12. GEOLOGY AND SOILS

12.1 Introduction

12.1.1 This chapter provides a preliminary assessment of the likely significant effects of contamination (existing or created) on human health and sensitive environmental receptors such as geology, hydrogeology.

12.1.2 The baseline conditions and any assessments undertaken with regard to waste are covered within Chapter 13: Materials.

12.1.3 Any assessments undertaken with regard to groundwater flood risk are covered within Chapter 16: Water Environment.

12.2 Regulatory and policy framework

12.2.1 The assessment has been conducted with reference to relevant legislation specific to geology, hydrogeology and human health. In addition, it has also considered relevant policy and guideline documents at the national, regional and local scales.

Table 12-1 Geology and soils regulatory and policy framework

Policy /Legislation	Summary of requirements	Scheme response
The Environmental Protection Act 1990 (Ref 12-1)	The Environmental Protection Act 1990 defines, within England, Wales and Scotland, the fundamental structure and authority for waste management and control of emissions into the environment. The Act was intended to strengthen pollution controls and support enforcement with heavier penalties. Part IIA of the Environmental Protection Act 1990 was inserted into that Act by section 57 of the Environment Act 1995 – contains a regulatory regime for the identification and remediation of contaminated land. In addition to the requirements contained in the primary legislation, operation of the regime is subject to regulations and statutory guidance. The main objective underlying the introduction of the Part IIA contaminated land regime was to provide an improved system for the identification and remediation of land where contamination is causing unacceptable risks to human health or the wider environment, assessed in the context of the	The Scheme will comply with the Environmental Protection Act by implementing suitable waste management procedures outlined in the Preliminary Code of Construction Practice (CoCP). Environment pollution controls will also be outlined within the Preliminary CoCP.

Policy /Legislation	Summary of requirements	Scheme response
	current use and circumstances of the land. It provides a means of identifying and remediating land that poses a significant risk to health or environment, where there is no alternative solution. It also works alongside planning rules to help ensure that this land is made suitable for use following development. Development of land will have to take into account Part IIA because a change in the use of the land may bring the development inside the statutory definition of contaminated land by creating a pollutant linkage. Part IIA of the Environmental Protection Act 1990 was inserted into that Act by section 57 of the Environment Act 1995 – contains a regulatory regime for the identification and remediation of contaminated land. In addition to the requirements contained in the primary legislation, operation of the regime is subject to regulations and statutory guidance. The main objective underlying the introduction of the Part IIA contaminated land regime was to	

Policy /Legislation	Summary of requirements	Scheme response
	provide an improved system for the identification and remediation of land where contamination is causing unacceptable risks to human health or the wider environment, assessed in the context of the current use and circumstances of the land. It provides a means of identifying and remediating land that poses a significant risk to health or environment, where there is no alternative solution. It also works alongside planning rules to help ensure that this land is made suitable for use following development.	
National Road and Rail Networks: National Policy Statement (NN NPS) (Ref 12-2)	The NN NPS sets out the value of geological conservation relating to sites that are designated for their geology and/or their geomorphological importance. These include Sites of Special Scientific Interest (SSSI), Marine Conservation Zones (MCZs), and Regional and Local Sites of geological interest. Regardless of the designation, the policy sets out the need to include appropriate mitigation measures as an integral part of their proposed development, including identifying where and how	The Scheme is not located within an area of important geology. No statutory designated sites of geological interest were identified within the study area. However, as part of the construction process appropriate mitigation measures will be put in place to minimise the effect of construction activities upon the site and the surrounding area through the CoCP.

Policy /Legislation	Summary of requirements	Scheme response
	they are proposed to be secured. In all areas particular, the applicant should demonstrate that: '*During construction, they will seek to ensure that activities will be confined to the minimum area required for the works.' (Paragraph 5.36)* The Secretary of State for Transport will consider what appropriate requirements should be attached to any consent and/or any planning obligations entered into in order to ensure that mitigations measures are delivered. *'For developments on previously developed land, applicants should ensure that they have considered the risk posed by land contamination and how this is proposed to address this.' (Paragraph 5.168)* *'Applicants should safeguard any mineral resources on the proposed site as far as possible.'(Paragraph 5.169).*	
National Planning Policy Framework 2012 (NPPF) (Ref 12-3)	The NPPF (paragraphs 120-122) provides guidance on land contamination issues. These include local policies and decisions that should ensure that development sites should be suitable for new use taking account of ground conditions	The Scheme will comply with the NPPF by providing suitable documentation outlining baseline data, background studies undertaken as well as consultation responses outlining the

Policy /Legislation	Summary of requirements	Scheme response
	and, pollution arising from previous uses, as well as any proposals for land remediation. Paragraph 120 of the NPPF states that: *'To prevent unacceptable risks from pollution and land instability, planning policies and decisions should ensure that new development is appropriate for its location. The effects (including cumulative effects) of pollution on health, the natural environment or general amenity, and the potential sensitivity of the area or proposed development to adverse effects from pollution, should be taken into account. Where a site is affected by contamination or land stability issues, responsibility for securing a safe development rests with the developer and/or landowner'.* *"To prevent unacceptable risks from pollution and land instability, planning policies and decisions should ensure that new development is appropriate for its location".* The risks at site need to be adequately characterised.	suitability of the Scheme location with regard to environmental issues.
Planning Practice Guidance (Ref 12 –4)	This document replaces The NPPF Technical Guidance, and sets out the Government's	The Scheme will be compliant with the practices outlined within the national

Policy /Legislation	Summary of requirements	Scheme response
	planning policies for England and how these are expected to be applied.	planning policy guidance.
Waste Management Regulations 2011 (Ref 12-5)	The Waste Management (England and Wales) Regulations 2011 states that excavated material generated by the development of land maybe subject to waste regulatory controls to ensure that waste does not harm human health or the environment. Suitable site characterisation is required to manage and dispose of contaminated soils in accordance with Waste Management Regulations 2011.	The Scheme will comply with the regulations by appropriately characterising the waste as either hazardous or non-hazardous waste and disposing to an appropriate landfill facility, should the material be deemed not suitable for re-use. The management of waste generated by the Scheme is covered in more detail in PEIR Chapter 13 (Materials).
Water Resources Act 2003 (Ref 12-6)	The Water Resources Act 1991 replaced the corresponding sections of the Water Act 1989. The Act sets out the responsibilities of the Environment Agency in relation to water pollution, resource management, flood defence, fisheries, and in some areas, navigation. The Act regulates discharges to controlled waters, namely rivers, estuaries, coastal waters, lakes and groundwaters.	The assessment aims to characterise the risk of pollution to controlled waters and sets out mitigation measures for these. The aim is to eliminate, as far as possible, the risk of pollution to controlled waters and ensure that the Scheme is appropriate for its location.

Policy /Legislation	Summary of requirements	Scheme response
	To prevent pollution of controlled waters, planning policies and decisions should ensure that new development is appropriate for its location. The risks at site need to be adequately characterised. As of 2016 an abstraction licence will be required for any dewatering processes.	
The Environment Agency's Model Procedures for the Management of Land Contamination (Contaminated Land Report 11) (Ref 12-7)	Contaminated Land Report 11 (CLR 11) has been developed to provide the technical framework for applying a risk management process when dealing with land affected by contamination. The process involves identifying, making decisions on, and taking appropriate action to deal with land contamination in a way that is consistent with government policies and legislation within the UK.	In accordance with the Environment Agency's publication CLR 11 procedures', a preliminary contaminated land risk assessment has been undertaken. A ground investigation has been undertaken which has adopted the principles of CLR 11 "Model Procedures for the Management of Land Contamination".
The Environment Agency's Guiding Principles for Land Contamination (GPLC), dated March 2010 (Ref	This is a suite of three documents providing generic guidance with the main aim to encourage good practice to promote compliance with regulatory requirements. The report largely	The Guiding Principles outlined in the GPLC have been incorporated into the Preliminary CoCP.

Policy /Legislation	Summary of requirements	Scheme response
12-8)	focuses on water and waste issues.	
Groundwater Protection: Principles and Practice (GP3) (Ref 12-9)	'Groundwater protection: Principles and practice' (commonly referred to as GP3) sets out: • aims and objectives for groundwater; • technical approach to its management and protection; and • Position and approach to the application of relevant legislation.	To prevent the pollution of controlled waters, the guidance set out in GP3, (relating to contaminant characteristics and assessment of compliance points) will be included in the risk assessments. The risk assessments will inform the mitigation and will be employed where necessary into the Preliminary CoCP and Construction Environmental Management Plan (CEMP). This can be done by the incorporating the necessary permits required, as well as guidance notes and codes of practice relevant for the scheme. Reference should also be made to pollution prevention guidance notes.
Water Framework Directive (WFD), 2000 (Ref 12-10)	The WFD implements goals to improve water quality (surface water and groundwater) and drives sustainable use of water. Goals are set out in Water Basin Management	The Scheme will remain compliant with the WFD by adequately preventing the mobilisation of historic contamination that could cause harm to human

Policy /Legislation	Summary of requirements	Scheme response
	Plans. According to Annex V, point 1.4.3 of the WFD, good chemical status is reached for a water body when it complies with the Environmental Quality Standards for all the priority substances and other pollutants listed in Annex I of the Environmental Quality Standards Directive.	health, property and the wider environment. Pollution prevention and mitigation measures to be implemented are documented in the Preliminary CoCP. Reference should be made to Chapter 16 Water and Environment. To comply with Annex V of the WFD a screening assessment has been undertaken (Appendix 10.A) and will be completed in the Environmental Statement.
Environmental Permitting Guidance: Core Guidance for the Environmental Permitting (England and Wales) Regulations 2010. March 2013 (Ref 12-11)	The Environmental Permitting Regulations create an environmental permitting system that replaces waste licences and pollution prevention and control permits in England and Wales, without changing the operating conditions already contained in existing permits. The Environment Agency (EA) and local councils enforce the regulations in England and Wales. Should any discharges be carried out directly into	The Scheme is likely to require environmental permits for activities that could impact upon air, water or land. For example, should any remediation of historical contamination be required, a Mobile Treatment Permit would be required for any on-site remediation system.

Policy /Legislation	Summary of requirements	Scheme response
	the environment then environmental permits will be required from the Environment Agency and will need to state the nature of the works for the permit. Should any discharges be made into sewage systems then consent would be required from the sewage undertaker.	Depending upon the form of groundwater control adopted, abstraction consent may be required from the Environment Agency. Appropriate permits will need to be obtained for any activities that may cause pollution during construction and operation.
CL:AIRE The Definition of Waste: Development Industry Code of Practice (Ref 12-12)	This Code of Practice (CoP) provides good practice for the development industry to use when assessing if materials are classified as waste, or not, and determining when treated waste can cease to be waste for a particular use. The CoP provides engineers, contractors, consultants and developers a basis upon which to demonstrate to the EA that they are following good practice with respect to the use and reuse of materials. It provides an auditable system to demonstrate that the CoP has been adhered to on a site by site basis. The development and use of the CoP is seen as a Better Regulation Approach by the EA. The CoP requires a normal risk assessment	The CoP provides a process which enables the reuse of excavated material on site or their movement between sites. It is intended that, where possible, the Scheme will re-use materials on site, such as for landscaping purposes. Other materials may be transported to be re-used as clean remediated material on other projects. Therefore, it can provide an alternative to materials becoming waste such that Environmental Permits or Waste

Policy /Legislation	Summary of requirements	Scheme response
	based approach (see CLR 11 above) to prove that materials are ‘“suitable for use”’. Where materials are not considered to be waste the Environmental Permitting Regulations (2010) need not be applied. Soils requiring treatment to allow their re-use are considered to be waste. Such treatment processes must be undertaken under an appropriate Mobile Treatment Permit. The CoP allows the user to demonstrate when wastes have been fully recovered, via treatment, and hence cease to be waste. The CoP requires regulatory agreement for each stage of the works. This is best achieved via a formal planning consent with appropriate conditions attached to the investigation, assessment and remediation. Approval is effectively obtained by discharge of the planning conditions that require regulatory agreement of: • Remediation Strategy; • Remediation Method Statement;	Exemptions would be required.

Policy /Legislation	Summary of requirements	Scheme response
	• Verification Report.	
Environment Agency Pollution Prevention Guidance Notes (Ref 12-13)	The Environment Agency has produced a range of Pollution Prevention Guidance Notes (PPGs) to provide advice on the laws and good environmental practice relevant to a number of industrial sectors and activities. These include the following: • PPG1 – General guide to the prevention of pollution; • PPG2 – Above ground oil storage tanks; • PPG5 – Works and maintenance in or near water; • PPG6 – Working at construction and demolition sites; • PPG8 – Safe storage and disposal of used oil;	Although withdrawn by the EA, these PPGs are considered consistent with good working practices and will be adopted where appropriate. Relevant specific requirements for the Scheme such as PPG1 –PPG6 are carried forward into the Preliminary CoCP (Appendix 4.A) and the CEMP.

Policy /Legislation	Summary of requirements	Scheme response
	• PPG13 – Vehicle washing and cleaning; and • PPG21 – Pollution incident response planning.	
Control of Substances Hazardous to Health 2002 (Ref 12-14)	The Control of Substances Hazardous to Health (COSHH) Regulations, 2002, and subsequent amendments and the Construction and Design Management (CDM) Regulations, 2015, require the developer to ensure that risks to the public and site workers, in relation to the likely presence of contaminated land, are minimised. COSHH is aimed designed to protect employees and others who may be affected from the health risks. COSHH requires employers to weigh up risks to the health of their employees arising from exposure to hazardous substances to prevent, or adequately control exposure.	The Scheme will be compliant with COSHH regulations.
The London Plan 2011 (Ref 12-15)	The document states that '*appropriate measures should be taken to ensure that development on previously contaminated land does not activate or spread contamination'.* Local Plans should also	The Scheme will comply with the London Plan by ensuring that appropriate measures are in place to remediate or remove contaminated

Policy /Legislation	Summary of requirements	Scheme response
	encourage the remediation of contaminated sites and set out policy to deal with contamination. The London Plan has been updated to incorporate the Further Alterations (FALP). It also incorporates the Revised Early Minor Alterations to the London Plan (REMA), which were published in October 2013.	land prior to construction.
Newham Local Plan (Ref 12-16)	The Newham Local Plan seeks to protect the environment through soil improvements and the sustainable remediation of contaminated land. Policy EQ49 outlines the requirements for completion of investigative works on a contaminated site and the need for developers to prove that any development satisfies the 'suitability of use' criteria of the Environment Act 1995. Planning applications for development of a site known or reasonably suspected of being contaminated or containing landfill gas will be required to be accompanied by an assessment of the type and extent of contamination, as well as proposals for any necessary remedial measures required to deal with the hazards, before the application can be determined by the council. Where the council suspects that there may be slight contamination, planning permission may be	The Scheme will comply with Newham Local Plan, a ground investigation and contaminated land assessment within the site to investigate contaminated land has already been completed to satisfy the suitability of use and is summarised in this chapter. .

Policy /Legislation	Summary of requirements	Scheme response
	granted only under conditions whereby developments will not be permitted to start construction until a site investigation and assessment has been carried out. The development itself will need to incorporate all the measures shown in the assessment.	
Royal Borough of Greenwich Local Plan (Ref 12-17)	A preliminary site investigation, prior to the determination of a planning application, will normally be required if a site is known or is likely to have been in contaminative uses. Where contamination is found, the borough will need to be assured that the development can be built and occupied safely without any adverse environment or health impacts, otherwise conditions requiring full remedial action will be imposed to deal with: • the particular type or types of contamination; • the problems of the ground exhalation of gases; • the protection of controlled waters; and	A ground investigation and contaminated land assessment within the Silvertown and Greenwich sites to investigate contaminated land has already been completed. Based upon the results of the investigation procedures will be put in place as part of the Preliminary CoCP and CEMP to construct the Scheme without any adverse effect to the environment, complying with the Royal Borough of Greenwich Local Plan.

Policy /Legislation	Summary of requirements	Scheme response
	• the restoration of land to beneficial use.	
Greenwich Peninsula Environmental Method Statement (EMS) (Ref 12-18)	The Greenwich Peninsula Environmental Method Statement (EMS) forms part of the Integrated Management System (IMS) for the re-development of Greenwich Peninsula, as required by clause 41 of the Section 106 Agreement for the Greenwich Peninsula Masterplan. All work on the Greenwich Peninsula that results in ground disturbance is subject to the requirements of the EMS objectives. The primary objectives of the EMS as follows: • to ensure compliance with environmental law; • to minimise any health and safety risks associated with the residual contaminants contained with the soils and groundwater on the peninsula;	The Scheme will ensure that long term solutions to contamination issues are adopted with full consultation with the competent authorities. The construction of the Scheme will be undertaken in accordance with environmental law and good practice to minimise any environmental impacts by adopting an appropriate remediation strategy, if required, and implementing a CoCP and CEMP.

Policy /Legislation	Summary of requirements	Scheme response
	• to ensure that good practice standard is achieved in the design and construction of all development works; • to minimise the environmental impacts and possible migrations of residual contamination; • to minimise any cross boundary migration of contamination between separate development sites; and • to ensure that long term solutions to contamination issues are adopted in full consultation with the competent authorities.	
Water Act 2003 (Ref 12–19)	Under the Water Act it is an offence to cause or knowingly permit a discharge of poisonous, noxious or polluting matter into any Controlled Waters without the proper authority. The four broad aims of the Act are:	The Scheme will be compliant with the Water Act by adhering to appropriate mitigation measures and construction procedures within a CEMP to ensure that polluting of Controlled Waters does not occur.

Policy /Legislation	Summary of requirements	Scheme response
	• the sustainable use of water resources; • strengthening the voice of consumers; • a measured increase in competition; and • the promotion of water conservation.	

12.3 Methodology

General approach

12.3.1 This section describes the methods used to determine the baseline conditions existing at the Silvertown and Greenwich site of the proposed Scheme sites for geology, hydrogeology and human health. It also describes the methodology used to assess the likely effects of the construction and operational phases of the Scheme on ground conditions, and identifies mitigation measures to prevent or reduce any adverse effects.

12.3.2 The assessment considers the environmental sensitivity of the Scheme and study area in relation to any suspected or known contamination which may significantly affect the Scheme. The study area for the scheme is characterised in section 12.3.6 below.

12.3.3 The information reviewed as part of the baseline included the recorded geology and hydrogeology of the site and study area, as well as details of site history. Information relevant to the assessment has been identified from available public sources, relevant regulatory authorities, historical land use research and pertinent ground investigation reports previously undertaken.

12.3.4 The information on baseline conditions informed and facilitated the development of a Conceptual Site Model (CSM). From the CSM, the requirements for mitigation (commonly referred to as a remediation strategy) will be ascertained in accordance with the procedures set out in CLR 11 guidance document published by the Environment Agency and Department for Environment Food and Rural Affairs (Ref 12-7)

Consultation

12.3.5 Consultations responses to initial enquiries relating to the Scheme are set below in Table 12-2. Consultation responses to the scoping report (Ref 12-20) are reported within Appendix 5.A

Table 12-2 Summary of consultation responses

Consultee	Consultation details
Environment Agency	The Environment Agency has been consulted on a number of occasions. In April 2015 the Environment Agency responded to the draft Reference Design and commented on the following topics:; • Construction material compatibility with contamination within the soils; • Tunnel design; • Disposal of dewatering effluent; • Pollution prevention measures; • Groundwater monitoring; • Groundwater flooding; and • Waste generation, storage and disposal; Where possible their comments have been considered in the design and EIA process.
Royal Borough of Greenwich	Royal Borough of Greenwich had no comments with regard to geology and soils.
London Borough of Tower Hamlets	Tower Hamlets had no comments with regard to geology and soils.
London Borough of Newham	Newham had no comments with regard to geology and soils.

The study area

12.3.6 The study area has focused on the footprint of the Scheme, site compounds, and storage areas. It also considers a 500m radius from the Limits of Land to be Acquired or Used for the contamination potential of the Scheme and the potential effects on any nearby sensitive receptors.

12.3.7 The overall potential significance of effect is then defined using the matrix below (Table 12-5) which describes the relationship between the value of the resource (importance of receptor) and the magnitude of the potential impact (change).

12.3.8 The significance of effect that remains after mitigation measures have been put in place (i.e. the residual impacts) is assessed and identified.

12.3.9 The study area for the Scheme can be seen with reference to Drawing 4.1 Limits of Land to be Acquired or Used.

Methodology for establishing baseline conditions

Establishing the existing baseline

12.3.10 The assessment of potential impacts on geology, hydrogeological and human health sensitive receptors has consisted of a desk-based study, informed by published and internet-based information sources as well as existing ground investigation reports for the Scheme.

12.3.11 The baseline geological, hydrogeological and human health conditions have been established with reference to the following sources of information:

- Mott MacDonald (May 2013), Transport for London (TfL) River Crossings – Ground Investigation Desk Study, Preliminary Sources Study Report (Ref 12-21);
- Atkins (July 2015) Ground Investigation Report Revision P01 (Ref 12-22);
- Mott MacDonald (June 2013), TfL River Crossings – Phase 1 Contamination Assessment, Silvertown to Greenwich Peninsula. (Envirocheck Report reproduced as Appendix 10A) (Ref 12-23);
- Landmark Information Group: Historical Maps and Environmental Data Pack (taken from the desk study reports) (Ref 12-24);
- Arup & Partners Ltd (December 2007) for Meridian Delta Limited. Greenwich Peninsula Remediation Strategy Framework Report. (Ref 12-25);
- Envirocheck Data Sheets (Landmark, 2013) (Ref 12-26);
- Geological logs via GeoRecords web portal (British Geological Survey, 2014) (Ref 12-27);
- Environment Agency (EA): https://www.gov.uk/government/organisations/environment-agency (Ref 12 -28);
- British Geological Survey, 1996. “London and the Thames Valley” (Ref 12-29);

- Ellison, R.A. (Ed), “Geology of London: Special Memoir for 1:50,000 Geological Sheets 256 (North London), 257 (Romford), 270 (South London) and 271 (Dartford) (England and Wales)” BGS, 2004 (Ref 12-30);
- England and Wales Sheet 256 North of London Solid and Drift Geology. 1:50,000 scale map, British Geological Survey 1981 (Ref 12-31);
- England and Wales Sheet 270 South London Solid and Drift Geology, 1:50,000 scale map, British Geological Survey, 1981 (Ref 12-32);
- England and Wales Sheet 271 Dartford Solid and Drift Geology. 1:50,000 scale map, British Geological Survey 1998 (Ref 12 -33);
- Soilscapes website (LandIS, 2014) (Ref 12-34);
- Lexicon Service (British Geological Survey, 2014) (Ref 12-35);
- Digital map viewer BGS website (British Geological Survey, 2014) (Ref 12-36);
- Aggregate Safeguarding Maps (British Geological Survey, 2014) (Ref 12-37); and
- Atkins: (April 2014), Silvertown Tunnel Reference Design Settlement Report. (Ref 12-39)

Forecasting the future baseline (“Without Scheme” scenario)

12.3.12 The future without Scheme scenario considers the current use of the site, but takes into account any future developments within the limits of land to be acquired or used and study area, as well as considering how this would change the existing site conditions, (e.g. excavation and remediation activities within the area, or additional contamination that could arise).

Defining the importance/sensitivity of resource

12.3.13 The value of (importance) of the resource is being described in this chapter using the guidelines outlined in Table 12-3 below, developed from the Design Manual for Roads and Bridges (DMRB) (Ref 12-40) .

12.3.14 Receptors considered within this assessment form the headings as shown in Table 12-3.

Table 12-3 Defining attribute importance (sensitivity) for receptor

Sensitivity	Geology/Soils	Construction workers	Site end users and neighbours (operational workers)	Surrounding land uses	Controlled waters (groundwater /surface water	Built environment	Ecological systems
High to Very High	Designated SSSI for geology/soils Grade 1 agricultural land. Land supports nationally rare plant species	Extensive earthworks and demolition of buildings	Residential / allotments, public open space	Greenfield sites / residential area	Principal aquifer or surface water in close proximity to site.	Listed buildings	Nationally or internationally designated sites.
Medium	Grade 2/3 agricultural land. Currently used for important crops. Land supports regionally/locally rare plant species.	Limited earthworks	Landscaping or public open space	Open space, commercial area.	Secondary aquifer	Buildings, including services and foundations.	Locally designated ecological sites.

Sensitivity	Geology/Soils	Construction workers	Site end users and neighbours (operational workers)	Surrounding land uses	Controlled waters (groundwater /surface water	Built environment	Ecological systems
Low (or Negligible)	Brownfield/industrial site. Site of little or no agricultural value.	Minimal ground disturbance	'Hard' end use (e.g. industrial car parking).	Industrial area	No surface water bodies or aquifers close to the site.	N/A	No sites of ecological importance

Methodology for assessing impacts

12.3.15 After developing an understanding of the baseline conditions, the significance of the identified effects is determined based on the value (importance) of the receptor taking into account the magnitude of potential impact.

12.3.16 The criteria for assessing the magnitude of impacts within this assessment are based upon source-pathway-receptor (all three must exist for an impact to be possible constituting a complete pollutant linkage). It must be recognised that no ground investigation is exhaustive when identifying contaminated land, therefore the word “potential” has been used when considering contamination issues as a worst case scenario.

12.3.17 Table 12-4 provides the definitions of magnitude used for the purposes of this assessment.

Table 12-4 Criteria for assessing magnitude of impacts

Qualitative description of source (hazard)	Previous and current land uses
Major Adverse	Previous or ongoing activity on or near to a site with high potential to cause land contamination (for example, gasworks, chemical works, landfills) or site investigation data indicating widespread or severe contamination.
Moderate Adverse	Previous or ongoing activities with some potential to cause moderate contamination (for example, railways, collieries and scrap yards) or site investigation data indicating no significant contamination.
Minor Adverse	Greenfield site or site with previous / present activities with low potential to cause land contamination (for example, residential, retail or offices) or site investigation data indicating no significant contamination.
Negligible	No impact would be detectable, either positive or negative. A greenfield site with no ongoing or previously recorded activities with potential for land contamination.
Major Beneficial	Large scale or major improvement of resource quality; extensive restoration or enhancement; major improvement of attribute quality.
Moderate Beneficial	Benefit to, or addition of key characteristics, features, or elements or improvement of attribute quality.

Qualitative description of source (hazard)	Previous and current land uses
Minor Beneficial	Minor benefit to, or addition of key characteristics, features or elements; some beneficial impact on attribute or a reduction in the risk of a negative impact occurring.

Source: Professional Judgement

12.3.18 The overall potential significance of the effect is then defined using the matrix below (Table 12-5) which describes the relationship between the value of the resource (importance of receptor) and the magnitude of the potential impact (change).

Table 12-5 Criterion for determining the impact significance of effects

		Magnitude of impact			
		Negligible	**Minor**	**Moderate**	**Major**
Importance of receptor	**Very High**	Neutral	Moderate	Large	Very Large
	High	Neutral	Slight/Moderate	Moderate/Large	Large/Very Large
	Medium	Neutral	Slight	Moderate	Large
	Low	Neutral	Neutral	Slight	Moderate

Source: Part 10 DMRB Volume 11, Section 2, Part 5, HA205/08 Chapter 2 Determining the Significance of Environmental Effects

12.3.19 Professional judgement has been used when assigning overall significance where there is a choice, with adherence to the precautionary principle. Only those effects that are shaded in Table 12-5 are considered likely significant effects with regard to the Town and Country Planning (Environmental Impact Assessment (EIA)) (England and Wales) Regulations 1999 (SI 1999 No 293) (as amended) (Ref 12-41).

12.3.20 Mitigation measures are recommended where significant potential adverse effects are identified. Where appropriate, mitigation measures are recommended with reference to current good practice guidelines.

12.3.21 The significance of the impacts effects that remain after mitigation measures have been put in place (i.e. the residual impacts) is assessed and identified.

Limitations and assumptions

12.3.22 As part of this consultation process and preparation of this PEIR a number of assumptions have been made. These are set out below:

- Information provided by third parties, including publicly available information and databases are correct and complete at the time of publication.
- Baseline conditions have been assumed to be accurate at the time of the surveys however, owing to the dynamic nature of the environment, conditions may change during the construction and operational phases.
- The approach which was adopted for the assessment of contamination at the site within previous reports is based on current guidance at the time of writing.

12.3.23 This preliminary assessment has been limited to the currently available desk-top information and site walkover undertaken by Mott McDonald (Ref 12-21).

12.3.24 Transport for London (TfL) carried out a ground investigation for the Scheme in 2015 (Ref 12-22). The Factual Report for this ground investigation has been reviewed as part of this Chapter as well as the Ground Investigation Report (Ref 12-22). The content includes a review of information presented in the Phase 1 Desk Study (May 2013) (Ref 12-21) and a review of the ground conditions encountered during the intrusive investigation in 2015. Presented within the report is a contamination assessment and the refinement of a conceptual site model.

12.3.25 A review of the ground investigation data and Environmental Statement for the nearby Emirates Air Line (EAL) (Ref 12-38) has also been undertaken to assess baseline conditions for the construction of the jetty. The information within this document was used as current investigation data is unavailable for the area of the proposed jetty.

12.4 Description of the baseline conditions

12.4.1 This section comprises the results of a desk-based assessment (DBA) and the findings of the ground investigation report (Ref 12-22) containing information pertinent to ground contamination, geology, hydrogeology and human health.

Existing baseline

12.4.2 A Geo-Environmental Desk Study Report was previously prepared in May 2013 (Ref 12-23). Subsequently a contamination risk assessment has been prepared using the resources listed in Section 12.3.11. Any risks identified in this report are perceived risks, based on the information within the Desk Study Report and therefore partially based on assumptions from available information. The presence of the completed assessment and intrusive investigation report at this stage allows actual ground and groundwater conditions to be verified and the confirmation or absence of any contamination to be confirmed.

Site history

12.4.3 Table 12.6 below provides a summary of the site history, including potentially contaminative activities and principal contaminants of concern in and around the site.

12.4.4 The table was produced following a review of historical mapping for the site dating back from the late 19th century as contained within the Geo-Environmental Desk Study Report (Ref 12-21).

Table 12-6 Historical summary

Item	Inferred date of operation	Associated contaminants
On site – north of the River Thames		
Royal Victoria Docks, wharfs and jetties	1855 – present day	Ground gases, metals, phenols, sulphides, asbestos, cyanides, hydrocarbons
Manure Chemical Works	Circa 1896 -1950	Ammonia, animal / plant waste, heavy metals and Poly Aromatic Hydrocarbons
Oil and Coke Mills	1950 -1970s	Hydrocarbons, heavy mineral oils, heavy metals, PAHs
Waste management and cement/aggregate/concrete batching facilities.	Present Day	Metals, inorganics, acids, asbestos, organics – hydrocarbons and Polychlorinated Biphenyl
On site – south of the River Thames		
Southern Metropolitan Gasworks	1860s -1987	Organics, inorganics, metals, asbestos
Chemical Works	Circa 1896	Metals, inorganics, organics, asbestos, fuels and PCBs
Goods Depot and Railway	Unknown -1960s	Metals, PAH and petroleum hydrocarbons
Study Area (Outside of Limit of Land to be Acquired or Used))		
Coal depot	Unknown to 1930s	Polycyclic Aromatic Hydrocarbons (PAH associated with coal ash
Paint Works	1950 to unknown	Metals, PAH, solvents, and petroleum hydrocarbons

Item	Inferred date of operation	Associated contaminants
Engineering works	1950s to 1960s	Heavy metals and hydrocarbons
Railway Sidings	Unknown to 1980s	Metals, PAH and petroleum hydrocarbons
Scrap yard	Pre -1990s to unknown	Heavy metals, lubricants, hydrocarbons, paints and solvents

Source: Department of the Environment Industry Profiles (EA) 1995

12.4.5 Historically the north and eastern part of the Greenwich Peninsula was occupied by one of the largest gasworks in Europe up until the 1970s. The gasworks complex had a range of associated industries, including a large tar works, a chemical works, and a power station. Between 1995 and 1999, there was extensive ground contamination remediation work on the site, consisting of the removal of grossly contaminated soil 'hotspots' and a large former tar well, and the placement of an overlying layer of 'barrier' material.

12.4.6 In addition, as part of the development works for the 2012 London Olympic Games, further remedial works were carried out on the Millennium Exhibition Site (MES) (extending to the eastern part of the Greenwich Peninsula). This was reported within the Greenwich Peninsula Remediation Strategy Framework Report, (Ref 12-38). The report presents the overall remediation strategy for the Greenwich Peninsula as required by the Environmental Method Statement (Ref 12-18), and provides key principles for dealing with contamination encountered during the development works. These measures included lined services trenches, steps to control lateral migration of contaminated perched groundwater, limitation on rainfall infiltration by provision of impermeable landscaping, pipe surface water drainage, and soft landscaping under-drainage.

12.4.7 Today the Greenwich Peninsula is predominantly occupied by car parking (i.e. hardstanding), with The O2 and commercial buildings located to the north-west, and a leisure facility to the south-east.

Site walkover survey

12.4.8 A site walkover survey was conducted in May 2013 as part of the Desk Study Report (Ref 12-21). The following general comments and observations are made which are expanded upon in subsequent sections on each specific aspect of the ground conditions, hydrogeology and human health.

12.4.9 The land situated north of the River Thames comprises industrial units, concrete batching plants, aggregate processing yards, waste recycling, scrap metal yards, storage yards and warehouses. These are all generally located between the A1011 Silvertown Way and Dock Road.

12.4.10 Waste recycling facilities and scrap metal yards, cement works and plant storage yards are located between Docklands Light Railway (DLR) and the river wall.

12.4.11 At the south side of the River Thames (Greenwich Peninsula) the Scheme is located in an area mostly covered by hardstanding, parking areas. The EAL terminal is located to the east of the Scheme.

12.4.12 The Scheme is situated beneath and approximately parallel to Edmund Halley Way; then veers southwards to connect in to the existing A102 Blackwall Tunnel Approach Southbound adjacent to gas holder on the peninsula which is no longer operational. This gas holder formed part of the South Metropolitan Gasworks which was demolished during circa 1976. Furthermore, the site passes near the Brenntag UK Ltd chemical storage area, which was noted to have sustained a substantial fire in 2012.

Ground conditions – geology

12.4.13 No statutory designated sites of geological interest, such as Sites of Special Scientific Interest (SSSI) and National Nature Reserves (NNR) were identified within the study area. This indicates that the Scheme is not located within an area of important geology.

12.4.14 The Desk Study Report (Ref 12-21), the BGS Mapping (Ref 12-29 to 33) and BGS digital map viewer (Ref 12-36), confirm that there are extensive areas of made ground at both the Silvertown site and the Greenwich site. These areas are primarily to the north-east and south-east of the Scheme and the perimeter of the docklands.

12.4.15 In addition to the above, the presence of made ground is also indicated around the perimeter of the Royal Victoria Dock, the Tidal Basin and the former Royal Victoria Dock Western Entrance. Historically, made ground was placed to raise the ground level above the marshland. Subsequently, made ground is likely to be associated with the demolition and redevelopment of sites in the area.

12.4.16 BGS mapping (Ref 12-29 to 33) and BGS Digital Map Viewer (Ref 12-36) identified that the majority of the Scheme contains superficial deposits. These sediments comprise alluvial deposits present around the docklands area and rests on the River Thames Terrace Deposits.

12.4.17 As detailed within the Atkins GI Report (Ref 12-22) Mott MacDonald (Ref 12-21) summarised the solid geology to comprise “the Thames Group, consisting of the London Clay Formation, which overlies the Harwich Formation. The Harwich Formation lies unconformably on the underlying Lambeth Group, which comprises the Laminated Beds over Lower Shelly Beds of the Woolwich Formation and Lower Mottled Beds of the Reading Formation over the Upnor

Formation. The Lambeth Group unconformably overlies the Thanet Sand Formation, which in turn overlies the White Chalk Subgroup".

12.4.18 Ground investigation data reported within the Atkins GI Report (Ref 12-22) confirmed the geology within the Greenwich and Silvertown sites to comprise the following:

Greenwich site

- Made Ground up to 4.5m thick;
- Superficial Deposits comprising Alluvium (up to 5.3m thick) above River Terrace Deposits up to a maximum thickness of 8.8m; and
- Solid Geology comprising the Thames Group comprising the London Clay Formation up to 10.7m thick above the Harwich Formation (maximum thickness of 5.48m). This overlies the Lambeth Group which comprises Laminated beds and channel sand (In excess of 6.9m thick), lower shelly clay and lower mottled beds.

Silvertown site

- Made Ground between 8.5m thick and in excess of 15.05m thick in areas;
- Superficial Deposits comprising Alluvium (up to 5.3m thick) above River Terrace Deposits up to a maximum thickness of 4.4m thick; and
- Solid Geology comprising Thames Group comprising the London Clay Formation up to 15.85m thick at -21.96 mAOD at its lowest elevation above the Harwich Formation (maximum thickness of 3.1m). This overlies the Lambeth Group which comprises Laminated beds and channel sand (In excess of 4.6m thick), lower shelly clay and lower mottled beds on top of the Upnor Formation (recovered at -33.32mAOD).

12.4.19 Within the London Clay and Lambeth Group, deep drift-filled features, termed 'scour hollows', may be present. These represent localised zones in which the strata vary abruptly from the surrounding geology. These features can have an effect on groundwater flow, whereby groundwater flow direction, levels and transmissivity may vary where large scour hollows are present. A number of 'scour hollows' have been suggested as being present within the site by Berry, Late Quaternary scour hollows and related features in central London (1979) (Ref12-46). A substantial scour hollow is present on the alignment of the

Blackwall Tunnel. One has also been suggested at the mouth of the River Lea, and one near the Butane Store at East Greenwich Gasworks.

12.4.20 The structural geology of the site has been assessed with reference to the Desk Study Report (Ref 12-21) and the BGS mapping (Ref 12-29 to 33). These sources identify that the study area and surrounding area lies within a gentle synclinal basin flanked by chalk escarpments. No other tectonic features were identified.

12.4.21 The Desk Study Report (Ref 12-21) identifies the 'Greenwich Fault' as a possible fault which crosses the Scheme in the vicinity of the Beckton Gasworks. Historic ground investigation data suggests this feature is a step faulted monoclinic feature.

12.4.22 A Conceptual Site Model for the scheme which represents the characteristics of the site in a form that shows possible relationships between contaminants (sources), pathways and receptors is provided in Table 12 -8.

Hydrology

12.4.23 The nearest surface water features to the Scheme are the River Thames and the Royal Victoria Dock. A minor river known as the Cut is located 120m south-west of Dock Road. Another unnamed minor river is located 180m north-west of the Scheme. The River Lea joins the River Thames near the northern boundary of the site.

12.4.24 Regionally, surface water flow direction in the vicinity of the Scheme is likely to be towards the east.

12.4.25 Locally, the superficial deposits are likely to be in hydraulic continuity with both the surface water features and the bedrock aquifer beneath.

Hydrogeology

12.4.26 Groundwater strike information available on the borehole logs sourced from the BGS GeoRecords web portal (Ref 12-27) identified areas both to the north and south of the River Thames as having groundwater phreatic surface at approximately 2.5m bgl (below ground level).

12.4.27 However, groundwater information obtained from the Atkins GI report (Ref 12-22) has confirmed groundwater conditions within the Greenwich and Silvertown site to comprise the following:

Greenwich site

- Groundwater strikes were encountered between 1.90m bgl (1.12 mAOD) and 20m bgl (-17.76mAOD) across the site.
- Groundwater monitoring data recorded levels between 7.90mbgl (G11A) and being dry over the three monitoring visits. The shallowest levels were recorded at 1.80m bgl with EB3A.

Silvertown site

- Groundwater strikes were encountered between 0.80m bgl (1.91 mAOD) and 8.5m bgl (-6.14mAOD) across the site.
- Groundwater monitoring data recorded levels between 7.85mbgl (G15) and being dry over the three monitoring visits. The shallowest levels were recorded at 1.67m bgl with EB5.

12.4.28 Regionally, groundwater flow direction in the vicinity of the Scheme is likely to be towards the River Thames.

12.4.29 The Desk Study Report (Ref 12-21) indicates that groundwater is likely to be encountered as perched water in the made ground, with an upper aquifer in the River Terrace Deposits and a lower aquifer in the granular Lambeth Group, underlying Thanet Sands and Chalk. The Lambeth Group is known to be locally permeable and therefore continuity with underlying Thanet Sands cannot be discounted.

12.4.30 The Environment Agency website (Ref 12-28) indicates that the Scheme will be situated within an area in which superficial deposits are designated as a Secondary (undifferentiated) aquifer status. This status is assigned *'in cases where it has not been possible to attribute either category A or B to a rock type. In most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type'*.

12.4.31 The bedrock deposits immediately underlying the Scheme are primarily designated with the following aquifer status:

- London Clay (unproductive strata);

- Harwich Formation, Lambeth Group and Thanet Sand Formation (Secondary A Aquifer); and
- White Chalk (Principal Aquifer).

12.4.32 The Harwich Formation, Lambeth Group and Thanet Sand Formation are likely to be to have some form of hydraulic continuity with the underlying white chalk principal aquifer.

12.4.33 According to the groundwater vulnerability map, the Scheme is situated in an area with soils classified as having a high leaching potential.

12.4.34 The Environment Agency website (Ref 12-28), indicates that the Scheme does not lie in close proximity to a source protection zone (SPZ), or source protection zone borehole. A nitrate vulnerable zone is located on the Silvertown site, on the north bank of the River Thames. The groundwater in the upper aquifer is likely to be in continuity with the River Thames.

12.4.35 Surface water quality within the area obtained from the EA assessed during 2009, was assessed as a Grade C (Fairly Good) for chemistry.

12.4.36 With reference to the Environment Agency website, groundwater abstraction catchment areas (Ref 12-13) are located at four locations within 500 m of the site at variable sizes. These are located both to the north and south of the River Thames. One is located near the Royal Victoria Dock which contains 80 groundwater abstraction licences within that catchment. Three other groundwater abstraction catchment areas are to the south of the O2 arena. Each of these is recorded as having 21 groundwater abstraction licences within its catchment. It is not known if water is currently being abstracted.

12.4.37 In the EAL Environmental Statement (Ref 12-38), the following was identified:

- One licensed groundwater abstraction catchment was recorded approximately 50 m north-west of the Limit of Land to be Acquired or Used, approximately 150 m to the north west of the south station site (EAL) used for a heat pump. A review of the EA data confirms that this groundwater abstraction catchment contains 21 other groundwater abstractions within the catchment area.
- One licenced discharge was recorded approximately 100 m north of the Limits of Land to be Acquired or Used, discharging cooling water.

12.4.38 A ground investigation was undertaken during 2015 and comprised 30 on shore cable percussive boreholes with rotary follow on, 36 trial pits and 10 structural trial pits, with associated geotechnical and geo-environmental testing. An additional three boreholes were undertaken over water. The ground investigation information was presented within a Factual Report (Ref 12-22). This information was then interpreted and presented within the Ground Investigation Report (12-22).

12.4.39 The Ground Investigation Report (Ref 12-22), noted the following information with regard to groundwater testing:

- To evaluate the potential risks to identified receptors within Silvertown, groundwater data was assessed with respect to Water Quality Standards (WQS).
- Groundwater results identified a large number of exceedances across both Greenwich and Silvertown sites for a number of contaminants such as inorganics, metals, phenols, Total Petroleum Hydrocarbons Criteria Working Group (TPH CWG), Poly Aromatic Hydrocarbons (PAHs) and Volatile Organic Compounds (VOCs) within all three monitoring wells. In particular Borehole G16 to the north.
- The boreholes can be located with reference to the exploratory hole location plan with accompanying cross sections (Appendix 12.A) taken from the Ground Investigation Report, June 2015 (Ref 12-22).
- Within the Greenwich Peninsula area, exceedances were recorded within all six borehole monitoring locations across differing strata at deep and shallow depths. Exceedances were for metals, PAHs, TPH CWG and VOCs.
- It was concluded that there was a widespread risk to controlled water receptors across the Silvertown site, within the superficial aquifer as well as contaminated perched water.
- It was concluded that as elevations within groundwater samples did not correspond with to the elevated constituents within soils found on site, it is believed that the contamination within groundwater is localised and from an offsite source.

Contaminated land

12.4.40 The Desk Study Report (Ref 12-21), identified the following potential historical sources of contamination within the study area:

- railway land (including coal and goods depots);
- manure works;
- chemical works;
- garages;
- engineering works; and
- historical landfills - associated with the infilling of the former Western Entrance lock to the Royal Victoria Dock with inert waste which remains largely unaltered once buried, such as glass, concrete, bricks, tiles, soil and stones.

12.4.41 The following potential historical sources of contamination were identified within the Greenwich site:

- Historical landfills - adjacent to the south portal of tunnel. This landfill accepted inert waste as above. Within this zone, south of Edmund Halley Way, there is a registered waste treatment or disposal site. The site has surrendered a completion certificate.
- Metropolitan Gasworks - operational between the 1860s and 1980s.

12.4.42 The contaminative sources were later refined within the Atkins GI (Ref 12 –22): report and are listed below:

Silvertown site

- contaminated soils from on site activities, such as aggregate manufacturing facilities, waste recycling facilities and scrap metal yard;
- contamination from former site activities, such as chemical works, oils storage facility and multiple docklands warehouses;
- ground gasses from made ground and alluvium;
- contaminated perched water in made ground; and

- contaminated groundwater from historical land uses.

Off-site sources included:

- contamination from ongoing activities such as paint works and surrounding warehouses; and
- residual contamination associated with former activities located off-site, such as manure works, iron works and soap works.

Greenwich site

- contamination from on-going activities such as South Metropolitan Gasworks and associated railway land DLR;
- contaminated perched water in made ground;
- elevated ground gases and leachate from East Greenwich landfill; and
- contaminated groundwater in River Terrace Deposits.

Off-site sources included:

- contamination from on-going activities off site such as the off-site aggregate works and disused gas holder; and
- residual off-site contamination sources, such as the cement works, chemical works, iron building works, wood paving, linoleum works and former power station.

12.4.43 Site wide remediation of the gasworks was undertaken during the late 1990s by British Gas and English Partnerships. It is understood that key sources of contamination, such as tar tanks and known contamination hot spots, were removed, groundwater remediation was undertaken and near surface soils were removed or cleaned prior to landscaping. However, it is understood that contaminated materials remain deeper beneath much of the site. A ground investigation was undertaken to confirm the extent of contamination within the study area, the results of which were reported within the Greenwich Peninsula Remediation Strategy Framework Report in 2007 (Ref 12-25). A summary of the results are presented within section 12.4.46.

12.4.44 It is believed that residual contamination from the South Metropolitan Gasworks is still impacting the nearby Blackwall Tunnel today. Tar has been found to seep into the Blackwall Tunnel which both degrades materials and blocks gulleys.

12.4.45 Asbestos was encountered in 'inert' backfill to the Western Entrance Lock of the Royal Victoria Dock during the ground investigation for the EAL.

12.4.46 The Desk Study Report (Ref 12-21), considered the potential for ground and groundwater contamination within the Scheme as having a moderate to high risk rating.

12.4.47 The Ground Investigation Report (Ref 12-22) identified the following contaminated land issues with regard to soils: Contaminated groundwater issues are covered within Section 12.4.36.

- Within the Greenwich site, asbestos fibres were recovered in nine soil samples at six locations between 0.30m bgl and 3m bgl.
- Within the Silvertown site, asbestos fibres were recorded within 19 soil samples at 15 locations between 0.50m bgl and 7m bgl.
- Visual hydrocarbon contamination of soils was encountered at two locations within the Greenwich site at EB3 and G10A. At EB3A a hydrocarbon odour and black tar staining was noted between 1.20m bgl and 3.3m bgl and testing confirmed contamination with hydrocarbons. Slight odours were noted at G10A, ET8A and generally corresponded with soil testing elevations. Other visual /olfactory indicators of potential contamination were found across Greenwich at multiple locations including the presence of clinker, coke and coal from E11 (0.80m bgl) as well as clinker, cement, concrete, coke and ferrous metal from ET12.
- No visual evidence of contamination was noted within the Silvertown site, however several exploratory holes contained made ground comprising ash, and clinker. These were primarily within borehole G20, G22, G26 and trial pit ET30.
- Chemical testing undertaken on 42 soil samples across the Silvertown site found six exceedances in total identified from three samples, all within made ground. These contained elevated levels of Cyanide, Lead and Benzo (a) pyrene. Levels of lead were found to be over three times above the C4SL criteria for commercial end use. However, given the limited number of exceedances of contaminants at the Silvertown site at relatively shallow

depths, they are likely to be removed as part of the construction process. Therefore, soils remaining post-construction are not considered to present a significant risk to human health.

- Within the Greenwich site, there were found in four samples out of 36 samples taken. There were elevations in cyanide (total and complex), lead, TPH, and PAH`s, comprising benzo (a) anthracene and benzo (a) pyrene. These also were likely to be removed as part of the construction process and therefore not considered a significant post construction risk.

- A ground gas assessment was undertaken in accordance with CIRIA 665 Guidance, based upon ground gas reading during the ground investigation. A number a results contained methane and CO_2 readings above a Characteristic Situation 1 (CS1) classification and therefore a classification of Characteristic Situation 2 (CS2) (low risk) was deemed appropriate.

12.4.48 Water Screening Values (WSVs) assess the chronic human health exposure from inhalation of vapours from contaminants within shallow groundwater or perched water. The Ground Investigation Report (Ref 12-22) screened groundwater data against Atkins derived WSVs. The GI report identified the following:

Silvertown site:

- No exceedances of the WSVs were identified from six groundwater samples from three locations. Therefore it was considered the risk to human health from inhalation of vapours on site is minimal.

Greenwich site:

- Exceedances of TPH (Benzene), PAH`s (Naphthalene), VOCs (Benzene, 1,2,4- trimthylbenzene, and Naphthalene) were identified within boreholes EB3A, G4 and G8 and were primarily concentrated towards the south western most part of the proposed tunnel. Although G8 is located within the central region.

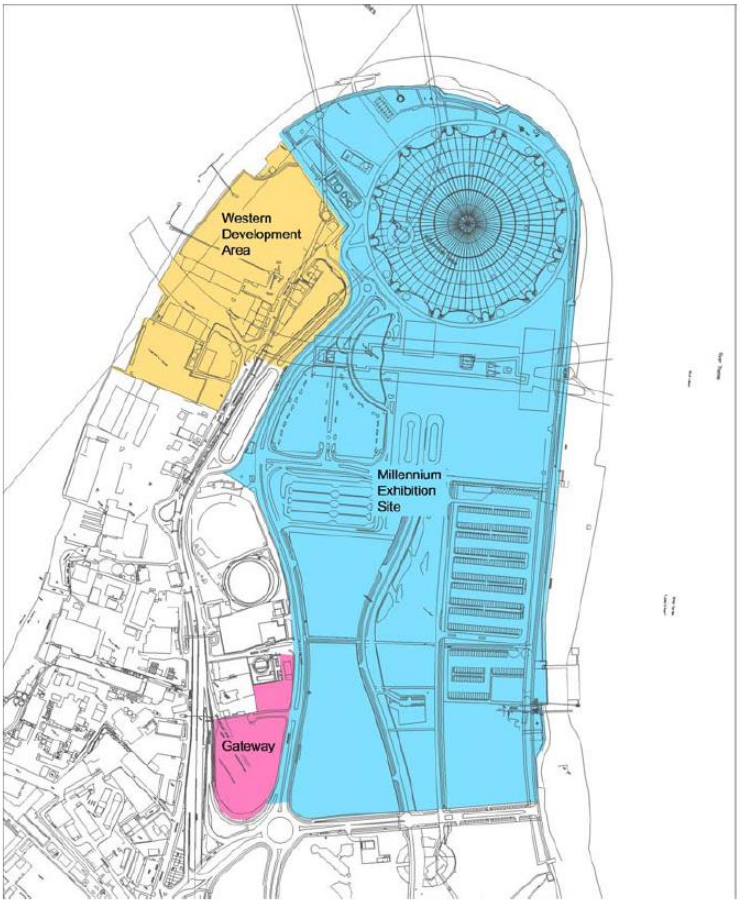
- The exceedances identified within the groundwater samples don’t correspond with constituents elevated within soils on site. This indicated an off-site source of groundwater contamination beneath the site towards the south western region of the site and is considered to be a localised source.

Greenwich Peninsula – Remediation Strategy Framework Report (Ref 12-25)

12.4.49 The Greenwich Peninsula Remediation Strategy Framework Report, (Ref 12-25), presents the overall remediation strategy for the Greenwich Peninsula as required by the Greenwich Peninsula Environmental Statement (Ref 12-18).

12.4.50 The development area was divided into three sub-areas: the former Millennium Exhibition Site (MES), the Western Development Area and the Gateway site. A plan showing these locations is shown below.

Figure 12-1 Greenwich Peninsula



Source: Greenwich Peninsula Remediation Strategy Framework Report, (Ref 12-25)

12.4.51 The Scheme intersects the middle of MES, the south-eastern end of the Western Development area and the outer eastern edge of the Gateway site sub-area.

12.4.52 The report states that present ground conditions across the whole of the MES comprise of an overlying 'barrier' layer of material underlain by ground. The ground under the barrier layer remains potentially contaminated by a wide range of organic and inorganic substances which are hazardous to human health and/or aggressive to buried construction, or toxic to flora or fauna. The contaminants include Tars –PAHs, Mineral Oil and Petroleum Hydrocarbons, Benzene, Cyanide, Phenols, Ammoniac Compounds, Sulphate and Sulphide and heavy metals and potentially asbestos. The upper 'barrier' layer was said to be separated from the underlying variably contaminated ground by a marker sheet (usually orange coloured plastic mesh sheet).

12.4.53 Organic and inorganic compounds were typically either below method of detection limit or of low concentration, with the exception of the far north of the Greenwich Peninsula. Elevated concentrations of gasworks contaminants are present at the northern tip of the peninsula near the area of the Ordnance Jetty, where heavy hydrocarbon contamination exists at depth.

12.4.54 The River Terrace gravel aquifer has been adversely impacted by the site's former uses, particularly at the northern end of the peninsula. The water quality is poor, with the presence of organic and inorganic pollutants throughout the aquifer, with significantly elevated amounts of ammoniac nitrogen. In general, the quality deteriorates within the River Terrace gravels towards the north of the peninsula.

12.4.55 No post remediation sampling or analysis of perched groundwater was undertaken as part of the Greenwich Peninsula – Remediation Strategy Framework Report.

12.4.56 The report states that post remediation ground gas monitoring had been limited. The potential exists for some residual hydrocarbon vapours to be present in the ground, particularly at the northern end of the peninsula.

12.4.57 The report also states that the northern part of the Western Development Area is not as contaminated as parts of the MES. Overall, metal and hydrocarbon contamination was largely confined to the made ground.

12.4.58 Generally, the quality of the groundwater in the River Terrace gravels within the western development area has been found to be poor with moderately elevated concentrations of cyanides and some heavy metals over the whole site. Along the northern boundary of the western development area there are significantly elevated concentrations of hydrocarbons. A previous abstraction well in the

centre of the northern part of the Western Development Area indicated that the Chalk aquifer in this area is not impacted by any contamination.

12.4.59 The site investigation indicated less than 2m of made ground is present within the Gateway area. With the exception of the southern corner of the area, concentrations of contaminants were found to be low compared to the development site as a whole. In the southern corner of the site, PAH and mineral oil concentrations were found to be moderately elevated. Benzene was found to be relatively elevated compared to the whole development site, but all concentrations were below applicable guideline concentrations.

12.4.60 The recommended remediation included the further installation of a ‘marker sheet’ across MES and a ’marker sheet’ may be installed on either the Western Development Area or Gateway area in any localised areas where significantly contaminated ground will remain beneath the capping layer.

Silvertown Tunnel Reference Design Settlement Assessment Report (Ref 12 –39)

12.4.61 The report outlines the theories behind the settlement damage assessment due to tunnelling works and provides findings from combined stage 1 and 2 of a 3 stage assessment process.

12.4.62 The surface and sub-surface settlement of tunnels are influenced by tunnel size, depth, construction method and trough factor of the geological strata between the tunnel and the surface.

12.4.63 The settlement assessment report predicted the ground movement and assessed possible damage caused to third party assets by works associated with the construction of the proposed tunnel. The report set out the assessment results from settlement damages using the “Settlement Assessment Process”. This process involves three stages of assessment; Stage I: Preliminary assessment, stage II: individual building assessment and Stage III: detailed evaluation. These stages have identified assets that could be affected within the 1mm and 10mm settlement contour zones.

12.4.64 The report found that The O2 car park was at a severe risk of damage but will be demolished as part of the overall Greenwich masterplan. The River Thames walls and buildings No. B1_N, B3_N and B4_N were all labelled as moderate to severe risk of damage and should be taken to a Stage III assessment.

12.4.65 The following recommendations were outlined:

- The DLR Woolwich Branch Viaduct and the EAL Ship Impact Protection Pontoon B should also undergo a Stage III assessment at the detailed design stage, to ensure no adverse effects are encountered.
- It was recommended that the proposed tunnel route is surveyed prior to construction to confirm that all assets are standing, and again prior to tunnelling for all assets including any constructed after the reports publication.
- The locations where existing asset demolition took place should be recorded. If residual deep obstructions are found which could affect the tunnel alignment, then then an extraction methodology should be undertaken and works completed prior to tunnelling.
- Condition surveys should be undertaken for all assets identified for a Stage II assessment. They should also be monitored before during and after the tunnel construction.
- The monitoring of ground movements along the tunnel and open cut approaches would provide conformation of the assessment; and
- Finally the operations of the EAL ship impact protection floating pontoons should be monitored before during and after the works. This should be discussed and agreed with the asset manager.

12.4.66 A full geotechnical and Geo-Environmental risk assessment has been included in the report. A list of geotechnical hazards include:

- settlement/ collapsible ground (shrink-swell clay/peat)
- groundwater conditions
- encountering underground structures or unforeseen obstructions
- damage to third party land
- distance of marginally stable grounds
- drivability of TBM
- driveability of piles
- base heave from tunnels

- dewatering of excavations

Unexploded Ordnance (UXO)

12.4.67 The Scheme is located within an area of London which is known to have been heavily bombed during the Second World War. A Stage 2/3 detailed UXO Threat Assessment in line with current guidance CIRIA C681 (2009) (Ref 12-43) was undertaken as part of the May 2013 Mott MacDonald Desk Study (Ref 12-21).

12.4.68 The assessment established that in the areas on either side of the River Thames there is a Medium / High risk of encountering UXO. This risk increases to High within the River Thames as bomb strikes are likely to have gone unnoticed.

12.4.69 A UXO Survey Report undertaken by EGS (international) Limited has been summarised within the Atkins GI report (Ref 12-22). The findings of the UXO survey report are as follows:

- UXO surveys comprising magnetometer, gradiometer and seismic refraction were undertaken to determine the UXO risk to the site. Due to programme constraints a revised scope was undertaken and focused on overwater borehole location G12, G13 and G14 and the footprint of the jackup platform.

- During the survey 660 magnetic anomalies were identified over the survey area, of which 104 anomalies cannot be related to any know infrastructure whereby UXO may be present. A further review of the data should be carried out by a UXO specialist should a clearance of the survey are be required.

- In terms of total magnetic field, EGSi could not identify any magnetic anomalies associated with UXO due to strong background disturbances.

Summary

12.4.70 The preliminary assessment suggests that the geo-environmental risks may be perceived as moderate to high, with a high risk from groundwater due to existing contamination found within groundwater.

12.4.71 The principal geotechnical hazards include the presence of made ground, potential risk of compressible / low bearing capacity soils, shallow contaminated groundwater and UXOs. The risks associated with these hazards if left unmitigated are high.

Future baseline

12.4.72 A number of developments are proposed for construction or currently being constructed within the study area. These comprise various infrastructure and commercial developments at locations shown within Drawing 17-1 Base Case and 17-2 Cumulative Developments, including the Thames Tideway Tunnel project.

12.4.73 The construction and operation of these developments have the potential to influence the future geology and soils baseline (primarily to the south of the River Thames). Examples of this could include the creation of new sources of contamination or creation / reactivation of contamination pathways in underlying soils.

12.4.74 The proposed neighbouring developments and re-developments will need to ensure that their intended schemes are fit for purpose. This may require some form of remediation, depending on the sensitivity of the scheme and the levels of contamination present. To ensure that any land affected by contamination is addressed and rendered suitable for its intended use, proposed developments and re-developments are subject to guidelines within the NPPF. This is to ensure that any issues are addressed prior to re-development, and that human health and the environment are protected from land contamination.

12.5 Scheme design and mitigation

Conceptual Site Model (CSM)

12.5.1 The CSM is based upon information from the desk study for both Silvertown and Greenwich sections of the Scheme. The CSM considers the site as it is currently and also in consideration of the proposed Scheme.

12.5.2 A CSM represents the characteristics of the site in a form that shows possible relationships between contaminants (sources), pathways and receptors.

12.5.3 A CSM approach has been used to assess the risks posed by contaminants to human health using a source - pathway - receptor model. This is based upon:

- Source (potential source of contamination);
- Pathway (means by which contamination can reach and impact upon a receptor); and
- Receptor which may be adversely affected by the presence of contamination.

12.5.4 The following section details the CSM and defines the potential pollutant linkages for the site. It does this by outlining the potential sources of contamination, the associated Contaminants of Concern (COC), and examines the pathways by looking at the construction methodology that would be active in allowing COC to reach sensitive receptors.

12.5.5 Table 12-7 below describes the credible pathways by which sources could impact receptors.

Table 12-7 Potential pathways of land contamination

End users (operational workers/users)	Surrounding land uses	Construction workers	Controlled waters	Ecological systems	Built environment
Direct or indirect ingestion of contaminated soil (operational)	Inhalation or deposition of wind-borne dust (construction stage)	Direct or indirect ingestion of contaminated soil (construction stage)	Ingestion of exposed contaminated groundwater (construction phase)	Phytoxic impacts on plant species and smothering of fauna with silt (operational and/or construction stage).	Direct contact of with structure. Chemical attack of buried concrete structures and permeation of volatile compounds through plastic potable water supply pipes.
Concentration of flammable or asphyxiating in-ground gases in enclosed spaces (operational)	Migration of contamination in the sub-surface strata (including gases) (operational and/or construction stage)	Concentration of flammable or asphyxiating gases in confined spaces (construction stage)	Migration/leaching of identified contaminants into controlled waters via horizontal and vertical migration (construction and operational stage)	Toxic impacts on fauna (operational and/or construction stage)	Concentration of flammable gases or vapours (potential for explosion or fire) in confined spaces. Operational phase

End users (operational workers/users)	Surrounding land uses	Construction workers	Controlled waters	Ecological systems	Built environment
Inhalation of harmful in-ground vapours indoors and outdoors (operational)		Inhalation of dusts and/or asbestos fibres during ground works	Migration of contaminated groundwater into aquifer through creation of preferential pathways (construction phase)	Indirect impacts via contamination of water resources (operational and/or construction stage)	
			Direct run off into the River Thames (construction phase).		

Potential pollutant linkages

12.5.6 Table 12-8 lists identified potential pollutant linkages at Silvertown and Greenwich sites, according to the source-pathway-receptor approach. The CSM at this stage comprises the identification of potential hazards (source of contaminant – the substances that might credibly be associated with historical and current land use), the potential receptors that may be affected and the credible pathways to those receptors.

12.5.7 Site users are those people accessing the Silvertown and Greenwich sites post construction. Site neighbours are those people accessing or living in areas adjacent to the Silvertown and Greenwich sites during the construction and post construction.

Table 12-8 Conceptual Site Model

Source	Potential contaminants	Credible pathway(s)	Receptors
Silvertown site – on-site sources			
• Contaminated soils from ongoing activities on-site such as the aggregate manufacturing facilities, waste recycling facilities and scrap metal yard. • Residual contamination from former on-site activities, such as the chemical works, oil storage facility and multiple dockland warehouses.	Various, heavy metals, hydrocarbons, PCBs and asbestos. Asbestos, acetone, hydrocarbons, PCBs and asbestos.	• Direct contact/accidental ingestion of contamination within soil or inhalation of dust. (construction stage) • Dermal contact with exposed soils and water during construction and maintenance involving excavation (construction stage). • Inhalation of soil/dust, volatilised compounds or ground gas via migration through permeable strata and conduits, with the latter at potentially asphyxiant concentrations (construction stage)	Human receptors: workers in temporary offices, adjacent site users and maintenance workers.

Source	Potential contaminants	Credible pathway(s)	Receptors
• Ground gases within the Made Ground and Alluvium. • Contaminated perched water in the Made Ground. Groundwater contaminated by historical land uses such as the former chemical works.		• Infiltration of rainfall and leaching of contamination from Made ground and near surface soils. • Migration and surface run-off into controlled waters (construction and operational stage) • Horizontal and vertical migration of leachable contaminants via groundwater within the Made Ground and River Terrace Deposits. • Migration of contaminated liquids/groundwater into the lower aquifer through the creation of preferential pathways.	Controlled waters (groundwater/aquifers/surface water body) and soils and geology.
		• Gas migration through permeable strata or conduits into confined spaces at potentially explosive concentrations	Built environment (buildings, structures and services).

Source	Potential contaminants	Credible pathway(s)	Receptors
		• Direct contact of soils with construction materials.	
		• Phytotoxic impacts on plant species and smothering of fauna with silt (operational and/or construction stage). • Inhalation or deposition of wind-borne dust (construction stage).	Ecological systems and surrounding land uses
Silvertown site – off-site sources			
• Contamination from ongoing activities such as the paint works to the south of Clyde Wharf and surrounding warehouses. • Residential contamination associated with former	Various, heavy metals, hydrocarbons, PCBs and asbestos. .	• Direct contact/accidental ingestion of contamination within soil or inhalation of dust (construction phase). • Ingestion of exposed contaminated soil and water during construction and maintenance involving excavation. • Gas/soil vapour migration (by diffusion or due to wind) and	Construction workers and site end users (human health - site end users and maintenance workers)

Source	Potential contaminants	Credible pathway(s)	Receptors
activities located off-site. • Railway land (including coal and goods depot) associated with the Docklands Light Railway (DLR) • Historical land uses including manure works & chemical works • Garages • Engineering works (Royal Victoria Docks including western entrance to the docks) • Historical landfills		wind- blown dust contaminant pathways from disturbance (construction phase).	
		• Infiltration of rainfall and leaching of contamination from made ground and near surface soils. • Migration and surface run-off in aquifer via preferential pathways and controlled waters (construction and operational).	Controlled waters (groundwater / aquifers/ surface water body).
		• Direct contact and permeation. • Gas migration through permeable strata or conduits into confined spaces at potentially explosive concentrations	Built environment (buildings, structures and services).
		• Phytotoxic impacts on plant species and smothering of fauna with silt (operational and/or construction stage).	Ecological systems and Surrounding land uses

Source	Potential contaminants	Credible pathway(s)	Receptors
		• Inhalation or deposition of wind-borne dust (construction stage).	
	Heavy metals, sulphates, phenols, hydrocarbons, PCBS, VOCs, dioxins and furans. Heavy metals, sulphates, phenols, hydrocarbons. Heavy metals, cyanides, hydrocarbons, PCBS. Ground gas, asbestos, unknown materials.	• Direct contact/accidental ingestion of contamination within soil or inhalation of dust (construction phase). • Ingestion of exposed contaminated soil and water during construction and maintenance involving excavation. • Gas/soil vapour migration (by diffusion or due to wind) and wind-blown dust contaminant pathways from disturbance (construction phase). • Build-up of ground gases in confined spaces. Inhalation of gases.	Construction Workers and Site End Users (Human health - site end users and maintenance workers)

Source	Potential contaminants	Credible pathway(s)	Receptors
		• Infiltration of rainfall and leaching of contamination from made ground and near surface soils. • Migration and surface run-off in aquifer via preferential pathways and controlled waters (construction and operational).	Controlled waters (groundwater/aquifers/surface water body) and soils and geology
		• Direct contact and permeation. • Concentration of flammable or asphyxiating in ground gases in enclosed spaces (operational).	Built environment (buildings, structures and services).
		• Phytotoxic impacts on plant species and smothering of fauna with silt (operational and / or construction stage). • Inhalation or deposition of wind-borne dust (construction stage).	Ecological systems and surrounding land uses

Source	Potential contaminants	Credible pathway(s)	Receptors
Greenwich site – on-site sources			
• Residual contamination from former on-site activities such as the South Metropolitan Gasworks and associated rail land. • Contaminated perched water in the Made Ground. • East Greenwich Landfill. • Contaminated groundwater within the River Terrace Deposits.	Heavy metals, cyanides, asbestos, phenols, PAHs, hydrocarbons, PCBs asbestos,	• Direct contact/accidental ingestion of contamination within soil or inhalation of dust. (construction stage) • Dermal contact with exposed soils and water during construction and maintenance involving excavation (construction stage). • Inhalation of soil/dust, volatilised compounds or ground gas via migration through permeable strata and conduits, with the latter at potentially asphyxiant concentrations (construction stage)	Construction workers and site end users (human health - site end users and maintenance workers)
		• Infiltration of rainfall and leaching of contamination from Made ground and near surface soils.	Controlled waters (groundwater/aquifers/surface

Source	Potential contaminants	Credible pathway(s)	Receptors
		• Migration and surface run-off into controlled waters / River Thames (construction and operational stage) • Horizontal and vertical migration of leachable contaminants via groundwater within the Made Ground and River Terrace Deposits. • Migration of contaminated liquids/groundwater into the lower aquifer through the creation of preferential pathways. • Lateral movement of contaminated groundwater into River Thames (Construction phase).	water body) and soils and geology
		• Direct contact and permeation.	Built environment (buildings, structures and services).

Source	Potential contaminants	Credible pathway(s)	Receptors
		• Concentration of flammable or asphyxiating in ground gases in enclosed spaces (operational).	
		• Phytotoxic impacts on plant species and smothering of fauna with silt (operational and / or construction stage). • Inhalation or deposition of wind-borne dust (construction stage).	Ecological systems and surrounding land uses
Greenwich site – off-site sources			
• Contamination from on- going activities off-site, such as the off-site aggregate processing works and disused gasholder. • Residual off-site contamination sources,	Heavy metals, cyanides, phenols, hydrocarbons, PCBs Ground gas, asbestos, unknown materials.	• Direct contact/accidental ingestion of contamination within soil or inhalation of dust. (construction stage) • Dermal contact with exposed soils and water during construction and maintenance involving excavation (construction stage).	Construction Workers and Site End Users (Human health - site end users and maintenance workers)

Source	Potential contaminants	Credible pathway(s)	Receptors
such as the cement works, chemical works, iron building works, wood paving and linoleum works. • Historical landfills		• Inhalation of soil/dust, volatilised compounds or ground gas via migration through permeable strata and conduits, with the latter at potentially asphyxiant concentrations (construction stage) • Concentration of flammable or asphyxiating in ground gases in enclosed spaces (operational).	
		• Horizontal and vertical migration of leachable contaminants via groundwater within the Made Ground and River Terrace Deposits (construction and operational phase). • Migration of contaminated liquids/groundwater into the lower aquifer through the creation of preferential pathways.	Controlled waters (groundwater/aquifers/surface water body) and Soils and Geology

Source	Potential contaminants	Credible pathway(s)	Receptors
		• Direct contact and permeation. • Concentration of flammable or asphyxiating in ground gases in enclosed spaces (operational).	Built environment (buildings, structures and services).
		• Phytotoxic impacts on plant species and smothering of fauna with silt (operational and / or construction stage). • Inhalation or deposition of wind-borne dust (construction stage).	Ecological systems and surrounding land uses

12.5.8 In order to address the linkages identified above, the following section outlines relevant aspects of the Scheme pre-construction, construction and construction approach, including proposed works, good practices and management plans that have been considered in this assessment.

Pre-construction

12.5.9 A linear unexploded ordnance survey of the Scheme has previously been undertaken and reported within the Ground Investigation Report (Ref 12-22) which identified areas of high risk within the River Thames. Further assessment will be undertaken within areas confirmed of as medium and high risk prior to any intrusive investigation works for retrieving information for design purposes and to assess any potential risk from UXO during the construction of the Scheme.

12.5.10 A detailed UXO mitigation strategy will be developed for the project prior to construction. The survey would likely include:

- a down hole magnetometer for deep intrusive works;
- the presence of an Explosive Ordnance Disposal (EOD) engineer; and
- jack up barge intrusive magnetometer for any areas within the River Thames to target high risk areas. These will be required prior to the construction of the jetty.

12.5.11 Details of good practice guidance which would be followed with regard to pollution are set out in Chapter 16: Water Environment.

12.5.12 A number of design measures are provided in Chapter 4: Description of the Scheme, a summary of which is provided below. The measures have been incorporated into the Scheme design to avoid and reduce impacts on receptors. These comprise:

- assessment of contaminated land based on the information obtained from the site investigation;
- completion of risk assessments and a Remediation Strategy (if required) and adherence to them throughout the construction works;
- adherence to the Construction Code of Practice for the Sustainable Use of Soils on Construction Sites (Defra, 2009);

- use of a CoCP and CEMP; and
- optimise the design of the Scheme to reduce need for materials import and minimise waste (although it is noted that waste is assessed within Chapter 13 Materials).

12.5.13 With the possibility that hydrocarbon contamination may yet still be encountered beneath the Greenwich site, during enabling works, a watching brief would be maintained with regards to currently unknown contamination. If visually contaminated or odorous material is encountered, the assistance of a suitably qualified and experienced person (a geo-environmental engineer) would be sought. Extra caution would be employed during the watching brief for the potential to encounter asbestos within soils.

12.5.14 Particular attention would be given to target areas (northern and eastern areas of Greenwich Peninsula) that are considered to have a greater potential for being the source of contamination.

12.5.15 In future phases of work, and following refinement of the site specific assessments, should contaminant linkages be proven to exist, the principles of CLR11 *'the Model Procedures for the Management of Land Contamination'* will be adopted, and appropriate mitigation of risk will be applied. The development will ensure this process of risk mitigation complies with UK principles of "suitable for use".

12.5.16 The Scheme will follow measures outlined within the "The Greenwich Peninsula Environmental Method Statement" (Ref 12-18), which details how any Scheme on the peninsula should be developed to stop the mobilisation of existing contamination. However, it should be stated that the document is currently subject to review and update as a result of the newly approved masterplan for the Greenwich Peninsula development.

12.5.17 The DCO will contain a requirement that a CEMP be put in place before the start of the works to ensure that good practice is employed and the environment is safeguarded. A Design Build Finance and Maintain (DBFM) structure has been proposed complete the detailed design, construct the tunnel and supporting infrastructure and be responsible for maintenance during a 30 year concession period. The DBFM contractor would need to prepare detailed method statements and appropriate controls would be employed to satisfy the general requirement to safeguard the environment. The plan would include method statements and protocols for activities.

12.5.18 Activities, pertinent to this Scheme that would be expected to be found within a CEMP, include:

- the provision of wheel washing facilities;
- site access points to be regularly cleaned;
- an Emergency Spill Response Plan (ESRP) would be produced, which site staff must have read and understood;
- areas for loading and unloading of plant and materials;
- defined access and haul roads for vehicles on site;
- clean down of vehicles and equipment;
- groundwater control to occur prior to concrete pouring, if required;
- defined areas for the storage of plant and materials used during construction; and
- sediment control measures (controlled in accordance with the Site Waste Management Plan).

12.5.19 The production and adherence to a CEMP is required so that geology and soils are not negatively impacted or contaminated as a result of the Scheme activities. Health and safety risks to construction workers will be mitigated by the designer's responsibility to design out risk embodied within Construction Design and Management Regulations and the implementation of appropriate health and safety measures. The DBFM contractor will be responsible for ensuring that members of the public and site workers are protected from the potential effects of any contamination encountered during the entire construction process. Measures utilised will be incorporated within the general construction site safety standards. The DBFM contractor will carry out a health and safety risk assessment with appropriate precautionary measures planned and recorded in advance by adequately training and qualified persons.

12.5.20 To limit the potential for effects to the soil resource, a Materials Management Plan and/or a Soil Resources Plan (as required by Good Practice Guide for Handling Soils (Ref 12-45)) would be developed and linked to a Site Waste Management Plan. Surplus excavated material would be re-used (where possible) within the area where it has been generated for landscaping etc.

12.5.21 It is recommended that a condition survey is undertaken prior to construction to assess the settlement risks for all assets listed in the Atkins settlement assessment report (Ref 12-39) to assess any predicted ground movement that could cause possible damage by works associated with the construction of the Scheme.

Construction

12.5.22 The construction of the Scheme would incorporate the use of construction methods within the temporary works which have the potential to disturb sediment/soil in the river channel in the vicinity of the tunnel. The soil/sediment in the vicinity of the Scheme has the potential to be contaminated from historical land use of the surrounding area. Silt pollution caused by working in surface water will be minimised by keeping water out of the works area using appropriate isolation techniques, such as coffer dams, pile jackets, by-pass channels, silt curtains or the use of special excavation plant. Water from the above activities will be disposed of by following the guidance set out in the Environment Agency's document PPG 5.

12.5.23 The construction activities in or near water have the potential to cause serious pollution or impact on the bed and banks of the River Thames and on the quality of the water. Some activities with the potential for affecting watercourses or groundwater may require either consent or authorisation in England under the Environmental Permitting (England and Wales) Regulations 2010.

12.5.24 If excavation works are undertaken in areas where locally contaminated water is identified, water may enter the excavations and lead to contaminants migrating vertically and horizontally or via run-off across the surface of soils.

12.5.25 Abstraction of potentially contaminated water from excavations will be controlled to prevent cross contamination of soils and potential impact upon the River Thames. Mitigation measures are outlined in the Environment Agency's PPG5: Works in, near or over watercourses.

12.5.26 The Scheme will adhere to EA Pollution Prevention Guidelines. These will include pollution prevention measures, such as bonding which would be provided for fuel storage areas to prevent contamination of the surrounding soils and groundwaters.

12.5.27 The Scheme will adhere to the Construction Code of Practice for the Sustainable Use of Soils on Construction Sites (Ref 12-46).

12.5.28 Contaminated land was identified during the ground investigation in 2015. This identified Chemicals of Concern as total Cyanide, Lead and Benzo (a) pyrene, asbestos and elevated ground gases. Therefore remediation / mitigation measures will likely be required at locations around the Millennium Exhibition Site and the north tip of the peninsula. The limits of land to be acquired or used lies within the MES site within Edmund Valley Way, Millennium Way and areas adjacent to the A102 main road.

12.5.29 The completion of Risk Assessments and a Remediation Strategy (if required) will need to be incorporated into the CEMP and undertaken prior and maintained throughout the construction works.

12.5.30 Adherence to Environment Agency Pollution Prevention Guidelines will be undertaken as part of the construction works via a CoCP and CEMP.

12.5.31 Where possible the Scheme will reduce the need for materials to be imported, and minimise waste (although it is noted that waste is assessed within Chapter 13 Materials).

12.5.32 A condition survey would be undertaken during construction to assess the settlement risks for all assets listed in the Atkins settlement assessment report (Ref 12-39) to assess the ground movement and possible damage caused to third party assets by works associated with the construction of the Scheme.

12.5.33 During tunnel construction, all assets identified in the Stage II of the risk assessment given in Table 9.1 of the Atkins Settlement Assessment Report (Ref 12-39) are to be monitored and have monitoring agreed with the asset owner.

12.5.34 Drivability of piles and Tunnel Boring Machine (TBM) in hard layers is known as a potential hazard during construction and therefore appropriate equipment must be utilised whilst working in hard material.

Operation

12.5.35 It has been considered that any remedial mitigation measures would have been completed during to construction and/or incorporated into the design (e.g. protection from ground gas and vapours). Therefore no additional mitigation measures would be required as part of the operational phase of the development. A drainage system with oil interceptor will be incorporated into the Scheme. Therefore the risk of contamination that could arise from traffic emissions entering the river sediments is lowered.

12.6 Assessment of impacts

Construction impacts

12.6.1 This section assesses the potential effects of the construction phase on the receptors identified in Table 12-8. This takes into account the measures described in Section 12.5. A summary of residual effects is presented in Table 12-9.

12.6.2 This assessment should be considered in conjunction with related assessments presented in Chapter 13: Materials and Chapter 16: Water Environment.

Geology and soils

12.6.3 A significant amount of contamination is anticipated within the Greenwich site as a result of historic on site process primarily associated with the gasworks. This has the potential to impact on geology and soils, controlled waters, as well as human health via the following pathways during construction:

- disturbance of potentially contaminated land such as areas of made ground associated with the former South Metropolitan Gasworks;
- mobilising contaminants in the soil that would otherwise be immobile e.g. contamination present in soils beneath former gasholder located on the Greenwich Peninsula; and
- creation of new pollutant pathways (e.g. vertical and horizontal migration of contamination in soils by the ingress of water into excavations or the removal of below ground objects currently providing containment to contamination), contamination to reach groundwater and surface water resources.

12.6.4 With the embedded design measures and employing good practice measures during construction, it is considered that risk to the geology and soils from contaminants will be reduced.

12.6.5 The underlying geology is considered to be a low sensitivity receptor with a minor adverse magnitude of impact, the resulting significance effect on geology and soils is **neutral**.

Site end users /construction workers (human health)

12.6.6 Contamination risks to site end users (including maintenance workers) are as follows:

- Ingestion of contaminated soil or dust created by on-site construction activity, particularly excavation and transportation of soil materials during cut and cover techniques used during the construction of the tunnel entrances. This is considered to be a moderate/large risk.
- Contamination risks to adjacent (surrounding) site users via inhalation of dust vapours and soil borne gas generation during construction works are considered to be moderate/large.
- Ground gas and vapours from contaminated groundwater potentially poses an inhalation risk if significant volatile contaminants are present beneath the Greenwich and Silvertown sites. These are associated with historical land uses e.g. South Metropolitan Gasworks. Groundwater quality was found to be poor across the Greenwich site particularly along the northern boundary of the Western Development Area and is therefore considered a moderate/large risk.

12.6.7 It is considered that the risk to site users from migration of contaminants (via vapours pathways) from contaminated groundwater will be mitigated by associated Method Statements and Risk Assessments and appropriate Personal Protective Equipment (PPE). Many of the exceedances of the water quality standards recorded did not correspond with notable contamination within the soil, which indicates a potential off-site source of groundwater contamination is present. This indication of a more general impairment to groundwater quality should form part of the objectives of future stages of ground investigation.

12.6.8 With suitable mitigation measures employed within a CoCP and CEMP as well as appropriate health and safety procedures, the risk to end users can be reduced.

12.6.9 Contamination of soils found as part of the ground investigation report (Ref 12-22) within the Sivertown site are considered to not pose a risk to human health as they were recovered at shallow depth, and will likely be removed as part of the construction process.

12.6.10 However, elevated concentrations of contaminates (Cyanide, Lead, Benzo (a) pyrene) within soils together with asbestos and ground gases have been identified at the Greenwich site during the ground investigation. It is likely that some form of remediation / mitigation measures will be required. The pathways are direct or indirect ingestion of contaminated soils and dusts. The appropriate form of mitigation will likely be identified once the detailed design has been

established. The likely form of mitigation will be removal of contamination source or the removal or blocking of the pathway to the contamination source e.g. provision of hardstanding cover.

12.6.11 Site workers are considered to be high sensitivity receptor and together with the presence of contamination being detected during the ground investigation correlating to a potential major adverse magnitude of impact, with a resulting significance of impact of large very large. However, with mitigation the actual significance of impact should be reduced to neutral.

Controlled waters (hydrogeology)

12.6.12 During the construction phase, a number of activities have the potential to result in changes to surface water and groundwater chemistry:

- Removal of topsoil and earthworks associated with construction and creation of stockpiles of soils and construction materials, increases potential for the generation of runoff with elevated concentrations of sediment which may enter controlled waters (surface water and groundwater bodies), in particular the River Thames.
- The excavation of material for infrastructure, construction of the Scheme (below groundwater level) and transportation of excavated materials via a floating barge have the potential to pollute surface water and groundwater bodies in particular the River Thames during transportation.
- Excavation and disposal of material from the construction of infrastructure creating temporary voids whereby water ingress could cause vertical and horizontal migration of soil contamination. Cohesive alluvial soils beneath the Greenwich and Silvertown sites will tend to limit the amount of vertical migration but potential construction methods such as piling have the potential to create new pathways for the migration of contamination to reach the underlying chalk.
- Transportation, storage and use of oils and fuels for construction plant and handling of wet cement and concrete, with increased potential for surface and groundwater contamination.
- Construction below the groundwater level. If wet concrete is used in contact with groundwater, the resulting effect could be detrimental to its quality.

- Construction works, including any vehicular movements within soft standing areas could result in compaction of the soils and a reduction in its infiltration capacity and therefore groundwater recharge.
- The provision of temporary on-site sanitary facilities for construction site staff could introduce an additional source of pollution that is not currently present.
- Creation and mobilisation of new pathways for existing contaminated groundwater onsite. This would have major adverse magnitude of impact, with a receptor of medium sensitivity resulting in a **large** significance effect. However, this could be reduced to a **slight** significance effect with the incorporation of appropriate design and mitigation measures during construction.
- Creation of contaminated run-off that could affect surface and groundwater resources e.g., construction methods can cause erosion prone areas that may cause volumes of silt and or sediment to be discharge to the River Thames if control measures are not put in place.

12.6.13 With the embedded design measures during construction, it is considered that only the excavation of material for infrastructure, construction of the Scheme (below groundwater level) and transportation of excavated materials via a floating barge would have the potential to contaminate groundwater.

12.6.14 As the underlying aquifer is likely to support water supplies at a local scale, the receptor has been classified as of medium sensitivity. The nature of construction works and the presence of existing groundwater contamination means that there is a major adverse magnitude of impact. However, with the mitigation measures suggested within the Preliminary CoCP to prevent migration or mobilisation of historic contamination implemented, the Scheme would have a minor magnitude of impact, with a receptor of medium sensitivity resulting in a **slight** significance effect. These measures may include avoiding using materials in the permanent or temporary works that could pollute groundwater and giving special consideration for the use of substances listed in relevant legislation.

12.6.15 The main proposed method of tunnel construction makes use of tunnel boring machinery (TBM). This method works by applying positive pressure at the cutting face and limits groundwater inflow into the tunnel face. The permanent support will comprise a waterproof membrane and cast in-situ concrete lining to achieve a high level of water-tightness.

12.6.16 Other construction methods being adopted for cut-and-cover tunnel and non-bored tunnel structures have a greater potential to require dewatering. However methods can be adopted to limit groundwater ingress, such as installation of a grout curtain or adoption of secant or diaphragm pile constructed retaining walls that would limit the volume of groundwater inflow. Excavation could then proceed by extending down to road formation level, with an option to fully seal structures in the long term.

12.6.17 During construction, it is likely that the overall groundwater flow direction would remain unchanged, where groundwater exclusion methods are adopted, and the Scheme would have no construction impacts on groundwater flow. An assessment of dewatering effects is required to quantify the potential effects of groundwater drawdown on pore-pressure changes and ground settlement potential and changes in groundwater flow direction and gradients that might alter existing contamination distributions. Suitable mitigation measures can then be adopted to manage residual risks appropriately. This may include groundwater control measures such as reducing the period of time that structures are drained, adoption of grout curtains and groundwater recharge to limit drawdown effects. Mitigation should be preceded by a monitoring programme to record natural variations in groundwater levels and seasonal ground settlement and appropriate mitigation methods selected.

Ecology receptors

12.6.18 No sites of ecological importance have been identified.

Unexploded Ordnance (UXO)

12.6.19 It has been established that in the areas on either side of the River Thames there is a medium/high risk of encountering UXO, with a high risk within the River Thames itself.

12.6.20 A UXO survey of the River Thames in the location of the proposed tunnel has been undertaken and found out of 660 No. magnetic anomalies identified over the survey area, 104 No. anomalies may be indicative of UXOs being present. ESGi could not identify any magnetic anomalies associated with UXO due to strong back ground disturbances.

12.6.21 Prior to construction, a detailed UXO risk mitigation strategy would be put in place and non-intrusive and intrusive survey methods undertaken to clear the Greenwich and Silvertown sites of any potential UXO threat in advance of any

intrusive ground works being undertaken. A watching brief as part of the construction works should also be implemented.

12.6.22 The Scheme would therefore have a minor magnitude of impact on human health, receptors of high sensitivity. This would result in a **slight moderate** significance effect.

12.6.23 When arriving at the significance of impacts using Table 12-5, where there has been the choice between significance ranks, a professional judgement has been made based on which rank the effect should be classified as. These have subsequently been tabulated within Table 12-9 below.

Services and built environment

12.6.24 The presence of historic contamination within the Greenwich and Silvertown sites means there is potential for damage to the tunnel itself and services via direct contact with contaminated soils. The risk associated with this has been assessed as a moderate adverse magnitude of impact on a receptor of high sensitivity. However, with the implementation of appropriate mitigation measures (e.g. remediation and selection of appropriate materials and concrete design class) the magnitude would reduce from moderate adverse to negligible. Therefore a negligible magnitude of impact on a receptor of high sensitivity would result in a **neutral** significance of effect.

Geotechnical Hazards

12.6.25 The geotechnical hazards identified in Section 12.4.62 which are listed below have the potential to occur both before and during the construction process.

- settlement/ collapsible ground (shrink-swell clay/peat)
- construction during excavation from encountering underground structures or unforeseen obstructions
- drivability of TBM
- driveability of piles
- base heave from tunnels

12.6.26 If appropriate mitigation measures are not employed then settlement or collapse of the structure could occur through the presence of soft shrinkable soils (superficial deposits, clays and peat). Without these measures it is

considered to have major magnitude of impact on a high sensitivity receptor. This would result in a **large/very large** significance of effect, but could be reduced to slight / moderate with appropriate mitigation measures employed.

Table 12-9 Significance of potential impacts during construction (mitigation applied)

Receptor	Credible pathway	Potential contaminant source	Mitigation measures (these lists are not exhaustive and further detail is presented within the text).	Magnitude of impact	Value of receptor sensitivity	Significance of Effect (Residual)
Site end users (maintenance workers/ site users) Construction workers	Direct or indirect ingestion of contaminated soil, dusts, leaching (construction stage)	Contaminated soils asbestos, cyanide, Benzo (a) pyrene.	Adherence to the principles set out in CLR 11 (Ref 12-7) Associated Method Statements and Risk Assessments, CDM Regulations, Designers Hazard Risk Assessment.	Minor	High	Neutral
Geology	Direct contact / via creation of new contamination pathways	Historic contaminated soils associated with Gasworks	Suitable pollution prevention precautions will be in place whilst removing historical substructures that have potential to provide containment of sources of contamination at present. Their removal and any retained liquids will be done carefully to minimise the creation of any preferential pathways for such contamination to migrate in the sub-surface through construction works. Adherence to CEMP. Provision of wheel washing, site access points	Minor	Low	Neutral

Receptor	Credible pathway	Potential contaminant source	Mitigation measures (these lists are not exhaustive and further detail is presented within the text).	Magnitude of impact	Value of receptor sensitivity	Significance of Effect (Residual)
			cleaned regularly, and Site Waste Management Plans.			
Built environment (structures and services)	Direct contact of structure. Chemical attack of buried concrete structures and permeation of volatile compounds through plastic construction materials. Damage to any existing structures due to ground movements or dewatering associated with	Contaminated soils Dewatering impacts from tunnel construction.	Adherence to the UK Water Industry Regulation guidance. Design of buried concrete in accordance with Concrete in aggressive ground (SD1) 2005. An engineering assessment of dewatering impacts to existing structures is required. Monitoring of dewatering effluent must consider the chemical quality of the material – alternative disposal and/or treatment methods may be required in the event of significant levels of contamination being found. Dewatering activities will require a licence from the EA.	Negligible	High	Neutral

Receptor	Credible pathway	Potential contaminant source	Mitigation measures (these lists are not exhaustive and further detail is presented within the text).	Magnitude of impact	Value of receptor sensitivity	Significance of Effect (Residual)
	tunnel construction.					
	Settlement / collapsible ground	N/A	Utilise existing ground investigation data to input into the foundations and settlement analysis design to mitigate risks. Monitoring of the assets prior, during and after construction of the tunnel	High	Minor	Slight /moderate
Controlled waters groundwater	Migration of identified contaminants into controlled waters. Dewatering activities could have an adverse impact on the aquifer resource.	Excavation and transportation of waste during construction.	Suitable pollution prevention precautions will be in place whilst removing historical substructures that have potential to provide containment of existing sources of contamination. Their removal and any retained liquids will be done carefully to minimise the creation of any preferential pathways for such contamination to migrate in the sub-surface through construction works.	Minor	Medium	Slight

Receptor	Credible pathway	Potential contaminant source	Mitigation measures (these lists are not exhaustive and further detail is presented within the text).	Magnitude of impact	Value of receptor sensitivity	Significance of Effect (Residual)
	Erosion and mobilisation of soil within and into surface waters.		General adherence to CEMP and Site Waste Management Plans. Groundwater monitoring will be required to demonstrate reduced mitigation of impact upon the groundwater table and the effect on nearby groundwater abstractions.			
Surface Water (the River Thames)			Adherence to Environmental Permits and PPGs.	Minor	Medium	Slight
Surrounding land users (off-site receptor)	Migration of fugitive dusts and soils on vehicles.		Vehicle cleaning, air quality monitoring, dust suppression.	Negligible	High	Neutral
Construction workers site users/ maintenance workers	Direct contact	Unexploded Ordnance	Adherence to recommendations presented within UXO Detailed Risk Assessment reports.	Minor	High	Slight / Moderate

Receptor	Credible pathway	Potential contaminant source	Mitigation measures (these lists are not exhaustive and further detail is presented within the text).	Magnitude of impact	Value of receptor sensitivity	Significance of Effect (Residual)
Controlled waters (groundwater)	The tunnel will be a fully waterproof design to minimise the amount of water ingress over the design lifetime. Tunnel is a linear obstruction that could divert contaminated groundwaters towards the River Thames.	Contaminated groundwater already identified from historical land uses e.g. South Metropolitan Gasworks	Annular spaces present outside the tunnels must be sufficiently sealed with suitable materials to avoid creating a pathway for groundwater movement longitudinally along the outside of the tunnel primary lining.	Minor	Medium	Slight

12.7 Operational impacts

Geology and soils

12.7.1 No significant effects are expected.

Geotechnical Hazards

12.7.2 No significant effects are expected.

Human health

12.7.3 No potential operational impacts are expected.

Controlled waters (Hydrogeology)

12.7.4 There are no anticipated changes to groundwater chemistry during operation. Therefore no potential operational impacts are expected.

12.7.5 Groundwater flow direction is expected to remain unchanged. Therefore no potential operational impacts are expected.

Ecological receptors

12.7.6 No ecological receptors have been identified. Therefore no potential operational impacts are expected.

Unexploded Ordnance

12.7.7 No effects on the Scheme are anticipated during the operational phase as any intrusive investigation and clearance of UXO would have been undertaken prior and during construction. Therefore no potential operational impacts are expected.

Built environment (structures and services)

12.7.8 As a result of tunnel construction, ground movement can occur during construction or shortly afterwards. The effect on the built environment depends on the amount of ground movement. Most structures are good at tolerating small ground movements of the magnitude produced by modern tunnelling. Whether there is a risk to long term (post construction) settlement and associated damage to the built environment (which may also occur due to dewatering activities and subsequent recharge), the design assessments will

have to be taken into account. Post construction monitoring is likely to form part of the design mitigation. This issue is also dealt with in Chapter 7 Community and Private Assets.

12.7.9 The risk associated with this has been assessed as a moderate adverse magnitude of impact on a receptor of high sensitivity. However, with the implementation of appropriate mitigation measures within a CoCP and CEMP as well as post construction monitoring the magnitude would reduce from moderate negligible. Therefore this would result in a **neutral** significance of effect.

Table 12-10 Significance of potential impacts during operation (mitigation applied)

Receptor	Credible pathway	Potential contaminant source	Mitigation measures (these lists are not exhaustive and further detail is presented within the body of the text).	Magnitude of impact	Value of receptor	Significance of Effect (Residual)
Maintenance workers/ site users	Direct or indirect ingestion of contaminated soil (operation stage)	Contaminated soils (Asbestos, cyanide and benzo (a) pyrene).	Remediation and /or mitigation will be required. Likely to comprise contaminant source removal or the blocking or removal of pathways. Such mitigation will be realised during the finalising of detailed design and could take the form of capping contamination with hardstanding.	Negligible	High	Neutral
Site end user/maintenance workers Built environment Surrounding land users	Build-up of ground gas in a confined space leading to inhalation. Severe explosion, asphyxiation. Build-up of gas in confined spaces.	Ground Gas within natural soil and made ground – Methane, Carbon Dioxide and depleted oxygen.	The waterproof primary liner will be designed to afford protection to the tunnel. Any ancillary buildings/structures with confined space will likely require protection measures subject to regulatory approval and further assessment.	Negligible.	High	Neutral
Structures and services	Integrity of the primary lining. Direct contact of structure. Chemical attack of buried concrete	Contaminated soils and chemically aggressive	Routine maintenance checks are likely to be mandatory and the construction design will include for aggressive chemical environment,	Negligible	High	Neutral

	structures including drainage and oil interceptors.	perched groundwaters	subject to levels of remedial action undertaken at the site.			
	Collapsible /soft ground	N/A	Monitoring of the assets after construction and during operation.	Negligible	High	Neutral
Controlled waters (groundwater)	The tunnel will be a fully waterproof design to minimise the amount of water ingress over the design lifetime. Tunnel is a linear obstruction that could divert contaminated groundwaters towards the River Thames.	Contaminated groundwater already identified from historical land uses e.g. South Metropolitan Gasworks	The tunnel would have been constructed to be sufficiently sealed with suitable materials eliminating a pathway for groundwater movement longitudinally along the outside of the tunnel primary lining.	Minor	Medium	Slight

12.8 Cumulative impacts

12.8.1 The cumulative impacts consider committed and planned developments building the vicinity of the Scheme. These at present generally comprise various infrastructure and commercial developments which includes the 2015 Greenwich Masterplan and Thames Tideway Tunnel at locations shown within Drawing 17-2 Cumulative Developments.

12.8.2 A qualitative assessment of the cumulative effects arising through interactions with consented/planned developments has been undertaken.

12.8.3 The assessment has identified that off-site impacts on the Scheme would be limited due to the mitigation measures implemented via the Greenwich Peninsula Remediation Strategy. Disposal of contaminated and uncontaminated soils to landfill would be avoided through the implementation of Materials Management Plans. Therefore, provided that the requirements of the relevant policy and legislation relating to land contamination and remediation are adopted in design and appropriate mitigation measures are applied, it is considered that there will be no significant cumulative impacts.

12.9 Further work to be done

12.9.1 Additional UXO work is currently being undertaken and results will be reviewed at a later stage. With the exception of further UXO data, no further additional information is outstanding with regard to geology and soils. Therefore at the time of writing the only additional work outstanding is that of additional UXO data currently being progressed.

12.9.2 The assessment will be reviewed and updated accordingly should any design changes as a result of the consultation are implemented.

12.10 NN NPS compliance

12.10.1 The NN NPS (Ref 12-2) sets out the need for, and Government's policies to deliver, development of nationally significant infrastructure projects on the national road and rail networks in England.

12.10.2 The NN NPS states that 'Applicants should identify any effects, and seek to minimise impacts, on soil quality, taking into account any mitigation measures proposed. Where developments are on previously developed land applicants should ensure they have considered the risk posed by land contamination and how it is proposed to address this'.

12.10.3 The NN NPS states that the information included within the EIA should include a description of the likely significant effects of the Scheme on the environment including short and long term temporary and permanent effects of the Scheme.

12.10.4 The NN NPS indicates that consent will not be granted for a Scheme unless the Secretary of State for Transport is satisfied there will be no *"significant adverse impacts*".

12.10.5 The likely significant effects of the Scheme on the environment including short and long term temporary and permanent effects have been assessed within the PEIR. The Scheme will comply with the requirements of the NN NPS.

12.10.6 It has been demonstrated within the PEIR document that no significant adverse impacts, after the implementation of mitigation measures are present.

12.11 Summary

12.11.1 An assessment has been undertaken of the effects of the Scheme on the geology, hydrogeology and human health.

12.11.2 Geo-Environmental design measures have been incorporated into the Scheme to prevent or minimise adverse effects on the geology, hydrogeology and human health.

12.11.3 The potential effects, without Geo-Environmental design measures, on geology, hydrogeology and human health during the construction phase would arise from:

- Disturbance of current contaminated soils, creating new contamination pathways into underlying soils and groundwater. This results in a moderate significance effect.
- Risks to site end users and site workers from contaminated soils via direct contact of soils and inhalation of vapours. This results in a moderate significance impact.
- Contaminating controlled waters from removal of topsoil, transportation of waste materials and contamination associated with the construction of the Scheme and mobilisation of existing contaminated groundwater into unaffected areas. This results in a large significance effect.

- Risk to human health from underlying unidentified unexploded ordnance. This would result in a large/very large significant effect.

12.11.4 No potential operational effects were identified during the assessment.

12.11.5 No significant residual effects were identified during the assessment.

12.11.6 A tabular summary of the significance of overall impacts as well as residual impacts (after mitigation) assessed as part of this report are provided in Table 12-11 below.

Table 12-11 Geology and soils construction phase impact summary table

Impact description	**Temporary/ Permanent**	**Significance of Effect**	**Residual effect**
Contamination to geology from disturbing of contaminated ground & creation of new pathways.	Temporary	Moderate	Neutral
Contamination in controlled waters from disturbing of contaminated groundwater & creation of new pathways.	Temporary	Large	Slight
Contamination to site end users and site workers	Temporary	Moderate/Large	Neutral
Encountering UXO and effect on site users and site workers	Temporary	Large/very large	Slight moderate
Changes to groundwater chemistry via excavated and transportation of materials	Temporary	Moderate	Slight
Changes to groundwater chemistry via excavated and transportation of materials	Temporary	Moderate	Slight
Contamination chemical attack on build environment from direct contact of contamination soils.	Temporary	Moderate/large	Neutral
Settlement/ compressible ground	permanent	Major	Slight moderate

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