Former Rayware Site

Speke Boulevard, Liverpool

Ground Investigation Report

Prepared for TJ Morris Limited

March 2016

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Issue 2

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1	23rd March 2016	Original issue.
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Appendices

Executive Summary and Conceptual Site Model

SITE INFORMATION AND SETTING	
Report Purpose	The work has been undertaken to address anticipated planning conditions relating to contamination and provide ground related design and construction recommendations for the proposed development.
Client	TJ Morris Limited.
Site Name and Location	The site is located to the immediate north of Speke Boulevard, Liverpool. The nearest postcode is L24 9HZ. The National Grid Reference of the approximate centre of the site is 343049E, 384049N.
Proposed Development	It is understood that the proposed development is to comprise a mixed use retail scheme consisting of a number of retail units and ancillary food and drink outlets with associated landscaping, infrastructure, roads and parking areas.
PHASE 1 (DESK STUDY + WALK-OVER)	
Current Land Use and Description	Approximately 60% of the site is occupied by current buildings in a poor state of repair. A further 25% of the site comprised hardstanding in a similarly poor state of repair with the remainder surfaced in compacted aggregate. An existing two storey office block is present in the southwest corner of the site.
Site History	Up until 1936 the site was predominately agricultural with a number of small associated structures. From 1938 the site became industrialised with a series of buildings developed in the late 1930's, 1950's and 1960's to the current configuration. The two storage tanks were added in the early 1970's. The site is currently used for the storage of cars (airport parking).
Geology	The regional geological information indicates the majority of the site is directly underlain by Glacial Till. However, the northwest corner of the site is shown to be devoid of superficial deposits. The underlying solid geology comprises the Triassic Chester Pebble Beds formation of the Sherwood Sandstone Group.
Hydrogeology	The Triassic Chester Pebble Beds Formation underlying the site is a Principal Aquifer. The overlying Glacial Till deposits are classified as Unproductive Strata.
Hydrology	According to the GroundSure Screening Report included as part of the Capita Symonds report there is no detailed river network within 500m and no surface water features within 250m of the subject site.
PHASE 2 – GROUND INVESTIGATION	
Hydrock Site Works	The Hydrock ground investigation comprised: • 23 window sample boreholes to a maximum depth of 5.45m bgl; • chemical testing of soils, waters and leachates and geotechnical testing of soils and rocks; • 6 gas and groundwater monitoring installations; • monitoring of ground gas and groundwater. A number of the exploratory holes were located to target areas of suspected contamination such as former above ground and suspected below ground fuel tanks.
Ground Conditions Encountered	The ground conditions encountered during the investigation comprised: • Concrete, ranging from 0.06m bgl to 2.0m bgl with some areas consisting of 10mm reinforcement at 160mm bgl and 20mm rebar at 230mm bgl. • Made Ground – to depths of between 0.3mbgl and 3.0m bgl, consisting of soft to firm dark brown sandy gravelly CLAY. Gravel is angular to subangular fine to coarse of sandstone and brick. • Glacial Till – to depths of between 0.4mbgl and 3.0m bgl, consisting of Very stiff red brown slightly sandy slightly gravelly CLAY • Sherwood Sandstone – present below the Made Ground or Glacial Till from between 0.2m bgl and 5.45m bgl, consisting of extremely weak red brown fine to medium sandstone. A second slab/

	basement has been encountered during the investigation works.
Groundwater Encountered	Limited water seepage was encountered at depth on drilling and groundwater was recorded during subsequent monitoring between 0.69m and 2.63m bgl (28.35m bgl and 30.51mOD).
GEO-ENVIRONMENTAL ASSESSMENT AND CONCLUSIONS	
Conclusions of Contamination Generic Risk Assessment	**Human health:** • Elevated PAH's and asbestos were identified within a limited number of samples tested; • No other exceedances above the relevant GAC's were reported. • On the basis of the sites proposed hardstanding end use and isolated nature of the PAH exceedances, the identified elevated PAH results are considered not to represent a significant risk to future users of the site; • In view of the hardstanding end use, the limited presence of asbestos is considered not to represent a significant risk to future users of the site. However, green space should be installed with a cover system. Ground workers will need to take appropriate actions with regards to low concentrations of asbestos in the soil **Plant growth:** • A significantly elevated boron result was identified within WS01 at 0.5m (2500mg/kg). A review of this sample indicates it to be an outlier and not representative of the wider data obtained. • In view of the hardstanding end use the limited presence of boron and zinc are not considered to represent a significant risk to future plants at the site. **Controlled Waters:** • Soil leachate samples exceed drinking water standards for aluminium, manganese, antimony and ammonium and nitrite. However not assessed as a risk due to slight exceedances of the threshold values and no potable water abstraction licences within 2km. No elevated metals or chemicals of potential concern were identified in the soils. • The proposed development comprises hardstanding covering the majority of the area limiting the potential for chemicals of potential concern to lead further into the groundwater. **Ground gases or vapours:** • Low risk from ground gases is present and CS1 conditions apply. **Radon:** • The site is not in a Radon Affected Area. **Water supply pipes:** • Brownfield site with organic contamination and barrier pipe is considered suitable for this site. However, confirmation should be sought from the water supply company at the earliest opportunity.
Proposed Mitigation Measures	• An imported capping layer should be installed in areas of landscaping to ensure the potential pollutant linkage associated with identified Asbestos and PAH is broken; • Placed on a geotextile membrane a suitable plant growing medium is; and • Potable barrier pipe should be installed at the site.
GEOTECHNICAL CONCLUSIONS	
Obstructions	The site comprises around 60% buildings with a further 25% of the site comprising hardstanding with the remainder surfaced in compacted aggregate. Obstructions associated with this development, including foundations, floor slabs and services, should be anticipated.
Groundworks and Earthworks	Excavation to proposed founding depth generally should be readily achievable with standard excavation plant. Heavy duty excavation plant/breaking equipment will be required to break out obstructions encountered. Deep slabs/ basements have been encountered. Instability of excavation faces is likely during excavation, particularly in the Made Ground and natural coarse soils or where groundwater is present. Random and sudden falls shoul be expected and as such temporary trench support, or battering of excavation sides is likely to be required for all excavations that are left open and definitely required where man entry is needed. Water seepages into excavations are likely to be adequately controlled by sump pumping. Excavated soils will be suitable for use in accordance with suitable earthworks specification.

Foundations	On the basis of an appropriate earthworks specification including all comments relating to proof rolling and removal of soft spots. Allowable net bearing pressure of 125kPa for foundations to be founded at shallow depth should be available, keeping total and differential settlement within acceptable limits (less than 25mm and 1:500). Deepening of foundations/heave protection is likely to be required to allow for the effects of trees. Foundations will need to be deepened where existing foundations are present.
Ground Floor Slabs	On the basis that all Made Ground and soft spots are removed and all fill placed in accordance with earthworks specification then ground bearing floor slabs may be adopted with an allowable bearing capacity of 3%. A modulus of subgrade reaction of 27 MN/m² should be used.
Road Pavement Design (CBR)	3% on re-engineered general fill.
Soakaways	Bases on the soil descriptions encountered soakaway drainage may be possible where the Sherwood Sandstone Formation has been encountered at shallow depths. Additional works would be required to finalise design.
Buried Concrete	Design Sulfate Class - DS-1 and ACEC Class AC-1. Equivalent to Design Chemical Class DC-1 for a 50 year design life.
Waste Management	The majority of the soils tested indicate that they would be classified as non-hazardous (subject to further testing). Subject to further WAC testing it is possible that the natural soils would be classified as inert waste.
FUTURE CONSIDERATIONS	
Uncertainties and Limitations	The footprints of the buildings have not been investigated full access was not possible to most buildings.
Further Work	The following further works will be required: • design of a capping layer to any areas of proposed landscaping; • design of potable water barrier pipes: • design of the foundations roads and pavements; • writing of a remediation method statement; • writing of a material management plan; and • discussions and agreement of the conclusions of this report with the local authority, water company and any other appropriate body.

This Executive Summary forms part of Hydrock Consultants Limited report number R/151811/G001 (Issue 2) and should not be used as a separate document.

1.0 INTRODUCTION

1.1 Terms of Reference

In November 2015, Hydrock Consultants Limited (Hydrock) was commissioned by Quod Limited on behalf of TJ Morris Limited (e-mail dated 13th November 2015) to undertake ground investigation at the former Rayware site, Speke Boulevard, Liverpool.

The site is approximately 4.501 hectares in area and currently consists of two disused and unoccupied factory/warehouse buildings which occupy the majority of the site, together with an area of hardstanding comprising car parking located at the northeastern extent

It is understood that the proposed development is to comprise a mixed use retail scheme consisting of a number of retail units and ancillary food and drink outlets with associated landscaping, infrastructure, roads and parking areas.

A Site Location Plan (Drawing 151811/D001), a Site Survey Plan (Drawing 151811/D002), and a proposed development layout are presented in Appendix A.

1.2 Objectives

The objectives of this investigation are to provide ground related design and construction information for the proposed development. Planning permission is outstanding and consequently any conditions relating to the permission are unknown. Notwithstanding this, this report is anticipated to address a proportion of the planning conditions relating to contamination.

1.3 Scope

The scope of work for this commission comprises:

- A ground investigation including UXO desk study and UXO engineering attendance, windowless sampling, gas and groundwater monitoring, laboratory chemical and geotechnical testing; and
- reporting on findings of the ground investigation, geo-environmental assessment of the site conditions and geotechnical interpretation of the ground and groundwater conditions.

See Appendix F for detailed reporting methodology.

1.4 Provided Information

The following has been provided to Hydrock by Quod for use in the preparation of this report:

- Searchflow, dated 6th August 2012, Groundsure Screening report, reference SF-425238;
- Land registry title plan , reference MS427065, 1:1250 (red line boundary plan);
- Bracewell Stirling Consulting, Drawing reference 4098-SK151023-1, 'Indicative Masterplan', not dated;
- Edward Symmons, 'Former Rayware Site, Speke Boulevard, Speke, Liverpool L24', sale particulars; and
- Capita Symonds. 30th April 2013. 'Phase 1 Geo-Environmental Desk Study, Former Rayware Site, Speke, Liverpool', reference 18900-DS01 Issue / Revision 1.

The Capita Symonds desk study has been used as the basis for the preliminary conceptual site model presented in Section 2.0. No further desk study information has been obtained.

1.5 Approach

The work has been carried out in general accordance with recognised best practice as detailed in guidance documents such as the CLR 11 M*odel Procedures* (Environment Agency 2004), the AGS (2006) *Good Practice Guidelines for Site Investigations*, BS 5930:2015 and BS 10175:2011+A1:2013. The technical details of the approach and the methodologies adopted are given in Appendix F.

A recognised phased approach has been followed, starting with a desk study and walk-over to produce a preliminary assessment of the site conditions and the important factors that require further investigation to reduce uncertainty. This has been undertaken and reported by Capita Symonds (reference 18900-DS01 Issue / Revision 1).

Phase 2 comprises intrusive investigation work and testing. The factual data from Phases 1 and 2 are used to develop a conceptual site model (CSM). This comprises a ground model (of the physical conditions) and an exposure model (of the possible contaminant linkages). The CSM forms the basis for a number of risk assessments in accordance with current guidelines. Professional judgement is then used to evaluate the findings of the risk assessments and to provide recommendations for the project.

By convention, the geo-environmental and the geotechnical aspects are discussed in separate sections, but in instances where interaction is required to produce a holistic design, this is discussed at the end of the geotechnical recommendations section.

Remaining uncertainties and recommendations for further work are listed at the end of the report.

2.0 PRELIMINARY CONCEPTUAL SITE MODEL

A preliminary conceptual model for the site has been developed from the Capita Symonds desk study (reference 18900-DS01).

2.1 Physical Setting

The preliminary ground model of the site is the basis of the understanding of the ground conditions that will inform the geo-environmental exposure model and the geotechnical hazard assessment.

2.1.1 Location and Site History

The subject site is a parcel of land fronting Speke Boulevard (A561) and located to the south and east of Evans Road in Speke, Liverpool; approximately 1.0km north of Liverpool John Lennon Airport and 10km southeast of Liverpool city centre. The site is roughly rectangular in plan and covers an area of approximately 4.501ha in the southwest of the Venture Point estate.

Approximately 60% of the site is occupied by current buildings in a poor state of repair. A further 25% of the site comprised hardstanding in a similarly poor state of repair with the remainder surfaced in compacted aggregate. An existing two storey office block is present in the southwest corner of the site.

Up until 1936 the site was predominately agricultural with a number of small associated structures. From 1938 the site became industrialised with a series of buildings developed in the late 1930's, 1950's and 1960's to the current configuration. The two storage tanks were added in the early 1970's.

The site is currently used for the storage of cars (airport parking).

To the north of the site are two large above ground bulk storage tanks separated by a switch and/or pump room. The facilities inside the room suggest the tanks were used for large scale diesel storage. Outside the switch room a small cubic container is present which has evidence of fuel leakage around it in the form of ground staining.

2.1.2 Landscape and Topography

There is a general fall in elevation from the north of the site to the south with terracing of the car-parking apparent. There is also an apparent fall from west to east with the lowest point in the site being the south-easternmost corner. The southern building is anticipated to have a suspended floor with a greater sub-floor void space in the east.

2.1.3 Geology

Given the history of the site it is considered likely that at least parts of the site are directly underlain by Made Ground deposits.

The regional geological information indicates the majority of the site is directly underlain by Glacial Till. However, the northwest corner of the site is shown to be devoid of superficial deposits.

The underlying solid geology comprises the Triassic Chester Pebble Beds formation of the Sherwood Sandstone Group.

2.1.4 Hydrology and Drainage

According to the GroundSure Screening Report included as part of the Capita Symonds report there is no detailed river network within 500m and no surface water features within 250m of the subject site.

The nearest visible water features are several small watercourses/drains located within Stockton's Wood adjacent to Speke Hall approximately 1.1km southwest of the subject site.

2.2 Hydrogeology

The Triassic Chester Pebble Beds Formation underlying the site is a Principal Aquifer. The overlying Glacial Till deposits are classified as Unproductive Strata. The overlying Glacial Till deposits are classified as Unproductive Strata.

2.3 Geo-environmental Exposure Model

The preliminary exposure model is used for geo-environmental hazard identification and establishing potential contaminant linkages based on the contaminant-pathway-receptor approach.

2.3.1 Potential Contaminants

For the purpose of this assessment the potential contaminants have been separated according to whether they are likely to have originated from on-site or off-site sources.

Potential On-Site Sources of Contamination

- Made Ground possibly including metals, metalloids, asbestos, PAH and petroleum hydrocarbons;
- Leaks or spills from historic above ground storage Tanks (ASTs) or below ground storage tanks (USTs);
- Ground gases (carbon dioxide and methane) from organic materials present in the historic in-filled ponds;
- Historic Farm buildings;
- Industrial Buildings including electricity substations and tanks.

Potential Off-Site Sources of Contamination

The primary off-site contaminant source is the two bulk storage tanks and infrastructure (diesel contamination) present to the north of the site.

In addition, the surrounding area has seen significant industrial and commercial development throughout the past 100 years. Consequently Made Ground is likely to be present to some degree and such deposits could contain ash-related contaminants (e.g.toxic/phytotoxic

elements), but could also include hydrocarbon impacts (e.g. Poly Aromatic Hydrocarbons (PAHs)) and other potentially harmful inorganic determinants (e.g. sulphates).

2.3.2 Potential Receptors

The following potential receptors have been identified.

- Humans (neighbours, site end users);
- Development end use (buildings, utilities and landscaping);
- Controlled Waters including the Principal Aquifer status of the Triassic Chester Pebble Beds;

It should be noted that health and safety risks to site contractors and maintenance workers have not been assessed during these works and will need to be considered separately.

2.3.3 Potential Pathways

The following potential pathways have been identified.

- Humans: ingestion, skin contact, inhalation of dust and outdoor air;
- Buildings: direct contact with substances deleterious to building materials;
- Buildings: methane ingress via permeable soils and/or construction gaps;
- Plant life: root uptake;
- Underlying groundwater: migration of contaminant into the Triassic Chester Pebble Beds;
- Surface water: overland flow.
- Surface water: drainage discharge.
- Surface water: base flow from groundwater.

2.4 Geotechnical Hazard Identification

Potential geotechnical hazards based on the expected ground conditions are listed below.

- Uncontrolled Made Ground – excessive settlement (creep and inundation settlement or differential settlement of foundations, roads, sports pitches and infrastructure elements.
- Low strength, compressible ground – excessive settlement of foundations, roads, and infrastructure elements.
- Attack of buried concrete by aggressive ground conditions – the development site may contain unknown Made Ground and potentially sulfate bearing soils.
- Shrinkage/swelling of clay – settlement/heave of foundations when located within the influence of trees and vegetation.
- Running sands, loose landfill and shallow groundwater, leading to difficulty with excavation due to trench collapse.

2.5 Unresolved Issues and Uncertainties

The Phase 1 investigation has highlighted a number of issues that require further assessment to inform the design of the proposed development.

These are principally associated with the historic activities undertaken at the site and the potential for these to adversely impact on the future development. Consequently intrusive site investigation works are proposed to address the outstanding uncertainties.

3.0 GROUND INVESTIGATION

3.1 Investigation Rationale

The ground investigation rationale based on the findings of the preliminary risk assessment is summarised in Table 3.1.

Table 3.1: Investigation Rationale

Exploratory Holes	Purpose
WS01-WS23	To assess ground conditions and allow SPTs and samples for geotechnical characterisation. To allow collection of samples for contamination testing.
WS03, WS09, WS11, WS12, WS16A, WS20	Installation of gas and groundwater wells.
HDTP01	Hand dug trial pit.

3.2 Ground Gas Regime

Given the available desk based information the gas generation potential at the site is considered to be low and the industrial nature of the proposed development is considered to have a low sensitivity.

Consequently, Hydrock believe an appropriate minimum monitoring regime is three readings over five weeks, provided other monitoring requirements are also met, such as prevailing atmospheric pressure conditions (for example, BS 8485:2015 suggests monitoring shall include a period of falling atmospheric pressure).

3.3 Site Works

The fieldwork took place between 30/11/15 and 02/12/15 and is summarised in Table 3.2 and the approximate position of site investigation locations (surveyed in using a tape measure from landmarks) are shown on the Ground Investigation Plan in Appendix C.

The logs, including details of ground conditions, soil sampling, *in situ* testing and any installations, are presented in Appendix C.

The weather conditions during the fieldwork and for the previous week were generally overcast.

Table 3.2: Summary of Site Works

Activity	Method	No.	Max. Depth (m bgl)	*In Situ* Tests	Notes (e.g. Installations)
Utility Survey	GPR	-	-	-	Utility detection
Drilling	Windowless Sampler Boreholes	WS01-WS23	5.45	SPT	63mm HDPE wells with gas taps in 6 holes
Hand Excavated Trial Pits	Hand Excavation	HDP01	0.80	-	-

3.4 Geo-Environmental Testing

3.4.1 Sampling Strategy and Protocols

Investigatory hole locations were determined by reference to the conditions identified in the preliminary risk assessment. Certain specific features such as the existing diesel tanks were targeted for specific investigation, but a reasonably even spacing was used for the remainder of the site.

Access was restricted due to the existing buildings and associated services present on the site.

Samples were taken stored and transported in general accordance with BS10175:2011 +A1:2013.

3.4.2 Geo-environmental Monitoring

Gas monitoring boreholes have been monitored on three occasions. The results are presented in Appendix E.

3.4.3 Geo-environmental Laboratory Analyses

The geo-environmental analyses undertaken on soils are summarised in Table 3.3 and the chemical test certificates are provided in Appendix G. Wherever possible, UKAS accredited procedures have been used.

Table 3.3: Summary of Sample Numbers for Geo-environmental Analyses of Soils

Determinand Suite (see Appendix F for Details of Suites)	Made Ground	Glacial Till	Sherwood Sandstone
Hydrock default suite of determinands for solids	17	5	2
Volatile organic compounds (VOC target list plus TIC by GC-MS	5	1	0
Benzene, toluene, ethylbenzene and xylene (BTEX) by GC-MS)	6	3	1
Semi-volatile organic compounds (SVOC target list plus TIC by GC-MS)	5	1	0
Total petroleum hydrocarbons by GC-FID	6	3	1
Polychlorinated biphenyls (PCB, total as Arolcors WHO 12 ICES 7)	2	0	0

The geo-environmental analyses undertaken on waters are summarised in Table 3.4.

Table 3.4: Summary of Sample Numbers for Geo-environmental Analyses of Waters

Determinand Suite (see Appendix F for Details of Suites)	Groundwater
Hydrock default suite of determinands for waters	2
Volatile organic compounds (VOC target list plus TIC by GC-MS)	2
Total petroleum hydrocarbons by GC-FID (Hydrock Level 2 suite)	2

3.5 Geotechnical Laboratory Testing

The tests undertaken are summarised in Table 3.3 and the geotechnical test certificates are provided in Appendix D. Wherever possible, UKAS accredited procedures have been used.

Table 3.5: Summary of Sample Numbers for Geotechnical Tests

Test	Made Ground	Glacial Till	Sherwood Sandstone
Moisture Content	2	9	-
Atterberg Limits	2	9	-
Particle Size Distribution	2	4	1
Moisture Content/Dry Density Relationship	2	2	-
Particle Density	2	2	-
SD1 (Full BRE Suite)	2	6	-

4.0 GROUND INVESTIGATION RECORDS AND DATA

4.1 Physical Ground Conditions

4.1.1 Introduction

The following presents a summary of the properties of the ground and groundwater conditions encountered, based on field observations, interpretation of the field data and laboratory test results, taking into account drilling, excavation and sampling methods, transport, handling and specimen preparation.

All relevant data from the Hydrock investigation detailed in Section 3.0 are used from this point forward. Derived[1] geotechnical parameters are presented also.

For the purposes of property designation, soils are divided into fine soils (clays and silts) and coarse soils (sands, gravels, cobbles and boulders) in accordance with BS 5930.

Soil plasticity class for fine soils is based on the classification system of BS 5930, adopting modified plasticity index values (based on percentage passing 425 µm sieve). Volume change potential of fine soils on change of moisture content has been assessed using guidance provided in BRE Digest 240 - Part 1.

Equivalent approximate undrained shear strengths (cu) and equivalent approximate coefficients of volume compressibility (mv) have been calculated from recorded SPT N values, adopting f1 and f2 values respectively (based on CIRIA Report 143 (Clayton 1995)) appropriate to the recorded plasticity.

The angle of shearing resistance (ϕ') of the coarse soils has been derived from the uncorrected standard penetration resistance N-value using the relationship published by Hatanaka and Uchida (1996).

4.1.2 Summary of Strata Encountered

The ground conditions proven during the current investigation are in general accordance with the published geological literature and expectations from the desk study and previous investigation works.

Details are provided in the logs in Appendix C, a summary is presented in Table 4.1 and the individual strata are described in the sections below.

[1] **Derived values** of geotechnical parameters and/or coefficients are obtained from test results, by theory, correlation or empiricism in line with BS EN 1997-2:2007, Section 1.6.

Table 4.1: Strata Encountered

Stratum	Brief Description	Depth to Top (m bgl)	Depth to Base (m bgl)	Thickness (m) (average)
Concrete	Varies across the site from reinforced to unreinforced concrete. Occasionally multiple layers of concrete are present.	0.00	0.06 - 0.55	0.06 – 0.55 (0.25)
Made Ground	Soft to firm dark brown sandy gravelly clay.	0.06 - 0.55	0.40 – 3.00	0.20 – 2.85 (0.97)
Glacial Till	Very stiff red brown slightly sandy slightly gravelly clay.	0.06 – 3.00	0.35 - >5.45	0.10 – >5.45 (2.21)
Sherwood Sandstone	Extremely weak red brown fine to medium sandstone.	0.20 - >5.45	Not proven	Not Proven

4.1.3 Concrete

Concrete was encountered across the site and varied in depth from absent to 0.55m thick and varies as both reinforced and unreinforced concrete. Occasionally multiple layers of concrete are present. Where present, reinforcement generally comprises 2 layers, with 10mm of reinforcement encountered at approximately 160mm bgl and 20mm of reinforcement encountered at approximately 230mm bgl.

A number of concrete obstructions were also encountered at depth including WS07 at 2.0m, WS13A at 0.5m, WS14 at 0.5m, WS15 at 0.1m, WS16 at 0.75m, WS17 at 0.45m, WS18 at 0.45m, WS21 at 0.5m. Generally where obstructions were encountered, the borehole of pit was unable to be advanced beyond the concrete obstruction.

A second concrete slab (possible basement was encountered at WS07.

4.1.4 Made Ground

Made Ground was encountered across the majority of the site to depths of between 0.40m bgl and 3.00m bgl. However was generally absent in the northwest of the site, where concrete was directly underlain by the underlain by Sherwood Sandstone.

Typically the Made Ground consisted of soft to firm dark brown sandy gravelly clay. The gravel was angular to subangular fine to coarse of sandstone and brick.

The Made Ground is inherently variable and as such representative values of geotechnical properties are impracticable to determine. In areas of deeper Made Ground (<1.00m bgl), SPTs were undertaken with the N-values being recorded as between 1 and 19, very loose to medium dense.

Particle Size Distribution analysis indicates the Made Ground comprises slightly gravelly clayey to very clayey sand.

4.1.5 Glacial Till

Glacial Till was encountered in the majority of the windowless boreholes. It appeared to be absent or more limited to the west of the site, becoming greater in thickness to the east. The western most extent was directly underlain by Sherwood Sandstone.

The Glacial Till typically comprised very stiff dark brown slightly sandy slightly gravelly clay. The gravel was angular to rounded fine to coarse of sandstone.

Particle Size Distribution analysis indicates the Glacial Till comprises slightly gravelly sandy clays.

Natural moisture contents in the fine units of these materials range from 13% to 26%, and modified plasticity indices range from 12% to 26%. On this basis these soils are classified as of low to intermediate plasticity (CL to CI soils) and of low to medium volume change potential. The modified plasticity indices, and volume change potential, decrease with depth.

Undrained shear strength parameters of the fine units of these materials based on in situ testing are presented in Table 4.2.

Table 4.2: Soil Strength Results and Derived Values

SPT (N-Value) (Range)	Shear Strength (Range)	Method	No. of Results
	c_u (kPa)		
0 - >50	0 – 225	Correlation with Stroud (1975) based on 'average' plasticity	32

Approximate coefficients of volume compressibility (m_v) derived from the *in situ* SPT testing within the cohesive units of these materials range from 0.02 m^2/MN to 1 m^2/MN adopting an f_2 value of 0.7 (based on the 'average' plasticity).

4.1.6 Sherwood Sandstone

Sherwood Sandstone was encountered in the majority of the windowless boreholes except where these were terminated early due to obstructions. Where the boreholes reached the Sherwood Sandstone they were terminated due to the density of the rock. The exception to this was BH15A that indicated Glacial Till to 5.00m.

The Sherwood Sandstone was reported as extremely weak red brown fine to medium sandstone recovered as red brown silty sandy angular fine to coarse gravel of sandstone.

SPT N-values within the coarse units of these materials were in excess of 50, showing them to be very dense. The exception to this was in WS19 and WS23 that indicated SPT N-values of between 35 and 42, showing them to be dense.

Particle Size Distribution analysis indicates the Sherwood Sandstone comprises slightly gravelly sandy clay/silt. This may indicate that the Sherwood Sandstone is a siltstone instead of sandstone, but the recovery inhibited the logging of the sample.

4.2 Obstructions

There were a number of windowless sample boreholes that encountered obstructions during excavation. These intrusive locations are summarised in Table 4.3.

Table 4.3: Obstructions Encountered During Hydrock Investigations

Exploratory Hole	Depth	Description	Stratum
WS07	2.0	Concrete.	Made Ground
WS08	0.65	Brick.	Made Ground
WS08A	0.6	Brick.	Made Ground
WS13	0.5	Concrete.	Made Ground
WS13A	0.5	Concrete.	Made Ground
WS14A	0.25	Asphalt.	Made Ground
WS15	0.1	Concrete.	Made Ground
WS16	0.75	Concrete.	Made Ground
WS17	0.45	Concrete.	Made Ground
WS18	0.45	Concrete.	Made Ground
WS21	0.5	Concrete.	Made Ground

4.3 Visual and Olfactory Evidence of Contamination

Apart from the presence of ash evident within the Made Ground, no evidence of visual or olfactory contamination was recorded during the investigation.

4.4 Sulfate Content

In accordance with BRE (Special Digest 1), the Design Sulfate (DS) classification and the Aggressive Chemical Environment for Concrete (ACEC) classification are presented in Table 4.4. The assessment summary sheet is presented in Appendix D.

Table 4.4: Aggressive Chemical Environment Concrete Classification

Stratum	No. Tests	DS	ACEC
Made Ground	6	DS-1	AC-1
Glacial Till	2	DS-1	AC-1

4.5 Density Tests

Moisture content/dry density relationship and particle density tests were undertaken and are presented in Table 4.5 below. The results are presented in Appendix F.

Table 4.5: Moisture Content/Dry Density Relationship

Stratum	Depth	Moisture Content (%)	Optimum Moisture Content (%)	Maximum Dry Density (Mg/m^3)	Particle Density (Mg/m^3)
Made Ground	0.25 – 1.00	16	14	1.91	2.64
	0.25 – 0.50	16	21	1.70	2.63
Glacial Till	0.25 – 0.80	19	18	1.71	2.74
	0.70 – 1.50	19	17	1.79	2.74

4.6 Groundwater

Groundwater strikes and subsequent monitoring are summarised in Table 4.6.

Table 4.6: Groundwater Data

Stratum	Date Range	Exploratory Hole	Fieldwork		Post-Fieldwork Monitoring	
			Depth Groundwater Encountered (m bgl)	Groundwater Elevation (mOD)	Depth to Groundwater (Range) (m bgl)	Groundwater Elevation (Range) (mOD)
Glacial Till	11/01/16 – 04/02/16	WS03	-	-	0.69 – 1.38	29.82 – 30.51
		WS11	-	-	2.46 – 2.63	28.35 – 28.52
	01/12/15 – 04/02/16	WS09	4.00	27.36	2.50 – 2.56	28.80 – 28.86
		WS12	3.50	28.15	1.52 – 1.68	28.97 – 29.13
	26/01/16 – 04/02/16	WS16A	-	-	1.10	30.11
	01/12/15	WS20	3.50	37.94	Unable to locate.	
		WS15A	3.00	28.48	-	-
		WS19	4.50	27.22	-	-
		WS23	3.00	28.44	-	-

4.7 Geo-Environmental Results

The chemical test results for soil are given in Appendix G, which also includes summary tables of the data.

4.8 Ground Gases (Carbon Dioxide and Methane)

Records from the gas monitoring boreholes are presented in Appendix E and summarised in Table 4.7.

Table 4.7: Range of Ground Gas Data

Methane (%)	Carbon Dioxide (%)	Oxygen (%)	Flow Rate (l/hr)
<0.1	0.1 – 0.8	17.0 – 20.7	<0.1

5.0 GEO-ENVIRONMENTAL ASSESSMENT

5.1 Approach

A number of generic risk assessments are undertaken in accordance with the principles of CLR 11 (Environment Agency 2004) using the CSM that has been updated following the ground investigation. Firstly, the risks associated with the identified potential contaminant linkages are estimated using standardised methods (typically involving comparison of site data with published 'screening values'. Secondly, where screening values are exceeded, the risks are evaluated in an authoritative review of the findings with other pertinent information to determine if exceedance may be acceptable in the particular circumstances. For details please refer to Appendix F.

The data sets used comprise the appropriate analytical results obtained by Hydrock and listed in Section 3.4.

In cases where unacceptable risks are indicated, mitigation measures such as more advanced stages of risk assessment or remediation will be proposed in Section 5.7.

5.2 Human Health Risk Assessment

This is a Tier 2 assessment using soil screening values for the CLEA land use scenario for a commercial / industrial end use and, based on field data, a 1% soil organic matter (SOM).

The soil screening values used are generic assessment criteria (GAC) and results are given in Appendix G. Note that the Category 4 Screening Levels (C4SL) for lead have been used as there are no recognised GACs and the use of the term 'GAC' in this report includes these.

Statistical testing is used where data sets are suitable. For data sets with low sample numbers and/or a non-random spatial distribution (e.g. where sampling is targeted at specific areas) individual sample test results are compared directly with the screening values.

It should be noted that the phrase 'further assessment required' is used to denote soil concentrations that are equal to, or exceed, a GAC. This does not necessarily mean that the soil is 'contaminated' or not fit for use.

5.2.1 Risk Estimation

Hydrock Default List of Determinands

The individual analytical results have been compared with the relevant GACs in the summary table in Appendix G.

With the exception of elevated poly-aromatic hydrocarbons (PAH) associated with a sample from WS13 (benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3,cd)pyrene) no sample exceed their relevant GAC. WS13 was obtained from the Made Ground and was reported as containing ash. The ash is likely to be predominant source of the identified PAH's.

Asbestos

No visible asbestos containing materials were noted in the soils.

Of the 21 samples assessed, 19 did not indicate the presence of asbestos. Asbestos was identified in WS03 (0.3-0.5m) and WS15A (0.5m).

Identification of the asbestos indicated WS03 (0.3-0.5m) contained amosite loose fibres at < 0.001% and WS15A (0.5m) contained amosite loose fibres and insulation lagging at 0.001%.

Petroleum Hydrocarbons (PHC)

Petroleum hydrocarbons and BTEX's were not encountered above their respective GAC's for the 10 samples analysed.

Volatiles and the Indoor Air Pathway

Elevated short chain volatile TPH fractions (EC5-<EC12) did not exceed relevant assessment criteria. BTEX also did not exceed relevant assessment criteria.

VOCs were not encountered above the laboratory detection limits.

No visual or olfactory indication of hydrocarbon contamination was noted on site.

PCB's

PCB's were not encountered above the laboratory detection limits.

5.2.2 Risk Evaluation

The screening exercise identified elevated PAH's (benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3,cd)pyrene) within the Made Ground. No other exceedances above the relevant GAC's were reported within the samples tested.

Asbestos was identified in WS03 (0.3-0.5m) and WS15A (0.5m). However, the concentrations of asbestos have been quantified as low (maximum of 0.001%)

On the basis of above and the sites proposed hardstanding end use, subject to installation of a cover system, comprising a Terram layer and a suitable growing medium in areas of soft landscaping the site is not considered a significant risk.

5.3 Plant Life Risk Assessment

5.3.1 Risk Estimation

Priority phytotoxic chemical concentrations have screened against published values to determine the likely risk to plant growth and the findings presented in Appendix G. As with human health, statistical testing is used where data sets are suitable, otherwise individual sample test results are compared directly with the screening values.

Based on test results that exceed the GAC, the pervasive chemicals of potential concern which require further assessment are summarised in Table 5.1.

Table 5.1: Pervasive Chemicals of Potential Concern for Which Further Assessment is Required (Risk to Plants)

Chemical of Potential Concern	Generic Criterion (mg/kg)	Basis for Generic Criterion	No. Samples	Min. (mg/kg)	Max. (mg/kg)	US_{95} (mg/kg)	No. Samples Exceeding Generic Criterion
Boron	3	New Zealand timber 1997	21	0.6	2500	639	3
Zinc	300	BS3882 2015	21		790	244	1

5.3.2 Risk Evaluation

A significantly elevated Boron result was identified within WS01 at 0.5m (2500mg/kg). A review of this sample indicates it to be an outlier and not representative of the wider data obtained.

In view of the hardstanding end use the limited presence of boron and zinc are not considered to represent a significant risk to future plants at the site. An imported capping layer should be installed in areas of landscaping to ensure the potential pollutant linkage is broken.

5.4 Pollution of Controlled Waters Risk Assessment

5.4.1 Risk Estimation

The risks to groundwater and surface water from contaminants on site have been assessed according to the Environment Agency (2006) Remedial Targets Methodology (RTM).

Under the European Water Framework Directive (2000/60/EC) pollutants from contaminated land sites are considered as passive inputs. Inputs to surface waters and inputs of non-hazardous pollutants to groundwater and are regulated under the Agency's 'limit' pollution objective. As such, site contaminant loadings are compared with relevant threshold values (Water Quality Targets) which are linked to the conceptual site model. Acceptable WQT are defined for protection of human health (based on Drinking Water Standards (DWS)) and for protection of aquatic ecosystems (Environmental Quality Standards (EQS)).

The approach for hazardous substances in groundwater is to use the 'prevent' pollution objective. Acceptable WQT are listed by UKTAG (November 2013, amended January 2014) and are minimum reporting values (MRV), referred to in this report as HAZ-MRV.

For the purposes of this report, the site data are compared with the various targets as set out according to the Hydrock scenario(s) in Table 5.2 (see Appendix F for de tails), on the basis that the Sherwood Sandstone underlying the site is a Principal Aquifer.

Table 5.2: Summary of Water Quality Risk Assessment Protocol

Hydrock Scenario	Water Body Receptors	Secondary Receptors	Example Contaminant Linkages	RTM Level and Data Used	Water Quality Targets
A	Groundwater.	Human health (abstraction).	Contaminants from site leach or seep into groundwater body and this is a (potential) source of human consumption or a strategic resource.	RTM Level 2 - Groundwater.	DWS HAZ-MRV
Notes: This table and the results of the assessment are considered as a first screening for potential risks of pollution of Controlled Waters. More specific requirements may be stipulated by the relevant Agency.					

The results of the Remedial Targets Methodology assessment are presented in Appendix G and are summarised in Table 5.3.

It should be noted that in some instances the reporting limit (or detection limit) quoted by the laboratory may be greater than the WQT that it is being assessed against. As the current exercise is an initial screening assessment, further assessment of these elements has not been undertaken.

Table 5.3: Chemicals of Potential Concern for Which Further Assessment is Required (Controlled Waters)

Chemical of Potential Concern	Water Quality Target (ug/l)	Basis for Water Quality Target	No. Samples	Min. (ug/l)	Max. (ug/l)	No. Samples Exceeding Target
Groundwater						
Aluminium (Al)	200	DWS	2	75.3	317	1
Manganese (Mn)	50	DWS	2	5	1600	1
Antimony (Sb)	5	DWS	2	1.1	13	1
Ammonium (NH_4^+)	500	DWS	2	100	550	1
Nitrite (NO_2^-)	500	DWS	2	100	890	1

5.4.2 Risk Evaluation

The data indicate that the DWS are exceeded for metals (aluminium, manganese and antimony) and ammonium and nitrite. Whilst these Chemicals of Potential Concern are elevated, based on the investigation works to date and subject to agreement with the Environment Agency, Hydrock does not believe the site poses a significant risk to Controlled Waters for the following reasons:

- the exceedance are generally slight;
- there are no potable water abstraction licenses within 2km of the site;
- no elevated metals or Chemicals of Potential Concern were identified in the soils sampled at the site;

- the proposed development comprises hardstanding across the site, limiting the potential for Chemicals of Potential Concern to leach further into the groundwater.

Subject to regulatory agreement, no further consideration with regards to Controlled Waters risk is recommended.

5.5 Ground Gases Risk Assessment

5.5.1 Assessment

The risks associated with the ground gases methane (CH_4) and carbon dioxide (CO_2) are assessed using BS 8485:2015 and guidance from CIRIA Report 665 (Wilson *et al* 2007) and [only for housing] NHBC (Boyle and Witherington 2007). The development proposals require consideration of Situation A (all forms of development).

The guidance requires the calculation of Gas Screening Values (GSV). For the purposes of the calculation, were the recorded gas flow rate is below the manufacturer's limit of detection for the instrument used, the detection limit has been adopted for the gas flow rate.

Ground gas monitoring is ongoing. Two of the required four monitoring visits have been undertaken to date. The ground gas readings and gas regime conceptual model derived from the works to date are considered to be sufficiently rigorous to provide a preliminary assessment of the ground gas regime and the likely scope of protection measures, although this will be confirmed once the monitoring programme is complete.

Methane concentrations have been recorded as below the limit of detection (<0.1% v/v) and the flow rate has been recorded at the limit of the analytical equipment (<0.1).

Carbon dioxide concentrations have been recorded as between 0.1 and 0.8% v/v.

The typical worst case GSV to date have been calculated as <0.07 for methane and <0.07 for carbon dioxide (the lower limit value quoted by CIRIA).

The site is classified as Characteristic Situation 1 for the proposed development and no mitigation measures are required.

5.5.2 Ground Workers

It is noted that concentrations of carbon dioxide (an asphyxiant) in the soil exceed HSE Workplace Exposure Limits for personnel in the working environment of 0.5% for long term exposure. Furthermore, soil concentrations of oxygen are below the HSE recommendations of 18%.

Whilst risks to construction workers are not generally discussed in this report, and soil gas concentrations are not necessarily reflected by those in the breathing zone, all contractors and maintenance workers should be made aware of the possible presence of carbon dioxide and should take all necessary health and safety precautions when working in trenches or confined spaces.

5.6 Water Pipelines

The current guidance on selection of materials for potable water supply pipes to be laid in contaminated land is contained in a document published jointly by Water UK and the Home Builders Federation (Water UK HBF (2014)). The protocols in that document are for guidance and are not subject to enforcement by Water UK or any agency, but have been adopted by Water UK and by HBF as best practice for their members. Accordingly this guidance is used in the following assessment. For further details see Appendix F.

A formal water pipe risk assessment is beyond the scope of this report, however, the findings of this investigation have been compared to the threshold values in Water UK Table 1 as far as is practicable to give an indication of the possible restrictions to the use of plastic pipes for water supply to the site.

The site is brownfield and organic contamination (PAH,) has been identified in exceedance of the threshold values and Hydrock believes barrier pipe is required. However, confirmation should be sought from the water supply company.

5.7 Findings of the Generic Risk Assessments

The source-pathway-receptor contaminant linkages given in Table 5.4 are those which, following the risk evaluation process, require further consideration and are discussed further in Section 5.8.

Table 5.4: Final Conceptual Model and Residual Risks Following Risk Evaluation

Contaminant Linkage			Comments	
Sources	**Pathways**	**Receptors**	**General**	**Mitigation**
Elevated PAH identified above GAC.	Ingestion, inhalation or direct contact.	Proposed end users of the site.	A hardstanding commercial end use is proposed for the site. The presence of the hardstanding will break the potential pollutant linkage between any residual elevated contaminants and the proposed end users. Any areas of landscaping should encompass a clean capping layer to break the potential pollutant linkage.	
Asbestos	inhalation			
Elevated phytotoxic contaminants identified above GAC.	Root uptake	Flora and Fauna	Any areas of landscaping should encompass a clean capping layer to break the potential pollutant linkage.	
Elevated PAH identified above GAC.	Ingestion, direct contact.	Building and services	Barrier pipes should be used for water supply.	

5.8 Mitigation Measures

An imported capping layer should be installed in areas of landscaping to ensure the potential pollutant linkage with asbestos is broken. This will also provide a suitable medium for plant growth.

Barrier pipes should be installed for potable water.

The mitigation measures and validation criteria should be detailed within a Remediation Method Statement.

5.9 Waste Management

Any material excavated on site may be classified as waste and it is the responsibility of the holder of a material to form their own view on whether or not it is waste. This includes determining when waste that has been treated in some way can cease to be classed as waste for a particular purpose. Further details are given in Appendix F.

If material is to be removed from the site the laboratory test results in Appendix G should be presented to the proposed receiving landfill site (to aid Waste Characterisation), prior to export, to confirm that the landfill site is suitably licensed to accept the waste. Some additional testing may be necessary at the time of disposal for the receiving landfill to confirm the Waste Acceptance Criteria (WAC) are acceptable for it to receive the waste.

In order to inform the waste characterisation process, Hydrock has undertaken a preliminary exercise using the proprietary web-based tool HazWasteOnline™, to characterise the soils encountered in the investigation (presented in Appendix G). Based on the HazWasteOnline™ output:

- the majority of the soils are classified as non-hazardous and may (subject to WAC testing) be inert; and
- the shallow soils at WS13 are non-hazardous.

All wastes require pre-treatment prior to disposal. Effective pre-treatment, involving separation, sorting and screening would be required and can offer cost reductions through reducing volumes of any hazardous content and volume of hazardous waste if any is present. Costs for disposal of hazardous soils are significant compared to disposal of non-hazardous waste or inert waste.

Prior to disposal, the characteristics of any excavated soils will need classification in consultation with landfill sites and waste disposal contractors. Testing and analysis will be required to be carried out on the actual soil arisings which will constitute the waste.

This will form the actual basis for classification of the waste.

5.10 Materials Management

Any material excavated on site may be classified as waste and it is the responsibility of the holder of a material to form their own view on whether or not it is waste. This includes determining when waste that has been treated in some way can cease to be classed as waste for a particular purpose.

If site-won material is to be re-used on site, a Materials Management Plan will be required, signed off by a Qualified Person as defined in the ‘Development Industry Code of Practice’ (CL:AIRE, March 2011).

6.0 GEOTECHNICAL ASSESSMENT

6.1 Geotechnical Categorization of the Proposed Development

Eurocode 7, Section 2 advocates the use of geotechnical categorization of the proposed structures to establish the design requirements. For the purposes of this investigation, the proposed structures have been classed as Geotechnical Category 2.

The Geotechnical Category should be re-assessed at the design stage and a specific Geotechnical Design Report is required for Category 2 structures.

6.2 Site Preparation

It is presumed that the redevelopment will involve demolition of the existing buildings. Buried obstructions were encountered during this investigation associated with buried concrete. In addition, foundations of existing buildings will be present. Therefore, it is recommended that an allowance be made for breaking out obstructions, for example provision of pneumatic breakers for site plant. If underground structures cannot be removed, they will need to be surveyed in three dimensions and the new structures will need to be designed to accommodate them.

Unsuitable Made Ground should be removed from beneath all building and hard standing areas. Subsequent to the removal of these materials, the sub-formation shall be proof-rolled and testing undertaken in accordance with an appropriate Earthworks Specification. Where localised soft spots are identified, they are to be removed and replaced with suitable engineered fill material.

6.3 Groundworks

Following breaking out of hardstanding and/or obstructions, excavation of shallow made Ground and Glacial Till soils should be readily undertaken by conventional plant and equipment. However, excavation through any buried construction and the intact rock quality strata of the Sherwood Sandstone will likely require heavy-duty excavation plant.

The site investigation has identified a second concrete slab in parts of the site and it is envisaged that existing basements are present at the site (filled and potentially unfilled). These will need to be broken out, over excavated and filled in accordance with and appropriate earthworks Specification.

Instability of excavation faces is likely during excavation, particularly in the Made Ground and natural coarse soils or where groundwater is present. Random and sudden falls should be expected from the faces of near vertically sided excavations put down at the site. Temporary trench support, or battering of excavation sides, is likely to be required for all excavations that are to be left open for any length of time, and will definitely be required where man entry is required. Particular attention should be paid to excavation at, or close to, site boundaries / adjoining existing roads / structures, where collapse of excavation faces could have a disproportionate effect.

A risk assessment of the stability of any open excavation should be undertaken by a competent person and appropriate measures adopted to ensure safe working practise in and around open

excavations. Further guidance on responsibilities and requirements for working near, and in, excavations can be obtained from the Construction Design and Management Regulations (2015). The Contractor should address the issue of stability of excavations within their Temporary Works Design.

Recorded groundwater levels are between 1.1m bgl and 3.93m bgl. However, it should be recognised that groundwater levels will fluctuate seasonally and the timing of construction may dictate the extent of groundwater control required. Any potential groundwater seepage during excavation should be dealt with by sump pumping and addressed within the Temporary Works Design to be completed by the appointed Contractor.

Any water pumped from excavations is likely to need to be passed via settlement tanks before being discharged to the sewer. Discharge consents will also be required.

6.4 Foundations

The proposed development is understood to include the demolition of the existing development and the construction of warehouse and sales units, with associated offices, areas of hardstanding for car and lorry parking and infrastructure.

The preliminary foundation designs in this section are based on the parameters given in Section 4.5. Recommendations for Geotechnical Category 2 and 3 structures (according to EC7) are presented to aid development proposals. Selection of geotechnical design parameters should be undertaken as part of the geotechnical design.

While the Made Ground is unlikely to be a suitable bearing strata. On the basis that an appropriate Earthworks Specification is followed, including all comments relating to proof-rolling and removal of soft spots, then it is recommended to adopt an allowable bearing pressure for design purposes of 125kPa for foundations, to be founded at shallow depth within the engineered fill material, the underlying Glacial Till or the Sherwood Sandstone.

This bearing capacity will be able to be increased for foundations which are placed within the rock strata of the Sherwood Sandstone and additional allowable bearing pressure calculations will be undertaken during the geotechnical design to optimise the foundations.

The comments regarding the allowable bearing pressure are appropriate to limit total settlement after construction to less than 25mm, with differential settlement of better than 1:500.

The depth of foundations should be designed appropriate to the adopted allowable bearing pressure and the formations inspected by a competent geotechnical engineer. Any sub-formation materials deemed as unsuitable such as soft or loose zones should be excavated and replaced with well compacted suitable granular fill or lean mix concrete.

Whilst considered unlikely (due to the lack of trees currently on site), deepening of foundations will be required where foundations are within the zone of influence of existing or proposed trees and proposed shrub planting. Where foundations are within the influence of trees and are deeper than 1.5m bgl, a suitable compressible material or void former will be required.

The formation level of foundations should be inspected by a suitably qualified person. Any sub-formation materials deemed as unsuitable such as soft or loose zones should be excavated and replaced with well compacted suitable granular fill or lean mix concrete.

Foundation excavations should be protected from water and inclement weather including frost and any water should be removed by pumping from a sump in the base of the excavation.

6.5 Ground Floor Slabs

On the basis that all Made Ground and soft spots will be removed and all fill will be placed strictly in accordance with an appropriate Earthworks Specification, then ground bearing floor slabs may be adopted with an allowable bearing capacity of 50kPa. A modulus subgrade reaction of 27MN/m^2 should be used.

Prior to the placement of the founding materials and the construction of the ground bearing floor slab, the sub-formation and formation will need to be inspected and checked by a geotechnical engineer to ensure the ground conditions are as expected and that any soft Made Ground has been removed. Subgrade assessment is to include sufficient appropriate testing, carried out in accordance with the DMRB IAN 73/06, to confirm the ground conditions at time of construction are consistent with the previous design parameters derived from this ground investigation. There are a number of different methods defined by DMRB IAN 73/06, which includes the use of Static Plate Load Testing (PLT), Dynamic Plate Load Testing (DPLT) and Dynamic Cone Penetrometer (DCP).

If low bearing capacity and soft strata are suspected at the formation, this should be reported to the Geotechnical Engineer immediately and remedial actions agreed. It is anticipated that the remedial action would consist of over-excavation of the low bearing strata and replaced with engineered fill to an appropriate Specification.

6.6 Roads and Pavements

Earthworks are proposed to create a level platform for the proposed building. The existing Made Ground is unsuitable for pavements and it is assumed that fill will be re-engineered to a general specification in external areas of the site. For re-engineered general cohesive fill, a CBR value of 3% should be assumed for design. Where Class 1 general granular fill is utilised within the external areas, it is anticipated that a CBR of 5% can be assumed. However this would be subject to testing and confirmation as part of the earthworks operation.

Prior to the placement of the founding materials and the construction of the road pavement, the sub-formation and formation will need to be inspected and checked in accordance with a suitable Specification to ensure the ground conditions are as expected. All testing should be carried out in accordance with DMRB IAN 73/06 and confirm that the ground conditions at time of construction are consistent with the previous design parameters.

Where the CBR is found to be less than 2.5%, the sub-grade may be unsuitable for both the trafficking of site plant and as support for a permanent foundation, without improvement works being undertaken.

Improvement works should be carried out in accordance with DMRB IAN 73/06 Rev 1 Chapter 5. In summary, consideration may be given to the following potential remedial techniques:

- excavation and re-engineering or replacement of weaker soils; and
- the inclusion of geosynthetic reinforcement within the unbound layers of the capping and sub-grade.

6.7 Reuse of Site-Won Materials

Where is it proposed to utilise spoil resulting from excavations for re-use as engineered fill material, source approval testing will be required to be completed by the Contractor.

An initial assessment has been completed on the potential to re-use site-won materials as an engineered fill material as it is understood this is being considered as part of the proposed development.

The geotechnical assessment of the site-won materials indicates the soils which are likely to be re-used can be classified as a combination of Class 1 granular (less than 15% finer than the 63µm) or Class 2 cohesive (more than 15% passing the 63µm), which may be able to be used for General Fill Material.

From the sulfate measurements undertaken during the ground investigation, the soils may be suitable (subject to further detailed design and testing) for improvement by the inclusion of binders. Before the use of hydraulic binders is approved on this site, comprehensive testing will need to be completed, by a Specialist Contractor. This work must be completed in order to satisfy both themselves and the Engineer of the suitability of the soils for treatment, and confirm that the requisite end-performance of the material is achievable.

Where an increased end-performance of the material is required over and above those defined for General Fill materials additional testing and specification will be required, which is outside the scope of the current assessment. However, if the soils are to be used below structures they should be reclassified as Class 7 Selected Fill as defined in the Specification for Highway Works (Highways Agency 2014). Where the as dug material does not meet the requirements of a Class 7 Fill, but is still required for use below structures, it can be treated with hydraulic binders to form a suitable Class 9 fill. The exact sub-class under Class 9 will depend on the hydraulic binder used. This will be subject to detailed design by a specialist Contractor.

Where it is proposed to re-use site won materials as an engineered fill, it will be necessary to develop an appropriate Site Specific Earthworks Specification as part of the geotechnical design. The basis for the Specification should be BS 6031:2009 and the latest version of the SHW, Series 600 Earthworks.

In order to develop the earthworks specification, addition information on the design loadings and tolerable settlements for all structures will need to be provided so a full assessment of their implications can be accounted for within the acceptability limits for the various materials.

6.8 Soakaways and Drainage

No infiltration testing has been undertaken due to the restricted nature of the site for trail pit excavation.

Based on the soil descriptions and subject to testing, where the Sherwood Sandstone is present at shallow depth, soakaway drainage may be possible.

6.9 Buried Concrete

Based on guidelines provided in BRE Special Digest 1 (BRE 2005), the soils can be classified as Design Sulfate Class DS-1 and ACEC Class AC-1 (see Section 4.4).

This equates to a Design Chemical Class DC-1 for a 50 year design life (see BS 8500-1:2006 for details).

7.0 UNCERTAINTIES AND LIMITATIONS

7.1 Site-Specific Comments

The footprints of the buildings have not been investigated as most buildings could not be accessed due to safely concerns, preventing detailed intrusive ground investigation.

Whilst the desk study report and information provided by the Client has been reviewed and incorporated, where appropriate, within this report, no reliance is provided by Hydrock for 3rd party information provided to them.

7.2 General Comments

This report details the findings of work carried out in December to February 2015. The report has been prepared by Hydrock on the basis of available information obtained during the study period. Although every reasonable effort has been made to gather all relevant information, all potential environmental constraints or liabilities associated with the site may not have been revealed.

The report has been prepared for the exclusive benefit of T J Morris Ltd and those parties designated by them for the purpose of providing geotechnical and geo-environmental recommendations for the site. The report contents should only be used in that context. Furthermore, new information, changed practices or new legislation may necessitate revised interpretation of the report after the date of its submission.

Hydrock has used reasonable skill, care and diligence in the design of the investigation of the site. The inherent variation of ground conditions allows only definition of the actual conditions at the locations and depths of trial pits and boreholes at the time of the investigation. At intermediate locations, conditions can only be inferred.

Groundwater findings described are only representative of the dates on which they were made and levels may vary.

Unless otherwise stated, the recommendations in this report assume that ground levels will remain as existing. If there is to be any re-profiling (e.g. to create development platforms or for flood alleviation) then the recommendations may not apply.

Information provided by third parties has been used in good faith and is taken at face value; however, Hydrock cannot guarantee its accuracy or completeness. It is assumed that previous reports provided have been assigned to the Client and can be relied upon. Should this not be the case Hydrock should be informed immediately as additional work may be required.

The work has been carried out in general accordance with recognised best practice. The various methodologies used are explained in Appendix F. Unless otherwise stated, no assessment has been made for the presence of radioactive substances or unexploded ordnance. Where the phrase ‘suitable for use’ is used in this report, it is in keeping with the terminology used in planning control and does not imply any specific warranty or guarantee offered by Hydrock.

The chemical analyses reported were scheduled for the purposes of risk assessment with respect to human health, plant life and controlled waters as discussed in the report. Whilst the results may be useful in applying the Hazardous Waste Assessment Methodology given in Environment Agency Technical Guidance WM3, they are not primarily intended for that purpose and additional analysis may be required should waste classification be required for consideration of off-site disposal of contaminated soils. Separate analyses will be required to meet the Waste Acceptance Criteria for specific landfill sites.

Unless otherwise stated, the chemical testing carried out for this report was not scoped to comply with the requirements of the water supply company and further work may be required.

The preliminary risk assessment process may identify potential risks to site demolition and redevelopment workers. However, consideration of occupational health and safety issues is beyond the scope of this report.

Please note that notwithstanding any site observations concerning the presence or otherwise of archaeological sites, asbestos-containing materials or invasive weeds such as Japanese knotweed, this report does not constitute a formal survey of these potential hazards.

Any site boundary line depicted on plans does not imply legal ownership of land.

8.0 RECOMMENDATIONS FOR FURTHER WORK

The following further works will be required:

- design of a capping layer to any areas of proposed landscaping ;
- design of potable water barrier pipes:
- design of the foundations roads and pavements;
- writing of a remediation method statement;
- writing of a material management plan; and
- discussions and agreement of the conclusions of this report with the local authority, water company and any other appropriate body.

9.0 REFERENCES

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Appendix A

Drawings

Drawings included in this report:

C151811/D001 – Site Location Plan

C151811/D002 – Site Features Plan

C151811/D003 – Exploratory Hole Plan