

Contaminant Group	PE-threshold (mg/kg)	Concentrations at <u>Current</u> pipeline depth (mg/kg)
Could hydrocarbon impact at greater depth than current pipeline depth be mobilised by rising groundwater levels?	No hydrocarbon impact identified at a greater depth than current pipeline depth.	
Will soils impacted with above determinands likely be utilised elsewhere on site?	Subject to cut/fill proposals.	
Will soils be imported to site as part of any future earth works	Currently unknown. The importation of materials may affect the WIR Risk Assessment which should be updated after completion.	

Notes

Pipe line depth normally between 0.75 m – 1.35 m

Based on the assessment of current site conditions it is likely that barrier pipe will be required for the proposed development.



4.9. CONCEPTUAL SITE MODEL

Following the completion of the intrusive site investigation, chemical analysis and risk assessment, the conceptual model shown in Table 4.8 has been prepared for the site.

TABLE 4.9 CONCEPTUAL MODEL

POLLUTANT LINKAGE	CONTAMINANT (SOURCE)	PATHWAY	RECEPTOR	PROBABILITY	CURRENT RISK	RESIDUAL RISK AFTER MITIGATION
PL1 PL2	Heavy Metals, non-volatile PAH (Made Ground / Former Landfill)	Dermal contact. Dermal contact and ingestion.	Future site users. Off-site receptors.	Likely	High	LOW
Discussion: Heavy metals (arsenic, lead and mercury [potentially volatile]) were identified throughout Made Ground between depths of 0.80 m and 1.20 m bgl. Non-volatile PAHs have been identified throughout Made Ground between depths of 0.20 m and 1.00 m bgl. Recommendation: Cover system to garden and landscaped areas will prevent exposure to future site users. Construction works completed with PPE and provision of welfare.						
PL3	ACM (Made Ground / Former Landfill)	Inhalation of dust.	Future site users. Buildings. Off-site land users.	Likely	High	LOW
Assessment: Asbestos in the form of loose chrysotile/amosite (0.003% wt/wt) and chrysotile fibres (0.002 % wt/wt) have been identified in the Made Ground in TP102 at 0.80 m bgl and TP105 at 1.00 m bgl, respectively. Recommendation: The soils will require placement in accordance with the asbestos CSM. Construction works completed with PPE and provision of welfare.						



POLLUTANT LINKAGE	CONTAMINANT (SOURCE)	PATHWAY	RECEPTOR	PROBABILITY	CURRENT RISK	RESIDUAL RISK AFTER MITIGATION
PL4	Volatile Contaminants such as hydrocarbons (Made Ground/Formal Landfill)	Inhalation of vapours. Migration through permeable strata and preferential pathways.	Future site users. Off-site receptors.	Likely	Moderate	LOW
Assessment: Elevated concentrations of TPH C12-C16 have been identified in the Made Ground in TP102 at 0.80 m bgl. Mercury (potentially elemental / volatile, has also been encountered in TP101 at 1.20 m bgl (requiring speciation to confirm). Recommendation: During a process of cut/fill enabling works, a hotspot removal should be undertaken where these soils may be chemically validated to assess chemical suitability for retention on site in an area of no future sensitivity. Speciation of mercury may determine this to be non-volatile, in which case it would be suitable to remain in-situ beneath a clean cover system. Visual and olfactory evidence of contamination has been identified in a number of locations, therefore a watching brief should be completed during remediation works to monitor the locations where visual or olfactory hydrocarbon impact has been identified during all phases of investigation completed to date.						
PL4	Methane, carbon dioxide (Localised Made Ground, historical landfill to the south and infilled features on and within 250 m of the site)	Inhalation of gas. Migration through permeable strata and preferential pathways. Explosion in confined spaces.	Future site users. Buildings. Off-site land users.	Likely	Moderate	LOW
Assessment: The southern part of the site forms part of a larger historical landfill and deep Made Ground (up to 7.10m bgl in CP102), with degradable inclusions of wood and timber have been encountered. Other degradable organic materials may be present at intervening locations and cannot be discounted.						



POLLUTANT LINKAGE	CONTAMINANT (SOURCE)	PATHWAY	RECEPTOR	PROBABILITY	CURRENT RISK	RESIDUAL RISK AFTER MITIGATION
WS102, WS103, WS104 and WS106, predominantly in the south of the site and area of former landfill, have recorded carbon dioxide above 5% v/v threshold, however the GSV is noted to be within a CS1 classification due to the absence of flow. Recommendation: Given the presence of the recorded historical landfill that encroaches on the south of the site, and the elevated carbon dioxide concentrations recorded, it is recommended that precautionary allowances be made for CS2 gas protection measures. The final classification will be confirmed on completion of the full ground gas monitoring programme to enable an appraisal of the full dataset. The assessment should also include a ternary gas assessment to assess the gas composition.						
PL5	Mobile contaminants such as metals, PAHs, hydrocarbons, volatile compounds (Made Ground / Landfill)	Surface runoff. Migration through permeable strata and preferential pathways. Perched waters migration.	Groundwater (Principal aquifer). Surface water (Moston Brook).	Likely	Moderate	LOW
Assessment: The primary receptor has been identified as the underlying Principal Aquifer (bedrock). No exceedances of DWS values have been found in the two leachate samples analysed. It has not been possible to obtain groundwater samples for a full appraisal due to boreholes either being dry or containing insufficient volumes of water. The drift deposits across the site are variable. Given the presence of lower permeability fine grained soils which will reduce downward migration of contamination and the absence of any exceedances in the leachate, or shallow groundwater to mobilise soil contamination, the overall risk may be considered low. Given the absence of a groundwater abstraction point or surface watercourse within close proximity to the site, there is not considered to be a complete pollutant linkage. Recommendation: Given the nature of the site and presence of deep Made Ground / landfill materials, it would be prudent to obtain water samples for assessment if resting water levels are found to rise over the monitoring period.						
PL6	Sulphate (Made Ground / Former Landfill)	Sulphate attack on concrete.	Building structure.	Likely	Low	LOW



POLLUTANT LINKAGE	CONTAMINANT (SOURCE)	PATHWAY	RECEPTOR	PROBABILITY	CURRENT RISK	RESIDUAL RISK AFTER MITIGATION
Assessment: The soils at the site meet class DS-1, AC-1s.						
Recommendation: Concrete should be designed in accordance with the chemical testing results.						
PL7	Organic contaminants such as hydrocarbons, solvents (Made Ground)	Ingestion of tainted water supply.	Future site users. Water pipes.	Likely	Moderate	LOW
Assessment: Elevated concentrations of TPH have been identified at the proposed pipeline depth (0.75 m – 1.35 m).						
Recommendation: Based on the assessment of current site conditions, it is likely that barrier pipe will be required. This will need to be confirmed with a UKWIR risk assessment post remediation.						
PL8	Phytotoxic contaminants (Made Ground)	Direct Contact (plant uptake).	Flora.	Likely	Low	LOW
Assessment: Generally low concentrations of zinc, nickel and copper have been recorded in the soils at the site. Low risk to flora anticipated.						
Recommendation: Installation of a clean cover system within any areas of soft landscaping to prevent plant uptake of contaminants.						

Notes:

Main exposure pathways: PL1 = soil ingestion, PL2 = dermal contact and ingestion, PL3 = dust inhalation; PL4 = Vapour/Gas Inhalation; PL5 = Vertical / Lateral Migration; PL6 = Corrosion of concrete; PL7=Tainting of water supply; PL8 = Uptake by plants;



5. GEOTECHNICAL ASSESSMENT

5.1. SITE PREPARATION

The site should be cleared and any vegetation below areas of proposed development stripped in accordance with Series 200 of the *Manual of Contract Documents for Highway Works (MCHW)*. This should include the following:

- ✦ Roots present below the footprint of proposed structures and infrastructure should be grubbed out and the resulting void infilled with suitable compacted engineered fill.
- ✦ Redundant services should be sealed off and grubbed out and replaced with suitable compacted engineered fill.
- ✦ Buried structures and old foundations have been encountered on-site in areas of former structures. Relict slabs/cobble obstructions have also been observed in the landfill material in the southern sector. These should be excavated from below the proposed development footprint with the resulting void backfilled.
- ✦ The highwall of the former landfill will need to be accurately located and extent delineated. Foundations straddling the highwall will require an engineered foundation solution to tolerate potential differential settlement (raft foundation likely required).

5.2. FOUNDATION ASSESSMENT

In due consideration of the identified ground conditions, in-situ and laboratory geotechnical testing, E3P has undertaken an assessment of the net safe allowable bearing pressure (ABP) within the underlying natural stratum to assist in the detailed design of foundations and infrastructure and determine the target founding stratum. The results of this assessment are summarised in Table 5.1.



TABLE 5.1 SUMMARY OF ESTIMATED ABP

GRANULAR SOILS			
Description	Depth (Range m bgl)	Relative Density	Allowable Bearing Pressure (kN/m ²)
Silty SAND with clay bands	8.00-9.95	Medium Dense	129
Sandy GRAVEL	12.00-12.45	Dense	372
COHESIVE SOILS			
Description	Depth (range m bgl)	Undrained Shear Strength (Cu) (kN/m ²)	Allowable Bearing Pressure (kN/m ²)
Soft-Firm SILT	2.00–5.45	22-50	43-100
Firm-Stiff Sandy SILT	3.00–5.45	39-75	80-150
Firm-Stiff Sandy CLAY	2.00–5.45	32-54	66-111
Very Stiff Sandy CLAY	6.50–11.45	193-204	398-420

Based on the above, assessment of the relative undrained shear strength, relative in-situ densities and corresponding safe net allowable bearing pressure, the suitable target founding stratum has been identified as the underlying firm to stiff CLAY or medium dense-dense silty SAND if encountered at founding depth.

Based on existing levels, the depth to suitable founding strata is generally greater than 2.50 m below existing ground level due to the presence of deep Made Ground and unsuitable soft low strength shallow SILT deposits.

However, prior to the detailed design of suitable foundations solutions, a programme of remediation and enabling works will be required to remove the extensive buried obstructions and cut/fill the site to provide suitable development platform levels. Enabling works will also be required to delineate the highwall of the landfill in the southern sector.

At this time it is not possible to accurately define the foundation types due to the absence of a detailed tree survey and final development levels; however, given the ground conditions encountered and considering future potential cut/fill works to create a development platform, foundation options may include:

- ✿ Piled foundations in areas of tree influence where cohesive soils are present and in area of former landfill in the southern sector where fill extends to depths >7.0 m bgl.
- ✿ Ground improvement using VSC in areas of deep Made Ground outside of tree influence or landfill area.
- ✿ Raft foundations for plots straddling the landfill highwall to mitigate risks of potential differential settlement.
- ✿ In the centre of the northern sector, it may be possible to utilise deep mass trench foundations, where firm CLAY is present at depths shallower than 2.50 m bffl, outside of tree influence.

To determine if VSC is viable at the subject site, E3P has completed a Ground Improvement Design Risk Matrix that is summarised in Table 5.2.



TABLE 5.2 GROUND IMPROVEMENT DESIGN RISK MATRIX

RISK ITEM	COMMENT	PASS/FAIL
Soft clays with an undrained shear strength less than 30 kN/m ²	The limited CLAY soils identified were generally firm to stiff with a Cu > 50 kN. Soft/low strength CLAY was identified in one location with a Cu of 32 kN.	PASS
Ground with peat layers close to foundation level or the base of the stone column, or where intermediate layers of peat are thicker than 200 mm, either as a single layer or the sum of the thicknesses of individual layers throughout the length of the stone column	No peat deposits have been identified.	PASS
Voided filled ground, e.g. old water tanks, pottery, glass bottles, concrete rubble or brick fill of unsuitable grading	A former landfill is present in the southern sector of the site, containing inert industrial waste, obstructions and potential voids. Made Ground would require processing/re-engineering to render the site suitable for VSC. Affected plots will likely be subject to a piled foundation solution.	SIGNIFICANT RE-ENGINEERING OF MADE GROUND REQUIRED.
Loose or non-engineered fill not previously subject to rising or fluctuating water levels saturation	Limited groundwater encountered on site. Loose fill has unlikely been subject to rising or fluctuating water levels.	SIGNIFICANT RE-ENGINEERING OF MADE GROUND REQUIRED.
Filled ground still settling or expected to settle under its own weight or due to the effects of surcharging/upfilling where there is a high organic content or where decay is continuing.	A former landfill is present in the southern sector of the site, containing inert industrial waste including wood and timber and other potential degradable inclusions. Made Ground would require processing/re-engineering to render the site suitable for VSC. Affected plots will likely be subject to a piled foundation solution.	SIGNIFICANT RE-ENGINEERING OF MADE GROUND REQUIRED.
Fill, containing degradable material where organic material forms more than 15% of fill by volume	Potential to be present in former landfill in southern sector of site.	TBC
Clays with a plasticity index greater than 40%	None identified.	PASS
Highly sensitive soils liable to collapse or remoulding	None identified.	PASS



RISK ITEM	COMMENT	PASS/FAIL
Cohesive soils with trees in influencing distance	An area of woodland is present in the centre of the site, occupying approximately 35-40% of the total site area. Plots within tree influence will either be subject to a piled or mass trench-fill solution.	PASS
Overall Risk Rating and Suitability for Vibratory Ground Improvement		FURTHER ASSESSMENT REQUIRED ON RECEIPT OF PROPOSED FINISHED LEVELS

Foundation depths should take account of the presence of existing and proposed trees, with foundations deepened locally to mitigate the potential for volumetric instability attributed to fluctuations in moisture content, in accordance with the requirements of NHBC standards.

It is recommended that at working drawing stage a foundation schedule is prepared for the development, taking account of the physical change of natural clay soils and the current/proposed locations of trees.

5.3. GROUND FLOOR SLABS

Current building control regulations require that where infilled ground is present to depths in excess of 600 mm, or where the substratum is variable in terms of the structure and settlement potential, or where clay soils are present within the influence of existing or proposed trees, a suspended floor slab is required.

In this instance, it is considered that for the majority of substructures, the underlying stratum would have in excess of 600 mm of infill and, as such, a suspended floor slab will be required.

Where a cast in-situ suspended slab is utilised with no subfloor void, appropriate compressible material (heave precautions) will be required in the construction of the substructure.

5.4. HEAVE PRECAUTIONS

The site has been proven to be underlain by clay soils, which are susceptible to volumetric instability due to fluctuations in moisture content, particularly within influencing distance of trees as per the NHBC/LABC conjectured zones of influence.

As the clay is deemed to be low plasticity, heave precautions are not required to the internal face of the external load-bearing walls (outside or within tree influence).

If a ground beam is to be constructed within the zone of tree influence, heave precautions are required to the underside of this and edge beams.

If the ground floor slab is to be constructed with a beam and block floor, a minimum subfloor void of 200 mm is required within any structures located in the zone of conjectured tree influence.

If the ground floor slab is constructed with a cast in-situ suspended floor slab, then heave precautions that can tolerate 50 mm of clay swelling are required within any part of the floor slab to be located within the zone of influence of a tree.



A summary of heave precautions is presented in Table 5.3.

TABLE 5.3 SUMMARY OF HEAVE PRECAUTIONS

		MINIMUM VOID DIMENSION FOR FOUNDATIONS, GROUND BEAMS AND SUSPENDED IN-SITU CONCRETE GROUND FLOORS		MINIMUM VOID DIMENSIONS UNDER PRECAST CONCRETE AND SUSPENDED TIMBER FLOORS
Plasticity Index of Soil	Required Foundation Depth (m)	Thickness of Void Former Against Side of Foundation or Ground Beam (mm)	Thickness of Void Former on Underside of Edge Beam and Floor Slab (mm)	Void Dimension (mm)
High Plasticity (> 40)	> 2.5	Engineer Design		Engineer Design
	2.0–2.5	35	150	300
	1.5–2.0	25	75	
Moderate Plasticity (20–40)	> 2.5	Engineer Design		Engineer Design
	2.0–2.5	25	100	250
	1.5–2.0	25	50	
Low Plasticity (< 20)	2.0–2.5	N/A	50	200
	> 2.0	No Special Precautions		

5.5. HIGHWAYS CONSTRUCTION

A programme of remediation and enabling works will be required to remediate the proposed road subgrade in accordance with the requirements of the Manual of Contract Documents for Highway Works Volume 1 Specification For Highway Works (Series 600-Earthworks) for a method compaction.

It is considered that the material can be re-engineered using method compaction to achieve a CBR in excess of 5% if works are completed in favourable climatic conditions.

5.6. DRAINAGE

The presence of substantial depths of Made Ground across some areas of the site may result in settlement. It is therefore recommended that drain runs are designed using steeper gradients and flexible joints to allow for some differential settlement.

As the lateral continuity of the Made Ground cannot be assured, it is not recommended that soakaways are utilised for disposal of surface water runoff.

If soakaway drainage is to be considered, full BRE 365 testing must be completed to inform the detailed design.

