

Phase 2 Geo-environmental Investigation & Assessment

For

Site 1 Broadoak Road, Wythenshawe

Undertaken on behalf of

Wythenshawe Community Housing Group

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Executive Summary

Site Location	The site comprises land at the junctions of Broadoak Road and Panfield Road, Benchill, Wythenshawe. It is centred on approximate Ordnance Survey National Grid Reference 382411E, 387931N with an indicative postcode of M22 9NJ.
Development Proposals	It is understood that the redevelopment will comprise the construction of 4no semi-detached single storey residential structures with hardstanding for parking together with private gardens and landscaped areas.
Ground Conditions	Ground conditions encountered during the intrusive investigation generally comprise made ground to depths of between 0.60m and 2.50mbgl underlain by pond deposits in the western section of the site to a maximum depth of 3.45mbgl and more locally by cohesive glacial till. Both the pond deposits and glacial till are in turn underlain by the weathered Bollin Mudstone to a maximum proven depth of 4.45mbgl.
Site Preparation and Earthworks	Construction near retained trees and importantly within the Root Protection Areas should be undertaken with due regard to guidance provided in BS5837:2012 'Trees in Relation to Design, Demolition and Construction – Recommendations'. No significant earthworks are anticipated to facilitate redevelopment of the site with the exception of localised re-grading.
Foundations and Floor Slabs	Due to the depth of incompetent soils a piled foundation solution would need to be adopted with piles being taken down through the incompetent strata to the competent Bollin Mudstone Member at depths beneath the proposed structures between 1.90m and 3.45mbgl. The final choice and design of pile type should to be undertaken in conjunction with a reputable, specialist piling contractor, ideally with local experience and following further ground investigations. In consideration of the thickness of made ground new floor slabs will need to be suspended.
Excavations and Groundwater	Excavations at the site will be feasible using conventional hydraulic plant. All excavations at the site deeper than 1.20m and requiring man-entry will need adequate lateral support, or will need to be battering back to a safe angle to ensure their stability. Perched groundwater inflows should be anticipated during excavations within the pond deposits. Conventional 'sump and pump' dewatering measures are likely to be adequate to keep excavations dry but it cannot be fully discounted that groundwater exclusion measures such as interlocking sheet piles may be required to prevent excessive ingress of water into excavations.
Pavements	New road pavement design should be based on a California Bearing Ratio (CBR) value of no more than 2.5% in made ground or cohesive glacial deposits.
Concrete Classification	The typical design sulphate (DS) class and "Aggressive Chemical Environment for Concrete" (ACEC) class for the site are DS-1 and AC-1 respectively.
Soakaways	In consideration of the site being generally underlain by significant thicknesses of made ground and relatively impermeable cohesive deposits, soakaways are not considered to be a feasible drainage option for the site.
Ground Gas	New structures may need to incorporate ground gas protection measures to provide a score of 3.5 in accordance with Table 4 of BS8485:2015 and would typically comprise:- • Passive sub-floor dispersal (minimum 100mm clear void); • Sub-slab ventilation at minimum 1500mm²/m centres to at least opposing sides of the structure; • Lapped, taped and sealed gas resistant membrane to reasonable levels of workmanship in line with current good practice. • Membrane to be sealed around all penetrations and to damp proof course. This will need to be confirmed on completion of the ground gas monitoring and risk assessment in due course.

Contamination Assessment	Analysis results indicate that made ground beneath the site contains elevated levels of PAH's that are elevated above their respective SL's. Following site development, where surfaced with buildings and hardstanding, there will be no mechanism for a direct contact pollution linkage with these or any other unidentified contaminants. Therefore the risk to end-users and to the general public will be negligible in such areas. However, a 600mm thick cover of clean soil cover, comprising 450mm of sub-soil and 150mm of topsoil will be required in proposed garden areas to break any exposure pathway to future site users. In consideration of the above, it is anticipated that a remediation strategy may be required to bring the site to a condition suitable for the intended use by removing unacceptable risks to human health. The strategy will need to be submitted to the Local Planning Authority for their approval prior to any development commencing.
Potable Water Supplies	The utilities company will need to be consulted with regards the selection of suitable water supply pipe materials for the development. In light of the ground conditions encountered at proposed water pipe depths, the requirement for specific materials and measures to protect the water supply from ground contamination cannot be discounted.
Waste Soils	For guidance purposes and on the basis of the current information, it is likely that the majority of excavated soil would be classified as 'Non-Hazardous' or even 'Inert' for landfill disposal. However is found to include significant ACM and/or fibres that cannot be segregated, it may classify as Hazardous, subject to further quantification testing.

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1.0 INTRODUCTION

Appointment

- 1.1 WML Consulting has been commissioned by AEW Architects, on behalf of Wythenshawe Community Housing Group, to undertake a Phase 2 Geo-environmental Investigation and Assessment of a site located at the junction of Broadoak Road and Panfield Road, Wythenshawe.

Proposed Development

- 1.2 It is understood that the redevelopment will comprise the construction of 4no semi-detached single-storey residential units with hardstanding for parking together with private gardens and landscaped area.
- 1.3 The proposed development plan is presented in Appendix 01.

Objective

- 1.4 The objective of the ground investigation and assessment was to provide geotechnical recommendations for construction design purposes together with a geo-environmental risk assessment in terms of possible ground contamination.
- 1.5 To achieve the objective, the following tasks were undertaken:
- Establish, through undertaking a Phase 1 Desk Study, the geological, hydrogeological and environmental setting of the site so as to identify any potential ground constraints to development through a site specific conceptual model.
 - From the findings of the desk study, design a Phase 2 Ground Investigation in accordance with the Environment Agency (2004) Model Procedures for the Management of Land Contamination, CLR11.
 - Characterise the ground conditions in terms of geology, soil geotechnical parameters and ground contamination from information provided by the ground investigation.
 - Provide recommendations regarding suitable foundations, floor slabs and new pavement construction, together with any other geotechnical considerations that could affect possible future development.
 - Determine a ground conceptual model for the site so as to undertake an appropriate Phase 2 ground contamination Generic Quantitative Risk Assessment (GQRA).

Scope

- 1.6 The Phase 1 Desk Study has been undertaken and is presented in the following WML Consulting report:
- Phase 1 Desk Study and Preliminary Geo-environmental Assessment, Reference 8398/G/01, dated September 2018.
- 1.7 This report includes the findings of a ground investigation designed on conclusions and recommendations provided in the Phase 1 report. For ease of reference, the findings of the Phase 1 desk study are summarised in the following sections. The two reports however are not exclusive and should be read in conjunction.
- 1.8 The ground investigation comprised the formation of window sample probeholes undertaken with reference to BS5930:2015 Code of Practice for Ground Investigation and BS10175:2011 together with A1:2013, "Investigation of Potentially Contaminated Sites - Code of Practice" except where superseded by EN ISO 22475-1 "Geotechnical Investigation and Assessment – Sampling by Drilling and Excavation and Groundwater Measurements".

- 1.9 Samples for chemical analysis were obtained and handled generally in accordance with the current guidelines (BS10175: 2011 and A1:2013).
- 1.10 The ground investigation has also been undertaken with reference to BS8576:2013, Guidance on investigations for ground gas – Permanent gases and Volatile Organic Compounds (VOCs).

2.0 SITE LOCATION AND DESCRIPTION

Site Location

- 2.1 The site comprises land at the junctions of Broadoak Road and Panfield Road, Benchill, Wythenshawe. It is centred on approximate Ordnance Survey National Grid Reference 382411E, 387931N with an indicative postcode of M22 9NJ.
- 2.2 The proposed development site is bounded to the north, east and south by Panfield Road and to the west by Broadoak Road with residential properties beyond.

Site Description

- 2.3 The site comprises a generally level area of grassed public open space surrounded on all sides by asphalt footpaths and highways.
- 2.4 A single mature oak tree is located partially within the site and partially within the pedestrian footpath in the south-western corner.
- 2.5 Telecommunication poles are located in the northern, eastern and southern sections of the site close to the adjacent footpaths.
- 2.6 The site is noted to be generally level with more localised grassy undulations.

3.0 SUMMARY OF ENVIRONMENTAL AND HISTORICAL SETTING

3.1 The following paragraphs summarise the most relevant findings of the Phase 1 desk study report.

Geology

3.2 British Geological Survey (BGS) plans indicate the site to be underlain by Devensian Glacial Till which mainly comprises clay with occasional sand and silt.

3.3 The superficial deposits are indicated to be underlain by strata of the Triassic Bollin Mudstone Member which generally comprise mudstone with horizons of halite.

Radon

3.4 The property is not in a radon affected area as defined by the BGS/Public Health England as less than 1% of properties are above the action level of exposure. Therefore, no radon protection measures are necessary for new structures as described in publication BR211 by the Building Research Establishment.

Environmental Setting

3.5 The glacial till is classified as a 'Secondary Aquifer – Undifferentiated' (formerly unproductive). The bedrock underlying the site is classified as a 'Secondary (B) Aquifer'.

3.6 The nearest surface water feature is Baguley Brook, 417m west of the site boundary.

3.7 There are no active, non-operational or historic landfills recorded within 1km of the site.

3.8 There are 2no potentially contaminative industrial sites within 250m of the subject site, both electricity sub-stations around 70m north-east.

3.9 There are no records of sites which have been determined as Contaminated Land under Section 78R of the Environmental Protection Act 1990 within 500m of the study site.

Site History

3.10 The earliest maps dated 1876 indicate the site to mainly comprise a field pond in a rural setting. The pond was delineated to the northern and eastern sections by a tree-lined field boundary. Further trees were located along the western site boundary.

3.11 The surrounding area originally comprised undeveloped rural / agricultural land with several small field ponds and localised residential structures.

3.12 By 1938 the pond within the site and those in the surrounding areas had been infilled. Although the site has since remained undeveloped public open space, by this time, the immediately surrounding area had been extensively developed for residential housing.

4.0 PRELIMINARY CONTAMINATION RISK ASSESSMENT

- 4.1 Based on the above findings, the Phase 1 desk study report concluded that pollution linkages were either not envisaged or were considered unlikely with the overall preliminary contamination risk assessed as very low to low.
- 4.2 However, the report recommended that assumptions in the conceptual model be verified by providing information on the physical and chemical ground conditions through site investigation.
- 4.3 The investigations were to comprise sampling and chemical analysis of the near surface soil and possibly groundwater and the installation of ground gas monitoring standpipe with subsequent monitoring for hazardous ground gas concentrations and flows.
- 4.4 In addition, appropriate investigations were to be undertaken to establish geotechnical parameters for the design of foundations, floor slabs and pavement construction.

5.0 SITE INVESTIGATION

Rationale

- 5.1 Intrusive investigations were undertaken primarily to provide geotechnical parameters for structural design purposes but also to verify the preliminary site conceptual model and confirm the anticipated low environmental risk.
- 5.2 Window sample probeholes WS8 to WS14 were undertaken to provide information on near surface deposits and to provide samples for chemical analysis.
- 5.3 A general coverage of the site was considered appropriate although the investigation locations were also chosen so as not to impact on the presence of known/suspected services beneath the site.
- 5.4 Gas monitoring standpipes were installed in selected probeholes for the measurement of ground gas and groundwater levels.
- 5.5 Chemical analysis of a general suite of contaminants was undertaken on selected samples of soil. This was to confirm the anticipated low contamination risk and to establish the chemical suitability of soils for possible re-use within the development.

Intrusive Works

- 5.6 Ground investigation work was undertaken by LOT Geotechnics Ltd on the 10th October 2018. This comprised the formation of 7no window sample probeholes to a maximum depth of 4.45 metres below ground level (mbgl).
- 5.7 The exploratory hole records are presented in Appendix 02 of this report whilst the exploratory hole locations are shown on sketch Drawing 8398G-SK02 in Appendix 01.

Monitoring Standpipe

- 5.8 Monitoring wells for groundwater and ground gas measurements were installed in 3no probeholes as indicated on the logs presented in Appendix 02.

Geotechnical and Chemical Testing

- 5.9 In-situ geotechnical testing was undertaken at regular intervals during the formation of the probeholes in the form of Standard Penetration Tests (SPTs). The results for this testing are presented on the descriptive logs in Appendix 02.
- 5.10 Chemical analysis was undertaken on selected soil samples for the following contaminants of concern:
- Total Arsenic, Boron, Cadmium, Chromium VI, Copper, Lead, Mercury, Nickel, Selenium, Vanadium, Zinc.
 - Total Cyanide, Phenols, Sulphur, Sulphate.
 - Speciated USEPA Polyaromatic Hydrocarbons (PAH).
 - Asbestos Screen and Identification.
 - 2:1 water/soil sulphate extract, pH.
- 5.11 The results of the chemical analysis are presented in Appendix 03.

Gas and Groundwater Monitoring

- 5.12 Gas and groundwater monitoring has been carried out on three occasions to date, between 23rd October and 16th November 2018. The monitoring results are presented in Appendix 04.

6.0 GROUND CONDITIONS

Stratigraphy

- 6.1 Ground conditions encountered during the intrusive investigation generally comprise made ground to depths of between 0.60m and 2.50mbgl. This is underlain by pond deposits in the western section of the site to a maximum depth of 3.45mbgl and more locally by cohesive glacial till. Both the pond deposits and glacial till are in turn underlain by the weathered Bollin Mudstone to a maximum proven depth of 4.45mbgl.

Made Ground

- 6.2 Made ground was encountered within all of the exploratory holes from ground level to depths of between 0.60m and 2.50mbgl.
- 6.3 It generally comprised a surface horizon of reworked topsoil described as brown, locally slightly clayey, slightly silty sand with rootlets to depths of between 0.10m and 0.35mbgl.
- 6.4 In the majority of exploratory holes (WS9 to WS12) this was in turn underlain by brown and grey mottled, locally slightly silty, slightly gravelly sandy clay extending to depths of between 0.60m and 2.50mbgl. Gravel sized particles included brick, sandstone and locally siltstone, coal, clinker and wood.
- 6.5 Within WS8 in the south-western corner of the site, the surface horizon of reworked topsoil was underlain by dark brown, locally slightly clayey, gravelly sand to depths of 1.00m and brown and grey mottled, slightly gravelly, sandy clay to 1.80mbgl. Gravel sized particles included brick, concrete, slate, sandstone, siltstone, coal and brick.
- 6.6 Within WS14 in the south-eastern part of the site, the surface horizon of reworked topsoil was underlain by dark brownish grey, sandy gravel extending to a depth of 0.60mbgl. Gravel sized particles included brick, sandstone, concrete and metal.
- 6.7 SPT 'N' values within the cohesive made ground ranged between 4 and 9 indicating a soft consistency.

Pond Deposits

- 6.8 Pond deposits were encountered within the western half of the site, namely WS8, WS9 & WS10, underlying the made ground at depths of between 1.20m and 1.80mbgl and extending to depths ranging between 1.70m and 3.45mbgl.
- 6.9 In WS8 these comprised dark brownish grey, slightly sandy, peaty clay with abundant organic flecks and wood fragments to 3.45mbgl.
- 6.10 In WS9 they comprised grey, slightly sandy, silty clay to 1.60mbgl, underlain by a basal band of dark brown, fibrous peat to 1.70mbgl.
- 6.11 In WS10 the pond deposits comprised brownish grey, slightly silty, sandy clay to 2.40mbgl, underlain by a dark grey, slightly clayey, slightly silty, slightly gravelly sand with abundant organic flecks to 3.20mbgl. Gravel sized fragments included sandstone.
- 6.12 SPT 'N' values within the cohesive pond deposits ranged between 0 and 3 indicating a very soft consistency.
- 6.13 SPT 'N' values within the granular pond deposits ranged between 4 and 5, indicating a very loose to loose state of compaction.

Glacial Till

- 6.14 Glacial till was encountered only within the south-eastern and eastern sections of the site, namely WS12, WS13 & WS14, underlying the made ground at depths of between 0.60m and 0.90mbgl and extending to depths of between 1.40m and 2.15mbgl.
- 6.15 The glacial till generally comprised soft, locally firm, brownish grey, slightly silty, slightly gravelly, sandy clay. Gravel sized fragments include sandstone, siltstone, mudstone and quartz.
- 6.16 SPT 'N' values within the glacial till ranged between 4 and 8 confirming a generally soft consistency.

Weathered Bollin Mudstone Member

- 6.17 Within the majority of the exploratory holes, the pond deposits and/or glacial till were underlain by strata considered to represent weathered Bollin Mudstone at depths of between 1.40m and 3.45mbgl. These extended to a maximum proven depth of 4.45mbgl.
- 6.18 The upper horizon of the mudstone was generally weathered to the consistency of a soil. This was recovered as red brown, brown locally mottled grey, variably sandy, silty clay with mudstone lithorelicts.
- 6.19 Below depths ranging between 1.80m and 3.90mbgl, the strata graded into extremely weak, distinctly weathered and locally destructured, light grey, slightly silty mudstone and more locally red brown, slightly micaceous mudstone.
- 6.20 SPT 'N' values within the weathered mudstone ranged between 3 and 8 indicating a generally soft consistency.
- 6.21 SPT 'N' values within the less weathered mudstone ranged between 32 and in excess of 50, indicating the transition between extremely weak and weak mudstone.

Visual/Olfactory Evidence of Contamination

- 6.22 No visual and/or olfactory evidence of significant ground contamination was identified within the exploratory holes during the investigation.

Groundwater

- 6.23 Groundwater seepages were encountered during the formation of WS8 and WS10, within pond deposits at depths of 2.80m and 3.00mbgl respectively.
- 6.24 During the subsequent monitoring visits standing groundwater was recorded within standpipes at depths of between 1.00m and 2.77mbgl.
- 6.25 It should be appreciated that the groundwater monitoring described above has been undertaken during a very short period of time. Significant variations in the long term groundwater regime may occur at other times, particularly with prolonged, extreme weather conditions, and that no account can be taken of such in this report.

General

- 6.26 It should also be appreciated that ground conditions may vary between and away from the exploratory hole positions, and that no account can be taken in this report of such variations.

7.0 GEOTECHNICAL APPRAISAL

Site Preparation and Earthworks

- 7.1 It is assumed that the current development configuration has been outlined in consideration of any retained trees and specifically Root Protection Areas (RPA) as would need to be determined by the landscape architect.
- 7.2 Notwithstanding this, construction near retained trees and importantly within the RPA should be undertaken with due regard to guidance provided in BS5837:2012 'Trees in Relation to Design, Demolition and Construction – Recommendations'.
- 7.3 No significant earthworks are anticipated to facilitate redevelopment of the site with the exception of localised re-grading.

Foundations

- 7.4 Made ground and pond deposits should be considered unsuitable for the direct support of structural loads as their generally weak nature could result in unacceptable total and differential settlements.
- 7.5 Therefore, due to the depth of such soils across the proposed development area, the use of both traditional and mass concrete trench fill foundations would be considered impractical and uneconomical.
- 7.6 Therefore, a piled foundation solution will need to be adopted with piles being taken down into competent Bollin Mudstone which occurs at approximate depths beneath the proposed structures of 2.00m to 3.50mbgl. The final choice and design of pile type should to be undertaken in conjunction with a reputable, specialist piling contractor, ideally with local experience and following further ground investigations.
- 7.7 However, for preliminary considerations, the use of pre-cast or cast in-situ driven concrete piles may be considered suitable. This option would have the advantage of minimising waste soil arisings although potential noise and vibration effects would need to be considered.

Floor Slabs

- 7.8 In consideration of the thickness of made ground and pond deposits, new floor slabs will need to be suspended.

Excavations and Groundwater

- 7.9 Excavations at the site will be feasible using conventional hydraulic plant. All excavations at the site deeper than 1.20m and requiring man-entry will need adequate lateral support, or will need to be battering back to a safe angle to ensure their stability.
- 7.10 Perched groundwater inflows should be anticipated below 1.00mbgl during excavations. Conventional 'sump and pump' dewatering measures are likely to be adequate to keep excavations dry but it cannot be fully discounted that groundwater exclusion measures such as interlocking sheet piles may be required to prevent excessive ingress of water into excavations.
- 7.11 Such support measures will also prevent loss of ground beneath nearby adjacent structures or infrastructure. Sheet piles would also need to be adequately supported or of sufficient section as not to deflect laterally and thus lead to settlement of adjacent retained ground.

Pavement Design

- 7.12 In consideration of the ground conditions it is recommended that new pavement design should be based on a California Bearing Ratio (CBR) value of no more than 2.5% in made ground or cohesive glacial deposits.
- 7.13 The CBR would need to be reviewed and confirmed by site inspection and possibly suitable in-situ testing at formation levels following any earthwork operations and prior to pavement construction.

Concrete Design

- 7.14 Design/mix of buried concrete should be undertaken in accordance with the "Aggressive Chemical Environment for Concrete" (ACEC) classification, of BRE Special Digest 1:2005 (Concrete in Aggressive Ground). With reference to the site history, it is deemed appropriate to classify the site as "Brownfield", with respect to BRE Special Digest.
- 7.15 Values of 2:1 water/soil extract for sulphate for soils not exceed 100mg/l. Excluding the topsoil, values of pH range from 7.8 to 8.3 indicating near neutral to slightly alkaline conditions.
- 7.16 On the basis of these results, the typical design sulphate (DS) class and "Aggressive Chemical Environment for Concrete" (ACEC) class for the site are DS-1 and AC-1 respectively.

Drainage and Soakaways

- 7.17 In consideration of the site being generally underlain by significant thicknesses of made ground and relatively impermeable cohesive deposits, soakaways are not considered to be a feasible drainage option for the site.

8.0 GENERIC QUANTITATIVE RISK ASSESSMENT (GQRA)

General

- 8.1 A review of the desk study information has concluded that the potential for a significant pollution linkage to be present at the site is low with corresponding low risk to human health and the environment.
- 8.2 Furthermore, no visual or olfactory evidence of significant ground contamination has been recorded from the intrusive investigations.
- 8.3 Notwithstanding this, it has been considered prudent to adopt a precautionary principal and undertake chemical analysis of the sub-surface soils to establish in more detail the human health risk status of the site.

Human Health

- 8.4 Selected samples have been analysed for a general suite of contaminants of concern and compared against Screening Levels (SL's) for human health to determine the significance of the measured concentrations in relation to the site conceptual model. Thus a Generic Quantitative Risk Assessment has been undertaken in line with guidelines provided in CLR11, Model Procedures for the Management of Land Contamination, 2004.GQRA).
- 8.5 The criteria for a limited number of contaminants have been derived by DEFRA in their document entitled SP1010: Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination, April 2014.
- 8.6 Within the document, Category 4 Screening Levels (C4SL's) are described as being more pragmatic than previous screening criteria and represent concentrations in soil that present an 'acceptable' level of risk within the context of Part 2A.
- 8.7 The National Planning Policy Framework states that 'after development, as a minimum, land should not be capable of being determined as contaminated land under Part 2A of the Environmental Protection Act 1990'. Therefore by inference, the C4SL's are appropriate for use in the planning context.
- 8.8 Although the SP1010 document states that C4SL only apply for a 'sandy loam soil with 6% soil organic matter', it is generally accepted that assessment criteria for metals are not sensitive to changes in soil organic content (SOM). The C4SL's have therefore been adopted as assessment criteria in this report for the listed metals within the SP1010.
- 8.9 Subsequent to SP1010, LQM/CIEH have published a document entitled 'The LQM/CIEH S4ULs for Human Health Risk Assessment' 2015. In brief, the document provides updated assessment criteria which have been derived in accordance with UK legislation, national as well as EA policy and using a modified version of the CLEA software and available guidance. The new screening criteria, or Suitable 4 Use Levels (S4ULs), are intended to provide a complete and updated replacement to the previous LQM/CIEH GAC of 2009. As such they are considered appropriate for use in this assessment for other contaminants not covered by C4SL's and/or for organic contaminants assuming a worst case Soil Organic Matter (SOM) of 1% as an initial conservative assessment.
- 8.10 For each contaminant, S4UL's and C4SL's have been calculated for six land use scenarios, namely:
- Residential with homegrown produce.
 - Residential without homegrown produce.
 - Allotments.
 - Commercial.
 - Public Open Space near residential housing.
 - Public Parks (remote from residential housing).

- 8.11 In light of the proposed development, the SL's for a "Residential with homegrown produce" end-use are considered appropriate for a conservative assessment at this stage.
- 8.12 A table of relevant SL's protective of human health is provided in Appendix 05.

Soil Test Results

- 8.13 5no soil samples were analysed for a suite of Contaminants of Concern (CoC). The majority of the concentrations measured were below the stringent SL's for "Residential with homegrown produce" end-use with the exception of the following PAHs.

Contaminant	Number of Exceedances	SL (mg/kg)	Recorded Concentrations (mg/kg)	Samples
Benzo[a]anthracene	1	7.2	280	WS10 – 0.40m
Benzo[a]pyrene	4	2.2	4.2 – 300	WS8 – 0.30m WS10 – 0.40m WS12 – 0.40m WS14 – 0.30m
Benzo[b]fluoranthene	4	2.6	5.4 – 420	WS8 – 0.30m WS10 – 0.40m WS12 – 0.40m WS14 – 0.30m
Benzo[k]fluoranthene	1	77	170	WS10 – 0.40m
Chrysene	1	15	260	WS10 – 0.40m
Dibenz[a,h]anthracene	2	0.24	0.26 – 27	WS8 – 0.30m WS10 – 0.40m
Fluoranthene	1	280	680	WS10 – 0.40m
Indeno[1,2,3-c,d]pyrene	1	27	260	WS10 – 0.40m
Naphthalene	1	2.3	83	WS10 – 0.40m
Pyrene	1	620	680	WS10 – 0.40m

- 8.14 Although PAH mixtures are commonly encountered in urban soils, the measured concentration within WS10 at 0.40mbgl, are considered unusually high, particularly as the site has not been subject to past industrial use. It has therefore been considered prudent to consult with the chemical analysis laboratory, on the validity of the results and they have confirmed that they have no reason to suspect any inaccuracies in the data provided.
- 8.15 It has therefore been considered prudent to undertake further assessment of the results in an attempt to clarify the site conceptual model and hence the human health risk that may be posed by the PAH compounds.
- 8.16 PAH's can be associated with a diverse range of contaminative sources including petrogenic (for example oil spills and coal storage), pyrolytic (ash, clinker, soot and atmospheric deposition of smoke, coal tars for example) and phytogenic (for example plant-derived peat). Due to the prevailing chemical processes, the profile of PAH mixtures generated at high temperatures (pyrolytic sources) differ from those formed at more moderate temperatures (petrogenic sources).
- 8.17 The concentration ratios of certain PAH congeners can be used to infer a possible source of PAH mixtures and, by plotting each sample in terms of varying ratios, it is possible to further characterise the PAH profiles and conjecture a possible source based on where the results cluster within the plot.

- 8.18 The 'PAH - Double Ratio Plots' for different congeners are presented in Appendix 03 and suggest urban background combustion/pyrolytic signatures, for example where organic materials such as wood and coal have been burned at high temperatures resulting in ash and soot and more locally clinker such as inferred in WS10.
- 8.19 This would confirm to a degree the site observations, in that no visual or olfactory evidence of hydrocarbon contamination was identified with the investigation logs indicating the presence of ash, coal, wood and clinker in the made ground in the majority of locations.
- 8.20 The elevated concentrations of PAH encountered are therefore attributed to these materials being entrained within the soil matrix.
- 8.21 No asbestos fibres were detected in any of the samples analysed.

Conclusions

- 8.22 Analysis results indicate that made ground beneath the site contains elevated levels of PAH's that are elevated above their respective SL's.
- 8.23 Following site development, where surfaced with buildings and hardstanding, there will be no mechanism for a direct contact pollution linkage with these or any other unidentified contaminants. Therefore the risk to end-users and to the general public will be negligible in such areas.
- 8.24 However, a 600mm thick cover of clean soil cover, comprising 450mm of sub-soil and 150mm of topsoil will be required in proposed garden areas to break any exposure pathway to future site users.
- 8.25 In consideration of the above, it is anticipated that a remediation strategy may be required to bring the site to a condition suitable for the intended use by removing unacceptable risks to human health. The strategy will need to be submitted to the Local Planning Authority for their approval prior to any development commencing.

9.0 GROUND GAS RISK ASSESSMENT

Methodology

- 9.1 Current guidance for the assessment of risk associated with the presence of hazardous ground gases (principally methane and carbon dioxide) is provided in two key documents, namely:
- Code of practice for the Characterisation and remediation from Ground Gas in Affected Developments. British Standard Institution (BS 8485: 2015); and
 - Assessing Risks posed by Hazardous Ground Gases to Buildings CIRIA (C665, 2007).
- 9.2 The assessment presented herein is primarily based on the BS8485 document.
- 9.3 Hazardous ground gas qualitative risk assessment is based on a conceptual model similar to that used for soil and groundwater contamination sources (i.e., source-pathway-receptor pollutant linkages). A semi-quantitative estimate of risk can be assessed based on knowledge of the conceptual model and a measure of hazardous gas concentration and gas flow at the site within monitoring standpipes.
- 9.4 Based on the measured flow rates and hazardous gas concentrations, individual "hazardous gas flow rates" (Qhg) can be derived for each monitoring point, from which the "site characteristic hazardous gas flow rate" (Qhgs), and then the "Characteristic Situation" (CS) can be determined.
- 9.5 BS8485 provides guidance on the level of gas protection requirements based upon the characteristic situation and the proposed development based on building type as outlined in Table 3.

Table 3 - Building Types

	Type A	Type B	Type C	Type D
Ownership	Private	Private or commercial/ Public, possible multiple	Commercial / Public	Commercial / Industrial
Control (Change of use)	None	Some but not all	Full	Full
Room Sizes	Small	Small/ medium	Small to Large	Large Industrial/ Retail Park

- 9.6 The proposed development is indicated to comprise the construction of **Type A** buildings, the definition of which is provided in BS8485:2015 as:
- *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 present.*

Ground Gas Conceptual Model

- 9.7 The site is not in a radon affected area as defined by the BGS/Public Health England as less than 1% of properties are above the action level of exposure.
- 9.8 There are no recorded landfills within influencing distance of the site. However, there is an in-filled pond at the site although historic records indicate this was in-filled sometime before 1938. Due to the age of infilling together with the low occurrence of organic material encountered in the made ground, continued generation of significant volumes of ground gas in this stratum is not anticipated.

- 9.9 However, the ground investigation has encountered localised, relative thin horizon of peat and more widespread peaty clay across the site which could contain elevated concentrations of ground gas but with low potential for continued generation of significant volumes.
- 9.10 Due to the underlying geology, the presence of ground gas resulting from shallow unrecorded mine workings is considered unlikely.
- 9.11 In consideration of the above, the preliminary risk to the development from ground gas has been assessed as low. However, it has been considered prudent to undertake monitoring, primarily for methane and carbon dioxide, with associated flow rates, on 3no occasions to date, between 23rd October and 16th November 2018.

Results and Recommendations

- 9.12 The results to date indicate a maximum methane concentration of 0.10% by volume in air (v/v) with carbon dioxide concentrations ranging between 0.8 and 9.3% v/v.
- 9.13 A single detectable ground gas flow of 0.1l/hr has been recorded in WS12 on a single occasion.
- 9.14 The initial results give a maximum Q_{hg} value of <0.0093l/hr and indicate the site to classify as Characteristic Situation (CS) 1 – 'Very Low Gas Risk'. However, as carbon dioxide concentrations exceed 5% the site may need to be classified as Characteristic Situation (CS) 2 – 'Low Gas Risk' in accordance with BS8485:2015.
- 9.15 This would require new structures to incorporate ground gas protection measures to provide a score of 3.5 in accordance with Table 4 of BS8485:2015 and would typically comprise:-
- Passive sub-floor dispersal (minimum 100mm clear void);
 - Sub-slab ventilation at minimum 1500mm²/m centres to at least opposing sides of the structure;
 - Lapped, taped and sealed gas resistant membrane to reasonable levels of workmanship in line with current good practice.
 - Membrane to be sealed around all penetrations and to damp proof course.
- 9.16 This will need to be confirmed on completion of the ground gas monitoring and risk assessment in due course and should also be confirmed with the local authority Environmental Health / Building Control Officer prior to any building design being finalised.

10.0 OTHER POTENTIAL DEVELOPMENT CONSIDERATIONS

Excavated Soils

- 10.1 Excavation works undertaken during the development are likely to produce waste soils for which appropriate waste management will be required. In line with current sustainability principals, any waste soils should firstly be considered for re-use where possible by incorporation into the development.
- 10.2 However, in consideration of the limited site area, it is likely that the majority of excavated soils will be surplus to requirements, and as such they will need to be disposed of under appropriate duty of care.
- 10.3 It should be noted that the chemical analysis results for disposal classification are assessed against different assessment criteria to those relating to contamination risk assessment. Soils that are deemed suitable for use in terms of risk to human health and the environment may not necessary be uncontaminated and could be classified as Non-Hazardous or even Hazardous for disposal purposes.
- 10.4 Therefore, it will be the responsibility of the waste producer to undertake additional testing and classification of any waste soils for disposal to an appropriately licenced landfill in accordance with current guidelines.
- 10.5 For guidance purposes and on the basis of the current information, it is likely that the majority of excavated soil would be classified as 'Non-Hazardous' or even 'Inert' for landfill disposal.
- 10.6 However, where excavated material is found to include significant Asbestos Containing Materials and/or fibres that cannot be segregated, it may classify as Hazardous, subject to further quantification testing.
- 10.7 This would need to be confirmed by further analysis of bulk soils destined for disposal under consultation with the landfill operator.
- 10.8 In addition, for Inert and Hazardous waste disposal, allowance will need to be made for adequate Waste Acceptance Criteria (WAC) testing with appropriate consideration of the additional time and cost associated with this.

Imported Fill

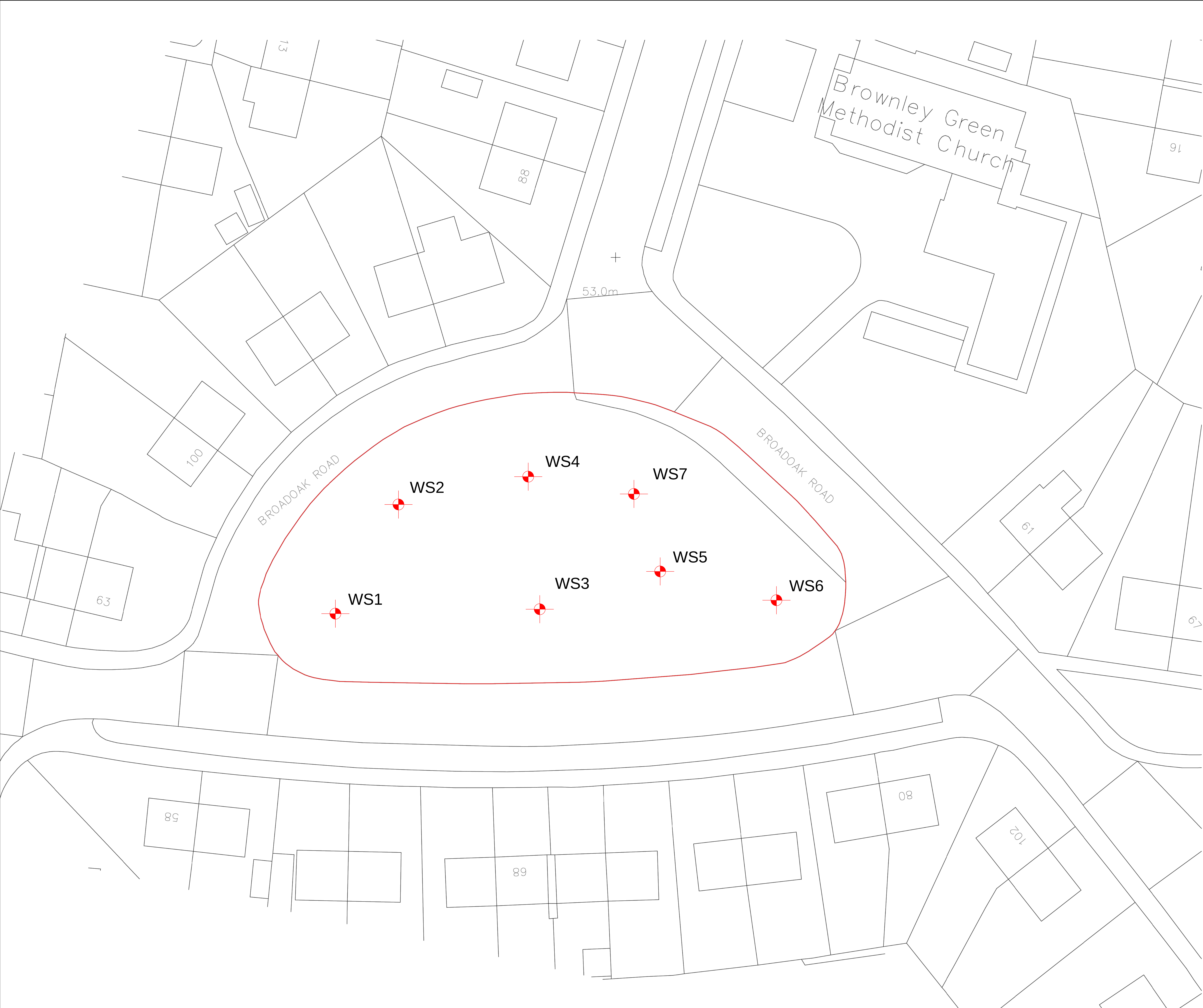
- 10.9 Imported fill will be subject to specific quality requirements and will need to be accompanied by appropriate certification prior to it being brought to site. Allowance should also be made for testing imported fill materials prior to placement to ensure suitability.

Water Supply Pipes

- 10.10 The utilities company will need to be consulted with regards the selection of suitable water supply pipe materials for the development. In light of the ground conditions encountered at proposed water pipe depths, the requirement for specific materials and measures to protect the water supply from ground contamination cannot be discounted.
- 10.11 The utilities company may therefore require a risk assessment to be undertaken once the route of the water supply is known.

APPENDIX 01

Drawings



GENERAL NOTES

- DO NOT SCALE FROM THIS DRAWING WORK TO FIGURED DIMENSIONS ONLY.
- NO DEVIATION FROM THE DETAILS SHOWN ON THIS DRAWING IS ALLOWED WITHOUT PRIOR PERMISSION IN WRITING.
- ALL DRAWINGS ARE TO BE READ IN CONJUNCTION WITH ALL ARCHITECTS, ENGINEERS AND SPECIALISTS DRAWINGS AND THE SPECIFICATION.
- THE CONTRACTOR SHALL INCORPORATE ALL THE REQUIREMENTS OF THE PRE-TENDER STAGE HEALTH & SAFETY PLAN.

KEY

SITE BOUNDARY

WS8

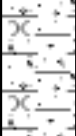
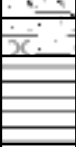
WINDOW SAMPLE PROBEHOLES

P1	FIRST PRELIMINARY ISSUE.	FEB '14	OC	SS
Rev.	Amendment	Date	By	Chkd
Project SITE 2 BROADOAK ROAD				
Client WCHG				
Title EXPLORATORY HOLE LOCATION PLAN				
Drawn OC	Checked SS	Date 26-11-18	Scale 1:500@A3	
WML CONSULTING Chartered Civil and Structural Engineers		No.8 Oak Green Earl Road Stanley Green Business Park Cheadle Hulme Cheshire SK8 9QL Tel 0161 482 0600 Fax 0161 486 9210 e-mail info@wmlconsulting.com www.wmlconsulting.com		
Job No. 8398G		Drawing No. SK-01P1		

APPENDIX 02

Exploratory Hole Records

			Project Title: Broadoak Road				WS1																															
			Project Number: 8398G		Client: AEW Architects					Sheet 1 Of 1																												
			GL (mAOD):		N Coord: 0		E Coord: 0																															
Date: 05/10/2018			Method: Window Sample		Driller: LOT Geotechnics Ltd		Logged By: TPB																															
Depth (m)	Type	Test Result	Level	Legend	Depth (m)	Description	Water	Standpipe																														
0.20	E				0.35	Turf over dark brown, slightly clayey, slightly silty, slightly gravelly SAND with rootlets. Gravel is subangular, fine to coarse, including sandstone, brick and ash. (MADE GROUND) Stiff, brown and occasionally grey mottled, slightly silty, slightly gravelly, sandy CLAY. Gravel is subangular, fine to coarse, including sandstone and siltstone. (GLACIAL TILL)																																
1.20	D	N=26			1.00																																	
		N=27			2.00	Medium dense, light grey, slightly clayey, sandy SILT with siltstone lithorelicts. (WEATHERED BOLLIN MUDSTONE MEMBER) Extremely weak, distinctly weathered, light grey SILTSTONE. (BOLLIN MUDSTONE MEMBER) End Of Borehole At 2.90 m																																
		pp 50/185mm			2.80																																	
					2.90																																	
					3.00																																	
					4.00																																	
KEY D - Disturbed Sample B - Bulk Sample U - Undisturbed W - Water Sample S - Standard Penetration Test C - Cone Penetration Test N - Penetration Test 'N' Value V - Hand Shear Vane kPa  - Groundwater Strike  - Groundwater Level			REMARKS No Groundwater Encountered 			Water Strikes <table border="1"> <thead> <tr> <th>Date</th> <th>Strike</th> <th>Level</th> <th>Minutes</th> <th>Casing</th> <th>Sealed</th> </tr> </thead> <tbody> <tr><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td></tr> </tbody> </table>			Date	Strike	Level	Minutes	Casing	Sealed																								
Date	Strike	Level	Minutes	Casing	Sealed																																	
			Scale: 1:30			Daily Log Of Depths <table border="1"> <thead> <tr> <th>Date</th> <th>Casing</th> <th>Water</th> <th>From</th> <th>To</th> <th>Hours</th> </tr> </thead> <tbody> <tr><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td></tr> </tbody> </table>			Date	Casing	Water	From	To	Hours																								
Date	Casing	Water	From	To	Hours																																	

			Project Title: Broadoak Road				WS2																																																	
			Project Number: 8398G		Client: AEW Architects					Sheet 1 Of 1																																														
			GL (mAOD):		N Coord: 0		E Coord: 0																																																	
Date: 05/10/2018			Method: Window Sample		Driller: LOT Geotechnics Ltd		Logged By: TPB																																																	
Depth (m)	Type	Test Result	Level	Legend	Depth (m)	Description	Water	Standpipe																																																
0.30	E					Turf over dark brown, slightly silty, slightly gravelly SAND with rootlets. Gravel is angular to subangular, fine to coarse, including sandstone, brick, glass and metal. (MADE GROUND)																																																		
1.10	D	N=19			1.00	Soft to stiff, brown and occasionally grey mottled, slightly silty, slightly gravelly, sandy CLAY. Gravel is subangular, fine to coarse, including sandstone and siltstone. (GLACIAL TILL)																																																		
		N=7			2.00																																																			
		N=46			2.50 2.65 3.00	Light grey, slightly silty, sandy CLAY with mudstone lithorelicts. (WEATHERED BOLLIN MUDSTONE MEMBER)																																																		
						Extremely weak, distinctly weathered, reddish brown, slightly silty MUDSTONE. (BOLLIN MUDSTONE MEMBER)																																																		
						End Of Borehole At 3.00 m																																																		
					4.00																																																			
KEY D - Disturbed Sample B - Bulk Sample U - Undisturbed W - Water Sample S - Standard Penetration Test C - Cone Penetration Test N - Penetration Test 'N' Value V - Hand Shear Vane kPa  - Groundwater Strike  - Groundwater Level 			REMARKS Scale: 1:30			Water Strikes <table border="1"> <thead> <tr> <th>Date</th> <th>Strike</th> <th>Level</th> <th>Minutes</th> <th>Casing</th> <th>Sealed</th> </tr> </thead> <tbody> <tr> <td>08/10/2018</td> <td>2.2</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <table border="1"> <thead> <tr> <th colspan="3">Daily Log Of Depths</th> <th colspan="3">Chiselling</th> </tr> <tr> <th>Date</th> <th>Casing</th> <th>Water</th> <th>From</th> <th>To</th> <th>Hours</th> </tr> </thead> <tbody> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table>			Date	Strike	Level	Minutes	Casing	Sealed	08/10/2018	2.2																	Daily Log Of Depths			Chiselling			Date	Casing	Water	From	To	Hours												
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08/10/2018	2.2																																																							
Daily Log Of Depths			Chiselling																																																					
Date	Casing	Water	From	To	Hours																																																			

			Project Title: Broadoak Road				WS5																																					
			Project Number: 8398G		Client: AEW Architects					Sheet 1 Of 1																																		
			GL (mAOD):		N Coord: 0		E Coord: 0																																					
Date: 05/10/2018			Method: Window Sample		Driller: LOT Geotechnics Ltd		Logged By: TPB																																					
Depth (m)	Type	Test Result	Level	Legend	Depth (m)	Description	Water	Standpipe																																				
0.40	E					Turf over dark brown, slightly silty, gravelly SAND with rootlets. Gravel is angular to subangular, fine to coarse, including sandstone, brick, concrete, plastic and metal. (MADE GROUND)																																						
					0.90																																							
					1.00	Grey, subangular COBBLES including marble and granite. (MADE GROUND)																																						
					1.20	End Of Borehole At 1.20 m																																						
					2.00																																							
					3.00																																							
					4.00																																							
KEY D - Disturbed Sample B - Bulk Sample U - Undisturbed W - Water Sample S - Standard Penetration Test C - Cone Penetration Test N - Penetration Test 'N' Value V - Hand Shear Vane kPa  - Groundwater Strike  - Groundwater Level			REMARKS No Groundwater Encountered Hole refused on cobbles at 1.20mbgl. 			Water Strikes <table border="1"> <thead> <tr> <th>Date</th> <th>Strike</th> <th>Level</th> <th>Minutes</th> <th>Casing</th> <th>Sealed</th> </tr> </thead> <tbody> <tr><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td></tr> </tbody> </table>			Date	Strike	Level	Minutes	Casing	Sealed																														
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Date	Casing	Water	From	To	Hours																																							

			Project Title: Broadoak Road				WS6																																																	
			Project Number: 8398G		Client: AEW Architects					Sheet 1 Of 1																																														
			GL (mAOD):		N Coord: 0		E Coord: 0																																																	
Date: 05/10/2018			Method: Window Sample		Driller: LOT Geotechnics Ltd		Logged By: TPB																																																	
Depth (m)	Type	Test Result	Level	Legend	Depth (m)	Description	Water	Standpipe																																																
0.20	E					Turf over dark brown, slightly silty, slightly gravelly SAND with rootlets. Gravel is subangular, fine to coarse, including sandstone, brick and ash. (MADE GROUND)																																																		
1.10	D	N=40			0.80 1.00	Stiff, brown and occasionally grey mottled, slightly silty, slightly gravelly, sandy CLAY. Gravel is subangular, fine to coarse, including sandstone, siltstone and coal. (GLACIAL TILL)																																																		
		N=22			2.00																																																			
		N=33			2.70 3.00	Extremely weak, distinctly weathered, reddish brown, slightly silty MUDSTONE. (BOLLIN MUDSTONE MEMBER)																																																		
					4.00	End Of Borehole At 3.00 m																																																		
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			Project Title: Broadoak Road				WS7																																		
			Project Number: 8398G		Client: AEW Architects					Sheet 1 Of 1																															
			GL (mAOD):		N Coord: 0		E Coord: 0																																		
Date: 05/10/2018			Method: Window Sample		Driller: LOT Geotechnics Ltd		Logged By: TPB																																		
Depth (m)	Type	Test Result	Level	Legend	Depth (m)	Description	Water	Standpipe																																	
0.50	E	N=20			0.80	Turf over dark brown, slightly silty, slightly gravelly SAND with rootlets. Gravel is angular to subangular, fine to coarse, including sandstone, brick, glass and metal. (MADE GROUND)																																			
1.20	J				1.00	Firm to stiff, brown and occasionally grey mottled, slightly silty, slightly gravelly, sandy CLAY. Gravel is subangular, fine to coarse, including sandstone and siltstone. (GLACIAL TILL)																																			
			N=15			2.00																																			
			N=34			2.50																																			
					3.00	Extremely weak, distinctly weathered, reddish brown, slightly silty MUDSTONE. (BOLLIN MUDSTONE MEMBER)																																			
						End Of Borehole At 3.00 m																																			
					4.00																																				
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Date	Casing	Water	From	To	Hours																																				
Date	Casing	Water	From	To	Hours																																				

APPENDIX 03

Chemical Analytical Results



2183

Final Report

Report No.:	18-30878-1		
Initial Date of Issue:	17-Oct-2018		
Client	WML Consulting Ltd		
Client Address:	No. 8 Oak Green Stanley Green Business Park Earl Rd Cheadle SK8 6QL		
Contact(s):	Sam Seddon		
Project	8398G Broadoak Road		
Quotation No.:		Date Received:	09-Oct-2018
Order No.:	8398G	Date Instructed:	09-Oct-2018
No. of Samples:	9		
Turnaround (Wkdays):	5	Results Due:	15-Oct-2018
Date Approved:	16-Oct-2018		
Approved By:			
Details:	Glynn Harvey, Laboratory Manager		

Results - Soil

Project: 8398G Broadoak Road

Client: WML Consulting Ltd	Chemtest Job No.:				18-30878	18-30878	18-30878	18-30878	18-30878	18-30878	18-30878	18-30878	18-30878
Quotation No.:	Chemtest Sample ID.:				702433	702434	702435	702436	702437	702438	702439	702440	702442
Order No.: 8398G	Client Sample Ref.:				DJ	J	DJ	JV	DJ	J	DJ	DJ	J
	Client Sample ID.:				2	3	4	5	6	7	8	9	11
	Sample Location:				WS2	WS2	WS3	WS3	WS4	WS4	WS5	WS6	WS7
	Sample Type:				SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
	Top Depth (m):				0.30	1.10	0.40	2.30	0.20	3.80	0.40	0.20	1.20
	Date Sampled:				05-Oct-2018	05-Oct-2018	05-Oct-2018	05-Oct-2018	05-Oct-2018	05-Oct-2018	05-Oct-2018	05-Oct-2018	05-Oct-2018
	Asbestos Lab:				COVENTRY		COVENTRY		COVENTRY		COVENTRY	COVENTRY	
Determinand	Accred.	SOP	Units	LOD									
ACM Type	U	2192		N/A	-		-		-		-	-	
Asbestos Identification	U	2192	%	0.001	No Asbestos Detected		No Asbestos Detected		No Asbestos Detected		No Asbestos Detected	No Asbestos Detected	
Moisture	N	2030	%	0.020	8.8	12	12	51	10	11	7.5	9.0	9.8
pH	U	2010		N/A	7.7	8.2	7.9		7.6	8.6	7.9	7.9	7.9
Boron (Hot Water Soluble)	U	2120	mg/kg	0.40	0.61		0.76		0.65		0.79	0.63	
Sulphate (2:1 Water Soluble) as SO4	U	2120	g/l	0.010	< 0.010	0.039	< 0.010		0.028	< 0.010	0.011	< 0.010	< 0.010
Total Sulphur	U	2175	%	0.010	0.075	< 0.010	0.060		0.099	0.014	0.096	0.048	< 0.010
Cyanide (Total)	U	2300	mg/kg	0.50	0.80		0.80		0.70		0.90	1.0	
Sulphate (Total)	U	2430	mg/kg	100	950		910		2200		1300	1000	
Arsenic	U	2450	mg/kg	1.0	18		17		18		19	25	
Cadmium	U	2450	mg/kg	0.10	9.7		3.0		1.6		2.1	1.3	
Copper	U	2450	mg/kg	0.50	69		56		66		58	68	
Mercury	U	2450	mg/kg	0.10	0.69		0.53		0.41		5.7	1.4	
Nickel	U	2450	mg/kg	0.50	26		23		29		25	24	
Lead	U	2450	mg/kg	0.50	220		130		130		210	120	
Selenium	U	2450	mg/kg	0.20	< 0.20		< 0.20		< 0.20		< 0.20	< 0.20	
Vanadium	U	2450	mg/kg	5.0	24		21		22		24	23	
Zinc	U	2450	mg/kg	0.50	250		280		250		270	340	
Chromium (Hexavalent)	N	2490	mg/kg	0.50	< 0.50		< 0.50		< 0.50		< 0.50	< 0.50	
Organic Matter	U	2625	%	0.40	7.4		5.0		8.3		5.9	4.5	
Aliphatic TPH >C5-C6	N	2680	mg/kg	1.0				< 1.0					
Aliphatic TPH >C6-C8	N	2680	mg/kg	1.0				< 1.0					
Aliphatic TPH >C8-C10	U	2680	mg/kg	1.0				< 1.0					
Aliphatic TPH >C10-C12	U	2680	mg/kg	1.0				< 1.0					
Aliphatic TPH >C12-C16	U	2680	mg/kg	1.0				< 1.0					
Aliphatic TPH >C16-C21	U	2680	mg/kg	1.0				< 1.0					
Aliphatic TPH >C21-C35	U	2680	mg/kg	1.0				25					
Aliphatic TPH >C35-C44	N	2680	mg/kg	1.0				< 1.0					
Total Aliphatic Hydrocarbons	N	2680	mg/kg	5.0				25					
Aromatic TPH >C5-C7	N	2680	mg/kg	1.0				< 1.0					
Aromatic TPH >C7-C8	N	2680	mg/kg	1.0				< 1.0					
Aromatic TPH >C8-C10	U	2680	mg/kg	1.0				< 1.0					
Aromatic TPH >C10-C12	U	2680	mg/kg	1.0				< 1.0					
Aromatic TPH >C12-C16	U	2680	mg/kg	1.0				< 1.0					
Aromatic TPH >C16-C21	U	2680	mg/kg	1.0				22					
Aromatic TPH >C21-C35	U	2680	mg/kg	1.0				140					

Results - Soil

Project: 8398G Broadoak Road

Client: WML Consulting Ltd	Chemtest Job No.:		18-30878	18-30878	18-30878	18-30878	18-30878	18-30878	18-30878	18-30878	18-30878
Quotation No.:	Chemtest Sample ID.:		702433	702434	702435	702436	702437	702438	702439	702440	702442
Order No.: 8398G	Client Sample Ref.:		DJ	J	DJ	JV	DJ	J	DJ	DJ	J
	Client Sample ID.:		2	3	4	5	6	7	8	9	11
	Sample Location:		WS2	WS2	WS3	WS3	WS4	WS4	WS5	WS6	WS7
	Sample Type:		SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
	Top Depth (m):		0.30	1.10	0.40	2.30	0.20	3.80	0.40	0.20	1.20
	Date Sampled:		05-Oct-2018	05-Oct-2018	05-Oct-2018	05-Oct-2018	05-Oct-2018	05-Oct-2018	05-Oct-2018	05-Oct-2018	05-Oct-2018
	Asbestos Lab:		COVENTRY		COVENTRY		COVENTRY		COVENTRY	COVENTRY	
Determinand	Accred.	SOP	Units	LOD							
Aromatic TPH >C35-C44	N	2680	mg/kg	1.0			< 1.0				
Total Aromatic Hydrocarbons	N	2680	mg/kg	5.0			160				
Total Petroleum Hydrocarbons	N	2680	mg/kg	10.0			180				
Naphthalene	U	2700	mg/kg	0.10	1.5	0.42	1.1	3.0	0.51	0.41	
Acenaphthylene	U	2700	mg/kg	0.10	1.3	0.20	3.3	0.53	0.44	0.23	
Acenaphthene	U	2700	mg/kg	0.10	0.82	0.27	22	0.49	0.97	0.41	
Fluorene	U	2700	mg/kg	0.10	1.4	0.27	29	0.91	0.97	0.32	
Phenanthrene	U	2700	mg/kg	0.10	10	2.8	140	4.2	11	2.6	
Anthracene	U	2700	mg/kg	0.10	3.0	0.92	47	1.3	4.1	0.78	
Fluoranthene	U	2700	mg/kg	0.10	13	7.3	140	12	20	4.6	
Pyrene	U	2700	mg/kg	0.10	13	7.3	120	12	20	4.4	
Benzo[a]anthracene	U	2700	mg/kg	0.10	6.5	3.3	51	6.2	9.6	2.2	
Chrysene	U	2700	mg/kg	0.10	8.5	4.8	65	7.8	11	3.7	
Benzo[b]fluoranthene	U	2700	mg/kg	0.10	7.3	5.2	46	7.2	12	2.8	
Benzo[k]fluoranthene	U	2700	mg/kg	0.10	3.0	2.1	20	3.0	4.4	0.88	
Benzo[a]pyrene	U	2700	mg/kg	0.10	6.4	4.1	40	5.7	10	2.5	
Indeno(1,2,3-c,d)Pyrene	U	2700	mg/kg	0.10	4.2	3.0	25	4.0	7.3	1.9	
Dibenz(a,h)Anthracene	U	2700	mg/kg	0.10	1.2	0.82	6.9	1.3	1.9	0.51	
Benzo[g,h,i]perylene	U	2700	mg/kg	0.10	4.5	3.5	21	3.8	7.6	2.9	
Total Of 16 PAH's	U	2700	mg/kg	2.0	86	46	780	73	120	31	
Total Phenols	U	2920	mg/kg	0.30	< 0.30	< 0.30		< 0.30	0.69	< 0.30	

SOP	Title	Parameters included	Method summary
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2120	Water Soluble Boron, Sulphate, Magnesium & Chromium	Boron; Sulphate; Magnesium; Chromium	Aqueous extraction / ICP-OES
2175	Total Sulphur in Soils	Total Sulphur	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2192	Asbestos	Asbestos	Polarised light microscopy / Gravimetry
2300	Cyanides & Thiocyanate in Soils	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Alkaline extraction followed by colorimetric determination using Automated Flow Injection Analyser.
2430	Total Sulphate in soils	Total Sulphate	Acid digestion followed by determination of sulphate in extract by ICP-OES.
2450	Acid Soluble Metals in Soils	Metals, including: Arsenic; Barium; Beryllium; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Vanadium; Zinc	Acid digestion followed by determination of metals in extract by ICP-MS.
2490	Hexavalent Chromium in Soils	Chromium [VI]	Soil extracts are prepared by extracting dried and ground soil samples into boiling water. Chromium [VI] is determined by 'Aquakem 600' Discrete Analyser using 1,5-diphenylcarbazide.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2680	TPH A/A Split	Aliphatics: >C5–C6, >C6–C8,>C8–C10, >C10–C12, >C12–C16, >C16–C21, >C21–C35, >C35– C44Aromatics: >C5–C7, >C7–C8, >C8– C10, >C10–C12, >C12–C16, >C16– C21, >C21– C35, >C35– C44	Dichloromethane extraction / GCxGC FID detection
2700	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-FID	Acenaphthene; Acenaphthylene; Anthracene; Benzo[a]Anthracene; Benzo[a]Pyrene; Benzo[b]Fluoranthene; Benzo[ghi]Perylene; Benzo[k]Fluoranthene; Chrysene; Dibenzo[ah]Anthracene; Fluoranthene; Fluorene; Indeno[123cd]Pyrene; Naphthalene; Phenanthrene; Pyrene	Dichloromethane extraction / GC-FID
2920	Phenols in Soils by HPLC	Phenolic compounds including Resorcinol, Phenol, Methylphenols, Dimethylphenols, 1-Naphthol and TrimethylphenolsNote: chlorophenols are excluded.	60:40 methanol/water mixture extraction, followed by HPLC determination using electrochemical detection.

Report Information

Key

- U UKAS accredited
- M MCERTS and UKAS accredited
- N Unaccredited
- S This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
- SN This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
- T This analysis has been subcontracted to an unaccredited laboratory
- I/S Insufficient Sample
- U/S Unsuitable Sample
- N/E not evaluated
- < "less than"
- > "greater than"

Comments or interpretations are beyond the scope of UKAS accreditation

The results relate only to the items tested

Uncertainty of measurement for the determinands tested are available upon request

None of the results in this report have been recovery corrected

All results are expressed on a dry weight basis

The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols

For all other tests the samples were dried at < 37°C prior to analysis

All Asbestos testing is performed at the indicated laboratory

Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

- A - Date of sampling not supplied
- B - Sample age exceeds stability time (sampling to extraction)
- C - Sample not received in appropriate containers
- D - Broken Container
- E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

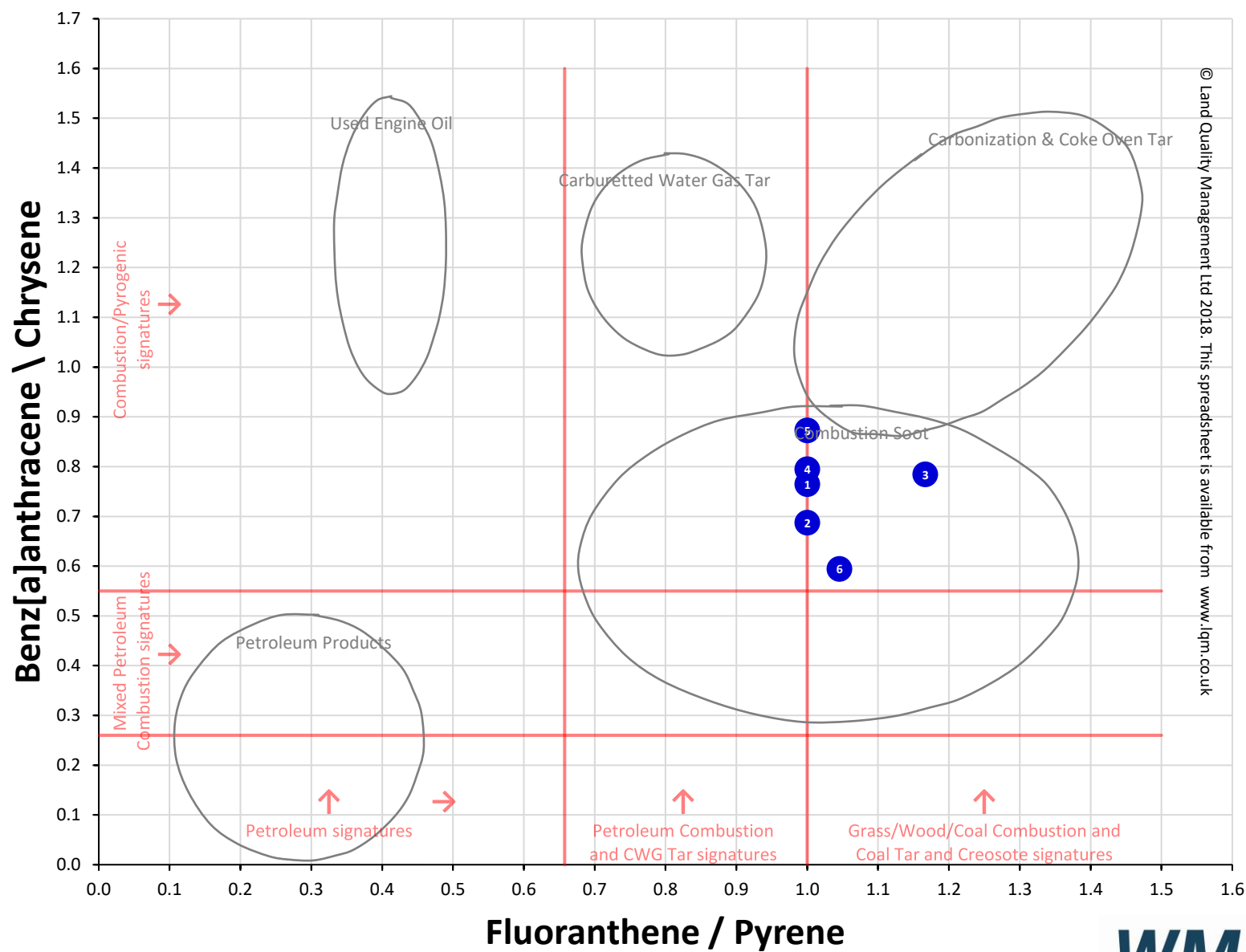
All soil samples will be retained for a period of 45 days from the date of receipt

All water samples will be retained for 14 days from the date of receipt

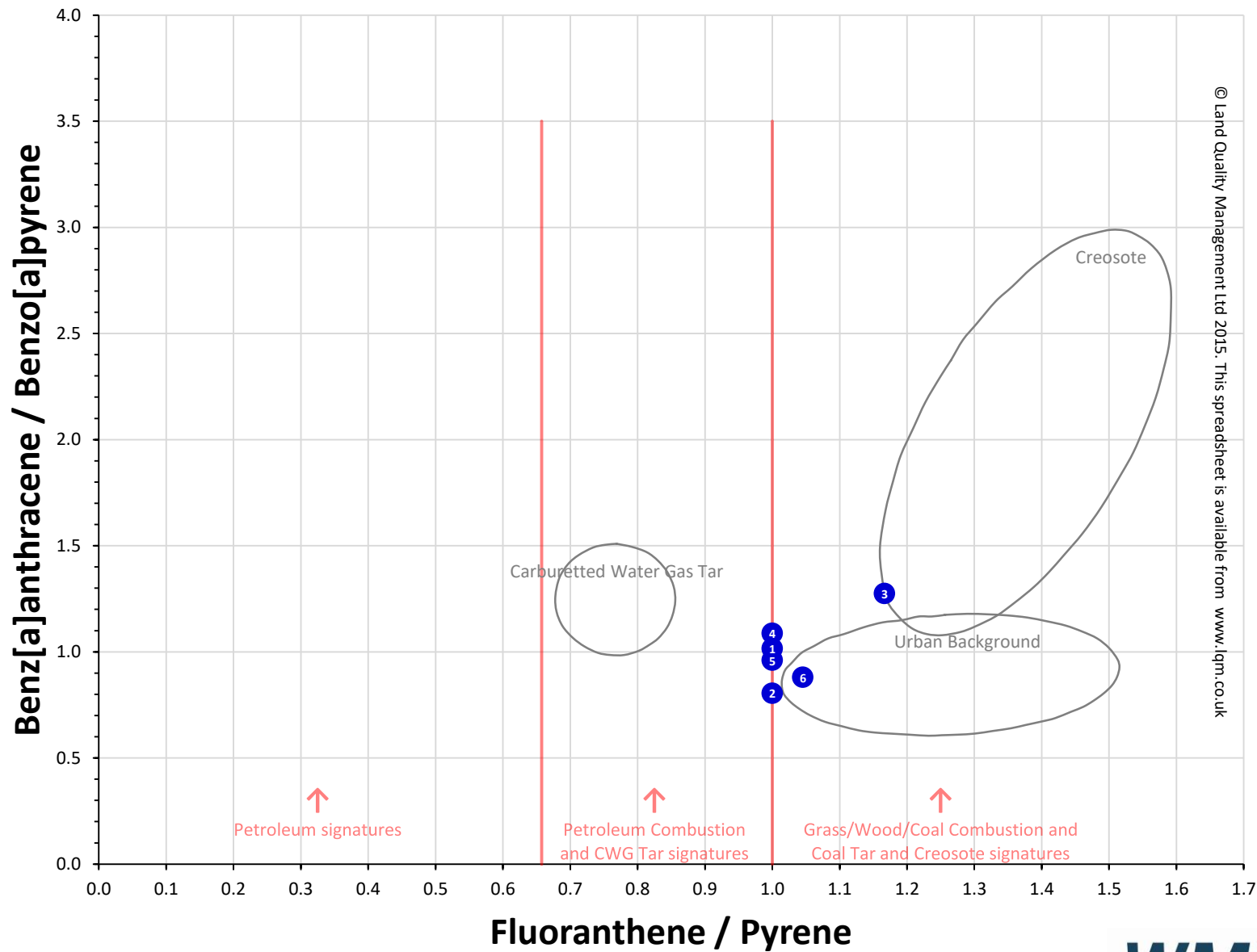
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:

customerservices@chemtest.com



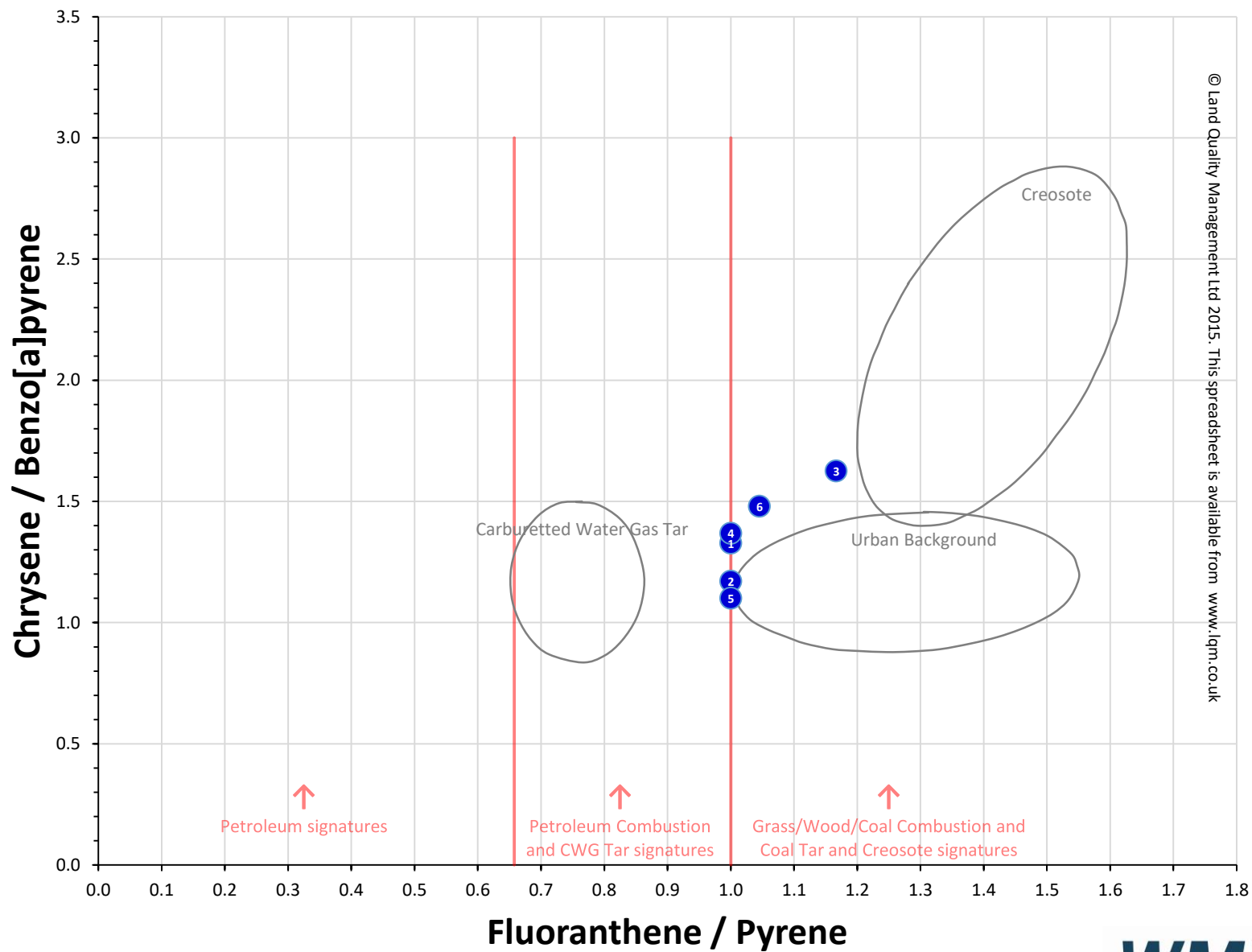
Based on Figure 6 in Costa & Sauer (2005) with additional details based on a conference presentation by Costa (2005) in San Diego. The potential sources shown are indicative only.



Key:
● Samples collected on site

Based on Figure 7 in Costa & Sauer (2005). The potential sources shown are indicative only.

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Key:

● Samples collected on site

Based on Figure 8 in Costa & Sauer (2005). The potential sources shown are indicative only.

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APPENDIX 04

Gas Monitoring Results

Gas & Groundwater Monitoring Record Sheet



Project Name:- Broadoak Road - Site 2
Project No:- 8398G
Client:- WCHA

Date:- 23/10/2018
Start Time:- 10:50
End Time:- 11:30
Ground Conditions:- Dry
Weather Conditions:- Overcast

Atmospheric Pressure
Start:- 1024mb
End:- 1024mb
Trend:- Falling

Instrument:- Gas Data GFM436

Operator:- P Hobson

Hole ID	Peak Flow l/hr	Steady Flow l/hr	DP	CH4		CO2		Min O2 %	Peak H2S ppm	Peak CO ppm	Hexane %	Water Level mbgl	Base of Hole mbgl
				Peak	GSV l/hr	Peak	GSV l/hr						
WS1	<0.1	<0.1	0	0.0	0.0000	1.3	0.0013	18.6	0	0	0.000	1.20	2.81
WS3	<0.1	<0.1	0	0.0	0.0000	3.3	0.0033	17.3	0	0	0.000	1.40	2.50
WS4	<0.1	<0.1	0	0.1	0.0001	6.2	0.0062	13.9	0	0	0.000	1.77	2.57

Additional Comments

Gas & Groundwater Monitoring Record Sheet



Project Name:- Broadoak Road - Site 2
Project No:- 8398G
Client:- WCHA

Date:- 07/11/2018
Start Time:- 11:20
End Time:- 11:40
Ground Conditions:- Wet
Weather Conditions:- Raining

Atmospheric Pressure
Start:- 983mb
End:- 983mb
Trend:- Rising

Instrument:- Gas Data GFM436

Operator:- P Hobson

Hole ID	Peak Flow l/hr	Steady Flow l/hr	DP	CH4		CO2		Min O2 %	Peak H2S ppm	Peak CO ppm	Hexane %	Water Level mbgl	Base of Hole mbgl
				Peak	GSV l/hr	Peak	GSV l/hr						
WS1	<0.1	<0.1	0	0.0	0.0000	1.5	0.0015	18.6	0	0	0.000	2.00	2.70
WS3	<0.1	<0.1	0	0.0	0.0000	2.2	0.0022	18.6	0	0	0.016	Dry	2.80
WS4	<0.1	<0.1	0	0.0	0.0000	3.6	0.0036	17.5	0	0	0.000	1.20	2.40

Additional Comments

Gas & Groundwater Monitoring Record Sheet



Project Name:- Broadoak Road - Site 2
Project No:- 8398G
Client:- WCHA

Date:- 16/11/2018
Start Time:- 11:40
End Time:- 12:00
Ground Conditions:- Dry
Weather Conditions:- Overcast

Atmospheric Pressure
Start:- 1018mb
End:- 1018mb
Trend:- Rising

Instrument:- Gas Data GFM436

Operator:- P Hobson

Hole ID	Peak Flow l/hr	Steady Flow l/hr	DP	CH4		CO2		Min O2 %	Peak H2S ppm	Peak CO ppm	Hexane %	Water Level mbgl	Base of Hole mbgl
				Peak	GSV l/hr	Peak	GSV l/hr						
WS1	<0.1	<0.1	0	0.0	0.0000	1.5	0.0015	18.5	0	0	0.000	1.30	2.77
WS3	<0.1	<0.1	0	0.0	0.0000	3.7	0.0037	16.3	0	0	0.000	1.40	2.46
WS4	<0.1	<0.1	0	0.1	0.0001	3.8	0.0038	16.9	0	0	0.000	1.50	2.37

Additional Comments

Monitoring Well	Date	SWL (mbgl)	Max Flow (l/hr)	Max CH4 (%v/v)	Max CH4 Qhg (l/hr)	Max CO2 (%v/v)	Max CO2 Qhg (l/hr)	Characteristic Situation	NHBC Traffic Light
WS1	23/10/2018	1.20	<0.1	0.00	0.0001	1.30	0.0013	CS1	Green
	07/11/2018	2.00	<0.1	0.00	0.0001	1.50	0.0015	CS1	Green
	16/11/2018	1.30	<0.1	0.00	0.0001	1.50	0.0015	CS1	Green
WS3	23/10/2018	1.40	<0.1	0.00	0.0001	3.30	0.0033	CS1	Green
	07/11/2018	Dry	<0.1	0.00	0.0001	2.20	0.0022	CS1	Green
	16/11/2018	1.40	<0.1	0.00	0.0001	3.70	0.0037	CS1	Green
WS4	23/10/2018	1.77	<0.1	0.10	0.0001	6.20	0.0062	CS2	Amber 1
	07/11/2018	1.20	<0.1	0.00	0.0001	3.60	0.0036	CS1	Green
	16/11/2018	1.50	<0.1	0.10	0.0001	3.80	0.0038	CS1	Green
Project Name - Broadoak Road - Site 2				Table 1 - Characteristic Ground Gas Risk Assessment				WMLCONSULTING	
Project No - 8398G									
Client - WCHA									

Notes Where no flows are detected, a value of 0.1l/hr has been assumed to calculate the Q_{hg}.
Where gas concentrations are recorded below detection limits, a value of 0.1% has been assumed.



APPENDIX 05

Site Specific Acceptance Criteria

**Site Specific Assessment Criteria for
Residential (with homegrown produce) based on 1% SOM**

Contaminant	Assessment Criteria for Residential 6% SOM (mg/kg)
Metals	
Arsenic	37
Boron	290
Cadmium	26
Chromium III	910
Chromium VI	6
Copper	2400
Lead*	200
Mercury	1.2
Nickel	130
Selenium	250
Vanadium	410
Zinc	3700
Non – Metals	
Phenol	120
Polyaromatic Hydrocarbons (PAH) 1% SOM	
Benz[a]anthracene	7.2
Benzo[a]pyrene	2.2
Benzo[b]fluoranthene	2.6
Benzo[ghi]perylene	320
Benzo[k]fluoranthene	77
Chrysene	15
Dibenz[ah]anthracene	0.24
Fluoranthene	280
Indeno[123-cd]pyrene	27
Naphthalene	2.3
Pyrene	620

Contaminant	Criteria for Residential End Use (mg/kg)
Volatile Organic Compounds – (VOCs) 1% SOM	
Benzene	0.087
Ethylbenzene	47
Toluene	130
Xylene	56
1,2-Dichloroethane	0.0071
1,1,1-Trichloroethane	8.8
Tetrachloroethane	1.6
Tetrachloroethene (PCE)	0.18
Tetrachloromethane	0.026
Trichloroethene (TCE)	0.016
Trichloromethane	0.91
Vinyl Chloride	0.00064
Semi-Volatile Organic Compounds (SVOCs) 1% SOM	
1,2-Dichlorobenzene	23
1,4-Dichlorobenzene	61 ^f
1,2,4-Trichlorobenzene	2.6
Hexachlorobenzene	1.8 (0.2) ^{vap}
Total Petroleum Hydrocarbons – TPH	
Aliphatic C5-6	42
Aliphatic C6-8	100
Aliphatic C8-10	27
Aliphatic C10-12	130(48) ^{vap}
Aliphatic C12-16	1100(24) ^{sol}
Aliphatic C16-35	65,000(8.48) ^{f.sol}
Aliphatic C35 - 44	65,000(8.84) ^{f.sol}
Aromatic C5 – 7 (benzene)	70
Aromatic C7 – 8 (toluene)	130
Aromatic C8-10	34
Aromatic C10-12	74
Aromatic C12-16	140
Aromatic C16-21	260 ^f
Aromatic C21-35	1100 ^f
Aromatic C35 - 44	1100 ^f

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* Where not included in the S4UL's criteria for a limited number of contaminants, namely lead, have been derived by DEFRA in their document entitled SP1010: Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination, April 2014.