



e3p

Phase II Geoenvironmental Site Assessment
Northenden College

Reference:13-969-R1-1
Date: July 2020



PHASE II GEOENVIRONMENTAL SITE ASSESSMENT

Northenden College
Moss Hey Drive
Wythenshawe
Manchester
M23 0DH

Prepared for:
Cushman and Wakefield / The Manchester College

Report Ref: 13-969-R1-1
Date Issued: 21/07/2020

Northenden College

Phase II Geoenvironmental Site Assessment

July 2020

E3P

Taylor Road
Trafford Park
Urmston
M41 7JQ

+ 44 (0) 161 707 9612
<https://e3p.co.uk/>

Registered in England
CRN: 807255262

QUALITY ASSURANCE

PROJECT NUMBER	13-969		
VERSION	Version 1		
REMARKS	Final		
DATE	21 st July 2020		
PREPARED BY	E. Fearn		
QUALIFICATIONS	BSc (Hons), MSc, FGS		
SIGNATURE			
CHECKED BY	R. Hodnett		
QUALIFICATIONS	BSc (Hons), FGS		
SIGNATURE			
AUTHORISED BY	D. Cox		
QUALIFICATIONS	BSc (Hons), FGS, PIEMA, MIEEnvSci, CEnv		
SIGNATURE			

EXECUTIVE SUMMARY

Site Address	The Manchester College, Northenden Campus, Moss Hey Drive, Wythenshawe, Manchester, M23 0DH.	
Grid Reference	E 381981, N 390319.	
Site Area	7.37 Ha.	
Current Site Use	The current site consists of an active college campus. There is a large building in the north east of the site utilised as the main teaching facility with associated office, a residential building with an associated garage is located in the north west with skip containers along the northern boundary. A further two brick buildings are present along the western boundary of the site adjacent to the site entrance. A basketball court is located in the south east within the playing field area of the site. The west of the site is generally utilised as a car park with a further two car parks in the central area of the site. The site surface is made up of asphalt, soft landscaping areas with semi-mature and matures trees and the south east of the site being utilised as a playing field. The buildings are all in good condition and the site is relatively topographically flat with isolated areas of higher ground due to landscaping. The site is bound by a mixture of metal fencing, brick walls and mature trees. Vehicular access can be gained from the main site entrance through a large gate off Moss Hey Drive, with two pedestrian gates located either side. A second vehicular and pedestrian access gate is located along the northern boundary off Hollyhey Drive. A small pedestrian access point is also located in the south east corner of the site.	
Proposed Development	E3P understands that Cushman and Wakefield are retained for its professional services in relation to the proposed divestment and future redevelopment of Northenden College, Greater Manchester for low-rise residential housing with associated adopted estate roads and utility infrastructure.	
Previous Reports	E3P have been provided with a Phase I Environmental Report undertaken by REC Ltd (ref: 108393p1r0, dated October 2019) on behalf of The Manchester College. The pertinent information from the report is summarised in section 2.0 of this report.	
Environmental Setting	Drift Geology	Glaciofluvial Sheet Deposits – Devensian – SAND and GRAVELS.
	Bedrock Geology	Tarporley Siltstone Formation – SILTSTONE, MUDSTONE and SANDSTONE.
	Faults	There are no geological faults located within 1.00km of the site boundary.
	Hydrogeology	A Secondary A Aquifer (drift deposits) overlies a Secondary B Aquifer (bedrock). There are no groundwater abstractions identified within a 1.00 km radius of the site.
	Hydrology	The nearest surface water feature is an inland river located 205m south west. The river is not named but is within the catchment of the River Mersey.
	Flood Risk	Unaffected by flooding from rivers.



Site History	A review of the pertinent Ordnance Survey mapping dating from circa 1850 indicated that the site was undeveloped until 1935 when a school was constructed, and a large-scale development of residential properties had commenced in the surrounding area. Since 2010 the school had been demolished and replaced with a college, the site has remained relatively unchanged to the present day.
Utility Locations	A full ground penetrating radar (GPR) survey has been undertaken for the site identifying drainage, electricity, Virgin Media and gas infrastructure within the site boundary. The majority of services enter the site through the main gate off Moss Hey Drive to the west or via the entrance to the north of the site off Hollyhey Drive.
Landfill Sites and Ground Gases	A review of data from environmental searches indicates that there are two historical landfill sites located within 1.00km of the site boundary. The closest was located 478m north on Princess Road/Yew Tree Road, with waste type being disposed of is unknown and operational between 1948 and 1994. A further landfill is located at the Former Northenden Sewage Works 684m north east of the site and was operational between 1950 and 1965.
Radon	Unaffected – no special precautions required.
Coal Mining/Land Stability	The site is not located within a Coal Mining Reporting Area as defined by the Coal Authority.
Hazardous Installations	No hazardous installations that could potentially prejudice the proposed construction of highly sensitive residential dwellings have been identified within influencing distance of the subject site.
Ecology and Invasive Species	During the site investigation walkover there were no invasive species identified, however their presence cannot be ruled out as there are areas of overgrown vegetation along the boundaries of the site. There are two badger sets located on-site, in the north-western corner and north-eastern boundary of the site.

SITE INVESTIGATION

Ground Investigation Works	E3P has completed an intrusive ground investigation comprising mechanically excavated trial pits, window sample boreholes, BRE365 soakaway testing, concrete coring, dynamic cone penetrometers, super heavy dynamic probeholes and environmental monitoring installations.
Ground Conditions	TOPSOIL – 0.00m bgl to 0.70m bgl Across the southern area of the site, all exploratory hole locations encountered natural topsoil, with discrete areas in the north-east of the site. Topsoil was encountered from ground level to a maximum depth of 0.70m bgl. The topsoil comprised of a black brown slightly gravelly medium SAND with frequent rootlets and gravel of mudstone. MADE GROUND – 0.00m bgl to >2.10m bgl Made Ground was encountered primarily within the northern section of the site with an isolated area in the south of the site associated with the basketball court. Made Ground underlying the current buildings on site is anticipated to be at a depth > 1.60mbg. Furthermore, it should be assumed that the paths in the southern sector of the site will be underlain by 0.30m of Made Ground. The bund along the south-eastern boundary is assumed to contain Made Ground or reworked natural materials. Made Ground was encountered to a maximum depth of 2.10mbgl within TP129, however the full depth could not be proven due to inability to progress excavation due to the density of materials. This was also the case in WS122.



Ground Conditions	Within the northern and central areas of the site TP107, TP108, TP127, TP134, WS119 and WS122 were terminated due to the presence of concrete obstructions, which are considered to be attributed to historical development on the site. TP126 and TP134 were terminated within Made Ground deposits due to the collapse of the strata. TP128 was terminated due to the presence of a suspected former land drain. At exploratory hole locations within the landscaped areas of the site, this generally comprised of a reworked topsoil that was black brown slightly clayey medium sand with occasional gravel of mudstone and brick. This was underlain by a dark brown slightly clayey gravelly medium sand with occasional cobbles. The gravel comprised of mudstone, brick, concrete, plastic and timber with cobbles of brick. At three locations, TP124, TP125 and TP133 the dark brown gravelly medium sand is overlain by asphalt and a grey sandy gravel (MOT). In the very northern area of the site (TP106, TP136 and TP137) encountered a grey sandy gravel (MOT) with occasional rootlets and gravel of mudstone, limestone and brick from ground level to 0.30m bgl. Within exploratory hole locations within the car parks, these encountered asphalt underlain by a grey sandy gravel (MOT) which was underlain by a black red sandy gravel with gravel of brick or a black brown slightly clayey gravelly medium sand with gravel of mudstone, asphalt and brick. DRIFT – 0.20m bgl to 5.45m bgl The drift deposits underlying the site generally comprised of a light yellow brown gravelly medium SAND with gravel of mudstone and sandstone underlain by a light grey brown gravelly medium SAND with gravel of mudstone and sandstone. A stiff high strength to very stiff high strength light brown mottled grey gravelly sandy CLAY with gravel of mudstone was subsequently encountered beneath granular deposits. Within WS107 and WS115, a very soft extremely low strength light brown very sandy gravelly CLAY with gravel of mudstone and sandstone was encountered at 1.90m bgl and 3.20m bgl respectively. Furthermore, soft CLAY was identified from 3.10-3.40mbgl within SHDP102, SHDP105 at 3.20-3.30mbgl, 3.00-3.10mbgl within SHDP112, 3.20-3.80mbgl within SHDP116. Laboratory undrained shear strength testing has identified soft clays within WS129 at 3.50-4.00mbgl. SOLID – The solid bedrock geology was not encountered across the site. GROUNDWATER – Groundwater was encountered between 1.50m bgl and 3.00m bgl as seepages and saturated strata.
---------------------------------	--



CONTAMINATED LAND ASSESSMENT

Human Health

A Tier I human health risk assessment has been undertaken using the chemical analysis results of the soils and comparing to the relevant Tier I criteria. This assessment has identified the presence of elevated arsenic, dibenzo(a,h)anthracene and asbestos.

The majority of the identified elevated concentrations have primary exposure pathways related to dermal contact and ingestion, soil ingestion and consumption of homegrown produce. These exceedances can be mitigated by the installation of a chemically suitable cover system within all proposed garden areas.

Asbestos, in the form of chrysotile loose fibres, has also been identified within one localised areas in shallow Made Ground deposits at WS118 at 0.30m bgl. Asbestos quantification was undertaken to further assess where these soils may be placed which identified 0.002% asbestos by volume/weight. No visual signs of asbestos-containing material (ACM) were encountered during the ground investigation, therefore it is likely only trace fibres are present within these localised soils and a process of hotspot excavation with placement of impacted soils in accordance with the E3P Asbestos CSM should be undertaken within an area of low sensitivity.

Chemical analysis of the natural SAND and CLAY drift deposits have identified these soils to be acceptable for use as subsoil within the proposed garden areas; however, further chemical validation samples will be required to confirm this.

There are potential suitable sources of topsoil available on the site, however isolated occurrences of exceedances of dibenzo(a,h)anthracene have been identified within natural topsoil deposits. Analysis of exceedances against human health remediation targets for residential end use at an SOM of 2.5% for dibenzo(a,h)anthracene of 0.28mg/kg show that the two natural topsoil samples which have exceeded the GAC at 1% SOM are still noted to be exceeding.

During the enabling works these soils should be segregated, and further chemical analysis undertaken of the remaining natural topsoil deposits to ensure suitability for use within the proposed development and confirm the identified elevated concentrations are indeed hotspots and not representative of the topsoil as a whole. Excavated impacted topsoil materials not suitable for use within the garden cover system cannot be placed at a depth greater than 1.00 m with gardens and must be 2.00 m off-set from plots.

Anthropogenic topsoil is likely to be impacted across the site and therefore will not be suitable for use within the proposed development. During enabling works these soils should be segregated and disposed off-site at a licensed waste facility.

Further post-demolition investigations are required beneath current buildings on site and areas in which access has been prohibited due to utility infrastructure, to confirm the findings of this initial assessment as and when full and unrestricted access is available.



Controlled Waters	There is considered to be a low risk to controlled waters. SVOC analysis of groundwater samples have identified concentrations above the laboratory limit of detection of Isophorone (WS102 – 8.0 µg/l; WS117 – 2.9 µg/l), Diethyl phthalate (WS102 – 2.5 µg/l; WS117 – 1.5 µg/l; WS123 – 0.92 µg/l); and, Dibutyl phthalate (WS102 – 0.29 µg/l; WS117 – 1.0 µg/l; WS123 – 0.81 µg/l). A primary source for these determinants has not been identified on site however may be attributed to the presence of paint or degradation of plastics within the Made Ground. It is recommended further groundwater monitoring and soil analysis in the vicinity of WS102, WS117 and WS123. The underlying granular drift deposits are underlain by >5.0m of glacial till deposits which will afford the protection of the underlying aquifer.
Ground Gas	Ground gas monitoring thus far has indicated the majority of the site would be classified as Characteristic Situation 1 or Green, suggesting no gas protection measures will be required across the majority of the site, with localised areas of Characteristic Situation 2. The final ground gas regime will be confirmed following the completion of the ground gas monitoring programme. With isolated areas falling into classification CS2 / Amber 1 it is considered that upon completion of the ground gas monitoring period a zoned approach may be feasible.
Potable Water Infrastructure	This will need to be confirmed following the completion of a UKWIR risk assessment. Post-remediation and enabling works ground conditions may be different from those identified during this site investigation which have indicated PE pipe will be suitable. However an allowance for barrier pipeline may be required at the proposed development dependent upon imported materials.

GEOTECHNICAL ASSESSMENT

Underground Obstructions	Significant concrete and brick obstructions have been encountered within the Made Ground, indicative of historical development and potential infilled areas in the landscaped areas in the north of the site. Slabs and foundations are also anticipated beneath the current buildings on-site. During a phase of cut-and-fill enabling works to create a developable platform, all below-ground obstructions will require grubbing out to the base of the Made Ground to enable the construction of proposed plots
Allowable Bearing Pressure	The underlying natural clay drift deposits have been assessed as generally being firm low strength to very stiff, high strength with a net allowable bearing pressure (ABP) in the order of between 71 kN/m² and 426 kN/m² at depths between 3.00m bgl and 5.00m bgl. At WS107, the natural clay drift deposits have been assessed as being very soft extremely low strength with a net allowable bearing pressure (ABP) of 18 kN/m² at a depth of 2.00m bgl. Within WS115 a calculated ABP of 17 kN/m² has been encountered at 3.00m bgl. Laboratory undrained shear strength testing of WS101 and WS129 identified soft clays with undrained shear strengths of 28 kN/m² and 39 kN/m² respectively between 3.50-4.00mbgl. The use of VSC will be limited where the calculated ABP is <30 kN/m². The granular drift deposits have been assessed as being loose to dense with a net allowable bearing pressure (ABP) of 17 kN/m² and 342 kN/m² between 1.00m bgl and 2.00m bgl. The deeper soil profiles are saturated by the natural groundwater body that results in the reduction in the calculated safe ABP by 50% as is demonstrated by the significant decrease in the calculated SPT N Value at depth.



Foundation Options	Upon completion of enabling works, it is likely that the most cost effective option for the majority of the site would be a combination of strip and mass trench fill foundations, and an engineered solution where founding strata has been encountered at greater depths in excess of 2.00m bgl due to loose SANDs, soft CLAYs or deeper Made Ground. Very loose or loose SAND deposits and very soft CLAY deposits have been identified across the site, in addition to saturated sand strata within window sample probe holes where groundwater has been encountered. The deeper soil profiles are saturated by the natural groundwater body that results in the reduction in the calculated safe ABP by 50% as is demonstrated by the significant decrease in the calculated SPT N Value at depth. Within the areas of loose SANDs the use of vibro stone columns (VSC) is advised. However, where soft CLAYs have been identified with an ABP <30kN/m², either driven piled foundations are required, or soft clays should be removed and replaced with granular material to allow the use of VSC. Within areas of saturated strata the VSC should be completed via the use of a bottom feed. At WS107, the natural clay drift deposits have been assessed as being very soft extremely low strength with a net allowable bearing pressure (ABP) of 18 kN/m² at a depth of 2.00m bgl. Within WS115 a calculated ABP of 17 kN/m² has been encountered at 3.00m bgl. Laboratory undrained shear strength testing of WS101 and WS129 identified soft clays with undrained shear strengths of 28 kN/m² and 39 kN/m² respectively. The use of VSC will be limited where ABP is <30 kN/m². It should be noted that mechanically excavated trial pits were generally stable within granular deposits. Collapse in window samples occurred when the groundwater or saturated strata was encountered. SHDPs have identified loose granular deposits within both shallow and deep granular horizons. Consideration of the bulb of pressure on the underlying loose sands at depth should be taken and will require an engineered design. Foundation depths within the conjectured influence of former, existing or proposed trees will need to be deepened to ensure that structural loading bears within the underlying target founding stratum, which cannot be subject to volumetric instability associated with fluctuation in moisture content. Furthermore, following the demolition of the current buildings on site, there will likely be in excess of 1.50m of Made Ground, therefore it would be considered necessary to remediate the ground to enable the use of VSC. Where Made Ground has been identified to be depths >1.45mbgl. dependent on development levels, for plots in these areas it may be more economic to consider the use of VSC in areas outside of tree influence in the event cohesive materials subject to volumetric instability are encountered. Consideration must be given to the aforementioned soft clay deposits that are isolated on site. Where cohesive deposits are present in influencing distance of trees consideration must be given to the viability as the foundation will still require locally deepening or the clays that are subject to volumetric instability. Materials could be removed and replaced with site won natural sands during the enabling works to accommodate for this solution. Side walls of trial pits generally remained stable during excavation; however, where water strikes were observed the stability was compromised.
Building Floor Slabs	Ground-bearing floor slabs are unlikely to be viable given the anticipated depths or reworked Made Ground > 600 mm.



Heave Precautions	Given that the majority of the underlying clay is of low volume change potential, heave precautions will not be required to the internal face of a foundation less than 1.5 m in depth. Heave precautions will be required to the underside of floor slabs (where there is no 200 mm void and in areas of medium volume change potential) and pile ground beams are required within the modelled influencing distance of trees. Heave precautions will be required in areas in which medium volume change potential clays have been identified.
Soakaway Drainage	The BRE365 soakaways tests completed across the site have calculated permeability coefficients of between 3.65 E-05 and 9.33 E-05. The design and viability of soakaways on site should be designed by a suitably qualified drainage engineer.
Sulphate Assessment	Concrete classification will be DS-1 AC-1s.
CBR Design %	Granular soils can be re-engineered to ensure 5% within the subgrade during favourable climatic conditions. Natural clay soils will provide a CBR in the order of 3–5% during drier climatic periods; however, if water is allowed to shed onto the formation, the CBR will reduce to < 2%, which will require specialist engineering of the subgrade.
Cut/Fill	Development levels unknown at this time; however, significant cut-and-fill works may be required to prepare the development platform. Demolition of the college and associated buildings is required which will necessitate engineering works to create a suitable development platform.
Civil Engineering Excavations	The E3P Intrusive Ground Investigation has not identified the presence of weathered/competent bedrock at a shallow depth. Running sands have not been encountered on site. Obstructions have been encountered on site which will require grubbing out and removal in their entirety during remediation and enabling works. Minor water ingress will require localised dewatering/sump pumping during the construction of site drainage infrastructure. Ingress of water into foundation excavation will potentially flood foundation excavations, limiting the viability of spread foundations to be constructed. Trial pits were generally stable in the shallow granular natural strata; as such, it is considered that near-surface excavations will be feasible. In areas where Made Ground was encountered, excavations were generally less stable. Window sample probeholes were noted to be unstable in granular deposits, in particular where groundwater was encountered.
Waste Characterisation	Any material that is to be disposed off-site should undergo assessment using Technical Guidance WM3: <i>Waste Classification – Guidance on the classification and assessment of waste</i> .



RECOMMENDATIONS

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

-  Post-demolition site investigation beneath current buildings and in the vicinity of the electricity substation;
-  Further groundwater monitoring within WS102; WS117 and WS123 to further refine the controlled waters risk assessment;
-  Plot-specific foundation schedule (upon receipt of the final development levels);
-  Arboricultural survey;
-  Materials management plan;
-  Geotechnical earthworks strategy (infrastructure);
-  Remediation and enabling works strategy; and,
-  Full three-dimensional earthworks cut/fill model.



Table of Contents

EXECUTIVE SUMMARY	2
1. INTRODUCTION	12
1.1. Background	12
1.2. Proposed Development	12
1.3. Objectives	12
1.4. Limitations	13
1.5. Confidentiality	13
2. PREVIOUS REPORTS	14
3. GROUND INVESTIGATION	15
3.1. General Overview	15
3.2. In-Situ Standard Penetration Testing (SPT)	17
3.3. In-Situ California Bearing Ratio (CBR)	17
3.4. Permeability Tests	18
3.5. Laboratory Analysis	18
4. GROUND AND GROUNDWATER CONDITIONS	19
4.1. Summary of Ground Conditions	19
4.2. Topsoil	21
4.3. Made Ground	21
4.4. Drift Deposits	21
4.5. Solid Geology	22
4.6. Groundwater	22
4.7. Visual and Olfactory Evidence of Contamination	22
4.8. Soil Consistency	23
4.9. Side Stability and Ease of Excavation	23
4.10. Soil Compressibility	31
4.11. Soil Infiltration	31
4.12. Soil Plasticity	32
4.13. Particle Size Distribution	33
4.14. California Bearing Ratio	33
4.15. pH and Sulphate	34
4.16. Ground Gas	35
4.17. Investigation Rationale	35
4.18. Monitoring Methodology	36
5. TIER I QUALITATIVE CONTAMINATED LAND RISK ASSESSMENT	40
5.1. Deviating Samples	40
5.2. Human Health Risk Assessment	40
5.3. Controlled Waters Risk Assessment	44
5.4. Ground Gas	48
5.4.1. Sources of Ground Gas	49
5.4.2. Groundwater	49
5.4.3. Gas Flow	49
5.4.4. Gas Concentrations	49
5.4.5. Gas Assessment	49
5.5. Residential Building Gas Risk Mitigation	51
5.6. Potable water supply	55
5.7. Conceptual Site Model	56
6. GEOTECHNICAL ASSESSMENT	60
6.1. Proposed Development	60
6.2. Summary of Ground Conditions	60
6.3. Site Preparation	61



6.4.	Foundation Conditions and Assessment of Potential Bearing Capacities	61
6.5.	Ground Floor Slabs.....	69
6.6.	Heave Precautions	69
6.7.	Highways Construction	70
6.8.	Drainage	70
6.9.	Concrete Durability	71
6.10.	Excavations.....	71
6.11.	Further Works	71
6.12.	Construction Activity and Inspection.....	72
6.13.	GEOTECHNICAL RISK REGISTER	73
7.	CONCLUSIONS AND RECOMMENDATIONS	75
	Contaminated Land Assessment.....	75
	Geotechnical Assessment	76
	APPENDIX I LIMITATIONS	78
	APPENDIX II GLOSSARY	80
	APPENDIX III DRAWINGS	83
	APPENDIX IV PHOTOGRAPHS	85
	APPENDIX V E3P EXPLORATORY HOLE LOGS	91
	APPENDIX VI CHEMICAL TESTING RESULTS	92
	APPENDIX VII ORIGIN OF TIER I GENERIC ASSESSMENT CRITERIA	93
	APPENDIX VIII GEOTECHNICAL TEST CERTIFICATES	95
	APPENDIX IX SOAKAWAY TEST CERTIFICATES	96
	APPENDIX X DYNAMIC CONE PENETROMETER TEST CERTIFICATES	97
	APPENDIX XI SUPER HEAVY DYNAMIC PROBE CERTIFICATES	98

DRAWING LIST

13-969-R1-001 - Site Location Plan
13-969-R1-003 - Historical Features Plan
13-969-R1-004 - Site Features Plan
13-969-R1-005 - Exploratory Hole Location Plan
13-969-R1-006 - Depth of Made Ground Plan
13-969-R1-007 - Depth to Topsoil Plan
13-969-R1-008 - Depth to Founding Strata Plan
13-969-R1-010 - Conceptual Site Model
13-969-R1-015 - Development Constraints Plan



1. INTRODUCTION

1.1. BACKGROUND

E3P has been commissioned by Cushman and Wakefield on behalf of The Manchester College to undertake a detailed Phase II Geoenvironmental Site Assessment for the land at Northenden College, Greater Manchester.

This report is required to determine potential contaminated land liabilities, remediation requirements and geotechnical engineering works that will be required as part of the proposed development for a proposed low-rise residential development.

The scope of work includes the following elements:

-  Detailed review of historic information;
-  Design of suitable intrusive ground investigation;
-  Window sample probeholes with, and construction of, environmental monitoring installations;
-  Mechanically excavated trial pits;
-  Super heavy dynamic probes;
-  BRE 365 Soakaway testing;
-  Dynamic cone penetrometer testing;
-  In-situ geotechnical testing;
-  Chemical and geotechnical laboratory analysis;
-  Groundwater monitoring and sampling;
-  Ground gas monitoring;
-  Contamination risk assessment and conceptual site model;
-  Geotechnical assessment and interpretation; and
-  Factual and interpretive reporting.

1.2. PROPOSED DEVELOPMENT

E3P understands that Cushman and Wakefield are progressing a marketing campaign in relation to the proposed divestment and future redevelopment of Northenden College, Greater Manchester for low-rise residential housing with associated adopted estate roads and utility infrastructure.

At present, there is no proposed development plan available.

1.3. OBJECTIVES

The objectives of the geoenvironmental assessment are as follows:

-  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.
-  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.



2. PREVIOUS REPORTS

A Phase I Environmental Report was undertaken by REC Ltd– TMC Northenden Campus, Wythenshawe (ref: 108393p1r0, dated October 2019) on behalf of The Manchester College. The pertinent information from the report is summarised below:

- ✳ The site is currently utilised as an active college campus with a large building in the north used for offices and teaching facilities. A residential building with associated garage is located in the north western corner with various storage skips present along the northern boundary. An unidentified brick structure is also present in the west by the entrance gate that is likely to be a utilities box but was not labelled. The western area of the site is generally utilised as a car park. The south eastern area of the site is used as playing fields and is bound by metal fencing. A basketball court is also located in the south eastern area of the site.
- ✳ The site is underlain by Glaciofluvial Sheet Deposits drift deposits which is in turn underlain by the Tarporley Siltstone Formation of siltstone, mudstone and sandstone. The drift deposits comprise a Secondary A Aquifer and the underlying bedrock comprise a Secondary B Aquifer.
- ✳ The data search indicates that there are no historical or active groundwater abstraction licenses within 1.0km of the site. The site also does not lie within a Groundwater Source Protection Zone (SPZ).
- ✳ The nearest surface water feature is an inland river located 205m south west of the site boundary. The river is not named, however it is in the catchment area of the River Mersey.
- ✳ The site is not located within any Environment Agency Floodplain Zones and is in an area with a “Very Low” risk of flooding from rivers and the sea.
- ✳ The site is not located within a Coal Mining Reporting Area as defined by the Coal Authority.
- ✳ The site is not located within a radon affected area as less than 1% of properties are above the action level. No radon protective measures are necessary.
- ✳ There are three Local Nature Reserves recorded within 250m of the site boundary; the closest being Wythenshawe Park located 42m south. There are four records of green belt land the closest being the Liverpool, Manchester and West Yorks Greenbelt located 153 m north.
- ✳ A review of the data searches indicates that there are two historic Environmental Agency licensed waste sites within 1.00km. The closest was a located 478m north on Princess Road / Yew Tree Road, Greater Manchester. The waste type disposed of at this landfill is unknown and was last recorded in December 1994.
- ✳ The site is considered to be within a low to moderate sensitivity setting.
- ✳ On-site contaminant sources are deemed to be the underlying Made Ground associated with historic development and electricity substation on the western boundary.
- ✳ REC Ltd concluded that the preliminary risk classification of the site in relation to future development is low to moderate. The risk to human health is considered to be low / moderate, and potential risks from off-site are negligible. The risk to groundwater aquifers is considered to be low.
- ✳ The REC report recommends an intrusive ground investigation should be undertaken.



3. GROUND INVESTIGATION

3.1. GENERAL OVERVIEW

A ground investigation has been designed based on the findings of the desk study, with exploratory holes advanced to target specific potential contaminant sources summarised in Table 3.1. The investigation has also been used to collect geotechnical information to assist in the design and construction of the proposed development.

Exploratory fieldwork was completed between 12th May 2020 and 21st May 2020. The works are summarised in Table 3.1.

Ground investigation works were limited to areas of landscaping and located in areas that would limit disruption to areas of hardstanding / car parking due to the active nature of the site. Live utility services are present across the site which limited areas suitable for intrusive investigation. Investigation could not be completed in close proximity to the electricity substation in the west of the site due to its active nature.



TABLE 3.1 SUMMARY OF FIELDWORK

POTENTIAL SOURCE/RATIONALE	LOCATION HOLE	TYPE	MAXIMUM DEPTH (m bgl)	MONITORING WELLS RESPONSE ZONE (m bgl)
General Ground Conditions Including the Presence/Nature of Obstructions in the South of the Site (Former and Current Playing Fields, Sports Pitch, Hardstanding)	WS101	Window Sample Probehole	4.45	N/A
	WS102		5.45	1.00-5.00
	WS103		5.45	1.00-5.00
	WS104		5.45	N/A
	WS105		4.45	1.00-2.00
	WS106		5.45	1.00-5.00
	WS107		4.45	N/A
	WS108		5.45	N/A
	WS109		5.45	1.00-5.00
	WS110		5.45	1.00-5.00
	WS111		4.45	1.00-3.00
	WS112		4.45	N/A
	WS117		5.45	1.00-5.00
	TP101 – TP104, TP109-TP124	Mechanically Excavated Trial Pit	2.20	N/A
	SHDP101-SHDP113	Super Heavy Dynamic Probes	6.00	N/A
General Ground Conditions Including the Presence/Nature of Obstructions in the Central Sector of the Site (Former Yew Tree School, Former Buildings, Former Playing Field; Current Car Parking and Landscaped Areas)	WS113	Window Sample Probehole	4.45	1.00-3.00
	WS114		4.45	N/A
	WS115		5.45	0.50-3.50
	WS116		5.45	N/A
	WS118		5.45	N/A
	WS119		1.45	N/A
	WS125		5.45	1.00-3.00
	TP105, TP107, TP125-TP134	Mechanically Excavated Trial Pit	2.20	N/A
	SHDP114 - SHDP117	Super Heavy Dynamic Probes	6.00	N/A
General Ground Conditions Including the Presence/Nature of Obstructions in the Northern Sector of the Site (former Allotments, Former Arden College, Former Tennis Court, Former Playing Field; Current Car Parking, Former Development Areas)	WS120	Window Sample Probehole	4.45	N/A
	WS121		5.45	1.00-5.00
	WS122		0.95	N/A
	WS123		5.45	1.00-5.00



POTENTIAL SOURCE/RATIONALE	LOCATION HOLE	TYPE	MAXIMUM DEPTH (m bgl)	MONITORING WELLS RESPONSE ZONE (m bgl)
General Ground Conditions Including the Presence/Nature of Obstructions in the Northern Sector of the Site (former Allotments, Former Arden College, Former Tennis Court, Former Playing Field; Current Car Parking, Former Development Areas)	WS124	Window Sample Probehole	5.45	1.00-5.00
	WS126		5.45	N/A
	WS127		5.45	1.00-5.00
	WS128		5.45	1.00-5.00
	WS129		5.45	1.00-4.00
	TP106, TP108, TP135-TP137	Mechanically Excavated Trial Pit	2.20	N/A
	SHDP118-SHDP124	Super Heavy Dynamic Probes	6.00	N/A
Assessment of Infiltration Potential	SA101-SA106	BRE 365 Soakaway Test	1.90	N/A

Mechanically excavated trial pits were advanced to investigate ground conditions and to retrieve environmental samples, spatially distributed to offer the maximum site coverage whilst also being advanced to target specific contaminant sources.

Window sample probeholes were advanced to undertake in-situ detailed geotechnical testing, obtain environmental samples and install groundwater and ground gas monitoring wells.

The super heavy dynamic probeholes were advanced to undertake detailed in-situ geotechnical testing at deeper soil horizons.

BRE365 soakaway testing was completed to determine the infiltration rate and potential suitability for soakaway drainage within the proposed development.

The sampling locations are illustrated in Drawing 13-969-005 (Appendix III). The ground conditions encountered are indicated on the logs, which are provided in Appendix V.

Return visits were made to monitor installations for groundwater level and gas concentrations. In addition, selected wells were purged and samples of groundwater recovered for chemical analysis.

3.2. 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 60° cone (SPT(C)) was used instead of the sampling tube. The results are shown in the probehole logs in Appendix V and presented in Table 4.5 and discussed in Section 6.

Super heavy dynamic probes were also undertaken to gain geotechnical information and densities of underlying materials across the site.

3.3. IN-SITU CALIFORNIA BEARING RATIO (CBR)

In-situ CBR tests were undertaken at selected locations using a TRL probe. Tests were undertaken at depths of between 0.03 m and 0.89 m below ground level in order to intersect the likely pavement sub formation level. The results are presented in Table 4.10 and test certificates are included within Appendix X.



3.4. PERMEABILITY TESTS

Six BRE365 soakaway permeability tests were undertaken at SA101, SA102, SA103, SA104, SA105 and SA106 in order to assess the likely permeability of the underlying strata to determine the potential suitability for soakaway drainage within the proposed development. The results are presented in Table 4.7 and the test certificates are included within Appendix IX.

3.5. LABORATORY ANALYSIS

Selected soil samples were submitted for a range of chemical analysis comprising:

-  Metals.
-  pH, total sulphate, water-soluble sulphate (2:1 extract).
-  Sulphide.
-  Cyanide.
-  Phenols. -
-  Total and speciated polycyclic aromatic hydrocarbons (PAHs).
-  Total Organic Carbon (TOC).
-  Semi Volatile Organic Compounds (SVOC).
-  Volatile Organic Compounds (VOC).
-  Asbestos identification and quantification.
-  Speciated and banded total petroleum hydrocarbon (TPH).

I2 Analytical undertook the analytical work and the testing results are included in Appendix VI and discussed in Section 5.

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

-  Atterberg limits determinations;
-  Moisture content;
-  Single-stage triaxial tests;
-  One-dimensional consolidation tests; and
-  Particle Size Distribution tests.

Laboratory analysis sheets are included in Appendix VIII and are summarised in Section 6.



4. GROUND AND GROUNDWATER CONDITIONS

4.1. SUMMARY OF GROUND CONDITIONS

The ground investigation generally confirms the published geology and identifies the strata set out in Table 4.1.

TABLE 4.1 SUMMARY OF STRATA

HOLE	DEPTH TO STRATUM (m bgl)			
	MADE GROUND	TOPSOIL	STIFF CLAY	SAND
TP101/SA101	-	0.00-0.20	-	0.20-1.50
TP102/SA102	-	0.00-0.30	-	0.30-1.50
TP103/SA103	-	0.00-0.30	-	0.30-1.50
TP104/SA104	-	0.00-0.20	-	0.20-1.50
TP105/SA105	0.00-0.30	-	-	0.30-1.90
TP106/SA106	0.00-0.30	-	-	0.30-1.80
TP107	0.00-1.00	-	-	-
TP108	0.00-0.80	-	-	-
TP109	-	0.00-0.30	-	0.30-2.00
TP110	-	0.00-0.30	-	0.30-2.20
TP111	-	0.00-0.30	0.30-0.80	0.80-1.90
TP112	-	0.00-0.30	-	0.30-0.60
TP113	-	0.00-0.60	-	0.60-2.00
TP114	-	0.00-0.40	-	0.40-2.00
TP115	-	0.00-0.40	-	0.40-1.70
TP116	-	0.00-0.30	-	0.30-1.80
TP117	-	0.00-0.30	-	0.30-1.90
TP118	-	0.00-0.40	-	0.40-2.00
TP119	-	0.00-0.30	-	0.30-2.00
TP120	-	0.00-0.30	-	0.30-1.80
TP121	-	0.00-0.40	-	0.40-2.00
TP122	-	0.00-0.40	-	0.40-2.10
TP123	-	0.00-0.40	-	0.40-2.00
TP124	0.00-0.40	-	-	0.40-1.80
TP125	0.00-0.40	-	-	0.40-1.80
TP126	0.00-1.20	-	-	-
TP127	0.00-0.90	-	-	-
TP128	0.00-1.00	-	-	-
TP129	0.00-2.10	-	-	-
TP130	0.00-1.00	-	-	1.00-1.80
TP131	0.00-1.40	-	-	1.40-2.20



HOLE	DEPTH TO STRATUM (m bgl)			
	MADE GROUND	TOPSOIL	STIFF CLAY	SAND
TP132	0.00-0.80	-	-	0.80-2.20
TP133	0.00-0.70	-	-	0.70-1.80
TP134	0.00-1.60	-	-	-
TP135	0.00-0.50	-	-	0.50-2.20
TP136	0.00-0.60	-	-	0.60-2.20
TP137	0.00-0.20	-	-	0.20-1.80
WS101	-	0.00-0.20	2.50-4.45	0.20-2.50
WS102	-	0.00-0.30	2.60-5.45	0.30-2.60
WS103	-	0.00-0.20	2.00-5.45	0.20-2.00
WS104	-	0.00-0.30	3.20-5.45	0.30-3.20
WS105	-	0.00-0.30	3.30-4.45	0.30-3.30
WS106	-	0.00-0.40	2.50-5.45	0.40-2.50
WS107	0.00-0.60	-	0.60-4.45	-
WS108	-	0.00-0.70	3.60-5.45	0.70-3.60
WS109	-	0.00-0.50	2.40-5.45	0.50-2.40
WS110	-	0.00-0.40	2.40-5.45	0.40-2.40
WS111	-	0.00-0.30	3.80-4.45	0.30-3.80
WS112	0.00-0.80	-	4.20-4.45	0.80-4.20
WS113	0.00-1.10	-	3.40-4.45	1.10-3.40
WS114	-	0.00-0.15	2.50-4.45	0.15-2.50
WS115	0.00-1.40	-	3.20-5.45	1.40-3.20
WS116	-	0.00-0.80	3.20-5.45	0.80-3.20
WS117	0.00-0.90	-	3.20-5.45	0.90-3.20
WS118	0.00-0.90	-	2.50-5.45	0.90-2.50
WS119	0.00-1.45	-	-	-
WS120	0.00-0.50	-	3.60-4.45	0.50-3.60
WS121	0.00-0.70	-	2.70-5.45	0.70-2.70
WS122	0.00-0.95	-	-	-
WS123	0.00-0.90	-	2.80-5.45	0.90-2.80
WS124	0.00-0.80	-	2.60-5.45	0.80-2.60
WS125	0.00-1.60	-	3.10-5.45	1.60-3.10
WS126	0.00-0.30	-	2.60-5.45	0.30-2.60
WS127	0.00-0.20	-	2.40-5.45	0.20-2.40
WS128	0.00-0.30	-	2.20-5.45	0.30-2.20
WS129	0.00-0.30	-	2.80-4.45	0.30-2.80



4.2. TOPSOIL

Across the southern area of the site, all exploratory hole locations encountered natural topsoil, with discrete areas in the north-east of the site. Topsoil was encountered from ground level to a maximum depth of 0.70m bgl. The topsoil comprised of a black brown slightly gravelly medium SAND with frequent rootlets and gravel of mudstone.

4.3. MADE GROUND

Made Ground was encountered primarily within the northern section of the site with an isolated area in the south of the site associated with the basketball court. Made Ground underlying the current buildings on site is anticipated to be at a depth > 1.60mbgl. Furthermore, it should be assumed that the paths in the southern sector of the site will be underlain by 0.30m of Made Ground. The bund along the south-eastern boundary is assumed to contain Made Ground or reworked natural materials.

Made Ground was encountered to a maximum depth of 2.10mbgl within TP129, however the full depth could not be proven due to inability to progress excavation due to the density of materials. This was also the case in WS122.

Within the northern and central areas of the site TP107, TP108, TP127, TP134, WS119 and WS122 were terminated due to the presence of concrete obstructions, which are considered to be attributed to historical development on the site.

TP126 and TP134 were terminated within Made Ground deposits due to the collapse of the strata.

TP128 was terminated due to the presence of a suspected former land drain.

At exploratory hole locations within the landscaped areas of the site, this generally comprised of a reworked topsoil that was black brown slightly clayey medium sand with occasional gravel of mudstone and brick. This was underlain by a dark brown slightly clayey gravelly medium sand with occasional cobbles. The gravel comprised of mudstone, brick, concrete, plastic and timber with cobbles of brick.

At three locations, TP124, TP125 and TP133 the dark brown gravelly medium sand is overlain by asphalt and a grey sandy gravel (MOT).

In the very northern area of the site (TP106, TP136 and TP137) encountered a grey sandy gravel (MOT) with occasional rootlets and gravel of mudstone, limestone and brick from ground level to 0.30m bgl.

Within exploratory hole locations within the car parks, these encountered asphalt underlain by a grey sandy gravel (MOT) which was underlain by a black red sandy gravel with gravel of brick or a black brown slightly clayey gravelly medium sand with gravel of mudstone, asphalt and brick.

4.4. DRIFT DEPOSITS

The drift deposits underlying the site generally comprised of a light yellow brown gravelly medium SAND with gravel of mudstone and sandstone underlain by a light grey brown gravelly medium SAND with gravel of mudstone and sandstone. A stiff high strength to very stiff high strength light brown mottled grey gravelly sandy CLAY with gravel of mudstone was subsequently encountered beneath granular deposits.

Within WS107 and WS115, a very soft extremely low strength light brown very sandy gravelly CLAY with gravel of mudstone and sandstone was encountered at 1.90m bgl and 3.20m bgl respectively. Furthermore, soft CLAY was identified from 3.10-3.40mbgl within SHDP102, SHDP105 at 3.20-3.30mbgl, 3.00-3.10mbgl within SHDP112, 3.20-3.80mbgl within SHDP116. Laboratory undrained shear strength testing has identified soft clays within WS129 at 3.50-4.00mbgl.



4.5. SOLID GEOLOGY

The solid bedrock geology was not encountered throughout the site investigation works.

4.6. GROUNDWATER

Groundwater strikes were encountered as seepages. The depth of the seepages are shown on the exploratory hole records in Appendix V and are summarised in Table 4.2.

TABLE 4.2 SUMMARY GROUNDWATER STRIKES

LOCATION	DEPTH TO STRIKE (m)	NOTES
WS101	2.50	Seepage - Slight ingress
WS103	2.30	Seepage - Slight ingress
WS105	2.00	Seepage - Slight ingress
WS107	2.00	Seepage - Slight ingress
WS108	2.00	Seepage - Slight ingress
WS109	1.50	Seepage - Slight ingress
WS110	1.50	Seepage - Slight ingress
WS111	2.20	Seepage - Slight ingress
WS113	2.00	Seepage - Slight ingress
WS114	2.00	Seepage - Slight ingress
WS115	2.50	Seepage - Slight ingress
WS116	2.50	Seepage - Slight ingress
WS117	3.00	Seepage - Slight ingress
WS118	2.00	Seepage - Slight ingress
WS120	2.00	Seepage - Slight ingress
WS123	2.00	Seepage - Slight ingress
WS124	2.00	Seepage - Slight ingress
TP110	2.00	Strike - Slight ingress

It should be noted that within window sample probeholes, granular deposits were noted to be saturated beneath groundwater strikes / seepages.

Monitoring was undertaken using an electronic dip meter and interface probe to record the depth to groundwater. These results are summarised in Table 4.13.

4.7. VISUAL AND OLFACTORY EVIDENCE OF CONTAMINATION

Visual and olfactory evidence of potential contamination has not been identified during the site investigation completed to date.



4.8. SOIL CONSISTENCY

Undrained shear strength values were measured using both field hand shear vane tests and laboratory undrained triaxial tests. Results of the tests are presented in Table 4.3 and Table 4.4, which indicate the shallow clay soils to be soft to firm. Strength test data is generally consistent with the field descriptions of the aforementioned soils.

TABLE 4.3 SUMMARY OF HAND SHEAR VANE TESTS

LOCATION	DEPTH	SHEAR STRENGTH (kPA)	CALCULATED ALLOWABLE BEARING PRESSURE (kN/m ²)
TP111	0.50	61	143.35

Results of the standard penetration tests, including undrained shear strengths derived from SPTs are included in Table 4.5.

TABLE 4.4 SUMMARY OF UNDRAINED SHEAR STRENGTH TEST RESULTS

LOCATION	SAMPLE DEPTH (m)	LAB DESCRIPTION	UNDRAINED SHEAR STRENGTH (kN/m ²)	CONSISTENCY
WS101	3.50-4.00	Soft brown slightly gravelly sandy CLAY	28	Soft
WS108	3.50-4.00	Firm brown slightly gravelly very sandy CLAY	62	Firm
WS118	3.50-4.00	Firm brown slightly gravelly very sandy CLAY	53	Firm
WS129	3.50-4.00	Soft brown slightly gravelly CLAY	39	Soft

4.9. SIDE STABILITY AND EASE OF EXCAVATION

The sides of the exploratory trial pit excavations within the natural strata appeared to be generally stable during excavation. SAND deposits were noted to be unstable within window sample probeholes, largely at the water table and within saturated strata causing the collapse and therefore termination of locations.

Made Ground was encountered to a maximum depth of 2.10mbgl within TP129, however the full depth could not be proven due to inability to progress excavation due to the density of materials. This was also the case in WS122.

Within the northern and central areas of the site TP107, TP108, TP127, TP134, WS119 and WS122 were terminated due to the presence of concrete obstructions (slabs), which are considered to be attributed to historical development on the site.

TP126 and TP134 were terminated within Made Ground deposits due to the collapse of the strata.

TP128 was terminated due to the presence of a suspected former land drain.

The natural strata was excavated with relative ease.

The presence of brick and concrete cobbles within the Made Ground deposits meant that in certain places, excavation was slow through the Made Ground and in some places, Made Ground could not be fully penetrated. This also resulted in some instability within shallow Made Ground deposits and locations had to be terminated.



TABLE 4.5 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 (BS 5930)	TERZAGHI & PECK APPROXIMATE UNDRAINED SHEAR STRENGTH (kN/m ²)
WS101	1	Gravelly SAND	18	18.15	Medium Dense	N/A	N/A	N/A
WS101	2	Gravelly SAND	14	12.79	Medium Dense	N/A	N/A	N/A
WS101	3	Sandy CLAY	11	9.57	N/A	Medium strength	Stiff	47.83
WS101	4	Sandy CLAY	12	10.14	N/A	Medium strength	Stiff	50.69
WS102	1	Gravelly SAND	20	20.16	Medium Dense	N/A	N/A	N/A
WS102	2	Gravelly SAND	8	7.31	Loose	N/A	N/A	N/A
WS102	3	Sandy CLAY	12	10.44	N/A	Medium strength	Stiff	52.18
WS102	4	Sandy CLAY	11	9.29	N/A	Medium strength	Stiff	46.47
WS102	5	Sandy CLAY	12	9.96	N/A	Medium strength	Stiff	49.78
WS103	1	Gravelly SAND	20	20.16	Medium Dense	N/A	N/A	N/A
WS103	2	Sandy CLAY	9	8.22	N/A	Medium strength	Stiff	41.11
WS103	3	Sandy CLAY	14	12.18	N/A	Medium strength	Stiff	60.88
WS103	4	Sandy CLAY	13	10.98	N/A	Medium strength	Stiff	54.92
WS103	5	Sandy CLAY	17	14.10	N/A	Medium strength	Stiff	70.52
WS104	1	Gravelly SAND	20	20.16	Medium Dense	N/A	N/A	N/A
WS104	2	Gravelly SAND	11	10.05	Medium Dense	N/A	N/A	N/A
WS104	3	Sandy CLAY	15	13.04	N/A	Medium strength	Stiff	65.22
WS104	4	Sandy CLAY	15	12.67	N/A	Medium strength	Stiff	63.36
WS104	5	Sandy CLAY	19	15.76	N/A	High strength	Very Stiff	78.81
WS105	1	Gravelly SAND	34	34.28	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 (BS 5930)	TERZAGHI & PECK APPROXIMATE UNDRAINED SHEAR STRENGTH (kN/m ²)
WS105	2	Gravelly SAND	22	20.10	Medium Dense	N/A	N/A	N/A
WS105	3	Sandy CLAY	12	10.44	N/A	Medium strength	Stiff	52.18
WS105	4	Sandy CLAY	18	15.21	N/A	High strength	Very Stiff	76.04
WS106	1	Gravelly SAND	18	18.15	Medium Dense	N/A	N/A	N/A
WS106	2	Gravelly SAND	15	13.70	Medium Dense	N/A	N/A	N/A
WS106	3	Sandy CLAY	19	16.52	N/A	High strength	Very Stiff	82.62
WS106	4	Sandy CLAY	19	16.05	N/A	High strength	Very Stiff	80.26
WS106	5	Sandy CLAY	22	18.25	N/A	High strength	Very Stiff	91.26
WS107	1	Sandy CLAY	13	13.11	N/A	Medium strength	Stiff	65.53
WS107	2	Gravelly CLAY	2	1.83	N/A	Extremely low strength	Very Soft	9.14
WS107	3	Gravelly CLAY	7	6.09	N/A	Low strength	Firm	30.44
WS107	4	Sandy CLAY	23	19.43	N/A	High strength	Very Stiff	97.16
WS108	1	Gravelly SAND	18	18.15	Medium Dense	N/A	N/A	N/A
WS108	2	Gravelly SAND	19	17.36	Medium Dense	N/A	N/A	N/A
WS108	3	Gravelly SAND	17	14.78	Medium Dense	N/A	N/A	N/A
WS108	4	Sandy CLAY	21	17.74	N/A	High strength	Very Stiff	88.71
WS108	5	Sandy CLAY	21	17.42	N/A	High strength	Very Stiff	87.11
WS109	1	Gravelly SAND	17	17.14	Medium Dense	N/A	N/A	N/A
WS109	2	Gravelly SAND	12	10.96	Medium Dense	N/A	N/A	N/A
WS109	3	Sandy CLAY	13	11.31	N/A	Medium strength	Stiff	56.53



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 (BS 5930)	TERZAGHI & PECK APPROXIMATE UNDRAINED SHEAR STRENGTH (kN/m ²)
WS109	4	Sandy CLAY	15	12.67	N/A	Medium strength	Stiff	63.36
WS109	5	Sandy CLAY	21	17.42	N/A	High strength	Very Stiff	87.11
WS110	1	Gravelly SAND	13	13.11	Medium Dense	N/A	N/A	N/A
WS110	2	Gravelly SAND	15	13.70	Medium Dense	N/A	N/A	N/A
WS110	3	Sandy CLAY	16	13.91	N/A	Medium strength	Stiff	69.57
WS110	4	Sandy CLAY	15	12.67	N/A	Medium strength	Stiff	63.36
WS110	5	Sandy CLAY	12	9.96	N/A	Medium strength	Stiff	49.78
WS111	1	Gravelly SAND	18	18.15	Medium Dense	N/A	N/A	N/A
WS111	2	Gravelly SAND	14	12.79	Medium Dense	N/A	N/A	N/A
WS111	3	Gravelly SAND	13	11.31	Medium Dense	N/A	N/A	N/A
WS111	4	Gravelly CLAY	22	18.59	N/A	High strength	Very Stiff	92.93
WS112	1	Gravelly SAND	24	24.20	Medium Dense	N/A	N/A	N/A
WS112	2	Gravelly SAND	19	17.36	Medium Dense	N/A	N/A	N/A
WS112	3	Clayey SAND	6	5.22	Loose	N/A	N/A	N/A
WS112	4	Sandy CLAY	23	19.43	N/A	High strength	Very Stiff	97.16
WS113	1	Gravelly SAND	17	17.14	Medium Dense	N/A	N/A	N/A
WS113	2	Gravelly SAND	22	20.10	Medium Dense	N/A	N/A	N/A
WS113	3	Gravelly SAND	8	6.96	Loose	N/A	N/A	N/A
WS113	4	Sandy CLAY	17	14.36	N/A	Medium strength	Stiff	71.81
WS114	1	Gravelly SAND	19	19.15	Medium Dense	N/A	N/A	N/A
WS114	2	Gravelly SAND	8	7.31	Loose	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 (BS 5930)	TERZAGHI & PECK APPROXIMATE UNDRAINED SHEAR STRENGTH (kN/m ²)
WS114	3	Sandy CLAY	12	10.44	N/A	Medium strength	Stiff	52.18
WS114	4	Sandy CLAY	21	17.74	N/A	High strength	Very Stiff	88.71
WS115	1	MG: Gravelly SAND	9	9.07	Loose	N/A	N/A	N/A
WS115	2	Gravelly SAND	28	25.58	Medium Dense	N/A	N/A	N/A
WS115	3	Sandy CLAY	2	1.74	N/A	Extremely low strength	Very Soft	8.70
WS115	4	Sandy CLAY	16	13.52	N/A	Medium strength	Stiff	67.59
WS115	5	Sandy CLAY	15	12.44	N/A	Medium strength	Stiff	62.22
WS116	1	Gravelly SAND	8	8.07	Loose	N/A	N/A	N/A
WS116	2	Gravelly SAND	13	11.88	Medium Dense	N/A	N/A	N/A
WS116	3	Sandy CLAY	6	5.22	N/A	Low strength	Firm	26.09
WS116	4	Sandy CLAY	20	16.90	N/A	High strength	Very Stiff	84.49
WS116	5	Sandy CLAY	15	12.44	N/A	Medium strength	Stiff	62.22
WS117	1	Gravelly SAND	10	10.08	Medium Dense	N/A	N/A	N/A
WS117	2	Gravelly SAND	30	27.41	Medium Dense	N/A	N/A	N/A
WS117	3	Sandy CLAY	11	9.57	N/A	Medium strength	Stiff	47.83
WS117	4	Sandy CLAY	15	12.67	N/A	Medium strength	Stiff	63.36
WS117	5	Sandy CLAY	28	23.23	N/A	High strength	Very Stiff	116.15
WS118	1	Gravelly SAND	11	11.09	Medium Dense	N/A	N/A	N/A
WS118	2	Gravelly SAND	15	13.70	Medium Dense	N/A	N/A	N/A
WS118	3	Sandy CLAY	13	11.31	N/A	Medium strength	Stiff	56.53



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 (BS 5930)	TERZAGHI & PECK APPROXIMATE UNDRAINED SHEAR STRENGTH (kN/m ²)
WS118	4	Sandy CLAY	15	12.67	N/A	Medium strength	Stiff	63.36
WS118	5	Sandy CLAY	22	18.25	N/A	High strength	Very Stiff	91.26
WS119	1	MG: Sand	50	50.41	Very Dense	N/A	N/A	N/A
WS120	1	Gravelly SAND	33	33.27	Dense	N/A	N/A	N/A
WS120	2	Gravelly SAND	11	10.05	Medium Dense	N/A	N/A	N/A
WS120	3	Gravelly SAND	10	8.70	Loose	N/A	N/A	N/A
WS120	4	Sandy CLAY	20	16.90	N/A	High strength	Very Stiff	84.49
WS121	1	Gravelly SAND	27	27.22	Medium Dense	N/A	N/A	N/A
WS121	2	Gravelly SAND	10	9.14	Loose	N/A	N/A	N/A
WS121	3	Sandy CLAY	12	10.44	N/A	Medium strength	Stiff	52.18
WS121	4	Sandy CLAY	15	12.67	N/A	Medium strength	Stiff	63.36
WS121	5	Sandy CLAY	28	23.23	N/A	High strength	Very Stiff	116.15
WS122	0.5	MG: Gravel	50	56.02	Very Dense	N/A	N/A	N/A
WS123	1	Gravelly SAND	16	16.13	Medium Dense	N/A	N/A	N/A
WS123	2	Gravelly SAND	17	15.53	Medium Dense	N/A	N/A	N/A
WS123	3	Sandy CLAY	12	10.44	N/A	Medium strength	Stiff	52.18
WS123	4	Sandy CLAY	18	15.21	N/A	High strength	Very Stiff	76.04
WS123	5	Sandy CLAY	24	19.91	N/A	High strength	Very Stiff	99.55
WS124	1	Gravelly SAND	16	16.13	Medium Dense	N/A	N/A	N/A
WS124	2	Gravelly SAND	16	14.62	Medium Dense	N/A	N/A	N/A
WS124	3	Sandy CLAY	16	13.91	N/A	Medium strength	Stiff	69.57



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 (BS 5930)	TERZAGHI & PECK APPROXIMATE UNDRAINED SHEAR STRENGTH (kN/m ²)
WS124	4	Sandy CLAY	18	15.21	N/A	High strength	Very Stiff	76.04
WS124	5	Sandy CLAY	50	41.48	N/A	Very high strength	Very Stiff	207.41
WS125	1	MG: Gravelly sand	8	8.07	Loose	N/A	N/A	N/A
WS125	2	Gravelly SAND	8	7.31	Loose	N/A	N/A	N/A
WS125	3	Sandy CLAY	8	6.96	N/A	Low strength	Firm	34.79
WS125	4	Sandy CLAY	11	9.29	N/A	Medium strength	Stiff	46.47
WS125	5	Sandy CLAY	22	18.25	N/A	High strength	Very Stiff	91.26
WS126	1	Gravelly SAND	11	11.09	Medium Dense	N/A	N/A	N/A
WS126	2	Gravelly SAND	8	7.31	Loose	N/A	N/A	N/A
WS126	3	Sandy CLAY	13	11.31	N/A	Medium strength	Stiff	56.53
WS126	4	Sandy CLAY	18	15.21	N/A	High strength	Very Stiff	76.04
WS126	5	Sandy CLAY	16	13.27	N/A	Medium strength	Stiff	66.37
WS127	1	Gravelly SAND	9	9.07	Loose	N/A	N/A	N/A
WS127	2	Gravelly SAND	8	7.31	Loose	N/A	N/A	N/A
WS127	3	Sandy CLAY	11	9.57	N/A	Medium strength	Stiff	47.83
WS127	4	Sandy CLAY	12	10.14	N/A	Medium strength	Stiff	50.69
WS127	5	Sandy CLAY	50	41.48	N/A	Very high strength	Very Stiff	207.41
WS128	1	Gravelly SAND	10	10.08	Medium Dense	N/A	N/A	N/A
WS128	2	Sandy CLAY	8	7.31	N/A	Low strength	Firm	36.54
WS128	3	Sandy CLAY	23	20.00	N/A	High strength	Very Stiff	100.01
WS128	4	Sandy CLAY	15	12.67	N/A	Medium strength	Stiff	63.36



Northenden College

Phase II Geoenvironmental Site Assessment
July 2020

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 (BS 5930)	TERZAGHI & PECK APPROXIMATE UNDRAINED SHEAR STRENGTH (kN/m ²)
WS128	5	Sandy CLAY	27	22.40	N/A	High strength	Very Stiff	112.00
WS129	1	Gravelly SAND	10	10.08	Medium Dense	N/A	N/A	N/A
WS129	2	Gravelly SAND	11	10.05	Medium Dense	N/A	N/A	N/A
WS129	3	Sandy CLAY	10	8.70	N/A	Medium strength	Stiff	43.48
WS129	4	Sandy CLAY	15	12.67	N/A	Medium strength	Stiff	63.36



4.10. SOIL COMPRESSIBILITY

Consolidation tests have been undertaken on selected samples of CLAY using an odometer to obtain consolidation properties. Tests include an unload cycle to help assess potential heave. The results are included in Table 4.6 and show the CLAY to be of very low to high compressibility – consistent with the soil's visual description.

TABLE 4.6 SUMMARY CONSOLIDATION TEST DATA

LOCATION	DEPTH (m)	LOAD INCREMENT	VOLUME CHANGE COEFFICIENT, M_v	CONSOLIDATION COEFFICIENT, C_v
WS118	3.50-4.00	0-75	0.411	14.869
		75-150	0.155	1.451
		150-300	0.089	1.603
		300-600	0.060	1.728
		600-75	0.019	2.737

The results have determined that the clay soil is of medium compressibility under a loading of 75-150 kN/m². It should be noted that if this material is excavated for use in a cut/fill operation, then careful consideration should be taken in the stabilisation of this material as it would appear that at depth, the cohesive deposits are wetter than the optimum.

Engineering of this type of material will need to be completed during dry weather periods only.

4.11. SOIL INFILTRATION

In-situ BRE 365 Soakaway tests were undertaken over a 48 hour period within trial pits completed as SA101-SA106.

The results are presented in Table 4.7 below and the test certificates are included within Appendix IX.

TABLE 4.7 BRE365 SOAKAWAY TESTING RESULTS

LOCATION	DEPTH (m)	MATERIAL	TEST NO.	SOIL INFILTRATION RATE (m/s)
TP101/SA101	1.50	Gravelly SAND	1	2.36E-02
			2	1.53E-04
			3	5.22 E-05
TP102/SA102	1.50	Slightly gravelly SAND	1	4.41 E-05
			2	7.86E-06
			3	1.65E-05
TP103/SA103	1.50	Slightly gravelly SAND	1	3.65 E-05
			2	2.34E-05



LOCATION	DEPTH (m)	MATERIAL	TEST NO.	SOIL INFILTRATION RATE (m/s)
TP103/SA103	1.50	Slightly gravelly SAND	3	2.01E-05
TP104/SA104	1.50	Slightly clayey slightly gravelly SAND / Slightly gravelly SAND	1	N/A
TP105/SA105	1.90	Gravelly SAND	1	9.33 E-05
			2	4.96E-05
			3	2.33E-05
TP106/SA106	1.80	Gravelly SAND	1	7.13E-05
			2	7.63E-05
			3	3.11E-05

Soil infiltration was taken over the wetted area from between 75% and 25% of the effective depth. All tests showed granular drift deposits to have good to moderate soakage potential. A soil infiltration rate could not be calculated within TP104/SA104.

Therefore, considering the significant volumes of permeable SANDs on the site, it is considered that soakaway drainage may be suitable for the proposed development within areas of gravelly SAND. However, the application of soakaway drainage will ultimately be dependent on the specific requirements of the development. All soakaways should be designed in accordance with BRE Special Digest 365 – *Soakaway Design*.

4.12. SOIL PLASTICITY

The liquid and plastic limits of samples of natural in-situ clay are determined using the cone penetrometer method and the rolling thread test. These tests enable determination of an average plasticity index (PI) for each “type” of clay, although judgement is applied where variable results are reported.

PI can be related to shrinkability (low, medium or high) and then to minimum founding depth.

E3P typically only consider a soil to be shrinkable if the proportion finer than 63 µm is > 35%.

PI results are compared against guidance given in the NHBC standards, Chapter 4.2 (revised January 2014), which advocates the use of modified plasticity index (I'p), defined as:

$$I'p = Ip \times (\% < 425 \mu\text{m} / 100)$$

In other words, if PI is 30%, but the soil contains 80% < 425 µm, then $I'p = 30 \times 80/100 = 24\%$.

It should be noted that in accordance with the requirements of BS 1377, the % passing the 425 µm sieve is routinely reported by testing labs.

E3P apply engineering judgement where PI results are spread over a range of classifications. Consideration is given to the average values for each particular soil type (differentiate between residual soil and alluvium), the number of results in each class and the actual values.

The Atterberg limits determinations, summarised in Table 4.8, show the clay to be of predominantly low plasticity with discrete areas of moderate plasticity clay.



TABLE 4.8 SUMMARY OF PLASTICITY INDEX TEST RESULTS

LOCATION	DEPTH (m)	NATURAL MOISTURE CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	PASSING 425 µm SIEVE (%)	MODIFIED PLASTICITY INDEX	NHBC VOLUME CHANGE POTENTIAL
WS107	2.00-2.45	15	16	30	14	90	12.6	Low
WS114	3.00-3.45	13	15	28	13	98	12.74	Low
WS123	3.00-3.45	19	16	31	15	99	14.85	Low
WS127	3.00-3.45	18	17	35	18	100	18	Low
TP111	0.60	33	26	57	31	100	31	Medium

The results of the Atterberg limits testing confirmed that the majority of the soils would be deemed to be of “Low Volume Change Potential” with discrete areas of soils deemed to be “Medium Volume Change Potential” in accordance with the classification system utilised by the LABC/NHBC industry guidance.

The areas of medium volume change potential CLAY was located within shallow cohesive deposits in the south-west of the site. We have further found this shallow CLAY band at WS107 and therefore the sample at TP111 may be indicative of clay at this shallow depth rather than materials at a greater depth below granular stratum.

4.13. PARTICLE SIZE DISTRIBUTION

Particle Size Distribution (PSD) tests have been undertaken on selected samples of granular material via dry sieve to obtain information on the soil fractions. The results are included in Table 4.9 below. The full results can be found in Appendix VIII.

TABLE 4.9 SUMMARY OF PARTICLE SIZE DISTRIBUTION TEST RESULTS

LOCATION	LABORATORY DESCRIPTION	DEPTH (M)	SOIL FRACTION (%)			
			COBBLES	GRAVEL	SAND	SILT/CLAY
TP103	Brown very gravelly silty SAND.	1.00	0	30	65	5
TP110	Brown slightly silty very sandy GRAVEL.	1.00	0	51	45	4
TP126	Made Ground: Brown silty very sandy gravel with cobbles.	0.70	19	40	34	7
TP134	Made Ground: Brown very gravelly silty sand.	1.00	0	36	55	9
TP137	Brown very gravelly slightly silty SAND.	1.50	0	46	53	1

4.14. CALIFORNIA BEARING RATIO

The California bearing ratio (CBR) for the soils were measured using an in-situ TRL probe. The results are summarised in Table 4.10.



The result sheets are included in Appendix X and the locations are shown on Drawing 13-969-005 (Appendix III). CBR results have been averaged from the blow counts across the strata tested and any abnormally high blow counts ignored as these are likely to be from larger granular material and so represent anomalies.

TABLE 4.10 SUMMARY OF DCP RESULTS

LOCATION	DEPTH (m)	STRATA	IN-SITU OR LAB TEST	CBR (%)
DCP101	0.08-0.10	MADE GROUND: Slightly gravelly medium sand (Topsoil).	In-Situ	26.49 ¹
DCP102	0.18-0.23	MADE GROUND: Gravelly medium sand with occasional cobbles.	In-Situ	41.28 ¹
DCP103	0.033-0.036	MADE GROUND: Sandy gravel.	In-Situ	94.55 ¹
DCP104	0.17-0.22	MADE GROUND: Gravelly medium sand (Topsoil).	In-Situ	43.53 ¹
DCP105	0.45-0.63	MADE GROUND: Gravelly medium sand.	In-Situ	13.04
DCP106	0.11-0.12	MADE GROUND: Gravelly medium sand (Topsoil).	In-Situ	118.22 ¹
DCP107	0.35-0.84	Gravelly SAND (TOPSOIL) / Gravelly medium SAND.	In-Situ	2.93
DCP108	0.16-0.19	Gravelly medium SAND (TOPSOIL).	In-Situ	17.25 ¹
DCP109	0.36-0.39	Gravelly coarse SAND.	In-Situ	22.50

Notes:

1. Locations terminated due to obstruction.

It should be noted that the reported CBR results were obtained from soils in a highly undisturbed state. If, however, the topsoil and surface cover is removed during periods of wetter climatic condition, the formation will soften, reducing the CBR.

4.15. pH AND SULPHATE

Chemical analyses for pH and soluble sulphate content contained in Appendix VI (summarised in Table 4.11), 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).

TABLE 4.11 SUMMARY OF pH AND SULPHATE DATA

LOCATION	DEPTH (m)	SO ₄ IN 2:1 WATER/SOIL (g/l)	pH VALUE	CLASSIFICATION
WS101	0.10	0.0075	5.3	DS-1, AC-1s
WS104	1.60	0.0047	8.4	DS-1, AC-1s
WS107	0.55	0.048	8.3	DS-1, AC-1s
WS110	0.80	0.0045	8.3	DS-1, AC-1s
WS112	0.40	0.037	7.1	DS-1, AC-1s
TP125	1.00	0.010	6.9	DS-1, AC-1s
TP128	0.80	0.024	7.7	DS-1, AC-1s



LOCATION	DEPTH (m)	SO ₄ IN 2:1 WATER/SOIL (g/l)	pH VALUE	CLASSIFICATION
TP133	0.50	0.35	7.8	DS-1, AC-1s

4.16. GROUND GAS

A ground gas assessment has been completed in accordance with guidance provided within CIRIA 665 – *Assessing risk posed by hazardous ground gases to buildings*.

4.17. INVESTIGATION RATIONALE

The ICSM has identified that any underlying Made Ground may represent a potential source of ground gas generation. Based on the identification of these sources, E3P has determined that the site represents a low ground gas source generation potential.

Within the context of the proposed residential end use and ground gas generation potential, the gas assessment requires that nine visits are required over six months, with at least two sets of readings at low or falling atmospheric pressure as set out within CIRIA 665 Tables 5.5a and 5.5b.

The spacing requirements for monitoring wells are detailed within CIRIA 665 Table 4.2, which indicates that for low gas hazard sites (Made Ground with limited degradable material, organic clay of limited thickness) and a high sensitivity development, nominal well spacing should be between 25 m and 50 m.



TABLE 4.12 GROUND GAS MONITORING LOCATION RATIONALE

LOCATION	GROUND GAS SOURCE	DEPTH OF MONITORING WELL (m)
WS102	Natural strata / Deeper Groundwater Well	1.00-5.00
WS103	Natural strata / Deeper Groundwater Well	1.00-5.00
WS105	Natural strata / Deeper Groundwater Well	1.00-2.00
WS106	Natural strata / Deeper Groundwater Well	1.00-5.00
WS109	Natural strata / Deeper Groundwater Well	1.00-5.00
WS110	Natural strata / Deeper Groundwater Well	1.00-5.00
WS111	Natural strata / Deeper Groundwater Well	1.00-3.00
WS113	Made Ground / Natural Strata / Deeper Groundwater Well	1.00-3.00
WS115	Made Ground / Natural Strata / Deeper Groundwater Well	0.50-3.50
WS117	Natural strata / Deeper Groundwater Well	1.00-5.00
WS121	Natural strata / Deeper Groundwater Well	1.00-5.00
WS123	Natural strata / Deeper Groundwater Well	1.00-5.00
WS124	Natural strata / Deeper Groundwater Well	1.00-5.00
WS125	Made Ground / Natural Strata / Deeper Groundwater Well	1.00-3.00
WS127	Natural strata / Deeper Groundwater Well	1.00-5.00
WS128	Natural strata / Deeper Groundwater Well	1.00-5.00
WS129	Natural strata / Deeper Groundwater Well	1.00-4.00

4.18. MONITORING METHODOLOGY

Concentrations of methane (CH₄), carbon dioxide (CO₂) and oxygen (O₂) were measured using a calibrated infra-red gas analyser (GFM435) with gas flow rates were measured using an integrated flow meter.

Gas measurements were recorded for a minimum of 60 seconds at each location, at which point the maximum concentration of CH₄ and CO₂, together with the lowest concentration of O₂ were recorded. The results of the ground gas monitoring are presented in Table 4.13.



TABLE 4.13 SUMMARY OF GROUND GAS MONITORING RESULTS

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)	RESPON SE ZONE (m bgl)	DEPTH TO BASE (m bgl)	DEPTH TO WATE R (m bgl)
WS102	4/6/20	0.1	0.1	-0.00039	1.4	1.4	-0.00546	19.7	1002	Falling	-0.39	1.00-5.00	4.95	2.46
	18/6/20	0.1	0.1	0.00026	1.1	1.1	0.00286	19.8	1007	Falling	0.26		4.90	2.54
	8/7/20	0.1	0.1	0.00052	1.3	1.3	0.00676	19.6	1010	Steady	0.52		4.92	2.50
WS103	4/6/20	0.1	0.1	0.00199	1.8	1.8	0.03582	19.5	1002	Falling	1.99	1.00-5.00	5.06	2.18
	18/6/20	0.1	0.1	0.00183	1.4	1.4	0.02562	19.6	1007	Falling	1.83		5.06	2.24
	8/7/20	0.1	0.1	0.00152	1.5	1.5	0.0228	19.4	1010	Steady	1.52		5.05	2.30
WS105	4/6/20	0.1	0.1	-0.00039	0.9	0.9	-0.00351	20.1	1002	Falling	-0.39	1.00-2.00	2.08	2.07
	18/6/20	0.1	0.1	-0.00013	0.8	0.8	-0.00104	20.2	1007	Falling	-0.13		2.07	2.07
	8/7/20	0.1	0.1	0.00013	0.6	0.6	0.00078	20.3	1010	Steady	0.13		2.07	2.07
WS106	4/6/20	0.1	0.1	-0.00013	2.3	2.3	-0.00299	19.2	1002	Falling	-0.13	1.00-5.00	3.82	1.95
	18/6/20	0.1	0.1	-0.00052	2.1	2.1	-0.01092	19.4	1007	Falling	-0.52		3.81	1.97
	8/7/20	0.1	0.1	-0.00026	2.4	2.4	-0.00624	19.1	1010	Steady	-0.26		3.81	1.99
WS109	4/6/20	0.1	0.1	-0.00039	1.8	1.8	-0.00702	19.2	1002	Falling	-0.39	1.00-5.00	4.94	1.83
	18/6/20	0.1	0.1	0.00026	1.6	1.6	0.00416	19.4	1007	Falling	0.26		4.92	1.70
	8/7/20	0.1	0.1	0.00052	2.0	2.0	0.0104	18.9	1010	Steady	0.52		4.93	1.74
WS110	4/6/20	0.1	0.1	-0.00039	0.8	0.8	-0.00312	20.1	1002	Falling	-0.39	1.00-5.00	4.87	1.93
	18/6/20	0.1	0.1	-0.00013	0.7	0.7	-0.00091	20.2	1007	Falling	-0.13		4.86	1.97
	8/7/20	0.1	0.1	-0.00026	0.9	0.9	-0.00234	19.9	1010	Steady	-0.26		4.85	1.92



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)	RESPON SE ZONE (m bgl)	DEPTH TO BASE (m bgl)	DEPTH TO WATER (m bgl)
WS111	4/6/20	0.1	0.1	-0.00052	0.7	0.7	-0.00364	20.2	1002	Falling	-0.52	1.00-3.00	2.62	2.29
	18/6/20	0.1	0.1	-0.00052	0.7	0.7	-0.00364	20.1	1007	Falling	-0.52		2.64	2.30
	8/7/20	0.1	0.1	-0.00013	0.5	0.5	-0.00065	20.3	1010	Steady	-0.13		2.64	2.28
WS113	4/6/20	0.1	0.1	-0.00039	2.7	2.7	-0.01053	18.4	1002	Falling	-0.39	1.00-3.00	2.46	2.43
	18/6/20	0.1	0.1	0.00052	2.7	2.7	0.01404	18.2	1007	Falling	0.52		2.44	2.40
	8/7/20	0.1	0.1	0.00026	2.5	2.5	0.0065	18.7	1010	Steady	0.26		2.45	2.41
WS115	4/6/20	0.1	0.1	0.00092	1.3	1.3	0.01196	19.1	1002	Falling	0.92	0.50-3.00	3.06	2.88
	18/6/20	0.1	0.1	0.00013	0.7	0.7	0.00091	19.7	1007	Falling	0.13		3.04	2.70
	8/7/20	0.1	0.1	0.00052	0.9	0.9	0.00468	19.5	1010	Steady	0.52		3.05	2.74
WS117	4/6/20	0.1	0.1	-0.00013	3.7	3.7	-0.00481	18.1	1002	Falling	-0.13	1.00-5.00	4.88	2.06
	18/6/20	0.1	0.1	-0.00052	1.3	1.3	-0.00676	19.0	1007	Falling	-0.52		4.76	2.07
	8/7/20	0.1	0.1	-0.00013	1.9	1.9	-0.00247	18.9	1010	Steady	-0.13		4.77	2.10
WS121	4/6/20	0.1	0.1	-0.00039	0.1	0.1	-0.00039	20.3	1002	Falling	-0.39	1.00-5.00	4.91	1.95
	18/6/20	0.1	0.1	0.0001	0.8	0.8	0.0008	18.5	1007	Falling	0.1		4.95	2.00
	8/7/20	0.1	0.1	0.00026	0.6	0.6	0.00156	18.9	1010	Steady	0.26		4.94	2.10
WS123	4/6/20	0.1	0.1	0.00741	2.2	2.2	0.16302	15.7	1002	Falling	7.41	1.00-5.00	4.96	1.96
	18/6/20	0.1	0.1	0.00026	0.9	0.9	0.00234	18.9	1007	Falling	0.26		4.74	1.95
	8/7/20	0.1	0.1	0.00052	1.1	1.1	0.00572	18.5	1010	Steady	0.52		4.75	1.99



WELL	DATE	CH4 INITIAL (%V/V)	CH4 STEADY (%V/V)	CH4 GSV (l/hr)	CO2 INITIAL (%V/V)	CO2 STEADY (%V/V)	CO2 GSV (l/hr)	O2 (%V/V)	ATMOS (mb)	ATMOS. DYNAMIC	FLOW (l/hr)	RESPON SE ZONE (m bgl)	DEPTH TO BASE (m bgl)	DEPTH TO WATE R (m bgl)
WS124	4/6/20	0.1	0.1	-0.00114	3.3	3.3	-0.03762	13.0	1002	Falling	-1.14	1.00-5.00	4.88	1.79
	18/6/20	0.1	0.1	0.00273	3.3	3.3	0.09009	12.0	1007	Falling	2.73		4.86	1.75
	8/7/20	0.1	0.1	0.00196	3.0	3.1	0.0588	12.4	1010	Steady	1.96		4.86	1.80
WS125	4/6/20	0.1	0.1	-0.00052	1.4	1.4	-0.00728	17.6	1002	Falling	-0.52	1.00-3.00	2.74	2.48
	18/6/20	0.1	0.1	0.00026	1.9	1.9	0.00494	17.7	1007	Falling	0.26		2.75	2.43
	8/7/20	0.1	0.1	0.00052	1.8	1.8	0.00936	18.0	1010	Steady	0.52		2.74	2.50
WS127	4/6/20	0.1	0.1	-0.00052	2.2	2.2	-0.01144	18.5	1002	Falling	-0.52	1.00-5.00	4.80	1.86
	18/6/20	0.1	0.1	0.0001	0.4	0.4	0.0004	19.4	1007	Falling	0.1		4.62	1.84
	8/7/20	0.1	0.1	0.00026	0.7	0.7	0.00182	19.1	1010	Steady	0.26		4.63	1.89
WS128	4/6/20	0.1	0.1	-0.00079	5.4	5.4	-0.04266	11.8	1002	Falling	-0.79	1.00-5.00	3.81	1.80
	18/6/20	0.1	0.1	0.00013	4.9	4.9	0.00637	12.5	1007	Falling	0.13		3.77	1.65
	8/7/20	0.1	0.1	0.00052	5.1	5.1	0.02652	12.1	1010	Steady	0.52		3.79	1.70
WS129	4/6/20	0.1	0.1	-0.00052	3.3	3.3	-0.01716	18.0	1002	Falling	-0.52	1.00-4.00	3.88	1.80
	18/6/20	0.1	0.1	0.00013	3.7	3.7	0.00481	17.6	1007	Falling	0.13		3.82	1.86
	8/7/20	0.1	0.1	0.00026	3.4	3.4	0.00884	17.9	1010	Steady	0.26		3.84	1.90



5. TIER I QUALITATIVE CONTAMINATED LAND RISK ASSESSMENT

E3P has undertaken a Tier 1 qualitative risk assessment to determine if any potential contaminants within the underlying soils and groundwater pose an unacceptable level of risk to the identified receptors.

5.1. DEVIATING SAMPLES

Deviating samples were to be avoided during the ground investigation by using best practice sampling procedures including use of appropriate sampling containers and adhering to the laboratory holding times for each contaminant analysis undertaken.

Samples from TP110, TP122, WS101, WS103 and WS104 have been noted to deviate for total cyanide in soil due to holding times. However when compared to all sampling of this determinant results are in direct comparison.

There were no sample deviations noted regarding the samples taken at the site.

5.2. HUMAN HEALTH RISK ASSESSMENT

At 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 values published in LQM/CIEH S4UL (S4UL3267).

The results of this comparison have been summarised within Table 5.1.



TABLE 5.1 SUMMARY OF INORGANIC AND HYDROCARBON TOXICITY ASSESSMENT FOR A RESIDENTIAL END USE

DETERMINANT	UNIT	GAC	N	MC	LOC. OF EX	PATH-WAY	ASSESSMENT
Arsenic	mg/kg	37	19	68	WS107 (0.55m)	1	Further Action
Cadmium	mg/kg	17	19	1.0	N/A	1	No Further Action
Chromium (VI)	mg/kg	6.1	19	<4.0	N/A	1	No Further Action
Lead	mg/kg	200	19	150	N/A	1	No Further Action
Mercury	mg/kg	1.2	19	1.0	N/A	3	No Further Action
Nickel	mg/kg	180	19	35	N/A	1	No Further Action
Selenium	mg/kg	250	19	2.0	N/A	1	No Further Action
Copper	mg/kg	2400	19	56	N/A	1	No Further Action
Zinc	mg/kg	3700	19	250	N/A	1	No Further Action
Cyanide – Total	mg/kg	791	19	<1	N/A	1	No Further Action
Phenols – Total	mg/kg	210	8	<1.0	N/A	1	No Further Action
Asbestos	Fibres	NFD	12	0.002 %	WS118 (0.30m)	4	Further Action
Naphthalene	mg/kg	2.3	18	2.0	N/A	3	No Further Action
Acenaphthylene	mg/kg	170	18	<0.05	N/A	2	No Further Action
Acenaphthene	mg/kg	210	18	0.76	N/A	1	No Further Action
Fluorene	mg/kg	170	18	0.47	N/A	1	No Further Action
Phenanthrene	mg/kg	95	18	4.6	N/A	2	No Further Action
Anthracene	mg/kg	2400	18	0.96	N/A	2	No Further Action
Fluoranthene	mg/kg	280	18	5.4	N/A	2	No Further Action
Pyrene	mg/kg	620	18	5.5	N/A	2	No Further Action
Benzo(a)Anthracene	mg/kg	7.2	18	2.9	N/A	2	No Further Action
Chrysene	mg/kg	15	18	2.7	N/A	2	No Further Action
Benzo(b)Fluoranthene	mg/kg	2.6	18	2.5	N/A	2	No Further Action
Benzo(k)Fluoranthene	mg/kg	77	18	1.4	N/A	2	No Further Action
Benzo(a)Pyrene**	mg/kg	2.2	18	2.2	N/A	2	No Further Action
Indeno(123-cd)Pyrene	mg/kg	27	18	1.1	N/A	2	No Further Action
Dibenzo(a,h)Anthracene	mg/kg	0.24	15	0.32 0.29 0.35 0.28 0.31	WS111 (0.20m) WS118 (0.30m) TP110 (0.20m) TP128 (0.80m) TP129 (0.20m)	2	Further Action
Benzo(ghi)Perylene	mg/kg	320	15	1.3	N/A	2	No Further Action
TPH C5-C6 (aliphatic)*	mg/kg	42	9	<1.0	N/A	3	No Further Action
TPH C6-C8 (aliphatic)*	mg/kg	100	9	<0.1	N/A	3	No Further Action
TPH C8-C10 (aliphatic)*	mg/kg	27	9	<0.1	N/A	3	No Further Action
TPH C10-C12 (aromatic)*	mg/kg	74	9	4.1	N/A	3	No Further Action



DETERMINANT	UNIT	GAC	N	MC	LOC. OF EX	PATH-WAY	ASSESSMENT
TPH C12-C16 (aromatic)*	mg/kg	140	9	5.8	N/A	3	No Further Action
TPH C16-C21 (aromatic)*	mg/kg	260	9	30	N/A	1	No Further Action
TPH C21-C35 (aromatic)*	mg/kg	1100	9	57	N/A	1	No Further Action

Notes

Main exposure pathways: 1 = soil ingestion, 2 = dermal contact and ingestion, 3 = vapour inhalation (indoor), 4 = dust inhalation.

Abbreviations: GAC = general assessment criteria, n = number of samples, MC = maximum concentration; Loc of Ex = location of exceedance; NFD = no fibres detected.

Referring to Table 5.1, the results of this direct comparison indicates that the data exceeds the screening criteria for a residential end use for the following contaminants:

- ☛ Arsenic (WS107 0.55 m – Made Ground gravel);
- ☛ Dibenzo(a,h)Anthracene (WS111 - 0.20m – Natural topsoil, WS118 - 0.30m – Made Ground gravel, TP110 - 0.20m – Natural topsoil, TP128 - 0.80m - Made Ground sand, and TP129 - 0.20m – Made Ground topsoil); and,
- ☛ Chrysotile (WS118 0.80 m – Made Ground clay).

Asbestos in the form of loose chrysotile fibres has been identified in the granular Made Ground in WS118 at 0.30m bgl.

No elevated concentrations of VOCs were identified in the soils submitted for chemical analysis.

The laboratory analysis confirms the assessment within the initial conceptual site model that the main constituents of concern were likely to be asbestos, PAHs, hydrocarbon compounds and heavy metals.

In relation to these exceedances, the following can be determined:

- ☛ The main exposure pathways based on the Tier I exceedances are:
 - Soil ingestion;
 - Dermal contact and ingestion;
 - Consumption of homegrown vegetables; and
 - Fibre/dust inhalation.
- ☛ The exceedances for all determinants are associated with shallow Made Ground deposits between 0.20m bgl and 0.55m bgl. Dibenzo(a,h)Anthracene exceedances have been identified in what has been deemed natural topsoil deposits in the playing fields located in the southern half of the site.

HUMAN HEALTH RISK ASSESSMENT AND MITIGATION

All of the identified elevated concentrations have primary exposure pathways related to dermal contact and ingestion of soils, inhalation of particulate and consumption of homegrown vegetables. The risk to chronic human health associated with the elevated concentrations on inorganic heavy metals and non-volatile PAH compounds can be mitigated through the installation of a suitable cover system in all proposed private gardens, landscaping and public open space to remove any potential for direct exposure to impacted soils.



The specific design and installation process for the appropriate cover systems will be clearly defined within the site remediation and enabling works strategy.

Asbestos in the form of chrysotile has also been identified within one localised area within shallow Made Ground deposits at WS118 at 0.30m bgl. Asbestos quantification was undertaken to further assess where these soils may be placed and identified concentrations of 0.002%. No visual signs of ACM were encountered during the ground investigation; it is therefore likely that only trace fibres are present. Impacted soils should be managed according to the asbestos risk mitigation conceptual site model shown in Figure 5.1. It should be assumed at this stage that asbestos loose fibres are throughout the Made Ground on site.

FIGURE 5.1 ASBESTOS RISK MITIGATION CONCEPTUAL SITE MODEL



Notes

ND None Detect

0.001% Soils may contain $\leq 0.001\%$ asbestos using composite testing to ensure there is no potential risk to human health. This value is present within areas where there may be a short term low level exposure of soils containing trace asbestos fibres by construction workers where an appropriate level of asbestos management is employed (dust suppression)

0.1% Soils at a depth of $>1.00\text{m}$ bgl may contain $<0.1\%$ asbestos using composite testing where they will not be likely to be disturbed in the future and will therefore be in an area of low sensitivity. Risk assessment completed in accordance with Asbestos JIWG risk assessment tools.

Undefined- this will be dependent upon soils encountered during earthworks, which may be placed at these depths to ensure no potential risk to human health.

Chemical analysis of the natural clay drift deposits has identified these soils to be acceptable for use as subsoil within the proposed garden areas; however, further chemical validation samples will be required to confirm this.

There are potential suitable sources of topsoil available on the site, however isolated occurrences of exceedances of dibenzo(a,h)anthracene have been identified within natural topsoil deposits. Analysis of exceedances against human health remediation targets for residential end use at an SOM of 2.5% for dibenzo(a,h)anthracene (0.28mg/kg) show that the two natural topsoil samples which have exceeded the GAC at 1% SOM are still noted to be exceeding when compared against the higher SOM concentrations.



During the enabling works these soils should be segregated, and further chemical analysis undertaken of the remaining natural topsoil deposits to ensure suitability for use within the proposed development and confirm the identified elevated concentrations are indeed hotspots and not representative of the topsoil as a whole. Excavated impacted topsoil materials not suitable for use within the garden cover system cannot be placed at a depth greater than 1.00 m with gardens and must be 2.00 m off-set from plots.

Anthropogenic topsoil is likely to be impacted across the site and therefore will not be suitable for use within the proposed development. During enabling works these soils should be segregated and disposed off-site at a licensed waste facility.

5.3. CONTROLLED WATERS RISK ASSESSMENT

The site sensitivity with respect to controlled waters is summarised within Table 5.2.

TABLE 5.2 CONTROLLED WATERS SENSITIVITY PROFILE

RISK PROFILE	DISCUSSION	SENSITIVITY RATING
Groundwater Source Protection Zone or Drinking Water Safeguard Zone	The site is not located within a Groundwater Source Protection Zone.	Low
Distance to the Closest Groundwater Abstraction Point	There are no groundwater abstraction points located within 1.00km of the site. The closest abstraction point is located 1.65km north of the site.	Low
Aquifer Classification in Superficial Drift Deposits	Shallow, gravelly sands are interbedded and underlain by low-permeability clay soils to depths in excess of 5.00 m, which may reduce the potential for mobile phase contaminants to migrate towards a viable receptor. The aquifer within the superficial deposits has been classified as a Secondary A quifer.	Moderate
Aquifer Classification in Bedrock	Secondary B Aquifer.	Moderate
Viability for Anthropogenic Soil in Direct Contact with Aquifer (Drift or Bedrock)	There is no Made Ground with low-level (predominantly low-solubility) hydrocarbon impact in the near surface. Made Ground directly overlies the superficial drift deposits.	Low
Is the Site Located Within 50 m of a Surface Watercourse?	The risk to surface water is negligible given the absence of a viable receptor within influencing distance of the site.	Low
SUMMARY The ICSM developed within the context of the site setting has only identified a single viable pollutant risk, which would be the downward migration of potentially mobile phase-soluble contaminants towards the underlying Secondary B Aquifer. However, the overall sensitivity of this receptor is reduced given the absence of any groundwater abstraction and thus the potential for the creation of a complete pollutant linkage.		

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 5.3.



TABLE 5.3 QUALITATIVE RISK TO CONTROLLED WATERS FROM SOIL ANALYTICAL RESULTS

BTEX > 1 mg/kg	The soil data analysis has not identified any detectable concentrations of TPH C5 to C6 that might otherwise be indicative of VOC impact.
Total VOC > 1 mg/kg	
Total SVOC > 1 mg/kg	PAH analysis recorded concentrations either below or only slightly elevated above the laboratory LOD. The maximum PAH concentration identified is 5.5 mg/kg of Pyrene.
C5-C10 > 5 mg/kg	All concentrations are below the laboratory LOD.
C10-C12 > 10 mg/kg	All concentrations are below or slightly elevated above the laboratory LOD. The maximum concentration identified is below 10 mg/kg.
C12-C16 > 50 mg/kg	All concentrations are below or slightly elevated above the laboratory LOD. The maximum concentration identified is below 50 mg/kg.
Phenols > 2 mg/kg	All concentrations are below the laboratory LOD.
Naphthalene > 2 mg/kg	The most soluble SVOC (naphthalene) has been not identified at concentrations greater than 2 mg/kg.
Total PAH > 10 mg/kg	Concentrations of low-solubility PAH compounds greater than 10 mg/kg have been detected in the soil analysis at WS111 at 0.20m, WS118 at 0.30m, TP110 at 0.20m and TP129 at 0.20m.
PCB > 1 mg/kg	The electrical substation situated in the west of the site may be a potential source of PCBs, however analysis was inhibited as the substation is currently active and therefore unsafe to investigate. It is recommended that further investigation of the area is completed during the remediation and enabling works.
Heavy metals > 500 mg/kg	Concentrations of heavy metals are all below 500 mg/kg.

In due consideration of the ICSM, which has identified a potential pollutant linkage associated with the migration towards the underlying Secondary B Aquifer, E3P has undertaken a Tier I controlled waters risk assessment. The Tier I assessment has included a comparison of leachate analysis from samples of the Made Ground and groundwater samples to drinking water standards (DWS) in the first instance and if absent against environmental quality standards (EQS).

These are presented in Table 5.4.



TABLE 5.4 COMPARISON OF GROUNDWATER ANALYSIS WITH TIER 1 SCREENING LEVELS

DETERMINAND	UNIT	EQS SCREENING VALUE ^{1, 2, 3}	DWS _{3,4,5}	N		MC	LOC. OF EX	ASSESSMENT
		AA		L	GW			
Arsenic	µg/l	50	10	3	4	8.22	N/A	No Further Action
Cadmium	µg/l	0.08-0.25	5	3	4	0.14	N/A	No Further Action
Chromium (VI)	µg/l	3.4	–	3	4	<5.0	N/A	No Further Action
Chromium (III)	µg/l	4.7	50	3	4	1.3	N/A	No Further Action
Copper	µg/l	1	2000	3	4	6.4	N/A	No Further Action
Total Cyanide	µg/l	1	50	3	4	3.0	N/A	No Further Action
Lead	µg/l	1.2	10	3	4	6.9	N/A	No Further Action
Mercury	µg/l	–	1.0	3	4	<0.5	N/A	No Further Action
Nickel	µg/l	4	20	3	4	8.5	N/A	No Further Action
Selenium	µg/l	–	10	3	4	<4.0	N/A	No Further Action
Zinc	µg/l	10.9	–	3	4	9.7	N/A	No Further Action
pH		6–9		3	4	8.0	N/A	No Further Action
PAH								
Naphthalene	µg/l	2	10*	3	4	<0.01	N/A	No Further Action
Anthracene	µg/l	0.1		3	4	<0.01	N/A	No Further Action
Benzo[b]fluoranthene	µg/l	0.00017*		3	4	<0.01	N/A	No Further Action
Benzo[k]fluoranthene	µg/l	0.00017*		3	4	<0.01	N/A	No Further Action
Benzo(a)pyrene	µg/l	0.00017*		3	4	<0.01	N/A	No Further Action
Indeno(123-cd)pyrene	µg/l	0.00017*		3	4	<0.01	N/A	No Further Action
Benzo(ghi)pyrene	µg/l	0.00017*		3	4	<0.01	N/A	No Further Action
Fluoranthene	µg/l	0.0063		3	4	<0.01	N/A	No Further Action
Benzo(ghi)perylene	µg/l	1.7–4		3	4	<0.01	N/A	No Further Action
TPH-Aromatic								
TPH C5-C6 (benzene)	µg/l	10	1	3	4	<1.0	N/A	No Further Action
TPH C6-C8 (toluene)	µg/l	74	700	3	4	<1.0	N/A	No Further Action
TPH C8-C10 (ethyl benzene)	µg/l	20	300	3	4	<1.0	N/A	No Further Action
TPH C10-C12 (xylene)	µg/l	30	500	3	4	<1.0	N/A	No Further Action
TPH C12-C16	µg/l	2	90 ⁵	3	4	<1.0	N/A	No Further Action
TPH C16-C35	µg/l	50#	90 ⁵	3	4	<10	N/A	No Further Action
TPH Aliphatic⁵								
TPH C5-C6	µg/l	–	15000	3	4	<1.0	N/A	No Further Action
TPH C6-C8	µg/l	–	15000	3	4	<1.0	N/A	No Further Action



DETERMINAND	UNIT	EQS SCREENING VALUE ^{1, 2, 3}	DWS _{3,4,5}	N		MC	LOC. OF EX	ASSESSMENT
		AA		L	GW			
TPH C8-C10	µg/l	–	300	3	4	<1.0	N/A	No Further Action
TPH C10-C12	µg/l	–	300	3	4	<10	N/A	No Further Action
TPH C12-C16	µg/l	–	300	3	4	<10	N/A	No Further Action
TPH C16 – C21	µg/l	–	300**	3	4	<10	N/A	No Further Action
TPH C21-C35	µg/l	–	300**	3	4	<10	N/A	No Further Action
VOC								
Tetrachloroethylene	µg/l	0.4	10	0	4	<1.0	N/A	No Further Action
Trichloroethylene	µg/l	10	10	0	4	<1.0	N/A	No Further Action
Trichlorobenzene	µg/l	0.4	–	0	4	<1.0	N/A	No Further Action
Trichloromethane	µg/l	2.5	–	0	4	<1.0	N/A	No Further Action
Dichloromethane	µg/l	20	200	0	4	<1.0	N/A	No Further Action
Carbon Tetrachloride	µg/l	12	3	0	4	<1.0	N/A	No Further Action
Vinyl Chloride	µg/l	–	0.3	0	4	<1.0	N/A	No Further Action

Notes

Solubility <0.01µg/l

AA – Annual Average

MAC- Maximum Admissible Concentration

* Polyaromatic hydrocarbons (PAH) - Benzo(a)pyrene (BaP), Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(g,h,i)-perylene and Indeno(1,2,3-cd)-pyrene. Benzo(a)pyrene can be considered as a marker for the other PAHs, hence only benzo(a)pyrene needs to be monitored for comparison with the biota EQS or the corresponding AA-EQS in water

** There are no WHO Guideline Values for aliphatic fractions C16-C21 and C21-C35, therefore the guideline value for aliphatic fractions inclusive of C8-C16 (300µg/l) has been applied.

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)

CONTROLLED WATER RISK ASSESSMENT AND MITIGATION

The developed conceptual site model identified a single viable exposure pathway that was attributed to the potential vertical migrations of soluble phase compounds towards the underlying secondary B aquifer. In this instance, no samples within Table 5.4 have been found to exceed the DWS values and therefore a full pollution linkage cannot be proven indicating there is no risk related to the underlying secondary B aquifer.

Elevated concentrations of heavy metals against EQS values have been identified, however due to the absence of a surface watercourse in close proximity to the site, the exceedances are considered negligible and not considered to be a potential risk.

Within the SVOC analysis of groundwater samples, the following determinants have been identified noted to be above the laboratory limit of detection (LOD):

- ☼ Isophorone (WS102 – 8.0 µg/l; WS117 – 2.9 µg/l);
- ☼ Diethyl phthalate (WS102 – 2.5 µg/l; WS117 – 1.5 µg/l; WS123 – 0.92 µg/l); and,



 Dibutyl phthalate (WS102 – 0.29 µg/l; WS117 – 1.0 µg/l; WS123 – 0.81 µg/l).

Soil analysis across the site has not identified elevated concentrations of SVOCs above the LOD other than PAHs identified within the human health risk assessment. Historical land uses on site do not indicate a significant potential source of these determinants. However Isophorone is a solvent within coatings, paints and printing which may be present within the Made Ground. Phthalates are associated with plastics; plastic has been noted within Made Ground deposits on-site and therefore the concentrations identified may be attributed to degradation of these materials.

Overall there is not considered to be a primary source on-site, however it is recommended further groundwater and soil sampling is completed within these locations.

Given that the site is underlain by low-permeability, predominantly cohesive glacial till deposits beneath granular deposits, these will afford protection to the underlying Secondary B Aquifer, furthermore, there are no groundwater abstraction points within close proximity of the site. Therefore, it is considered the site poses a low risk to controlled waters and the wider environ as no complete pollutant linkage can be determined.

It is considered that based on the above, there is a low level of risk to the controlled water receptors.

5.4. 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.

CIRIA C665 and NHBC Report No 10627-R01 provide assessments for carbon dioxide and methane based upon gas screening values (GSVs) utilising flow rates and concentrations. The site-based GSVs for steady state methane and carbon dioxide are based upon the following equation:

$$GSV = \frac{\text{concentration (by vol)}}{100} \times \text{flowrate (l / hr)}$$

The GSVs within CIRIA C665 are based upon all buildings other than standard residential houses. The NHBC GSVs are based upon standard residential houses with precast concrete floors (block and beam). The CIRIA 665 report author (Steve Wilson) since provided further clarification regarding which guidance should be adopted for residential houses that have suspended cast in-situ concrete floor slab: for the avoidance of doubt, it was confirmed that the GSVs within the CIRIA 665 guidance should be adopted. The thresholds for GSVs based upon NHBC and CIRIA guidance are provided within Table 5.5.

TABLE 5.5 RESIDENTIAL THRESHOLDS FOR GAS SCREENING VALUES (GSV) IN ACCORDANCE WITH CIRIA C665 AND NHBS REPORT NO 10627-R01 – RESIDENTIAL END USE

CIRIA – NO SUBFLOOR VOID		NHBC – SUBFLOOR VOID		
CLASSIFICATION	GSV (METHANE AND CARBON DIOXIDE)	CLASSIFICATION	GSV (METHANE)	GSV (CARBON DIOXIDE)
CS1	< 0.07	Green	< 0.13	< 0.76
CS2	< 0.70	Amber 1	< 0.63	< 1.60
CS3	< 3.5	Amber 2	< 1.60	< 3.10
CS4	< 15	Red	> 1.60	> 3.10
CS5	< 70	N/A	N/A	N/A



CS6	> 70	N/A	N/A	N/A
-----	------	-----	-----	-----

5.4.1. SOURCES OF GROUND GAS

The Phase I report and subsequent ground investigation has identified the following potential sources of ground gas:

- ☛ Made Ground deposits.

5.4.2. GROUNDWATER

Groundwater levels were observed to marginally fluctuate over the monitoring period this far, with levels generally decreasing over the monitoring period, however changes in groundwater are considered to be minor.

WS105 on one occasion was noted to be dry. No wells have been identified to be flooded during the monitoring completed to date.

The greatest groundwater change occurred within WS121 where levels decreased by 0.15 m over the monitoring period. WS121 was set within high permeability granular deposits and low permeability clay stratum.

5.4.3. GAS FLOW

During the monitoring, a positive flow was noted in WS102, WS103, WS105, WS109, WS113, WS115, WS121, WS123, WS124, WS125, WS127, WS128 and WS129. The measure of positive flow may be attributed to the result of groundwater fluctuations however these are considered marginal. The positive flow identified is considered to also be due to ground gas generation as groundwater fluctuations are considered marginal and for instance a positive flow has been identified within WS105 where the depth to groundwater level has not changed.

Negative flows are indicative of back pressure from wind being greater than the active flow from the wells. Negative flows were recorded within all monitoring wells other than WS103, WS115 and WS123.

5.4.4. GAS CONCENTRATIONS

Methane has not been recorded above the limit of detection (0.10 % v/v) within any of the monitoring wells.

Carbon dioxide concentrations were recorded at concentrations ranging from 0.10% v/v (LOD) to 5.40% v/v (WS128). The maximum carbon dioxide levels were also associated with low oxygen concentrations and appear to be associated with natural granular and cohesive drift deposits identified in WS128.

5.4.5. GAS ASSESSMENT

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 GSVs for the monitoring positions are summarised in Table 5.6.



TABLE 5.6 GAS RISK PROFILE AND LOCATION

LOCATION	MAX CO ₂ (% v/v)	GSV (l/hr)	MAX CH ₄ (% v/v)	GSV (l/hr)	CLASSIFICATION
WS102	1.40	0.00676	0.10	0.00052	Green/CS1
WS103	1.80	0.03582	0.10	0.00199	Green/CS1
WS105	0.90	-0.00351	0.10	-0.00039	Green/CS1
WS106	2.30	-0.01092	0.10	-0.00052	Green/CS1
WS109	2.00	0.0104	0.10	0.00052	Green/CS1
WS110	0.90	-0.00234	0.10	-0.00026	Green/CS1
WS111	0.70	-0.00364	0.10	-0.00052	Green/CS1
WS113	2.70	0.01404	0.10	0.00052	Green/CS1
WS115	1.30	0.01196	0.10	0.00092	Green/CS1
WS117	3.70	-0.00676	0.10	-0.00052	Green/CS1
WS121	0.80	0.00156	0.10	0.0001	Green/CS1
WS123	2.20	0.16302	0.10	0.00741	Amber 1/CS2
WS124	3.30	0.09009	0.10	0.00273	Amber 1/CS2
WS125	1.90	0.00936	0.10	0.00052	Green/CS1
WS127	2.20	-0.01144	0.10	-0.00052	Green/CS1
WS128	5.40	-0.04266	0.10	-0.00079	Amber 1/CS2
WS129	3.70	-0.01716	0.10	-0.00052	Green/CS1

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.

Preliminary ground gas monitoring suggests that the site can be predominantly classified as Green / CS1, and in these areas it is considered that ground gas protection measures will not be required. However, localised areas of the site have been assessed as being Amber 1 / CS2 and properties within this area will likely require specialist protection measures as detailed herein.

However, should properties be constructed within a sub-floor void, NHBC guidance can be followed, which would mean properties within the vicinity of WS123 and WS124 would be classified as Green and would not require ground gas protection measures as the calculated GSV is <0.76l/hr. However, ground gas protection measures will be required in the vicinity of WS128 due to the presence of elevated carbon dioxide concentrations.

The site may be zoned however agreement with the local authority will be required.

The final ground gas regime will be confirmed following completion of the ground gas monitoring programme.



5.5. RESIDENTIAL BUILDING GAS RISK MITIGATION

British Standard BS8485 (2015)+A1(2019) provides two types of residential property that require assessment. These building types are:

-  **Type A Building** – Private ownership with no building management controls on alterations to the internal structure, the use of rooms, the ventilation of rooms or the structural fabric of the building. Some small rooms are present. Probably conventional building construction (rather than civil engineering). Examples include private housing and some retail premises.
-  **Type B Building** – Private or commercial property with central building management control of any alterations to the building or its uses but limited or no central building management control of the maintenance of the building, including the gas protection measures. Multiple occupancy. Small- to medium-sized rooms with passive ventilation of rooms and other internal spaces throughout ground floor and basement areas. May be conventional building or civil engineering construction. Examples include managed apartments, multiple occupancy offices, some retail premises and parts of some public buildings (such as schools, hospitals, leisure centres) and parts of hotels.

Based on the ground gas risk assessment and the proposed Type A Building, it is envisaged that a point score of 3.5 will be required for affected properties, as summarised in Table 5.7.

TABLE 5.7 BS 8485 (2015) POINTS REQUIRED FOR TYPE A AND TYPE B BUILDINGS

CHARACTERISTIC SITUATION	NHBC TRAFFIC LIGHT SYSTEM	MINIMUM GAS PROTECTION SCORE (POINTS)	
		HIGH SENSITIVITY	
		TYPE A BUILDING	TYPE B BUILDING
1	Green	0	0
2	Amber 1	3.5	3.5
3	Amber 2	4.5	4
4	Red	6.5	5.5
5	N/A	N/A	6.5
6	N/A	N/A	N/A

Residential buildings should not be built on CS4 or higher sites unless the type of construction or site circumstances allow additional levels of protection to be incorporated, for example, high-performance ventilation or pathway intervention measures, and an associated sustainable system of management of maintenance of the gas control system such as in institutional and/or fully serviced contractual situations.

The requisite 3.5 points must be achieved by installation of a suitable combination of measures detailed in Table 5.8.



TABLE 5.8 SUMMARY OF GROUND GAS MITIGATION MEASURES – BS8485 (2015)+A1(2019)

GAS PROTECTION SCORES FOR THE STRUCTURAL BARRIER		SCORE ^A	
Floor and Substructure Design			
Precast Suspended Segmental Subfloor (Beam and Block)		0	
Cast In-Situ Ground-Bearing Floor Slab (With Only Nominal Mesh Reinforcement)		0.5	
Cast In-Situ Monolithic Reinforced Ground-Bearing Raft or Reinforced Cast In-Situ Suspended Floor Slab With Minimal Penetrations		1 or 1.5 ^B	
Basement Floor and Walls Conforming to BS 8102:2009, Grade 2 Waterproofing ^C		2	
Basement Floor and Walls Conforming to BS 8102:2009, Grade 3 Waterproofing ^C		2.5	
A) The scores are conditional on breaches of floor slabs, etc. being effectively sealed. B) To achieve a score of 1.5 the raft or suspended slab should be well reinforced to control cracking and have minimal penetrations cast in (see A.2.2.2). C) The score is conditional on the waterproofing not being based on the use of a geosynthetic clay liner waterproofing product (see C.3, Note 4).			
PROTECTION ELEMENT SYSTEM		SCORE	COMMENTS
Gas protection scores for ventilation protection measures			
(a) Pressure Relief Pathway – Usually formed of low fines gravel or with a thin geocomposite blanket or strips terminating in a gravel trench external to the building.		0.5	Whenever possible a pressure relief pathway (as a minimum) should be installed in all gas protection measures systems. If the layer has a low permeability and/or is not terminated in a venting trench (or similar), then the score is 0.
(b) Passive Subfloor Dispersal Layer – Media used to provide the dispersal layer are:  Clear void;  Polystyrene void former blanket;  Geocomposite void former blanket;  No-fines gravel layer with gas drains; and  No-fines gravel layer.	Very good performance	2.5	The ventilation effectiveness of different media depends on a number of different factors including the transmissivity of the medium, the width of the building, the side ventilation spacing and type and the thickness of the layer. The selected score should be assigned taking into account the recommendations in Annex B of BS 8485 (2015). Passive ventilation should be designed to meet at least “good performance”.
	Good performance	1.5	
(c) Active Dispersal Layer – Usually comprising fans with active abstraction (suction) from a subfloor dilution layer with roof-level vents. The dilution layer may comprise a clear void or be formed of geocomposite or polystyrene void formers.		1.5 to 2.5	This system relies on continued serviceability of the pumps, therefore alarm and response systems should be in place.



PROTECTION ELEMENT SYSTEM	SCORE	COMMENTS
(c) Active Dispersal Layer – Usually comprising fans with active abstraction (suction) from a subfloor dilution layer with roof-level vents. The dilution layer may comprise a clear void or be formed of geocomposite or polystyrene void formers.	1.5 to 2.5	There should be robust management systems in place to ensure the continued maintenance of the system, including pumps and vents. Active ventilation should always be designed to meet at least “good performance”.
(d) Active Positive Pressurisation – Provided by the creation of a blanket of external fresh air beneath the building floor slab by pumps supplying air to points across the central footprint of the building into a permeable layer, usually formed of a thin geocomposite blanket.	1.5 to 2.5	This system relies on continued operation of the pumps, therefore alarm and response systems should be in place. The score assigned should be based on the efficient “coverage” of the building footprint and the redundancy of the system. Active ventilation should always be designed to meet at least “good performance”.
(e) Ventilated Car Park – Floor slab of occupied part of the building under consideration is underlain by a basement or undercroft car park.	4	Assumes that the car park is vented to deal with car exhaust fumes, designed to Buildings Regulations 2000, Approved Document F [9].



Gas Protection Score for the Gas-Resistant Membrane		
Gas-resistant membrane meeting all of the following criteria: ✳ Sufficiently impervious to the gases with a methane gas transmission rate < 40.0 ml/day/m²/atm (average) for sheet and joints (tested in accordance with BS ISO 15105-1 manometric method); ✳ Sufficiently durable to remain serviceable for the anticipated life of the building and duration of gas emissions; ✳ Sufficiently strong to withstand in-service stresses (e.g. settlement if placed below a floor slab); ✳ Sufficiently strong to withstand the installation process and following trades until covered (e.g. penetration from steel fibres in fibre-reinforced concrete, penetration of reinforcement ties, tearing due to working above it, dropping tools); ✳ Capable, after installation, of providing a complete barrier to the entry of the relevant gas; and ✳ Verified in accordance with CIRIA C735.	2	The performance of membranes is heavily dependent on the quality and design of the installation, resistance to damage after installation and integrity of joints. For example, a minimum 0.4 mm thickness (equivalent to 370 g/m² for polyethylene) reinforced membrane (virgin polymer) meets the performance criteria opposite. If a membrane is installed that does not meet all the criteria opposite, then the score is 0.
This table should be read in conjunction with the notes presented in BS 8485 (2015)+A1 (2019)		



5.6. POTABLE WATER SUPPLY

This section provides a summary of the site investigation data with reference to the selection of potable water supply pipework. The assessment is made with reference to the UK Water Industry Research (UKWIR) publication “Guidance on the selection of Water Supply Pipes to be used in Brownfield Sites”

TABLE 5.9 PIPELINE SELECTION PE THRESHOLD CONCENTRATIONS

Contaminant Group	PE-threshold (mg/kg)	Concentrations at <u>Current</u> pipeline depth (mg/kg)
Total VOC	0.5	<1.0
Total BTEX And MTBE	0.1	<1.0
Total SVOCs (Excluding PAH and those substances marked with an *)	2	<0.2
EC5-EC10 Aliphatic and Aromatic Hydrocarbons	2	<1.2
EC10-EC16- Aliphatic and Aromatic Hydrocarbons	10	7.7
EC16-EC40 Aliphatic and Aromatic Hydrocarbons	500	94
Phenols (From SVOC Analysis)*	2	<1.0
Cresols and Chlorinated Phenols (From SVOC Analysis)	2	<0.2
Ethers*	0.5	-
Nitrobenzene*	0.5	-
Ketones*	0.5	-
Aldehydes*	0.5	-
Amines	Fail	-
Other Consideration		
Are there any exceedances of the PE threshold outside of the pipeline depth?	None identified.	
Is free product present in soil and groundwater?	None identified.	
Could hydrocarbon impact at greater depth than current pipeline depth be mobilised by rising groundwater levels?	No – Made Ground to have the potential for elevated PAH or hydrocarbon concentrations is located above the water table. Groundwater levels are generally significantly deeper than pipeline depth.	
Will soils impacted with above determinands likely be utilised elsewhere on site?	No.	
Will soils be imported to site as part of any future earth works	Currently unknown, however it is likely soils will be required to be imported to site. The importation of materials may affect the WIR Risk Assessment which should be updated after completion.	

Notes - Pipe line depth normally between 0.75m–1.35m

Based on the assessment of current site conditions it is likely that PE pipe will be suitable, however an allowance barrier pipeline may be required at the proposed development dependent upon imported materials.



5.7. CONCEPTUAL SITE MODEL

Following the completion of the intrusive site investigation, chemical analysis and risk assessment, the conceptual model shown in Table 5.10 has been prepared for the site.

TABLE 5.10 CONCEPTUAL MODEL

POLLUTANT LINKAGE	CONTAMINANT (SOURCE)	PATHWAY	RECEPTOR	PROBABILITY	CURRENT RISK	RESIDUAL RISK AFTER MITIGATION
PL1 PL2	Heavy metals and PAHs in Made Ground	Dermal contact. Dermal contact and ingestion.	Future site users. Off-site receptors.	Likely	High	LOW
Discussion: Elevated concentrations of arsenic and non-volatile PAH dibenzo(a,h)anthracene have been identified in localised Made Ground and natural topsoil deposits. Recommendation: Segregation of impacted natural topsoil materials and reworked topsoil, with further analysis of remaining natural topsoil deposits to determine if suitable for retention on site. 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 in Made Ground	Inhalation of dust.	Future site users. Buildings. Off-site land users.	Likely	High	LOW
Assessment: Asbestos in the form of loose chrysotile fibres at a quantification of 0.002% have been identified within localised Made Ground at WS118 at 0.30m bgl. Recommendation: Placement of materials in line with E3P Asbestos Conceptual Site Model; materials from WS118 should be placed >1.00 m below garden plots or POS areas. Cover system to garden and landscaped areas will prevent exposure to future site users and materials must be placed within an area of low future sensitivity. Construction works completed with PPE and provision of welfare.						



POLLUTANT LINKAGE	CONTAMINANT (SOURCE)	PATHWAY	RECEPTOR	PROBABILITY	CURRENT RISK	RESIDUAL RISK AFTER MITIGATION
PL4	Methane, carbon dioxide (Made Ground and potentially 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.	Low likelihood	Moderate	LOW
Assessment: Low likelihood due to the presence of glacial till that will likely restrict migration of any ground gas into shallow foundations. Ground gas monitoring to date indicates that the majority of the site can be classified as Green/CS1, with localised areas of Amber 1/CS2 where ground gas protection measures will be required. Recommendation: Completion of gas monitoring or precautionary CS2 /Amber 1 measures required. The full ground gas regime will be confirmed following the completion of ground gas monitoring.						
PL5	Mobile contaminants such as metals, PAHs, hydrocarbons, volatile compounds (Made Ground)	Surface runoff. Migration through permeable strata and preferential pathways. Perched waters migration.	Groundwater (Secondary B Aquifer).	Unlikely	Moderate	LOW
Assessment: Unlikely probability as significant sources of mobile contamination have not been identified. SVOC analysis of groundwater samples have identified concentrations above the laboratory limit of detection of Isophorone (WS102 – 8.0 µg/l; WS117 – 2.9 µg/l), Diethyl phthalate (WS102 – 2.5 µg/l; WS117 – 1.5 µg/l; WS123 – 0.92 µg/l); and, Dibutyl phthalate (WS102 – 0.29 µg/l; WS117 – 1.0 µg/l; WS123 – 0.81 µg/l). A source for these determinants has not been identified on site and therefore it is considered the concentrations are isolated.						



POLLUTANT LINKAGE	CONTAMINANT (SOURCE)	PATHWAY	RECEPTOR	PROBABILITY	CURRENT RISK	RESIDUAL RISK AFTER MITIGATION
Recommendation: Further groundwater monitoring and soil analysis in the vicinity of WS102, WS117 and WS123. The underlying granular drift deposits are underlain by >5.0m of glacial till deposits which will afford the protection of the underlying aquifer.						
PL6	Sulphate (potential ash within Made Ground)	Sulphate attack on concrete.	Building structure.	Unlikely	Moderate/Low	LOW
Assessment: Unlikely probability as significant contamination has not been identified across the site.						
Recommendation: Chemical analysis for pH and soluble sulphate content shows the site generally meets Class DS-1, Aggressive Chemical Environment for Concrete Classification (ACEC) AC-1s in accordance with BRE Special Digest 1 (2005).						
PL7	Organic contaminants such as hydrocarbons, solvents (Made Ground)	Ingestion of tainted water supply.	Future site users. Water pipes.	Low likelihood	Moderate	LOW
Assessment: Low likelihood as significant contamination anticipated at pipeline depth across the site (0.75–1.35 m).						
Recommendation: Further intrusive investigation will be required once development levels have been agreed and following remediation and enabling works.						
PL8	Phytotoxic contaminants (Made Ground)	Direct Contact (plant uptake).	Flora.	Likely	Low	LOW
Assessment: Unlikely probability as contamination has not been encountered, which may be taken up by flora in soft landscaping/gardens.						
Recommendation: Provision of clean cover system.						



Main exposure pathways:

PL1 = soil ingestion, PL2 = dermal contact and ingestion, PL3 = vapour inhalation (indoor), PL4 = dust inhalation; PL5 = Vertical/lateral migration;
PL6 = Corrosion of concrete; PL7=Tainting of water supply; PL8 = Uptake by plants



6. GEOTECHNICAL ASSESSMENT

6.1. PROPOSED DEVELOPMENT

E3P understands that Cushman and Wakefield are progressing a marketing campaign in relation to the proposed divestment and future redevelopment of Northenden College, Greater Manchester for low-rise residential housing with associated adopted estate roads and utility infrastructure.

6.2. SUMMARY OF GROUND CONDITIONS

TOPSOIL

Across the southern area of the site, all exploratory hole locations encountered natural topsoil, with discrete areas in the north-east of the site. Topsoil was encountered from ground level to a maximum depth of 0.70m bgl. The topsoil comprised of a black brown slightly gravelly medium SAND with frequent rootlets and gravel of mudstone.

MADE GROUND

Made Ground was encountered primarily within the northern section of the site with an isolated area in the south of the site associated with the basketball court. Made Ground underlying the current buildings on site is anticipated to be at a depth > 1.60mbgl. Furthermore, it should be assumed that the paths in the southern sector of the site will be underlain by 0.30m of Made Ground. The bund along the south-eastern boundary is assumed to contain Made Ground or reworked natural materials.

Made Ground was encountered to a maximum depth of 2.10mbgl within TP129, however the full depth could not be proven due to inability to progress excavation due to the density of materials. This was also the case in WS122.

Within the northern and central areas of the site TP107, TP108, TP127, TP134, WS119 and WS122 were terminated due to the presence of concrete obstructions, which are considered to be attributed to historical development on the site.

TP126 and TP134 were terminated within Made Ground deposits due to the collapse of the strata.

TP128 was terminated due to the presence of a suspected former land drain.

At exploratory hole locations within the landscaped areas of the site, this generally comprised of a reworked topsoil that was black brown slightly clayey medium sand with occasional gravel of mudstone and brick. This was underlain by a dark brown slightly clayey gravelly medium sand with occasional cobbles. The gravel comprised of mudstone, brick, concrete, plastic and timber with cobbles of brick.

At three locations, TP124, TP125 and TP133 the dark brown gravelly medium sand is overlain by asphalt and a grey sandy gravel (MOT).

In the very northern area of the site (TP106, TP136 and TP137) encountered a grey sandy gravel (MOT) with occasional rootlets and gravel of mudstone, limestone and brick from ground level to 0.30m bgl.

Within exploratory hole locations within the car parks, these encountered asphalt underlain by a grey sandy gravel (MOT) which was underlain by a black red sandy gravel with gravel of brick or a black brown slightly clayey gravelly medium sand with gravel of mudstone, asphalt and brick.



DRIFT DEPOSITS

The drift deposits underlying the site generally comprised of a light yellow brown gravelly medium SAND with gravel of mudstone and sandstone underlain by a light grey brown gravelly medium SAND with gravel of mudstone and sandstone. A stiff high strength to very stiff high strength light brown mottled grey gravelly sandy CLAY with gravel of mudstone was subsequently encountered beneath granular deposits.

Within WS107 and WS115, a very soft extremely low strength light brown very sandy gravelly CLAY with gravel of mudstone and sandstone was encountered at 1.90m bgl and 3.20m bgl respectively. Furthermore, soft CLAY was identified from 3.10-3.40mbgl within SHDP102, SHDP105 at 3.20-3.30mbgl, 3.00-3.10mbgl within SHDP112, 3.20-3.80mbgl within SHDP116. Laboratory undrained shear strength testing has identified soft clays within WS129 at 3.50-4.00mbgl.

SOLID GEOLOGY

The solid bedrock geology was not encountered throughout the site investigation works.

GROUNDWATER

Groundwater was encountered as seepages at depths of between 1.50 m bgl and 3.00 m bgl.

6.3. 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.
-  Demolition of all existing buildings and removal of all concrete hardstanding.
-  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. These should be excavated from below the proposed development footprint with the resulting void backfilled.

6.4. FOUNDATION CONDITIONS AND ASSESSMENT OF POTENTIAL BEARING CAPACITIES

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 6.1



TABLE 6.1 SUMMARY OF ABPS

GRANULAR SOILS			
Description	Depth (Range m bgl)	Relative Density	Allowable Bearing Pressure (kN/m ²)
Gravelly SAND	1.00-3.00	Loose	52-95
Gravelly SAND	1.00-3.00	Medium Dense	100-274
Gravelly SAND	1.00	Dense	332-342
COHESIVE SOILS			
Description	Depth (range m bgl)	Undrained Shear Strength (Cu) (kN/m ²)	Allowable Bearing Pressure (kN/m ²)
Very soft sandy CLAY	2.00-3.00	8-9	17-18
Firm sandy CLAY	2.00-3.00	26-36	53-75
Description	Depth (range m bgl)	Undrained Shear Strength (Cu) (kN/m ²)	Allowable Bearing Pressure (kN/m ²)
Stiff sandy CLAY	1.00-5.00	41-71	84-147
Very stiff sandy CLAY	3.00-5.00	76-207	156-426

Super Heavy Dynamic Probes (SHDPs) were completed across the site in addition to window sample probe holes and mechanically excavated trial pits to show relative densities of the underlying strata. Exploratory hole logs within Appendix V detail the raw data, and the SHDPs with associated SPT N values are detailed within Appendix XI. A comparison of SHDP calculated N values against in-situ window sample SPT N values show that they present similar data trends and profile. In general, the SHDPs, have shown the underlying cohesive deposits underlying granular deposits to be firm, and increasing in strength with depth.

When compared against the closest window sample probeholes, the following soft CLAY and loose SAND deposits have been identified:

- ✿ Within SHDP101 loose SANDs were identified at circa. 2.40m – 3.40mbgl.
- ✿ SHDP102 identified loose SAND at 1.80-2.40mbgl, which were underlain by firm CLAY to 3.10mbgl, and soft clays from 3.10-3.40mbgl.
- ✿ Within SHDP103 loose sands have been identified between 0.40-1.70mbgl and at 2.20-2.30mbgl. Underlying the SAND deposits, CLAY was noted to be firm increasing to very stiff with depth.
- ✿ Loose SANDs have been between 2.70-3.20mbgl within SHDP104.
- ✿ A thin band of soft CLAYs have been identified within SHDP105 at 3.20-3.30mbgl.
- ✿ Loose SAND deposits have been identified between 0.60m - 2.40mbgl. and 2.80m-3.20mbgl within SHDP106.
- ✿ Loose SANDs have been identified within SHDP107 between 0.00m-0.50mbgl. and 2.00m-2.90mbgl.



- ✿ Within SHDP108 loose SANDS were identified between 0.00m-1.20mbgl.
- ✿ Very loose to loose SANDS were identified within SHDP109 at 0.70m-1.60mbgl. and at 2.40mbgl.
- ✿ Within SHDP110 loose SANDS have been identified between 2.10m-2.90mbgl.
- ✿ Loose SAND deposits have been identified within SHDP111 at 2.50-2.90mbgl. and 3.20-4.10mbgl.
- ✿ Within SHDP112 loose SANDS were identified between 0.20m-0.60mbgl. Furthermore soft CLAY was identified at 3.00-3.10mbgl.
- ✿ At SHDP113 loose SAND is present between 0.50m-1.20mbgl and 2.10-3.00mbgl.
- ✿ Loose SANDS have been identified within SHDP114 at 2.50m-3.00mbgl.
- ✿ Within SHDP115 loose SANDS were identified between 2.50m-3.00mbgl.
- ✿ At SHDP116 loose SANDS were identified at 0.90-1.90mbgl. and at 3.10-3.20mbgl. Underlying the SAND deposits, CLAY deposits were noted to be soft at 3.20-3.80mbgl.
- ✿ Within SHDP117 between 1.30m-2.20mbgl. loose SANDS were identified.
- ✿ Within SHDP118 loose SANDS have been identified between 0.60m-1.10m and 2.40m-3.30mbgl.
- ✿ Loose SANDS have been identified within SHDP119 at 2.60-2.80mbgl.
- ✿ Within SHDP120 loose SAND has been identified between 2.10m-2.70mbgl.
- ✿ Loose SANDS are present in SHDP121 at 0.60m-0.80mbgl.
- ✿ SHDP122 has identified loose SANDS at 2.50m-2.80mbgl.
- ✿ Within SHDP124 loose SAND has been identified between 0.40m-0.80mbgl.

Based on the 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 medium dense to dense SANDS or localised areas of stiff to very stiff glacial CLAYS.

However, given the topographical variances on the site, prior to the detailed design of suitable foundations solutions, a programme of remediation and enabling works will be required to remove the building, the extensive buried obstructions and cut/fill the site to provide suitable development platform levels.

Upon completion of enabling works, it is likely that the most cost effective option for the majority of the site would be a combination of strip and mass trench fill foundations, and an engineered solution where founding strata has been encountered at greater depths in excess of 2.00m bgl due to loose SANDS, soft CLAYS or deeper Made Ground.



Very loose or loose SAND deposits and very soft CLAY deposits have been identified across the site, in addition to saturated sand strata within window sample probe holes where groundwater has been encountered. The deeper soil profiles are saturated by the natural groundwater body that results in the reduction in the calculated safe ABP by 50% as is demonstrated by the significant decrease in the calculated SPT N Value at depth. Within the areas of loose SANDs the use of vibro stone columns (VSC) is advised. However, where soft CLAYs have been identified with an ABP $<30\text{ kN/m}^2$, either driven piled foundations are required, or soft clays should be removed and replaced with granular material to allow the use of VSC. Within areas of saturated strata the VSC should be completed via the use of a bottom feed. At WS107, the natural clay drift deposits have been assessed as being very soft extremely low strength with a net allowable bearing pressure (ABP) of 18 kN/m^2 at a depth of 2.00m bgl. Within WS115 a calculated ABP of 17 kN/m^2 has been encountered at 3.00m bgl. Laboratory undrained shear strength testing of WS101 and WS129 identified soft clays with undrained shear strengths of 28 kN/m^2 and 39 kN/m^2 respectively. The use of VSC will be limited where ABP is $<30\text{ kN/m}^2$.

It should be noted that mechanically excavated trial pits were generally stable within granular deposits. Collapse in window samples occurred when the groundwater or saturated strata was encountered.

SHDPs have identified loose granular deposits within both shallow and deep granular horizons. Consideration of the bulb of pressure on the underlying loose sands at depth should be taken and will require an engineered design.

Furthermore, following the demolition of the current buildings on site, there will likely be in excess of 1.50m of Made Ground, therefore it would be considered necessary to remediate the ground to enable the use of VSC.

Where Made Ground has been identified to be depths $>1.45\text{mbgl}$. dependent on development levels, for plots in these areas it may be more economic to consider the use of VSC in areas outside of tree influence in the event cohesive materials subject to volumetric instability are encountered.

Consideration must be given to the aforementioned soft clay deposits that are isolated on site. Where cohesive deposits are present in influencing distance of trees consideration must be given to the viability as the foundation will still require locally deepening or the clays that are subject to volumetric instability. Materials could be removed and replaced with site won natural sands during the enabling works to accommodate for this solution.

Side walls of trial pits generally remained stable during excavation; however, where water strikes were observed the stability was compromised.

Foundation depths within the conjectured influence of former, existing or proposed trees will need to be deepened to ensure that structural loading bears within the underlying target founding stratum, which cannot be subject to volumetric instability associated with fluctuation in moisture content.

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.



TABLE 6.2 ANTICIPATED FOUNDATIONS

LOCATION	ANTICIPATED FOUNDING STRATA DEPTH (m bgl)	GROUND WATER (m bgl)	TARGET STRATUM	TREES	FOUNDATION TYPE	TYPE OF CONCRETE
WS101	0.75	2.50	MD SAND	Y	Shallow Strip	DS-1, AC-1s
WS102	>2.50	-	Stiff CLAY	Y	Engineered solution	-
WS103	0.75	2.30	MD SAND	N	Shallow Strip	-
WS104	0.75	-	MD SAND	N	Shallow Strip	DS-1, AC-1s
WS105	0.75	2.00	D SAND	Y	Shallow Strip	-
WS106	0.75	-	MD SAND	N	Shallow Strip	-
WS107	>2.50	2.00	Stiff CLAY	Y	Engineered solution	DS-1, AC-1s
WS108	1.05	2.00	MD SAND	Y	Shallow Strip	-
WS109	>2.50	1.50	Stiff CLAY	Y	Engineered solution	-
WS110	0.75	-	MD SAND	N	Shallow Strip	DS-1, AC-1s
WS111	0.75	2.20	MD SAND	N	Shallow Strip	-
WS112	1.15	-	MD SAND	Y	Shallow Strip	DS-1, AC-1s
WS113	1.45	2.00	MD SAND	Y	Shallow Strip	-
WS114	0.75	2.00	MD SAND	Y	Shallow Strip	-
WS115	1.75	2.00	MD SAND	Y	Mass Trench / VSC	-
WS116	2.35	2.50	MD SAND	Y	Mass Trench / VSC	-
WS117	1.25	3.00	MD SAND	Y	Shallow Strip	-
WS118	1.25	2.00	MD SAND	Y	Shallow Strip	-
WS120	0.85	2.00	D SAND	Y	Shallow Strip	-
WS121	>2.50	1.50	Stiff CLAY	Y	Engineered solution	-
WS123	1.25	2.00	MD SAND	Y	Shallow Strip	-
WS124	1.15	2.00	MD SAND	Y	Shallow Strip	-
WS125	>2.50	-	-	Y	VSC	-
WS126	>2.50	-	Stiff CLAY	Y	Engineered solution	-
WS127	>2.50	-	-	N	VSC	-
WS128	0.75	-	MD SAND	N	Shallow Strip	-
WS129	0.75	-	MD SAND	Y	Shallow Strip	-
TP101	0.75	-	MD SAND	Y	Shallow Strip	-



TP102	0.75	-	MD SAND	Y	Shallow Strip	-
TP103	>2.50	-	MD SAND	Y	Engineered Solution	-
TP104	0.75	-	MD SAND	Y	Shallow Strip	-
TP105	1.45	-	MD SAND	Y	Shallow Strip	-
TP106	0.75	-	MD SAND	Y	Shallow Strip	-
TP109	0.75	-	MD SAND	N	Shallow Strip	-
TP110	>2.50	1.50	Stiff CLAY	Y	Engineered solution	-
TP111	>2.50	1.50	Stiff CLAY	Y	Engineered solution	-
TP112	>2.50	1.50	Stiff CLAY	Y	Engineered solution	-
TP113	0.95	-	MD SAND	N	Shallow Strip	-
TP114	0.75	-	MD SAND	N	Shallow Strip	DS-1, AC-1s
TP115	0.75	-	MD SAND	Y	Shallow Strip	-
TP116	0.75	-	MD sand	N	Shallow Strip	-
TP117	0.75	-	MD SAND	N	Shallow Strip	-
TP118	0.75	-	MD SAND	N	Shallow Strip	-
TP119	>2.50	-	-	N	Engineered solution	-
TP120	0.75	-	MD SAND	N	Shallow Strip	-
TP121	>2.50	-	-	N	Engineered solution	-
TP122	1.05	-	MD SAND	Y	Shallow Strip	-
TP123	1.15	-	MD SAND	Y	Shallow Strip	-
TP124	1.15	-	MD SAND	Y	Shallow Strip	-
TP125	1.45	-	MD SAND	Y	Shallow Strip	DS-1, AC-1s
TP129	>2.50	-	-	N	Engineered solution	-
TP130	1.45	-	MD SAND	Y	Shallow Strip	-
TP131	2.35	-	MD SAND	Y	VSC	-
TP132	2.35	2.50	MD SAND	Y	Mass Trench / VSC	-
TP133	1.25	2.00	MD SAND	Y	Shallow Strip	-
TP135	0.85	-	MD SAND	Y	Shallow Strip	-
TP136	0.95	-	MD SAND	Y	Shallow Strip	-
TP137	0.75	-	MD SAND	Y	Shallow Strip	-



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.

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, based on our extensive experience of similar sites, we would anticipate that the final foundation solution would be a combination of the following:

-  Shallow strip foundations bearing on medium dense to dense gravelly SAND at circa 1 m bgl;
-  Trench fill to support reinforced strip foundations in areas of variable ground and/or potential tree influence;
-  Vibro stone columns in the vicinity of deep Made Ground or loose SANDs; and,
-  Driven piled foundation solution.



TABLE 6.3 GROUND IMPROVEMENT DESIGN RISK MATRIX

RISK ITEM	COMMENT	PASS/FAIL
Soft clays with an undrained shear strength less than 30 kN/m ²	CLAY soils are generally firm to stiff with $C_u > 80$ kN. Isolated areas of softer clay soils were encountered with $C_u > 30$ kN/m ² at WS107 at 2.00mbgl, WS115 at 3.00mbgl and WS101 and WS129 at 3.50-4.00mbgl; however, it is considered that these will either be piled or soft material excavated to remove the organic deposits.	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	Peat and organic silts have not been identified within the site boundary.	PASS
Voided filled ground, e.g. old water tanks, pottery, glass bottles, concrete rubble or brick fill of unsuitable grading	Made Ground beneath the northern sector will require removal and processing to render the site suitable for VSC. The existing buildings substructure will also require excavation and processing into a graded aggregate suitable for vibro treatment.	PASS – on completion of enabling works
Loose or non-engineered fill not previously subject to rising or fluctuating water levels saturation	None identified.	PASS
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	None identified.	PASS
Fill, containing degradable material where organic material forms more than 15% of fill by volume	None identified.	PASS
Clays with a plasticity index greater than 40%	None identified.	PASS
Highly sensitive soils liable to collapse or remoulding	None identified.	PASS
Cohesive soils with trees in influencing distance	Plots where tree influence has been modelled and will either be subject to a piled, mass trench-fill solution, or excavation and replacement with granular material.	PASS



RISK ITEM	COMMENT	PASS/FAIL
Overall Risk Rating and Suitability for Vibratory Ground Improvement		PASS

A depth to founding plan is included as Drawing 13-969-008 in Appendix III.

6.5. 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.

6.6. 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 majority of the underlying 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). However where medium volume change potential clays have been identified within the shallow CLAY strata on site, heave precautions will be required.

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 for low plasticity areas and 250 mm for moderate plasticity clays 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 6.4.



TABLE 6.4 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		

6.7. 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.

6.8. 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.

Furthermore, permeability tests showed granular drift deposits to have a good soakage potential.

Therefore, considering the significant volumes of permeable SAND on the site, it is considered that soakaway drainage may be suitable for the proposed development. However, the application of soakaway drainage will ultimately be dependent on the specific requirements of the development. All soakaways should be designed in accordance with BRE Special Digest 365 – Soakaway Design.



6.9. CONCRETE DURABILITY

Based upon the results of the chemical analyses it is considered that subsurface concrete can 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).

6.10. EXCAVATIONS

Trial pits were generally stable in the shallow granular natural strata; as such, it is considered that near-surface excavations will be feasible. In areas where Made Ground was encountered, excavations were generally less stable. Window sample probeholes were noted to be unstable in granular deposits, in particular where groundwater was encountered.

Site observations indicated that excavations should be feasible in the near surface with normal plant; however, obstructions were identified in the near surface, including former foundations and concrete slabs. It is anticipated that any obstructions will be grubbed out during the reduced-level dig for the substructure works.

However, due to the depth and variability of the granular drift deposits and Made Ground and likelihood of trench collapse, it is considered that all excavations are supported or battered back in accordance with guidance contained in CIRIA R97.

If local pumping of groundwater is required during the advancement of excavations for the proposed foundations then consideration should be given to the potential for dewatering gravels in the surrounding areas that may cause structural damage to building substructures in close proximity to the site.

TABLE 6.5 CIVIL ENGINEERING EXCAVATION RISK MATRIX

RISK ITEM	PRESENT	COMMENT
Running Sands	No	No running sand has been identified.
Minor Water Ingress	No	Minor water ingress will require localised dewatering/sump pumping during the construction of site drainage infrastructure. Ingress of water into foundation excavation will potentially flood foundation excavations, limiting the viability of spread foundations to be constructed.
Shallow Bedrock	No	Shallow bedrock has not been identified within the site boundary.

6.11. FURTHER WORKS

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

- 🔧 Post-demolition site investigation beneath current buildings and in the vicinity of the electricity substation;
- 🔧 Plot-specific foundation schedule (upon receipt of the final development levels);
- 🔧 Arboricultural survey;
- 🔧 Materials management plan;



- ✳ Geotechnical earthworks strategy (infrastructure);
- ✳ Remediation and enabling works strategy; and,
- ✳ Full three-dimensional earthworks cut/fill model.

6.12. CONSTRUCTION ACTIVITY AND INSPECTION

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

- ✳ Due to the variability of the soils at the site, it is recommended that sufficient allowance is made for the inspection of formations and subformations 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 should be utilised.
- ✳ It is considered that dewatering may be required, especially 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, to include the use of personnel protective equipment (PPE).



6.13. GEOTECHNICAL RISK REGISTER

POTENTIAL CONSTRAINT	ABNORMAL	LOCATION ON SITE	ESTIMATED AREA OF SITE AT RISK (%)	ASSESSMENT AND MITIGATION
Remediation of contaminated soils		On-site	10	A localised area of asbestos was encountered at WS118, the placement of the soils in areas of low sensitivity in accordance with the E3P Asbestos CSM is required. Elevated concentrations of arsenic and dibenzo(a,h)anthracene can be mitigated by placement below a suitable clean garden cover system. Excavated impacted topsoil materials not suitable for use within the garden cover system cannot be placed at a depth greater than 1.00 m with gardens and must be 2.00 m off-set from plots.
Obstructions		On-site	35	Site has been subject to significant historical development in the northern areas and, subsurface obstruction from relict foundations and slabs remain. Current buildings on site will require demolition and all slabs and founds removed; following this it is anticipated there to be >2.50 m of Made Ground present.
Artificially levelled and filled platforms		On-site	10	The site appears to have been landscaped and artificially backfilled around the car parking areas of the site.
Trench collapse		On-site	35	Made Ground present beneath the site is likely to be loosely compacted and possibly prone to collapse. Made Ground and drift deposits were generally stable during the intrusive site investigation, however there were areas of instability especially where groundwater was identified and subsequent saturated granular strata.
Mature trees		On-site / Periphery	25	Arboriculture survey required to determine areas of potential tree influence. The site is predominantly surfaced by hardstanding, with an area of soft standing (playing field) in the south, however a number of mature and semi mature trees are present within the site boundary and create the periphery to much of the site.
Volume change potential clay		On site	80	The site is underlain by cohesive and granular soils. The deeper cohesive soils encountered between 2.00m bgl and 5.45m bgl are assessed as having a low volume change potential, therefore heave precautions will not be required. Shallow cohesive soils within TP111 at 0.60 mbgl have been noted to be of medium volume change potential.



POTENTIAL CONSTRAINT	ABNORMAL	LOCATION ON SITE	ESTIMATED AREA OF SITE AT RISK (%)	ASSESSMENT AND MITIGATION
Running sands		N/A	N/A	Data searches indicate very low risk.
Ground dissolution		N/A	N/A	Data searches indicate no hazard.
Concrete design		On-site	100	DS-1, AC-1s.
Low-permeability ground		On-site	70	The BRE365 soakaways tests completed across the site have calculated permeability coefficients of between 3.65 E-05 and 9.33 E-05. The design and viability of soakaways on site should be designed by a suitably qualified drainage engineer.
Services/sensitive structures		On-site	100	A review of online services and GPR survey supplied by the client has identified a number of services within the site boundary which should be considered sensitive in this case. Piling may not be possible within close proximity to any sensitive infrastructure that is to remain as part of the development.
Abnormal foundation solutions		On-site	15	In areas where significant Made Ground, very loose to loose SAND and very soft to soft CLAY that will be subject to volume change, has been identified on site, an abnormal foundation solution (MTF, VSC, Pile) may be required.
Areas not investigated		On-site	20	Beneath the current buildings on-site and of the live electricity substation. Further investigation will be required following demolition.



7. CONCLUSIONS AND RECOMMENDATIONS

CONTAMINATED LAND ASSESSMENT

Human Health

A Tier I human health risk assessment has been undertaken using the chemical analysis results of the soils and comparing to the relevant Tier I criteria. This assessment has identified the presence of elevated arsenic, dibenzo(a,h)anthracene and asbestos.

The majority of the identified elevated concentrations have primary exposure pathways related to dermal contact and ingestion, soil ingestion and consumption of homegrown produce. These exceedances can be mitigated by the installation of a chemically suitable cover system within all proposed garden areas.

Asbestos, in the form of chrysotile loose fibres, has also been identified within one localised areas in shallow Made Ground deposits at WS118 at 0.30m bgl. Asbestos quantification was undertaken to further assess where these soils may be placed which identified 0.002% asbestos by volume/weight. No visual signs of asbestos-containing material (ACM) were encountered during the ground investigation, therefore it is likely only trace fibres are present within these localised soils and a process of hotspot excavation with placement of impacted soils in accordance with the E3P Asbestos CSM should be undertaken within an area of low sensitivity.

Chemical analysis of the natural SAND and CLAY drift deposits have identified these soils to be acceptable for use as subsoil within the proposed garden areas; however, further chemical validation samples will be required to confirm this.

There are potential suitable sources of topsoil available on the site, however isolated occurrences of exceedances of dibenzo(a,h)anthracene have been identified within natural topsoil deposits. Analysis of exceedances against human health remediation targets for residential end use at an SOM of 2.5% for dibenzo(a,h)anthracene of 0.28mg/kg show that the two natural topsoil samples which have exceeded the GAC at 1% SOM are still noted to be exceeding.

During the enabling works these soils should be segregated, and further chemical analysis undertaken of the remaining natural topsoil deposits to ensure suitability for use within the proposed development and confirm the identified elevated concentrations are indeed hotspots and not representative of the topsoil as a whole. Excavated impacted topsoil materials not suitable for use within the garden cover system cannot be placed at a depth greater than 1.00 m with gardens and must be 2.00 m off-set from plots.

Anthropogenic topsoil is likely to be impacted across the site and therefore will not be suitable for use within the proposed development. During enabling works these soils should be segregated and disposed off-site at a licensed waste facility.

Further post-demolition investigations are required beneath current buildings on site and areas in which access has been prohibited due to utility infrastructure, to confirm the findings of this initial assessment as and when full and unrestricted access is available.



Controlled Waters	There is considered to be a low risk to controlled waters. SVOC analysis of groundwater samples have identified concentrations above the laboratory limit of detection of Isophorone (WS102 – 8.0 µg/l; WS117 – 2.9 µg/l), Diethyl phthalate (WS102 – 2.5 µg/l; WS117 – 1.5 µg/l; WS123 – 0.92 µg/l); and, Dibutyl phthalate (WS102 – 0.29 µg/l; WS117 – 1.0 µg/l; WS123 – 0.81 µg/l). A primary source for these determinants has not been identified on site however may be attributed to the presence of paint or degradation of plastics within the Made Ground. It is recommended further groundwater monitoring and soil analysis in the vicinity of WS102, WS117 and WS123. The underlying granular drift deposits are underlain by >5.0m of glacial till deposits which will afford the protection of the underlying aquifer.
Ground Gas	Ground gas monitoring thus far has indicated the majority of the site would be classified as Characteristic Situation 1 or Green, suggesting no gas protection measures will be required across the majority of the site, with localised areas of Characteristic Situation 2. The final ground gas regime will be confirmed following the completion of the ground gas monitoring programme. With isolated areas falling into classification CS2 / Amber 1 it is considered that upon completion of the ground gas monitoring period a zoned approach may be feasible.
Potable Water	This will need to be confirmed following the completion of a UKWIR risk assessment. Post-remediation and enabling works ground conditions may be different from those identified during this site investigation which have indicated PE pipe will be suitable. However an allowance for barrier pipeline may be required at the proposed development dependent upon imported materials.

GEOTECHNICAL ASSESSMENT

The underlying natural clay drift deposits have been assessed as generally being firm low strength to very stiff, high strength with a net allowable bearing pressure (ABP) in the order of between 71 kN/m² and 426 kN/m² at depths between 3.00m bgl and 5.00m bgl.

At WS107, the natural clay drift deposits have been assessed as being very soft extremely low strength with a net allowable bearing pressure (ABP) of 18 kN/m² at a depth of 2.00m bgl. Within WS115 a calculated ABP of 17 kN/m² has been encountered at 3.00m bgl. Laboratory undrained shear strength testing of WS101 and WS129 identified soft clays with undrained shear strengths of 28 kN/m² and 39 kN/m² respectively between 3.50-4.00mbgl. The use of VSC will be limited where the calculated ABP is <30 kN/m².

The granular drift deposits have been assessed as being loose to dense with a net allowable bearing pressure (ABP) of 17 kN/m² and 342 kN/m² between 1.00m bgl and 2.00m bgl.

The deeper soil profiles are saturated by the natural groundwater body that results in the reduction in the calculated safe ABP by 50% as is demonstrated by the significant decrease in the calculated SPT N Value at depth.

Upon completion of enabling works, it is likely that the most cost effective option for the majority of the site would be a combination of strip and mass trench fill foundations, and an engineered solution where founding strata has been encountered at greater depths in excess of 2.00m bgl due to loose SANDs, soft CLAYs or deeper Made Ground.

Foundation depths within the conjectured influence of former, existing or proposed trees will need to be deepened to ensure that structural loading bears within the underlying target founding stratum, which cannot be subject to volumetric instability associated with fluctuation in moisture content.



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 1.3.
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 been 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

ACM	Asbestos-containing material	MMP	Materials management plan
ADS	Acoustic design statement	ND	Not detected
AST	Above-ground storage tank	NDP	Nuclear density probe
BGS	British Geological Survey	NMP	Noise management plan
BSI	British Standards Institute	NPSE	Noise policy statement for England
BTEX	Benzene, toluene, ethylbenzene, xylenes	NR	Not recorded
CA	Coal Authority	PAH	Polycyclic aromatic hydrocarbon
CBR	California bearing ratio	PCB	Polychlorinated biphenyl
CIEH	Chartered Institute of Environmental Health	PI	Plasticity index
CIRIA	Construction Industry Research Association	PID	Photo ionisation detector
CLEA	Contaminated land exposure assessment	POS	Public open space
CML	Council of Mortgage Lenders	PPE	Personnel protective equipment
CoC	Contaminants of concern	ProPG	Professional practice guidance
CSM	Conceptual site model	QA	Quality assurance
DNAPL	Dense non-aqueous phase liquid (chlorinated solvents, PCB)	SGV	Soil guideline value
DWS	Drinking water standard	SPH	Separate-phase hydrocarbon
EA	Environment Agency	SPT	Standard penetration test
EQS	Environmental quality standard	SVOC	Semi-volatile organic compound
FFL	Finished floor level	TPH	Total and speciated petroleum hydrocarbon
GAC	General assessment criteria	TPH CWG	Total Petroleum Hydrocarbon (Criteria Working Group)
GL	Ground level	UKWIR	United Kingdom Water Infrastructure Risk
GSV	Gas screening value	UST	Underground storage tank
HCV	Health criteria value	VCC	Vibro-concrete column
ICSM	Initial conceptual site model	VOC	Volatile organic compound
LEL	Lower explosive limit	VRSC	Vibro-replacement stone columns
LMRL	Lower method reporting limit	VSC	Vibro-stone columns
LNAPL	Light non-aqueous phase liquid (petrol, diesel, kerosene)	WHO	World Health Organisation
MCV	Moisture condition value	WRAP	Waste and Resources Action Programme
MIBK	Methyl isobutyl ketone	WTE	Water table elevation



m	Metres	ppm	Parts per million
km	Kilometres	mg/m³	Milligram per metre cubed
% v/v	Percent volume in air	m bgl	Metres below ground level
mb	Millibars (atmospheric pressure)	m bcl	Metre below cover level
l/hr	Litres per hour	mAOD	Metres above ordnance datum (sea level)
µg/l	Micrograms per litre (parts per billion)	kN/m²	Kilonewtons per metre squared
ppb	Parts per billion	µm	Micrometre
mg/kg	Milligrams per kilogram (parts per million)	SSRT	Site Specific Remediation Target
PSD	Particle Size Distribution	DD	Dry Density
CL:AIRE	Contaminated Land: Applications in Real Environments	Mc	Moisture Content
ρ	Bulk Density	GPR	Ground Penetrating Radar
NDP	Nuclear Density Probe	FFL	Finished Floor Level
LEL	Lower Explosive Limit	UKWIR	UK Water Industry Research
CIRIA	Construction Industry Research and Information Association	LOD	Limit of Detection



APPENDIX III

DRAWINGS

DRAWING 13-969-001 – SITE LOCATION PLAN



APPENDIX IV

PHOTOGRAPHS

PLATE 1 CENTRAL BUILDING AND ROUNDABOUT



PLATE 2 ELECTRICITY SUBSTATION BUILDING ON WESTERN BOUNDARY OF SITE



PLATE 3 NORTH EASTERN CORNER OF SITE – WITHIN VICINITY OF WS126



PLATE 4 SOUTH EASTERN FIELD AREA OF SITE – SOUTHERN BOUNDARY



PLATE 5 SOUTH EASTERN FIELD – FACING NORTH TOWARDS SPORTS PITCH



PLATE 6 SPORTS PITCH IN SOUTH EAST OF SITE



PLATE 7 CAR PARKING AREAS IN NORTH OF THE SITE



PLATE 8 FLYTIPPED WASTE AREA NORTH EAST OF FIELD (1)



PLATE 9 FLYTIPPED WASTE AREA NORTH EAST OF FIELD (2)



PLATE 10 AREA OF VEGETATION REQUIRING A NEST BIRD CHECK – NEAR WS125





Historical Features

- Former Allotment Gardens (Pre 1956 - Pre 2010)
- Former Tennis Court (Pre 1987 - Pre 2010)
- Hardstanding (Pre 1934 - Present)
- Former Playing Field (Pre 1987 - Pre 2010)
- Former Arden College Buildings (Pre 1975 - Pre 2010)
- Former Arden College Building (Pre 1987 - Pre 2010)
- Buildings (Pre 1934 - Present)
- Former Yew Tree School (Pre 1934 - Pre 2010)
- Former Footpath (Pre 1897 - Pre 1938)
- Former Field Boundary (Pre 1897 - Pre 1938)

Notes:

P1	-	26.02.2020	DRAFT	HM	BH
Phase	Revision	Date	Issue	Drawn	Checked

Client:

Cushman and Wakefield

Job Title:

Northenden College

Job No:

13-969

Drawing No:

003

Date:

26.02.2020

Scale:

NTS

Drawing Title:

Historical Features Plan



Environmental Engineering Partnerships Ltd
City Heliport & Business Centre
Eccles, Manchester, M30 7RU
Tel: 0161 707 9612
E-mail: info@e3p.co.uk
Website: www.e3p.co.uk

The client must not amend any drawing, design or other intellectual property produced by E3P Ltd without permission in writing from E3P Ltd in advance of any amendments being made. In the event that such written permission is not obtained in advance of the amendments being made, E3P Ltd shall not be liable for any damage and/or losses occurring as a result of the amended drawing, design or intellectual property.



Site Features

	Overgrown Vegetation		Asphalt Scrubland
	Trees		Bikeshelter
	Hedges		
	Grass		
	College Buildings		
	Site Entrances		
	Sports Pitch		
	Overgrown Asphalt area		
	Asphalt Car Park		
	Elevated Landscape		

Notes:

P1	R1	20.07.2020	REVISION	LM	BH
P1	-	26.06.2020	DRAFT	LM	BH
Phase	Revision	Date	Issue	Drawn	Checked

Client:

Cushman and Wakefield

Job Title:

Northenden College

Job No:

13-969

Drawing No:

004

Date:

20.07.2020

Scale:

NTS

Drawing Title:

Site Features Plan



Environmental Engineering Partnerships Ltd
City Heliport & Business Centre
Eccles, Manchester, M30 7RU
Tel: 0161 707 9612
E-mail: info@e3p.co.uk
Website: www.e3p.co.uk

The client must not amend any drawing, design or other intellectual property produced by E3P Ltd without permission in writing from E3P Ltd in advance of any amendments being made. In the event that such written permission is not obtained in advance of the amendments being made, E3P Ltd shall not be liable for any damage and/or losses occurring as a result of the amended drawing, design or intellectual property.

