# Earthworks & Remediation Plan

**Zone A Building** 

King's Cross Central General Partner Ltd and Google UK Limited

May 2017

**King's Cross** 



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King's Cross Central, Zone A Building

Reserved Matters Submission, Earthworks and Remediation Plan

ERP/ZONE A Building/Reserved Matters/REP005

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This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

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## 1 Introduction

#### 1.1 Scope

This Earthworks and Remediation Plan ('ERP') has been prepared by Ove Arup and Partners Limited ('Arup') at the instruction of King's Cross Central General Partners Ltd ('KCCGPL') to support the Reserved Matters submission for a new commercial building on Development Zone A at King's Cross Central (KXC). Specifically, it is submitted to discharge Condition 18 of the KXC Outline Planning Permission dated 22 December 2006 (ref. 2004/2307/P) in relation to the proposed development.

Development Zone A (the Site) has already been the subject of a number of 'Enabling Works' approvals, each with their own ERP. These approvals were for the construction and completion of the Shared Service Yard/Access Ramp (South) and the Interim Service Road, the Access Ramp (North), the Zone A site preparation works ('Early Works') and, more recently, for the construction of a previous Zone A Building and its basement (for which Reserved Matters were granted in September 2013, with reference 2013/4001/P – the '2013 Zone A Building'). Details of these approvals and works are provided in Section 1.3 below.

This ERP describes the earthworks and remediation strategy for the construction of a revised Zone A Building and its basement, which will extend below the levels of the previously approved basement. In particular, it addresses the outstanding remediation of the north-western part of the Site and the basement excavation and piling works across the Site for the proposed Zone A Building. This ERP does not address earlier, approved Enabling Works. However, it has regard (and refers) to those Enabling Works to provide context to the current proposals and demonstrate a joined up approach across the whole of Development Zone A ('Zone A').

A plan showing the location of Zone A in the context of the KXC Development area is provided as Figure 1. A plan showing the Reserved Matters boundary indicating the extent of the area covered by this ERP (the 'Site') as well as the areas covered by other previously submitted ERPs, is included as Figure 2.

#### **1.2** Structure of this Report

The layout and content of this ERP is as follows:

- A description of the planning background, existing site conditions and site history are given in the subsequent parts of this Section 1.
- Section 2 describes the proposed Zone A Building basement excavation levels, perimeter retaining walls and piled foundation.
- Section 3 describes the ground and groundwater conditions and summarises the scope of investigations undertaken.
- Section 4 describes the extent of the proposed earthworks, estimated quantities of different materials arising, proposals for recycling and re-use. The anticipated volume of material arising from the current proposals is

also described cumulatively with the spoil removal figures quoted in the ERPs for the previously approved and completed Enabling Works, in order to provide a complete picture for Zone A.

- Section 5 describes the proposed approach to remediation works, the results of contamination ground investigations, the conceptual site model and the remediation strategy.
- Figures illustrating the location and extent of the proposed earthworks and remediation follow the text.
- Appendix A contains selected plans and cross sections of the basement of the proposed Zone A Building.
- Appendix B contains the logs of boreholes and a trial pit carried out in the part of the Site where remediation is to be undertaken, together with selected other ground investigation information.
- Appendix C contains Unexploded Ordnance (UXO) risk plans.
- Appendix D contains spreadsheets of the contamination testing undertaken on soil and groundwater samples from that part of Zone A not subject to earlier Enabling Works remediation (referred to as "Sub-Area 5", see Section 1.4), screened against commercial end-use human health criteria and water quality standards and guidelines, respectively.
- Appendix E contains historical Ordnance Survey plans.
- Appendix F contains a selection of plans and sections of the approved temporary Railway Children Theatre (now removed).

#### **1.3 Background**

The infrastructure and development in Zone A has been brought forward in phases, with a number of 'Enabling Works'<sup>1</sup> packages having already been approved and constructed. Those works and the relevant approvals are summarised below.

#### **1.3.1** Approved and Constructed

Construction has been completed for the following elements which were granted Enabling Works approval in 2007/2009, 2010, 2013 and 2014:

- The Shared Service Yard ('SSY') (ref. 2007/3284/P, as amended by 2009/0208/P), which sits below ground level at the southern end of Zone A, and provides vehicular access for the servicing of King's Cross Station;
- The Access Ramp (South) ('AR(S)') (approved under the same reference numbers as the SSY), which provides the southern part of the vehicular access from Goods Way to the Shared Service Yard (and eventually to the central and

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<sup>&</sup>lt;sup>1</sup> Details of Enabling Works are submitted pursuant to Condition 25 of the KXC Outline Planning Permission (ref. 2004/2307/P). Enabling Works are defined under the Outline Planning Permission as including, among other works, 'site preparation works'; 'the Service Access and potential Kings Cross Station servicing...as shown on Parameter Plan KXC016'; and 'the installation of site utilities in accordance with the strategy shown in KXC018'.

southern parts of the Zone A Building basement). It was initially connected to Goods Way by way of the Interim Service Road (see below).

- The Interim Service Road ('ISR') (ref. 2010/1495/P), which provided temporary vehicular access from Goods Way to the AR(S), before completion of the construction of the Access Ramp (North) (see below).
- The Access Ramp (North) ('AR(N)') (ref. 2013/0510/P), which has now replaced the ISR and provides the permanent vehicular access from Goods Way to the AR(S) and will eventually provide vehicular access into the basement areas of the proposed Zone A Building. The AR(N) construction works were completed in April 2014.
- The 'Zone A Site Preparation Works' (ref. 2013/1027/P), encompassing Enabling Works works within the southern 'half' of Zone A and the northern area between the ISR and AR(N). The works, which are also referred to as the Early Works, were completed in April 2014 and included an initial site strip of all the Made Ground and the top of the London Clay (up to 4m) encompassing contamination remediation over the same area, and installation of retaining wall piling on the southern and central parts of the western perimeter of the Site. Figure 3 provides an aerial view of the Site annotated to show the completed, approved enabling works in Zone A as at April 2014.
- A planning application for the construction and temporary use of the central part of the Site as a theatre for the Railway Children production was made by Theatre Tracks Limited in October 2014 (ref. 2014/6593/P). Planning permission was granted in December 2014 for this temporary use until January 2016; a second planning permission (2015/6618/P) was granted in December 2015 for continued use of the three Railway Children theatre temporary structures until January 2018 and the construction of an additional tented structure and a temporary box office. To enable the erection of the temporary theatre, clean granular fill was imported, placed and compacted in layers to provide a level platform. These works are described in Section 1.4.6 of this ERP. Selected plans and sections of the Railway Children development are included in Appendix F of this ERP, for reference.

None of the earthworks and remediation described in the June 2013 Zone A Building ERP, which were approved in September 2013 (reserved matters approval ref. 2013/4001/P), have been carried out.

#### **1.3.2** Related Previous Documentation

This ERP should be read in conjunction with the following documents:

- King's Cross Central Environmental Statement ('ES') Volume 4: Part 16 Soils and Contamination Specialist Report [2];
- King's Cross Central ES Volume 2: Part 9 Cultural Heritage and Townscape Specialist Report and Part 10 Archaeology Specialist Report [3];
- King's Cross Central ES Volume 5: Supplement [4];
- King's Cross Central Revised Code of Construction Practice ('CoCP') [5].

Where appropriate, this document incorporates and/or refers to information presented in the earlier ES and CoCP documents.

The following ERPs have previously been submitted and approved for the abovementioned SSY and AR(S), public realm along the Goods Way/King's Boulevard<sup>2</sup>, the AR(N), the Zone A Enabling Works and the 2013 Zone A Building. A consistent, joined up approach to earthworks and remediation has been adopted across Zone A, with the current proposals and strategies directly informed by those approved as part of the earlier Enabling Works applications and as set out in the 2013 Zone A Building ERP:

- Shared Service Yard and Access Ramp (South) Earthworks and Remediation Plan [6] [part of the Enabling Works approval dated 7 September 2007, reference 2007/3284/P].
- Goods Way and Boulevard Earthworks and Remediation Plan [7] [part of the Enabling Works/Reserved Matters approval dated 31 October 2008, reference 2008/3731/P].
- Access Ramp (North) Earthworks and Remediation Plan, August 2012 [8] [part of the Enabling Works approval dated 8 March 2013, reference 2013/0510/P].
- Zone A Site Preparation Works ('Early Works') Earthworks and Remediation Plan, February 2013 [9] [approval dated 4 April, 2013,ref. 2013/1027/P].
- 2013 Zone A Building Earthworks and Remediation Plan, June 2013 [10] [approved in September 2013 with ref. 2013/4001/P].

#### **1.3.3 Purpose of this ERP**

This ERP is submitted for approval to discharge Condition 18 of the KXC Outline Planning Permission in so far as it relates to revised proposals for a new commercial building and basement within Development Zone A. As such, this ERP replaces the previously approved 2013 Zone A Building ERP, dated June 2013. The proposed earthworks and remediation works build on and are consistent with the Enabling Works that have already taken place across Zone A.

#### **1.4** Site Description

For the purposes of describing the Site and the areas which have already been subject to construction and/or site preparation works, Zone A has been subdivided into 5 'Sub-Areas', denoted as Sub-Area 1 to Sub-Area 5, plus the existing SSY/AR(S) and AR(N) structure footprints, as shown in Figure 3.

The condition of each Sub-Area prior to the temporary establishment of the Railway Children theatre on the Site in December 2014 is described in Sub-Sections 1.4.1 to 1.4.5 below. The temporary filling of the central part of the Site for the construction of the Railway Children theatre is then described in Sub-Section 1.4.6.

#### 1.4.1 Sub-Area 1

The southernmost part of the Site (Sub-Area 1) is bounded to the west by a temporary 'king post' retaining wall which supports King's Boulevard immediately to the west. The steel column 'king posts' are cast into a concrete

<sup>&</sup>lt;sup>2</sup> Formerly known as the Boulevard.

beam which is itself the capping beam of a shallow contiguous pile foundation. Inside and adjacent to the shallow contiguous pile foundation and kingpost wall is the much deeper contiguous pile wall and capping beam that was constructed during the Early Works, along the line of the Zone A Building basement. The Sub-Area is bounded to the south and east by the concrete walls of the SSY and AR(S), respectively. Its northern boundary is defined by the interfaces with Sub-Areas 2 and 4.



Photo 1 View of Sub-Area 1 looking south from Sub-Area 4 after completion of the Early Works piling and excavation (in 2014), but before the additional temporary filling of the northern part of the Sub-Area for the Railway Children theatre development.

Remediation, by removal of all of the overlying Made Ground in Sub-Area 1, was undertaken during the Early Works enabling works and a reduced formation ground level was formed at 13.5mAOD, by placement of a 0.7m to 2.9m thick layer of compacted London Clay fill over the excavated profile (see Photo 2 above). This surface was subsequently capped with a thin layer of clean granular fill.

#### 1.4.2 Sub-Areas 2 and 4

Sub-Areas 2 and 4 sit centrally within Zone A, immediately west of the AR(S). Their northern boundary is defined by the foot of the ISR, which led into the AR(S). The western concrete wall of the AR(S) and its supporting contiguous pile wall and capping beam defines the eastern boundary of Sub-Area 2 and the secant pile wall and capping beam that was constructed during the Early Works, along the line of the Zone A Building basement, defines the western edge of Sub-Area 4. The southern boundaries of Sub-Areas 2 and 4 are defined by the interface with Sub-Area 1, at the southern end of the secant pile wall.

Remediation in Sub-Areas 2 and 4, by removal of all of the overlying Made Ground, was undertaken during the Early Works. In Sub-Area 2 a clean London Clay surface was formed at a general level +13.5mAOD in the southern and central portions of the Sub-Area, and at +14mAOD in the northern portion of the Sub-Area. An in-ground clay perched groundwater cut-off wall was constructed along the northern edge of Sub-Areas 2 and 4.

The western side of Sub-Area 4 is occupied by a berm providing temporary lateral support to the secant bored pile retaining wall along its western perimeter. The top of the berm is approximately 5m wide at an elevation of +18.0mAOD and is covered with a 2m layer of compacted Type 1 virgin crushed rock aggregate. The berm is formed of undisturbed clean London Clay below an elevation of +16.0mAOD. To the east of the 5m berm, the clean London Clay surface slopes down to +14.0mAOD at 1 vertical:1 horizontal and is capped by the Type 1 virgin crushed rock aggregate.

A photograph of these two Sub-Areas, looking north in January 2014 is given below. Subsequently additional Type 1 crushed rock granular fill was placed and compacted over much of Sub-Area 2 to extend the berm at +18.0mAOD for the Railway Children theatre development.



Photo 2 View of Sub-Areas 2 and 4 looking north from Sub-Area 1 after completion of the Early Works piling, excavation of Made Ground and granular bund placement (in 2014), but before the additional temporary filling over much of Sub-Area 2 for the Railway Children theatre development (to provide a wider platform at +18.0mAOD).

#### 1.4.3 Sub-Area 3

Sub-Area 3 is at the northern end of Zone A. Its northern boundary is defined by the existing masonry retaining wall supporting Goods Way and its eastern boundary is formed by the western side of the AR(N) structure. Its southern boundary is defined by the northern edge of the former ISR road. To the west, the Sub-Area is approximately 2m from the base of the reinforced earth and concrete structures that define the eastern edge of the ISR embankment structure.

Remediation, by removal of all of the overlying Made Ground in Sub-Area 3, was undertaken during the Early Works and a reduced formation ground level was formed at 14.5mAOD, by placement of a 0.3m thick (approx.) layer of compacted London Clay fill over the excavated profile. This surface was subsequently capped with a thin layer of clean granular fill. The surface of the western and southern edges of the Sub-Area comprise a Type 1 granular fill and concrete capped slope, beneath which is an in-ground perched groundwater clay cut-off.



Photo 3 : Sub-Area 3 View looking south from the northern end of Sub-Area 3 after concrete weatherproof capping of slope but before the placement of additional granular fill for the Railway Children theatre development)

#### 1.4.4 Sub-Area 5

Sub-Area 5 is located in the north west corner of the Site, as shown on Figure 3, and is the only area of the Site that still requires source removal remediation. It comprises the ISR, a rough grass and shrub covered embankment to the west of the road, the reinforced earth embankment supporting the northern end of the ISR and the area of concrete paving from the southern end of the ISR to the previous entrance into the AR(S). A view of the northern end of the ISR (prior to the Railway Children theatre development) is given in Photo 4 below.



Photo 4 Sub-Area 5 viewed from the top (northern end) of the ISR, looking south (before the Railway Children temporary development).

Sub-Area 5 was outside of the scope of the Early Works, as the ISR was required to provide access to the Site and the AR(S) when those works were undertaken.

#### **1.4.5 Ground Levels**

Ground levels across KXC were surveyed by Plowman & Craven in February 2012. The highest ground levels on Zone A are about 24.2m AOD, at the top of the ISR, at its junction with Goods Way. The low point on Zone A is in the south and at the time of the survey was at an elevation of about 15m AOD.

The King's Boulevard, which has been completed with temporary finishes and lies immediately to the west of Zone A, sits at an elevated level of approximately 25mAOD in the north and 17mAOD in the south.

The railway land to the east of the AR(N) and AR(S) is generally flat and at a slightly lower elevation than Zone A.

The Early Works, which were completed in April 2014, removed all the Made Ground and any contamination of the surface of the underlying London Clay across all of Sub-Areas 1, 2, 3 and 4. On conclusion of the Early Works, the previous ground levels across Sub-Areas 1, 2, 3 and 4 were lowered by typically 2m to 3m, to the formation levels shown on Figure 3 of this ERP.

In November and December 2014 approximately  $4,000m^3$  of Type 1 virgin crushed rock aggregate was imported to the Site to provide a platform at +18.0mAOD for the Railway Children theatre temporary development. An outline description of that filling is given below.

#### **1.4.6** Railway Children theatre site preparation works

The Railway Children was a marquee theatre temporary structure formed of 3 parts: a central auditorium, with tiered seating for almost 1,000 persons; an entrance tent; and a back-of-house tent. Plans and vertical sections of the structure are included in Appendix F.

The steel pole columns supporting the tent canopy and auditorium seating required a firm level surface on which they could be supported. This level surface was created by importing approximately 4,000m<sup>3</sup> of crushed rock aggregate to the Site, of the same type, and from the same quarry source, as had been used during the Early Works for the berm in Sub-Area 4. This temporary fill was laid on a permeable geotextile at its base and compacted in layers under engineering supervision. The fill included reinforcing geogrid geotextiles over the lower sections of slopes and an L-shaped retaining wall was constructed over the opening into the AR(S) from the base of the ISR..

An aerial view of the Site in December 2016 showing the theatre in position, together with a further two temporary theatres further south in Zone A, approved with ref. 2015/6618/P, but for which no earthworks were required, is given below.



Photo 5 December 2016 view looking south from viewing platform showing Railway Children temporary theatre occupying Sub-Areas 2 & 4 and parts of Sub-Areas 1, 3 and 5. (Southern part of ISR in foreground).

All of the temporary theatre structures have now been removed and a view of the central and northern parts of the Site in March 2017 is shown in Photo 6 below.



Photo 6 : View of central part of Zone A in March 2017 (from viewing platform at northern end of King's Boulevard)

#### 1.5 Site History

#### 1.5.1 Summary

The area surrounding and occupied by Zone A has a history of industrial usage from the early 1800s until recent times, with residential usage in the southern part of Zone A until the mid- 1800s. A summary of the Site's history is given in Table 1 below and a set of historic maps are provided in Appendix E.

The principal historical 'on-site' activities which might have caused ground contamination on Zone A are those associated with the former gas manufacturing activities in Sub-Areas 3 and 5, the railway sidings in Sub Areas 1, 2 and 3 (e.g. spills and leaks of oils and diesel associated with refuelling), and from any unsuitable fill material placed to raise or level the ground surface as a result of infilling of the hotel curve cutting or for raising ground levels or forming embankments. Historical activities 'offsite' (on adjacent land) which may have caused contamination within the Site include spillages of polluting liquids on railway lands to the east, and contamination arising from the former gasworks to the west.

#### Table 1 Summary history of Zone A

Map Date	Zone A and surrounding area description
Pre 1820s	Zone A and surrounding area to the east, north and west was occupied by fields, with residential development to the south.
1827	The Regent's Canal had been constructed to the north and the Imperial Gas Light Company had established a gasworks to the north and west of Zone A, extending into the north western portion of Zone A.
1834	Little change from 1827. An inlet from the Regent's Canal Basin is shown just on the north-eastern corner of Zone A. It is understood that coal was delivered to the gasworks by the Regent's Canal. The southern area of Zone A is mostly occupied by residential housing.
1852 - 1877	King's Cross Station was built immediately east of Zone A and was operational by 1852. The railway lines heading north from King's Cross enter a cutting and pass under the Regent's Canal. St Pancras station to the south-west of Zone A opened in 1868. During this time a rail line partly in cutting and partly in tunnel, known as the Hotel Curve, was constructed. The Hotel Curve ran through the south- eastern portion of Zone A and connected the mainline railway from King's Cross to the Metropolitan Railway.
1871 (northern area only)	King's Cross Station has been built and rail lines occupy adjacent land to east of Zone A. The inlet from the Regents Canal has now been extended to the south and east and become a "Basin" which occupies much of the north-eastern corner of Zone A. The gas works buildings (Store house and Retort house) are occupying the north-west of Zone A (these buildings extend off-site to the west). There is also a building, labelled as "Office", located centrally within Zone A. This building is located at the western end of Congreve St., which crosses the rail lines which terminate in King's Cross station.
1894-96 1894-96 (continued)	No change on the north section of Zone A, with an exception that one of the small buildings adjacent to the east side of the Basin is no longer present. [The remaining building(s) are marked as "office" on the Goad Insurance Plan of 1891.] The residential housing in the southern part of Zone A has been demolished and replaced by railway sidings known as the Milk Dock. Battle Bridge Road had been constructed crossing over the railway lines, centrally on Zone A. The Culross Building was also constructed at this time along the southern edge of Battle Bridge Road, with basement level workshops to serve the sidings in the Milk Dock.
1921 (Goad plan of northern area only)	Wharf Road (now Goods Way) has now been built and crosses just beyond the north edge of Zone A. The gas works had ceased production, many of the associated buildings had been demolished and the basin was demolished or infilled. The (same) buildings north of Battle Bridge Road are still present and one is marked "stores". The Congreve St. Bridge over the railway lines is no longer present.
1933 (LNER plan northern area only)	This shows a locomotive turntable in the northern eastern area of Zone A. Wharf Road is now named Goods Way.
1730	before the main portion of railway tracks. Railway sidings are still present across most of this portion of Zone A.

Map Date	Zone A and surrounding area description
1942 (Goad plan, northern area	The north east area of Zone A is marked as "goods sidings", with the locomotive turntable in the north east corner and with buildings marked as "stores" and "mess" on the eastern boundary.
only)	A slope (believed to be a cutting slope) is shown to the north west of Zone A, indicating that the ground level on the north eastern part of Zone A has been lowered. A "piggery" and "stone yard" are shown on the land to the west of Zone A (where the former gasworks stood).
1953 (northern area only)	No change in land use in the northern part of Zone A, however details of the railway siding tracks are shown. A small "coal hopper" is marked on one siding centrally within the northern area of Zone A.
	The piggery is marked as "ruins" and there are two lines of steps shown on the embankment slope to the west of Zone A.
1963	The north eastern side is still occupied by sidings and a turntable to the north. However a large tank is now shown at the foot of the cutting slope on the western edge. Also, at the top of the slope a large "depot" building has been built.
	Just beyond the eastern boundary of Zone A a new sidings shed is shown. A garage, known to include a filling station, is located to the northeast corner of Zone A, on the corner of Goods Way and York Way. (There is no change on the OS map of 1970 - 75)
1982-86	All the railway siding tracks on Zone A appear to have been removed and the turntable is no longer shown. One remaining siding line is still shown centrally within this portion of Zone A, close to the foot of the cutting slope. A second large tank is shown at the base of the cutting slope, immediately south of the first tank. These tanks are believed to have been diesel for locomotive re-fuelling.
	There are no longer railway lines on Zone A, although a railway siding crosses Zone A just below Battle Bridge Road. In the area immediately to the west is a building marked "Motorail Terminal".
1992-1994	The building just beyond the eastern boundary of Zone A is no longer present, otherwise no change. The railway siding no longer crosses Zone A and the building is no longer labelled "Motorail Terminal". A row of buildings labelled Culross Buildings, to the south of Battle Bridge Road, slightly intercept the western
2004-2005 (aerial photo)	Site boundary. Much of the northern half of Zone A has been paved over and is in use as a car park. A temporary building occupies the northern eastern corner of Zone A (at the northern end of the AR(N). The cutting slope along the western side of the northern half of Zone A is shown vegetated. The "depot" building has gone from the top of the cutting slope and the land (Zone B) is in temporary construction use. All railway infrastructure is gone in the southern area. Zone A and area to the west occupied by temporary construction buildings.
2008 (aerial photo)	Temporary site offices (Cubitt House) occupy most of the north eastern area of Zone A, and the car parking surface has been removed from the remainder of the northern area of Zone A. Shared Service Yard piling (top-down construction) underway in the southern portion of Zone A. To the south of the area, the below-ground Network Rail Plant Room under construction.
Mid 2012	The Interim Service Road is now constructed at north west corner of Zone A, sloping down from Goods Way and providing vehicular access into the Zone/SSY. All temporary offices have been removed.

Map Date	Zone A and surrounding area description
	Shared Service Yard and Access Ramp South (AR(S)) construction is complete and in operation. King's Boulevard located to the west of Zone A has been constructed (albeit with temporary finishes) and is in use as a pedestrian thoroughfare.
July – September 2012	A geotechnical and geo-environmental ground investigation was carried out by Ground Technology Limited (GTL), as a sub-contractor to BAM Nuttall (BAMN) and at the instruction of KCCLP across the footprint of the AR(N) and across Sub-Areas 1 to 5.
January 2013 – April 2014	The AR(N) structure was constructed and Early Works piled retaining wall and ground remediation across Sub-Areas 1, 2, 3 and 4 was carried out by BAMN, at the instruction of KCCLP. The AR(N) came into use from April 2014 as the sole access into the SSY.
December 2014	Clean granular fill was imported onto the central and northern parts of the Site to provide a level platform at 18.0m AOD and the Railway Children temporary theatre was constructed, at the instruction of Google.
January 2015 to April 2017	The Site was in use by Theatre Tracks Limited for showings of the Railway Children production until April 2017. All temporary theatre structures have now been removed.

#### 1.5.2 Potentially Contaminative Sources remaining after Zone A Enabling Works

Now that the collective Zone A Enabling Works are complete, all Made Ground and impacted London Clay within Sub-Areas 1 to 4, and beneath the AR(N), have been excavated. All contaminative sources have been removed from those Sub-Areas, however, it is likely that there will be contaminative historic sources remaining beneath Sub-Area 5 (the ISR). These would most likely be associated with the former gas manufacturing activities, unsuitable fill material used to raise ground levels or spills or leaks arising from railway use activities. As part of the Zone A Enabling Works, clay bunds were installed on the north side of Sub-Areas 2 and 4, and on the west side of Sub-Area 3 to prevent possible re-contamination of remediated areas from Sub-Area 5. Remediation will therefore be required in Sub-Area 5, but not in Sub-Areas 1 to 4.

## 2 Summary Description of Development and Ground Works

#### 2.1 Phasing of Works

The phasing of works on Zone A, including the construction of the proposed building and basement, is summarised below:

- 1. Shared Service Yard and Access Ramp (South) vehicular service access to King's Cross Station and eventually Zone A basement areas. Already constructed and in use pursuant to Enabling Works approval 2007/3284/P (as amended by 2009/0208/P), this structure will ultimately be enveloped by the Zone A building.
- Interim Service Road a temporary vehicular route between Goods Way and the AR(S). Already constructed and in use pursuant to Enabling Works approval 2010/1495/P. Since the opening of the AR(N) in April 2014, the ISR has not been used to access the AR(S) and the southern section of the ISR has now been covered over by the Railway Children fill.
- 3. Access Ramp (North) permanent connection between the SSY/AR(S) and Goods Way, which has replaced the ISR since its completion and opening. Construction of the AR(N) was pursuant to Enabling Works approval 2013/0510/P.
- 4. Zone A Site Preparation ('Early Works') Enabling Works in Sub-Areas 1, 2, 3 and 4 and construction of a retaining wall along the western side of Sub-Areas 1 and 4. Construction commenced in May 2013, pursuant to Enabling Works approval 2013/1027/P and was completed in April 2014.
- 5. **Proposed Zone A Building Works** Construction of a single building and associated basement within Development Zone A. Details of the building and basement are outlined in Sections 2.2, 2.3 and 2.4 below.

As stated previously, none of the earthworks and remediation described in the June 2013 Zone A Building ERP, which were approved in September 2013 (reserved matters approval ref. 2013/4001/P), have been carried out.

#### 2.2 Zone A Building and its Basement

The proposed Zone A Building will comprise a single, predominantly office building of 7 to 11 storeys, above retail uses at ground floor, and two levels of basement space (levels B1 and B2). At ground level the main office entrance will be at the southern end of the building and there will be retail spaces and office lobbies fronting onto Battle Bridge Place and along King's Boulevard. The building will rise in height from the south to the north with landscaped terraces and a walking 'Trim Track' at roof level to provide outdoor amenity and recreation space for employees. The existing access ramp will provide service access to the basement areas, as well as to the existing Shared Service Yard. The proposed Zone A Building will provide accommodation for Google UK Ltd's staff, with a mix of different retailers at ground floor.

An architectural image of the three main elements of the proposed building (Roof Plane, Workplace and Ground Plane) is included as Plate 1 overleaf. An isometric view of the proposed lower (B2) basement level of the building is shown on Figure 4. Architectural and structural general arrangement plans and sections of the building are included in Appendix A.



#### 2.3 Basement Levels, Excavation Depths and Retaining Walls

The lower B2 basement floor level will be at +7.9m AOD over all of the central and southern parts of the Zone A Building and at +9.2m AOD at the northern end (as indicated on Figure 4). To achieve these basement levels there will need to be bulk excavation across the whole footprint of the Site to formation levels lower than these finished floor levels.

Across Sub-Areas 1, 2, 3 and 4, and after removal of Type 1 granular fill placed for the Railway Children theatre temporary development, this bulk excavation will be entirely within London Clay beneath the previous remediation levels (shown on Figure 3). The depth of excavation into London Clay in these areas will be between 7 and 9 metres.

In Sub-Area 5 the bulk excavation will remove the ISR road pavement, gabion walls, structural fill and all the residual overlying Made Ground and then extend into the underlying London Clay. The estimated levels of the top of London Clay in Sub-Area 5 are illustrated by the interpreted contours on Figure 5. The maximum overall depth of excavation at the north western corner of the Site is estimated to be about 16m and the depth of excavation at the southern end of Sub-Area 5 is estimated to be about 11.5m.

The excavation in Sub-Area 5 will be undertaken in two stages, which is explained in more detail in Section 4.1 of this ERP. The initial stage of excavation in this northern part of the Site will be to the B1 piling platform level of 14.5m AOD and will complete all the required 'source removal' remediation works, which are the same remediation works as previously described in the Zone A ERP approved in September 2013, as part of that reserved matters planning application [10]. The bund in Sub-Area 4 supporting the previously installed secant pile wall will also be removed in that initial stage of the earthworks (once ground anchors have been installed beneath King's Boulevard to provide lateral support to the upper part of that retaining wall – as also noted below).

Existing and new perimeter retaining walls will be required along the western and north western sides of the Site in advance of the initial Remediation Works excavation in Sub-Area 5 and subsequent bulk excavation across the whole of the Site to be able to achieve the substantial excavation depths proposed. On the western and northern sides of Sub-Area 5, a temporary sheet pile retaining wall will initially be installed, before a secant or contiguous piled wall is installed from a lower level. (A secant pile wall will be installed where external Made Ground is to be retained and a contiguous piled wall installed where the wall is entirely within impermeable natural clay soils.) On the western side of Sub-Area 4, the existing secant pile retaining wall will have ground anchors installed before bulk excavation takes place to the east of this wall. On the western side of the AR(N) and AR(S) ramp structure, a new contiguous retaining wall will be installed from the B1 piling platform level, before excavation down to the B2 formation level to the west of that ramp structure.

Vertical cross sections illustrating the anticipated retaining wall and excavation construction sequence and bottom-up basement construction are included in Appendix A. A sketch plan showing the type and locations of new retaining walls is included as Plate 2 below.



#### 2.4 Building Foundations

The vertical building loads will be supported by a hybrid 'piled raft' throughout the central footprint of the building (where the loads are greatest) and by the secant and contiguous retaining walls around the perimeter of the building. This solution reduces the number and depth of structural piles and optimises the good ground bearing characteristics of the London Clay, which will have had significant load removed by the bulk excavation. The internal piles are expected to be bored piles 1.05m to 1.2m in diameter and approximately 25m in length, designed to terminate in the Lambeth Clays 3m above the Thanet Sand horizon. The thickness of the piled raft will be 1.8m. A sketch cross section of the basement foundation design is given in Plate 3 below.



## **3 Ground Conditions**

#### 3.1 Scope

The following description of ground investigations and conditions deals primarily with Sub-Area 5. As noted in earlier sections, Sub-Areas 1 to 4 were fully remediated following completion of the Zone A Enabling Works, in accordance with the strategy set out in the ERP relating to those works. Similarly, the SSY and AR(S) areas were remediated at the time the ground works for those structures were undertaken.

A full description of ground investigations and conditions relating to other parts of Zone A are given in the ERPs that accompany those previous Enabling Works submissions (see Section 1.3.3).

#### **3.2 Ground Investigations**

#### **3.2.1 Pre-2012 Ground Investigations**

Three phases of ground investigation with exploration locations within Sub-Area 5 were undertaken prior to 2012, as summarised in Table 2 below. These investigations were undertaken in connection with the construction of the Channel Tunnel Rail Link (CTRL) infrastructure, the SSY/AR(S), King's Boulevard, Goods Way and the ISR. A plan of the locations of the exploratory boreholes within Sub-Area 5 is included as Figure B1 in Appendix B. The logs of the boreholes are also included in Appendix B.

Ground Investigation Works	Contractor	Date	Investigation objectives	Summary Scope (Hole locations positioned within Sub-Area 5 only)
Channel Tunnel Rail Link (CTRL) Contract 1	Foundation Exploration Services (FES)	1993	To gather geotechnical information on and along the proposed route of the CTRL.	One exploratory hole location (BH OP3837). Chemical test data is not held by Arup for these locations. No gas or groundwater monitoring.
Shared Service Yard and Access Ramp (South), for Argent Estates Limited	Soil Mechanics	2008	Geotechnical and geo- environmental information for the construction of the SSY and AR(S)	One exploratory hole location (BH7). One soil sample chemically tested. No ground gas monitoring from locations within Sub-Area 5. No groundwater monitoring or testing.
Goods Way and Boulevard Area, for Edmund Nuttall Ltd.	Norwest Holst	2008	To gather geotechnical and geo- environmental information for the construction of the Kings Boulevard	Three exploratory hole locations (BH 1004, TP 1001 and TP 1003). Four soil samples chemically tested. No ground gas monitoring from locations within Sub-Area 5. No groundwater monitoring or testing.

Table 2 Summary of pre-2012 ground investigations within Sub-Area 5

The investigations were carried out for geotechnical purposes and very little contamination laboratory testing information is available from these investigations. Available chemical testing data is limited to five soil samples collected from four exploratory hole locations. The results of this testing are discussed in Section 5.2.3, together with the contamination testing results for the more recent ground investigation in 2012 (see Section 3.2.2 below) and are compared with human health screening criteria for commercial development in Appendix D.

#### **3.2.2** Recent (2012) Ground Investigation

A geo-environmental ground investigation was undertaken by BAM Nuttall Limited (BNL) at the instruction of KCCLP in summer 2012 across all accessible areas of Zone A, in accordance with a specification provided by Arup. A plan of the investigation locations located within Sub-Area 5 is included as Figure B2 in Appendix B. At the time of the investigation, only limited access to Sub-Area 5 was possible due to the area being occupied by the ISR (which remained operational) and the construction of the ISR on a reinforced earth structure, which could not be disturbed.

The investigations on Sub-Area 5 were conducted in accordance with a technical specification issued by Arup. BNL appointed Ground Technology Services (GTS) to undertake the drilling of boreholes, soil sampling and geotechnical testing under the technical supervision of AMEC Environment & Infrastructure UK Limited (AMEC). The chemical laboratory testing was undertaken by i2, under the technical supervision of AMEC. AMEC carried out the water quality sampling and gas monitoring in standpipes installed by GTS.

The scope of the ground investigation in Sub-Area 5 was as follows:

- One shallow cable percussion (CP) borehole (BH 1225) to 1m into the London Clay (depth 4m 7.4m bgl);
- Two shallow windowless sample boreholes (WS 1217 and WS 1219) to 1m into the London Clay, with installation of gas and groundwater monitoring standpipes (depth 1m 4m bgl);
- One trial pit (TP 1201) to a depth of 0.5m into the London Clay;
- Collection and testing of soil samples for contaminants;
- Field headspace analysis for volatiles on soil samples, using a photo-ionisation detector (PID);
- Collection and testing of perched groundwater samples (if present) for contaminants;
- One round of groundwater sampling in the standpipe installed in WS 1219 (the standpipes in BH 1225 and WS 1217 were dry);
- Six rounds of ground gas monitoring in each new standpipe installed for the investigation, water level monitoring;
- Contamination testing of soil and groundwater samples;

A total of 11 soil samples (excluding any duplicates) from the four exploratory hole locations across Sub-Area 5 were tested for a comprehensive suite of potential contaminants. The results of the chemical analysis of soil samples are described in Section 5.2.3 of this ERP and are compared to screening criteria in Appendix D.

### 3.3 Stratigraphy

Local ground conditions beneath Zone A, and specifically Sub-Area 5, have been interpreted from ground investigation information contained in Table 16.1 of the ES and subsequent ground investigations, as referred to in Section 3.2 above. The general geological sequence underlying Zone A is Made Ground overlying approximately 20m thickness of London Clay. Below the London Clay lie, in turn, the Lambeth Group (mainly stiff clays), Thanet Sands and Upper Chalk as detailed in paragraph 16.4.12 of the ES.

The interpreted contours of the base of the Made Ground/top of London Clay across Sub-Area 5 are shown on Figure 5. The thickness is estimated to vary between 0.5m and approximately 6m. Made Ground in Sub-Areas 1-4 was removed as part of the Zone A Enabling Works.

There were no field observations of contamination in the 3 exploratory boreholes undertaken by BNL in Sub-Area 5 in 2012, however hydrocarbon staining and a strong odour was noted in a thin (0.1m thick) layer of Made Ground immediately overlying the London Clay in TP1201. There was also a hydrocarbon odour noted on the log of TP1205 for ashy Made Ground immediately above the London Clay (TP1205 is situated in Sub-Area 3, close to the boundary of Sub-Area 5). No observations of contamination are recorded on the logs of historic boreholes and trial pits in Sub-Area 5.

Copies of the logs of the boreholes and trial pits in Sub-Area 5 are provided in Appendix B.

#### 3.4 Groundwater

#### 3.4.1 Perched Water

Perched groundwater was not generally encountered in the two window sampling boreholes and cable percussion borehole in Sub-Area 5. However following heavy rainfall, perched groundwater was recorded in WS1219.

Perched groundwater and groundwater seepages in the Made Ground, where present, generally occur immediately above the underlying London Clay stratum. The perched groundwater is interpreted as discontinuous in Sub-Area 5. Perched groundwater is not defined as 'controlled water' and therefore is not classified as a water environment receptor under the Environmental Protection Act 1990 and water legislation.

A total of one sample of perched groundwater was collected from the standpipes in Sub-Area 5, and the sample was analysed in i2's laboratory for a wide suite of water quality parameters. The results of the chemical analyses are described in Section 5.2.3 of this ERP and are compared to screening criteria in Appendix D.

#### 3.4.2 Local Aquifers

The London Clay is classified as Unproductive Strata by the EA, due to its impermeable nature. At the Site, the thickness of London Clay provides a hydraulic barrier to the downward migration of perched groundwater in the Made Ground to the underlying Lambeth Group, Thanet Sands and Upper Chalk.

The Lambeth Group comprises the Woolwich and Reading Beds. The Woolwich Beds are typically dark grey, laminated clays of low permeability. The Reading Beds generally comprise more sandy horizons and are likely to be in limited hydraulic connection with the underlying Thanet Sands. The Thanet Sands comprise dense, permeable, greenish-grey fine sand and are likely to be in hydraulic continuity with the underlying Upper Chalk in the KXC area. The Lambeth Group and Thanet Sand are classified by the EA as Secondary A Aquifers.

The Upper Chalk is classified as a Principal Aquifer by the EA due to its importance for potable water supply. The EA interprets that the regional flow direction of groundwater in the Chalk is towards the south-west and with a rest water level of approximately -35mAOD to -40mAOD in the vicinity of the Site [10].

The Zone A development area does not lie within an EA groundwater source protection zone and the Envirocheck Report does not record any active groundwater abstractions on or close to the Site. However, there are three groundwater abstractions located within 1km of the Site boundary

Three deep boreholes (BH1227, NRA1 and NRA2) were drilled on Zone A as part of the 2012 ground investigation by BNL. Groundwater monitoring standpipes were installed in all boreholes on completion. Details of the screened sections of these standpipes and the groundwater levels observed is given in Table 3 below. The locations of these 3 deep borehole standpipes are shown on Figure B1 in Appendix B. BH1227 was located Sub-Area 1 and the other two standpipes were located in the footprint of the AR(N).

Borehole/ Standpipe	Location	Screened section (mAOD)	Strata in screened section	Measured water lewel, mAOD (depth, m)
BH 1227	Sub-Area 1	-14 to -17	Lambeth Sand	-1.74 (16.73)
NRA1	AR(N)	-20.3 to -25.4	Thanet Sand	Dry
NRA2	AR(N)	-33.6 to -38.6	Chalk	-36.3 (52.7)

	Table 1	3 Deep	standpipe	details
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The measurements indicate a piezometric pressure of about -2mAOD in the Lambeth Sand and hydraulic separation of this layer (or lense) from the underlying Thanet Sand and Chalk, which are significantly under-drained (by abstraction in the Chalk). The recorded piezometric pressure in the Chalk corresponds well to the EA's published information on rest water levels. The presence/absence of groundwater and prevailing pressures in the deep aquifers beneath Sub-Area 5 can be inferred from these former (now decommissioned) standpipes in the AR(N) footprint and in BH1227 in Sub-Area 1 (still operational).

#### **3.5 Obstructions**

#### **3.5.1** Thames Water Camden Sewer

The Thames Water Camden Sewer passes under the north-east corner of Zone A, near to the south portal of the Network Rail tunnel beneath Goods Way. This will not be affected during the proposed building construction works. The AR(N) was constructed in this area using appropriate measures to protect the sewer.

#### 3.5.2 Unexploded Ordnance

RPS Planning and Development was commissioned by Argent in 2007 to undertake a desk study to determine the potential for historic unexploded ordnance (UXO) across the KXC site. The Volume 2 (UXO Assessment Area 4) report results indicate that Zone A was classified as having a low to moderate/low risk of encountering UXO. However, parts of Sub-Area 5 are classified as Moderate Risk, as shown on the risk map from the RPS report included as Appendix C of this ERP.

Taking into consideration the geological profile of the Site, RPS calculated that likely maximum bomb penetration in the area would be 9.8m bgl.

#### **3.5.3 Remnant Structures and Features**

All remnant structures on Sub-Areas 1, 2, 3 and 4 of Zone A were removed during the Zone A Enabling Works.

There are likely to be remnant structures in the ground in Sub-Area 5 due to former industrial and infrastructure developments and features on this part of Zone A, in particular from the former gasworks, railway infrastructure and possibly foundations of the former canal "Basin". There are also features associated with the ISR structure present in Sub-Area 5, namely:

- Gabion basket retaining wall, located along south-west edge of the ISR;
- Tensartech TR2 earth retaining structure beneath the ISR;
- Reinforced Geogrid earth retaining structure constructed along the edge of the IRS; and
- Wall and base from the LUL Blue accommodation block, located at the base of the reinforced Geogrid earth retaining structure on the eastern edge of Sub-Area 5.

Details of the construction of the ISR are contained in Appendix E of the Arup Ground Conditions Factual Report [12].

## 4 Earthworks

#### 4.1 Extent of Earthworks

The construction of the proposed building will require bulk excavation within new boundary retaining walls to achieve the intended basement levels. The earthworks have and will be carried out in five main phases, as outlined previously in Section 1.5.1 of this ERP. The excavation for the basement of the Zone A Building is the final phase, Phase 5, of the earthworks:

- Phase 1: Access Ramp South (AR(S)) (and SSY) completed.
- Phase 2: Interim Service Road completed.
- Phase 3: Access Ramp North (AR(N)) completed.
- Phase 4: Zone A Enabling Works (Sub-Areas 1, 2, 3 and 4) completed.
- **Phase 5: Proposed Zone A Building** (Sub-Area 5 remediation excavation, and further London Clay excavation in Sub-Areas 1, 2, 3, 4 and 5).

The extent of remediation earthworks for Phases 1 to 4 has been described in the previously submitted ERPs referenced in Section 1.3.3. The extent of the initial remediation earthworks in Sub-Area 5 and the subsequent bulk excavation into London Clay across all of Sub-Areas 1 to 5 for Phase 5, relating to the construction of the proposed Zone A Building basement, are described in the following sub-sections, with reference to the earlier phases where relevant.

In essence, the excavation works for Phase 5 will be undertaken in two separate stages, namely:

- 1. Initial excavation works down to the B1 piling platform level across the whole Site, including removal of all contaminated ground in Sub-Area 5; and
- 2. Subsequent bulk excavation works in London Clay down to the final basement formation level, after the foundation and retaining wall piling works have been completed,

#### 4.1.1 Initial Ground Remediation Package Earthworks

The initial stage earthworks comprises:

- (a) excavation of the virgin crushed aggregate fill placed on top of the clay berm in Sub-Area 4 and for the Railway Children theatre platform – this material will be temporarily stored in the southern part of the Site for reuse as the B1 piling mat;
- (b) Excavation of the clay berm in Sub-Area 4 down to the B1 piling mat formation level of 13.5m AOD in the southern part of the Site (after installation of ground anchors in the existing secant pile wall);
- (c) remediation excavation of all or the overlying Made Ground and impacted upper surface of the London Clay in Sub-Area 5, down to the remediation subgrade level (RSL); and

- (d) excavation of London Clay beneath the RSL in Sub-Area 5 to achieve the B1 piling mat formation level of 14.5m AOD in the northern part of the Site; and
- (e) placement of the temporarily stockpiled virgin crushed aggregate fill (item (a) above) as a 500mm thick piling mat on top of the B1 piling mat formation level across the whole Site.

A plan of the extent and levels of the B1 piling mat is included in Appendix A.

By the time of the scheduled planning committee meeting for the reserved matters planning application for the proposed Zone A Building, in August 2017, very little of the initial stage earthworks is programmed to take place and minimal off-site lorry movements associated with those earthworks would occur.

## 4.1.2 Post-Piling Bulk Earthworks for the Zone A Building Basement

Once the initial ground remediation and piling packages of work have been completed, the remaining Phase 5 bulk earthworks for the proposed building will be carried out. These bulk earthworks will comprises excavation across all Sub-Areas to achieve the final basement formation levels.

A description of the levels, types of soil materials to be excavated and depths of excavation for Phase 5 of the Zone A development has previously been detailed in Section 2.3 of this ERP.

In addition to the bulk excavation, there are also Infill Works outside the retaining walls on the western and northern sides of the future building, to infill the ground between the retaining walls and the adjacent King's Boulevard and Goods Way. This infilling will be undertaken concurrently with the construction of the basement walls.

The estimated quantities of spoil, pile arisings and other types of materials generated as a result of the construction of the proposed Zone A building and basement (i.e. Phase 5 only) are given in Table 4 below.

Description	Material type	Export from Site (m <sup>3</sup> )	Import to Site (m <sup>3</sup> )	
Removal of clean Type 1 granular fill imported to (a) create the Railway Children platform and (b) used as a capping layer over the bund in Sub-Area 4 and over the ground in Sub-Area 3 during the Zone A Enabling Works (after it's temporary use as piling mat material)	Type 1 crushed rock aggregate	4,750	-	
ISR road surface materials	Asphalt, concrete and sub-base	200	-	
Reinforced earth structures in Sub-Area 5	Clean structural granular fill	2,500		
Made Ground excavation in Sub-Area 5	Made Ground, potentially contaminated	8,000		
Removal of ISR gabion wall	Rock aggregate	200		
Excavation of London Clay down to the final basement formation in all Sub-Areas, including allowance for pile caps	London Clay	85,000	-	
Allowance for additional granular fill for piling mats	Piling mat material	2,500	2,500	
Pile arisings from new secant and contiguous pile retaining walls around the north-western, northern and eastern sides of the basement.	London Clay (mainly)	8,000	-	
Pile arisings from foundation piles within the building footprint	London Clay & Lambeth Group	6,000	-	
Infill Works backfill material between new basement retaining walls and (a) King's Boulevard and (b) Goods Way	Clean structural granular fill	-	5,000	
Estimated total material quantities		117,150	7,500	
Notes: Volumes were calculated by AKT II or estimated by Arup. Estimated volumes do not include for material bulking. It should be noted that bulking of earthworks can vary significantly, often between 5% – 30% of the excavated volume.				

#### Table 4 Estimated quantities arising from the proposed Zone A Building Works

# 4.2 Estimated lorry movements for earthworks activities

The total number of lorry loads of spoil and soil fill materials that will be generated by the proposed Zone A Building have been estimated based on 8.5m<sup>3</sup> of un-bulked material/lorry (as per Appendix 16A of the ES). The estimated number of lorry movements, based on a total quantity of 124,650m<sup>3</sup>, as described in Table 4 above, will equal 14,665 lorry movements. Of this, 13,783 lorry movements are associated with the disposal of arisings from the Site and 882 lorry movements are associated with importation of soil materials to the Site.

The vast majority of spoil arising from the excavation and piling works will be London Clay and Lambeth Group clays, which will be suitable for re-use and likely to be transported to other construction sites under a waste management exemption. The remediation of Sub-Area 5 will generate an estimated 8,000m<sup>3</sup> of Made Ground soils, which will be transported to licensed landfill site(s) or waste recycling facilities.

#### 4.3 Cumulative Earthworks Volumes and Lorry Movements for Zone A

The total estimated earthworks quantity for Phase 5 of the development (124,650m<sup>3</sup>) is greater than the combined volumes arising from the earthworks for all the previous phases of development on Zone A, as set out in Table 5 below.

Wiovements		
	Estimated Earthworks Quantity (m <sup>3</sup> )	Estimated Lorry Movements
SSY/AR(S) - Phase 1	31,000	3,650
ISR - Phase 2	550	65
AR(N) - Phase 3	6,500 - 8,500	765-1,000
Zone A Early Works - Phase 4	25,500	3,000

124,650

14.665

 Table 5
 Comparison of Estimated Earthworks Quantities and associated Lorry Movements

#### 4.4 Suitable Material

Proposed Zone A Building Works -

#### 4.4.1 **Definition**

Phase 5

Suitable material is defined as excavated material that, by its chemical and physical properties, is suitable for use in the development.

Engineering fill material is defined as suitable material that can be compacted beneath or around structures or pavements to carry load within serviceability limits. However moisture content (which varies given the weather) will govern whether the material can be reused.

The following Specification for Highway Works classifications will be used for suitable engineering fill.

- General fill: Class 1 or Class 2. Principally Class 2 material (cohesive clay soil) will be used as engineering fill due to the production of significant quantities of this material from the basement excavation into London Clay and the piling works;
- Capping: Class 6F or 7F; and
- Sub-base: Type 1.

All imported clay fill material used in the main building works (Class 2 material) will also be required to comply with the validation chemical criteria for London

Clay (see Table 6 in Section 5). Imported granular fill will also be required to be 'clean' material, meeting chemical criteria applicable to their source and use.

#### 4.4.2 **Re-use of existing material**

The Type 1 rock aggregate fill that has been used to provide the platform for the Railway Children theatre and to cap the berm in Sub-Area 4 is a good quality granular fill that it is proposed will be re-used on site for temporary piling platforms, before being removed from Site. There is no requirement for permanent fill in the construction of the development, except a very small quantity for the Infill Works outside the retaining walls on King's Boulevard and Goods Way.

#### 4.5 Unsuitable Material

#### 4.5.1 **Definition**

Unsuitable excavated material is defined as material that is unsuitable for use in the development and must be removed from site to a suitably licensed landfill, or off-site treatment centre.

#### 4.5.2 Classification

Unsuitable material will be categorised as Classes U1A, U1B or U2 in accordance with Specification for Highway Works.

Unsuitable materials which may arise could include:

- soft cohesive material;
- contamination encountered during the works, which will be temporarily stockpiled on plastic sheeting (type to be determined by the contractor) and covered on site for testing prior to identifying the appropriate strategy for dealing with the material;
- Made Ground with unsuitable engineering properties (e.g. high fines content, high moisture content, significant quantities of organic matter); or
- other unsuitable materials designated as such due to non-compliance with particular engineering fill parameters for either pavements or landscape areas.

#### 4.6 Materials handling

#### 4.6.1 Stockpiling

The relatively narrow width of the Site and proposed basement construction across the whole footprint, means that there is very little opportunity to stockpile soil materials within Zone A. The anticipated volume of excavation arisings to be removed from site (Table 4) assumes that the only re-use of site-won material will be as described in Section 4.4.2 above.

Made Ground materials excavated from Sub-Area 5 will be taken directly to a licensed waste treatment centre or disposal site. The classification of these soils

for off-site disposal will be based on the results of sample testing from the 2012 ground investigation and from additional waste classification sampling in advance of their excavation. For localised 'hotspots' of contaminated Made Ground it may be necessary for temporary covered stockpiles to be created on plastic sheeting or on hard standing areas, whilst additional classification testing is undertaken. Measures will be taken to restrict dust and surface water run-off from the temporary stockpiling in order to reduce the potential for contaminant migration and dust generation.

#### 4.6.2 Treatment

Pre-treatment of excavated soils from Site prior to transfer to a licensed landfill or soil recycling site, would only be necessary for the Made Ground soils remaining in Sub-Area 5. Treatment on-site is expected to be limited to separate segregation, handling and disposal of hotspots of heavily contaminated soils.

#### 4.7 Drainage

As noted in Section 3.4.1, there is likely to be perched water in the lower part of the Made Ground across Sub-Area 5, particularly at the southern end of this area. The source of this perched water is believed to be largely precipitation on the unpaved areas of the Site, although some groundwater migration from the west of Zone A may be occurring.

Since the end of the Zone A Enabling Works, there has been an installed surface water drainage system across Sub-Areas 1, 2, 3 and 4, as described in the ERP for those works [9]. Once the temporary sheet pile wall, new pile retaining walls and new building basement walls have been installed around the western and northern sides of Sub-Area 5, there will no longer be potential migration of perched water onto Sub-Area 5 from those external areas.

During the course of the proposed works, perched water will be removed by sump pumping in advance of the final excavation to the remediation subgrade level in Sub-Area 5 and excavations into London Clay will be kept free of standing water (arising from rainfall), also by sump pumping. Any accumulated water will be discharged to the existing combined/foul sewers adjacent to Zone A, subject to Thames Water consent. No significant groundwater from the London Clay strata is expected to add to periodic rainfall input into the basement excavation.

## 5 **Remediation**

#### 5.1 Approach

The proposed approach to remediation for Phase 5 of the Zone A development is in accordance with the remediation strategy set out in Volume 4, Part 16 of the ES.

A conceptual model ('CM') has been established from field observations, investigation data and details of the works. The CM has been used to develop a source-pathway-receptor ('SPR') model of the Site, which in turn has been used to identify the plausible pollutant linkages ('PPL') remaining following the construction of the Zone A building and basement. The requirements for remediation measures associated with the PPLs have then been considered.

#### 5.2 Conceptual Model

#### 5.2.1 Introduction

The CM identifies the sources of potential contamination and the behaviour of the contamination in environmental media such as soils, ground water, surface water and air. In accordance with the current UK approach to contaminated land assessment and in line with the ES (paragraph 16.6.9), the potential human health and environmental risks after development have been considered in the context of a SPR model of the Site.

#### 5.2.2 **Potential Sources**

Based on the historical uses in Sub-Area 5, described in Section 1.5 of this document, and knowledge of the underlying soil stratigraphy, the potential sources of contamination are considered to be:

- Locally occurring impacted Made Ground and shallow groundwater from the former gasworks retort house and other associated buildings located across the western section of the northern half of the Site. The upper surface of the London Clay may also locally be impacted in this area.
- Made Ground and shallow groundwater locally impacted by former railway siding activities, particularly diesel refuelling in the north area of the Site. The upper part of the London Clay may also locally be impacted.
- Backfill (if any) to the remnant foundations of the former canal basin, although research suggests that the canal basin was above existing ground levels; and
- Fill imported into the Site to make up ground levels, if contaminated.

The above sources of historical contamination are consistent with those reported in paragraphs 16.4.19 and 16.4.25 of the ES. A plan of potentially contaminative past uses on and close to Sub-Area 5 is included below.



#### 5.2.3 Contamination Sources identified by Ground Investigations (Sub-Area 5)

In order to assess the type and degree of any actual contamination in Sub-Area 5 (the only area not remediated during the AR(N) and Zone A Enabling Works), a Hazard Screening Assessment of the soil chemical testing results from the BNL ground investigation in Sub-Area 5 (2012) has been undertaken using screening criteria, selected in line with the Contaminated Land Exposure Assessment (CLEA) methodology for a commercial end use. The screening criteria and details of the assessment are presented in Appendix D of this report.

A summary of the results which were elevated or exceeded the screening criteria and a record of visual and olfactory observations made during the investigations is given below. The soil and perched groundwater chemistry results are presented in Appendix D.

Observations of contamination and a strong hydrocarbon odour were noted in the base of Made Ground on the log for TP1201 (and also in TP1205 close to the edge of Sub-Area 5). Slightly elevated PID readings were also recorded in TP1201.

Soils:

- Asbestos was recorded as present at three locations, two samples in WS1217 and one sample in BH1225 contained chrysotile aggregates, and one sample contained amosite free fibres at TP1205.
- The concentration of Benzo(a)pyrene slightly exceeded the commercial end use screening criteria (14mg/kg) in one sample of Made Ground from WS1217 (measured concentration = 23mg/kg).
- The concentrations of total petroleum hydrocarbons<sup>3</sup> (TPH) were also elevated in the following samples: TP1201 at 1.1m depth (1,900mg/kg); TP1201 at 1.6m depth (550mg/kg); WS1217 at 3.2m depth (300mg/kg).
- During piling at the very northern end of the existing secant pile retaining wall installed on the western side of Sub-Area 4 during the Early Works, strong hydrocarbon odours were noted in the upper few metres of the London Clay.

Perched groundwater:

• Concentrations of total cyanide, sulphate, ammoniacal nitrogen and chloride well above stringent drinking water and EQS criteria were recorded in a sample from WS1219.

#### 5.2.4 Receptors

#### 5.2.4.1 Construction Period

The relevant human and environmental receptors during the construction period, and the incorporated mitigation which will apply to those receptors, are described below.

• **Construction Workers and Construction Site Visitors**, specifically those workers and visitors who are on-site during the ground works phase of

<sup>&</sup>lt;sup>3</sup> As C<sub>10</sub> to C<sub>25</sub>

redevelopment. All persons on site will be required to wear the appropriate personal protection equipment (PPE) and to comply with the Site health and safety procedures.

- Site Neighbours. The general public using the areas bordering Zone A. Risks to these receptors is minimised by environmental management procedures adopted to minimise dust generation and dust emissions from plant leaving the Site, in accordance with the Revised Construction Code of Practice (RCoCP).
- **Groundwater**. "Controlled waters" contained within the Upper Chalk (Principal Aquifer) and Lambeth Group sands and Thanet Sands (Secondary A Aquifers) are sensitive receptors. This groundwater is currently hydraulically separated from any potentially contaminated perched water in the Made Ground. Piling which extends to the depth of these underlying aquifers could have the potential to bridge this hydraulic separation, if the sources of contamination in the upper ground are present at the time of piling, or subsequently. If this is the case, a piling foundations work risk assessment (FWRA) will be prepared and submitted to the Environment Agency for its agreement with the proposed type and method of piling. However, the proposed construction sequence is that all the potentially contaminated ground remaining on Site (in Sub-Area 5) will be excavated and removed from Site prior to any piling that would extend to the underlying Secondary A and Principal Aquifers. Also, the proposed piling is not proposed to extend to the Principal Aquifer.

Perched groundwater is not classified as "controlled waters" and therefore is not a sensitive receptor.

• **Surface Water.** The nearest surface water "controlled waters" receptor is the Regent's Canal, to the north of Zone A. The canal water is confined within an impermeable liner at a higher elevation than any perched groundwater encountered on the Site.

There are no sensitive ecological (flora and fauna) receptors within the Site footprint or its immediate environs (see Part 14 of the ES).

#### 5.2.4.2 **Operational Period**

The relevant human and environmental receptors during the post-construction, operational period of the development are described below.

- **Future site users**. Within the future building, these will be office and retail workers, building maintenance staff, office visitors, persons entering the building for deliveries and servicing, and members of the public visiting the ground floor retail stores. The southern part of Zone A will not be building but will become public realm, part of Battle Bridge Place, as explained in Section 1.1.
- **Groundwater**. "Controlled waters" contained within the Upper Chalk (Principal Aquifer) and Lambeth Group sands and Thanet Sands (Secondary A Aquifers) beneath the future building are sensitive receptors.

- **Building materials and services**. All parts of the built structure which are in contact with the ground must be designed, in accordance with the Building Regulations, to resist any aggressive ground conditions.
- Surface Water. The Regent's Canal, to the north of Zone A, as shown in Figure 1.

#### 5.2.5 **Potential Pathways**

Potential pathways between sources and the relevant receptors that require consideration are:

- Human ingestion, inhalation and dermal contact.
- Migration of ground gas and hydrocarbon vapours into confined spaces.
- Lateral and vertical migration of perched groundwater.
- Direct contact of the ground with concrete in the basement substructure.

There are no potential pathways to the water in the Regents Canal, as it is confined within an impermeable liner at a higher elevation than any perched groundwater or soil contamination encountered on Zone A.

#### 5.2.6 Plausible Pollutant Linkages

From the sources, pathways and receptors identified above, the possible SPR linkages for the completed development are identified below.

During the construction phase, appropriate mitigation measures to prevent risk of harm to human health and risk of pollution of controlled waters will be implemented as detailed in the ES (paragraph 16.6.10) and in the CoCP. As such the SPR linkages only consider the risk to receptors during the operational phase of the development only.

#### 5.3 **Remediation Strategy**

#### 5.3.1 KXC Development Strategy

The site-wide remediation strategy for the KXC development is described within Volume 4 Part 16 of the ES (paragraphs 16.6.7 to 16.6.9). Paragraph 16.6.8 addresses the strategy for various sub-areas within the development site, which for Zones A is:

- Removal of hotspots of metals.
- Removal, for off-site disposal, of liquid.
- Excavate and treat on-site material.
- Inert backfill for services trenches.

#### **5.3.2 Zone A Remediation Strategy**

This ERP has considered all the ground investigation information now available for Zone A, in order to develop a site-specific remediation strategy for Sub-Area 5 that is consistent with those approved for previous Enabling Works across Zone A. The proposed measures are described below and comprise a combination of:

- (f) Source Removal;
- (g) Perimeter containment; and
- (h) Risk assessment for the proposed piling works.

The application of this strategy to Sub-Area 5 is given below.

#### 5.3.2.1 Source removal

The 'source removal' aspect of the remediation strategy for Sub-Area 5 is to excavate and remove all Made Ground and the surface of the London Clay, together with perched water within the Made Ground, as part of the reduction in site levels for the proposed building/basement. Contamination 'source removal' has already been completed in Sub-Areas 1 to 4 and in the AR(N) footprint by the Zone A Enabling Works and AR(N) construction works.

Once all of the Made Ground has been excavated in Sub-Area 5 and a clean London Clay surface has been exposed, it will be sampled on a grid pattern for compliance with the Validation Criteria for London Clay set out in Table 6 below. The estimated contours of the top of the London Clay are shown on Figure 5 of this ERP.

Determinands	Units	Validation Criteria
Inorganics		
Total Cyanide	mg/kg	78
BTEX		
Benzene	mg/kg	28
Toluene	mg/kg	200
Ethylbenzene	mg/kg	200
Xylenes (total)	mg/kg	200
Petroleum Hydrocarbons		
TPH Aliphatic EC5-EC6	mg/kg	3,380
TPH Aliphatic >EC6-EC8	mg/kg	1440
TPH Aliphatic >EC8-EC10	mg/kg	780
TPH Aliphatic >EC10-EC12	mg/kg	480
TPH Aliphatic >EC12-EC16	mg/kg	240
TPH Aliphatic >EC16-EC35	mg/kg	6500
TPH Aliphatic >EC35-EC44	mg/kg	6500
TPH Aromatic >EC8-EC10	mg/kg	3670
TPH Aromatic >EC10-EC12	mg/kg	3620
TPH Aromatic >EC12-EC16	mg/kg	1680
TPH Aromatic >EC16-EC21	mg/kg	6500
TPH Aromatic >EC21-EC35	mg/kg	6500
TPH Aromatic >EC35-EC44	mg/kg	6500
Polyaromatic Hydrocarbons		
Acenaphthene	mg/kg	567
Acenaphthylene	mg/kg	855
Anthracene	mg/kg	2000

Table 6 Validation Criteria for London Clay

Determinands	Units	Validation Criteria
Benz(a)anthracene	mg/kg	90
Benzo(a)pyrene	mg/kg	14
Benzo(b)fluoranthene	mg/kg	100
Benzo(k)fluoranthene	mg/kg	140
Benzo(ghi)perylene	mg/kg	650
Chrysene	mg/kg	135
Dibenzo(ah)anthracene	mg/kg	13
Indeno(123-cd)pyrene	mg/kg	60
Fluoranthene	mg/kg	2000
Fluorene	mg/kg	308
Naphthalene	mg/kg	204
Phenanthrene	mg/kg	2000
Pyrene		2000
Total PAH	mg/kg	2,000
Phenols		
Phenol	mg/kg	500

Notes:

1. No validation criteria for metals or asbestos as there have been assessed to be no relevant pollutant linkages for these determinands.

2. Sampling pattern, laboratory test methods, use of on-site monitoring equipment and personnel to be specified in a Remediation Implementation and Verification Plan (RIVP) to be issued in advance of the building and basement Main Building Works contract.

#### 5.3.2.2 Perimeter containment

In order to maintain a 'clean' site in the long term, it is necessary to install perimeter cut-offs to prevent contaminated perched groundwater and ground gases from adjacent off-site areas entering onto the land to be occupied by habitable basement spaces. The off-site sources comprise locally contaminated soils, perched water and ground gases and vapours within the Made Ground surrounding the west, north and east of the Site. The southern side of the future building is occupied by the SSY and all former Made Ground and perched water have previously been removed.

Along the western side of the building, adjacent to King's Boulevard, the perimeter containment will be formed by the retaining wall piling and the internal basement wall of the future building, with an integral gas and waterproof membrane. At the southern end (Sub-Area 1) the capping beam of a length of contiguous retaining wall piles has been seated into the underlying London Clay (to provide a cut-off) as part of the Early Works construction (see Photo 1). The basement retaining wall that will be constructed on top of that capping beam will be designed to be watertight and resist the ingress of ground gases. In Sub-Area 4, the retaining wall will be formed by secant piles, which were constructed as part of the Early Works, with the capping beam at a higher level; above that capping beam the basement retaining wall will be designed to be watertight and resist the ingress of ground gases. In Sub-Area 5, the initial perimeter containment will be provided by the temporary sheet pile wall, constructed during the first Ground Remediation package of the main building/basement works. Subsequent to the excavation down to the B1 piling formation level, a contiguous pile retaining wall will be constructed inside the temporary sheet pile wall (which will

remain in place) and then a basement retaining wall will be constructed inside and above that contiguous pile wall, with an integral gas and waterproof membrane.

Along the northern side of Zone A, adjacent to Goods Way, the perimeter containment will be provided by a secant pile basement retaining wall (same as the western side of Sub-Area 4). After basement excavation, an internal basement wall with an integral gas and waterproof membrane will be constructed.

Along eastern side of the proposed basement, on the western side of the AR(N) and AR(S) structures, the containment will be provided by an internal basement wall with integral gas and waterproof membrane constructed inside the line of a new contiguous pile wall.

#### 5.3.2.3 Piling Risk Assessment

A piling foundation works risk assessment (FWRA) will be carried out in accordance with Environment Agency (EA) guidance to assess the suitability of the contractor's proposed piling methods and the mitigation measures that will be taken to ensure that the piling does not cause pollution of the underlying aquifer. The FWRA report will be submitted to the EA for review and agreement prior to piling.

The retaining wall piles in Sub-Area 5 are the only piles that will be constructed through contaminated ground and therefore pose the greatest risk to groundwater quality in underlying aquifers. Preliminary pile design suggests that the retaining wall piles will not penetrate below the level of the base of the Lambeth Clays and if this is the case for the final pile design, then the risk of pollution of the underlying aquifer by piling is negligible.

#### **5.3.2.4** Plausible Pollutant Linkages after Remediation

There will be no plausible pollutant linkages between contamination sources and sensitive receptors following site remediation and construction of the Zone A building and basement, as summarised in Table 8 overleaf.

#### Table 7 Conceptual Site Model after Development / During Future Operation

Source	Pathway	Receptor	SPR	Plausible SPR Linkage after construction and remediation ?
Localised zones of contaminated Made Ground, contaminated London Clay or perched groundwater beneath the habitable areas of the building basement (including the northern end of the Access Ramp North).	Vapour migration into basement structure through cracks, joints and service penetrations. Inhalation of vapours. (Dermal contact and ingestion pathways broken by basement slab)	<u>Human health</u> Persons using the basement areas of the building, including office and service workers, visitors, and maintenance staff.	А	<ul> <li>NO: (Source removal, barrier &amp; ventilation)</li> <li>(i) All contaminated ground beneath the basement footprint and beneath the northern end of the Access Ramp will be removed from site and the surface verified to commercial end use verification criteria that consider this pathway (Source Removal);</li> <li>(ii) Basement slab and walls will be designed to be watertight and therefore provide a substantial barrier for any significant vapour ingress;</li> <li>(iii) All internal habitable basement areas will be mechanically ventilated.</li> </ul>
Made Ground soils beneath parts of the northern end of the Access Ramp South (already constructed).	Vapour migration into basement/ramp through cracks, joints and service penetrations. Inhalation of vapours. (Dermal contact and ingestion pathways broken by ramp and SSY roadway/ basement slab)	<u>Human health</u> Future ramp users	В	NO: (Ventilation, barrier and source removal) (i) These areas are all mechanically ventilated to a high level, to minimise human health risks from vehicle emissions; ii) The floors and walls of these structures are designed to resist groundwater ingress and therefore will provide a barrier for any significant vapour ingress; (iii) All contaminated ground beneath the southern end of the Access Ramp North will be removed from site. The SSY and southern end of Access Ramp (South) and founded on clean London Clay. Only the northern end of the (already constructed) Access Ramp (South) has Made Ground remaining beneath the ramp roadway. While the potential for this residual made ground to be contaminated cannot be completely ruled out, the residual Made Ground is of limited thickness and the site investigation data of perched water adjacent to this part of the ramp does not indicate the presence of contamination. Therefore this is not considered to be a plausible SPR linkage
Localised zones of perched groundwater on Zone A	Groundwater migration from Zone A to adjacent properties	<u>Human health</u> Persons on neighbouring land <u>Building materials</u> Ground and structures/services on adjacent land	C(1) C(2)	NO: (Source removal) All perched groundwater beneath the basement footprint and beneath the Access Ramp (North) will be removed from site and vertical barriers keyed into the underlying London Clay to prevent migration to off-site areas (Source Removal)

Source	Pathway	Receptor	SPR	Plausible SPR Linkage after construction and remediation ?
Localised zones of contaminated Made Ground, contaminated London Clay and perched groundwater in areas where piling is to be undertaken	Vertical downwards migration of contaminants around pile annulus	<u>Controlled</u> <u>Waters</u> : Groundwater within the Lambeth Group, Thanet Sand or Chalk	D	<ul> <li>NO: (Piling method, source removal before piling and depth of piles)</li> <li>(i) Piling methods to be adopted which minimise potential risks to underlying aquifers, in agreement with the EA;</li> <li>(ii) Piling will be undertaken after overlying contaminated ground has been removed, except for retaining wall piling in the north western part of the Site (retaining wall piling will not extend to the level of the underlying aquifers).</li> </ul>
Localised zones of contaminated Made Ground, contaminated London Clay and perched groundwater in areas where piling is to be undertaken	Direct contact with contaminated ground and contaminated perched groundwater.	Building materials on-site Below ground elements of the future building	Е	<ul> <li>NO: (Source removal and structural design)</li> <li>(i) All contaminated ground and perched groundwater in the areas of construction will be removed from site and the surface verified to commercial end use verification criteria (Source Removal);</li> <li>(ii) Substructure of building will be designed for the soil and groundwater chemistry known to be present.</li> </ul>
Potentially contaminated perched groundwater and Made Ground adjacent to the Site (beneath King's Boulevard and Goods Way).	Lateral migration of groundwater or vapours into or below the building basement.	Human health Persons using the basement areas of the building, including office and service workers, visitors, and maintenance staff.	F	<b>NO: (Barrier)</b> The new basement perimeter walls on the western and northern sides of the Site will be designed and constructed to provide an effective hydraulic and vapour barrier to prevent contaminated water and vapours entering the basement areas of the new development.
Potentially contaminated perched groundwater and Made Ground adjacent to the eastern side of the Site (beneath King's Cross railway station and tracks)	Lateral migration of groundwater or vapours below the Access Ramp structure and into or below the building basement.	<u>Human health</u> Persons using the basement areas of the building, including office and service workers, visitors, and maintenance staff.	G	<ul> <li>NO: (Barrier)</li> <li>(i) The Access Ramp North will be constructed at its northern end to preclude lateral perched water migration beneath habitable areas of the ramp (secant wall);</li> <li>(ii) Along the eastern side of the remaining lengths of the Access Ramp North and South, the future basement wall will be designed as a watertight liner wall against the contiguous piling;</li> <li>(iii) Groundwater ingress beneath the SSY and Access Ramp South (both already constructed) is collected in a sump and discharged to sewer under consent. Analysis of this discharged water indicates it is not contaminated.</li> </ul>

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Figures

Figure 1 Site Location Plan

- Figure 2 Plan of ERP Boundaries
- Figure 3 Site Plan at End of Zone A Enabling Works
- Figure 4 Isometric View of Future Development Basement
- Figure 5 Interpreted contours of the top of London Clay in Sub-Area 5





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Zone A Reserved Matters Boundary						0	15	30	60		
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Zone A Main Building Works (This ER	P)				ARTIP						
AR(N) (ERP 2013/0510/P)					Plan of ERP Boundaries						
Sub Area 5 Remediation (This ERP)											
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Site Preparation Enabling Works (ERI	P 2013/1027/P)				London W1T 4BQ						
Network Rail Plant Room					Tel +44 20 7636 1531 Fax +44 20 7580 3924						
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Perched Water Drainage Sump Perched Water Drain Installed in Early Works Retaining Wall Piling Installed in Early Works Is-Ground Clay Cut-off Installed in Early Works Secant Pile Support Beam Access Ramp North (AR4) Acce						ARUP 13 Fitzroy Street London W1T 4BQ Tel +44 20 7580 3924 www.arup.com	Site Plan showing ground levels and features installed at end of Zone A Enabling Works (Early Works) Scale at A4 1:1,500			
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