Generic Quantitative Risk Assessment

Phoenix Place Site, Mount Pleasant, London

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This document has been prepared and checked in accordance with Waterman Group's IMS (BS EN ISO 9001: 2008, BS EN ISO 14001: 2004 and BS OHSAS 18001:2007)

Issue	Date	Prepared by	Checked by	Approved by
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Comments

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Objectives

Waterman Infrastructure & Environment was instructed by Royal Mail to undertake a Generic Quantitative Risk Assessment for the redevelopment of land adjacent to, and forming part of the existing Mount Pleasant Sorting Office in Farringdon.

Site Setting

Current Use	Staff car parking for Royal Mail.
History	Industrial use, with garages, a print works, a food factory, a foundry and residential properties on-site. The Site was cleared of buildings during the mid-1970's and Mail Rail House (Petrone House) was demolished in 2014/2015.
Ground Conditions	Poly-cyclic Aromatic Hydrocarbons (PAH) and metals have been recorded in the Made Ground in exceedance of the commercial Generic Assessment Criteria (GAC). Asbestos was recorded on both Plot P1 and Plot P2. Post development completion Made Ground will largely be removed on Plot P1 and partly removed on Plot P2. Hardstanding will primarily be at formation level. These will act to break the pollutant linkage through source removal and breaking of the valid pollutant pathways. Soft landscaping will be present at formation level in the north-west corner of Plot P2, contaminants have however not been recorded in exceedance of the Public Open Space Near Residential Housing GAC, breaking the pollutant linkage.
Controlled Waters	Metal contaminants in exceedance of the EQS threshold values have been recorded within the Made Ground and alluvium groundwater in the alluvium and Made Ground. Groundwater within the immediate surroundings is of poor quality, and the marginal increase in contaminant concentrations by the Site, will not have a significant impact on controlled waters. Groundwater samples form the Alluvium, Made Ground, and Lambeth Group have recorded alcohol and 2 heptanone on the north eastern Site portion. Given the distance to the closest groundwater abstraction (517m north east), restricted groundwater movement within the Lambeth Group, the contaminants non-toxic nature, and they readily degrade they are not considered to present a significant risk to controlled water receptors.
Ground Gas Regime	Ground gas monitoring classified the Site as Characteristic Situation 1. Ground gas protections are not required.

Conclusions

Given the current land use, and assessment of the results of the ground investigation the overall risk rating for the Site is **Medium**. However, following the implementation of the recommendations post redevelopment the risk rating could be reduced to **Low** and the Site should not be capable of being classified as Contaminated Land under Part IIA of the Environmental Protection Act 1990

Recommendations

The following actions are recommended to address the potentially unacceptable risks that remain;

- Material/topsoil imported for use within soft landscaping areas should be certified suitable for the proposed end use prior to being brought to site;
- Where piled foundations breach the London Clay Formation a FWRA detailing the mitigation measures necessary to prevent formation of preferential pathways will be required;
- The interceptor in the south west Site corner close to TP9, should be drained and decommissioned by a suitably qualified contractor in accordance with all relevant regulations;
- Concrete should be designed with due attention paid to the classifications set out in Section 8.5;
- Thames Water should be consulted on the required potable water supply pipe specification, given the intrusive investigation results.
- During excavation of basements effective groundwater management should be in place to prevent groundwater being exposed to contaminated material. Water removed from excavations should be suitability treated prior to disposal under licence;
- During construction, potentially contaminative substances should be stored and handled appropriately so as, to prevent fugitive releases. The details of the storage and handling procedures should be detailed within a CEMP;

- During groundworks dust mitigation measures set out in a CEMP should be employed to restrict the formation and distribution off-site of dust;
- As standard precaution, construction workers should wear the appropriate PPE, if required RPE, adopt good hygiene and safety practices, and adhere to the Confined Space Entry Regulations 1997, and Control of Asbestos Regulations 2012;
- A Remediation Strategy should be prepared detailing measures to mitigate active pollutant pathway linkages. Post construction of the development a Validation Report should be prepared, detailing the remedial measures taken, and confirming all active pollutant pathways have been mitigated; and
- The recommendations set out in the PWCA (WIE13235-102.R.8.1.1.JC), geotechnical interpretative report (28549-R02(00)), and archaeology report (CAL16, MOLA, 2016) should be followed.

1. Introduction

1.1 Objectives

Royal Mail Group (RMG), instructed Waterman Infrastructure & Environment Limited (Waterman) to undertake a Generic Quantitative Risk Assessment (GQRA), for the redevelopment of land adjacent to, and forming part of, the existing Mount Pleasant Sorting Office in Farringdon (Phoenix Place) (hereafter termed the 'Site'). A separate GQRA has been prepared for the adjacent Calthorpe Street Site, which is in the London Borough of Islington.

This assessment follows on from the Preliminary Environmental Risk Assessment (PERA) (WIE13235-102-R-2-2-3-BGAH), and Site Investigation Strategy (WIE13235-102-S-2-3-2-BGjd) prepared by Waterman in September 2016.

The main objectives of this GQRA are to;

- Detail the findings of an intrusive investigation undertaken to quantify where possible the potential pollutant pathways identified in the preliminary Conceptual Site Model (CSM);
- Develop an updated CSM based on the intrusive investigation, including a decision record for the CSM development; and
- Provide recommendations going forward to enable the proposed developments construction.

An assessment of the Site's geotechnical parameters and characterization of the ground for the purposes of geotechnical design specific to the proposed development, are included within a separate report produced by RSK (28549-R02(00)).

A Preliminary Waste Classification Assessment (PWCA) of the material to be removed as part of the Site's redevelopment is included within a separate report by Waterman (WIE13235-102.8.1.5.JC).

An intrusive investigation on the Calthorpe Street site, located directly to the north east (Appendix A) was undertaken at the same time as the intrusive investigation on the Site. The results of the intrusive investigation on the Calthorpe Street Site is reported under a separate cover (WIE13235-102-R-4-1-8-BG).

1.2 Planning Context

Planning permission (2013/3807/P) for the Site was granted in March 2015 for the following;

Comprehensive redevelopment, following the demolition of existing buildings, to construct four new buildings ranging from 5 to 15 storeys (above basement level) in height, to provide 38,724sqm. (GIA) of residential floorspace (345 dwellings) (Class C3), 823sqm (GIA) of flexible retail and community floorspace (Use Classes A1, A2, A3,D1, or D2) with associated energy centre, waste and storage areas, basement level residential car parking (54 spaces), the re-provision of Royal Mail staff car parking (approx. 196 spaces) cycle parking , residential cycle parking (431 residential spaces) hard and soft landscaping to provide public and private areas of open space, alterations to the public highway and all other necessary excavation and enabling works.

Condition 6 of the planning permission (ref. 2013/3807/P) relates to contaminated land and seeks prior to the commencement of work for each section or development stage the following components are undertaken, submitted, and approved by the London Borough of Camden:

- Condition 6(a): PERA;

- Condition 6(b): Site Investigation Strategy, accompanying Site Investigation and Geo-environmental Interpretative Report;
- Condition 6(c): Generic Quantitative Risk Assessment, and Remediation strategy;
- Condition 6(d): Verification plan; and
- Condition 6(e): UXO and any further mitigation measures required.

This GQRA is intended to be submitted for approval in accordance with Planning Condition 6(c).

1.3 Current Site Use

The Site is located at National Grid Reference 530945, 182264, located within the Clerkenwell area of London and within the administrative boundary of the London Borough of Camden. The location of the Site is shown in Appendix A.

The Site topography falls from north-west to south-east with four distinct levels present due to historical buildings, all of which have now been demolished. The lowest part of the Site is in the eastern corner.

Site access is from Calthorpe Street to the north or Mount Pleasant to the south both of which lead on to Phoenix Place. Apart from Phoenix Place (road) the remainder of the Site is in use as a Royal Mail staff car park. The car park surface comprises compacted fill material and concrete. Where present the concrete surface is predominately in poor condition. No buildings are present on-site.

The culverted River Fleet Sewer passes beneath Phoenix Place (road) and flows in a southerly direction, outfalling to the River Thames. The River Fleet Sewer is of brick construction. The top and bottom of the culvert lies at 13.225mAOD and 9.740mAOD respectively.

1.4 Proposed Development

The Phoenix Place Development is split into two areas, Plot P1 and Plot P2, as shown in Appendix A, comprising four separate buildings known as Buildings A, B, C and D. A representation of the Phoenix Place Development (Plot P1 and Plot P2) is given in Figure 1.

Figure 1: Phoenix Place proposed development

Source: Wilkinson Eyre

Building A, a 'U' shaped building located in the southern part of the Phoenix Place Development forms Plot P1, which closely follows the alignment of Gough Street, Mount Pleasant and Phoenix Place. Building A, proposed to be between 5 and 15 storeys in height, would accommodate residential, retail and community uses. The two-storey basement beneath Building A, which also extends under a public square, would provide Royal Mail staff parking, residential car parking, bike storage, water storage, plant rooms and a ground source heat pump.

The northern part of the Phoenix Place Development, which forms Plot P2, would comprise Buildings B, C and D separated above ground by a communal garden, a courtyard and public open space. Buildings B, C and D, which would be between five and 10 storeys in height, would accommodate residential, retail and

community uses. A separate basement would be created beneath Buildings B and C, and below the courtyard to accommodate car parking, plant rooms, lobby, residential and commercial uses.

Public and private communal amenity space provided within the Phoenix Place Development at ground level would comprise a combination of hard and soft landscaped areas. Soft landscaped areas within public open space would comprise lawn, planting and raised planting beds. Trees would be planted throughout the Phoenix Place Development and within public open spaces.

In general, soft landscaping will be underlain by basements, with a few trees and small areas of soft landscaping at ground level.

1.5 Regulatory Context

The National Planning Policy Framework (NPPF) sets out Government planning policy for England and how this is expected to be applied to development. Paragraphs 120 to 122 of Section 11 – Conserving and enhancing the natural environment of the NPPF relate to contaminated land matters and state the following:

"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.

Planning policies and decisions should ensure that:

- *the site is suitable for its new use taking account of ground conditions and land instability, including from natural hazards or former activities such as mining, pollution arising from previous uses and any proposals for mitigation including land remediation or impacts on the natural environment arising from that remediation;*
- *after remediation, as a minimum, land should not be capable of being determined as contaminated land under Part IIA of the Environmental Protection Act 1990; and*
- *Adequate site investigation information, prepared by a competent person, is presented.*

In doing so, local planning authorities should focus on whether the development itself is an acceptable use of the land and the impact of the use, rather than the control of processes or emissions themselves where these are subject to approval under pollution control regimes. Local planning authorities should assume that these regimes will operate effectively. Equally, where a planning decision has been made on a particular development, the planning issues should not be revisited through the permitting regimes operated by pollution control authorities."

In order to assess the contamination status of the Site, with respect to the proposed end use, it is necessary to assess whether the Site could potentially be classified as "Contaminated Land", as defined in Part IIA of the Environmental Protection Act 1990 and Contaminated Land Statutory Guidance 2012. This is assessed by the identification and assessment of potential pollutant linkages. The linkage between the potential sources and potential receptors identified needs to be established and evaluated.

To fall within this definition, it is necessary that, as a result of the condition of the land, substances may be present in, on or under the land such that:

a) significant harm is being caused or there is a significant possibility of such harm being caused; or

b) significant pollution of controlled waters is being caused, or there is significant possibility of such pollution being caused.

It should be noted that DEFRA has advised (Ref. Section 4, DEFRA Contaminated Land Statutory Guidance 2012) Local Authorities that land should not be designated as “Contaminated Land” where:

a) the relevant substance(s) are already present in controlled waters;

b) entry into controlled waters of the substance(s) from land has ceased; and

c) it is not likely that that further entry will take place.

These exclusions do not necessarily preclude regulatory action under the Environmental Permitting (England and Wales) Regulations 2016, which make it a criminal offence to cause or knowingly permit a water discharge of any poisonous, noxious or polluting matter to controlled waters. In England and Wales, under The Water Resources Act 1991 (Amendment) (England and Wales) Regulations 2009, a works notice may be served by the regulator requiring appropriate investigation and clean-up.

1.6 Constraints

This report was produced under the terms of, and in accordance with the Consultant’s appointment with Royal Mail Group, and may be relied upon in accordance with the terms and conditions of the Appointment.

The information contained in this report is based on the findings of the PERA (WIE13235-102.R.2.2.3.BGAH), observations throughout the intrusive investigations, exploratory hole logs, soil laboratory results, groundwater monitoring and ground gas monitoring.

The ground conditions reported relate only to the point of excavation and do not necessarily guarantee a continuation of the ground conditions throughout the non-inspected Site areas. Whilst such exploratory holes would usually provide a reasonable indication as to the general ground conditions, these cannot be determined with complete certainty.

Waterman has endeavoured to assess all information provided to them during this GQRA, but makes no guarantees or warranties as to the accuracy or completeness of this information.

The scope of this intrusive investigation includes an assessment of the presence of asbestos containing materials in the ground on-site but not within above or below ground structures.

The conclusions resulting from this GQRA are not necessarily indicative of future conditions or operating practices at or adjacent to the Site.

2. Procedures

This GQRA has been undertaken in general accordance with the Model Procedures for Management of Land Contamination (Contaminated Land Report 11 – Environment Agency, September 2004).

The report includes the following:

- The preliminary CSM as detailed in the PERA;
- Results of the intrusive investigation;
- Confirmation of Generic Assessment Criteria (GAC) used to assess risks, and the intrusive investigation results;
- Formulation of an updated CSM;
- Identification of potentially unacceptable risks; and
- Recommendations for further action.

This GQRA forms a decision record for the pollutant linkages identified, the GAC used to assess risks, the unacceptable risks identified and the proposed next steps to enable development. The report also provides an explanation of the preliminary CSM refinement following the intrusive investigation, the selection of criteria and assumptions, the evaluation of potential risks and the basis for the decision on future steps.

3. Outline Conceptual Model

3.1 Potentially Contaminative Activities

Walkovers undertaken as part of the PERA and throughout the intrusive investigation, identified the following potential contaminative sources;

- Vehicle parking on hardstanding in poor condition, and compacted Made Ground;
- Flytipped material, including wood, soil, metal, and pipes within the vaults in the south western corner; and
- Compacted Made Ground as the car park surface; and
- Fragments of possible Asbestos Containing Material (ACM) in the form of cement roof sheeting was present at surface level.

The Envirocheck Report did not record any Environmental Permits on-site.

3.2 Ground Conditions

The Site's anticipated ground conditions and hydrogeology are detailed in Table 1.

Table 1: Phoenix Place geology and hydrogeology

Stratum	Area Covered	Estimated Thickness	Typical Description	Aquifer Designation
Made Ground	Entire site	1.5m to 5.2m	Clayey sandy gravelly material with fragments of brick, concrete, oyster shells, ceramic, ash,	Unproductive Strata
Alluvium	The former River Fleet courses	1m to 2m	Sandy silty clay, with organic matter present	Secondary A Aquifer
Hackney Gravel Member	Majority of Phoenix Place site	0.9m to 1.2m	Sand gravels with rare clay	Secondary A Aquifer
London Clay Formation	Entire site	5.4m to 9.4m	Silty clay	Unproductive Strata
Harwich Formation	North west Corner	1.5m to 4.5m	Sandy silty coarse medium and fine gravel	Secondary A Aquifer
Lambeth Group	Entire site	15.5m to 15.8m	Mottled sandy clay containing shell fragments	Secondary A Aquifer
Thanet Formation	Entire site	7.0m	Fine grained sand with rare clay	Secondary A Aquifer
Upper Chalk Formation	Entire site	>13.0m (not proven)	White chalk with flints	Principal Aquifer

The Lambeth Group can be further split up into several formations including the Upper Mottled Beds, Lower Mottled Beds, and the Upnor Formation. These reflect the cohesive/granular interbedded nature of the Lambeth Group.

The River Fleet and associated floodplains were historically present on the eastern part of the Site. In this area, there is the potential for Alluvium to be encountered. In localised areas, the Hackney Gravel Member has been replaced by Made Ground.

The Site is not located within a groundwater Source Protection Zone (SPZ).

Groundwater flow within the Hackney Gravel Member and Alluvium is likely to flow south-east towards the culverted River Fleet Sewer beneath Phoenix Place (road).

The closest groundwater abstraction borehole is located 517m north east, and is operated by Thames Water as a potable water supply, abstracting from the Upper Chalk Formation.

3.3 Surface Waters

The River Thames is located 1.6km south and the Regents Canal is located 1.1km north. The former River Fleet (River Fleet Sewer) flows beneath Phoenix Place (road) in a southerly direction towards the River Thames.

The River Fleet Sewer is in a brick culvert located within the Alluvium and Hackney Gravel Member. The top and bottom of the culvert lies at 13.225mAOD and 9.740mAOD respectively.

The River Fleet Sewer outfalls in the River Thames, at the base of Blackfriars Bridge and may act as a preferential pathway for contaminants to reach the River Thames.

There are no recorded Environmental Permits for discharges to controlled waters within 500m of the Site.

3.4 Site History

Since the late 1800's the Site has been in use by various industrial processes, which remained on-site up until the 1970's. Industries identified included a foundry, works, garages, food factory, printing works and joinery works. On detailed Goad fire insurance plans several tanks are located on-site predominately associated with former garages. Several changes to the Site layout and purpose of buildings occurred between the late 1800's and 1970's. By 1974 most of the structures on-site had been demolished or were disused. Mail Rail house was constructed on the Site centre during the early 1990's and demolished post 2010.

3.5 Previous Environmental Assessments

An intrusive investigation was undertaken in 2005 by Geotechnics on-site, and adjacent Calthorpe Street site. The intrusive investigation findings are reported within a factual report (Ground Investigation at Mount Pleasant Redevelopment – PC051744, November 2005). A summary of the results is included below.

3.5.1 Geotechnics (2005)

Works undertaken included the following,

- Eleven boreholes to maximum depths of between 20.0mbgl and 45.0mbgl (BH101-111). Rotary core follow on was employed at BH108 and BH110;
- Thirteen trial pits (TP1-TP13) to depths between 2.50mbgl and 4.50mbgl;
- Five window sample boreholes (WS309, WS312, WS315, WS317, and WS318) to a maximum depth of 4.0mbgl;

- Ground gas and groundwater level monitoring visits on four occasions; and
- In-situ and ex-situ geotechnical testing and ex-situ contamination testing.

Exploratory holes on Phoenix Place were limited to BH101-104, BH111, TP301-308 and TP310;

Human Health

Soil sample laboratory results were assessed against the Generic Assessment Criteria (GAC) for a residential end use without plant uptake. Given the Site's proposed commercial and residential basement uses this is a conservative assessment. Contaminants in exceedance of the GAC for a residential end use without plant uptake are detailed in Table 2.

Table 2: Contaminants exceedances within soil sample laboratory results (Geotechnics 2005)

Contaminant	GAC (mg/kg)	Exploratory Hole Locations	Concentration Range (mg/kg)
Lead	310	BH101, BH103, BH104, BH111, BH102, TP303, TP301, TP302, TP304, TP305, TP306, TP307, TP308	530 – 1,200
Mercury	1.2	BH101, BH103, BH104, BH111, BH102, TP303, TP301, TP302, TP304, TP305, TP306, TP307, TP308	1.5 - 71
Benzo(a)pyrene	3.2	BH104, BH111	5.0 – 7.1
Dibenzo(a,h)anthracene	0.31	BH111	0.50
Benzo(b)fluoranthene	3.9	BH111	4.3

The laboratory results show Made Ground generally contains elevated lead, and mercury levels, with Poly-cyclic Aromatic Hydrocarbon (PAH) contamination in the south west, and south east corners. As part of the proposed development Made Ground will generally be removed to form the basements. This will act to remove contaminants from Site, and to prevent future site users coming into direct contact with residual contamination, breaking the pollutant pathway linkage, through source and pathway removal.

Controlled Waters

Groundwater levels on-site were recorded in the Made Ground and Alluvium between 9.60mAOD and 14.70mAOD. Groundwater on site flows towards the south east in direction of the River Fleet Sewer.

Groundwater samples from the Made Ground and Alluvium were assessed against the Environment Agency (EA) derived Environmental Quality Standards (EQS), and those from the Lambeth Group, Thanet Formation, and Upper Chalk Formation were assessed against the Drinking Water Standards (DWS). Contaminants more than the relevant threshold values were not recorded.

Ground Gas

Ground gas monitoring was undertaken on four occasions. Oxygen, methane, carbon dioxide, and flow levels were recorded. Methane remained below the equipment's Limit of Detection (LoD) (<0.10%), and a peak carbon dioxide and flow level of 3.60%, and 0.02l/hr respectively was recorded. A minimum oxygen concentration of 1.90% was recorded.

Based on the peak methane and carbon dioxide concentrations recorded the ground gas regime was classified as Characteristic Situation 1 (CS1), whereby no ground gas protection measures would be required.

3.6 Preliminary Conceptual Site Model

The preliminary CSM produced as part of the PERA (WIE13235-R-2-2-3-BG) is presented in Table 3.

Table 3: Preliminary Conceptual Site Model

Receptor	Potential Sources	Pathways	Risk	Justification / Mitigation	Residual Risk
Human Health					
Existing Site Users	Contaminants within the underlying Made Ground and groundwater	Dermal contact, ingestion, and inhalation	Low	The Site is currently used as car parking for RMG staff. Ground conditions comprise a mix of compacted soils and hardstanding in poor condition. Site users have a short residence time on the Site and are not considered to be at significant risk of harm from contaminants present within the underlying soils and groundwater.	Low
	Ground gas and vapours from Site sources (Made Ground, Alluvium, compromised fuel tanks if present).	Migration to and accumulation within confined spaces	Low	Ground gas monitoring undertaken by Geotechnics in 2005 classified the ground gas regime of the Site as Characteristic Situation 1, whereby no ground gas protection measures would be required. The vapour risk to current users is considered to be low in view of the nature and use of the Site.	Low
Future Site Users	Contaminants within the Made ground and underlying groundwater	Dermal Contact, ingestion, and inhalation	Low	Contaminants were recorded within the Made Ground during the 2005 Site Investigation. The presence of buildings and hardstanding of the Development would prevent pollutant pathway linkages. Areas of soft landscaping would use validated imported material suitable for its intended use and would be located above basements, therefore breaking the pollutant linkage. A Site Investigation will quantify the contamination status of the underlying deposits and groundwater and, where possible, identify the presence of historical fuel tanks, if present.	Low
	Ground gas and vapours originating from on-site sources (Made Ground, alluvial deposits, compromised fuel tanks if present)	Migration to and accumulation within confined spaces	Low	Ground gas monitoring undertaken by Geotechnics in 2005 classified the ground gas regime of the Site as Characteristic Situation 1. Vapour monitoring was not undertaken. The proposed basement used for car parking, plant rooms, residential and commercial uses are likely to have high ventilation rates reducing the potential for ground gases and vapours to accumulate to unacceptable levels. Within areas of the Phoenix Place site in which residential uses are present at ground floor and within basements, ventilation rates are likely to be lower. Potential	Low

				is therefore present for the accumulation of ground gases and vapours to unacceptable levels. Ground gas and vapour monitoring undertaken as part of the Site Investigation will determine the ground gas regime. Appropriate mitigation measures compliant with BS8485 would be implemented, if required.	
Off-site residents	Contaminants within the Made Ground on-site	Lateral migration off-site via wind entrainment, leading to direct contact, and inhalation	Low	Contaminants have been recorded within the Made Ground during the 2005 Site Investigation and further contamination is possibly present given the historical uses of the Site. A Site Investigation would determine the contamination status of the Phoenix Place site. Soft landscaping within the surrounding area is limited, decreasing the potential for off-site receptors to contact contaminants. Any exposure to contaminated dust would be short term and unlikely to significantly affect human health. During construction, good working practices for dust suppression (as set out in the Construction Environmental Management Plan) should be employed to limit dust migration, where practicably possible.	Low
Construction Workers	Organic and in-organic contaminants within the Made Ground and groundwater	Direct contact, ingestion and inhalation	Medium	Contaminants have been recorded within the Made Ground during the 2005 Site Investigation. During construction, workers would come into direct contact with the Made Ground and groundwater. Construction workers should wear the appropriate PPE, adhere to good practice hygiene and safety measures, the Confined Space Regulations 1997, the Control of Asbestos Regulations 2012 and CDM Regulations 2015.	Low
	Ground gas and vapours originating from on-site sources (Made Ground, alluvial deposits, compromised fuel tanks if present)	Migration to and accumulation within confined spaces	Medium	Potential is present for vapours to exist on the Phoenix Place site. During construction, workers may be exposed to vapour within confined spaces. Construction workers should avoid entering excavations. If entry cannot be avoided, a risk assessment should be undertaken with PPE and RPE used, where appropriate, and work done in-line with the Confined Space Entry Regulations 1997 and CDM Regulations 2015.	Low

Property					
On site structures	Determinands within the underlying soil and groundwater	Chemical attack on buried foundations and services	Medium	Following completion of the Phoenix Place Development, foundations and services would be in contact with the underlying soils and groundwater. If necessary mitigation measures such as the use of sulphate resistant concrete and appropriate potable water pipes should be used. A Site Investigation, which includes the testing of soils and groundwater, is required to determine the specification of buried foundations and services.	Low
Controlled Waters					
River Thames	Made Ground, fuel tanks if present, print works, car parking	Migration via the culverted River Fleet Sewer, which outfalls into the River Thames	Low	The River Thames is located 1.6km from the Site. Contaminants originating from the Site are likely to have naturally attenuated prior to reaching the River Thames when migrating through the Secondary A Aquifer within the Hackney Gravel Formation. The culverted River Fleet Sewer, which outfalls into the River Thames, is considered to be a viable pathway for contaminants originating from the Site. Widespread contamination was not recorded within the Secondary A Aquifer located within the Hackney Gravel Member during the 2005 Site Investigation indicating contaminants are unlikely to have migrated into the River Fleet Sewer and subsequently the River Thames. As part of a Site Investigation, groundwater samples should be recovered from the Hackney Gravel Member to determine the Secondary A Aquifer's contamination status and allow a qualitative assessment to be undertaken of the potential for contamination to reach the River Thames via the River Fleet Sewer pathway.	Low
Secondary A Aquifer within the Hackney Gravel Formation	Made Ground, fuel tanks if present, print works, car parking	Vertical migration into the unconfined aquifer from the Made Ground.	Low	Gross contamination has not been identified within the Secondary A Aquifer from groundwater samples recovered from the 2005 Site Investigation. Following completion of the Phoenix Place Development, the Phoenix Place site would predominately be covered in hardstanding, restricting the leaching of contaminants within the Made Ground. As part of a Site Investigation, the recovery of samples from the Secondary A Aquifer within the Hackney Gravel Formation will determine the contamination status. Appropriate remediation measures would be undertaken, if necessary.	Low

Secondary A Aquifer within Lambeth Group and Thanet Formation, Principal Aquifer within Upper Chalk Formation	Made Ground, fuel tanks if present, print works, car parking	Preferential pathways created during piling. Potential groundwater abstraction well founded within the Upper Chalk Formation	Low	The deeper aquifers are overlain by 5.4m to 9.4m of London Clay Formation , which is considered likely to act as an aquiclude, preventing the vertical migration of contaminants within the overlying Secondary A Aquifer to the deeper strata. Groundwater samples recovered from the Upper Chalk Formation during the 2005 Site Investigation did not record contaminant exceedances. Viable pathways may be created during construction through piles penetrating the London Clay Formation and from the uncovering of historical abstraction wells, if present. A FWRA should be undertaken should piles penetrate the London Clay Formation . The FWRA would outline the mitigation measures required to prevent the creation of preferential pathways. The validity of the presence of an historical groundwater abstraction well should be determined. Should an abstraction well(s) be present and founded below the London Clay Formation , measures should be taken to appropriately decommission the groundwater abstraction well, if necessary.	Low

4. Methodology

The intrusive investigation design is detailed within the Ground Investigation Strategy produced by Waterman in 2016 (WIE13235-102-S-2-3-2-BGJD), which sets out the framework and nature of the intrusive investigation. This section provides a summary of the relevant methodology.

The intrusive investigation was undertaken in general accordance with Eurocode 7, The Code of Practice for Site Investigation BS 5930 (2015) and The Code of Practice for the Investigation of Potentially Contaminated Sites BS 10175 (2013).

4.1 Design of Investigation

The investigation has been designed to achieve the following objectives as identified in the preliminary CSM;

- Determine the ground conditions, and confirm the contamination status of the underlying soils;
- Confirm groundwater levels, and groundwater flow on-site;
- Determine the contamination status of the Secondary A Aquifer within the Hackney Gravel Member and Alluvium;
- Determine the contamination status of the groundwater underlying the London Clay Formation ;
- Assess the soil properties to inform foundation design;
- Undertake a PWCA of the soils to be removed; and
- Determination of the Site's ground gas and vapour regime.

The intrusive investigation and the accompanying results and assessment has been designed to sit separately to the 2005 Geotechnics intrusive investigation, as reliance on the information has not been provided. The results from the 2005 Geotechnics intrusive investigation will therefore not be assessed further within this GQRA. They have however been used to inform the intrusive investigation design.

4.1.1 Soil

The proposed Development incorporates a two level basement on Plot P1 and the courtyard on Plot P2, and a single level basement on Plot P2 in the region of 0.75 – 1.55mbgl. Excavated material from the basement will be disposed off-site.

Building and hardstanding dominate the proposed development, with soft landscaping present on two courtyard areas on Plot P2, a courtyard on Plot P1, the north-west corner, and various tree pits located across the Site. Both courtyards on Plot P2, and the courtyard on Plot P1 will be underlain by basements.

The likely removal of all Made Ground on Plot P1, the partial removal of Made Ground on Plot P2, and the presence of hardstanding at formation level will act to break the pollutant linkage through removal of valid pathways and contaminant sources. The assessment of soil samples will be conservative.

4.1.2 Controlled Waters

Groundwater samples will be recovered using low flow sampling techniques to ensure Volatile Organic Compounds (VOC) are not lost, and a representative sample is gained. The samples will be taken when the parameters in Table 4 have reached a steady state.

Table 4: Stabilisation Parameters

Parameter	Stabilisation Levels
Dissolved Oxygen	±10% of reading or ±0.2mg/l, whichever is greater
Temperature	±0.2°C
pH	±0.2 pH units
Eh or ORP	±20mV
Conductivity	±3% of reading

Groundwater samples will be transferred to suitable containers with pre-measured fixatives where required, and transferred to Jones, for contaminant testing. To minimise microbial degradation during transport and allow the collection of samples representative of the formation water, cool boxes and cool packs will be used to keep samples below the 11°c.

Secondary A Aquifer - Hackney Gravel Member, Alluvium, and Made Ground

The groundwater flow regime within the Hackney Gravel Member/Alluvium/Made Ground will be determined through six rounds of groundwater level monitoring over a three-month period.

The contamination status of the groundwater shall be determined by sampling groundwater from suitably installed boreholes located up hydraulic gradient and down hydraulic gradient of the Site, based on the anticipated and previously determined south east groundwater flow. The samples will enable the background groundwater quality, and the Site's impact to be sufficiently assessed.

Secondary A Aquifer – Harwich Formation; Lambeth Group, Thanet Formation; Principal Aquifer – Upper Chalk Formation

The London Clay Formation has been recorded between 4.8m and 12m thick, it is unlikely to be acting as an aquiclude. Groundwater samples shall be recovered from a select number of installed boreholes to determine the contamination status of the groundwater below the London Clay Formation .

The assessment of the groundwater underlying the London Clay Formation is in contradiction to the Ground Investigation Strategy (WIE13235-102-S-2-3-2-BG). This is due to possible pollutant pathways being present through the London Clay Formation and the drift filled hollow located to the north east of the Site.

River Thames

The culverted River Fleet Sewer outfalls into the River Thames underneath Blackfriars Bridge 1.6km south east, and may therefore act as a possible pathway for contaminants originating on-site to impact the River Thames. The River Fleet Sewer is founded in the Hackney Gravel Member and Alluvium, and lies within a brick culvert. The brick construction will act to limit the through migration of groundwater, however given the porous nature of bricks and the possible presence of cracks, the ingress of groundwater may still occur.

To assess the risk groundwater samples from the wells installed within the Hackney Gravel Member/Alluvium/Made Ground will be assessed to determine its contamination status, and the Site's potential impact to off-site sources. A qualitative assessment will then be undertaken using the above results, to determine whether a risk exists to the River Thames.

4.1.3 Ground Gas and Vapour

Potential ground gas and vapour sources identified in the PERA include:

- Made Ground;
- Alluvial Deposits towards the western boundary (ground gas only); and
- Various off-site sources, including Made Ground, Alluvial Deposits, industrial and commercial activities.

To assess the Site's ground gas and vapour regime wells installed within the Made Ground or superficial deposits will be monitored on six occasions. Where possible two of these visits will be undertaken during a low or falling pressure. During each visit peak readings of methane, carbon dioxide, oxygen, vapour, gas flow, and the atmospheric pressure will be recorded. The model type and detection limits of the equipment to be used are included in Appendix E.

The proposed Development incorporates substantial excavations to reach the finished levels. Monitoring wells will be installed so the well response zone is below the proposed finish level, and a representative assessment of the Site's ground gas regime can be obtained. Where the proposed finish level will result in the Made Ground and Alluvium being removed significant ground gas and vapour sources at these locations will not be present, and a monitoring well for the purposes of ground gas and vapour will not be installed.

The risk to receptors from vapours will be assessed semi-quantitatively, through soil headspace analysis, VOC testing, and vapour monitoring within installed exploratory holes.

4.1.4 Strategy for Selection of Exploratory Hole Locations

Exploratory hole locations were selected to accomplish the objectives in Section 4.1, and where required target possible contaminant sources. The following information was used to determine the required exploratory hole locations;

- Geotechnics 2005 intrusive investigation;
- RSK 2016 Geophysical survey (ref. 191747_R03);
- Historical ordinance Survey Plans; and
- Goad Fire Insurance Plans.

Table 5 summarises the principal objectives of the exploratory holes, and the potential contaminant sources targeted where present.

Table 5: Exploratory Hole Purpose

Exploratory Hole	Depth (mbgl)	Objectives	Specific Source Targeted
TP1 – TP10	3.00 – 3.60	• Preliminary Waste Classification • Human Health Assessment	• TP9: Fuel tank on GPR survey and historical plans • TP1: Fuel tank on historical plans • TP7, TP8, TP10: Foundry • TP1 – TP5: Garages • TP6: Food factory, garages, bakery
TP19 – TP21	0.25 – 1.50	• Preliminary Waste Classification • Human Health Assessment	• Made Ground
WS13 – WS18	5.00	• Preliminary Waste Classification • Human Health Assessment • Ground gas and vapour regime	• WS13: Garages, printers • WS14, WS18: Garages • WS15: Made Ground • WS16: Foundry • WS17: Food factory, garages, bakery
BH11 – BH15 BH19 – BH23	35.8 – 41.4	• Human Health Assessment • Design Parameters for Foundation Design • Contamination status of groundwater • Preliminary Waste Classification	• BH13: Fuel tank on GPR survey and historical plans • BH20; Fuel tank on historical plans • BH14, BH11, BH12, BH21: Garages • BH22: Foundry

5. Site Activities

The intrusive investigation was undertaken over a period of 63 days (03/10/2016 to 05/12/2016). Table 6 provides a summary of the completed fieldwork.

Table 6: Summary of Fieldwork Activities

Phase of Work.	Activity	Contractor	Date	Supervision
Service survey	Scanning for services	RSK	September 2016	none
Ground Investigation	15No. Trial Pits	RSK	October 2016	Waterman
	6No. Window samples	RSK	October 2016	Waterman
	10No. Boreholes	RSK	October/December 2016	Waterman
Groundwater and Ground Gas Monitoring	Monitoring and sampling of wells	Waterman	November 2016 – March 2017	Waterman

5.1 Deviations and Additional Works

Prior to commencement of Trial Pit 9 (TP9) a three chamber interceptor was encountered following a surface scrape. TP9 was excavated immediately to the south to establish whether contaminants had impacted the surrounding soils/groundwater, no significant impact was identified. Water was encountered in the interceptor indicating its structure had not been compromised. A sheen of possible hydrocarbon origin was present on the water. This is not unexpected given the interceptors use.

Three trial pits along the bank of material in the south Site portion (TP18, TP20, and TP21), and one trial pit (TP19) from underneath the vaults were excavated in addition to the ground investigation. The purpose of the trial pits was to establish the materials contamination status in terms of the Sites redevelopment and the likely waste classification of the material.

BH20 was advanced through TP1, which had previously been cleared of obstructions through its excavation. Soil samples from the ground level to 3.5mbgl in BH20 have therefore not been recovered.

White Young Green (WYG) were employed by Royal Mail to act as their asbestos consultants during the ground investigation and the wider operations at the Mount Pleasant Sorting Office. They were in attendance during key phases of the investigation to assess the immediate risk to human health receptors form the works.

5.2 Service Survey

As parts of their works on behalf of the client, RSK undertook a GPR survey of the Site, the results of which are reported by RSK under a separate cover (191747-Mount Pleasant LR03). Following further correspondence with RSK (Mathew Stringfellow) the locations of two possible tanks were identified, one directly to the south of the vaults in the southern corner, and one to the south of the car park entrance off Phoenix Place. To assess their presence and impact on the soil and groundwater in the immediate surrounding area TP9, and BH13 were located in their immediate vicinity.

The possible tank at TP9 was identified as a three-chamber interceptor. No tank or contaminative impact on the surrounding soils and groundwater was encountered in BH13.

5.3 Soil Sampling

During excavation, representative soil samples were obtained and sealed in various containers, as appropriate. The soil samples taken were subject to screening by a photo ionisation detector (PID). A peak total vapour level of 0.1ppm was recorded. The remaining results are included on the exploratory hole logs in Appendix D.

Disturbed and undisturbed samples were taken at regular intervals and retained for geotechnical and geo-environmental testing and logging.

5.4 Quality Control

Samples were dispatched daily on a chain of custody procedure to Jones Environmental Ltd (Jones), for chemical analysis based on the contaminants of concern identified within the PERA and Ground Investigation Strategy. Jones are a UKAS accredited laboratory.

All contractors used during this project have been approved by Waterman as a part of in-house Integrated Management System (BS ISO 9001, BS ISO 14001) procedure.

5.5 Monitoring Wells

Ground gas and vapour, and/or groundwater sampling wells were installed within a select number of exploratory holes. Well installation details for exploratory holes principally installed for ground gas and vapour monitoring purposes are included in Table 7, and those for groundwater level and sampling purposes are included in Table 8. Made Ground was recorded to have replaced the Hackney Gravel Member and/or the Alluvium within several exploratory holes. Where this has occurred the monitoring well was installed within the Made Ground. Groundwater within the Hackney Gravel Member, Alluvium, and Made Ground are however likely to be in hydraulic continuity.

Several boreholes were installed with multiple installations, to target different receptor zones. This has been recorded in Table 8 through Install 1, Install 2, and Install 3.

As detailed in Section 4.1.3 the proposed formation depth was considered when determining the installation design of ground gas and vapour monitoring wells. Where material will be removed to reach the formation depth the ground gas and vapour monitoring well was installed so the response zone was located below the proposed formation depth. Where the Made Ground and Alluvium would have been removed to reach the formation depth, significant ground gas and vapour sources were considered also to have been removed at that location. A monitoring well to assess the Site's ground gas and vapour regime was subsequently not installed at that location.

Table 7: Ground gas and Vapour Monitoring Wells

Borehole	Install Details	Response Zone
WS13, WS15	0.0mbgl – 1.0mbg Plain Pipe 1.0mbgl – 4.0mbgl Slotted Pipe	Made Ground
WS17	0.0mbgl – 1.0mbgl Plain Pipe 1.0mbgl – 5.0mbgl Slotted Pipe	Made Ground
WS18	0.0mbgl – 1.0mbgl Plain Pipe 1.0mbgl – 3.0mbgl Slotted Pipe	Made Ground
BH13	0.0mbgl – 1.0mbgl Plain Pipe 1.0mbgl – 2.0mbgl Slotted Pipe	Made Ground
BH19	0.0mbgl – 1.0mbgl Plain Pipe 1.0mbgl – 5.0mbgl Slotted Pipe	Made Ground

Table 8: Groundwater level and sampling wells

Borehole	Install 1	Receptor Zone	Install 2	Response Zone	Install 3	Receptor Zone
BH11	0.0mbgl – 3.5mbgl Plain Pipe 3.5mbgl – 8.0mbgl Slotted Pipe	Alluvium	0.0mbgl – 15.0mbgl Plain Pipe 15.0mbgl – 18.0mbgl Slotted Pipe	Harwich Formation		
BH12	0.0mbgl – 4.0mbgl Plain Pipe 4.0 – 8.0mbgl Slotted Pipe	Made Ground	0.0mbgl – 23.0mbgl Plain Pipe 23.0mbgl – 29.0mbgl Slotted Pipe	Lambeth Group		
BH13	0.0mbgl – 4.50mbgl Plain Pipe 4.50mbgl – 8.0mbgl Slotted Pipe	Made Ground	0.0mbgl – 1.0mbgl Plain Pipe 1.0mbgl – 2.0mbgl Slotted Pipe	Made Ground		
BH14	0.0mbgl – 2.0mbgl Plain Pipe 2.0mbgl – 6.0mbgl Slotted Pipe	Made Ground	0.0mbgl – 20.0mbgl Plain Pipe 20.0mbgl – 27.0mbgl Slotted Pipe	Lambeth Group		
BH15B	0.0mbgl – 2.0mbgl Plain Pipe 2.0mbgl – 5.0mbgl Slotted Pipe	Made Ground	0.0mbgl – 17.5mbgl Plain Pipe 17.5mbgl – 19.0mbgl Slotted Pipe	Harwich Formation	0.0mbgl – 22.0mbgl Plain Pipe 22.0mbgl – 23.5mbgl Slotted Pipe	Lambeth Group
BH19	0.0mbgl – 1.0mbgl Plain Pipe 1.0mbgl – 5.0mbgl Slotted Pipe	Made Ground	0.0mbgl – 11.0mbgl Plain Pipe 11.0mbgl – 15.0mbgl Slotted Pipe	Harwich Formation	0.0mbgl – 27.0mbgl Plain Pipe 27.0mbgl – 28.0mbgl Slotted Pipe	Lambeth Group
BH20	0.0mbgl – 4.0mbgl Plain Pipe 4.0mbgl – 7.50mbgl Slotted Pipe	Made Ground	0.0mbgl – 32.50mbgl Plain Pipe 32.50mbgl to 38.50mbgl Slotted Pipe	Thanet Formation		
BH21	0.0mbgl – 1.0mbgl Plain Pipe 1.0mbgl – 4.5mbgl	Made Ground	0.0mbgl – 14.0mbgl Plain pipe 14.0mbgl – 18.0mbgl Slotted pipe	Harwich Formation		
BH22	0.0mbgl 1.0mbgl Plain Pipe 1.0mbgl – 4.0mbgl Slotted Pipe	Made Ground				
BH23	0.0mbgl – 3.0mbgl Plain Pipe 3.0mbgl – 6.0mbgl Slotted Pipe	Made Ground	0.0mbgl – 24.50mbgl Plain Pipe 24.50mbgl – 24.80mbgl Piezo Tip	Thanet Formation		

5.6 Groundwater Monitoring

Six rounds of groundwater level monitoring have been completed. During each monitoring round the presence of hydrocarbon contamination was investigated using an interface probe.

Groundwater sampling has been undertaken on three occasion (09/01/2017, 30/01/2017, and 09/02/2017). An additional groundwater sampling round was undertaken to clarify the presence of contamination on-site.

5.7 Ground Gas and Vapour Monitoring

Ground gas and vapour monitoring has been completed on six occasions. A monitoring round has been completed during a period of low pressure (23/02/2017).

6. Results

Detailed logs of the strata within all completed exploratory holes, the borehole installations, and PID readings are included in Appendix D.

6.1 Geological Strata

The strata encountered during the intrusive investigation were generally consistent with the 2005 Geotechnics intrusive investigation, and anticipated within the PERA. The exception was the presence of the Harwich Formation at the interface between the London Clay Formation and the Lambeth Group in boreholes located on the north-eastern Site portion. A review of BGS borehole records identify the Harwich Formation to be restricted in the surrounding area.

Made Ground and Alluvium were recorded to increase in thickness towards the historic River Fleet path, with boreholes close to the historic path recording Made Ground between 4.70m and 8.00m thick. Further away from the River Fleet's historic path the Made Ground was generally recorded between 2.50m and 4.00m thick. This increase in Made Ground thickness towards the historic River Fleet is associated with tipping on the river banks between the 16th and 19th century.

As anticipated and recorded previously during the Geotechnics 2005 investigation the Made Ground has generally replaced both the Alluvium and Hackney Gravel Member deposits. Where the Alluvium and Hackney Gravel Member deposits are encountered, they are isolated and do not present a continuous band across the Site.

A summary of the Site geology is included in Table 9.

Table 9: Geological strata on-site

Strata	Site Area	Depth of Top of Stratum (mAOD)	Thickness (m)	Typical Description
Hardstanding	Limited patches predominately located to the north and south	12.10 to 17.72	0.10 to 0.50	Bituminous Surfacing/concrete hardstanding
Made Ground	Whole Site	11.89 to 18.72	1.30 to 8.00	Light brown/brown/dark grey silty gravelly to very gravelly slightly clayey fine to coarse sand. Gravel of angular to sub-rounded fine to coarse brick, concrete, ceramics, ash, clinker and slate. Rare concrete and brick boulders. (Granular made Ground)
Made Ground	Eastern portion	11.05 to 14.69	1.40 to 7.50	Dark brown/black silty slightly gravelly to gravelly sandy clay. Gravel of subrounded to angular medium to coarse flint, with fragments of brick, concrete, lead, ash, clinker, wood, metal, and shell (Reworked Alluvium)
Alluvium	South eastern portion	7.99 to 9.47	1.30	Dark greenish brown/dark greenish grey slightly silty CLAY, with rare selenite and roots.
Hackney Gravel Member	North western portion (BH19, WS18)	13.22 to 14.09	0.40 to 0.70	Reddish brown/light brown slightly silty slightly sandy to sandy fine to coarse GRAVEL. Gravel of subrounded to subangular flint.
London Clay Formation	Whole Site	7.19 to 13.69	3.00 to 11.50	Brownish grey/brown mottled light bluish/dark grey silty CLAY
Harwich Formation	North eastern Site portion	11.00 to 18.00	0.80 to 1.50	Grey/light brown slightly clayey silty fine to coarse SAND/sandy subangular fine to medium flint GRAVEL, with cobbles
Lambeth Group (Upper Mottled Beds, Lower Mottled Beds, and Upnor Formation)	Whole Site	-14.10 to - 10.50	17.30 to 19.50	Dark grey, light bluish grey, orangish brown silty CLAY. Rare bands of light grey/light orangish brown silty fine SAND/sandy slightly clayey GRAVEL Base marked by layer of black pebbles.
Thanet Formation	Whole Site	-15.91 to -13.30	6.30 to 12.20	Grey silty fine SAND
Chalk Formation	Whole Site	-21.43 to -23.60	At least 13.10	Greenish white sandy chalky subangular fine to coarse GRAVEL. Gravel of flint.

6.2 Underground Structures and Obstructions

Throughout the investigation several underground structures and obstructions were encountered. Given the Site's industrial history, this is not unexpected. During basement excavations, further underground obstructions are likely to be encountered. A summary of the underground obstructions encountered is included in Table 10.

Table 10: Encountered obstructions

Exploratory Hole	Composition	Depth (mAOD)	Thickness (m)
BH19	Concrete	17.92	0.30
BH22	Large piece of timber (0.2mx0.2mx0.4m)	8.39	0.20
TP7	Bricks, mortar, and concrete	11.97	0.80
TP8	Bricks and mortar	11.60	0.20
TP9	Concrete obstruction	13.80	0.40

6.3 Chemical Analysis

All scheduled soil and groundwater laboratory results have been received.

6.4 Controlled Waters

The results of the completed groundwater level monitoring are included in Appendix F, and a summary of the minimum, maximum, and average groundwater levels in relation to the borehole level is included in Table 11, Table 12, and Table 13.

Table 11: Groundwater levels within the Made Ground and Alluvium

Exploratory Hole	Ground Level (mAOD)	Highest Groundwater level (mAOD)	Lowest Groundwater Level (MAOD)	Average Groundwater Level (mAOD)
BH11	17.46	11.89	11.62	11.78
BH12	16.05	11.43	11.23	11.34
BH13	14.69	12.74	12.72	12.73
BH14	14.20	10.25	9.54	10.12
BH15B	17.61	12.61	12.61	12.61
BH19	18.72	14.99	14.77	14.88
BH20	17.17	11.80	11.48	11.66
BH21	16.92	14.17	12.62	13.83
BH22	11.89	9.92	9.82	9.89
BH23	14.01	10.50	10.38	10.44

Based on the groundwater levels recorded, groundwater flow is predominately south east towards the historic flow path of the River Fleet (Appendix A). In the south-east Site portion (BH13, BH23, and WS15), where the River Fleet historically ran down the Site centre groundwater flow is south west. A figure depicting the groundwater flow contours within the superficial deposits has been included within Appendix A.

The groundwater levels show the groundwater in the Made Ground and Alluvium, where present, is in hydraulic continuity. Given the predominately granular nature of the Made Ground, which would allow the relatively unrestricted vertical and lateral migration of groundwater, this is as anticipated.

Groundwater monitoring and sampling wells were not installed within the Hackney Gravel Member given their limited and isolated presence across the Site.

Table 12: Groundwater Levels within the Harwich Formation

Exploratory Hole	Ground Level (mAOD)	Highest Groundwater level (mAOD)	Lowest Groundwater Level (MAOD)	Average Groundwater Level (mAOD)
BH11	17.46	7.11	6.90	7.04
BH19	18.723	11.22	10.60	10.87
BH21	16.92	7.39	7.07	7.15

Groundwater levels within the Harwich Formation are different from those recorded within the overlying superficial deposits and those within the Lambeth Group and Thanet Formation. Therefore, indicating the deposits are not in complete hydraulic continuity, with the cohesive layers of the Lambeth Group acting to limit the vertical migration of groundwater.

The sub-artesian nature of the groundwater level within the Harwich Formation, means confirmation of the groundwater flow is not possible.

Table 13: Groundwater levels within the Lambeth Group and Thanet Formation

Exploratory Hole	Ground Level (mAOD)	Highest Groundwater level (mAOD)	Lowest Groundwater Level (MAOD)	Average Groundwater Level (mAOD)
Lambeth Group - Upper Mottled Beds				
BH15B	17.61	4.42	1.91	3.34
Lambeth Group – Upnor Formation				
BH12	16.05	-1.09	-3.45	-2.20
BH15B	17.61	-5.49	-5.68	-5.54
BH19	18.723	-2.75	-2.97	-2.84
Thanet Formation				
BH14	14.20	-12.12	-12.62	-12.44
BH23	14.01	-10.19	-10.34	-10.27

The variation of groundwater levels in the Lambeth Group is due to the well response zones located in different granular layers (Upper Mottled Beds, and the Upnor Formation). These granular layers are separated by cohesive layers acting to limit the vertical migration of groundwater between the granular layers within the Lambeth Group.

Groundwater levels with BH12 (Lambeth Group) declined substantially from -1.60mAOD to -3.45mAOD following purging till dry during the second round of groundwater sampling (30/01/2017). Therefore, indicating the recharge rate within the granular layers of the Lambeth Group is poor. This corresponds with description of the Lambeth Group which is described as a Clay with some silty partings.

It is considered the Lambeth Group underlying the Site is exhibits poor connectivity which is demonstrated by the varying groundwater depths recorded in installations targeting this stratum.

6.5 Ground Gas and Vapour

Ground gas and vapour monitoring results are presented in Appendix E, and a summary in Table 14.

Table 14: Ground gas and vapour monitoring summary

Exploratory Hole	Peak Gas Concentration (%)					Total Vapour (ppm)	Flow Rate (l/hr)
	Methane	Carbon Dioxide	Oxygen	Hydrogen Sulphide	Carbon Monoxide		
WS13	<0.1	1.9	19.3	<0.1	<0.1	<0.1	**0.1**
WS15	<0.1	0.2	20.2	<0.1	<0.1	<0.1	<0.1
WS17	<0.1	**4.3**	**13.4**	<0.1	<0.1	<0.1	<0.1
WS18	<0.1	1.8	17.4	<0.1	<0.1	<0.1	**0.1**
BH13	<0.1	0.2	19.7	<0.1	<0.1	<0.1	<0.1
BH19	<0.1	0.6	19.0	<0.1	<0.1	<0.1	<0.1

*Peak ground gas levels, vapour concentrations, and flow rates are highlighted **Bold**. The minimum oxygen level is highlighted **Bold**.

7. Generic Assessment Criteria

The Site's preliminary CSM has identified potential pollutant linkages which have been investigated as part of this GQRA. The intrusive investigation results have been assessed against the GAC detailed in Table 15.

The GAC used are included in Appendix K.

Table 15: Generic assessment criteria

Source	Pathway	Receptor	Generic Assessment Criteria
Contaminated Soils	Direct contact, inhalation, ingestion, and dermal contact	Existing Site users	Plot P1 and Plot P2 – Waterman GAC for a Commercial end use.
Contaminated Soils	Direct contact, inhalation, ingestion, and dermal contact	Future Site users of the proposed development	Plot P1 and Plot P2 – Waterman GAC for a Residential end use without plant uptake North west Site corner (Plot P2) – Waterman GAC for a POS_{RESI} land use
Contaminated soils	Direct contact, inhalation, ingestion, and dermal contact	Construction workers	Qualitative Assessment
Contaminated soils	Direct contact	Vegetation	BS3882:2015 Specification for topsoil.
Contaminated soils	Vertical migration through Made Ground	Secondary A Aquifer (Hackney Gravel Member)	EA derived EQS
Contaminated groundwater	Vertical migration through overlying deposits within groundwater	Secondary A Aquifer (Harwich Formation, Lambeth Group, Thanet Formation) Principal Aquifer (Upper Chalk Formation)	DWS
Contaminated groundwater	Lateral migration through the River Fleet Sewer	River Thames	Semi-quantitative assessment
Ground gas	Vertical and lateral migration though soil matrix	On and off-site structures Future Site users Construction workers	Gas Screening Value determination and assessment in accordance with CIRIA C665 and BS8485. Qualitative assessment for construction staff
Vapour	Vertical and lateral migration though soil matrix	Construction workers On and off-site structures	Semi-quantitative assessment in accordance with CIRIA C682.
Contaminated soils and groundwater	Direct Contact	New water supply pipes	UKWIR Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites BRE Special digest 1: 2005 Concrete in Aggressive Ground.

7.1 Site Specific Information used to Support the Generic Risk Assessment

7.1.1 Human Health Risk

Existing Site Users

Ground conditions at surface generally comprise compacted Made Ground. A direct pollutant pathway to existing Site users from contaminants within the shallow Made Ground may therefore exist. The Site is currently in use as a RMG staff car park. The residence time of existing human health receptors is low.

Soil laboratory results from the top 1.0m will be assessed against the commercial GAC. Given the low residence time of existing human health receptors, the assessment is conservative.

Based on the laboratory results a Soil Organic Matter (SOM) content of 2.5% will be used in the assessment of the results.

Future Site Users

The proposed Development predominately comprises hardstanding, with soft landscaping areas underlain by basements. As part of the proposed Development Made Ground will largely be removed on Plot P1, and partly removed on Plot P2 to construct the basements and achieve the required level changes. This will act to remove much of the potential contamination source on-site.

Material removed as part of the basement will not be assessed against GAC, given the material will be disposed off-site thereby removing the source and breaking the pollutant linkage.

Soil results will be screened against GAC for residential land use without plant uptake.

Based on laboratory results a SOM of 2.5% and 1.0% will be used for Made Ground and natural soil samples respectively.

Soils sample results from material to be removed as part of the Development will not be assessed against the GAC, given the pollutant linkage will be broken through the removal and disposal of material off-site. The principal purpose of sampling this material was for was for the PWCA.

Soft landscaping at formation level not underlain by hardstanding or a basement will be located in the north-west Site corner (Appendix A). Watermans GAC for a Public Open Space near Residential Housing (POS_{RES}) will be used to assess soil samples within 1.20m of the proposed formation level in the north-west Site corner.

Construction Workers

Specific GAC are not currently available for construction workers. Therefore, a qualitative assessment will be undertaken.

A qualitative assessment will be made on the risk to construction workers from ground gases.

7.1.2 Vegetation

Soft landscaping proposed in the central courtyard areas on Plot P1 and Plot P2, will be located above basements. Given the composition of existing deposits on-site imported material will be used to form these areas. Where the imported material is suitable for use, it will act to break the pollutant linkage. Soil

samples from the central soft landscaped areas on Plot P1 and Plot P2 will therefore not be assessed against the GAC given in BS3882:2015 – Specification for Topsoil.

Where imported material is imported for use in soft landscaping areas it shall be confirmed as suitable for use from a chemical standpoint, to prevent a potential pollutant linkage to vegetation from being present. Material will also be compliant with BS3882:2015

Soft landscaping in the north-west Site corner will be underlain by Made Ground. Vegetation in the north-west Site corner may come into contact and be impacted by phytotoxic contaminants within the Made Ground. An assessment of the soil samples against GAC in accordance with BS3882:2015 will therefore be undertaken from soil samples located in the north-west Site corner recovered below the proposed Development formation level.

7.1.3 Controlled Waters

Superficial Deposits – Groundwater

As detailed previously Made Ground has generally replaced the Alluvium and Hackney Gravel Member on-site. With the Alluvium and Hackney Gravel Member limited to isolated pockets. Groundwater levels has shown the Made Ground, Alluvium and Hackney Gravel Member to be in hydraulic continuity.

The Site is not within a groundwater SPZ, and there are no recorded potable abstractions from the Hackney Gravel Member/Alluvium. Samples from the groundwater within the superficial deposits will therefore be assessed against the EA derived EQS.

The Water Framework Directive UK Technical Advisory Group (WFD-UKTAG) Metal Bioavailability Assessment Tool (M-BAT) has been used to determine the EQS values for copper, nickel, zinc, and manganese. The closest receptor is the River Thames, literature values for pH (8), Dissolved Organic Carbon (2.07mg/l), and water hardness (112mg/l) in the River Thames have been used in the M-BAT tool. Based on these literature values, the following EQS values for copper, zinc, manganese, and nickel have been calculated;

- Copper – 5.04µg/l
- Zinc – 21.66µg/l (19.66µg/l plus background concentration of 2.0µg/l)
- Nickel – 7.17µg/l
- Manganese – 219.55µg/l

The closest down hydraulic gradient surface water receptor is the River Thames, 1.6km south. Given the Site's distance from the River Thames and intervening potentially contaminative activities the assessment is conservative.

Secondary A Aquifer – Harwich Formation/Lambeth Group/Thanet Formation
Principal Aquifer – Upper Chalk Formation

The aquifers underlying the London Clay Formation are in limited hydraulic continuity and are abstracted from for potable purposes 537m to the north east. Groundwater samples from these aquifers will therefore be assessed against the DWS.

However, given the Site is not located within a groundwater SPZ, and the presence of numerous potential sources in the surrounding area, the assessment is conservative.

River Thames

The risk to the River Thames will be assessed semi-quantitatively using groundwater sample results from wells installed within the superficial deposits, and the potential for these contaminants to laterally migrate into the River Fleet Sewer.

7.1.4 Ground Gas

Buildings

The risk to on or off-site structures, and future Site users from ground gases will be assessed through calculation of the Site's Gas Screening Value (GSV) in accordance with CIRIA C665 and BS8485. The GSV will be calculated using ground gas results recorded during the series of monitoring visits.

Construction Workers

A qualitative assessment will be made on the risk to construction workers from ground gases.

7.1.5 Vapour

A semi-quantitative approach, consistent with CIRIA C682 will be used to assess risks from vapours.

7.1.6 Risk to Water Supply Pipes and Buried Infrastructure

The risk to water supply pipes will be assessed in accordance with the UKWIR Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites.

The risk to buried structures will be assessed in accordance with the guidelines included within BRE Special Digest 1:2005 Concrete in Aggressive Ground.

8. Quantitative Environmental Risk Assessment

The potential pollutant linkages have been evaluated using the relevant GAC (Section 7). The results of the evaluation are detailed within this section.

8.1 Risk to Human Health

8.1.1 Existing Site Users

Comparison of the soil samples in the uppermost 1.0m of Made Ground against the commercial GAC (2.5% SOM) has identified the following exceedances;

- Lead: BH15 (0.50mbgl) – 2,837mg/kg);
- Nickel: BH21 (0.50mbgl) – 3,759.50mg/kg);
- Benzo(b)fluoranthene: TP8 (0.40mbgl) – 96.14mg/kg;
- Benzo(a)pyrene: TP8 (0.40mbgl) – 82.51mg/kg; and
- Dibenzo(a,h)anthracene: TP8 (0.40mbgl) – 5.49mg/kg).

Asbestos fibres have been recorded in 10 samples within the top 1.0m of Made Ground following a screen. Quantification analysis on the above samples have recorded levels below the laboratory Limit of Quantification (LoQ) (<0.001%), except for TP10 (0.50mbgl) in which asbestos was recorded at 0.005%.

In addition to the asbestos recorded in the soil samples cement bound asbestos fragments were encountered within the shallow subsurface material during the excavation of TP10 and the hand dug pit for WS16. The fragments were confirmed as containing asbestos by WYG and were 3-6cm in diameter.

The laboratory results identify elevated metal and PAH concentrations within the near surface soils, in addition to a low level of asbestos fibres. Given the short residence time of users on-site and that activities on site comprise car parking, significant amounts of dust are not generated. Where visible Asbestos Containing Materials (ACMs) are present at surface level they should be removed and disposed of in accordance with all relevant legislation.

8.1.2 Future Site Users

The development proposed on Phoenix Place will be split into Plot P1, and Plot P2, which may be staggered and brought forward by two different developers. The soil sample results have therefore been split into those located in Plot P1, and Plot P2.

Plot P1

Comparison of the laboratory results from Plot P1 against the Residential without plant uptake GAC (2.5% SOM Made Ground, 1.0% SOM natural strata) has identified the following contaminant exceedances (Table 16).

Table 16: Contaminant exceedances Plot P1

Contaminant	GAC (mg/kg)	Exploratory Hole (mbgl)	Concentration (mg/kg)
Arsenic	40.00	WS15 (2.00)	130.80
Mercury	1.20	WS15 (0.50)	1.70
		WS15 (2.00)	90.80
		WS17 (4.40)	1.30
		BH13 (0.50)	3.40
		BH13 (4.50)	3.10
Lead	310.00	WS15 (2.00)	9,155.00
		WS17 (4.40)	318.00
		BH13 (0.50)	453.00
		BH13 (4.50)	425.00
Copper	7,100.00	WS15 (2.00)	62,869.00
Nickel	180.00	WS15 (2.00)	723.30
Benzo(b)fluoranthene	4.00	WS15 (2.00)	21.31
Benzo(a)pyrene	3.2	WS15 (2.00)	10.87
Dibenzo(a,h)anthracene	0.32	WS15 (2.00)	2.09

The laboratory results have recorded high PAH and metal concentrations within the Made Ground, with particularly high levels recorded in the south east Site portion. The historic location of a foundry. The contaminants and levels recorded are typical of a foundry, in which surface enrichment of soils by non-mobile metal contaminants are commonly recorded.

The removal of significant depths of material on Plot P1 to form the double height basement will remove most the Made Ground, which will be disposed off-site. This will act to break the pollutant linkage through source removal. Where existing levels are to be retained along the eastern border in the south east corner, hardstanding is proposed at formation level acting to break the pollutant pathway linkage.

Soft landscaping areas in Plot P1 will be underlain by basements. Excavated material on-site is unlikely to be suitable for re-use. Soft landscaping will therefore be formed from imported materials. This material should be confirmed suitable for use to prevent posing a contamination risk to future Site users.

Asbestos fibres have been recorded in 13 soil samples, quantification analysis on the samples have recorded the following results (Table 17).

Table 17: Asbestos quantification results Plot P1

Exploratory Hole	Depth	Asbestos	Quantification Level (%)
WS15	2.00	Chrysotile fibre bundles	<0.001
WS17	1.90	Chrysotile fibre bundles	<0.001
BH15	0.50	Amosite	<0.001
TP10	0.50	Chrysotile cement debris	0.005
TP7	0.50	Chrysotile fibre bundles	<0.001
TP8	0.40	Chrysotile fibre bundles	<0.001
BH22	3.00	Chrysotile fibre bundles	<0.001
TP18	0.60	Chrysotile fibre bundles	<0.001
TP19	0.40	Chrysotile fibre bundles	<0.001
TP20	0.80	Chrysotile fibre bundles	<0.001
TP21	0.60	Chrysotile fibre bundles	<0.001
TP9	0.50	Amosite fibre bundles	<0.001
BH14	1.50	Chrysotile fibre bundles	<0.001

*Samples from material to be removed as part of the proposed basement excavations are highlighted in grey.

As reported in Section 8.1.1 cement bound asbestos containing fragments, 3-6cm in diameter were encountered within the shallow sub-surface material in TP10, and WS16 on Plot P1. These were confirmed as containing asbestos fibres by WYG.

Asbestos has been generally recorded within the granular Made Ground, and given the spread of locations on Plot P1, it will likely be encountered within the granular Made Ground Site wide during development. To mitigate the risk to construction workers mitigation measures will be required. The removal of Made Ground as part of the proposed basement, and presence of hardstanding at formation level will mitigate the risk to future Site users.

Plot P2

Comparison of the laboratory results from Plot P2 against the Residential without plant uptake GAC (2.5% SOM Made Ground, 1.0% SOM natural strata) has identified the following contaminant exceedances (Table 18**)**.

Table 18: Contaminant exceedances Plot P2

Contaminant	GAC (mg/kg)	Exploratory Hole (mbgl)	Concentration (mg/kg)
Lead	310.00	WS13 (1.40)	575.00
		WS18 (1.40)	787.00
		TP4 (1.00)	747.00
		TP1 (2.00)	406.00
		TP3 (1.50)	655.00
Mercury	1.20	WS18 (1.40)	5.40
		TP4 (1.00)	2.00

Elevated metal concentrations have been recorded in the Made Ground, similar to Plot P1, and are not unexpected given the Site's industrial legacy.

Hardstanding will generally be present at formation level on Plot P2, except for soft landscaping in the north-west corner, which has been targeted by BH19. The hardstanding will act to break the pollutant linkages to future Site users, and mitigate the risk from contaminants and asbestos within the Made Ground.

Asbestos fibres have been recorded in five soil samples on Plot P2, quantification analysis on the samples have recorded the following results (Table 19).

Table 19: Asbestos quantification results Plot P2

Exploratory Hole	Depth	Asbestos	Quantification Level (%)
TP4	0.50	Chrysotile fibre bundles	<0.001
BH19	0.50	Chrysotile fibre bundles	<0.001
BH21	0.50	Amosite fibre bundles	<0.001
BH21	1.50	Chrysotile fibre bundles	<0.001
BH21	3.50	Chrysotile fibre bundles	<0.001

*Samples from material to be removed as part of the proposed basement excavations are highlighted in grey.

In Plot P2 asbestos has been recorded in the shallow granular Made Ground. As part of the proposed development material will be removed to form the basement and achieve the required level changes. This will act to break the pollutant linkage through source removal at TP4. Hardstanding at formation level at BH21 and on the remaining parts of the Site will act to further break the pollutant linkage to future Site users, should asbestos fibres be present in the areas of granular Made Ground not sampled as part of this investigation.

Contaminants have not been recorded in exceedance of the POS_{RES} within samples from BH19. Asbestos fibres have however been recorded below the LoD within BH19 at 0.50mbgl. As part of the proposed development suitable for use material will be imported for use in the soft landscaping area. This will act to prevent future Site users from coming into direct contact with the asbestos fibres identified within Made Ground on this area.

8.1.3 Construction Workers

High contaminant concentrations, have been recorded within the Made Ground. During development works, construction staff should wear the appropriate Personal Protective Equipment (PPE) and where necessary the Respiratory Protective Equipment (RPE). In addition, the requirements of the Confined Space Regulations (1997) should be adhered to.

Asbestos has been recorded within the granular Made Ground. The Control of Asbestos Regulations 2012 (CAR 2012) should be adhered to, including the completion of an asbestos risk assessment and plan of work.

All construction workers should be subject to mandatory health and safety requirements under the Construction, Design, and Maintenance (CDM) regulations 2015, the Control of Substances Hazardous to Health (COSHH) Regulations 2002, and the Confined Space Regulations 1997.

8.1.4 Off-Site Users/Residents

High contaminant concentrations, in addition to asbestos have been recorded in the Made Ground. During construction works dust and asbestos fibres may become mobilised via wind entrainment and migrate off-site, potentially impacting off-site residents and users. To mitigate the risk dust suppression methods should be employed during construction, the details of which should be set out in a Construction Environmental Management Plan (CEMP).

8.2 Vegetation

Soil samples from BH19 have been assessed against the criteria given in BS3882:2015; Specification for Topsoil. An exceedance of the zinc threshold value (300mg/kg (>7pH)) was recorded in the sample from 0.50mbgl (336mg/kg).

Given the ground composition in the north-west Site portion (BH19) suitable for use material will be imported to form the soft landscaping area. This material where suitable for use will act to mitigate to proposed vegetation in the north-west Site portion, through breaking of the pollutant pathway.

8.3 Risk to Controlled Waters

8.3.1 Groundwater – Made Ground and Alluvium

Groundwater sample laboratory results from the groundwater within the Made Ground and alluvium deposits have been assessed against the EA derived EQS. Table 20 details the contaminants in exceedance. Boreholes within Table 20 have been split into up hydraulic gradient boreholes and down hydraulic gradient boreholes. This has been determined based on the calculated groundwater flow direction.

Table 20: Contaminants in exceedance; groundwater in alluvium and Made Ground

Contaminant	EQS (µg/l)	Location (concentration (µg/l))
Up Hydraulic Gradient Boreholes		
Iron	1.0	BH19 (73.3)
Mercury	0.07	BH19 (1.0),
Copper	5.04	BH21 (8.0)
Nickel	7.17	BH19 (8.6)
Down Hydraulic Gradient Boreholes		
Iron	1.0	BH12 (46.6), BH23 (4310.0), BH14 (5775.0, 3466.0) BH13 (5630.0, 14060.0), BH20 (15.4)
Zinc	21.66	BH14 (45.62), BH22 (157.1)
Mercury	0.07	BH14 (0.6) BH13 (0.7)
Nickel	7.17	BH12 (7.6, 10.3)
Copper	5.04	BH22 (24.0)
Benzo(b)fluoranthene	0.017	BH14 (0.06), BH22 (0.25)
Benzo(k)fluoranthene	0.017	BH14 (0.02)

Metal contaminants are in exceedance in up and down hydraulic gradient boreholes. This is indicative of the groundwater quality of the area surrounding the site and is not unexpected given the historical activities. Elevated PAH contaminants have been recorded in down hydraulic gradient boreholes. The source of these is likely to be the former foundry located on the southern Site portion. Given the distance to the closest controlled water receptor (River Thames 1.6km south), the magnitude of the contaminant in down hydraulic gradient boreholes is not substantial enough to present a risk.

VOC or SVOC contaminants have not been recorded above the laboratory LoD, within groundwater samples recovered from the Made Ground/Alluvium.

TPH Contamination

Short chain aliphatic TPH hydrocarbons have been recorded within BH12 above the laboratory LoD in all three groundwater sampling rounds (30 - 38µg/l C6-C8, and 185 - 283µg/l C8-C10). Further analysis confirmed these aliphatic compounds comprised alcohols (methanol to n-hexyl alcohol).

Analysis within BH20, located immediately up hydraulic gradient also recorded the presence of alcohols of a similar magnitude as BH12. Given the south-eastern groundwater flow and the location of BH20 on the northern border it indicates the contaminant source maybe off-site.

TPH and alcohol concentrations in Made Ground and Alluvium aquifer in Phoenix Place BH12, and BH20 have been summarised in Table 21.

Table 21: TPH aliphatic and alcohol concentrations; in the Made Ground and Alluvium

Borehole	Groundwater Round 1 (27/01/2017)	Groundwater Round 2 (01/02/2017)		Groundwater Round 3 (09/02/2017)	
	Total TPH Aliphatic Concentration (µg/l)	Total Alcohol Concentration (µg/l)	Total TPH Aliphatic Concentration (µg/l)	Total Alcohol Concentration (µg/l)	Total TPH Aliphatic Concentration (µg/l)
BH11	Not Sampled	Not Tested	<10.0	Not Sampled	Not Sampled
BH12	215.0	2537.0	279.0	2305.00	321
BH13	<10.0	Not Tested	<10.0	Not Sampled	Not Sampled
BH14	<10.0	Not Tested	<10.0	Not Sampled	Not Sampled
BH19	<10.0	Not Tested	<10.0	Not Sampled	Not Sampled
BH20	Not Sampled	Not Sampled	Not Sampled	2986.00	<10
BH21	<10.0	Not Tested	<10.0	Not Sampled	Not Sampled
BH23	<10.0	Not Tested	<10.0	Not Sampled	Not Sampled

The results of the multiparameter analysis of groundwater shows conditions across Phoenix Place to be mildly reducing to reducing. This implies degradation in the aquifer would be dominated by anaerobic and/or abiotic processes which can be much slower in terms of degrading contamination in comparison to bio-aerobic processes.

The presence of alcohols may be indicators of breakdown products of solvents previously in use on the site. Concentrations of these compounds are restricted to boreholes BH12 and BH20, TPH analysis of down hydraulic gradient boreholes BH13, BH14, and BH22 recorded concentrations below the laboratory LoD. The absence of chlorinated solvent compounds and their daughter products do not point to a chlorinated solvent as the source.

The proposed Development will work to improve groundwater quality in two respects;

- The substantial removal of Made Ground to form the basements, acting to decrease the contaminant body on-site; and
- The relative increase in hardstanding acting to reduce precipitation infiltration rates, and the leaching of contaminants from the remaining Made Ground into the Secondary A Aquifer within the superficial deposits.

During construction, the unconfined Secondary A Aquifer will be exposed, bringing it at risk from fugitive emissions from construction equipment and tanks. To mitigate the risk substances hazardous to the environment should be appropriately stored and methodology put in place where spillages occur during use. The details of which will be set out in the CEMP.

The proposed excavations will extend below the groundwater level in some areas of the Site. Where this occurs water management measures will be required to prevent excessive flooding on-site restricting work, the specific water management measures will be detailed in a CEMP.

8.3.2 Secondary A Aquifer – Harwich Formation and Lambeth Group

Groundwater laboratory results from samples taken from the Harwich Formation and Lambeth Group been assessed against the DWS. Table 22 details the contaminants in exceedance.

Table 22: Contaminants in exceedance within the groundwater underlying the London Clay Formation

Contaminant	DWS (µg/l)	Location (concentration (µg/l))
Iron	200	BH12 (291.60)
Arsenic	10	BH11 (11.5)
Nickel	20	BH12 (24.30)
Selenium	10	BH12 (28.90)
Lead	10	BH19 (21.0)

Metal Contaminants

Groundwater samples from the aquifers underlying the London Clay Formation have recorded metal contaminants in exceedance of the DWS. The nickel and iron concentrations have been recorded below background groundwater concentrations as determined by BGS[1], 24.8mg/l and 40.6µg/l for iron and nickel respectively, and are therefore considered to be representative of groundwater in the area. The

[1] Bearcock, Smedley, 2010, Baseline Groundwater Chemistry: Palaeogene of the Thames Basin, Keyworth, Nottingham, British Geological Survey.

elevated selenium concentrations are likely caused by pyrite present within the overlying London Clay Formation, and do not represent contamination of the aquifer by anthropogenic sources on-site.

The lead and arsenic DWS are for water at consumer taps. The assessment of groundwater samples against these standards are inherently conservative. The marginal exceedances of lead and arsenic against these standards do not therefore represent gross contamination of the aquifer. In addition, given the distance to the closest groundwater abstraction well (517m north east), and the intervening contaminative sources the marginal exceedances recorded on-site will not have a significant impact on controlled water receptors, diluting and dispersing within the aquifer prior to reaching them.

TPH Contamination

Short chain aliphatic TPH hydrocarbons above the laboratory LoD have been recorded within BH12 (well installed with the Lambeth Group). Further alcohol analysis has identified the contamination to comprise alcohols of various carbon bands (methanol to n-hexyl alcohol). While the “Tentatively Identified Compound” analysis identified a 2-heptanone, a ketone, at a concentration range of 423µg/l to 637ug/l in the deep borehole at BH12.

The alcohols recorded were similar to those recorded in the Made Ground and alluvium aquifer in BH12 and BH20, but of a greater magnitude. Table 23 details the total alcohol concentrations recorded at depth in BH12 and BH19 (located up hydraulic gradient).

Table 23: Groundwater alcohol concentrations: Deep aquifers

Borehole	Stratum well installed in	Total Alcohol Concentration (µg/l)	
		Groundwater Round 2 (30/01/2017)	Groundwater Round 3 (09/02/2017)
BH12	Lambeth Group	20,222.00	15,442.00
BH19	Lambeth Group	Not Tested	<100.00 (below LoD)

Groundwater samples from BH11 and BH21, which targeted the Harwich Formation, have not recorded TPH contaminants in exceedance of the laboratory LoD.

Groundwater levels within BH12 were seen to decrease significantly during the programme of groundwater sampling. Prior to the third groundwater sampling round in which the borehole was purged dry groundwater was recorded between -1.60mAOD and -1.09mAOD during previous groundwater level monitoring. Post completion of the third groundwater sampling round the level was recorded between -3.45mAOD and -3.34mAOD. This shows recharge rate within the Lambeth Group is poor, which correlates with the cohesive nature of the aquifer. The low permeability of the Lambeth Group will mean contaminants present in groundwater are unlikely to laterally migrate significant distances off-site. Therefore, reducing the potential impact contaminants within the Lambeth Group will have on receptors off-site.

Groundwater samples were attempted to be taken from wells installed within the Lambeth Group and Thanet Formation at BH14 and BH23 located close to the south-eastern Site boundary. BH14 and BH23 are down hydraulic gradient of the Site. Groundwater levels within BH14 and BH23 were too low however to enable representative groundwater samples to be recovered. The low groundwater levels within BH14 and BH23 provides further evidence of the poor connectivity and movement of groundwater within the Lambeth Group and Thanet Formation.

VOC, and SVOC contaminants were recorded below the laboratory LoD during all three groundwater monitoring rounds, including chlorinated solvent products and their daughter breakdown products. These would have been expected if the contamination source was a chlorinated solvent.

London Clay Formation in this area of the site is about 3.0m thick therefore the presence of these aqueous contaminants in the Lambeth Group may be evidence of connectivity between the aquifer in the above the London Clay Formation and below it.

Results of groundwater analysis show the alcohols and 2 heptanone are restricted to the Lambeth Group within BH12 and BH20 (Alluvium) located in the Site's north east corner and are not a Site wide contaminant. Given the distance to the closest groundwater abstraction (517m north east, up hydraulic gradient from the Site), the restricted groundwater movement within the Lambeth Group due to its low permeability, and the expected rapid biodegradation of alcohols and the 2 heptanone in an aerobic groundwater system combined with their relatively low toxicity these contaminants do not impact on the groundwater quality.

A detailed foundation design as not been formulated however, piled foundations extending through the London Clay Formation are likely to be used. Where this occurs a preferential pathway for contaminants within the overlying groundwater may be created. Where piled foundations are used a Foundation Works Risk Assessment (FWRA) detailing the mitigation measures to prevent the formation of preferential pathway will be required.

8.3.3 River Thames

Given the distance of the Site from the River Thames (1.6km south), the general poor quality of the groundwater body in the surrounding area and the level of contaminants in the aquifer in which the sewer lies the potential impact to the River Thames is not significant.

8.4 Risk to Structures

8.4.1 Ground Gas

Peak methane, carbon dioxide, vapour, and flow level rates recorded during the monitoring within suitably installed wells are set out in Table 24.

Table 24: Peak gas, and flow rates

Gas/Flow	Peak Reading	Monitoring Location
Methane	<0.1	WS13, WS15, WS17, WS18, BH13, BH19
Carbon dioxide	4.3	WS17
Flow	0.1	WS13, WS18
Carbon monoxide	<0.1	WS13, WS15, WS17, WS18, BH13, BH19
Hydrogen Sulphide	<0.1	WS13, WS15, WS17, WS18, BH13, BH19

Based on the completed ground gas monitoring a maximum GSV of 0.0043l/hr would be calculated based on the peak carbon dioxide level recorded (4.3%). Given a GSV of 0.0043l/hr and a peak carbon dioxide

concentration of 4.3% would classify the Site's ground gas regime as Characteristic Situation 1 (CS1) whereby no ground gas protection measures would be required.

8.4.2 Vapour

Peak total vapour during headspace analysis of soil samples was 0.1ppm. Low levels of Semi Volatile Organic Compounds (SVOC) and Volatile Organic Compound (VOC) have been recorded within soil samples, and have been recorded below the laboratory LoD within groundwater samples. Vapour monitoring within installed wells has recorded a peak total vapour of 0.1ppm.

Given the vapour levels recorded a significant vapour regime is not present, and the risk to structures/human health receptors is low. No mitigation measures are required.

8.5 Risk to Water Supply Pipes and Buried Infrastructure

The UKWIR project steering group decided that barrier pipes would provide sufficient protection for the supply of drinking water in all Brownfield site conditions. However, this approach needs to be agreed with Thames Water.

The results of the BRE SD1 suite laboratory testing are summarised in Table 25.

Table 25: SD1 suite analysis summary

Stratum / Geological Origin	Characteristic Water Soluble Sulphate Value (mg/l SO4)	Characteristic pH Value
Made Ground	423.81	8.60
Alluvium	52	8.32
London Clay Formation	674.60	7.92
Lambeth Group	194.64	8.72
Thanet Formation	140	8.36
Upper Chalk Formation	590	8.20

As the characteristic value of sulphate is less than 3000mg/l and the characteristic pH is greater than 5.5, the concentrations of magnesium, nitrate and chloride are not significant in determining the design sulphate class.

Based on the results the Design Sulphate (DS) and Aggressive Chemical Environment for Concrete (ACEC) classifications for each stratum are given in Table 26.

Table 26: DS ACEC classifications

Strata	DS ACEC Classification
Made Ground	DS-1 AC-1
Alluvium	DS-1 AC-1
London Clay Formation	DS-2 AC-2
Lambeth Group	DS-1 AC-1
Thanet Formation	DS-1 AC-1
Upper Chalk Formation	DS-2 AC-2

9. Conclusions

Following the implementation of the ground investigation, the pollutant linkages identified during the PERA have been re-evaluated and reclassified in relation to the additional information obtained. The results of the reassessment are summarised in Table 9.

Overall the risk rating for the Site has been assessed as **Medium**, whereby without implementing the recommendations within Section 10 complete pollutant linkages are present. Where the recommendations in Section 10 are implemented, the pollutant linkages will be broken and the Site's overall risk rating will be reduced to **Low**. In addition, the Site is unlikely to be capable of being classified as Contaminated Land under the Environmental Protection Act 1990, thus meeting the requirements of paragraphs 120 to 122 of the National Planning Policy Framework.

Table 27: Updated Conceptual Site Model

Receptor	Potential sources	Pathways	Risk	Justification	Risk Post Mitigation
Human Health					
Existing Site Users	Contaminants within Made Ground and groundwater	Direct contact, ingestion, and inhalation	Low	PAH, and metal contaminants in exceedance of the commercial GAC have been recorded in near surface soils, in addition to a low level of asbestos fibres. Given the short residence time existing users have on-site the risk of significant harm is low. Where visible ACM are present on the Site surface they should be removed and disposed of in-line with all appropriate regulatory guidance.	Low
	Ground gas and vapours from Made Ground	Migration to and accumulation in confined spaces	Low	The Site is open, ground gases and vapours will not accumulate to explosive/lethal levels, and no risk to existing Site users exists.	Low
Future Site Users	Contaminants within soils and groundwater	Direct contact, ingestion, and inhalation	Low	The part/complete removal of Made Ground in addition to hardstanding at formation level as part of the proposed development on Plot P1 and P2 will act to break the pollutant linkage to future Site users from contaminants. Further mitigation measures are not required. Contaminants below the GAC for a POS_{RESi} have been recorded in the proposed soft landscaping at formation level in the north west corner of Plot P2, breaking the pollutant linkage. The proposed Development will incorporate a cover layer of suitable for use material on area of soft landscaping. This will act to break the pollutant pathway to any elevated contaminants or asbestos within the Made Ground not encountered during the ground investigation.	Low
	Ground gas and vapours from the Made Ground	Migration to and accumulation in confined spaces	Low	The Site's ground gas regime has been classified as CS1, whereby ground gas protection measures are not required. ased on ground investigation the Site's vapour regime has been assessed as low, with no mitigation measures required. The remaining groundwater sampling, and vapour monitoring results are required to confirm the Site's vapour regime.	Low
Off-site Residents	Contaminants within soils and groundwater	Wind entrainment of dust and lateral migration off-site, leading to contaminants being inhaled or coming into direct contact with off-site residents.	Low	Contaminants have been recorded in the Made Ground including asbestos. During construction dust suppression measures should be employed to limit dust generation. The details of which should be set out in a Construction Environmental Management Plan (CEMP).	Low

Construction Workers	Contaminants within soils and groundwater	Direct contact, ingestion, and inhalation.	Medium	Contaminants including asbestos have been recorded within the Made Ground, during construction, workers will come into direct contact with the contaminants within the soils and groundwater. Construction workers should wear the appropriate PPE, adhere to good practice hygiene and safety measures, the Confined Space Regulations 1997 and the Control of Asbestos Regulations 2012.	Low
	Ground gas and vapour form the Made Ground	Migration to and accumulation within confined spaces	Medium	The Site's ground gas regime has been assessed as CS1, potential however remains for elevated ground gas levels to occur in confined spaces. Construction workers should avoid entering excavations. If entry cannot be avoided, a risk assessment should be undertaken, PPE and Respiratory Protective Equipment (RPE) used and works done in-line with the Confined Space Entry Regulations 1997	Low
Property					
Site structures	Contaminants within soils and groundwater	Chemical attack on buried structures or services	Medium	Concrete should be designed in accordance with the above classifications to mitigate the risk of unacceptable levels of deterioration.	Low
Surface Waters					
River Thames	Made Ground, contaminants from historic activities, car parking	Migration via the culverted River Fleet Sewer, which outfalls into the River Thames	Low	It is assessed that the contaminations detected on site do not pose a risk to the River Thames via the River Fleet Sewer pathway due to the distance to the river, poor quality of the groundwater in the surrounding area and the concentrations of contaminants detected.	Low
Secondary A Aquifer within the Hackney Gravel Member/Alluvium/Made Ground	Made Ground, contaminants from historic activities, car parking	Vertical migration into the unconfined aquifer from the Made Ground.	Low	Elevated contaminants within up hydraulic gradient boreholes indicates the groundwater body within the surrounding area is of poor quality. The increase in contaminant concentrations within down hydraulic gradient borehole shows the Site is having a marginal impact. However, contaminants will attenuate within the groundwater body prior to reaching the closest controlled water receptor (River Thames 1.6km south) mitigating the impact. Alcohols contamination above the LoD has been restricted to BH20, and BH12. The contamination is therefore localised, and does not represent a significant risk to the wider aquifer.	Low

Secondary A Aquifer within the Harwich Formation, Lambeth Group, and Thanet Formation. Principal Aquifer within the Upper Chalk Formation.	Made Ground, contaminants from historic activities, car parking	Preferential pathways created during piling.	Low	Metals in exceedance of the DWS have been recorded within the aquifers underlying the London Clay Formation . Concentrations of nickel and iron are within background concentrations, and the selenium is the result of leaching from the pyrite within the London Clay Formation . The concentrations of nickel, iron, and selenium are not representative of degradation of the aquifer from anthropogenic sources. The marginal exceedances of the DWS of arsenic, and lead do not represent gross contamination of the aquifer. Given the distance to the closest groundwater abstraction borehole (517m north east, and up gradient), the contaminants will attenuate to concentrations below the DWS, and therefore not represent a risk. Alcohol and 2 heptanone compounds above the laboratory LoD have been recorded in the Lambeth Group at BH12. However, for the following reasons the risk to controlled water receptors in the surrounding area will be low • The Lambeth Group has a low permeability meaning the alcohol and 2-heptanone contaminants will be restricted in their lateral migration; • Alcohols and 2-heptanone rapidly degrade within the environment further restricting their lateral migration off-site; and • The relative non-toxic nature of the compounds will mean their impact on controlled water receptors and environment will not be significant.	Low

10. Recommendations

The following actions are recommended to address the potentially unacceptable remaining risks:

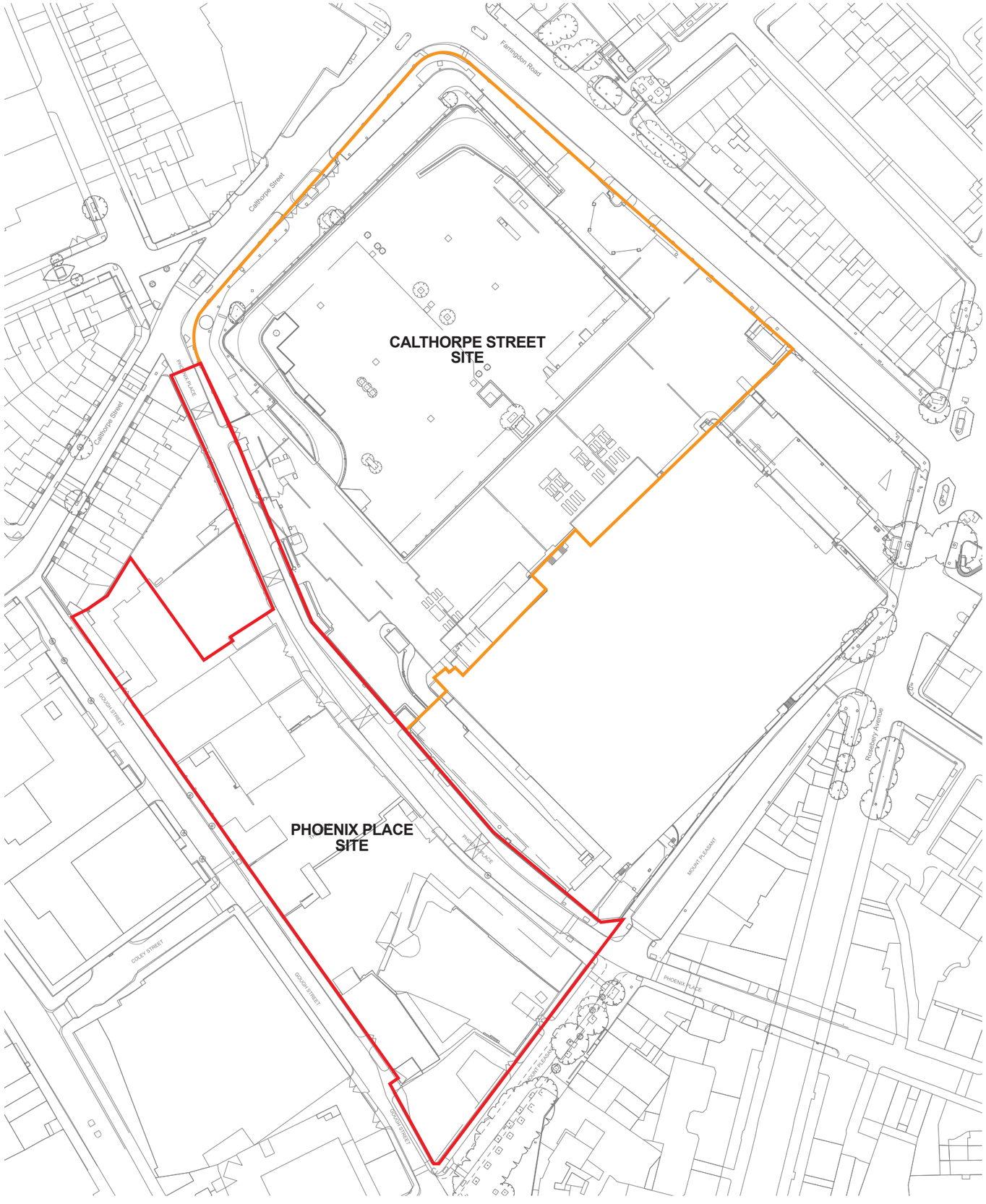
- Material/topsoil imported for use within soft landscaping areas should be certified suitable for the proposed end use prior to being brought to site;
- Where piled foundations breach the London Clay Formation a FWRA detailing the mitigation measures necessary to prevent formation of preferential pathways will be required;
- The interceptor in the south west Site corner close to TP9, should be drained and decommissioned by a suitably qualified contractor in accordance with all relevant regulations;
- Concrete should be designed with due attention paid to the classifications set out in Section 8.5;
- Thames Water should be consulted on the required potable water supply pipe specification, given the intrusive investigation results.
- During excavation of basements effective groundwater management should be in place to prevent groundwater being exposed to contaminated material. Water removed from excavations should be suitability treated prior to disposal under licence;
- During construction, potentially contaminative substances should be stored and handled appropriately so as, to prevent fugitive releases. The details of the storage and handling procedures should be detailed within a CEMP;
- During groundworks dust mitigation measures set out in a CEMP should be employed to restrict the formation and distribution off-site of dust;
- As standard precaution, construction workers should wear the appropriate PPE, if required RPE, adopt good hygiene and safety practices, and adhere to the Confined Space Entry Regulations 1997, and Control of Asbestos Regulations 2012;
- A Remediation Strategy should be prepared detailing measures to mitigate active pollutant pathway linkages. Post construction of the development a Validation Report should be prepared, detailing the remedial measures taken, and confirming all active pollutant pathways have been mitigated; and
- The recommendations set out in the PWCA (WIE13235-102.R.8.1.1.JC), geotechnical interpretative report (28549-R02(00)), and archaeology report (CAL16, MOLA, 2016) should be followed.

APPENDICES

Appendix A Site Plans

- Site Location Plan
- Site Plan
- Phoenix Place Street Plots
- Proposed Development Plans
- Exploratory Hole Location Plan
- Soil Contamination Exceedance Plan
- Asbestos Location Plan
- Simplified flow path of the Historic River Fleet
- Groundwater Level – Hackney Gravel Member, Alluvium, and Made Ground

Project Details	WIB13235-102: Royal Mail Mount Pleasant Sorting Office
Figure Title	Figure A1: Site Location
Figure Ref	WIB13235-102_GR_GQRA_A1A
Date	December 2016
File Location	\\nt-lncs\weedl\projects\eed13235\102\graphics\gqra\issued figures



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Phoenix Place Site Boundary

Calthorpe Street Site Boundary

N

Project Details	WIB13235-102: Mount Pleasant Sorting Office - Phoenix Place
Figure Title	Figure A2: Planning Application Boundaries
Figure Ref	WIB13235-102_GR_WA_A2A
Date	January 2017
File Location	\\s-lncs\wiel\projects\wib13235\102\graphics\wa\issued figures

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Phoenix Place Site Boundary

D

C

PLOT P2

B

A7

A6

A1

PLOT P1

A5

A2

A4

A3

N

Project Details	WIB13235-102: Mount Pleasant Sorting Office - Phoenix Place
Figure Title	Figure A3: Proposed Phoenix Place Plots and Buildings
Figure Ref	WIB13235-102_GR_WA_A3A
Date	January 2017
File Location	\\s-lncs\wiel\projects\wib13235\102\graphics\wa\issued figures