Thames Tideway Tunnel
Thames Water Utilities Limited

Development Consent Order

Application Reference Number: WWO10001

Documents for Certification
September 2014

We, Lindsay Speed and Sarah Fairbrother hereby certify that this is a true copy of the environmental statement referred to in Article 61 (1) (f) of the Thames Water Utilities Limited (Thames Tideway Tunnel) Order 2014.

Lindsay Speed

Sarah Fairbrother

September 2014

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

Thames Tideway Tunnel
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Application for Development Consent

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Environmental Statement

Doc Ref: **6.2.17**

Volume 17: Victoria Embankment Foreshore appendices

APFP Regulations 2009: Regulation **5(2)(a)**

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Appendix A: Introduction

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Appendix A: Introduction

A.1 Summary

A.1.1 This document presents the appendices that accompany the *Environmental Statement* Volume 17 Victoria Embankment Foreshore site assessment.

A.1.2 Figures associated with the appendices are provided within a separate volume of figures.

A.1.3 For consistency and ease of use Volumes 3 to 27 of the *Environmental Statement* all utilise the same appendices contents and labelling protocol. For these volumes the appendices are as follows:

a. Appendix A: Introduction
b. Appendix B: Air quality and odour
c. Appendix C: Ecology – aquatic
d. Appendix D: Ecology – terrestrial
e. Appendix E: Historic environment
f. Appendix F: Land quality
g. Appendix G: Noise and vibration
h. Appendix H: Socio-economics
i. Appendix I: Townscape and visual
j. Appendix J: Transport
k. Appendix K: Water resources – groundwater
l. Appendix L: Water resources – surface water
m. Appendix M: Water resources – flood risk
n. Appendix N: Development schedule.

A.1.4 Where a topic has not been assessed the associated appendix does not include any supporting information. Also, if a topic has been assessed but does not need to present any supporting information then the appendix is intentionally empty.

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Appendix B: Air quality and odour

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Appendix B: Air quality and odour

B.1 Model verification

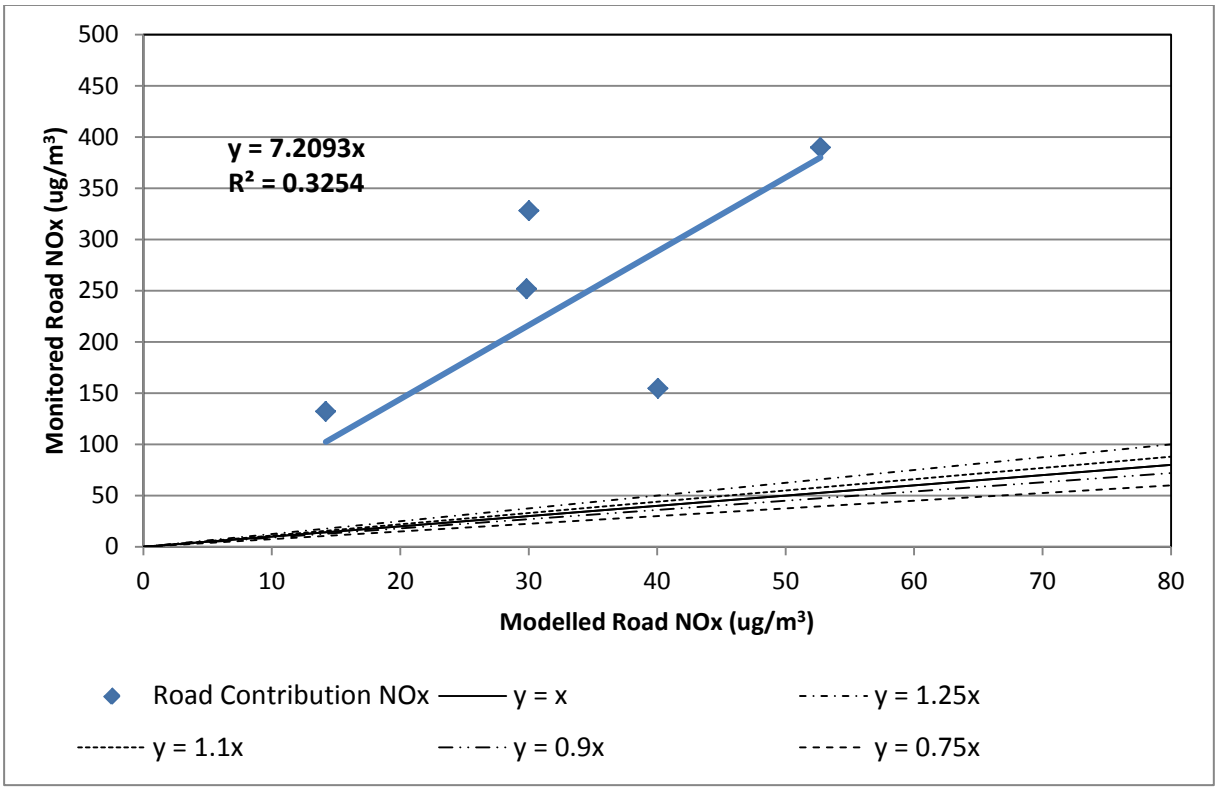
B.1.1 Modelled NO_2 concentrations have been plotted against monitored concentrations at five diffusion tube sites (VEFM1-VEFM5) as shown in Vol 17 Figure 4.4.1 (see separate volume of figures).

B.1.2 This showed that the modelled results underestimated NO_2 concentrations by between 32% and 54%. As the model has been optimised and no further improvement of the model was considered feasible (such as reducing vehicle speeds or using different pollutant backgrounds, etc), a model adjustment factor was therefore deemed necessary.

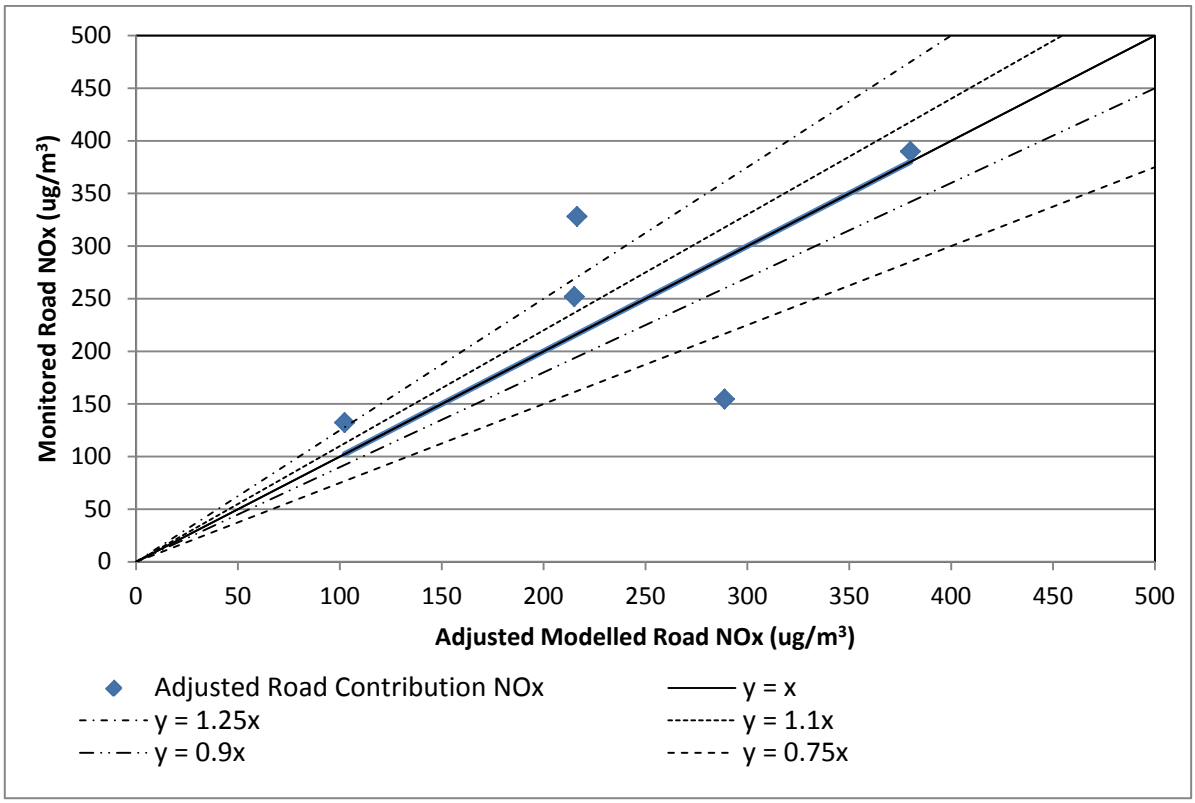
B.1.3 To derive the adjustment factor, modelled road NO_X concentrations were plotted against calculated monitored road NO_X concentrations (see Vol 17 Plate B.1 below). An adjustment factor of 7.21 was calculated for adjusting modelled roadside NO_X concentrations, in accordance with LAQM.TG(09)[1] and subsequently applied. This factor was also applied to the PM_{10} results as no local PM_{10} monitoring data were available for an area where traffic data were also available.

B.1.4 Applying the NO_X adjustment factor and then calculating NO_2 concentrations, as shown in Vol 17 Plate B.2, provides better overall agreement between actual and predicted data. The subsequent linear regression calculation for monitored versus modelled total NO_2, as shown in Vol 17 Plate B.3, indicated that three of the five modelled concentrations were within 10% of the measured value and that four of the five modelled concentrations were within 25% of the modelled value.

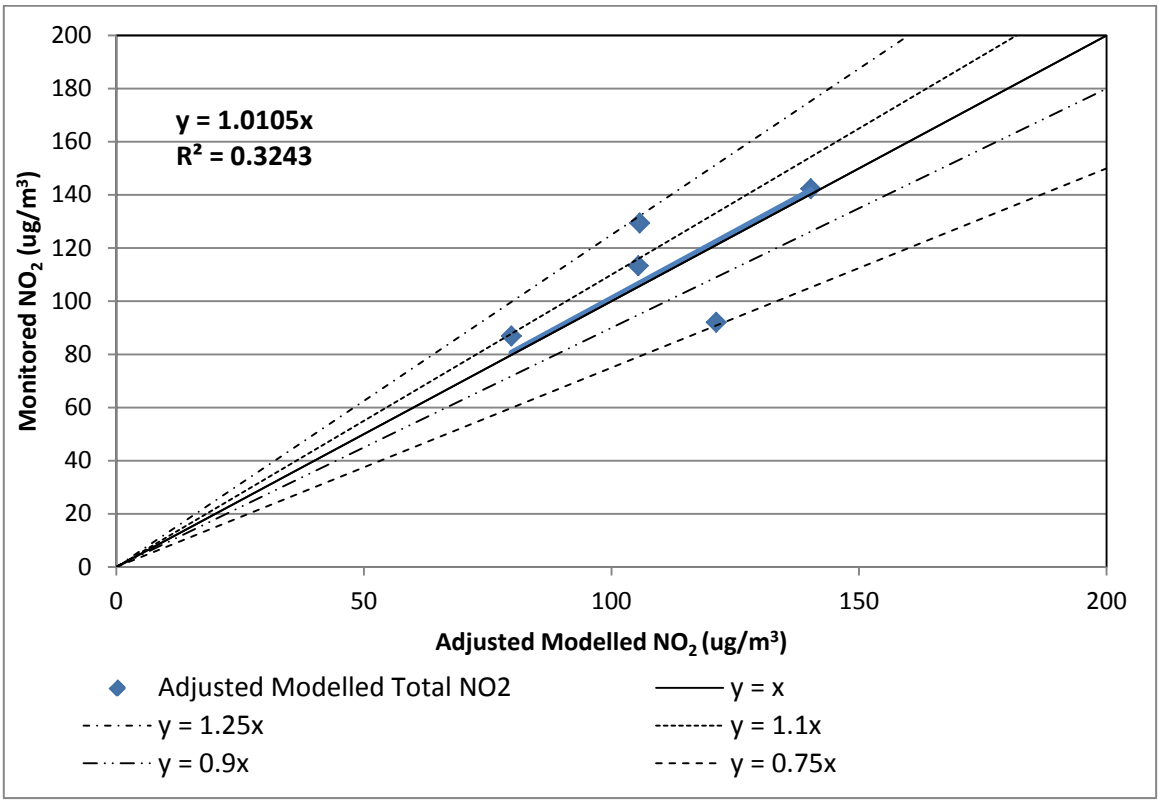
Vol 17 Plate B.1 Air quality - monitored road NO_X vs. modelled road NO_X



Vol 17 Plate B.2 Air quality – monitored road NO_X vs. adjusted modelled road NO_X



Vol 17 Plate B.3 Air quality – total monitored NO_2 vs. total adjusted modelled NO_2



B.2 Traffic data

B.2.1 The traffic data used in the air quality modelling for the Victoria Embankment Foreshore site are shown in Vol 17 Table B.1.

Vol 17 Table B.1 Air quality - traffic data model inputs

Source	Road link	2010 baseline AADT*	Baseline % HGV >3.5t	Speed limit (mph)	Model input speed (mph)	Growth factor % (2009 - 2018)	Peak const-ruction year AADT	Peak construction year AADT scheme construction HGV (HGV >3.5t)	Peak construction year development case (total AADT)	Peak construct-ion year develop-ment case AADT % HGV (>3.5t)
TfL Model	Victoria Embankment south (A3211)	47954	6.0%	30	13.7	5.7%	50685	34	50749	6.1%
ATC 'direct'	Northumberland Avenue	19196	13.5%	30	22.4	5.7%	20289	16	20305	13.6%
TfL Model	Victoria Embankment north (A3211)	64230	5.7%	30	13.7	5.7%	67887	18	67936	5.7%
TfL Model	Whitehall (A3212)	9431	19.1%	30	9.2	5.7%	9968	1	9969	19.1%
TfL Model	Cockspur Street (A4)	19371	21.3%	30	8.2	5.7%	20474	9	20491	21.3%
TfL Model	The Strand (A4)	13029	7.5%	30	4.9	5.7%	13770	0	13786	7.5%

** AADT – annual average daily traffic. ATC – annual traffic count.*

B.3 River tug emission factors

B.3.1 Emissions of NO_X and PM_{10} from tugs pulling the barges were calculated using the data shown in Vol 17 Table B.2 for the Victoria Embankment Foreshore site.

Vol 17 Table B.2 Air quality - tug assessment model inputs

Parameter	Value	Units
Total tugs	143	Tugs/year
Time per tug*	20	minutes
NO_X base emission factor	10.2	g/kWhr
PM_{10} base emission factor	0.9	g/kWhr
Average tug engine size	984	kW
Manoeuvring and hotelling** load factor	0.2	No units
Total tug area***	3919	m^2
NO_X emissions per tug	1.4×10^{-04}	$g/s/m^2$
PM_{10} emissions per tug	1.3×10^{-05}	$g/s/m^2$

* Time that tug is at the site.
** Hotelling refers to when the tug is securely moored or anchored.
*** Area of the mooring and manoeuvring of tugs.

B.4 Construction plant emission factors

B.4.1 For the purpose of the assessment, the following listed equipment in Vol 17 Table B.3 has been modelled for the peak construction year at the Victoria Embankment Foreshore site.

Vol 17 Table B.3 Air quality - construction plant assessment model inputs

Construction activity	Typical location	Typical plant	Unit No(s)	% on-time	Power (kW)	NO_X emission rate ($g/s/m^2$)	PM_{10} emission rate ($g/s/m^2$)
Hoarding	Ground level behind hoarding	Excavator digging post holes for hoarding	1	30	301	1.0×10^{-06}	6.5×10^{-08}
	Ground level behind hoarding	Generator 35kVA	1	100	28	5.1×10^{-06}	4.8×10^{-07}
	Ground level behind hoarding	Cutting equipment (diamond saw)	1	10	2.3	4.2×10^{-08}	4.0×10^{-09}
	Ground level behind hoarding	Compressor 250cfm*	1	30	104	3.6×10^{-07}	2.2×10^{-08}
Site set up and general site	Ground level behind hoarding	Compressor 250cfm	1	50	104	6.0×10^{-07}	3.7×10^{-08}
	Ground level behind hoarding	Generator - 200kVA	1	100	160	1.8×10^{-06}	1.1×10^{-07}
	Ground level behind hoarding	JCB with hydraulic breaker	1	50	67	3.8×10^{-07}	2.4×10^{-08}
	Ground level behind hoarding	Cutting equipment (diamond saw)	2	10	2.3	1.3×10^{-08}	2.9×10^{-08}
	Ground level behind hoarding	Telescopic handler / FLT**	1	30	60	2.1×10^{-07}	1.3×10^{-08}

Construction activity	Typical location	Typical plant	Unit No(s)	% on-time	Power (kW)	NO_X emission rate ($g/s/m^2$)	PM_{10} emission rate ($g/s/m^2$)
	Ground level behind hoarding	Hiab*** lorry/crane	1	5	56	3.2×10^{-08}	2.0×10^{-09}
	Ground level behind hoarding	Well drilling rig	1	50	403	2.3×10^{-06}	1.4×10^{-07}
Culvert works	Ground level behind hoarding	100t crawler crane	1	50	240	1.4×10^{-06}	8.6×10^{-08}
	Ground level behind hoarding	Service crane 25t mobile crane	1	25	275	7.9×10^{-07}	4.9×10^{-08}
	Ground level behind hoarding	25t excavator	1	50	125	7.2×10^{-07}	4.5×10^{-08}
	Ground level behind hoarding	Dumper	1	50	81	4.6×10^{-07}	2.9×10^{-08}
	Ground level behind hoarding	Concrete deliveries (discharging)	1	20	223	5.1×10^{-07}	3.2×10^{-08}
	Ground level behind hoarding	Concrete boom pump	1	20	223	5.1×10^{-07}	3.2×10^{-08}
Landscaping	Ground level behind hoarding	25t excavator	1	50	125	7.2×10^{-07}	4.5×10^{-08}
	Ground level behind hoarding	Dumper	1	70	81	6.5×10^{-07}	4.1×10^{-08}
	Ground level behind hoarding	Telescopic Handler / FLT	1	30	60	2.1×10^{-07}	1.3×10^{-08}
	Ground level	Hiab*** lorry / crane	1	5	56	3.2×10^{-08}	2.0×10^{-09}

Construction activity	Typical location	Typical plant	Unit No(s)	% on-time	Power (kW)	NO_X emission rate ($g/s/m^2$)	PM_{10} emission rate ($g/s/m^2$)
	behind hoarding						
	Ground level behind hoarding	Compressor for hand-held breaker	1	10	6	1.1×10^{-07}	1.0×10^{-08}
	Ground level behind hoarding	Plate compactors	2	10	3	1.8×10^{-08}	3.8×10^{-08}
	Ground level behind hoarding	Vibrating rollers	1	20	145	3.3×10^{-07}	2.1×10^{-08}

*Note: For the purposes of this assessment, the above listed equipment has been modelled for the peak construction year. The data assumes a 10 hour working day. This schedule provides an illustration of typical plant that could be used in the construction of the Thames Tideway Tunnel at this site. The appointed Contractor must comply with section 6 of the CoCP but may vary the method and plant to be used. This schedule therefore represents the most reasonable assumption for the assessment that can be made at this stage. * cfm - cubic feet per minute. ** FLT – fork lift truck. ***Hiab – loader crane.*

References

[1] Defra, *Local Air Quality Management - Technical Guidance, LAQM.TG(09)* (2009).

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Appendix C: Ecology - aquatic

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Appendix C: Ecology - aquatic

C.1 Introduction

C.1.1 Construction and operational effects assessments at this site for this topic do not require the provision of any supporting information, so this appendix is intentionally empty.

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Appendix D: Ecology - terrestrial

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Appendix D: Ecology – terrestrial

D.1 Introduction

D.1.1 Construction and operational effects assessments at this site have not been undertaken so this appendix contains no supporting information.

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Appendix E: Historic environment

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Appendix E: Historic environment

E.1 Gazetteer of known heritage assets

E.1.1 Details of known heritage assets within the assessment area are provided in Vol 17 Table E.1 below, with their location shown on the historic environment features map (Vol 17 Figure 7.4.1, see separate volume of figures).

E.1.2 All known heritage assets within the assessment area are referred to by a historic environment assessment (HEA) number. Assets within the site are referred to (and labelled in the historic environment features map) with the prefix 1, e.g., **HEA 1A**, **1B**, **1C**. References to assets outside the site but within the assessment area begin with 2 and continue onwards, e.g., **HEA 3**, **4**, **5.**

Vol 17 Table E.1 Historic Environment – gazetteer of known heritage assets within the site and assessment area

HEA Ref no.	Description	Site code/ GLHER ref/ List Entry Number
1A	Thirty-four catenary lamp standards on the Victoria Embankment. Grade II listed. Catenary lamp standards; 32 of c. 1900, by Walter MacFarlane and Company and 2 of c. 1929 by Carron and Company. The majority of the original lamp standards have marks on the base reading 'Walter MacFarlane & Co / Saracen Foundry / Glasgow', but few of these are legible due to many layers of paint. Others are numbered, although there does not appear to be any logical sequence to the numbering. The final pair, at either side of the road, where the Embankment meets Westminster Bridge is marked 'Carron Company / Stirlingshire' and dated 1929.	1392513
1B	The permanently moored Tattershall Castle 'hulk' (a vessel stripped of its fittings and permanently moored or abandoned), as recorded by Seazone. This was built in 1934 by William Gray and Co. for the London and North Eastern Railway, as a passenger steamer ferry on the River Humber, between Kingston upon Hull and New Holland, and served as a tether barge for barrage balloons and a ferry for troops and munitions during the Second World War (National Historic Ships, 2011). It was one of the first civilian vessels to be equipped with radar. By 1971, after the opening of the Humber Bridge its services as a ferry boat were no longer needed and in 1981 she was brought to London. It has since been extensively remodelled, including the introduction of windows, a bridge and removal of	486000006 148549

HEA Ref no.	Description	Site code/ GLHER ref/ List Entry Number
	paddles. It is listed on the National Register of Historic Vessels Certificate no. 72.	
1C	Twenty-one bench seats set on Embankment pavement. Grade II listed. 1872–74 designed by Lewis and G F Vulliamy. Cast iron mounted and timber slatted. The seats take the form of long benches with curved backs supported on cast iron brackets, the terminal arm-brackets designed as winged sphinxes, with the exception of the bench opposite the junction with Horse Guards Avenue which has the feature of seated camels instead of sphinxes. Included in their own right as original street furniture and as part of the Embankment design.	1357348
1D	Embankment river wall, stairs and lamp standards. Grade II listed. Built 1864–70 by Sir Joseph Bazalgette as part of the engineering works to improve London's drainage system with interceptor sewers along both sides of the Thames. The 'dolphin' lamp standards designed by Timothy Butler (most of them dated 1870). Granite retaining walls, cast iron lamp standards. The boldly detailed retaining walls are battered to river with bronze lion heads holding mooring rings and the parapet has a heavy segmental rolled coping with regularly spaced dies surmounted by the ornately designed 'dolphin' (also called 'sturgeon') lamp standards with globe lanterns. At the Westminster Bridge end a similarly detailed wall separates the Embankment proper from the road which rises to bridge level with stone paving and steps between the two levels and a flight of stairs alongside the Boadicea monument. Temple Stairs at the east end has a large boldly channelled semicircular archway.	1237712
1E	King's Reach. A pontoon recorded by Seazone.	486000006 148456
1F	The approximate location of the chance find of a 9th century iron axe.	MLO27006 112024
1G	Victoria Embankment. Constructed by Joseph Bazalgette, finished and opened in 1869, a single phase construction including the Grade II listed embankment wall (**HEA 1D**) and fill behind as far as the historic riverbank. Fill is a single construction of Portland Cement concrete, incorporating a stretch of the Northern Outfall Low Level Sewer, a subway beneath the	---

HEA Ref no.	Description	Site code/ GLHER ref/ List Entry Number
	pavement (containing gas and electricity lines) and the tunnel of the Circle and District lines). The embankment supports a surface roadway, lined with trees planted at 20ft intervals along the pavement beside the river wall. The scheme included a uniform line of London Plane trees along the pavement. The existing trees are varied in age and those within the site are classed as young and middle aged and are possibly replacement to those that were originally planted	
2	In 1882, c. 100 early medieval silver coins were found near 'Waterloo Railway Bridge', presumed to be Hungerford Bridge as noted on the Greater London Historic Environment Record (GLHER).	MLO26846 114009
3	Northumberland Avenue/Whitehall Place: the site of the medieval St Mary Rounceval Wharf, which in the post-medieval period may have been held by the Crown as part of Whitehall Palace (**HEA 10**).	MLO36471 081346/01
4	The town house of the Abbot of Bury is documented c. 1200 as close to York Place (later Whitehall Palace, **HEA 10**), although the Greater London Historic Environment Record (GLHER) locates this point in the Thames channel.	MLO9193 081379
5	Scotland Dock which supplied Whitehall Palace (**HEA 10**) from warehouses, and included a bakery, a small brewhouse and a buttery, as seen on Fisher's c. 1680 plan of the Palace. It is documented that c. 1531, material for building the dock was collected in the Scotland Yard Area and was protected by a hedge of thorns and stakes. The dock was built in 1532 and was later enlarged and the area of water was roofed over.	MLO55659 081349/22
6	The chance find of a Bronze Age palstave/axe and spear from the River Thames.	MLO8881 112031 MLO8889 112046
7	Thames Foreshore, adjacent to Hungerford Bridge, SE1. An archaeological evaluation by the Museum of London Archaeology Service (MoLAS, now MOLA) in 1997. An auger survey recorded natural gravels gradually sloping down towards the river, though one of the transects showed a sharp fall, possibly the result of truncation by dredging for the clearance of an entrance to one of the numerous wharves that lined this part of the river in the 18th and 19th century.	TFC97

HEA Ref no.	Description	Site code/ GLHER ref/ List Entry Number
8	The medieval Whitehall Stairs which provided a public river landing place, with a corresponding right of way through Whitehall Gate and the Palace (**HEA 10**) to the main road (Whitehall), until the 1860s when they were demolished during the building of the Victoria Embankment.	MLO38551 081349/06
9	The GLHER includes a river embankment wall with six bastions shown on Fisher's c. 1680 plan of Whitehall Palace (**HEA 10**) running south from Whitehall Stairs (**HEA 8**). It was c. 18m beyond the earlier river line and c. 90m behind the present embankment. The bastions may have been designed to hold many-windowed turrets, as at other Tudor Palaces at Richmond and Greenwich. See also **HEA 11**.	MLO36479 081349/15
10	York Place, Whitehall, later Whitehall Palace. Richard Fitznigel Bishop of London (1189–98) had a house here on Abbey lands. In 1245 it was given to the see of York and became the London house of the Archbishop of York. Building work was recorded in 1298. Greatly extended by Cardinal Wolsey as Archbishop of York 1514–29. Taken by Henry VIII on Wolsey's fall and renamed Whitehall Palace. The Palace buildings as recorded in c. 1680 extended across much of the western part of the assessment area, approximately from modern Northumberland Avenue in the north to Richmond Terrace in the south. Damaged by fire in 1691 and almost entirely burnt down in 1698.	MLO18833 081356
11	Additional GLHER entry for the 16th–17th century river wall associated with Whitehall Palace and possibly originally built for the earlier York Place (see also **HEA 9**).	MLO37042 081356/06
12	Medieval to post-medieval beer-house of the knights of St John of Jerusalem. In 1530 it passed to the Crown. The site was redeveloped by William, 5th Baron of Craven in 1730.	MLO9175 081354
13	Thames Foreshore, Jubilee Gardens, SE1. An archaeological evaluation by MoLAS in 1996. Examination of small trial holes along a measured grid indicated that post-medieval aggradation (material deposited on the foreshore by riverine action) overlay alluvial silts of possible medieval date. A record of features on the foreshore south of Hungerford Bridge made by the Thames Archaeological Survey (TAS) in 1999 was reviewed and expanded by the Thames Discovery Programme (TDP), which identified features exposed prior to and during dredging for repairs and	TFJ96 FLM05 A101– A112

HEA Ref no.	Description	Site code/ GLHER ref/ List Entry Number
	strengthening of the Underground line: • Palaeolithic forest remains (A101 and 109) comprising branches and roots in peat/organic clay, and related deposit (A110) comprising a high concentration of shells; • a possible Palaeolithic timber (A111) represented by a round wood displaying a likely joint and toolmarks; • post-medieval artefact scatter (A107) comprising Delftware kiln material; • post-medieval mooring block (A108) represented by six or more vertical stakes with metal caps; • post-medieval unclassified structures (A102 and 103) each comprising a box formed of four vertical timbers with pierced plank sides, and a possible 'door' on one side, possibly fishing or storage related; • deposit of 19th century date (A105–7) comprising a sequence of organic clays, shelly sands and dumped material; • layer of aggradations (A112) comprising gravel dumped to fill a dredged area (A104).	
14	The kitchen of Whitehall Palace (**HEA 10**). The building works were probably started by Wolsey but accounts of payments suggest that the work was finished by Henry VIII.	MLO36488 081356/04
15	The chapel of York Place which is believed to have been renovated or rebuilt by Wolsey in the early 16th century. Also the site of 'Cromwell House' constructed c. 1722 which incorporated a vaulted undercroft of c. 1530. Cromwell House was demolished in 1913.	MLO36486 081356/02 MLO21731 205034 MLO36485 081356/01
16	A 15th century battlemented parapet, part of Whitehall Palace. In 1665 it was fitted up as a theatre but burnt down in 1698.	MLO36487 081356/03
17	A kitchen of York Place/Whitehall Palace to the north of the great hall, believed to have been built by Wolsey.	MLO36489 081356/05
18	Charing Cross Station, Villiers Street, WC2. An archaeological watching brief by the Museum of London's Department of Greater London Archaeology (DGLA) in 1987 recorded good organic preservation in the lower layers, some of which contained quantities of domestic refuse but	CHA87

HEA Ref no.	Description	Site code/ GLHER ref/ List Entry Number
	few dateable artefacts. Evidence of a late or early post-medieval water channel was found along with the remains of a wall of the same period, when the site formed part of the garden of York House.	
19	Medieval Hungerford Stairs. Recorded on the GLHER.	MLO38549 081341/01
20	The 17th century Kings Arms Glasshouse which produced plate glass and looking glasses. Its proprietors included John Gumley (1706–12) and the Vauxhall plate glasshouse (1723).	MLO77753
21	Pembroke House which was built in 1756 on the site of an earlier building of 1729. Demolished in 1913.	MLO21967 205033
22	A 15th century and later watching chamber, privy chamber, presence chamber etc. for the Queen at Whitehall Palace, probably originally part of York Place. Rebuilt in 1688, burnt in 1698, and the shell demolished in 1701.	MLO36474 081349/04
23	The Privy Stairs of Whitehall Palace for the use of the Royal family. There was also a two-storey structure with a shield gallery and balustrade from which pageants could be watched.	MLO36476 081349/07
24	13–14 Buckingham Street, WC2. An archaeological watching brief by DGLA in 1988 produced evidence of the local natural topography and land reclamation.	BKS88
25	The chance find of a Bronze Age ‘chisel’-type implement in 1920 between Westminster and Waterloo Bridges.	MLO26940 114031
26	The approximate location of a Roman coin (LON-800382), a medieval buckle (LON-6493D1) and a post-medieval coin (LON-8E19E7) recovered from the banks of the Thames, and recorded by the Portable Antiquities Scheme (PAS).	LON-800382 LON-6493D1 LON-8E19E7
27	Plimsoll Memorial on edge of Embankment Gardens. Grade II listed. 1929 by F. V. Blundstone. Bronze portrait bust on granite pedestal with two bronze supporters and cartouche with inscription.	1274547
28	Memorial to Sir W. S. Gilbert. Grade II listed. Fixed to granite block at Charing Cross Pier. 1914, by George Frampton. Bronze plaque with portrait relief and two small figures of Comedy and Tragedy.	1237829

HEA Ref no.	Description	Site code/ GLHER ref/ List Entry Number
29	Memorial to Sir J. Bazalgette. Grade II listed. 1890. White marbled pedimented tabernacle in early Renaissance style: fixed to granite block upstream from Hungerford Bridge. The tabernacle contains a bronze portrait bust in roundel and bronze cartouche.	1357347
30	River Thames Dredging (Flood Mitigation 3), north side of Hungerford Bridge on the South Bank, SE1. An archaeological watching brief by MoLAS in 1996. Material dredged from the River Thames proved to be modern with only one or two pieces of much abraded earlier pottery.	TDR96
31	Statue of Sir James Outram. Grade II listed. 1871, by Matthew Noble. Bronze standing figure on polished granite pedestal with groups of Indian arms and trophies at the corners.	1237908
32	Statue of William Tyndale. Grade II listed. 1884, by Sir Edgar Boehm. Bronze standing figure on Portland stone pedestal.	1357350
33	Queen Mary's steps and fragment of Whitehall Palace. Grade I listed. Reconstructed Tudor Palace wall and north end of terrace and river steps by Sir Christopher Wren 1691–93. Portland stone. The reconstructed Tudor work is part of the base of the corner of the river wall to King Henry VIII's Whitehall Palace. In front of it is the surviving north end of Queen Mary's Terrace with curved flight of steps flanked by ashlar retaining walls of terrace; at the top of the steps, bases of four columns and the doorway sill of the river gate.	1066636
34	Ministry of Defence. Grade I listed. Government offices incorporating 16th century vaulted undercroft and 18th century historic rooms removed and reset from houses formerly on the site. Office building designed 1913 by Vincent Harris but only built after World War II, completed 1959. Portland stone ashlar facing, copper clad roofs.	1278223
35	The National Liberal Club. Grade II* listed. Part of Whitehall Court (**HEA 36**). 1884–1887, by Alfred Waterhouse. Portland stone, slate roofs.	1066072
36	Whitehall Court. Grade II* listed. Mansion block of flats. 1884 by Thomas Archer and A. Green. Portland stone, slate roofs.	1266894

HEA Ref no.	Description	Site code/ GLHER ref/ List Entry Number
37	Playhouse Theatre. Grade II listed. 1881–82 by F.H. Fowler as the Royal Avenue Theatre, interior reconstructed 1906–07 by Blow and Billerey. Painted stone, concealed roof. Restrained and elegant classical design. Two storeys.	1356962
38	Statue of General Gordon. Grade II listed. 1887–88, by Hamo Thornycroft. Bronze, over life-size statue of Gordon of Khartoum on Portland stone base with enrichments and two plaques also of bronze.	1066175
39	Statue of Sir Bartle Frere. Grade II listed. 1888, by T. Brock. Bronze standing figure on granite pedestal.	1066176
40	Royal Air Force Memorial Whitehall Stairs. Grade II listed. By Sir R. Blomfield, c. 1920. Portland stone pylon surmounted by gilt bronze eagle.	1066171
41	Hungerford House. Grade II listed.	1237857
42	Unclassified obstruction: concrete underwater structure recorded by acoustic sensor and digitised by Seazone.	637000001 130826
43	As **HEA 42**.	637000001 130820
44	As **HEA 42**.	637000001 130823
45	As **HEA 42**.	637000001 130825
46	As **HEA 42**.	637000001 130819
47	As **HEA 42**.	637000001 130822
48	As **HEA 42**.	637000001 130821
49	King's Reach. Location of a post/pile recorded by Seazone.	486000006 148226
50	As **HEA 49**.	486000006 147565
51	As **HEA 49**.	486000006 146856
52	Northumberland Avenue, Westminster. Watching brief in 2006 by MoLAS during the excavation of sewer connection	NUM06

HEA Ref no.	Description	Site code/ GLHER ref/ List Entry Number
	shafts. The earliest recorded deposit in the most easterly of the shafts contained 15th-century material. Two brick-built tunnels were seen running north–south c. 5m below the current ground surface. The tunnels are thought to be the remains of a drainage system or garden feature from Northumberland House (previously Suffolk House). The bricks included examples of possible Tudor type. In a second shaft, a reclamation or garden deposit of probable 17th century date was recorded, above which lay 19th century deposits associated with the construction of a nearby sewer. Brick rubble, possibly associated with the late 19th century demolition of Northumberland House and the construction of Northumberland Avenue, was recorded in a third shaft; later monitoring of this shaft revealed possible Saxon deposits.	MLO98853
53	Gateway and railings across south end of street with retaining wall and steps down to Victoria Embankment Gardens. Grade II listed.	1220330
54	King's Reach. Location of a pontoon recorded by Seazone.	486000006 149142
55	Government offices, Ministry of Agriculture Fisheries and Food West Block. Grade II* listed.	1066106
56	Statue of Sir Walter Raleigh. Grade II listed.	1224167
57	Royal United Services Institute. Grade II* listed.	1266924
58	Gwydyr House (Welsh Office). Grade II* listed.	1066107
59	Harrington House. Grade II* listed.	1356938
60	1, Great Scotland Yard. Grade II listed.	1357068
61	Ship and Shovel public house. Grade II listed.	1220801
62	War Office (Ministry of Defence). Grade II* listed.	1224143
63	Forecourt railings, gates and guardhouses to Horseguards. Grade I listed.	1267077
64	Whitehall House. Grade II listed.	1066105
65	35, 36, 37, 38 Craven Street. Grade II listed.	1356964 1356965 1066930 1066931
66	Dover House Scottish Office. Grade I listed.	1066101
67	11–12, 13–14, 15 Craven Street. Grade II listed.	1220845

HEA Ref no.	Description	Site code/ GLHER ref/ List Entry Number
		1066962 1066926
68	Victoria Embankment Gardens. Grade II* registered park and garden.	32901
69	Two lamp standards. Grade II listed.	1235175
70	Chance find of a Mesolithic flint axe recorded on the GLHER.	MLO9125 081302
71	Great Scotland Yard, Whitehall. Part of the Tudor and later Whitehall Palace (**HEA 10**), traditionally a reference to a residence of the kings of Scotland, recorded on the GLHER.	MLO18770 081350
72	Banqueting House (outside). MoLAS watching brief 1994 recorded a partially backfilled brick well apparently shown on Fisher's plan of c. 1680, probably associated with Whitehall Palace. No other archaeological deposits were exposed.	BHW94
73	Horseguards Avenue. Medieval to post-medieval flood defences.	MLO37042 081356/06
74	Richmond Terrace Mews. Evaluation trial trenching by the Inner London Archaeological Unit (ILAU) in 1980 indicated that the vicinity was frequently flooded by the Thames and possibly used as a refuse dump in the late medieval period. A watching brief by the Central Excavation Unit of English Heritage in 1983 during building construction revealed an alder wood baseplate and post set into it at –1.4m OD (98.6 ATD) immediately overlying a peaty deposit, itself resting on alluvial clays. Radiocarbon dating of the timber, if reliable, placed the structure in the Late Bronze Age or early Iron Age. The investigation also confirmed the presence of 15th–16th century dumps, which were overlain by rubble make-up for 17th–18th century structures.	RCH80 CEU259 MLO21966 081462 MLO63539 083097 MLO21964 081461
75	St Martin's Lane. Medieval to post-medieval conduit.	MLO18782 081417
76	Sir Walter Raleigh Statue. MoLAS watching brief in 2001. Garden soil, probably of 20th century date, was overlain by make-up and topsoil.	WTI01
77	Ministry of Defence. MoLAS watching brief 2001. Groundworks on either side of Horse Guards Avenue revealed a brick wall (thought to have been part of the Royal Palace of Whitehall) in Tudor-style brick and possibly dating to works by Cardinal Wolsey or Henry VIII. A large fragment of floor tile may have been from one of the central panels in	WIH01

HEA Ref no.	Description	Site code/ GLHER ref/ List Entry Number
	a maiolica mosaic possibly dating to the 1520s. To the west, further walls were thought to be from Pelham House, a private residence on the site in c. 1800 and subsequently 19th-century office buildings.	
78	Statue of the Duke of Cambridge. Grade II listed.	1066108
79	The medieval York Place, later Whitehall Palace (**HEA 10**). Archaeological excavations in 1950 and 1960–62 in areas between Whitehall and the river and the Treasury buildings added much information to Fisher's 1680 ground plan and other documentary sources. Fabric from the Tudor palace was incorporated into later treasury buildings. A Neolithic greenstone axe is noted in the GLHER as having come from the 1950's excavation.	MLO18826 081349 MLO3240 081253
80	Post-medieval building range, part of Whitehall Palace.	MLO53618 081349/27
81	Post-medieval building range, part of Whitehall Palace.	MLO53618 081349/27
82	Post-medieval garden, orchard, part of Whitehall Palace.	MLO36478 081349/13
83	Post-medieval cellar, part of Whitehall Palace.	MLO36485 081356/01
84	Post-medieval 'stone gallery' or covered way, part of Whitehall Palace.	MLO48344 081349/12
85	Post-medieval garden, part of Whitehall Palace.	MLO48345 081349/14
86	Belvedere Road, Lambeth. Documentary sources record the location of two post-medieval post mills.	MLO13525 090945
87	11 Buckingham Street. A watching brief by DGLA in 1987. Walls of late medieval or early post-medieval date were recorded.	BKS87
88	South Bank, Lambeth. River Stairs, later known as the King's Arms Stairs. Also the documented site of two docks on ground called The Hopes.	MLO4127 090109 MLO24425 090056
89	South Bank, Lambeth. A post-medieval glass works, recorded as being in the possession of the Vauxhall Glasshouse in the early 18th century.	MLO4130 090117
90	The Board of Trade building, Westminster. An aviary recorded here was moved to St James's Park in 1667.	MLO56346 081349/03/

HEA Ref no.	Description	Site code/ GLHER ref/ List Entry Number
		001
91	Richmond Terrace: landing steps built 1563–5 with an ornamental gate added in 1600–1.	MLO56347 081349/13/ 001
92	Whitehall Gardens: in 1668–9, a gallery (covered way) was built for Whitehall Palace that divided Pebble Court and the Great Court.	MLO56439 081349/14/ 002
93	Millennium Wheel Site (London Eye), Jubilee Gardens, Belvedere Road. MoLAS evaluation and watching brief in 1997. A sequence of gravels was overlain by the sands and silts typical of a floodplain, in turn overlain by organic silty clays indicative of a marsh-like environment, probably Roman. Above alluvial clay was an organic clay deposit, probably Saxon (670–960): the upper levels dated to 1020–1260. A timber conduit was also recorded. Evidence of post-medieval land reclamation, piling, wall, well, ditch and revetment as well as a medieval to post-medieval water channel and causeway were recorded on the GLHER.	JUL97 092702 092723 092725 093280 093281 093282 093278 093279
94	12 Buckingham Street. DGLA watching brief in 1988. Waterlogged deposits were recorded which included the apparent remains of a wattle fence. Animal bone was also recovered. The levels were possibly Saxon, though no dating evidence was found.	BHM88
95	22–25 Northumberland Avenue. A site code was issued in 2001 but ownership of the site changed and the planned fieldwork was not carried out.	NMB01
96	Whitehall Palace. Excavations in 1939. No further information available at present. Work also carried out 1933 to 1936.	WAL39
97	45–51 Whitehall. Inner London Archaeological Unit (ILAU) excavation in 1979 showed that the Taplow Gravels did not extend as far south from Trafalgar Square as this site, which lay on alluvial deposits. Modern buildings had destroyed any later archaeological strata.	WHI79
98	Richmond Terrace balustrade and five lamps on it. Grade II* listed.	1265182
99	Northumberland Avenue. The chance discovery in 1883 of sections of polished deer antler, thought to be Lower Palaeolithic but re-examined in 1987 and assessed as possibly medieval.	MLO12950 081129
100	Women in World War II War Memorial. MoLAS watching	WWM05

HEA Ref no.	Description	Site code/ GLHER ref/ List Entry Number
	brief in 2005. Two large gas mains had truncated most of the stratigraphy, although a small amount of the post-medieval sequence survived, containing some animal bone and a small quantity of c. 16th–17th century pottery.	
101	70 Whitehall. MoLAS excavation in 2008. A trench was located in a ground floor room in Dorset House, built in the 18th century but now part of a complex of government buildings that occupies the site of Henry VIII's Whitehall Palace. A remnant of Tudor wall was recorded, along with an 18th century culvert.	WHX08
102	Household Cavalry Museum, Horse Guards. MoLAS watching brief and standing structure recording in 2006. Several red brick foundations and drains that form part of the construction of the present building were revealed, including an earlier yellow brick drain probably from the stable floor of the first Horse Guards c.1663–1750. Evidence was also found of a mixture of timber floor construction methods, reminiscent of those used in 18th century warehouses.	HOG06
103	Statue of the eighth Duke of Devonshire. Grade II listed.	1224271
104	Banqueting House. Grade I listed.	1357353
105	Former Paymaster General's office (The Parliamentary Counsel). Grade II* listed.	1357390
106	Horse Guards. Grade I listed.	1066100
107	Richmond Terrace. Grade II* listed.	1235174
108	Statue of Lord Trenchard. Grade II listed. 1961 by W McMillan. Bronze standing figure of the Air Marshal on Portland stone pedestal with granite steps.	1237902
109	Richmond Terrace east garden wall with pier and urn adjoining number 1. Grade II listed.	1265164
110	13 Buckingham Street. Grade II* listed.	1066366
111	Northumberland House (Victoria Buildings). Grade II listed.	1225350
112	Statue of Field Marshal Earl Haig. Grade II listed.	1066109
113	Victoria Embankment. The Hispaniola 'hulk' as recorded by Seazone. Originally named the Maid of Ashton and launched in 1953 as the first of a quartet of passenger vessels ordered in 1951 to modernise the Clyde fleet of the Caledonian Steam Packet Company. It was built by Yarrow's naval yard at Scotstoun. With the switch to car	486000006 149229

HEA Ref no.	Description	Site code/ GLHER ref/ List Entry Number
	ferry services, it became redundant and was laid up in 1971. In 1973 it was moved to the Thames and sold to the Yardarm private dining club of London and renamed Hispaniola. In 2002, it was refitted at the George Prior yard in Ipswich and resumed business in its present position as a restaurant.	

E.2 Site location, topography and geology

Site location

E.2.1 The majority of the site lies in the River Thames and is permanently submerged, whilst its western (inland) boundary includes parts of the Victoria Embankment river wall and the main road. Hungerford Bridge lies c. 50m to the north. Along this stretch of the river, there is no visible foreshore, even at low tide, except at the southernmost end of the site, where it is exposed at around 97.8m ATD, as the Embankment (constructed 1864–70) was built out into the deeper river channel and was probably subsequently dredged.

Topography

E.2.2 Street level along the Victoria Embankment is c. 104.6m ATD (above Tunnel Datum; the equivalent of 4.6m above Ordnance Datum).

Geology

E.2.3 The landward part of the site was formerly within the Thames and was reclaimed from the river during construction of the Embankment. Geotechnical borehole data from the vicinity is not extensive but indicates that there is likely to be a c. 6m depth of made ground on the landward (Embankment) side, overlying possibly another 2–3m depth of earlier foreshore and alluvium, over terrace gravel (as described below).

E.2.4 No borehole data exists for the overland part of the site although there are a number of British Geological Survey (BGS) boreholes within a 100m radius to the north, south and west. With the exception of one borehole to the southwest of the site[1] all other boreholes are antiquated and lack detail. Examination of borehole data some 20m to the west of the site[2], although limited in detail, indicates sands and gravels lie at around 96.5m ATD, ie c. 8m below ground level (bgl) overlain by alluvium ('stiff blue mud') to c. 98.0m ATD (c. 6.5m bgl).

E.2.5 Further west, at the north end of Victoria Embankment Gardens some 70m northwest from the site where ground level was recorded at 105.3m ATD, was a spread of four boreholes[3]. Most encountered concrete or other obstructions at c. 1.5m bgl, but one recorded made ground, presumably relating to the Embankment, to 7m bgl (c. 98.3m ATD) where the borehole ended. One other borehole in the Gardens, c. 100m to the

south of this group[4] (ground level also 105.3m ATD) shows made ground over (probably truncated) gravels at c. 98.7m ATD (6.7m bgl).

E.2.6 The Pelor Multibeam Bathymetry data held by the Thames Tunnel project suggests that the surface of the riverbed below the site varies between 98.0m and 95.0m ATD (6.6–9.6m bgl), generally becoming deeper from west to east. Deposits of Mesolithic date have occasionally been found to about 94.0m ATD in Central London and alluvial deposits might exist at this depth.

E.2.7 The current riverbed levels from bathymetry data are deeper than the levels shown on historic sections of the foreshore and channel prior to the Victoria Embankment construction[5], which show the top of the riverbed about 5ft (c. 1.5m) below Ordnance Datum (98.5m ATD) just east of the proposed Embankment wall (see Vol 17 Plate E.5). This suggests that the river bed has been dredged by up to around 3.5m on the east side of the riverwall and would imply a low potential for archaeological deposit survival in this part of the site.

E.2.8 Four vibro cores drilled along the eastern limit of the site record the riverbed between 95.4 m and 94.7 ATD with London clay being encountered at c. 93.6m ATD. One vibro core (VC6632) to the centre of the eastern limit records slightly organic silty clay from c. 94.4m ATD, possibly signifying a prehistoric vegetated mudflat. If the sediment is of a prehistoric date it may only survive in very localised areas having been dredged or scoured out by river action.

E.3 Past archaeological investigations within the assessment area

E.3.1 No archaeological investigations have taken place within the site itself. A number of fairly small-scale archaeological investigations have been carried out in the 350m-radius assessment area. Those to the west (landward side) of the site (**HEA 18, 24, 52, 72, 76, 77, 79, 87, 94, 95, 97, 100**–**102**) mostly recorded post-medieval remains in the form of truncated building remains and demolition material associated with York Place and Whitehall Palace, and Northumberland House. On the opposite foreshore, c. 180m to the east of the site, evaluation by MoLAS and field survey by the Thames Discovery Programme (TDP) in 1996/1997 (**HEA 13** and **30**) have recorded generally modern material although some deposits were thought to be of earlier origin[6]. Work carried out on the same stretch of the Thames by the Thames Discovery Programme (TDP) recorded remains of prehistoric wood, possibly part of a prehistoric forest, and other deposits, various post-medieval foreshore structures and artefact scatters, and 19th century organic deposits.

E.3.2 The results of these investigations, along with other known sites and finds within the assessment area are discussed by period below.

E.4 Archaeological and historical background of the site

E.4.1 The following section provides a detailed archaeological and historical background for the site. It should be read alongside the research framework presented in Appendix C to Vol 2 Appendix E2, which sets the overall Thames Tideway Tunnel project, and the individual site-specific assessments, within a broader historic environment context (i.e. past landscapes and human activity within such landscapes). It identifies the main route-wide heritage themes, of which the built and buried heritage assets identified within this assessment form a part.

Prehistoric period (700,000 BC–AD 43)

E.4.2 The site lies at the northern edge of a large delta formed by the confluence of the former Tyburn and Tachbrook tributaries with the Thames. This river system has cut through the earlier Kempton Park Gravel terrace to the west and created Thorney Island (now the site of Westminster Abbey and the Houses of Parliament) some 300m to the south of the site. Tributaries were important features in the prehistoric landscape especially at interfaces with the major rivers such as the Thames. They served as communication routes into the interior (linking settlements within areas which were still largely forested) and provided dependable food resources of fish and waterfowl. With deforestation and the rise of agriculture from the Neolithic period onwards, thick alluvium/colluvium accumulated through sedimentary in-wash into tributaries and led to the creation of areas with high potential for palaeoenvironmental recovery as well as other (cultural) items associated with waterways such as boats, jetties and fish traps.

E.4.3 Despite this background potential there is a lack of specific information for the site since there have been few systematic archaeological investigations within the assessment area. A Neolithic axe may have been found during archaeological excavations in the vicinity of the Ministry of Defence buildings in the 1950s (**HEA 79**) c. 180m west of the site. Evaluation at Richmond Terrace Mews c. 300m southwest of the site (**HEA 74**) revealed a timber baseplate and post possibly dated to the Late Bronze Age or early Iron Age. The GLHER notes chance finds of possible Lower Palaeolithic animal remains (**HEA 99**) c. 200m northwest of the site (although it has more recently been suggested that these are medieval). Further chance finds recorded on the GLHER are a Mesolithic axe (**HEA 70**) 50m southeast, a Bronze Age palstave or axe (**HEA 6**), c. 170m to the east of the site, and a Bronze Age 'chisel'-type tool (**HEA 25**), c. 190m to the south/southeast. The latter three were recovered from within the Thames and are therefore probably redeposited (or possibly ritually deposited into the river).

Roman period (AD 43–410)

E.4.4 The site is located c. 1.2km to the southwest of the Roman town of *Londinium,* a major commercial centre and the hub of the Roman road system in Britain. The nearest major Roman road to the site was Akeman

Street, c. 340m to the northwest of the site. This road ran from Ludgate on the western side of *Londinium* towards the modern Hammersmith area[7].

E.4.5 Evidence of Roman occupation has been recorded on Thorney Island, c. 430m to the southwest of the site, including remains of a stone building found in the 19th century beneath the nave of Westminster Abbey c. 720m to the southwest of the site,. It is thought that there was an early ford crossing of the Thames between Lambeth and Thorney Island, c. 640m to the south of the site, near to what later became a ferry crossing in medieval times, north of Lambeth Palace (Stangate Stairs)[89]. There are no known settlement sites of this period within the assessment area.

E.4.6 In 2005–6, an archaeological excavation at St Martin in the Fields church in Trafalgar Square, c. 420m to the northwest of the site, found part of a large Roman tile kiln, last used in the first half of the 5th century. Otherwise, much of the area and the land adjacent to the river would have been a rural landscape of open fields, possibly used for agriculture or pasture. Potential for Roman remains within the site is probably low, because throughout this period the site would have been submerged, due to rising river levels. Roman evidence from the assessment area is limited to a single Roman coin recovered from the banks of the Thames, 250m to the east of the site (**HEA 26**).

Early medieval (Saxon) period (AD 410–1066)

E.4.7 Following the withdrawal of the Roman army from England in the early 5th century AD, Roman *Londinium* was abandoned and Germanic settlers arrived from the Continent. The basis of their economy was agriculture and early Saxon settlement was exclusively rural, but during the 7th to 9th centuries the trading port of *Lundenwic* developed in the area now occupied by Aldwych, the Strand and Covent Garden, c. 300m to the northeast of the site[10]. Elsewhere, rural settlement developed around minsters (religious centres) and royal estate centres.

E.4.8 The site fell within the extensive estate (manor) of Westminster, which is first mentioned in a charter dated to c. AD 785, referring to the founding of a religious community on Thorney Island, c. 700m to the south of the site. Westminster Abbey is thought to have been founded by Sebert, king of the East Saxons[11]. This church became known as the 'West Minster' to distinguish it from St Paul's Cathedral[12].

E.4.9 In 1961–3, archaeological investigations just outside the assessment area at the Treasury Buildings, c. 360m to the southwest of the site, revealed evidence of occupation in the late 8th to mid 9th century, on a low-lying spur at the confluence of the Thames and Tyburn rivers. A succession of timber buildings included a substantial hall. Its position midway between *Lundenwic* to the northeast and Westminster Abbey, suggest high status. Its abandonment may be connected with Viking activity in the area[13].

E.4.10 In the 9th century, *Lundenwic* declined and *Londinium* was reoccupied and its walls repaired as part of the defensive system established by King Alfred against the Danes. This settlement, named *Lundenburh*, formed the basis of the medieval city.

E.4.11 In the early 11th century, King Cnut constructed the Royal Palace of Westminster on the eastern side of Thorney Island, c. 720m to the southwest of the site. Although the island was still marshy the palace was well located for river access and had good views towards London, and was next to the Abbey. The palace burnt down in *c.* 1030 and was rebuilt by King Edward the Confessor (1042–66), who also constructed a large stone church in honour of St Peter the Apostle on the site of the earlier Abbey. It was the first cruciform church in England and was consecrated in 1065[14].

E.4.12 The site was located along a stretch of the riverfront, between the settlements at Thorney Island and *Lundenwic*. There is little evidence for early medieval activity in the immediate area of the site. An investigation at Buckingham Street recorded waterlogged deposits which included the apparent remains of a wattle fence and animal bone c. 220m northwest of the site (**HEA 94**). No dating evidence was found but the levels were thought to be Saxon. An archaeological watching brief on sewer connection shafts at Northumberland Avenue in 2006 c. 310m to the northwest of the site (**HEA 52**) recorded possible Saxon deposits in one of the shafts.

E.4.13 Additionally, two chance finds from the river are recorded on the GLHER, comprising a hoard of 100 silver coins (**HEA 2**), c. 80m to the east of the site, and a 9th century iron axe (**HEA 1F**), within the southeastern part of the site. During this period, the bank of the Thames would have been some distance to the west of the site, which was therefore probably mostly submerged.

Later medieval period (AD 1066–1485)

E.4.14 Westminster Palace was the main London residence of the kings of England throughout this period[15], and lay c. 580m to the south of the site. Much of Thorney Island to the southwest of the site was still prone to periodic flooding and occasionally boats were used to move across the island. It is likely that during this period successive attempts were made to reclaim the lower-lying land to the south of the site by digging drainage ditches and dumping soil to raise ground levels. Parliament began to meet regularly at Westminster from the reign of King Edward I (1272–1307), and following drainage and reclamation the area of settlement expanded.

E.4.15 Some development grew up along the bank of the Thames and it is likely that a river wall was built along this stretch of the river, with associated drainage and reclamation. This would have allowed the construction of substantial buildings: in the 12th century Richard Fitznigel, Bishop of London, had a house c. 160m to the southwest of the site (**HEA 10**). It later became the property of the Archbishop of York, and was known as York Place, and later the Palace of Whitehall. The site of a house of the Abbot of Bury is documented nearby (**HEA 4**). The medieval river wall is included in the GLHER c. 140m to the west/southwest of the site (**HEA 11**). Documentary sources record the site of two river stairs, which provided access down to the river: the Hungerford Stairs c. 150m to the northwest of the site (**HEA 19**) and the Whitehall Stairs c. 130m to the

southwest (**HEA 8**). Medieval flood defences are recorded c. 100m to the west (**HEA 73**), 200m northwest (**HEA 74**) and 170m to the west of the site (**HEA 75**).

E.4.16 In 1961 remains of the medieval St Mary Rounceval Wharf were recorded c. 120m to the west of the site (**HEA 3 and HEA 79**). The wharf was used by the House and Hospital of Runchivalle (Rounceval) at Charing Cross[16]. The site of the medieval beer house of the Knights of St John of Jerusalem lay c. 160m to the northwest of the site (**HEA 12**). A medieval buckle was recovered by chance from the Thames c. 250m to the east of the site (**HEA 26**).

E.4.17 During this period the site lay within the River Thames, possibly some 100m away from the later medieval embankment.

Post-medieval period (AD 1485–present)

E.4.18 The site lay within the River Thames throughout this period, whilst the riverbank adjacent to the west became developed as part of the expanding royal and government centre of Westminster.

E.4.19 York Place, to the west of the site, (**HEA 10**) was greatly extended by Cardinal Wolsey, Archbishop of York 1514–29. On Wolsey's fall from power it was taken by Henry VIII and renamed Whitehall Palace. An extensive rebuilding programme was carried out, with new gardens and orchards laid out and additional land acquired to the west[17]. Henry VIII died at Whitehall in 1547: it continued as a royal residence until the end of the 17th century. The Palace buildings as recorded on a plan of c. 1680 extended across much of the western part of the assessment area, approximately from modern Northumberland Avenue in the north to Richmond Terrace in the south. The GLHER includes a number of additional entries for the Palace and its associated features, including gardens and a bastioned river wall (**HEA 5**, **8**, **9**, **11**, **14–17**, **22**, **71**, **80–85** and **92**): the private river stairs for the Palace were c. 125m southwest of the site (**HEA 23**). The Palace was almost entirely destroyed by fire in 1698. A fragment of reconstructed Tudor wall is c. 95m southwest of the site and Grade I listed (**HEA 33**). Truncated and fragmentary remains of the Palace have been recorded in a number of archaeological investigations to the west and southwest of the site (**HEA 72**, **77**, **79**, **96** and **101**).

E.4.20 The earliest map consulted, Faithorne and Newcourt's map of 1658 (Vol 17 Plate E.1), shows the site within the Thames channel, some distance from the embankment. The whole bank of the river along this stretch has been developed, although much of this comprises gardens of the grand houses between the river and Whitehall and the Strand. The map shows the Palace of Whitehall to the west and southwest of the site. 'Scotland Yard' is also shown, which was part of the Palace, traditionally a reference to a residence of the kings of Scotland. (**HEA 71**),

E.4.21 Rocque's map of 1746 (Vol 17 Plate E.2) and Horwood's map of 1799 (Vol 17 Plate E.3) show the site in the river, and little change in the vicinity. Rocque's map clearly shows the Whitehall Stairs providing access to the river c. 100m west of the site (**HEA 8**) (further north than the current

Whitehall Stairs outside the southwestern corner of the site). Horwood's map shows some building out from the river wall Vol 17 Plate E.3).

E.4.22 In 1845, the River Thames was spanned for the first time along this stretch, by the construction of the Hungerford Suspension Bridge, designed by the engineer Brunel. In 1859, the Charing Cross Railway Act authorised a railway crossing over the Thames and as a result, in 1860 and 1864, the earlier bridge was removed and replaced with the current bridge[18], c. 125m to the north of the site.

E.4.23 The construction of the Victoria Embankment (**HEA 1G**) took place between 1864 and 1870, as part of the works of Sir Joseph Bazalgette[19] which reclaimed an extensive area from the river and involved substantial construction work over the foreshore, creating a new carriageway and footways, and a number of ornamental gardens. Archive plans of the Thames Water 'Abbey Mills Books'[20] show the extent of the work (Vol 17 Plate E.4 to Vol 17 Plate E.6).

E.4.24 A description of the construction of the embankment is provided by Bazalgette's son Edward in 1878: "The road from Westminster to Blackfriars is 100 feet wide and about 1 ¼ mile in Length". He notes the extension of the new road to Blackfriars, Mansion House and New Earl Street: "The total area of land thus reclaimed from the river was 37 ¼ acres, of which 19 acres are occupied by carriageway and footways; 7 ½ acres have, under Act of Parliament, been conveyed to the Crown, the Societies of the Inner and Middle Temple and adjacent landowners; and about 8 acres have been devoted to the use of the public as ornamental grounds." …."The main roadway is divided into a central carriageway 64 feet in width, with two footways, that on the landside being 16 feet wide and that on the river side 20 feet, along which are rows of plane trees at intervals of 20 feet apart. The public way is protected on the river side by a moulded granite parapet 3 feet 6 inches in height; on the land side it is divided from the garden grounds by an ornamental cast-iron railing. Opposite Whitehall Gardens, the separation has been effected by a wall of masonry and brickwork 7 feet 6 inches high, and from Temple Gardens to Chatham Place by a brick parapet about 5 feet 6 inches in height."[21]

E.4.25 Although the embankment wall within the site is statutorily listed (**HEA 1D**), it is a part of the wider Victoria Embankment structure, as demonstrated from the same description: "Within the Embankment wall, and forming a portion of its structure, is the Low Level Intercepting Sewer, and above it is a subway for gas and water pipes. The subway is 7 feet 6 inches in height, and 9 feet in diameter. Both are situate (sic) under the footway next to the river, and form a buttress to the wall".

E.4.26 A section (Vol 17 Plate E.6) shows the embankment wall to curve outwards as it drops towards its base, so that the outer face of the uppermost stone course correlates to the rear face of the bottommost. The lower section of the wall is a stepped buttress of a different stone to the visible section above and is likely to be a measure against soft subsoils. Rising from this, the embankment wall appears dentilled in section, offering greater structural strength to the bond between the stone of the embankment wall and the Portland Cement concrete that forms the

fill of the embankment behind. The sewer tunnel wall is a self-supporting circular structure of stone while the utility subway above is constructed as a semi-circle above a square base with a stepped base to its side walls to support both the structure itself and the York stone pavement above. At the base of the sewer tunnel is approximately 3 inches of gravel.

E.4.27 The Ordnance Survey (OS) 1st edition 25":mile map of 1862–1895 (Vol 17 Plate E.7) and subsequent OS maps up to the present day show the embankment and the site in their current relative positions.

E.4.28 The OS 1st edition map shows the 'Charing Cross Piers' immediately north of the site and on either side of the Hungerford Bridge. These were part of Bazalgette's design and were probably floating pontoons. The pontoons currently in this location are unlikely to date wholly from the Bazalgette work, but may incorporate elements of this date or later modifications.

E.4.29 The OS 2nd edition 25":mile map of 1896–8 (Vol 17 Plate E.8), shows a 'Floating Fire Engine Station' on the Charing Cross Pier immediately north of the site, likely to have been associated with the use of water from the river for fire-fighting. The map shows no change to the site itself. The OS 3rd edition 25" mile map of 1909–20 (not reproduced) shows no change within the site.

E.4.30 The OS 25":mile map of 1947–72 (Vol 17 Plate E.9) no longer shows the fire brigade platform to the north of the site but instead the current permanent structure and stairs that extend down to the water in the northwestern edge of the site.

The current site

E.4.31 The current site is largely adjacent to, but partially overlapping Victoria Embankment, which runs between Westminster and Blackfriars Bridges.

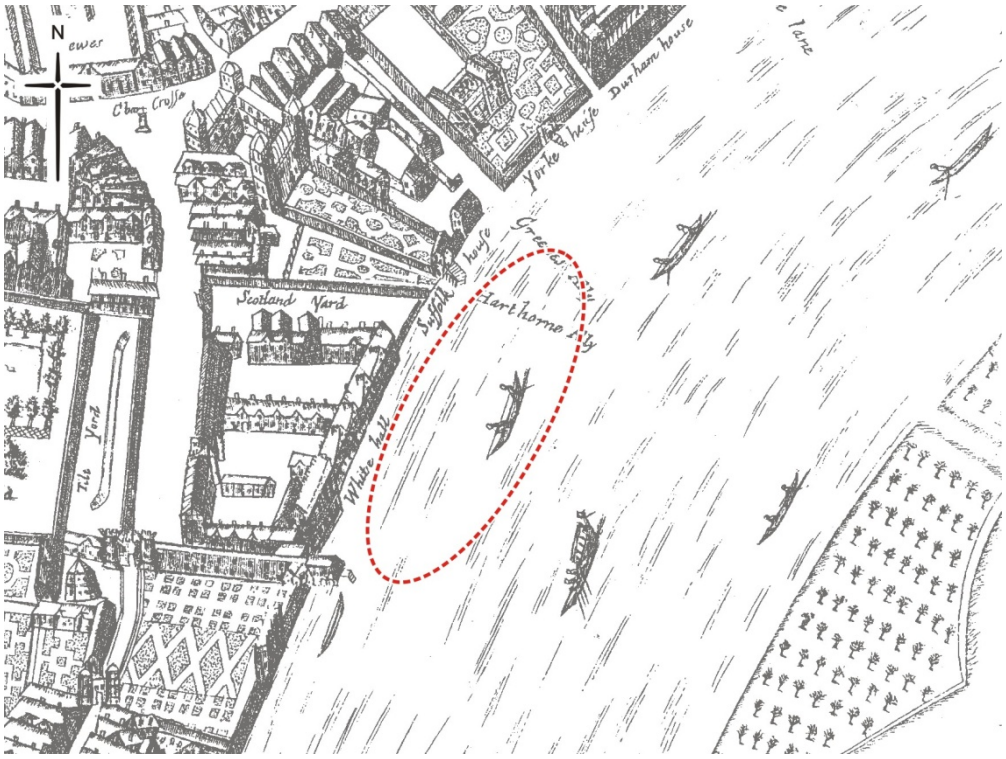
E.4.32 The site has remained largely unchanged since the late 1940s other than by the construction of the mooring and the gangway to the Tattershall Castle vessel in the 1980s and the recent restoration by Westminster City Council of the globe lanterns atop the lamp standards (**HEA 1D**). The main change in the immediate vicinity of the site has been the construction of the Golden Jubilee footbridges which opened in 2002 on either side of the Hungerford railway bridge. The United Kingdom Hydrographic Office data for the Thames channel includes the permanently moored vessel Tattershall Castle within the northern part of the site (**HEA 1B**), and the site of a pontoon in the southern half of the site (**HEA 1E**). Immediately to the north of (outside) the site is the permanently moored vessel Hispaniola (**HEA 1C**).

E.4.33 Beneath the Embankment on the site is an arched structure immediately to the west of the Bazalgette Northern Low Level Sewer No. 1 and forming part of the overall scheme of construction for the sewage system. This structure lies at the junction of that sewer and the Regent Street Sewer and performs the function of a CSO shaft and interception chamber. It measures *c* 10m north-south by *c* 13m east-west and has a foundation

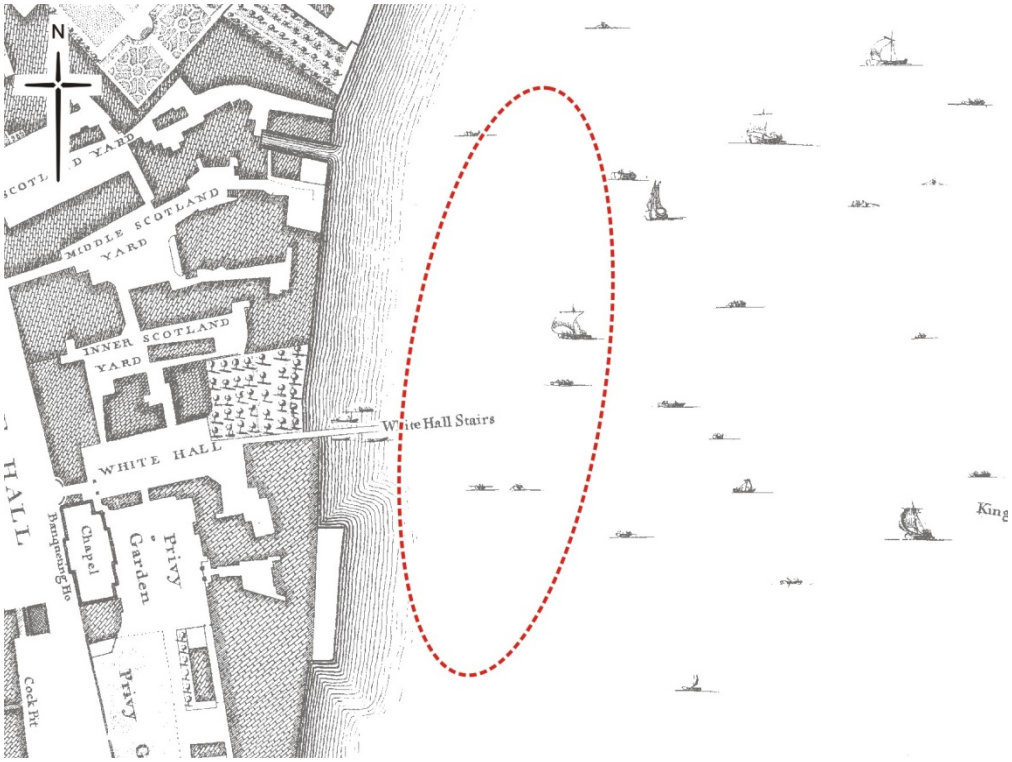
level at *c* 96.0m ATD. On its eastern side it has an outlet through the riverside wall into the Thames.

E.5 Plates

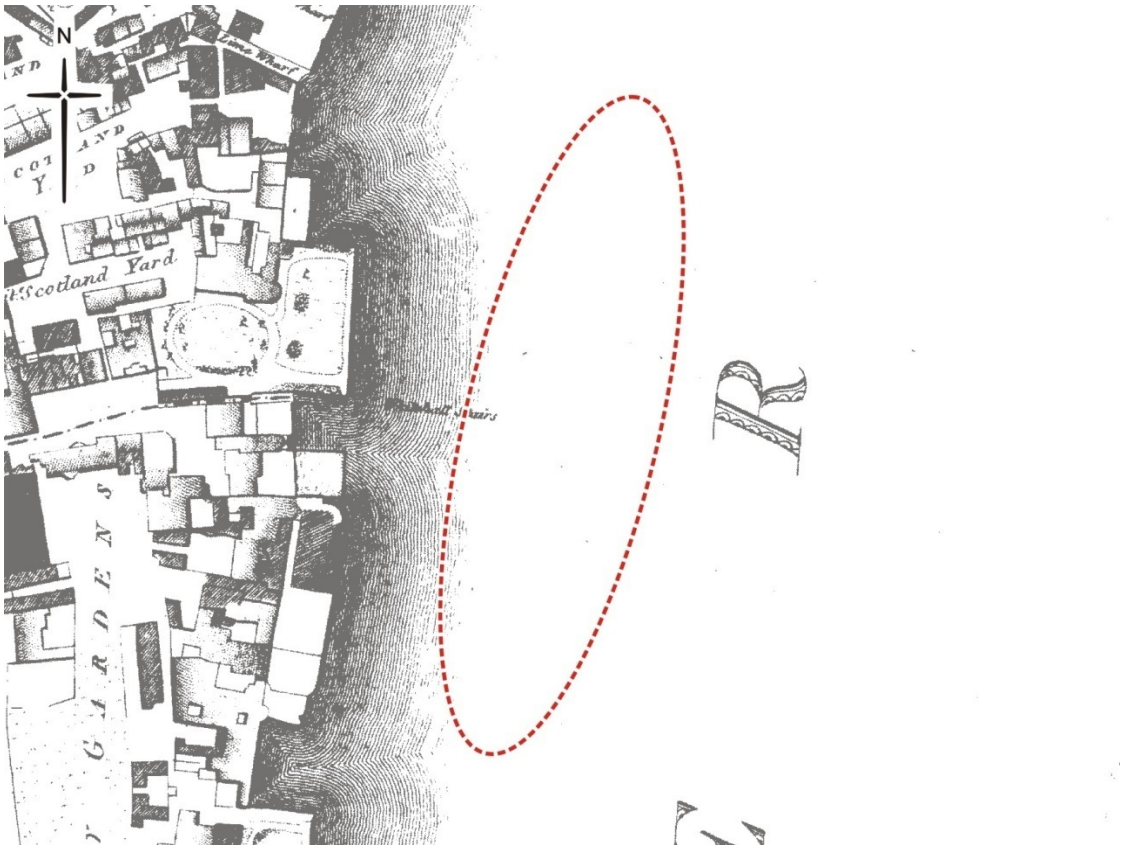
Vol 17 Plate E.1 Historic environment – Faithorne and Newcourt's map of 1658



Vol 17 Plate E.2 Historic environment – Rocque's map of 1746

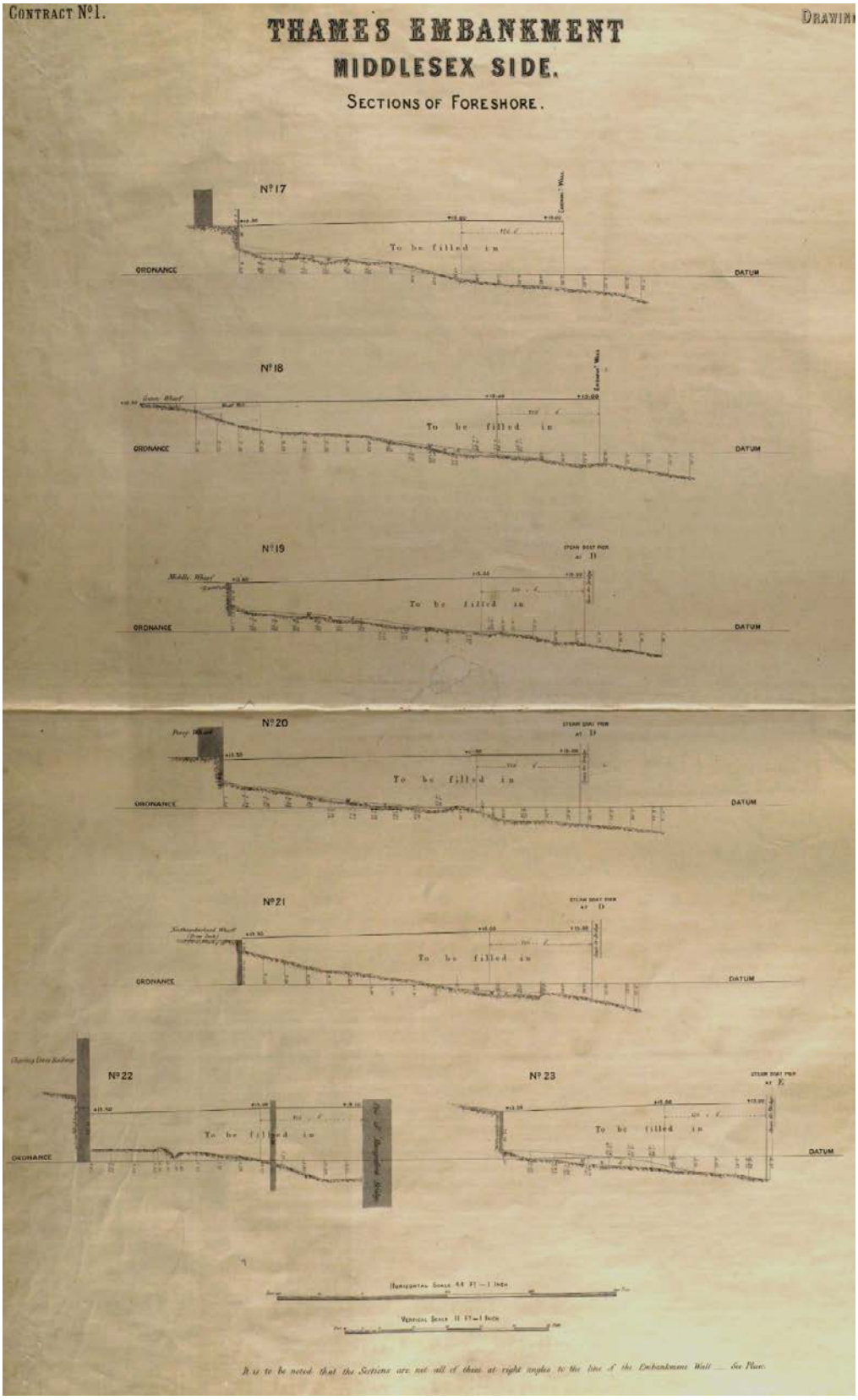


Vol 17 Plate E.3 Historic environment – Horwood's map of 1799

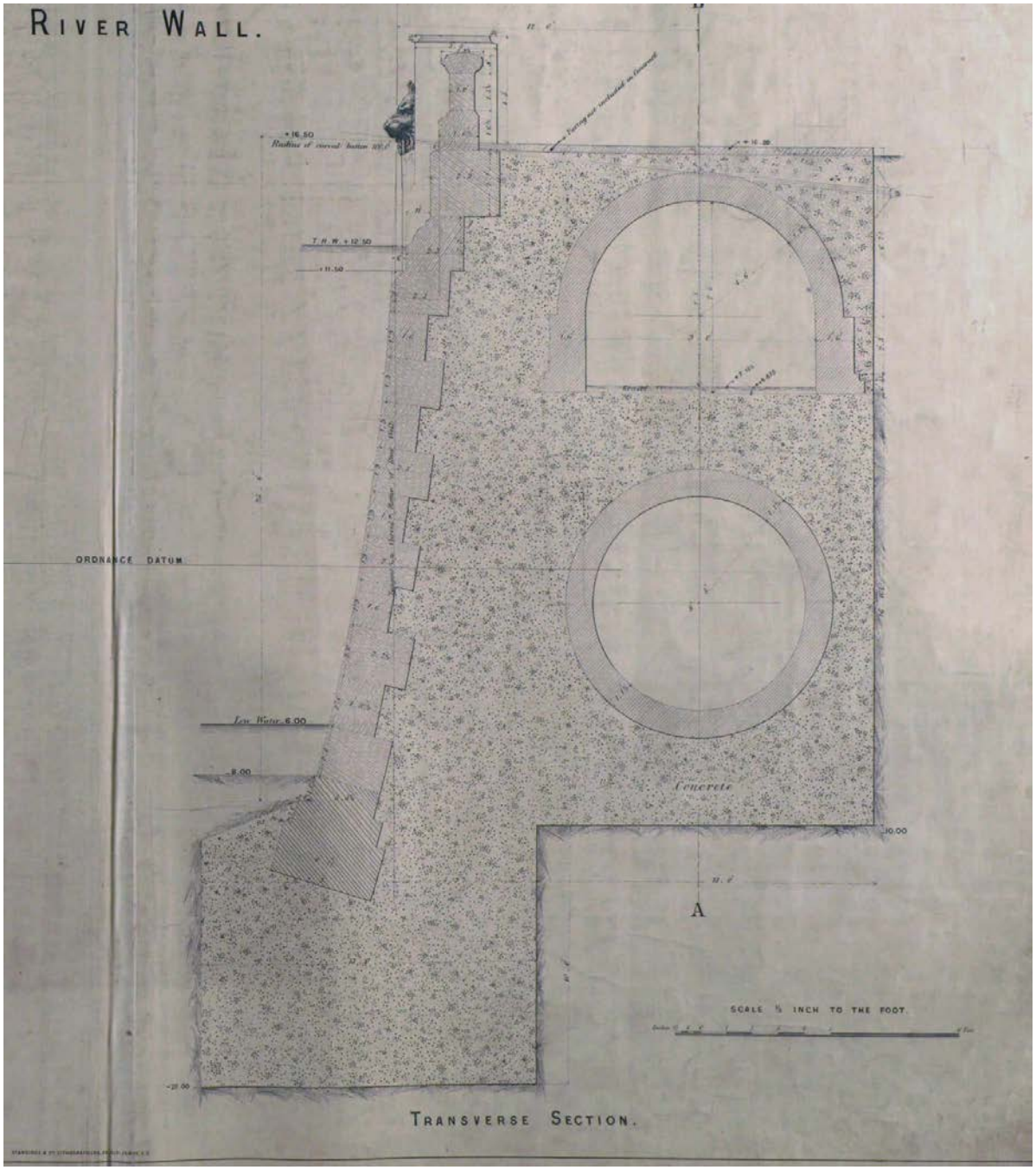


Vol 17 Plate E.4 Historic environment – Thames Water 'Abbey Mills Books' Book 90 Thames Embankment Contract No 1 (1863). Plan showing extent of Embankment works.

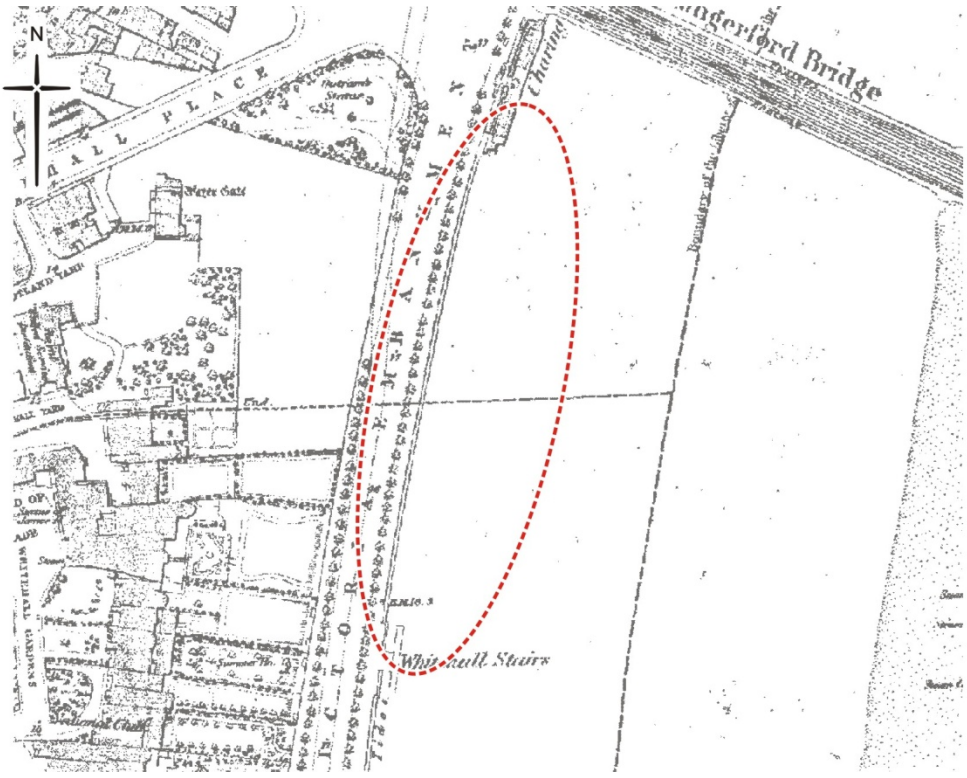
Vol 17 Plate E.5 Historic environment – Thames Water 'Abbey Mills Books' Book 90 Thames Embankment Contract No 1 (1863). Section of foreshore and river wall prior to Embankment works.



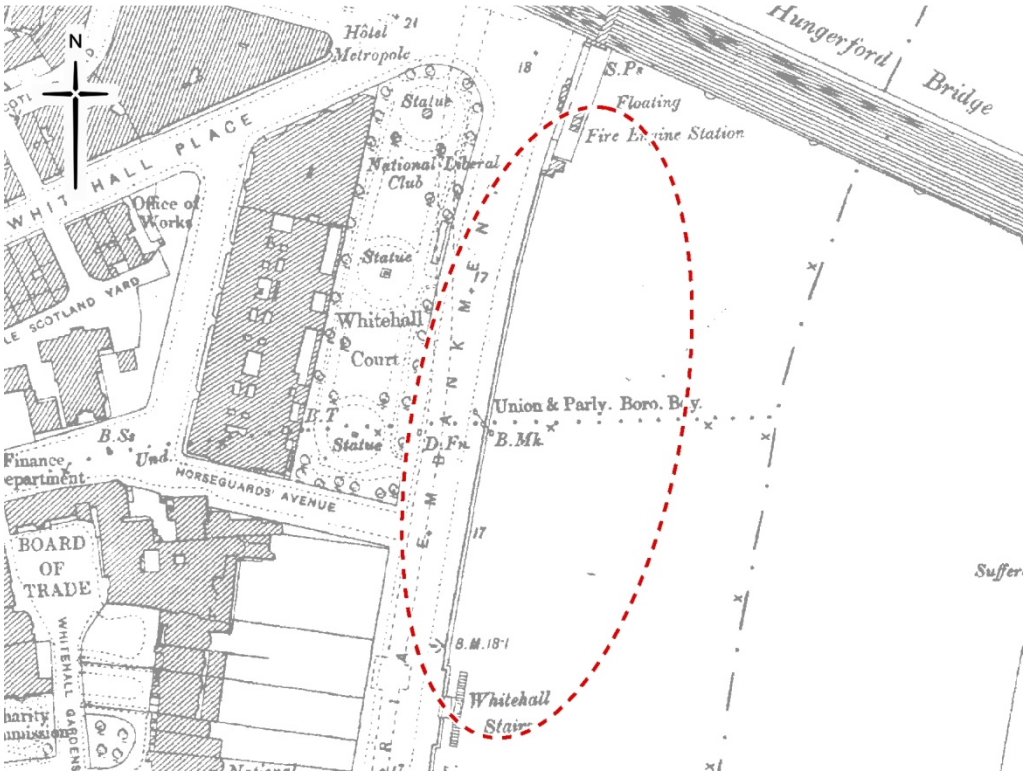
Vol 17 Plate E.6 Historic environment – Thames Water 'Abbey Mills Books' Book 90 Thames Embankment Contract No 1 (1863). Section of the Victoria Embankment showing the Bazalgette works.



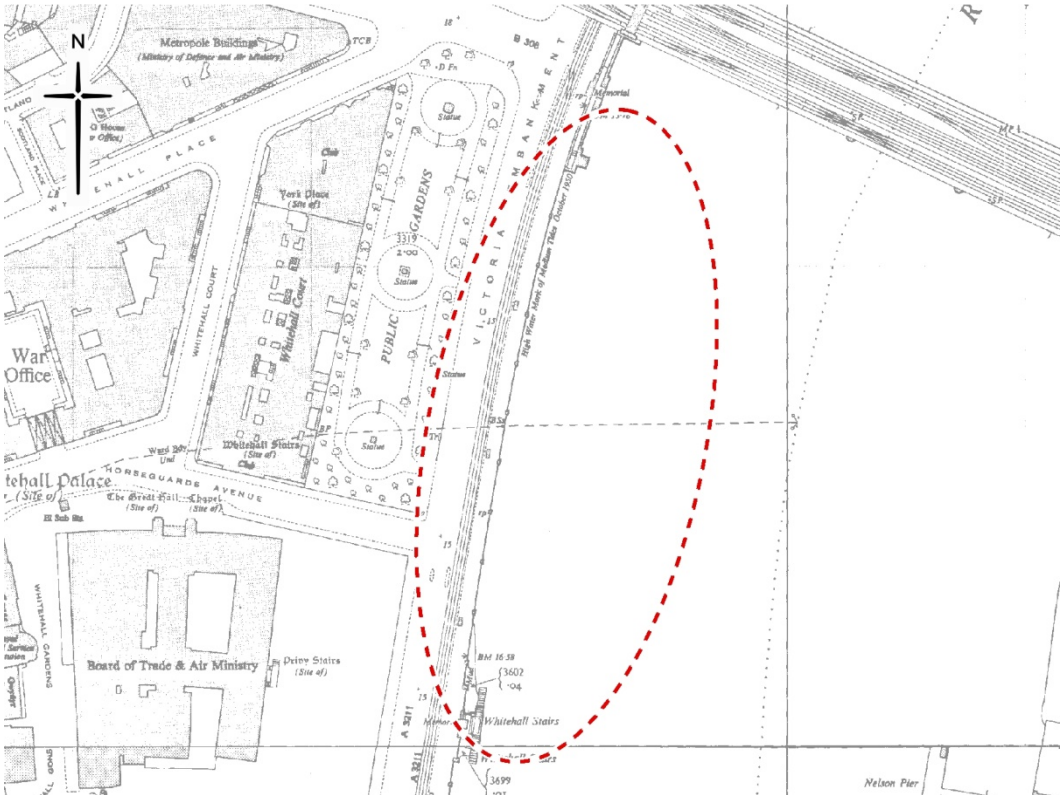
Vol 17 Plate E.7 Historic environment – Ordnance Survey 1st edition 25”:mile map of 1862–95 (not to scale)



Vol 17 Plate E.8 Historic environment – Ordnance Survey 2nd edition 25”:mile map of 1896–8 (not to scale)



Vol 17 Plate E.9 Historic environment – Ordnance Survey 25”:mile map of 1947–72 (not to scale)



Vol 17 Plate E.10 Historic environment – The Victoria Embankment (HEA 1D) looking southwest from Hungerford Footbridge, showing The Hispaniola (HEA 113) in the foreground with the Tattershall Castle (HEA 1B) on the left. April 2011; standard lens.

Vol 17 Plate E.11 Historic environment – One of the "dolphin" lamps dating to 1870 surmounting Bazalgette's Embankment wall (HEA 1D). April 2011; standard lens; looking north.

Vol 17 Plate E.12 Historic environment – A sphinx bench (HEA 1C) with one of the Grade II listed catenary lamp standards (HEA 1A) behind. April 2011; standard lens; looking north.

Vol 17 Plate E.13 Historic environment – Catenary lamp standard (HEA 1A) on Victoria Embankment; standard lens, looking east.

Vol 17 Plate E.14 Historic environment – The Tattershall Castle (HEA 1B); standard lens, looking southwest.

References

[1] British Geological Survey borehole ref. SA1066D.

[2] British Geological Survey borehole ref. TQ38SW181.

[3] British Geological Survey borehole refs. SA1066, SA1066A to C.

[4] British Geological Survey borehole ref. SA1066D.

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[20] Thames Water 'Abbey Mills Books' Book 90 *Thames Embankment Contract No 1* (1863).

[21] Bazalgette, E. 1878. The Victoria, Albert and Chelsea Embankments of the river Thames. *Excerpt Minutes of the Proceedings of the Institution of Civil Engineers*, Vol. liv. Session 1877 – 78 part iv

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Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.17**

Volume 17: Victoria Embankment Foreshore appendices

Appendix F: Land quality

APFP Regulations 2009: Regulation **5(2)(a)**

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Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

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Thames Tideway Tunnel

Environmental Statement

Volume 17 appendices: Victoria Embankment Foreshore site assessment

Appendix F: Land quality

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Appendix F: Land quality

F.1 Baseline report

F.1.1 Baseline data is sourced from:

a. walkover survey

b. the Landmark Information Group database, including historic maps and environmental records

c. stakeholder consultation

d. the initial results from a preliminary intrusive ground investigation.

Site walkover

F.1.2 A site walkover was undertaken on 4th November 2010.

F.1.3 The aim of the walkover survey was to inspect the condition of the site and surrounding areas in order to identify evidence of historical or ongoing contamination sources, as well as any nearby sensitive receptors.

F.1.4 No potential contaminative sources were identified during the survey and no tidal outflows were visible within the river wall at the time of the survey.

F.1.5 Detailed site walkover notes are provided in Vol 17 Table F.1 below.

Vol 17 Table F.1 Land quality – site walkover report

Item (Site ref: PWR1X, Victoria Embankment Foreshore)		Details
Date of walkover	4th November 2010	
Site location and access	The proposed work site is located on the foreshore of the River Thames along Victoria Embankment. The site encompasses the foreshore area at which the PS Tattershall (a river bar and restaurant) is moored, at the junction of Northumberland Bridge (A400) and Victoria Embankment (A3211) with a section of pavement and roadway of the Victoria Embankment. Access was available across the entire site.	
Size and topography of site and surroundings	Record elevation in relation to surroundings, any hummocks, breaks of slope etc.	On the foreshore of the River Thames, the pavement and roadway section are located at a slightly higher elevation that the foreshore section.
Neighbouring site use (in particular note any potentially contaminative activities or	North	The Hungerford foot and rail bridge is located north of the site. The bridge links the national rail train station Charing Cross south across the river to Waterloo train station. River Thames is also located north

Item (Site ref: PWR1X, Victoria Embankment Foreshore)		Details
sensitive receptors)	South	Ministry of Defence buildings are located southwest of the site. Directly south of the site is occupied by the foreshore of the River Thames.
	East	The River Thames is immediately east of the site with the Jubilee gardens and the London Eye on the opposite side of the river.
	West	The surrounding area is predominantly commercial and residential properties with pockets of retail and entertainment use; these areas are located on the opposite side of the A3211, Victoria Embankment, which runs parallel to the site. Whitehall Gardens and Victoria Embankment Gardens are located west.
Site buildings	Record extent, size, type and usage. Any boiler rooms, electrical switchgear?	N/A –There are two moored boats within the foreshore of the proposed worksite.
Surfacing	Record type and condition	Made Ground within the pavement and road section
Vegetation	Any evidence of distress, unusual growth or invasive species such as Japanese Knotweed?	None observed
Services	Evidence of buried services?	None identified
Fuels or chemicals on-site	Types/ quantities?	None observed
	Tanks (above ground or below ground)	None observed
	Containment systems (eg, bund, drainage interceptors). Record condition and standing liquids	None observed
	Refill points located inside bunds or on impermeable surfaces	None observed

Item (Site ref: PWR1X, Victoria Embankment Foreshore)		Details
	etc?	
Vehicle servicing or refuelling onsite	Record locations, tanks and inspection pits etc.	None observed
Waste generated/stored on-site	Adequate storage and security? Fly tipping?	No observed
Surface water	Record on-site or nearby standing water	River Thames
Site drainage	Is the site drained, if so to where? Evidence of flooding?	No tidal outflows were visible in the river wall at the time of the survey.
Evidence of previous site investigations	Eg, trial pits, borehole covers.	None observed
Evidence of land contamination	Evidence of discoloured ground, seepage of liquids, strong odours?	None observed
Summary of potential contamination sources		None
Any other comments	Eg, access restrictions/ limitations	No

Review of historical contamination sources

F.1.6 Historical mapping (dated after 1879) has been reviewed in order to identify potentially contaminating land-uses at the site and within the 250m assessment area

F.1.7 Vol 17 Table F.2 tabulates the potentially contaminating land-uses, inferred dates of operation and typical contaminants associated with the land-uses in question. Potential contaminants are sourced from CLR8: *Potential contaminants for the assessment of land* (Defra and EA, 2002)[1] and former Department of the Environment industry profiles (Department of the Environment, 2011)[2].

F.1.8 All dates are approximate, where no other information is available the dates relate to when the items first appeared and disappeared from the mapping rather than actual dates of construction, operation or demolition.

F.1.9 Items listed in the table below are also shown on Vol 17 Figure F.1.1(see separate volume of figures). In addition, figures illustrating the historical

environment of the site and surrounding area are provided in Vol 17 Appendix E.

Vol 17 Table F.2 Land quality – potentially contaminating land-uses

Ref	Item	Inferred date of operation	Potentially contaminative substances associated with item 1,2
On-site			
None			
Off-site			
1	Hungerford Railway Bridge (40m north)	c1896-present	Sulphate, ash, ferrous residue, metal fines, ethylene glycol, polychlorinated biphenyls (PCBs), paraffin
2	Charing Cross National Rail Station (115m north west)	c1896-present	Polyaromatic hydrocarbons (PAHs), heavy metals, phenols, sulphates, fuel oil, lubricating oil, greases, PCBs, solvents, asbestos, chlorinated aliphatic hydrocarbons
3	Whitehall Yard (130m west)	c1879-c1896	Unknown
4	Electrical substation (220m southeast)	c1951	Oils, PCBs

On-site

F.1.10 The historical mapping has not identified any potentially contaminative land-uses. The site has always formed the foreshore of the River Thames.

Off-site

F.1.11 Within the 250m assessment area, the historical mapping has shown the nearest potential contamination source to relate to the railway land (passenger terminal and rail bridge) located approximately 40m to the north.

Geology

F.1.12 Data from the Thames Tideway Tunnel project ground investigation indicates the anticipated geological succession, as summarised in Vol 17 Table F.3 below.

Vol 17 Table F.3 Land quality – anticipated site geology

Geological unit/ strata	Description	Approximate depth below river bed (m)
Alluvium	Silty sandy clay / clayey gravel	0-3.0
River Terrace	Medium dense to dense to dense sand	3.0-6.1

Geological unit/ strata	Description	Approximate depth below river bed (m)
Deposits	and gravel (predominantly quartz sand and flint gravel)	
London Clay Formation	Fissured grey clay that weathers to a brown colour. Locally with pockets of selenite crystals (gypsum)	6.1-39.0
Harwich Formation	Sand and shelly sandstone	39.0-39.48
Lambeth Group (Sand Unit)	The Lower and Upper Mottled Beds can be described as a mottled or multicoloured, stiff or very stiff fissured clay, compact silt, and dense or very dense sand The Laminated Beds consists of thinly interbedded fine- to medium-grained sand, silt and clay, with locally more extensive sand bodies and thin shell and lignite beds The Lower Shelly Clay is a dark grey to black clay with abundant shells but may also be Shelly sand. Where shells predominate, thin limestone bands are formed The base of the Lambeth Group is marked by the Upnor Formation which comprises dense silty glauconitic sand	39.48-42.33
Lambeth Group (Upper Mottled Beds)		42.33-46.53
Lambeth Group (Laminated Beds/Lower Shelly Beds)		46.53-47.93
Lambeth Group Lower Mottled Beds)		47.93-55.08
Lambeth Group (Upnor Formation)		55.08-57.43
Thanet Sand Formation	Generally dense glauconitic silty fine sand with occasional rounded flint gravel	57.43-67.44
Chalk Group	Weak fine grained limestone with nodular and tabular flints	67.44-unproven

Unexploded ordnance

F.1.13 During World Wars I and II, the London area was subject to bombing. In some cases bombs failed to detonate on impact. During construction works Unexploded Ordnance (UXO) are sometimes encountered and require safe disposal.

F.1.14 A desk based assessment for UXO threat was undertaken by 6 Alpha Associates Limited at the Victoria Embankment Foreshore site (see Vol 17 Appendix F.2). The report reviews information sources such as the Ministry of Defence (MoD), Public Records Office and the Port of London Authority (PLA).

F.1.15 The report identified that no high explosive bomb strikes occurred within the site area, however two occurred within the buffered site boundary and a further 13 were recorded within 100m of the buffered site boundary. In

addition, a V1 bomb strike occurred north of the site on the Hungerford Bridge and a unexploded bomb was recovered on the opposite foreshore to Victoria Embankment.. The report further identifies that the site has not been developed since WWII and as such is unlikey to have removed buried items of UXO.

F.1.16 The site was therefore given a high risk rating.

Thames Tideway Tunnel ground investigation data

F.1.17 This section summarises the ground investigation undertaken by the Thames Tideway Tunnel project.

F.1.18 Boreholes were drilled in the vicinity of the Victoria Embankment site as part of the project-wide ground investigation, as shown on Vol 17 Figure F.1.2 (see separate volume of figures).

F.1.19 Vol 17 Figure F.1.2(see separate volume of figures) also identifies boreholes excavated in vicinity of the sitethat are not considered relevant to the contamination status of the site either due to their distance from the proposed shaft location or because certain boreholes were excavated purely for geotechnical purposes.

Soil contamination testing

F.1.20 No contamination testing has been undertaken within the land side area of the site. See para. F.1.26 for sediment quality within the foreshore environment.

Soil gas testing

F.1.21 Soil gas testing was undertaken within borehole SA1066D in a standpipe with a response zone in the River Terrace Deposits (RTD) (10m bgl).

F.1.22 Results show 0.2% maximum volume of methane, 3.1% maximum volume of carbon dioxide and minimum volume of oxygen of 2.2% from three monitoring rounds.

Groundwater contamination data

F.1.23 No notably elevated levels of contamination were recorded in the shallow (RTD) aquifer in the vicinity of the site.

F.1.24 Refer to Section 13 Water resources – groundwater for further information.

Sediment quality testing

F.1.25 An investigation into the sediment quality of the foreshore at the Victoria Embankment Foreshore site was undertaken by the Port of London Authority (PLA) hydrographic department in December 2011 (PLA, 2011)[3]. A report on the findings is presented in *Thames Tunnel Foreshore Sediment Quality Interpretative Report* (Mott MacDonald Limited, 2012)[4].

F.1.26 Four samples of sediment taken from the foreshore of the River Thames at Victoria Embankment were sent for laboratory analysis. The testing showed relatively low levels of PAHs and metals within the foreshore sediments which are typical of the sediments along the tidal River Thames.

F.1.27 These contaminants reflect the former industrial nature of the river and are present as they tend to bind with soils. The results are not elevated in terms of risk to human health but slightly elevated over PLA approved sediment quality guideline.

F.1.28 Refer to Volume 2 Environmental assessment methodology for full guidance on the criteria used.

Third party ground investigation data

F.1.29 No third party ground investigation was available for review at the Victoria Embankment Foreshore site.

Other environmental records

F.1.30 Details of environmental records (hazard and waste sites) in the vicinity of the site held by the Environment Agency (EA) and other bodies have been obtained from the Landmark Information Group and are presented in Vol 17 Table F.4. Pertinent records are discussed in further detail below.

F.1.31 The location of these records is shown on Vol 17 Figure F.1.3 (see separate volume of figures).

Vol 17 Table F.4 Land quality – hazard and waste sites

Item	On-site	Within 250m of site boundary
Active integrated pollution prevention and control	0	0
Control of major accident hazard sites	0	0
Historical landfill site	0	0
LA pollution prevention and control	0	0
Licensed waste management facility	0	0
Notification of installations handling hazardous substances	0	0
Past potential contaminated industrial uses	0	There are a number of areas classified as past potential contaminated industrial uses within 250m of the site.
Pollution incident to controlled water*	1	2
Registered waste transfer site	0	0
Registered waste treatment or disposal site	0	0

**Does not include regular combined sewer overflow (CSO) discharges*

F.1.32 Inspection of the data has indentified one record of a pollution incident to controlled water present within the boundary of the site. There are two further pollution incidences to controlled water that are present within 250m of the site. Both are located in the River Thames and although unclear what these relate to, they are not considered to be significant for land quality at the foreshore site due to the distance and dilution within the river.

F.1.33 Within 250m of the Victoria Embankment Foreshore site, there are areas recorded as having past potential for contaminated industrial uses. From the historical mapping it could be inferred that these relate to the railway land (rail bridge and Charing Cross National Rail station) as shown on Vol 17 Figure F.1.1 (see separate volume of figures). Contaminants associated with these types of previous land-use are identified in Vol 17 Table F.2. Land quality data from local authority

F.1.34 Westminster City Council was consulted with respect to land quality information they may hold in respect of the site and assessment area.Westminster City Council responded that they did not hold any information on land quality at or within the search area of the site.

Summary of contamination sources

F.1.35 Following the review of the baseline data, the following sources of on-site contamination which may impact on the construction of the proposed development have been identified:

a. Thames foreshore sediments within the tidal reaches have been found to contain low levels of polycyclic aromatic hydrocarbons (PAHs) and metals from historic activities within the wider River Thames and coliforms from sewage discharges.

b. potential UXO.

F.1.36 Following the review of the baseline data no viable off-site contamination sources have been identified that are likely to have significantly impacted soil quality within the site.

F.2 Detailed Unexploded Ordnance (UXO) risk assessment

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Detailed Unexploded Ordnance (UXO) Risk Assessment

Study Site: Work Area PWR1X – Victoria Embankment Foreshore
Document Number: 336-RG-TPI-PWR1X-000001
Client Name: Thames Water
6 Alpha Project Number: P2853_R11_V1.0
Date: 12th June 2012

Originator: Max Chainey (30th May 2012)
Quality Review: Lisa Askham (8th June 2012)
Released by: Lee Gooderham (12th June 2012)

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EXECUTIVE SUMMARY	
Study Site	The Client has specified the Study Site as Work Area PWR1X, located at National Grid Reference "530405, 180146". Whilst this Site is predominantly situated on the foreshore, there is a marginal overlap at street level. However this street level overlap is considered too minor to warrant the division of the Site.
Key Findings	In light of the research for this report, 6 Alpha has assessed the threat on this Site based on these pertinent facts: • The Work Area is situated at *Victoria Embankment* on the foreshore of the *River Thames*. • Whilst no World War Two (WWII) bombing targets have been identified within the Work Area, numerous "opportunistic" targets were located within the vicinity of the Site. • *Westminster Metropolitan Borough*, where the Site is located, experienced a bombing density of 474 High Explosive (HE) bombs per 1,000 acres. This is a notable bombing density for *London*. • No HE bomb strikes occurred within the Work Area, however two strikes occurred within the buffered Site boundary. A further thirteen HE bomb strikes were recorded within 100m of the buffered Site boundary and a V1 bomb strike occurred north of the Work Area on *Hungerford Bridge*. Furthermore, an unexploded bomb (UXB) was recovered on the opposite foreshore of *Victoria Foreshore Embankment*. • Typically, it is unlikely that UXO would have been witnessed and reported given the environmental conditions. • Bomb damage was not recorded within the Work Area given the lack of structures and developments at this Site. • The Site has not been developed since WWII and thus is unlikely to have removed buried items of Unexploded Ordnance (UXO). The risk assessment and risk mitigation outlined below are based on the indicative engineering drawings and proposed works provided by *Thames Water*, and therefore it should be noted that any changes to the engineering drawings or proposed works may affect the risk assessment.
Potential Threat Source	The threat is primarily posed by WWII *German* HE bombs, with a secondary threat from Incendiary Bombs (IBs) and *British* Anti-Aircraft Artillery (AAA) projectiles.
Risk Pathway	Given the type of munitions that might be present on Site, all types of aggressive intrusive engineering activities may generate a significant risk pathway.
Risk Level	**HIGH**
Activities	**Recommended Risk Mitigation**
All Activities	**The following actions are recommended before undertaking any activity on the Study Site:** **1. Operational UXO Risk Management Plan;** appropriate site management documentation should be held on site in the event of a suspected or real UXO discovery. **2. UXO Safety & Awareness Briefings;** the briefings are essential when there is a possibility of explosive ordnance encounter and are a vital part of the general safety requirement.
Excavation Works	**3. On-Site Banksman;** all open excavation works should be accompanied by an UXO Specialist to monitor works down to the maximum bomb penetration depth.
Cofferdam, Piling and Dredging	**4. Non-intrusive Magnetometer Survey**; Prior to any dredging and cofferdam piling of the foreshore, 6 Alpha recommend a non-intrusive magnetometer survey. Any magnetic contacts that model as UXO should either be investigated or avoided.

ASSESSMENT METHODOLOGY	
Approach	6 Alpha Associates are independent, specialist risk management consultants and the UXO related risk on the Site has been assessed using the process advocated by both the *Construction Industry Research & Information Association* (CIRIA) best practice guide (C681) and by the *Health & Safety Executive* (HSE). Therefore, any risk levels identified in the assessments are objective, quantifiable and not simply designed to generate "follow on survey or contracting work"; any mitigation solution is recommended *only* because it delivers the Client a risk reduced to As Low As Reasonably Practicable (ALARP) at best value. Potential UXO hazards have been identified through investigation of Local and National archives covering the Site, *Ministry of Defence* (MoD) archives, local historical sources, historical mapping as well as contemporaneous aerial photography (as and if, it is available). Potential hazards have only been recorded if there is specific information that could reasonably place them within the boundaries of the Site. Key source material is referenced within this document, whilst data of lesser relevance (which may have been properly considered and discounted by 6 Alpha), is available upon request. The assessment of UXO risk is a measure of ***probability*** *of encounter* and ***consequence*** *of encounter*; the former being a function of the identified hazard and proposed development methodology; the latter being a function of the type of hazard and the proximity of personnel (and/or other "sensitive receptors"), to the hazard at the moment of encounter. Should a measurable UXO risk be identified, the methods of mitigation recommended are reasonably and sufficiently robust to reduce these to As Low As Reasonably Practicable (ALARP). We believe that the adoption of the legal ALARP principle is a key factor in efficiently and effectively ameliorating UXO risks. It also provides a ready means for assessing the Client's tolerability of UXO risk. In essence the principle states that if the cost of reducing a risk significantly outweighs the benefit, then the risk may be considered tolerable. Clearly this does not mean that there is no requirement for UXO risk mitigation, but any mitigation must demonstrate that it is beneficial. Any additional mitigation that delivers diminishing benefits **and** that consume disproportionate time, money and effort are considered *de minimis* and thus unnecessary. Because of this principle UXB risks will rarely be reduced to zero (nor need they be).
Important Notes	Although this report is up to date and accurate, our databases are continually being populated as and when additional information becomes available. Nonetheless, 6 Alpha have exercised all reasonable care, skill and due diligence in providing this service and producing this report. The assessment levels are based upon our professional opinion and have been supported by our interpretation of historical records and third party data sources. Wherever possible, 6 Alpha has sought to corroborate and to verify the accuracy of all data we have employed, but we are not accountable for any inherent errors that may be contained in third party data sets (e.g. National Archive or other library sources), and over which 6 Alpha can exercise no control. The intention of this report is to provide the Client with a concise summary of the risks posed to the site investigation and construction works. The background risk has been established in a Threat & Preliminary Risk Assessment Report that will be provided separately. Whilst this document may be used in isolation, an overarching report is available that outlines the procedures, details and methodologies used to assess the UXO risk to this project.

STAGE ONE – SITE LOCATION AND DESCRIPTION

Study Site	The Client has specified the Study Site as Work Area PWR1X. The Site is located at National Grid Reference 530405, 180146. For the purposes of this study, a 50m assessment radius will be applied to the work area to provide flexibility should it need to be relocated. See *Figures 1* and *2* for the Site location.
Location Description *(Figure 3)*	The Work Area is situated to the southwest of the *City of London* within the *Westminster Metropolitan Borough*. Current aerial photography has identified the Work Area as foreshore along the *River Thames*, with no structural developments on site.
Proposed Engineering Works	*Thames Water* have specified a summary of the proposed engineering works, including a working draft plan with drawing no. 100-DA-CNS-PWR1X-263107_AH. The proposed works may not represent the full scheme but rather those that may present an UXO risk: • A 10m internal diameter drop shaft, 49m deep. It is anticipated that the shaft will be constructed using precast concrete segmental linings by caisson or underpinning supported by ground dewatering and treatment. • The drop shaft will be connected with the main tunnel through a 60m long, 2.2m dia. connection tunnel. • Two interception chambers, either side of the proposed shaft. One of the chambers will be constructed in front of the existing outfall to the river. The other overflow weir will be located within the 1868 Victoria Embankment itself. • Connection culverts from the interception chambers to the drop shaft. • Valve chambers will be constructed adjacent to the drop shaft. • A 10m high ventilation column will need to be positioned near the shaft. • A control kiosk to house equipment to operate an actuated penstock valve. Within the construction compound there will be offices/welfare facilities, a storage area for shaft segments and storage and handling area for excavated material. The working area will be constructed in the foreshore at Victoria Embankment in front of Whitehall Gardens. This will include construction of a temporary cofferdam in the foreshore that will be filled to provide a working area. A possible alternative will be to create a temporary working area in the river with decking on piles, in which case only the permanent land take in the river will be constructed by filling a cofferdam.
Ground Conditions	*Thames Water* have indicated the following ground conditions for the Work Areas as:

Site Geology	Depth Below Ground Level (m)	Thickness (m)
Alluvium	0.00	3.00
River Terrace Deposits	3.00	3.10
London Clay	6.10	32.90
Harwich Formation	39.00	0.48
Lambeth Group	39.48	17.95
Thanet Sand	57.43	10.10
Seaford Chalk	67.53	Not Proven

It is important to establish the ground conditions within this report to determine both the maximum *German* UXB bomb penetration depth (BPD) as well as the potential for other types of munitions to be buried on this Site.

STAGE TWO – REVIEW OF HISTORICAL DATASETS	
Sources of Information Consulted	The following primary information sources have been used in order to establish the background UXO threat: 1. Home Office WWII Bomb Census Maps; 2. WWII & post-WWII Aerial Photography; 3. Official Abandoned Bomb Register; 4. National Archives in Kew; 5. Internet based research; 6. Historic UXO information provided by 33 Engineer Regiment (Explosive Ordnance Disposal) at Carver Barracks, Wimbish.
Site History and Use	According to the County Series (CS) & Ordnance Survey (OS) historical mapping, the following site history can be recorded immediately prior to and post-WWII: **1938 CS mapping –** The Work Area is situated on predominantly undeveloped foreshore. *Whitechapel Stairs* is labelled within the Site. **1949 OS mapping –** There are no significant or noticeable changes to the Site.
1945 Aerial Photography ***(Figure 4)***	The 1945 aerial photography confirms the landscape of the Work Area, however it is not possible to infer what damage may have occurred on the Site given the lack of structures within the area.
WWII Luftwaffe Bombing Targets ***(Figure 5)***	A primary target identified as a "drainage canal" was located approximately 1,000m to the north of the Site. "Opportunistic" targets located within 1,000m of the Site include railway stations and railway infrastructure, "depots", "docks", "wharves" and "warehouses".
WWII HE Bomb Strikes ***(Figure 6)***	Air Raid Precaution (ARP) reports indicate no bomb strikes occurred within the Work Area. However, two bomb strikes occurred within the buffered Site boundary and thirteen strikes occurred within 100m of the buffered Site boundary. There was also one V1 strike on *Hungerford Bridge* within the buffered Site boundary to the north. Additionally, research indicates a dredging vessel discovered a UXB near the foreshore of *Hungerford Bridge* on the east side.
WWII Bomb Damage ***(Figure 7)***	*London County Council* (LCC) bomb damage maps indicate no bomb damage within the Work Area or buffered Site boundary. Bomb damage was typically only recorded for building structures and not for damage sustained by "land" features. This may explain the lack of damage recorded within the Site, as no building structures are present.
WWII HE Bomb Density ***(Figure 8)***	The Study Site is located within the *Westminster Metropolitan Borough,* which recorded 474 HE bombs per 1,000 acres. This figure does not include incendiary devices, as they were often released in such large numbers that they were seldom recorded.
Abandoned Bombs	The Official Abandoned Bomb Register recorded no abandoned bombs on or within 1,000m of the Work Area.

STAGE THREE – DATA ANALYSIS	
Was the ground undeveloped during WWII?	Yes; the Work Area is located on the foreshore and was undeveloped.
Is there a reason to suspect that the immediate area was a bombing target during WWII?	Yes; numerous "opportunistic" bombing targets have been identified within the vicinity of the Site.
Is there firm evidence that ordnance landed on Site?	No; there were no bomb strikes within the Work Area, however two strikes occurred within the buffered Site boundary (within 50m of the Work Area boundary).
Is there evidence of damage sustained on Site?	No; but this is unlikely to have been recorded given the environment and lack of structures within the Work Area.
Is there any reason to suspect that military training may have occurred at this location?	No; there is no record of military training or live firing on, or in the immediate vicinity of the Work Area. It is considered unlikely that any training would have occurred at this location, as this would have posed an intolerable threat to the local population.
Would an UXB entry hole have been observed and reported during WWII?	Unlikely; UXBs falling in the *River Thames* are unlikely to have been observed and reported. Additionally, any impact craters of UXBs falling on the foreshore during low tide would have been masked and covered by tidal changes.
What is the expected UXO contamination?	The most likely source of UXO contamination is from *German* aerial delivered ordnance, which ranges from small IBs through to large HE bombs (of which the latter forms the principal threat).
Would previous earthworks have removed the potential for UXO to be present?	No; no significant earthworks have occurred within the Work Area.

STAGE FOUR – RISK ASSESSMENT		
Explanation For Non-Division Of Site	The Site has a slight overlap at street level off the foreshore. However this street level overlap is considered too marginal to warrant the division of the Site.	
Threat Items	The threat is predominately posed by WWII *German* HE bombs and IBs. Additionally, *British* Anti Aircraft Artillery (AAA) projectiles may also be present. However, AAA does not have the potential for deep burial, and thus is unlikely to be encountered at depths greater than 1m below ground level **(**bgl).	
Maximum Penetration	The general ground conditions (highlighted in Stage 1) of the Work Area that are relevant consist of Alluvium, River Terrace Deposits and London Clay, and thus the most likely Bomb Penetration Depth (BPD) for a 250kg bomb is assessed to be a maximum of 8m below ground level (bgl), dependant on the depth of any rock sediment. As the Work Area overlaps with the foreshore of the *River Thames* and the river itself, the BPD will vary due to the softer ground conditions and the water causing a deceleration of the impacting bomb. It is important to note that strong river currents, sedimentation build-up and erosion over time can significantly alter the depth of UXO. Whilst the *Luftwaffe* used larger bombs, their deployment was so few and only used against notable targets, to use them within this risk assessment would not be justified. Additionally, smaller items such as *German* IBs and *British* AAA projectiles would have a significantly reduced penetration capability and would not be expected to be encountered at depths greater than 1m.	
Risk Pathway	Intrusive engineering activities are likely to be in the form of excavations. Although for the purposes of this report 6 Alpha will use a range of generic construction activities for the risk assessment.	
Consequence	**Potential consequences of UXO initiation**	1. Kill and/or critically injure personnel 2. Severe damage to plant and equipment 3. Blast damage to nearby buildings 4. Rupture and damage underground services
	Potential consequences of UXO discovery	1. Delay the project 2. Disruption to local community/infrastructure 3. Incurring of additional costs
Site Activities	A number of construction methodologies have been identified for analysis on this Site. There is a large amount of variation in the probability of encountering, or initiating items of UXO when conducting different activities on Site. Additionally the consequences of initiating UXO vary greatly depending on how the item of UXO was initiated on Site.	

STAGE FOUR – RISK ASSESSMENT (…continued)

UXO RISK CALCULATION TABLE

Risk Rating Calculation	6 Alpha's Semi-Quantitative Risk Assessment identifies the Risk Rating posed by the most probable threat items when conducting a number of different construction activities on the Site. Risk Rating is determined by calculating the probability of encountering UXO and the consequences of initiating it.

Activity	WORK AREA		
	Probability (SHxEM=P)	**Consequence** (DxPSR=C)	**Risk Rating** (PxC=RR)
Enabling Works	3x1=3	3x2=6	3x6=18
Tunnelling	3x2=6	1x2=2	6x2=12
Shaft Installation	3x2=6	1x2=2	6x2=12
Open Excavations	3x2=6	2x2=4	6x4=24
Cofferdams (including Piling)	3x3=9	2x2=4	9x4=36
Dredging	3x3=9	3x2=6	9x6=54

Abbreviations – Site History (SH), Engineering Methodology (EM), Probability (P), Depth (D), Consequence (C), Proximity to Sensitive Receptors (PSR) and Risk Rating (RR).

STAGE FIVE – RECOMMENDED RISK MITIGATION MEASURES WITH RESULTING RISK RATING	
If a geophysical survey is required are the ground conditions an issue?	**Non-Intrusive Methods of Mitigation** – The suitability for an effective non-intrusive method of mitigation is largely dependent on the depth and composition of made ground (which in this case is largely non-existent) as any magnetometer results are highly likely to be affected by ferro-magnetic contamination due to previous construction activities within the Study Site location. This method is likely to be effective on the foreshore and within the cofferdam as this is area is undeveloped, however any scrap metal may mask buried items of UXO. **Intrusive Methods of Mitigation** – Intrusive magnetometry is expected to be possible on this Site. It should be noted that ferro-contamination of any made ground/fill material, particularly at the fill layer, is likely to adversely affect detection capability of the equipment.

MITIGATION MEASURES TO REDUCE RISK TO 'ALARP'		
Activity	**Risk Mitigation Measures**	**Final Risk Rating**
ALL ACTIVITIES	**The following actions are recommended before undertaking any activity on the Study Site:** **1. Operational UXO Risk Management Plan;** appropriate site management documentation should be held on site to plan for and guide upon the actions to be carried out in the event of a suspected or real UXO discovery. **2. UXO Safety & Awareness Briefings;** the briefings are essential when there is a possibility of explosive ordnance encounter and are a vital part of the general safety requirement. All personnel working on the site should receive a general briefing on the identification of UXB, what actions they should take to keep people and equipment away from the hazard and to alert site management. Posters and information of the general nature of the UXB threat should be held in the site office for reference and as a reminder.	ALARP
EXCAVATION WORKS	**3. On-Site Banksman;** all open excavation works should be accompanied by an UXO Specialist to monitor works down to the maximum bomb penetration depth.	
COFFERDAM PILING AND DREDGING	**4. Non-intrusive Magnetometer Survey**; Prior to any cofferdam piling and dredging of the foreshore, 6 Alpha recommend a non-intrusive magnetometer survey. Any magnetic contacts that model as UXO should either be investigated or avoided. It should be noted that there is likely to be scrap metal on the foreshore and riverbed that will reduce the effectiveness of non-intrusive magnetometry.	
This assessment has been conducted based on the information provided by the Client, should the proposed works change then 6 Alpha should be re-engaged to refine this risk assessment.		

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Report Figures

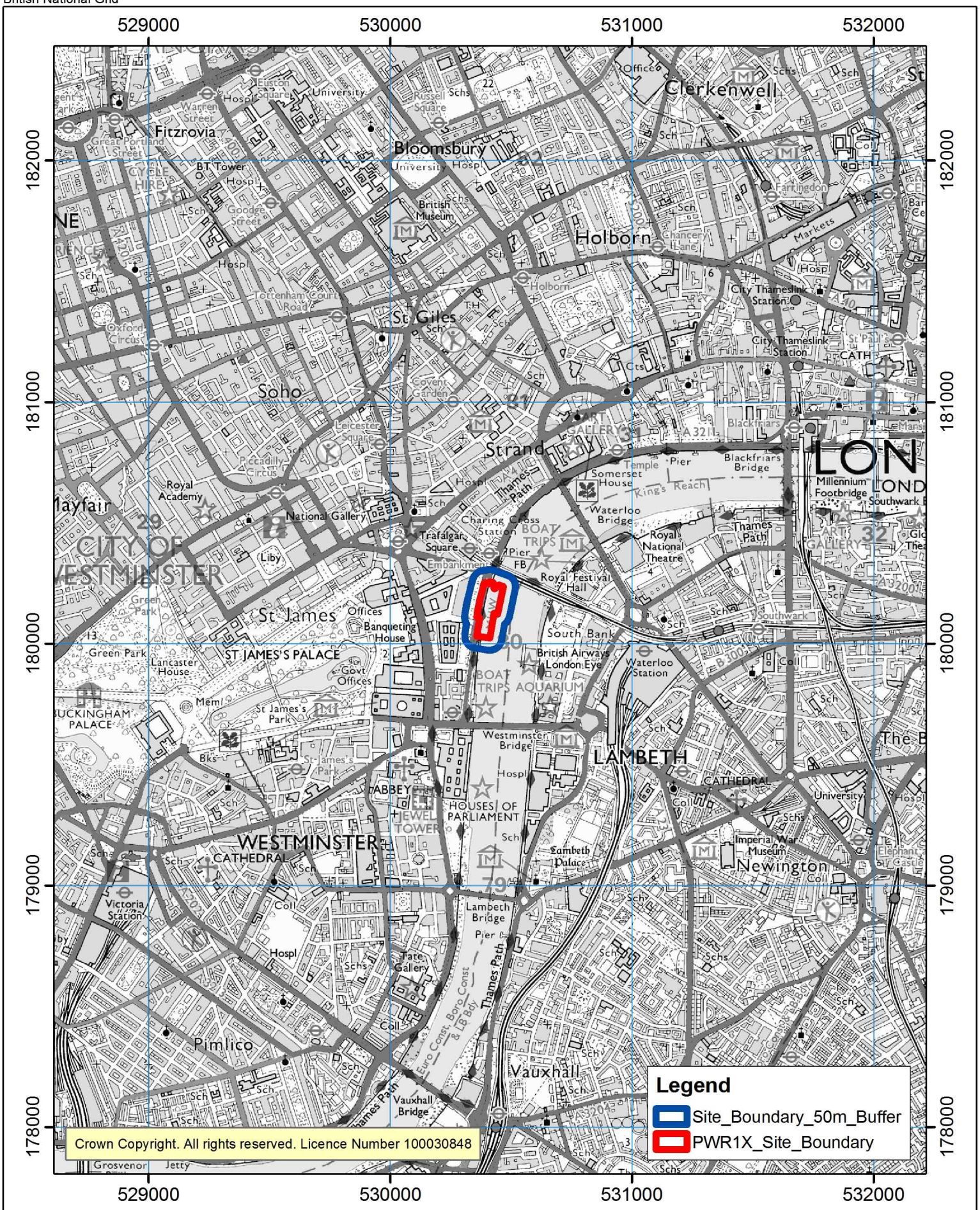
Figure One

Site Location

Thames Tideway Tunnel - Work Area PWR1X
Site Location

Figure 1

British National Grid



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Checked by: Lee Gooderham
Date: 21st May 2012

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Figure Two

Site Plan

Thames Tideway Tunnel - Work Area PWR1X Site Boundary

Figure 2

British National Grid

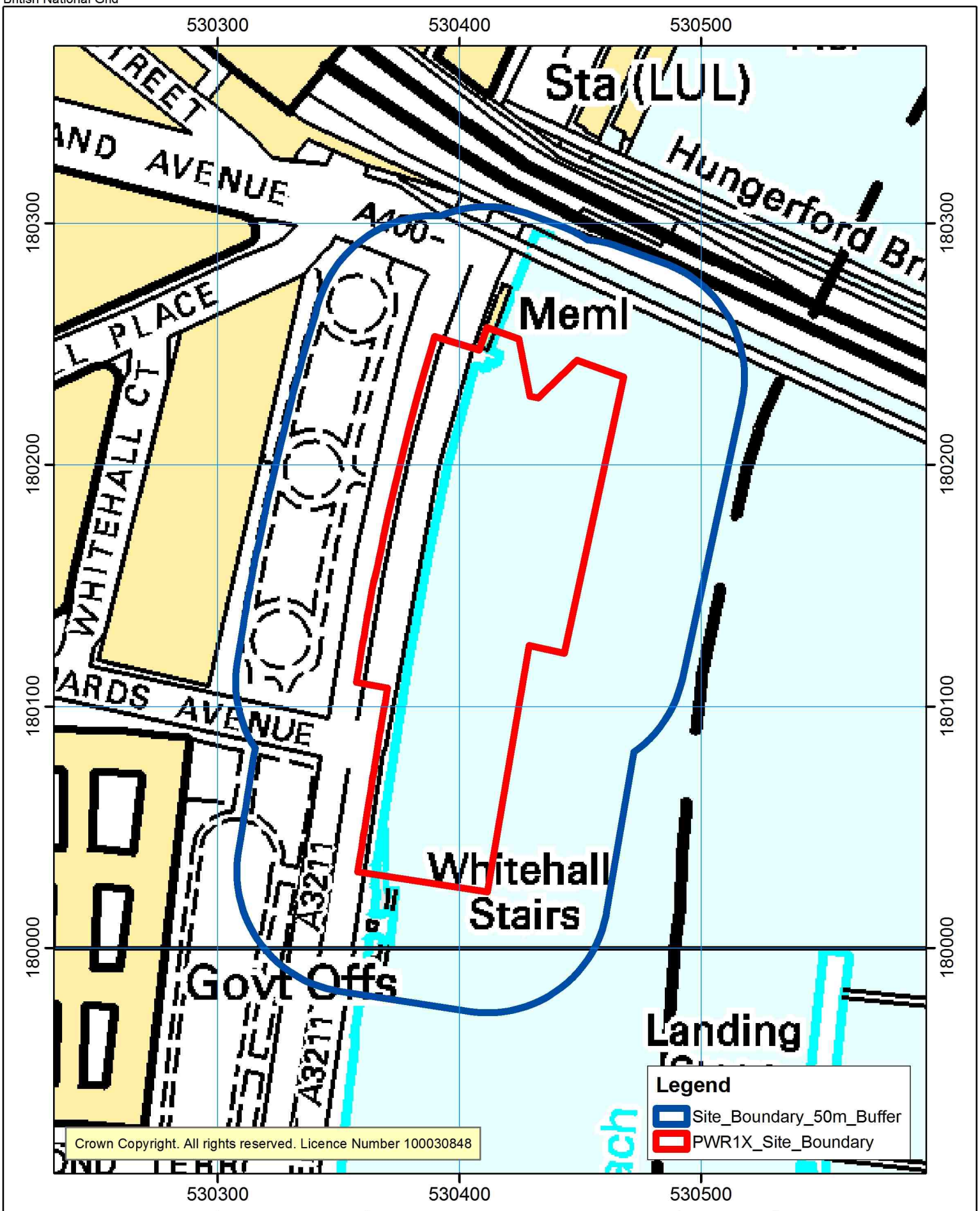

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Figure Three

Current Aerial Photography

Thames Tideway Tunnel - Work Area PWR1X
Current Aerial Photography

Figure 3

British National Grid

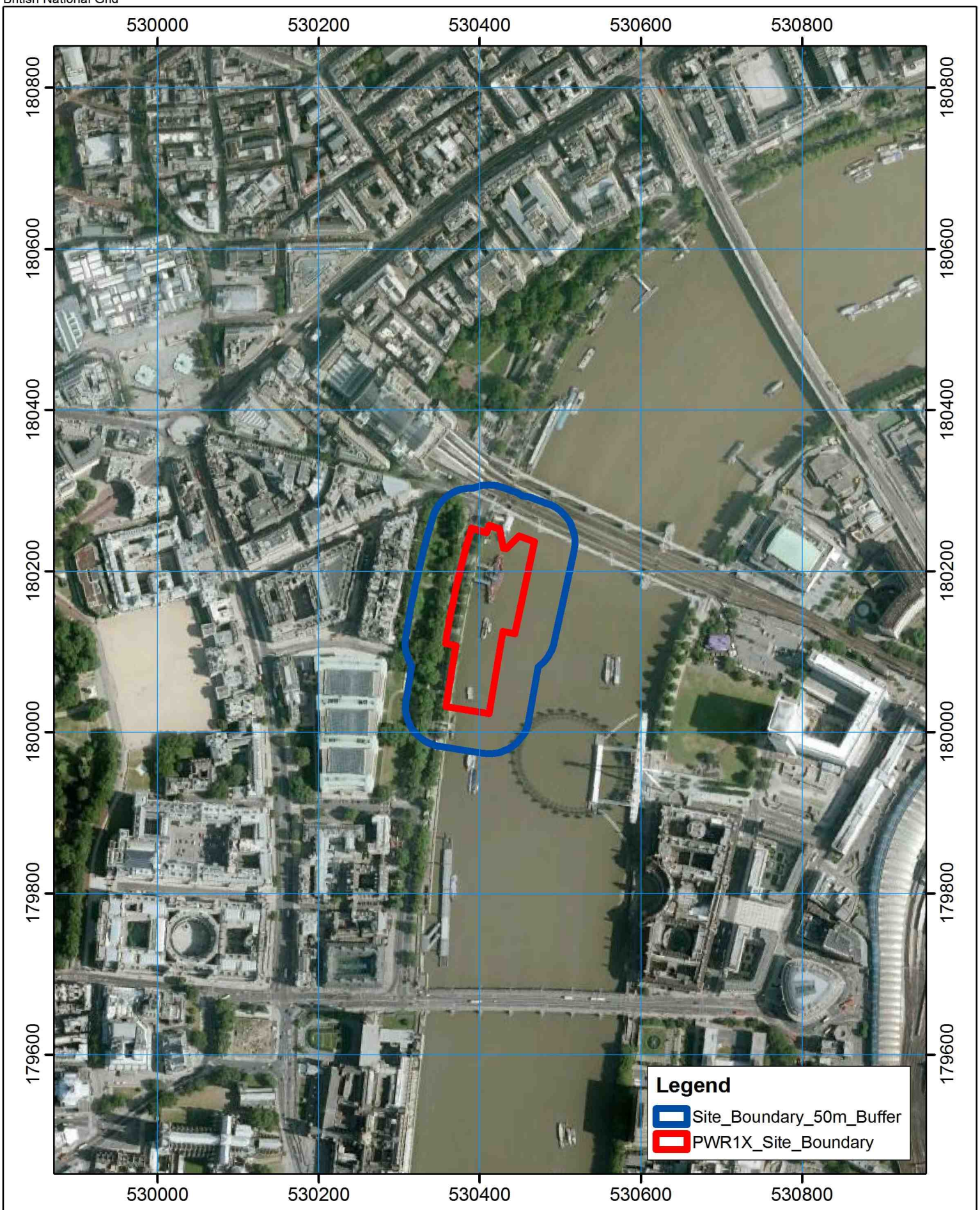

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Figure Four

1945 Aerial Photography

Thames Tideway Tunnel - Work Area PWR1X
1945 Aerial Photography

Figure 4

British National Grid

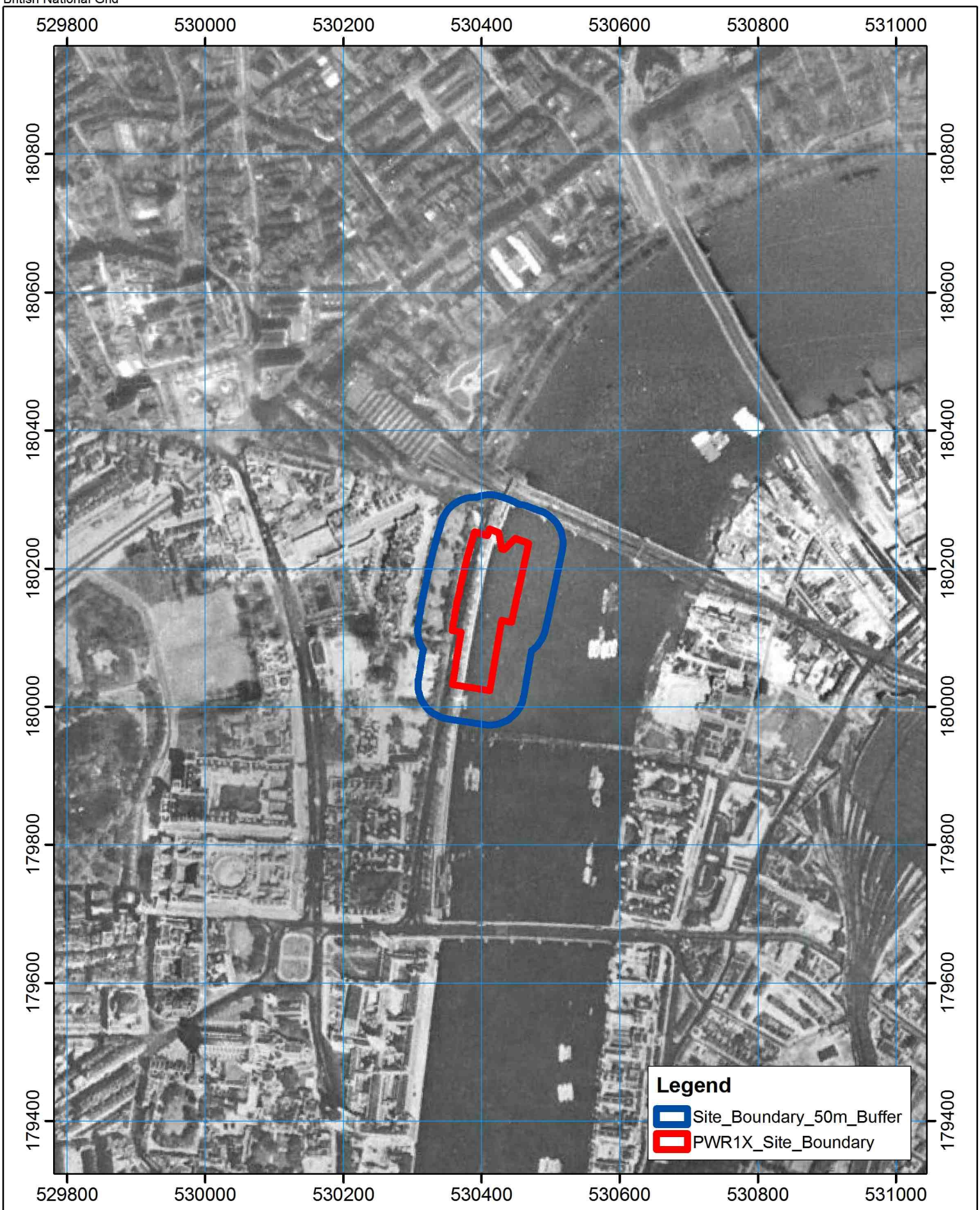

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Figure Five

WWII Luftwaffe Bombing Targets

Thames Tideway Tunnel - Work Area PWR1X
WWII Luftwaffe Bombing Targets

Figure 5

British National Grid

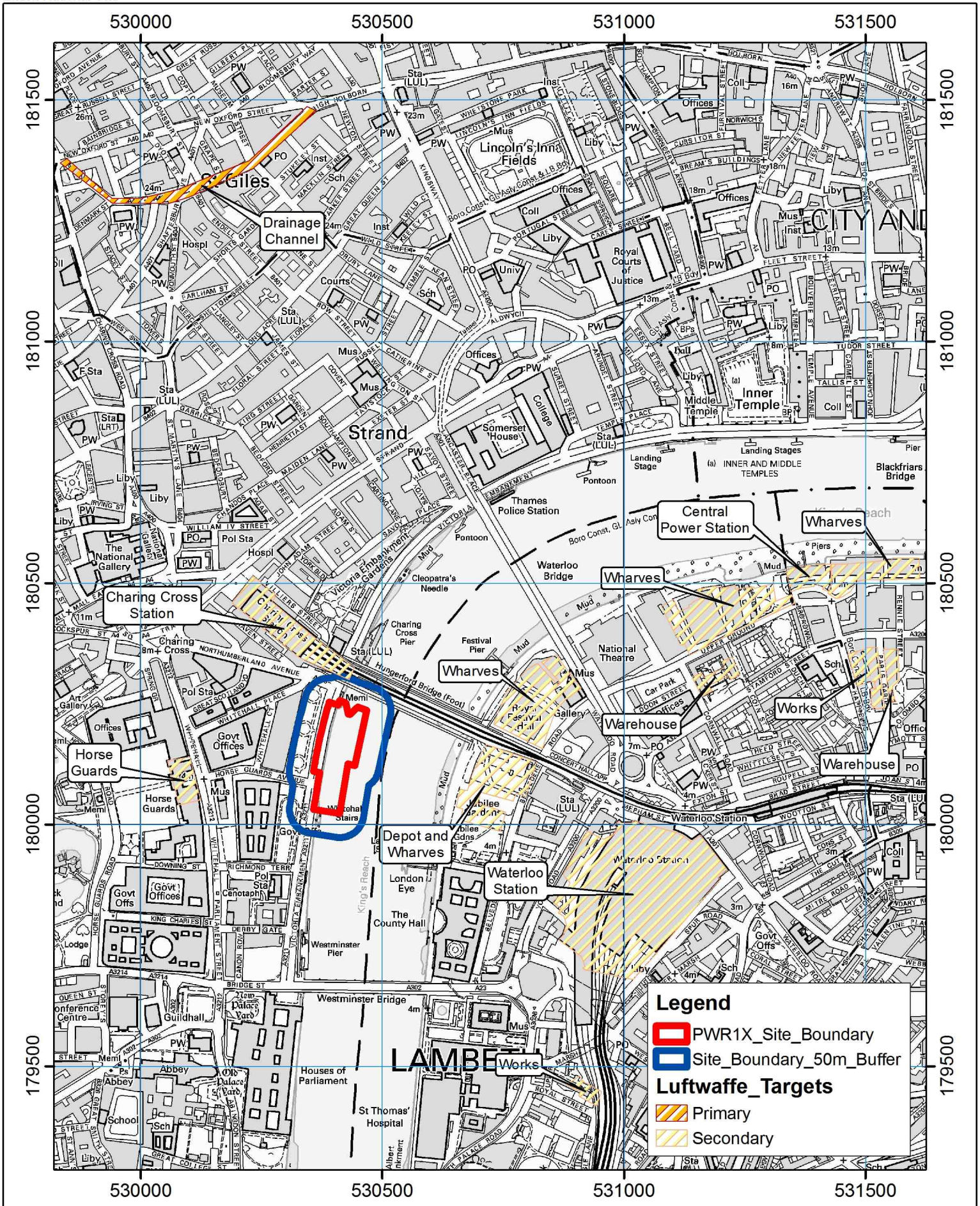

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Figure Six

WWII High Explosive Bomb Strikes

Thames Tideway Tunnel - Work Area PWR1X
WWII High Explosive Bomb Strikes

Figure 6

British National Grid

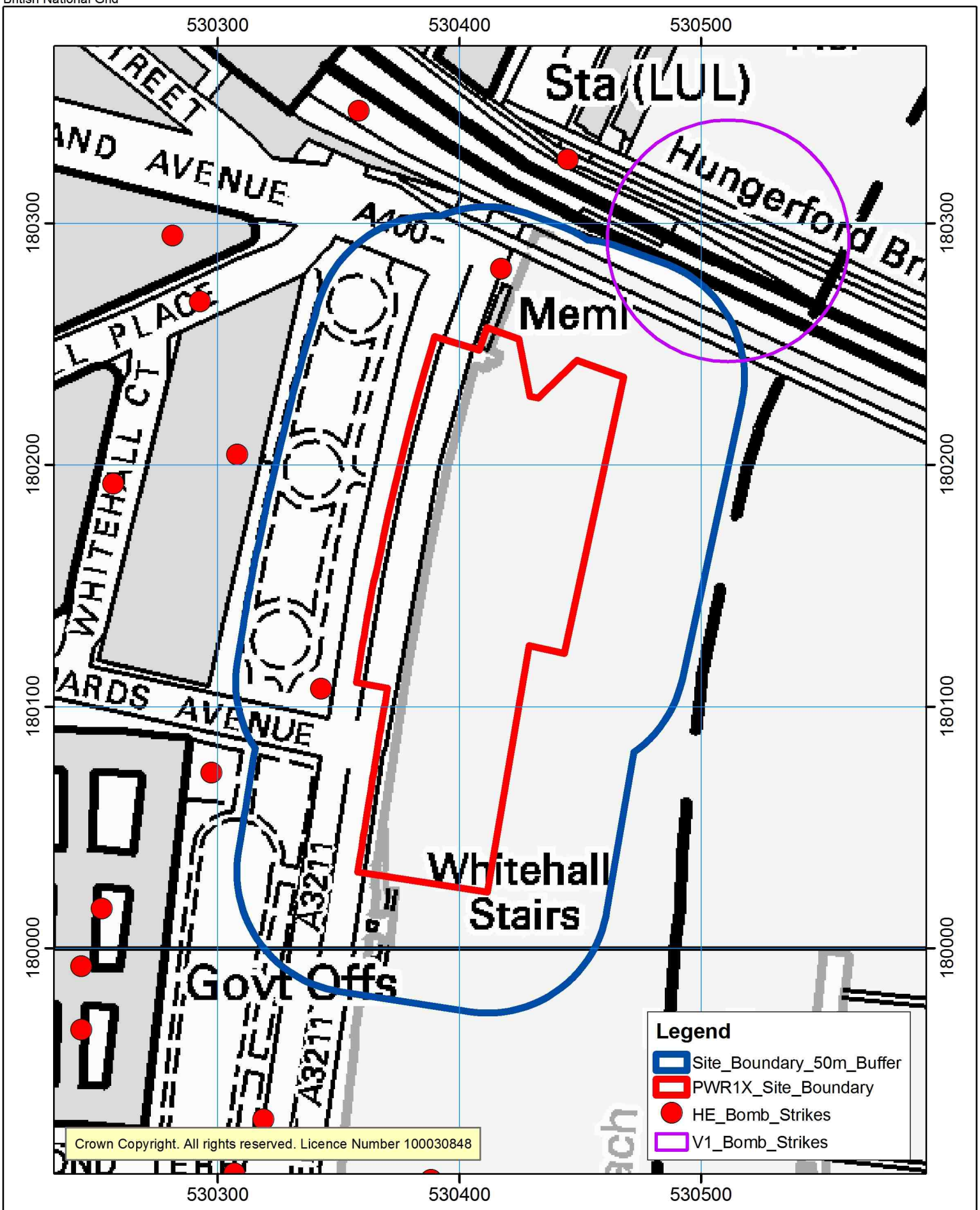

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Figure Seven

London County Council Bomb Damage Mapping

Thames Tideway Tunnel - Work Area PWR1X
London County Council Bomb Damage Map

Figure 7

British National Grid

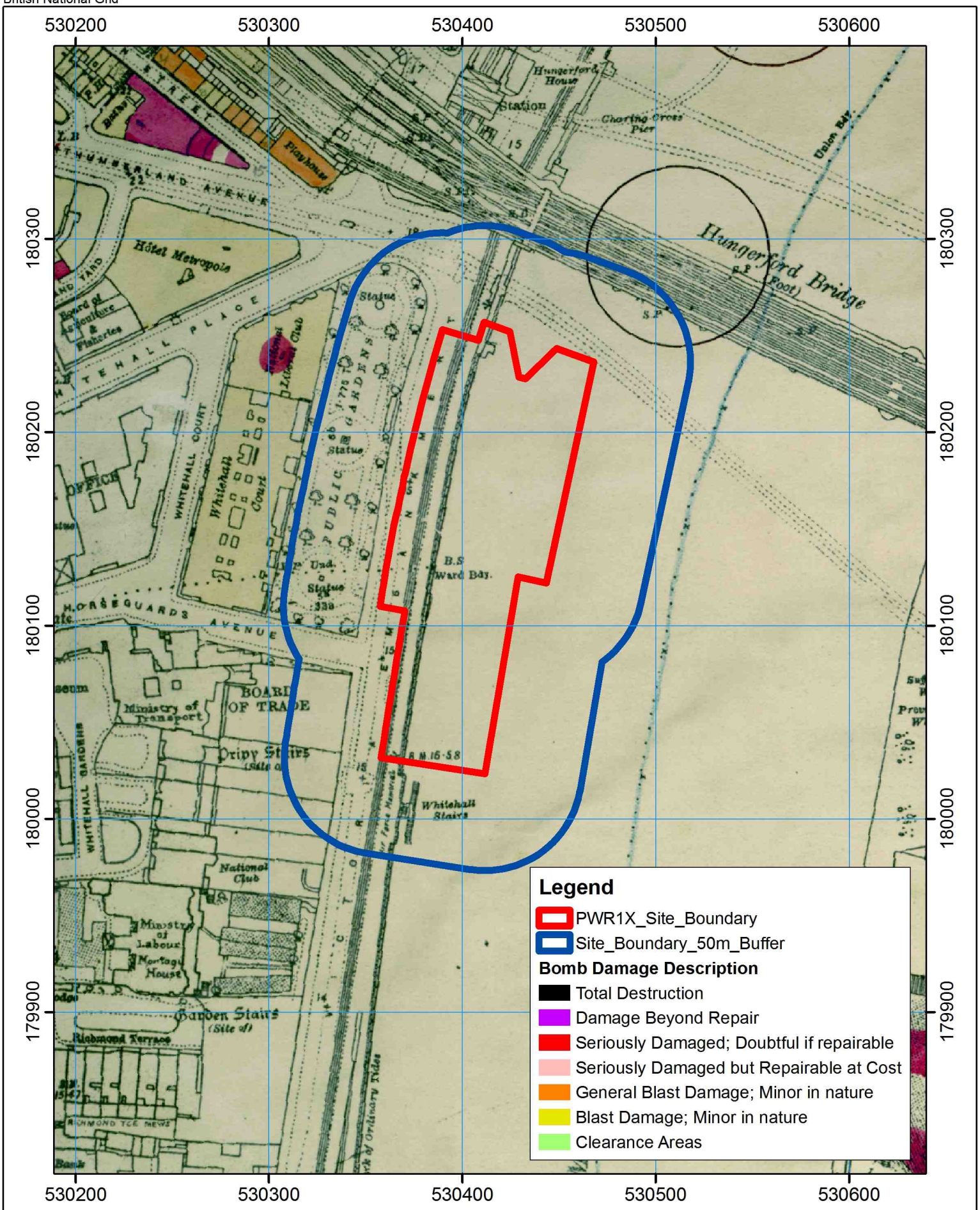

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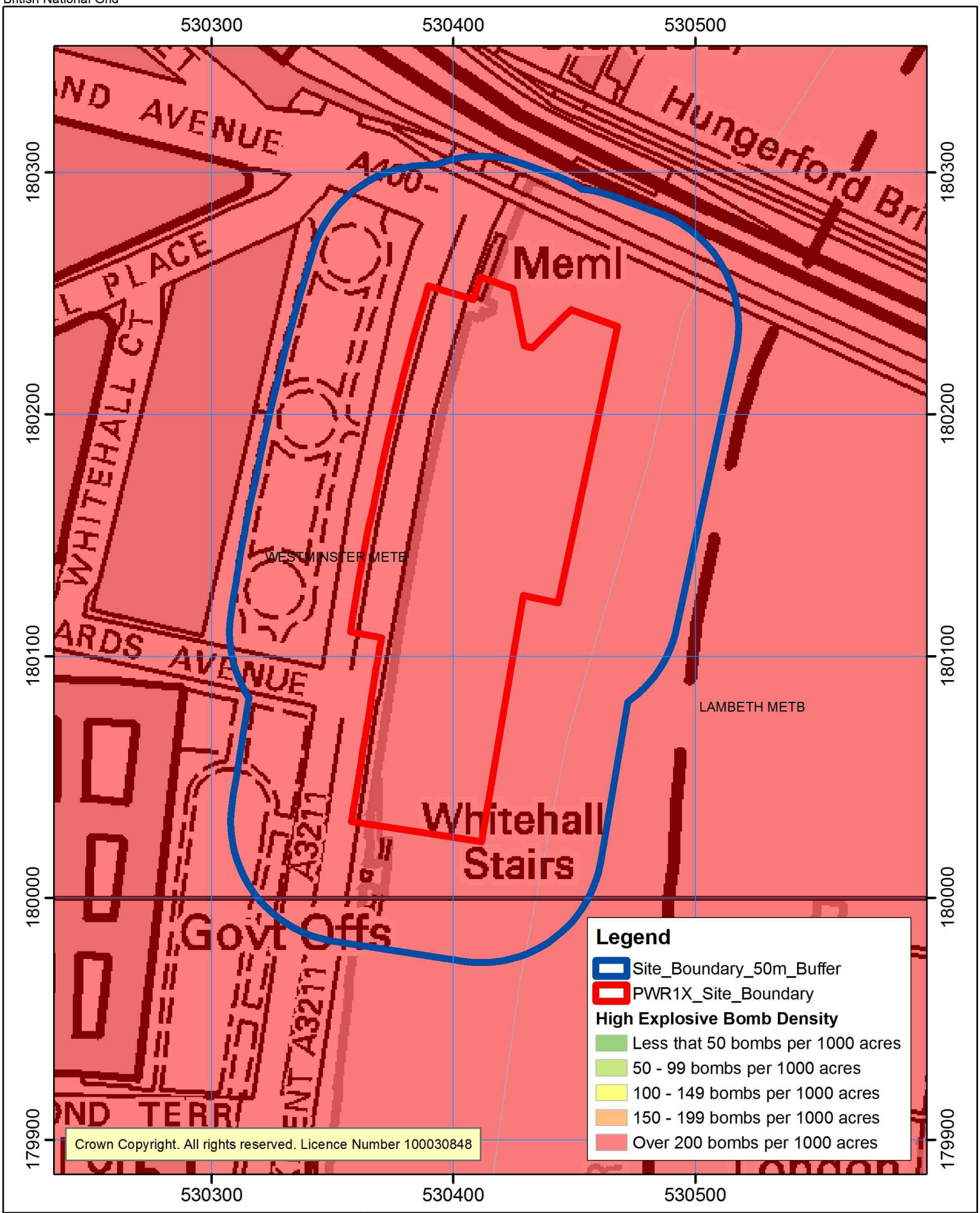
Figure Eight

WWII High Explosive Bomb Density

Thames Tideway Tunnel - Work Area PWR1X
WWII High Explosive Bomb Density

Figure 8

British National Grid



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[2] Department of the Environment. *Industry Profiles* (various). Available at: http://www.environment-agency.gov.uk/research/planning/33708.aspx. Accessed 25th March 2011.

[3] Port of London Authority. *Thames Tunnel Foreshore Contamination Sampling Report*. PLA Ref Q55/11 (December, 2011).

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Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.17**

Volume 17: Victoria Embankment Foreshore appendices

Appendix G: Noise and vibration

APFP Regulations 2009: Regulation **5(2)(a)**

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Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

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Thames Tideway Tunnel

Environmental Statement

Volume 17 Victoria Embankment Foreshore appendices

Appendix G: Noise and vibration

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Appendix G: Noise and vibration

G.1 Baseline noise survey

Introduction

G.1.1 As described in Volume 2 Environmental assessment methodology, the main purpose of the noise survey has been to determine representative ambient and background noise levels at a number of different types of noise sensitive receptor.

G.1.2 The nearest identified noise sensitive receptors to Victoria Embankment are the residential flats located west of the development at Whitehall Court which are within the City of Westminster, The Playhouse Theatre on Craven Road, Whitehall Gardens (part of Victoria Embankment Gardens), Jubilee Gardens (across the River Thames), Ministry of Defence Offices to the south of Horse Guards Avenue, and two moored ships, the Tattershall Castle and the Hispaniola.

Survey methodology

G.1.3 The survey methodology originally covered the collection of day time measurements only. As the scheme design progressed, additional surveys were undertaken to collect evening and night time measurements. The daytime baseline noise survey was completed on 6th April 2011 and the additional evening and night-time data was collected on 8th through 10th January 2012.

G.1.4 For the initial baseline survey in April 2011, short term attended noise monitoring was completed at all measurement positions. Measurements were undertaken during the interpeak periods of 10:00-12:00 and 14:00-16:00 so that the baseline data is representative of the quieter periods where any disturbance from construction would be most noticeable.

G.1.5 For the additional baseline survey in January 2012, further short term attended noise monitoring was completed at one location (VEF03) and representative overnight continuous unattended monitoring data was collected at two locations (VEF01 and VEF02) for a typical weekday and weekend. The continuous unattended monitoring was agreed with the Environmental Health Officer at Westminster City Council following consultation on the survey methodology and prior to undertaking the survey.

G.1.6 Vol 17 Table G.1 describes the survey equipment that was used to collect the baseline data at the site.

Vol 17 Table G.1 Noise – survey equipment

Item	Type	Manufacturer	Serial number(s)	Laboratory calibration date
Initial baseline survey: 6th April, 2011				
Hand-held analyzers	2250	Brüel & Kjær	2626232 2626233	15/02/2010
½ " Microphones	4189	Brüel & Kjær	2621211 2621212	15/02/2010
B&K sound calibrator	4231	Brüel & Kjær	2619375	21/01/2010
Additional baseline survey: 8th - 10th January, 2012				
Hand-held analyzers	2250	Brüel & Kjær	2626232 2626233	15/02/2010
			2626231	20/01/2010
½ " Microphones	4189	Brüel & Kjær	2621211 2621212	15/02/2010
			2621208	20/01/2010
B&K sound calibrator	4231	Brüel & Kjær	2619373	10/02/2011

** Hand-held analyzers and ½ inch microphones valid for two years from the date listed, calibrators valid for one year from the date listed*

G.1.7 Prior to and on completion of the surveys, the sound level meters and microphone calibration was checked using a Brüel and Kjær sound level meter calibrator Type 4231. On-site calibration checks were performed before and after all measurements with no significant deviation being observed. The sound level meters and calibrators have valid laboratory calibration certificates.

G.1.8 The sound level meters were tripod-mounted with the microphone approximately 1.3m above ground level. A windshield was fitted over the microphone at all times during the survey period to minimise the effects of any wind induced noise.

G.1.9 For the attended measurements, the sound level meters were tripod-mounted with the microphone approximately 1.3m above ground level. A windshield was fitted over the microphone at all times during the survey period to minimise the effects of any wind induced noise.

G.1.10 For the unattended measurements, the environmental cases used for the continuous data logging were locked to avoid any potential tampering. The microphones were tripod-mounted approximately 1.3m above ground level. Windshields with bird spikes were fitted over the microphones at all times during the survey period to minimise the effects of any wind induced noise, and also to prevent birds from perching on the equipment.

G.1.11 The prevailing weather conditions observed for both baseline surveys are described in Vol 17 Table G.2.

Vol 17 Table G.2 Noise – weather conditions during baseline noise surveys

Wind Speed (ms^{-1})	Wind Direction	Temperature (°C)	Precipitation	Description
Initial Baseline Survey – 6th April, 2011				
Maximum: 2.0-4.5 Average: 0.5-1.4	WSW; SW	19-24	No	Warm and sunny
Additional baseline survey – 8th January, 2012				
Maximum: 2.0-4.5 Average: 0.5-1.4	W; SW	10-11	Yes – light drizzle observed during last measurement (17:38)	Cloudy, mild, calm with occasional light breeze and dry (except for one measurement)
Additional baseline survey – 9th January, 2012				
Maximum: 0.6-3.0 Average: 0-0.8	W; SW	8-11	No	Cloudy, dry, mild and calm with occasional light breeze
Additional baseline survey – 10th January, 2012				
Maximum: 0.7-3.0 Average: 0-0.9	W; SW	10-11	Yes - light drizzle observed at 00:30 and again at 01:15	Cloudy, mainly dry, mild and calm with occasional light breeze

Measurement locations

G.1.12 Vol 17 Table G.3 details the measurement locations which are also presented in Vol 17 Figure G.1 (see separate volume of figures), and shown in Vol 17 Plate G.1 to Vol 17 Plate G.5.

Vol 17 Table G.3 Noise – measurement locations

Measurement location number	Description	Co-ordinates	
		X	Y
VEF01	Whitehall Gardens (near Whitehall Court)	530321	180179
VEF02	Whitehall Gardens	530361	180230
VEF03	Jubilee Gardens	530666	180083
VEF04	The Hispaniola (ship) (opposite existing location)	530370	180081
VEF05	Tattershall Castle (ship) (opposite proposed relocation)	530413	180270

Results

G.1.13 The range of values for each of the parameters collected during the initial baseline survey are summarised in Vol 17 Table G.4 to Vol 17 Table G.6 for reference purposes.

G.1.14 A review has been undertaken of the unattended measurements, which confirms that the attended measurements were undertaken over periods with typical ambient and background noise levels.

Vol 17 Table G.4 Noise – sampled noise survey results – VEF01

Location Detail: VEF01, within Whitehall Gardens (approximately 40m from carriageway edge and 15m east of Whitehall Court)						
Measurement period	**Noise level (dB(A) free-field)**			**Averaged ambient noise level, $dBL_{Aeq,15min}$**		**$dBL_{Aeq,15min}$ (rounded to nearest 5dB)**
	L_{AFmax}	**$L_{A90,15min}$**	**$L_{Aeq,15min}$**	**Free field**	**Façade**	**Façade**
Daytime (10.00-12.00, 14.00-16.00)	80	58	60-65	62	65*	65

** An approximation of the averaged ambient façade noise level has been obtained by adding 3dB to the calculated averaged ambient free-field level*

Vol 17 Table G.5 Noise – sampled noise survey results – VEF02

Location Detail: VEF02, within Whitehall Gardens (approximately 16.5m from carriageway edge and 40m east of Whitehall Court)						
Measurement period	**Noise level (dB(A) free-field)**			**Averaged ambient noise level, $dBL_{Aeq,15min}$**		**$dBL_{Aeq,15min}$ (rounded to nearest 5dB)**
	L_{AFmax}	**$L_{A90,15min}$**	**$L_{Aeq,15min}$**	**Free field**	**Façade**	**Façade**
Daytime (10.00-12.00, 14.00-16.00)	82	61	64-67	66	69*	70

** An approximation of the averaged ambient façade noise level has been obtained by adding 3dB to the calculated averaged ambient free-field level*

Vol 17 Table G.6 Noise – sampled noise survey results - VEF03

Location Detail: VEF03, Within Jubilee Gardens (approximately 20m from River Thames foreshore						
Measurement period	**Noise level (dB(A) free-field)**			**Averaged ambient noise level, $dBL_{Aeq,15min}$**		**$dBL_{Aeq,15min}$ (rounded to nearest 5dB)**
	L_{AFmax}	**$L_{A90,15min}$**	**$L_{Aeq,15min}$**	**Free field**	**Façade**	**Façade**
Daytime (10.00-12.00, 14.00-16.00)	86	59	58-71	67	70*	70

** An approximation of the averaged ambient façade noise level has been obtained by adding 3dB to the calculated averaged ambient free-field level*

G.1.15 The range of values for each of the parameters collected during the additional baseline survey are summarised in Vol 17 Table G.7 to Vol 17 Table G.9 for reference purposes. This included data collection at two additional sensitive receptors (VEF04 and VEF05).

Vol 17 Table G.7 Noise –sampled noise survey results - VEF03

Location Detail: VEF03, adjacent to Jubilee Gardens* (approximately 15m from River Thames foreshore						
Measurement period	**Noise level (dB(A) free-field)**			**Averaged ambient noise level, $dBL_{Aeq,15min}$**		**$dBL_{Aeq,15min}$ (rounded to nearest 5dB)**
	L_{AFmax}	**$L_{A90,15min}$**	**$L_{Aeq,15min}$**	**Free field**	**Façade**	**Façade**
Evening (20.00-22.00)	76	54	59-60	57**	60	60
Night (00.00-04.00)	68	46	51-55	50**	53	55
Weekend day (14.00-18.00)	81	57	60-71	68**	71	70
Weekend night (00.00-04.00)	70	46	50-52	48**	51	50

** It wasn't possible to go back to the original location that was surveyed because that location now forms part of an active construction site, therefore the noise monitoring was taken as close to the original location as possible.*

*** An approximation of the averaged ambient free-field level has been obtained by subtracting 3dB from the calculated averaged ambient façade noise level*

Vol 17 Table G.8 Noise –sampled noise survey results - VEF04

Location Detail: VEF04, on public footpath adjacent to Victoria Embankment (opposite the existing location of the Hispaniola)						
Measurement period	**Noise level (dB(A) free-field)**			**Averaged ambient noise level, $dBL_{Aeq,15min}$**		**$dBL_{Aeq,15min}$ (rounded to nearest 5dB)**
	L_{AFmax}	**$L_{A90,15min}$**	**$L_{Aeq,15min}$**	**Free field**	**Façade**	**Façade**
Evening (20.00-22.00)	102	62	70-74	72	75*	75
Night (00.00-04.00)	99	56	64-74	70	73*	75
Weekend day (14.00-18.00)	82	61	67	67	70*	70
Weekend night (00.00-04.00)	79	51	61-64	63	66*	65

** An approximation of the averaged ambient façade noise level has been obtained by adding 3dB to the calculated averaged ambient free-field level*

Vol 17 Table G.9 Noise –sampled noise survey results - VEF05

Location Detail: VEF05, on public footpath adjacent to Victoria Embankment (opposite the proposed relocation of the Tattershall Castle)						
Measurement period	**Noise level (dB(A) free-field)**			**Averaged ambient noise level, $dBL_{Aeq,15min}$**		**$dBL_{Aeq,15min}$ (rounded to nearest 5dB)**
	L_{AFmax}	**$L_{A90,15min}$**	**$L_{Aeq,15min}$**	**Free field**	**Façade**	**Façade**
Evening (20.00-22.00)	84	60	68-69	68	71*	70
Night (00.00-04.00)	82	51	64-65	64	67*	65
Weekend day (14.00-18.00)	84	60	67-68	68	71*	70
Weekend night (00.00-04.00)	78	48	61-63	63	66*	65

** An approximation of the averaged ambient façade noise level has been obtained by adding 3dB to the calculated averaged ambient free-field level*

G.1.16 Following consultation with the Borough it was agreed that continuous unattended monitoring equipment could be left securely within the gardens once they closed. Data was collected on Sunday 8th January and Monday 9th January to obtain typical weekday and weekend noise levels. Vol 17 Table G.10 and Vol 17 Table G.11 summarise the data that was collected showing the average noise levels over the reference periods quoted.

Vol 17 Table G.10 Noise – continuously logged noise survey results - VEF01

Location Detail: VEF01, within Whitehall Gardens (approximately 40m from carriageway edge and 15m east of Whitehall Court)							
Day	**Period**	**Period noise level (dB(A) free-field)**			**Period noise level (dB(A) facade)**		
		L_{AFmax}	**L_{A90}**	**L_{Aeq}**	**L_{AFmax}**	**L_{A90}**	**L_{Aeq}**
Weekday	07.00-08.00	93	58	64	96	61	67
	08.00-18.00*	89	59	64	92	62	67
	18.00-19.00	84	57	62	87	60	65
	19.00-22.00	77	60	63	80	63	66
	22.00-07.00	84	50	59	87	53	62
Sunday	07.00-21.00	81	55	60	84	58	63

Location Detail: VEF01, within Whitehall Gardens (approximately 40m from carriageway edge and 15m east of Whitehall Court)							
Day	**Period**	**Period noise level (dB(A) free-field)**			**Period noise level (dB(A) facade)**		
		L_{AFmax}	**L_{A90}**	**L_{Aeq}**	**L_{AFmax}**	**L_{A90}**	**L_{Aeq}**
	21.00-07.00	78	47	58	81	50	61

** The data presented in this row is deemed to be representative of the reference period. The continuous monitors started collecting data from 5PM once the park was closed to the public and the equipment was secure*

Vol 17 Table G.11 Noise – continuously logged noise survey results - VEF02

Location Detail: VEF02, within Whitehall Gardens (approximately 16.5m from carriageway edge and 40m east of Whitehall Court)							
Day	**Period**	**Period noise level (dB(A) free-field)**			**Period noise level (dB(A) facade)**		
		L_{AFmax}	**L_{A90}**	**L_{Aeq}**	**L_{AFmax}**	**L_{A90}**	**L_{Aeq}**
Weekday	07.00-08.00*						
	08.00-18.00**	93	62	68	96	65	71
	18.00-19.00	86	63	67	89	66	70
	19.00-22.00	92	60	66	95	63	70
	22.00-07.00	91	53	64	74	51	60
Sunday	07.00-21.00	95	57	65	98	60	68
	21.00-07.00	87	51	63	74	48	59

** Data was not obtained for this reference period as the equipment had to be collected when the park reopened at dusk for security reasons.*
*** The data presented in this row is deemed to be representative of the reference period. The continuous monitors started collecting data from 5PM once the park was closed to the public and the equipment was secure*

Vol 17 Table G.12 Noise – measurements near embankment (for river-based traffic assessment)

Sensitive receptor locations	Measurement location	Measurement period	Noise level (dBL_{Aeq}, facade)
Whitehall Court	VEF01	Day/evening (07.00-23.00)	65
Victoria Embankment	VEF02	Day/evening (07.00-23.00)	70-75

Plates of noise measurement locations

G.1.17 The following plates (Vol 17 Plate G.1 to Vol 17 Plate G.5) illustrate the noise measurement locations.

Vol 17 Plate G.1 Noise measurement location VEF01

Note: Within Whitehall Gardens looking north towards Northumberland Avenue, near to Whitehall Court

Vol 17 Plate G.2 Noise measurement location VEF02

Note: Within Whitehall Gardens looking north towards Northumberland Avenue, near to Victoria Embankment

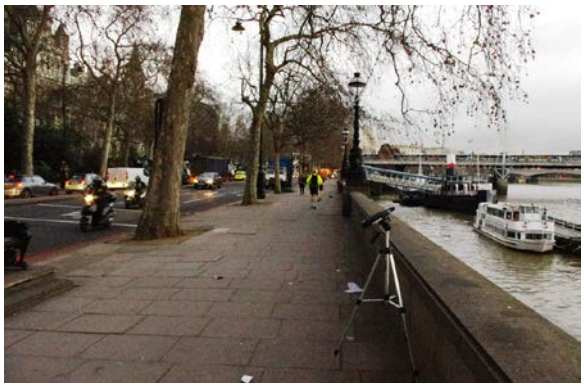
Vol 17 Plate G.3 Noise measurement location VEF03

Note: Within Jubilee Gardens looking south towards Westminster Bridge

Vol 17 Plate G.4 Noise measurement location VEF04

Note: On public footpath adjacent to Victoria Embankment looking east towards River Thames (Opposite existing location of the Hispaniola)

Vol 17 Plate G.5 Noise measurement location VEF05



Note: On public footpath adjacent to Victoria Embankment looking north towards Hungerford Bridge (Opposite proposed relocation of the Tattershall Castle)

G.2 Construction noise prediction results

G.2.1 The construction noise prediction methodology follows the methodology provided in Volume 2 Environmental assessment methodology. .

G.2.2 The assessment has been carried out based on a typical construction programme which has been used to calculate the average monthly noise levels.

G.2.3 Construction plant assumptions used in the assessment are presented in Vol 17 Table G.13.

G.2.4 Time histories of the predicted daytime construction noise levels across the programme of construction works are shown in Vol 17 Plate G.6 to Vol 17 Plate G.12.

Vol 17 Table G.13 Noise – typical construction plant schedule

Construction activity	Plant	Unit No(s)	Activity LWA (dB)	% on-time	Data Source	Description of equipment used in the assessment
Hoarding **General site equipment NOT applicable during this phase**	Excavator digging post holes for hoarding	1	105	30	BS5228-1[i]: Table C.2, Item 2	Tracked excavator, 71 t
	Generator 35kVA	1	94	100	BS5228-1: Table C.4, Item 78	Diesel generator,
	Circular saw cutting timber	1	113	10	BS5228-1: Table D.7, Item 71	Circular bench saw,
	Cutting equipment (diamond saw)	1	108	10	BS5228-1: Table C.4, Item 93	Angle grinder (grinding steel), 4.7 kg
	Nail guns for erection of hoarding	2	101	10	BS5228-1: Table C.4, Item 95	Handheld cordless nail gun, 15 to 50 mm nails
	Compressor 250cfm	1	93	30	BS5228-1: Table D.5, Item 5	Compressor for hand-held pneumatic breaker,
	Hand tools (e.g. drills and wrenches)	4	95	80	Estimated	Impact wrench and compressor,
	Hand-held percussive breaker	1	111	30	BS5228-1: Table C.1, Item 6	Hand-held pneumatic breaker,
	Waste collection via skip or tipper lorry	1	106	10	BS5228-1: Table C.8, Item 21	Skip wagon,
	Oxyaceteline cutting equipment	1	93	25	BS5228-1: Table C.3, Item 35	Hand-held gas cutter, 230 bar
Site set up	Oxyaceteline cutting	1	93	10	BS5228-1: Table C.3,	Hand-held gas cutter,

Construction activity	Plant	Unit No(s)	Activity LWA (dB)	% on-time	Data Source	Description of equipment used in the assessment
and general site	equipment				Item 35	230 bar
	Compressor 250cfm	1	102	50	BS5228-1: Table C.1, Item 8	Hydraulic breaker power pack, 63 kg/ 138 bar
	Cutting equipment (diamond saw)	2	108	10	BS5228-1: Table C.4, Item 93	Angle grinder (grinding steel), 4.7 kg
	Generator - 200 kVA	1	94	50	BS5228-1: Table C.4, Item 78	Diesel generator,
	JCB with hydraulic breaker	1	116	50	BS5228-1: Table C.5, Item 1	Backhoe Mounted Hydraulic Breaker
	Fuel delivery vehicle	1	104	5	BS5228-1: Table C.4, Item 15	Fuel tanker lorry,
	Telescopic Handler/FLT	1	99	30	BS5228-1: Table C.2, Item 35	Telescopic handler, 10 t
	Wheel wash	1	91	20	BS5228-1: Table C.3, Item 13	Water Jet Pump,
	Hiab lorry/crane	1	105	5	BS5228-1: Table C.4, Item 53	Lorry with lifting boom, 6 t
	Water settling/treatment	1	104	100	Measured	Dirty water plant,
	Dewatering Pump	1	96	100	BS5228-1: Table C.4, Item 88	Water pump,
	Well drilling Rig	1	107	50	Manufacturer	Bauer BBA well drilling rig,

Construction activity	Plant	Unit No(s)	Activity LWA (dB)	% on-time	Data Source	Description of equipment used in the assessment
Demolition General site equipment also applicable during this phase	Service Crane 25T mobile Crane	1	98	30	BS5228-1: Table C.4, Item 43	Wheeled mobile crane, 35 t
	22T Excavator c/w hydraulic hammer	1	118	20	BS5228-1: Table C.1, Item 9	Breaker mounted on excavator, 15 t, 1650 kg breaker
	Site dumper	1	104	30	BS5228-1: Table C.4, Item 3	Dumper, 7 t
	Pneumatic breaker	1	111	20	BS5228-1: Table C.1, Item 6	Hand-held pneumatic breaker,
	Vibrating rollers	2	101	50	BS5228-1: Table C.2, Item 38	Roller, 18 t
Cofferdam construction General site equipment also applicable during this phase note: piling and backfilling will be concurrent however the two	400 cfm compressor	2	93	50	BS5228-1: Table C.5, Item 5	Compressor for hand-held pneumatic breaker, 1 t
	150t crawler crane	1	103	100	BS5228-1: Table C.4, Item 52	Tracked mobile crane, 105 t
	Generator	1	94	100	BS5228-1: Table C.4, Item 78	Diesel generator,
	Oxyaceteline cutting equipment	1	93	10	BS5228-1: Table C.3, Item 35	Hand-held gas cutter, 230 bar
	Secant pile rig	1	107	30	BS5228-1: Table C.3, Item 16	Crane mounted auger
	Silent piler	1	91	70	BS5228-1: Table C.3, Item 9	Piling, 10 t

Construction activity	Plant	Unit No(s)	Activity LWA (dB)	% on-time	Data Source	Description of equipment used in the assessment
operations will be separated by some distance.	Vibratory piling rig	1	116	60	BS5228-1: Table C.3, Item 8	Vibratory piling rig, 52 t
	Jack-up barge	1	96	70	BS5228-1: Table C.3, Item 10	Piling power pack,
	Barges	1	100	100	Measured	Jack up barge,
	25t excavator	1	105	80	BS5228-1: Table C.2, Item 19	Tracked excavator, 25 t
	Plate compactors	2	108	10	BS5228-1: Table C.2, Item 41	Vibratory plate (petrol),
	Vibrating rollers	2	101	50	BS5228-1: Table C.2, Item 38	Roller, 18 t
Shaft sinking General site equipment also applicable during this phase	100t crawler crane	1	103	50	BS5228-1: Table C.4, Item 52	Tracked mobile crane, 105 t
	40t crawler crane	1	98	50	BS5228-1: Table C.4, Item 43	Wheeled mobile crane, 35 t
	Bentonite/ mixing plant	1	96	50	Measured data	Electric Bentonite pump,
	Ventilation fans	1	100	100	Measured	Ventilation fans,
	Long reach excavator	1	106	80	BS5228-1: Table C.7, Item 2	Long reach tracked excavator, 2136 t
	12t excavator with breaker	1	118	20	BS5228-1: Table C.1, Item 9	Breaker mounted on excavator,

Construction activity	Plant	Unit No(s)	Activity LWA (dB)	% on-time	Data Source	Description of equipment used in the assessment
	25t excavator	1	105	80	BS5228-1: Table C.2, Item 19	Tracked excavator, 25 t
	Dumper	1	104	50	BS5228-1: Table C.4, Item 3	Dumper, 7 t
	Waste collection via skip or tipper lorry	1	106	10	BS5228-1: Table C.8, Item 21	Skip wagon,
Connection tunnel construction General site equipment also applicable during this phase	100t crawler crane	1	103	50	BS5228-1: Table C.4, Item 52	Tracked mobile crane, 105 t
	Service Crane 40T mobile Crane	1	98	25	BS5228-1: Table C.4, Item 43	Wheeled mobile crane, 35 t
	Grout mixer including silos and feeders	1	108	100	BS5228-1: Table D.6, Item 13	Grout and mixer,
	Dumper	1	104	25	BS5228-1: Table C.4, Item 3	Dumper, 7 t
	Ventilation fans	1	100	100	Measured	Ventilation fans,
	Loading shovel	1	107	30	BS5228-1: Table C.2, Item 26	Wheeled loader,
	Mains substation	1	94	100	BS5228-1: Table C.4, Item 78	Diesel generator,
	Waste collection via skip or tipper lorry	1	106	10	BS5228-1: Table C.8, Item 21	Skip wagon,
Shaft	100t crawler crane	1	103	50	BS5228-1: Table C.4,	Tracked mobile crane,

Construction activity	Plant	Unit No(s)	Activity LWA (dB)	% on-time	Data Source	Description of equipment used in the assessment
secondary lining					Item 52	105 t
General site equipment also applicable during this phase	Service Crane 40T mobile Crane	1	98	25	BS5228-1: Table C.4, Item 43	Wheeled mobile crane, 35 t
	Service crane 25T mobile crane	1	98	25	BS5228-1: Table C.4, Item 43	Wheeled mobile crane, 35 t
	Concrete deliveries (discharging)	1	99	20	BS5228-1: Table C.4, Item 19	Cement mixer truck (idling),
	Concrete pump	2	95	20	BS5228-1: Table C.4, Item 24	Concrete pump + cement mixer truck (discharging), 8 t / 350 bar
Piling for culvert support	100t crawler crane	1	103	50	BS5228-1: Table C.4, Item 52	Tracked mobile crane, 105 t
	25t mobile crane	1	98	50	BS5228-1: Table C.4, Item 43	Wheeled mobile crane, 35 t
	Vibratory piling rig	1	116	80	BS5228-1: Table C.3, Item 8	Vibratory piling rig, 52 t
Culvert works	100t crawler crane	1	103	50	BS5228-1: Table C.4, Item 52	Tracked mobile crane, 105 t
General site equipment also applicable during this	Service crane 25T mobile crane	1	98	25	BS5228-1: Table C.4, Item 43	Wheeled mobile crane, 35 t
	25t excavator	1	105	50	BS5228-1: Table C.2, Item 19	Tracked excavator, 25 t

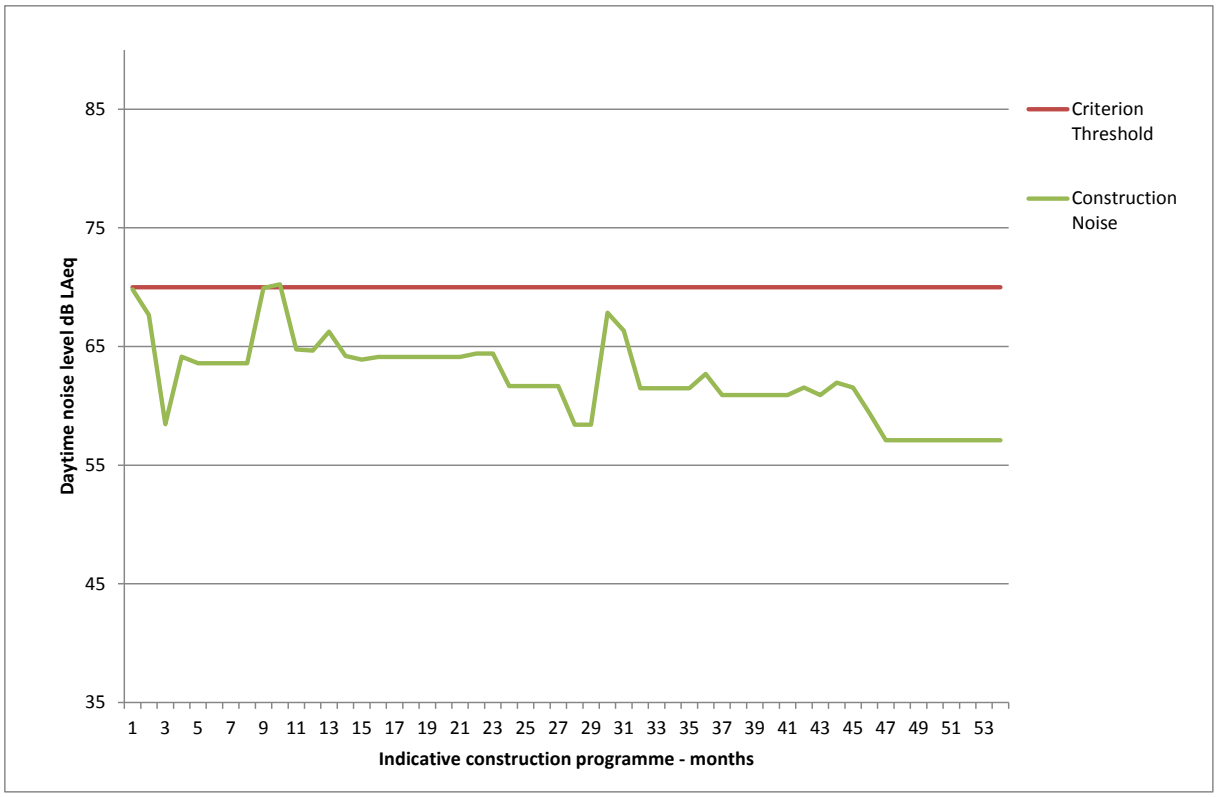
Construction activity	Plant	Unit No(s)	Activity LWA (dB)	% on-time	Data Source	Description of equipment used in the assessment
phase	Dumper	1	104	50	BS5228-1: Table C.4, Item 3	Dumper, 7 t
	Concrete deliveries (discharging)	1	103	20	BS5228-1: Table C.4, Item 18	Cement mixer truck (discharging),
	Concrete boom pump	1	108	20	BS5228-1: Table C.4, Item 29	Truck mounted concrete pump + boom arm, 26 t
	Fixed and portable concrete vibrators	4	106	20	BS5228-1: Table C.4, Item 33	Poker vibrator,
	Hand tools (e.g. drills and wrenches)	4	95	80	Estimated	Impact wrench and compressor,
Landscaping General site equipment NOT applicable during this phase	25t excavator	1	105	50	BS5228-1: Table C.2, Item 19	Tracked excavator, 25 t
	Dumper	1	104	70	BS5228-1: Table C.4, Item 3	Dumper, 7 t
	Telescopic Handler/FLT	1	99	30	BS5228-1: Table C.2, Item 35	Telescopic handler, 10 t
	Hiab lorry/crane	1	105	5	BS5228-1: Table C.4, Item 53	Lorry with lifting boom, 6 t
	Compressor for hand-held breaker	1	93	10	BS5228-1: Table D.5, Item 5	Compressor for hand-held pneumatic breaker,
	Hand-held percussive breaker	1	111	10	BS5228-1: Table C.1, Item 6	Hand-held pneumatic breaker,

Construction activity	Plant	Unit No(s)	Activity LWA (dB)	% on-time	Data Source	Description of equipment used in the assessment
	Plate compactors	2	108	10	BS5228-1: Table C.2, Item 41	Vibratory plate (petrol),
	Vibrating rollers	1	101	20	BS5228-1: Table C.2, Item 38	Roller, 18 t

Note: This schedule provides an illustration of typical plant that could be used in the construction of the Thames Tideway Tunnel at this site. The appointed Contractor must comply with section 6 of the CoCP but may vary the method and plant to be used. This schedule therefore represents the most reasonable assumption for the assessment that can be made at this stage.

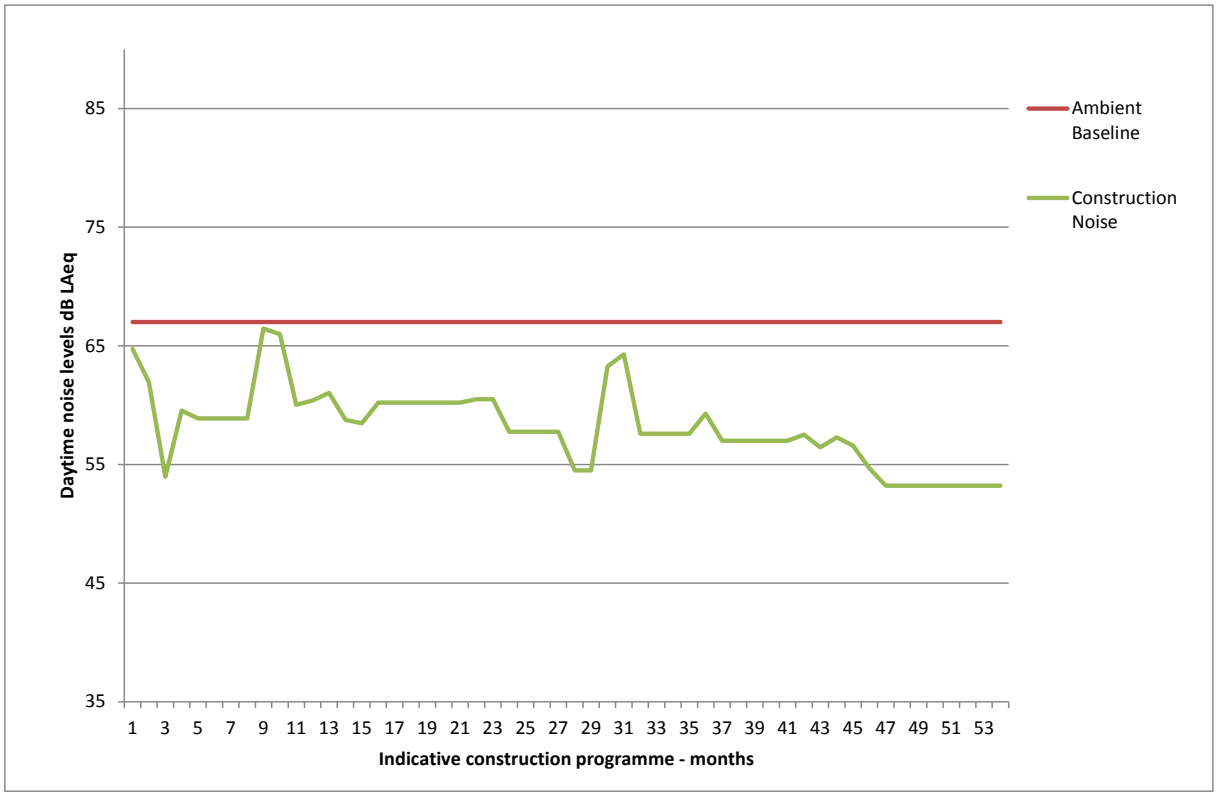
G.2.5 The predicted construction noise over time at each receptor is shown in the figures below. It should be noted that these representations are for the worst-case scenarios for noise exposure at the upper floors. For comparison with the construction noise, the figures also show either the potential significance criterion threshold for residential receptors, or the ambient noise level. This comparison is discussed in the main assessment text. The night-time noise levels have also been assessed for the short period of night-time works; these results are described in the main assessment text and not presented here.

Vol 17 Plate G.6 Average monthly daytime noise level over duration of construction - Whitehall Court (VE1)

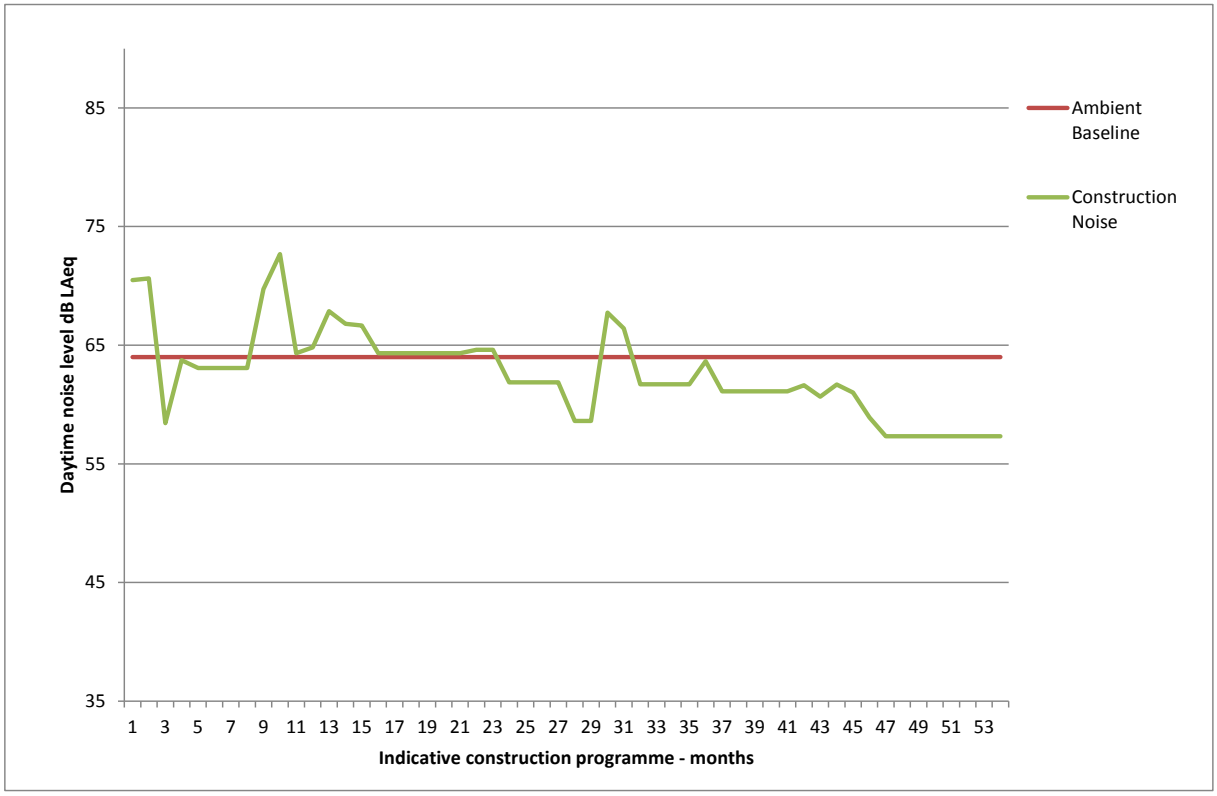


Vol 17 Plate G.7 Average monthly daytime noise level over duration of construction - Whitehall Gardens (VE2)

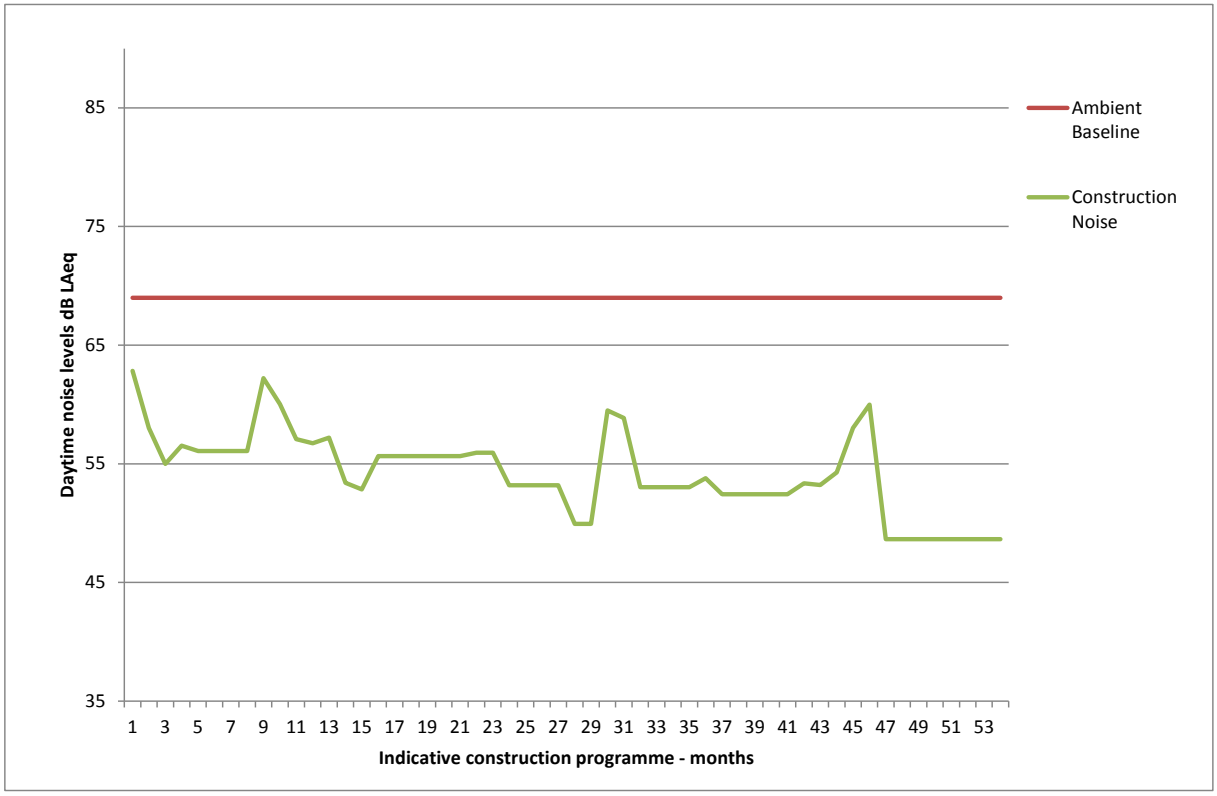
Vol 17 Plate G.8 Average monthly daytime noise level over duration of construction - Jubilee Gardens (VE3)



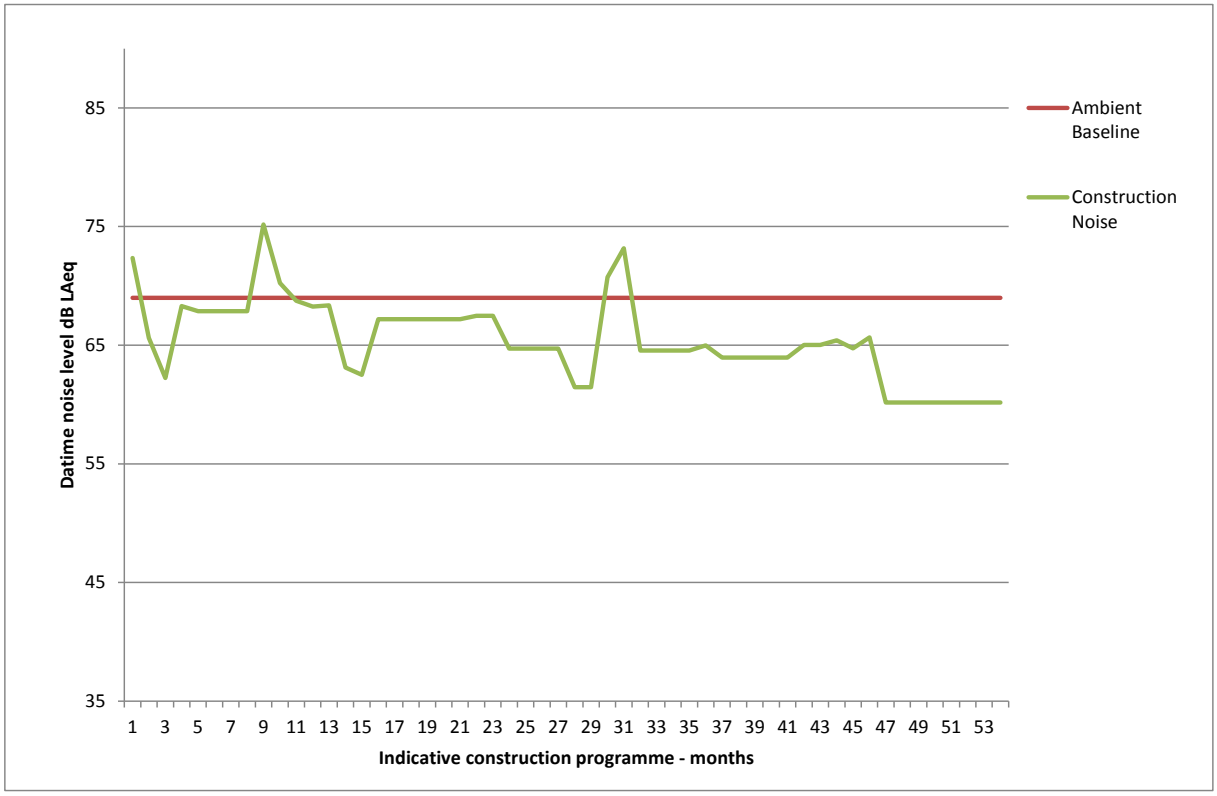
Vol 17 Plate G.9 Average monthly daytime noise level over duration of construction - Ministry of Defence (VE4)



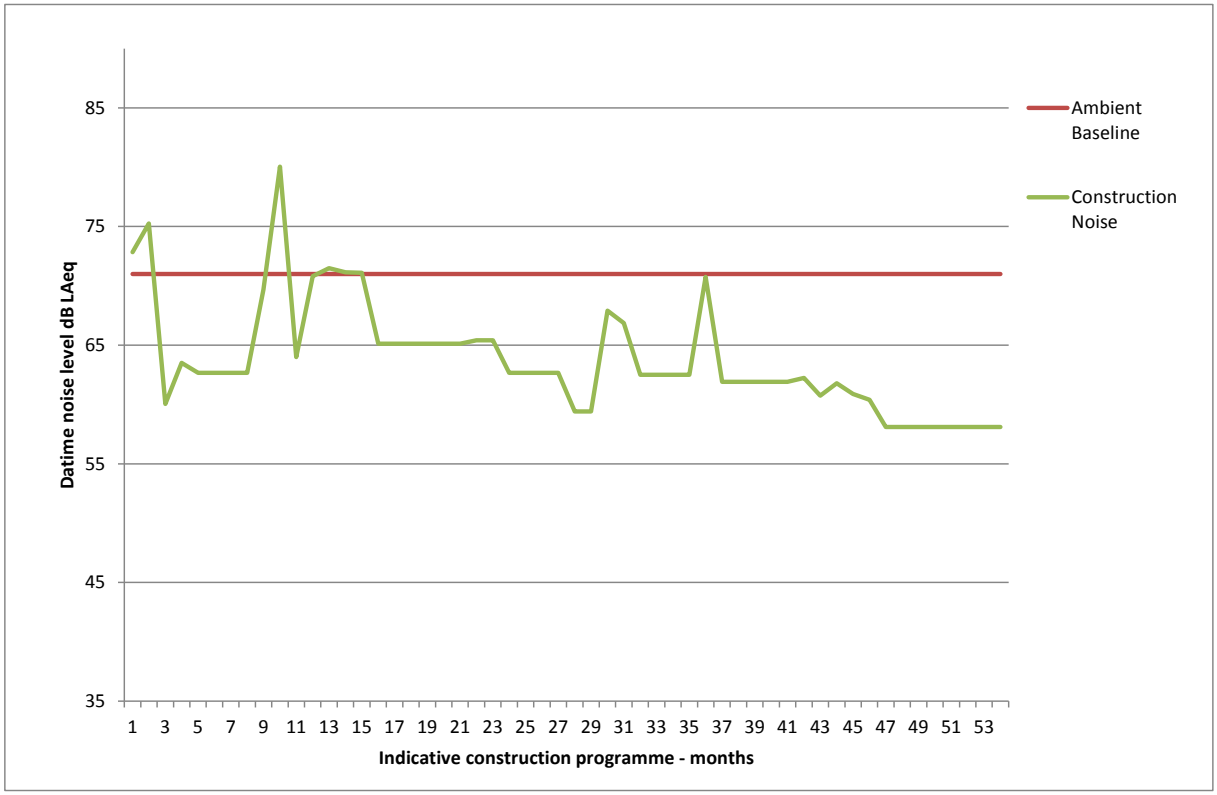
Vol 17 Plate G.10 Average monthly daytime noise level over duration of construction –Playhouse Theatre (VE5)



Vol 17 Plate G.11 Average monthly daytime noise level over duration of construction –The Hispaniola (VE6)



Vol 17 Plate G.12 Average monthly daytime noise level over duration of construction –Tattershall Castle (VE7)



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[i] BRITISH STANDARDS INSTITUTION, *BS 5228 Code of Practice for Noise and Vibration Control on Open Construction Sites*, British Standards Institution (2009)

Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

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Appendix H: Socio-economics

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Appendix H: Socio-economics

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Appendix H: Socio-economics

H.1 Baseline community profile

H.1.1 The community profile is based on both Output Area (OA) and local authority level data from the Office of National Statistics (ONS). The data have been obtained from four sources: Census 2001[1] (the last census for which data are available[i]), Department of Communities and Local Government Deprivation Indices 2010[2], London Public Health Observatory 2012[3], and the Network of Public Health Observatories 2011[4] (see Volume 2 Methodology). Data is grouped according to those 'protected characteristics'[ii] or groups which are relevant for consideration in relation to this socio-economic impact assessment. This baseline community profile provides context for this socio-economic assessment.

H.1.2 On the basis of likely impacts on receptors in this socio-economic assessment, the community profile examines the 'immediate area' surrounding the construction site (ie, within an assessment area of 250m) the 'wider local area' (ie, within an assessment area of 1km), the overall borough level (which in this case is the City of Westminster) and Greater London.

H.1.3 The main protected characteristic group concentrated within the immediate area surrounding the proposed construction site is persons aged over 65 years.

H.1.4 The main protected characteristic groups concentrated[iii] within the wider local area surrounding the proposed construction site are persons of Black and Mixed ethnicity.

Resident population

H.1.5 The resident population was approximately 150 people within 250m of the site and 10,475 within 1km at the time of the last census.

Gender and age

H.1.6 Of the total population within 250m 55.6% residents are male, slightly higher than within 1km (51.7%) where males are also predominant.

H.1.7 Vol 17 Table H.1 outlines age breakdown by assessment area, it illustrates that the proportion of under 16 year olds within 250m (8.3%) is somewhat lower than within 1km (10.6%), and moderately lower than the proportion of under 16 year olds within the City of Westminster (13.5%). The proportion of under 16 year olds at a Greater London level (20.2%) is considerably higher than within the above areas.

[i] Census 2001. This type of data for the 2011 Census had not been released at the time of the assessment.

[ii] The Equalities Act 2010 defines 'protected characteristics' as: age, disability, gender reassignment, marriage and civil partnership, pregnancy and maternity, race, religion or belief, sex, and sexual orientation. Of these characteristics, age, disability, race and religion are relevant for consideration in relation to this socio-economic impact assessment.

[iii] In this instance 'concentrated' refers to the occurrence of a particular protected characteristic group, the proportion of which is much higher than borough wide proportions.

H.1.8 Within 250m, over 65 year olds (23.3%) account for almost a quarter of the residential population. This is considerably higher than the proportion within 1km (10.6%), the borough (12.4%) and Greater London (12.4%), where the proportion of over 65 year olds is broadly in line.

Vol 17 Table H.1 Socio-economics - age breakdown by assessment area

Age group	Assessment area			
	Immediate area (250m)	Wider local area (1km)	Borough wide (City of Westminster)	Greater London
Under 16 years old	8.3%	12.1%	13.5%	20.2%
Over 65 years old	23.3%	10.6%	12.4%	12.4%

Ethnicity

H.1.9 Vol 17 Table H.2 outlines ethnicity by assessment area, showing that within 250m, residents are predominantly of White (91.6%) ethnicity, with Black and Minority Ethnic (BME) groups comprising the remaining 8.4% of residents.

H.1.10 The proportion of White residents within 250m (91.6%) is moderately higher than within 1km (72.3%), at a borough wide (73.2%) and Greater London level (71.2%).

H.1.11 The proportion of BME residents within 1km (27.7%), the City of Westminster (26.8%) and across Greater London (28.8%) is broadly in line with each other and almost four times as high as within 250m (8.4%).

Vol 17 Table H.2 Socio-economics - ethnicity by assessment area

Ethnicity	Assessment area			
	Immediate area (250m)	Wider local area (1km)	Borough wide (City of Westminster)	Greater London
White	91.6%	72.3%	73.2%	71.2%
BME	8.4%	27.7%	26.8%	28.8%
Asian	0.3%	6.6%	8.9%	12.1%
Black	1.4%	11.1%	7.5%	10.9%
Other	6.1%	6.6%	6.4%	2.7%
Mixed	0.6%	3.4%	4.1%	3.2%

Note: The figure for BME data presented in Table H.2 is the sum of data for Asian, Black, Other and Mixed ethnicities.

Religion and belief

H.1.12 Within 250m, 1km and at a borough wide level, residents identifying as Christian are the largest religious group at 62.6%, 57.3% and 55.1% respectively. Within 250m of the site, Jewish residents are the second most predominant religious group (5.9%) approximately three times higher than the Greater London average (2.1%).

H.1.13 Within 1km, Muslims make up 6.2% of the population. This proportion is considerably lower than the borough wide level (11.8%) but much higher than the proportion within 250m (1.6%).

Health indicators

H.1.14 Vol 17 Table H.3 outlines health indicators by assessment area, noting that the proportion of residents suffering from a long term limiting illness within 250m of the site (14.0%) is slightly lower than the proportion within 1km (15.2%), the City of Westminster (14.8%) and Greater London (15.5%).

H.1.15 The proportion of disability allowance claimants within 1km (4.8%) and at a borough wide level (5.1%) is broadly in line with the Greater London level (4.5%). However, the proportion of disability allowance claimants within 250m (1.0%) is considerably lower than within all of the above assessment areas.

Vol 17 Table H.3 Socio-economics - health indicators by assessment area

Health indicator	Assessment area			
	Immediate area (250m)	Wider local area (1km)	Borough wide (City of Westminster)	Greater London
Long term limiting sick	14.0%	15.2%	14.8%	15.5%
Disability living allowance	1.0%	4.8%	5.1%	4.5%

H.1.16 Levels of adult obesity fall within the lowest quintile (ie, the lowest being the best) relative to Greater London. Contrastingly, child obesity falls within the highest quintile (ie, the highest being the worst) relative to all Greater London boroughs.

H.1.17 Data available at borough wide level only indicates that adults within the City of Westminster have amongst the highest level of physical activity relative to adults across Greater London. In contrast children the level of physical activity amongst children places the City of Westminster within the second lowest quintile (ie, the lowest being the worst) relative to Greater London.

H.1.18 Death rates by cancer, heart disease, circulatory disease and strokes within the Middle Layer Super Output Area (MSOA)[iv5] are all in the lowest quintile (ie, the lowest being the best) relative to Greater London. Deaths by respiratory disease are slightly more prevalent and as such the local MSOA ranks within the second lowest quintile.

H.1.19 For male and female life expectancy, the local MSOA falls within in the highest quintile (ie, the highest being the best) relative to Greater London. Average life expectancy for both male and female residents is 84.9 to 93.1 years old.

Lifestyle and deprivation indicators

H.1.20 Vol 17 Table H.4 outlines lifestyle and income deprivation indicators by assessment area, showing that a moderately high proportion of households within 250m (50.9%) do not own cars, in comparison with the Greater London level of 37.5%. This proportion increases considerably within 1km to 66.6% of households without cars.

H.1.21 It is notable that within 250m there is no recorded income deprivation or overall deprivation. Levels of deprivation[v] measured by income deprivation within 1km (6.8%) are considerably lower than the borough wide (21.5%) and Greater London (30.8%) levels. Overall deprivation within 1km (9.7%) is also considerably lower than the borough wide (18.3%) and Greater London (24.5%) levels.

Vol 17 Table H.4 Socio-economics – lifestyle and income deprivation levels by assessment area

Indicator	Assessment area			
	Immediate area (250m)	Wider local area (1km)	Borough wide (City of Westminster)	Greater London
No car households	50.9%	66.6%	56.4%	37.5%
Income	0.0%	6.8%	21.5%	30.8%
Overall	0.0%	9.7%	18.3%	24.5%

[iv] MSOAs are areas determined by the Office of National Statistics (ONS) to collect local area statistics. MSOAs have a minimum size of 5,000 residents and 2,000 households. MSOAs have an average population size of 7,200 residents.

[v] Income deprivation and overall deprivation in this instance both refer to the percentage of the population which fall within the top 20% of deprived areas nationally. Percentages therefore refer to the proportion of residents within each assessment area who fall within the highest quintile of deprivation within England.

H.2 Baseline economic profile

H.2.1 This section presents a profile of the economy local to the proposed construction site at Victoria Embankment Foreshore.

H.2.2 Data are presented for the geographical area within a radius or 'catchment' of approximately 250m from the boundary of the Limits of land to be acquired or used (LLAU) of the project site. Data are also provided at the overall borough level (which in this case is the City of Westminster) and for Greater London.

H.2.3 Data is sourced from Experian's National Business Database (2012)[6], which draws primarily on regularly updated records from Companies House[vi].

Employment and Businesses

H.2.4 Within 250m of the site there are approximately 13,900 jobs.[vii] Vol 17 Table H.5[viii] below illustrates the breakdown of employment by sector, based on the UK Standard Industrial Classification (SIC) 2007[7]. It shows data for those sectors accounting for more than 4% of total employment within approximately 250m. It can be seen that:

a. Public Administration and Defence account for 40% of employment within 250m, which is considerably more than within the City of Westminster (4%) and within Greater London as a whole (2%).

b. Professional, Scientific and Technical Services account for 33% of employment within 250m, considerably higher than within both the City of Westminster (15%) and Greater London as a whole (11%).

c. Accommodation and Food Services Activities account for 12% of employment within 250m, somewhat lower than within the City of Westminster (14%) and somewhat higher than Greater London (8%).

d. Wholesale and Retail Trade Activities account for 4% of employment within 250m, considerably lower than within both the City of Westminster (14%) and Greater London (16%).

[vi] Information on employees and businesses reflects aggregated data for seven digit post-code units falling wholly or partially within a 250m boundary of the LLAU. This includes post code units on the opposite side of the River Thames, if relevant. Please refer to Volume 2 Appendix H for further details.

[vii] Employees data reflect a head count of workers on-site rather than Full Time Equivalent (FTE) jobs. While employee figures are mostly based on actual reported data, a proportion is based on modelled data.

[viii] Data in tables rounded to nearest whole percentage and do not always sum due to rounding.

Vol 17 Table H.5 Socio-economics – employment by top four sectors (2012)

	Assessment area		
Sector (Standard Industrial Code 2007)	**Immediate area (250m)**	**Borough wide (City of Westminster)**	**Greater London**
Public Administration and Defence; Compulsory Social Security	40%	4%	2%
Professional, Scientific and Technical Activities	33%	15%	11%
Accommodation and Food Service Activities	12%	14%	8%
Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	4%	14%	16%
Other (including unclassified)	11%	53%	63%

H.2.5 Within approximately 250m of the site there are approximately 280 businesses (defined here as business locations[ix]). Generally the number of businesses by sector within 250m follows a somewhat different pattern to the breakdown of employment by sector set out in Vol 17 Table H.5, with Public Administration and Defence accounting for 1% of businesses, and Professional, Scientific and Technical Activities accounting for 12%. Accommodation and Food Service Activities account for 16% of businesses with Wholesale and Retail Trade businesses accounting for 11%.

H.2.6 Vol 17 Table H.6 below illustrates the size of businesses in terms of the number of employees on site. At all geographical levels, businesses within the smallest size band (1 to 9 employees) account for the greatest proportion. However, there are a greater proportion of larger businesses within approximately 250m of the site than within the wider geographical areas.

H.2.7 Within approximately 250m, 64% of business units have 1 to 9 employees on site, compared to 78% within the City of Westminster and 88% within Greater London. Businesses with 25 or more employees account for 14% of all businesses within 250m of the site, considerably higher than within both the City of Westminster (7%) and Greater London as a whole (4%). The two businesses recorded within the Public Administration and Defence sector employ over 250 employees each and together account for 40% of employment within 250m.

H.2.8 For the sectors accounting for the greatest proportions of jobs and businesses within 250m, businesses with 1 to 9 employees account for the majority (64%). However, all of the Public Administration and Defence businesses have more than 250 employees, and 33% of Accommodation

[ix] This count relates to business 'locations' or 'units'; an enterprise may have a number of business locations / units. It includes private sector, public sector and voluntary sector / charitable entities.

and Food Service Activities businesses have over 25employees. Within the Professional, Scientific and Technical Activities sector, 50% of businesses employ 1 to 9 employees, with 77% of Wholesale and Retail Trade businesses employing this number.

Vol 17 Table H.6 Socio-economics - businesses by size band (employees at site)

Assessment area / sector	Size Band (employees at site)					
	1-9	**10-24**	**25-49**	**50-99**	**100-249**	**250+**
Immediate area (250m)	64%	23%	7%	4%	1%	2%
Public Administration and Defence	0%	0%	0%	0%	0%	100%
Accommodation and Food Service Activities	24%	42%	20%	7%	4%	2%
Professional, Scientific and Technical Activities	50%	29%	6%	12%	0%	3%
Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	77%	16%	3%	0%	0%	3%
Borough wide (City of Westminster)	78%	15%	3%	2%	1%	1%
Greater London	88%	8%	2%	1%	1%	0%

H.3 Baseline usage surveys

H.3.1 Please refer to Volume 2 Appendix H for details on the methodology used for the usage surveys and subsequent analysis.

Survey dates and times

H.3.2 Surveys were undertaken as follows.

Summer

e. Monday 1st August 2011, 12pm to 1pm, 2pm to 3pm and 4pm to 5pm (sunny, 26°C)

f. Sunday 14th August 2011, 2pm to 3pm and 4pm to 5pm (sunny, 19°C)

Autumn

g. Tuesday 4th October 2011, 12pm to 1pm, 2pm to 3pm and 4pm to 5pm (partly cloudy, 18°C)

h. Saturday 15th October 2011, 1pm to 2pm and 3pm to 4pm (sunny, 16°C)

Survey points

H.3.3 The Survey Plan (Vol 17 Figure H.1, see separate volume of figures) shows the location of the survey points listed in Vol 17 Table H.7 below.

Vol 17 Table H.7 Socio-economics – survey points and duration of survey period

Name	Location	On-site survey times	Frequency
Survey point 1	Thames Path: at proposed construction site	20 minutes	Every 2 hours
Survey point 2	Thames Path: at Embankment Pier	10 minutes	Every 2 hours

Key findings and observations

Survey point 1 – Thames Path: at proposed construction site

i. Observed to be very well used, especially during weekday lunch times and in the late afternoon (between 4pm and 5pm).

j. A recorded peak of 840 users per hour during a summer weekday late afternoon, with lower usage recorded on autumn weekdays.

k. During office lunch hours between 12pm and 2pm and between 4pm and 5pm, the use of the Thames Path was predominantly by walkers (on average 80% to 90%) and joggers (on average 15%).

l. At other times, walking accounted for an even greater proportion of usage (on average 95%). Users were a mix of local office workers and tourists.

m. The Thames Path was well used on weekends during both summer and autumn with an estimated peak of 1,125 users per hour recorded in the summer.

n. Based on the appearance of walkers (eg, carrying cameras, travelling in large groups, speaking non-English languages and the manner in which they took note of nearby sights) the Thames Path appeared to be heavily used by tourists; both domestic and international. Direct interviews were not conducted to confirm this observation.

o. Over the course of the survey programme the majority (on average 75% to 85%) of users recorded were White, though the proportion of users from Black and Minority Ethnic (BME) groups increased during mid-afternoons and on weekends.

p. On average, 80% of all users and over 90% of joggers around lunchtimes and late afternoons were young adults (18 to 39 years old). During mid-afternoons, the proportion of older adults (40 to 59 and 60+ years old) increased to around 30% to 35%.

q. The seating located along the path was used at least 50% of the time.

H.3.4 See Vol 17 Plate H.1, Vol 17 Plate H.2 and Vol 17 Table H.8 for further details.

Survey point 2 – Thames Path: Embankment Pier

a. User numbers were somewhat lower than those recorded at point 1 in summer, though they were more variable during autumn survey periods, indicating that the Jubilee Bridge to Westminster Bridge route is more popular.

b. On weekends, user numbers were broadly similar to those at point 1, with a peak of around 880 users per hour (around lunchtime) recorded during the summer survey.

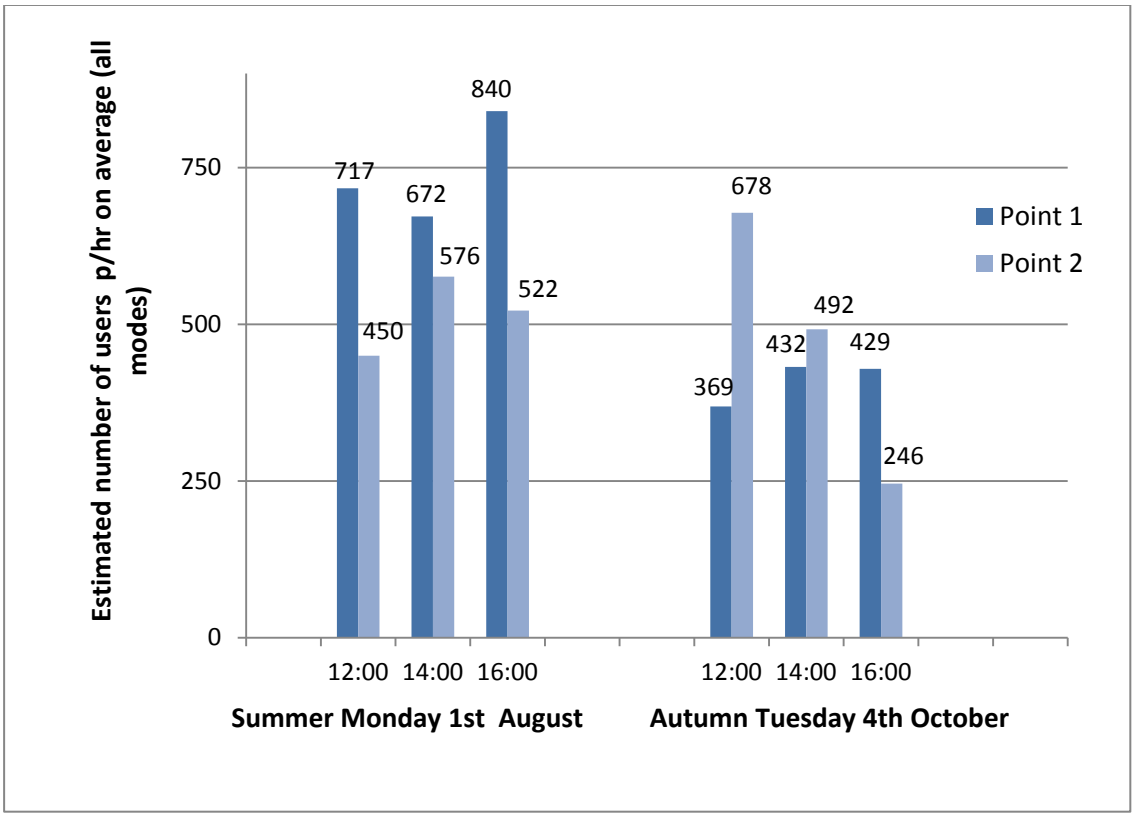
c. It appeared, again based on similar user characteristics to those noted above, that tourists made up a significant proportion of users.

d. Over the course of the survey programme the majority of users (on average 75% to 85%) were White, however usage by BME groups increased during mid-afternoon survey periods and at weekends.

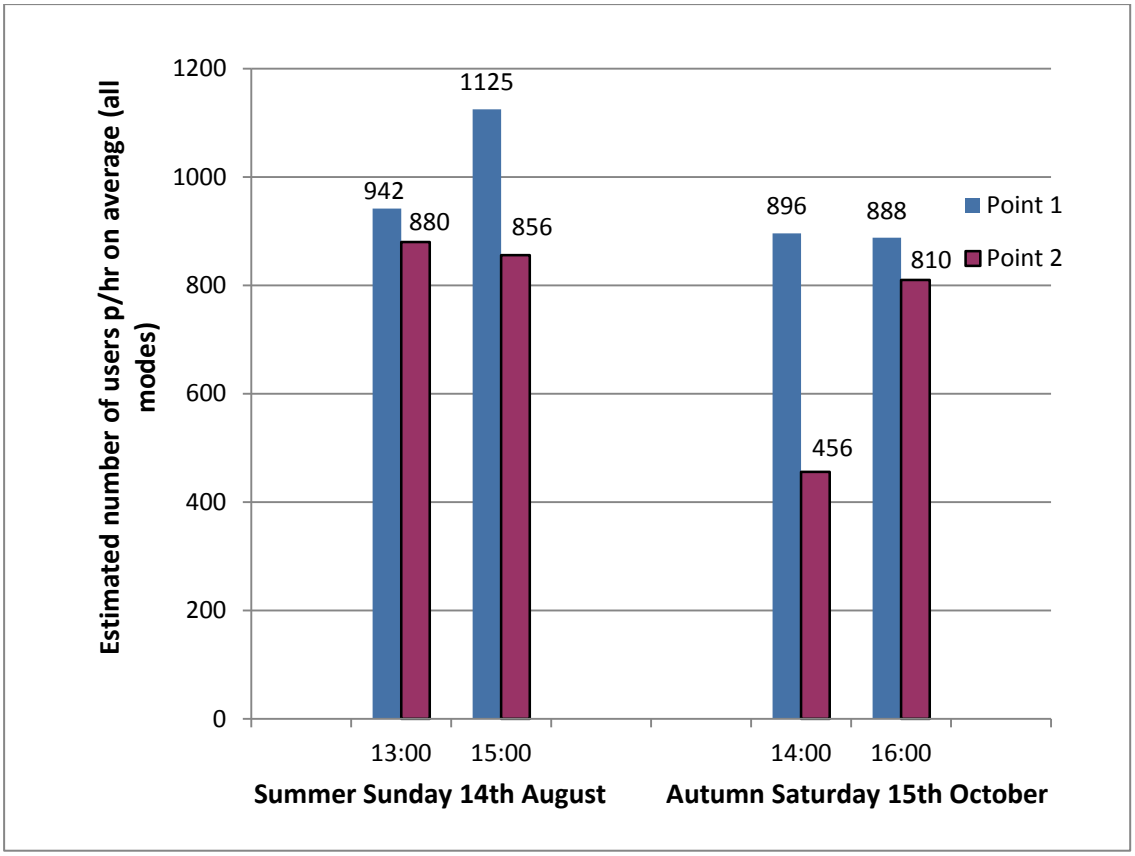
e. Other characteristics relating to the type, ethnicity and age of users observed here were similar to those observed at point 1.

f. See Vol 17 Plate H.1, Vol 17 Plate H.2 and Vol 17 Table H.8 below for further details.

Vol 17 Plate H.1 Socio-economics – Thames Path usage (weekdays)



Vol 17 Plate H.2 Socio-economics –Thames Path usage (weekends)



Vol 17 Table H.8 Socio-economics – approximate ethnicity of Thames Path users

Date	Ethnicity (approximate %)			
	Black	E. Asian	S. Asian	White
Summer				
Monday 1st August	4	8	8	80
Sunday 14th August	5	10	10	75
Autumn				
Tuesday 4th October	5	5	5	85
Saturday 15th October	6	7	7	80

Other findings

a. Momentary observations of Victoria Embankment Gardens, to the west of the busy Victoria Embankment carriageway, noted that Whitehall Garden spaces were generally well used on both weekends and weekdays.

b. Whitehall Garden was primarily used by people sitting around the perimeter of the garden and by people strolling through it.

c. Momentary observations of the Hispaniola and Tattershall Castle floating restaurants/bar noted that both were well used for outdoor dining and drinking on the two weekend surveys with few available outdoor seats on both days. They were busier after 2pm than before.

d. Weekday surveys recorded markedly fewer patrons, although both restaurants hosted outdoor patrons in the late afternoon of the summer survey.

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[1] ONS. *Neighbourhood Statistics* (2001). Available at: http://neighbourhood.statistics.gov.uk/dissemination/

[2] Department for Communities and Local Government. *Index of Multiple Deprivation 2010* (2010). Available at: http://www.communities.gov.uk/communities/research/indicesdeprivation/deprivation10/

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Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

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Appendix I: Townscape and visual

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I.1 Introduction

I.1.1 Construction and operational effects assessments at this site for this topic do not require the provision of any supporting information, so this appendix is intentionally empty.

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Appendix J: Transport

J.1 Introduction

J.1.1 Construction and operational effects assessments at this site for this topic do not require the provision of any supporting information, so this appendix is intentionally empty.

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Appendix K: Water resources - groundwater

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Appendix K: Water resources – groundwater

K.1 Geology

K.1.1 A summary of the anticipated geological succession at the Victoria Embankment Foreshore site is shown in Vol 17 Table K.1.

Vol 17 Table K.1 Groundwater − anticipated geological succession

Period	Series	Group	Formation
Quaternary	Holocene	Superficial deposits	Made ground
			Alluvium
	Pleistocene		River Terrace Deposits
Palaeogene	Eocene	Thames	London Clay
			Harwich
	Palaeocene	Lambeth	Upper Shelly Beds
			Upper Mottled Beds
			Laminated Beds
			Lower Shelly Beds
			Mid-Lambeth Hiatus*
			Lower Mottled Beds
			Upnor

** Not a Formation but an important depositional feature*

K.1.2 The superficial and solid geology in the vicinity of the site, as published by the British Geological Survey (BGS)[1], is shown in Vol 17 Figure 13.4.1 and Vol 17 Figure 13.4.2 respectively (see separate volume of figures).

K.1.3 The ground investigation undertaken for the Thames Tideway Tunnel project has involved drilling boreholes both on the banks and within the main river channel for the purposes of understanding the geology and hydrogeology within the assessment area. The depths and thicknesses of geological layers are based on ground investigation boreholes drilled on site; within 75m of the site in the case of SA1066D and the within river borehole SR2050. In addition, a number of other boreholes have been used to assess the lateral continuity of the site geology. The locations of boreholes around the site are shown in Vol 17 Figure 13.4.1 (see separate volume of figures). The depths and thicknesses of geological layers encountered are summarised in Vol 17 Table K.2.

Vol 17 Table K.2 Groundwater − anticipated ground conditions

Formation	Top elevation* (mATD)**	Depth below river bed (m)	Thickness (m)
Alluvium	100.00	0.00	3.00
River Terrace Deposits	97.00	3.00	3.10
London Clay			
B	93.90	6.10	8.40
A3ii	85.50	14.50	9.90
A3i	75.60	24.40	2.50
A2	73.10	26.90	11.85
Harwich Formation	61.00	38.75	0.48
Lambeth Group			
Sand Unit	60.52	39.23	2.85
UMB	57.67	42.08	4.20
LtB/LSB	53.47	46.28	1.40
LMB	52.07	47.68	5.25
UPN (Gv)	46.82	52.93	1.90
UPN	44.92	54.83	2.35

** Top elevation of over-water boreholes is approximately 4m below assumed ground level*
***mATD = metres above tunnel datum. A commonly used term for sub-surface construction projects, which defines height above a datum set at -100mAOD (above Ordnance Datum).*
UMB–Upper Mottled Beds; LtB–Laminated Beds; LSB-Lower Shelly Beds; LMB-Lower Mottled Beds; UPN (Gv)-Upnor Formation (Gravel); UPN-Upnor Formation

K.1.4 The combined sewer overflow (CSO) drop shaft at the Victoria Embankment Foreshore site would extend down to approximately 55.03mATD and would pass through the Alluvium, River Terrace Deposits, London Clay Formation and a sand unit within the Lambeth Group and be founded in the Upper Mottled Beds (Lambeth Group). The base slab would extend to approximately 52.03mATD and would be founded in the top of the Lower Mottled Beds (Lambeth Group).

K.1.5 The interception chamber and culvert approximately 9.4m, as assumed for the purpose of this assessment, would extend down to 95mATD into the River Terrace Deposits. The connection tunnel would be constructed within the Upper Mottled Beds and the overlying sand unit of the Lambeth Group.

K.1.6 The Alluvium, comprising of silty clay and clayey silt with occasional scattered pebbles and granules, is expected to be 3m thick at the Victoria Embankment Foreshore site.

K.1.7 The River Terrace Deposits are formed of extensive alluvial sand and gravel deposits laid down in river terraces by a braided river system of

approximately 5 km width, in river terraces since the Anglian glaciation. The River Terrace Deposits are expected to be 3.1m thick at the Victoria Embankment Foreshore site.

K.1.8 The London Clay is described by the BGS as "fine, sandy, silty clay/silty clay, glauconitic at base"[2] and is comprised of clayey silt beds at the Victoria Embankment Foreshore site. The London Clay is divided into sub-units referred from oldest to youngest as A to E, with some of these sub-units dividing further, for example A2, A3i-iii, B in decreasing age order. The London Clay Formation is expected to be 32.65m thick at the Victoria Embankment Foreshore site.

K.1.9 The Harwich Formation comprises of fine-grained glauconitic sand and rounded black flinty pebble beds, commonly deposited in a series of superimposed channels. The Harwich Formation is expected to be 0.48m thick at the Victoria Embankment Foreshore site.

K.1.10 A significant sand unit has been recorded at the junction between the Harwich Formation and Upper Mottled Beds, up to 2.85m thick, in the ground investigation boreholes. The lateral extent of this sand unit is unknown.

K.1.11 The Upper Mottled Beds (UMB) of the Lambeth Group comprises silty clay and clay, generally un-bedded, fissured and blocky, with up to 50% silt and sand and is expected to be 4.2.m thick at the Victoria Embankment Foreshore site.

K.1.12 The Laminated Beds (LtB)/ Lower Shelly Beds (LSB) comprises thinly interbedded fine to medium grained sand, silt and clay with shells, with sand lenses found locally and dark grey to black clay with abundant shells respectively. These units in combination are expected to be 1.4m thick at the Victoria Embankment Foreshore site.

K.1.13 The Lower Mottled Beds (LMB) of the Lambeth Group comprises silty clay and clay, generally un-bedded, fissured and blocky and is expected to be 5.25m thick at the Victoria Embankment Foreshore site.

K.1.14 The Upnor Formation (UPN) is a variably bioturbated fine- to medium-grained sand with glauconite, rounded flint pebbles and minor clay, with distinctive pebble beds at the base and top (UPN (Gv)). The Upnor Formation is expected to be 4.25m thick at the Victoria Embankment Foreshore site.

K.2 Hydrogeology

K.2.1 A summary of the anticipated hydrogeological conditions at the Victoria Embankment Foreshore site is shown in Vol 17 Table K.3.

Vol 17 Table K.3 Groundwater − anticipated hydrogeological units

Group	Formation	Hydrogeology
Superficial Deposits	(Made ground) Alluvium	Confining layer
	River Terrace Deposits	Upper aquifer
Thames	London Clay	Aquiclude*
	Harwich	Aquitard** / aquifer
Lambeth	Upper Shelly Beds Upper Mottled Beds Laminated Beds Lower Shelly Beds -----Mid Lambeth Hiatus***----- Lower Mottled Beds Upnor	Aquitards/ aquifers
		Lower aquifer

** Aquiclude - a hydrogeological unit which, although porous and capable of storing water, does not transmit it at rates sufficient to furnish an appreciable supply for a well or spring3.*
*** Aquitard - a poorly-permeable geological formation that does not yield water freely, but may still transmit significant quantities of water to or from adjacent aquifers[4].*
**** Not a Formation but an important depositional feature*

K.2.2 The Alluvium, overlying the River Terrace Deposits or upper aquifer, was drilled dry in the ground investigation boreholes, with groundwater encountered within the River Terrace Deposits. This suggests that the Alluvium acts to confine these deposits.

K.2.3 The upper aquifer (River Terrace Deposits) is defined by the Environment Agency (EA) as a secondary A aquifer. These deposits are described as "permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers" (EA, 2012).

K.2.4 The lower aquifer, comprising of the Upnor Formation, the Thanet Sands and the Chalk, is not expected to be encountered by the Thames Tideway Tunnel project at the Victoria Embankment Foreshore site. However the separation distance between the base slab and the top of the lower aquifer (the top of the Upnor Formation) is 5.21m.

K.2.5 The CSO drop shaft would pass through the London Clay Formation (B, A3ii, A3i and A2 sub divisions). The London Clay Formation is generally acknowledged as an aquiclude between the upper and lower aquifers. Any groundwater present is likely to consist of localised seepages and/or minor flows. It is anticipated that below the River Terrace Deposits the shaft would be excavated in predominantly dry London Clay Formation with the exception of minor seepage at various horizons, namely silt or

claystone horizons. In unit A3ii, the presence of fine sand laminea/lenses at this horizon, may act as horizontal conduits for migration of groundwater from a nearby source.

K.2.6 Within the Lambeth Group, several confined groundwater layers are expected to be encountered. Groundwater is expected during the excavation of through the Upper Shelly Beds (at the top of the Lambeth Group); and more significantly at sub-artesian pressures within the Laminated Beds (formerly part of the Woolwich Formation).

K.3 Groundwater level monitoring

K.3.1 Groundwater level monitoring was undertaken at a number of ground investigation boreholes across the assessment area with a few exceptions. In addition, the EA has a regional network of monitoring boreholes, mainly within the lower aquifer, across London which records are available dating back over 50 years.

K.3.2 Information on groundwater levels for this assessment was collected from one ground investigation borehole located off site within 75m (SA1066D). This borehole has a response zone[i] and monitors groundwater levels in the River Terrace Deposits and in the Lower Mottled Beds (Lambeth Group). The response zone depths, the monitored strata and the frequency of monitoring are detailed in Vol 17 Table K.4. The manual dip data collected from this monitoring borehole is shown in Vol 17 Table K.5.

Vol 17 Table K.4 Groundwater – monitoring boreholes

Borehole	Response zone depths mATD	Strata	Monitoring
SA1066D (U)	98.3 – 95.3	River Terrace Deposits/ London Clay Formation	Irregular dips
SA1066D (L)	49.3 – 45.3	Lower Mottled Beds	Irregular dips

[i] Response zone - the section of a borehole that is open to the host strata.

Vol 17 Table K.5 Groundwater – summary level data

Borehole	Period of record	Maximum (Year Month)		Minimum (Year Month)		Average over the period of record	
		mbgl	mATD	mbgl	mATD	mbgl	mATD
SA1066D (U)	22/10/2009 – 09/05/2012	7.49 (May 2011)	97.81 (May 2011)	8.01 (November 2009)	97.29 (November 2009)	7.77	97.52
SA1066D (L)	22/10/2009 – 09/05/2012	44.48 (July 2011)	60.82 (July 2011)	46.98 (October 2009)	58.32 (October 2009)	45.16	60.13

K.3.3 The recorded water levels in the River Terrace Deposits at SA1066D range from 97.29mATD to 97.81mATD. These water levels consistently remain above the top of the formation at 97mATD, indicating that this formation is fully saturated and confined by the overlying Alluvium.

K.3.4 The recorded water levels in the Upper Shelly Beds at SA1066D range from 58.32mATD to 60.82mATD. These water levels consistently remain above the top of the formation at 57.67mATD, indicating that this formation is fully saturated and is confined by the overlying London Clay Formation.

K.3.5 A plot of groundwater levels within the upper and lower aquifers in the vicinity of the site is shown in Vol 17 Figure 13.4.3 (see separate volume of figures). There is only one borehole in the upper aquifer near the site (SA1066D) and as such it is difficult to determine the direction of groundwater flow. However, it is likely that the direction of groundwater movement is west to east, towards the River Thames, in these shallow deposits.

K.3.6 The EA network does not include any monitoring boreholes sufficiently close by to provide representative water level in the upper aquifer at the site. The nearest EA borehole, TQ28/119 records groundwater levels in the Chalk aquifer and a record of levels dating back to 1976 is shown in Vol 17 Figure 13.4.4 (see separate volume of figures).

K.4 Groundwater abstractions and protected rights

Groundwater licensing policy

K.4.1 The London Catchment Abstraction Management Strategy (CAMS), (EA, 2006)[5] does not identify a condition status for the upper aquifer.

K.4.2 The status of the lower aquifer is not relevant to this assessment as the construction would not reach to this depth at the Victoria Embankment Foreshore site.

K.4.3 No dewatering of the upper aquifer is anticipated at the Victoria Embankment Foreshore site. However, vacuum ejector wells would be drilled into the Lambeth Group around the outside of the shaft and

pumped to lower the water pressure in the Lambeth Group. Pumps would be placed in the wells and groundwater would be extracted at a rate of less than 200m^3/d and discharged directly to the River Thames on site, following any necessary treatment and subject to EA approval. This volume of dewatering is within the most restrictive abstraction licensing limit set by the EA of 0.2Ml/d (200m^3/d) for Central and South London (EA, 2006). Therefore a detailed local assessment is unlikely to be required by the EA.

K.4.4 Any water entering the excavation from either the superficial deposits, from minor seepages through silt layers in the London Clay Formation or from water-bearing horizons in the Lambeth Group would be pumped to the River Thames via appropriate settlement tanks.

Licensed abstractions

K.4.5 The EA licenses abstraction from groundwater within London for all sources in exceeds of 20m^3/d. Groundwater abstractions within 1km of the site have been identified.

K.4.6 There are no licensed groundwater abstractions from the River Terrace Deposits or upper aquifer located within 1km of the Victoria Embankment Foreshore site.

K.4.7 There are six licensed groundwater abstractions from the Chalk or lower aquifer located within 1km of the site. However the licensed abstractions from the lower aquifer (Chalk) would be unaffected due to construction taking place entirely within the upper aquifer, the London Clay Formation and the Lambeth Group.

K.4.8 There are no known unlicensed groundwater abstractions within the upper or lower aquifers within 1km of the Victoria Embankment Foreshore site.

K.5 Groundwater Source Protection Zones

K.5.1 The EA defines Source Protection Zones (SPZ) around all major public water supply abstractions sources and large licensed private abstractions in order to safeguard groundwater resources from potentially polluting activities.

K.5.2 The nearest modelled SPZ for a Chalk source is approximately 1.7km to the south of the Victoria Embankment Foreshore site.

K.6 Environmental designations

K.6.1 There are no environmental designations relevant to groundwater such as SSSI, SAC and SNCIs within 1km of the Victoria Embankment Foreshore site.

K.7 Groundwater quality and land quality assessment

K.7.1 Historical land use mapping at the Victoria Embankment Foreshore site reviewed as part of the land quality assessment identified no potentially contaminative onsite or nearby land uses (Vol 17 Section 8). Land quality

may impact on groundwater quality through the creation or promotion of preferential pathways for existing contamination during construction of the proposed development.

K.7.2 The groundwater quality data presented in Vol 17 Table K.6 has been sourced from the ground investigation and monitoring works undertaken as part of the Thames Tideway Tunnel project and includes data from monitoring boreholes located approximately 75m and 850m from the site (SA1066D and SR1062) (for locations see Vol 17 Figure 13.4.1 in separate volume of figures). Any exceedances of the UK drinking water standards[6] or relevant Environmental Quality Standards (EQS)[7] are shaded in blue in this table.

K.7.3 The data shows one exceedance only of the relevant standards within the River Terrace Deposits for sulphate at SR1062 (within 850m of the site).

K.7.4 The EA monitors groundwater quality at number of points across London, mainly the Chalk and Lower London Tertiaries (Lambeth Group) (EA, 2006). The nearest EA monitoring is at Dolphin Square at approximately 2km from the Victoria Embankment Foreshore site. However this borehole monitors water quality in the lower aquifer only and is therefore not relevant as construction would take place entirely with the upper aquifer, the London Clay Formation and the Lambeth Group.

Vol 17 Table K.6 Groundwater – groundwater quality results

Source of data*				SI	SI
Name				SA1066D	SR1062
Hydrogeological unit**				RTD	RTD
Distance from site	EQS Criteria			75m	852m
Chemical	Value	Units	Source	2009	2009
1,1 - Dichloroethane	10	ug/l	WFD 2010	-	-
1,1 - Dichloroethene	30	ug/l	WHO 2004	-	-
1,1,1 - Trichloroethane	100	ug/l	SW Regs 98	-	-
1,1,2 - Trichloroethane	400	ug/l	SW Regs 98	-	-
1,2 - Dichloroethane {Ethylene Dichloride}	3	ug/l	WS Regs 20	-	-
1,2 - Dichloroethene (Trans)	30	ug/l	WHO 2004	-	-
2 - Chlorophenol	50	ug/l	WFD 2010	-	-
2 - Methylphenol {O-Cresol}	-	ug/l	None	-	-
2,3 - Dimethylphenol {2,3-Xylenol}	-	ug/l	None	-	-
2,3,5,6 - Tetrachloroaminobenzene {2,...Aniline}	-	ug/l	None	-	-
2,3,6 - TBA {2,3,6-Trichlorobenzoic Acid}{Cas Rn 50-31-7}	-	ug/l	None	-	-
2,4 - Dichlorophenol	20	ug/l	WFD 2010	<0.4	<0.25
2,4 - Dimethylphenol {2,4-Xylenol}	-	ug/l	None	<0.4	<0.25
2,4,5 - Trichlorophenol	-	ug/l	None	-	-
2,4,6 - Trichlorophenol	-	ug/l	None	<0.4	<0.25
2,4-D {2,4-Dichlorophenoxyacetic acid}	0.1	ug/l	DWS 2010	-	-
2,4-DB {4-(2,4-dichlorophenoxy)butyric acid}	0.1	ug/l	DWS 2010	-	-
2,6 - Dichlorophenol	-	ug/l	None	<0.4	<0.25
2,6 - Dimethylphenol {2,6 Xylenol}	-	ug/l	None	-	-
3 - Chlorophenol	-	ug/l	None	-	-
3 - Methylphenol {M-Cresol}	-	ug/l	None	-	-
3,4 - Dimethylphenol {3,4 Xylenol}	-	ug/l	None	-	-
3,5 - Dimethylphenol {3,5-Xylenol}	-	ug/l	None	-	-
4 - Chloro - 3- Methylphenol {P-Chloro-M-Cresol}	40	ug/l	WFD 2010	<0.4	<0.25
4 - Chlorophenol	-	ug/l	None	-	-
4-Methylphenol {para-Cresol}	-	ug/l	None	-	-
Acenaphthene	-	ug/l	None	<0.01	<0.01
Acenaphthylene	-	ug/l	None	<0.01	<0.01
Acenapthene	-	ug/l	None	-	-
Acenapthylene	-	ug/l	None	-	-
Aldicarb	0.1	ug/l	DWS 2010	-	-
Aldicarb Sulphone	-	ug/l	None	-	-
Aldrin	0.03	ug/l	DWS 2010	-	-
Aliphatics >C10-C12	-	ug/l	None	1	270
Aliphatics >C12-C16 (Aqueous)	-	ug/l	None	4	330
Aliphatics >C16-C21 (Aqueous)	-	ug/l	None	8	<1
Aliphatics >C21-C35 (Aqueous)	-	ug/l	None	7	<1
Aliphatics >C6-C8	-	ug/l	None	<0.1	<0.1
Aliphatics >C8-C10	-	ug/l	None	<0.1	<0.1
Aliphatics C5-C6	-	ug/l	None	<0.1	<0.1
Alkalinity (Carbonate)	-	mg/l as CaCO3	None	-	-
Alkalinity Ph 4.5 - As CaCO3	-	mg/l as CaCO3	None	200	460
Aluminium Dissolved	200	ug/l as Al	DWS 2010	-	-
Aluminium Total	200	ug/l as Al	DWS 2010	-	-
Ammonia - As N	0.39	mg/l as N	WS Regs 20	-	-
Ammoniacal nitrogen	-	mg/l	None	0.23	6.6
Anions	-	meq/l	None	-	-
Anthracene	0.1	ug/l	SW WFD	<0.01	<0.01
Antimony Total	5	ug/l	DWS 2010	-	-
Aromatics >C7-C8	50	ug/l	WFD 2010	<0.1	<0.1
Aromatics >EC10-EC12	-	ug/l	None	7	17
Aromatics >EC12-EC16 (Aqueous)	-	ug/l	None	6	22
Aromatics >EC16-EC21 (Aqueous)	-	ug/l	None	22	5
Aromatics >EC21-EC35 (Aqueous)	-	ug/l	None	19	8
Aromatics >EC8-EC10	-	ug/l	None	<0.1	<0.1
Aromatics C6-C7	1	ug/l	DWS 2010	<0.1	<0.1
Arsenic Total	10	ug/l as As	DWS 2010	<1	5
Asulam	-	ug/l	None	-	-
Atrazine { }	0.1	ug/l	DWS 2010	-	-
Atrazine Desethyl {De-Ethyl Atrazine}	-	ug/l	None	-	-
Atrazine Desisopropyl	-	ug/l	None	-	-
Azinphos-Ethyl	-	ug/l	None	-	-
Azinphos-Methyl	0.1	ug/l	DWS 2010	-	-
Barium Dissolved	100	ug/l as Ba	SW Regs 96	-	-
Barium Total	100	ug/l as Ba	SW Regs 96	-	-
Benazolin	-	ug/l	None	-	-
Bendiocarb	-	ug/l	None	-	-
Bentazone	0.1	ug/l	DWS 2010	-	-
Benz[a]-Anthracene	-	ug/l	None	-	-

Source of data*				SI	SI
Name				SA1066D	SR1062
Hydrogeological unit**				RTD	RTD
Distance from site	EQS Criteria			75m	852m
Chemical	Value	Units	Source	2009	2009
Benzene	1	ug/l	DWS 2010	<1	<1
Benzene (1,2,3 Trichlorobenzene)	-	ug/l	None	-	-
Benzene (1,2,4 Trichlorobenzene)	-	ug/l	None	-	-
Benzene (1,3,5 Trichlorobenzene)	-	ug/l	None	-	-
Benzene (Ethylbenzene)	20	ug/l	FW List II	-	-
Benzo (a) anthracene	-	ug/l	None	<0.01	<0.01
Benzo[a]Pyrene	0.01	ug/l	DWS 2010	<0.01	<0.01
Benzo[b]Fluoranthene	0.03	ug/l	WFD D 10	<0.01	<0.01
Benzo[g,h,i]Perylene	0.002	ug/l	WFD D 10	<0.01	<0.01
Benzo[k]Fluoranthene	0.03	ug/l	WFD D 10	<0.01	<0.01
Beryllium Total	0	ug/l as Be	GW Regs 98	-	-
Bifenthrin	-	ug/l	None	-	-
Boron Dissolved	1000	ug/l as B	DWS 2010	-	-
Boron Total	1000	ug/l as B	DWS 2010	410	560
Bromate	10	ug/l as BrO3	DWS 2010	-	-
Bromide ion	2	ug/l as Br	FW List II	-	-
Bromodichloromethane	100	ug/l	WS Regs 20	-	-
Bromoform	100	ug/l	WS Regs 20	-	-
Bromoxynil	0.1	ug/l	DWS 2010	-	-
Bupirimate	-	ug/l	None	-	-
Cadmium Dissolved	5	ug/l as Cd	DWS 2010	-	-
Cadmium Total	5	ug/l as Cd	DWS 2010	<2	<2
Calcium Dissolved	250	mg/l as Ca	DWS 2010	-	-
Calcium Total	250	mg/l as Ca	DWS 2010	-	-
Carbaryl	-	ug/l	None	-	-
Carbendazim / Benomyl	0.1	ug/l	FW List II	-	-
Carbetamide	-	ug/l	None	-	-
Carbofuran	0.1	ug/l	DWS 2010	-	-
Carbon Dioxide	-	ug/l	None	-	-
Carbon Organic Dissolved	-	mg/l as C	None	-	-
Carbon tetrachloride	3	ug/l	DWS 2010	-	-
Carbophenothion	-	ug/l	None	-	-
Cations	-	meq/l	None	-	-
Chlordane (cis)	0.1	ug/l	DWS 2010	-	-
Chlordane Trans	0.1	ug/l	DWS 2010	-	-
Chlorfenvinphos	0.1	ug/l	DWS 2010	-	-
Chloridazon	-	ug/l	None	-	-
Chloride	250	mg/l as Cl	DWS 2010	140	210
Chlormequat	-	ug/l	None	-	-
Chlorodibromomethane	-	ug/l	None	-	-
Chloroform	100	ug/l	WS Regs 20	-	-
Chloroxuron	-	ug/l	None	-	-
Chlorpropham	-	ug/l	None	-	-
Chlorpyrifos	0.03	ug/l	WFD 2010	-	-
Chlorpyriphos-Methyl	-	ug/l	None	-	-
Chlorthalonil	-	ug/l	None	-	-
Chlortoluron	2	ug/l	FW List II	-	-
Chromium Dissolved	50	ug/l as Cr	DWS 2010	-	-
Chromium Total	50	ug/l as Cr	DWS 2010	<5	<5
Chrysene	-	ug/l	None	<0.01	<0.01
cis-1-2-Dichloroethene	-	ug/l	None	-	-
Clopyralid	-	ug/l	None	-	-
Cobalt - As Co	0	ug/l	GW Regs 98	-	-
Conductivity @ 20°C	2500	uS/cm	WS Regs 20	1170	2080
Copper Dissolved	2000	ug/l as Cu	DWS 2010	-	-
Copper Total	2000	ug/l as Cu	DWS 2010	<2	10
Coumaphos	0.1	ug/l	DWS 2010	-	-
Cresols	-	ug/l	None	<0.4	<0.25
Cyanazine	0.1	ug/l	DWS 2010	-	-
Cyanide (Free)	50	ug/l as CN	DWS 2010	<20	<20
Cyanide (Total)	50	ug/l as CN	DWS 2010	<40	<40
Cyfluthrin	0.1	ug/l	DWS 2010	-	-
Cypermethrin	0.0001	ug/l	WFD 2010	-	-
Cypermethrin ID	-	Code	None	-	-
Dalapon	-	ug/l	None	-	-
DDD (OP)	0.1	ug/l	DWS 2010	-	-
DDD (PP)	0.1	ug/l	DWS 2010	-	-
DDE (OP)	0.1	ug/l	DWS 2010	-	-
DDE (PP)	0.1	ug/l	DWS 2010	-	-
DDT (OP)	0.1	ug/l	DWS 2010	-	-
DDT (PP)	0.1	ug/l	DWS 2010	-	-
Deltamethrin	-	ug/l	None	-	-
Diazinon	0.1	ug/l	DWS 2010	-	-

Source of data*				SI	SI
Name				SA1066D	SR1062
Hydrogeological unit**				RTD	RTD
Distance from site	EQS Criteria			75m	852m
Chemical	Value	Units	Source	2009	2009
Dibenz-[A,H]-Anthracene	-	ug/l	None	<0.01	<0.01
Dicamba {3,6-Dichloro(O-Methoxybenzoic Acid)}	-	ug/l	None	-	-
Dichlobenil	-	ug/l	None	-	-
Dichlor(2,4+2,5)phenols	-	ug/l	None	-	-
Dichloromethane	20	ug/l	WFD 2010	-	-
Dichlorprop	0.1	ug/l	DWS 2010	-	-
Dichlorvos	0.1	ug/l	DWS 2010	-	-
Dieldrin	0.03	ug/l	DWS 2010	-	-
Diflurobenzuron	-	ug/l	None	-	-
Dimethoate	-	ug/l	None	-	-
Diuron	0.1	ug/l	DWS 2010	-	-
Endosulphan Alpha	0.1	ug/l	DWS 2010	-	-
Endosulphan Beta	0.1	ug/l	DWS 2010	-	-
Endrin	0.1	ug/l	DWS 2010	-	-
Enterococci (Species)	-	Nr/100ml	None	-	-
Escherichia coli (Confirmed)	0	Nr/100ml	WS Regs 20	-	-
Ethiofencarb	-	ug/l	None	-	-
Ethion	-	ug/l	None	-	-
Ethofumesate	-	ug/l	None	-	-
Ethyl Tertiary Butyl Ether (ETBE)	-	ug/l	None	-	-
Ethylbenzene	-	ug/l	None	<1	<1
Fenchlorphos {Ronnel.}	0.1	ug/l	DWS 2010	-	-
Fenitrothion	0.1	ug/l	DWS 2010	-	-
Fenoprop	0.1	ug/l	DWS 2010	-	-
Fenpropimorph	-	ug/l	None	-	-
Fenthion	-	ug/l	None	-	-
Fenuron	-	ug/l	None	-	-
Flumethrin	-	ug/l	None	-	-
Fluoranthene	0.2	ug/l	EEC MAC	<0.01	0.03
Fluorene	-	ug/l	None	0.02	<0.01
Fluoride	1.5	mg/l as F	DWS 2010	-	-
Fluroxypyr	-	ug/l	None	-	-
Flutriafol	-	ug/l	None	-	-
Fonofos	-	ug/l	None	-	-
Glyphosate	-	ug/l	None	-	-
Hardness Total - As CaCO3	-	mg/l as CaCO3	None	-	-
Heptachlor	0.03	ug/l	DWS 2010	-	-
Hexachloro 1,3 Butadiene	0.1	ug/l	WFD 2010	-	-
Hexachlorobenzene	0.01	ug/l	WFD 2010	-	-
Hexachlorocyclohexane (alpha)	0.1	ug/l	DWS 2010	-	-
Hexachlorocyclohexane (beta)	0.1	ug/l	DWS 2010	-	-
Hexachlorocyclohexane (delta)	0.1	ug/l	DWS 2010	-	-
Hexachlorocyclohexane (gamma)	0.1	ug/l	DWS 2010	-	-
Indeno-[1,2,3-Cd]-Pyrene	0.002	ug/l	WFD D 10	<0.01	<0.01
Iodide Ion	-	ug/l as I	None	-	-
Iodofenphos	-	ug/l	None	-	-
Ionic Balance (Anions/Cations)	-	%	None	-	-
Ioxynil	0.1	ug/l	DWS 2010	-	-
Iprodione	-	ug/l	None	-	-
Irgarol 1051	-	ug/l	None	-	-
Iron Dissolved	200	ug/l as Fe	DWS 2010	-	-
Iron Total	200	ug/l as Fe	DWS 2010	-	-
Isodrin	0.1	ug/l	DWS 2010	-	-
Isoproturon (Diip1,3Dithiolan-2-Ylidenemalonate)	0.1	ug/l	DWS 2010	-	-
Lambda Cyhalothrin	-	ug/l	None	-	-
Lead Dissolved	10	ug/l	WS Regs 20	-	-
Lead Total	10	ug/l	WS Regs 20	<4	<4
Linuron	0.1	ug/l	DWS 2010	-	-
Lithium Dissolved	-	ug/l as Li	None	-	-
Lithium Total	-	ug/l as Li	None	-	-
Magnesium Dissolved	50	mg/l as Mg	EEC MAC	-	-
Magnesium Total	50	mg/l as Mg	EEC MAC	19	24
Malathion	0.1	ug/l	DWS 2010	-	-
Manganese Dissolved	50	ug/l as Mn	DWS 2010	-	-
Manganese Total	50	ug/l as Mn	DWS 2010	-	-
MCPA {2-methyl-4-chlorophenoxyacetic acid }	0.1	ug/l	DWS 2010	-	-
MCPB	10	ug/l	WHO 2004	-	-
Mecoprop { }	0.1	ug/l	DWS 2010	-	-
Mercury Total	1	ug/l Hg	WS Regs 20	<0.05	<0.05
Metalaxyl	-	ug/l	None	-	-
Metazachlor	-	ug/l	None	-	-
Methabenzthiazuron	-	ug/l	None	-	-

Source of data*				SI	SI
Name				SA1066D	SR1062
Hydrogeological unit**				RTD	RTD
Distance from site	EQS Criteria			75m	852m
Chemical	Value	Units	Source	2009	2009
Methane	-	ug/l	None	-	-
Methiocarb	-	ug/l	None	-	-
Methomyl	-	ug/l	None	-	-
Methoxychlor	0.1	ug/l	DWS 2010	-	-
Metoxuron	-	ug/l	None	-	-
Metsulfuron - Methyl	-	ug/l	None	-	-
Mevinphos	0.1	ug/l	DWS 2010	-	-
Molybdenum Total	0	ug/l	GW Regs 98	-	-
Monolinuron	-	ug/l	None	-	-
Monuron	-	ug/l	None	-	-
MTBE {Methyl Tert-Butyl Ether}	-	ug/l	None	<1	<1
Multi Residual Scan	-	ug/l	None	-	-
Naphthalene	1.2	ug/l	WFD D 10	<0.01	<0.01
Napropamide	-	ug/l	None	-	-
Neburon	-	ug/l	None	-	-
Nickel Total	20	ug/l as Ni	DWS 2010	<10	<10
Nitrate - N	11.3	mg/l as N	WS Regs 20	<0.1	<0.1
Nitrite - N	0.03	mg/l as N	WS Regs 20	-	-
Nitrogen Total Oxidised	11.3	mg/l as N	WS Regs 20	-	-
Orthophosphate	-	mg/l as P	None	-	-
Oxamyl	-	ug/l	None	-	-
PAHs Total	0.1	ug/l	DWS 2010	-	-
Parathion (Parathion-ethyl)	1	ug/l	SW Regs 96	-	-
Parathion (Parathion-methyl)	1	ug/l	SW Regs 96	-	-
PCB Congener 028	0.1	ug/l	DWS 2010	-	-
PCB Congener 052	0.1	ug/l	DWS 2010	-	-
PCB Congener 101	0.1	ug/l	DWS 2010	-	-
PCB Congener 105	0.1	ug/l	DWS 2010	-	-
PCB Congener 118	0.1	ug/l	DWS 2010	-	-
PCB Congener 138	0.1	ug/l	DWS 2010	-	-
PCB Congener 153	0.1	ug/l	DWS 2010	-	-
PCB Congener 156	0.1	ug/l	DWS 2010	-	-
PCB Congener 180	0.1	ug/l	DWS 2010	-	-
Pendimethalin	0.1	ug/l	DWS 2010	-	-
Permethrin (Cis + Trans)	0.01	ug/l	WFD D 10	-	-
pH	10	pH units	DWS 2010	7.4	7.4
Phenanthrene	-	ug/l	None	0.02	0.01
Phenol	0.5	ug/l	EEC MAC	<0.4	<0.25
Phenol (Pentachlorophenol (PCP))	-	ug/l	None	-	-
Phenols Total For SWAD (7 Compounds)	-	ug/l	None	-	-
Pichloram	-	ug/l	None	-	-
Pirimephos (Pirimephos-methyl)	-	ug/l	None	-	-
Pirimicarb	1	ug/l	FW List II	-	-
Polynuclear Aromatic Hydrocarbons (Total)	0.1	ug/l	DWS 2010	<0.2	<0.2
Potassium Dissolved	-	mg/l as K	None	-	-
Potassium Total	-	mg/l as K	None	-	-
Preparation (Purge And Trap)	-	Text	None	-	-
Prochloraz	4	ug/l	FW List II	-	-
Promethryn	-	ug/l	None	-	-
Propachlor	-	ug/l	None	-	-
Propazine	0.1	ug/l	DWS 2010	-	-
Propetamphos	0.1	ug/l	DWS 2010	-	-
Propoxur	-	ug/l	None	-	-
Propyzamide	-	ug/l	None	-	-
Pyrene	-	ug/l	None	<0.01	<0.01
Qualitative Scan (Volatiles By GCMS) NP	-	Text	None	-	-
Selenium	10	ug/l as Se	DWS 2010	<3	<3
Silicate Reactive Dissolved - As SiO2	-	mg/l	None	-	-
Silver Total	0	ug/l	GW Regs 98	-	-
Simazine	0.1	ug/l	DWS 2010	-	-
Sodium Dissolved	200	mg/l as Na	DWS 2010	-	-
Sodium Total	200	mg/l as Na	DWS 2010	110	130
Strontium Dissolved	-	ug/l as Sr	None	-	-
Strontium Total	-	ug/l as Sr	None	-	-
Sulphate	250	mg/l as SO4	DWS 2010	77	350
Sulphide	-	ug/l	None	<10	12
Tecnazene	0.1	ug/l	DWS 2010	-	-
Terbutryn	0.1	ug/l	DWS 2010	-	-
Tertiary Amyl Methyl Ether (TAME)	-	ug/l	None	-	-
Tetrachloroethane	10	ug/l	DWS 2010	-	-
Tetrachloroethylene	-	ug/l	None	-	-
Tetrachlorothioanisole	-	ug/l	None	-	-
Thallium Total	0	ug/l as Tl	GW Regs 98	-	-

Source of data*				SI	SI
Name				SA1066D	SR1062
Hydrogeological unit**				RTD	RTD
Distance from site	EQS Criteria			75m	852m
Chemical	Value	Units	Source	2009	2009
Tin Total	0	ug/l as Sn	GW Regs 98	-	-
Titanium	0	ug/l as Ti	GW Regs 98	-	-
Toluene (Methylbenzene)	50	ug/l	WFD 2010	<1	<1
Total Aliphatic TPH	-	ug/l	None	20	600
Total Aromatic TPH	-	ug/l	None	54	51
Total Chemical Oxygen Demand	-	mg/l	None	<10	200
Total Petroleum Hydrocarbons (TPH)	-	ug/l	None	-	-
Total Petroleum Hydrocarbons 10-20 (TPH)	-	ug/l	None	-	-
Total Petroleum Hydrocarbons 20-30 (TPH)	-	ug/l	None	-	-
Triazophos	0.1	ug/l	DWS 2010	-	-
Trichloroethene (Trichloroethylene)	10	ug/l	DWS 2010	-	-
Trichlorophenoxyacetic Acid (2,4,5)	-	ug/l	None	-	-
Triclopyr	-	ug/l	None	-	-
Trietazine	-	ug/l	None	-	-
Trifluralin	0.1	ug/l	DWS 2010	-	-
Turbidity	1	FTU	WS Regs 20	-	-
Uranium	0	ug/l as U	GW Regs 98	-	-
Vanadium	0	ug/l as V	GW Regs 98	-	-
Xylene (Meta & Para){1,3+1,4-Dimethylbenzene}	30	ug/l	WFD 2010	<1	<1
Xylene (ortho)	30	ug/l	SW Regs 98	-	-
Zinc Dissolved	50	ug/l as Zn	DWS 2010	-	-
Zinc Total	50	ug/l as Zn	DWS 2010	2	7

Notes:

xx	GAC1 exceedance
' - '	Not tested
' < '	Less than MDL

** Origin of data: SI – Groundwater quality data collected during site investigation works by Thames Tideway Tunnel project (2009-2011), TT – Groundwater quality data collected during ongoing monitoring works by Thames Tideway Tunnel project (2009-2012)*
*** Hydrogeological unit: RTD – River Terrace Deposits*

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K.8 Groundwater resources status

K.8.1 The EC Water Framework Directive (WFD) requires the status of groundwater management units (groundwater bodies) within each river basin to be determined as 'good' or 'poor' by 2015. For groundwater there are two separate classifications for groundwater bodies; chemical status and quantitative status. The WFD aims to achieve good status by 2015, or, where this is not possible and subject to the criteria set out in the Directive, the WFD aims to achieve good status by 2021 or 2027.

K.8.2 The Thames River Basin Management Plan (RBMP)[8] shows no groundwater body designation for either the upper or lower aquifers within the area in which the Victoria Embankment Foreshore site is located; therefore no baseline assessment of quantitative or chemical status is available.

K.8.3 The baseline assessment for groundwater status classification for the nearby Greenwich Chalk and Tertiaries (consisting of the Lambeth Group, Thanet Sands, Blackheath Formation and Chalk Formation) shows poor quantitative status and poor quality status for 2009. The predicted quantitative and chemical quality was poor for 2015 due to treatment or improvement being disproportionately expensive or technically infeasible.

K.8.4 The baseline assessment for groundwater status classification for the nearby Lower Thames Gravels is good quantitative status and poor quality status for 2009. The predicted chemical quality was poor for 2015 due to treatment or improvement being disproportionately expensive or technically infeasible.

K.8.5 Only eight out of 46 groundwater bodies within the Thames River basin district are at good status overall; this is not expected to change by 2015 (EA, 2009)8.

K.8.6 The Thames Tideway Tunnel project would prevent deterioration of the current and predicted status and would adhere to the key actions identified in the RBMP to achieve good status by 2021 or 2027, as follows (EA, 2009):

a. The control of pollution to groundwater that may arise from any development which takes place on land.

b. Prevent input of nitrates to groundwater body.

c. Prevent inputs to and mitigate potential mobilisation of copper, other metals and hazardous substances in groundwater.

d. Prevent and mitigate potential inflow of river water to groundwater due to dewatering/ abstraction by implementing working methods to protect surface and groundwater from impacts, including changes to flow, by producing site-specific water management plans and by monitoring where required.

e. Prevent direct discharges of pollutants to groundwater.

K.9 Data sources

K.9.1 A list of data used for the Victoria Embankment Foreshore assessment is given in Vol 17 Table K.7.

Vol 17 Table K.7 Groundwater − desk based baseline data sources

Source	Data	Date received	Notes
BGS	BGS 1:50,000 scale digital geological data	February 2009	
EA	Licensed groundwater abstraction boreholes, their ownership and purpose	Dec. 2010, Feb. 2011 and March 2012	Licensed abstraction rates, aquifer, and status (active or dormant)
LB's*	Unlicensed groundwater abstraction boreholes and their details	June 2009	Contacted 14 London Boroughs along tunnel alignment
EA	Designated source protection zones (SPZ)	December 2010	
EA	Groundwater level records for EA observation boreholes	Sept. 2009, June 2011, Dec. 2011 and Oct. 2012	
EA	Groundwater quality results for EA observation boreholes	August 2009 and May 2011	
EA	Ground Source Heat Pump (GSHP) schemes and their details	December 2010 and March 2012	
Thames Tideway Tunnel project	Ground Investigation (2009) borehole logs, construction details, monitoring regime and available water level records and water quality results from 2009 to 2012	Last updated September 2012	Final ES
Thames Tideway Tunnel project	Groundwater monitoring strategy	Draft strategy Feb 2012	
Thames Tideway Tunnel project	Land quality data	February 2011	
Individual licence holders	Letters sent out to 30 licence holders	Dece. 2011 (last updated 15th October 2012)	

** LBs – London Borough,*

References

[1] British Geological Survey. British geology onshore digital maps 1:50 000 scale. Received from Thames Tideway Tunnel, February 2009.

[2] British Geological Survey. The BGS Lexicon of Named Rock Units (Accessed May 2012). Available at: http://www.bgs.ac.uk/Lexicon/

[3] USGS. Glossary of Hydrologic Terms in The Federal Glossary of Selected Terms: Subsurface-Water Flow and Solute Transport": Department of Interior, U.S. Geological Survey, Office of Water Data Coordination, August 1989

[4] Environment Agency. Environment Agency Website (Accessed April 2012). Available at: http://www.environment-agency.gov.uk/homeandleisure/117020.aspx

[5] Environment Agency. The London Catchment Abstraction Management Strategy (CAMS). Final Strategy Document (2006). Available at: http://publications.environment-agency.gov.uk/PDF/GETH0406BKRM-E-E.pdf

[6] The Water Supply (Water Quality) Regulations, 2000. Available at: http://www.legislation.gov.uk/uksi/2000/3184/contents/made

[7] River Basin Districts Typology, Standards and Groundwater Threshold Values (Water Framework Directive) (England and Wales) Direction 2010. Available at: http://www.defra.gov.uk/environment/quality/water/legislation/water-framework-directive/

[8] Environment Agency. River Basin Management Plan, Thames River Basin District (December 2009). Available at: http://publications.environment-agency.gov.uk/PDF/GETH0910BSWA-E-E.pdf

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Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.17**

Volume 17: Victoria Embankment Foreshore appendices

Appendix L: Water resources - surface water

APFP Regulations 2009: Regulation **5(2)(a)**

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Appendix L: Water resources – surface water

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Appendix L: Water resources – surface water

L.1 Introduction

L.1.1 Construction and operational effects assessments at this site for this topic do not require the provision of any supporting information, so this appendix is intentionally empty.

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Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

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Volume 17: Victoria Embankment Foreshore appendices

Appendix M: Water resources - flood risk

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Appendix M: Water resources – flood risk

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Appendix M: Water resources – flood risk

M.1 Policy considerations

M.1.1 The relevant planning document that would be used to assess the proposals is the National Policy Statement (NPS) for Waste Water (Defra, 2012)[1] which was published in February 2012.

M.1.2 The Waste Water NPS considers the Thames Tideway Tunnel project as 'nationally significant waste water infrastructure.'

M.1.3 General policy documents (eg, NPS) have been reviewed within Volume 2 Environmental assessment methodology. A summary of local and regional policy relevant to flood risk at Victoria Embankment Foreshore is provided below.

Local policy

Strategic Flood Risk Assessment

M.1.4 The Victoria Embankment Foreshore site lies within the City of Westminster. The Westminster City Council has produced a Level 1 Strategic Flood Risk Assessment (SFRA) (Westminster City Council, 2010)[2]. This outlines the main flood sources to the City of Westminster and investigates the residual risk of breaches in the Thames Tideway Defences at a number of locations along the River Thames.

M.1.5 The City of Westminster SFRA confirms that the Thames Tidal Defence network (the River Thames tidal flood defence walls and the Thames Barriet) reduces the annual probability of flooding from the Thames to less than 0.1%. The risk of flooding is a residual risk associated with a breach in the defences.

M.1.6 According to the SFRA:

a. The site overlies Alluvium.

b. The primary sources of flooding are tidal and surface water flooding.

c. The area of Whitehall, including the site, is identified as a location of critical surface water flooding.

d. The site is within the Environment Agency (EA) Flood Zone 3.

e. There have been '7-10' sewer flooding incidents recorded by Thames Water in the last 10 years in the vicinity.

f. There were 48 burst main incidents within the postcode area in which the site lies between 2003 and 2007.

M.1.7 The SFRA promotes the use of Sustainable Drainage Systems (SuDS) suitable to specific site locations within the City of Westminster , depending on underlying geology.

Surface Water Management Plan

M.1.8 The Council, in partnership with the Greater London Authority (GLA), Thames Water and the EA has produced a Surface Water Management Plan (SWMP) (GLA, 2011)[3] as part of the Drain London project. The SWMP sets out the preferred surface water management strategy for the borough.

M.1.9 According to the SWMP:

a. The site lies within the East Westminster Critical Drainage Area (CDA)i.

b. The site does not lie along any identified flow paths for the 1% AEP + 30% climate change rainfall event.

Regional policy

Thames Estuary 2100

M.1.10 The Victoria Embankment Foreshore site lies within the London City Policy Unit which has been assigned flood risk management policy 'P5' within the Thames Estuary 2100 (TE2100) Plan (EA, 2012)[4] meaning that further action will be taken to reduce flood risk beyond that required to mitigate the impact of climate change.

M.1.11 The TE2100 Plan identifies the local sources of flood risk (relative to Victoria Embankment Foreshore) as including

a. tidal flooding from the River Thames

b. pluvial (heavy rainfall) and urban drainage sources

c. a risk of groundwater flooding from superficial strata which is possibly connected to high water levels in the Thames.

M.1.12 Flood mitigation measures currently managing flooding from these sources include:

a. the Thames Barrier and secondary tidal defences along the Thames frontage

b. combined sewer overflows (CSOs) for mitigation of urban drainage

c. flood forecasting and warning.

M.1.13 The TE2100 Plan seeks to promote, where possible, defence improvements that ensure views are maintained and impacts to river access/views are minimised. Where defence raising in the future to manage the consequences of climate change is not possible, secondary defences and floodplain management should be introduced. There is also the vision to increase flood risk awareness within the area.

M.1.14 It is acknowledged in the TE2100 Plan that natural accretion of the river bed is occurring at Westminster

[i] Area susceptible to surfacw water flooding

M.1.15 Westminster is highlighted as having a risk of surface water and urban drainage flooding, possibly due to sewer capacity, pump station failure and tide locking of outfalls.

London Regional Flood Risk Appraisal

M.1.16 For the reach between Hammersmith Bridge and the Thames Barrier (City Reach) the London Regional Flood Risk Appraisal (RFRA) (GLA, 2009)[5] encourages small scale set back of development from the river walls where possible. The aim of this is to enable modification, raising and maintenance in a sustainable, environmentally acceptable and cost effective way. Development should be designed in such a way as to take opportunities to reduce flood risk and include resilience.

M.1.17 There is particular concern surrounding confluences of tributaries into the River Thames and the interactions between tidal and fluvial flows in the future due to climate change. This should be taken into consideration during the re-development process.

M.1.18 The RFRA indicates that SuDS should be included within developments to reduce surface water discharge.

References

[1] Department of Environment, Food and Rural Affairs (Defra), *National Planning Policy for Waste Water.* (February 2012)

[2] Westminster City Council. *City of Westminster Strategic Flood Risk Assessment*. (May 2010).

[3] Greater London Authority. *London Borough of Westminster Surface Water Management Plan Final Report*. (Aug 2011).

[4] Environment Agency. *Thames Estuary 2100 Plan*. (November 2012).

[5] Greater London Authority. *London Regional Flood Risk Appraisal*. (Oct 2009).

Thames Tideway Tunnel
Thames Water Utilities Limited

Application for Development Consent

Application Reference Number: WWO10001

Environmental Statement

Doc Ref: **6.2.17**

Volume 17: Victoria Embankment Foreshore appendices

Appendix N: Development schedule

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Appendix N: Development schedule

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Appendix N: Development schedule

N.1 Summary

N.1.1 The assessments undertaken for this site take account of other relevant development projects within the vicinity of the site which are under construction, permitted but not yet implemented or submitted but not yet determined. In order to identify the relevant developments for consideration, the Planning Inspectorate, local planning authorities and the Greater London Authority have been consulted on the methodology (see Volume 2) and asked to assist in identifying and verifying the development projects included in the assessment. A schedule is provided in Vol 17 Table N.1 of the resulting development projects, a description of what is proposed and assumptions on phasing. Longer term development projects may be included under both base case, with construction preceding that of the Thames Tideway Tunnel site, and cumulative with construction or operation occurring at the same time as a given Thames Tideway Tunnel site.

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Vol 17 Table N.1 Development schedule for Victoria Embankment Foreshore

Category types:

a. Under construction

b. Permitted but not yet implemented

c. Submitted but not yet determined

Development within 1km (IPC or Mayoral referral unless otherwise noted)	Dist from site (closest point)	Development description			Category type (based on 'current' status)	Year specific assumptions			Source of assumption information / Notes	Base case or cumulative dev?
		Appl. No.	Developer	Description		2016 (Site Year 1 of construction)	2017 (peak construction traffic year)	2023 (Year 1 of operation)		
London Eye Pier Extension	160m southeast	11/03292/ FUL	EDF Energy London Eye	Proposal for a Pier extension to the south of the existing London Eye Millennium Pier.	B	100% complete & operational	100% complete & operational	100% complete & operational	Information provided by LB Lambeth. Likely to be completed by 2013.	Base case (all years)
Elizabeth House, 39 York Road	Approx 570m southeast	12/01327/ FUL	Elizabeth House GP LLC	Demolition of all buildings and structures on the site, including removal of the high level footbridge over York Road, and redevelopment to provide two new buildings of part 29 and part 14 storeys (north building) and 11 storeys (south building) respectively with a part one/part two level common basement to provide 132,127sqm of floorspace (GEA), comprising B1 offices (88,649sqm), C3 residential (comprising 142 units), areas of flexible Use Classes A1- A5 and B1 at ground level and ancillary parking and servicing space; works of hard and soft landscaping to Cab Road and Mepham Street, the provision of a new access to Waterloo Station on West Road and associated works; works of hard and soft landscaping and the provision of a single storey structure providing car lifts and Class A use on West Road; works of hard landscaping to York Road and Leake Street; plant and other associated infrastructure and works.	C	Under construction	100% complete & operational	100% complete & operational	Assumptions made on basis that ES (Volume 1, Chapter 6) specifies a construction period of 46 months commencing in Sept 2012 and finishing in latter half of 2016.	**2016:** Cumulative **2017 & 2023:** Base case
Land bounded by Upper Ground and Doon St - east part of site (adjacent to Cornwall Rd)	Approx 600m east	05/03498/ FUL	Coin Street Community Builders	Redevelopment of site to provide a 8,292sqm multi purpose community sports centre and swimming pool, 902 sq m retail/commercial/restaurant/bar floorspace (use classes A1, A2, A3 and A4), 329 residential units and underground parking for 56 cars contained within a 43 storey tower measuring 144.3m in height and a part 7, part 8 storey block with roof terraces and courtyard.	A	100% complete and operational.	100% complete and operational.	100% complete and operational.	Information provided by LB Lambeth. Works expected to take three years. Possible 2012/2013 start date so assume completion by Site Year 1 of construction.	Base case (all years)

Development within 1km (IPC or Mayoral referral unless otherwise noted)	Dist from site (closest point)	Development description			Category type (based on 'current' status)	Year specific assumptions			Source of assumption information / Notes	Base case or cumulative dev?
		Appl. No.	Developer	Description		2016 (Site Year 1 of construction)	2017 (peak construction traffic year)	2023 (Year 1 of operation)		
York House	Approx 610m southeast	08/00629/FUL 11/01327/FUL	York Trust For Land	Demolition of York House and erection of a new building comprising of two basement levels, ground and fifteen upper floors of offices (class B1), rooftop plant and a retail (Class A1/A3/A4 use) and office (Class B1) unit at ground floor, together with associated plant, access and service arrangements, disabled car and bicycle parking and landscaping works.	B	100% complete & operational	100% complete & operational	100% complete & operational	Application to extend time limit submitted. However, still assumed to be complete & operational by Site Year 1 of construction.	Base case (all years)
Odeon West End - land bounded by Leicester Square, Panton Street, Whitcomb Street, Orange Street and St. Martin's Street London	Approx 670m northwest	08/03016/FULL	The Leicester Square Group	Demolition of existing buildings and redevelopment of the site to provide a two screen cinema (Class D2), a 245 bedroom hotel (Class C1), 33 residential units (Class C3), four restaurants at ground floor and one at ninth floor level (Class A3), with associated access and servicing and hard/soft landscaping. Application includes an Environmental Impact Assessment.	B	100% complete & operational	100% complete & operational	100% complete & operational	No information available regarding construction duration – ES on website cannot be opened. Revised application made in Sept 2011 but no new ES (only townscape update). Therefore assume completion by Site Year 1 of construction.	Base case (all years)
St James's Market	Approx 700m northwest	12/08886/FULL	The Crown Estate	Demolition and redevelopment of 53-54 Haymarket, 56 Haymarket and 1-3 Norris Street, 4-7 Norris Street, 14 St Albans Street and 1-3 St James's Market W1 and erection of an eight storey building plus basement and roof top plant area comprising retail (A1 and A3) on part basement and ground floor with offices (Class B1) above; associated public realm works and basement tunnel link to Regent Street block. Demolition behind retained 14-22 Regent Street, Carlton Street, part St Albans St and part Jermyn St facades and erection of an eight storey building plus basement and roof top plant area comprising retail (A1 and A3) on part basement, ground and part mezzanine floors with offices (B1) above: associated public realm enhancements and highway works including pedestrianisation of Norris Street, part of St Albans Street and creation of new public square at the junction of St Albans Street, Norris Street and Carlton Street.	C	Under construction	Under construction	100% complete and operational	Planning application documentation does not contain any information regarding start/completion dates for construction. Assuming the application is approved in 2012 and construction commences within three years, it is assumed to be under construction for two years and so be complete by 2018.	**2016 & 2017**: Cumulative **2023**: Base case

Note: phasing and site layout information has been sourced from local authority planning portals unless otherwise indicated.

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