

Appendix 11-3

Phase 2 Ground Condition Assessment

East Reading Mass Rapid Transit Scheme

Phase 2 Ground Condition Assessment

On behalf of **Reading Borough Council**



Project Ref: 28791/3501 | R002 | Rev: 0 | Date: June 2017



Document Control Sheet

Project Name: Proposed MRT Scheme, East Reading

Project Ref: 28791/3501

Report Title: Ground Investigation Report

Doc Ref: R002 / Rev0

Date: June 2017

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Revision	Date	Description	Prepared	Reviewed	Approved
Rev0	June 2017	Final for Issue	AZ	RHT	RHT

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Summary

This report presents an interpretation of the findings of the geoenvironmental investigation carried out to determine the ground conditions on a parcel of land (Zone D) forming part of the western section of the Proposed Mass Rapid Transit (MRT) Scheme, East Reading.

The ground investigation was carried out to determine the ground conditions, and the nature and extent of any existing contamination of the ground and groundwater on the site.

Site Location The MRT Scheme is situated about 1.5 km to the northeast of Reading Town Centre. The proposed scheme is a new road link connecting Napier Road in the west to Thames Valley Park to the east. The overall site comprises a narrow corridor situated along the southern bank of the River Thames with a bridge over the River Kennet. The ground investigation was carried out on a parcel of land in the western part of the Scheme between the Tesco Superstore car park and the River Kennet, where there is a history of potentially contaminative land use.

Historical Land Use Previously the western part of the MRT Scheme site was raised with materials from unidentified sources and is defined by the Environment Agency as a historical landfill, and was used as railway land and fuel tanks. Subsequently, some of the western part of the site was redeveloped as part of the Tesco Superstore development. The eastern part of the proposed Scheme comprises principally undeveloped land.

Ground Conditions The ground conditions revealed by the investigations comprise Made Ground to between 1.5 and 2.20 m depth overlying Alluvium to between 2.5 and 3.9 m depth, River Terrace Deposits to between 5.4 and 8.0 m depth and Chalk a maximum investigated depth of 25 m. Groundwater level was measured between about 1.6 and 2.4 m depth with a hydraulic gradient in a general direction to the north-east towards the River Thames.

Geoenvironmental Conditions Olfactory and visual signs of unusual solids and liquids were not noted during the investigation. The measured concentrations of potential contaminants are below the selected assessment values appropriate for land uses as commercial development. The majority of the measured concentrations of potential groundwater contaminants are below the adopted screening criteria with the exception of copper, nickel, lead and zinc, and some individual Polycyclic Aromatic Hydrocarbons (PAHs). It is expected that the source of the elevated concentrations of metals and the individual PAHs in groundwater is the former offsite gas works situated up-gradient 150m (at its closest) south -west of the site rather than the Site itself, and this is not unexpected. The measured concentrations of ground gases indicate slightly elevated concentrations of carbon dioxide and methane, depleted oxygen concentrations and very low gas flows.

Tier 2 Geoenvironmental Risk Assessment A Tier 2 risk assessment was carried out to assess risks posed by the existing ground conditions to the proposed development is summarised in the following table.

Potential Receptor	Risk Assessment	Description
Future Site Users	Low	There is a Low hazard potential associated with measured concentrations of potential contaminants in the soils, therefore the potential risk to future site users associated with contamination is assessed to be Low.
Site Workers	Low	The risk to site workers is expected to be Low provided appropriate protective clothing and equipment are worn, and good standards of hygiene are adopted to prevent prolonged skin contact, inhalation and ingestion of soils.
Ground Waters	Low	

Potential Receptor	Risk Assessment	Description
Surface Waters	Low	Given the nature of the proposed development, the potential for any mobile contaminants to adversely affect the quality of ground and surface waters is considered to be Low provided that piles installed as part of the proposed scheme will be designed and installed in accordance with the Environment Agency guidance for piling in potentially contaminated sites.
Buildings	Low	Owing to the potential for low hazard potential for contaminants to be present in the ground, the risk to buildings and structures is expected to be Low.
Ecology	Very Low	Owing to the potential for low hazard potential for contaminants to be present in the ground, the risk to ecology is expected to be Very Low.

The geoenvironmental risk assessment indicates that any potential contaminants are not themselves likely to represent an unacceptable risk to human health, controlled waters or ecology and wildlife associated with the development of the Site as currently proposed.

It is considered that additional contaminated land investigation is not required to support the planning application for the proposed Scheme.

The summary contains an overview of the key findings and conclusions. However no reliance should be placed on any part of the summary until the whole of the report has been read.

1 Introduction

Peter Brett Associates LLP, PBA, has been retained by Reading Borough Council, the Client, to carry out a geoenvironmental investigation and a Phase 2 Ground Condition Assessment for the proposed Mass Rapid Transit (MRT) Scheme at East Reading. The MRT scheme comprises a proposed new bus, cycle and pedestrian link road connecting Napier Road to the west and Thames Valley Park to the east.

Previously, a desk study review of readily available published information was carried out to assess the ground conditions for the proposed Scheme and the potential for contamination to be present associated with previous and present land uses within the proposed Scheme and the surrounding areas. The report includes a Tier 1 qualitative assessment on the geoenvironmental conditions at the site. The findings of the study are presented in a separate report prepared Peter Brett Associates (PBA, 2017).

The desk study identified that the western part of the proposed Scheme had an industrial history with a number of industrial uses including a historical landfill, railway land, railway sheds, and large fuel tanks. By the 1990s the some of the Western Part of the proposed Scheme was redeveloped as part of the Tesco Superstore. The eastern part of the proposed Scheme comprises principally undeveloped land.

Given the level of risk and the relatively low sensitivity of the proposed end use it is considered that a ground investigation and Tier 2 risk assessment is not required to support the planning application for the Scheme and this can be dealt with post consent during the ground investigations for design purposes. However, it was recommended that a preliminary geoenvironmental ground investigation is carried out in Zone D. This is an area of embankment construction and piled foundations for structures, where the risk assessment has identified as moderate geoenvironmental risk associated with the historical landfill and railway land. The investigation should target in particular the potential impacts from the proposed scheme on the highly sensitive Controlled Waters in the adjacent Rives Thames and Kennet, and the aquifer beneath the site.

The intrusive ground investigation has been carried out principally to provide information on the ground conditions and the potential for contamination to be present. Basic geotechnical information was obtained also to assist with future design and construction of the scheme.

The fieldwork was carried out by Endeavour Drilling Limited acting under the technical direction of Peter Brett Associates LLP. The factual results of the investigation are presented in a separate report prepared by Endeavour Drilling Limited (EDL, 2017).

This Phase 2 Ground Condition Assessment presents an assessment of the ground conditions at the Site and immediate surrounding land and a Tier 2 qualitative geoenvironmental assessment of the risks and hazards associated with existing or potential contamination in the ground. In accordance with the requirements of the National Planning Policy Framework (DCLoG, 2012), the Tier 2 assessment has been carried out in accordance with "established procedures" using current UK best practice and guidance as given in British Standard 10175 (2013) and Contaminated Land Report 11 (EA, 2004).

This report will be submitted to Reading Borough Council to support the planning application for the proposed Scheme.

Attention is drawn to the Guidance Note included after the text of this report which provides guidance on the context of the report.

2 Site Description

2.1 Introduction

A summary of the Proposed Scheme and overall Site description including location, history, current use and geology are presented in the section below. Further details of the history and present layout of the Proposed Scheme are given in the desk study report prepared by PBA (2017).

2.2 The Scheme

The proposed Scheme is situated about 1.5 km to the northeast of Reading Town Centre. The Proposed Scheme comprises a narrow corridor about 1.2 km long along the line of a proposed new bus, cycle and pedestrian link road connecting Napier Road to the west and Thames Valley Park to the east along the southern bank of the River Thames with a bridge over the River Kennet.

A site location plan is presented as **Figure 1**.

For ease of reference the Scheme was divided in the desk study into seven zones along the narrow corridor as shown on **Figure 2**. The basic description from west to east along the corridor for each of the zones, is as follows:

- | | |
|---------------|---|
| Zone A | A narrow strip of land comprising carriageway, pavements, and associated landscaping along Napier Road leading to Tesco Superstore |
| Zone B | Mostly landscaping, and an access road forming part of Tesco Superstore |
| Zone C | Access roads and car parking areas serving Tesco Superstore and a narrow band of landscaping to the south |
| Zone D | A triangular parcel of land covered with dense vegetation, situated between Tesco Superstore car park and the River Kennet |
| Zone E | The River Kennet flowing from south-west under the Kings Mead railway bridge and the Horseshoe Footbridge to the north-east where it joins the River Thames |
| Zone F | A narrow strip of land situated immediately to the south of the River Thames and north of the Network Rail land |
| Zone G | A vacant parcel of land covered with scrub and dense vegetation to the west of the A3290 roundabout |

2.3 The Site Location

The Site is situated in Zone D of the Proposed Scheme. The Site comprises a triangular parcel of land about 140 m long and up to 90 m wide and is covered with dense vegetation including semi-mature and mature trees and shrubs. The Thames Towing Path is situated along the River Thames. In addition, a paved footpath crosses the Site connecting the Tesco Superstore car park and the Thames Path through the Site. The Site is centred at National Grid Reference SU 730 738.

The layout of the Site is shown on the Exploratory Hole Plan presented as **Figure 3**.

2.4 Site History

The history of the development of the whole scheme area including the Site and surrounding area has been obtained from a number of available historical Ordnance Survey (OS) maps presented in the desk study (PBA, 2017). A summary of the history of the Site is presented below.

Historically the Site was situated on the flood plain of the Rivers Thames and Kennet. The surrounding area was used for trade along the River Thames and the Kennet and Avon Canal.

According to available information in 1840 the railway line between Reading and London Paddington named The Great Western Railway was completed with a large embankment and a railway bridge crossing the River Kennet immediately to the south of the Site.

In the late 1870s, the Site was in a semi-rural setting to the north-east of the town of Reading. A ferry crossing is recorded across the River Kennet connecting the tow path along the River Thames. Railway sidings, the Great Western Railway embankment and a railway bridge over the River Kennet are recorded immediately to the south of the Site. A railway underpass is shown to cross the railway embankment connecting between the Huntley and Palmers Biscuit Factory and a large gasworks to the south of the railway embankment.

By early 1910s Zones B and C were occupied by railway sidings constructed on raised land. Subsequently, the map dated 1932 shows that the land in most of Zones B, C and D to be raised and occupied by railway sidings. A number of goods and gas coal sheds were constructed in Zones C and D. Electricity pylons with overhead cables crossed the Site orientated east to west.

The map dated 1956 shows that the majority of the railway sidings and the goods and gas coal sheds have been removed.

The maps dating from the early 1970s label Zones B and C as 'Depot'. Two bunded tanks and a rectangular shed appear in the north western part of Zone B with three larger bunded tanks to the north of the site. A 'wagon tippler', typically used to drop off coal loads from railway wagons, is recorded at the railway sidings.

By early 1980s the former Biscuit Factory and the majority of the former gasworks to the south of the railway embankment have been removed.

By the early 1990s Zones A, B and C are vacant with the former tanks and rail sidings having been removed. Subsequently, by the mid 1990s a Tesco Superstore was constructed to the north of the site and some of the associated car parking areas and access roads occupy Zones B and Zones C. A petrol station was constructed immediately to the north of Zone B.

By early 2000s a number of large pylons are recorded on the site with overhead cables shown to run from east to west parallel to the southern Site boundary.

By 2010, the warehouse that was situated immediately to the north of Zone A of the site was demolished and a number of blocks of flats named Luscinia View Development were constructed at this location.

2.5 Current Land Use

At the time of the investigation the Site was unoccupied and covered with dense vegetation including mature and semi mature trees and shrub. A paved footpath crosses the Site in a south-east to north-west direction, that allows public access from Tesco Superstore to the Thames Path. The footpath is demarcated by a metal fence barrier. The southern boundary of the site is fenced off by Network Rail. The northern extent of the Site is the Thames Path and the River Thames. The confluence of the River Thames and the River Kennet forms the eastern boundary of the Site.

The land to the south is occupied by Network Rail with a metal fence present along the boundary. The Tesco Superstore car park is segregated with a metal fence to the west of the Site. The River Thames and the River Kennet are present along the northern and eastern edges of the Site.

2.6 Geology

2.6.1 Geological Map

The 1:50 000 scale geological map of the area; Sheet 268 (BGS, 2000) indicates the Scheme lies on superficial deposits comprising Alluvium, and the Shepperton Gravel Member, a River Terrace Deposit. The Superficial Deposits are underlain by the Seaford Chalk Formation and the Newhaven Chalk Formation (undifferentiated) as part of the White Chalk Subgroup.

According to the lexicon of Named Rock Units of the British Geological Survey the Alluvium generally comprise silty clay with occasional layers of silt, sand, peat and gravel, whilst the Shepperton Gravel Member comprises primarily sand and gravel. The White Chalk Subgroup is described as white chalk with nodular and tabular flint seams and bands.

It is expected that locally Made Ground is present associated with current and past developments of the site.

2.6.2 Historical Borehole Records

The British Geological Survey archives contain records of a number of exploratory holes sunk during two ground investigations in 1986 and 1989 in the vicinity of the Scheme mainly associated with earlier proposals for a bridge over the River Kennet approximately on the alignment of the current scheme.

A summary of the ground conditions based on the historical borehole records in the vicinity of the Scheme is presented in the table below.

Table 2.1 Summary of typical depths and strata descriptions

Strata	Approximate Depth to base (m bgl)	Approximate thickness (m)	Typical Description
Made Ground	0.3 to 3.0 typically 1.0 to 2.5	0.3 to 3.0 typically 1.0 to 2.5	Variable composition, typically CLAY with fragments of brick, clinker, concrete, chalk and flint, locally with ash and organic matter
Alluvium	2.5 to 4.3 Typically about 3.5 to 4.0	0.2 to 3.7 typically about 2.0	CLAY and SILT locally peaty or organic with traces of decaying organic matter, flint gravel and shells. Locally with rare layers of peat (up to 2.1 m thick)
River Terrace Deposits	3.8 to >10.0 Typically about 6.0	0.6 to 6.8, Typically about 3.0	SAND and GRAVEL in variable proportion locally with a thin layer of clayey sandy silt
White Chalk Subgroup	> 25	> 20	White Chalk with flints. Recovered as remoulded chalk with fragments of weak chalk becoming rubbly and blocky with depth

Where recorded, groundwater strikes were recorded between 1.8 and 4.5 m below ground level and rose to between about 0.3 and 2.9 m below ground level.

2.7 Hydrogeology

The Shepperton Gravel Member and the Seaford and Newhaven Chalk Formations are classified as Principal Aquifers. Principal Aquifers are defined as formations that may be highly productive and able to support large abstractions for public supply and other purposes.

The Alluvium is classified as Secondary A Aquifer. This is a formation of variable permeability that, although seldom producing large quantities of water for abstraction, may be important for local supplies and in supplying base flow to rivers.

The proposed Scheme is located within a groundwater Source Protection Zone 3 for a groundwater abstraction well situated about 2.2 km to the south of the site. Groundwater source protection zones are

defined as the groundwater catchment zones for significant public water supply and private wells or boreholes that supply water to portable or equivalent standards. A total catchment (Zone 3) is defined by the Environment Agency as the area around a groundwater abstraction well within which groundwater recharge is presumed to provide water to the abstraction well.

The 1:100,000 Hydrogeological Map of South West Chilterns and the Berkshire and Marlborough Down (BGS, 1978) indicates the groundwater level in the Chalk in August 1976 is recorded at about 40 m AOD with the groundwater flowing in a general direction toward the River Thames.

It is expected that the groundwater in the Alluvium, River Terrace Deposits and the White Chalk Subgroup are in hydraulic continuity with the water in the adjacent rivers and groundwater level is at roughly at the same elevation.

The presence of a Principal Aquifer and a Secondary A Aquifer need to be considered in assessing the effects of the built development on the hydrogeological regime and the risk associated with potential pollutants with regards to both the aquifer as a water source for human consumption, and the potential impact on the adjacent rivers and their aquatic habitat.

2.8 Hydrology

The River Thames flows to the north of the Scheme in general direction to the north-east. The River Kennet crosses the centre of the Scheme flowing from south-west to the north-east where it joins with the River Thames.

The River Thames and the River Kennet are classified by the Environment Agency as a Primary River of Very Good and Good (Grades A and B) Biological and Chemical Quality, respectively.

The chemistry grade is assigned by averaging results for biochemical oxygen demand (BOD), ammonia and dissolved oxygen measured by the Environment Agency until 2009.

The presence of the adjacent rivers need to be considered in assessing the effects of the built development on the hydrogeological and hydrological regime and the risk associated with potential pollutants with regards to the adjacent rivers and their aquatic habitat.

2.9 Proposed Development

It is understood that Reading Borough Council is proposing to construct a new bus, cycle and pedestrian link road connecting Napier Road in the west and the A3290 roundabout in the east via a bridge crossing over the River Kennet. The proposed scheme comprises the construction of an approach road off Napier Road at grade, with an approach embankment leading to the bridge abutment with a 59 m span bridge over the River Kennet. The proposed road to the west of the River Kennet will be constructed on a viaduct to minimise the footprint of the proposed road over the flood plain of the River Thames. The road is proposed for the use of buses, with a cycleway and footpath alongside.

The proposed scheme will also comprise the extension of the Tesco Superstore Car park in Zone D, and realignment of the existing paved footpath in Zone D.

The proposed outline layout of the scheme is presented on **Figure 3**.

3 Ground Investigation

3.1 Introduction

The ground conditions on the Site have been investigated by an intrusive ground investigation to provide geoenvironmental information for the Scheme. The scope of works is summarised in the following sections of this report. The factual results of the investigation are presented in a separate report prepared by Endeavour Drilling Limited (EDL, 2017).

3.2 Aim of the Investigation

The desk study assessed the ground conditions on the site and the potential for contamination to be present associated with previous and present uses of the site and the surrounding areas (PBA, 2017). The potential for significant contamination to be present in the western part of the Scheme associated with its industrial history was assessed to be Moderate, whilst the potential for significant contamination in the eastern part of the Scheme was assessed to be Very Low with Low potential for localised contamination to be present.

The aim of the investigation was to target potential sources of contamination identified in the desk study in Zone D where the area was identified to have a Moderate potential for significant contamination to be present, and the proposed scheme comprises the construction of an embankment and a bridge as part of the Scheme.

The principal aims of the investigation were to determine:

- a) The nature and extent of potential contamination of the ground and groundwater in order to assess the potential impact of the proposed scheme.
- b) The hydrogeological characteristics of the ground to assess the potential for migration of potential contaminants in the area.
- c) Basic geotechnical information to assist with subsequent geotechnical design of the scheme.

With regard to the investigation for potential contamination of the ground, a non-targeted investigation strategy was adopted for the site. The exploratory holes were selected from consideration of the recommendations given in BS 10175 (2013) for exploratory investigations for sites with a potential for contamination to be present making allowance for the expected heterogeneous conditions on the site. Sampling depths were selected to ensure that representative material from the various strata encountered were recovered for laboratory testing to ensure that information on the distribution of potential contaminants in the soils could be determined.

To satisfy the aims of the investigation, the design of the ground investigation allowed for:

- a) The sinking of 3 boreholes to a depth of 8.45 m below the existing ground level using combination of continuous drive sampling and hollow stem auguring with recovery of cores to provide information on the ground conditions.
- b) The sinking of 3 window sample boreholes to between 1.4 and 3.0 m below ground level using hand held equipment.
- c) The installation of a monitoring well in each borehole to allow monitoring of ground gas concentrations and flows, and groundwater levels.
- d) The excavation of 4 trial pits to between 2.0 and 2.5 m below ground level to obtain information on the variation of the near surface ground conditions.
- e) The sampling of groundwater from each of the monitoring wells.

- f) The sampling of surface water from three selected locations along the River Thames and the River Kennet up and down stream of the Site.

3.3 Fieldwork

The fieldwork for the investigation was carried out between 13 and 15 March 2017.

On completion groundwater and ground gas monitoring wells were constructed in each borehole to allow monitoring of groundwater levels and ground gas concentrations in the near-surface soils. The installations were constructed with a 50 mm diameter well.

The installations in the boreholes were screened between 0.5 m to 6.0 m depth. The installations in the window sample boreholes were screened between 0.5 m and the base of the borehole.

The locations of the exploratory holes relative to the existing site layout are shown on **Figure 3**.

3.4 Laboratory Testing

Geochemical Laboratory Testing A programme of geochemical laboratory testing was carried out on 25 soil samples, 5 groundwater samples, and 3 surface water samples to determine the concentrations of a range of commonly occurring potential contaminants. In addition, Waste Acceptance Criteria (WAC) testing was carried out on 4 soil samples for waste disposal classification purposes.

A summary of the geoenvironmental testing carried out is presented in the table below.

Table 3.1 Summary of Geochemical Testing Suites

Testing Suite	Soil samples tested	Water samples tested
Metals	25	6
Inorganic Compounds	25	6
TPH - CWG (C5-35) Aliphatic/Aromatic Split	25	8
Speciated PAH – USEPA 16	25	8
Asbestos	25	-
Volatile Organic Compounds and semi Volatile Organic Compounds	5	-
WAC	4	-

The geochemical analyses were scheduled by PBA, and carried out by Derwentside Environmental Testing Services Ltd of Consett acting on behalf of Endeavour Drilling Ltd. The suites specified use methods that are accredited by MCERTS where available.

The results of the chemical analyses are presented in the factual report (EDL, 2017). A summary of the geochemical test results is discussed in **Section 5.0**.

Geotechnical Laboratory Testing A programme of geotechnical laboratory soils testing was carried out to verify the visual identification and classification, and to determine the physical properties of selected samples of the materials encountered.

The testing was scheduled by PBA, and carried out in accordance with BS 1377 (1990) by Professional Soils Limited, who hold UKAS accreditation for geotechnical soil testing, acting on behalf of Endeavour Drilling Ltd.

The results of the geotechnical testing are presented in the factual report (EDL, 2017). A summary of the geotechnical testing results is presented and discussed in **Section 4.0**.

3.5 In-situ Soil Screening

Volatile Organic Compounds Screening for the presence of Volatile Organic Compounds (VOCs) was carried out using a photo-ionisation detector (PID) at each exploratory hole location. The screening was carried out on the Topsoil, nominal 0.5 m intervals in Made Ground and in the upper 1.0 m of the underlying natural soils.

The PID screening is a qualitative method. The numerical output of which cannot be directly compared to measured soil concentrations of contaminants of concern. Nevertheless, PID readings are a useful field tool for assessing the potential presence of elevated VOCs in the soil.

3.6 Monitoring

The monitoring wells were monitored on three occasions between 23 March and 4 April 2017 on a one weekly basis to determine the water level and the concentrations of methane, carbon dioxide and oxygen together with gas flow rates and differential and atmospheric pressure.

3.7 Limitations

At the time of the investigation the Site was covered with dense vegetation limiting the access across the Site. Therefore, there may be conditions pertaining to the site which were not disclosed by the investigation and which therefore could not be taken into account in the interpretation of the conceptual ground model and in the assessment of the geoenvironmental conditions on the Site that are presented in the following **Sections 4.0 to 6.0** of this report.

4 Ground Conditions

4.1 Introduction

The ground conditions, as revealed by the ground investigation, are in general agreement with the published geological information and known history of the site and comprise locally Made Ground over the superficial deposits of Alluvium and River Terrace Deposits. The White Chalk was encountered in all the boreholes.

4.2 Made Ground

Description Made Ground was encountered at all the locations investigated and was found to comprise principally black, brown and grey SAND with variable proportions of ash and clay and gravel. The gravel size fractions comprised flint, and chalk, and fragments of brick, concrete, glass, clicker and rare cinder. Locally the Made Ground contained cobble size fragments of brick and concrete.

The Made Ground was found to be between 1.55 and 2.20 m deep.

Olfactory and visual signs of Contamination Olfactory and visual signs of unusual solids and liquids were not noted during the investigation.

Penetration Resistance Values of normalised (for hammer efficiency) penetration resistance SPT (N_{60}) determined by standard penetration testing are presented in **Figure 4**. The N_{60} values in the Made Ground are between 1 and 4 corresponding to very loose state in-situ.

4.3 Alluvium

Description Alluvium was encountered at all the locations where the Made Ground was fully penetrated. The Alluvium was typically found to comprise grey, blue, green and brown CLAY or SILT with sand particles and shell fragments. Locally the Alluvium contained rare flint gravel.

Typically, the Alluvium was found to be between about 0.9 and 1.7 m thick extending to between 2.5 and 3.9 m depth, corresponding to reduced levels of between about 32.4 and 35.6 m OD. At one historical borehole (SU77SW310) the Alluvium was found to be 0.2 m thick.

Classification Results of classification testing are presented on a Casagrande Plasticity Chart on **Figure 5**. The results of the classification testing indicate that the Alluvium is SILT (plotted below the A line) of extremely high plasticity with measured values of liquid and plastic limit respectively between 93% and 180%, and 49% and 91%, with corresponding plasticity indices of between 52% and 98%. The measured moisture content was recorded between 56% and 116%.

Results of particle size distribution analyses for the Alluvium is presented on **Figure 6** with measured fines fractions ($<63 \mu\text{m}$) between 39% and 82% by weight of which the clay sized fraction vary between 10% and 28%, and the silt fraction is between 28% and 54%. The sand size fraction is between 14% and 56% and the gravel fractions are below 5%.

The results are indicative that the Alluvium comprises extremely high plasticity silt with variable proportions of clay, sand, and locally little gravel.

Undrained Shear Strength Manual examination of the material indicates the clay and silt are typically very soft and soft in consistency.

The SPT normalised N_{60} in the Alluvium recorded values of 1 and 2, with a single value of zero indicative of the SPT hammer penetrated the soil under its own weight. Derived values of undrained shear strength determined using the empirical correlation with SPT N_{60} values (Stroud, 1989) using a factor N_c of 4.5, are below 10 kPa.

4.4 River Terrace Deposits

Description River Terrace Deposits were encountered at all the locations investigated where the Made Ground or the Alluvium were fully penetrated. The River Terrace Deposits were typically found to comprise brown and grey principally SAND and locally GRAVEL with little clay and silt. The gravel fraction was found to be fine to coarse angular to subrounded and composed of flint and rare chalk.

The River Terrace Deposits were found to be typically between about 1.5 and 3.6 m thick and locally in the historical borehole (SU77SW81) up to 4.9 m thick. The base of the River Terrace Deposits was encountered between about 5.4 and 8.0 m depth, corresponding to a reduced level of between about 29.5 and 31.9 m OD.

Classification Results of particle size distribution analyses for the River Terrace Deposits are presented on **Figure 5** and indicate the sand size fraction is between about 60% and 95% and the gravel sized fraction is up to about 30% by weight. The samples tested were found to contain fines fraction (<63 µm) of between about 5% and 10%.

Penetration Resistance Values of normalised penetration resistance SPT (N_{60}) value determined by standard penetration testing are presented as a plot against reduced level on **Figure 4**. The normalised N_{60} values were found to be variable between 8 and 59 corresponding to loose to very dense state in-situ. A higher value of 92 was recorded, it is expected that the higher value may have been affected by coarse gravel or cobble presenting an obstruction to the test.

4.5 White Chalk

Description The White Chalk was encountered underlying the River Terrace Deposits in all the boreholes sunk on Site.

The White Chalk was described as structureless CHALK recovered as off white slightly sandy, silty gravel. The gravel fragments were found to be fine to coarse gravel and rare cobbles of very weak and low density Chalk and rare nodules of flint. The White Chalk was classified as Grade Dc in accordance with CIRIA (2002) grading system. However, it should be noted that the drilling technique used is likely to have given rise to disturbance of Chalk within the sample tube remoulding structured Chalk to a structureless melange. Therefore, the Chalk grades reported in the Factual Report (EDL 2017) should not be used for Engineering design purposes unless confirmed by other investigatory techniques.

The White Chalk was encountered in an historical borehole situated in the near vicinity of the Site (SU377SW316) to the maximum investigated depth of 25.0 m below ground level corresponding to a reduced level of about 12.5 m OD.

Standard Penetration Test The normalised penetration resistance SPT (N_{60}) values typically increase with depth from less than 10 near the top surface of the Chalk at about 30m OD to greater than 50 below 25m OD.

4.6 Groundwater

The groundwater entries and measured groundwater levels are presented in the ground investigation report (EDL, 2017) and are discussed in this section of the report.

During the fieldwork, groundwater entries into the exploratory holes were recorded in the Made Ground, Alluvium and River Terrace Deposits at five locations between about 2.0 and 3.6 m depth. The water level rose by between 0.05 and 1.55 m within 20 minutes to between about 1.6 and 2.3 m depth.

On completion of the fieldwork recorded groundwater levels were found between about 1.6 and 2.4 m depth corresponding to reduced level of between about 34.5 and 35.5 m OD. The monitoring well installed in HP2A was found to be dry.

The levels are considered to be representative of the groundwater level in the time of the monitoring within the River Terrace Deposits. The groundwater levels indicate a general groundwater flow from

south-west to north-east towards the River Thames with a relatively gentle hydraulic gradient. It should be noted, however that higher groundwater levels may be present following periods of prolonged rainfall or flooding.

5 Geoenvironmental Conditions

5.1 Introduction

This section of the report discusses the measured concentrations of contaminants and assesses the geoenvironmental conditions on the site with respect to the proposed development and the environment from any hazards posed by these conditions.

5.2 Screening - Volatile Organic Compounds

Screening for the presence of Volatile Organic Compounds was carried out using a photo-ionisation detector (PID) at each exploratory hole location. The numerical output of PID cannot be directly compared to measured soil concentrations of contaminants of concern. Nevertheless, PID readings above 100 ppm are considered to be an indicative of potential presence of elevated Volatile Organic Compounds in the soil.

The PID readings were up to 0.4 ppm indicative that the soils screened do not contain elevated concentrations of Volatile Organic Compounds.

5.3 Contamination

5.3.1 Geochemical Testing

Geochemical testing was carried out on 25 samples of soil for a range of potential contaminants, together with carbon banding of total petroleum hydrocarbons (TPH), speciated determination of polynuclear aromatic hydrocarbons (PAH), and individual Volatile Organic Compounds (VOCs) and semi Volatile Organic Compounds (sVOCs). The results are summarised in Table 1.

Geochemical testing was also carried out on 5 samples of groundwater and 3 samples of surface water for a range of determinands and the results of the analysis are summarised in **Table 2**.

In addition, the waste acceptance criteria (WAC) of 4 samples of the near surface Made Ground have been determined to allow a preliminary determination of the waste classification of any material to be disposed of off-site as part of the proposed scheme.

Full results of the chemical analysis are presented in the factual report of the ground investigation (EDL, 2017).

5.3.2 Contamination Assessment Regime

Soils The results of the geochemical testing on the soil samples have been compared to the Category 4 Screening Levels (C4SL) for commercial land use prepared under the auspices of DEFRA (CLAIRE, 2014). Where a C4SL is not available the concentrations were compared against the Land Quality Management Ltd (LQM) Suitable 4 Use Levels (S4UL) for commercial land use (CIEH, 2015).

In addition, the additive effect of the hydrocarbon fractions is considered by calculating a hazard quotient for each carbon banding which is the concentration divided by the fraction S4UL criterion. All hazard quotients are added to give a Hazard Index for each sample assessed. A Hazard Index that exceeds 1 can be indicative of a potentially significant human health risk.

Full details of the selected assessment criteria are given in the note presented in **Appendix 1**.

Groundwater Under the EC Groundwater Daughter Directive the quality of groundwater is related to the potential to adversely impact the quality of surface waters and the potential for use as a water resource. On this basis the quality of groundwater has been assessed in relation to the directions to the Environment Agency in regard to the implementation of the Water Framework Directive (WFD) (DEFRA, 2010) and the UK drinking water quality standards (DETR, 2000). Full details of the assessment criteria are given in the guidance note included after the text of this report.

5.3.3 Assessment of Contamination

Soils

In general, the measured concentrations of potential contaminants, as summarised on **Table 1**, are below the selected assessment values appropriate for land use as commercial land use.

Metals Review of the metal concentrations tested, as summarised on Table 1, indicates that in general the measured concentration of metals are below the corresponding assessment values appropriate for commercial land use. The only exception comprises an elevated concentration of mercury recorded in a single location TP4 in the Made Ground at 1.0 m depth.

The mercury concentrations have been assessed using the ESI CIEH Statistics Calculator which compares the true mean of the sample population to the critical concentration of the dataset. The results of the statistical analysis indicate that there is a 97% confidence level that the true mean of the dataset is below the critical concentration. Anything above 95% confidence level is considered robust in this instance. The elevated mercury result recorded above is considered to be an outlier for Made Ground. As such, mercury has been ruled out as a potential hazard to the identified human health receptors over the site area.

A copy of the outputs of the ESI CIEH Statistical Calculator are presented in **Appendix 2**.

Review of the leachability testing carried out on 4 soil samples recorded mercury concentrations below the analytical detection limit. Furthermore, all the groundwater samples tested recorded mercury concentrations below the analytical detection limit. Furthermore, the surface water samples tested up and downstream from the site recorded concentrations below the analytical limit and the assessment criteria indicating that there is no significant impact in the adjacent rivers. Therefore, mercury is not considered to represent a potential hazard for groundwater or surface waters.

Petroleum Hydrocarbons (TPHs) Review of the Petroleum Hydrocarbons banded analysis (TPH), as summarised on **Table 1**, indicates that the measured concentration of petroleum hydrocarbons are below the corresponding assessment values appropriate for commercial land use.

Furthermore, the TPH Hazard Index for all the samples tested were significantly below 1, therefore, the additive effect of the hydrocarbon fractions for the samples tested is not considered to represent a significant human health risk.

A copy of the outputs of the TPH Hazard Index are presented in **Appendix 3**.

Polycyclic Aromatic Hydrocarbons (PAHs) Review of the Polycyclic Aromatic Hydrocarbons analysis (PAHs), as summarised on **Table 1**, indicates that the measured concentration of individual PAHs are below the corresponding assessment values appropriate for commercial land use.

Volatile Organic Compounds (VOCs) Review of the Volatile Organic Compounds (VOCs) and semi Volatile Organic Compounds (SVOCs), as summarised on **Table 1**, indicates that the measured concentration of VOCs and SVOCs are below the corresponding assessment values appropriate for commercial land use.

Asbestos Asbestos was not detected in any of the soil samples tested.

Groundwater

The measured concentrations of potential contaminants, as summarised on **Table 2a and 2b**, are in general below the selected assessment criteria for assessing potential groundwater impacts on surface waters and the UK drinking water quality standards.

Metals Review of the metals, as summarised on **Table 2a and 2b**, indicates that the measured concentrations of metals are below the corresponding assessment values appropriate for protection of surface waters and the UK drinking water quality standards. The exceptions included slightly elevated

concentrations of metals comprising copper in 2 locations, lead in 1 location, and nickel in 2 locations, Zinc in 1 location, and sulphate in 2 locations.

The advisory group UK Water Framework Directive TAG has developed a simplified Metal Bioavailability Assessment Tool (M-BAT) for copper, zinc, manganese, nickel and lead in water. The M-BAT tool has been used to determine the bioavailability of certain metals through the use of local water chemistry data, specifically pH, dissolved organic carbon, and Calcium.

The samples contained total metal concentrations that exceed the assessment criteria that triggered further assessment using the M-BAT tool. All the samples with the exception of a single elevated concentration of zinc did not exceed the calculated predicted i.e. predicts no effect concentration (PNEC). Therefore, the total metal exceedances are not considered a significant risk to human health or the environment and are not considered further.

Petroleum Hydrocarbons (TPH) Review of the Petroleum Hydrocarbons banded analysis (TPH), as summarised on **Tables 2a and 2b**, indicates that in general, the measured concentration of petroleum hydrocarbons are below the corresponding assessment values appropriate for groundwater impacts on surface waters and the UK drinking water quality standards. The only exception comprises a slightly elevated concentration of total TPH that was recorded at a single location above the UK drinking water quality standards.

Polycyclic Aromatic Hydrocarbons (PAHs) Review of the Polycyclic Aromatic Hydrocarbons analysis (PAHs), as summarised on **Tables 2a and 2b**, indicates that in general the measured concentration of individual PAHs are below the corresponding assessment values appropriate for surface waters and the UK drinking water quality standards.

The only exceptions comprise a slightly elevated concentration for benzo(b)fluoranthene recorded above the selected assessment criterion for the protection of surface waters in a single location (BH2). In addition, a number of individual Polycyclic Aromatic Hydrocarbons recorded concentrations above the analytical limit of detection, where the limit of detection is above the assessment criteria for the protection of surface waters comprising fluoranthene in 5 locations, benzo(a)pyrene in 1 location, and benzo(g,h,i)perylene in 2 locations. A slightly elevated concentration of benzo(a)pyrene was recorded at a single location above the UK drinking water quality standard. In addition, all the groundwater samples tested recorded marginally elevated concentrations of total PAHs above the assessment criterion for UK drinking water quality standards.

The groundwater samples tested indicate that the groundwater quality is fair, albeit with slight exceedances for the screening criteria for several PAHs, total TPH, and metal compounds. When comparing the concentrations of up and down gradient wells there is no obvious trend of the water quality tested. The precise reason for the slight exceedances is unknown, however, considering the urban environment in which the site lies and the former gas works situated in the near vicinity of the Site up gradient for groundwater flow and previous industrialised nature of the Site and surrounding area, this is not unexpected.

Surface Water

The measured concentrations of potential contaminants, as summarised on **Table 2a and 2b**, are in general below the assessment criteria for fresh water or the UK drinking water quality standards.

Metals Review of the metals, as summarised on **Table 2a and 2b**, indicates that the measured concentrations of metals are below the corresponding assessment values. The exceptions included slightly elevated concentrations of chromium trivalent and copper in all the locations tested.

Polycyclic Aromatic Hydrocarbons (PAHs) Review of the Polycyclic Aromatic Hydrocarbons analysis (PAHs), as summarised on **Tables 2a and 2b**, indicates that in general the measured concentration of individual PAHs are below the corresponding assessment values with the exception of slightly elevated fluorene concentration in a single location tested.

The surface water samples tested up and downstream from the site record concentrations below the analytical limit of detection and the assessment criteria indicating that there is no significant impact in the adjacent rivers. Therefore, the exceedances in the groundwater do not appear to have a significant impact on the adjacent rivers.

Further discussion on the hazard potential of the PAH and metal concentrations within the groundwater is presented in Section 6.

5.4 Off Site Disposal

5.4.1 Total Concentrations

An initial classification for disposal purposes was carried out using a web-hosted software programme, Hazwasteonline™. The programme uses total concentrations of various contaminants to characterise the waste classification for the samples tested. The software follows the latest Environment Agency guidance and European regulations. The software is maintained, updated and operated by One Touch Data Ltd and classifies the waste in accordance with EA Technical Guidance WM3 (EA, 2015).

The results of the waste classification assessment indicate that the majority of samples tested are likely to be classified as Non-Hazardous waste under List of Waste Codes and should be described using EWC Code 17 05 04 (soils including excavated soil from contaminated sites).

Three samples (BH1 @ 0.8m, BH3 @ 2.2m and TP1 @ 0.5m) have been classified as Potentially Hazardous (HP3(i) Flammable) due to toluene and TPH(C6-C40) concentrations above the assessment criteria for Non-Hazardous Waste.

One sample (TP4 @ 1.0m) was classified as Hazardous (HP7 Carcinogenic) due to the elevated concentration of zinc and the potential for zinc chromate to be present. In accordance with the Classification, Labelling and Packaging (CLP) Zinc chromate is the worst case species for zinc and is the default compound used for the Hazwaste online assessment. Zinc chromate is generally associated with paint works; being used for coatings and pigments. The site has no recorded history as a paint works or similar land use, nor has there been any record in the nearby surrounding area. The site has historically been occupied by railway sidings and ashy Made Ground material has been recorded in the shallow soils. As such, it was considered appropriate to amend the zinc determinand to zinc sulphate, which is the next worst case CLP and is generally associated with mining, fly ash and other smelter wastes. Following this change to the determinand, the sample for TP4 at 1.0 m depth was re-run through the classification tool and is considered to be representative of Non-Hazardous waste.

A copy of the outputs of the Hazwasteonline™ classification is presented in **Appendix 4**.

5.4.2 Waste Acceptance Criteria (WAC)

The results of the analyses to determine the waste acceptance classification of recovered samples of the soils encountered are presented in the factual report of the ground investigation (ED, 2017). In general, the concentrations of the determinants tested are typically below the limiting values for classification as inert waste outlined within the waste acceptance procedures (Defra, 2005). The exceptions comprise elevated concentrations of molybdenum, total sulphate, organic content (loss of ignition method) and total dissolved solids in one or two of the four samples tested above the limiting value for classification as inert waste. In addition, elevated concentrations of total organic carbon and organic content (loss of ignition method) above the limiting value for classification as stable non-reactive waste in three and one of the four samples tested, respectively.

Classification of the materials for disposal off site will depend on the acceptability of the elevated concentrations to the EA regional office that regulates the landfill where the material is to be disposed. However, considering the results of the waste acceptance classification analysis and the nature and variability of the material, an allowance should be made for the disposal of any Made Ground arising to an off-site facility as non-hazardous or hazardous waste, principally owing to the presence of elevated concentrations of organic carbon and organic content. Similarly, the Alluvium might be classified as stable non-reactive hazardous waste or hazardous waste owing to its high organic content.

It is expected that the River Terrace Deposits and Chalk will be classified as inert waste.

Additional testing of the materials will be required to confirm the actual classification of any material for off-site disposal.

It should be noted that there are a number of techniques for the treatment of soils with high organic content in order to reduce disposal costs associated with the disposal of the materials as Hazardous Waste. The cost effectiveness of treatment of soils will depend principally on the nature of the soil, the organic content concentrations and the volume of soils required to be treated and disposed off-site. Additional advice and costing can be sought from a soil disposal and treatment specialist.

5.5 Ground Gases

The concentrations and flow of ground gases have been measured in the monitoring wells installed in the boreholes sunk as part of the ground investigation and are summarised in the following table.

Table 5.1 Summary of Gas Concentrations and Flow

Gas	Concentration / flow
Methane, %v/v	0.2 – 0.3
Carbon Dioxide, %v/v	0.7 – 6.5
Oxygen, %v/v	12.3 – 20.8
Gas Flow, l/hr	ND – 0.1
Note ND denotes None Detected	

The measured concentrations of ground gases indicate slightly elevated concentrations of carbon dioxide and methane and corresponding depleted oxygen concentrations.

Using the procedure for classifying gassing sites proposed by BS 8485 (2015), the site would be classified as Characteristic Situation 2 assuming the measured concentrations of ground gases are representative of the long term equilibrium values. This Situation is representative of ground with a low risk associated with natural soil, high peat/organic content or a “Typical” Made Ground. The source of the elevated carbon dioxide and methane concentrations is likely to be related to the Made Ground and/or the Alluvium present on Site.

The proposed Scheme does not include habited structures. However, in line with current regulations and best practice, appropriate ventilation will need to be provided to all confined spaces during construction and appropriate procedures should be adopted to ensure they are checked for hazardous gases prior to man-entry to ensure any potential risk associated with ground gases does not occur. Any enclosed spaces provided as part of the permanent works such as manholes etc, will require similarly suitable health and safety procedures before man entry.

6 Tier 2 Environmental Risk Assessment

6.1 Introduction

To assess the potential risk from the proposed Scheme in relation to the quality of the ground and groundwaters, a qualitative risk assessment has been carried out utilising a Conceptual Site Model and 'source-pathway-receptor' to identify significant pollutant linkages. The assessment has been carried out by considering both historical information and the findings of the ground investigation including a review of site specific data against applicable screening criteria.

The hazard identification and Conceptual Site Model (CSM) has been updated from that presented in Tier 1 Preliminary Risk Assessment presented in the Phase 1 report (PBA, 2017), with a Tier 2 Generic Risk Assessment presented in this Section in accordance with the Contaminated Land Report CLR11 (EA, 2004).

For the purposes of this study the potential for a significant source, pathway or receptor being present have been assessed in terms of their probability and magnitude as being very low, low, moderate, high or very high. The geoenvironmental risk is determined by the interrelationship between the potential for a source of contamination to be present, the potential for migration along a given pathway, and the significance of potential receptors for any plausible source-pathway-receptor linkage. This approach allows the probability and magnitude of the possible consequences that may arise as a result of a hazard to be assessed and possible unacceptable risks to be identified.

The methodology developed and adopted by PBA for the assessment of risks and hazards associated with existing contamination in the ground is presented in **Appendix 5** of this report.

6.2 Hazard Identification

The western part of the Scheme had an industrial history with a number of industrial uses. Based on the ground investigation the following potential hazards have been considered to be taken forward to the risk assessment.

6.2.1 Human Health Hazards

The ground investigation identified that concentrations of potential contaminants in the soils across the Site are below the assessment criteria for a commercial land use. On this basis, the soils on site are not considered to be represent a significant hazard for human health at the site.

The one exception to above statement is the presence of mercury above the assessment criterion for commercial use. The mercury was identified to be an outlier and therefore is not considered to be representative of the Made Ground on site. As such, the hazard associated with mercury in the Made Ground has not been taken forward for future site users.

6.2.2 Controlled Waters Hazards

The results of the groundwater analysis undertaken show that the majority of the measured concentrations of potential groundwater contaminants are below the adopted screening criteria. Hydrocarbons (TPH) were not recorded in any of the positions investigated with the exception of a single location and a marginally elevated total TPH concentration.

The concentrations of metals were similarly low albeit with exceedances for copper, lead, nickel, zinc and sulphate. The majority of these metals did not exceed the calculated predicted no effect concentration and therefore were not considered further as a potential hazard to groundwater.

With regard to Polycyclic Aromatic Hydrocarbons (PAHs), a number of groundwater samples recorded slightly elevated concentrations of PAHs. The groundwater samples tested indicate that the groundwater quality is fair, albeit with slight exceedances for the screening criteria for several PAHs and metal compounds. When comparing the concentrations of up and down gradient wells there is no obvious trend of the water quality tested. The precise reasons for the slight exceedances are unknown,

however, it is highly likely that the elevated PAHs are associated with the former gas works which lies just a short distance up the groundwater gradient from the site and this would not be unexpected.

The surface water samples tested up and downstream from the site record concentrations below the analytical limit of detection and the assessment criteria indicating that there is no significant impact in the adjacent rivers. Therefore, the exceedances in the groundwater do not appear to have a significant impact on the adjacent rivers.

In consideration of the findings of the ground investigation it is considered that the minor exceedances that have been identified in the groundwater have been interpreted to reflect a regional baseline of slightly impaired groundwater quality and do not pose a significant hazard to controlled waters in the vicinity of the Site.

6.3 Pathways

Potential environmental hazards need a pathway connecting the source (if present) to potential receptors in order to be able to impact upon the receptors. These pathways are capable of conveying the contaminants. Pathways may be anthropogenic (artificial) or natural.

Anthropogenic pathways are artificial routes capable of conveying contaminants and include such routes as surface water drains, high permeability backfill materials, poorly consolidated Made Ground, foundations, and persons disturbing contamination sources in such a way as to liberate contaminants.

In the case of persons working with contaminated ground (e.g. to lay foundations or install services) direct contact with the source becomes possible, and pathways such as dermal contact, inhalation or ingestion require consideration.

The proposed development in western part of the Scheme consists of the construction of a new road, car parking and paved footpaths with restricted access elsewhere so the potential pathways to future site users would also be generally limited to the migration of soil gas and vapours.

The site is expected to be underlain by a layer of Alluvium. Downward and lateral migration of contaminants within the Alluvium is likely to be somewhat limited owing to the presence of a mantle of relatively low permeability cohesive Alluvium in the near surface soils. However, it is expected that the installation of piled foundations as part of the proposed development is likely to form a potential pathway for groundwater migration. Therefore, the impacts on the Alluvium, River Terrace Deposits and Chalk Aquifers should be taken into account.

The groundwater flow direction in the Superficial Deposits was found to be flowing in general direction to the north-east towards the River Thames and Kennet. The Alluvium, River Terrace Deposits and the White Chalk are considered to be in hydraulic continuity. Therefore, groundwater flow is a potential pathway for migration of potential contaminants to the adjacent rivers.

6.4 Receptor Identification

The proposed development is for a road and a bridge transport link with pedestrian use. Access in the western part of the Site will be restricted.

The Chalk and River Terrace Deposits Aquifers are considered to be sensitive receptor. Similarly, the adjacent River Thames and the River Kennet are considered to be highly sensitive controlled water receptors.

Details of the potential receptors considered and whether or not the receptor is plausible are summarised in the table presented below.

Table 6.1 - Potential Receptors

Receptor Type	Potential Receptor? (Y/N) / Sensitivity Value	Comment
Human Health Current	Y / 5	Open space
Human Health Future	Y / 5	Pedestrians
Neighbouring Human Health	Y / 5	commercial/light industrial
Construction Workers	Y / 4	Full development with excavations
Surface Waters	Y / 5	The River Kennet and the River Thames
Groundwater	Y / 3	Superficial Deposits (Shallow) - Secondary Aquifer
	Y / 5	Chalk Aquifer (Deep) - Principal Aquifer
Property (Buildings/Materials)	Y / 2	Proposed river bridge crossing
Property (Animals / Crop)	N	Crops/produce or domestic animals/livestock are not present on or immediately adjacent to the site.
Ecological Systems	Y/2	A Local Wildlife Site known as "The Coal, Kennetmouth and Kings Meadow East".

Note: The Sensitivity Value is based on Table 2 of the PBA Methodology given in Appendix 5.

Table 2 in the PBA methodology describes possible pathways for each receptor type. Each of these possible pathways is then considered when assessing the possible pollutant linkage (see below).

Potential pollutant linkages have been identified using the information on potential sources (contaminant types), receptors and exposure pathways. **Table 1** in **Appendix 6** identifies which pollutant linkages are considered to potentially exist.

6.5 Risk Estimation

Further to the findings of the ground investigation, the Conceptual Site Model has been revised. The hazard potential for the western part of the Scheme for significant site wide contamination to be present at the site has been reduced from **Moderate** to **Low**. A Low hazard potential is assigned to sites with locally or slightly elevated concentrations of contaminants.

The risk estimation in the Phase 1 Report (PBA, 2017) has been updated using the recent data available for the Site. The risk estimation involves predicting the likely consequence (what degree of harm might result) and the probability that the consequences will arise (how likely the outcome is). An updated table summarising the estimated risks for the identified pollutant linkages is presented in **Appendix 6**.

Risk estimation involves predicting the likely consequence (what degree of harm might result) and the probability that the consequences will arise (how likely the outcome is). The table in **Appendix 6** summarises the estimated risks for the identified pollutant linkages.

Based on the information available, the estimated risks from the proposed development have been designated with further comments are given in the sections below:

- **Human Health** (Future use as Commercial) – **Low**
- **Human Health Off-Site** (Commercial) – **Low**
- **Human Health** (Construction Workers) – **Moderate** (See Section 6.5.1 below)

- **Groundwater – Low** (Shallow Aquifer) and **Moderate** (Deep Aquifer) (See Section 6.5.2 below)
- **Surface Water – Moderate or Low** (See Section 6.5.2 below)
- **Property (Buildings/Structures) – Low**
- **Ecological Systems – Very Low**

6.5.1 Human Health – Construction Workers

The risk to construction workers relates to the risk of ingestion, inhalation or skin contact of contaminated materials on the Site and inhalation of any potentially hazardous ground gases. Considering the expected variable and locally potentially significant concentrations of potential contaminants within the soils present on the Site, the potential risk to site workers is expected to be **Moderate**.

The provision of appropriate protective clothing and equipment to be worn by site workers together with the adoption of good standards of hygiene to prevent prolonged skin contact, inhalation and ingestion of soils during construction will be required to mitigate the risk to site workers. In addition, the methods of working should be selected to limit disturbance to the existing near-surface soils present on the Site.

Given the adoption of appropriate measures, the risks associated with the potential for skin contact, inhalation and ingestion of the near-surface soils to construction workers involved in earthworks or groundworks is expected to be **Low**.

6.5.2 Controlled Waters

The installation of piled foundations might create a pathway through the Alluvium for migration of potential contaminants from the Made Ground to the Aquifer at depth and subsequently to the adjacent rivers. It is recommended that in order to minimise the potential for groundwater contamination any piles installed as part of the proposed scheme will be designed and installed in accordance with the Environment Agency guidance for piling in potentially contaminated sites (EA, 2001 and 2002).

Given the adoption of appropriate measures for the installations of piles for the Scheme, the risks associated with the potential for migration of contamination, if present from the near-surface soils to the aquifer and subsequently to the adjacent rivers is expected to be **Low**.

6.6 Risk Evaluation

Possible pollutant linkages are determined using professional judgement. If a linkage is considered possible, it is considered that this represents a potentially 'unacceptable risk' and therefore requires further consideration. This may be through remediation or mitigation or through further tiers of assessment.

Based on the findings of this investigation it is not considered that further tiers of assessment are required to support the planning application for the Scheme. Furthermore, on the basis of the Tier 2 Risk Assessment, remediation is unlikely to be required. Mitigation measures principally required for the protection of construction workers and for the installation of piles are detailed in **Section 7.0** below.

Further ground investigation will be required as part of the geotechnical design of the Scheme. Any requirement to carry out further site wide geoenvironmental intrusive investigation can be satisfactorily dealt with by incorporation as a condition in any granted Planning Consent and carried out as part of the geotechnical investigation for the Scheme.

7 Outline Remediation and Mitigation Strategy

7.1 Introduction

The geoenvironmental risk assessment presented in **Section 6.0** indicates that any potential contaminants in the ground or groundwater do not by themselves represent an unacceptable risk to human health, controlled waters or ecology and wildlife, associated with the development of the site as currently proposed. Remediation and/or mitigation measures are not required for the scheme with the exception of the risks to site workers associated with ingestion, inhalation or prolonged skin contact of contaminated material during the construction works, and for the installations of piles.

7.2 Protection of Site Workers

Measures to be adopted to mitigate the risk to site workers will include (i) informing the site workers of the potential risk through site induction and 'tool box talks'; (ii) the provision of appropriate protective clothing and equipment to be worn by site workers; and (iii) the adoption of good standards of hygiene to prevent prolonged skin contact, inhalation and ingestion of soils during construction. In addition, in line with current regulations and best practice, appropriate methods of working will be selected to limit disturbance to the contaminated materials and the potential for air-borne dust to arise associated with the excavation and disturbance of the soils present on the site.

7.3 Installation of Piles

It is recommended that in order to minimise the potential for groundwater contamination any piles installed as part of the proposed scheme will be designed and installed in accordance with the Environment Agency guidance for piling in potentially contaminated sites (EA, 2001 and 2002).

7.4 Management of Unidentified Sources of Contamination

There is a possibility that other sources of contamination may be encountered during site clearance or ground works that have not been previously identified. It is recommended that a watching brief will be maintained throughout the excavation works for unsuitable or unexpected condition are encountered. If previously unidentified areas of potential contamination are encountered, they will be dealt with in line with an agreed protocol. Soil will either be sampled in-situ in the ground (and left undisturbed while the samples are tested and the results interpreted) or excavated and stockpiled in an appropriate manner while verification testing for potential contamination is carried out. The storage area will be contained to ensure that contamination does not migrate and affect other areas of the site.

Once the nature, location and extent of the contamination has been identified appropriate mitigation measures should be adopted. Although these cannot be identified at this time, the main emphasis will be on methods of isolating or treating these materials. If such measures are unlikely to be practical or effective in mitigating the risk from the identified contamination, consideration will be given to excavating and removing the contaminated soil from site for disposal at a suitably licensed landfill.

Where remediation of unidentified sources of contamination is required, an implementation and verification process will be established to identify the remediation activities required and to confirm that the remediation has been undertaken correctly. As part of this process, remediation objectives will be identified and remediation criteria selected for measuring compliance against these objectives in consultation with the Local Authority and other statutory consultees.

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This report has been prepared within an agreed timeframe and to an agreed budget that will necessarily apply some constraints on its content and usage. The remarks below are presented to assist the reader in understanding the context of this report and any general limitations or constraints. If there are any specific limitations and constraints they are described in the report text.

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The conclusions and recommendations made in this report and the opinions expressed are based on the information reviewed and/or the ground conditions encountered in exploratory holes and the results of any field or laboratory testing undertaken. There may be ground conditions at the site that have not been disclosed by the information reviewed or by the investigative work undertaken. Such undisclosed conditions cannot be taken into account in any analysis and reporting.

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