PHASE II GEO-ENVIRONMENTAL SITE ASSESSMENT

Plot 2
Potato Wharf
Castlefield
Manchester
M3 4NB

Prepared for:

Shepherd Gilmour
Consulting Engineers

Report Ref: 10-609-r3
Date Issued: April 2016



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Executive Summary		
Site Address	Potato Wharf, Castlefield, Manchester M3 4NB	
Grid Reference	E 382860, N 397580	
Site Area	1.06 Ha	
Current Site Use	The subject site is a triangular shaped parcel of land located to the west of Manchester City Centre. The site is currently un-used and was previously occupied by a Hanson Concrete Works that utilised the majority of the central and western sectors of the subject site. The eastern sector of the site was occupied by a building a yard associated with HJ Hanson Ltd with signage indicating that this sold or hired steel and plastic containers.	
Proposed Development	It is understood SGI Ltd are acting as civil and structural engineers for a residential development comprising the construction of two multi-storey apartment blocks with associated access road, external car parking, landscaped areas and adopted utility infrastructure.	
Previous Reports	E3P were provided with a Preliminary Geo-environmental Desk Study and Ground Investigation (Ref: N1903 DH ME947) dated January 2007 which should be read in conjunction with this report. E3P subsequently completed a Phase I Geo-Environmental Site Assessment (Ref: 10-609-r2) dated June 2015; The pertinent points of which are herein.	
Environmental Setting	*Drift Geology*	None Recorded
	Bedrock Geology	Cheshire Pebble Beds (Sandstone)
	Hydrogeology	Unproductive Strata (drift deposits) overlying Principal Aquifer (solid geology).
	Groundwater Source Protection	Not within a Groundwater Source Protection Zone or Drinking Water Safeguard Zone.
	Hydrology	River Medlock (adjacent to NW boundary) and Bridgewater Canal (adjacent to southern boundary).
	Flood Risk	The site is potentially affected by flooding from rivers (Flood Zone 2).
	Ecology	No identified risk to ecological or aquatic ecosystems. The ecological status of the River Medlock is deemed to be Poor.
	Sensitive Land Uses	Residential Apartments (<50m east).
	Industrial Land Use	No current industrial land use identified.
	Ground Instability / Subsidence Hazards	No hazard identified within data searches.
Site History	Historical OS maps for the area indicate a canal basin occupied the eastern portion of the site which was later in-filled and utilised as a depot (pre 1980). During this time the central and western portions of the site were marked as a concrete works constructed in the mid-late 1970s and operated by Hanson.	
Utility Locations	A formal utilities survey has not been completed, however a review of online records indicates service infrastructure is present in the surrounding area.	

Executive Summary	
Landfill Sites & Ground Gases	No recorded landfill sites (current or historic) are located within influencing distance of the proposed development. Made Ground associated with historic construction and demolition activities is the only plausible source of low-level hazardous ground gas.
Radon	Unaffected – No special precautions required.
Coal Mining / Land Stability	The site is not located within an area deemed to be at risk from ground instability arising from historic shallow coal mining activities.
Ground Conditions	E3P completed an intrusive GI comprising and the ground conditions are summarised below: **Made Ground** Made Ground was encountered in all exploratory hole locations from ground level (GL) to a maximum proven depth of >5.45m bgl. (WS117) with the site predominantly covered by concrete hardstanding (up to 1000m in thick) and cobbles associated with a historic road leading from Potato Wharf traversing the northern profile. Made Ground deposits underlying the surface course generally comprise a slightly clayey sandy gravel / gravelly sand of fine to coarse angular to sub-rounded brick, limestone, concrete, ash and clinker with occasional cobbles of sandstone. A number of discontinuous re-worked sandy and/or silty clay strata were recorded between depths of 1.00-3.80m bgl. **Drift** Drift deposits were encountered in all locations where Made Ground was penetrated to a maximum proven depth of 7.45m bgl (WS116) and comprised a loose dense gravelly SAND and/or sandy GRAVEL interbedded with bands of soft to stiff low to very high strength sandy CLAY strata. The granular soils at depth in excess of 2.85m bgl were noted as fluvial deposits (river gravel) which were immediately underlain by bedrock. **Solid** A red weathered SANDSTONE was encountered at depth of between 5.20-5.80m bgl to a proven cored depth of 14.20m (CP101). **Groundwater** A number groundwater strike were encountered between 0.90-3.00m bgl across the central and eastern sector of the site, in proximity to the former canal basin. Subsequent water monitoring has identified groundwater at depth of between 1.50-3.00m bgl across the wider site.
Contaminated Land Risk Assessment – Residential End Use	
Human Health	The Tier I Human Health risk assessment has identified the presence of heavy metals, PAHs, asbestos and localised naphthalene within the sub-surface across the site. The naphthalene / volatile range TPH hotspot (WS116) is located within an area of proposed landscaping and as such, E3P do not consider the impacted soils to pose an unacceptable degree of risk to human health via volatilisation to indoor air.

Executive Summary	
	Asbestos in the form of chrysotile /amosite loose fibres have been identified within the Made Ground deposits at the site. As such, it will be necessary to design a phase of remediation and enabling works where methodologies are agreed to carefully manage these impacted soils and place them in a legislatively complaint manner that will negate any possibility of future exposure. External areas will be covered by hard-standing or a chemically suitable cover system within any external landscaped areas thereby removing the exposure pathway heavy metals and PAHs to future site users. In the event that any previously unidentified potential contaminants of concern are identified an appropriately qualified consultant should be contacted at the first available opportunity to ensure any issue is dealt with in the appropriate manner.
Controlled Waters	Given the absence of any potentially soluble / mobile contaminants of concern within the soil or current sources of potential pollutants and absence of a viable exposure pathway, it is concluded there is unlikely to be any unacceptable degree of risk to the identified controlled water receptors and the wider environ.
Ground Gas	Ground gas monitoring thus far (ongoing) has indicated the site would be classed as Characteristic Situation 1 in accordance with CIRIA 665 which states that ground gas protection measures are not required. However, the final ground gas regime will be confirmed following the completion of the ground gas monitoring programme.
Potable Water Infrastructure	A full UKWIR will be required upon completion of the proposed Remediation and Enabling works.
Geotechnical Assessment	
Underground Obstructions	A number of buried obstructions and relict foundations have been encountered which will need grubbing out in their entirety as part of the proposed residential development.
Allowable Bearing Potential (ABP)	The underlying Sherwood sandstone has been assessed as having an ABP in excess of 400kN/m^2 at depths of >6.00m bgl.
Foundation Options	In consideration of the proposed development the Made Ground and underlying natural glacial soils are not considered a suitable target founding stratum due to their inherent variability and anticipated structural loading. E3P consider it feasible to construct the proposed residential apartment blocks using piled foundations bearing within the underlying bedrock The final foundation solution will be dependent on the structural loadings, elevation and should be designed by the structural engineer with detailed designs from a specialist piling contractor.
Soakaway Drainage	The underlying natural strata are likely to offer very good effective permeability, however due to the visual and olfactory evidence of hydrocarbon impact at the site, the use of soakaway drainage systems are not considered viable in this instance.
Sulphate Assessment	Localised areas of Made Ground currently pose a risk to buried concrete. However upon completion of the proposed remediation and enabling works the soils are likely to meet Concrete classification DS1 AC1s.

Executive Summary	
CBR Design %	It is considered that the shallow Made Ground soils can be re-engineered in accordance with Class 1 (a-c) or 6 material under favourable climatic conditions to achieve a CBR of 3-5%. However, it is imperative that the sub-formation be protected to prevent deterioration.
Cut / Fill	It is assumed that site levels will remain close to present for the proposed residential development, however a programme of cut / fill works may be required for the removal of buried obstructions such as the canal basin.
Waste Classification	Predominantly Stable Non -Reactive (Non Hazardous / Inert); and Volatile phase contaminants in soils may be considered Hazardous.
Recommendations	Based on the Ground Investigation, E3P recommend the following: - Detailed Remediation & Enabling Works Strategy; - Foundations to be designed by suitably qualified Structural Engineer; - Geo-technical Earthworks Compaction Specification for the engineering of the sub-grade to support any associated slab and/or infrastructure; and - A Materials Management Plan should be completed on receipt of the proposed FFLs.

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1. INTRODUCTION

1.1 Background

E3P Ltd have been commissioned by Shepherd Gilmour (SGI) on behalf of their client to undertake a Phase II Geo-Environmental Ground Investigation on a parcel of land located off Potato Wharf, Manchester; herein referred to as ***the site***.

E3P has previously completed a desk based Phase I Geo-Environmental Site Assessment (Ref: 10-609-r2) dated June 2015 and summarised herein.

The scope of work consisted of the following key elements:

- *Detailed UXO Threat Assessment and on-site Exploratory Location UXO Clearance;*
- *6 No. Cable Percussive Boreholes with follow-on Rotary Coring;*
- *18 No. Window Sample Probeholes & 9 No. completed as environmental monitoring wells;*
- *In-situ Geotechnical Testing & Chemical Laboratory Analysis;*
- *Groundwater Sampling & Ground Gas Monitoring;*
- *Contamination Risk Assessment & Conceptual Site Model;*
- *Geotechnical Assessment & Interpretation; and,*
- *Factual and Interpretive Reporting.*

1.2 Proposed Development

E3P understands that SGI Ltd are acting as structural engineers for a residential development comprising the construction of two multi-storey apartment blocks with associated access road, external car parking, landscaping and adopted utility infrastructure as detailed in excerpt Figure 1.1 (below):

Figure 1.1 – Proposed Development Scheme



1.3 Objectives

The objectives of the Geo-Environmental Investigation are to:

- Undertake a desk study review of the subject site and previous reports to determine the site sensitivity and potential sources of historical / current contamination or surrounding constraints;
- Undertake a preliminary stage of sampling and analysis to provide an overview of environmental issues identified;
- Assess the implications of any potential environmental risks, liabilities and development constraints associated with the site in relation to the future use of the site and in relation to off-site receptors;
- Assess the geotechnical information and provide preliminary recommendations in relation to foundations, pavement construction and floor slabs; and,
- Provide recommendations regarding future works required.

1.4 Limitations

The limitations of this report are presented in Appendix I.

1.5 Confidentiality

E3P has prepared this report solely for the use of the Client and those parties with whom a warranty agreement has been executed, or with whom an assignment has been agreed. Should any third party wish to use or rely upon the contents of the report, written approval must be sought from E3P; a charge may be levied against such approval.

1.6 Previous Reports

E3P were provided with a Preliminary Geo-environmental Desk Study and Ground Investigation (Ref: N1903 DH ME947) dated January 2007 which should be read in conjunction with this report. The pertinent points of which are summarised below:

- The study site was historically occupied by a canal basin, scrap yard, Hanson concrete works and depot;
- The presence of relict obstructions underlying the site is therefore considered likely;
- The site is not affected by coal mining activity or any ground instability issues;
- Potentially contaminative land uses / activities have been identified at the subject site which may pose a risk to human health, controlled waters of the wider environ;
- Hydrocarbon impact to shallow soils and potential impact to groundwater was identified;
- Substantial Made Ground may present a low-level source of hazardous ground gas; and
- It is anticipated that, dependent on ground conditions and likely required loadings, the optimal foundation solution will be driven piled foundations.

E3P subsequently completed a Phase I Geo-Environmental Site Assessment (Ref: 10-609r2) dated June 2015 which should also be read in conjunction with this report.

2. E3P INTRUSIVE GROUND INVESTIGATION

2.1 Site Details

Site Address	Potato Wharf, Castlefield, Manchester M3 4NB
National Grid Reference	E 382860, N 397580
Site Area	1.06 Ha

All acronyms used within this report are defined in the Glossary presented in Appendix II.

A site location map is presented in Appendix III as Drawing 10-609-001.

2.2 Current Site Use

SITE DESCRIPTION	
Occupancy/use	The subject site is a triangular shaped parcel of land located to the west of Manchester City Centre. The site is currently un-used through was previously occupied by a Hanson Concrete Works that occupied the majority central and western sectors of the subject site. The eastern sector of the site was occupied by a building a yard associated with HJ Hambley Ltd with signage indicating that this sold or hired steel and plastic containers.
Structures	The plant and areas of hardstanding associated with the concrete works are still present at the site. A site map indicates that in addition to office and administrations areas, the site also comprised: ▪ Technical Labs ▪ Hoppers ▪ Portland Cement Regeneration facilities ▪ Concrete and aggregate storage facilities ▪ Water recycling, ▪ Truck wash ▪ Water catchment pit ▪ Waste tank ▪ External and ground water storage ▪ Electrical substation The hardstanding between the plant items was observed to be in a variable condition with areas of standing water noted in areas, perhaps in the vicinity of the below ground water storage facilities and former canal basin. Aggregate storage appeared to be located between the arches of the adjacent railway viaduct. Some small stockpiles were still present. The HJ Hambley Ltd yard area did not contain any plant and was observed to be surfaced with cobbles.
Access	Access to the site via Potato Wharf which forms the northern and western site boundary.
Slope	The site is generally level but a slope is present to the north where it falls to the River Medlock. An in-filled basin forms a slight depression in the eastern portion.
Retaining structures	A retaining structures along the southern bank of the River Medlock was noted during the site walkover.

Surface Cover (%)	*Buildings:*	10
	Hardstand:	90
	Soft cover:	Nil
Vegetation/Ecology	Areas of self-seeding vegetation are present throughout the subject site with denser vegetation along the boundary with the River Medlock.	
Hazardous Material Storage	No obvious above or below ground chemical storage was noted at the time of the site inspection.	
Asbestos Containing Material (ACM)	No obvious ACM was noted at the subject site. Given the age of the HJ Hambley building the presence of ACM within the building fabric cannot be discounted. Furthermore, based on the likely industrial use of the site, ACM may also be present within any Made Ground beneath the site.	
Polychlorinated Biphenyls (PCBs)	An electrical sub-station is present at the Hanson concrete facility. Historical maps and planning data indicate that the electrical sub-station has been present since c. 1978. As the use of PCBs was banned c. 1977 which pre-dates this construction, the presence of PCBs is considered unlikely.	
Waste Storage	There is a waste storage compound that is signed as being operated by Lend Lease. The compound was locked but contained a number of wheeled bins. No areas of potential concern were noted.	
Drainage	A formal drainage survey has not been completed. As discussed, there are areas of standing water within the Hanson facility which may be related to the site's drainage and presence of the former canal basin.	

2.3 E3P Intrusive Ground Investigation

A Ground Investigation (GI) was completed between the 8th and 10th February 2016, the scope and specification was designed based on the requirement of the proposed residential apartment development.

The GI consisted of advancing window sample probeholes and cable percussive boreholes with rotary follow-on to collect geotechnical information to assist in the design and construction of the development, provide information on baseline conditions and target potential contaminant sources as summarised in Table 2.1.

Table 2.1 Summary of Fieldwork

POTENTIAL SOURCE / RATIONALE	*LOCATION HOLE*	*TYPE*	*MAX DEPTH (M BGL)*		*WELL RESPONSE ZONE*
Investigation of former HJ Hambley site.	WS101	Window Sample Probehole	5.45		N/A
	WS102		4.80		1.00-2.00
Investigation of former Hanson concrete works.	WS103		4.00		1.00-3.00
	WS104		0.80		N/A
	WS104b		0.80		N/A
Investigation of the in-filled canal basin.	WS105		1.90		N/A
	WS106		5.45		N/A
	WS107		5.45		2.00-3.00
Investigation of former Hanson concrete works.	WS108		0.80		N/A
	WS109		5.45		1.00-3.00
	WS110		5.45		2.00-3.50
	WS111		1.00		0.50 – 1.00
	WS112		5.45		2.00-2.50
	WS113		3.45		2.00-3.00
	WS114		5.45		N/A
Investigation adjacent to River Medlock.	WS116		7.45		2.00-4.15
	WS117		5.45		1.00-3.00
Investigation of former Hanson site.	WS118		2.00		N/A
Investigation of general ground conditions, depth to bedrock and competency of solid geology underlying the proposed apartment blocks.	CP101	Cable Percussive w/ follow-on Rotary.	5.60	12.20	N/A
	CP102		5.80	14.20	N/A
	CP103		5.60	12.20	N/A
	CP104		5.60	13.30	N/A
	CP105		5.40	12.50	N/A
	CP106		4.10	N/A	N/A

The sampling locations are illustrated in Drawing 10-609-002 (Appendix III). The ground conditions encountered and the depths of response zone are indicated on the exploratory hole logs, which are provided in Appendix IV.

Return visits were made to monitor installations for groundwater level and gas concentrations.

2.3.1 In-Situ Standard Penetration Testing (SPT)

In-situ geotechnical testing was conducted using the Standard Penetration Test (SPT) and where the ground is granular, a 60º cone (SPT(C)) was used instead of the sampling tube.

The results are shown in the probehole logs in Appendix IV and presented in Table 3.4 and discussed in Section 5.4.

2.3.2 Laboratory Analysis

Selected soil and groundwater samples were submitted to ESG (soils) and I2 Analytical (groundwater) Laboratories for a range of chemical analysis comprising:

- Metals, cyanide, pH, total sulphate, water soluble sulphate (2:1 extract), sulphide;
- Asbestos;
- Phenols;
- Total and speciated poly-aromatic hydrocarbons (PAHs); and
- Total and speciated petroleum hydrocarbons (TPH).

Selected samples were submitted to Professional Soils Laboratory where the following geotechnical tests were undertaken:

- Point Load Tests; and
- Unconfined Compressive Strength (UCS).

Laboratory analysis results for rock cores samples are currently awaited and will be issued as an addendum to this report upon receipt.

3. GROUND AND GROUNDWATER CONDITIONS

3.1 Summary of Ground Conditions

The Ground Investigation generally confirms the published geology and identifies the strata set out in Table 3.1 below:

Table 3.1 Summary of Strata

STRATA:	GENERAL DESCRIPTION:	TYPICAL DEPTH (mBGL):				LOCATION
		TOP:		BASE:		
		MIN	MAX	MIN	MAX	
Made Ground						
Concrete	*MG: Reinforced Concrete.*	GL	GL	0.15	1.00	WS104-WS111 WS118, CP101-CP103
Cobbles	*MG: Cobbles.*	GL	0.30	0.18	0.45	WS101, WS105 CP106
Sandy / Clayey Gravel(s)	*MG: Sandy gravel with frequent cobbles. Gravel is fine to coarse angular to sub-rounded of brick, limestone, concrete, ash, clinker and sandstone. Cobbles are angular to sub-angular of sandstone.*	GL	1.50	0.16	2.00	All Locations
Gravelly SAND	*MG: Black / red slightly clayey gravelly sand. Gravel is fine to coarse angular to sub-rounded of sandstone, brick, ash and clinker.*	GL	3.85	0.18	5.45	WS102-WS103, WS105-WS107 WS111-WS117 CP101-CP103
Gravelly / Sandy CLAY	*MG: Red / brown sandy gravelly clay. Gravel is fine to coarse angular to sub-rounded of slag, ash, clinker and sandstone.*	1.00	0.55	1.50	2.40	WS101, WS104, WS109, WS117
Silty CLAY	*Grey brown silty CLAY. [Reworked]*	2.65	2.65	3.80	3.80	WS111
Natural Strata						
Sandy CLAY	*Soft to very stiff gravelly sandy CLAY. Gravel is fine to medium angular to sub-angular of sandstone.*	0.80	4.30	2.20	7.45	WS101-WS102 WS106-WS107 WS109, WS112, WS116 CP101-CP105
Clayey SAND	*Very loose to dense dark brown slightly silty clayey SAND.*	2.35	2.40	2.45	2.50	WS109, WS112
Sandy GRAVEL / Gravelly SAND	*Loose to dense brown / red / orange grey SAND and/or GRAVEL. Gravel is fine to coarse sub-rounded of sandstone and mixed lithology .*	0.35	4.45	1.65	6.25	WS101-WS104 WS106-WS107 WS109, WS112-WS118 CP101-CP105
SAND	*Loose to dense grey medium to coarse SAND.*	3.50	3.50	4.45	4.45	WS106
SANDSTONE	*Weak to very weak red weathered SANDSTONE. .*	5.40	5.80	12.20	14.20	CP101-CP105

3.1.1 Made Ground

Made Ground was encountered in all exploratory hole locations from ground level (GL) to a maximum proven depth of 5.45m bgl. (WS117).

The former concrete works is covered by concrete hardstanding (up to 1000m in thick), however the historic road leading from Potato Wharf traversing the northern profile of the site is cobbled. Made Ground deposits underlying the surface course generally comprise a slightly clayey sandy gravel / gravelly sand of fine to coarse angular to sub-rounded brick, limestone, concrete, plastic, ash and clinker with occasional cobbles of sandstone.

A number of discontinuous re-worked sandy and/or silty clay strata were recorded between depths of 1.00-3.80m bgl.

Railway infrastructure / viaducts present a vast installation of brick-built arches which straddle the southern portion of the site, however Made Ground across this sector was generally <1.00m bgl. Made Ground deposits were generally deeper across the northern sector where anthropogenic materials were typically recorded to depth in excess of 1.00m bgl and up to 5.45m bgl and 3.80m bgl to the east and north, respectively

Visual and olfactory evidence of hydrocarbon contamination was identified within a number of locations as detailed below:

Evidence of Contamination

LOCATION	DEPTH (m)	STRATA	FIELDWORK OBSERVATION
WS106	2.90-3.20	Sandy CLAY	Faint hydrocarbon odour
WS107	2.20-3.00	Sandy CLAY	Faint hydrocarbon odour
WS111	2.65-3.80	Silty Clay (MG)	Faint hydrocarbon odour and visible staining
CP101	2.70-3.00	Sandy CLAY	Faint hydrocarbon odour
CP102	2.80-3.45	Sandy CLAY	Faint hydrocarbon odour and slight staining
CP106	3.90-4.00	Sandy CLAY	Moderate hydrocarbon odour and slight staining

3.1.2 Drift

Drift deposits were encountered in all locations where Made Ground was penetrated to a maximum proven depth of 7.45m bgl (WS116).

The superficial glacial soil deposits comprised a loose dense gravelly SAND and/or sandy GRAVEL interbedded with bands of soft to stiff low to very high strength sandy CLAY strata. The granular soils at depth in excess of 2.85m bgl were noted as fluvial deposits (river gravel) which were immediately underlain by bedrock.

3.1.3 Solid Geology

A red weathered SANDSTONE was encountered at depth of between 5.20-5.80m bgl to a proven cored depth of 14.20m (CP101).

A Depth of Made Ground Plan and Depth to Bedrock Plan are presented in Drawing No. 10-609-005 & Drawing No. 10-609-006, respectively.

3.2 Soil Consistency

Results of the Standard Penetration Tests, including undrained shear strengths derived from SPTs are included on Table 3.4 (overleaf). Consideration must be made to the granular content of the glacial soils which can lead to misrepresentative results.

3.3 Side Stability and Ease of Excavation

A number of below ground obstructions and relict foundations were encountered during the GI which will require grubbing out in their entirety as part of the residential development.

However, the natural glacial soils were penetrated with relative ease and future excavation activities should be feasible with normal plant.

3.4 pH and Sulphate

Chemical analyses for pH and soluble sulphate content contained in Appendix V (summarised overleaf in (Table 3.2), shows that the soils at the site generally meet Class DS-1, Aggressive Chemical Environment for Concrete Classification (ACEC) AC-1s in accordance with BRE Special Digest 1 (2005).

However, localised soils which meet DS-2 where encountered at 1.70m bgl and 2.50m bgl in WS105 & WS109, respectively.

Table 3.2 Summary of pH and Sulphate Data

LOCATION	DEPTH (m)	SO_4 IN 2:1 WATER / SOIL (g/l)	pH VALUE
WS101	1.50	0.098	7.7
WS102	1.90	0.128	8.0
WS103	0.90	0.157	7.7
WS105	1.70	0.597	6.9
WS106	1.80	0.044	7.7
WS107	1.00	0.080	7.9
WS109	2.50	1.090	6.8
WS110	1.10	0.130	5.8
WS110	3.50	0.133	8.0
WS112	1.20	0.153	8.5
WS113	2.90	0.363	9.7
WS116	0.40	0.163	8.8
WS117	0.20	0.026	8.3
CP106	4.00	0.099	8.3

Based on the results of the analysis, localised ground conditions may pose a risk to buried concrete, however this risk may be removed as part of any remediation and enabling works.

3.5 Groundwater Conditions

A number groundwater strike were encountered between 0.90-3.00m bgl in window sample boreholes in the central and eastern sector of the site, in proximity to the former canal basin.

Subsequent water monitoring has identified groundwater at depth of between 1.50-3.00m bgl across the wider site.

3.6 Soil Infiltration

In-situ variable (falling) head permeability tests were not undertaken for the purpose of this report due to the presence of visual and olfactory hydrocarbon impact to shallow soils.

3.7 Ground Gas

Concentrations of methane (CH_4), carbon dioxide (CO_2) and Oxygen (O_2) were measured using an infra-red gas analyser (GFM435) calibrated to a reference standard (before and after each survey) and gas flow rates were measured using an attached flow pod.

Gas measurements were recorded for a minimum of sixty seconds at each location, at which point the maximum concentration of CH_4 and CO_2 together with the lowest concentration of O_2 were recorded. The results of the ground gas monitoring are presented in Table 3.5 (overleaf).

Table 3.4 Standard/Cone Penetration Test Results

Boreholes	Depth (m bgl)	Material Field Description	CPT/SPT "N" Value	Corrected "N" Value $(N_1)_{60}$	Terzaghi & Peck Relative Density (Sands)	Eurocode Soil Strength	Consistency (BS5930)	Terzaghi & Peck Approximate Undrained Shear Strength (kN/m^2)
WS101	1	Gravelly Clay (MG)	5	10.08	N/A	Medium Strength	Stiff	50.41
	2	Sandy CLAY	9	8.22	N/A	Medium Strength	Stiff	41.11
	3	Sandy GRAVEL	19	16.52	Medium Dense	N/A	N/A	N/A
	4	Sandy GRAVEL	9	7.60	Loose	N/A	N/A	N/A
WS102	1	Gravelly SAND	4	4.03	Loose	N/A	N/A	N/A
	2	Sandy CLAY	8	7.31	N/A	Low Strength	Firm	36.54
	3	Sandy CLAY	17	14.78	N/A	Medium Strength	Stiff	73.92
WS103	1	Gravelly SAND	7	7.06	Loose	N/A	N/A	N/A
	2	Clayey SAND	12	10.96	Medium Dense	N/A	N/A	N/A
	3	Sandy GRAVEL	18	15.65	Medium Dense	N/A	N/A	N/A
	4	Sandy GRAVEL	13	10.98	Medium Dense	N/A	N/A	N/A
WS105	1	Gravelly SAND	15	15.12	Medium Dense	N/A	N/A	N/A
	1.7	Sandy GRAVEL	40	37.35	Dense	N/A	N/A	N/A
WS106	1	Gravelly SAND	8	8.07	Loose	N/A	N/A	N/A
	2	Sandy CLAY	1	0.91	N/A	Extremely Low Strength	Very Soft	4.57
	3	Sandy CLAY	19	16.52	N/A	High Strength	Very Stiff	82.62
	4	SAND	17	14.36	Medium Dense	N/A	N/A	N/A
	5	Inferred SAND	50	41.48	Dense	N/A	N/A	N/A
WS107	1	Gravelly Sand (MG)	13	13.11	Medium Dense	N/A	N/A	N/A
	2	Sandy CLAY	6	5.48	N/A	Low Strength	Firm	27.41
	3	Sandy CLAY	1	0.87	N/A	Extremely Low Strength	Very Soft	4.35
	4	Inferred SAND	1	0.84	Very Loose	N/A	N/A	N/A
	5	Inferred SAND	50	41.48	Dense	N/A	N/A	N/A

Boreholes	Depth (m bgl)	Material Field Description	CPT/SPT "N" Value	Corrected "N" Value $(N_1)_{60}$	Terzaghi & Peck Relative Density (Sands)	Eurocode Soil Strength	Consistency (BS5930)	Terzaghi & Peck Approximate Undrained Shear Strength (kN/m^2)
WS109	1	Sandy Clay (MG)	7	7.06	N/A	Low Strength	Firm	35.29
	2	Sandy Clay (MG)	8	7.31	N/A	Low Strength	Firm	36.54
	3	Sandy CLAY	7	6.09	N/A	Low Strength	Firm	30.44
	4	Sandy CLAY	17	14.36	N/A	Medium Strength	Stiff	71.81
	5	Gravelly SAND	50	41.48	Dense	N/A	N/A	N/A
WS110	1	Gravelly Sand (MG)	5	5.04	Loose	N/A	N/A	N/A
	2	Gravelly Sand (MG)	15	13.70	Medium Dense	N/A	N/A	N/A
	3	Silty CLAY (MG)	7	6.09	N/A	Low Strength	Firm	30.44
	4	Sandy CLAY	36	30.41	N/A	Very High Strength	Very Stiff	152.07
	5	Gravelly SAND	50	41.48	Dense	N/A	N/A	N/A
WS112	1	Gravelly SAND	2	2.02	Very Loose	N/A	N/A	N/A
	2	Gravelly SAND	7	6.39	Loose	N/A	N/A	N/A
	3	Sandy CLAY	7	6.09	N/A	Low Strength	Firm	30.44
	4	Sandy CLAY	1	0.84	N/A	Extremely Low Strength	Very Soft	4.22
	5	Inferred SAND & GRAVEL	50	41.48	Dense	N/A	N/A	N/A
WS113	1	GRAVEL	11	11.09	Medium Dense	N/A	N/A	N/A
	2	GRAVEL	22	20.10	Medium Dense	N/A	N/A	N/A
WS114	1	Gravelly SAND	14	14.11	Medium Dense	N/A	N/A	N/A
	2	Gravelly SAND	6	5.48	Loose	N/A	N/A	N/A
	3	Gravelly SAND	7	6.09	Loose	N/A	N/A	N/A
	4	Sandy GRAVEL	2	1.69	Very Loose	N/A	N/A	N/A
	5	Sandy CLAY	41	34.01	N/A	Very High Strength	Very Stiff	170.07

Boreholes	Depth (m bgl)	Material Field Description	CPT/SPT "N" Value	Corrected "N" Value $(N_1)_{60}$	Terzaghi & Peck Relative Density (Sands)	Eurocode Soil Strength	Consistency (BS5930)	Terzaghi & Peck Approximate Undrained Shear Strength (kN/m^2)
WS116	1	Gravelly SAND	8	8.07	Loose	N/A	N/A	N/A
	2	Gravelly SAND	4	3.65	Very Loose	N/A	N/A	N/A
	4	Sandy CLAY	10	8.45	N/A	Medium Strength	Stiff	42.24
	5	Sandy CLAY	1	0.83	N/A	Extremely Low Strength	Very Soft	4.15
	6	Sandy CLAY	5	4.10	N/A	Low Strength	Firm	20.50
	7	Sandy CLAY	11	8.95	N/A	Medium Strength	Stiff	44.75
WS117	1	Sandy Gravel (MG)	11	11.09	Medium Dense	N/A	N/A	N/A
	2	Sandy CLAY (MG)	11	10.05	N/A	Medium Strength	Stiff	50.24
	3	Sandy CLAY(MG)	7	6.09	N/A	Low Strength	Firm	30.44
	4	Clayey Sand (MG)	38	32.10	Dense	N/A	N/A	N/A
	5	Clayey Sand (MG)	11	9.13	Loose	N/A	N/A	N/A
WS118	1	SAND	21	21.17	Medium Dense	N/A	N/A	N/A
CP101	1.2	Gravelly Sand (MG)	6	5.89	Loose	N/A	N/A	N/A
	2	Gravelly SAND	10	9.14	Loose	N/A	N/A	N/A
	3	CLAY	6	8.70	N/A	Medium Strength	Stiff	43.48
	4	Gravelly SAND	6	5.07	Loose	N/A	N/A	N/A
	5	Sandy GRAVEL	16	13.27	Medium Dense	N/A	N/A	N/A
CP102	1.2	Gravelly Sand (MG)	29	29.24	Medium Dense	N/A	N/A	N/A
	2	Gravelly Sand (MG)	10	9.14	Loose	N/A	N/A	N/A
	3	Sandy CLAY	6	5.22	N/A	Low Strength	Firm	26.09
	4	Sandy CLAY	3	2.53	N/A	Very Low Strength	Soft	12.67
	5	Sandy GRAVEL	>50	41.48	Very Dense	N/A	N/A	N/A
CP103	1.2	Gravelly SAND	8	8.07	Loose	N/A	N/A	N/A
	2	Gravelly SAND	11	10.05	Medium Dense	N/A	N/A	N/A
	3	Silty CLAY	8	6.96	N/A	Low Strength	Firm	34.79
	4	Silty CLAY	6	5.07	N/A	Low Strength	Firm	25.35
	5	Sandy GRAVEL	>50	41.48	Very Dense	N/A	N/A	N/A

Boreholes	Depth (m bgl)	Material Field Description	CPT/SPT "N" Value	Corrected "N" Value $(N_1)_{60}$	Terzaghi & Peck Relative Density (Sands)	Eurocode Soil Strength	Consistency (BS5930)	Terzaghi & Peck Approximate Undrained Shear Strength (kN/m^2)
CP104	1.2	Sandy CLAY	5	5.04	N/A	Low Strength	Firm	25.20
	2	Sandy CLAY	3	2.74	N/A	Very Low Strength	Soft	13.70
	3	Sandy CLAY	11	9.57	N/A	Medium Strength	Stiff	47.83
	4	Sandy GRAVEL	39	32.95	Dense	N/A	N/A	N/A
	5	Sandy GRAVEL	23	19.08	Medium Dense	N/A	N/A	N/A
CP105	1.2	Gravelly SAND	5	5.04	Loose	N/A	N/A	N/A
	2	Gravelly SAND	4	3.65	Very Loose	N/A	N/A	N/A
	3	CLAY	3	2.61	N/A	Very Low Strength	Soft	13.04
	4	Sandy GRAVEL	41	34.64	Dense	N/A	N/A	N/A
	5	Sandy GRAVEL	45	37.33	Dense	N/A	N/A	N/A
CP106	1.2	Sandy CLAY	10	10.08	N/A	Medium Strength	Stiff	50.41
	2	Sandy CLAY	7	6.39	N/A	Low Strength	Firm	31.97
	3	Clayey SAND	6	5.22	Loose	N/A	N/A	N/A
	4	Sandy CLAY	31	26.19	N/A	High Strength	Very Stiff	130.95

Table 3.5 Summary of Ground Gas and Groundwater Monitoring

Well	Date	CH_4 Initial %v/v	CH_4 Steady %v/v	CH_4 GSV l/hr	CO_2 Initial %v/v	CO_2 Steady %v/v	CO_2 GSV l/hr	O_2 %v/v	Atmos (mb)	Atmos. Dynamic	Flow (l/hr)	Depth to Base (mbgl)	Depth to Water (mbgl)
WS102	17/02/2016	0.1	0.1	0.00105	3.3	3.3	0.03465	16.6	1008	Falling	1.05	2.03	1.65
	10/03/2016	0.1	0.1	0.00095	4.2	4.2	0.0399	16.1	1019	Rising	0.95	1.97	1.55
	22/03/2016	0.1	0.1	0.00052	4.1	4.1	0.02132	16.4	1007	Falling	0.52	1.98	1.60
WS103	17/02/2016	0.1	0.1	0.00105	0.7	0.7	0.00735	19.7	1008	Falling	1.05	2.62	1.86
	10/03/2016	0.1	0.1	0.00088	0.4	0.4	0.00352	20.3	1019	Rising	0.88	2.48	1.77
	22/03/2016	0.1	0.1	0.00026	0.5	0.5	0.0013	20.1	1007	Falling	0.26	2.5	1.81
WS107	17/02/2016	0.1	0.1	-0.00026	0.3	0.2	-0.00078	19.5	1008	Falling	-0.26	2.55	1.95
	10/03/2016	0.1	0.1	0.00102	0.4	0.4	0.00408	19.8	1019	Rising	1.02	2.46	1.90
	22/03/2016	0.1	0.1	0.00052	0.3	0.3	0.00156	19.6	1007	Falling	0.52	2.49	1.91
WS109	17/02/2016	0.1	0.1	0.00112	2.1	2.1	0.02352	15.8	1008	Falling	1.12	2.99	2.87
	10/03/2016	0.1	0.1	0.00095	0.1	0.1	0.00095	20.6	1019	Rising	0.95	3.00	3.00
	22/03/2016	0.1	0.1	0.00013	0.3	0.3	0.00039	20.1	1007	Falling	0.13	3.00	3.00
WS110	17/02/2016	0.1	0.1	0.00128	0.5	0.5	0.0064	19.7	1008	Falling	1.28	3.47	2.64
	10/03/2016	0.1	0.1	0.0001	0.4	0.3	0.0004	20.3	1019	Rising	0.10	3.44	2.87
	22/03/2016	0.1	0.1	0.0001	0.3	0.3	0.0003	20.1	1007	Falling	0.10	3.45	2.90
WS111	17/02/2016	0.1	0.1	0.00105	2.0	2.0	0.021	17.4	1008	Falling	1.05	1.10	Dry
	10/03/2016	0.1	0.1	0.00095	1.9	1.9	0.01805	17.0	1019	Rising	0.95	1.10	Dry
	22/03/2016	0.1	0.1	0.0012	2.0	2	0.024	17.3	1007	Falling	1.2	1.10	Dry
WS112	17/02/2016	0.1	0.1	0.00105	3.3	3.3	0.03465	14.9	1008	Falling	1.05	2.65	2.65
	10/03/2016	0.1	0.1	0.00088	2.9	2.9	0.02552	15.1	1019	Rising	0.88	2.58	2.55
	22/03/2016	0.1	0.1	0.00052	3.0	3.0	0.0156	15.0	1007	Falling	0.52	2.60	2.58
WS113	17/02/2016	0.1	0.1	0.00105	3.3	3.3	0.03465	14.9	1008	Falling	1.05	2.65	2.65
WS116	17/02/2016	0.1	0.1	0.00095	4.4	4.4	0.0418	16.0	1008	Falling	0.95	4.08	4.08
	10/03/2016	0.1	0.1	0.00112	4.3	4.3	0.04816	16.1	1019	Rising	1.12	4.04	Dry
	22/03/2016	0.1	0.1	0.00013	4.5	4.5	0.00585	15.8	1008	Falling	0.13	4.05	Dry
WS117	17/02/2016	0.1	0.1	0.00102	1.6	1.6	0.01632	18.4	1008	Falling	1.02	3.16	Dry
	10/03/2016	0.1	0.1	0.00095	0.7	0.7	0.00665	20.0	1019	Rising	0.95	3.15	Dry
	22/03/2016	0.1	0.1	0.0016	1.0	1.0	0.016	19.5	1008	Falling	1.60	3.15	Dry

4. TIER 1 QUALITATIVE CONTAMINATED LAND RISK ASSESSMENT

4.1 Human Health Risk Assessment

At a Tier 1 stage the long term (chronic) human health toxicity of the soil has been assessed by comparing the on-site concentrations of organic and inorganic compounds with reference to Generic Assessment Criteria (GACs) values published by LQM / CIEH 2nd edition - Suitable 4 Use Levels (S4UL), DEFRA - Category 4 Screening Levels (C4SL), and EA - Contaminated Land Exposure Assessment (CLEA), Soil Guideline Values (SGV).

The results of this comparison have been summarised within Table 4.1 (overleaf).

Table 4.1 Summary of Inorganic and Hydrocarbon Toxicity Assessment for Residential End Use Without Plant Uptake

DETERMINANT	UNIT	GAC	N	MC	LOC. OF EX/(m)	STRATA	PATHWAY	ASSESSMENT
Arsenic	mg/kg	40	14	56.5	WS116-0.4	MG	1	**Further Assessment**
Cadmium	mg/kg	85	14	0.57	2.04	N/A	1	No Further Action
Chromium (VI)	mg/kg	6	14	0.3	N/A	N/A	1	No Further Action
Lead	mg/kg	200	14	389.4 2740	WS105-1.7 WS116-0.4	MG MG	1	**Further Assessment**
Mercury	mg/kg	1.2	14	0.88	N/A	N/A	2	No Further Action
Nickel	mg/kg	180	14	36.9	N/A	N/A	1	No Further Action
Selenium	mg/kg	430	14	1.9	N/A	N/A	1	No Further Action
Copper	mg/kg	7100	14	110.7	N/A	N/A	1	No Further Action
Zinc	mg/kg	40000	14	134.7	N/A	N/A	1	No Further Action
Cyanide - Total	mg/kg	791	14	1.0	N/A	N/A	1	No Further Action
Phenols - Total.	mg/kg	210	14	<0.7	N/A	N/A	1	No Further Action
Asbestos	Fibres	NFD	14	FD	WS105-1.7 WS116-0.4	MG MG	4	**Further Assessment**
Naphthalene	mg/kg	2.3	14	3.23	WS116-0.4	MG	2	**Further Assessment**
Acenaphthylene	mg/kg	2900	14	0.50	N/A	N/A	3	No Further Action
Acenaphthene	mg/kg	3000	14	1.40	N/A	N/A	1	No Further Action
Fluorene	mg/kg	2800	14	1.00	N/A	N/A	1	No Further Action
Phenanthrene	mg/kg	1300	14	11.68	N/A	N/A	3	No Further Action
Anthracene	mg/kg	31000	14	2.40	N/A	N/A	3	No Further Action
Fluoranthene	mg/kg	1500	14	15.90	N/A	N/A	3	No Further Action
Pyrene	mg/kg	3700	14	15.70	N/A	N/A	3	No Further Action
Benzo(a)Anthracene	mg/kg	11	14	7.51	WS1051.45	N/A	3	**Further Assessment**
Chrysene	mg/kg	30	14	7.87	N/A	N/A	3	No Further Action
Benzo(b/k)Fluoranthene	mg/kg	3.9	14	11.90 11.59	WS105-1.7 WS116-0.4	MG MG	3	**Further Assessment**
Benzo(a)Pyrene**	mg/kg	3.2	14	7.72 5.49	WS105-1.7 WS116-0.4	MG MG	3	**Further Assessment**
Indeno(123-cd)Pyrene	mg/kg	45	14	5.15	N/A	N/A	3	No Further Action
Dibenzo(a,h)Anthracene	mg/kg	0.31	14	0.99 0.81	WS105-1.7 WS116-0.4	MG MG	3	**Further Assessment**
Benzo(ghi)Perylene	mg/kg	360	14	4.71	N/A	N/A	3	No Further Action
TPH C5-C6 (aliphatic)*	mg/kg	42	14		N/A	N/A	2	No Further Action
TPH C6-C8 (aliphatic)*	mg/kg	100	14		N/A	N/A	2	No Further Action
TPH C8-C10 (aliphatic)*	mg/kg	27	14	37.1	WS116-0.4	N/A	2	**Further Assessment**
TPH C10-C12 (aromatic)*	mg/kg	250	14	31.6	N/A	N/A	2	No Further Action
TPH C12-C16 (aromatic)*	mg/kg	1800	14	138	N/A	N/A	2	No Further Action
TPH C16-C21 (aromatic)*	mg/kg	1900	14	311	N/A	N/A	1	No Further Action
TPH C21-C35 (aromatic)*	mg/kg	1900	14	915	N/A	N/A	1	No Further Action

Notes
Main Exposure Pathways: 1 = Soil Ingestion, 2 = Vapour Inhalation (indoor), 3 = Dermal Contact & Ingestion, 4 = Dust Inhalation.
Abbreviations: GAC = General Assessment Criteria, n = number of samples, MC = Maximum Concentration; Loc of Ex/m = Location of Exceedance and depth in metres; NFD = No Fibres Detected, S4UL = LQM/CIEH Suitable For Use Levels
* The Tier 1 GAC for the hydrocarbon fraction is derived from the CIEH assessment for petroleum hydrocarbons Criteria Working Group (CWG) for both aliphatic and aromatic compounds. E3P has utilised the Tier 1 values for aliphatic compounds for the volatile and semi volatile fractions (C_5-C_{12}) and the Tier 1 values for aromatic compound for the non-volatile fractions (C_{12}-C_{35}). The comparison of a total (aliphatic/aromatic) compounds to an individual fraction is considered to be a conservative approach and satisfactory for the protection of human health.

Referring to Table 4.1 overleaf, the direct comparison identified the following exceedances:

- Arsenic
- Lead
- Asbestos
- Napthalene
- Benzo(a)Annthracene
- Benzo(b/k)Fluoranthene
- Benzo(a)Pyrene
- Dibenzo(a,h)Anthracene

In relation to these above exceedance, the following can be determined:

- The main exposure pathways based on the Tier I exceedances are:
  - Dust Inhalation (asbestos);
  - Soil Ingestion (arsenic and lead);
  - Dermal Contact and Soil Ingestion (non-volatile PAHs); and
  - Vapour inhalation (TPH C8-C10 and naphthalene).

- Asbestos (chrysotile / amosite fibres) was identified at two locations within shallow Made Ground between 0.40-1.70m bgl associated with historic fill material.

Risk Assessment and Mitigation

Heavy Metals and PAHs

For the elevated concentrations of heavy metal and PAHs the viable exposure pathway is directly related to soil ingestion and/or dermal contact. The exceedances were identified in the upper horizons (<1.70m bgl) of Made Ground.

These risks can be mitigated through careful management of earthworks so as to prevent impacted soils being exposed to constructions workers through the use of appropriate Personal Protective Equipment (PPE) and provision of welfare facilities.

When considered within the context of the proposed development the external areas will be predominantly hard-standing capping or a chemically suitable cover system in any landscaped areas thereby removing the exposure pathway and ensuring no unacceptable degree of risk is posed to future residential site users.

Naphthalene / volatile hydrocarbons (TPH C8-C10)

Elevated concentrations of naphthalene and volatile-range hydrocarbons were encountered at WS116 (0.40m) which is considered to represent a localised contamination hotspot.

Theoretically, this material poses an unacceptable degree of chronic risk to human health through volatilisation to indoor air.

However, when considered within the context of the proposed development the hotspot is located within an area of proposed landscaping and furthermore, any reduced level dig or soil inversion (to win chemically suitable underlying natural soils) to facilitate the installation of a cover system in this locality will remove the shallow contamination soils.

In addition, a moderate hydrocarbon odour and staining was noted in CP106, however samples of the underlying clay soils did not indicate concentrations above the Tier I GAC.

As such, E3P do not consider the impacted soils to pose an unacceptable degree of risk to human health.

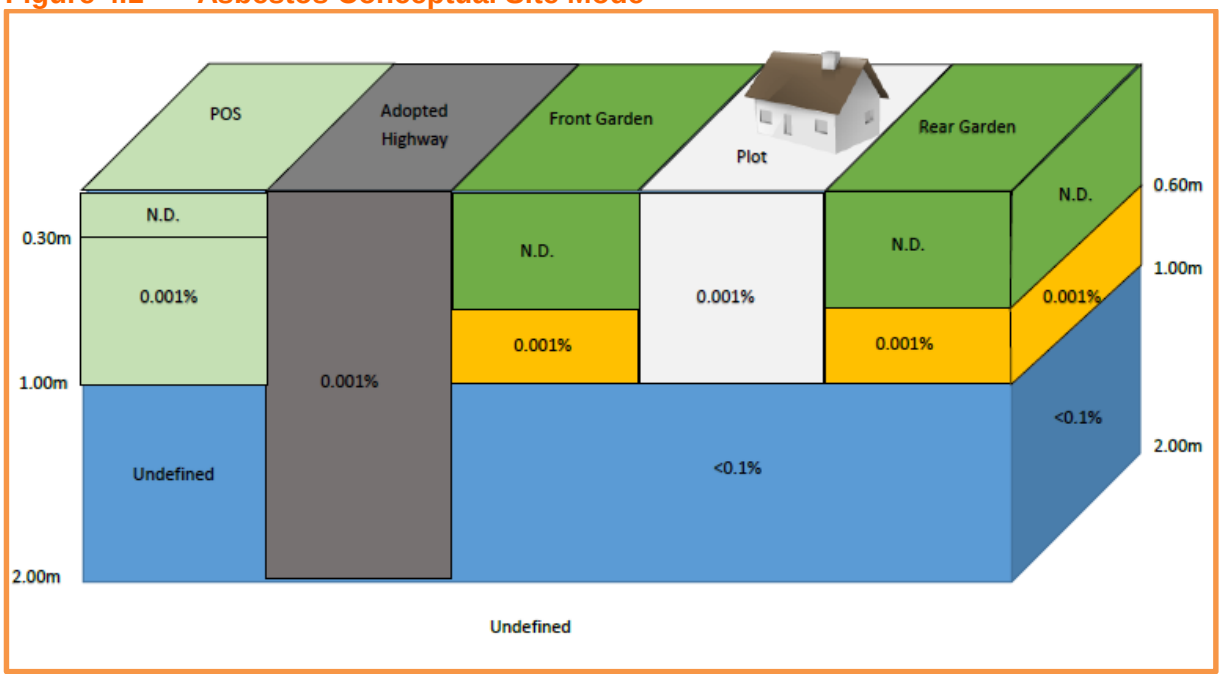
Asbestos

Given the presence of asbestos fibres within the Made Ground, a suitably detailed remediation strategy will be required to document the safe handling, management and placement of all Made Ground so as to ensure that no unacceptable degree of risk is presented to construction workers or future commercial site users.

Subsequent quantification of the impacted soils identified asbestos content of <0.001% by volume / weight.

E3P has produced an asbestos specific CSM for an apartment development which identifies the locations that asbestos impacted soils may be placed in a residential setting to ensure there is no unacceptable level of risk to the future residential site users, included as Figure 4.1 below:

Figure 4.1 Asbestos Conceptual Site Mode



Chemical analysis confirms that the natural underlying drift strata is suitable for use within the development, therefore any drift deposits cut within the enabling works (albeit unlikely), pending chemical validation, may be utilised as subsoil within any proposed landscaped areas.

The shallow Made Ground will not be suitable for use as Topsoil or subsoil element within any proposed landscaped areas due to the aforementioned impacted soils.

4.2 Controlled Waters

The site sensitivity with respect to controlled waters is summarised within Table 4.2

Table 4.2 Controlled Waters Sensitivity Profile

Risk Profile	Discussion	Sensitivity Rating & Rationale
Groundwater Source Protection Zone or Drinking Water Safeguard Zone	No	**Low**
Distance to the closest groundwater abstraction point.	335m	**Low** – The closest abstraction is for general industrial cooling use and operated by Computer Design Systems Ltd on Ordsall Lane. There are no potable groundwater abstraction within a 1km radius of the site.
Aquifer Classification in Superficial Drift Deposits.	Unproductive	**Low** – Natural sand and gravels interbedded with low permeability clay soils underlie the site to a proven depth of 7.45m bgl which will serve to reduce the potential for any mobile phase contaminants to migrate towards a viable receptor.
Aquifer classification in Bedrock.	Principal	**High**
Viability for Anthropogenic soil in direct contact with Aquifer. *(Drift or Bedrock).*	No	**High –** Made Ground deposits directly overlie natural glacial soils which comprise interbedded granular and clay strata.
Is the site underlain by low permeability Drift to depths in excess of 10.0m?	No	**Low to Medium –** The site is underlain by interbedded granular soils and cohesive glacial clays to a proven depth of 7.45m bgl. The cohesive strata are consistent across the site and as such are considered to provide some degree of protection against vertical migration.
Is the site located within 50m of a surface watercourse?	Yes	**Yes –** The Bridgewater Canal (south) and River Medlock (north and east) are located immediately adjacent to the site boundary.

Summary

The ICSM developed within the context of the site setting has identified two viable pollutant risk pathways which would be the vertical migration and lateral migration of potentially mobile phase soluble contaminants towards the underlying Principal Aquifer within the sandstone bedrock and adjacent surface watercourses (River Medlock and Bridgewater Canal), respectively.

However, the overall risk to Principal Aquifer is reduced given there are no potable groundwater abstractions within the locality (<1km) and presence of interbedded low permeability glacial clay soils which will effectively reduce any downward migration and thus the potential for the creation of a complete pollutant linkage.

Furthermore, the presence of dock wall / retaining structures may serve to inhibit the lateral migration of any mobile phase contaminants into the Bridgewater Canal and River Medlock, both of which lie down hydraulic gradient of the study site.

To further refine the ICSM, E3P has undertaken an initial qualitative assessment of the soil data analysis to assess the potential for a source of separate phase or dissolved phase contamination originating from either a defined on-site source or from impacted soils. This assessment is summarised in Table 4.3.

Table 4.3 Qualitative Risk to Controlled Waters from Soil Analytical Results

BTEX - <1ppm	The soil data analysis has not identified any significantly elevated concentrations of TPH C5 to C6 that might otherwise be indicative of VOC impact.
Total VOC - <1ppm	
Total SVOC - <1ppm	PAH analysis recorded concentrations either below or only slightly elevated above the laboratory LOD. No SVOC concentrations were identified above the LOD from three samples tested from across the site.
C5-C10 <5ppm	Concentrations in excess of 5mg/kg have been encountered.
C10-C12 <10ppm	Concentrations in excess of 10mg/kg have been encountered.
C12-C16 <50ppm	Concentrations in excess of 50mg/kg have been encountered.
Phenols – <2ppm	All concentrations are below the laboratory LOD.
Naphthalene - <2ppm	The most soluble SVOC (Naphthalene) has been identified at concentrations greater than 2mg/kg at one location (WS116).
Total PAH <10ppm	Marginally elevated concentrations of low solubility PAH compounds greater than 10mg/kg have been detected in the soil analysis.
PCB < 1ppm	No potential sources of PCB have been identified. An electrical sub-station was constructed c. 1978 and as such will not have contained PCBs due to a UK ban in 1976.
Heavy metals - <500ppm	Concentrations of heavy metals are all below 500mg/kg with the exception of lead at WS116.

To confirm absence of any risk to controlled waters, E3P has undertaken a Tier I controlled waters risk assessment. The Tier I assessment has included a comparison of groundwater analysis from samples taken across the site to Environmental Quality Standards (EQS) in the first instance and where absent Drinking Water Standards (DWS).

The results of the comparison are presented in Table 4.4 overleaf.

Table 4.4 Comparison of Groundwater Analysis with Tier 1 Screening Levels

DETERMINAND	UNITS	EQS SCREENING VALUE [1, 2, 3]		DWS [3,4]	N	MC	LOC OF EX	ASSESSMENT
		AA	MAC					
Arsenic	µg/l	50	-	10	4	6.66	N/A	No Further Action
Cadmium	µg/l	0.08	0.45	5	4	0.75	WS113	Further Assessment
Chromium (VI)	µg/l	3.4	-	-	4	<5.0	N/A	No Further Action
Chromium (III)	µg/l	4.7	-	50	4	N/A	N/A	No Further Action
Copper (hardness)	µg/l	1-28		2000	4	5.8	N/A	No Further Action
Total Cyanide	µg/l	1	-	50	4	15	WS107	Further Assessment
Lead	µg/l	1.2	14	10	4	0.7	N/A	No Further Action
Mercury	µg/l	-	0.07	1.0	4	<0.05	N/A	No Further Action
Nickel	µg/l	4	34	20	4	21	WS113	Further Assessment
Selenium	µg/l		-	10	4	2.1	N/A	No Further Action
Zinc(hardness)	µg/l	8-125	-	-	4	87	N/A	No Further Action
pH	6-9				4	7.1-7.7	N/A	No Further Action
PAH								
Naphthalene	µg/l	2	130	10*	4	<0.01	N/A	No Further Action
Anthracene	µg/l	0.1	0.1		4	<0.01	N/A	No Further Action
Benzo[b]fluoranthene	µg/l	1.7^{-4}	0.017		4	<0.01	N/A	No Further Action
Benzo[k]fluoranthene	µg/l	1.7^{-4}	0.017		4	<0.01	N/A	No Further Action
Benzo(a)pyrene	µg/l	1.7^{-4}	0.27		4	<0.01	N/A	No Further Action
Fluoranthene	µg/l	0.0063	0.12		4	<0.01	N/A	No Further Action
Benzo(ghi)perylene	µg/l	1.7^{-4}	8.2^{-3}		4	<0.01	N/A	No Further Action
TPH								
TPH C5-C6 (benzene)	µg/l	10	50	1	4	<10	N/A	No Further Action
TPH C6-C8 (toluene)	µg/l	50	-	700	4	<10	N/A	No Further Action
TPH C8-C10 (ethyl benzene)	µg/l	20	-	300	4	<10	N/A	No Further Action
TPH C10-C12 (xylene)	µg/l	30	-	500	4	<10	N/A	No Further Action
TPH C12-C16 (naphthalene)	µg/l	2	130	10	4	<10	N/A	No Further Action
TPH C16-C35	µg/l	50#	50#	-	4	<10	N/A	No Further Action

Notes
Solubility <0.01µg/l
AA – Annual Average
MAC- Maximum Admissible Concentration
* Sum of The specified compounds are benzo[b]fluoranthene (CAS 205-99-2), benzo[k]fluoranthene (CAS 207-08-9), benzo[g,h,i]perylene (CAS 191-24-2) and indeno[1,2,3-c,d]pyrene (CAS 193-39-5)
1. The Water Environment (Water Framework Directive) (England and Wales) (Amendment) Regulations (2015)
2. Directive establishing a framework for Community action in the field of water policy (Water Framework Directive)
3. Council Directive on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community (Dangerous Substances Directive) - List II substances
4. Council Directive on the quality of water intended for human consumption (Drinking Water Directive)
5. WHO Guidelines for Drinking Water Quality. Third edition (2004)

Referring to Table 4.4 above, the Tier 1 assessment indicates that the data exceeds for the following determinands:

- Cadmium
- Nickel
- Total Cyanide

It should be noted that the Tier 1 assessment criteria provides a conservative review, which may over-state the risk, and cadmium and nickel are generally considered to be of a low solubility and therefore mobility, with the results likely representative of trace suspended solid within the sample matrix.

Further chemical analysis for Free Cyanide (bioavailable) did not record concentrations above the limit of detection (LOD) and as such is not considered to pose a risk to controlled water.

Furthermore, the subject site is situated within a low to medium sensitivity location with respect to the underlying Principal Aquifer given its limited potential to support potable water abstractions.

No elevated SVOC concentrations were recorded above the LOD and no BTEX compounds were recorded above the LOD.

Based on the above, the site and historical land uses are not considered to pose an unacceptable level of risk to controlled water or the wider environ with the impact recorded in soils at WS116 representative of adsorbed phase impact.

4.3 Ground Gas

The potential impact on the development from ground gases has been assessed with reference to standards and guidelines published in CIRIA Report 665 (*Assessing risks posed by hazardous ground gases to buildings*, 2007). However, it is recommended that the full ground gas assessment and recommended protection measures are agreed with the local authority prior to their adoption on-site. Furthermore, all protection measures adopted should be validated by a suitably qualified engineer.

The Phase I Desk Study and subsequent Ground Investigation has identified the following potential sources of ground gas:

- Historic Made Ground deposits to a maximum proven depth of 5.45m bgl;
- Visual and olfactory evidence of hydrocarbon impact to shallow soils.

During the monitoring visit completed to date, no significantly elevated concentrations of methane (<0.1 % v/v) or carbon dioxide (4.5 % v/v) have been encountered.

The monitoring has been undertaken during a periods of high (>1000mb) / falling & rising atmospheric pressure. Further monitoring should be undertaken during periods of low and falling atmospheric pressure episodes, demonstrating worst case scenario.

In accordance with the methodology outlined with the CIRIA publication C665, E3P have utilised the results of the ground gas monitoring surveys to calculate a tentative Gas Screening Value (GSV). The maximum GSV calculated for methane was 0.00128 l/hr (WS110) and for carbon dioxide was 0.04816 l/hr (WS116).

The GSV has been compared to the criteria outlined with CIRIA C665 to determine the level of risk to the proposed development and to ensure the appropriate remedial options are incorporated into any future building design in this area.

The calculated GSVs generally reflect the absence of any significant flow with CIRIA C665 stating that in instances where the maximum GSV for carbon dioxide and methane is <0.07 l/hr and typical methane and carbon dioxide are less than 1% v/v and 5% v/v respectively, then this is equivalent to Characteristic Situation 1 - Green (No protection measures required).

This is an interim assessment based on preliminary ground gas readings, the final classification will be supplied as an addendum to this report on completion of the remaining monitoring visits.

4.4 Potable Water Infrastructure

Poly-Ethylene Pipe (PE) will not likely be suitable for the proposed development in its current condition. A full UKWIR assessment will be required upon completion of remediation and enabling works.

4.5 Conceptual Site Model

Following the completion of the intrusive site investigation, chemical analysis and risk assessment the conceptual model shown in Table 4.5 has been prepared for the site.

Table 4.5 Conceptual Model

SOURCE	EXPOSURE	POTENTIAL PATHWAY
Human Health		
Heavy Metals / PAH	Soil Ingestion & Dermal Contact	Construction Workers Residential End Users
Discussion: Heavy metal and PAHs have been identified in Made Ground soils across the site. The contaminants pose a short term risk to construction workers who may come into contact with impacted soils during any future earthworks. All construction works must be undertaken using the appropriate health and safety controls and where required Personal Protective Equipment (PPE) to remove this potential risk. However, external areas of the proposed development will mainly comprise hard-standing cover or a suitable cover system designed in accordance with BRE465 (*Cover Systems for Land Regeneration)* in any landscaped area, thereby removing the exposure pathway and mitigating the risk to human health for future site users.		
Asbestos Containing Materials (ACM)	Fibre / Dust Inhalation	Construction Workers Residential End Users Third Party Property
Discussion: Loose chrysotile / amosite fibres have been identified within the Made Ground deposits at two locations which could be released during earthworks and then subsequently inhaled by construction workers and possibly third party property. Construction phase health and safety controls and the fact that any ACM will likely be buried at depth means that asbestos is likely to represent a low risk with appropriate controls, and in addition, the presence of hard-standing across the majority of the site will ensure that there is no unacceptable risk to future site users.		

SOURCE	EXPOSURE	POTENTIAL PATHWAY
Naphthalene **Volatile TPH (C5-C10)**	Volatilisation Vapour Inhalation	Construction Workers Residential End Users
Discussion: Localised naphthalene and volatile range hydrocarbon compound impact has been identified in the shallow (~0.40m bgl) Made Ground soils at WS116. The hotspot is located within an area of proposed landscaping and as such, E3P do not consider the impacted soils to pose an unacceptable degree of risk to human health via volatilisation to indoor air.		
Controlled Waters		
Heavy Metals **Hydrocarbon Compounds**	Vertical / Lateral Migration	River Medlock Bridgewater Canal Principal Aquifer
Discussion: In the absence of any elevated concentrations of potentially soluble contaminants of concern within the soil and groundwater samples; the site is deemed to pose no unacceptable degree of risk to controlled waters and the wider environ.		
Ecology		
Heavy Metals **Hydrocarbon Compounds**	Migration to nearby watercourse	River Medlock Bridgewater Canal
Discussion: In the absence of any significantly elevated concentrations of potentially soluble contaminants of concern within the soil and groundwater samples; the site poses no unacceptable degree of risk to ecology or aquatic ecosystems.		

5. GEOTECHNICAL ASSESSMENT

5.1 Proposed Development

E3P understands that SGI Ltd are acting as structural engineers for a residential development comprising the construction of two multi-storey apartment blocks with associated access road, external car parking, landscaping and adopted utility infrastructure.

5.2 Summary of Ground Conditions

Made Ground

Made Ground was encountered in all exploratory hole locations from ground level (GL) to a maximum proven depth of 5.45m bgl. (WS117).

The former works is covered by concrete hardstanding (up to 1000m in thick), however the historic road leading from Potato Wharf traversing the northern profile of the site is cobbled. Made Ground deposits underlying the surface course generally comprise a slightly clayey sandy gravel / gravelly sand of fine to coarse angular to sub-rounded brick, limestone, concrete, ash and clinker with occasional cobbles of sandstone.

A number of discontinuous re-worked sandy and/or silty clay strata were recorded between depths of 1.00-3.80m bgl.

Railway infrastructure / viaducts present a vast installation of brick-built arches which straddle the southern portion of the site, however Made Ground across this sector was generally <1.00m bgl. Made Ground deposits were generally deeper across the northern sector where anthropogenic materials were typically recorded to depth in excess of 1.00m bgl and up to 5.45m bgl and 3.80m bgl to the east and north, respectively

Drift

Drift deposits were encountered in all locations where Made Ground was penetrated to a maximum proven depth of 7.45m bgl (WS116).

The superficial glacial soil deposits comprised a loose dense gravelly SAND and/or sandy GRAVEL interbedded with bands of soft to stiff low to very high strength sandy CLAY strata. The granular soils at depth in excess of 2.85m bgl were noted as fluvial deposits (river gravel) which were immediately underlain by bedrock.

Solid

A red weathered SANDSTONE was encountered at depth of between 5.20-5.80m bgl to a proven cored depth of 14.20m (CP101).

5.3 Site Preparation

The site should be cleared and any vegetation below areas of proposed development and stripped in accordance with Series 200 of the Specification for Highway Works. This should include:

- Any roots present below the footprint of proposed structures and infrastructure should be grubbed out and the resulting void infilled with suitable compacted engineered fill;
- No invasive plant species have been identified on site. If identified during future works this material and the infested soils will require treatment / removal by a suitably qualified contractor;

- Redundant services should be sealed off and grubbed out and replaced with suitable compacted engineered fill;
- Buried structures and relic foundations were encountered and these should be excavated from below the proposed development footprint with the resulting void backfilled; and,
- Consideration should be given to any proposed retaining structures on the site and should be assessed by a structural engineer prior to development.

5.4 Foundation Conditions and Bearing Potential

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.

NATURAL COHESIVE SOILS			
DESCRIPTION	**DEPTH RANGE (m BGL)**	**UNDRAINED SHEAR STRENGTH (CU) kN/m²**	**ALLOWABLE BEARING POTENTIAL (kN/m²)**
Sandy / Silty CLAY	1.00 – 7.45	5 – 170	**10 – 350**
NATURAL GRANULAR SOILS			
DESCRIPTION	**DEPTH RANGE (m BGL)**	**RELATIVE DENSITY**	**ALLOWABLE BEARING POTENTIAL (kN/m²)**
Gravelly SAND / Sandy GRAVEL	1.00-5.45	Very Loose to Medium Dense	**20 – 415**
SANDSTONE	6.00 – 14.20	Dense	**>400**

Based on the assessment of the relative undrained shear strength, relative in-situ densities and corresponding safe net ABP, the target founding stratum has been identified as the very weak to weak SANDSTONE bedrock at a depth >6.50m bgl where an ABP in excess of 400kN/m² can be achieved which will likely increase with depth.

A summary of rock strengths based on laboratory analysis results will be issued as an addendum to this report upon receipt.

5.5 Foundation Solution

In consideration of the highly variable ground conditions and likely loadings of the proposed development the most feasible options is the use of driven piled foundations

While a detailed assessment of pile depths and bearing capacity is beyond the scope of this report, it is likely that piles would achieve a ‘set’ within the weathered sandstone at circa 10.00 – 15.50m bgl. Consideration of the effects of negative skin friction due to variability on the Made Ground and natural drift strata will be required.

A specialist piling contractor should be contacted to obtain detailed designs and costs for a specialist piling technique and to allow them to reduce the factor of safety based on their extensive pile testing data.

5.6 Ground Floor Slabs

Due to the presence of substantial and varying thickness' of Made Ground it is considered that ground bearing floor slabs, whilst viable, will require detailed design to accommodate variability of the formation and account for differential settlement.

Where suspended floor slabs are employed ventilation of the under floor void will be required to address condensation issues. This would also assist in the mitigation of potential gas issues.

5.7 Pavement Construction

An assessment of the likely California Bearing Ratio (CBR) for has not been undertaken due to the widespread hard-standing within the external areas of the site

Due to there currently being hard-standing on site, it is probable that adequate CBR values will be encountered. But it is considered that a CBR of less than 3% may be required to account for variability of the Made Ground.

It is, however, recommended that this be re-assessed using on site plate tests of the formation and it is possible that a higher design CBR of 5% may then be achievable.

Following excavation the sub formation should be proof rolled and any soft material inspected and removed.

5.8 Drainage

The presence of substantial depths of Made Ground across 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.

Falling Head Permeability tests could not be undertaken due to the visual presence of hydrocarbon impact to shallow soils at a number of locations across the site.

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

5.9 Concrete Durability

Based upon the results of the chemical analyses summarised herein it is considered that subsurface concrete can generally be designed in accordance with Design Sulphate Class DS-1, Aggressive Chemical Environment for Concrete Classification (ACEC) AC-1s in accordance with the recommendations provided in BRE Special Digest 1 (2005).

However, localised soils which meet DS-2 (WS105 – 1.70m bgl & WS109 – 2.50m bgl) where encountered and as such localised ground conditions across the site do appear to pose a potential risk to buried concrete, however this risk may be removed as part of any proposed remediation and enabling works.

5.10 Excavations

- Site observations indicated that excavations should be feasible with normal plant.
- A number of underground obstructions or relic foundations were encountered which will require grubbing out in their entirety.

5.11 Minerals

There are no minerals of economic value underlying the site at shallow depth and future mining is considered to be very unlikely. The site is considered to be minerally stable.

5.12 Further Works

Based on the findings of the site investigation, the following additional works are recommended to be completed in due course:

- Detailed Remediation & Enabling Works Strategy;
- Foundations to be designed by suitably qualified Structural Engineer;
- Geo-technical Earthworks Compaction Specification for the engineering of the sub-grade to support any associated slab and/or infrastructure; and
- A Materials Management Plan should be completed on receipt of the proposed FFLs.

5.13 Construction Activity and Inspection

The following activities and inspections should be incorporated in to the site works:

- It is recommended that sufficient allowance is made for the inspection of formation and sub formations to foundations and pavement construction:
- Excavations where access is required should be subject to a risk assessment from a competent person and where appropriate mitigation measures such as benching back the sides or use of support systems in accordance with CIRIA R97 utilised;
- It is considered that de-watering at depth may be required, particularly following periods of heavy rainfall. Removal of surface water and water within trenches should be possible with conventional sump pumping. Discharge of any water should be agreed with the relevant regulatory body and be undertaken under a trade effluent discharge, where required. Measures to remove silt and suspended solids may be required and consideration should be given to provision of space for settling tanks or an attenuation pond;
- Where access to confined spaces is required appropriate mitigation measures should be addressed within the Construction Stage Health and Safety Plan. Particular account should be taken of the gas results;
- The presence of potential contamination and mitigation measures should be addressed as part of the Construction Stage Health and Safety Plan and should include measures to design out the risks, reduce their impact and finally the use of Personnel Protective Equipment (PPE).

6. CONCLUSIONS AND RECOMMENDATIONS

Current Environmental Impact	
The subject site is a triangular shaped parcel of land located to the west of Manchester City Centre. The site is currently un-used through was previously occupied by a Hanson Concrete Works that occupied the majority central and western sectors of the subject site. The eastern sector of the site was occupied by a building yard / depot associated with HJ Hambley Ltd with signage indicating that this sold or hired steel and plastic containers. The site in its current and future usage is not deemed to pose unacceptable degree of risk to human health, controlled waters and the wider environ.	
Revised Conceptual Site Model	
Human Health	The preliminary Tier I Human Health risk assessment has identified the presence of heavy metals, PAHs, asbestos and localised naphthalene within the sub-surface across the site. The naphthalene / volatile range TPH hotspot (WS116) is located within an area of proposed landscaping and as such, E3P do not consider the impacted soils to pose an unacceptable degree of risk to human health via volatilisation to indoor air. Asbestos in the form of chrysotile /amosite loose fibres have been identified within the Made Ground deposits at the site. As such, it will be necessary to design a phase of remediation and enabling works where methodologies are agreed to carefully manage these impacted soils and place them in a legislatively complaint manner that will negate any possibility of future exposure. External areas will be covered by hard-standing or a chemically suitable cover system within any external landscaped areas thereby removing the exposure pathway heavy metals and PAHs to future site users. It is possible that as yet unidentified impact is present underlying the site. It is considered that any such contamination could be addressed by the delineation, excavation and treatment of impacted soils during the build-phase development.
Controlled Waters	Given the absence of any potentially soluble / mobile contaminants of concern within the soil or current sources of potential pollutants and absence of a viable exposure pathway, it is concluded there is unlikely to be any unacceptable degree of risk to the identified controlled water receptors and the wider environ.
Ground Gas	Ground gas monitoring thus far (ongoing) has indicated the site would be classed as Characteristic Situation 1 in accordance with CIRIA 665 which states that ground gas protection measures are not required. However, the final ground gas regime will be confirmed following the completion of the ground gas monitoring programme.
Potable Water	A full UKWIR will be required upon completion of the proposed Remediation and Enabling works.

Geotechnical Issues

The underlying Sherwood sandstone has been assessed as having an ABP in excess of 400kN/m^2 at depths of >6.00m bgl.

E3P consider it feasible to construct the proposed residential apartment blocks on driven piled foundations;

The final foundation solution will be dependent on the structural loadings, elevation and should be designed by a suitably qualified structural engineer with detailed designs from a specialist piling contractor;

It is assumed that site levels will remain close to present for the proposed residential development, however a minor programme of cut and fill works may be required to remove buried obstructions;

The granular Made Ground deposits could likely be re-engineered to provide a sub-grade formation to support proposed roads and infrastructure with a likely CBR in excess of 5% during periods of favourable climatic weather conditions; and

The underlying natural strata are likely to offer very good effective permeability, however due to the visual and olfactory evidence of hydrocarbon impact at the site, the use of soakaway drainage systems are not considered viable in this instance.

END OF REPORT

APPENDIX I
LIMITATIONS



1. This report and its findings should be considered in relation to the terms of reference and objectives agreed between E3P and the Client as indicated in Section 1.2.

2. For the work, reliance has been placed on publicly available data obtained from the sources identified. The information is not necessarily exhaustive and further information relevant to the site may be available from other sources. When using the information it has been assumed it is correct. No attempt has been made to verify the information.

3. This report has been produced in accordance with current UK policy and legislative requirements for land and groundwater contamination which are enforced by the local authority and the Environment Agency. Liabilities associated with land contamination are complex and requires advice from legal professionals.

4. During the site walkover reasonable effort has been made to obtain an overview of the site conditions. However, during the site walkover no attempt has been made to enter areas of the site that are unsafe or present a risk to health and safety, are locked, barricaded, overgrown, or the location of the area has not be made known or accessible.

5. Access considerations, the presence of services and the activities being carried out on the site limited the locations where sampling locations could be installed and the techniques that could be used.

6. Site sensitivity assessments have been made based on available information at the time of writing and are ultimately for the decision of the regulatory authorities.

7. Where mention has been made to the identification of Japanese Knotweed and other invasive plant species and asbestos or asbestos-containing materials this is for indicative purposes only and do not constitute or replace full and proper surveys.

8. The executive summary, conclusions and recommendations sections of the report provide an overview and guidance only and should not be specifically relied upon without considering the context of the report in full.

9. E3P cannot be held responsible for any use of the report or its contents for any purpose other than that for which it was prepared. The copyright in this report and other plans and documents prepared by E3P is owned by them and no such plans or documents may be reproduced, published or adapted without written consent. Complete copies of this may, however, be made and distributed by the client as is expected in dealing with matters related to its commission. Should the client pass copies of the report to other parties for information, the whole report should be copied, but no professional liability or warranties shall be extended to other parties by E3P in this connection without their explicit written agreement there to by E3P.

10. New information, revised practices or changes in legislation may necessitate the re-interpretation of the report, in whole or in part.

APPENDIX II
GLOSSARY



TERMS

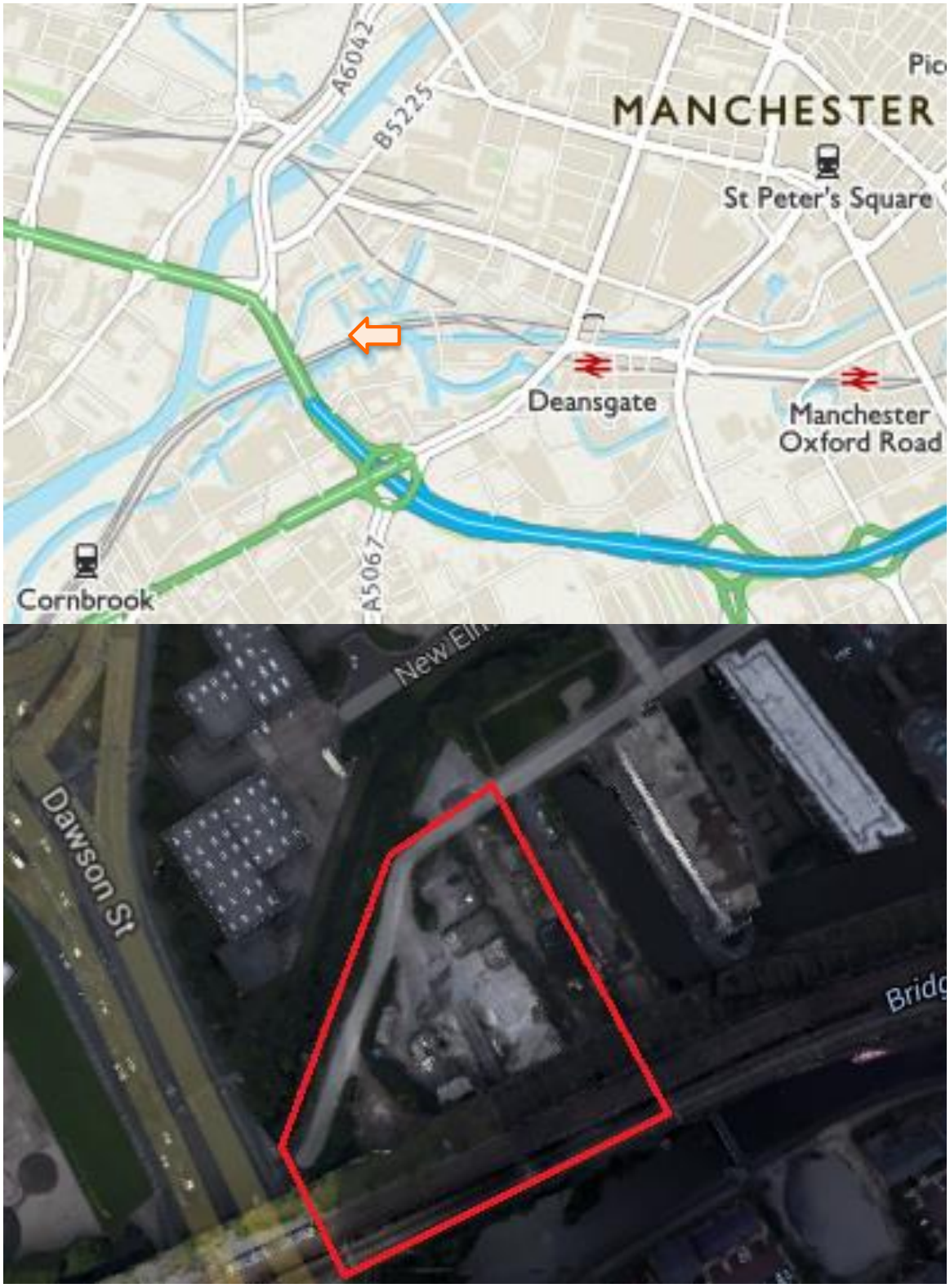
AST	Above Ground Storage Tank
BGS	British Geological Survey
BSI	British Standards Institute
BTEX	Benzene, Toluene, Ethylbenzene, Xylenes
CIEH	Chartered Institute of Environmental Health
CIRIA	Construction Industry Research Association
CLEA	Contaminated Land Exposure Assessment
CSM	Conceptual Site Model
DNAPL	Dense Non-Aqueous Phase Liquid (chlorinated solvents, PCB)
DWS	Drinking Water Standard
EA	Environment Agency
EQS	Environmental Quality Standard
GAC	General Assessment Criteria
GL	Ground Level
GSV	Gas Screening Value
HCV	Health Criteria Value
ICSM	Initial Conceptual Site Model
LNAPL	Light Non-Aqueous Phase Liquid (petrol, diesel, kerosene)
ND	Not Detected
LMRL	Lower Method Reporting Limit
NR	Not Recorded
PAH	Poly Aromatic Hydrocarbon
PCB	Poly-Chlorinated Biphenyl
PID	Photo Ionisation Detector
QA	Quality Assurance
SGV	Soil Guideline Value
SPH	Separate Phase Hydrocarbon
Sp.TPH (CWG)	Total Petroleum Hydrocarbon (Criteria Working Group)
SPT	Standard Penetration Test
SVOC	Semi Volatile Organic Compound
UST	Underground Storage Tank
VCCs	Vibro Concrete Columns
VOC	Volatile Organic Compound
WTE	Water Table Elevation

UNITS

m	Metres
km	Kilometres
%	Percent
%v/v	Percent volume in air
mb	Milli Bars (atmospheric pressure)
l/hr	Litres per hour
µg/l	Micrograms per Litre (parts per billion)
ppb	Parts Per Billion
mg/kg	Milligrams per kilogram (parts per million)
ppm	Parts Per Million
mg/m^3	Milligram per metre cubed
m bgl	Metres Below Ground Level
m bcl	Metre Below Cover Level
mAOD	Metres Above Ordnance Datum (sea level)
kN/m^2	Kilo Newtons per metre squared
µm	Micro metre

APPENDIX III
DRAWINGS





Drawing 10-609-001 - Site Location Plan

APPENDIX IV
EXPLORATORY HOLE LOGS



APPENDIX V
CHEMICAL TESTING RESULTS



APPENDIX VI
GEO-TECHNICAL TESTING RESULTS



APPENDIX VII
ORIGIN OF TIER I GENERIC ASSESSMENT CRITERIA



CONSTITUENT	ORIGIN OF RISK ASSESSMENT VALUE
Arsenic	S4UL's - LQM CIEH 2nd Edition 2009
Cadmium	S4UL's - LQM CIEH 2nd Edition 2009
Chromium	S4UL's - LQM CIEH 2nd Edition 2009
Lead	PC4SL
Mercury	S4UL's - LQM CIEH 2nd Edition 2009
Nickel	S4UL's - LQM CIEH 2nd Edition 2009
Selenium	S4UL's - LQM CIEH 2nd Edition 2009
Copper	S4UL's - LQM CIEH 2nd Edition 2009
Zinc	S4UL's - LQM CIEH 2nd Edition 2009
Cyanide - Total	CLEA 1.06 Derived Value
Phenols - Total.	LQM CIEH 2nd Edition 2009 – 1% SOM
Naphthalene	General Assessment Criteria (GAC) developed by CIEH / LQM the using CLEA 1-06 with supporting data from SR3, SR7 and existing Tox report where applicable. 1% SOM S4UL's
Acenaphthylene	
Acenaphthene	
Fluorene	
Phenanthrene	
Anthracene	
Fluoranthene	
Pyrene	
Benzo(a)Anthracene(	
Chrysene	
Benzo(b/k)Fluoranthene (iii)	
Benzo(a)Pyrene	PC4SL
Indeno(123-cd)Pyrene	S4ULs – 2015- General Assessment Criteria (GAC) developed by CIEH / LQM the using CLEA 1-06 with supporting data from SR3, SR7 and existing Tox report where applicable. 1% SOM
Dibenzo(a,h)Anthracene	
Benzo(ghi)Perylene	
TPH C_5-C_6 (aliphatic)	
TPH C_6-C_8 (aliphatic)	
TPH C_8-C_{10} (aliphatic)	
TPH C_{10}-C_{12} (aliphatic)	
TPH C_{12}-C_{16} (aromatic)	
TPH C_{16}-C_{21} (aromatic)	
TPH C_{21}-C_{35} (aromatic)	