE).
- Migration of contaminants to surrounding land users during construction activities (as wind-blown dust or vapours). Again, such risks can be mitigated through appropriate environmental controls.
- Migration of contaminants through preferential pathways during tunnel excavation works (e.g. during piling). The proposed excavation works in the Greenwich side will breach the current capping layer that is present. Piling works have the potential to link the poor quality soils and groundwater that could reasonably be expected in the upper aquifer with the lower aquifer in the Thanet Sand Formation/Chalk. This can be mitigated though additional investigation of the groundwater regime, remediation (where necessary) and the undertaking of piling risk assessments in accordance with in National Groundwater & Contaminated Land Centre report NC/99/73; and
- Should dewatering works be proposed, risks associated with the migration of shallow contaminants into the lower aquifer would also need to be appropriately managed and mitigated where necessary.

It is recommended that an intrusive site investigation and programme of environmental monitoring and laboratory testing is undertaken to more fully understand the conceptualised pollutant linkages highlighted in this report.

The results of the investigation should be used to inform a quantitative risk assessment, and can also be used in materials management and site construction environmental management plans.

It is advised that the scope of any investigation that may be required for planning purposes should be discussed with the regulators (local planning authority environmental health and Environment Agency)

1 Introduction

1.1 Background

The Phase 1 Contamination Assessment Study for the Transport for London (TfL) Silvertown to Greenwich Peninsula River Crossing scheme was requested in January 2013. This report will consider the first of three options for a new river crossing at two sites in east London. The report was requested to provide an early assessment of the potential contaminated land risks associated with the construction of the proposed scheme.

1.2 Terms of Reference

Mott MacDonald has been commissioned by TfL to undertake a Phase 1 Contamination Assessment Desk Study for potential projects collectively known as the River Crossings Programme which will provide new River Thames crossings in east London.

1.3 Scope of Work

This report has been prepared by Mott MacDonald. The report presents a review based on available factual data and summary in terms of:

- existing and historic land use;
- geological setting;
- ground and groundwater conditions;
- unexploded ordnance (UXO) risk;
- existing third party site investigation data;
- potential for ground contamination; and
- engineering assessment.

This document provides an assessment of the contamination risks associated with the proposed construction scheme. The assessment considers the geo-environmental setting together with the development history of the area to build up a picture of the types of contamination that may be expected to be present. An assessment is then made of the potential pollutant linkages that may be present, either currently or at the time of construction.

This assessment does not consider archaeology, aquatic ecology or terrestrial ecology, with the exception of the presence of invasive plant species. Although UXO data is reviewed, advice will need to be sought from an appropriate specialist with respect to these risks.

The assessment has been produced in line with current UK legislation, government guidelines and best practice such as British Standards (BS) 10175 (2011[i]) *Code of practice for investigation of potentially contaminated sites*, Contaminated Land Report (CLR) 11 *Model procedures for the management of land contamination* (2004[ii]), Construction Industry Research and Information Association (CIRIA) C552 Contaminated land risk assessment – a guide to good practice (2001[iii]).

1.4 Proposed Scheme

The first option option currently being considered by TfL is:

- A bored tunnel crossing from Silvertown to Greenwich Peninsula (described further in Section 2.2);

In addition a further two options are proposed located to the east of the Silvertown area:

- A replacement for the Woolwich Ferry (at Woolwich/Gallions Reach); and
- A fixed link (either a bridge or bored/immersed tube tunnel) at Gallions Reach.

A decision on which options to progress will be made during 2013. An envisaged programme for delivery into service of the first two projects is 2021 and 2018 respectively. The programme for the third scheme is still in development but its completion date would be after 2021. An application has been made for the Silvertown Tunnel to be developed via a Development Consent Order (DCO) application. The replacement for the Woolwich Ferry would be taken forward via a Transport and Works Act (TWA) Order.

Due to their distinct and separate locations, it is considered appropriate to produce two separate contamination assessments. An initial desk study focussing on the Silvertown Tunnel Crossing (option 1) (this report), followed by a second desk study for the proposed ferry crossing between Thamesmead/Gallions Reach (option 2) and the fixed link (either a bridge or immersed tube tunnel) from Gallions Reach (option 3). Further information on the scheme is also given in Section 2.

1.5 Sources of Information & Desk Study

1.5.1 London Cable Car & Silvertown Tunnel Desk Study

In October 2010[iv], Mott MacDonald prepared a comprehensive geotechnical desk study to assist with the design of the London Cable Car scheme across the River Thames between Royal Victoria Dock on the north side of the river and the Greenwich Peninsula on the south side. Although the desk study was primarily carried out for the cable car project, the scope of the desk study was expanded to cover the proposed tunnel crossing scheme being developed at the same location (Silvertown). Ground investigation for the cable car project was subsequently undertaken. Therefore, an extensive database of existing ground investigation information for the Silvertown study area is available.

1.5.2 Other Sources

The following sources of information have been utilised in the preparation of this report:

- information relating to the historical use of the site and its existing conditions;
- historical map review into previous site uses and notable off-site land uses using information provided by the Landmark Information Group (Envirocheck Report);
- environmental hazards and waste records;
- published geological mapping;
- British Geological Survey historic boreholes;
- Mott MacDonald database of historic boreholes;
- site reconnaissance/walkover survey; and

1.5.2.1 Local Authority Consultation

A request for land contamination information pertinent to the study area was put forward to both the Royal Borough of Greenwich and the London Borough of Newham.

Information received from the Royal Borough of Greenwich includes:

- Historical photographs and remediation plans for the Greenwich Peninsula during a visit to council offices dated 12th April;
- third party Groundwater Monitoring reports (Atkins) also for the Greenwich Peninsula received electronically dated 15th April; and
- East Greenwich Peninsula Gas Holder consultation zone plan received electronically dated 16th April;

A subsequent verbal request to the London Borough of Newham yielded 2 No. CDs for the Gallions Reach area and 1 No. CD for Silvertown area dated 15th April.

The information supplied by Royal Borough of Greenwich has been used to supplement the other data sources and is contained within the relevant sections of this report (Sections 4, 5 and 6).

2 Site Description

2.1 Introduction

This section outlines the environmental setting in terms of scheme description, site feature, surrounding land uses and topography.

2.2 Scheme Description

2.2.1 Bored Tunnel and Portal Entrances

The proposed crossing scheme from Silvertown to Greenwich Peninsula comprises a 12.1m diameter twin bored tunnel providing a dual 2-lane connection between the A102 on the Greenwich Peninsula and the Tidal Basin Roundabout on Silvertown Way. The tunnel will comprise 3 No. cross passages (CP1 - CP3)along the alignment of the bored tunnel section. The 4.55m diameter cross passages will be formed using a sprayed concrete lining (SCL) technique. Plans of the bored tunnel crossing and associated longitudinal sections are contained in Appendix A.1-3.

The approximate coordinates of the proposed tunnel portals are as follows:

- North tunnel portal: TQ 539930E 180520N; and
- South tunnel portal: TQ 540170E 179500N.

The tunnel approaches will be formed of cut and cover tunnels and open cut ramps. The embedded retaining walls will be formed using a combination of diaphragm and secant pile walling techniques.

At each end of the tunnel, it is proposed to undertake a redevelopment of the adjacent road junction and highway areas in order to accommodate the new tunnel. The proposed tunnel scheme and adjacent highways redevelopment is contained in Appendix A.4

2.2.2 Northern & South Junctions

The northern junction will merge the tunnel portal entrance with Dock Road leading tunnel traffic northwards before entering the Tidal Basin roundabout allowing a cut through to the Lower Lea Crossing (A1020) carriageway.

The southern junction proposal involves the significant realignment of the southbound section of the Blackwall Tunnel Approach road (A102) in order to facilitate appropriate gradients for changes in level. A slip road diverging from the offside of the northbound A102 will connect to the Silvertown Tunnel, passing under the southbound carriageway. The currently severed Tunnel Avenue adjacent west of the A102 will also be reconnected.

Given that the Silvertown Tunnel highway infrastructure will be well used by commercial vehicles, the lane widths of the new highway layouts will generally be 3.65m with some narrowing (down to 3m) as dictated by usage, vehicle speed and site constraints. Single lane slip roads will be maintained at 6m in width to allow for a broken down vehicle to be overtaken.

2.3 Site Location and Description

The northern side of the site is located within the London Borough of Newham and the southern side within the London Borough of Greenwich.

To the north of the River Thames, the study area includes the Thames and Clyde Wharves and is bounded to the north by the Canning Town London Underground and DLR station, to the south east by the West Silvertown DLR station and to the east by Royal Victoria DLR station. The Royal Victoria Docks are located to the east between the two stations and are situated approximately 100m away from the proposed northern tunnel portal entrance.

On the south side of the River Thames, the study area includes the area around Edmund Halley/Millennium Way and Cutter Lane, south of the O_2 arena on the Greenwich Peninsula, and extends south within the confines of the Blackwall Tunnel Approach and West Parkside.

2.4 Topography

The land on both sides of the River Thames in generally flat with ground levels generally between 1m AOD and 6m AOD.

The bed of the Thames is anticipated to have a gentle dip ranging from -3 m AOD to -10 m AOD.

2.5 Current Land Use

Silvertown Area

The land use on the northern side of the river is mixed with residential and recreational use around the perimeter of Royal Victoria Docks and light commercial use to the south of the elevated Silvertown Way and the Docklands Light Rail (DLR). Waste management and aggregate facilities dominate to the north and west of the proposed northern tunnel portal.

The Silvertown study area also includes the London Cable Car (Emirates Air Line), which provides a pedestrian and cycle crossing between the Greenwich Peninsula on the south side of the River Thames and the Royal Docks on the north side of the River Thames.

Greenwich Peninsula

On the south side of the River Thames, the land use is predominantly car parking with the O_2 arena and commercial buildings located to the northwest and a leisure facility to the southeast. To the west of the Blackwall Tunnel Approach carriageway a large aggregate distribution site is located. Directly south of the proposed southern tunnel portal, a single gasholder is located.

2.6 Site Reconnaissance

A preliminary site walkover of both the Greenwich Peninsula (south of the River Thames) and Silverton area, north of the River Thames, was undertaken on 14th March 2013 by Mott MacDonald in order to establish the baseline condition of the tunnel and tunnel portal sites and gather additional information pertinent to the Phase 1 contamination study.

To the north of the River Thames access to sites within the footprint of the proposed tunnel scheme was not available on this date and observation was restricted solely to viewing from above in an Emirates cable car.

A summary of the key observations made during the site reconnaissance is detailed in the following sections.

2.6.1 Silvertown Area

In the Silvertown area the tunnel follows a north-easterly alignment through an industrial estate containing large expanses of hardstanding[1], car parking areas, multiple industrial style units and aggregate screening plant.

Overlying the tunnel portal footprint area there are two rectangular parcels of land confined on the west by the River Thames and the Docklands Light Railway/Silvertown Way highway to the east. Separating these two parcels of land is a narrow ribbon of land which appears to be unused and overgrown. The tunnel portal entrance will be located in an area which is currently occupied by a narrow parcel of land containing multiple vehicles and apparent piles of refuse. Directly north a waste recycling facility is situated and west there is a large aggregate distribution facility.

The northern rectangular parcel of land is divided into an aggregate screening plant site to the west and a car park to the east (location of proposed northern tunnel portal). There appears to be a refuse pile to the southwest of the car park and a small brick building adjacent, possibly a sub- station.

The southern rectangular parcel of land is dominated in the west by a square building structure and adjacent aggregate dispensing area comprising an aggregate screening tower and transport vehicles. To the east is located a large area of hardstanding, used as a car park and containing a selection of smaller industrial units. To the south of the proposed tunnel site, a large rectangular haulage yard is located and a paint manufacturing facility immediately adjacent south of that.

2.6.2 Greenwich Peninsula

The Greenwich Peninsula site comprises a linear parcel of land running in a principally east to west direction from the Greenwich Peninsula Emirate Cable Car Terminal (adjacent the Thames) and terminating west, approximately 30m east of the Blackwall Tunnel Southern Approach (A102). The proposed tunnel alignment generally runs in a southwest to northeast alignment beneath and around Edmund Halley Way.

The majority of the proposed tunnel footprint to the east of Millennium Way underlies an area of hardstanding comprising Edmund Halley Way and car parks.

To the west of Millennium Way, at the location of the proposed tunnel portal entrance, the area comprises a storage enclosure with multiple vehicles, a metal storage container, areas of hardstanding, a small outcrop of trees and low level shrubbery.

[1] Observation of the Silvertown industrial area was undertaken offsite from height using the Emirates Cable Car facility; it was not possible to establish the integrity of any areas of hardstanding.

No current sources of contamination are evident within the footprint of the proposed scheme. However an operational gas holder is located adjacent to the southern end of the scheme, which is known to have comprised part of the South Metropolitan Gas Works (refer to site history in Section 4.1). Additionally in this area to the west of the proposed tunnel portal entrance, a large aggregate distribution site is located.

A location plan for the Greenwich Peninsula site reconnaissance is provided in Appendix A.6.

3 Geology, hydrogeology and hydrology

3.1 Geological Information Sources

A number of references of the geology of the site have been consulted in order to determine the stratigraphy and anticipated succession of geology within the study area.

References consulted are summarised in Table 3.1.

Table 3.1: Summary of Geological Maps and Memoirs

Reference	Date of Publication	Format	Publisher
England and Wales sheet 271 Dartford, Solid and Drift Geology	1998	1:50,000	British Geological Survey
England and Wales sheet 270 south London, Solid and Drift Geology	1981	1:50,000	British Geological Survey
England and Wales sheet 256 North London, Solid and Drift Geology	1994	1:50,000	British Geological Survey
Geology of London	2004	Memoir	British Geological Survey
British Regional Geology - London and the Thames Valley	1996	Memoir	British Geological Survey
Groundwater Vulnerability Map	1999	1:10000	Envirocheck report, sourced from Environment Agency
BGS Digital Geological Map Superficial and Bedrock Geology Maps		1:10,000 1:50,000	Envirocheck report, sourced from the BGS

3.2 Regional Geology

Extensive Made Ground is located to the northeast and south east of the proposed routes of the Thames river crossings. Superficial sediments exist around the docklands area comprising alluvial deposits of the flood plain of the Thames, which rest on flood plain gravels (Thames River Terrace Deposits). These superficial sediments overlie a solid geological succession comprising the London Clay Formation, the Woolwich and Reading Beds, Upnor Formation of the Lambeth Group, Thanet Sand Formation and the Seaford Chalk Formation.

Map extracts from the Envirocheck report (2013[v]) detail the Made Ground, superficial and bedrock geology of the study area. Extracts are contained within Appendix B.

In addition to the above, the presence of Made Ground is also indicated around the perimeter of the Royal Victoria Dock, the Tidal Basin and the former Royal Victoria Dock Western Entrance. Most of the Made Ground was placed to raise the level of land above the original level of the marshes which were prone to regular flooding, for example during construction of the Royal Victoria Dock. Made ground is likely to include materials generated during the demolition and redevelopment of sites in the area.

The stratigraphy of the site is summarised in Table 3.2.

Table 3.2: Regional Stratigraphy of the Site

Period	Epoch	Group	Formation
Quaternary	Holocene		Alluvium
	Pleistocene		River Terrace Deposits
Tertiary (Palaeogene)	Eocene	Thames Group	London Clay
			Harwich
	Palaeocene	Lambeth Group	Woolwich Reading Upnor
			Thanet Sand
Cretaceous	Upper Cretaceous	White Chalk	Seaford Chalk
			Lewes Chalk

3.3 British Geological Survey

Historical ground investigation borehole logs have been selected and sourced from the British Geological Survey (BGS) at locations in the immediate vicinity of the north and south tunnel portals and along the alignment of the running tunnels. This information has been used to support an understanding of the ground conditions. The historic borehole information also includes data derived for the design and construction of the Jubilee Line Extension tunnels that cross beneath the Thames and more recently, the London Cable Car crossing.

3.4 Mott MacDonald Database of Ground Investigations

Mott MacDonald has a database of information detailing previous investigations that have been carried out across the United Kingdom and in particular the greater London area. The borehole data held has been used to develop an understanding of the stratigraphy and develop the ground profiles in the following section.

3.5 Ground Profiles

The following subsections provide a description of the anticipated ground and groundwater conditions at the Silvertown study areas based upon available factual information described in Sections 3.3 and 3.4. For a more detailed explanation of the geology and ground conditions, reference should be made to the Mott MacDonald Preliminary Sources Report (2013[vi]).

The location plan of the previous ground investigation exploratory holes and the anticipated stratigraphic profile along the proposed tunnel alignment is contained in Appendix C.

North of the River Thames

Table 3.3 Typical strata boundaries in proximity of Tidal Basin Roundabout (Tunnel North Portal)

Formation	Soil Description	Top (m AOD)		Bottom (m AOD)		Top (mbgl)		Bottom (mbgl)		Thickness (m)	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Made Ground	Brick rubble, ash, sand	1.4	5.3	-9.2	1.8	0.0	0.0	1.0	14.5	1.0	14.5
Alluvium	Silty Clay	-3.2	1.8	-6.0 (EOH)	-1.1	1.0	8.1	3.2	10.3	1.5	7.7 (EOH)

Formation	Soil Description	Top (m AOD)		Bottom (m AOD)		Top (mbgl)		Bottom (mbgl)		Thickness (m)	
River Terrace Deposits	Silty sandy Gravel	-5.8	-1.1	-8.7	-4.43	3.2	10.3	6.6	13.9	1.6	4.4
London Clay	Stiff silty Clay	-9.2	-4.4	-22.3	-16.5	6.6	14.5	18	26.0	9	17.9 (P)
Harwich Formation	Very dense Gravels	-20.8	-19.5	-25.5	-20.5	14.5	26.0	15.02	30.6	0.5	5.2
Lambeth Group	Very Dense pale green blue SAND	-25.5	-20.2	-40.1 (EOH)	-27.8	15.02	30.6	30.85	45.2 (EOH)	5	15.8
Upnor Formation	Silty fine to medium SAND	-40.0	-36.4	-40.5	-39.3	30.85	44.3	33.81	45.3	1.5	3.0
Thanet Sand	Very dense grey silty fine SAND	-40.5	-39.3	-52.5	-50.4	33.81	45.8	47.0	56.9	10.02	13.2
Chalk		-52.5	-50.4	N/A	N/A	47.0	56.9	N/A	N/A	N/A	N/A

EOH End of hole
P Proven

Table 3.4: Typical strata boundaries beneath the Thames River

Formation	Soil Description	Top (m AOD)		Bottom (m AOD)		Top (mbgl)		Bottom (mbgl)		Thickness (m)	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Alluvium	Silty Clay	-9.3	-1.4	-8.9	-4.5	0.0	2	0.3	3.5	0.3	3.5
River Terrace Deposits	Sandy Gravel Silty	-8.4	-4.5	-11.3	-7.4	0.0	3.5	1.6	9.0	1.2	6.1
London Clay	Stiff silty Clay	-11.3	-7.4	-18.6	-11.9	0.4	9.0	6.6	14.7	2.7	9.6
Harwich Formation	Very dense Gravels	-17.5	-11.9	-20.4	--17.0	6.6	14.7	8.6	17.5	0.7	6.0
Lambeth Group	Very Dense pale green blue SAND	-20.4	-17.00	-38.3	-25.3	8.0	17.5	20	31.3	8.8	18.0
Upnor Formation	Silty fine to medium SAND	-35.2	-30.9	-37	-31.1	25.1	30.3	27.43	32.8	0.2	2.4
Thanet Sand	V dense grey silty fine SAND	-38.3	-25.3	-50.6	-33.4	24.7	32.8	25	46.1	0.3	14.8
Chalk		-50.6	-45.9	N/A	N/A	40.2	46.3	N/A	N/A	N/A	N/A

Table 3.5 Typical strata boundaries on the southern side of the Thames

Formation	Soil Description	Top (m AOD)		Bottom (m AOD)		Top (mbgl)		Bottom (mbgl)		Thickness (m)	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Made Ground	Brick rubble, ash, sand	2.1	5.7	-0.9	2.6	0.0	0.0	0.9	6.2	0.9	6.2
Alluvium	Silty Clay with pockets of peat	-0.9	2.6	-4.0	-0.5	0.9	6.2	3.7	9.5	1.2	4.5
River Terrace Deposits	Sandy Gravel Silty	-4.0	-0.5	-11.0	-6.9	3.66	9.5	10.4	16.0	6.0	8.4
London Clay	Stiff silty Clay	-11.0	-6.9	-16.9	-11.9	11.6	16.0	14.0	22.7	0.9	6.8
Harwich Formation	Dense black Pebbles	-16.9	-14.5	-22.8	-15.4	17.5	22.7	18.4	28.5	1.02	5.8
Lambeth Group	Very Dense pale green blue SAND	-22.7	-6.9	-35.3	-18.8	10.4	28.5	24.3	40.6	8.9	14.8
Upnor Formation*	Silty fine to medium SAND	-35.3	-	-37.4	-	40.6	-	42.8	-	2.2	-
Thanet Sand	Very dense silty fine SAND	-37.4	-18.8	-45.9	-29.5	24.3	42.8	35	49.4	10.7	12.5 (P)
Chalk*		-45.9	-	N/A	N/A	49.4	-	N/A	N/A	N/A	N/A

* Only encountered in one borehole.

3.6 Radon

According to the radon mapping for England and Wales produced by the Health Protection Agency (HPA) and BGS (2007[vii]) the location of the site falls into an area classified as having less than 1% of homes at or above the Action Level for Radon of 200Bqm-^{3}. Additionally, no protection is required from radon to satisfy the guidance in Building Regulations (New Building Research Establishment (BRE) guide BR211 (2007[viii]).

3.7 Hydrogeology

Based on the Water Framework Directive (WFD), the EA has classified three groundwater resource types (aquifers) as Principal aquifers, Secondary aquifers and Unproductive Strata based upon their capacity to supply drinking water and support ecosystems. Principal aquifers are considered to have the greatest capacity and unproductive strata the least.

The hydrogeological regime of the London Basin incorporates two key aquifers: the upper aquifer (Alluvium and River Terrace Deposits) is defined by the EA as a Secondary A aquifer. The London Clay is defined by the EA as unproductive strata and forms an aquitard between the upper and lower aquifer. The lower aquifer comprises the Lambeth Group, the Thanet Sands and the Chalk. The Chalk is classified as a Principal aquifer and as all three strata are likely to be in hydraulic continuity; this classification applies to the whole of the lower aquifer. The London Clay is thickest on the northern side of the river and is very thin (and may be locally absent) on the southern side, additionally the Lambeth Group in this area is predominantly granular, as such there may be some connectivity between the two aquifers in this area.

The River Terrace Deposits are also likely to be subject to tidal influences due to the proximity to the Thames.

A local perched water table, possibly of limited extent and volume may exist above low permeability layers in the Alluvium and Made Ground. Porous sandy units of the Made Ground and the pseudo fibrous peat within the Alluvium may retain water especially when sealed by a less permeable cohesive layer.

Historic ground investigations undertaken in the vicinity of the site encountered groundwater at elevations between -1 m AOD and +1 m AOD within the River Terrace Deposits. This is consistent with influence from the river. Groundwater can also be anticipated within the granular layers of the Lambeth Group and Thanet Sand Formation and, during the Cable Car GI in 2010, groundwater levels fluctuated between -0.67 and -1.42m AOD.

According to the Envirocheck Report[v] the proposed tunnel crossing does not lie in close proximity to a source protection zone.

3.8 Hydrology

The nearest surface water features are the Thames and the Royal Victoria Dock. In addition to these two surface water bodies, the River Lea joins the Thames adjacent to the northern approaches for the proposed tunnel alignment.

3.9 Flood risk

The Envirocheck report details the susceptibility of the site to flood risk. On the northern side of the Thames, the flood risk potential is categorised as 'Flooding from Rivers or Sea without Defences (Zone 3)' along the proposed tunnel alignment. This classification equates to a chance of flooding each year at 0.5% (1 in 200) or less and is deemed unlikely to flood except in extreme conditions (EA 2012[ix]).

On the southern side of the Thames, immediately adjacent to the Thames the flood risk is categorised as 'Extreme Flooding from Rivers or Sea without Defences (Zone 2)', whilst further inland on the Greenwich Peninsula the flood risk is defined as 'Flooding from Rivers or Sea without Defences (Zone 3)'.

The site is upstream of the Thames Barrier and is expected to be protected from a 1 in 1,000 year event.

3.10 Groundwater abstraction

Groundwater abstraction is undertaken at five locations in proximity to the site. On the north of the Thames, adjacent to the north quay of the Royal Victoria Dock, there is an abstraction well operated by Hanson Quarry Products Europe Ltd. Groundwater is utilised as process water, it is not known whether this is sourced from the Chalk aquifer.

On the south side of the Thames, one location near to the proposed tunnel alignment is situated close to the London Underground North Greenwich underground station, where there is an abstraction operated by Greenwich Peninsula N0204 Block A Nominee 1 & 2 Limited. This abstraction is sourced from the lower aquifer (Chalk).

There are two locations along the southern approaches alignment. One is operated by the Urban Regeneration Agency from a borehole situation in Boord Street (additionally abstracted for groundwater remediation). The other abstraction is by "Hanson Quarry Prod Europe Ltd" from a borehole in Victoria Deep Water Terminal, Tunnel Ave, Greenwich. It is not known whether groundwater is currently being abstracted from either of these wells.

3.11 Discharge consents

Discharge consents have been granted to approximately five operators located less than 100 metres southwest and northwest of the site. Discharge types include: cooling waters, miscellaneous discharges (mine/groundwater), "other matter[2]" to surface waters and trade effluent.

[2] Floats as debris, scum, or other such matter not comprising trade effluent.

4 Historical Development of the Site

Published historical records of the site area were obtained as part of the Envirocheck Report. In addition, supplementary information was sourced form a review of Royal Borough of Greenwich archives relating the former gas works site on the Greenwich peninsula. A plan of the gasworks from 1966 is presented in Appendix B.2 and an aerial photograph as Appendix B.3.

The two sides of the river retain a similar industrial history. The northern part of the site encompasses the Royal Victoria Docks and the historic Western Entrance to the docks that was closed in 1957.

The southern part of the site was dominated by a gasworks until 1987. Thereafter redevelopment of the site included extensive remediation to make it suitable for residential, commercial and industrial uses.

The history of the site and surrounding areas as indicated in available records are summarised in the following sections.

Table 4.1: Historical Land Use North of the River Thames

Map Year of First Occurrence (Scale)	Land Use at and in the Vicinity of the Site
1850 (1:10,560)	Site is largely undeveloped. A few lanes and a railway are shown. The 'Eastern Counties Railway' follows roughly the alignment of the current DLR, with a possible spur to the currently named 'Thames Wharf' area. To the north of the site (west of the proposed northern tunnel approach and portal), 'Northumberland and Durham Coal Company's Wharf' is written along the river bank in the current location of Thames Wharf. However, no buildings can be seen on the map.
1868 - 1869 (1:2,500)	1868 - 1869 mapping shows the Royal Victoria Dock to the northeast of the site. At its western end, there is a 'Tidal Basin' which is separated from the main dock by a lock gate. In the south western corner of the Tidal Basin there is a lock linking the basin to the Thames across which is a swing bridge. This was originally the only entrance to Royal Victoria Dock. The railway line crosses the swing bridge. On the western side of the Tidal Basin there are three buildings and then further to the west are residential buildings. The Victoria Docks Road separates the residential area from the railway. The railway is shown as having a similar alignment to the current day DLR, with spurs leading to Thames Wharf, and to some dry docks which have been constructed adjacent to the entry of the River Lea, in the area of the approaches to the northern tunnel portal. There is also a large iron works ('Thames Iron Works') to the west of the railway on the banks of the River Lea. On the northern side of the Tidal Basin there are a number of railway lines which extend to warehouses along the northern edge of the Royal Victoria Docks. Further north, the railway line pass through Tidal Basin Station and continues east approximately 100m north of the quay wall. On the bank of the Thames, to the south of the dock entrance there are several buildings designated as 'Manure Works', 'Chemical Works' and a "Sugar Refining Works". To the south and east of the Sugar Refining Works multiple tanks are present. Approximately 200m south of the Sugar Refining Works a building designated as a "Paraffin Oil Store". Several cranes are noted along the river wall.
1873 (1:10,560)	Very little change has occurred since 1868 - 1869.
1896 (1:2,500)	The Victoria Dock has now been re-named as the Royal Victoria Dock. On the western boundary of the Royal Victoria Dock a Goods and Coal depot is now present. Within the Tidal Basin there are now two jetties extending into it along with the construction of a number of buildings around the northern and western perimeter of the basin. A 'Goods and Coal Depot' is on the western side of the basin. To the north of the lock entrance the railway sidings (now called the "Royal Albert & Victoria) have been extended with many more tracks present. To the east of the railway and north of the residential buildings a cricket ground is now present. Around the southwest perimeter of the Tidal Basin and south of the lock entrance, there has been further development with a Manure Works, Chemical Works, Peruvian Guano Works, Sugar Refining Works, Soap Works and a generally larger complex of buildings. This spread of industrial buildings is located on a series of wharves called Odam's Wharf, Clyde Wharf, Hall's Wharf and Plaistow Wharf.

Map Year of First Occurrence (Scale)	Land Use at and in the Vicinity of the Site
1916 (1:2,500)	On the north side of the Thames, the mapping indicates very little change relative to 1898. The area north of the lock is now called the Thames Wharf area. The 'N. Warehouse' on the north quay is now named 'No. 23 Shed'. To the southwest of Thames Wharf a number of small piers are now present
1920 (1:10,560)	Little change has occurred since1916. There is further development of the land to the south of the Royal Victoria Dock, with additional residential buildings and industrial works. Additionally, a number of the wharves have changed name; the wharf area to the south of the lock is now called Alexandra Wharf. To the south on Pinchin's Wharf, a Malt Factory is present. A footbridge bridge is now shown crossing the lock adjacent to the swing bridge.
1938 (1:10,560)	The Royal Victoria Dock has been remodelled. Most of the jetties which extended into the Tidal Basin and into the main Royal Albert Docks have been demolished. The jetties which separated the Tidal Basin from the main Royal Victoria Dock have also been demolished creating one larger dock without the provision of a tidal basin. The cricket ground (South West Ham Cricket Ground) and many of the nearby residential buildings have also been demolished for the redevelopment of the main road through Silvertown (Silvertown Way) including new approach road from the north and a new bridge spanning the Western Entrance lock.
1940 - 1951 (1:10,560)	Very little change has occurred relative to 1938. The redevelopment of the main road through Silvertown is named North Woolwich Road and appears elevated with access from Tidal Basin Road in the north. The footbridge adjacent to the bridge crossing is not visible in the aerial photograph (1947). The Royal Docks were reported to have experienced heavy bombing during the war. Evidence of bomb damage can be seen in the aerial photograph. The 1946-1947photograph appears to show that the housing north of Tidal Basin Road is almost completely demolished.
1951 – 1952 (1:2,500) 1950 - 1955 (1:10,560)	The redevelopment of the main road through Silvertown is now complete and named A1011 Silvertown Way. Located adjacent North and south of the Tidal Basin Road Paint works are now present. To the west of Silvertown Way and south of Usk Street several garages are present. To the east of Silverton Way a number of warehouses are present on the southwest perimeter of Royal Victoria Dock. The building on the south side of the lock (in the previously named Alexandra Wharf) now appears diminished, and is now designated as "Union Mill (Oil & Cake) Works is present here. To the south of the previous Alexandra Wharf a large circular tank is present. Between Clyde Wharf and Peruvian Wharf a Varnish and Paint Works is present. To the north of the lock a Goods and Coal Depot is present adjacent the railway sidings.
1962 - 1967 (1:10,560)	Very little change has occurred relative to 1951 – 1952, although locally along the banks of the Thames there has been a reduction in the extent of some of the historic buildings. A large circular building is present on Plaistow Wharf. The building on the western side of the basin (named Good Depot in 1950) and its associated railway tracks are no longer shown. The jetty structure within the Tidal Basin on the south western side has also been demolished.
1953 – 1969/1971 (1:2,500)	Some re-development has occurred on the western perimeter of the Tidal Basin, with the construction of a warehouse building. The building adjacent south of the Union Mills building has a number of tanks present on both the north and south side. On the northern side of the lock channel some of the railway sidings have been removed.
1969 - 1974 (1:2,500)	The garages located adjacent to Silvertown Way and Usk Street are now designated as a transport depot. To the east of Thames Wharf, abutting the north and south sides of Alfred Street an Marine Engineering Works and a Depot are present, respectively To the west of the transport depot some of the railway sidings have been removed. The paint works adjacent north of Tidal Basin Road is now designated as "Works".
1981 - 1984 (1:10,560)	The railway tracks along the northern side of the Tidal Basin and again to the west of the site in the area of the former sidings have been removed. There has also been a slight modification to the configuration of the buildings immediately to the south of the lock that extends from the Thames into the Tidal Basin. The dock was closed to commercial traffic in 1981.

Map Year of First Occurrence (Scale)	Land Use at and in the Vicinity of the Site
1990 – 1991 (1:2500)	On the north side of the Thames there has been further redevelopment and landscaping around the northern side of the Tidal Basin and around the perimeter of the Royal Victoria Docks. In addition, the former Western Entrance to the dock is no longer designated 'Lock' (1990). A pumping station is now shown just to the north of the north quay. The parcel of land directly north of the lock channel is designated a Scrap Yard. To the east of the scrap yard adjacent Dock Road an Unspecified Works and Depot are present. To the northwest of Usk Street two buildings are designated as "Works".
1995 – 1996 (1:10,560)	On the north side of the Thames there is little change from 1990 – 1991. The former channel connecting the Thames to the Tidal Basin is now designated as a car park. All but one warehouse shown in the Royal Victoria Dock has been demolished. Lower Lea Crossing has been constructed, running from East India Dock basin across to Silvertown Way, ending at the roundabout to the north of the proposed tunnel route. The railway tracks leading to buildings on Thames Wharf have been removed to facilitate this.
1999 (1:10,560)	A water sports recreational centre is now located on the western side of the Tidal Basin, along with extensive residential development along the southern side of the Tidal Basin and the Royal Victoria Dock. The roundabout from the Lower Lea Crossing is now shown.
2006 (1:10,560)	The elevated DLR has been constructed to the west of Silvertown Way, along with some additional development to the west of the DLR. An embankment has been built over the Royal Albert and Victoria cut, so that the cut is now shown both sides of the embankment. The DLR crosses the former Western Entrance which is divided into sections. There has also been further residential development along the southern side of the Royal Victoria Dock along with the construction of the Excel Exhibition Centre on the northern side of the Royal Victoria Dock. It is noted that the Exhibition Centre extends into the Dock. There is also a pedestrian bridge linking the north and south sides of Royal Victoria Dock..
2012 (1:10,560)	On the north side of the Thames, on the northern side of the Tidal Basin and around the DLR infrastructure in Thames Wharf, there has been the construction of some additional buildings. This includes the London Cable Car Royal Docks terminal, constructed north west of the proposed tunnel portal. To the south of the former lock there has been some re-modelling of existing buildings. This includes demolition of part of the structure above the proposed tunnel alignment and the construction of new structures possibly over the tunnel alignment.

4.1 South of the River Thames

Map Year of First Occurrence (Scale)	Land Use in the Vicinity of the Site
1850 (1:10,560)	The site area is largely undeveloped, comprising field and a several lanes. Blackwall Lane follows the approximate alignment of the current Blackwall Tunnel Approach to the west of the site.
1868 - 1869 (1:2500)	There is a chemical works shown on the western side of the Greenwich Peninsula adjacent the proposed location of the western tunnel portal entrance. Directly north of the chemical works a parcel of land comprising a "Brick Field" is denoted. Several tanks are present within the perimeter of the Brick Field. There is a chemical works shown on the eastern side of the Greenwich Peninsula. Approximately 200m south of the Chemical Works is located an 'Iron Boat Building Yard' immediately to the east of the southern tunnel approach and a cement works and 'Thames Soap Works' east of the site boundary.
1873 (1:10,560)	The available historical mapping does not cover the majority of the study area on Greenwich Peninsula. The area to the south of the study area remains unchanged from the 1869 mapping.
1896 (1:2,500)	To the east of the Greenwich Peninsula there are a series of large buildings and the area is designated as the 'South Metropolitan Gas Works'. Around these works are a series of railway tracks. The proposed tunnel alignment is likely to be positioned below the south edge of the building and possibly partially below the rail tracks. The chemical works identified in 1869 map located along the banks of the Thames on the

Map Year of First Occurrence (Scale)	Land Use in the Vicinity of the Site
	eastern side of the Greenwich Peninsula remain present. A jetty associated with the gas works is also shown in the Thames around 150 m in length. Further industrial development is shown around the location of the proposed southern tunnel portal including two large circular structures (which are associated with the gas works on later maps) to the southeast. Located to the west are Sussex Wharf, a Wood Paving Works, Thames Silicated Stone Works and Victoria Works on the banks of the River Thames. A school is also shown to the east of the proposed road alignment. Further residential development has taken place to the north and to the south of the alignment of the proposed tunnel approaches, including a school and St. Andrew's Church. Following the completion of the Blackwall tunnel north of the study area, the Blackwall Tunnel Approach road is now present.
1916 (1:1,250)	Further expansion of the South Metropolitan Gas Works has occurred inland towards the centre of the Greenwich Peninsula and the filter beds and pools are no longer shown. To the west of the study area Blackwall Lane is now associated with the road previously named Marsh Lane. The road previously named Blackwall Lane is now designated 'Tunnel Avenue' adjacent to the Tunnel Approach. The southern part of the road previously named Blackwall Lane shows a tramway extending through a previously residential area. The parcel of land to the north of the Wood Paving Works now comprises Greenwich Linoleum Works. A cricket ground and football ground with a pavilion are shown along the alignment of the proposed southern tunnel approach. The railway line associated with the South Metropolitan Gas Works now connects to a newly built line carried on an embankment.
1920 (1:10,560)	Very little change relative to 1916. Further residential development continues to the south east of the proposed tunnel approach infrastructure, including allotments.
1938 (1:10,560)	An unnamed linear feature, possibly associated with the gas works, is now present.
1940 - 1951 (1:10,560)	Very little change has occurred since 1938. The aerial photograph (1948) shows that there is possibly a bund of earth just to the north of the two circular structures near the proposed tunnel approach infrastructure
1950 - 1952 (1:1,250)	Some additional buildings have been constructed on the east of the Greenwich peninsula immediately onshore from the jetty structure and a further extension of the jetty to the south east has been undertaken. One of the large buildings associated with the gas works on the eastern bank of the Greenwich Peninsula is designated as the Retort House. Further infrastructure associated with the gas works is also shown including several conveyors, tanks, hoppers and a "travelling crane". Additionally, several substations are to the north and east of the Retort House. The chemical plant near the river (south of the tunnel alignment) has expanded inland (following the previous large scale map from 1916). On the western side of the Greenwich Peninsula, to the north of Weetman Street, several tanks have appeared "Blackwall Tunnel Approach" now extends into "Tunnel Avenue" to the south (in the location of the 1916 map tramway).
1965 - 1968 (1:1,250)	Some change relative to 1940 – 1950. Retort House has been downsized and immediately to the north the former industrial building has been replaced with a gas works with gas tanks. Further infrastructure, associated with the gas works, has also been extended further inland. Some of the infrastructure appears to be labelled 'tanks'. The railway heading south from the gas works is not shown on the map.
1973 - 1975 (1:1,250)	The building overlying the proposed tunnel on the southern side of the gas works has been demolished. However, the tanks and infrastructure (mostly hoppers/cranes) which are located along the alignment of the proposed tunnel approaches remain. The railway associated with the gas works appears to have been dismantled. The embankments leading south from the gas works are still shown. A footbridge is now shown passing over Tunnel Avenue from Sigismund Avenue to near Boord Street and Greenfell Street. The second Blackwall Tunnel is now shown with Ordnance Crescent re-aligned and upgraded to accommodate the additional traffic.
1981 - 1984 (1:10,560)	On the south side of the Thames there is very little change relative to 1973 – 1975 maps. The residential development near the large circular structures has been demolished. A building associated with the gas works at Phoenix Wharf, south of the proposed tunnel alignment, has

Map Year of First Occurrence (Scale)	Land Use in the Vicinity of the Site
	also been demolished.
1990 – 1991 (1:2,500)	Further demolition of existing gas works structures has occurred on the Greenwich Peninsula. The majority of the remaining infrastructure is no longer present. The two large circular structures (gas holders) in the vicinity of the proposed western tunnel portal approach still remain. The former residential area near the circular structures is now labelled "Lorry Park". The historic church is no longer shown (on the smaller scale maps) and the historic school is now labelled 'Warehouse'.
1995 – 1996 (1:10,500)	The northern of the two circular structures (gas holders) is no longer shown.
1999 (1:10,500)	On the south side of the Thames there has also been further demolition of existing structures on the Greenwich peninsula adjacent to the jetty along with the construction of the Millennium Dome (currently the O_2 arena). The London Underground Jubilee Line station North Greenwich is also shown on the map with the surrounding infrastructure being in the process of being completed.
2006 (1:10,500)	On the south side of the Thames the historic jetty has been demolished and replaced by a new structure located slightly further into the Thames. Onshore adjacent to the new jetty there has been landscaping works and the construction of what appears to be paved areas between the tube station and the Millennium Dome. Edmund Halley Way has now been constructed. A small building is now shown on the south side of Edmund Halley Way. The road junction at the location of the lower extent of the proposed tunnel approach infrastructure has been changed to connect to John Harrison Way.
2012 (1:10,500)	A Football Centre now occupies the land to the south of the tunnel alignment, on the eastern side of the Greenwich Peninsula. The map shows the newly built London Cable Car Greenwich Peninsula terminal, which overlies the proposed tunnel alignment. The map also shows a number of developments to the north of proposed tunnel alignment, south east of the O_2 arena.

4.2 Historical map review summary

4.2.1 Silvertown Area – summary key issues from historic maps

A review of historic maps has identified a number of potential contamination sources with respect to the proposed development:

- On-site potential contamination sources comprising former and on-going industrial activities include: Rail land (including coal and goods depots), manure works, chemical works, warehouses, a scrap yard, marine engineering works, a depot and several garages and unspecified works.
- Off-site potential contamination sources comprising former and on-going industrial activities include: Rail land, iron works, manure works, sugar refining works, an oil paraffin store, Peruvian guano works, soap works, malt factory, and paint works.
- A number of former storage tanks have been identified both on-site and off-site;
- A large area of infilled ground, formerly the Western Entrance to the Royal Victoria Docks; and
- Possible unexploded ordnance from aerial bombing during the Second World War.

4.2.2 Greenwich Peninsula – summary key issues from historic maps

A review of historic maps has identified a number of potential contamination sources with respect to the proposed development:

- On-site potential contamination sources comprising former and on-going industrial activities include: Rail land (including coal and goods depots), South Metropolitan Gas Works (including associated infrastructure) and substations. A plan of the gasworks dating from 1969

- Off-site potential contamination sources comprising former and on-going industrial activities include: Rail land, several chemical works, cement works, silicate stone works, soap works, warehouses, wood paving works, Victoria works and Greenwich linoleum works.
- A number of former on-site and off-site storage tanks have been identified on both eastern and western sides of the Greenwich Peninsula.

4.3 Potential Contaminants of Concern

4.3.1 Silvertown Area

4.3.1.1 On-site

Typical contaminants associated with the previous on-site land uses found by the study could include, heavy metals, complex and free cyanide, nitrates, sulphates, sulphides, asbestos, polycyclic aromatic hydrocarbons (PAHs), phenols, acetones, aromatic hydrocarbons, polychlorinated biphenyls (PCBs), dioxins, furans, volatile organic compounds (VOCs), total petroleum hydrocarbons (TPH), ethanol/methanol, ammonia, chlorinated alkalis, fuel and oil hydrocarbons, benzene, toluene, ethylbenzene, xylenes (BTEX) and arsenic.

4.3.1.2 Off-site

Typical contaminants associated with the off-site potential contamination sources would include: heavy metals, PAHs, phenols, fuel and oil hydrocarbons, cyanide, sulphates, PCBs, aromatic hydrocarbons, organolead compounds, asbestos, BTEX compounds, chlorinated aliphatic hydrocarbons and VOCs.

4.3.2 Greenwich Peninsula

4.3.2.1 On-site

Typical contaminants associated with the previous on-site land uses found by the study include: heavy metals and metalloids , cyanide, thiocyanate, sulphates, sulphide, asbestos, PAHs, phenols, acetones, ethanol, methanol, ammonia and ammoniacal liquors, aromatic hydrocarbons, PCBs, VOCs, TPH (such as oils/fuels), BTEX.

4.3.2.2 Off-site

As 4.3.2.1.

5 Other Environmental Information

5.1 Introduction

The following sections describe other records pertinent to land condition at and in the vicinity of the site.

The records comprise the following:

- Waste activities including: registered waste treatment and disposal sites, landfill site (both historic and current), registered and licensed waste transfer stations
- Fuel station entries;
- Contemporary Trade Directory entries;
- Regulatory permit and license registers, including: Integrated Pollution Prevention and Control Permits, Local Authority Pollution Controls and Control of Major Accident Hazards Sites
- Sensitive land uses, including statutory and non-statutory designations including: Sites of Special Scientific Interest, Areas of Outstanding Natural Beauty, Sites of Nature Conservation; and
- Unexploded ordnance.

5.2 Waste Activities

A summary of waste activities within 100m of the site are contained within Table 5.1 and significant entries are discussed below.

Table 5.1: Summary of waste activities

Record / Source of Information	On Site	0m to 50m	51<100m from Site
Recorded Historic Landfill Sites	2	0	0
Licensed Waste Management Facilities	1	0	0
Registered Waste Treatment Site	0	1	1

The Envirocheck report identifies landfill on both the northern and southern sides of the Thames within the footprint of the proposed scheme. On the north side the landfill is situated in the location of the proposed northern tunnel portal and is associated with the infilling of the former Western Entrance lock to the Royal Victoria Dock.

On the south of the Thames, EA records indicate the area immediately adjacent to and underlying the south portal of the tunnel (the East Greenwich Site) as landfill containing inert waste such as glass, concrete, bricks, tiles, soil and stones. To the southeast of Edmund Halley Way is located another landfill situated over the site of a former Coalite Works. The Environment Agency records this landfill as containing inert waste such as glass, concrete, bricks, tiles, soil and stones.

To the southwest of the remaining gasholder neighbouring the Blackwall Tunnel Approach is a registered waste treatment or disposal site. The site has now surrendered it's license and been issued a completion certificate by the Environment Agency.

5.3 Fuel Station Entries

There are no fuel station entries registered within 250m of the site.

5.4 Other Environmental Records

Other environmental records are contained in Table 5.2: Other Environmental Records and notable entries discussed below.

Table 5.2: Other Environmental Records

Record / Source of Information	On site	0m to 50m	51<100m from Site
Contemporary Trade Directories	3	0	3
Part A(1) Integrated Pollution Prevention and Control (IPPC), and former Integrated Pollution Control (IPC) authorisations	1	0	1
Control of Major Accident Hazards (COMAH) Sites	0	2	0

5.4.1 Contemporary Trade Directory Entries

There are three contemporary trade directory entries within the footprint of the site. Notable classifications include printing, concrete and mortar production and commercial cleaning services in the location of the proposed Silvertown tunnel portal.

5.4.2 Local Authority Pollution Prevention and Control Permits

A single Local Authority Pollution Prevention and Control permit has been issued in the Silvertown area, within the proposed highways development area, adjacent Dock Road. This is for blending, packing, loading and use of bulk cement.

5.4.3 COMAH Sites

Two entries exist for COMAH sites within 50m of the site. These both relate to lower tier incidents in the vicinity of the gas holder adjacent to Millennium Way which is subject to a COMAH designation. A plan showing the Health and Safety Executive development exclusion zones associated with this facility is presented in Appendix A.5.

5.4.4 Part IIA notices

There are no sites determined as Contaminated Land under Part IIA of the Environmental Protection Act 1990 within 250m of the site.

5.1 Sensitive land uses

Sensitive land uses comprise statutory and non-statutory designations such as sites of special scientific interest or areas of outstanding natural beauty. The Envirocheck report has not identified any ‘Sensitive Land Uses’ near the tunnel, tunnel portals or highway areas or within the greater study area.

5.2 Unexploded Ordnance (UXO)

The findings of the UXO assessment are detailed in the 'Detailed Unexploded Ordnance (UXO) Risk Assessment' report, prepared by 6 Alpha Associates. For the purposes of the assessment the site was divided into three areas:

- The area north of the River Thames;
- The River Thames; and
- The area south of the River Thames.

The assessment established that in the areas north and south of the River Thames, there is a 'Medium/High' risk of encountering UXO. However, in the River Thames, where bomb strikes are considered more likely to go unnoticed, the risk level is increased to 'High'. This is highlighted in WWII High Explosive (HE) bomb strike location plan shown in Appendix D.

6 Alpha have recommended that once the scheme design and construction programme has been finalised, a detailed UXO risk mitigation strategy should be developed for the project. For the areas north and south of the River Thames, 6 Alpha have recommended that, in the first instance, that both non-intrusive and intrusive survey methods may be employed to clear the site of any potential UXO threat in advance of any intrusive ground works.

For the River Thames section, 6 Alpha have recommended that a magnetometer survey should be employed to clear the site of any potential UXO threat. Where any intrusive ground works, such as ground investigation, piling or tunnelling are to be undertaken, 6 Alpha have advised that a specialist UXO banksman should be present on site to identify the potential for any UXO threat.

6 Ground Investigation and Remediation Data

6.1 Cable Car Ground Investigation 2010

During the Cable Car Ground Investigation undertaken in October 2010, three separate areas within the footprint of the proposed Silvertown Tunnel were subject to intrusive investigation. A summary of each investigation area is provided below with exploratory borehole positions shown on the plan contained in Appendix E.1 – E.3.

6.1.1 Overlying the Former Royal Victoria Dock Western Entrance

Overlying the former Royal Victoria Dock Western entrance, an intrusive investigation comprising six trial pits and seventeen boreholes was undertaken. The majority of boreholes terminated at shallow depths within the Made Ground due to obstructions; however a single borehole (NIT BH02) was terminated at depth, in the Seaford Chalk at 60.75m.

6.1.1.1 Soil Sampling

Soil sampling for contamination testing was confined to the Made Ground. Laboratory analysis identified a number of contaminants present above their respective limit of detection concentrations, including: Polycyclic Aromatic Hydrocarbons (PAH), lead and Volatile Organic Compounds (VOCs). Asbestos fibres were also identified in a number of locations. In the shallower Made Ground, slightly elevated concentrations of heavier end TPH and BTEX compounds were recorded in several trial pit locations.

6.1.1.2 Groundwater

Groundwater monitoring wells were installed in a range of geological strata and this information is outlined in Table 6.1.

Table 6.1 Groundwater monitoring installations

Borehole	Installation type	Top of Response Zone (m bgl)	Base of Response Zone (m bgl)	Average Groundwater Level (m bgl)	Response Strata
NIT BH01A	Standpipe	1.00	7.00	0.48	Made Ground
NIT BH02	Standpipe	58.00	60.00	6.21	Seaford Chalk
NIT BH04	Standpipe	0.50	7.40	2.3	Made Ground

Average groundwater levels calculated in NIT BH01A and NIT BH04 indicate the presence of a perched water body. Groundwater samples taken from NIT BH01A recorded marginally elevated concentrations of PAH, phenols and heavier end TPH.

6.1.1.3 Ground Gas

Ground gas monitoring was undertaken in boreholes NIT BH01A and NIT BH04 to provide data on the land gas regime at the former Royal Victoria Dock entrance landfill site. The results are summarised in Table 6.2.

Table 6.2: Summary of gas monitoring results

Borehole	Max Flow Rate (l/hr)	CH_4 Peak (%vol)	O_2 min (% vol)	CO Peak (ppm)	CO_2 Peak (%vol)	H_2S (%)
NIT BH01A	0.1	11.5	17.4	<1	<0.1	<1
NIT BH04	0.2	12.5	18.5	3.8	<0.1	<1

Methane was recorded in both boreholes at maximum concentrations of 11.5 and 12.5% respectively. Maximum methane concentrations were accompanied by corresponding minimum oxygen concentrations of 17.4 and 18.5%. In NIT BH04, peak carbon monoxide concentrations reached 3.8ppm. Maximum flow rates in NIT BH01A and NIT BH04 were 0.1 and 0.2 l/hr respectively.

The elevated methane concentrations may be regarded as relatively high. The source of the methane could relate to made ground with high organic matter content, through flow from the underlying alluvium or possibly some cross gas interference associated with hydrocarbon contamination. The readings are between the lower and upper explosive limits for methane at 5% and 15% respectively. The gas flow rates can be considered however as very low/negligible. When considering gas risks to buildings it normal to use both the concentration of the gas and the flow rate (to derive a gas screening value) which in this case gives an overall relatively low risk – although risks to personnel during construction must be recognised.

6.1.2 Adjacent, South of the Former Royal Victoria Dock Western Entrance

A ground investigation comprising four trial pits and eleven boreholes was undertaken on an industrial site abutting the east bank of the River Thames and adjacent to the south of the former Royal Victoria Dock Western Entrance. Borehole depths ranged between 4m bgl in the Made Ground (NT DS01) to 61.07m bgl in the Seaford Chalk (NT BH02).

6.1.2.1 Soil Sampling

Laboratory analysis of the Made Ground confirmed the presence of elevated arsenic, lead concentrations including concentrations of PAH and VOC above the limit of detection. Asbestos (in the less hazardous form Chrysotile) was also encountered in the Made Ground. A single soil sample from within the deeper River Terrace Deposits (NT BH02 at 13m bgl) identified PAH concentrations marginally above the limit of detection.

6.1.2.2 Groundwater

Groundwater monitoring wells were installed in a range of geological strata and this information is outlined in Table 6.3.

Table 6.3 Groundwater monitoring installations

Borehole	Installation type	Top of Response Zone (m bgl)	Base of Response Zone (m bgl)	Average Groundwater Level (m bgl)	Response Strata
NT BH01	Standpipe Piezometer	49.00	50	3.96	Lower Mottled Beds (Lambeth Group)
NT BH02	Standpipe Piezometer	36.00	40	7.20	Thanet Sand Formation
NT DS01	Standpipe	1.00	2.00	1.03	Made Ground
NT DS02F	Standpipe	1.00	3.00	1.25	Made Ground

Elevated concentrations of PAHs, metals and phenolic compounds were recorded in groundwater samples from boreholes NT DS01 and NT DS02F, completed in the Made Ground. Marginally elevated concentrations of PAH and phenolic compounds were recorded in groundwater samples from boreholes NT BH02 and NT BH01. Additionally, BTEX compounds were identified in a groundwater sample from NT BH02.

6.1.2.3 Ground Gas

Ground gas monitoring was undertaken in boreholes NT BH01, NT BH02, NT DS01 and NT DS02E to gain an understanding of the underlying land gas regime. Gas monitoring results are summarised in Table 6.4.

Table 6.4: Summary of gas monitoring results

Borehole	Max Flow Rate (l/hr)	CH_4 Peak (%vol)	O_2 min (% vol)	CO Peak (ppm)	CO_2 Peak (%vol)	H_2S (%)
NT DS01	0.1	<0.1	20.6	5.6	0.2	<1
NT DS02F	0.3	<0.1	0.3	1.2	3.8	<1

* Not detected

A maximum flow rate of 0.3l/hr was recorded in NT DS02F. Methane was not recorded above detection limit. A minimum oxygen concentration of 0.3% was recorded in NT DS02F. Peak carbon dioxide and carbon monoxide concentrations were only slightly elevated and recorded in NT DS02F (3.8%) and NT DS01 (5.6ppm) respectively.

Oxygen concentrations ranged between 0.3% in NT DS02F and 20.6% in NT DS01.

6.1.3 Cutter Lane, adjacent to the Emirates Greenwich Peninsula Terminal

A ground investigation was undertaken to the south of the River Thames, on a parcel of land neighbouring Cutter Lane. Thirteen boreholes were drilled, although only six are located in close proximity to the footprint of the proposed tunnel development and therefore considered within this review. Borehole depths range between 3m bgl (terminating in the Made Ground) to 45.00m bgl (terminating in the Thanet Sand Formation.

6.1.3.1 Soil Sampling

Soil sampling was undertaken from a range of strata including Made Ground, Alluvium, River Terrace Deposits and the upper levels of the London Clay Formation, although laboratory analysis restricted to the Made Ground. Laboratory analysis identified a number of contaminants in concentrations above the laboratory limit of detection within the Made Ground including: PAHs, BTEX compounds, metals, metalloids, TPH and VOCs. Additionally, fibres of all three types of asbestos (Chrysotile, Crocidilite and Amosite) were detected during an asbestos screening.

6.1.3.2 Visual and Olfactory Evidence of Contamination

Hydrocarbon odours were recorded below 0.6m to depths of up to 5.5m within the Made Ground. Additionally, Clinker, ash or coal was noted within Made Ground below 0.6m to depths of 4.6m. A strong hydrocarbon odour was noted within the alluvial strata at 6.7mbgl in a single location.

As outlined in Section 6.2, a capping layer and capillary break layer were installed to separate users from contamination that remained in the underlying Made Ground, as part of the remediation works undertaken on the Greenwich Peninsula. This layer was encountered as an orange and black plastic geomembrane in all exploratory locations. No soil samples were taken from within the remediation layer.

6.1.3.3 Groundwater

Groundwater monitoring wells were installed in the Made Ground and River Terrace Deposits, this information is summarised in Table 6.5 Groundwater monitoring installations

Table 6.5 Groundwater monitoring installations

Borehole	Installation type	Top of Response Zone (m bgl)	Base of Response Zone (m bgl)	Average Groundwater Level (m bgl)	Response Strata
SS BH01C	Standpipe Piezometer	9.00	15.00	6.67	River Terrace Deposits
SS BH02D	Standpipe Piezometer	27.0	28.0	6.37	Lambeth Group
SS BH03	Standpipe Piezometer	43.0	44.00	6.52	Lambeth Group
SS BH03	Standpipe	1.2	4.00	6.52	Made Ground
SS DS02	Standpipe	1.00	3.00	2.9	Made Ground
SS DS03	Standpipe	1.00	3.00	Dry	Made Ground
SS DS04	Standpipe	2.1	4.1	Dry	Made Ground

Elevated concentrations of PAHs, BTEX compounds, metals, TPH, VOCs and phenolic compounds were recorded in a groundwater sample from the River Terrace Deposits (borehole SS BH01C). Marginally elevated concentrations of PAH, phenolic compounds and TPH were recorded in groundwater samples from borehole SS BH03 (in the Thanet Sand Formation).

6.1.3.4 Ground Gas

Ground gas monitoring was undertaken in boreholes SS BH03, SS DS02, SS DS03 and SS DS04. The results are summarised in Table 6.4.

Table 6.6 Summary of gas monitoring results

Borehole	Max Flow Rate (l/hr)	CH_4 Peak (%vol)	O_2 min (% vol)	CO Peak (ppm)	CO_2 Peak (%vol)	H_2S (%)
SS BH03	1.0	0.5	0.3	5.7	4.4	<1
SS DS02	0.2	<0.1	5.9	5.8	0.9	<0.1
SS DS03	0.2	<0.1	5.9	3.8	1.1	<1
SS DS04	0.2	0.3	5.8	<1	4.8	<1

A maximum flow rate of 1.0 l/hr was recorded in SS BH03. Methane was recorded in wells screening the Made Ground with a maximum concentration of 0.3% recorded in SS DS04. Carbon dioxide was encountered in all wells, at concentrations ranging between 0.9 – 4.8%. Peak carbon monoxide concentrations were recorded in SS DS02 at 5.8ppm. Methane and carbon dioxide concentrations recorded were low however a notable flow rate of 1 l/hr was recorded in one location (SS BH03). Additional ground gas installations and gas monitoring should be undertaken in order to fully characterise the underlying land gas regime in this area.

Elevated concentrations of VOCs were detected in SS BH03, which screens the Made Ground.

6.2 Previous Remediation Works

Extensive remediation is known to have taken place on Greenwich Peninsula which was previously dominated by the South Metropolitan Gasworks. The remediation undertaken is summarised in the Buro Happold Geo-environmental Report (2011[x]) Following the industrial use of the site, land was subject to two phases of remediation. These stages were:

- Statutory Remediation', undertaken by Port Greenwich Limited (British Gas PLC) in 1996/97; and
- Development Remediation', undertaken by English Partnership's during the period 1997 –1999.

6.2.1 Statutory Remediation

The statutory remediation works were designed to remove the major source areas of contamination. This was largely achieved by removal of buried infrastructure and the excavation and disposal of heavily contaminated soils off-site to landfill. However it also included in-situ remediation of benzene contamination by dual-phase groundwater and soil vapour extraction.

6.2.2 Development Remediation

Following English Partnership's purchase of land on the northern and eastern side of Greenwich Peninsula from British Gas in 1997, it was necessary to supplement elements of the statutory remediation scheme in order to prepare the land for the proposed Millennium Exhibition, including the study area.

Extensive site investigations and a remediation strategy were developed by WS Atkins. An extract from the WS Atkins Area 3 and 6 remediation plan showing remediation zones in the study area is given in Appendix B.4.

Development remediation is known to have been undertaken for the entirety of the eastern side of the Greenwich peninsula in the region of the proposed tunnel and tunnel portal sites. Remediation was limited to the eastern side with the boundary approximately demarcated by the Blackwall Tunnel Approach carriageway.

The development remediation and site enabling works included additional removal of buried infrastructure and contaminated soils and installation of barrier systems to prevent migration of vapour and human contact with contaminated ground. The areas under roads and car parks were capped by hard standing, and in park areas, a marker sheet was laid above contaminated soils, followed by a capillary break, geotextile and 900 mm of clay. Although two phases of remediation have been undertaken, the ground remains heavily affected by contaminants locally beneath the engineered capping layer across the Millennium site, thus leading to a potential risk of contaminant migration during the construction phase.

It is understood from the Royal Borough of Greenwich that as part of the remediation groundwater quality is monitored by Atkins on a yearly basis. Although monitoring is relatively sparse within the study area, general trends are that concentrations of various contaminants have stabilised or reducing in the shallow aquifer (although it is noted that there is a tidal influence on quality which is difficult to assess at the annual resolution of the monitoring). Impacts from contaminants (in particular organic contaminants such as TPH

and PAHs) to the deeper aquifer are worse in the northern part of the peninsula away from the location of the proposed works.

6.2.3 East Greenwich Gas Holder

Located to the south of the proposed southern tunnel portal entrance a gas holder structure currently exists on Blackwall Lane. Previous records indicated this gas holder to be under the jurisdiction of National Grid (formerly BG Transco) however when further queried it was understood that Scotia Gas Networks now contain this structure within their portfolio.

Unfortunately no further written information regarding the gas holder was forthcoming however discussion was held with the local plant engineers and it is understood that this gas holder has recently (since May 2013) been decommissioned and is no longer active. Due to confidentiality the date for dismantling of the gas holder was not divulged at this time although it was of the opinion of the local plant engineers that this would not be occurring for some years ahead.

A record of correspondence and conversation records is contained within Mott MacDonald report *Silvertown Tunnel - Further development of Tunnel Engineering* (Report No. 298348/MNC/TUN/002).

7 Conceptual Model and Hazard Assessment

7.1 Regulatory framework

The primary regulatory regime under which contaminated land is managed in the UK is Part IIA of the Environmental Protection Act (EPA), 1990.

Section 78A of the Act provides the legal definition of "contaminated land" "…any land which appears to the local authority in whose area it is situated to be in such a condition, by reasons of substances in, on or under the land that:

- Significant harm is being caused or there is the significant possibility of such harm being caused; or
- Significant pollution of controlled waters is being caused, or there is a significant possibility of such pollution being caused…"

The majority of the inspection and remediation of land contamination is however managed through the planning process as sites are redeveloped. Typically this is managed via a set of planning conditions relating to land contamination under the Town and Country Planning Act, although other avenues are possible, such as a Hybrid Bill, or Development Consent Orders (DCO).

The framework for the assessment of potential land contamination adopted in this report (as required by the aforementioned) is based on current guidance documents regarding the implementation of Part IIA of the EPA 2012[xi]) and the assessment of potentially contaminated land, with particular reference to CLR 11[ii], CIRIA C552[iii] and BS10175.

7.2 Development of conceptual model

A key element of undertaking an environmental risk assessment is the development of a conceptual model of the site that describes the environmental features of the site together with the expected interaction of potential contamination sources with the environment. This is done by undertaking a Source – Pathway – Receptor analysis of the site:

- Sources (S) are potential or known contaminant sources e.g. a former fuel storage area
- Pathways (P) are environmental systems thorough which a contaminant could migrate e.g. air, groundwater
- Receptors (R) are sensitive environmental receptors that could be adversely affected by a contaminant e.g. site occupiers, groundwater resources.

Where a source, relevant pathway and receptor are present, a pollutant linkage is considered to exist whereby there is a circumstance through which environmental harm could occur and a potential environmental liability is considered to exist.

A summary of potential sources, pathways and receptors relevant to the site are described below and given alpha numeric codes for identification (e.g. S1 – Source 1).

Conceptual models for both north and southern sections of the proposed tunnel development area have been constructed. The models consider the site as it is currently and also in consideration of the proposed scheme works (i.e. proposed tunnel, tunnel portals and adjacent highway area redevelopment).

The conceptual model considers the current status of the site along with the redevelopment of the site for the proposed construction phase of the Silvertown Tunnel Crossing development. The assessment considers risk to current workers and workers involved in the site's redevelopment, in addition to controlled waters and built environment receptors.

The following assessment assumes that areas of highway redevelopment will either be hard covered or that the existing remediation capping will be reinstated on completion. This action would effectively sever the critical pollutant linkage and therefore the risks to motorists or other land users (e.g. pedestrians) within the scheme footprint are not considered in the following conceptual model.

The tunnel design incorporates a ventilation system which effectively removes any gas pathways and subsequent gas risks to motorists within the tunnel. As this pathway has been removed, this pollutant linkage has not been considered within the following conceptual model. An exception is potential future maintenance workers who may be required to access below ground excavations.

7.3 Silvertown Area Conceptual Model – Hazard Identification

7.3.1 Sources of Contamination

7.3.1.1 On site

S1. Contaminated soils from on-going activities on site such as the aggregate manufacturing facilities, waste recycling facilities and scrap metal yard.

S2. Residual contamination from former onsite activities such as the chemical works, oil storage facility and multiple dockland warehouses.

S3. Ground gases within the Made Ground and Alluvium. Previous investigation at the site has recorded varying and in some locations elevated levels of carbon dioxide, carbon monoxide and methane to be present within the Made Ground, particularly within the infilled former Royal Victoria Dock Western Entrance area.

S4. Contaminated perched water in the Made Ground. Previous site investigation has identified elevated concentrations of PAHs, metals, phenolic compounds and TPH within bodies of perched water in the Made Ground.

S5. Groundwater contaminated by historic land uses such as the former chemical works.

7.3.1.2 Off Site

S6. Contamination from ongoing activities located off-site such as the paint works to the south of Clyde Wharf and surrounding warehouses.

S7. Residual contamination from former activities located off-site such as manure works, iron works and soap works.

7.3.2 Potential Contamination Transport Pathways

P1. Human uptake pathways: ingestion of exposed contaminated soil and water during construction and maintenance involving excavation; inhalation of soil/dust, volatilised compounds or ground

gas via migration through permeable strata and conduits; or dermal contact with exposed soils and water during construction and maintenance involving excavation;

P2. Offsite gas/ soil vapour migration (by diffusion or due to wind) and wind-blown dust contaminant pathways from disturbance during construction activities

P3. Horizontal and vertical migration of leachable contaminants via groundwater within the Made Ground and River Terrace Deposits;

P4. Migration of contaminated liquids/groundwater into the lower aquifer through the creation of preferential pathways (for example during the piling operations, in addition to the disturbance of perched groundwater during excavation/construction activities)

P5. Gas migration through permeable strata or conduits into confined spaces at potentially asphyxiant or explosive concentrations.

P6. Direct runoff into the River Thames; and

P7. Direct contact of soils with construction materials.

7.3.3 Potential Receptors

7.3.3.1 Human Receptors

R1. Construction workers involved in site works such as groundworks and tunnel excavation works, in addition to those present in offices on site;

R2. Adjacent site users during construction, such as those within residential properties and workers in the surrounding commercial areas;

R3. Tunnel end users (maintenance workers).

7.3.3.2 Environmental receptors

R4. Groundwater within the upper aquifer (River Terrace Deposits)

R5. Groundwater within the lower aquifer of the Lower London Tertiaries and Chalk Group

R6. Surface water body (River Thames)

7.3.3.3 Built environment receptors

R7. Fabric of tunnel building, infrastructure and services (such as impact by hydrocarbons and high sulphate levels)

7.4 Conceptual Model

Based upon the potentially active Sources, Pathways and Receptors defined in the previous sections, a conceptual model can be derived, including the potential pollutant linkages presented below:

Table 7.1: Potential Pollutant Linkages at this Site

Source	Pathway	Receptor
S1 + S2. Contamination from on-going and former on-site land uses.	P1. Human uptake pathways such as inhalation, ingestion or dermal contact	R1. Construction workers undertaking tunnel construction/excavation works
	P1. Human uptake pathways such as inhalation, ingestion or dermal contact	R3. Tunnel end users (maintenance workers)
	P2. Migration of soil vapour, volatile organic compounds (by diffusion or due to wind) and windblown dust contaminant pathways	R2. Adjacent site users
	P3. Horizontal and vertical migration of leachable contaminants via perched water within the Made Ground	R6. River Thames
	P6. Direct runoff	
	P4: Migration of contaminated liquids/groundwater into the upper and lower aquifers through the creation of preferential pathways (for example during tunnel excavation)	R4. Upper aquifer
		R5. Lower aquifer
	P7: Direct contact	R7. Fabric of tunnel building and services
S3. Elevated carbon dioxide, carbon monoxide and methane levels in the infilled lock entrance:	P5. Gas/vapour migration through pipes/foundations, along piles and into structures	R1. Construction workers undertaking tunnel construction/excavation works
		R3. Tunnel end users (maintenance workers)
S4. Perched water bodies in the Made Ground	P1. Human uptake pathways such as inhalation, ingestion or dermal contact	R1. Construction workers undertaking tunnel construction/excavation works
	P3. Horizontal and vertical migration of leachable contaminants via groundwater within the Made Ground	R4. Upper aquifer
		R6. River Thames
	P4: Migration of contaminated liquids/groundwater into the lower and upper aquifer through the creation of preferential pathways (for example during tunnel excavation)	R4. Upper aquifer
		R5. Lower aquifer
S5. Groundwater contaminated by historic land uses such as the former chemical works.	P1. Human uptake pathways such as inhalation, ingestion or dermal contact	R1. Construction workers undertaking tunnel construction/excavation works
	P1. Human uptake pathways such as inhalation, ingestion or dermal contact	R3. Tunnel end users (maintenance workers)

Source	Pathway	Receptor
	P5. Gas migration through permeable strata or conduits into confined spaces at potentially asphyxiant or explosive concentrations.	
	P3. Horizontal and vertical migration of leachable contaminants via groundwater in the Made Ground and River Terrace Deposits	R6. River Thames
		R4. Upper aquifer
	P4: Migration of contaminated liquids/groundwater into the lower and upper aquifers through the creation of preferential pathways (for example during tunnel excavation)	R4. Upper aquifer
		R5. Lower aquifer
	P7: Direct contact	R7. Fabric of tunnel building and services
S6 + S7. Contamination from on-going and former off-site land uses	P3. Horizontal and vertical migration of leachable contaminants via groundwater → P1. human uptake through: ingestion, inhalation or dermal contact	R1. Construction workers undertaking tunnel construction/excavation works
	→ P3. Horizontal and vertical migration of leachable contaminants via groundwater	R3. Tunnel end users (maintenance workers)
		R4. Upper aquifer
	→ P7: Direct contact	R7. Fabric of tunnel building and services
	P5. Gas/vapour migration through pipes/foundations, along piles and into structures → P1. human uptake through: ingestion, inhalation or dermal contact	R1 Construction workers undertaking tunnel construction/excavation works and
		R3. Tunnel end users (maintenance workers)

A schematic representation of this conceptual model is presented in Appendix G.

7.5 Greenwich Peninsula Conceptual Model – Hazard Identification

7.5.1 Sources of Contamination

7.5.1.1 On site

S1. Residual contamination from former onsite activities such as the South Metropolitan Gasworks and associated rail land.

S2. Contaminated perched water in the Made Ground. Previous site investigation has identified elevated concentrations of PAHs, metals, phenolic compounds and TPH within bodies of perched water in the Made Ground.

S3. East Greenwich Landfill. A large extent of the proposed tunnel development including the western tunnel portal will be constructed in the footprint of the East Greenwich Historic landfill. Potential source of elevated ground gas levels and leachate.

S4. River Terrace Deposits. Contaminated groundwater within the River Terrace Deposits.

7.5.1.2 Off Site

S5. Contamination from on-going activities offsite. Offsite aggregate processing works and disused gasholder.

S6. Residual off-site contamination sources (such as for cement works, chemical works, iron building works, wood paving and linoleum works).

7.5.2 Potential Contamination Transport Pathways

P1. Human uptake pathways: ingestion of exposed contaminated soil and water during construction and maintenance involving excavation; inhalation of soil/dust, volatilised compounds or ground gas via migration through permeable strata and conduits; or dermal contact with exposed soils and water during construction and maintenance involving excavation.

P2. Off-site gas/ soil vapour migration (by diffusion or due to wind) and wind-blown dust contaminant pathways from disturbance during construction activities.

P3. Horizontal and vertical migration of leachable contaminants via groundwater within the Made Ground and River Terrace Deposits;

P4. Migration of contaminated liquids/groundwater into the lower aquifer through the creation of preferential pathways (for example during the piling operations, in addition to the disturbance of perched groundwater during excavation/construction activities)

P5. Gas migration through permeable strata or conduits into confined spaces at potentially asphyxiant or explosive concentrations.

P6. Direct runoff into the River Thames; and

P7. Direct contact of soils with construction materials;

7.5.3 Potential Human and Environmental Receptors

7.5.3.1 Human Receptors

R1. Construction workers involved in site works such as groundworks and tunnel excavation works, in addition to those present in offices on site.

R2. Adjacent site users, such as those within residential properties and workers in the surrounding commercial areas

R3. Tunnel end users (maintenance workers)

7.5.3.2 Environmental receptors

R4. Groundwater within the upper aquifer (River Terrace Deposits)

R5. Groundwater within the lower aquifer of the Lower London Tertiaries and Chalk Group

R6. Surface water body (River Thames)

7.5.3.3 Built environment receptors

R7. Fabric of tunnel building, infrastructure and services

7.6 Conceptual Model

Based upon the potentially active Sources, Pathways and Receptors defined in the previous sections, a conceptual model can be derived, including the potential pollutant linkages presented below:

Table 7.2: Potential Pollutant Linkages at this Site

Source	Pathway	Receptor
S1. Contamination from former on-site land uses.	P1. Human uptake pathways such as inhalation, ingestion or dermal contact	R1. Construction workers
	P1. Human uptake pathways such as inhalation, ingestion or dermal contact	R3. Tunnel end users (maintenance workers)
	P2. Migration of soil vapour, volatile organic compounds (by diffusion or due to wind) and windblown dust contaminant pathways	R2. Adjacent site users
	P3. Horizontal and vertical migration of leachable contaminants via groundwater within the Made Ground and River Terrace Deposits	R6. River Thames
	P6. Direct runoff	
	P4: Migration of contaminated liquids/groundwater into the lower aquifer through the creation of preferential pathways (for example during tunnel excavation)	R4. Upper aquifer
		R5. Lower aquifer
	P7: Direct contact	R7. Fabric of tunnel building and services
S2. Perched water bodies in the Made Ground	P1. Human uptake pathways such as inhalation, ingestion or dermal contact	R1. Construction workers
	P3. Horizontal and vertical migration of leachable contaminants via groundwater within the Made Ground and River Terrace Deposits	R4. Upper aquifer
		R6. River Thames
	P4: Migration of contaminated liquids/groundwater into the lower aquifer through the creation of preferential pathways (for example during tunnel excavation)	R4. Upper aquifer
		R5. Lower aquifer

Source	Pathway	Receptor
S3. East Greenwich Landfill	P5. Gas migration through permeable strata or conduits into confined spaces at potentially asphyxiant or explosive concentrations.	R1. Construction workers
		R3. Tunnel end users
	P3. Horizontal and vertical migration of leachable contaminants	R4. Upper aquifer
		R6. River Thames
S4. Contaminated groundwater within the River Terrace Deposits	P1. Human uptake pathways such as inhalation, ingestion or dermal contact	R1. Construction workers undertaking tunnel construction/excavation works
	P1. Human uptake pathways such as inhalation, ingestion or dermal contact	R3. Tunnel end users (maintenance workers)
	P3. Horizontal and vertical migration of leachable contaminants via groundwater in the Made Ground and River Terrace Deposits	R4. Upper aquifer
		R6. River Thames
	P4: Migration of contaminated liquids/groundwater into the lower and upper aquifers through the creation of preferential pathways (for example during tunnel excavation)	R4. Upper aquifer
		R5. Lower aquifer
	P7: Direct contact	R7. Fabric of tunnel building and services
S5 + S6. Contamination from on-going and former off-site land uses:	P3. Horizontal and vertical migration of leachable contaminants via groundwater → P1. human uptake through: ingestion, inhalation or dermal contact	R1. Construction workers undertaking tunnel construction/excavation works
		R3. Tunnel end users (maintenance workers)
	→ P7: Direct contact	R7. Fabric of tunnel building and services
		R4. Upper aquifer
	P5. Gas/vapour migration through pipes/foundations, along piles and into structures → P1. Inhalation of contaminated dust and/ or gas and vapours	R1 Construction workers undertaking tunnel construction/excavation works and
		R3. Tunnel end users (maintenance workers)

A schematic representation of this conceptual model is presented in Appendix G.

8 Phase 1 Contaminated Land Risk Assessment

8.1 Risk Estimation & Risk Evaluation

The term risk is widely used in different contexts and circumstances, often with differing definitions. In UK Government publications about the environment, the standard definition is that “Risk is a combination of the probability, or frequency, of occurrence of a defined hazard and the magnitude of the consequences of the occurrence.” (CLR11) [ii].

Following the development of the conceptual model and the identification and assessment of potential pollutant linkages, a preliminary attempt can be made at the further steps of risk estimation and risk evaluation, as discussed in CLR 11 and CIRIA C552 [iii], to determine whether an unacceptable contamination risk is likely to exist.

CLR 11 defines risk estimation as predicting the magnitude (or consequence) and probability of the risk occurring that may arise as a result of that hazard. This is also identified in CIRIA C552 in which the risk assessment methodology uses qualitative descriptors of consequence, probability and thus risk. These descriptors are adopted for the purposes of this risk assessment. A brief summary of the risk assessment methodology adopted is presented below.

The "hazard" or consequence of a risk occurring is classified into the following categories:

- Severe
- Medium
- Mild
- Minor

The probability or "likelihood" of a risk occurring is classified into the following categories:

- High Likelihood
- Likely
- Low Likelihood
- Unlikely

For each potential pollutant linkage identified in the conceptual model, the potential risk can be evaluated qualitatively, based on the following principle:

Overall contamination risk = Probability of event occurring x Consequence of event occurring

This relationship can be represented graphically as a matrix (Table 6.1), which is adapted from the CIRIA guidance.

Table 6.1 Preliminary Contamination Risk Assessment Matrix

Probability		Consequence			
		Severe	**Medium**	**Mild**	**Minor**
	High likelihood	Very high risk	High risk	Moderate risk	Low risk
	Likely	High risk	Moderate risk	Moderate risk	Low risk
	Low likelihood	Moderate risk	Moderate risk	Low risk	Very low risk
	Unlikely	Low risk	Low risk	Very low risk	Very low risk

The following preliminary qualitative risk evaluation can therefore be made for each significant pollutant linkage at this site, based upon the defined conceptual model and the risk estimation process discussed above, as presented in Table 8.1 and Table 8.2.

Table 8.1 Preliminary Risk Evaluation for north of the River Thames

Source	Pathway	Receptor	Likelihood	Consequence	Risk	Comments
S1 + S2. Contamination from on-going and former on-site land uses.	P1. Human uptake pathways (including dermal contact with exposed soil, inhalation of contaminated dust, gases and/or vapours, volatilised contaminants and ingestion of contaminated soils	R1. Construction workers undertaking tunnel construction/excavation works	High	Medium	High risk	Risk to construction staff is greatly reduced by use of correct PPE, training, use of safe working practices and welfare facilities.
	P1. Human uptake pathways (including dermal contact with exposed soil, inhalation of contaminated dust, gases and/or vapours, volatilised contaminants and ingestion of contaminated soils	R3. Tunnel end users (maintenance workers)	Low Likelihood	Medium	Moderate risk	The development involves the extensive removal of Made Ground to construct the shaft, tunnel portal entrances and highway areas. The final development will be almost completely hard-cover. These actions would effectively sever to most significant contaminant pathway for site end users.
	P5. Gas migration through permeable strata or conduits into confined spaces at potentially asphyxiant or explosive concentrations.		Unlikely	Severe	Low risk	The proposed tunnel structure is designed to be well ventilated due to the nature of the tunnel use and therefore not at risk from residual land gas sources that may be present. Impacts to maintenance workers can be mitigated through the provision of PPE
	P2. Migration of soil vapour, volatile organic compounds (by diffusion or due to wind) and windblown dust contaminant pathways	R2. Adjacent site users	Unlikely	Medium	Low risk	Site investigations have shown that asbestos is present at least locally in the Made Ground. Although not a risk currently, this could pose risk where soils are exposed, allowed to dry and out and be blown to neighbouring sites. A specialist subcontractor should be consulted in this regard. Good site practice and environmental management can prevent the migration of airborne contaminants (e.g. covering stockpiles of arisings)
	P3. Horizontal and vertical migration of leachable contaminants via perched water within the Made Ground	R6. River Thames	Low Likelihood	Mild	Low risk	The tunnel and tunnel portal entrances will be hard covered which will greatly reduce the leaching of contaminants from the Made Ground to the River Thames or upper aquifer.
	P6. Direct runoff		Likely	Mild	Moderate risk	Schemes will be designed to remove or isolate contamination and minimise migration in groundwater particularly in surface highway areas.
	P4: Migration of contaminated liquids/groundwater into the upper and lower aquifers through the creation of preferential pathways (for example during tunnel excavation)	R4. Upper aquifer	Likely	Mild	Moderate risk	During excavation works there will be a requirement for the identification and removal of below ground potentially contaminating soils, liquids and infrastructure. Piling risk assessments and soakaway drainage design in accordance with best practice and regulatory guidance as necessary. The upper aquifer is not used as a potable source and is likely impacted due to the legacy of industrial land use in the area.
		R5. Lower aquifer	Likely	Medium	Moderate risk	Currently likely to be a moderate risk from existing site conditions due to the presence of the low permeability London Clay effectively acting as an aquitard. Measures to be adopted in during construction will be agreed with EA to limit risk to the aquifer
	P7: Direct contact	R7. Fabric of tunnel building and services	Likely	Mild	Moderate risk	Can be mitigated through design.
S3. Elevated carbon dioxide, carbon monoxide and methane levels in the infilled lock entrance:	P5. Gas/vapour migration through pipes/foundations, along piles and into structures	R1. Construction workers undertaking tunnel construction/excavation works	Likely	Severe	High risk	Risk could potentially be severe due to asphyxiant hazard in below ground operations. Gas risk assessment will be undertaken prior to commencing works on site. Impacts to construction workers can be mitigated through the provision of PPE.

Source	Pathway	Receptor	Likelihood	Consequence	Risk	Comments
		R3. Tunnel end users (maintenance workers)	Unlikely	Severe	Moderate risk	The proposed tunnel structure is designed to be well ventilated due to the nature of the tunnel contents and therefore are not at risk from residual land gas sources that may be present. Impacts to maintenance workers can be mitigated through the provision of PPE.
S4. Perched water bodies in the Made Ground	P1. Human uptake pathways (including dermal contact with exposed soil, inhalation of contaminated dust, gases and/or vapours, volatilised contaminants and ingestion of contaminated soils	R1. Construction workers undertaking tunnel construction/excavation works	High	Medium	High risk	Risk to construction staff is greatly reduced by use of correct PPE, training, use of safe working practices and welfare facilities.
	P3. Horizontal and vertical migration of leachable contaminants via groundwater within the Made Ground	R4. Upper aquifer	Likely	Medium	Moderate risk	The tunnel and tunnel portal entrances will be hard covered which will greatly reduce the leaching of contaminants from the Made Ground to the River Thames or upper aquifer.
		R6. River Thames	Unlikely	Medium	Low risk	
	P4: Migration of contaminated liquids/groundwater into the lower and upper aquifer through the creation of preferential pathways (for example during tunnel excavation)	R5. Upper aquifer	Likely	Mild	Moderate risk	During excavation works there will be a requirement for the identification and removal of below ground potentially contaminating soils, liquids and infrastructure. Piling risk assessments and soakaway drainage design in accordance with best practice and regulatory guidance as necessary.
		R5. Lower aquifer	Likely	Mild	Moderate risk	Currently likely to be a moderate risk from existing site conditions due to the presence of the low permeability the London Clay. Measures to be adopted in during construction will be agreed with EA to limit risk to the aquifer.
S5. Groundwater contaminated by historic land uses such as the former chemical works.	P1. Human uptake pathways (including dermal contact with exposed soil, inhalation of contaminated dust, gases and/or vapours, volatilised contaminants and ingestion of contaminated soils	R1. Construction workers undertaking tunnel construction/excavation works	High	Medium	High risk	Risk to construction staff is greatly reduced by use of correct PPE, training, use of safe working practices and welfare facilities.
	P1. Human uptake pathways (including dermal contact with exposed soil, inhalation of contaminated dust, gases and/or vapours, volatilised contaminants and ingestion of contaminated soils	R3. Tunnel end users (maintenance workers)	Low Likelihood	Medium	Moderate risk	The development involves the extensive removal of Made Ground to construct the shaft, tunnel portal entrances and highway areas. The final development will be almost completely hard-cover. These actions would effectively sever to most significant contaminant pathway for site end users
	P5. Gas migration through permeable strata or conduits into confined spaces at potentially asphyxiant or explosive concentrations.		Low Likelihood	Severe	Moderate risk	Gas risk assessment will be undertaken prior to commencing works on site. Impacts to maintenance workers are mitigated through the provision of PPE.
	P3. Horizontal and vertical migration of leachable contaminants via groundwater in the Made Ground and River Terrace Deposits	R6. River Thames	Likely	Mild	Moderate risk	The tunnel and tunnel portal entrances will be hard covered which will greatly reduce the leaching of contaminants from the Made Ground to the River Thames or upper aquifer.
		R4. Upper aquifer	Likely	Medium	Moderate risk	
	P4: Migration of contaminated liquids/groundwater into the lower and upper aquifers through the creation of preferential pathways (for example during tunnel excavation)	R4. Upper aquifer	Likely	Medium	Moderate risk	During excavation works there will be a requirement for the identification and removal of below ground potentially contaminating soils, liquids and infrastructure. Piling risk assessments and soakaway drainage design in accordance with best practice and regulatory guidance as necessary.
		R5. Lower aquifer	Likely	Medium	Moderate risk	Currently likely to be a moderate risk from existing site conditions due to the presence of the low permeability the London Clay. Measures to be adopted in during construction will be agreed with EA to limit risk to the aquifer

Source	Pathway	Receptor	Likelihood	Consequence	Risk	Comments
	P7: Direct contact	R7. Fabric of tunnel building and services	Likely	Mild	Moderate risk	Can be mitigated through design.
S6 + S7. Contaminated soil from on-going and former off-site land uses	P3. Horizontal and vertical migration of leachable contaminants via groundwater → P1. human uptake through: ingestion, inhalation or dermal contact	R1. Construction workers undertaking tunnel construction/excavation works	Likely	Medium	Moderate risk	Impacts are mitigated through the provision of PPE, good site practice and environmental management.
		R3. Tunnel end users (maintenance workers)	Low Likelihood	Medium	Moderate risk	The development involves the extensive removal of Made Ground to construct the shaft, tunnel portal entrances and highway areas. The final development will be almost completely hard-cover. These actions would effectively sever to most significant contaminant pathway for site end users
		R7. Fabric of tunnel building and services	Low Likelihood	Mild	Low risk	Can be mitigated through design.
	→ P7: Direct contact	R5. Upper aquifer	Low Likelihood	Mild	Low risk	It is possible the residual and on-going sources could potentially be impacting the site. Further work in characterising the groundwater regime and quality is recommended to assess this risk.
	P5. Gas/vapour migration through pipes/foundations, along piles and into structures → P1. human uptake through: ingestion, inhalation or dermal contact	R1 Construction workers undertaking tunnel construction/excavation works and	Low Likelihood	Severe	Moderate risk	Risk to construction staff is greatly reduced by use of correct PPE, training, use of safe working practices and welfare facilities.
		R3 Tunnel end users (maintenance workers)	Unlikely	Severe	Moderate risk	The proposed tunnel structure is designed to be well ventilated due to the nature of the tunnel contents and therefore are not at risk from residual land gas sources that may be present. Impacts to maintenance workers can be mitigated through the provision of PPE.

Table 8.2 Preliminary Risk Evaluation for the south of the River Thames

Source	Pathway	Receptor	Likelihood	Consequence	Risk	Comments
S1. Contamination from former on-site land uses.	P1. Human uptake pathways (including dermal contact with exposed soil, inhalation of contaminated dust, gases and/or vapours, volatilised contaminants and ingestion of contaminated soils	R1. Construction workers	High	Medium	High risk	Risk to construction staff is greatly reduced by use of correct PPE, training, use of safe working practices and welfare facilities.
	P1. Human uptake pathways (including dermal contact with exposed soil, inhalation of contaminated dust, gases and/or vapours, volatilised contaminants and ingestion of contaminated soils	R3. Tunnel end users (maintenance workers)	Low Likelihood	Medium	Moderate risk	The development involves the extensive removal of Made Ground to construct the shaft, tunnel portal entrances and highway areas. The final development will be almost completely hard-cover. These actions would effectively sever to most significant contaminant pathway for site end users.
	P5. Gas migration through permeable strata or conduits into confined spaces at potentially asphyxiant or explosive concentrations.		Unlikely	Severe	Moderate risk	The proposed tunnel structure would need to be well ventilated due to the nature of the proposed use and therefore not at risk from residual land gas sources that may be present. Impacts to maintenance workers can be mitigated through the provision of PPE.
	P2. Migration of soil vapour, volatile organic compounds (by diffusion or due to wind) and windblown dust contaminant pathways	R2. Adjacent site users	Unlikely	Medium	Low risk	Site investigations have shown that asbestos is present at least locally in the Made Ground. Although not a risk currently, this could pose risk where soils are exposed, allowed to dry and out and be blown to neighbouring sites. A specialist subcontractor should be consulted in this regard. Good site practice and environmental management can prevent the migration of airborne contaminants (e.g. covering stockpiles of arisings).
	P3. Horizontal and vertical migration of leachable contaminants via groundwater within the Made Ground	R6. River Thames	Low Likelihood	Mild	Low risk	The tunnel and tunnel portal entrances will be hard covered which will greatly reduce the leaching of contaminants from the Made Ground to the River Thames or upper aquifer.
	P6. Direct runoff		Likely	Mild	Moderate risk	Schemes will be designed to remove or isolate contamination and minimise migration in groundwater particularly in surface highway areas.
	P4: Migration of contaminated liquids/groundwater into the lower aquifer through the creation of preferential pathways (for example during tunnel excavation)	R4. Upper aquifer	Likely	Mild	Moderate risk	During excavation works there will be a requirement for the identification and removal of below ground potentially contaminating soils, liquids and infrastructure. Piling risk assessments and soakaway drainage design in accordance with best practice and regulatory guidance as necessary. The upper aquifer is not used as a potable source and is likely impacted due to the legacy of industrial land use in the area.
		R5. Lower aquifer	Likely	Medium	Moderate risk	Currently likely to be a moderate risk from existing site conditions due to the presence of the low permeability London Clay effectively acting as an aquitard beneath the majority of the area. Design measures to be adopted in during construction (e.g. appropriate piling choice) should be agreed with EA to limit risk to the aquifer.
	P7: Direct contact	R7. Fabric of tunnel building and services	Likely	Mild	Moderate risk	Can be mitigated through design.

Source	Pathway	Receptor	Likelihood	Consequence	Risk	Comments
S2. Perched water bodies in the Made Ground	P1. Human uptake pathways (including dermal contact with exposed soil, inhalation of contaminated dust, gases and/or vapours, volatilised contaminants and ingestion of contaminated soils	R1. Construction workers	High	Medium	High risk	Risk to construction staff is greatly reduced by use of correct PPE, training, use of safe working practices and welfare facilities.
	P3. Horizontal and vertical migration of leachable contaminants via groundwater within the Made Ground	R4. Upper aquifer	Likely	Medium	Moderate risk	The tunnel and tunnel portal entrances will be hard covered which will greatly reduce the leaching of contaminants from the Made Ground to the River Thames or upper aquifer.
		R6. River Thames	Unlikely	Medium	Low risk	
	P4: Migration of contaminated liquids/groundwater into the lower aquifer through the creation of preferential pathways (for example during tunnel excavation)	R4. Upper aquifer	Likely	Mild	Moderate risk	During excavation works there will be a requirement for the identification and removal of below ground potentially contaminating soils, liquids and infrastructure. Piling risk assessments and soakaway drainage design in accordance with best practice and regulatory guidance as necessary.
		R5. Lower aquifer	Likely	Mild	Moderate risk	Measures to be adopted in during construction should be agreed with EA to limit risk to the aquifer (e.g. piling risk assessments).
S3. East Greenwich Landfill	P5. Gas migration through permeable strata or conduits into confined spaces at potentially asphyxiant or explosive concentrations.	R1. Construction workers	Likely	Severe	High risk	Risk could potentially be severe due to asphyxiant hazard in below ground operations. Gas risk assessment will be undertaken prior to commencing works on site. Impacts to construction workers can be mitigated through the provision of PPE.
		R3. Tunnel end users (maintenance workers)	Unlikely	Severe	Moderate risk	The proposed tunnel structure is designed to be well ventilated due to the nature of the tunnel contents and therefore are not at risk from residual land gas sources that may be present. Impacts to maintenance workers can be mitigated through the provision of PPE.
	P3. Horizontal and vertical migration of leachable contaminants	R4. Upper aquifer	Likely	Mild	Moderate risk	During excavation works there will be a requirement for the identification and removal of below ground potentially contaminating soils, liquids and infrastructure. Piling risk assessments and soakaway drainage design in accordance with best practice and regulatory guidance as necessary. The upper aquifer is not used as a potable source and is already likely impacted due to the legacy of industrial land use in the area.
		R6. River Thames	Likely	Mild	Moderate risk	Schemes will be designed to remove or isolate contamination and minimise migration in groundwater particularly in surface highway areas.
S4. Contaminated groundwater within the River Terrace Deposits	P1. Human uptake pathways (including dermal contact with exposed soil, inhalation of contaminated dust, gases and/or vapours, volatilised contaminants and ingestion of contaminated soils	R1. Construction workers undertaking tunnel construction/excavation works	High	Medium	High risk	Risk to construction staff is greatly reduced by use of correct PPE, training, use of safe working practices and welfare facilities.
	P1. Human uptake pathways (including dermal contact with exposed soil, inhalation of contaminated dust, gases and/or vapours, volatilised contaminants and ingestion of contaminated soils	R3. Tunnel end users (maintenance workers)	Low Likelihood	Medium	Moderate risk	The development involves the extensive removal of Made Ground to construct the shaft, tunnel portal entrances and highway areas. The final development will be almost completely hard-cover. These actions would effectively sever to most significant contaminant pathway for site end users.

Source	Pathway	Receptor	Likelihood	Consequence	Risk	Comments
	P5. Gas migration through permeable strata or conduits into confined spaces at potentially asphyxiant or explosive concentrations.		Low Likelihood	Severe	Moderate risk	Gas risk assessment will be undertaken prior to commencing works on site. Impacts to maintenance workers are mitigated through the provision of PPE.
	P3. Horizontal and vertical migration of leachable contaminants via groundwater in the Made Ground and River Terrace Deposits	R4. Upper aquifer	Likely	Mild	Moderate risk	The tunnel and tunnel portal entrances will be hard covered which will greatly reduce the leaching of contaminants from the Made Ground to the River Thames or upper aquifer.
		R6. River Thames	Low Likelihood	Mild	Low risk	
	P4: Migration of contaminated liquids/groundwater into the lower and upper aquifers through the creation of preferential pathways (for example during tunnel excavation)	R4. Upper aquifer	Likely	Mild	Moderate risk	During excavation works there will be a requirement for the identification and removal of below ground potentially contaminating soils, liquids and infrastructure. Piling risk assessments and soakaway drainage design in accordance with best practice and regulatory guidance as necessary.
		R5. Lower aquifer	Likely	Medium	Moderate risk	Currently likely to be a moderate risk from existing site conditions due to the presence of the low permeability the London Clay beneath the majority of the scheme. Measures to be adopted in during construction will be agreed with EA to limit risk to the aquifer
	P7: Direct contact	R7. Fabric of tunnel building and services	Likely	Mild	Moderate risk	Can be mitigated through design.
S5 + S6. Contamination from on-going and former off-site land uses:	P3. Horizontal and vertical migration of leachable contaminants via groundwater → P1. human uptake through: ingestion, inhalation or dermal contact	R1. Construction workers undertaking tunnel construction/excavation works	Likely	Medium	Moderate risk	Impacts are mitigated through the provision of PPE, good site practice and environmental management.
		R3. Tunnel end users (maintenance workers)	Low Likelihood	Medium	Moderate risk	The development involves the extensive removal of Made Ground to construct the shaft, tunnel portal entrances and highway areas. The final development will be almost completely hard-cover. These actions would effectively sever to most significant contaminant pathway for site end users
	→ P7: Direct contact	R7. Fabric of tunnel building and services	Low Likelihood	Mild	Low risk	Can be mitigated through design.
		R4. Upper aquifer	Low Likelihood	Mild	Low risk	It is possible the residual and on-going sources could potentially be impacting the site. Further work in characterising the groundwater regime and quality is recommended to assess this risk.
	P5. Gas/vapour migration through pipes/foundations, along piles and into structures → P1. Inhalation of contaminated dust and/ or gas and vapours	R1 Construction workers undertaking tunnel construction/excavation works and	Low Likelihood	Severe	Moderate risk	Risk to construction staff is greatly reduced by use of correct PPE, training, use of safe working practices and welfare facilities.
		R3 Tunnel end users (maintenance workers)	Unlikely	Severe	Moderate risk	The proposed tunnel structure is designed to be well ventilated due to the nature of the tunnel contents and therefore are not at risk from residual land gas sources that may be present. Impacts to maintenance workers can be mitigated through the provision of PPE.

8.2 Preliminary Overall Phase 1 Risk Assessment

A number of contamination risks have been highlighted by the Phase 1 contamination assessment and relate largely to former industrial land uses within the site area.

To the north of the River Thames a number of potential sources of contamination were identified, including:

- Rail land (including coal and goods depots), manure works, chemical works, a scrap yard, garages and engineering works.

To the south of the River Thames a number of potential sources of contamination were identified, including:

- Rail land (including coal and goods depots), substations and in particular the former South Metropolitan Gasworks.

The sites as a whole have been given a **MODERATE - HIGH** risk rating; specifically the following points should be noted:

- Much of the site on the Greenwich peninsula was formerly used for industrial activities including gasworks and waste disposal. Although remediation has previously been undertaken, ground heavily affected by contaminants remains locally beneath the engineered capping layer across the Millennium site, and therefore potentially in areas of excavation for the southern entrance tunnel portal;
- The previous western entrance to the Royal Victoria Lock has been infilled and comprises a considerable amount of unknown fill material; in particular asbestos has been identified from soil sampling.
- The desk study has identified large thicknesses of Made Ground throughout the footprint of the proposed tunnel development and adjacent highway areas.
- There will be a risk to construction operatives during the development of the site from identified contamination sources, including metals, hydrocarbons and ground gases. This can be mitigated by use of appropriate PPE;
- Overall risks to controlled waters, in particular the Lower Aquifer, can be mitigated through further ground investigations, risk assessment and development of appropriate design measures to isolate or remove contaminated material and minimize migration of contaminants;
- There is a potential risk of cross contamination of groundwater from the shallow Secondary (considered to be locally impacted) to the deeper Principal Aquifers by or during tunnel excavation, where the London Clay is thin (or absent) and if foundations are designed to penetrate through the London Clay in areas with shallow groundwater contamination. This can be mitigated though additional investigation of the groundwater regime, remediation (where necessary) and the undertaking of piling risk assessments in accordance with in National Groundwater & Contaminated Land Centre report NC/99/73;

- Unexploded ordnance - the location of the site both north and south of the Thames River was subject to the direct impact of bombs during WWII and whilst the site area has undergone extensive redevelopment following WWII, there remains the potential for unexploded ordnance to exist.

9 Conclusions and Recommendations

9.1 Conclusions

- The site is located in the Silvertown area, within the North Greenwich Peninsula and underlying the River Thames.
- The superficial geology beneath the study area comprises alluvial deposits overlying River Terrace Deposits. The underlying bedrock geology comprises a thin layer of London Clay, in turn overlying the largely granular Harwich Formation, Lambeth Group, and the Thanet Sand Formation beneath which lies the Chalk. In addition, Made Ground is known to overlie the alluvial deposits across the majority of the study area.
- The superficial deposits are classified by the Environment Agency as a Secondary A aquifer. This aquifer is separated from underlying Principal aquifer by the London Clay which, in the southern (Greenwich) area is locally very thin and may be absent; additionally the Lambeth Group in this area is predominantly granular. Therefore there is likely to be a degree of existing connectivity between the upper and lower aquifers, at least locally.
- Both site areas north and south of the River Thames maintain a long industrial legacy. Notable industrial land uses to the north of the River Thames include rail land (including coal and goods depots), manure works, chemical works, a scrap yard, garages and engineering works. To the south of the River Thames a considerable area of the site was dominated by the South Metropolitan Gasworks and now comprises a landfill.
- The site as a whole has been given a **MODERATE** – **HIGH** risk rating in the absence of any specific mitigation measures. Specifically the following key points, contaminant linkages and potential mitigation options should be noted:

  - A large area of the site on the Greenwich Peninsula is located on a historic landfill site, considered to be associated with the remediation of the former gasworks;
  - Much of the site on the Greenwich peninsula was formerly used for industrial activities including gasworks and waste disposal. Although remediation has previously been undertaken, ground heavily affected by contaminants remains locally beneath the engineered capping layer across the Millennium site, and therefore potentially in areas of excavation for the southern entrance tunnel portal;
  - The previous western entrance to the Royal Victoria Dock has been infilled and comprises a considerable amount of unknown fill material; in particular asbestos has been identified from soil sampling.
  - The desk study has identified large amounts of Made Ground throughout the footprint of the proposed tunnel development and adjacent highway areas.
  - There will be a risk to construction operatives during the development of the site from identified contamination sources, including metals, hydrocarbons and ground gases. This can be mitigated by use of appropriate PPE;
  - There will also be risk to surrounding land users from migration of contaminants during construction activities (via wind-blown dust or vapour pathways). Such risks can be mitigated through appropriate environmental controls;

- Overall risks to controlled waters, in particular the Lower Aquifer, can be mitigated through further ground investigations, risk assessment and development of appropriate design measures to isolate or remove contaminated material and minimize migration of contaminants through preferential pathways;
- There is a potential risk of cross contamination of groundwater from the shallow Secondary (considered to be locally impacted) to the deeper Principal aquifer by or during tunnel excavation, especially where the London Clay is thin or absent and if tunnel foundations are designed to penetrate through the London Clay in areas with shallow groundwater contamination. This can be mitigated though additional investigation of the groundwater regime, remediation (where necessary) and the undertaking of piling risk assessments in accordance with in National Groundwater & Contaminated Land Centre report NC/99/73;
- Should dewatering works be proposed, risks associated with the migration of shallow contaminants into the lower aquifer would also need to be appropriately managed and mitigated;
- Unexploded ordnance - the location of the site both north and south of the Thames River was subject to the direct impact of bombs during WWII and whilst the site area has undergone extensive redevelopment following WWII, there remains the potential for unexploded ordnance to exist.

9.2 Recommendations

It is recommended that an intrusive site investigation and programme of environmental monitoring and laboratory testing is undertaken to more fully understand the conceptualised pollutant linkages highlighted in this reports

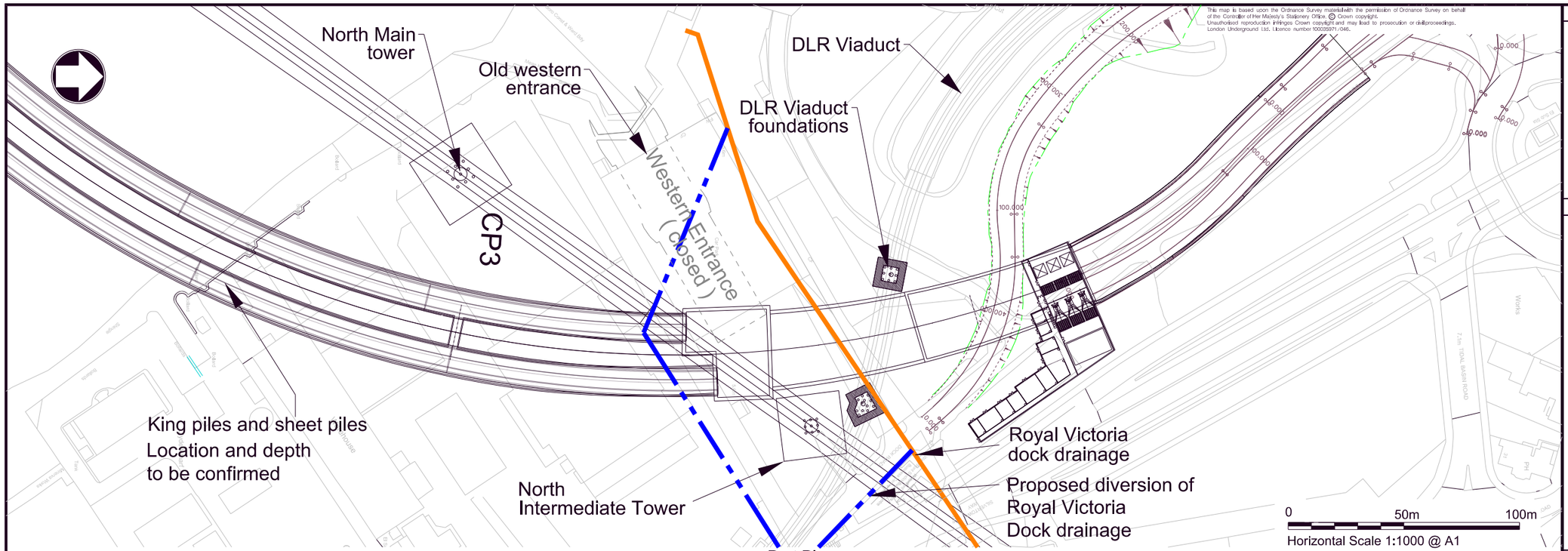
The results of the investigation should be used to inform a quantitative risk assessment, and can also be used in materials management and site construction environmental management plans.

It is advised that the scope of any investigation that may be required for planning purposes should be discussed with the regulators (local planning authority environmental health officer and Environment Agency).

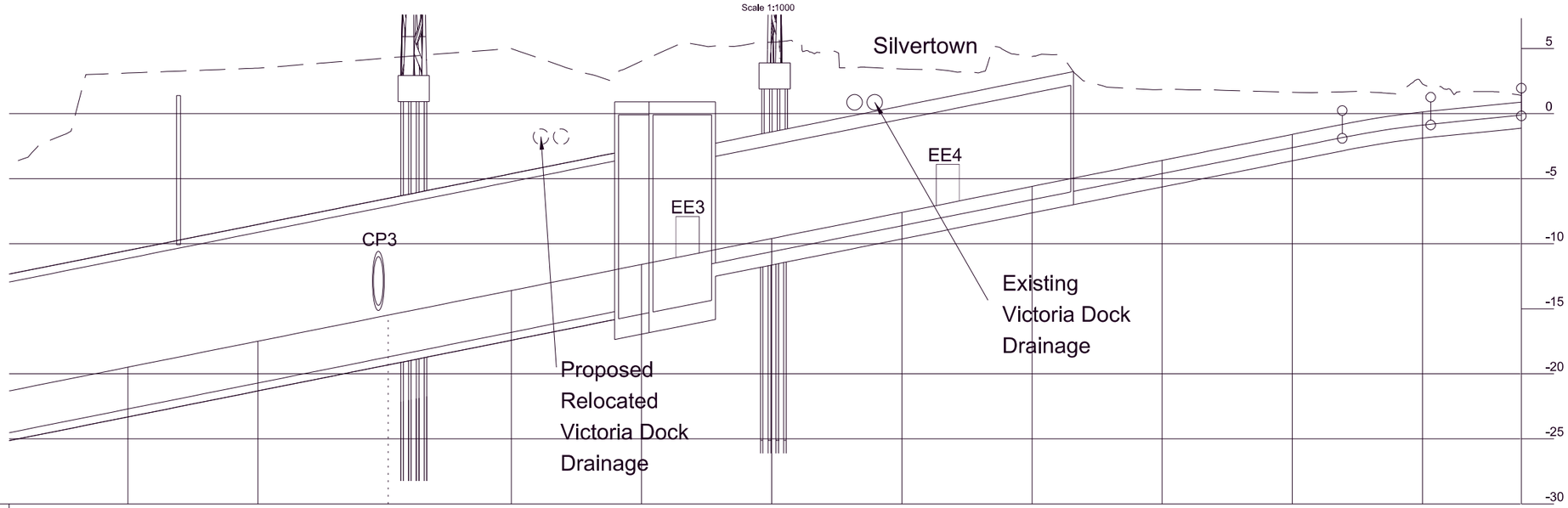
Appendices

Appendix A. Drawings and Plans

A.1 Silvertown Area Longitudinal Section



Part Plan
Scale 1:1000



CHAINAGE (M)	1010.00	1020.00	1030.00	1040.00	1050.00	1060.00	1070.00	1080.00	1090.00	1100.00	1110.00	1120.00	1130.00	1140.00	1150.00	1160.00	1170.00	1180.00	1190.00	1200.00	1210.00	1220.00	1230.00	1240.00	1250.00	1260.00	1270.00	1280.00	1290.00	1300.00	1310.00	1320.00	1330.00	1340.00	1350.00	1360.00	1370.00	1380.00	1390.00	1400.00	1410.00	1420.00	1430.00	1440.00	1450.00	1460.00	1470.00	1480.00	1490.00	1500.00	1510.00	1520.00	1530.00	1540.00	1550.00	1560.00	1570.00	1580.00
PROPOSED LEVEL (M)	-21.090	-20.690	-20.290	-19.890	-19.490	-19.090	-18.690	-18.290	-17.890	-17.490	-17.090	-16.690	-16.290	-15.890	-15.490	-15.090	-14.690	-14.290	-13.890	-13.490	-13.090	-12.690	-12.290	-11.890	-11.490	-11.090	-10.690	-10.290	-9.890	-9.490	-9.090	-8.690	-8.290	-7.890	-7.490	-7.090	-6.690	-6.290	-5.890	-5.490	-5.090	-4.690	-4.290	-3.890	-3.490	-3.090	-2.690	-2.290	-1.890	-1.490	-1.090	-0.694	-0.343	-0.052	-0.180	-0.380	-0.580	-0.780
EXISTING LEVEL (M)	-4.527	-3.819	-3.026	-1.661	2.234	3.077	3.152	3.227	3.303	3.379	3.454	3.566	3.727	3.869	4.000	4.116	4.265	4.435	4.587	4.739	4.892	4.804	4.121	3.070	2.558	3.812	4.725	5.470	5.144	5.152	5.441	5.498	5.531	4.676	3.519	3.577	3.450	3.394	3.322	3.220	3.925	4.586	4.414	2.535	2.103	1.938	1.841	1.858	1.798	1.738	1.684	1.629	1.638	1.689	1.642	1.532	2.389	
HORIZONTAL GEOMETRY	R=-460.000 L=600.009																																																												CL	D=88.954					
VERTICAL GEOMETRY	P= - 4.000% L=599.514																																																													R	P					

Scheme Layout Long Section
Horizontal Scale 1:1000 Vertical Scale 1:250

Notes

1. All dimensions in millimetres unless otherwise stated.
2. Do not scale this drawing.

Key to symbols

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	22/04/2013	RGH	PRELIMINARY ISSUE	DN	JB

Mott MacDonald
Mott MacDonald House
8-10 Sydenham Road
Croydon CR0 2EE
United Kingdom
+44 (0)20 8774 2000
+44 (0)20 8681 5706
www.mottmac.com

Client

Transport for London

Transport for London
50 Victoria Street
London
SW1H 0TL

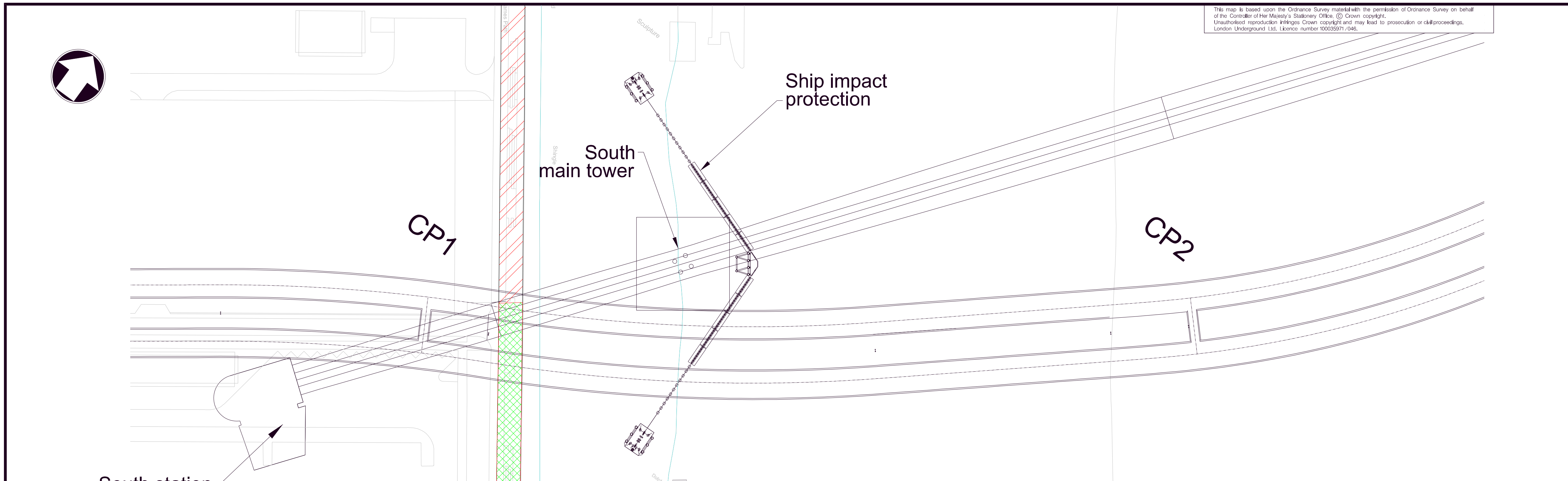
Title

Silvertown Tunnel Crossing
Bored Tunnel Option
Plan & Longitudinal Section
Sheet 3 of 3

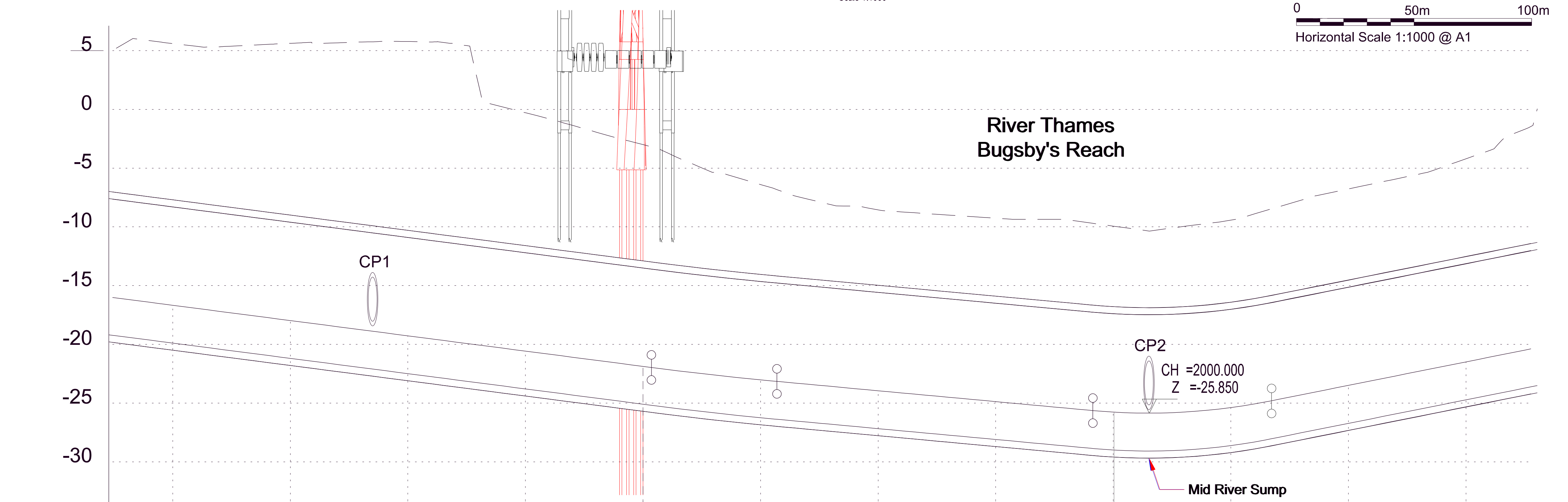
Designed	DN		Eng check	JB	
Drawn	RGH		Coordination	JB	
Dwg check	DN		Approved	MS	
Scale at A1		Status PRE		Rev P1	

Drawing Number
MMD-298348-C-DR-00-ZZ-1008

A.2 River Thames Area Longitudinal Section



Part Plan
Scale 1:1000



CHAINAGE (M)	PROPOSED LEVEL (M)	EXISTING LEVEL (M)
430.00	-16.153	4.844
440.00	-16.413	5.709
450.00	-16.673	5.882
460.00	-16.933	5.676
470.00	-17.193	5.484
480.00	-17.453	5.353
490.00	-17.713	5.441
500.00	-17.973	5.544
510.00	-18.233	5.632
520.00	-18.493	5.707
530.00	-18.753	5.675
540.00	-19.013	5.744
550.00	-19.273	5.792
560.00	-19.533	5.781
570.00	-19.793	5.760
580.00	-20.053	5.695
590.00	-20.313	5.457
600.00	-20.573	0.468
610.00	-20.833	-0.041
620.00	-21.093	-0.551
630.00	-21.353	-1.090
640.00	-21.613	-1.656
650.00	-21.873	-2.222
660.00	-22.129	-2.694
670.00	-22.373	-3.186
680.00	-22.603	-4.079
690.00	-22.818	-4.999
700.00	-23.020	-5.516
710.00	-23.208	-6.109
720.00	-23.393	-6.700
730.00	-23.578	-7.350
740.00	-23.762	-7.878
750.00	-23.947	-8.214
760.00	-24.132	-8.368
770.00	-24.317	-8.658
780.00	-24.501	-8.791
790.00	-24.686	-8.925
800.00	-24.871	-9.059
810.00	-25.056	-9.192
820.00	-25.240	-9.326
830.00	-25.425	-9.350
840.00	-25.610	-9.350
850.00	-25.763	-9.526
860.00	-25.840	-9.801
870.00	-25.840	-10.076
880.00	-25.763	-10.348
890.00	-25.610	-10.079
900.00	-25.379	-9.822
910.00	-25.071	-9.571
920.00	-24.690	-9.169
930.00	-24.290	-8.578
940.00	-23.890	-7.990
950.00	-23.490	-7.392
960.00	-23.090	-6.967
970.00	-22.690	-6.543
980.00	-22.290	-6.120
990.00	-21.890	-5.699
1000.00	-21.490	-5.350
1010.00	-21.090	-4.527
1020.00	-20.690	-3.819

HORIZONTAL GEOMETRY: R=-720.000 L=115.642; R=-720.000 L=166.780; D=101.493; CL

VERTICAL GEOMETRY: R; P= - 1.848% L=133.992; R=1300.000 L=76.020

Scheme Layout Long Section
Horizontal Scale 1:1000 Vertical Scale 1:250

Notes
1. All dimensions in millimetres unless otherwise stated.
2. Do not scale this drawing.

Key to symbols

Option E River Wall. see note 1.

Option A River Wall. see note 1.

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	22/04/2013	RGH	PRELIMINARY ISSUE	DN	JB

Mott MacDonald
Mott MacDonald House
8-10 Sydenham Road
Croydon CR0 2EE
United Kingdom
+44 (0)20 8774 2000
+44 (0)20 8681 5706
www.mottmac.com

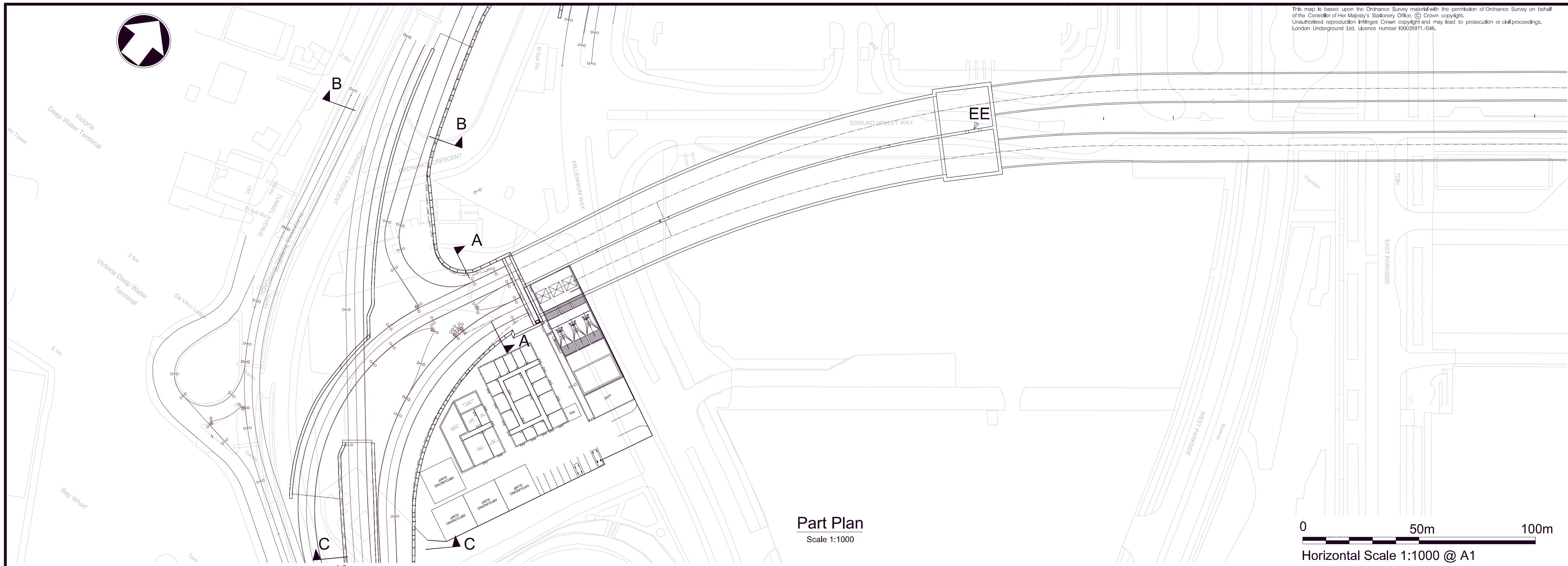
Client
Transport for London
Transport for London
50 Victoria Street
London
SW1H 0TL

Title
Silvertown Tunnel Crossing
Bored Tunnel Option
Plan & Longitudinal Section
Sheet 2 of 3

Designed	DN	Eng check	JB
Drawn	RGH	Coordination	JB
Dwg check	DN	Approved	MS
Scale at A1	Status PRE	Rev P1	

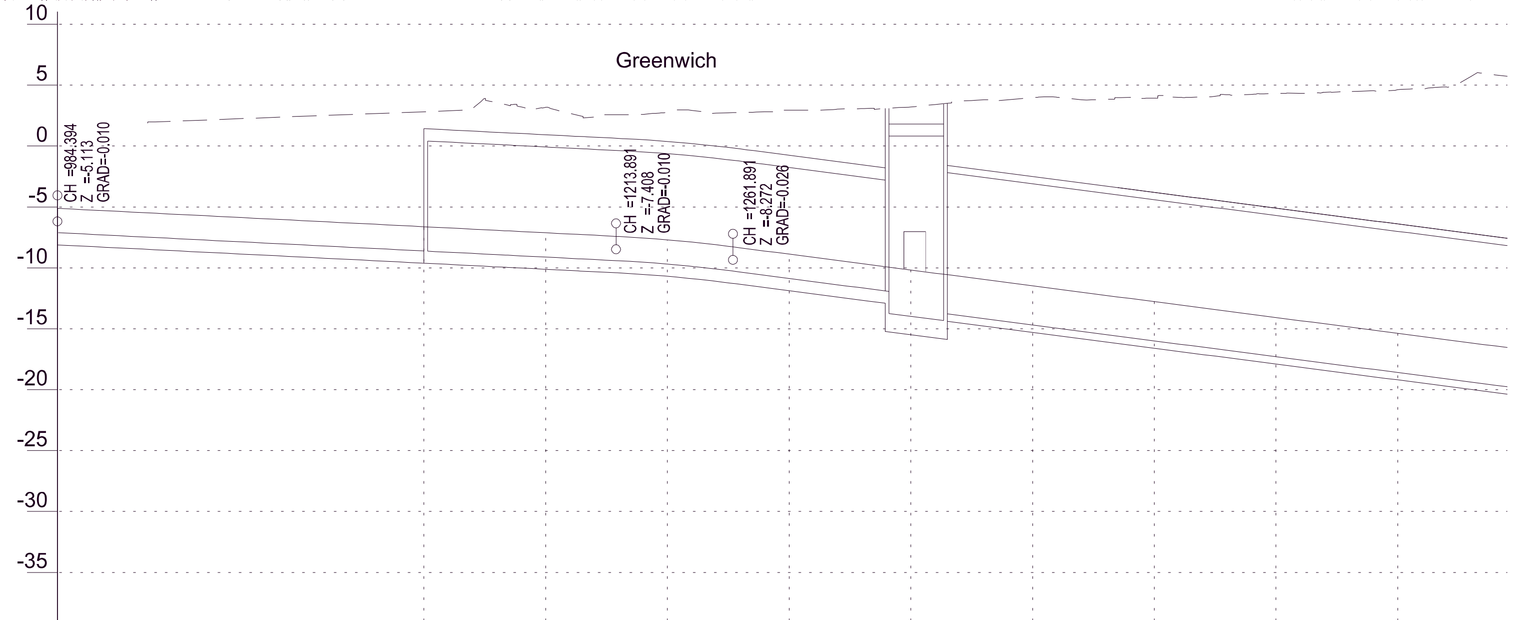
Drawing Number
MMD-298348-C-DR-00-ZZ-1007

A.3 Greenwich Peninsula Longitudinal Section



Part Plan
Scale 1:1000

0 50m 100m
Horizontal Scale 1:1000 @ A1



CHAINAGE (M)	PROPOSED LEVEL (M)	EXISTING LEVEL (M)
0.000	-6.619	-999.00
10.00	-6.719	-999.00
20.00	-6.819	-999.00
30.00	-6.919	2.966
40.00	-7.019	3.622
50.00	-7.119	3.422
60.00	-7.219	2.960
70.00	-7.319	2.925
80.00	-7.419	2.538
90.00	-7.539	2.458
100.00	-7.693	2.577
110.00	-7.880	2.595
120.00	-8.101	2.714
130.00	-8.353	2.970
140.00	-8.613	2.809
150.00	-8.873	2.731
160.00	-9.133	2.782
170.00	-9.393	2.826
180.00	-9.653	2.938
190.00	-9.913	2.976
200.00	-10.173	3.045
210.00	-10.433	3.091
220.00	-10.693	3.157
230.00	-10.953	3.297
240.00	-11.213	3.507
250.00	-11.473	3.739
260.00	-11.733	3.814
270.00	-11.933	3.895
280.00	-12.253	3.933
290.00	-12.513	3.828
300.00	-12.773	3.994
310.00	-13.033	3.931
320.00	-13.293	3.970
330.00	-13.553	4.043
340.00	-13.813	4.188
350.00	-14.073	4.246
360.00	-14.333	4.309
370.00	-14.593	4.326
380.00	-14.853	4.355
390.00	-15.113	4.461
400.00	-15.373	4.544
410.00	-15.633	4.564
420.00	-15.893	4.712
430.00	-16.153	4.844
440.00	-16.413	5.709

HORIZONTAL GEOMETRY	D=183.790	CL	R=-510.000 L=196.786	CL	D=155.305
VERTICAL GEOMETRY	P=-1.000% L=229.497	R	P= - 2.600% L=526.381		

Scheme Layout Long Section
Horizontal Scale 1:200 Vertical Scale 1:250

Notes
1. All dimensions in millimetres unless otherwise stated.
2. Do not scale this drawing.

For Sections See Drawing MMD- 298348-C-DR-00-ZZ-1016 and 1017

Key to symbols

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	22/04/2013	RGH	PRELIMINARY ISSUE	DN	JB

Mott MacDonald
Mott MacDonald House
8-10 Sydenham Road
Croydon CR0 2EE
United Kingdom
+44 (0)20 8774 2000
+44 (0)20 8681 5706
www.mottmac.com

Client
Transport for London
Transport for London
50 Victoria Street
London
SW1H 0TL

Title
Silvertown Tunnel Crossing
Bored Tunnel
Plan and Part Longitudinal Section
Sheet 1

Designed	DN		Eng check	JB
Drawn	RGH		Coordination	JB
Dwg check	DN		Approved	MS

Scale at A1	Status	Rev
As Shown	PRE	P1

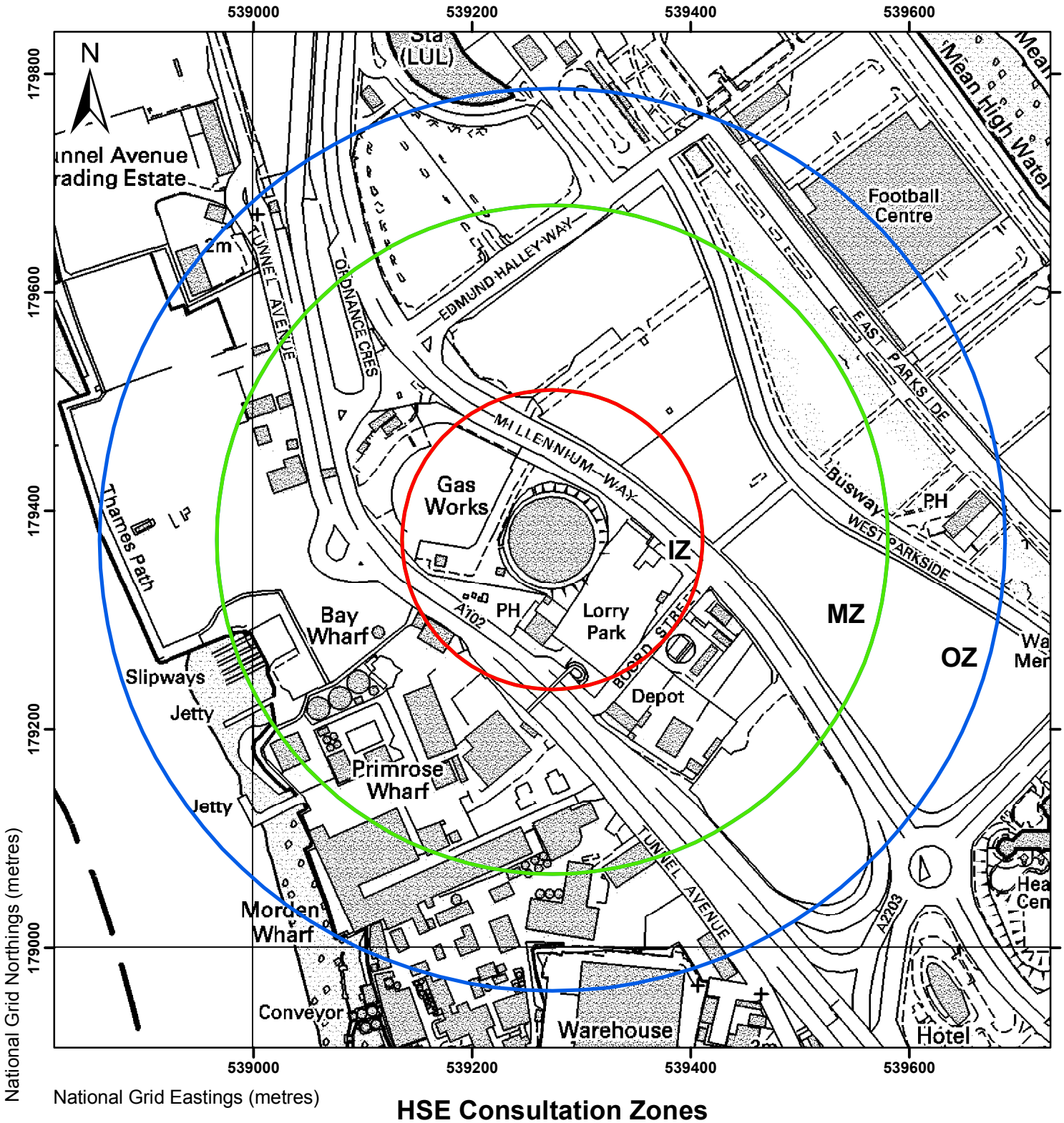
Drawing Number
MMD-29348-C-DR-00-ZZ-1006

Formerly Drawing No:- P:\Croydon\MMH\Tunnels\298348 Silvertown Tunnel\Drawings\Perament Works\Bored\MMD-298348-TUN-203.dwg Feb 20, 2012 - 3:58PM kni56149

A.4 Site Location Plan

CP1
CP2
CP3
CP4
CP5
CP6
CP7
CP8
CP9
CP10
EE1
EE2
EE3
EE4

A.5 COMAH exclusion zones associated with existing gas holder



HSE Consultation Zones

Transco PLC
East Greenwich Gasholder Station

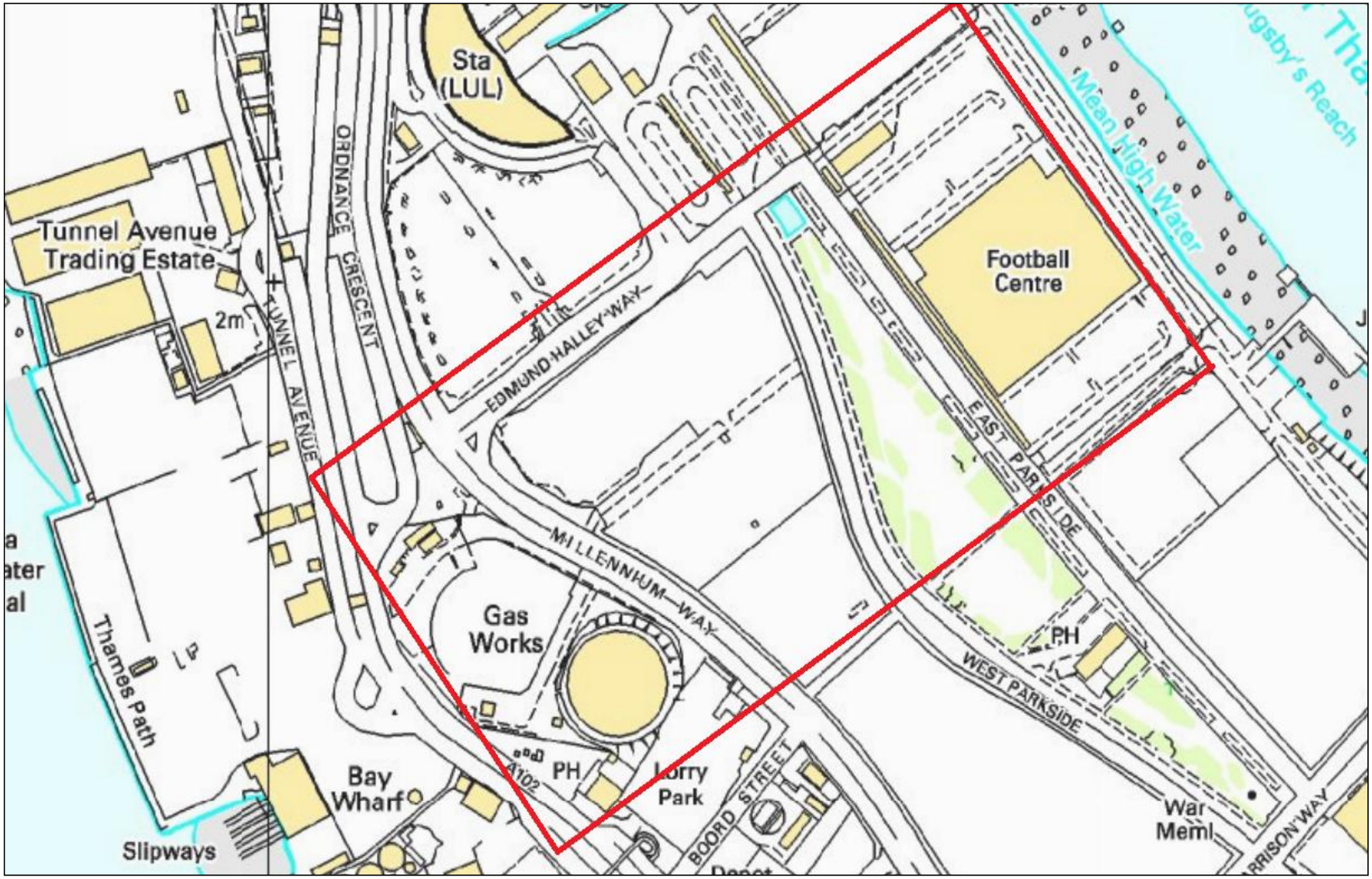
HSE HID CI5 Ref: H0195
Grid Ref: TQ 392 793

Prepared - February 2011
This map supersedes all previous or undated maps

IZ = Inner Zone
MZ = Middle Zone
OZ = Outer Zone

0 75 150 300 Metres

A.6 Greenwich Site Walkover Area



Mott MacDonald
Tel +44 (0)1223 463500
Fax +44 (0)1223 461007

Mott MacDonald House
Wellesley Road
Croydon
CR0 2EE

Client
Transport for London (TfL)

Project
Thames River Crossings

Key

Site walkover area

NOT TO SCALE

Drawn	MH	10.05.13	
320230/MNC/TUN/03/B			

Title

Appendix A.6 Greenwich Site Walkover Plan

Appendix B. Envirocheck Extracts and Historical Plans/Photographs

B.1 Envirocheck Extracts

B.1.1 Geology Legends

Geology 1:50,000 Maps Legends

Artificial Ground and Landslip

Map Colour	Lex Code	Rock Name	Rock Type	Min and Max Age
	MGR	Made Ground (Undivided)	Artificial Deposit	Holocene - Holocene
	LSGR	Landscaped Ground (Undivided)	Unknown/Unclassified Entry	Holocene - Holocene
	WMGR	Infilled Ground	Artificial Deposit	Present Day - Present Day
	WGR	Worked Ground (Undivided)	Void	Holocene - Holocene

Superficial Geology

Map Colour	Lex Code	Rock Name	Rock Type	Min and Max Age
	ALV	Alluvium	Silty Peaty Sandy Clay	Flandrian - Flandrian
	TRD	Tidal River Or Creek Deposits	Clay and Silt	Flandrian - Flandrian
	KPGR	Kempton Park Gravel Formation	Sand and Gravel	Devensian - Devensian
	LASI	Langley Silt Member	Clay and Silt	Devensian - Devensian
	HEAD	Head	Clay, Silt, Sand and Gravel	Quaternary - Quaternary

Bedrock and Faults

Map Colour	Lex Code	Rock Name	Rock Type	Min and Max Age
	LC	London Clay Formation	Clay and Silt	Eocene - Eocene
	LC	London Clay Formation	Clay, Silt and Sand	Eocene - Eocene
	TAB	Thanet Sand Formation	Sand	Thanetian - Thanetian
	LMBE	Lambeth Group	Sand, Silt and Clay	Paleocene - Paleocene
	LMBE	Lambeth Group	Clay, Silt and Sand	Paleocene - Paleocene
	HWH	Harwich Formation	Sand and Gravel	Eocene - Paleocene
	LSNCK	Lewes Nodular Chalk Formation, Seaford Chalk Formation and Newhaven Chalk Formation (Undifferentiated)	Chalk	Campanian - Turonian
		Faults		

Envirocheck® Geology

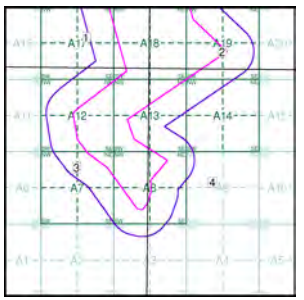
Geology 1:50,000 Maps

This report contains geological map extracts taken from the BGS Digital Geological map of Great Britain at 1:50,000 scale and is designed for users carrying out preliminary site assessments who require geological maps for the area around the site. This mapping may be more up to date than previously published paper maps.
The various geological layers - artificial and landslip deposits, superficial geology and solid (bedrock) geology are displayed in separate maps, but superimposed on the final 'Combined Surface Geology' map. All map legends feature on this page. Not all layers have complete nationwide coverage, so availability of data for relevant map sheets is indicated below.

Geology 1:50,000 Maps Coverage

Map ID:	1	**Map ID:**	2
Map Sheet No:	256	**Map Sheet No:**	257
Map Name:	North London	**Map Name:**	Romford
Map Date:	2006	**Map Date:**	1996
Bedrock Geology:	Available	**Bedrock Geology:**	Available
Superficial Geology:	Available	**Superficial Geology:**	Available
Artificial Geology:	Available	**Artificial Geology:**	Available
Faults:	Not Available	**Faults:**	Not Available
Landslip:	Available	**Landslip:**	Available
Rock Segments:	Not Available	**Rock Segments:**	Not Available
Map ID:	3	**Map ID:**	4
Map Sheet No:	270	**Map Sheet No:**	271
Map Name:	South London	**Map Name:**	Dartford
Map Date:	1998	**Map Date:**	1998
Bedrock Geology:	Available	**Bedrock Geology:**	Available
Superficial Geology:	Available	**Superficial Geology:**	Available
Artificial Geology:	Available	**Artificial Geology:**	Available
Faults:	Available	**Faults:**	Available
Landslip:	Available	**Landslip:**	Available
Rock Segments:	Not Available	**Rock Segments:**	Not Available

Geology 1:50,000 Maps - Slice A



Order Details:

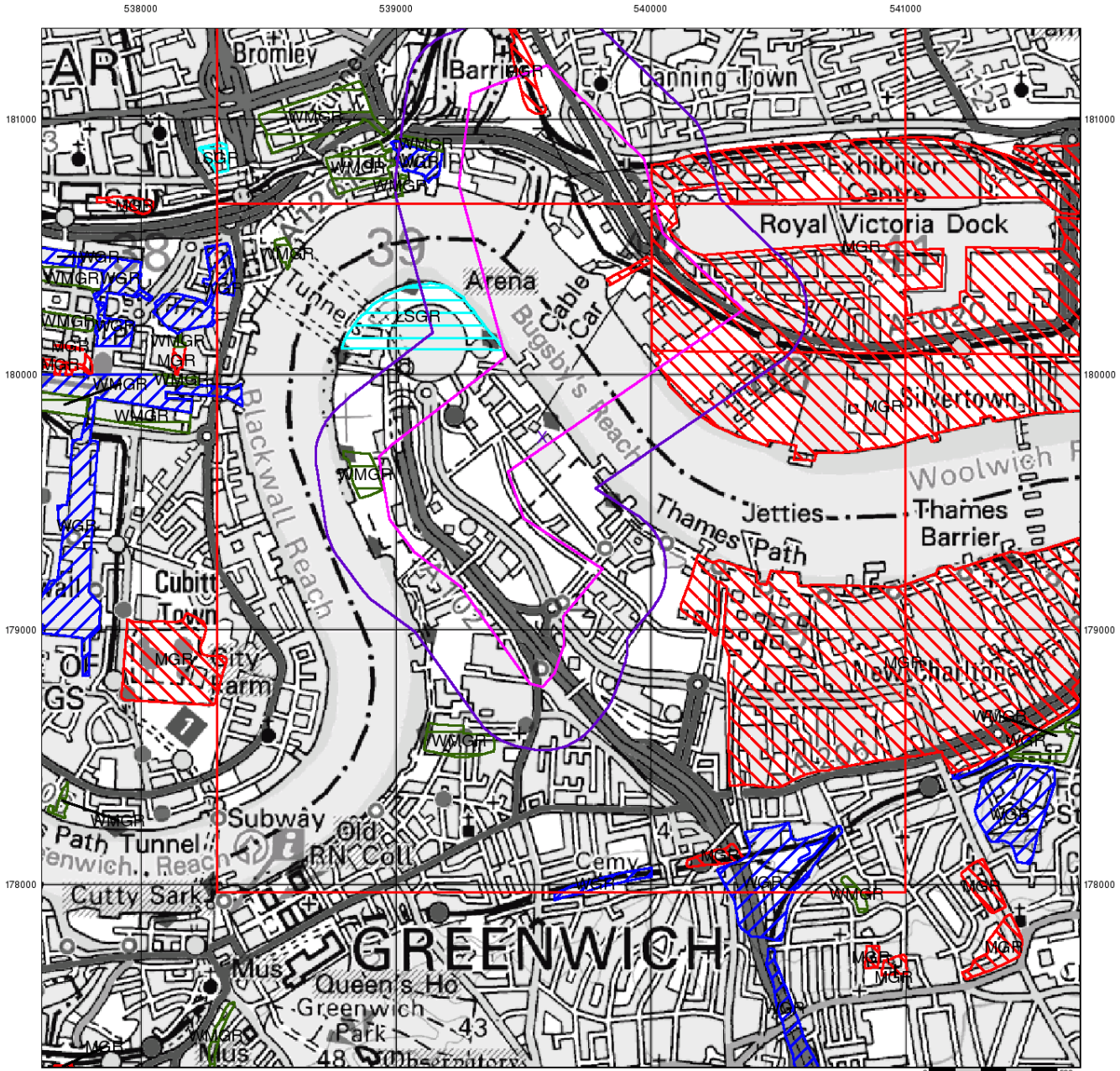
Order Number:	44579755_1_1
Customer Reference:	320530BB01
National Grid Reference:	539580, 179760
Slice:	A
Site Area (Ha):	143.07
Search Buffer (m):	250

Site Details:

Site at 539648,179995

Landmark Information Group
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk

B.1.2 Artificial Ground and Landslip Map



Envirocheck® Geology

Artificial Ground and Landslip

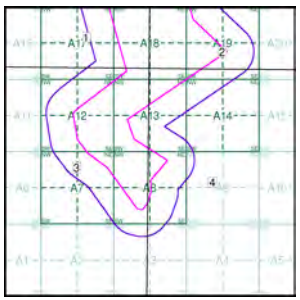
Artificial ground is a term used by BGS for those areas where the ground surface has been significantly modified by human activity. Information about previously developed ground is especially important, as it is often associated with potentially contaminated material, unpredictable engineering conditions and unstable ground.

Artificial ground includes:

- Made ground - man-made deposits such as embankments and spoil heaps on the natural ground surface.
- Worked ground - areas where the ground has been cut away such as quarries and road cuttings.
- Infilled ground - areas where the ground has been cut away then wholly or partially backfilled.
- Landscaped ground - areas where the surface has been reshaped.
- Disturbed ground - areas of ill-defined shallow or near surface mineral workings where it is impracticable to map made and worked ground separately.

Mass movement (landslip) deposits on BGS geological maps are primarily superficial deposits that have moved down slope under gravity to form landslips. These affect bedrock, other superficial deposits and artificial ground. The dataset also includes foundered strata, where the ground has collapsed due to subsidence.

Artificial Ground and Landslip Map - Slice A



Order Details:

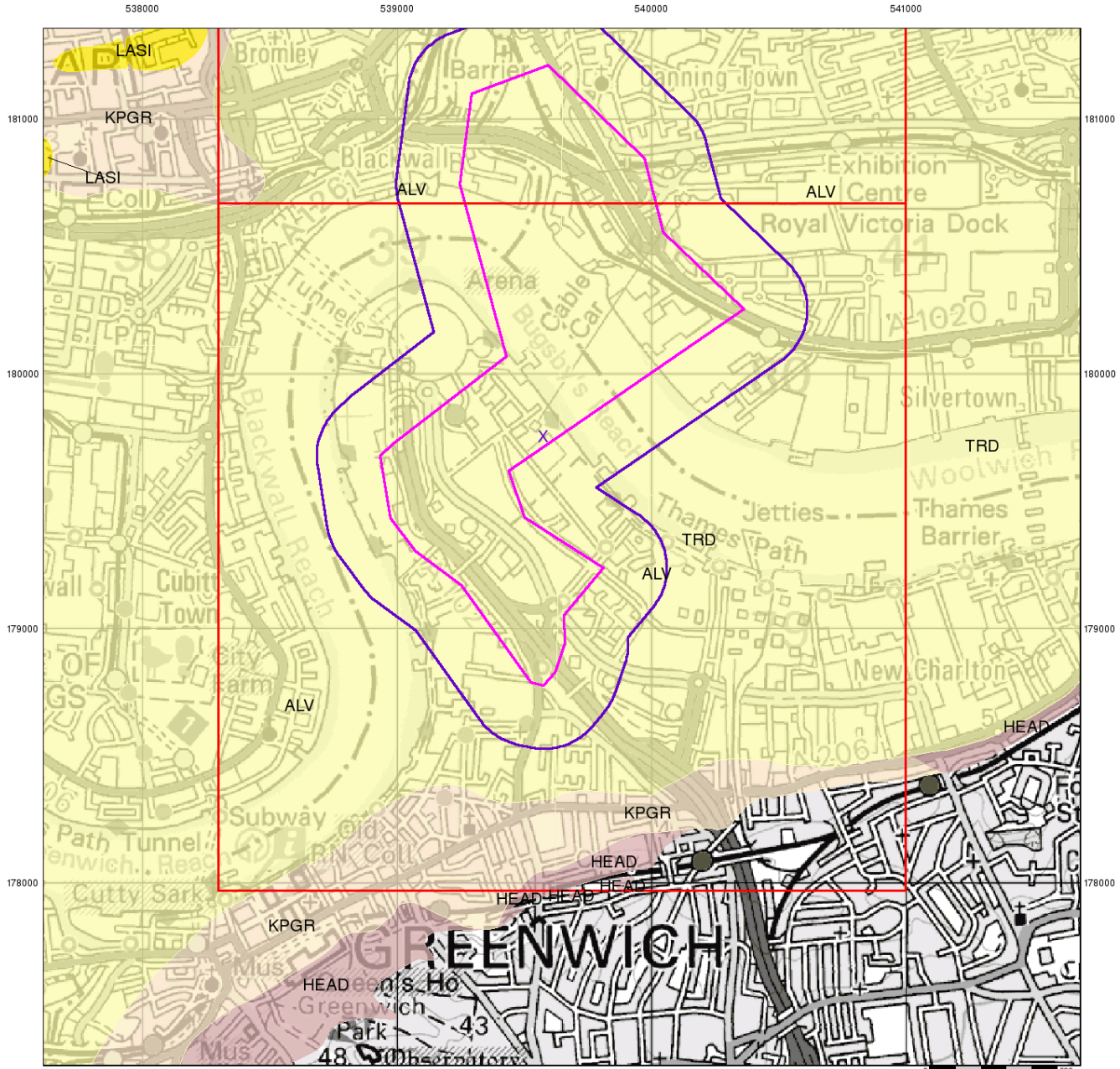
Order Number:	44579755_1_1
Customer Reference:	320530BB01
National Grid Reference:	539580, 179760
Slice:	A
Site Area (Ha):	143.07
Search Buffer (m):	250

Site Details:

Site at 539648,179995

Landmark Information Group
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk

B.1.3 Superficial Geology Map



Envirocheck® Geology

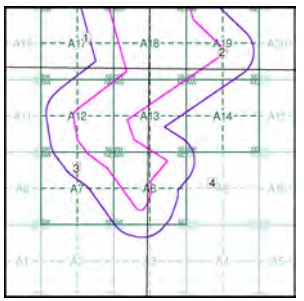
Superficial Geology

Superficial Deposits are the youngest geological deposits formed during the most recent period of geological time, the Quaternary, which extends back about 1.8 million years from the present.

They rest on older deposits or rocks referred to as Bedrock. This dataset contains Superficial deposits that are of natural origin and 'in place'. Other superficial strata may be held in the Mass Movement dataset where they have been moved, or in the Artificial Ground dataset where they are of man-made origin.

Most of these Superficial deposits are unconsolidated sediments such as gravel, sand, silt and clay, and onshore they form relatively thin, often discontinuous patches or larger spreads.

Superficial Geology Map - Slice A



Order Details:

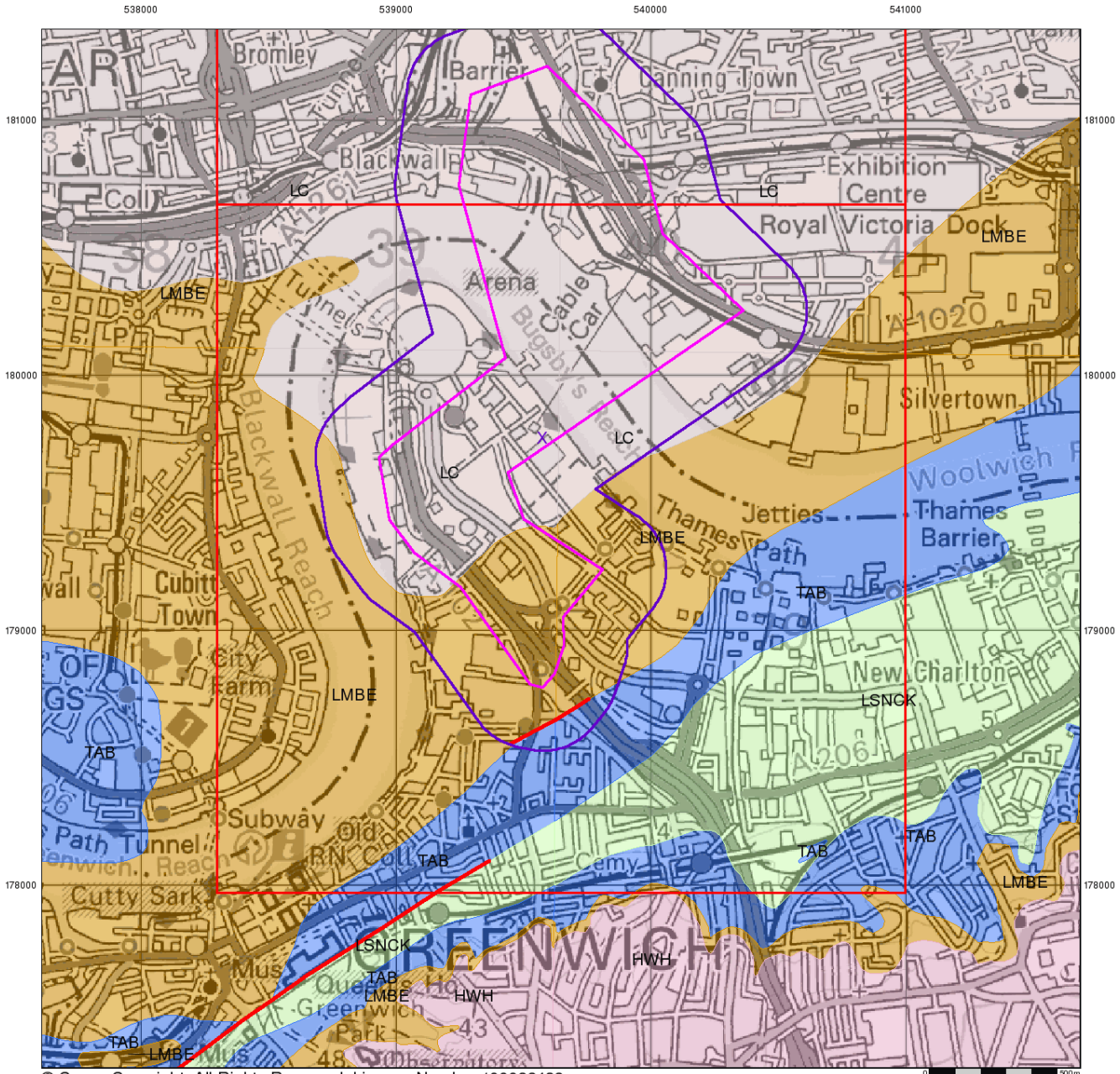
Order Number:	44579755_1_1
Customer Reference:	320530BB01
National Grid Reference:	539580, 179760
Slice:	A
Site Area (Ha):	143.07
Search Buffer (m):	250

Site Details:

Site at 539648,179995

Landmark Information Group
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk

B.1.4 Bedrock and Fault Geology Map



Envirocheck® Geology

Bedrock and Faults

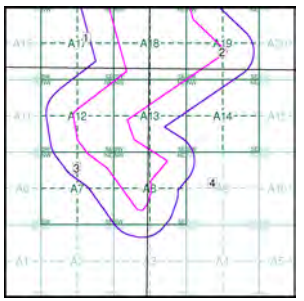
Bedrock geology is a term used for the main mass of rocks forming the Earth and are present everywhere, whether exposed at the surface in outcrops or concealed beneath superficial deposits or water.

The bedrock has formed over vast lengths of geological time ranging from ancient and highly altered rocks of the Proterozoic, some 2500 million years ago, or older, up to the relatively young Pliocene, 1.8 million years ago.

The bedrock geology includes many lithologies, often classified into three types based on origin: igneous, metamorphic and sedimentary.

The BGS Faults and Rock Segments dataset includes geological faults (e.g. normal, thrust), and thin beds mapped as lines (e.g. coal seam, gypsum bed). Some of these are linked to other particular 1:50,000 Geology datasets, for example, coal seams are part of the bedrock sequence, most faults and mineral veins primarily affect the bedrock but cut across the strata and post date its deposition.

Bedrock and Faults Map - Slice A



N

Order Details:

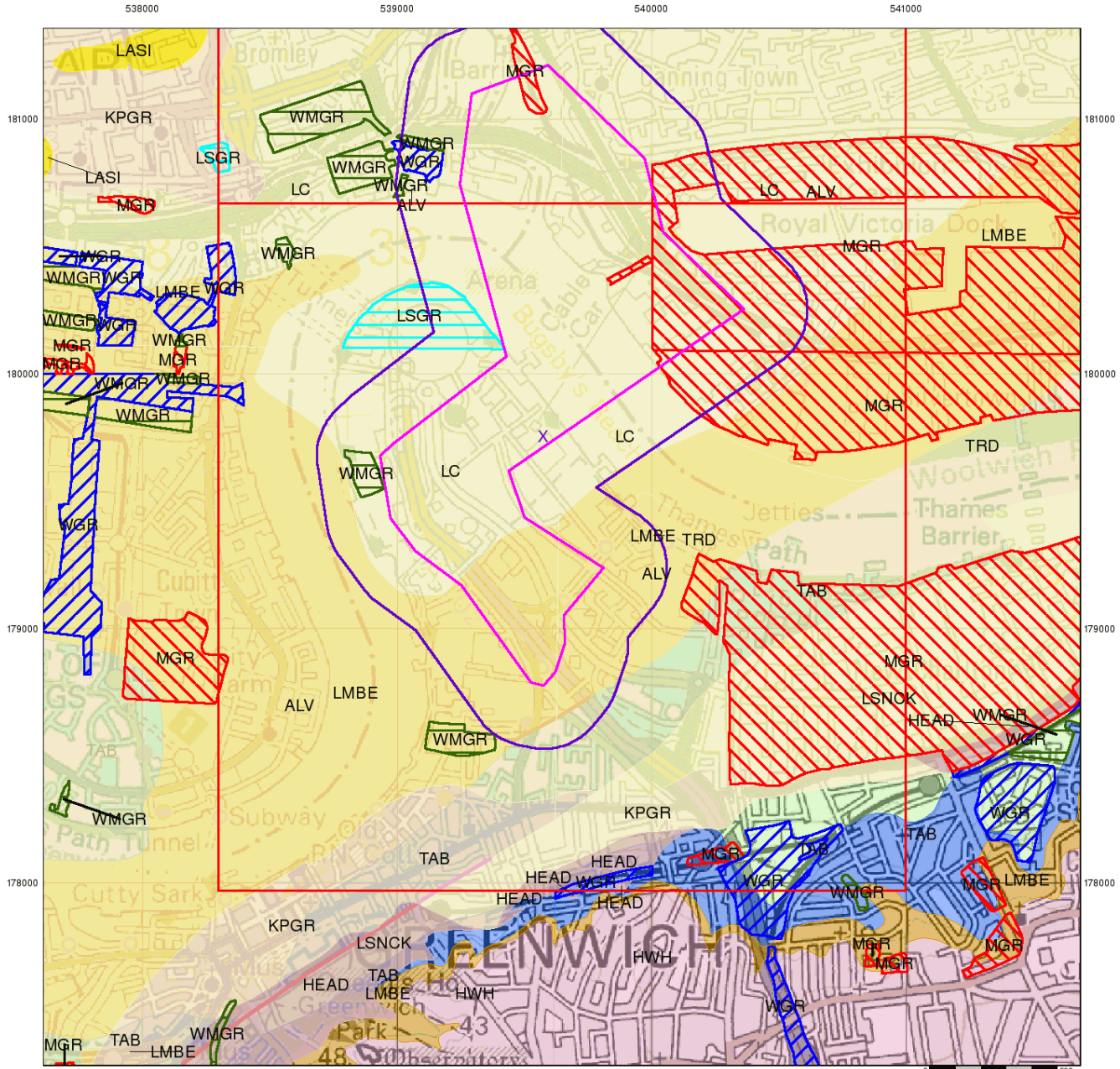
Order Number:	44579755_1_1
Customer Reference:	320530BB01
National Grid Reference:	539580, 179760
Slice:	A
Site Area (Ha):	143.07
Search Buffer (m):	250

Site Details:

Site at 539648,179995

Landmark Information Group
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk

B.1.5 Combined Surface Geology Map



Envirocheck® Geology

Combined Surface Geology

The Combined Surface Geology map combines all the previous maps into one combined geological overview of your site.

Please consult the legends to the previous maps to interpret the Combined "Surface Geology" map.

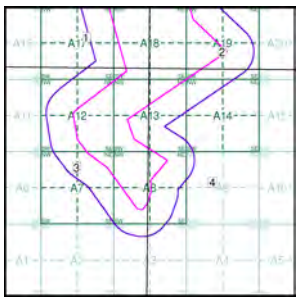
Additional Information

More information on 1:50,000 Geological mapping and explanations of rock classifications can be found on the BGS website. Using the LEX Codes in this report, further descriptions of rock types can be obtained by interrogating the 'BGS Lexicon of Named Rock Units'. This database can be accessed by following the 'Information and Data' link on the BGS website.

Contact

British Geological Survey
Kingsley Dunham Centre
Keyworth
Nottingham
NG12 5GG
Telephone: 0115 936 3143
Fax: 0115 936 3276
email: enquiries@bgs.ac.uk
website: www.bgs.ac.uk

Combined Geology Map - Slice A



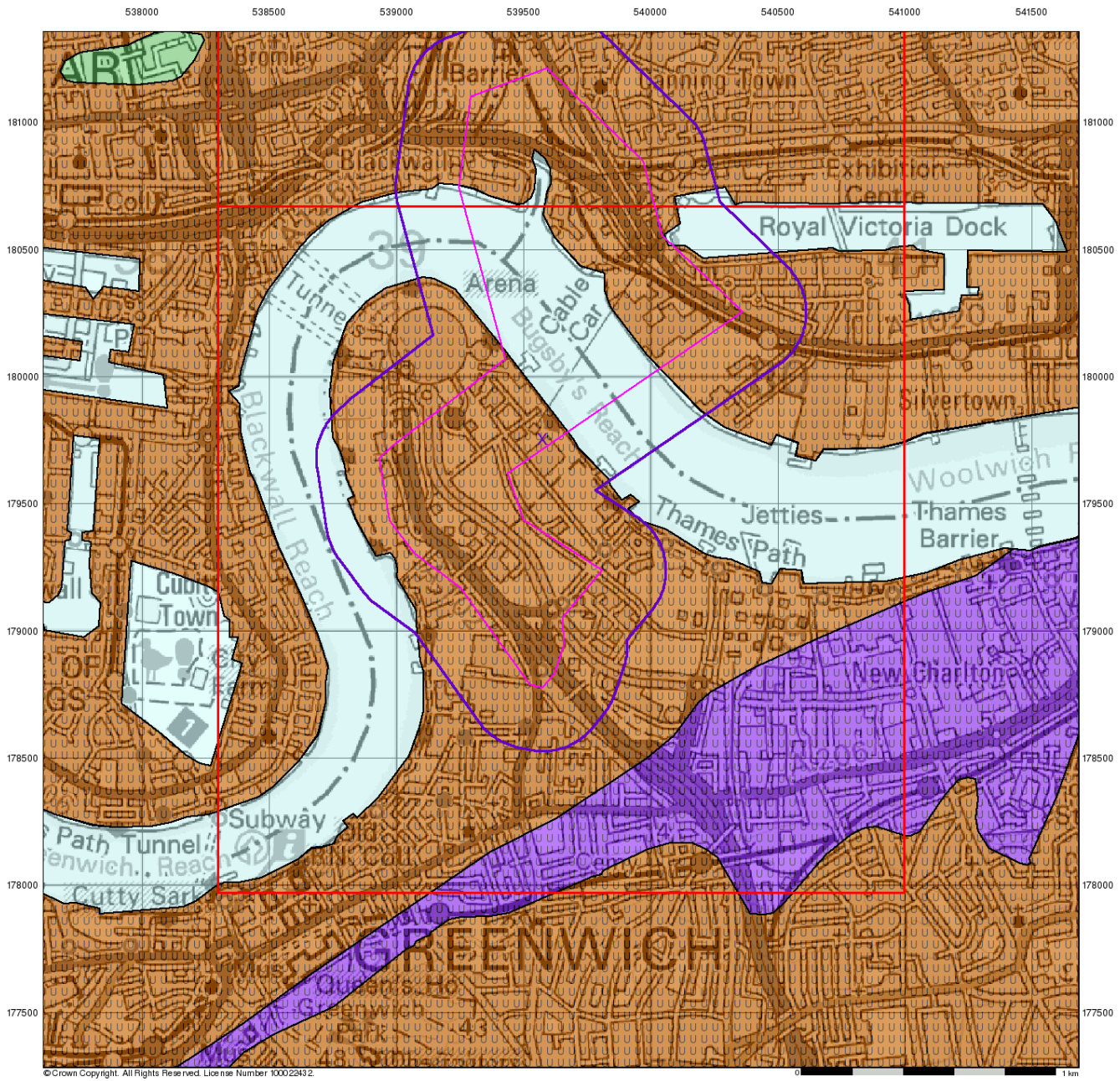
Order Details:

Order Number:	44579755_1_1
Customer Reference:	320530BB01
National Grid Reference:	539580, 179760
Slice:	A
Site Area (Ha):	143.07
Search Buffer (m):	250

Site Details:

Site at 539648,179995

B.1.6 Groundwater Vulnerability Map



Groundwater Vulnerability

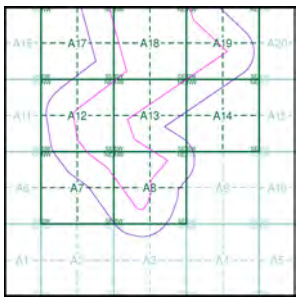
General

Specified Site | Specified Buffer(s) | Bearing Reference Point
Slice | Map ID

Agency and Hydrological

Geological Classes	Soil Classes
Major Aquifer (Highly Permeable)	High (H) 1, 2, 3, U
	Intermediate (I) 1, 2
	Low
Minor Aquifer (Variably Permeable)	High (H) 1, 2, 3, U
	Intermediate (I) 1, 2
	Low
Non Aquifer (Negligibly Permeable)	
Water or Sea	
Drift Deposit	

Site Sensitivity Context Map - Slice A



Order Details

Order Number:	44579755_1_1
Customer Ref:	320530BB01
National Grid Reference:	539580, 179760
Slice:	A
Site Area (Ha):	143.07
Search Buffer (m):	250

Site Details

Site at 539648,179995

Landmark Information Group
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk

B.1.7 Bedrock Aquifer Designation Map

Envirocheck®

Bedrock Aquifer Designation

General

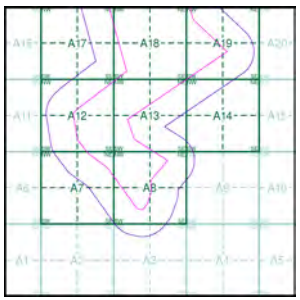
Specified Site | Specified Buffer(s) | Bearing Reference Point
Slice | Map ID

Agency and Hydrological

Geological Classes

- Principal Aquifer
- Secondary A Aquifer
- Secondary B Aquifer
- Secondary Undifferentiated
- Unproductive Strata
- Unknown

Site Sensitivity Context Map - Slice A



Order Details

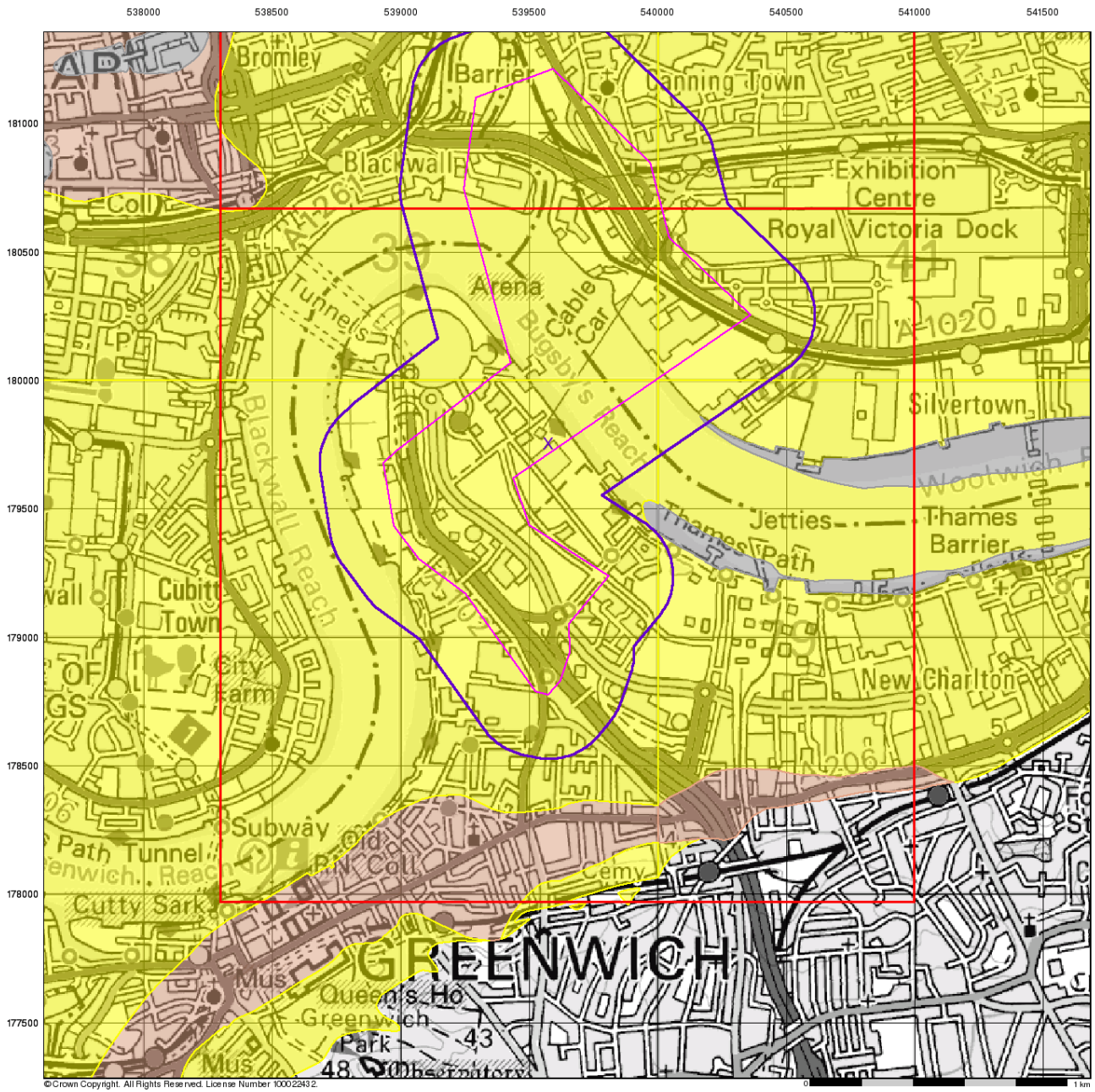
Order Number:	44579755_1_1
Customer Ref:	320530BB01
National Grid Reference:	539580, 179760
Slice:	A
Site Area (Ha):	143.07
Search Buffer (m):	250

Site Details

Site at 539648,179995

Landmark Information Group
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk

B.1.8 Superficial Aquifer Designation Map



Superficial Aquifer Designation

General

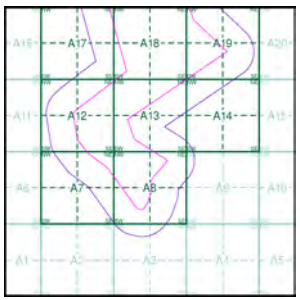
Specified Site | Specified Buffer(s) | Bearing Reference Point
Slice | Map ID

Agency and Hydrological

Geological Classes

- Principal Aquifer
- Secondary A Aquifer
- Secondary B Aquifer
- Secondary Undifferentiated
- Unproductive Strata
- Unknown

Site Sensitivity Context Map - Slice A



Order Details

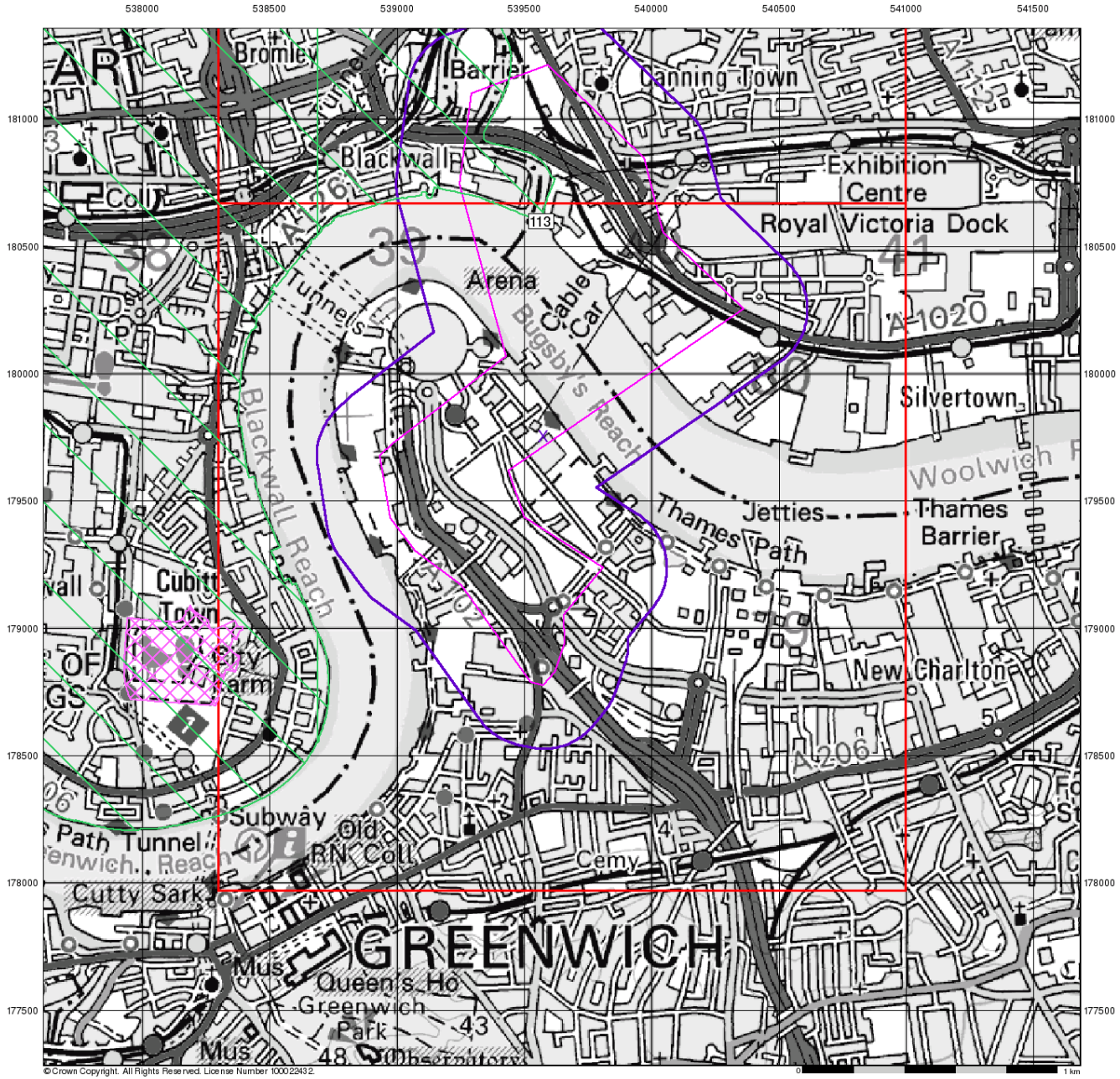
Order Number:	44579755_1_1
Customer Ref:	320530BB01
National Grid Reference:	539580, 179760
Slice:	A
Site Area (Ha):	143.07
Search Buffer (m):	250

Site Details

Site at 539648,179995

Landmark Information Group
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk

B.1.9 Source Protection Zone Map



Envirocheck®

Sensitive Land Uses

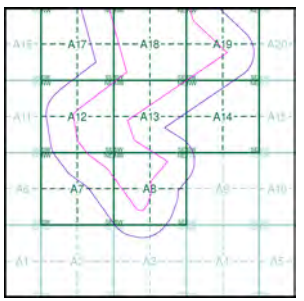
General

Specified Site | Specified Buffer(s) | Bearing Reference Point
Slice | Map ID

Sensitive Land Uses

- Area of Adopted Green Belt
- Area of Unadopted Green Belt
- Area of Outstanding Natural Beauty
- Environmentally Sensitive Area
- Forest Park
- Local Nature Reserve
- Marine Nature Reserve
- National Nature Reserve
- National Park
- Nitrate Sensitive Area
- Nitrate Vulnerable Zone
- Ramsar Site
- Site of Special Scientific Interest
- Special Area of Conservation
- Special Protection Area

Site Sensitivity Context Map - Slice A



Order Details

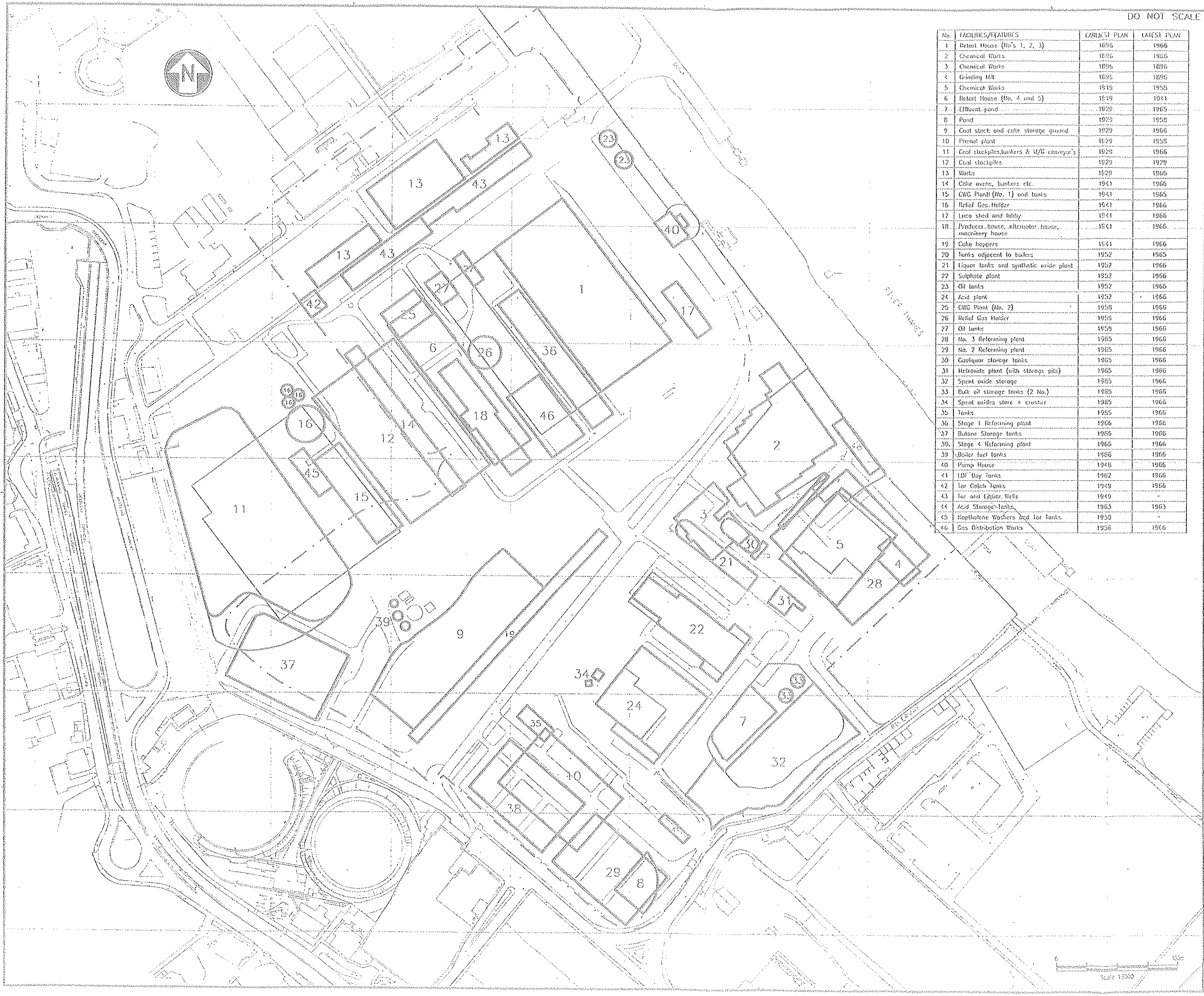
Order Number:	44579755_1_1
Customer Ref:	320530BB01
National Grid Reference:	539580, 179760
Slice:	A
Site Area (Ha):	143.07
Search Buffer (m):	250

Site Details

Site at 539648,179995

Landmark Information Group
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk

B.2 Plan of Gasworks from 1966



No.	FACILITIES/FEATURES	EARLIEST PLAN	LATEST PLAN
1	Retort House (No's 1, 2, 3)	1896	1966
2	Chemical Works	1896	1966
3	Chemical Works	1896	1896
4	Grinding Mill	1896	1896
5	Chemical Works	1919	1959
6	Retort House (No. 4 and 5)	1919	1941
7	Effluent pond	1929	1965
8	Pond	1929	1958
9	Coal stock and coke storage ground	1929	1966
10	Phenol plant	1929	1958
11	Coal stockpiles,bunkers & U/G conveyor's	1929	1966
12	Coal stockpiles	1929	1929
13	Works	1929	1966
14	Coke ovens, bunkers etc.	1941	1966
15	CWG Plant (No. 1) and tanks	1941	1965
16	Relief Gas Holder	1941	1966
17	Loco shed and lobby	1941	1966
18	Producer house, alternator house, machinery house	1941	1966
19	Coke hoppers	1941	1966
20	Tanks adjacent to boilers	1952	1965
21	Liquor tanks and synthetic oxide plant	1952	1966
22	Sulphate plant	1952	1966
23	Oil tanks	1952	1966
24	Acid plant	1952	1966
25	CWG Plant (No. 2)	1959	1966
26	Relief Gas Holder	1959	1966
27	Oil tanks	1959	1966
28	No. 3 Reforming plant	1965	1966
29	No. 2 Reforming plant	1965	1966
30	Gasliquor storage tanks	1965	1966
31	Metroxide plant (with storage pits)	1965	1966
32	Spent oxide storage	1965	1966
33	Bulk oil storage tanks (2 No.)	1965	1966
34	Spent oxides store + crusher	1965	1966
35	Tanks	1965	1966
36	Stage 1 Reforming plant	1966	1966
37	Butane Storage tanks	1966	1966
38	Stage 4 Reforming plant	1966	1966
39	Boiler fuel tanks	1966	1966
40	Pump House	1948	1966
41	LDF Day Tanks	1962	1966
42	Tar Catch Tanks	1949	1966
43	Tar and Liquor Wells	1949	-
44	Acid Storage Tanks	1963	1963
45	Napthalene Washers and Tar Tanks	1950	-
46	Gas Distribution Works	1956	1966

WS Atkins

Rev	Description	By	Date	Chk'd	Auth

Purpose of Issue	Rev	Date	Authorised

Complete to show purpose of each issue

Initial box for client signatures when required

WS Atkins Consultants Limited ©
Consulting Engineers,
Woodcote Grove,
Ashley Road,
Epsom, Surrey, England,
KT18 5BW
Fax (01372) 740055
Tel. (01372) 726140

Client
PORT GREENWICH LIMITED

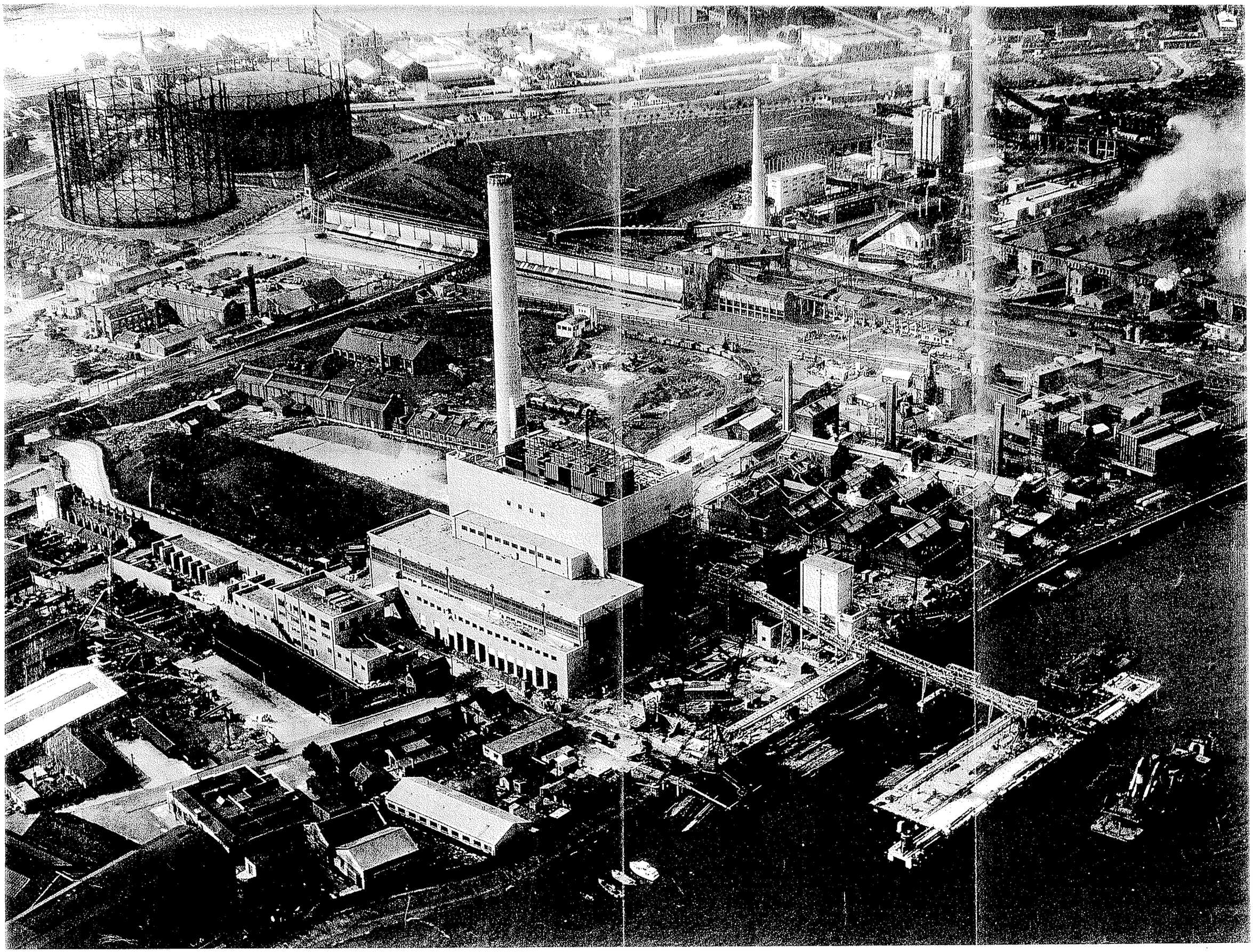
Project
MILLENNIUM EXHIBITION SITE
STAGE 1 (PHASE 2)
REMEDIATION WORKS

Title
AREAS 3 & 6
DIGITISED HISTORICAL DATA
COMPOSITE PLAN

Original Scale	Drawn	Checked	Authorised
1:3000	CVK	[signature]	[signature]
	Date 18.11.96	Date 3/12/96	Date 2.12.96

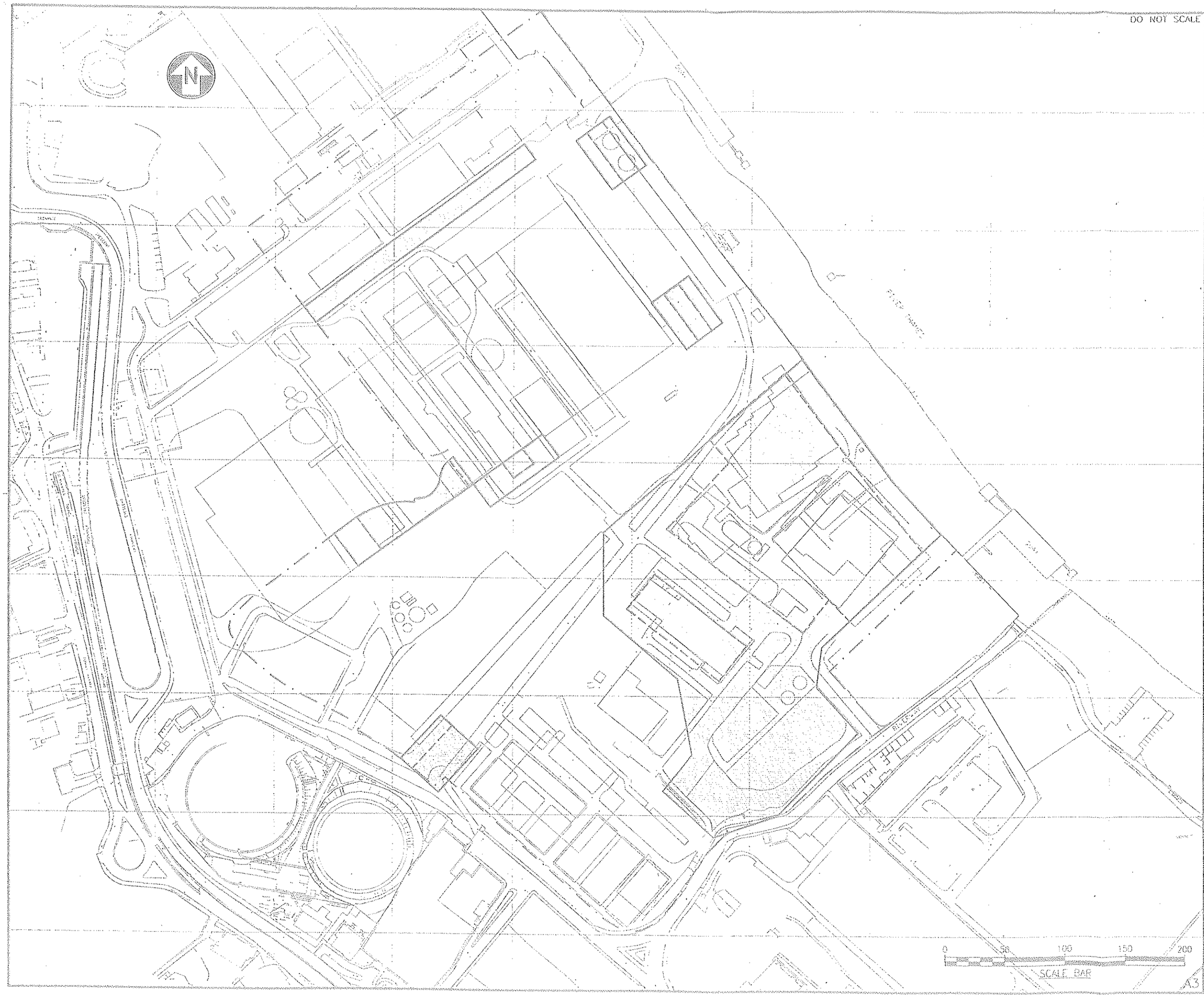
Drawing Number AC1806 / C / 102 — Rev 0

B.3 Aerial photograph of Gasworks, date unknown



B.4 Extract from WS Atkins Remediation Strategy, 1996

DO NOT SCALE



WS Atkins

LEGEND:

- PROVISIONAL EXCAVATION.
- OBSTRUCTION BREAKOUT (RELATED TO CONTAMINATION ONLY).
- SITE BOUNDARY.
- PROVISIONAL REMEDIATION AREAS.

Rev	Description	By	Date	Chk'd	Auth

Purpose of issue	Rev	Date	Authorised

WS Atkins Consultants Limited ©
Consulting Engineers,
Woodcote Grove,
Ashley Road,
Epsom, Surrey, England,
KT18 5BW
Fax (01372) 740055
Tel. (01372) 726140

Client

PORT GREENWICH LIMITED

Project

MILLENNIUM EXHIBITION SITE
STAGE 1 (PHASE 2)
REMEDIATION WORKS

Title

ESTIMATED EXTENT
OF REMEDIATION

Original Scale	Drawn	Checked	Authorised
1:3000	CMH		
	Date 19.11.96	Date	Date

Drawing Number: AC1806 / C / 103

Rev: 0

A3

AC1806 / C / 103 0

B.R.Box for client signature where required

Complete to show purpose of each issue

Note revision

Sub. revision

Detail

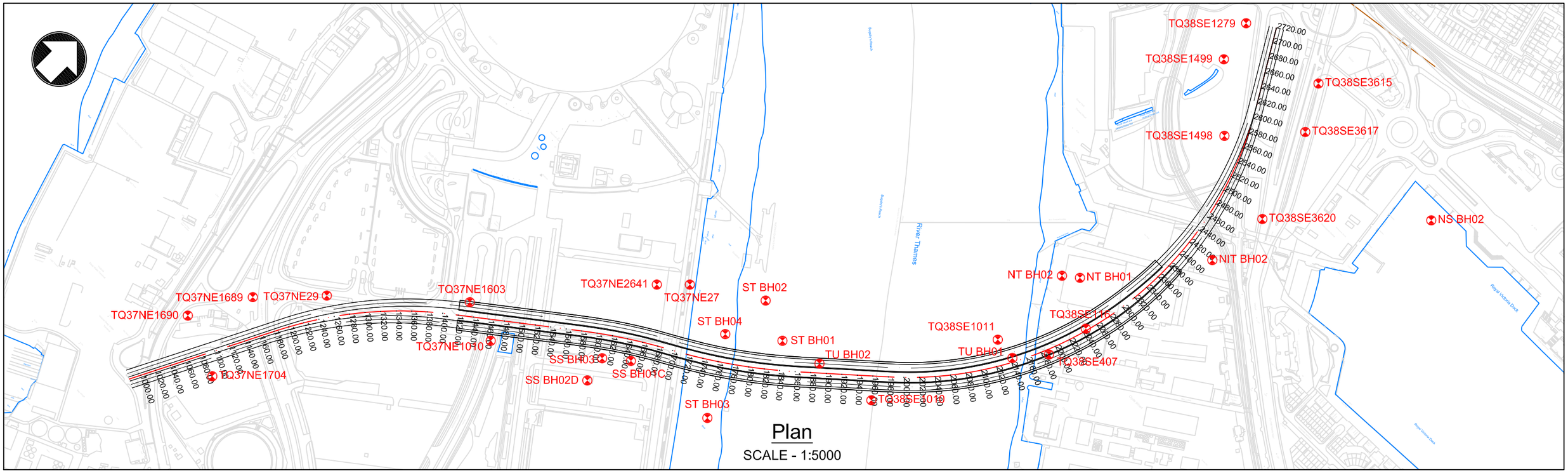
Initial issue

Engineering

Eng. rev. & Status Changes

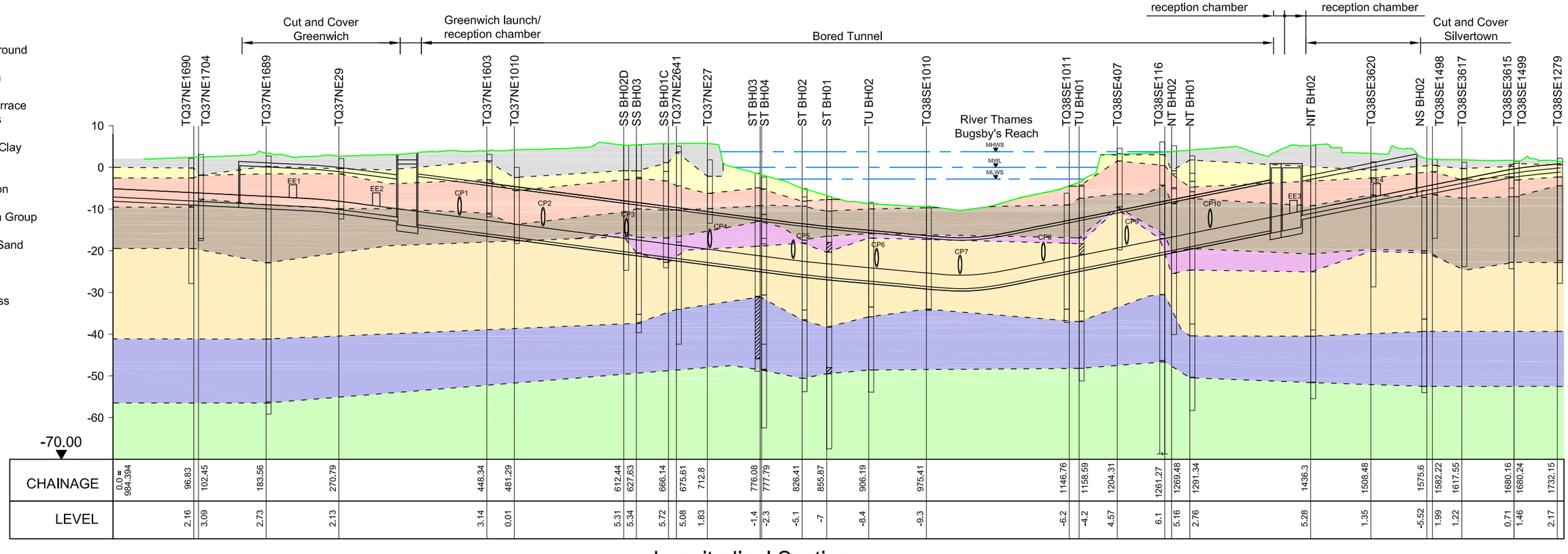
Appendix C. Stratigraphic Profile

C.1 Stratigraphic Profile



Key:

- Made Ground
- Alluvium
- River Terrace Deposits
- London Clay
- Harwich Formation
- Lambeth Group
- Thanet Sand
- Chalk
- Core Loss



CHAINAGE	0.0 = 984.394	96.83	102.45	183.56	270.79	448.34	481.29	612.44	627.63	666.14	675.61	712.8	776.08	777.79	826.41	855.87	906.19	975.41	1146.76	1158.59	1204.31	1261.27	1269.48	1291.34	1436.3	1508.48	1575.6	1582.22	1617.55	1680.16	1680.24	1732.15
LEVEL		2.16	3.09	2.73	2.13	3.14	0.01	5.31	5.34	5.72	5.08	1.83	-1.4	-2.3	-5.1	-7	-8.4	-9.3	-6.2	-4.2	4.57	6.1	5.16	2.76	5.28	1.35	-5.52	1.99	1.22	0.71	1.46	2.17

Longitudinal Section

SCALE - 1:5000(H), 1:1000 (V)

Silvertown Tunnel
Geological Long Section
Figure 1

Appendix D. UXO Report

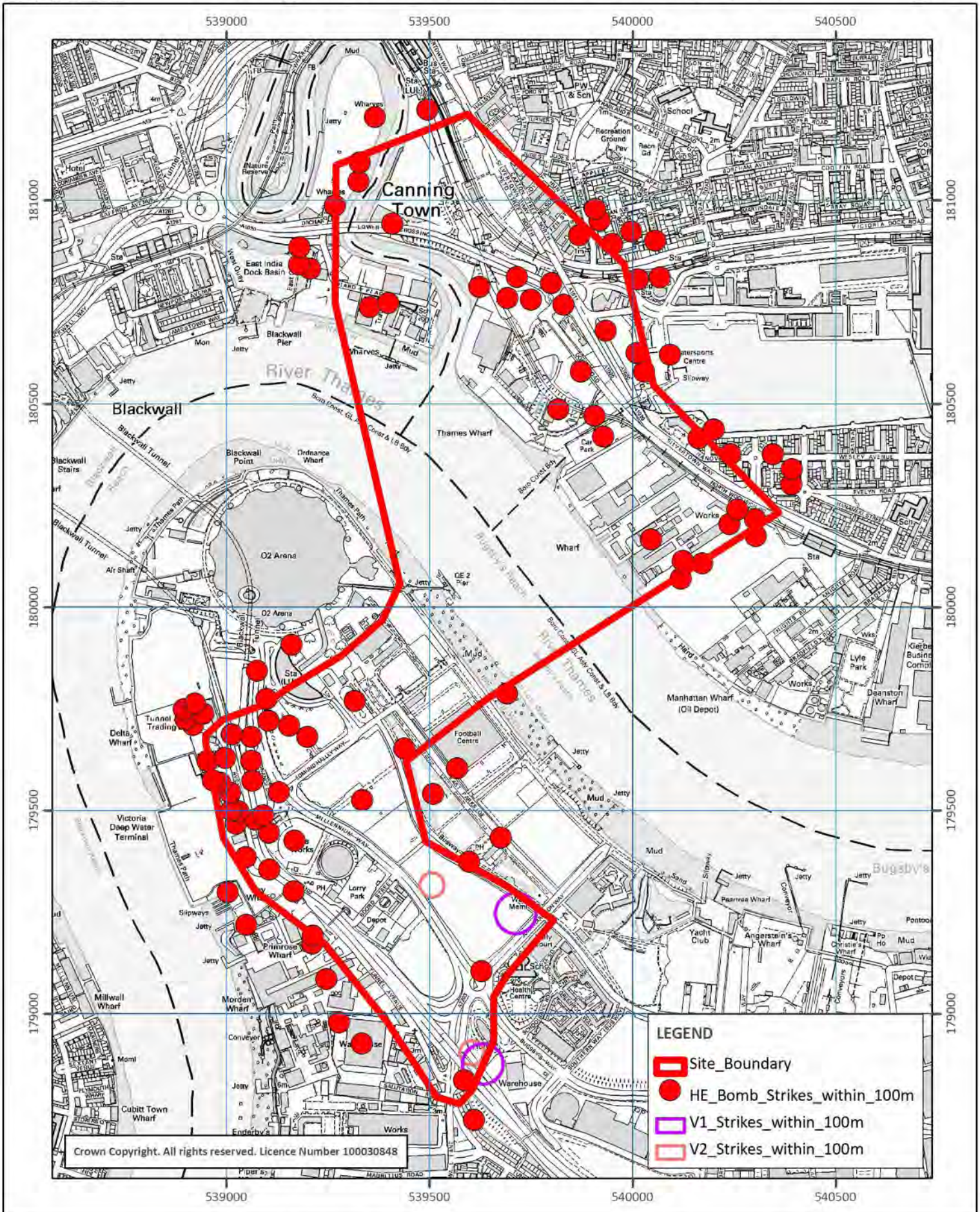
D.1 UXO Report

SILVERTOWN, LONDON

WWII High Explosive Bomb Strikes within 100m of Site

BRITISH NATIONAL GRID

Figure 6



BOMB SEARCH
WWW.6ALPHA.COM

0 50 100 200 300 400 500 Meters

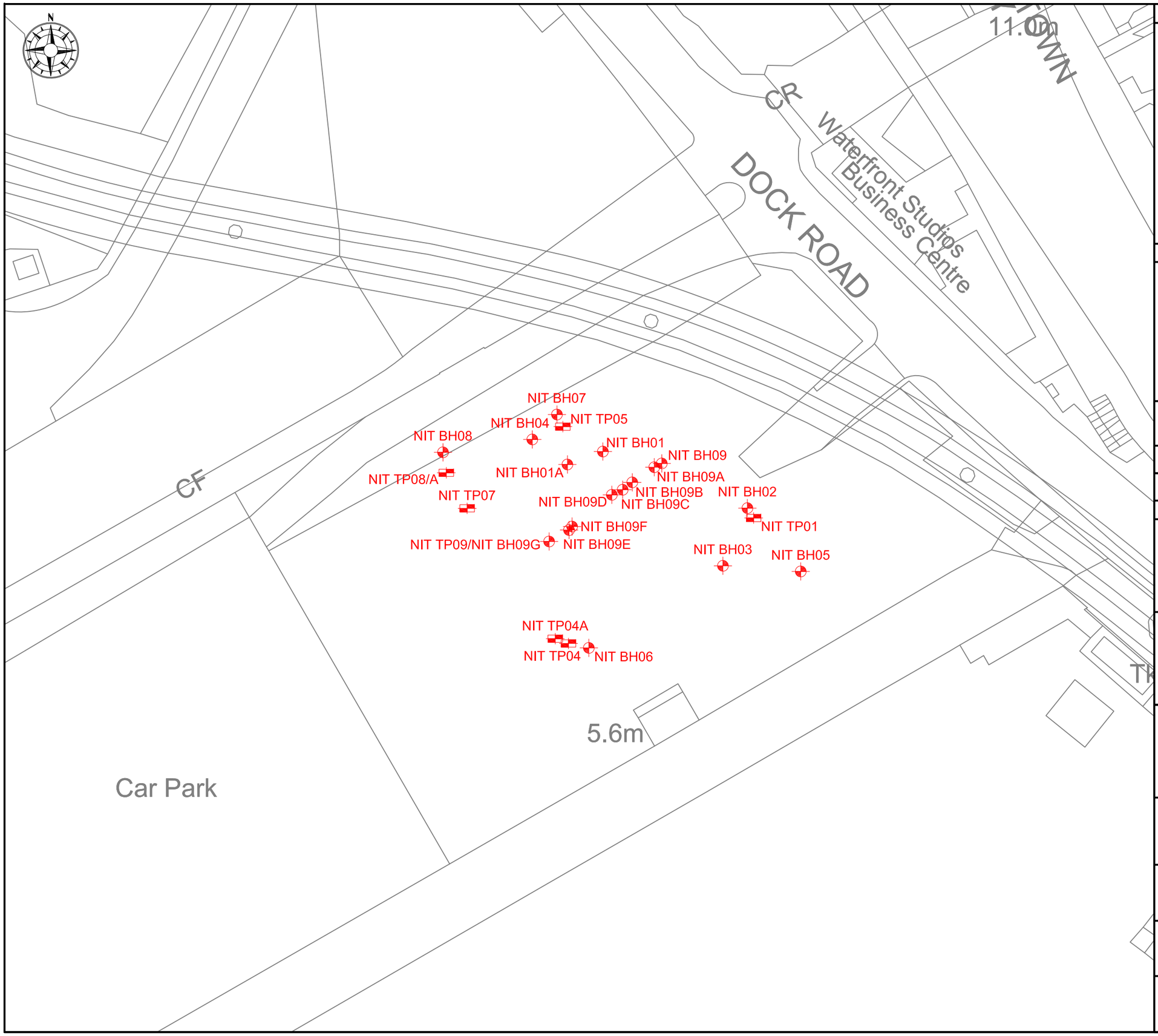
N

Produced by and Copyright to 6 Alpha Associates Ltd.
Users noting any errors please forward to 6 Alpha.
Background data supplied by Ordnance Survey under licence.

PROJECT NO.	P3246
DRAWN BY	DR
CHECKED BY	GW
DATE	6th March 2013

Appendix E. Cable Car (2011) Ground Investigation Locations

E.1 Overlying the Former Royal Victoria Dock Western Entrance



GENERAL NOTES

1. Reproduced from Transport For London's Drawing No. Exploratory Hole Plan – Fig 1 Rev No. 2.
2. Hole Locations to National Grid Co–ordinate Reference System.
3. All levels are in metres and related to Ordnance Datum (Newlyn) unless indicated otherwise.
4. Co–Ordinates and levels for exploratory hole locations NIT TP09/NIT BH09G are approximate.

LEGEND TO SYMBOLS

- Borehole Location
- Trial Pit Location
- Concrete Core Location
- Dynamic Sampling Location

Scale: 1:500

0 5m 10 15 20 25

Rev	Drawn	Date	Approv.	Date	Modification Details
x	x	x	x	x	x

AMENDMENTS

Title

SITE PLAN

Project

CABLE CAR FOR LONDON
GROUND INVESTIGATION

Client

TRANSPORT FOR LONDON

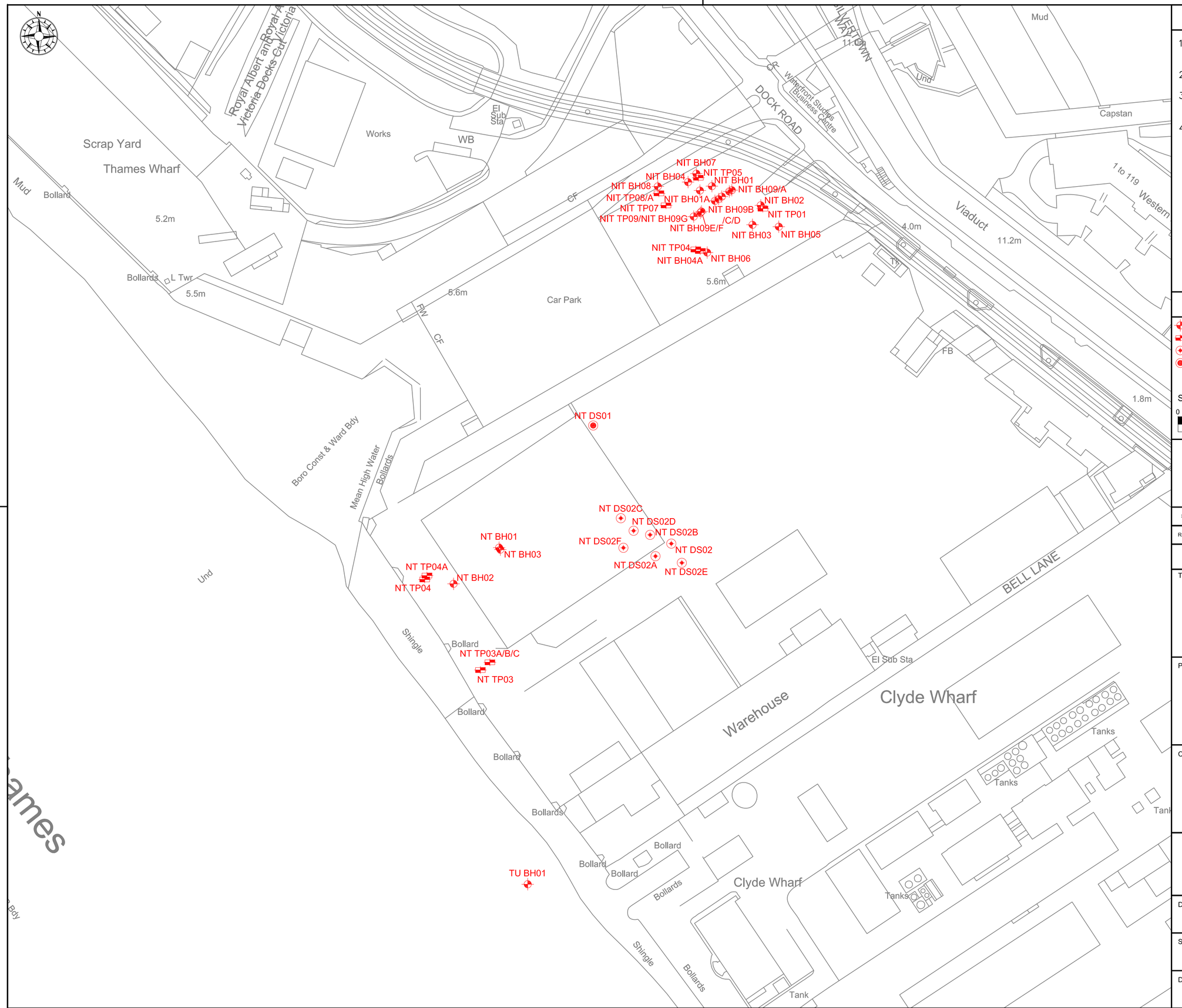
Soil Mechanics

Date	Drawn By	Approv. By
04/05/2011	BS	EC

Sheet Size	Scale	Project No
A3	1:500	D1002-11

Drawing No	Rev
C3/1	0

E.2 Adjacent, South of the Former Royal Victoria Dock Western Entrance



GENERAL NOTES

1. Reproduced from Transport For London's Drawing No. Exploratory Hole Plan – Fig 1 Rev No. 2.
2. Hole Locations to National Grid Co–ordinate Reference System.
3. All levels are in metres and related to Ordnance Datum (Newlyn) unless indicated otherwise.
4. Co–Ordinates and levels for exploratory hole locations NT DS02 to NT DS02E are approximate.

LEGEND TO SYMBOLS

- Borehole Location
- Trial Pit Location
- Concrete Core Location
- Dynamic Sampling Location

Scale: 1:1000

0 10m 20 40 80 100

Rev	Drawn	Date	Approv.	Date	Modification Details
x	x	x	x	x	x

AMENDMENTS

Title

SITE PLAN

Project

CABLE CAR FOR LONDON
GROUND INVESTIGATION

Client

TRANSPORT FOR LONDON

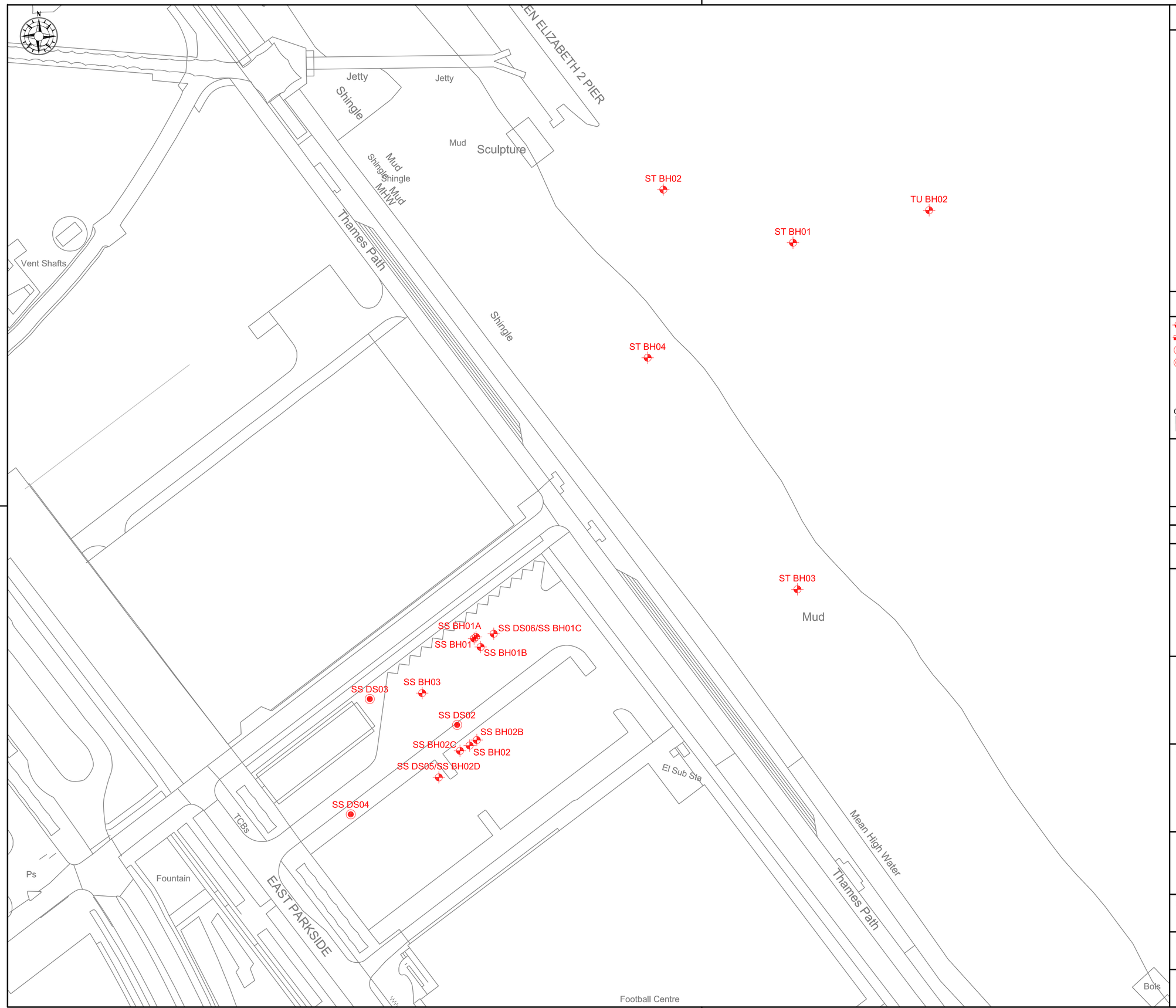
Soil Mechanics

Date	Drawn By	Approv. By
04/05/2011	BS	EC

Sheet Size	Scale	Project No
A2	1:1000	D1002-11

Drawing No	Rev
C4-1	0

E.3 Cutter Lane, adjacent to the Emirates Greenwich Peninsula Terminal



GENERAL NOTES

1. Reproduced from Transport For London's Drawing No. Exploratory Hole Plan – Fig 1 Rev No. 2.
2. Hole Locations to National Grid Co–ordinate Reference System.
3. All levels are in metres and related to Ordnance Datum (Newlyn) unless indicated otherwise.
4. Co–ordinate and level for exploratory hole location SS BH01A is approximate.

LEGEND TO SYMBOLS

- Borehole Location
- Trial Pit Location
- Concrete Core Location
- Dynamic Sampling Location

Scale: 1:1000

0 10m 20 40 80 100

Rev	Drawn	Date	Approv.	Date	Modification Details
x	x	x	x	x	x

AMENDMENTS

Title

SITE PLAN

Project

CABLE CAR FOR LONDON
GROUND INVESTIGATION

Client

TRANSPORT FOR LONDON

Soil Mechanics

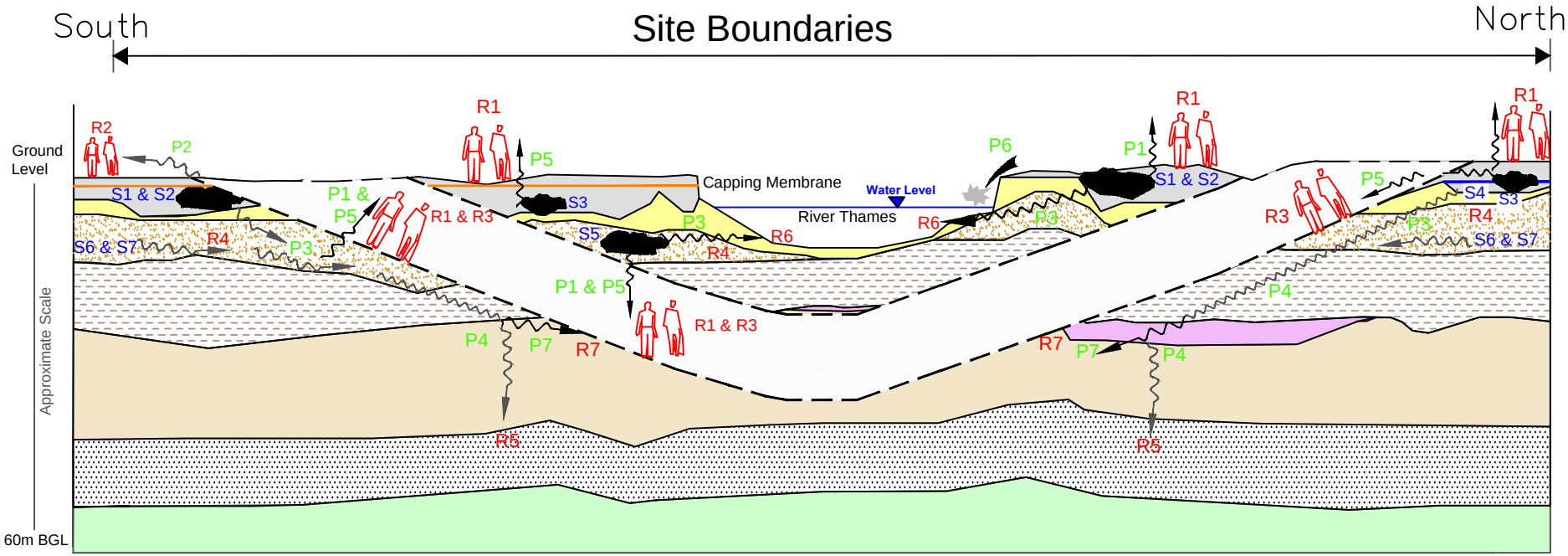
Date	Drawn By	Approv. By
04/05/2011	BS	EC

Sheet Size	Scale	Project No
A2	1:1000	D1002-11

Drawing No	Rev
C5-1	0

Appendix F. Conceptual Site Model

F.1 Conceptual Site Model



Sources

S1: Contamination from ongoing onsite activities
S2: Contamination from former onsite activities
S3: Ground gase from Made Ground, Alluvium and infilled western entrance lock
S4: Contaminated perched water in the Made Ground
S5: Contaminated groundwater within the River Terrace Deposits
S6: Contamination from ongoing offsite activities
S7: Residual contamination from former offsite activities

Pathways

P1: Human uptake pathways such as inhalation, ingestion or dermal contact
P2: Off-site gas/soil vapour migration (by diffusion or due to wind) and windblown sust contaminant pathways during construction activities
P3: Horizontal/vertical migration of leachable contaminants via groundwater within the Made Ground and River Terrace Deposits
P4: Migration of contaminated liquids/groundwater into the lower aquifer through the creation of preferential pathways.
P5: Gas migration through permeable strata or conduits at potentially asphyxiant/explosive concentrations
P6: Direct runoff into the River Thames
P7: Direct contact of soils with construction materials

Receptors

R1: Construction workers involved in site works
R2: Adjacent site users
R3: Tunnel maintenance workers
R4: Groundwater in the upper aquifer
R5: Groundwater in the lower aquifer of the London tertiaries and Chalk Group
R6: River Thames surface water
Deposits/Thanet Sand
R7: Fabric of existing and proposed buildings and services

LEGEND
MADE GROUND
ALLUVIUM
RIVER TERRACE DEPOSITS
LONDON CLAY FORMATION
HARWICH FORMATION
LAMBETH GROUP
THAET SAND FORMATION
SEAFORD CHALK

Mott MacDonald
Mott MacDonald House
Wellesley Road
Croydon
Surrey, CR0 2EE
Tel +44 (0)20 8774 2723
Fax +44 (0)161 926 4100
Web www.mottmac.com

Transport for London

Rev	Date	Drawn	Description	Ch'k'd	App'd

Title: Source – Pathway – Receptor Conceptual Model for Silvertown Tunnel Crossing

Drawn	MH
Checked	DG
Approved	JD
Scale	NTS
Drawing No.	B1
Rev	0
Status	DRAFT

10 References

i British Standards Institution, 2011, BS10175 Code of practice for investigation of potentially contaminated sites

ii Environment Agency (2004). Model procedures for the management of land contamination: Contaminated Land Report 11.

iii Construction Industry Research and Information Association, 2001, C552 Contaminated land risk assessment – a guide to good practice

iv Mott MacDonald. (2010) Geotechnical Desk Study Report for the New Thames River Crossings. Report No. 265453/MNC/FNG/1

v Landmark Information Group (2013) Silvertown, Ref number 44579755_1_1

vi Mott MacDonald. (2013) TfL River Crossings – Preliminary Sources Report. Report No. 320530/MNC/FNG/03

vii Health Protection Agency and British Geological Survey, 2007, Indicative Atlas of in England and Wales
[http://www.hpa.org.uk/Topics/Radiation/UnderstandingRadiation/UnderstandingRadiationTopics/Radon/radon_Map/ Date accessed 29/08/2012]

viii BRE Report BR211 ;Radon: Protective measures for new dwellings http://www.bre.co.uk/radon/Maps/BR211_Map5.pdf Date accessed 29/08/2012

ix Environment Agency, 2013 'What's in your backyard' http://www.environment-agency.gov.uk/homeandleisure/37837.aspx Date accessed 30/08/2012

x Buro Happold. (2011) London Cable Car South – Geo-environmental Investigation. Report No. 003-GS-BHD-REP-(03)001

xi The Environmental Protection Act 1990 (Commencement No.19) Order, April 2012