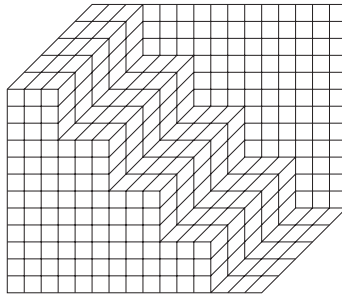




Buro Happold

023842 The co-operative Head Office, Manchester

Ground Engineering Interpretative Report

Job no 023842 October 2009

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1 Introduction

Buro Happold Limited has been appointed by the co-operative to carry out site investigation works and prepare an interpretative report for the site of their proposed new Head Office building development in Manchester.

The site of the proposed development is located to the north of Manchester City Centre, approximately 200 m east of Manchester Victoria Railway Station and to the immediate northeast of the existing Co-operative Insurance Society (CIS) Tower at Ordnance Survey (OS) National Grid Reference (NGR) 384349 E 399053 N. The site area is currently occupied by a public car parking area, managed by NCP. The immediate surrounding area comprises urban development including warehouses, offices and manufacturing facilities. A site location plan is presented as Figure 1 and a recent aerial photograph is included as Figure 2.

The proposed new co-operative Head Office will predominantly comprise flexible open plan office space organized around a large central atrium forming 3 equal wings. The building is symmetrical about the NW-SE axis, rising to a high point at its NW corner. The SE wing is lower, in accordance with neighbouring residential buildings and, therefore, provides the upper levels with extensive city views. The building occupies a footprint of approximately a quarter of the overall site area thus the remaining area is to be redeveloped as high quality public realm space. Information on the current development proposals is provided in Section 6.1 and architect's impressions are provided in Appendix A.

A desk study has been undertaken by Buro Happold (BH Desk Study)¹. The BH Desk Study was undertaken to allow the ground investigation works to be appropriately designed and to optimize, as far as possible, the positioning of the exploratory holes. A summary of the information sources consulted during the undertaking of the desk study is presented in Appendix B of the Desk Study Report and is not duplicated herein. Also available for the site is a unexploded ordnance (UXO) desk study, namely the EOD Contracts Ltd Explosive Ordnance Desk Top Study². The BH Desk Study and the UXO desk study should be read in conjunction with this report.

A site specific ground investigation was undertaken at the proposed development site between 14 April 2009 and 15 May 2009 by Structural Soils Limited, herein referred to as the Structural Soils Investigation, under the supervision of a member of the Buro Happold Ground Engineering (BHGE) Team. The Structural Soils Investigation comprised 22 No. hand dug trial pits, 7 No. machine dug trial pits and 2 No. cable percussive

¹ Buro Happold. *023842 The Co-operative Group HQ Building, Manchester. Ground Engineering Desk Study Report* (July 2009).

² EOD Contracts Limited, Report No: ECL/09/10360/DTS/MillerStManchester/Rev2 '*Explosive Ordnance Desk Top Study, Miller Street Manchester for the Co-operative Group*'. March 2009.

boreholes with rotary follow on. It was conducted to provide information on the ground conditions, groundwater and ground gas regimes, degrees of contamination (if any) and details of any obstructions encountered. A factual report for these investigatory works was prepared by Structural Soils Limited (Structural Soils Report)³. All referenced reports should be read in conjunction with this report.

The assessments undertaken and opinions expressed in this report are based on the ground conditions revealed by the investigatory works. As such, it should be noted that groundwater conditions summarized in this report are those observed as part of the investigation and take no account of fluctuations due to season, local drainage or any other localized affects.

³ Structural Soils Ltd. *Report on Ground Investigation at The Co-Operative Head Office, Manchester. Report No: 761072.* September 2009.

2 The Site

The site is located approximately 200 m east of Manchester Victoria Railway Station and to the immediate northeast of the CIS Tower. It is bordered to the north and northeast by Angel Street, to the southeast by NCP car parks, to the southwest by Miller Street and to the northwest by Dantzic Street.

As previously stated a desk study report is available for the site, namely the Buro Happold Ground Engineering Desk Study Report (BH Desk Study)¹. The reports included details for the Head Office development site and its environs and are not duplicated herein.

The BHGE Desk Study¹ presents details of the co-operative site, including:

- Site Location and Description.
- Site walkover photographs.
- Site Utilities.
- Site History.
- Archaeology.
- Published and Unpublished Geology.
- Hydrology.
- Hydrogeology (including groundwater vulnerability and groundwater details).
- Mining Activity.
- Ground Instability and Geo-Hazards.
- Trees.
- Environmental Setting.
- Preliminary Conceptual Site Model.
- Details of the Ground Investigation

Also available for the site is an UXO desk study, namely the EOD Contracts Ltd Explosive Ordnance Desk Top Study². The reports include details for the Head Office development site and its environs and are not duplicated herein.

The UXO desk study provides details of the UXO risk across the co-operative site and its environs, including:

- Site history.
- Attack history.

The Structural Soils Report³ presents details and results of the Structural Soils Investigation undertaken at the co-operative Head Office site in April and May 2009.

Reference should be made to all previous reports in respect of the above items and all reports should be read in conjunction with this report.

3 Ground Investigation

3.1 General

The site specific ground investigation works were undertaken at the proposed development site in general accordance with BS5930⁴ between 14 April 2009 and 15 May 2009 by Structural Soils Limited (herein referred to as Structural Soils) and Lankelma (UK) Limited (herein referred to as Lankelma) under the supervision of a member of the BHGE Team. It comprised 22 No. hand dug trial pits, 7 No. machine dug trial pits and 2 No. cable percussion and rotary cored boreholes all with associated testing. The results are presented in the Structural Soils Report³.

A summary of ground investigation works to date is provided in the following paragraphs. An exploratory hole location plan showing the locations of all investigation points from Structural Soils investigations is included as Figure 3.

3.2 Exploratory Holes

A total of 22 No. hand dug inspection pits were excavated by Structural Soils across the proposed development site in April 2009. Hand dug inspection pits were excavated at each location shown on Figure 3 using standard hand tools to depths of 1.20 – 1.30 m BGL to ‘clear’ locations for near surface utilities. Samples were taken in all trial pits to allow geotechnical and chemical testing to be undertaken. On completion all hand pits were backfilled with arisings.

A magnetometer cone test (mag-cone) was then also carried out at each location by Lankelma to ‘clear’ the positions in respect of the potential presence of UXO. Test results are presented in the Lankelma Report included as an appendix in the Structural Soils Report³. Unfortunately, due to the nature of the Made Ground and underlying materials, the mag-cone could not penetrate as deep as necessary thus machine dug trial pits, ‘cleared’ for UXO by appropriately qualified personnel (Bactec) using hand held detection equipment, were employed to penetrate the Made Ground at certain locations (identified with the prefix TP on Figure 3). This exploratory technique replaced the proposed window sampling and further ‘Dutch Cone’ CPT works (originally scheduled across the site) which were cancelled.

A total of 7 No. machine dug trial pits were excavated (TPBH01, TPBH02, TPCPT01 – TPCPT04 and TPCPT10) as part of the site wide ground investigation. Locations of the machine dug trial pits (annotated as the holes they assisted to penetrate the Made Ground) are shown on Figure 3. The trial pits range in depth between a minimum of 4.50 m BGL in TPCPT04 and a maximum of 5.00 m BGL in TPCPT01, 02 and 03. Samples were taken in all trial pits to allow geotechnical and chemical testing to be undertaken. Hand shear vanes were also undertaken in TPCPT10. The exploratory hole records prepared by Structural Soils are presented in the

⁴ BSI (1999). *Code of Practice for Site Investigations BS5930:1999*. British Standards Institution.

Structural Soils Report³. On completion all machine dug trial pits were back filled with arisings with the exception of TPBH01 and TPBH02 where 255 mm uPVC pipe was installed to the base of the exploratory holes with the rest of the pit backfilled with arisings.

A total of 2 No. boreholes (TPBH01 and TPBH02) were undertaken using a cable percussive boring techniques with a rotary core drilling follow on. The boreholes were undertaken within the 255 mm uPVC pipe within the relevant trial pits (ie commencing at base of trial pit level) at the locations shown on Figure 3. Stainless steel casing was used and the boreholes were 'cleared' for UXO by appropriately qualified personnel (Bactec) using hand held detection equipment.

The boreholes varied in depth from a minimum of 24.80 m BGL (16.00 m AOD) in TPBH01 to a maximum depth of 30.50 m BGL (12.40 m AOD) in TPBH02. Cable percussive drilling was undertaken in both holes to depths ranging between 10.50 m BGL (32.40 m AOD) in TPBH02 and 11.80 m BGL (29.00 m AOD) in TPBH01. Standard Penetration Tests (SPT) were undertaken in both boreholes at varying depths in general accordance with BS1377: Part 9: Section 3.3. On completion 50 mm and 19 mm diameter combined gas and water monitoring standpipe were installed in both boreholes to various depths. A rising head and a falling head permeability test was conducted in TPBH01 and a falling head permeability test was undertaken in TPBH02 in general accordance with BS5930: 1999 Section 4. Soil and rock logging was conducted in general accordance with BS5930:1999⁴ by Structural Soils and the exploratory hole records prepared by Structural Soils are presented in the Structural Soils Report³.

Post fieldwork 6 No. gas and groundwater monitoring events were undertaken by Structural Soils. A combined infrared gas meter and flow meter was used for gas monitoring whilst groundwater monitoring and sampling was conducted following purging of the boreholes using Waterra pumping equipment. The results of the gas and groundwater monitoring are included in the Structural Soils Report³.

3.3 Laboratory Testing

The following suite of geotechnical laboratory testing was scheduled on selected representative samples by BHGE as part of the Structural Soils Investigation:

- Atterberg Limits (including moisture content).
- Sulphate (Water soluble).
- Point Load Index.
- pH.
- Particle Size Distribution/Sedimentation.
- Unconfined Compressive Strength.

The geotechnical test results are presented in the Structural Soils Report³ and are summarized in Section 4.6 herein.

A suite of chemical laboratory testing was scheduled on selected representative soil and groundwater samples by BHGE as part of the Structural Soils Investigation. The suite of testing was based on an assessment of previous and current land usage in combination with on-site observations during site specific investigation

works. The testing included determination of soil and leachable concentrations in respect of the following determinands:

- Determinands listed in Environment Agency 'Guidance on Sampling and Testing of Wastes to meet Landfill Acceptance Procedures'.
- Selected determinands listed in EA 'Guidance on the Disposal of "Contaminated Soils"' not included in the above guidance.
- Asbestos identification.

This chemical suite was selected to assess the degree of contamination present, if any, in respect of the proposed end use, health and safety of the work force and to allow material to be characterized for waste disposal purposes. Chemical analysis was undertaken by Envirolab and Alcontrol Laboratories with the results presented in the Structural Soils Report³. An interpretation of the chemical results is provided in Section 5.3.

3.4 Installations

On completion boreholes TPBH01 and TPBH02 were installed with 50 mm and 19 mm diameter combined gas and water monitoring standpipe. Installation details are presented on the exploratory hole records presented in the Structural Soils Report³ and are summarized in Table 1.

Table 1: Borehole Installations.

Borehole No.	Installation	Response Zone (m BGL)	Response Strata (Strata Type)
TPBH01	50 mm standpipe	12.00 m to 24.70 m	Sherwood Sandstone
TPBH01	19 mm standpipe	2.50 m to 7.50 m	Glacial Till - Sand
TPBH02	50 mm standpipe	17.50 m to 25.00 m	Sherwood Sandstone
TPBH04	19 mm standpipe	1.50 m to 4.00 m	Made Ground

Groundwater levels and gas concentrations were monitored on the following occasions:

- 3 June 2009 – Groundwater level, gas concentration and gas flow rate measured in all installations.
- 17 June 2009 – Groundwater level, gas concentration and gas flow rate measured in all installations.
- 2 July 2009 – Groundwater level, gas concentration and gas flow rate measured in all installations.
- 15 July 2009 – Groundwater level, gas concentration and gas flow rate measured in all installations.
- 29 July 2009 – Groundwater level, gas concentration and gas flow rate measured in all installations.
- 13 August 2009 – Groundwater level, gas concentration and gas flow rate measured in all installations.

The monitoring results are presented in the Structural Soils Report³ and an interpretation is provided in Sections 7.3 and 7.7 herein for groundwater and ground gas respectively.

4 Ground Conditions

4.1 General

The ground conditions on site have been assessed on the basis of all currently available information from the Structural Soils Investigation at the proposed development site. The general sequence of strata encountered beneath the site based on the ground investigation data is summarized in Table 2 and additional information is provided in Sections 4.2 to 4.4.

Table 2: Summary of Ground Conditions Encountered.

Depth to Top of Strata (m BGL)	Typical Thickness (m)	Generalized Description
0.00	0.75 – 4.30	MADE GROUND: Predominantly orange red angular COBBLES of brick rubble in a matrix of black and brown slightly silty, locally clayey, gravelly sand of ash. Gravel comprises varying material including sandstone, mudstone, limestone, quartzite, tarmac, coal, slag, concrete, slate, clinker, brick, rare granite and ceramic fragments. Locally soft and stiff, grey and brown, sandy gravelly clay (gravel as above) with TPCPT10 recording a slightly organic clay. [MADE GROUND]
0.75 – 4.30	6.20 – 10.00 (Only proven in TPBH01 and BHTP02)	Orange brown, slightly clayey, slightly gravelly fine to coarse SAND. Gravel is fine to coarse, subangular to rounded of quartzite, limestone, sandstone and ironstone. Localized pockets of stiff brown sandy gravelly CLAY. Gravel is fine to coarse, angular to rounded of sandstone, mudstone, quartzite and coal. [GLACIAL TILL]
10.20 – 11.00 (Only encountered in TPBH01 and BHTP02)	>13.80 – >20.30	Weak locally very weak/extremely weak, orange red brown, fine to medium locally coarse grained SANDSTONE with subhorizontal to horizontal bedding. 0.70 m thick band of thinly laminated completely weathered brown MUDSTONE noted at 20.19 m BGL in TPBH01 only. [SHERWOOD SANDSTONE BEDROCK]

Note: During the ground investigation groundwater was recorded in TPBH02 'seepage' at 1.00 m BGL (41.90 m AOD), TPCPT10 'seepage' at 1.00 and 3.00 m BGL (45.90 and 43.90 m AOD respectively) and TPCPT04 'locally damp' below 2.50 m BGL (37.40 m AOD). Groundwater was not encountered in any other exploratory holes or boreholes prior to the introduction of water as a rotary drilling flushing medium.

4.2 Made Ground

Made Ground was encountered in all exploratory hole locations ranging from a minimum thickness/depth of 0.75 m BGL (41.75 m AOD) in WS02 and (39.85 m AOD) in WS04 to a maximum thickness/depth of 4.30 m BGL (42.60 m AOD) in TPCPT10. The composition of the Made Ground varied across the site both laterally and vertically but can predominantly be described as clayey ashy demolition rubble, including ceramics, iron pipes and sandstone blocks along with sandstone, mudstone, limestone, quartzite, tarmac, coal, slag, concrete, slate, plastic and clinker.

It is also worthy of note that obstructions were encountered in a number of exploratory holes (TPCPT01, TPCPT02, TPCPT03, TPCPT04 and TPBH01) typically consisting of buried brick walls running in a variety of orientations across the site. Some such obstructions have been exposed as part of the archaeological investigations undertaken as indicated in Appendix J.

In addition, localized areas (TPCPT10) of slightly organic clay with clinker, slag, sandstone and brick gravels have also been recorded.

4.3 Glacial Till

The Glacial Till was only encountered in the following exploratory hole locations TPCPT01, TPCPT02, TPCPT03, TPCPT04, TPCPT10, WS02, WS04, TPBH01 and TPBH02. The depth to the top of this material varied from 0.75 m BGL (41.75 m AOD) in WS02 to 4.30 m BGL (42.60 m AOD) in TPCPT10. The thickness of the Glacial Till, where penetrated, varied between a minimum thickness of 6.20 m in TPBH02 to a maximum thickness of 10.00 m in exploratory hole TPBH01.

The Glacial till generally consisted of two distinct material types, namely granular and cohesive. The more predominant granular material generally comprised orange brown, slightly clayey, slightly gravelly sand and was encountered in WS04, TPCPT01, TPCPT02, TPCPT03, TPCPT04, TPCPT10, TPBH01 and TPBH02.

The cohesive material is less prevalent and generally encountered in the upper portion of the Glacial Till (typically above 37.00 m AOD) and generally consisted of stiff to very stiff, friable, slightly sandy, slightly gravelly fissured clay and was only encountered in WS02, TPCPT04, TPCPT10, TPBH01 and TPBH02. Where encountered, the cohesive material typically occurred immediately below the Made Ground and above the granular Glacial Till varying in thickness. It is considered likely that where the cohesive material is not encountered, it may be due to the varying topography of the site and the material having been removed ie in areas of deeper Made Ground.

4.4 Sherwood Sandstone Bedrock

The Sherwood Sandstone bedrock strata were encountered in both boreholes that penetrated deep enough, namely TPBH01 and TPBH02. The depth to the top of this material varied from 10.20 m BGL (32.70 m AOD) in TPBH02 to 11.00 m BGL (29.80 m AOD) in TPBH01. The thickness of the Sherwood Sandstone was not

proven but was penetrated by a maximum of 20.30 m in TPBH02 to a depth of 30.50 m BGL (12.40 m AOD). The rock strata was recorded to comprise extremely weak to weak orange red brown fine to medium locally coarse grained sandstone, highly to completely weathered near rock head but becoming intact with depth. A band of thinly laminated, completely weathered mudstone 0.70m thick, was recorded in TPBH01 between 20.19 m BGL (20.61 m AOD) and 20.88 m BGL (19.92 m AOD).

4.5 In-situ Testing

In-situ testing undertaken during the Structural Soils Investigation included hand shear vane tests (where possible), standard penetration tests (SPTs) and 3 No. permeability tests. Results are summarized below in Sections 4.5.1 to 4.5.3.

4.5.1 Hand Shear Vane Tests

A total of 4 No. Hand Shear Vane tests were carried out in cohesive Made Ground materials encountered in 1 No. exploratory hole during the Structural Soils Investigation, namely TPCPT10. The results are presented in the Structural Soils Report³ and can be summarized as follows:

- Minimum Value: $c_u = 45$ kPa – recorded in TPCPT10 at 4.00 m BGL (42.90 m AOD).
- Maximum Value: $c_u = 81$ kPa – recorded in TPCPT10 at 3.00 m BGL (43.90 m AOD).
- Typical Range: $c_u = 45 - 55$ kPa.

4.5.2 Standard Penetration Tests (SPT)

Standard Penetration Tests (SPTs) were undertaken in all boreholes during the Structural Soils Investigation. The results are presented in the Structural Soils Report³, are presented graphically in Appendix B and are summarized in the following paragraphs.

Glacial Till

A total of 10 No. SPT results are available for the Glacial Till and can be summarized as follows:

- Minimum Value: $N = 50$ – recorded in TPBH01 at 4.50 m BGL (36.30 m AOD).
- Maximum Value: $N = 300^*$ – recorded in TPBH02 at 9.10 m BGL (33.80 m AOD).
- Typical Range: $N = 57^*$ to 143*.

*Extrapolated 'N' value where full penetration not achieved.

The material strength assessment based on the SPT results indicates the Glacial Till to have a typical density of very dense. However, it should be noted that 9 out of the 10 tests undertaken in the Glacial Till reached refusal indicating a material strength to be greater than that for which the test was originally designed.

Sherwood Sandstone

A total of 4 No. SPTs were carried out in the Sherwood Sandstone strata and can be summarized as follows:

- Minimum Value: N = 54* – recorded in TPBH01 at 11.00m BGL (29.80 m AOD).
- Maximum Value: N = 429* – recorded in TPBH01 at 11.80 m BGL (29.00 m AOD).
- Typical range: N/A.

*Extrapolated 'N' value where full penetration not achieved.

All tests reached refusal indicating a material strength of greater than that for which the test was originally designed.

4.5.3 Permeability Tests

A series of In-situ permeability tests were undertaken in general accordance with BS5930:1999⁴ in the installations in TPBH01 and TPBH02 within the Sherwood Sandstone strata as part of the Structural Soils Investigation. Two types of variable head test were carried out, namely falling and rising head tests. A brief description of this test is outlined in the following paragraphs.

Variable head (falling or rising) tests involve the introduction or removal of water to or from a borehole, piezometer or well installation. The head generated within the borehole or installation is allowed to equilibrate with the natural water level within the groundmass. Measurements of head of water are taken at intervals throughout the duration of the test at specific time periods from commencement of the test. These test results are then used to determine an approximate value of the hydraulic conductivity of the groundmass.

The rising and falling head tests were thus carried out in each hole to check the functionality of the instruments and provide additional information on the groundwater conditions in the surrounding groundmass. The results of the variable head tests are presented in the Structural Soils Report³ but the findings can be summarized as follows.

Monitoring Well in TPBH01 (50 mm Well in Sherwood Sandstone)

Rising Head Test (BS5930:1999)

- Rising head test undertaken on 13 June 2009.
- Commencement water level prior to test: 15.51 m BGL (25.29 m AOD).
- Water level reduced to 20.57 m BGL (20.23 m AOD).
- Water level rose to 17.39 m BGL (23.41 m AOD) in 20 minutes (test stopped early - still recovering).
- Rising head test: 7.51×10^{-7} m/s (only one test carried out).

Falling Head Test (non standard)

- Falling head test undertaken on 14 June 2009.
- Commencement water level prior to test: 15.45 m BGL (25.35 m AOD).

- Water level topped up to 12.30 m BGL (28.50 m AOD).
- Water level fell to 15.43 m BGL (25.37 m AOD) in 1 hour.
- Falling head test: 2.79×10^{-6} (only one test carried out).

Indications

- Given rate of drainage/recharge and the consistency of the results the well is considered to be functional.
- Given the similar commencement standing water levels of 15.51 and 15.45 m BGL (25.29 and 25.35 m AOD) coupled with the falling head test final level of 15.43 m BGL (25.37 m AOD), the water level monitored is considered to be accurate.

Monitoring Well in TPBH02 (50 mm Well in Sherwood Sandstone)

Falling Head Test (non standard)

- Falling head test undertaken on 15 June 2005.
- Commencement water level prior to test: 19.20 m BGL (23.70 m AOD).
- Water level topped up to 6.90 m BGL (36.00 m AOD).
- Water level fell to 15.51 m BGL (27.39 m AOD) in 1 hour (test stopped early - still recovering).
- Falling head test: 3.53×10^{-7} m/s.

Indications

- The commencement water level is considered to be low. The reason for this is unclear.
- Given rate of drainage for the falling head test the well is indicated to be functional.
- Given the consistency of the results with TPBH01 the well is considered to be functional.
- The final water level of 15.51 m BGL (27.39 m AOD) is above that of TPBH01 in terms of elevation.
- As test duration cut short, accurate standing water level must be below 15.51 m BGL (27.39 m AOD).
- The data available calls into question the accuracy of the commencement water level.

Summary

The tests also indicate that the sandstone strata have a hydraulic conductivity of 10^{-7} m/s which is not atypical for such a sequence. The water levels proven by the variable head tests broadly accord with the subsequent groundwater monitoring data (Section 0 refers) giving confidence in both data sets.

4.6 Geotechnical Testing

A suite of geotechnical testing as outlined in Section 3.3 was scheduled on selected representative samples. The results of the testing are presented in the Structural Soils Report³ and a summary is presented in Tables 4, 5 and 6. A summary of the rock testing data is presented in Appendix C.

Table 4: Summary of Geotechnical Test Results – Made Ground

Test	Units	No. of Tests	Minimum Test Value	Maximum Test Value	Average	Typical Range
Water Soluble Sulphate	g/l	1	0.17	0.17	0.17	-
pH	pH	1	8.8	8.8	8.8	-

Table 5: Summary of Geotechnical Test Results – Glacial Till

Test	Units	No. of Tests	Minimum Test Value	Maximum Test Value	Average	Typical Range
Water Soluble Sulphate	g/l	4	0.03	0.04	0.0325	-
pH	pH	4	8.8	8.9	8.85	-
Particle Size Distribution (PSD)	%	5	See Structural Soils Report ³			
4.5 kg Compaction Test	Mg/m ³	3	See Structural Soils Report ³			

Table 6: Summary of Geotechnical Test Results – Sherwood Sandstone

Test	Units	No. of Tests	Minimum Test Value	Maximum Test Value	Average	Typical Range
Water Soluble Sulphate	g/l	2	0.02	0.04	0.03	-
pH	pH	2	8.7	8.9	8.8	-
Unconfined Compressive Strength	MPa	3	3.90	7.10	5.47	-
Point Load Test (Axial Is_{50})	MPa	20	0.24	6.24	0.12	1.20 – 4.60
Point Load Test (Diametral Is_{50})	MPa	17	0.72	4.06	0.074	1.20 – 2.90
Point Load Test (Irregular Is_{50})	MPa	1	1.44	1.44	-	-

The point load tests (21 No. samples) carried out on suitable core samples indicate equivalent UCS values for the Sherwood Sandstone strata underlying the site to be generally in the range of 1.00 MPa to 4.00 MPa based on all test results. These results are generally lower than those indicated by the UCS data, which is typically in the range of 3.90 MPa to 7.10 MPa. This may be due to the fact that the length of core required to carry out a UCS test may result in the selection of more competent strata. As such, in this instance the point load strength data is considered to be more representative of the rock strength as a whole. Notwithstanding this, it should be noted that localized areas of material weaker than the typical range have been recorded. A summary of the point load test data and the conversion to UCS equivalent data is provided in Appendix C.

4.7 Groundwater

Groundwater was encountered in a number of exploratory holes during the Structural Soils Investigation with groundwater ingress recorded as follows:

- TPBH02 recorded as 'seepage' at 1.00 m BGL (41.90 m AOD).
- TPCPT04 recorded as 'locally damp' below 2.50 m BGL (37.40 m AOD).
- TPCPT10 recorded as 'seepage' at 1.00 and 3.00 m BGL (45.90 and 43.90 m AOD respectively).

Groundwater ingress was not recorded in any other exploratory holes prior to the introduction of water as a flushing medium. These groundwater levels range between approximately 37.40 m AOD to approximately 45.90 m AOD. Trial pit records indicate that groundwater strikes were typically encountered as 'seepage' and are thought to be localized perched water within the Made Ground.

Groundwater monitoring was undertaken as part of the Structural Soils Investigation with groundwater levels in TPBH01 and TPBH02 being measured during 6 No. monitoring visits conducted between 3 June 2009 and 13 August 2009. The results of the groundwater monitoring are presented in the Structural Soils Report³ and summarized in Appendix D.

The monitoring results indicate there are 2 No. groundwater regimes on site, namely:

- Glacial Till (perched water within the superficial deposits).
- Sherwood Sandstone (major aquifer).

There is only one instrument monitoring the groundwater level within the Made Ground, namely TPBH02 (19 mm), which was dry throughout the 6 No. monitoring visits indicating perched water in this area must be below 38.90 m AOD. Clearly, groundwater seepages have been noted above this level in other areas suggesting the perched water is present in discrete localized areas.

There is only one instrument monitoring the groundwater level within the Glacial Till, namely TPBH01 (19 mm), which records levels that vary between 7.11 m BGL (33.69 m AOD) and 7.39 m BGL (33.41 m AOD). These are reasonably consistent but with only one instrument, the persistence and magnitude of this groundwater body is difficult to assess.

There are 2 No. instruments monitoring the groundwater level within the Sherwood Sandstone strata, namely, TPBH01 (50 mm) and TPBH02 (50 mm). The readings in each instrument are very consistent with TPBH01 (50 mm) varying between a minimum level of 25.69 m AOD (15.11 m BGL) and a maximum level of 25.82 m AOD (14.98 m BGL) and TPBH02 (50 mm) varying between a minimum level of 26.13 m AOD (16.77 m BGL) and a maximum level of 26.27 m AOD (16.63 m BGL). This indicates that the prevailing direction of groundwater flow is likely to be to the north and west (probably northwest). This is broadly consistent with the fall in topography towards the River Irk to the northwest of the site. Taking into account both the monitoring data and the general topography and hydrology of the locality, it is likely that the prevailing direction of groundwater flow is to the northwest, that is towards and in the direction of flow of the nearest watercourse, the River Irk.

5 Geoenvironmental Assessment

5.1 General

A geoenvironmental assessment of the proposed development site has been undertaken to assess the degree of contamination present, if any, in respect of the current development proposal, the health and safety of the construction work force and to allow characterization of material for the waste disposal of surplus arisings.

Soil samples have been obtained during the site specific investigation and submitted for chemical testing as summarized in Section 3.3. The soil samples obtained were taken at a variety of depths from both Made Ground and natural materials.

The findings of the geoenvironmental assessment undertaken are summarized in the following sections.

5.2 Preliminary Review of Potential Sources of Contamination

A review of potential sources of contamination has been undertaken from information within the Buro Happold Desk Study¹. Pertinent information can be summarized as follows:

- There are 11 No. pollution incidents into controlled waters within 500 m of the site. 9 No. of the incidents are classified as 'Category 3 – Minor incident', whilst the remaining 2 No. incidents are classified as 'Category 2 – Significant incident'. Given the minor categorization of many of the impacts recorded, their distance from the site and the fact that none are located directly up hydraulic gradient of the site, the potential impact of contamination from these sources.
- There are 14 No. Contemporary Trade Directory Entries within 100 m of the site of which 5 No. are active and 9 No. are inactive. Given the commercial rather than industrial nature of the active facilities and their distance from the proposed development site the risk of contamination arising from these sources can be considered to be low.
- The site history indicates that a number of potentially contaminating land uses have been present across the site historically, including an infilled reservoir, a number of warehouses/factories, ruins, petrol store and a car park (oil/petrol spills). The degree of ground contamination arising from these activities is dependent on site specific industrial practices as well as the quality and distribution of hardstanding across the site.
- Due to the urban setting and long development history of the site there is considered to be a high probability that Made Ground is present on site. Urban fill commonly contains heavy metals, arsenic and polycyclic aromatic hydrocarbons (PAH's) in background concentrations and can include locally elevated 'hotspots' which may pose a risk to human health and/or controlled waters.
- There is 1 No. Registered Radioactive Substance within 500 m radius of the site. The Radioactive Substance has been decommissioned by a radioactive specialist in 2003 and subsequently the site has

been re-developed and new build flats now occupy the site. As such, the risk to the proposed development site from this source is considered to be low.

Given the foregoing information, it is considered that the site can generally be categorized as moderate/low risk with respect to contamination potential.

5.3 Chemical Testing

The suite of chemical testing carried out as part of the Structural Soils Investigation is outlined in Section 3.3. A summary of the results in respect of soil, leachate and groundwater concentrations is presented in the following paragraphs. Summary tables of the chemical test results are presented in Appendix E.

Soil Testing Results

A total of 7 No. soil samples were scheduled for chemical testing by BHGE as part of the Structural Soils Investigation of the proposed development site. The chemical test results have been compared with CLEA SGVs or GACs, Dutch Guidelines and other criteria considered appropriate. A brief explanation of selected guidelines typically used in the UK is presented in Appendix F.

The findings of the soil assessment can be summarized as follows:

- Lead is elevated in 1 No. soil sample above the 'Commercial/Industrial' concentration of 750 mg/kg, namely, 890 mg/kg recorded in TPCPT04 at a depth of 2.20 m BGL (37.70 m AOD).
- Mercury is elevated in 2 No. soil samples above the 'Residential with plant up take' concentration of 1.0 mg/kg, namely, 1.8 mg/kg recorded in TPCPT04 at 2.20 m BGL (37.70 m AOD) and 1.7 mg/kg recorded in TPCPT10 at 0.50 m BGL (46.40 m AOD).
- Extractable Petroleum Hydrocarbons (EPH) is elevated in 1 No. soil sample above the 'Inert Waste' concentration of 500 mg/kg, namely 613 mg/kg recorded in TPBH02 at a depth of 1.00 m BGL (41.90 m AOD).
- Benzo(a)pyrene is elevated in 3 No. soil samples above the 'Residential with plant up take' concentration of 1.0 mg/kg, namely, 2.06 mg/kg recorded in TPBH02 at a depth of 1.00 m BGL (41.90 m AOD), 3.34 mg/kg recorded in TPCPT04 at 2.20 m BGL (37.70 m AOD) and 5.00 mg/kg recorded in TPCPT10 at 0.50 m BGL (46.40 m AOD).

In summary, 3 No. out of 7 No. soil samples include one or more determinands that can be considered to be elevated, namely, lead, mercury, EPH and benzo(a)pyrene concentrations.

Leachate Testing Results

Chemical test results for 7 No. leachate samples have been compared to Freshwater Environmental Quality Standards (EQS) concentrations, UK Drinking Water Standards and where necessary Dutch Intervention Values. A brief explanation of selected guidelines typically used in the UK is presented in Appendix F.

The findings of the leachate assessment can be summarized as follows:

- Arsenic is elevated in 2 No. leachate samples above the 'UK Drinking Water Standard' concentration of 0.10 mg/kg but below the 'EQS' concentration of 0.50 mg/kg, namely, 0.15 mg/kg recorded in TPCPT04 at 2.20 m BGL (37.70 m AOD) and 0.11 mg/kg recorded in TPCPT10 at 0.50 m BGL (46.40 m AOD).
- Copper is elevated in 2 No. leachate samples above the 'EQS' concentration of 0.01 mg/kg but below the 'UK Drinking Water Standard' of 20 mg/kg, namely 0.018 mg/kg recorded in TPCPT03 at 2.00 m BGL (39.90 m AOD) and 0.038 mg/kg recorded in TPCPT04 at 2.20 m BGL (37.70 m AOD).

In summary, 3 No. out of 7 No. leachate samples include a determinand that can be considered to be elevated, namely, arsenic and copper concentrations.

Groundwater Testing Results

Groundwater samples were collected from TPBH01 and TPBH02. The chemical test results have been compared with UK Drinking Water Standards, Freshwater Environmental Quality Standards and where necessary the Dutch Intervention values. A brief explanation of selected guidelines typically used in the UK is presented in Appendix F.

The findings of this assessment can be summarized as follows:

- Sulphate is elevated in 1 No. groundwater sample above the EQS concentration of 4000 mg/kg, namely, 4400 mg/kg recorded in TPBH01.

In summary, 1 No. out of 2 No. groundwater samples include a determinand that can be considered to be elevated, namely, sulphate.

5.4 Data Analysis

Data Analysis is only required where chemical concentrations are elevated above the guideline values. Exceedances outlined in Section 5.3 are discussed in the following paragraphs.

Soil Concentrations

Lead was elevated above the CLEA GAC 'Commercial/Industrial' concentration in 1 out of 7 No. soil samples. The recorded concentration of 890 mg/kg is from Made Ground in TPCPT04 at a depth of 2.20 m BGL (37.70 m AOD). This material is likely to be removed by basement excavations but at the current depth is considered unlikely to significantly impact human health or environmental receptors particularly given the leachable concentrations recorded.

Mercury is elevated above the CLEA GAC 'Residential with plant up take' concentrations in 2 out of 7 No. soil samples. The recorded concentration of 1.8 mg/kg is from Made Ground in TPCPT04 at 2.20 m BGL (37.70 m AOD) and 1.7 mg/kg recorded in TPCPT10 at 0.50 m BGL (46.40 m AOD) are well below the CLEA GAC 'Commercial/Industrial' concentration of 26 mg/kg. Notwithstanding this, these materials are likely to be removed by basement excavations but at the current depths are considered unlikely to significantly impact human health or environmental receptors particularly given the leachable concentrations recorded.

Extractable Petroleum Hydrocarbons is elevated above the 'Inert Waste' concentration in 1 out of 7 No. soil samples. The recorded concentration of 613 mg/kg is from Made Ground in TPBH02 at a depth of 1.00 m BGL (41.90 m AOD). This material is to be removed by basement excavations thus will not be available to impact human health or environmental receptors.

Benzo(a)pyrene is elevated above the CLEA GAC 'Residential with plant up take' concentrations in 3 out of 7 No. soil samples. The recorded concentration of 2.06 mg/kg in TPBH02 at a depth of 1.00 m BGL (41.90 m AOD), 3.34 mg/kg in TPCPT04 at 2.20 m BGL (37.70 m AOD) and 5.00 mg/kg in TPCPT10 at 0.50 m BGL (46.40 m AOD) are all within Made Ground material and are well below the CLEA GAC 'Commercial/Industrial' concentration of 14 mg/kg. Notwithstanding this, these materials are likely to be removed by basement excavations but at the current depths are considered unlikely to significantly impact human health or environmental receptors particularly given the leachable concentrations recorded.

Leachable and Groundwater Concentrations

The Environment Agency classifies the Sherwood Sandstone beneath the site as a Major Aquifer. However, there are no Public Water Supply abstractions located within the zone of influence of the site thus the 'UK Drinking Water Standards' are considered to be onerous screening criteria for both leachate and groundwater results.

Arsenic is elevated above the 'UK Drinking Water Standards' but below the 'EQS' concentration in 2 out of 7 No. leachate samples. The recorded concentrations of 0.15 mg/kg is from Made Ground in TPCPT04 at a depth of 2.20 m BGL (37.70 m AOD) and 0.11 mg/kg is from Made Ground in TPCPT10 at 0.50 m BGL (46.40 m AOD). This material is likely to be removed by basement excavations but notwithstanding this such concentrations are considered unlikely to significantly impact human health or environmental receptors.

Copper is elevated above the 'EQS' but below the 'UK Drinking Water Standards' concentration in 2 out of 7 No. leachate samples. The recorded concentrations of 0.018 mg/kg is from Made Ground in TPCPT03 at 2.00 m BGL (39.90 m AOD) and 0.038 mg/kg is from Made Ground in TPCPT04 at 2.20 m BGL (37.70 m AOD). This material is likely to be removed by basement excavations but notwithstanding this such concentrations are considered unlikely to significantly impact human health or environmental receptors.

Sulphate is elevated above the 'EQS' and the 'UK Drinking Water Standards' concentration in 1 out of 2 No. groundwater samples. The recorded concentration of 4400 mg/kg in TPBH01 is from existing groundwater within the Sherwood Sandstone. This is an existing situation but in the current setting such concentrations are considered unlikely to significantly impact human health or environmental receptors.

In summary, none of the determinands assessed are considered to represent a significant risk to either environmental or human receptors. Notwithstanding this, much of the Made Ground material on site in the vicinity of the building will be removed for basement construction providing overall betterment.

5.5 Revised Potential Sources of Contamination

Potential sources of contamination identified in Section 5.2 have been reviewed based on the results of the Structural Soils Investigation. Pertinent points are detailed below:

- Made Ground has been confirmed to be present in all exploratory holes but chemical testing has indicated only locally elevated concentrations of 3 No. soil determinands, namely, lead, mercury, EPH and benzo(a)pyrene (at locations of TPBH02, TPCPT04 and TPCPT10) which are likely to be removed during basement construction.
- The former site uses and urban setting are not considered to have significantly impacted the site based on the findings of the Structural Soils Investigation with much of the Made Ground encountered considered to be demolition rubble.

The contamination sources identified above will be evaluated by means of a risk assessment in accordance with current UK guidance (Appendix F refers).

5.6 Risk Assessment

In the UK, the assessment of risk from contamination follows the source/pathway/target approach. If one of these three elements is absent it is considered that there is no risk of harm. A list of all possible sources, pathways and targets in respect of the current and proposed site condition is presented in Appendix G, Table CRA1. An assessment of risk to both human and natural environment receptors from these sources has been conducted and summarized in Tables CRA2 and CRA3 in Appendix G. These elements have been assessed by means of a qualitative risk assessment in accordance with CIRIA C552⁵. A summary of the risk assessment is provided below.

Human Health

Current Land Use: In terms of current land usage, the site is principally hard cover and, as such, the major exposure pathways between ground contaminants and human users, including skin contact, soil dust inhalation and soil ingestion are all broken. The only above ground contamination source identified (Japanese Knotweed) does not currently have a pathway to humans as the area is secured preventing public access. Given the foregoing no further specialist measures are considered necessary in the current condition.

Gas monitoring data from on-site boreholes at the location of the proposed building has confirmed the absence of high concentrations of methane and carbon dioxide ground gas. As such, the risk to off-site receptors due to gas migration is considered to be low.

⁵ CIRIA (2001). *Contaminated Land Risk Assessment: A Guide to Good Practice*. Construction Industry Research and Information Association, Report C552, 2001.

Construction Stage: In terms of construction stage activities, excavation works are likely to temporarily remove the areas of hard cover. Excavation and removal of potentially contaminated soils during the formation of basements, foundations and drainage/utilities could bring construction workers into direct contact with potentially contaminated soils, surface water and groundwater. However, the degree of contamination recorded within the Made Ground is considered to be marginal and the areas in question are likely to be within areas of bulk excavation and will be dealt with accordingly during earthworks. Low risks have therefore been identified to construction workers from direct contact with Made Ground and associated leachate.

Site works could also result in gas and/or vapour accumulations in confined spaces such as excavations or drainage runs which could in turn result in a risk of asphyxiation or fire/explosion. As high concentrations of ground gas have not been recorded in on-site monitoring wells the risk to construction workers from potential exposure to ground gas in confined spaces is considered to be Low and the likelihood of exposure is considered to be Low.

Proposed Land Use: In terms of the proposed development end use, namely a commercial office development, the site will be principally hard cover. As such significant exposure pathways between ground contaminants and human end users will be broken. Furthermore the potential contamination sources identified in Section 5.5, in addition to the Japanese Knotweed, are likely to be removed as part of the basement construction works. Notwithstanding this, any new water supply pipes should be routed to avoid any remaining 'hotspots' of contamination which may be encountered around the periphery of the basement and/or be laid within 'clean' material emplaced within any service trenches. Low risks have therefore been identified to future site users in respect of ground contamination.

A Low risk to future site users has been identified due to the potential for accumulation of ground gas and vapour within confined spaces and service runs. Gas monitoring at the site has not identified high levels of ground gas however and the likelihood is considered to be Low.

Natural Environment

Current Land Use: In terms of current land usage, the site is principally hard cover and, as such, minimal rainwater infiltration and subsequent leaching of Made Ground contaminants is considered to be occurring. Of the 3 No. possible environmental receptors, the highest risk indicated in Appendix G is to the Sherwood Sandstone Major Aquifer (Moderate/Low Risk). Marginal leachable concentrations of arsenic and copper have been identified within the Made Ground material on site. However, the risks to the Sherwood Sandstone Major Aquifer and the superficial deposits from all contaminant sources are considered to be 'Low' due to the degree of hardstanding and the protective layer of Glacial Till overlying the rock strata and no elevated concentrations of arsenic or copper have been observed in the groundwater samples taken. Given the foregoing, no specialist measures are considered necessary for the current condition.

Risk to surface waters/drainage from leaching of on-site Made Ground materials and groundwater migration is considered to be low. Although marginal leachable concentrations of arsenic and copper have been identified within the Made Ground material on site the shallow perched water is considered to collect in localized discrete areas which is likely to curtail lateral migration of any leachate. Furthermore, no visible physical effects have been recorded on the site, such as leachate discoloration of drainage waters. As such, the risk to these receptors is considered to be Low.

Construction Stage: In terms of construction stage activities, excavation works are likely to temporarily remove the areas of hard cover. Rainwater infiltration will in the short term be greater and, as such, greater leaching of contaminants within the Made Ground may occur. This risk can be mitigated through appropriate site drainage practices during construction and is considered acceptable due to the temporary nature of ground exposure. Appropriate site management to minimize spillage of fuel from storage areas, refuelling points and washing down areas will also be required during the construction phase. As such, the risk to environmental receptors is considered to be Low.

Consideration should be given to the possibility of opening up pathways between Made Ground contaminants and the Sherwood Sandstone Major Aquifer during piling operations, although this is considered to be a low risk.

Proposed Land Use: In terms of the proposed development 'end use', namely a commercial development with a double basement and principally hard cover, rainwater infiltration and contaminant leaching (that which has not been removed) will be minimal and all risks in Appendix G are considered acceptable. As such, the risk to environmental receptors is considered to be Low.

Summary

A qualitative risk assessment has been conducted to assess risk from contaminated material at the proposed development site to human and natural environment receptors. Exposure pathways to current users of the site are considered to be incomplete. The risk to current users is therefore considered to be low and no action is required to make the site safe.

Similarly, the levels of contamination generally encountered pose no threat to the construction workforce providing normal precautions are taken nor to end users of the proposed development providing any 'hot spots' which may be identified during excavation works are removed and/or suitable mitigation measures are undertaken in respect of the elevated concentrations of EPH and benzo(a)pyrene in the vicinity of any water supply pipes.

5.7 Waste Disposal

In respect of waste disposal, the chemical test results from the Structural Soils Investigation have been compared to both 'Old Waste Disposal' criteria (former Environment Agency Guidance) and 'New Waste

Disposal' Regulations (Environment Agency Technical Guidance WM2 and WAC), as any given waste disposal facility may be working to either of these acceptance criteria dependent upon the status of their current license. In the following comparison therefore, the results have been primarily compared to the 'New Waste Disposal' Regulations. However, as any surplus arisings from the proposed development could be theoretically removed to a facility operating to the 'Old Waste Disposal' criteria a short summary is provided in respect of these former guideline values. Further information on our interpretation of the current situation regarding waste disposal legislation is outlined in Appendix F.

New Waste Disposal Criteria

In July 2004, 'The Landfill (England and Wales) (Amendment) Regulations 2004' came into force as 'Statutory Instrument 2004 No. 1375'. These Regulations implement in England and Wales, Council Decision 2033/33/EC establishing criteria and procedures for the acceptance of waste at landfills. Waste Acceptance Criteria (WAC) help meet the Directives' main aim by prescribing the standards that waste must meet to be accepted at one of the three classes of landfill ('inert', 'non-hazardous', 'hazardous') established in the Landfill Directive. Waste is characterized through assessment of any hazardous properties of the soil defined in Environment Agency Technical Guidance WM2, together with the Waste Acceptance Criteria results for parameters determined on both soil and leachate.

The findings of the assessment on the 7 No soil samples tested can be summarized as follows:

- No determinands exceed the individual threshold for 'Hazardous Waste' as defined in Environment Agency Technical Guidance WM2 Hazardous Waste – Interpretation and Classification of Hazardous Waste (Version 1, June 2003).
- No determinands exceed the calculated combined thresholds for 'Hazardous Waste' as defined in Environment Agency Technical Guidance WM2 Hazardous Waste – Interpretation and Classification of Hazardous Waste (Version 1, June 2003).
- 1 No. determinand exceeds the Inert WAC parameters determined on solid waste, namely Total Organic Carbon (1 out of 7 No. soil samples).
- 2 No. determinands exceed the 'Inert' landfill WAC parameters determined on leachate results, namely fluoride (2 out of 7 No. leachate samples).

A broad assessment of the possible waste categorization of surplus arisings from the site, based on the Structural Soils Investigation chemical testing, is provided below:

- 7 No. samples have been assessed in respect of the 'New Waste Disposal' criteria: 2 No. in the granular Made Ground (brick rubble), 2 No. in the cohesive Made Ground and 3 No. in the natural Glacial Till.
- Of the 2 No. granular Made Ground samples tested, 1 No. can be categorized as 'inert' and 1 No. as 'Non Hazardous'.

- Of the 2 No. cohesive Made Ground samples tested, 1 No. can be categorized as 'inert' and 1 No. as 'Non Hazardous'.
- Of the 3 No. natural Glacial Till samples tested, 3 No. can be categorized as 'inert'.
- In Total, 5 No. samples can be categorized as 'Inert' and 2 No. soil samples as 'Non Hazardous'.
- 'Inert' arisings which have suitable engineering properties could be reused as engineered fill subject to the agreement of the relevant licensing authorities.

Given the foregoing, an overall assessment of the chemical testing results in respect of the New Waste Disposal criteria indicates that the majority of the Made Ground material encountered will require disposal as 'Inert Waste' or 'Non Hazardous Waste'. It is considered that the natural glacial deposits may be disposed of as 'Inert Waste'. Alternatively, material which has suitable engineering properties could be reused as 'inert fill' subject to the agreement of the relevant licensing authorities.

Old Waste Disposal Criteria

The chemical test results for 7 No. soil samples and 7 No. leachate samples have also been compared to former guidance on waste disposal published in Environment Agency document 'Guidance on the Disposal of Contaminated Soils' (Version 3, February 2001). The results of this assessment can be summarized as follows:

- No determinands exceed the Upper Threshold Concentration in soil samples.
- 6 No. determinands exceed the Lower Threshold Concentration in soil samples, namely arsenic (3 No. samples), copper (2 No. samples), lead (1 No. samples), mercury (2 No samples), pH (6 No. samples) and PAH (1 No. sample). Overall 6 out of 7 No. soil samples exceed one or more Lower Threshold Concentrations.
- 1 No. determinand exceeds the Leachate Quality Threshold for leachate samples, namely, arsenic (2 out of 7 No. leachate samples).
- Overall 2 out of 7 No. samples exceed the Leachate Quality Concentration.

Given the foregoing, an overall assessment of the chemical testing results from the ground investigation compared to the 'Old Waste Disposal' criteria indicates that the waste will need to be disposed of at a 'suitably licensed landfill facility' in respect of the above concentrations.

Summary – Waste Disposal

Further soil and leachate testing is required in order to accurately categorize the waste in accordance with the 'New Waste Disposal' criteria (Appendix F). Given the foregoing, a best approximation of an overall assessment of the chemical testing results indicates the following:

- Surplus arisings of Made Ground from most areas of the site are likely to be categorized as 'Inert Waste' with some localized areas of 'Non Hazardous Waste'.

- The majority of surplus arisings of natural Glacial Till and Sherwood Sandstone underlying the Made Ground are expected to be categorized as 'Inert' Waste'.

Removal of surplus arisings from site should be minimized as far as practicable. As such, it is considered prudent to re-use arisings on site where possible. Material which has suitable engineering properties could be reused subject to compliance with Waste Management Regulations and are likely to be exempt providing the volume remains below 1,000 m³, although this should be agreed with the relevant licensing authority.

Materials that are likely to be contaminated should be selectively excavated and stored separately to any that are considered to be uncontaminated. Any surplus waste arisings which will need to be removed from site should be tested for the complete chemical suite required by the 'New Waste Disposal' guidelines. Materials will require selective excavation, separation and handling as far as practicable to achieve the most cost-effective and optimum disposal regime.

5.8 Ground Gas

Monitoring during the Structural Soils Investigation was carried out in 2 No. borehole installations across the proposed area of the building in order to characterize the ground gas conditions. Full details and results of this monitoring can be found in the Structural Soils Report³.

Ground gas concentrations and flows measured during this monitoring period have been assessed against the classification scheme presented in CIRIA C665⁶. The findings of this assessment (Appendix H refers) is that all monitoring installations contained gas concentrations and flows which fall within Characteristic Situation 1 in accordance with CIRIA C665⁶.

It is worthy of note that basic gas control measures are included within the structural requirements of the buildings and will generally comply with Characteristic Situation 2 as a minimum. These include the following:

- Ventilation of confined spaces within the building, as good practice.
- Well constructed ground slab is a structural requirement.
- Low permeability gas membrane will be incorporated as a damp proof membrane (DPM).
- Minimum penetration of ground slab by services as good practice.

Notwithstanding the foregoing, given that the proposed development has two levels of tanked (Section 7.5 refers) and ventilated basement, the occupied parts of the building arguably have gas protection equivalent to Characteristic Situation 3/4 for commercial development based on the current building design requirements.

⁶ CIRIA C665 (2007). *Assessing risks posed by hazardous ground gases to buildings*. Construction Industry Research and Information Association.

5.9 Radon Affected Areas

The National Radiological Protection Board⁷ records that the site is in an area where less than 1% of homes are above the Action Level and the corresponding BRE⁸ guidance document indicates that no radon protection measures are required for development undertaken in this area.

5.10 Asbestos

No asbestos found during Structural Soils Investigation in any of the soil samples tested.

5.11 Japanese Knotweed

Japanese Knotweed is an invasive, non-native plant species. The Wildlife and Countryside Act (1981) made it illegal to spread Japanese Knotweed and guidance on the management of Japanese Knotweed on development sites is given in the Environment Agency's Code of Practice, 2001.

Currently available information indicates that the material is not hazardous but is highly invasive, destroying other flora and habitats for fauna. It spreads by root growth so can invade from neighbouring sites as well. There are a variety of methods available for treating infested areas including spraying with herbicides or digging, spraying and removal to landfill. A Japanese Knotweed specialist can be consulted with regards to site management and/or removal of this material if necessary.

Japanese Knotweed has been visually identified at the proposed development site and should be treated in accordance with current legislation. It is recommended that a Japanese Knotweed specialist should be consulted with regards to the site management and/or removal of this material.

⁷ NRPB 2002. *Radon Atlas of England and Wales. NRPB-W26*. National Radiological Protection Board. 2002.

⁸ BRE 1999. *Radon. Guidance on protective measures for new dwellings*. British Research Establishment. 1999.

6 Development Considerations

6.1 Proposed Development

The proposed development predominantly comprises flexible open plan office space organized around a large central atrium forming 3 equal wings (Appendix A refers). The building is symmetrical about the NW-SE axis, rising to high point at its NW corner. The SE wing is lower, in accordance with neighbouring residential buildings and therefore provides the upper levels with extensive city views. The building occupies a footprint of approximately one quarter of the proposed development site area and the remainder will be used for high quality public realm space.

The building itself occupies a footprint of approximately 4000 m² which is broadly consistent up to Level 8. Above Level 8 the floor plates reduce in size incrementally up to Level 14. The overall height of the building is around 70 m from ground level. The main column grid is 7.50 m x 16.50 m and has been selected to integrate with the car parking layout in the basement.

The design of the building has developed with a lower ground floor and full basement level. The basement provides parking for approximately 150 cars including disabled provision and some store/plant accommodation. It should be noted that the footprint of the basement is larger than the above ground structure, that is, the basement perimeter wall lies outside that of the 'visible' building. The lower ground floor is the servicing and operational centre of the building and allows the ground floor and upper floors to be clear of bulk plant, back of house and service functions.

The lower ground floor is incorporated within the topographic level changes across the site with the elevation facing Dantzic Street at grade with ground level outside ramping up so that the rest of the building at this level is embedded into the ground and is effectively full basement in the northeastern corner of the building.

An earth tube is also currently proposed as part of the building services strategy for heating/cooling the building. The details are yet to be finalized however, the current strategy is for the tube to run below ground for a specified distance and enter the building below basement level.

6.2 Existing Structures

The current land use is an open air car park operated by NCP, which occupies the area between Angel Street and Miller Street over three terraced levels with trees and vegetation on the slopes separating the various levels. The current site layout can be seen on the aerial photograph presented in Figure 2. However, it is worthy of note that an old brick retaining wall is located in the northeast of the site delineating the boundary between the lower and upper terrace. In addition, the car park infrastructure (Section 6.8 refers) should be noted along with buried walls from former buildings (Section 6.3 and Appendix I refer).

6.3 Buried Obstructions

No buildings currently exist on site however the site does have a rich industrial and residential history. Numerous buildings have historically existed within the confines of the site, as identified on the historic OS maps presented in the Buro Happold Desk Study¹. Furthermore, during the Structural Soils Investigation, numerous brick walls/structures were encountered in a number of trial pits (Structural Soils Report³ refers) and various archaeological investigations have recorded many more (Appendix I refers).

As such, old foundation and brick basement walls are considered likely to be present across the whole site. Further structures or unidentified services are likely to be encountered and will require removal/diversion as part of the enabling works. In addition, an abandoned brick lined sewer has been identified on the statutory service drawings to run below the proposed footprint of the building. From the plans available, the sewer is shown to be running in an east west orientation roughly parallel to Angel Street in the northern part of the site, although the exact location and redundant status needs to be verified on site (see also Section 6.8).

Structures/obstructions/services encountered may require removal as part of the enabling works/construction works. Any such obstructions removed or voids encountered should be replaced with suitable structural fill where appropriate i.e. where encountered beyond the confines of the basement excavation.

Materials arising from the removal of foundations/obstructions and any appropriate Made Ground material could, if cost effective, be considered for re-use as hardcore/reprocessed stone if appropriately sorted, processed and treated. As previously stated, this process, if cost effective, has the advantage of minimizing waste disposal requirements and reduction of import and use of raw materials in accordance with environmental guidelines and best practice.

6.4 Unexploded Ordnance (UXO)

The proposed development is situated in an area identified as being at significant risk from World War II unexploded ordnance (UXO) and, as such, the following points should be noted:

- An UXO specialist has been consulted and an UXO Desk Study Report² has been prepared.
- All intrusive investigation works undertaken on the project thus far have been suitably 'cleared' using UXO detection equipment operated by suitably qualified operatives to minimize the risk to both site personnel and the general public.
- No UXO have been encountered during the undertaking of the Structural Soils Investigation, the exploratory hole locations undertaken are presented in Figure 3. Indicative depths 'cleared' in respect of UXO can be summarized as follows:
 - Trial pits were cleared to a depth of approximately 5.00 m BGL (42.00 – 34.30 m AOD).
 - Boreholes were cleared to a depth of approximately 12.00 m BGL (29.00 – 32.40 m AOD).
- No UXO have been encountered during the undertaking of the archaeological investigation works to date. The areas of proposed excavation are presented in Appendix I.

- All intrusive works associated with any enabling works or construction works should be undertaken with due regard of the UXO risk and be suitably managed to minimize the risk to both site personnel and the general public.
- All UXO related works should be undertaken in accordance with CIRIA C681⁹. The requirements of CIRIA C681 Section 8.3 should be noted and the precautionary requirements of the Five Point Plan (Appendix J refers) should be prepared and be clearly communicated to all site staff and visitors as part of any site induction and tool box talks.

The UXO specialists involved with the project to date advise that the maximum overall depth subject to risk from UXO based upon site specific ground information available is approximately 10.00 m BGL or rockhead, whichever is the shallower.

The currently proposed strategy for managing the UXO risk for future intrusive site works involves the use of non-intrusive geophysical scans to at least the depth advised by the UXO specialists as being at risk to allow excavation/earthworks where required to proceed with minimal risk. Where clearance for excavation/earthworks purposes is required to depths in excess of those provided by the geophysical methods adopted, a series of successive scans is proposed (Figure 4 refers). The procedure envisaged is detailed in the Buro Happold Excavation and Filling Specification¹⁰.

It should be noted that where temporary embedded retaining walls are proposed and are required to penetrate beyond the limits of the geophysical scan depth at the time of the proposed installation, additional methods to manage the UXO risk shall be required. Furthermore, the proposed method of installation of any temporary embedded retaining walls needs to be considered in respect of UXO risk and mitigated accordingly.

6.5 Geoenvironmental Constraints

The current development proposal includes significant basement excavation works (Section 7.2 refers). A cut / fill balance exercise will be required to understand the amount of material resulting from the earthworks, the amount which can be retained on site and the amount that it is envisaged will need to be removed from site.

Based on the limited chemical testing undertaken to date (Section 5.3 refers), the chemical concentrations generally encountered pose no threat to end users of the proposed development providing that any 'hot spots' which may be identified during excavation works are removed and/or suitable mitigation measures are undertaken in respect of the elevated concentrations of EPH in the vicinity of any water supply pipes (Section 5.4 refers).

⁹ CIRIA C681 (2009). *Unexploded ordnance (UXO) A guide for the construction industry*. Construction Industry Research and Information Association.

¹⁰ Buro Happold 023842 *The co-operative Head Office, Manchester. Excavation and Filling Specification* (September 2009).

Given the levels of contamination observed (Section 5.3 refers), the risks to the construction workforce are considered to be low and it is envisaged that nominal safety precautions should be acceptable (the adoption of good hygiene and the use of overalls, gloves and dust masks if necessary). Site works should be undertaken in accordance with the guidelines prepared by the Health and Safety Executive (HSE, 1991)¹¹, Construction (Design and Management) Regulations (CDM, 2004)¹² and the Construction Industry Research and Information Association (CIRIA, 1996)¹³ in relation to the degree of contamination identified during the various ground investigation works.

Any surplus material that is removed from the site should be disposed of at a '*suitably licensed or permitted site (subject to relevant conditions being met)*'. However, with the exception of any isolated 'hot spots' that may be subsequently identified, any material which has suitable engineering properties could be reused where appropriate (Section 5.7 refers).

6.6 Landfill Sites

A review of landfill sites was undertaken from information detailed in the BH Desk Study¹. Pertinent details contained therein can be summarised as follows:

- No landfill sites are recorded by the local authority or the BGS within a 500 m radius of the site. The nearest recorded landfill site is 625 m NE of the site.
- 1 No. Licensed Waste Management Site within a 250 m radius of the site.
- 7 No Licensed Waste Management or Waste Transfer Sites are recorded between 251 m – 500 m.

Given that none of the above facilities are considered to be directly up hydraulic gradient of the site and are typically in the Irk Valley and/or on the opposite side of the River Irk, the risk of contamination to the proposed development site arising from these facilities is considered to be low.

In addition, gas monitoring was undertaken in 2 No. boreholes located within the proposed building footprint. Ground gas was not recorded at concentrations which would be considered to represent a risk to the development (Section 5.8 refers).

6.7 Sensitive Site Uses

A review of potential sensitive site land uses has been undertaken from information detailed in the BH Desk Study¹. Based on the Envirocheck data contained therein, no sensitive land uses are recorded within 1000 m of the proposed development site.

¹¹ HSE (1991). *Protection of Workers and the General Public During the Development of Contaminated Land*. Guidance Note HS(G)66, Health and Safety Executive, HMSO, 1991.

¹² CDM (2004). *A Guide for designers on the Construction (Design and Management) Regulations*.

¹³ CIRIA 132 (1996). *A Guide to Safe Working on Contaminated Sites*. Construction Industry Research and Information Association, Report 132, 1996.

6.8 Existing Services

Consideration of the constraints to the development from the presence of underground services is beyond the scope of this report and it is understood that this is being assessed/determined by others. However, the following are worthy of note.

- At present a below ground site services survey has yet to be undertaken. As such there is an associated risk of unknown existing utilities, likely to include NCP fibre optic cables and any service that may have run along the former road layouts. Utility diversions may be required.
- In addition, an 'abandoned' brick lined sewer has been identified on the statutory service drawings to run below the proposed footprint of the building. From the plans available, the sewer is shown to be running in an east-west orientation roughly parallel to Angel Street in the northern part of the site although the exact location, invert level and redundant status needs to be verified on site.

Notwithstanding the foregoing, it is considered advisable that a full utilities survey (typically including ground penetrating radar techniques) is undertaken prior to the commencement of any site works. Such a survey not only improves the health and safety aspects of any site works subsequently undertaken but also has the added advantage of the early identification of site specific service routes that may need to be diverted. Such early identification allows suitable provisions to be made in the scheme specific cost plan and also avoids delay and disruption of the future construction works which could arise from the presence of an unforeseen service route. A full utilities survey thus facilitates improvements in respect of health and safety, cost planning and project/construction management.

6.9 Existing Trees

Trees and vegetation currently exist on the slopes separating the various levels of the site. The proposed building footprint overlies and is adjacent to areas of existing trees currently located on these slopes and the periphery of the development area. Those trees located within the proposed building footprint will be removed as part of the bulk excavation for the basement. However, in areas beyond the building footprint and within the development area, it is recommended that any remaining trees are removed and/or grubbed out as part of the site clearance/enabling works package – special attention should be paid to the location of trees and associated root networks in respect of the proposed building substructure and utility runs, these and any new planting should be assessed and located in accordance with the guidance provided in NHBC Chapter 4.2¹⁴.

¹⁴ National House Building Council (NHBC) Standards - Chapter 4.2. *Building Near Trees*. July 2003.

7 Geotechnical Considerations

7.1 General

An engineering assessment of the geotechnical constraints of the proposed development has been carried out on the basis of the information available. The key elements in respect of the groundworks and foundations to the proposed development are summarized in the following sections.

7.2 Excavation and Earthworks

The proposed development site generally slopes down in a northwesterly direction towards Dantzic Street. The maximum elevation (to the nearest metre) is 47.00 m AOD is recorded on the upper terrace towards the northeastern boundary of the site with a minimum elevation of 39.00 m AOD in the northern corner. There is thus a significant change of approximately 8.00 m in height across the proposed development site rising towards the eastern area of the site, including two terraces which have an approximate 3 - 4 m and 4 - 5 m step in level respectively. It is worthy of note that there is an 'old wall' separating the existing lower and upper terraces which is retaining a height of approximately 2.50 m.

The current development proposal includes basements with the lowest basement levels at approximately 35.50 m AOD. As such, to accommodate the scheme, substantial excavation and filling will have to be undertaken in the vicinity of the proposed building location with more minor works associated with the proposed public realm area.

At present, preliminary three-dimensional earthwork modelling has been undertaken for a variety of basement construction options. Dependent upon which option is progressed, the modelling indicates that there will be an aggregate cut volume of between approximately 50,000 and 60,000 cubic metres. The reduced level excavations and those for structural foundations and service trenches are likely to encounter Made Ground and both cohesive and granular glacial deposits. It may be possible to re-use suitable material elsewhere on site, in particular any existing hard-standings and existing below ground obstructions could be crushed for re-use (Section 6.3 refers), however it is probable that some of the excavated material will be unsuitable for engineering purposes and will require disposal off site. If non-engineered landscaped areas are included within the development proposal, material considered unsuitable for engineered fill may be used in these areas provided it is tested for contamination in keeping with the end use of the development. Any excavation arisings leaving site will need to be classified for waste disposal purposes in the usual way (Section 5.7 refers).

Attention is once again drawn to the risks associated with UXO on the proposed development site and the information in Section 6.4 and Appendix J should be noted. The proposed risk minimization strategy is considered to be a workable cost effective solution and is to be undertaken as part of the earthworks process possibly as an enabling works package. If a different strategy is to be adopted this should be in accordance with CIRIA C681⁹ and agreed with the Project Health and Safety representative.

Excavations should be feasible using conventional plant although allowance should be made for the use of pneumatic breakers to assist in the removal of any buried foundations or similar obstructions if encountered. All excavations should be supported in accordance with the guidelines presented in CIRIA Report 97¹⁵.

For basement construction it is envisaged that any perched water seepages will be relatively minor and could be controlled by sump pumping methods. It should be noted, however, that where locally more significant water ingress is encountered then more substantial water control measures may be required.

For construction of the proposed earth tubes which pass beneath the lower basement and probably the base of the foundation pile caps, these are likely to be constructed (partially at least) below the perched water table observed during the monitoring period. As such, significant water control measures should be anticipated and suitable waterproofing measures will be required.

Any cohesive materials encountered are likely to be prone to deterioration from moisture and uncontrolled seepages. As such, any foundation excavations in such materials should be covered by a blinding layer of concrete or other approved material as soon as they are exposed and formations for infrastructure should be protected by a sacrificial layer until the Permanent Works are installed.

7.3 Groundwater

The majority of the post fieldwork groundwater monitoring results for the Sherwood Sandstone show a typical range of groundwater level to be between 25.69 m AOD and 26.28 m AOD (Appendix D refers). In addition, water was also encountered in the superficial deposits in 4 No. out of the 6 No. post fieldwork monitoring visits ranging between 33.41 m AOD and 33.69 m AOD with the remaining 2 No. visits recording groundwater levels to be below the base of the installation (<33.35 m AOD) as shown in Appendix D.

The current scheme incorporates lowest basement levels of approximately 35.50 m AOD and, as such, it is not anticipated that groundwater ingress will cause significant problems for the envisaged excavation works. For basement construction it is envisaged that most of the perched water seepages will be relatively minor and could be controlled by localized sump pumping methods. It should be noted, however, that where locally more significant water ingress is encountered then more substantial water control measures may be required.

For construction of the proposed earth tubes which pass beneath the lower basement and probably the base of the foundation pile caps, these are likely to be constructed (partially at least) below the perched water table observed during the monitoring period (TPBH01 19 mm installation- Section 4.7, 7.3 and Appendix D refer). As such, more substantial water control measures should be anticipated.

¹⁵ CIRIA Report 97. *Trenching Practice*. CIRIA R97, 1983.

7.4 Foundations

7.4.1 General

Based on the information obtained it is considered that a piled solution is likely to be the most cost-effective foundation solution for the Permanent Works. The piles will be used to transfer the loads of the building down to a suitable bearing stratum, namely the underlying Sherwood Sandstone bedrock.

The sulphate content and pH of soil samples indicates that the pH of soil is relatively low across the site and as such, a minimum concrete class of DS-2 with an ACEC Class of AC-2 could be adopted for buried structures in accordance with BRE Special Digest 1¹⁶.

7.4.2 Piled Foundations

A piled solution is considered to be a suitable technical solution that is practical and comparatively predictable in terms of buildability. The piling technique, method of installation and design will depend on many factors, such as applied load, groundwater level, bearing strata, presence of obstructions, cost and speed of construction. Given the ground conditions encountered and that the current development proposal includes a structure with reasonably large spans and high loads, it is anticipated that piled foundations will be the most cost-effective solution.

If a piled foundation solution is adopted, the pile design should be undertaken by a specialist piling contractor but for guidance purposes a rock socketed pile, socketed into the Sherwood Sandstone bedrock strata should provide the following capacities:

- 750 mm piles, 10.00 m – 15.00 m in length with a 5.00 – 7.00 m rock socket - approximately 2,750 kN.

Based on the current anticipated loads, internal and perimeter columns are likely to require 5 or 6 No. 750 mm diameter piles (the UXO risk should be noted – Section 6.4 refers). Although multiple piles per column will generally be used in this instance, because of the relatively high column loadings the pile design will need to allow for any minor eccentric loadings arising from the offset between the axis of the pile and the axis of the structural column caused by the limitations in the tolerance of installation.

7.5 Basement Construction

In the area of basement, retaining measures will be required to accommodate the changes in level. It is currently considered that the basement will be a concrete cast in-situ construction comprising two phases of work. It is envisaged that an enabling works package (Temporary Works) will be undertaken for bulk earthworks/excavation to provide a 'hole' within which the permanent basement structure can be constructed.

¹⁶ BRE (2001). *Concrete in aggressive ground*. Building Research Establishment, Special Digest 1, 2001.

The enabling works package is likely to use a combination of batters and some form of vertical temporary retaining structure, such as a steel sheet pile or contiguous bored pile wall (the UXO risk should be noted – Section 6.4 refers). This will then allow the foundation bearing piles to be installed and the concrete cast in-situ basement to be constructed during the main construction phase of the works forming part of the Permanent Works construction. This approach is considered to have the advantages of optimizing building/design programme and also brings the management of ground related risks forward to de-risk the build programme as far as practicable.

The concrete cast in-situ basement will be propped in the permanent case but under the current proposal will not be supporting any building column loads. The design intent is that the building columns will be supported by the 750 mm diameter rotary bored piles as detailed in Section 7.4.2. This is because the outline of the lower basement lies outside the footprint of the upper basement and the above ground superstructure.

The basement and below ground Lower Ground Floor structure are to be protected from water ingress to provide Grade 3 basement conditions in accordance with BS8102¹⁷ and CIRIA Report 139¹⁸. As such, a suitable tanking system is to be incorporated in accordance with the architect's specification and detailing. The tanking system should also enhance the degree of gas protection afforded to the building as detailed in Section 5.8.

7.6 Ground Bearing Slabs

The use of ground bearing slabs could be considered for the proposed development assuming typical loadings of 20 kN/m². A typical under slab formation may generally comprise 150 mm of compacted stone, sand layer and a damp proof membrane, although in this instance the basement will include a suitable tanking system (Section 7.5 refers).

The formation will need to be proof rolled to ensure suitability. It should be noted that any soft spots encountered should be removed and replaced with appropriate structural fill. Any obstructions encountered should also be removed.

The compacted stone should be DTp Type 1¹⁹ in frost susceptible areas but in non-frost susceptible areas, such as within the confines of the proposed buildings, alternative materials such as DTp Class 6F2²⁰ may be

¹⁷ BSI (1990). *Protection of structures against water from the ground* BS8102 :1990. British Standards Institution.

¹⁸ CIRIA (1995). *Water-resisting basements*. Construction Industry Research and Information Association, Report C139, 1995.

¹⁹ DTp (2001). *Specification for Highway Works, Volume 1 Series 800: Clause 803*. Department of Transport, HMSO, May 2001.

²⁰ DTp (2003). *Specification for Highway Works, Volume 1 Series 600: Table 6/1*. Department of Transport, HMSO, November 2003.

considered. Recycled site won material could be considered for re-use subject to suitability as outlined in Section 5.7.

Notwithstanding the above, it is envisaged that the provision of a piling mat in the temporary case to allow the installation of foundation piles should provide a platform capable of supporting the ground bearing slab with currently envisaged loadings. The temporary loading case of the piling works is envisaged to be more onerous than the permanent floor loadings proposed. It is currently envisaged that the top 300 mm of the piling mat will be redressed and left in-situ beneath the ground bearing slab.

7.7 Ground Gas

Gas monitoring during the Structural Soils Investigation was carried out in 2 No. boreholes located within the footprint of the proposed building. Full details and results of this monitoring can be found in the Structural Soils Report³ and Section 5.8. All monitoring installations contained gas concentrations and flows which fall within Characteristic Situation 1 in accordance with CIRIA C665⁶. The proposed design will arguably provide gas protection to Characteristic Situation 3/4 due to the structural and operational requirements of the building (Section 5.8 refers). As such, additional gas protection measures are considered unnecessary subject to Building Control approval.

Radon is not indicated to be a problem in the vicinity of the proposed development site and, as such, additional protection measures are considered unnecessary subject to Building Control approval. (Section 5.9 refers).

7.8 Retaining Structures and Slopes

The main retaining structures are those associated with the basement construction in both the Temporary Works and Permanent Works situations outlined in Section 7.5 and not duplicated here.

There may be some localized requirement for retaining structures as part of the landscaping and public realm works but the details of these are yet to be finalized. These will need to be reviewed on an individual basis as detailed requirements become available. The UXO risk should again be noted (Section 6.4 refers).

In terms of slopes, as outlined in Section 7.5, it is envisaged that an 'enabling works package' comprising a bulk dig for basement excavation is likely to include batter slopes for the full or partial height of the reduce level dig. This is a Temporary Works element and lies outside the scope of this report, although the general requirements of Section 7.2 are relevant and the UXO risk should be noted (Section 6.4 refers).

Some slopes may be introduced as part of the landscaping and public realm works but the details of these are yet to be finalized. For guidance purposes, the site profiles will need to be appropriately designed to ensure slope stability. It is suggested that slopes are typically kept to gradients of less than 1V:3H to avoid the use of soil reinforcement and for ease of maintenance. Although, steeper slopes can be engineered subject to suitable design, they are typically undesirable in terms of amenity and future maintenance. The UXO risk should again be noted (Section 6.4 refers).

7.9 Highway Issues and Permissions

The proposed development is bounded to the north, northwest and west by roads and to the southwest by a major road namely the A665 Miller Street. Proposed access to the construction site is currently unknown/undecided however given the proposed development is bounded by major roads, appropriate permits and permissions will be required from the relevant authorities to allow the construction works to be undertaken.

Pavement build ups will be a function of the material quality at formation level with the most cost-effective build up being selected on the basis of CBR testing at the proposed formation level although a minimum build up of 450 mm is likely to be required for areas subject to vehicular traffic. Road stone should be DTp Type 1¹⁹ in the top 450 mm in frost susceptible areas but below 450 mm or in non-frost susceptible areas, such as within the confines of the proposed building, alternative materials such as DTp Class 6F2²⁰ may be considered. Recycled site won material could be considered for re-use subject to suitability. Frost susceptibility of recycled materials in the top 450 mm of frost susceptible areas should be considered.

A number of services may need to be moved/diverted (Section 6.8 refers) prior to any construction works being undertaken all of which will need to be undertaken in accordance with the relevant permits and permissions from the relevant authorities.

Finally, any existing internal public rights of way across the site, if any, will need to be diverted. The status of the former road network which previously existed is not currently known.

8 Conclusion

The following paragraphs summarize the principal ground engineering issues in respect of the current development proposal as outlined in Section 6.1 and the ground conditions encountered during the investigatory works undertaken. Reference should be made to the relevant sections herein to ensure a full understanding is gained as to the issues, constraints and considerations pertinent to the key points summarized below.

The ground conditions encountered as part of the ground investigation works undertaken, as presented in Section 4, can be summarized as follows:

- Ground conditions comprise the following sequence with increasing depth: Made Ground overlying Glacial Till on to Sherwood Sandstone rock strata.
- The nature and characteristics of the materials encountered have been assessed by means of both in-situ and geotechnical laboratory testing.
- Structural Soils exploratory hole records indicate groundwater strikes were encountered in trial pits as a 'slight seepage' at 1.00 m BGL (41.90 m AOD) in TPBH 02, 'seepage' at 1.00 m BGL and 3.00 m BGL (45.90 and 43.90 m AOD respectively) in TPCPT10 and as 'locally damp' below 2.50 m BGL (37.40 m AOD) in TPCPT 04. The remaining trial pits are noted to be dry.
- The majority of the post fieldwork groundwater monitoring results for the Sherwood Sandstone show a typical range of groundwater level to be between 25.69 m AOD and 26.28 m AOD.
- Groundwater was also encountered in the superficial deposits in 4 No. out of the 6 No. post fieldwork monitoring visits ranging between 33.69 m AOD and 33.41 m AOD with the remaining 2 No. visits recording groundwater levels to be below the base of the installation (<33.35 m AOD). It should be noted, however, that there may also be perched water within the Made Ground.
- The Sherwood Sandstone is a major aquifer. It should be noted that the site falls within a Groundwater Source Protection Zone (GPZ) 2.

A geoenvironmental assessment has been undertaken on the basis of the information available, as presented in Sections 5 and 6.5, can be summarized in respect of 'end use' and health and safety of the construction workforce as follows:

- Chemical concentrations have been determined for soil samples collected from 2 No. boreholes and 5 No. trial pits. Laboratory testing was conducted for a typical suite of determinands selected on the basis of the recorded development history of the site, any observations made during the ground investigation works and other geoenvironmental development considerations. The assessments made as part of this document are based on the findings of these tests.
- Based on the chemical testing undertaken and the proposed end development, chemical concentrations in soils are not likely to pose a significant risk to end users of the proposed development, providing that any

'hot spots' or other areas of unidentified contamination which may be identified during the earthworks are removed. Protection of water supply pipes may also be required where these are to be laid in or near to contaminated soils or groundwater.

- Given the concentrations of determinands generally encountered across the proposed development site, the risk to construction workers due to direct contact with soils is considered to be low and it is envisaged that nominal safety precautions will be acceptable (the adoption of good hygiene and the use of overalls, gloves and dust masks if necessary).
- No unacceptable risks have been identified with respect to potential pollution to controlled waters.
- Japanese Knotweed has been visually identified at the site. This should be treated in accordance with current legislation and a Japanese Knotweed specialist should be consulted with regards to the site management and/or removal of this material.

A broad assessment of the possible waste categorization of surplus arisings from the site based on the Structural Soils Investigation chemical testing, as presented in Section 5.7, can be summarized as follows:

- Locally elevated soil concentrations of hydrocarbons and lead have been identified within the Made Ground in localized areas of the site. Surplus arisings in these areas are likely to be categorized as 'Non Hazardous Waste'.
- Surplus arisings of Made Ground from most areas of the site are likely to be categorized as 'Inert Waste' with some areas of 'Non Hazardous Waste'.
- The majority of surplus arisings of Glacial Till material are likely to be categorized as 'Inert Waste'.
- 'Inert' arisings which have suitable engineering properties could be reused as engineered fill subject to the agreement of the relevant licensing authorities.

Assessments of ground gas and radon have been undertaken, as presented in Sections 5.8 and 5.9, and the findings can be summarized as follows:

- Gas monitoring within boreholes located in the proposed area of the building have recorded gas concentrations and flows which fall within Characteristic Situation 1 in accordance with CIRIA guidelines. As such it is considered that only basic gas protection measures will be necessary for the proposed development, in accordance with current CIRIA guidelines. Such measures are accommodated within the structural requirements of the buildings and, therefore, additional bespoke gas protection measures are currently considered unnecessary subject to Building Control approval.
- The site is in an area where less than 1% of homes are above the Radon Action Level and, therefore, no radon protection measures are considered necessary for the proposed development.

The development considerations for the scheme, as presented in Section 6, can be summarized as follows:

- Former foundations to previously existing structures or other obstructions have been recorded. These and/or any unidentified services that may be encountered may require removal as part of the construction works. Any such obstructions removed or voids encountered below formation level should be replaced

with suitable structural fill where required. Materials arising from the removal of foundations/obstructions, if cost effective, could be considered for re-use as hardcore/reprocessed stone if appropriately sorted, processed and treated.

- An abandoned sewer/culvert is indicated to run below the proposed building footprint.
- No landfill sites are recorded by the local authority or the BGS within a 500 m radius of the site. The nearest recorded landfill site is 625 m NE of the site.
- There is 1 No. Licensed Waste Management Site within a 250 m radius of the site.
- 7 No Licensed Waste Management / Transfer Sites are recorded between 251 m – 500 m from the site.
- Identification of constraints to the development from the presence of underground services is beyond the scope of this document and it is understood that this is being assessed/determined by others. Section 6.8 refers.

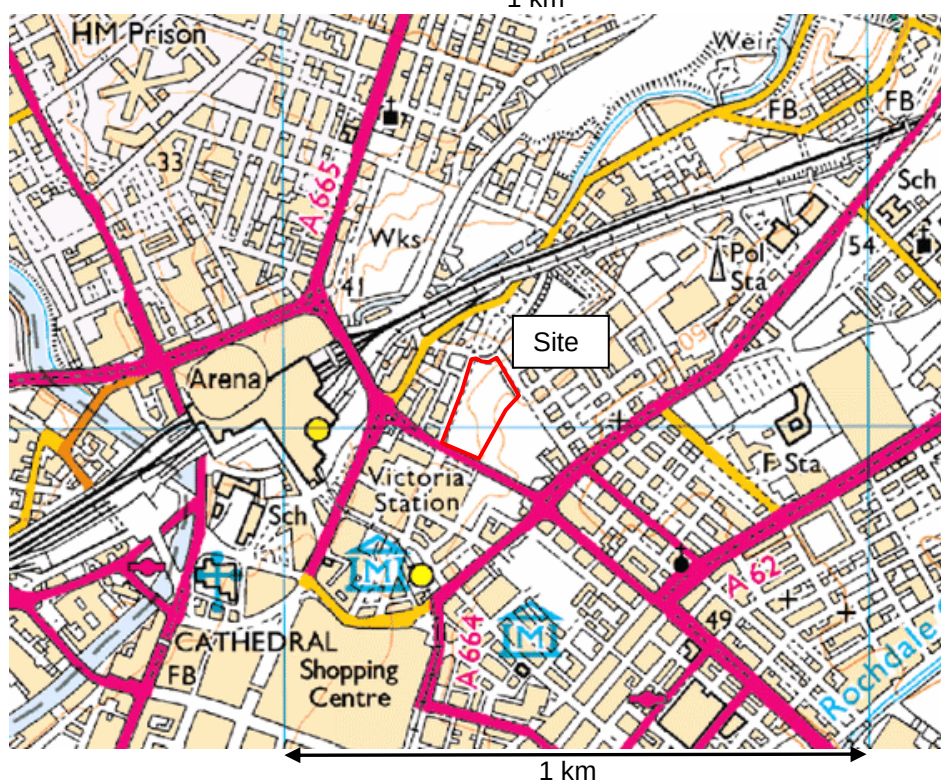
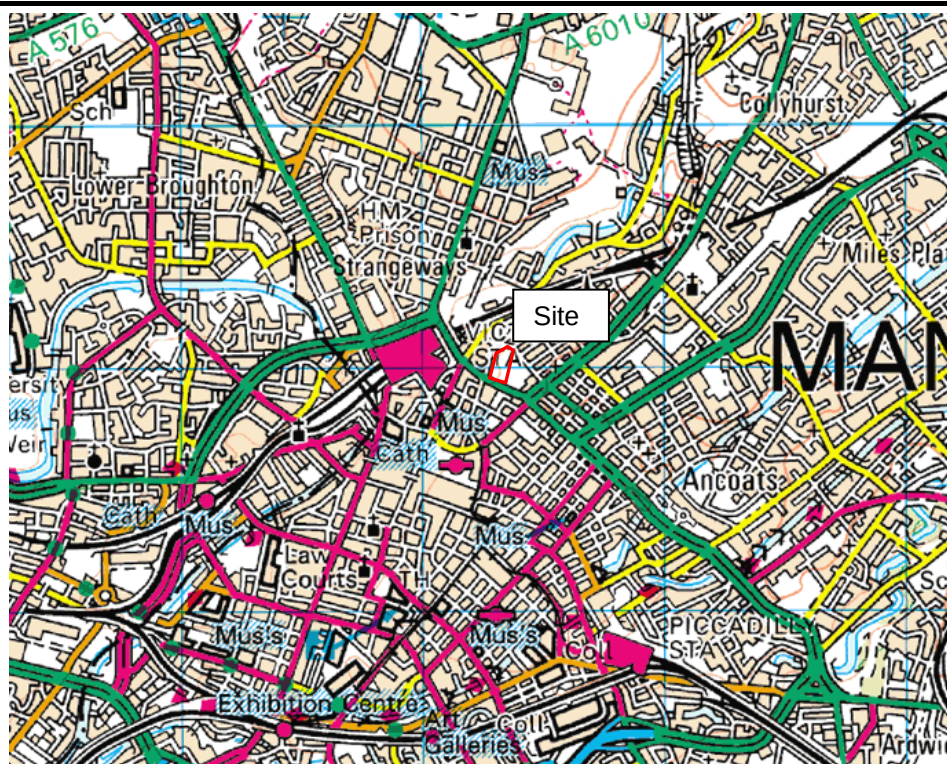
The principal geotechnical considerations for the current development proposal, as presented in Section 7, can be summarized as follows:

- The proposed development is situated in an area identified as being at significant risk from World War II unexploded ordnance (UXO). As such, UXO detection survey/clearance during both the enabling works package and the main construction works is likely to be required.
- Preliminary three-dimensional earthworks modelling has been undertaken for a variety of basement construction options. A detailed cut/fill exercise is required to ascertain the amount of surplus arisings that will need to be handled/placed/removed from site.
- Excavations should be feasible using conventional plant although allowance should be made for the use of pneumatic breakers to aid in the removal of obstructions if encountered. Note UXO requirements.
- It is envisaged that some groundwater may be encountered during earthworks/excavations. Where relatively minor seepages occur it is likely that these could be controlled by sump pumping methods. It should be noted, however, that where more significant water ingress is encountered then more substantial water control measures may be required.
- The construction of the proposed earth tubes is likely to be (partially at least) below the perched water table observed during the monitoring period. As such, water control measures will be required.
- Typically, a concrete class of DS-2 with an ACEC Class of AC-2 is likely to be required for buried structures.
- Given the anticipated column loads associated with the current development proposal a rock socketed piled foundation solution is anticipated to carry the structural columns. The pile design should be undertaken by a specialist piling contractor and should allow for minor eccentric loadings induced due to installation tolerances.
- The proposed development is to have two levels of car parking which due to the level change across the site results in a single level basement to the northwestern part of the building and double level basement to the southeastern part of the building.

- It is currently envisaged that the basement will be constructed in at least two distinct phases of work, namely an 'enabling works package' comprising a bulk dig for basement excavation and a 'main construction phase'. The 'enabling works package' is likely to comprise the installation of a temporary embedded retaining structure and/or partial/full battered slopes. This will be followed by the 'main construction phase' which will comprise the installation of the structural foundations and permanent retaining structures and main superstructure.
- The use of ground bearing slabs can be considered assuming that any soft spots encountered are removed and replaced with appropriate structural fill. Any obstructions encountered should also be removed.
- No specific retaining walls for the public realm area have been identified as part of the current development proposal thus will need to be reviewed on an individual basis.
- Slopes should be kept to gradients of less than 1V:3H to avoid the requirement for soil reinforcement and for ease of maintenance.
- Appropriate permissions and consents should be obtained from the relevant highway authorities for any works to be undertaken to, on or in the general vicinity of any highways.
- Pavement designs for roads and car parks should be based on CBR data for the relevant formations.

It should be noted that any significant changes to the current development proposals may affect the outcome of the assessments undertaken and the findings summarized above. As such, the foregoing should be read in the context of the current design philosophy, scope of work and envisaged construction and procurement strategies.

Figures



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Project Name : The co-operative Head Office, Manchester.

Report Title : Ground Engineering Interpretative Report

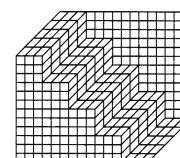
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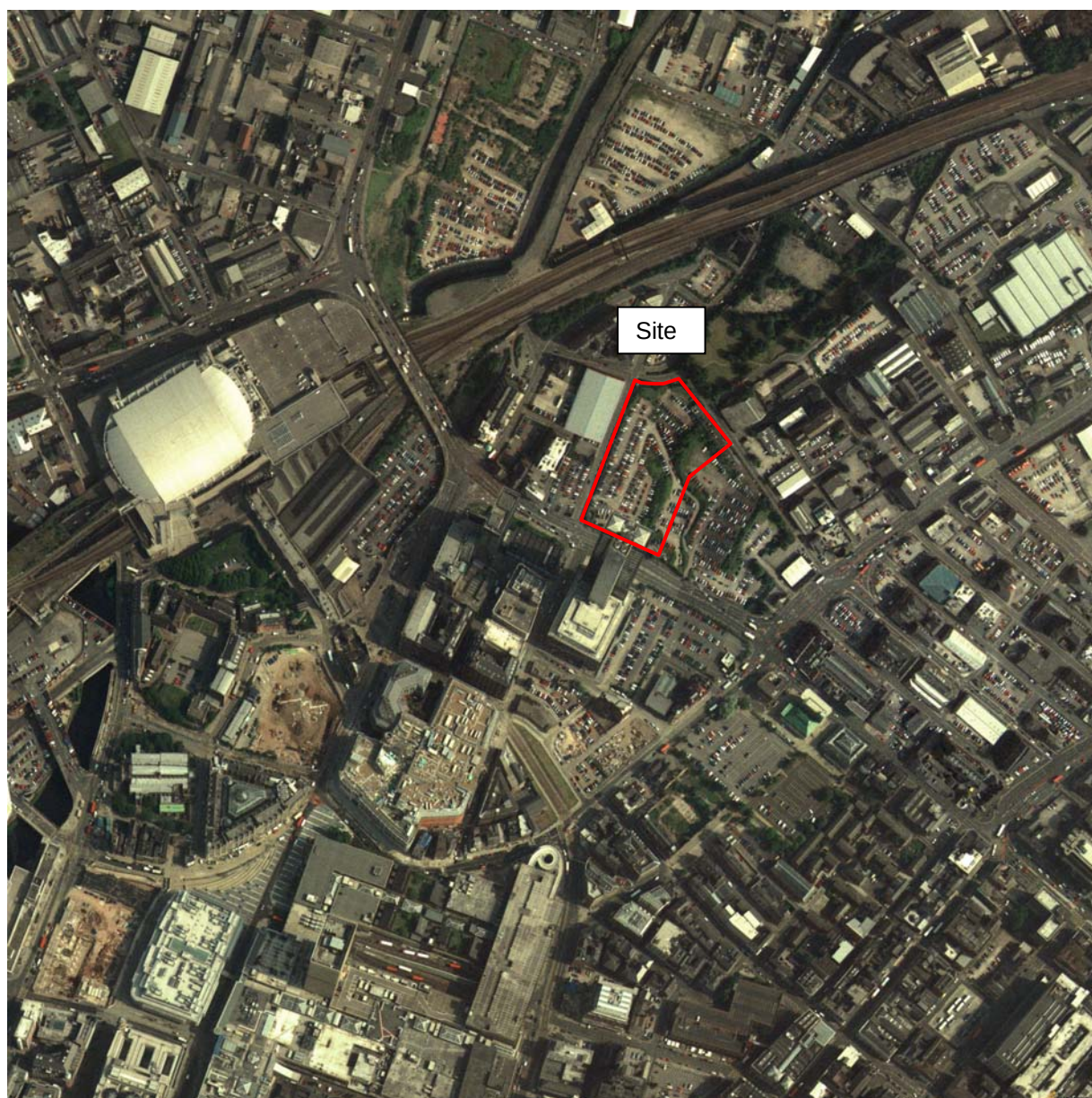
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Figure: 1



Buro Happold
Ground Engineering



500 m

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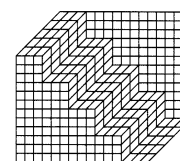
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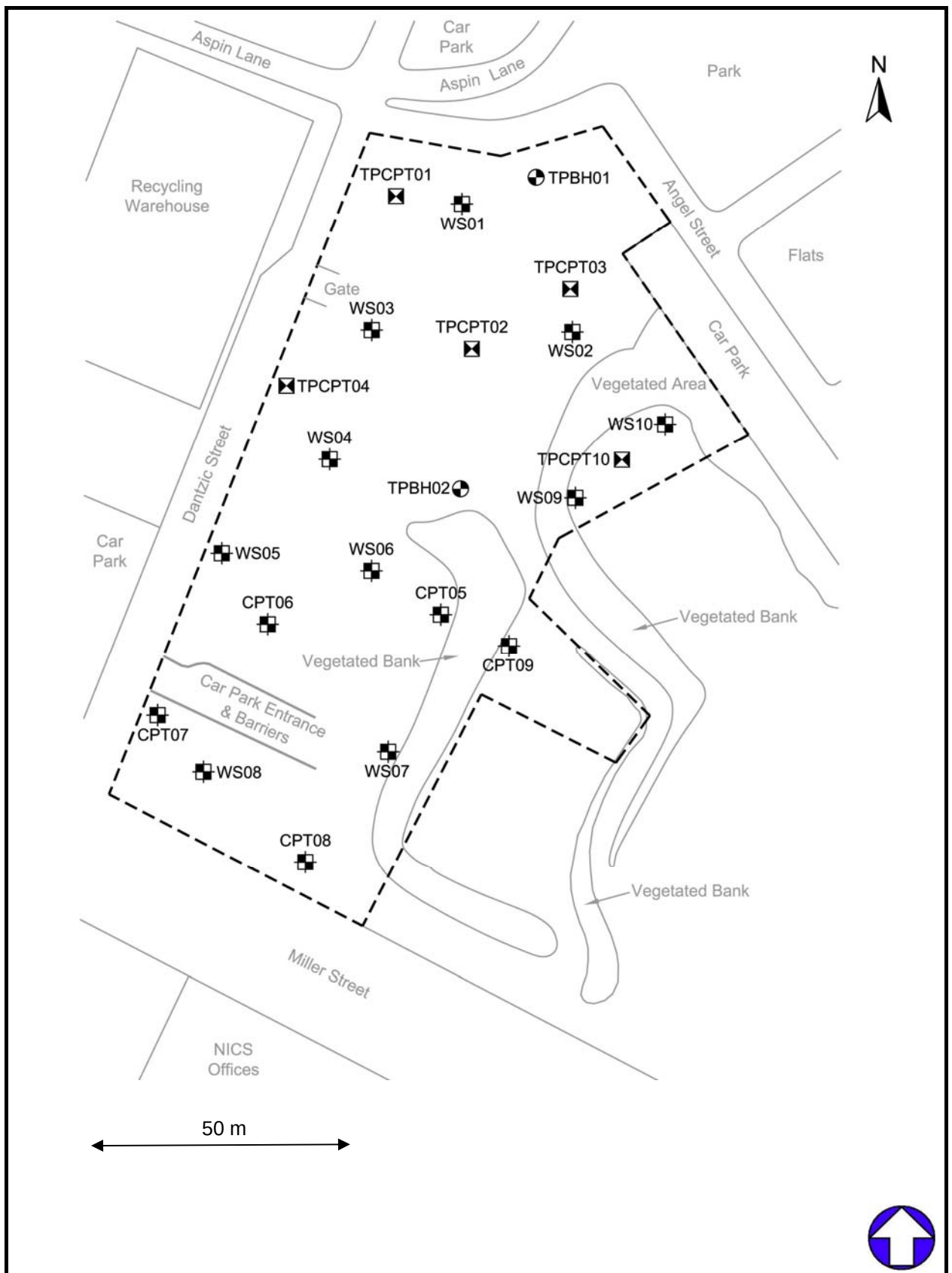
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Figure: 2



Buro Happold
Ground Engineering



Project Name : The co-operative Head Office, Manchester

Report Title : Ground Engineering Interpretative Report

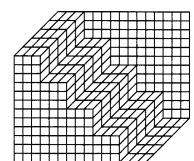
Figure Title : Exploratory Hole Location Plan

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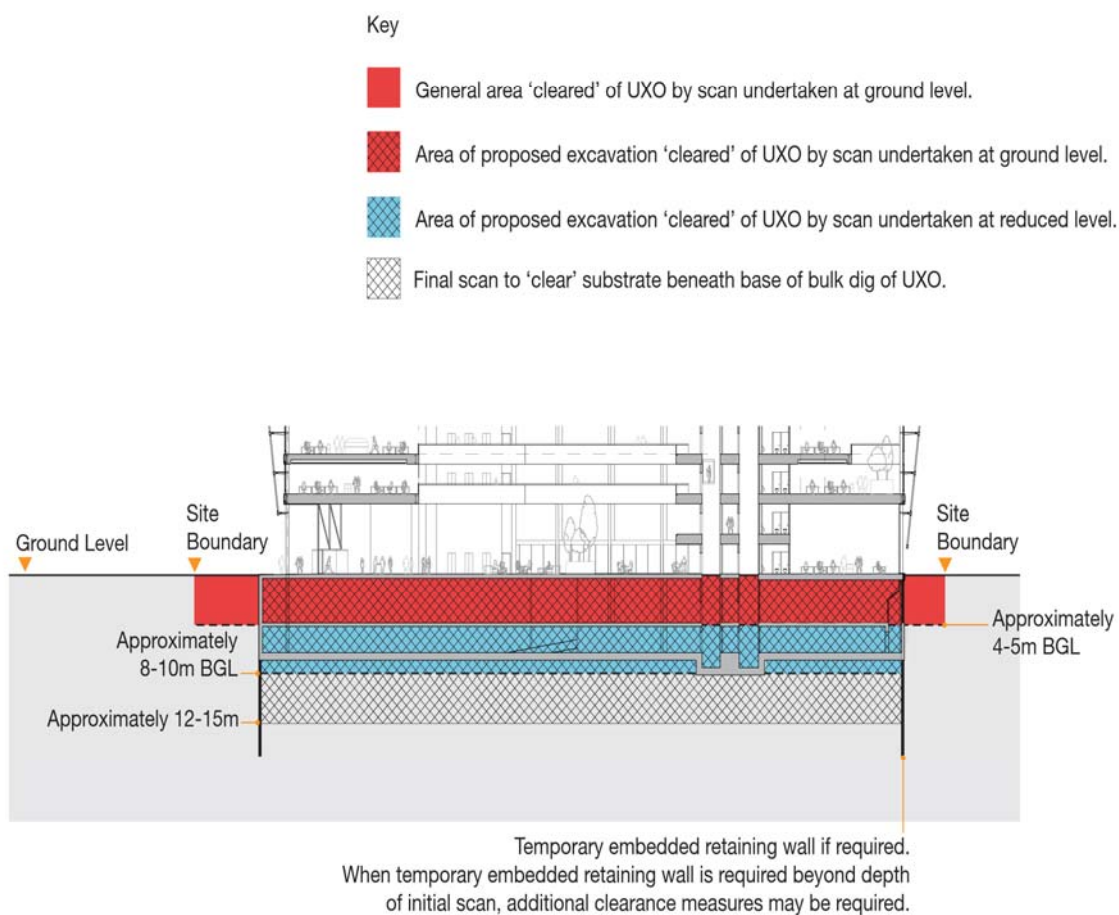
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Figure: 3



Buro Happold
Ground Engineering



Project Name : The co-operative Head Office, Manchester

Report Title : Ground Engineering Interpretative Report

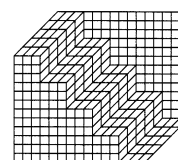
Figure Title : Proposed UXO Strategy

Scale: NTS

Date: October 2009

Job No: 023842

Figure: 4



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Ground Engineering

Appendix A – Architect's Impression



Project Name : The co-operative Head Office, Manchester.			
Report Title : Ground Engineering Interpretative Report			
Figure Title : Architects Impressions			
Scale: NTS	Date: October 2009	Job No: 023842	Appendix A

Notes
Do not scale from this drawing. All dimensions to be checked on site prior to construction and any discrepancies reported to the Architect. Copyright reserved.



* first issue 16/10/09 mrd

Revisions

Status

STAGE D

Client

THE CO-OPERATIVE GROUP

Project

**NEW HEAD OFFICE
MILLER STREET
MANCHESTER**

Title

**SECTION A-A
ALONG ROOF SLOPE**

Scale	Size	Date	Drawn	Checked
1:200	A1	September 2009	-	-

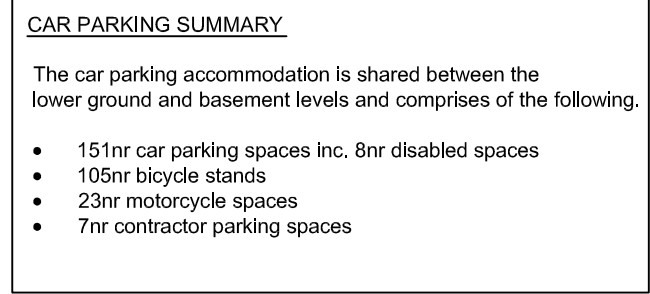
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Manchester, M2 2EE
t : +44 (0)161 236 7070
f : +44 (0)161 236 7077
w : http://www.3dreid.com
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Project No. Drawing No. Rev.

090109 (E) **301** *

0 2m 4m 6m 8m 10m

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Revisions

STAGE D

Scale	Size	Date	Drawn	Checked
1:200	A1	September 2009	—	—

3D
REID

Project No.	Drawing No.	Rev.
090109 (E)	B1-001	B





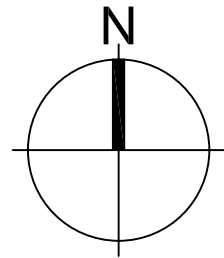
A circular diagram with a vertical line passing through its center. The top of the line is labeled 'N'.

Total louvre area 68m² providing 34m² free area

Project No.	Drawing No.	Rev.
090109 (E)	LG-001	A



Notes
Do not scale from this drawing. All dimensions to be checked on site prior to construction and any discrepancies reported to the Architect. Copyright reserved.



LOUVRE SCHEDULE	
Car park ventilation to comply with Approved Document B (Building Regulations). Louvres to provide a minimum 50% free area.	
• LV 01	- Total louvre area 8.6m²
• LV 02	- Total louvre area 6.5m²
• LV 03	- Total louvre area 6.3m²
• LV 04	- Total louvre area 6.3m²
• LV 05	- Total louvre area 8.6m²
• LV 06	- Total louvre area 6.5m²
• LV 07	- Total louvre area 6.5m²
• LV 08	- Total louvre area 18.9m²
Total louvre area 68m² providing 34m² free area	

A	Amendments to internal layout	07/10/09	GL
-	Issued for information	23/09/09	GL

Revisions

Status

STAGE D

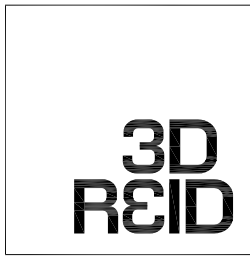
Client
THE CO-OPERATIVE GROUP

Project
**NEW HEAD OFFICE
MILLER STREET
MANCHESTER**

Title
**GENERAL ARRANGEMENT PLAN
GROUND FLOOR PLAN**

Scale	Size	Date	Drawn	Checked
1:200	A1	September 2009	-	-

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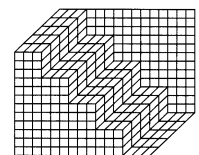
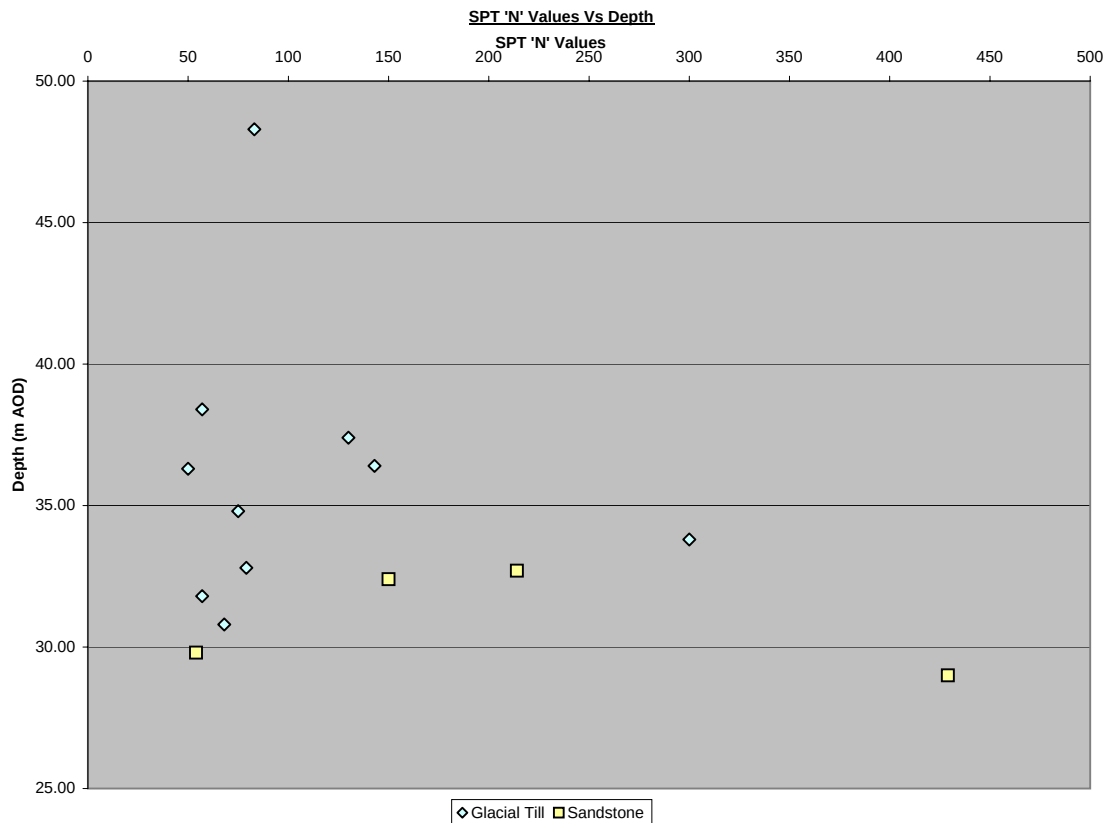
Project No.	Drawing No.	Rev.
090109 (E)	00-001	A

Appendix B – Standard Penetration Test Data Summary

The co-operative Head Office, Manchester
SPT results summary

Borehole	Depth (m BGL)	Depth (m AOD)	Material	SPT 'N' value	Penetration at refusal (mm)
TPBH01	4.50	36.30	Glacial Till	50	-
	6.00	34.80	Glacial Till	75	200
	7.50	48.30	Glacial Till	83	180
	8.00	32.80	Glacial Till	79	190
	9.00	31.80	Glacial Till	57	263
	10.00	30.80	Glacial Till	68	220
	11.00	29.80	Sandstone	54	280
	11.80	29.00	Sandstone	429	35
TPBH02	4.50	38.40	Glacial Till	57	265
	5.50	37.40	Glacial Till	130	115
	6.50	36.40	Glacial Till	143	105
	9.10	33.80	Glacial Till	300	50
	10.20	32.70	Sandstone	214	70
	10.50	32.40	Sandstone	150	100

Extrapolated 'N' value where full penetration not achieved



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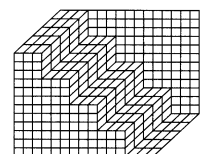
Appendix C – Rock Strength Data Summary

Site: The co-operative Head Office, Manchester
Rock test results.

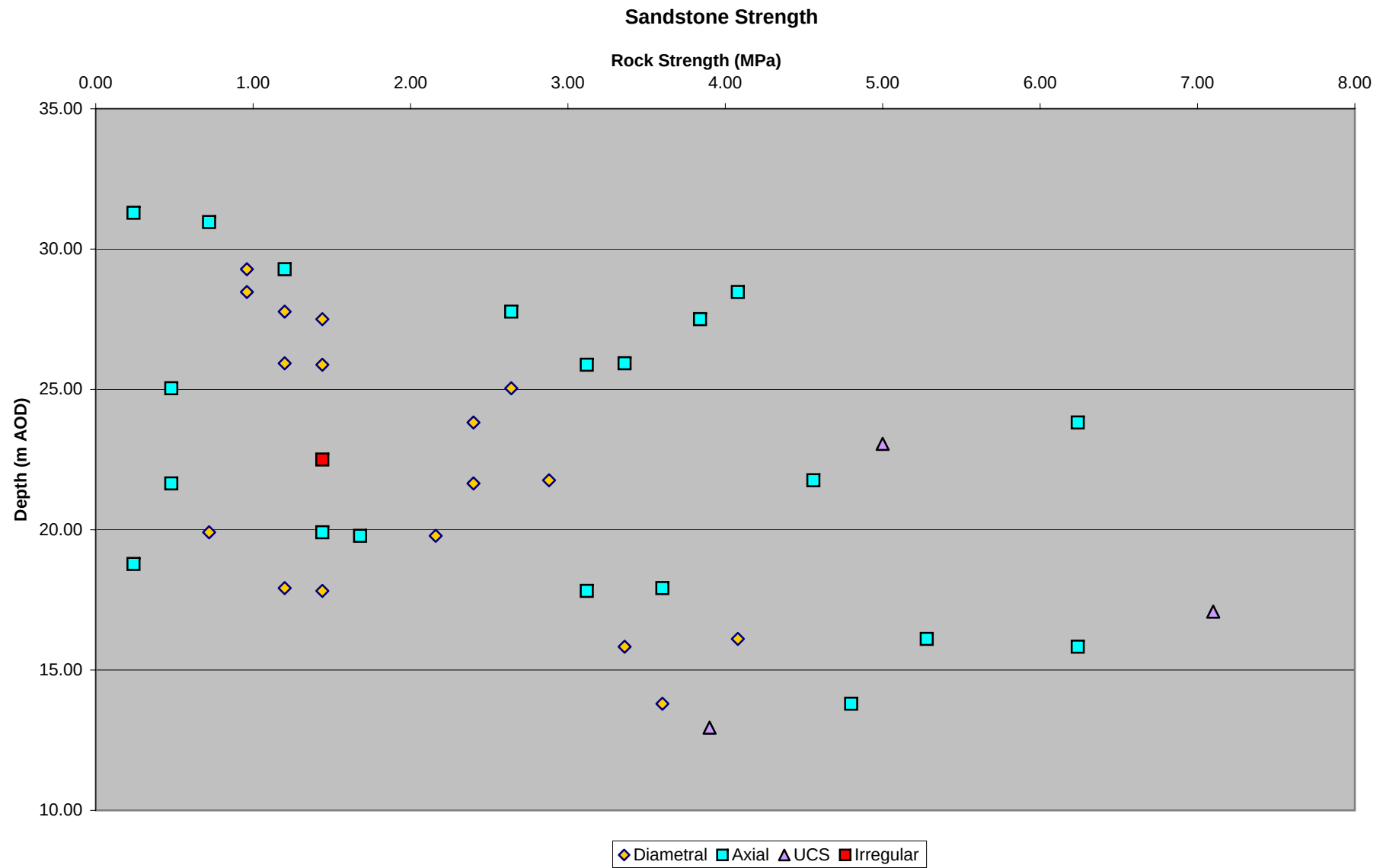
Borehole	Depth (m BGL)	Depth (m AOD)	Material	Test Type	Is50	UCS* (MPa)
BH01	12.33	28.47	Sandstone	D	0.04	0.96
	12.33	28.47	Sandstone	A	0.17	4.08
	13.03	27.77	Sandstone	D	0.05	1.20
	13.03	27.77	Sandstone	A	0.11	2.64
	14.92	25.88	Sandstone	D	0.06	1.44
	14.92	25.88	Sandstone	A	0.13	3.12
	16.98	23.82	Sandstone	D	0.10	2.40
	16.98	23.82	Sandstone	A	0.26	6.24
	17.74	23.06	Sandstone	UCS	-	5.00
	19.04	21.76	Sandstone	D	0.12	2.88
	19.04	21.76	Sandstone	A	0.19	4.56
	21.02	19.78	Sandstone	D	0.09	2.16
	21.02	19.78	Sandstone	A	0.07	1.68
	22.88	17.92	Sandstone	D	0.05	1.20
	22.88	17.92	Sandstone	A	0.15	3.60
	23.72	17.08	Sandstone	UCS	-	7.10
	24.69	16.11	Sandstone	D	0.17	4.08
	24.69	16.11	Sandstone	A	0.22	5.28
BH02	11.61	31.29	Sandstone	A	0.01	0.24
	11.94	30.96	Sandstone	A	0.03	0.72
	13.62	29.28	Sandstone	D	0.04	0.96
	13.62	29.28	Sandstone	A	0.05	1.20
	15.40	27.50	Sandstone	D	0.06	1.44
	15.40	27.50	Sandstone	A	0.16	3.84
	16.97	25.93	Sandstone	D	0.05	1.20
	16.97	25.93	Sandstone	A	0.14	3.36
	17.86	25.04	Sandstone	D	0.03	2.64
	17.86	25.04	Sandstone	A	0.02	0.48
	20.40	22.50	Sandstone	I	0.06	1.44
	21.25	21.65	Sandstone	D	0.01	2.40
	21.25	21.65	Sandstone	A	0.02	0.48
	22.99	19.91	Sandstone	D	0.03	0.72
	22.99	19.91	Sandstone	A	0.06	1.44
	24.12	18.78	Sandstone	A	0.01	0.24
	25.08	17.82	Sandstone	D	0.06	1.44
	25.08	17.82	Sandstone	A	0.13	3.12
	27.07	15.83	Sandstone	D	0.14	3.36
	27.07	15.83	Sandstone	A	0.26	6.24
	29.10	13.80	Sandstone	D	0.15	3.60
	29.10	13.80	Sandstone	A	0.20	4.80
	29.95	12.95	Sandstone	UCS	-	3.90

* Point load conversion = $24 \times \text{Is50}$

D	Diametral
A	Axial
I	Irregular
UCS	Unconfined Compressive Strength test



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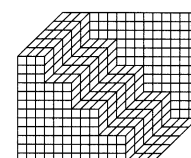
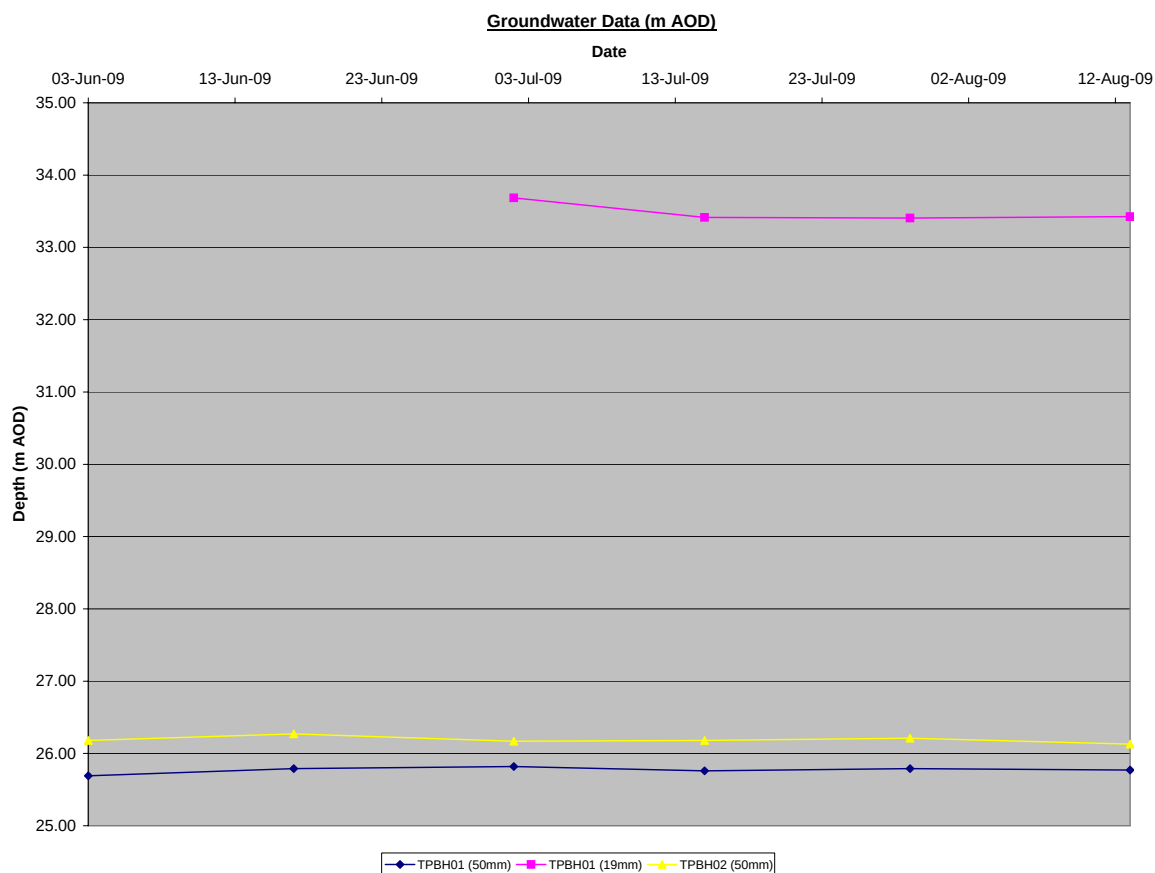


Appendix D – Groundwater Monitoring Summary

Site: The co-operative Head Office, Manchester
Monitoring well data

BH	GL	BASE DEPTH	WATER DEPTH (mBGL) :					
			Date					
	mAOD	mBGL	03-Jun-09	17-Jun-09	02-Jul-09	15-Jul-09	29-Jul-09	13-Aug-09
TPBH01 (50mm)	40.80	24.25	15.11	15.01	14.98	15.04	15.01	15.03
TPBH01 (19mm)	40.80	7.45	Dry	Dry	7.11	7.38	7.39	7.37
TPBH02 (50mm)	42.90	25.00	16.72	16.63	16.73	16.72	16.69	16.77
TPBH02 (19mm)	42.90	4.00	Dry	Dry	Dry	Dry	Dry	Dry

BH	GL	BASE DEPTH	WATER DEPTH (mAOD) :					
			Date					
	mAOD	mAOD	03-Jun-09	17-Jun-09	02-Jul-09	15-Jul-09	29-Jul-09	13-Aug-09
TPBH01 (50mm)	40.80	16.55	25.69	25.79	25.82	25.76	25.79	25.77
TPBH01 (19mm)	40.80	33.35	Dry	Dry	33.69	33.42	33.41	33.43
TPBH02 (50mm)	42.90	17.90	26.18	26.27	26.17	26.18	26.21	26.13
TPBH02 (19mm)	42.90	38.90	Dry	Dry	Dry	Dry	Dry	Dry



Appendix E – Chemical Testing Results Summary

Co-op HQ (023842): Soil contamination testing results assessment

Determiand	Method	Units	Sample Identity	TPBH01	TPBH02	TPCPT01	TPCPT03	TPCPT04	TPCPT10	TPCPT10	Minimum Value	Maximum Value	Residential Without Plant Uptake Guideline Value*	Commercial/ Industrial	Other Screening Values (refer to notes under table for explanation)	
			Depth	1.10	1.00	3.20	2.00	2.20	0.50	4.00						
			Sample Type	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID						
			Material	Glacial Till (Cohesive)	Made Ground (Cohesive)	Glacial Till (Granular)	Glacial Till (Granular)	Made Ground (Granular)	Made Ground (Granular)	Made Ground (Cohesive)						
Metals																
Arsenic	TM129	mg/kg	<3	6.0	<3	12.0	34.0	12.0	<3	6.0	34.0	35*	640			
Boron	TM129	mg/kg	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	
Cadmium	TM129	mg/kg	<0.2	0.5	<0.2	0.3	0.9	<0.2	<0.2	<0.2	<0.2	0.9	85*	230*		
Chromium	TM129	mg/kg	10.0	22.0	8.1	16.0	22.0	10.0	28.0	8.1	28.0	200 ⁽⁷⁾	5000 ⁽⁷⁾			
Copper	TM129	mg/kg	8.0	66.0	8.0	190.0	170.0	42.0	24.0	8.0	190.0				190 ⁽⁴⁾	
Lead	TM129	mg/kg	10.0	150.0	7.0	120.0	890.0	220.0	20.0	7.0	890.0	450	750			
Mercury	TM129	mg/kg	<0.4	<0.4	<0.4	<0.4	1.8	1.7	<0.4	<0.4	1.8	1*	26			
Nickel	TM129	mg/kg	13.0	17.0	11.0	22.0	24.0	17.0	38.0	11.0	38.0	130*	1800			
Selenium	TM129	mg/kg	<3	<3	<3	<3	<3	<3	<3	<3	<3	600*	13000			
Zinc	TM129	mg/kg	28.0	91.0	28.0	300.0	300.0	67.0	68.0	28.0	300.0				300 ⁽¹⁾	
Other determinands																
Acid Soluble Sulphide	TM101	mg/kg	-	-	-	-	-	-	-	-	-	-	-	-	-	
Water Soluble Sulphate as SO4 2	TM098	g/l	0.01	0.024	0.026	0.042	0.072	0.034	0.14	0.0	0.1	-	-	-	-	
Soil Organic Matter	TM132	%	0.4	5.0	<0.35	3.7	8.0	4.0	1.2	<0.35	8.0	-	-	-	-	
Total Organic Carbon	TM132	%	0.2	2.9	<0.2	2.2	4.6	2.3	0.7	<0.2	4.6	-	-	-	-	
Phenols Monohydric	TM062	mg/kg	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	520*	3200*			
Total Cyanide	TM153	mg/kg	<1	3.0	<1	<1	<1	<1	<1	<1	3.0	760*	16000*			
Easily Liberatable Cyanide	TM153	mg/kg	-	-	-	-	-	-	-	-	-	-	-	-	-	
% Stones Greater then 10mm	TM008	%	22.0	25.0	15.0	39.0	15.0	28.0	<0.1	<0.1	39.0	-	-	-	-	
Asbestos Presence Screen	TM001	NONE	NFD	NFD	NFD	NFD	NFD	NFD	NFD	NFD	NFD	-	-	-	0.1% ⁽²⁾	
Loss on Ignition	TM018	%	1.1	3.5	0.8	2.2	6.5	3.8	3.8	0.8	6.5	-	-	-	-	
pH Value	TM133	pH Units	8.7	8.6	7.8	8.8	8.5	8.6	8.2	7.8	8.8	-	-	-	5<pH<9 ⁽⁹⁾	
Petroleum Hydrocarbons																
EPH (DRO) (C10-C36)	TM061	mg/kg	<10	613	57	40	43	<10	<10	<10	613.0				500 ⁽³⁾	
Benzene	TM089	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1*	95*		
Toluene	TM089	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	2700*	4400		
Ethyl benzene	TM089	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	840*	2,800		
m & p Xylene	TM089	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	290*	2900		
o Xylene	TM089	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	
Sum of BTX	TM089	mg/kg	-	-	-	-	-	-	-	-	-	-	-	-	-	
MTBE	TM089	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	
Polycyclic Aromatic Hydrocarbons																
Naphthalene	TM142	mg/kg	0.02	0.54	0.01	0.27	0.05	0.18	<0.01	<0.01	0.54	9.3*	1100*			
Acenaphthylene	TM142	mg/kg	<0.01	0.04	<0.01	<0.01	0.06	0.19	<0.01	<0.01	0.19					
Acenaphthene	TM142	mg/kg	0.01	1.02	<0.01	0.17	1.05	0.54	0.01	<0.01	1.05					
Fluorene	TM142	mg/kg	0.02	0.80	<0.01	0.10	0.05	0.33	0.01	<0.01	0.80					
Phenanthrene	TM142	mg/kg	0.17	11.20	<0.01	1.62	2.62	5.72	0.14	<0.01	11.20					
Anthracene	TM142	mg/kg	<0.01	1.86	<0.01	0.09	0.29	0.96	0.05	<0.01	1.86					
Fluoranthene	TM142	mg/kg	0.09	6.50	<0.01	1.23	5.33	10.30	0.20	<0.01	10.30					
Pyrene	TM142	mg/kg	0.05	6.42	<0.01	1.09	5.60	10.90	0.21	<0.01	10.90					
Benzo(a)anthracene	TM142	mg/kg	<0.01	2.30	<0.01	0.38	2.74	4.44	0.07	<0.01	4.44					
Chrysene	TM142	mg/kg	0.01	4.61	<0.01	0.96	5.29	8.07	0.14	<0.01	8.07					
Benzo(b)fluoranthene	TM142	mg/kg	-	-	-	-	-	-	-	-	-	-	-	-	-	
Benzo(k)fluoranthene	TM142	mg/kg	-	-	-	-	-	-	-	-	-	-	-	-	-	
Benzo(a)pyrene	TM142	mg/kg	<0.01	2.06	<0.01	0.54	3.34	5.00	<0.01	<0.01	5.00	1*	14*			
Indeno(123cd)pyrene	TM142	mg/kg	<0.01	1.15	<0.01	0.40	2.55	3.04	<0.01	<0.01	3.04					
Dibenzo(a,h)anthracene	TM142	mg/kg	<0.01	0.48	<0.01	<0.01	0.55	1.00	<0.01	<0.01	1.00				1.3 ⁽⁶⁾	
Benzo(ghi)perylene	TM142	mg/kg	<0.01	2.28	<0.01	0.81	5.01	5.96	<0.01	<0.01	5.96					
PAH 16 Total	TM142	mg/kg	0.37	44.38	0.01	8.42	39.80	64.10	0.83	0.01	64.10				100 ⁽³⁾	
Coronene	TM154	mg/kg	<0.01	0.2	<0.01	<0.01	0.5	0.5	0.2	<0.01	0.51					
PAH USEPA 16 + coronene	TM142	mg/kg	0.4	44.4	<0.01	8.4	39.8	64.1	0.8	0.4	64.1					
Polychlorinated Bihenyls																
PCB congener 28	TM070	mg/kg	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005					
PCB congener 52	TM070	mg/kg	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005					
PCB congener 101	TM070	mg/kg	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005					
PCB congener 118	TM070	mg/kg	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.003	0.075			
PCB congener 153	TM070	mg/kg	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005					
PCB congener 138	TM070	mg/kg	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005					
PCB congener 180	TM070	mg/kg	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005					
Total of 7 Congener PCBs	TM070	mg/kg													1 ⁽¹⁾	
Project name			The co-operative Head Office, Manchester													
Report title			Ground Engineering Interpretative Report													
Table title			Contamination End Use Assessment - Soil results													
Date: October 2009			Appendix No. E					Job No: 009974								

GENERAL NOTES:

All results reported on dry weight basis

NAD = No ACMs Detected

NDP = No Determination Possible

* Conservative Generic Assessment Criteria derived in house using CLEA UK (v.1.04) , assuming SOM 6%.

SCREENING CRITERIA NOTES

(1) ICRL 59/83 Threshold Trigger Value: To assess phytotoxic risks only, not normally hazardous to human health.

(2) Based on Environment Agency Technical Guidance WM2 'Hazardous Waste' (2003, version 1)

(3) Based on Environment Agency 'Guidance on Sampling and Testing of Wastes to meet Landfill Acceptance Procedures' (2005, version 1) Inert waste criteria.

(4) 'New' Dutch - Circular on target values and intervention values for soil remediation. Ministry for Housing, Spatial Planning and Environment, February 2000.

(5) Guidance on the Disposal of "Contaminated Soils". Environment Agency, Version 3, February 2001 (Now withdrawn).

(6) Generic Assessment Criteria for Human Health Risk Assessment. Land Quality Management Ltd & The Chartered Institute of Environmental Health. Published by: Land Quality Press, a division of Land Quality Management Ltd (2007). Residential Without Plant Uptake.

(7) Former SGV retracted in 2007

Co-op HQ (023842): Soil leachate contamination testing results assessment

Determinand	Method	Units	Sample Identity		TPBH01 1.10 SOLID Glacial Till (Cohesive)	TPBH02 1.00 SOLID Made Ground (Cohesive)	TPCPT01 3.20 SOLID Glacial Till (Granular)	TPCPT03 2.00 SOLID Glacial Till (Granular)	TPCPT04 2.20 SOLID Made Ground (Granular)	TPCPT10 0.50 SOLID Made Ground (Granular)	TPCPT10 4.00 SOLID Made Ground (Cohesive)	TPBH01 W1 15.11 LIQUID	TPBH02 W1 16.72 LIQUID	Minimum Value	Maximum Value	UK Drinking Water Standards (The Water Supply (Water Quality) Regulations 2000)	Other Thresholds
Arsenic Dissolved (CEN 10:1C) (ICP-MS)	TM152	mg/kg	<0.0075	0.02	0.009	0.05	0.15	0.11	0.008	0.024	0.083	<0.0075	0.15	0.1	0.5 ⁽¹⁾		
Barium Dissolved (CEN 10:1C) (ICP-MS)	TM152	mg/kg	0.14	0.22	0.05	0.51	0.29	0.1	0.27	-	-	0.05	0.51	1**	0.05 ⁽¹⁾		
Cadmium Dissolved (CEN 10:1C) (ICP-MS)	TM152	mg/kg	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	<0.0022	0.0023	0.0022	<0.0022	0.0023	0.05	0.05 ⁽¹⁾		
Chromium Dissolved (CEN 10:1C) (ICP-MS)	TM152	mg/kg	<0.01	<0.01	<0.01	0.03	0.04	<0.01	<0.01	0.03	0.04	<0.01	0.04	0.5	1.5 ⁽¹⁾		
Copper Dissolved (CEN 10:1C) (ICP-MS)	TM152	mg/kg	<0.016	<0.016	<0.016	0.018	0.038	<0.016	<0.016	<0.016	<0.016	<0.016	0.038	20	0.01 ⁽¹⁾		
Lead Dissolved (CEN 10:1C) (ICP-MS)	TM152	mg/kg	<0.004	0.006	<0.004	<0.004	0.021	0.011	0.006	0.001	<0.004	<0.004	0.021	0.25	0.2 ⁽¹⁾		
Antimony Dissolved (CEN 10:1C) (ICP-MS)	TM152	mg/kg	0.039	0.020	<0.0075	0.014	0.049	0.015	0.009	<0.0075	0.008	<0.0075	0.049	0.05	0.2 ⁽²⁾		
Molybdenum Dissolved (CEN 10:1C) (ICP-MS)	TM152	mg/kg	0.03	0.11	<0.01	0.05	0.06	0.04	0.07	-	-	0.03	0.11		3 ⁽²⁾		
Nickel Dissolved (CEN 10:1C) (ICP-MS)	TM152	mg/kg	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	0.018	0.01	0.0036	<0.015	0.018	0.2	0.5 ⁽¹⁾		
Selenium Dissolved (CEN 10:1C) (ICP-MS)	TM152	mg/kg	<0.01	0.02	0.01	<0.01	<0.01	<0.01	0.1	0.01	0.03	<0.01	0.1	0.1			
Zinc Dissolved (CEN 10:1C) (ICP-MS)	TM152	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.11	0.07	<0.05	0.11	30**	0.75 ⁽¹⁾		
Mercury Dissolved (CEN 10:1C) (CVAF)	TM183	mg/kg	<0.0001	<0.0001	<0.0001	<0.0001	0.0008	0.0002	<0.0001	<0.0001	<0.0004	<0.0001	0.0008	0.01	0.01 ⁽¹⁾		
Chloride (CEN 10:1C)	TM097	mg/kg	<10	19	<10	<10	23	11	26	880	520	<10	880	2500			
Fluoride (CEN 10:1C)	TM104	mg/kg	7	7	<5	<5	14	9	12	<5	<5	<5	14	15			
Sulphate (CEN 10:1C)	TM098	mg/kg	80	100	35	31	84	<30	380	4400	1200	<30	4400	2500**	4000 ^{(1)*}		
Total Dissolved Solids (by meter) (CEN 10:1C)	TM123	mg/kg	420	480	240	370	650	460	1100	-	-	240	1100				
Phenols Monohydric (CEN 10:1C)	TM062	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.01**	0.3 ^{(1)*}		
Dissolved Organic Carbon (CEN 10:1C)	TM090	mg/kg	<30	<30	<30	<30	<30	<30	<30	40	60	<30	40				
Boron Dissolved (CEN 10:1C) (ICP-MS)	TM152	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	<0.2	<0.2	10	20 ⁽¹⁾		
EPH (CEN 10:1C)	TM172	mg/kg	0.0	0.058	0.0	0.0	0.0	0.0	0.0	0.5	<0.5	0	0.5	0.5**	6 ⁽²⁾		
PAH by GCMS																	
Naphthalene (CEN 10:1C)	TM178	mg/kg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.0001	<0.0001	0	<0.0001		0.1 ⁽¹⁾		
Acenaphthylene (CEN 10:1C)	TM178	mg/kg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.0001	<0.0001	0	<0.0001				
Acenaphthene (CEN 10:1C)	TM178	mg/kg	0.0	0.0	0.0	0.000021	0.0	0.0	0.0	<0.0001	<0.0001	0	0.000021				
Fluorene (CEN 10:1C)	TM178	mg/kg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.0001	<0.0001	0	<0.0001				
Phenanthrene (CEN 10:1C)	TM178	mg/kg	0.0	0.0	0.000025	0.000034	0.0	0.0	0.0	<0.0001	<0.0001	0	0.000034				
Anthracene (CEN 10:1C)	TM178	mg/kg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.0001	<0.0001	0	<0.0001				
Fluoranthene (CEN 10:1C)	TM178	mg/kg	0.0	0.0	0.000043	0.000018	0.000039	0.000036	0.0	<0.0001	<0.0001	0	0.000043				
Pyrene (CEN 10:1C)	TM178	mg/kg	0.0	0.0	0.000024	0.0	0.000046	0.000044	0.0	<0.0001	<0.0001	0	0.000046				
Benzo(a)anthracene (CEN 10:1C)	TM178	mg/kg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.0001	<0.0001	0	<0.0001				
Chrysene (CEN 10:1C)	TM178	mg/kg	0.0	0.0	0.0	0.0	0.000013	0.00002	0.0	<0.0001	<0.0001	0	0.00002				
Benzo(b)fluoranthene (CEN 10:1C)	TM178	mg/kg	0.0	0.0	0.0	0.0	0.00003	0.000048	0.0	<0.0001	<0.0001	0	0.000048				
Benzo(k)fluoranthene (CEN 10:1C)	TM178	mg/kg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.0001	<0.0001	0	<0.0001				
Benzo(a)pyrene (CEN 10:1C)	TM178	mg/kg	0.0	0.0	0.0	0.0	0.000019	0.000032	0.0	<0.0001	<0.0001	0	0.000032	0.0001	0.0005 ⁽²⁾		
Indeno(123cd)pyrene (CEN 10:1C)	TM178	mg/kg	0.0	0.0	0.0	0.0	0.000018	0.00002	0.0	<0.0001	<0.0001	0	0.00002				
Dibenzo(a,h)anthracene (CEN 10:1C)	TM178	mg/kg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.0001	<0.0001	0	<0.0001				
Benzo(ghi)perylene (CEN 10:1C)	TM178	mg/kg	0.0	0.0	0.0	0.0	0.000043	0.000043	0.0	<0.0001	<0.0001	0	0.000043				
PAH 16 Total (CEN 10:1C)	TM178	mg/kg	0.0	0.0	0.0	0.0	0.00021	0.00024	0.0	0.0	0.0	0	0.00024				

Project name	The co-operative Head Office, Manchester		 Buro Happold Ground Engineering
Report title	Ground Engineering Interpretative Report		
Table title	Contamination End Use Assessment - Lechate results		
Date: October 2009	Appendix No. E	Job No: 009974	

GENERAL NOTES:

(1) Freshwater Environmental Quality Standard. For hardness-related determinands, worse-case hardness band adopted 0 - 50 mg/l CaCO₃

(2) Dutch Intervention Value for groundwater, from 'Circular on target values and intervention values for soil remediation' (2000)

*EA non-statutory (operational)

**From The Surface Waters (Abstraction for Drinking Water) (Classification) Regulations 1996 (DW-1)

Appendix F – Geoenvironmental Assessment Guidance

CLEA Guidelines

In March 2002, DEFRA published the Contaminated Land Reports, including the Contaminated Land Exposure Assessment (CLEA) model²¹. This guidance was revised in August 2008 and the Environment Agency published revised CLEA technical guidance and associated CLEA software model [Version 1.03 (beta)].

Based on recently published statutory guidance documents^{22, 23} Generic Assessment Criteria (GAC) have been derived at Buro Happold with consideration of the most sensitive receptors in the respective CLEA standard land-uses scenarios (the 0 to 6 year old child for residential with and without plant uptake scenarios and adult for the commercial/industrial land-use scenario) using the software model 'CLEA 1.03 beta' and associated handbook^{24, 25}. It has to be noted that the new software model (CLEA 1.03) is a beta version issued by the Environment Agency for a three-month evaluation period for comment (until the end of November 2008) replacing the previous and withdrawn CLEA UK software²⁶. Despite the software still being in its evaluation period, it has been found to be the most suitable for the purpose of deriving human health risk assessment criteria. This is because the software has been developed and takes account of recent changes made to the contaminated land human health risk assessment approach.

Health Criteria Value (HCV) model input parameters have been adopted as issued in the 'old style tox reports'. The old style tox reports are to be superseded by 'new tox reports' in line with the new guidance. However, in the interim the Environment Agency advice is to use the old style tox reports as changes associated with the new guidance are unlikely to result in significantly different HCVs.

Assessment criteria for aliphatic and aromatic hydrocarbons bands have been derived in line with the EA publication 'The UK approach for evaluating human health risks'²⁷.

²¹ DEFRA (2002). *The contaminated Land Exposure Assessment (CLEA) Model*. Department of the Environment, Food & Rural Affairs/Environment Agency. R&D Publications CLR 1 to 10.

²² Environment Agency. 2008. Updated technical background to the CLEA model. Science Report – SC050021/SR3. August 2008.

²³ Environment Agency. 2008. Human health toxicological assessment of contaminants in soil. Science Report – SC050021/SR2. August 2008.

²⁴ Environment Agency 2008. CLEA Software Version 1.03 beta, Retrieved from the internet: http://www.environment-agency.gov.uk/subjects/landquality/113813/2021813/2021831/2023822/2029234/?version=1&lang=_e.

²⁵ Environment Agency. 2008. CLEA Software (Version 1.03) Handbook. Science Report – SC050021/SR4. August 2008.

²⁶ Environment Agency SEPA and DEFRA. 2005. Contaminated Land Exposure Assessment Model 'CLEA UK' – Version 1.0. Retrieved from the internet: http://www.environment-agency.gov.uk/subjects/landquality/113813/672771/1166367/1166388/?version=1&lang=_e (withdrawn by the Environment Agency in August 2008).

²⁷ Environment Agency. 2005. The UK Approach for Evaluating Human Health Risks from Petroleum Hydrocarbons in Soils. Science Report P5-080/TR3. February 2005.

In the near future assessment criteria for lead are to be derived using the CLEA 1.03 model. However, in the absence of an HCV value for this contaminant, assessment criteria for lead have been adopted as derived and detailed in the old style lead SGV (Soil Guideline Value) report²⁸. Lead assessment criteria as detailed in the old style SGV report had been derived on the basis of a response of the blood lead versus soil and dust lead relationship in line with a model developed by the Society for Environmental Geochemistry and Health (residential) and USEPA (commercial) respectively.

It should be noted that the CLEA methodology is only applicable to risk assessments in respect of human health and for long term (chronic) exposure. As such, they are not relevant to short term exposure such as transient construction groundworks.

CLEA GACs, which are set in terms of soil concentrations, are only relevant to the first metre of material below final ground level and to material that might be brought to the surface during construction.

For parameters which do not fall within these criteria or for which GACs are not currently available, assessment against site-specific criteria derived using the CLEA or SNIFFER methodologies, or other existing recognized guidelines is generally considered acceptable.

Dutch Guidelines

The Netherlands (Dutch) Standards²⁹ are sometimes used by UK statutory authorities such as the Environment Agency for assessing contaminants for which there are no UK guidelines, and particularly with respect to groundwater with 'Intervention Values' typically used as an unacceptable water quality for a minor aquifer.

The Dutch Standards have two levels of contamination, namely 'Target' and 'Intervention' values. The 'Target' values are used for reference and soils or waters with determinand concentrations below these values can be considered to be uncontaminated. The 'Intervention' values represent the upper limit of acceptability such that any soils or waters with determinand concentrations exceeding these values are considered unacceptable and require remediation. They are not equivalent in concept to assessment criteria derived in the CLEA framework. There are specific requirements regarding investigation and sampling.

It is worthy of note that the Dutch Standards are derived for specific use in the Netherlands and are, therefore, not necessarily applicable to the UK environment. Target and Intervention Values are set variously to be protective of human health or ecosystems (two values are derived and the lower one adopted for individual contaminants). They are, consequently, sometimes overprotective for human health. Furthermore, the Target Values provide "targets" for the remediation of a site so that it is suitable for any end use and, as such, are

²⁸ DEFRA and Environment Agency. 2002. Soil Guideline Values. Lead, R & D Publication SGV 10 (document withdrawn by the Environment Agency in August 2008).

²⁹ *Circular on target values and intervention values for soil remediation*. Ministry for Housing, Spatial Planning and Environment, February 2000,

designed for the most sensitive receptor – natural soil ecosystems and other ecosystems. They are, therefore, conservative for areas of light industry, commercial use or communal open space, and possibly also in respect of human health risks in domestic gardens.

Drinking Water Standards

The UK Drinking Water Standards³⁰ are often used to assess the quality of groundwater. Where a specific determinand is not listed, the Dutch Guidelines are typically used or other guidance as necessary in the context of the proposed development or specific requirements applicable to the zone of influence of the site. Clearly, where background groundwater quality is questionable, assessment using these standards is considered to be conservative.

Environmental Quality Standards

The Freshwater Environmental Quality Standards (EQS) for receiving watercourses are published by the Environment Agency. Every listed dangerous substance in the EC Dangerous Substance Directive has a concentration limit called an EQS which must not be exceeded in any controlled watercourse in England and Wales. The dangerous substance is not believed to be detrimental to aquatic flora and fauna at a concentration below its EQS limit. The Environment Agency recommends a tiered approach to assessing the risk to groundwater. A tier 1 assessment compares the pore fluid concentrations in the pollution source zone with the EQS. Pore fluid concentrations can be considered analogous with soil leachate concentrations for the purposes of this assessment. If leachate concentrations exceed the relevant Freshwater EQS values then further assessment with respect to pollution of controlled waters is necessary.

Waste Disposal Guidelines

The Environment Agency 'Guidance on the Disposal of "Contaminated Soils"'³¹ provides soil and leachate threshold concentrations to allow the degree of contamination present to be assessed in respect of waste disposal. It thus provides a general indication of the degree of hazard presented by any surplus materials which require disposal and allows a broad assessment of the type of site where the disposal of such surplus materials is considered acceptable.

The guidance provides three threshold concentration categories, namely:

- Upper Threshold Concentration (mg/kg) - Upper soil concentration criteria.
- Lower Threshold Concentration (mg/kg) - Lower soil concentration criteria.
- Leachate Quality Threshold (µg/l unless stated) - Leachate concentration criteria.

The soil and leachate concentrations are assessed against these threshold values and the number of determinands exceeding each threshold is reported, thus allowing large quantities of chemical testing data to

³⁰ *The Water Supply (Water Quality) Regulations 2000*. Statutory Instrument 2000 No. 3184.

be categorized in terms of waste disposal. The 'Guidance on the Disposal of "Contaminated Soils"' was withdrawn in December 2002.

In July 2004, '*The Landfill (England and Wales) (Amendment) Regulations 2004*' came into force as '*Statutory Instrument 2004 No. 1375*'. These regulations implement in England and Wales, Council Decision 2033/33/EC establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of Annex II to Directive 1999/31/EC on the landfill of waste ("*the Landfill Directive*"). They also make some minor amendments to the UK Regulations which transpose the Landfill Directive (The Landfill (England and Wales) Regulations 2002 (SI2002/1559)).

The Landfill Directive encourages waste minimization and increased levels of recycling and recovery. The main aim of this is to prevent or reduce as far as possible negative effects on the environment and any resulting risk to human health of landfilling by way of stringent operational and technical requirements, measures, procedures and guidance. The result is that landfilling becomes a less attractive waste management option overall in terms of cost and convenience.

A document entitled '*Framework for the Classification of Contaminated Soils as Hazardous Waste*'³², dated July 2004, has been provided by the Environment Agency to aid producers of contaminated soils in deciding when contaminated soils are 'hazardous' wastes in the terms set out in Environment Agency "Technical Guidance WM2"³³ issued in accordance with the EU Hazardous Waste Directive.

Waste Acceptance Criteria (WAC) help meet the Directives main aim by prescribing the standards that waste must meet to be accepted at one of the three classes of landfill ('*inert*', '*non-hazardous*', '*hazardous*') established in the Landfill Directive. The WAC provide soil and leachate limit concentrations for a number of contaminants and harmonizes this aspect of landfill regulation across Europe. The EU criteria (which are implemented in the UK by SI No. 1375) are summarized in Table 2.1 below.

Notwithstanding the above it should be noted that each waste disposal facility will have a list of site specific acceptance criteria which form part of their waste licence. Consequently, the broad assessment made on the basis of the Environment Agency guidance referred to above is an indicative overview. The selection of a specific waste disposal facility lies outside the scope of the appraisal of contamination normally undertaken for interpretative reporting purposes.

³¹ *Guidance on the Disposal of "Contaminated Soils"*. Environment Agency. Version 3, February 2001.

³² *Framework for the Classification of Contaminated Soils as Hazardous Waste*. Environment Agency. Version 1, July 2004.

³³ *Technical Guidance WM2 Hazardous Waste – Interpretation and Classification of Hazardous Waste*. Environment Agency. Version 1, June 2003.

Table 1: Summary of Council Decision waste acceptance criteria¹¹

Parameter	Inert waste landfill	Stable non-reactive hazardous waste in non-hazardous landfill [†]	Hazardous waste landfill
Parameters determined on the waste			
Total organic carbon (w/w %)	3%	5%	6%*
Loss on ignition			10%*
BTEX (benzene, toluene, ethylbenzene and xylenes) (mg kg ⁻¹)	6		
PCBs (polychlorinated biphenyls, 7 congeners) (7 congeners) (mg kg ⁻¹)	1		
Mineral oil C ₁₀ -C ₄₀ (mg kg ⁻¹)	500		
PAHs (polycyclic aromatic hydrocarbons)	To be set		
PH		>6	
Acid neutralisation capacity		To be evaluated	To be evaluated
Limit values (mg kg⁻¹) for compliance leaching test using BS EN 12457/ 3 at cumulative L/S 10 l kg⁻¹ ¹²			
As (arsenic)	0.5	2	25
Ba (barium)	20	100	300
Cd (cadmium)	0.04	1	5
Cr (chromium (total))	0.5	10	70
Cu (copper)	2	50	100
Hg (mercury)	0.01	0.2	2
Mo (molybdenum)	0.5	10	30
Ni (nickel)	0.4	10	40
Pb (lead)	0.5	10	50
Sb (antimony)	0.06	0.7	5
Se (selenium)	0.1	0.5	7
Zn (zinc)	4	50	200
Cl (chloride)	800	15,000	25,000
F (fluoride)	10	150	500
SO ₄ (sulphate)	1,000 [#]	20,000	50,000
Total dissolved solids (TDS) ⁺	4,000	60,000	100,000
Phenol index	1		
Dissolved organic carbon at own pH or pH7.5-8.0 [®]	500	800	1,000

[†] And non-hazardous wastes deposited in the same cell * Either TOC or LOI must be used or hazardous wastes

** UK PAH limit values are under development

Alternative limit values can be used to demonstrate compliance with the acceptance criteria for inert wastes as set out in the Council Decision.

+ The values for TDS can be used instead of the values for Cl and SO₄.

® DOC at pH 7.5-8.0 and L/S10 can alternatively be determined using prEN 14129 test.

¹¹ Environment Agency, Guidance on Sampling and Testing of Wastes to meet Landfill Acceptance Procedures, Version 4.3a (December 2003)

¹² The leaching limit values were derived by the Technical Adaptation Committee by risk modelling based on the technical requirements for the protection of soil and groundwater for the different classes of landfill imposed by Annex I of the Landfill Directive.

Appendix G – Contamination Risk Assessment

TABLE CRA1: POSSIBLE SOURCES, PATHWAYS AND TARGETS

Possible Sources	Comments	Further Assessment?
Made Ground	Proven on site to maximum depth of 4.30 m. Concentrations of lead exceed commercial/industrial SGV. Also elevated concentrations of mercury, EPH and BAP found.	Yes
Landfill sites	One licensed waste management facility within 250 m. No landfill sites recorded within 500 m of site.	No (not considered to affect site)
Radon source	Less than 1% of homes above the Action Level.	No
Pollution Incidents	4 No. Pollution Incidents to Controlled Waters recorded within a 250 m radius of the site, all categorized as Category 3 – Minor incident.	No
Contemporary Trade Entries	9 No. entries within 250 m.	No (not considered to affect site)
Historical land uses – Possible Buried fuel tank(s)	Petrol Store on 1968 OS map, within site boundary.	Yes
Unexploded Ordnance (UXO)	Site been identified as having significant risk of UXO	Yes

Possible Pathways	Further Assessment?
<i>To Human targets</i>	
Ingestion of soil (e.g. arsenic, cadmium, lead, cyanide, PAHs, phenols)	Yes
Inhalation of soil dust via air flow	Yes
Ingestion of soil attached to vegetables	No
Ingestion through consumption of contaminated vegetables (e.g. cadmium, lead,)	No
Ingestion via contaminated water supplies (e.g. phenols, cyanide)	Yes
Skin contact (e.g. tars, oils, corrosive substances, phenols)	Yes
Inhalation of gas/vapour (e.g. carbon dioxide, methane, VOCs)	Yes
Fire and explosion (e.g. methane, sulphur, combustible materials)	No
<i>To Natural Environment targets</i>	
Surface runoff	Yes
Leaching or liquid phase flow (e.g. soluble metals, phenols, free product hydrocarbons)	Yes
Groundwater transport in dissolved or liquid phase	Yes
Uptake by plants with resulting phytotoxic effects (e.g. copper, zinc, nickel, carbon dioxide, methane oxygen depletion)	Yes
Accumulation in ecosystems (e.g. cadmium, lead, pesticides)	Yes

Possible Targets	Relative sensitivity	Further Assessment?
<i>Human</i>		
Site users currently	High	Yes
Construction workers	High	Yes
Public offsite	High	Yes
Site end users	High	Yes
<i>Natural Environment</i>		
Perched water onsite	Low	Yes
Perched water offsite	Low	Yes
Major aquifer onsite	High	Yes
Major aquifer offsite	High	Yes
Surface water onsite	-	No
Surface water offsite	Medium	Yes
Vegetation onsite	Medium	Yes
Ecosystems	-	No

NOTE: Where further assessment is required, the relevant Contamination Risk Assessment element is carried forward to Risk Assessment Tables CRA 2 and CRA 3.

Sources of information and guidance used in this assessment.

- CIRIA (2001) C552 Contaminated Land Risk Assessment: A guide to good practice (Authors: Rudland D.J., Lancefield R.M. and Mayell P.N.).
- DEFRA (2004) Model Procedures for the Management of Land Contamination. Contaminated Land Report (CLR) 11.
- ODPM (2004) Planning Policy Statement 23: Planning and Pollution Control – Annex 2 Development on Land Affected By Contamination.

Definition of Severity (Consequence) and Likelihood (Probability)

Source: CIRIA 552 (2001)

Table 6.3 *Classification of consequence*

Classification	Definition	Examples
Severe	Short-term (acute) risk to human health likely to result in "significant harm" as defined by the Environment Protection Act 1990, Part IIA. Short-term risk of pollution (note: Water Resources Act contains no scope for considering significance of pollution) of sensitive water resource. Catastrophic damage to buildings/property. A short-term risk to a particular ecosystem, or organism forming part of such ecosystem (note: the definitions of ecological systems within the Draft Circular on Contaminated Land, DETR, 2000).	High concentrations of cyanide on the surface of an informal recreation area. Major spillage of contaminants from site into controlled water. Explosion, causing building collapse (can also equate to a short-term human health risk if buildings are occupied).
Medium	Chronic damage to Human Health ("significant harm" as defined in DETR, 2000). Pollution of sensitive water resources (note: Water Resources Act contains no scope for considering significance of pollution). A significant change in a particular ecosystem, or organism forming part of such ecosystem. (note: the definitions of ecological systems within Draft Circular on Contaminated Land, DETR, 2000).	Concentrations of a contaminant from site exceed the generic, or site-specific assessment criteria. Leaching of contaminants from a site to a major or minor aquifer. Death of a species within a designated nature reserve.
Mild	Pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services ("significant harm" as defined in the <i>Draft Circular on Contaminated Land</i> , DETR, 2000). Damage to sensitive buildings/structures/services or the environment.	Pollution of non-classified groundwater. Damage to building rendering it unsafe to occupy (eg foundation damage resulting in instability).
Minor	Harm, although not necessarily significant harm, which may result in a financial loss, or expenditure to resolve. Non-permanent health effects to human health (easily prevented by means such as personal protective clothing etc). Easily repairable effects of damage to buildings, structures and services.	The presence of contaminants at such concentrations that protective equipment is required during site works. The loss of plants in a landscaping scheme. Discoloration of concrete.

Table 6.4 *Classification of probability*

Classification	Definition
High likelihood	There is a pollution linkage and an event that either appears very likely in the short term and almost inevitable over the long term, or there is evidence at the receptor of harm or pollution.
Likely	There is a pollution linkage and all the elements are present and in the right place, which means that it is probable that an event will occur. Circumstances are such that an event is not inevitable, but possible in the short term and likely over the long term.
Low likelihood	There is a pollution linkage and circumstances are possible under which an event could occur. However, it is by no means certain that even over a longer period such event would take place, and is less likely in the shorter term.
Unlikely	There is a pollution linkage but circumstances are such that it is improbable that an event would occur even in the very long term

Definition of Risk

Source: CIRIA 552 (2001)

Table 6.5 Comparison of consequence against probability

		Consequence			
		Severe	Medium	Mild	Minor
Probability	High likelihood	Very high risk	High risk	Moderate risk	Moderate/low risk
	Likely	High risk	Moderate risk	Moderate/low risk	Low risk
	Low likelihood	Moderate risk	Moderate/low risk	Low risk	Very low risk
	Unlikely	Moderate/low risk	Low risk	Very low risk	Very low risk

Table 6.6 Description of the classified risks and likely action required

Very high risk	There is a high probability that severe harm could arise to a designated receptor from an identified hazard; OR, there is evidence that severe harm to a designated receptor is currently happening. This risk, if realised, is likely to result in a substantial liability. Urgent investigation (if not undertaken already) and remediation are likely to be required.
High risk	Harm is likely to arise to a designated receptor from an identified hazard. Realisation of the risk is likely to present a substantial liability. Urgent investigation (if not undertaken already) is required and remedial works may be necessary in the short term and are likely over the longer term
Moderate risk	It is possible that harm could arise to a designated receptor from an identified hazard. However, it is either relatively unlikely that any such harm would be severe, or if any harm were to occur it is more likely that the harm would be relatively mild Investigation (if not already undertaken) is normally required to clarify the risk and to determine the potential liability. Some remedial works may be required in the longer term
Low risk	It is possible that harm could arise to a designated receptor from an identified hazard, but it is likely that this harm, if realised, would at worst normally be mild.
Very low risk	There is a low possibility that harm could arise to a receptor. In the event of such harm being realised it is not likely to be severe.

TABLE CRA 2: RISK ASSESSMENT FOR HUMAN HEALTH

CURRENT CONDITION

Critical receptors: Adult/children – car parking, short term exposure

Source			Target	Pathway		Risk assessment			Actions required for acceptable risk
Type	Potential contaminants	Location and Depth		Exposure pathways considered viable	Exposure areas	Severity	Likelihood	Risk	
Made Ground	Heavy metals, EPH, BAP dependent on source of material.	Located in all exploratory holes to a maximum depth of 4.30 m BGL	Site users	Skin contact Ingestion of soil (all solid phase contaminants) Inhalation of soil dust via air flow (metals, some organics) Inhalation of gas/vapour (fuel derivatives/degradation products+ VOCs)	Site wide Site wide Site wide Site wide	Mild Medium Mild Medium	Unlikely Unlikely Unlikely Unlikely	Very Low Low Very Low Low	None
Possible buried fuel tanks	Petroleum hydrocarbons and fuel derivatives.	Central area of site. No tanks located in site or archaeological investigation.		Ingestion via contaminated water supplies (mobile organics) Inhalation of gas/vapour (fuel derivatives/degradation products+ VOCs)	In central area surrounding possible tank In central area surrounding possible tank	Medium Medium	Unlikely Unlikely	Low Low	None
UXO	Explosives	Site wide to maximum depth of rock head		Explosion	Site wide	Severe	Unlikely	Mod/ Low	None

CONSTRUCTION PHASE Key events: Demolition, new build structure, foundation solution, landscaping.

Critical receptors: Construction worker of adult age, short term exposure

Source			Target	Pathway		Risk assessment			Actions required for acceptable risk
Type	Potential contaminants	Location and Depth		Exposure pathways considered viable	Exposure areas	Severity	Likelihood	Risk	
Made Ground	Heavy metals, EPH, BAP dependent on source of material.	Located in all exploratory holes to a maximum depth of 4.30 m BGL	Construction workers (+ public)	Skin contact Ingestion of soil (all solid phase contaminants) Inhalation of soil dust (metals, some organics) Inhalation of gas/vapour (fuel derivatives/degradation products+ VOCs)	All areas of groundwork, including excavations for foundations, service laying and landscaping	Mild Medium Mild Medium	Unlikely Unlikely Unlikely Unlikely	Very Low Low Very Low Low	Use of PPE Use of PPE Site dust control Use of PPE
Possible buried fuel tanks	Petroleum hydrocarbons and fuel derivatives.	Central area of site. No tanks located in site or archaeological investigation.		Skin contact (tars, oils) Ingestion of soil Inhalation of soil dust via air flow (organics) Inhalation of gas/vapour (fuel derivatives/degradation products+ VOCs)	Immediate area around tanks (if found).	Mild Medium Mild Medium	Unlikely Unlikely Unlikely Unlikely	Very Low Low Very Low Low	Minimise excavation work in this area / Use of PPE when unavoidable
UXO	Explosives	Site wide to maximum depth of rock head		Explosion	Site wide	Severe	Low likelihood	Moderate	UXO clearance during site works

*Construction phase specific contaminants not considered in this assessment, refer to project specific Health and Safety, CDM and COSHH regulations.

PROPOSED DEVELOPMENT CONDITION

Critical receptors: Office worker, long term exposure

Source			Target	Pathway		Risk assessment			Actions required for acceptable risk
Type	Potential contaminants	Location and Depth		Exposure pathways considered viable	Exposure areas	Severity	Likelihood	Risk	
Made Ground	Heavy metals, EPH, BAP dependent on source of material.	Located in all exploratory holes to a maximum depth of 4.30 m BGL	Site users	Skin contact Ingestion of soil (all solid phase contaminants) Inhalation of soil dust via air flow (metals, some organics) Ingestion via contaminated water supplies (phenols) Inhalation of gas/vapour (fuel derivatives/degradation products+ VOCs)	Soft landscaping only Soft landscaping only Soft landscaping only Main building Confined spaces	Mild Medium Mild Medium Medium	Unlikely Unlikely Unlikely Unlikely Unlikely	Very Low Low Very Low Low Low	Clean topsoil Clean topsoil Clean Topsoil Water pipe protection Basic gas protection
Possible buried fuel tanks	Petroleum hydrocarbons and fuel derivatives.	Central area of site. No tanks located in site or archaeological investigation.		Ingestion via contaminated water supplies (mobile organics) Inhalation of gas/vapour (fuel derivatives/degradation products+ VOCs)	Main building Confined spaces	Medium Medium	Unlikely Unlikely	Moderate/Low Moderate/Low	Water pipe protection Basic gas protection
UXO	Explosives	Site wide to maximum depth of rock head		Explosion	Site Wide	Severe	Unlikely	Mod/Low	Site cleared of UXO

TABLE CRA 3: RISK ASSESSMENT FOR NATURAL ENVIRONMENT

CURRENT CONDITION

Critical receptors: Sherwood Sandstone (Major Aquifer)

Source			Target		Pathway	Risk assessment			Actions required for acceptable risk
Type	Potential contaminants	Location and Depth	Targets	Relative Sensitivity		Severity	Likelihood	Risk	
Made Ground	Heavy metals, EPH, BAP dependent on source of material.	Located in all exploratory holes to a maximum depth of 4.30 m BGL	Perched groundwater on site Perched groundwater off site Sherwood Sandstone major aquifer on site Sherwood Sandstone major aquifer off site River Irk (off site)	Low Low High High Medium Medium	Leaching or liquid phase flow Groundwater transport in dissolved or liquid phase Groundwater transport in dissolved or liquid phase Groundwater transport in dissolved or liquid phase Groundwater transport in dissolved or liquid phase Groundwater transport in dissolved or liquid phase Uptake by plants with resulting phytotoxic effects	Mild Mild Medium Medium Medium Minor	Low likelihood Low likelihood Unlikely Unlikely Unlikely Low likelihood	Low Low Low Low Low Very Low	None
Possible Buried fuel tanks	Petroleum hydrocarbons and fuel derivatives.	Central area of site. No tanks located in site or archaeological investigation.	On site vegetation						

CONSTRUCTION PHASE Key events: Demolition, new build structure, foundation solution, landscaping.

Critical receptors: Sherwood Sandstone (Major Aquifer)

Source			Target		Pathway	Risk assessment			Actions required for acceptable risk
Type	Potential contaminants	Location and Depth	Targets	Relative Sensitivity		Severity	Likelihood	Risk	
Made Ground	Heavy metals, EPH, BAP dependent on source of material.	Located in all exploratory holes to a maximum depth of 4.30 m BGL	Perched groundwater on site Perched groundwater off site Sherwood Sandstone major aquifer on site Sherwood Sandstone major aquifer off site River Irk (off site)	Low Low High High Medium Medium	Leaching or liquid phase flow Groundwater transport in dissolved or liquid phase Groundwater transport in dissolved or liquid phase Groundwater transport in dissolved or liquid phase Groundwater transport in dissolved or liquid phase and runoff Groundwater transport in dissolved or liquid phase and accumulation in ecosystems Uptake by plants with resulting phytotoxic effects	Mild Mild Medium Medium Medium Medium	Low likelihood Low likelihood Unlikely Unlikely Unlikely Unlikely	Low Low Low Low Low Low	Covers/drainage Covers/drainage Covers/drainage Covers/drainage Covers/drainage Covers/drainage
Possible Buried fuel tanks	Petroleum hydrocarbons and fuel derivatives.	Central area of site. No tanks located in site or archaeological investigation.	On site vegetation						
Construction phase specific	Fuels, construction materials, oils etc	All of site	Construction workers	High	Skin contact Ingestion of soil (all solid phase contaminants) Inhalation of soil dust via air flow	Minor Minor Minor Minor	Unlikely Low likelihood Low likelihood Low likelihood	Low Very Low Very Low Very Low	Covers/drainage Use of PPE Use of PPE Site dust control

PROPOSED DEVELOPMENT CONDITION

Critical receptors: Sherwood Sandstone (Major Aquifer)

Source			Target		Pathway	Risk assessment			Actions required for acceptable risk
Type	Potential contaminants	Location and Depth	Targets	Relative Sensitivity		Severity	Likelihood	Risk	
Made Ground	Heavy metals, EPH, BAP dependent on source of material.	Located in all exploratory holes to a maximum depth of 4.30 m BGL	Perched groundwater on site Perched groundwater off site Sherwood Sandstone major aquifer on site Sherwood Sandstone major aquifer off site Nearest surface watercourse (off site)	Low Low High High Medium High	Leaching or liquid phase flow Groundwater transport in dissolved or liquid phase Groundwater transport in dissolved or liquid phase Groundwater transport in dissolved or liquid phase Groundwater transport in dissolved or liquid phase Groundwater transport in dissolved or liquid phase and accumulation in ecosystems Uptake by plants with resulting phytotoxic effects	Mild Mild Medium Medium Medium Medium	Low likelihood Low likelihood Unlikely Unlikely Unlikely Unlikely	Low Low Low Low Low Low	Hardcover and surface water drainage incorporated into design will limit rainwater infiltratio
Possible Buried fuel tanks	Petroleum hydrocarbons and fuel derivatives.	Central area of site. No tanks located in site or archaeological investigation.	On site vegetation	Medium		Minor	Low likelihood	Very Low	

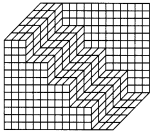
Appendix H – Ground Gas Summary

GROUND GAS ASSESSMENT	Job name: The co-operative Head Office	Job number: 023843
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GUIDANCE: Assessment based on guidance published in CIRIA C665 (2007) 'Assessing risks posed by hazardous ground gases to buildings.'	
Information from Table 8.5 of CIRIA C665	Key for shading
Characteristic Situation 1 conditions Gas screening value (CH4 or CO2) < 0.07 l/h Typically methane < 1 % by volume Typically carbon dioxide < 5% by volume Characteristic Situation 2 conditions Gas screening value (CH4 or CO2) < 0.7 l/h Borehole air flow rate < 70 l/h Characteristic Situation 3 conditions Gas screening value (CH4 or CO2) < 3.5 l/h	
NOTES: Maximum concentration and flow values are assessed below (minimum values for oxygen). Where no detectable flow is recorded the limit of detection of the instrument is used, following Note 5 of Table 8.5. CIRIA C665	

			Gas measurements					CO ₂ analysis		CH ₄ analysis		Characteristic
Exploratory Hole	Installation response zone stratum	Date	Flow Rate (l/hr)	Atmos Pres (mb)	O2 (%) air	CO2 (%) air	CH4 (%) air	CO2 as fraction	Gas screening value CO ₂ (l/hr)	CH ₄ as fraction	Gas screening value CH ₄ (l/hr)	Situation
BH1 (50 mm)	SANDSTONE	03/06/2009	0	1020	20.3	0.7	0	0.007	0.001	0.000	0.000	1
		17/06/2009	0	1008	19.1	1.6	0	0.016	0.002	0.000	0.000	1
		02/07/2009	0	1012	21.2	0.5	0	0.005	0.001	0.000	0.000	1
		15/07/2009	0	999	20.9	0	0	0.000	0.000	0.000	0.000	1
		29/07/2009	0	1002	21.3	0	0	0.000	0.000	0.000	0.000	1
		13/08/2009	0	1012	21.6	0.2	0	0.002	0.000	0.000	0.000	1
BH1 (19 mm)	SAND	03/06/2009	0	1020	19.2	1.1	0	0.011	0.001	0.000	0.000	1
		17/06/2009	0	1008	19.6	1	0	0.010	0.001	0.000	0.000	1
		02/07/2009	0	1012	20.5	0.7	0	0.007	0.001	0.000	0.000	1
		15/07/2009	0	999	20.9	0	0	0.000	0.000	0.000	0.000	1
		29/07/2009	0	1002	20.3	0.9	0	0.009	0.001	0.000	0.000	1
		13/08/2009	0	1011	20.1	1.4	0	0.014	0.001	0.000	0.000	1
BH2 (50 mm)	SANDSTONE	03/06/2009	0	1019	21	0.1	0	0.001	0.000	0.000	0.000	1
		17/06/2009	1.8	1007	20.8	0.1	0	0.001	0.002	0.000	0.000	1
		02/07/2009	0	1013	21.5	0.2	0	0.002	0.000	0.000	0.000	1
		15/07/2009	0	999	20.8	0.3	0	0.003	0.000	0.000	0.000	1
		29/07/2009	0	1003	21.3	0.1	0	0.001	0.000	0.000	0.000	1
		13/08/2009	0	1012	21.6	0.2	0	0.002	0.000	0.000	0.000	1
BH2 (19 mm)	MADE GROUND	03/06/2009	0	1019	18.6	1.2	0	0.012	0.001	0.000	0.000	1
		17/06/2009	0	1007	16.4	1.6	0	0.016	0.002	0.000	0.000	1
		02/07/2009	0	1013	21.6	0.1	0	0.001	0.000	0.000	0.000	1
		15/07/2009	0	999	21.1	0	0	0.000	0.000	0.000	0.000	1
		29/07/2009	0	1002	17.8	1.5	0	0.015	0.002	0.000	0.000	1
		13/08/2009	0	1013	20.4	0.7	0	0.007	0.001	0.000	0.000	1
		Max reading	1.8	1020	21.6	1.6	0	0.016	0.029	0.000	0.000	1
		Min reading	0	999	16.4	0	0	0.000	0.000	0.000	0.000	1

Project Name:	The co-operative Head Office, Manchester		
Report Title:	Ground Engineering Interpretative Report		
Figure Title:	Ground Gas Summary		
Scale: NTS:	Date: October 2009	Job No: 023842	Appendix H



Appendix I – Archaeological Investigation Plan



Project Name : The co-operative Head Office, Manchester			
Report Title : Ground Engineering Interpretative Report			
Figure Title : Archaeological Site Plan			
Scale: NTS	Date: October 2009	Job No: 023842	Appendix I

Appendix J – CIRIA C681 Section 8.3 Extract

8.3

EMERGENCY RESPONSE – FIVE POINT PLAN

This section provides a suggested structure for the preparation of UXO emergency response plans. The suggested format is typical of what will be required to ensure that the clients' duties with regard to health and safety are appropriately addressed and discharged. However, the suggested format is general in its approach and should be adapted as appropriate to consider any site specific conditions not addressed, such as distance to highly sensitive receptors.

When preparing the site specific UXO emergency response plan it may often be appropriate to retain the services of a UXO specialist, to help with or undertake its preparation. Typically it would be most appropriate to use the services of a UXO specialist who had been involved with previous phases of the UXO risk mitigation works for the site in question.

The UXO response plan should be included as an annex to the health and safety plan for the proposed works

8.3.1

Identify responsible persons and roles

The first step in preparing a UXO emergency response plan is to identify appropriate persons who will be responsible for carrying out the plan and their specific roles in the event of an incident. To account for absences, there should be multiple nominated persons for each role and at least one nominated person should be available at all times. However, to prevent the duplication of roles in the event of an incident there should be an established hierarchy for the staff identified to act in each specific role, which should be clearly communicated to all responsible persons involved.

8.3.2

Identify lines of communication

The communication of information in a clear and timely manner is essential to effectively carry out any emergency response plan. The UXO response should be communicated to the work force at the operational level, typically as part of a tool box talk. All site visitors should also be made aware of what to do in the event of an emergency as part of a visitor's induction. It should also be conveyed to all site staff and visitors that any suspect item should not be touched or moved and there should be clear and concise guidance for the reporting of the discovery of a suspect item including the appropriate responsible persons.

There should be appropriate equipment available to the identified responsible persons to enable the effective communication of information across site. For anything other than very small sites this will usually require the use of PA systems, radios or phones. If phones are to be used then all responsible persons should have access to relevant contact numbers, which should also be included in the emergency response plan.

At all stages of an emergency event it is important to keep site staff informed of what is happening. Nominated responsible persons should also be prepared to provide briefings to the emergency services and, if required, to local residents and the media.

8.3.3

Site evacuation plan

As soon as a suspect item with the potential to be UXO is encountered the first action should be to ensure the safety of those involved with the site works, ie remove all staff from the immediate area of the potential hazard, other than those that are on-site specifically to deal with the potential occurrence of UXO.

Once the alarm has been raised established site evacuation routes should be used to allow all staff to safely exit from the area of the suspect UXO. Such routes should ensure that the general movement of people is always away from and never towards, or past the location of the potential UXO. Consideration should also be given to the presence of secondary, non-UXO hazards (eg falling masonry from the presence of unsafe structures) at the site that may influence the choice of evacuation route. The routing of evacuation corridors will be more difficult for sites with limited access.

All site staff should ensure that as far as is reasonably practicable, all equipment is made safe and their work area is left so that no secondary hazards are created by the act of evacuation.

A safe muster point should be identified, at a location out of the immediate line of sight of potential UXO and, if possible, behind hard cover. In most cases a single off-site muster point common for other emergency situations would be most appropriate as this will be the simplest option to convey to the workforce. However, for larger sites it may be appropriate to identify a series of muster points within the site boundaries that will be activated depending on the location of the suspect device. In this case information should be effectively communicated to site staff.

Those responsible for carrying out the emergency response plan should ensure that all staff and visitors have been safely evacuated from the area.

The main points to remember when preparing a site evacuation plan are:

- stop work
- make the workplace safe and if necessary subject to degree of emergency
- evacuate to muster point
- establish appropriate exclusion zone/safety cordon
- contact police.

8.3.4

Establishment of site exclusion zone/safety cordon

The size of the exclusion zone will be determined by site conditions and the suspected nature of the object. If an explosive ordnance disposal engineer is available on site, they will provide recommendations as to the required extent of the exclusion zone. Appropriate nominated persons should supervise the exclusion zone to ensure that no one re-enters the cordoned off area.

8.3.5

Confirm status of suspect item

Once the immediate area of the suspect UXO has been cleared and an exclusion zone identified, the status of the suspect device can be confirmed. On sites where there is active UXO mitigation works taking place or on construction sites where the services of a UXO Banksman have been retained, this process will usually be undertaken by the UXO specialist on-site and would most likely have been undertaken before the site was evacuated. On sites with no UXO specialist in attendance an on-call UXO specialist may be asked to attend site. If no on-call UXO specialist is available then the police will need to be contacted to arrange for identification of the suspect device by an appropriate bomb disposal specialist.

All suspect items should be treated as actual UXO until confirmed as otherwise by an appropriately qualified UXO specialist (either retained contractor or member of the emergency services EOD units).

Once the status of the suspected item has been confirmed then an appropriate course of action can be identified. This is likely to involve one of four options:

- 1 The device is confirmed as non-UXO related and work is allowed to continue.
- 2 The device is confirmed as a low risk UXO item and is dealt with by the UXO specialist with minimal further delays to works.
- 3 The device is identified as a high risk UXO item.
- 4 Due to its position or other restrictive factors a positive confirmation of status is not possible.

If the device is identified as a high risk UXO item or it is not possible to confirm its status then further emergency response steps should be done. If not already contacted (as may be the case for sites where a UXO specialist is in attendance or an on-call UXO specialist has attended site) then the emergency services (police) should be notified of the discovery of the UXO device (or suspect UXO device). The police will take over the management of the incident and contact a bomb disposal (EOD) team. This process may take time, so the site safety zone may need to remain in place for a significant time.

Important note 18

In general, military EOD teams will be required to deal with most items of UXO other than items of SAA.

8.4

ADVANCE PLANNING WITH THE EMERGENCY SERVICES

Although the emergency services (police, fire, ambulance and Military Bomb Disposal Units) will always attend to the unexpected discovery of dangerous UXO, they will not usually involve themselves with the preparation of site specific emergency response plans. The exception to this rule would be for sites where there is a high probability of encountering UXO, eg typically on sites where dangerous UXO has already been discovered and is likely to be discovered again, and there is likely to be a requirement for a high level response (such as a large scale evacuation). For such sites it may be prudent to contact the local police and inform them of the proposed works and the identified risks with regard to UXO.

In such circumstances the local authority Emergency Management Team (EMT) should be contacted as part of the standard police procedure. The local EMT will already have procedures for dealing with the occurrence of a wide range of emergency incidents. The police will provide the EMT with site specific information regarding the potential hazards and associated level of risk, they will be able to make an assessment of the likely scale of response required to effectively deal with the occurrence of UXO at the site and, if appropriate, tailor their response procedures to address the site specific risks identified. They will also be able to provide useful information and to ensure that the site specific emergency response plan is appropriate (see Case study 8.1).

Removal of UXO by military in an emergency situation is normally free of charge but if a commercial EOD contractor is to remove benign UXO, there will normally be a charge.

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