# Phase 2 Site Investigation Report
# New Music Block, Martin Harris Centre for Music and Drama, University of Manchester

## Prepared for
## University of Manchester

**August 2022**

**10/2084/002 Rev. 00**

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| **Document** | Phase 2 Site Investigation Report | |
| **Project Name** | New Music Block, Martin Harris Centre for Music and Drama | |
| **Reference** | 10/2084/002 Rev. 00 | |
| **Date** | August 2022 | |

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# Document Origin

| Revision | Date | Revision Description | | Name |
|---|---|---|---|---|
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# Executive Summary

| | |
|---|---|
| **Client** | University of Manchester |
| **Location** | Martin Harris Centre for Music and Drama, The University of Manchester, Bridgeford Street, Manchester M13 9PL. |
| **Description** | The site is located in a courtyard in the north of the Music and Drama Centre and is currently occupied by an area of hardstanding off Bridgeford Street.<br><br>The site forms part of the University of Manchester campus and is surrounded by buildings associated with the University. |
| **Development** | It is proposed to develop the site with a two-storey music block within an existing courtyard of the Martin Harris Centre of Music and Drama. |
| **Site History** | The site comprised vacant land to the rear of residential dwellings in Manchester until the 1940's when the site became part of a depot. This was later removed and replaced with a dental hospital until the 2000's when the site was incorporated into the Drama and Music Centre.<br><br>Surrounding land saw extensive residential development in the 1800's and early 1900's, with buildings associated with University of Manchester developed around the site throughout the 1900's. Industrial works were also developed around the site including a stone yard, depot, engineering works and other unidentified industrial type buildings. |
| **Geology** | British Geological Survey mapping indicates the site to be underlain Devensian Till, overlying the Chester Formation. Given the historical development of the site, Made Ground may also be present overlying natural soils. |
| **Radon** | The radon guidance on protective measures for new dwellings indicates that the site is in a 'low' probability radon area where less than 1% of homes are estimated to be at or above the Action Level. Radon gas protection measures are therefore not required in the construction of new dwellings or extensions. |
| **Mining & Ground Stability** | The site is located within a Coal Mining Reporting Area. However, a review of the Coal Authority online interactive map viewer indicates that there are no mine entries, abandoned mines or coal outcrops within 500m of the site.<br><br>No BGS recorded mineral sites are indicated to be present within 500m of the site. Corn Brook, approximately 90m to the north of the site, was shown to have been infilled in the late 1800's. However, given its age and distance from the site, this is not considered to represent a significant risk to the proposed development. |
| **Flood Risk** | According to the Flood Map for Planning, available on the gov.uk website, the site is located within Flood Zone 3, whereby there is greater than 1% (1 in 100) chance of flooding from rivers or the sea occurring each year.<br><br>The Flood Risk Extent map on the gov.uk website indicates that the site is within the extent of flooding in case of reservoir failure (Audenshaw reservoirs no.1, 2 and 3).<br><br>If one is not already available, it is recommended that a Flood Risk Assessment is undertaken for the proposed development. |

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**Environmental Setting**

The site is underlain by an Undifferentiated Secondary Aquifer and Principal Aquifer, relating to the Devensian Till and Chester Formation, respectively. The site is also located within Zone III (Total Catchment) of a groundwater source protection zone (SPZ). However, this is considered likely to be associated with the deeper Chester Formation Principal Aquifer, which is likely afforded a degree of protection by the overlying cohesive Devensian Till. Furthermore, the nearest groundwater abstraction is in excess of 500m from the site. On this basis, the site is not considered to represent a significant risk to groundwater resource receptors.

The nearest surface water feature is the River Medlock located 790m to the north. Given its distance, this watercourse is not considered to be at significant risk from potential contaminants of concern beneath the site.

**UXO**

Zetica Bomb Risk Mapping indicates the site to be in a moderate bombing density area during the Second World War. Therefore, further assessment of the risk posed by UXO is considered to be required.

**Site Investigations**

The site investigation comprised four window sample boreholes (WS01 to WS04) to depths of up to 4.40m below ground level (bgl), with standard penetration testing (SPTs) undertaken throughout the depth of each borehole. Groundwater and ground gas monitoring wells were installed in boreholes WS02, WS03 and WS04.

Falling head tests were undertaken in boreholes WS03 and WS04 in order to provide preliminary infiltration rates.

**Ground Conditions**

Made Ground was present at each borehole location beneath a limited thickness of tarmac hard surfacing. Made Ground was underlain by superficial deposits, comprising Glaciofluvial Sheet Deposits and Devensian Till. The Chester Formation bedrock was encountered at depths ranging from approximately 3.45m to 4.15m bgl.

**Contamination**

Contaminants of concern were not recorded in soil samples analysed from beneath the site at concentrations in excess of assessment criteria protective of users of public open spaces.

Although not present at concentrations considered likely to pose a significant risk to human health receptors, recorded concentrations of polycyclic aromatic hydrocarbons (PAH) and diesel range total petroleum hydrocarbons (TPH) recorded in samples of Made Ground analysed from boreholes WS01 and WS02 may pose a potential risk to groundwater within the underlying Chester Formation Principal Aquifer. It is therefore recommended that Made Ground that is visually / olfactorily impacted with hydrocarbon contamination is removed as part of the development process and disposed of appropriately off-site.

The River Medlock is present approximately 790m to the north of the site. Given its distance, this watercourse is not considered to be at significant risk from contaminants of concern recorded beneath the site.

**Ground Gas**

Based on four rounds of monitoring undertaken at the site, the ground gas regime corresponds to CIRIA Characteristic Situation 1 (CS1). However carbon dioxide concentrations up to 6% v/v were recorded, the guidance states that consideration should be given to raising to CIRIA CS2 where Carbon Dioxide concentrations exceed 5% v/v. On this basis, allowance should be made for the provision of gas protection measures appropriate to this characterisation within all new structures at the site.

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**Geotechnical**

Based upon SPT results, the Glaciofluvial Sheet Deposits or Devensian Till are likely to provide suitable bearing strata for traditional foundations for light to moderately loaded structures, where they are present at relatively shallow depth and at least firm cohesive or medium dense granular material at formation level (assumed to be at approximately 2.00m bgl).

Made Ground is anticipated to be present at floor slab formation level beneath the proposed development at an assumed depth of approximately 0.60m bgl. Given the thickness of Made Ground beneath the site, a suspended slab is recommended, whereby settlement beneath the floor is controlled by foundations of the building.

Testing indicates that that a Design Sulphate Class of DS1 and an Aggressive Chemical Environment for Concrete (ACEC) Classification of AC1 would be suitable for all buried concrete structures.

**Further Works / Considerations**

Although not present at concentrations considered likely to pose a significant risk to human health receptors, recorded concentrations of hydrocarbon contaminants recorded in samples of Made Ground may pose a potential risk to groundwater within the underlying Chester Formation Principal Aquifer. Therefore, the following is recommended for the proposed development:

- Provide a Remediation Method Statement (RMS) detailing proposed measures to remove impacted Made Ground to mitigate the potential risk to the underlying Principal Aquifer.
- Following completion of recommended remedial measures on site, a Verification Report will need to be produced for submission to the Local Planning Authority. This should contain suitable evidence, demonstrating recommended remediation works have been completed successfully.

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# Drawings

Site Location Plan
Proposed Development Plan
Borehole Location Plan

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| Appendix III | Exploratory Hole Logs |
| Appendix IV | Chemical Laboratory Test Results |
| Appendix V | Geotechnical Laboratory Test Results |
| Appendix VI | Gas Monitoring Results |
| Appendix VII | Infiltration Test Sheets |

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# 1.0 Introduction

## 1.1 Background

Clancy Consulting Limited has been instructed by the University of Manchester to carry out a Phase 2 Site Investigation at the Martin Harrris Centre for Music and Drama, Bridgeford Street, Manchester M13 9PL. It is proposed to construct a two-storey extension to the Music Block. The extension will cover an area of approximately 9.90m by 10.30m.

A proposed development plan is included in Appendix I.

## 1.2 Objectives

The objectives of this investigation are summarised below:

- Undertake intrusive site investigation works to establish the ground conditions across the proposed development area.
- Carry out a geotechnical assessment of the ground conditions and provide preliminary recommendations for foundation design.
- Carry out chemical testing of soil and groundwater samples to determine the contamination status of the site and potential risk posed to human health and environmental receptors.
- Refine the preliminary risk assessment and conceptual site model undertaken as part of the Phase 1 assessment.
- Provide recommendations regarding the requirement for further investigations or remedial works, if required, to satisfy the Local Planning Authority and to inform detailed civil and structural design.

## 1.3 Limitations of the Study

Clancy Consulting Limited cannot be held responsible for any omissions, misrepresentation, errors or inaccuracies with the supplied third-party report information. The report is written in the context of an agreed scope of work and budget and should not be used in a different context. New information or improved practices and changes in legislation may require a reinterpretation of the report in whole or in part.

Clancy Consulting Limited reserves the right to amend either conclusions or recommendations in light of any further information that may become available. The report is provided for the sole use of the University of Manchester for the objectives discussed previously only and is confidential to them.

The report may not be relied upon by any other party without prior written consent of Clancy Consulting Limited. Those using this information in subsequent assessments or evaluations do so at their own risk.

It must be noted that whilst this investigation aims to characterise the general ground conditions beneath the proposed development site, Clancy Consulting Ltd cannot be held accountable for variations in ground and groundwater conditions, unidentified contamination or the presence of below ground structures present.

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# 2.0 Summary of Previous Phase 1 Preliminary Risk Assessment

## 2.1 General

Clancy Consulting Limited previously undertook a Phase 1 Preliminary Risk Assessment for the site:

*Phase 1 Preliminary Risk Assessment, New Music Block, Martin Harris Centre for Music and Drama, University of Manchester. Report Ref 10/2084/001, dated April 2021.*

This Phase 2 Site Investigation Report should be read in conjunction with the above document, summarised below.

The site is located in a courtyard in the north of the Music and Drama Centre and is currently occupied by an area of hardstanding off Bridgeford Street.

The site forms part of the University of Manchester campus and is surrounded by buildings associated with the University.

It is proposed to develop the site with a two-storey music block within an existing courtyard of the Martin Harris Centre of Music and Drama.

The site comprised vacant land to the rear of residential dwellings in Manchester until the 1940's when the site became part of a depot. This was later removed and replaced with a dental hospital until the 2000's when the site was incorporated into the Drama and Music Centre.

Surrounding land saw extensive residential development in the 1800's and early 1900's, with buildings associated with University of Manchester developed around the site throughout the 1900's. Industrial works were also developed around the site including a stone yard, depot, engineering works and other unidentified industrial type buildings.

British Geological Survey mapping indicates the site to be underlain Devensian Till, overlying the Chester Formation. Given the historical development of the site, Made Ground may also be present overlying natural soils.

The radon guidance on protective measures for new dwellings indicates that the site is in a 'low' probability radon area where less than 1% of homes are estimated to be at or above the Action Level. Radon gas protection measures are therefore not required in the construction of new dwellings or extensions.

The site is located within a Coal Mining Reporting Area. However, a review of the Coal Authority online interactive map viewer indicates that there are no mine entries, abandoned mines or coal outcrops within 500m of the site.

No BGS recorded mineral sites are indicated to be present within 500m of the site.
Corn Brook, approximately 90m to the north of the site, was shown to have been infilled in the late 1800's. However, given its age and distance from the site, this is not considered to represent a significant risk to the proposed development.

According to the Flood Map for Planning, available on the gov.uk website, the site is located within Flood Zone 3, whereby there is greater than 1% (1 in 100) chance of flooding from rivers or the sea occurring each year.

The Flood Risk Extent map on the gov.uk website indicates that the site is within the extent of flooding in case of reservoir failure (Audenshaw reservoirs no.1, 2 and 3).

If one is not already available, it is recommended that a Flood Risk Assessment is undertaken for the proposed development.

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The site is underlain by an Undifferentiated Secondary Aquifer and Principal Aquifer, relating to the Devensian Till and Chester Formation, respectively. The site is also located within Zone III (Total Catchment) of a groundwater source protection zone (SPZ). However, this is considered likely to be associated with the deeper Chester Formation Principal Aquifer, which is likely afforded a degree of protection by the overlying cohesive Devensian Till. Furthermore, the nearest groundwater abstraction is in excess of 500m from the site. On this basis, the site is not considered to represent a significant risk to groundwater resource receptors.

The nearest surface water feature is the River Medlock located 790m to the north. Given its distance, this watercourse is not considered to be at significant risk from potential contaminants of concern beneath the site.

Zetica Bomb Risk Mapping indicates the site to be in a moderate bombing density area during the Second World War. Therefore, further assessment of the risk posed by UXO is considered to be required.

A number of potential pollutant linkages have been identified, which may be active following the proposed redevelopment of the site. On the basis of the assessment, the following additional works were recommended:

- Flood Risk Assessment should be completed for the site.
- A Detailed UXO Desk Study should be undertaken to clarify the potential risk posed by buried ordnance beneath the site.
- Carry out an intrusive site investigation to confirm ground conditions at the site.
- Installation of wells in boreholes to allow the assessment of potential risk to future site users posed by ground gases.
- Soil samples should be recovered from selected exploratory holes and tested for potential contaminants of concern. This should include pH, metals, asbestos screening, speciated polycyclic aromatic hydrocarbons (PAH) and speciated total petroleum hydrocarbons (TPH).
- In-situ testing and geotechnical soil sampling should be carried out during intrusive investigation to provide adequate recommendations for foundation design.
- In-situ testing and geotechnical soil sampling should be carried out during intrusive investigation to provide adequate recommendations for foundation design.

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# 3.0 Site Investigation

## 3.1 Investigation Design & Objectives

Pollutant linkages identified within the Preliminary Conceptual Site Model are currently active or will be made active upon redevelopment of the site. The investigation design approach was based on guidance provided in BS 10175 Code of Practice for Investigation of Potentially Contaminated Land (2011). The investigation also provided information on ground conditions and data for the assessment geotechnical properties of the strata underlying the site.

It must be noted that whilst this investigation aims to characterise the general ground conditions beneath the proposed development site, Clancy Consulting Ltd cannot be held accountable for variations in ground and groundwater conditions, unidentified contamination or the presence of below ground structures in areas of the site which fall outside our borehole locations.

## 3.2 UXO Risk Assessment

Zetica bomb risk mapping indicated that the site was in a moderate bombing density area during the Second World War. On this basis, a UXO Desk Study and Risk Assessment was commissioned for the site. A copy of this is presented in Appendix II.

The report identified no significant sources of UXO hazard and no additional risk mitigation measures were considered to be required during intrusive excavation works.

## 3.3 Fieldwork

Site investigation works were carried out on 21st June 2022 and comprised:

- Four window sample boreholes (WS01 to WS04) to depths of up to approximately 4.40m below ground level (bgl).
- In situ geotechnical testing throughout the depth of each borehole.
- Installation of groundwater and ground gas monitoring wells in boreholes WS02, WS03 and WS04.
- Soil samples were collected at regular intervals from each exploratory hole for chemical and geotechnical laboratory analysis.

A plan indicating the positions of the exploratory hole boreholes is provided in Appendix I. Exploratory hole logs are provided as Appendix III.

## 3.4 Laboratory Testing

### 3.4.1 Environmental Laboratory Testing – Soil

Five samples of the Made Ground and two samples of the Glaciofluvial Sheet Deposits were submitted to a UKAS/MCERTS accredited laboratory and analysed for a number of determinands including:

*Inorganic Determinands:*

pH, arsenic, beryllium, cadmium, chromium, hexavalent chromium, copper, lead, mercury, nickel, sulphate, selenium, vanadium, zinc and asbestos.

*Organic Determinands:*

PAH and TPH.

Chemical Laboratory Certificates are presented as Appendix IV.

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### 3.4.2 Geotechnical Laboratory Testing

Samples collected from the Devensian Till and Glaciofluvial Sheet Deposits were analysed by a UKAS accredited laboratory for Atterberg Limits, pH and water-soluble sulphate content.

Geotechnical Laboratory Certificates are presented as Appendix V.

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# 4.0 Site Investigation Findings

## 4.1 Ground Conditions & Geotechnical Testing Parameters

The strata encountered during the intrusive investigation are summarised in the table below and described in the following section.

**Table 1 – Encountered Strata**

| Strata | Depth to Top of Strata **(m bgl)** | **Thickness (m)** |
|---|---|---|
| Made Ground | Ground level | 0.85 to 1.90 |
| Glaciofluvial Sheet Deposits | 0.85 to 1.90 | 0.10 to 1.45 |
| Devensian Till | 1.70 to 2.30 | 1.40 to 2.15 |
| Chester Sandstone Formation | 3.45 to 4.15 | Not proven at a maximum depth of approximately 4.40m bgl |

General descriptions of the strata encountered during the intrusive investigation are summarised below. Reference should be made to the borehole logs within Appendix III of this report for full descriptions of ground conditions underlying the site.

### 4.1.1 Made Ground

Made Ground was recorded beneath a limited thickness of tarmac hard surfacing in each borehole position, ranging in thickness from approximately 0.85m to 1.90m. The stratum was encountered at greatest thickness in borehole WS02, located in the southwestern corner of the site. The Made Ground was variable in nature, but typically comprised a granular grey to dark-brown sandy, gravel. Gravel comprised fine to coarse brick, concrete, clinker, metal, glass, and coal.

Clinker and coal are often associated with elevated concentrations of metals and PAH. Hydrocarbon odours or staining were also encountered in borehole WS01 at 0.60m to 0.70m bgl, borehole WS02 at 0.60m to 1.65m bgl and borehole WS03 at 0.60m to 1.40m bgl.

Three SPTs undertaken within the Made Ground at depths ranging from approximately 1.20m to 2.00m bgl gave results ranging from N = 2 to N = 8, which is indicative of a loose granular material.

### 4.1.2 Glaciofluvial Sheet Deposits

The Glaciofluvial Sheet Deposits were recorded beneath the Made Ground at depths ranging from approximately 0.85m to 1.90m bgl and ranged in thickness from approximately 0.10m to 1.45m. The stratum was variable in nature, but generally comprised light-brown, slightly gravelly, fine to medium sand, or a soft to firm, green-grey, slightly gravelly, slightly sandy clay with relict plant remains.

Atterberg Limit testing was undertaken on one soil sample collected from a predominantly cohesive layer of the Glaciofluvial Sheet Deposits at a depth of approximately 1.70m bgl. This testing was undertaken to determine values for Liquid Limit (LL), Plastic Limit (PL) and Plasticity Index (PI). The result for LL was 65%. The result for PL was 28%. The result for PI was 37%. The results are indicative of a high plasticity clay. Modified plasticity index values indicate that this sample has a moderate-volume change potential. The natural moisture content of this sample was 33%.

Three SPTs undertaken within predominantly granular layers of the Glaciofluvial Sheet Deposits at depths ranging from approximately 1.00m to 2.00m bgl gave results ranging from N = 6 to N = 9, which is indicative of a loose granular material.

### 4.1.3 Devensian Till

The Devensian Till was recorded beneath the Glaciofluvial Sheet Deposits at depths ranging from approximately 1.70m to 2.30m bgl. The stratum generally comprised dark brown, firm to stiff, slightly gravelly clay. Gravel comprised fine to medium mudstone, sandstone and siltstone. No visual or olfactory evidence of contamination was noted within this stratum.

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Atterberg Limit testing was undertaken on three soil sample collected from the Devensian Till at depths ranging from approximately 2.00m to 3.00m bgl. The results for LL ranged from 44% to 47%. The results for PL were 22%. The results for PI ranged from 22% to 25%. The results are indicative of an intermediate plasticity clay. Modified plasticity index values indicate that these sample have a moderate-volume change potential. The natural moisture content of these samples ranged from 17% to 23%.

Six SPTs undertaken within the Devensian Till at depths ranging from approximately 2.00m to 3.00m bgl gave results ranging from N = 15 to N = 40.

Approximate undrained shear strengths were calculated from the SPT results using the correlation by Stroud:

$$C = f_1 \times N$$

Where, a conservative value for $f_1 = 4.5$.

The SPT results correspond approximately to undrained shear strength values ranging from 68kN/m$^2$ to 180kN/m$^2$, which is indicative of a firm, ranging to very stiff cohesive material.

### 4.1.4 Chester Sandstone Formation

The Chester Formation was recorded beneath the Devensian Till at depths ranging from approximately 3.45m to 4.15m bgl and was present to the base of each borehole at a maximum depth of approximately 4.40m bgl. The stratum comprised weathered sandstone, recovered as red, slightly gravelly, fine to medium sand. Gravel comprised fine to coarse sandstone. No visual or olfactory evidence of contamination was noted within this stratum.

Four SPTs undertaken within the Cheshire Sandstone Formation at depths ranging from approximately 3.50m to 4.00m bgl gave results in excess of N = 50.

## 4.2 Groundwater

Groundwater strikes were not recorded in any of the boreholes during intrusive works. Groundwater levels recorded within wells during subsequent groundwater monitoring visits are summarised in the table below:

**Table 2 – Groundwater Level Data**

| Monitoring Well ID | Well Screen Depth (m bgl) | Strata | Depth to Water (m bgl) | | | |
|---|---|---|---|---|---|---|
| | | | *30/6/22* | *08/7/22* | *21/7/22* | *28/7/22* |
| WS02 | 0.60 to 1.60 | Made Ground | Dry | Dry | Dry | Dry |
| WS03 | 1.50 to 3.50 | Glaciofluvial Sheet Deposits and Devensian Till | 1.33 | 1.48 | 1.40 | 1.63 |
| WS04 | 2.00 to 3.50 | Devensian Till | Dry | Dry | Dry | Dry |

The results of monitoring appear to be representative of a relatively localised groundwater table within the Glaciofluvial Sheet Deposits and Devensian Till. Groundwater is likely to be restricted to more granular layers of these strata.

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# 5.0 Hazardous Ground Gas Assessment

## 5.1 Introduction

Made Ground was recorded beneath a limited thickness of tarmac hard surfacing in each borehole position, ranging in thickness from approximately 0.85m to 1.90m. The Made Ground was variable in nature, but typically comprised a granular grey to dark-brown sandy, gravel. Gravel comprised fine to coarse brick, concrete, clinker, metal, glass, and coal.

Clinker and coal are often associated with elevated concentrations of metals and PAH. Hydrocarbon odours or staining were also encountered in borehole WS01 at 0.60m to 0.70m bgl, borehole WS02 at 0.60m to 1.65m bgl and borehole WS03 at 0.60m to 1.40m bgl.

Laboratory testing has identified PAHs and TPHs within a number of samples of the Made Ground. Hydrocarbon impacted soils can generate hazardous ground gases and volatile vapours.

## 5.2 Scope of Works

Ground gas monitoring wells were installed in three boreholes with the response zones positioned within the Made Ground, Glaciofluvial Sheet Deposits and Devensian Till. An initial monitoring programme comprising four visits over a period of one month was carried out in accordance with the guidance within CIRIA Report C665 'Assessing risks posed by hazardous ground gases to buildings.

## 5.3 Monitoring Results

The four gas monitoring visits were carried out between 30th June and 28th July 2022. Atmospheric pressure ranged from 997mb to 1008mb during these visits. Copies of the monitoring results are presented in Appendix VI and summarised in the table below.

**Table 3 – Gas Monitoring Results**

| Hole ID | Max Methane (%v/v) | Max Carbon Dioxide (%v/v) | Flow Rate (l/hr) | Gas Screening Value (l/hr) | Characteristic Situation |
|---|---|---|---|---|---|
| WS2 | <0.1 | 2.1 | <0.1 | 0.0021 | CS1 |
| WS3 | <0.1 | 2.1 | <0.1 | 0.0021 | CS1 |
| WS4 | <0.1 | 6.0 | <0.1 | 0.0060 | CS1 |

Installations were monitored for concentrations of methane, carbon dioxide and oxygen. In addition, the flow rate and barometric pressure were recorded.

Methane was not recorded at concentrations in excess of the instrument limit of detection (<0.1% by volume (v/v)).

Carbon dioxide was recorded at a maximum concentration of 6.0% v/v within monitoring well WS04 on 30th June 2022.

Ground gas flow rates were all below the instrument level of detection (<0.1l/hr).

The lowest recorded oxygen concentration was 12.6% v/v within monitoring well WS04 on 30th June 2022.

## 5.4 Discussion

The CIRIA Report C665 outlines indicative guideline concentrations for carbon dioxide and methane in association with gas flow rates for which gas protection measures may be required in new residential or commercial developments. The methodology is based on the Modified Wilson and Card approach that characterises the gas regime into a series of Characteristic Situations (1 to 5), with corresponding indicative gas protection measures.

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Using this methodology, the ground gas regime at this site corresponds to CIRIA Characteristic Situation 1 (CS1), whereby ground gas protection measures are not required beneath new structures. However, the guidance also states that consideration should be given to raising to CIRIA CS2 where Carbon Dioxide concentrations exceed 5% v/v. On this basis, allowance should be made for the provision of gas protection measures appropriate to this characterisation within all new structures at the site. Any protective measures should be designed in accordance with guidance provided in BS8485: 2015 “Code of Practice for the Design of Protective Measures for Methane and Carbon Dioxide Ground Gases for New Buildings”.

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# 6.0 Tier 1 Contamination Analysis

The field investigation findings indicate that pathways are present by which contaminants of concern can impact identified receptors. Chemical analysis has been carried out on soils sampled from beneath the site. The concentrations of contaminants of concern within soil can be compared to assessment criteria (AC) to determine whether these represent an unacceptable risk to identified receptors. The derivation of AC to be used and the comparison of these criteria to the results of the chemical analyses are presented below.

## 6.1 Human Health Assessment Criteria

In order to assess risks to future site users, concentrations of contaminants of concern have been compared to Suitable 4 Use Levels (S4UL) generic AC published by Land Quality Management: Chartered Institute of Environmental Health (LQM:CIEH) in 2015.

The assessment has been based upon the use of the site as public open space, based on the proposed use of the site as a University College Building.

As a conservative measure, concentrations of contaminants of concern have been compared to the S4UL (1.00% Soil Organic Matter) values.

A notable exclusion from the S4ULs is lead. In the absence of a S4UL for lead, the Category 4 Screening Level (C4SL) has been selected, published by DEFRA in 2014. It is noted that the C4SL are based on the acceptance of a low level of toxicological concern, rather than the more conservative standard adopted in the derivation of S4ULs, which are based on a tolerable or minimal level of risk.

The potential risk posed to controlled waters from contaminants of concern within soils beneath the site is not addressed by these screening criteria.

## 6.2 Comparison of Soil Analyses to Human Health Assessment Criteria

Chemical analysis was undertaken on five samples of the Made Ground and two samples of the Glaciofluvial Sheet Deposits. A comparison of soil analyses to the relevant AC presented below.

### 6.2.1 Inorganic Determinands

Inorganic contaminants of concern were not recorded within soil samples analysed from beneath the site at concentrations in excess of adopted AC.

### 6.2.2 Organic Determinands

Organic determinands were not recorded within the soil samples analysed from beneath the site at concentrations in excess of adopted AC.

### 6.2.3 Asbestos

Asbestos containing materials (ACMs) were not identified in any of the soil samples submitted for screening.

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# 7.0 Contamination Assessment

## 7.1 Introduction

Based on the information obtained during the ground investigation and laboratory testing, the 'Preliminary Conceptual Site Model' has been amended accordingly. The Conceptual Site Model is used as a basis to identify contamination sources, pathways and receptors and is subject to constant refinement as more information becomes available.

## 7.2 Human Health Receptors

Contaminants of concern were not recorded in soil samples analysed from beneath the site at concentrations in excess of assessment criteria protective of users of public open spaces.

Based on the available information, concentrations of contaminants of concern detected within soil sampled from beneath the site are not considered to represent a potentially significant risk to on or off-site human health receptors.

## 7.3 Construction / Maintenance Workers

S4UL screening criteria cannot be used to assess the acute (short term exposure) risk that personnel in close contact with exposed soils may experience during construction/site maintenance duties.

Potential risks to construction/maintenance workers can be controlled by the use of appropriate personal protection equipment (e.g. disposable coveralls, gloves and particulate/vapour masks) and by adopting high levels of personal hygiene.

## 7.4 Groundwater

Although not present at concentrations considered likely to pose a significant risk to human health receptors, recorded concentrations of PAH and diesel range TPH recorded in samples of Made Ground analysed from boreholes WS01 and WS02 may pose a potential risk to groundwater within the underlying Chester Formation Principal Aquifer. It is therefore recommended that Made Ground that is visually / olfactorily impacted with hydrocarbon contamination is removed as part of the development process and disposed of appropriately off-site.

## 7.5 Surface Water

The River Medlock is present approximately 790m to the north of the site. Given its distance, this watercourse is not considered to be at significant risk from contaminants of concern recorded beneath the site.

## 7.6 Polymeric Utility Pipes

Concentrations of hydrocarbon compounds, considered potentially harmful to potable water supply pipes, were recorded within samples of Made Ground analysed from beneath the site. Standard polymeric utility pipes may therefore not be suitable for the proposed development. Barrier pipe may be required, or utility pipes laid in dedicated trenches and backfilled with clean, inert material.

Requirements for buried utility pipes should be discussed with service providers before the development stage.

## 7.7 Revised Conceptual Site Model

The potential source-pathway-receptor linkages and associated risks upon completion of the proposed development at the site, as identified following completion of the assessment, are summarised in the table below.

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**Table 4 – Revised Conceptual Site Model**

| Potential Source | Via | Potential Pathways | Linkage Potentially Active? (Yes/No) | Receptors |
|---|---|---|---|---|
| On site:<br>Made Ground Hydrocarbon contaminants recorded in samples of Made Ground in boreholes WS01 and WS02. | Soil | Direct contact/ingestion | No | Site users |
| | | Inhalation of volatiles | No | |
| | | Airborne migration of soil or dust | No | Off-site users |
| | | Leaching of mobile contaminants | Yes<br>Yes | Devensian Till and Glaciofluvial Sheet Deposits Undifferentiated Secondary Aquifers<br>Chester Formation Principal Aquifer |
| | Groundwater | Direct contact/ingestion | No | Site users |
| | | | No | Off-site users |
| | | Inhalation of volatiles | No | Site users |
| | | | No | Off-site users |
| | | Vertical and lateral migration in permeable strata | Yes<br>Yes | Devensian Till and Glaciofluvial Sheet Deposits Undifferentiated Secondary Aquifers<br>Chester Formation Principal Aquifer |
| | | | No | River Medlock |
| Off site:<br>Former stone yard, depot, engineering works and other unidentified industrial type buildings | Groundwater | Direct contact/ingestion | No | Site users |
| | | Inhalation of volatiles | No | Site users |
| | Service conduits | Direct contact/ingestion | No | Site users |
| | | Inhalation of volatiles | No | Site users |
| On and off-site:<br>Potential hazardous ground gas and vapours from Made Ground | Ground Gas | Inhalation of ground gas | No | Site users |
| | | | No | Off-site users |
| | | Explosive risks | No | Site users |
| | | | No | Off-site users |

The risk assessment is based upon the available information relating to the site. Should ground conditions inconsistent with those outlined in this report be encountered CCL should be contacted to enable further assessment. The findings of the CSM should be confirmed upon finalisation of the proposed redevelopment plans.

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# 8.0 Geotechnical Assessment

## 8.1 Introduction

It is proposed to construct a two-storey extension to the Music Block. The extension will cover an area of approximately 9.90m by 10.30m..

No preliminary structural loads have been received for the proposed development. Therefore, the preliminary recommendations below will need to be reviewed at the detailed design stage once these are known.

## 8.2 Preliminary Geotechnical Risk Register

The table below summarises the potential geotechnical hazards associated with the development. The table provides an assessment of whether the site is likely to be affected by the hazard and the possible consequences and engineering considerations.

**Table 5 – Geotechnical Risk Register**

| Hazard Description | Is hazard likely to be present / affect the site? | Comments/possible engineering requirements where hazard present |
|---|---|---|
| Sudden lateral/vertical changes in ground conditions | M | A variable thickness of Made Ground was recorded beneath the site, overlying Glaciofluvial Sheet Deposits and Devensian Till.<br>The main variation in ground conditions is likely to be associated with the thickness and composition of the Made Ground and compressibility of the underlying Glaciofluvial Sheet Deposits. |
| Highly compressible/low bearing capacity soils, (including peat and soft clay) | L/M | Made Ground is not considered suitable to support traditional foundations. However, the underlying Glaciofluvial Sheet Deposits or Devensian Till will likely form suitable bearing strata for traditional foundations supporting low to moderate loads. |
| Ground dissolution features/natural cavities | L | Ground conditions beneath the site are not consistent with these features. |
| Shrinking and swelling clays | M/H | Samples taken from the Glaciofluvial Sheet Deposits and Devensian Till had a moderate volume change potential. Where traditional foundations are adopted, these should be designed in accordance with Appendix 4.2H of the NHBC guidance (Building Near Trees). |
| Slope stability/Retaining wall issues | L | No slopes or retaining walls are understood to be proposed as part of the development. However, any temporary or permanent slopes or retaining walls created as part of the development should be subject to appropriate geotechnical design based on site-specific site investigation information. |
| High groundwater table (including waterlogged ground) | M | Groundwater was recorded from depths of approximately 1.33m bgl within monitoring well WS03 only. The results of monitoring appear to be representative of a relatively localised groundwater table within the Glaciofluvial Sheet Deposits and Devensian Till. Groundwater is likely to be restricted to more granular layers of these strata. On this basis, it is considered that groundwater may be controlled via pumping from a localised sump. |
| Filled and Made Ground (including embankments) | M/H | Made Ground was recorded beneath the site, up to 1.90m in thickness. |
| Obstructions (including foundations, services, basements, tunnels and adjacent sub-structures) | L | Historical development of the site has been limited. It is considered that any relic foundations and/or buried services encountered could be removed using standard construction plant. |
| Underground mining | L | The site is not located in an area affected by mining. |

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| Hazard Description | Is hazard likely to be present / affect the site? | Comments/possible engineering requirements where hazard present |
|---|---|---|
| Concrete classification | M/H | Testing indicates that that a Design Sulphate Class of DS1 and an Aggressive Chemical Environment for Concrete (ACEC) Classification of AC1 would be suitable for all buried concrete structures. |
| Seismic Activity | L | The Eurocode 8 seismic hazard zoning maps for the UK (Musson and Sargeant, 2007) indicate that horizontal Peak Ground Acceleration (PGA) values with 10% probability of being exceeded in 50 years (475 year return period) are between 0.00g and 0.02g, which is considered very low. |
| NOTES:<br>H – High Risk<br>M – Medium Risk<br>L – Low risk | | |

## 8.3 Foundation Solutions

### 8.3.1 Traditional Foundations

Based upon SPT results, the Glaciofluvial Sheet Deposits or Devensian Till are likely to provide suitable bearing strata for traditional foundations for light to moderately loaded structures, where they are present at relatively shallow depth and at least firm cohesive or medium dense granular material at formation level (assumed to be at approximately 2.00m bgl).

In accordance with the guidance set out in Eurocode 7, a 1.00m wide strip foundation placed at a depth of 2.50m bgl should be capable of supporting building loads of up to 100kN/m2, where the stratum is at least medium dense granular material at formation level.

Subsequent to foundation excavation, in accordance with the guidance set out in Eurocode 7 to satisfy Ultimate Limit State (ULS) and Serviceability Limit State (SLS) design, settlement underlying a 1.00m wide strip foundation, constructed in the manner discussed above, is estimated to be within acceptable limits (<25mm).

The formation should be inspected by the site engineer before placing foundations. If Made Ground, low strength cohesive or loose granular material is encountered at the target bearing depth, foundations should be taken deeper to an appropriate formation level or unsuitable material should be excavated and replaced with compacted granular fill

## 8.4 Floor Slabs

Made Ground is anticipated to be present at floor slab formation level beneath the proposed development at an assumed depth of approximately 0.60m bgl. Given the thickness of Made Ground beneath the site, a suspended slab is recommended, whereby settlement beneath the floor is controlled by foundations of the building.

## 8.5 Temporary Works and Excavations

Historical development of the site has been limited. It is considered that any relic foundations and/or buried services encountered could be removed using standard construction plant.

Groundwater was recorded from depths of approximately 1.33m bgl within monitoring well WS03 only. The results of monitoring appear to be representative of a relatively localised groundwater table within the Glaciofluvial Sheet Deposits and Devensian Till. Groundwater is likely to be restricted to more granular layers of these strata. On this basis, it is considered that groundwater may be controlled via pumping from a localised sump.

If groundwater is encountered during excavation, degradation of the formation may occur. The formation should therefore be adequately protected from seepages and protected from adverse weather conditions. If

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the formation layer becomes wet resulting in loosening or softening of the surface materials, then excavation may have to be taken deeper in order to find a suitable bearing layer. Instability of excavations in granular material should be expected, especially during periods of adverse weather. Suitable shoring measures or battering back of slopes may be required for any excavations greater than 1.20m bgl. All temporary excavations should be undertaken in accordance with CIRIA Report 97 'Trenching Practice'.

## 8.6 Chemical Attack on Buried Concrete

Samples of the Made Ground, Glaciofluvial Sheet Deposits and Devensian Till were tested for pH and for sulphate content. The results are presented below:

**Table 6 – Results of pH and sulphate testing**

| Stratum | No. Samples | Range of pH | Characteristic pH | Range of Sulphate (mg/kg) | Characteristic Sulphate (mg/kg) | Design Sulphate Class | ACEC Class |
|---|---|---|---|---|---|---|---|
| Made Ground | 3 | 7.1 to 8.4 | 7.1 | <10 to 150 | 150 | DS-1 | AC-1 |
| Glaciofluvial Sheet Deposits | 1 | 7.4 | 7.4 | 10 | 10 | DS-1 | AC-1 |
| Devensian Till | 1 | 8.2 | 8.2 | 10 | 10 | DS-1 | AC-1 |

The data was used to assess appropriate concrete classification for buried concrete in accordance with BRE Special Digest 1, based on the following assumptions:

- Brownfield ground conditions.
- Mobile groundwater conditions.
- For a dataset of less than five samples, the characteristic value for soluble sulphate has been taken as the highest result, while the characteristic value for pH is taken as the lowest pH result.
-

Based on the above, it is considered that a Design Sulphate Class of DS1 and an Aggressive Chemical Environment for Concrete (ACEC) Classification of AC1 would be suitable for all buried concrete structures.

## 8.7 Infiltration Testing

Falling head tests were undertaken in boreholes WS3 and WS4 in order to provide preliminary permeability rates to aid infiltration drainage design.

Calculated permeability values were 4.19 x $10^{-6}$ m/s in borehole WS3 and 7.86 x $10^{-6}$ m/s in borehole WS4.

If the above falling head permeability tests indicate soil infiltration rates to be favourable for the adoption of infiltration drainage systems, trial pit soakaway testing in accordance with BRE Special Digest 365 will likely be required by the regulator to provide permeability data for detailed drainage design.

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# 9.0 Conclusions and Recommendations

CCL was instructed by the University of Manchester to carry out a Phase 2 Site Investigation at the Martin Harrris Centre for Music and Drama, Bridgeford Street, Manchester M13 9PL. It is proposed to construct a two-storey extension to the Music Block.

The site investigation comprised four window sample boreholes (WS01 to WS04) to depths of up to 4.40m bgl, with SPTs undertaken throughout the depth of each borehole. Groundwater and ground gas monitoring wells were installed in boreholes WS02, WS03 and WS04.

Falling head tests were undertaken in boreholes WS03 and WS04 in order to provide preliminary infiltration rates.

Made Ground was present at each borehole location beneath a limited thickness of tarmac hard surfacing. Made Ground was underlain by superficial deposits, comprising Glaciofluvial Sheet Deposits and Devensian Till. The Chester Formation bedrock was encountered at depths ranging from approximately 3.45m to 4.15m bgl.

Contaminants of concern were not recorded in soil samples analysed from beneath the site at concentrations in excess of assessment criteria protective of users of public open spaces.

Although not present at concentrations considered likely to pose a significant risk to human health receptors, recorded concentrations of PAH and diesel range TPH recorded in samples of Made Ground analysed from boreholes WS01 and WS02 may pose a potential risk to groundwater within the underlying Chester Formation Principal Aquifer. It is therefore recommended that Made Ground that is visually / olfactorily impacted with hydrocarbon contamination is removed as part of the development process and disposed of appropriately off-site.

The River Medlock is present approximately 790m to the north of the site. Given its distance, this watercourse is not considered to be at significant risk from contaminants of concern recorded beneath the site.

Based on four rounds of monitoring undertaken at the site, the ground gas regime corresponds to CIRIA CS1.. However carbon dioxide concentrations up to 6% v/v were recorded, the guidance states that consideration should be given to raising to CIRIA CS2 where Carbon Dioxide concentrations exceed 5% v/v. On this basis, allowance should be made for the provision of gas protection measures appropriate to this characterisation within all new structures at the site.

Based upon SPT results, the Glaciofluvial Sheet Deposits or Devensian Till are likely to provide suitable bearing strata for traditional foundations for light to moderately loaded structures, where they are present at relatively shallow depth and at least firm cohesive or medium dense granular material at formation level (assumed to be at approximately 2.00m bgl).

Made Ground is anticipated to be present at floor slab formation level beneath the proposed development at an assumed depth of approximately 0.60m bgl. Given the thickness of Made Ground beneath the site, a suspended slab is recommended, whereby settlement beneath the floor is controlled by foundations of the building.

Testing indicates that that a Design Sulphate Class of DS1 and an ACEC Classification of AC1 would be suitable for all buried concrete structures.

Although not present at concentrations considered likely to pose a significant risk to human health receptors, recorded concentrations of hydrocarbon contaminants recorded in samples of Made Ground may pose a potential risk to groundwater within the underlying Chester Formation Principal Aquifer. Therefore, the following is recommended for the proposed development:

- Provide a Remediation Method Statement (RMS) detailing proposed measures to remove impacted Made Ground to mitigate the potential risk to the underlying Principal Aquifer.

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- Following completion of recommended remedial measures on site, a Verification Report will need to be produced for submission to the Local Planning Authority. This should contain suitable evidence, demonstrating recommended remediation works have been completed successfully.

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# APPENDIX I

# DRAWINGS

Birmingham 0121 200 7800 . Glasgow 0141 222 1720 . Liverpool 0151 227 5300 . London 020 3077 0970 . Manchester 0161 613 6000 . Newcastle 0191 221 0702 . Norwich 01603 305190 . Prestwick 01292 475375 . Reading 0118 941 7888

| | |
|---|---|
| Client | University of Manchester |
| Project | Martin Harris Drama and Music Centre |
| Title | Site Location Plan |
| Office | Altrincham |
| Discipline | Geo-environmental |

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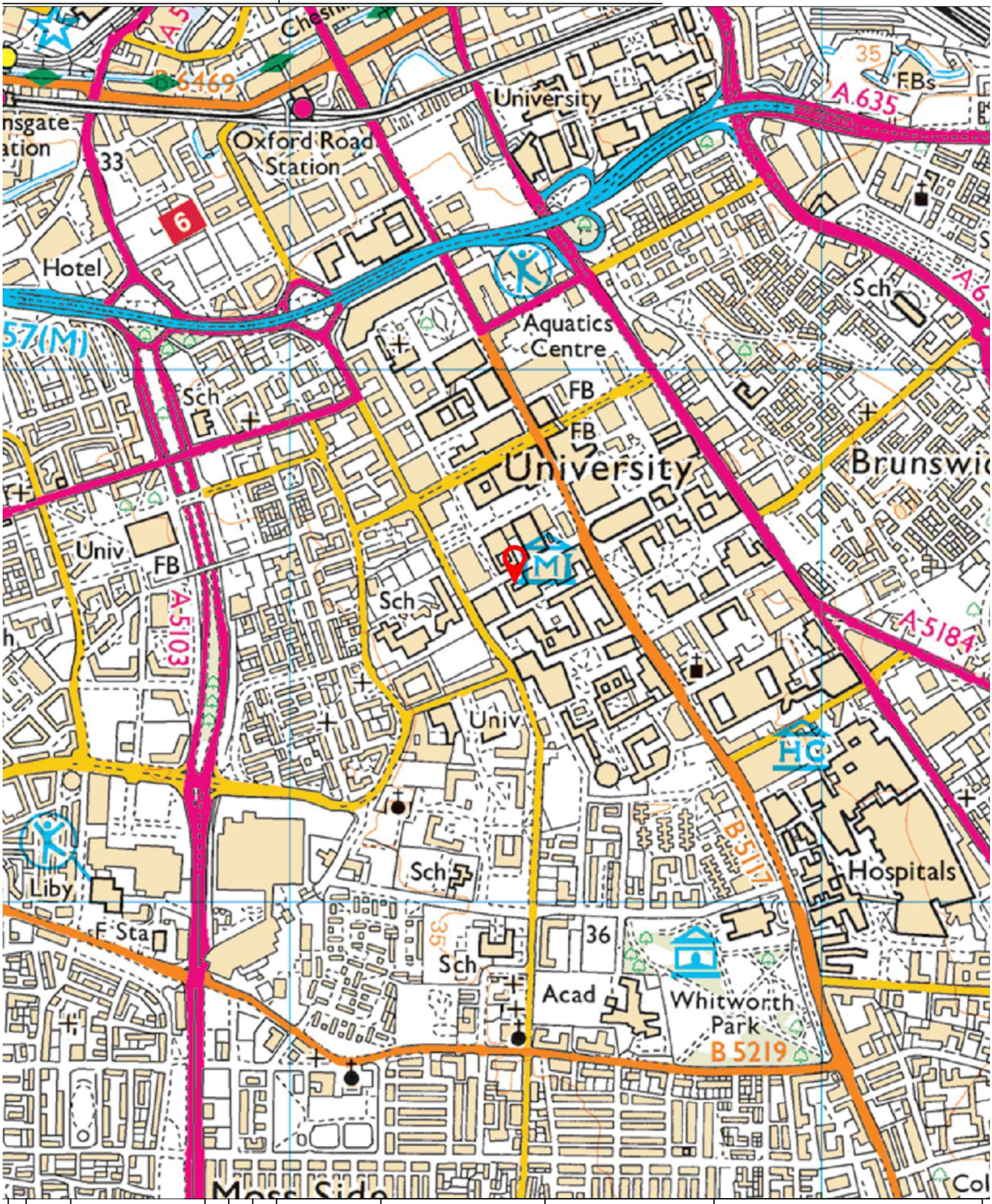


| Rev | Date | Description | By | Check | App. |
|---|---|---|---|---|---|
| 00 | March 22 | Site Location Plan | EB | RP | NR |

| | | | |
|---|---|---|---|
| Drawn | EB | Date | March 22 |
| Checked | DK | Scale @ A4 | NTS |
| Approved | NR | Status | FINAL |

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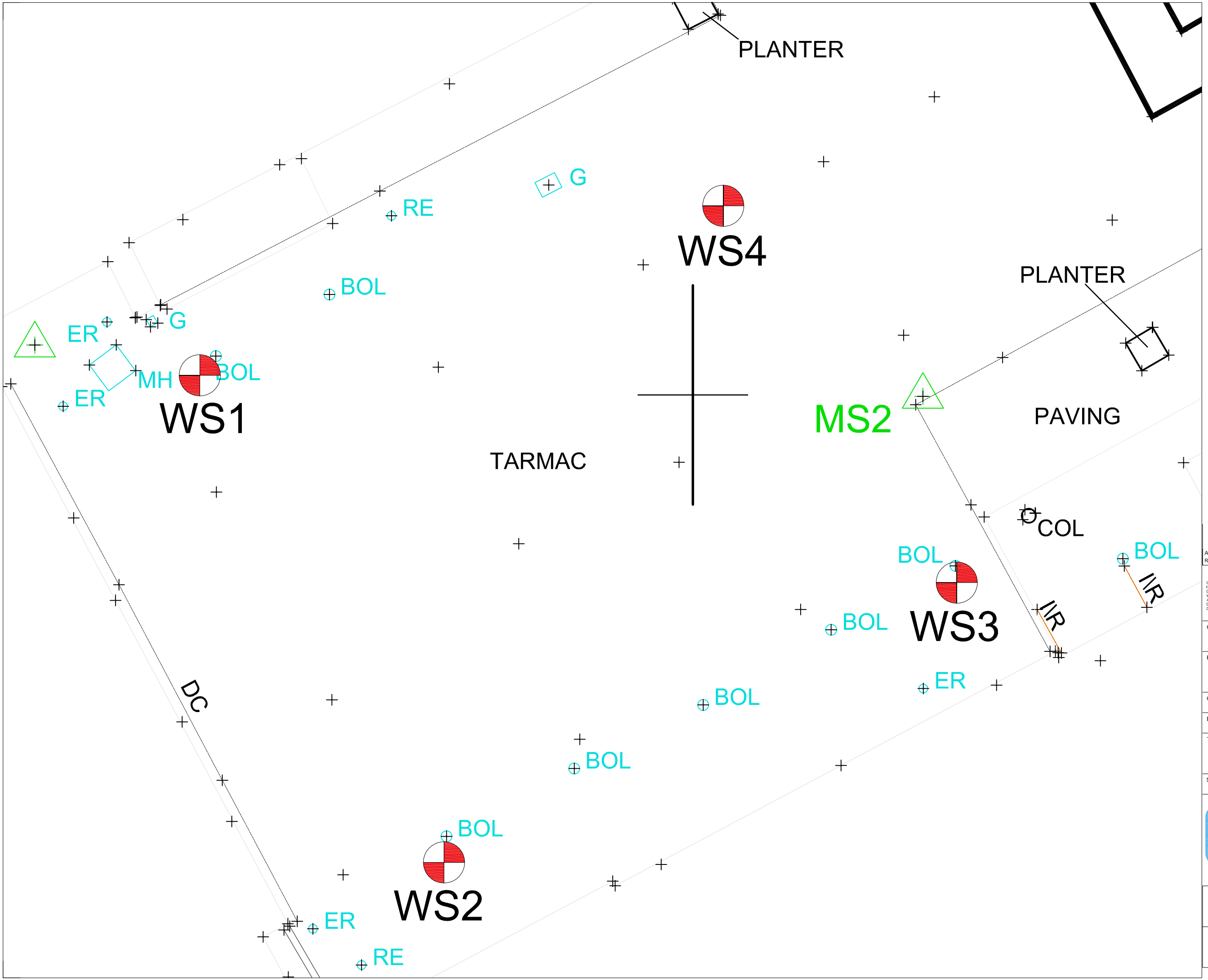
| Job number | Drawing number | Revision |
|---|---|---|
| 10/2084 | 01 | 00 |




Key

Window sample Borehole Location

| Rev | Date | Description | By | Check | App. |
|---|---|---|---|---|---|
| A | June 2022 | Original Drawing | SP | CHK. | APP. |

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Client: University of Manchester

Project: Martin Harris New Music Block
University of Manchester

Office: Altrincham

Discipline: Geo-Environmental

Title: Exploratory Hole Location Plan

Scale @ A3: NTS

Status: Draft

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| Originator | Job Number | Discipline | Building/Zone |
|---|---|---|---|
| CCL | 10/2084 | GEO | - |
| **Type** | **Level** | **Drawing No.** | **Revision** |
| GA | 00 | 002 | 1 |

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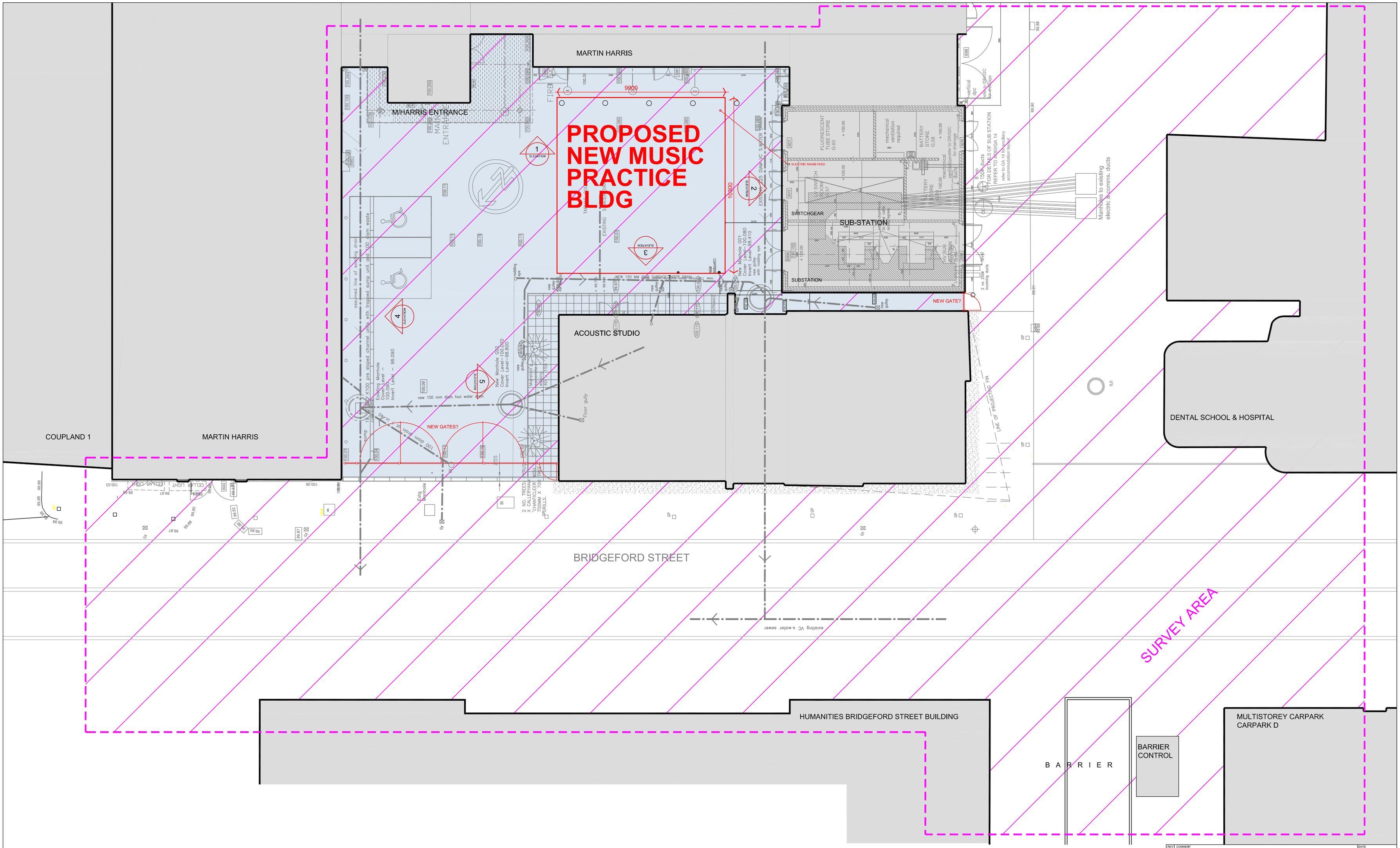


| REV | COMMENT | DATE |
|---|---|---|

The University of Manchester

MANCHESTER 1824

# DESIGN SERVICES UNIT

DRAWING STATUS: PRELIMINARY

PROJECT NAME: MUSIC PRACTICE SPACE MODULAR BUILDING FOR M-PODS

PROJECT NO.: 7989

BUILDING NAME: MARTIN HARRIS

BUILDING NUMBER: 012AA

SUB-SITE NAME:

SITE NAME: SOUTH CAMPUS

TITLE: SITE PLAN / SURVEY AREA

DRAWING NO.: 7989-012AA-A006

ISSUE: P1

PROJECT MANAGER: DATE:

SCALE: 1/100@A1

DRAWN: CHECKED: APPROVED:

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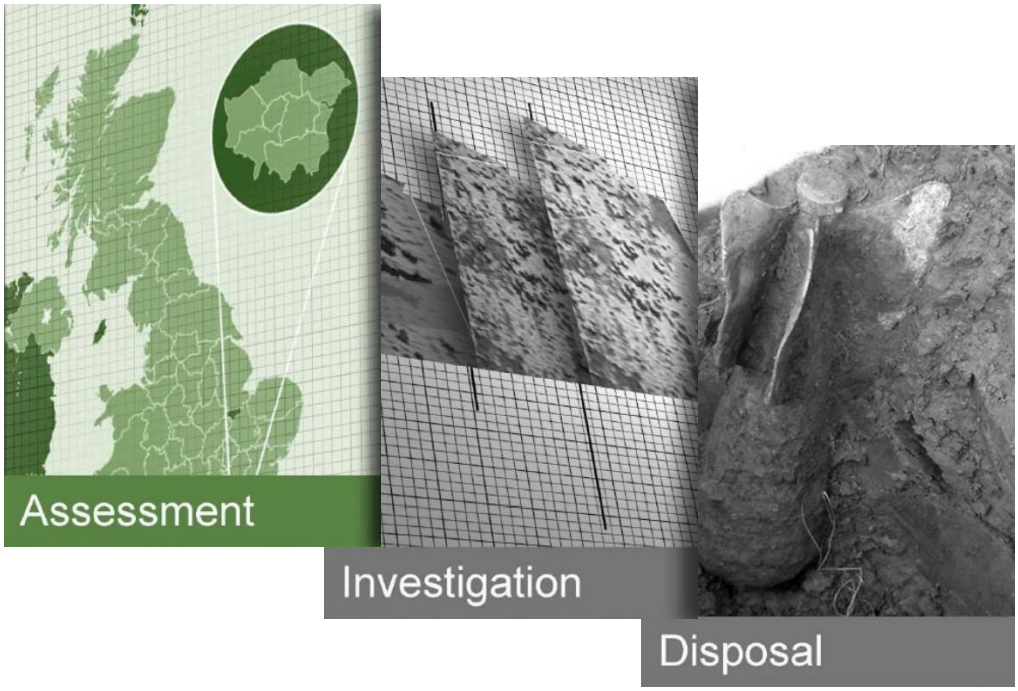
The University of Manchester
Oxford Road
Manchester
M13 9PL

Tel. 0161 275 2625
Fax. 0161 275 3880

# APPENDIX II

# UXO DESK TOP STUDY




**Martin Harris Music Block - UXO Desk Study & Risk Assessment**


**Drafted by** Callan Armknecht
**Checked by** Joe Lingard
**Authorised by** Stefan Lang

| | |
|---|---|
| **Document Title** | **UXO Desk Study & Risk Assessment** |
| **Document Ref.** | **P11803-22-R1** |
| **Revision** | **A** |
| **Project Location** | **Martin Harris Music Block** |
| **Client** | **Clancy Consulting** |
| **Date** | **29th April 2022** |

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# UXO DESK STUDY & RISK ASSESSMENT

## EXECUTIVE SUMMARY

**Key findings:** No significant sources of Unexploded Ordnance (UXO) hazard have been identified.

**Key actions:** Proceed with works.

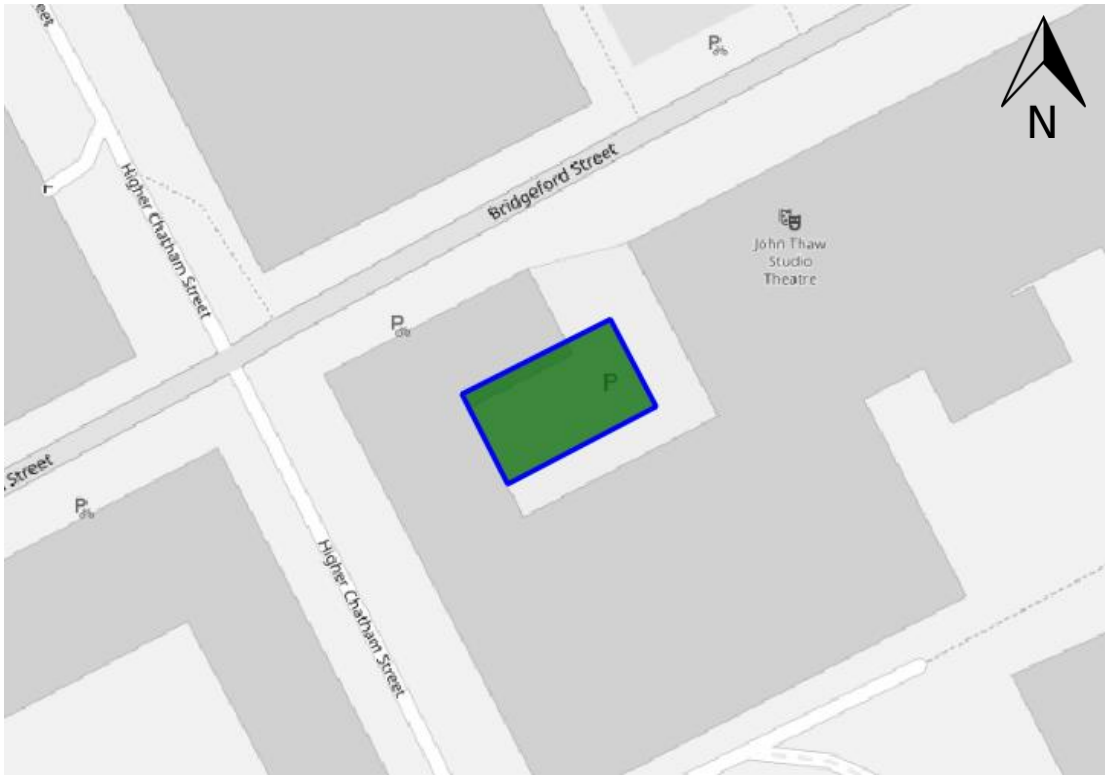
### UXO Hazard Assessment

No records have been found indicating that the Site was bombed and no other significant sources of UXO hazard have been identified on the Site.

Given this, it is considered that the Site has a low UXO hazard level, as shown in the following Figure, reproduced as Figure 4 in the main report.

The UXO hazard zone plan of the Site is also given in the accompanying P11803-22-R1-MAP01-A.

**UXO hazard zone plan of the Site**




*Source: OpenStreetMap* *Not to Scale*

| | | | | | | |
|---|---|---|---|---|---|---|
| **Legenda** | Very Low | | Low | | Moderate | |
| | High | | Very High | | Site boundary | |

The main findings of the report are summarised below.

- No records of bombing or military activity on the Site during World War One (WWI) have been found.
- During World War Two (WWII) the main strategic targets in the vicinity of the Site included Salford and Manchester docks, major transport infrastructure and public utilities, metal and engineering works.

- No records have been found indicating that the Site was bombed during WWII. Records indicate that the nearest High Explosive (HE) bomb fell approximately 60m west-southwest of the Site between the 22nd and 23rd December 1940.
- No records of military activity on the Site post-WWII have been found.

## Data Confidence Level

The findings of this report were based on good corroborative evidence of the military activity and bombing on the Site.

## Proposed Works

It is understood that the Site will be developed into a new two storey building associated with the University of Manchester.

Initial works on the Site will include intrusive ground investigations, including 5No. boreholes to a depth of 5m below ground level (bgl). For the purpose of this assessment, it is assumed that works on the Site may also include excavations.

## Risk Assessment

The Table below, reproduced as Table 3 in the main report, provides a UXO risk assessment for the proposed works on the Site.

Further details on the methodology for the risk assessment are provided in Section 7.2 of the main report.

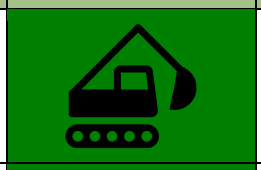
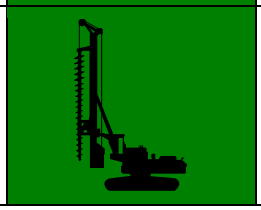
**UXO risk assessment for the Site**

| Potential UXO Hazard | Anticipated Works | PE | PD | P = PE x PD | Likelihood | Severity | Risk Rating | UXO Risk |
|---|---|---|---|---|---|---|---|---|
| UXB | Shallow Excavations | 1 | 1 | 1 | 1 | 5 | 5 | Low |
| | Deep Excavations | 1 | 1 | 1 | 1 | 5 | 5 | Low |
| | Boreholes | 1 | 1 | 1 | 1 | 4 | 4 | Low |
| Other UXO | Shallow Excavations | 1 | 1 | 1 | 1 | 4 | 4 | Low |
| | Deep Excavations | 1 | 1 | 1 | 1 | 4 | 4 | Low |
| | Boreholes | 1 | 1 | 1 | 1 | 3 | 3 | Low |
| **PE (Probability of Encounter), PD (Probability of Detonation), P (Overall Probability)** | | | | | | | | |
| **Shallow Excavations defined as <1.0m below ground level (bgl.)** | | | | | | | | |

## Risk Mitigation Plan

The Table below, reproduced as Table 4 in the main report, summarises the UXO risk for proposed works on the Site and recommended actions.

**Summary of UXO risk and mitigation recommendations**

| Proposed Works | UXO Risk | Recommended Mitigation |
|---|---|---|
| Excavations |  | **Proceed with works** – if additional comfort is required to address the residual UXO hazard, a formal UXO awareness briefing can be provided. |
| Boreholes |  | **Proceed with works** |

In summary, no additional measures are considered essential to reduce the UXO risk on the Site to As Low As is Reasonably Practicable (ALARP).

## What Do I Do Next?

If you have any comments or require further assistance, contact us via phone (01993 886682) or email (uxo@zetica.com) and we can help.

If you have requirements to identify other buried hazards (such as mapping utilities or obstructions) we can provide these surveys.

If proposed works on the Site change, or additional works are planned, contact Zetica for a re-assessment of the UXO risk and the risk mitigation requirements.

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P11803-22-R1-MAP01-A (UXO Desk Study)

## ABBREVIATIONS

| | |
|---|---|
| **AA** | Anti-Aircraft |
| **ALARP** | As Low As Reasonably Practicable |
| **ARP** | Air Raid Precaution |
| **AXO** | Abandoned Explosive Ordnance |
| **BD** | Bomb Disposal |
| **BDO** | Bomb Disposal Officer |
| **BDU** | Bomb Disposal Unit |
| **CMD** | Conventional Munitions Disposal |
| **DCLG** | Department of Communities and Local Government |
| **EO** | Explosive Ordnance |
| **EOC** | Explosive Ordnance Clearance |
| **EOR** | Explosive Ordnance Reconnaissance |
| **ERW** | Explosive Remnants of War |
| **ESA** | Explosive Substances and Articles |
| **FFE** | Free From Explosives |
| **HAA** | Heavy Anti-Aircraft |
| **HE** | High Explosive |
| **HSE** | Health and Safety Executive |
| **IB** | Incendiary Bomb |
| **IED** | Improvised Explosive Device |
| **IEDD** | Improvised Explosive Device Disposal |
| **JSEODOC** | Joint Services EOD Operations Centre |
| **LAA** | Light Anti-Aircraft |
| **MoD** | Ministry of Defence |
| **NSF** | National Shell Factory |
| **OB** | Oil Bomb |
| **PM** | Parachute Mine |
| **PUCA** | Pick Up and Carry Away |
| **RAF** | Royal Air Force |
| **TEP** | Time Expired Pyrotechnics |
| **UXAA** | Unexploded Anti-Aircraft |
| **UXB** | Unexploded Bomb |
| **UXO** | Unexploded Ordnance |
| **WWI** | World War One |
| **WWII** | World War Two |

# UXO DESK STUDY & RISK ASSESSMENT

**Please read:** Zetica has colour coded each paragraph. Paragraphs with black text on a white background are paragraphs that provide site-specific information or information specifically researched as part of this project.

Boxed paragraphs in a dark green text with a green background are paragraphs providing general information and, where appropriate, links to online resources giving further detail. These are all available at www.zeticauxo.com. If you cannot gain access to these resources, Zetica can forward them on request.

## 1 INTRODUCTION

### 1.1 Project Outline

Zetica Ltd was commissioned by Clancy Consulting to carry out a detailed Unexploded Ordnance (UXO) Desk Study and Risk Assessment for an area of less than 0.1 hectares (ha) off Bridgeford Street in Manchester (the 'Site').

The aim of this report is to gain a fair and representative view of the UXO hazard for the Site and its immediate surrounding area in accordance with the Construction Industry Research and Information Association (CIRIA) C681 'Unexploded Ordnance (UXO), a Guide for the Construction Industry'.

Where appropriate, this hazard assessment includes:

- Likelihood of ordnance being present.
- Type of ordnance (size, filling, fuze mechanisms).
- Quantity of ordnance.
- Potential for live ordnance.
- Probable location.
- Ordnance condition.

It should be noted that some military activity providing a source of UXO hazard may not be recorded and therefore there cannot be any guarantee that all UXO hazards affecting the Site have been identified in this report.

### 1.2 Sources of Information

Zetica Ltd researched the military history of the Site and its surrounding area using a range of information sources. The main sources of information are detailed in the following sections and referenced at the end of this report.

#### 1.2.1 Zetica Ltd Defence Related Site Records

Zetica Ltd's in-house records were consulted, including reference books and archived materials from past work in the region. Relevant documents have been cited within the bibliography of this report.

#### 1.2.2 Zetica Ltd Bombing Density Records and Maps

Reference has been made to the Zetica Ltd bomb risk maps located on Zetica's website (http://zeticauxo.com/downloads-and-resources/risk-maps/)

#### 1.2.3 Ministry of Defence and Government Records

Government departments and units within the Ministry of Defence (MoD) were approached for information of past and present military activity in the area. These included the Department of Communities and Local Government (DCLG) records of abandoned bombs.

#### 1.2.4 Other Historical Records, Maps and Drawings

Numerous reference documents including historical maps, aerial photographs and drawings have been consulted from sources such as the National Archives, the US National Archives & Records Administration (NARA), the Imperial War Museum (IWM), Historic England and the Defence of Britain Project.

The British Geological Survey (BGS) was consulted for borehole information.

#### 1.2.5 Local Authority Records

Information was obtained from Manchester City Council.

#### 1.2.6 Local Record Offices and Libraries

The Greater Manchester County Record Office was consulted for records.

#### 1.2.7 Local Historical and Other Groups

Local history groups and archaeological bodies were consulted, including the Greater Manchester and Lancashire Historic Environment Record (HER).

### 1.3 Data Confidence Level

In general, there is a high level of confidence in the researched information sources used for this report. Exceptions to this are specifically detailed in the text of the report.

# 2 THE SITE

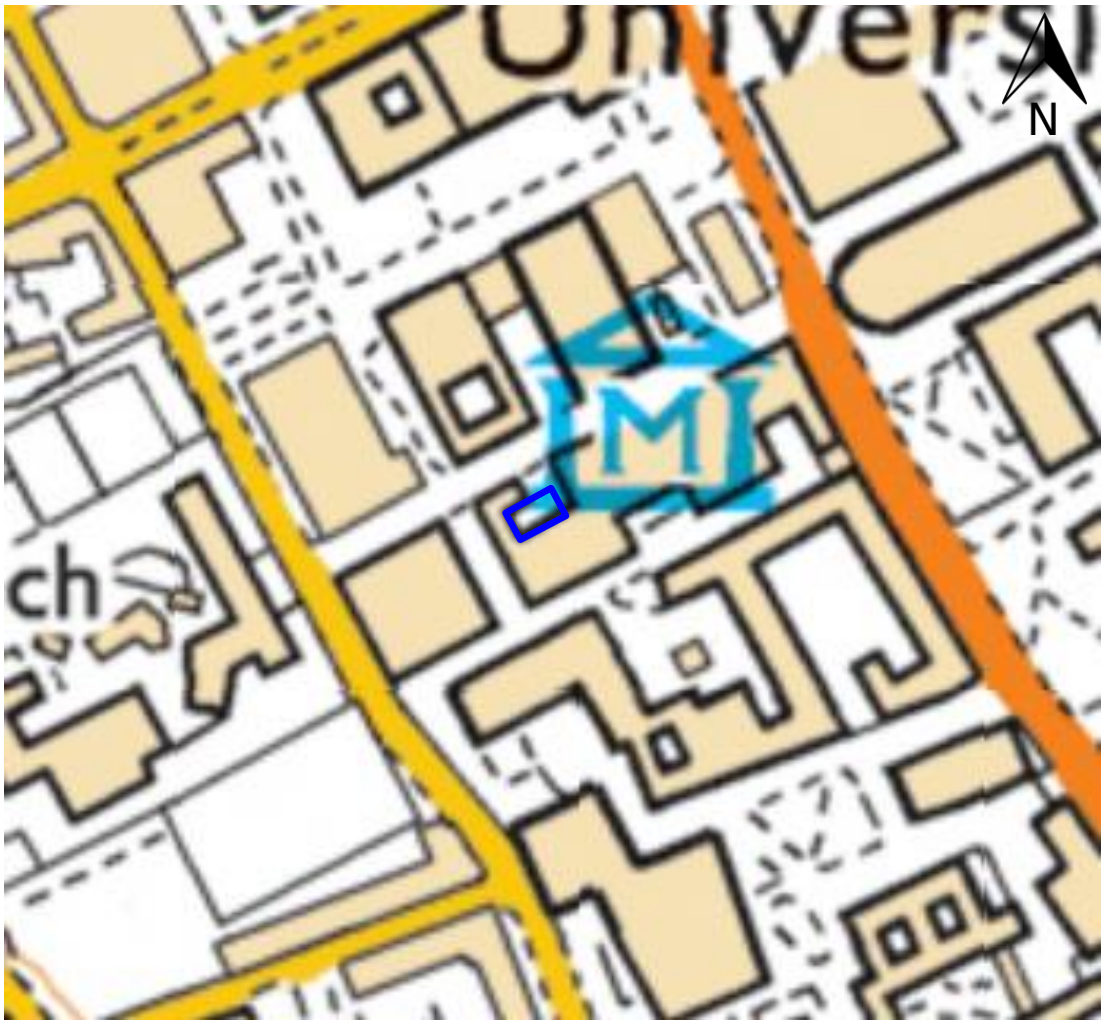
## 2.1 Site Location

The Site is centred on Ordnance Survey National Grid Reference (OSNGR) SJ 844966. It is located approximately 1.6km south-southeast of central Manchester.

The Site comprises hardstanding. It is bounded on all sides by property associated with the University of Manchester.

Figure 1 is a Site location map and Plate 1 is a recent aerial photograph of the Site.

**Figure 1 Site location map**




*Source: © Crown Copyright 2022. Reproduced by permission of Ordnance Survey* *Not to Scale*

| | |
|---|---|
| **Legend** | Site boundary |

**Plate 1 Recent aerial photograph of the Site**

*Source: Google Earth* *Not to Scale*

| | |
|---|---|
| **Legend** | Site boundary |

# 3 MILITARY ACTIVITY

The following sections outline the recorded military activity in the vicinity of the Site. The potential UXO hazard from WWI and WWII bombing is detailed in Section 4.

Each sub-section provides hyperlinks to further information on potential sources of UXO hazard. These are also available at www.zeticauxo.com. If you cannot gain access to these resources, Zetica can forward them on request.

## 3.1 Defences

For further information on military defences, and the potential UXO hazards associated with them, follow the links below:

- Anti-Aircraft Guns
- Anti-Invasion Defences
- Barrage Balloons
- Bombing Decoys
- Home Guard
- Mined Locations
- Mortar & Gun Emplacements
- Pillboxes

No military defences have been identified on the Site. The nearest are described below.

### 3.1.1 Anti-Aircraft Guns

During WWI there were 10No. Anti-Aircraft (AA) batteries within 10km of the Site. The nearest was located at Hough End (SD 825935), approximately 3.9km southwest of the Site. It was armed with 1No. 6-pounder (-pdr) gun.

During WWII there were 36No. Heavy AA (HAA) and ZAA batteries within 10km of the Site. The nearest was located at Whalley Range (SJ 837945), approximately 2.2km northeast of the Site. It was armed with 40No. Unrotated Projectile (UP) rocket launchers.

#### Potential UXO Hazard

Given the number of HAA gun batteries in the surrounding area during WWII, the potential for an Unexploded AA (UXAA) shell to have fallen on the Site unnoticed, whilst unlikely, cannot be totally discounted.

### 3.1.2 Bombing Decoys

The nearest recorded bombing decoy was located at Reddish (SJ 912939), approximately 7.3km east-southeast of the Site.

Bombing decoys are not considered to provide a source of UXO hazard to the Site.

## 3.2 Military Airfields

For further information on military airfields, and the potential UXO hazards associated with them, follow the link below:

- Military Airfields

No records of any military airfields on or in close proximity to the Site have been found.

During WWI, the nearest operational airfield was Royal Flying Corps (RFC) Didsbury (SJ 834932), approximately 3.5km south-southwest of the Site. It was used for the assembly and test-flying of military aircraft. Post-war it reverted to civilian use before its closure in 1924.

The nearest operational airfield during WWII was Royal Air Force (RAF) Barton (SJ 742972), approximately 10.2km west of the Site. This was mainly used for aircraft testing and pilot training. Post-war it reverted to civilian use and is currently in operation as City Airport Barton.

Military airfields are not considered to provide a source of UXO hazard to the Site.

## 3.3 Aircraft Crashes

For further information on military aircraft crashes, and the potential UXO hazards associated with them, follow the link below:

- Aircraft Crashes

No records of any aircraft crashes on or in close proximity to the Site have been found.

## 3.4 Explosives Factories, Munitions Depots and Disposal Areas

For further information on explosives factories, munitions depots and disposal areas, and the potential UXO hazards associated with them, follow the links below:

- Explosives Factories
- Munitions Depots
- Munitions Disposal Areas

No records of any explosives factories, munitions depots or munitions disposal areas on the Site have been found. The nearest is described below.

### 3.4.1 Manchester National Shell Factory

During WWI, Manchester National Shell Factory (NSF) was located on Hyde Road, approximately 1.5km east-northeast of the Site. It produced 4.5-inch shells.

Manchester NSF is not considered to provide a source of UXO hazard to the Site.

## 3.5 Firing Ranges and Military Training Areas

For further information on firing ranges and military training areas, and the potential UXO hazards associated with them, follow the links below:

- Artillery Ranges
- Bombing Ranges
- Military Training Areas
- Small Arms Ranges

No records of any firing ranges or military training areas on or in close proximity to the Site have been found.

## 3.6 Other Military Establishments

No other military establishments have been identified on or in close proximity to the Site.

# 4 BOMBING

## 4.1 WWI Bombing

For further information on WWI bombing in the UK, and the potential UXO hazard associated with it, see Appendix 2.1. Alternatively, use the following link.

- WWI Bombing

No records have been found indicating that the Site was bombed during WWI.

## 4.2 WWII Bombing

For further information on WWII bombing in the UK, and the potential UXO hazard associated with it, see Appendix 2.2. Alternatively, use the following link.

- WWII Bombing

No records have been found indicating that the Site was bombed during WWII. Details of WWII bombing in the vicinity of the Site are provided in the following sections.

### 4.2.1 Bombing in Manchester

Greater Manchester's industrial conurbations and port made it a principal target for enemy bombers. The Luftwaffe possessed detailed target photographs of many industrial complexes from as early as 1937.

Air raids began in August 1940 and continued until 1942. The heaviest raids on the city occurred between the 22nd and 24th December 1940, the 'Manchester Blitz', during which over 650No. High Explosive (HE) bombs were dropped across the area.

During WWII, the Greater Manchester region was raided on at least 314No. occasions with approximately 1,710No. HE bombs and 115No. Parachute Mines (PMs) falling. Bombing was mostly concentrated on Salford Docks and Manchester City Centre, approximately 3.4km west and 1.6km north-northwest respectively of the Site. The concentration of major industrial works at Trafford Park, approximately 3.5km west-northwest of the Site, also attracted heavy raids.

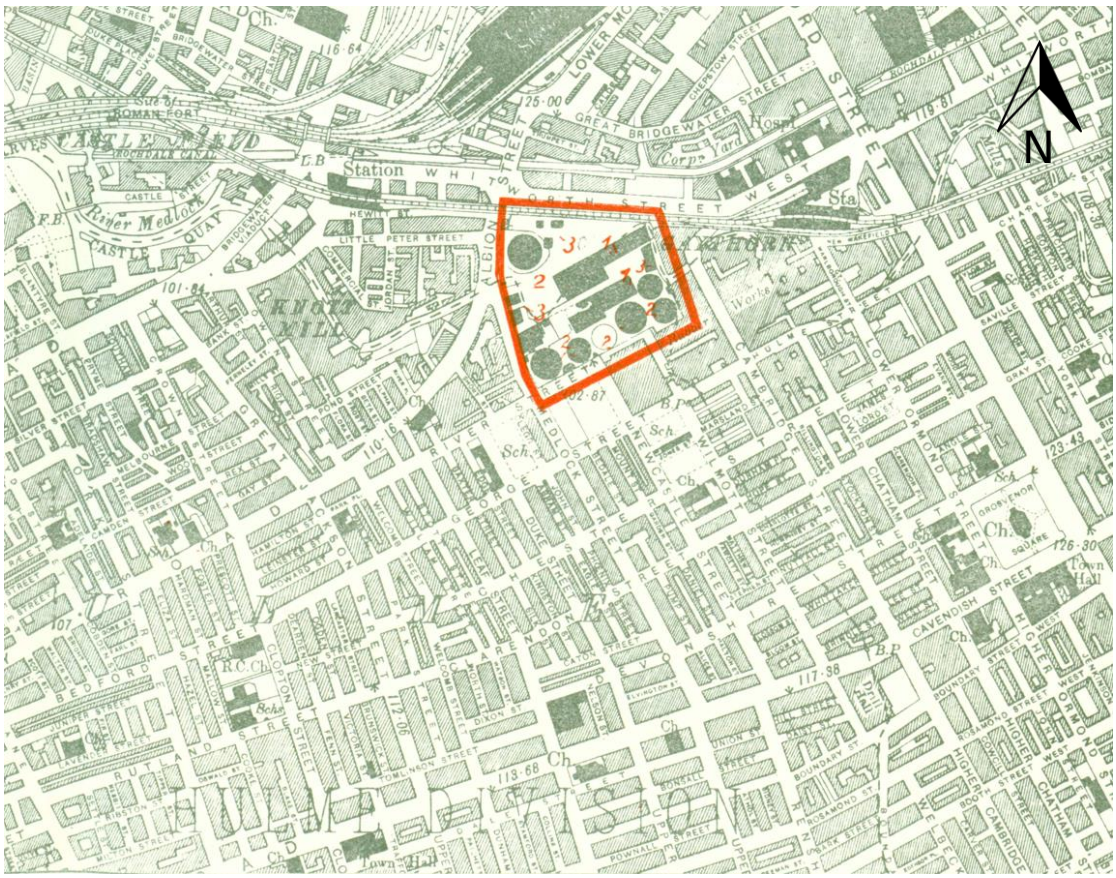
Bombing densities generally decreased away from the city centre and far less damage was sustained by properties in these areas.

### 4.2.2 Strategic Targets

The Site was located in an area which contained several potential strategic targets, including the Manchester Ship Canal and Salford Docks, major transport infrastructure and public utilities, metal and engineering works.

Figure 2 is a Luftwaffe target plan of Manchester Gasworks, approximately 1km northwest of the Site, dating from October 1939. It identifies the gasworks, coke furnaces (1), gasholders (2), and office buildings (3).

**Figure 2 Luftwaffe target plan of Manchester Gasworks, 1939**




*Source: NARA* *Not to Scale*

### 4.2.3 Bombing Densities and Incidents

Table 1 gives details of the overall bombing statistics recorded for the Local Authority Districts of the Site (highlighted by bold text) and surrounding districts. These were categorised as Rural Districts (RD), Urban Districts (UD), Municipal or Metropolitan Boroughs (MB) and County Boroughs (CB). WWII bomb density levels are defined below:

<5 bombs per 405ha is a Very Low regional bombing density.

5-15 bombs per 405ha is Low.

15-50 bombs per 405ha is Moderate.

50-250 bombs per 405ha is High.

>250 bombs per 405ha is Very High.

**Table 1 Bombing statistics**

| Area | Bombs Recorded | | | | |
|---|---|---|---|---|---|
| | High Explosive | Parachute Mines | Other | Total | Bombs per 405ha (1000 acres) |
| **Manchester CB** | **712** | **18** | **7** | **737** | **27.0** |
| Stretford MB | 456 | 64 | 0 | 520 | 147.3 |
| Salford CB | 406 | 29 | 16 | 451 | 86.7 |

Note that Table 1 excludes the figures for Incendiary Bombs (IBs). Discrepancies between this list and other records, such as bomb clearance records, demonstrate that this data is likely to under-represent actual bombing.

Details of the nearest recorded bombing incidents to the Site are given in the following section. Appendix 5 provides further details of recorded bombing incidents in the immediate vicinity of the Site.

**9th October 1940**

1No. IB fell on the junction of Coupland Street and Malcolm Square, approximately 0.2km southwest of the Site.

**10th October 1940**

1No. HE bomb fell on Welbeck Street, approximately 0.2km west of the Site.

**11th October 1940**

1No. IB fell on Bridge Street, approximately 20m northeast of the Site.

1No. IB fell on Coupland Street, approximately 0.1km south-southwest of the Site.

6No. IBs fell on the junction of Booth Street West and Higher Chatham Street, approximately 0.2km northwest of the Site.

1No. HE bomb fell on the Park Street Drill Hall, approximately 0.3km southwest of the Site.

4No. IBs fell on the junction of Rosamund Street West and Higher Chatham Street, approximately 0.3km northwest of the Site.

1No. IB fell on 30 New York Street, approximately 0.3km northeast of the Site.

**22nd - 23rd December 1940**

Manchester and Salford were heavily bombed between the 22nd and 24th December 1940 (the 'Manchester Blitz'). Over 400No. HE bombs and more than 30,000No. IBs fell across the region.

1No. HE bomb fell on St. Ambrose Church, Higher Chatham Street, approximately 60m north-northwest of the Site.

1No. HE bomb fell on the Turner Dental School on the corner of Bridge Street and Higher Chatham Street, approximately 60m west-southwest of the Site.

1No. HE bomb fell on 29 Jenkinson Street, approximately 0.2km north of the Site.

1No. HE bomb fell on Burlington Street, approximately 0.2km south of the Site.

1No. HE bomb fell on 93 Higher Cambridge Street, approximately 0.2km northwest of the Site.

1No. HE bomb fell on the junction of Boundary Lane and Bridge Street, approximately 0.3km west-southwest of the Site.

1No. IB fell on 30 New York Street, approximately 0.3km northeast of the Site.

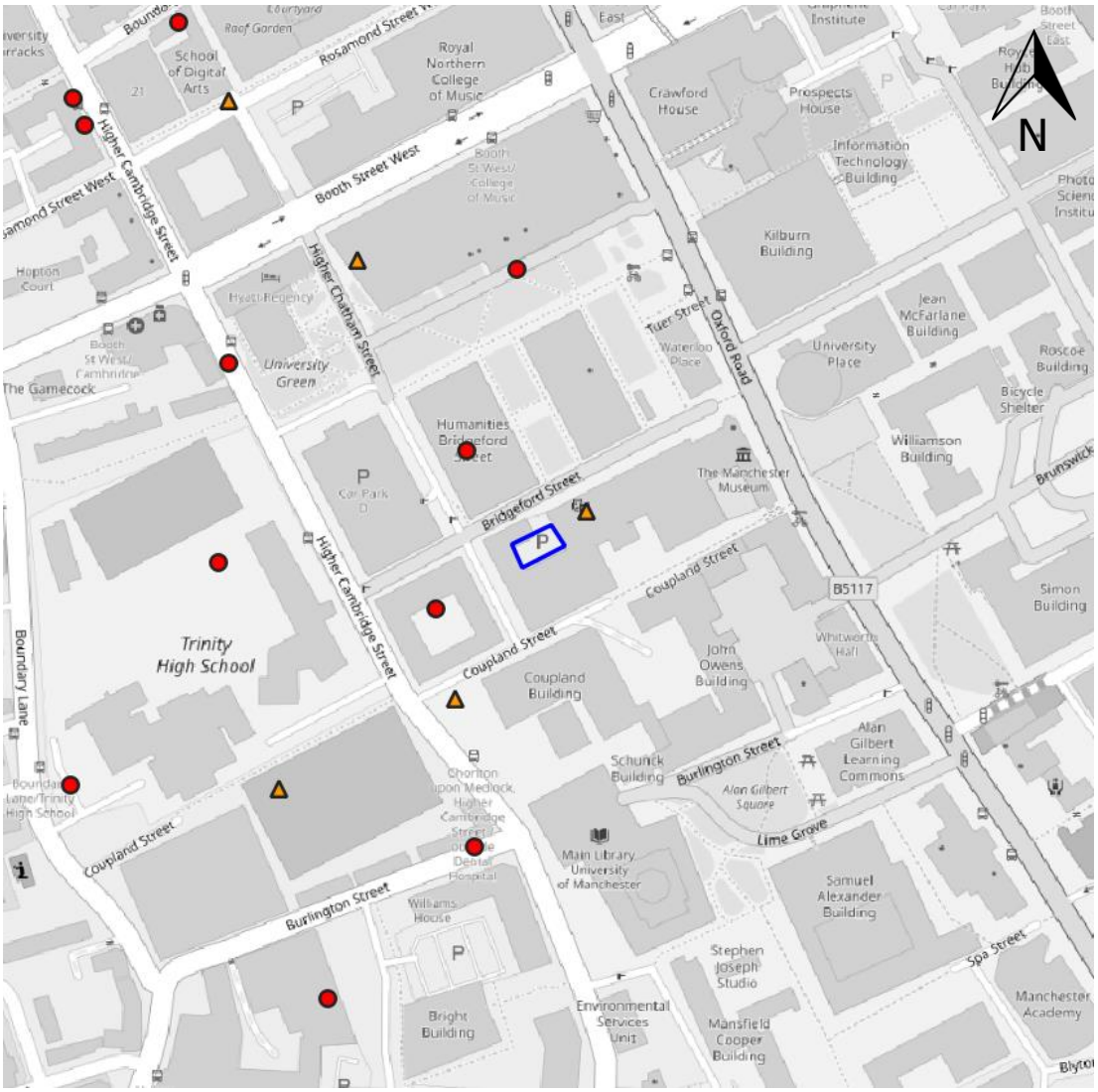
It should be noted that during WWII, many Unexploded Bombs (UXBs) were mapped and subsequently removed as and when conditions and demands on Bomb Disposal teams allowed. Their removal was not always accurately recorded and sometimes records were later destroyed. In practice, most UXB were probably removed and only a much smaller number were actually registered as officially abandoned bombs.

Figure 3 is a map showing the approximate location of recorded bomb impacts in the immediate vicinity of the Site. IBs shown are indicative of larger numbers of similar devices that fell within the given area.

The map has been compiled from a number of different sources, including air raid incident reports, historical aerial photographs and bomb census maps.

The bomb map is also given in the accompanying P11803-22-R1-MAP01-A.

**Figure 3 Compiled bomb impact map for the vicinity of the Site**




*Source: OpenStreetMap* *Not to Scale*

| **Legend** | Site boundary | HE bomb | IBs |
|---|---|---|---|

Plate 2 is an aerial photograph dated the 16th May 1948. No bomb damage has been identified on the Site.

Some areas of bomb damage have been identified in the vicinity of the Site. Some of these are likely the result of pre-WWII slum clearance.

**Plate 2 Aerial photograph, 16th May 1948**

*Source: Historic England* *Not to Scale*

| Legend | Site boundary | Possible bomb damage | Pre-WWI Redevelopment |
|---|---|---|---|

## Potential UXO Hazard

No records have been found indicating that the Site was bombed and no bomb damage has been identified on the Site on historical aerial photography.

WWII bombing is not considered to provide a source of UXO hazard to the Site.

### 4.2.4 Geology and Bomb Penetration Depths

It is important to consider the geological materials present at the time that a bomb was dropped in order to establish its maximum penetration depth.

At the time of writing, no Site-specific ground investigation data was available.

British Geological Survey (BGS) 1:50,000 Sheet 85 Manchester (Bedrock and Superficial) and BGS borehole records from nearby investigations have been consulted to get an indicative overview of the Site geology.

The geology of the Site is understood to consist of Made Ground, over till and diamicton of the Devensian Member, overlying the Chester Sandstone Formation.

Table 2 provides an estimate of average maximum bomb penetration depths for the Site assuming WWII ground conditions of 1m of Made Ground (modelled as gravel), over 3.5m of stiff clay, overlying more than 20m of weak rock.

**Table 2 Estimated average maximum bomb penetration depths**

| Estimated average bomb penetration depths for anticipated geology | | |
|---|---|---|
| **Bomb Weight** | 50kg | 4.0m |
| | 250kg | 5.5m |
| | 500kg | 8.0m |

These calculations can be refined on receipt of Site-specific information.

The estimated bomb penetration depths given in Table 2 are from the WWII ground level and are based on the following assumptions:

a) High level release of the bomb resulting in an impact velocity of 260m/s (>5,000m altitude).

b) A strike angle of 10 to 15 degrees to the vertical.

c) That the bomb is stable, both in flight and on penetration.

d) That no retarding units are fitted to the bomb.

e) That the soil type is homogenous.

A high altitude release of a bomb will result in ground entry at between 10° and 15° to the vertical with the bomb travelling on this trajectory until momentum is nearly lost. The bomb will then turn abruptly to the horizontal before coming to rest. The distance between the centre of the entry hole and the centre of the bomb at rest is known as the 'offset'. A marked lateral movement from the original line of entry is common.

Low-level attacks may have an impact angle of 45° or more, which will frequently lead to a much greater amount of offset movement during soil penetration.

The average offset is one third of the penetration depth, i.e. an offset of 2m may be expected for a 50kg bomb in dry silts and clays. If hard standings or Made Ground were present during WWII, bomb penetration depths would have been significantly reduced but offset distances may have been up to four times greater.

# 5 EXPLOSIVE ORDNANCE CLEARANCE ACTIVITIES

Official UK bombing statistics have been compiled from both British and German sources. There were differences in the way the figures were originally reported and collated which has led to discrepancies in the summary data.

Based on data from 1939 to 1945, War Office statistics indicate that 200,195No. HE bombs exploded within Great Britain. Additionally, 25,195No. HE bombs (representing 11%) were recorded as UXBs. However, records from the Royal Engineers who were responsible for bomb disposal at the time indicate that as of 27th February 1946 upwards of 45,000No. UXBs were disposed of.

On average 8.5% of UXBs later self-exploded. In some cases the bombs had delayed action fuzes or were never intended to explode, their purpose being to cause inconvenience and fear. Given the discrepancy in records and the fact that UXBs are still being found unexpectedly, it is clear that the original figures are understated and provide only an approximation of the number of potential UXBs in the UK.

War Office statistics also show that between October 1940 and May 1941 most of the UXBs (93%) were either 50kg or 250kg. It should be noted that details of the recovery and the size of the UXB were not always accurately reported.

The larger WWII UXBs are often difficult to recover due to both penetration depths and the presence of two or more fuzes, combined with more sensitive fillings of explosive mixtures including Amatol and Trialen.

## 5.1 Abandoned Bombs

For further information on abandoned bombs, and the potential UXO hazard associated with them, follow the link below:

- Abandoned Bombs

No records have been found indicating that any officially abandoned bombs are located on the Site.

## 5.2 EOC Tasks

Zetica holds no records of post-WWII EOC tasks having taken place in the vicinity of the Site.

# 6 UXO HAZARD ASSESSMENT

## 6.1 UXO Hazard Level

The definitions for the levels of UXO hazard are provided below.

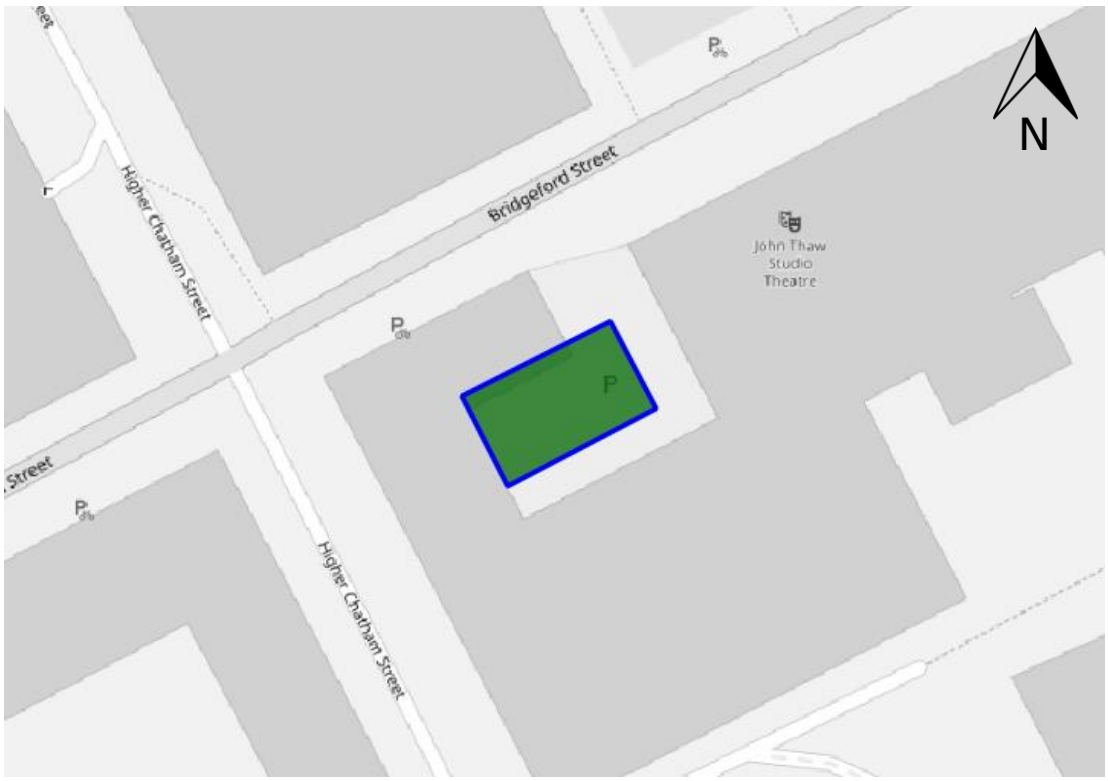
| Definitions of UXO Hazard Level for a Site | |
|---|---|
| **Hazard Level** | **Definition** |
| **Very Low** | There is positive evidence that UXO is not present, e.g. through physical constraints or removal. |
| **Low** | There is no positive evidence that UXO is present, but its occurrence cannot be totally discounted. |
| **Moderate** | There is positive evidence that ordnance was present or that other uncharted ordnance may be present as UXO. |
| **High** | There is positive evidence that UXO is present. |
| **Very High** | As high, but requires immediate or special attention due to the potential hazard. |

No records have been found indicating that the Site was bombed and no other significant sources of UXO hazard have been identified on the Site.

Given this, it is considered that the Site has a low UXO hazard level, as shown in Figure 4.

The UXO hazard zone plan of the Site is also given in the accompanying P11803-22-R1-MAP01-A.

**Figure 4 UXO hazard zone plan of the Site**




*Source: OpenStreetMap* *Not to Scale*

| | | | | | |
|---|---|---|---|---|---|
| **Legend** | Very Low | | Low | | Moderate |
| | High | | Very High | | Site boundary |

# 7 UXO RISK ASSESSMENT

## 7.1 Proposed Works

It is understood that the Site will be developed into a new two storey building associated with the University of Manchester.

Initial works on the Site will include intrusive ground investigations, including 5No. boreholes to a depth of 5m below ground level (bgl). For the purpose of this assessment, it is assumed that works on the Site may also include excavations.

## 7.2 Risk Assessment Methodology

A UXO risk assessment has been undertaken for the proposed works, taking into consideration the identified UXO hazard.

Firstly, the probability of encountering UXO (PE) has been considered and rated for the different construction techniques, as detailed below.

| Probability of Encounter (PE) | Rating |
|---|---|
| Frequent, highly likely, almost certain. | 5 |
| Probable, more likely to happen than not. | 4 |
| Occasional, increased chance or probability. | 3 |
| Remote, unlikely to happen but could. | 2 |
| Improbable, highly unlikely. | 1 |
| Impossible | 0 |

Secondly, the probability of detonating a UXO (PD) has been considered and rated for the different construction techniques, as detailed below.

| Probability of Detonation (PD) | Rating |
|---|---|
| Frequent, highly likely, almost certain. | 5 |
| Probable, more likely to happen than not. | 4 |
| Occasional, increased chance or probability. | 3 |
| Remote, unlikely to happen but could. | 2 |
| Improbable, highly unlikely. | 1 |
| Impossible | 0 |

Next, the probability of encountering and detonating the UXO (PE x PD) have been used to generate an overall likelihood rating (P).

| P = PE x PD | LIKELIHOOD of Encounter and Detonation | Rating |
|---|---|---|
| 21 to 25 | Frequent, highly likely, almost certain. | 5 |
| 16 to 20 | Probable, more likely to happen than not. | 4 |
| 6 to 15 | Occasional, increased chance or probability. | 3 |
| 2 to 5 | Remote, unlikely to happen but could. | 2 |
| 1 | Improbable, highly unlikely. | 1 |
| 0 | Impossible | 0 |
| **P ranges from 25, a certainty of UXO being encountered and detonated on the Site by engineering activity, to 0, a certainty that UXO does not occur on the Site and will not be detonated by engineering activity.** | | |

The likelihood of encountering and detonating UXO during site works is multiplied by the severity of such an event occurring (P x S), in order to provide a risk level using the following matrix.

| Severity (S) | Rating |
|---|---|
| Multiple fatalities | 5 |
| Major injury, long term health issues, single fatality. | 4 |
| Minor injury, short term health issues, no fatalities. | 3 |
| First aid case but no lost time or ill health. | 2 |
| Minor injuries, no first aid. | 1 |
| No injuries. | 0 |

| UXO Risk Matrix | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | SEVERITY (S) | | | | | |
| LIKELIHOOD (P) | | 5 | 4 | 3 | 2 | 1 | 0 |
| | 5 | 25 | 20 | 15 | 10 | 5 | 0 |
| | 4 | 20 | 16 | 12 | 8 | 4 | 0 |
| | 3 | 15 | 12 | 9 | 6 | 3 | 0 |
| | 2 | 10 | 8 | 6 | 4 | 2 | 0 |
| | 1 | 5 | 4 | 3 | 2 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## 7.3 UXO Risk Level

The UXO risk assessment for proposed works on the Site is given in Table 3.

**Table 3 UXO risk assessment for the Site**

| Potential UXO Hazard | Anticipated Works | PE | PD | P = PE x PD | Likelihood | Severity | Risk Rating | UXO Risk |
|---|---|---|---|---|---|---|---|---|
| UXB | Shallow Excavations | 1 | 1 | 1 | 1 | 5 | 5 | Low |
| | Deep Excavations | 1 | 1 | 1 | 1 | 5 | 5 | Low |
| | Boreholes | 1 | 1 | 1 | 1 | 4 | 4 | Low |
| Other UXO | Shallow Excavations | 1 | 1 | 1 | 1 | 4 | 4 | Low |
| | Deep Excavations | 1 | 1 | 1 | 1 | 4 | 4 | Low |
| | Boreholes | 1 | 1 | 1 | 1 | 3 | 3 | Low |
| **PE (Probability of Encounter), PD (Probability of Detonation), P (Overall Probability)** | | | | | | | | |
| **Shallow Excavations defined as <1.0m below ground level (bgl.)** | | | | | | | | |

# 8 RISK MITIGATION PLAN

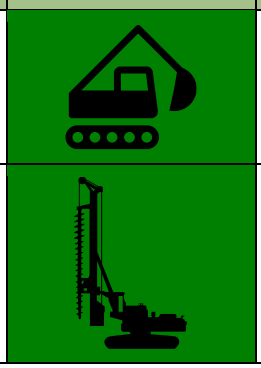
**Key findings:** No significant sources of UXO hazard have been identified.

**Key actions:** Proceed with works.

## 8.1 UXO Risk Summary

Table 4 summarises the UXO risk for proposed works on the Site and recommended actions.

**Table 4 Summary of UXO risk and mitigation recommendations**

| Proposed Works | UXO Risk | Recommended Mitigation |
|---|---|---|
| Excavations |  | **Proceed with works** – if additional comfort is required to address the residual UXO hazard, a formal UXO awareness briefing can be provided. |
| Boreholes |  | **Proceed with works** |

In summary, no additional measures are considered essential to reduce the UXO risk on the Site to As Low As is Reasonably Practicable (ALARP).

## 8.2 Risk Mitigation Techniques

Should you wish to provide staff involved in excavations with increased awareness regarding the potential (albeit low) for UXO encounter, this can be done through a formal briefing.

### 8.2.1 UXO Awareness Briefing

Typically ~1hour in duration, these briefings will be expected to provide site workers with:-

- Background to the potential UXO hazards that could be encountered.
- Awareness of how the UXO hazard could present a risk.
- Knowledge of what to do in the event that a suspect item is encountered.

The briefing is to be provided along with back-up materials such as UXO awareness posters, emergency contact numbers and other background information to assist site workers in becoming familiar with what potential UXO can look like.

The materials can also be used by key staff to pass on the relevant points of the induction to others who visit or work on the Site.

By providing the UXO awareness briefing, it ensures that in the unlikely event that UXO is encountered:-

- All site staff take appropriate action.
- A support mechanism and points of contact are established.
- The likelihood of harm to people or property is reduced.
- Significant delays to site work are prevented.

## 8.3 What Do I Do Next?

If you have any comments or require further assistance, contact us via phone (01993 886682) or email (uxo@zetica.com) and we can help.

If you have requirements to identify other buried hazards (such as mapping utilities or obstructions) we can provide these surveys.

If proposed works on the Site change, or additional works are planned, contact Zetica for a re-assessment of the UXO risk and the risk mitigation requirements.

# APPENDICES

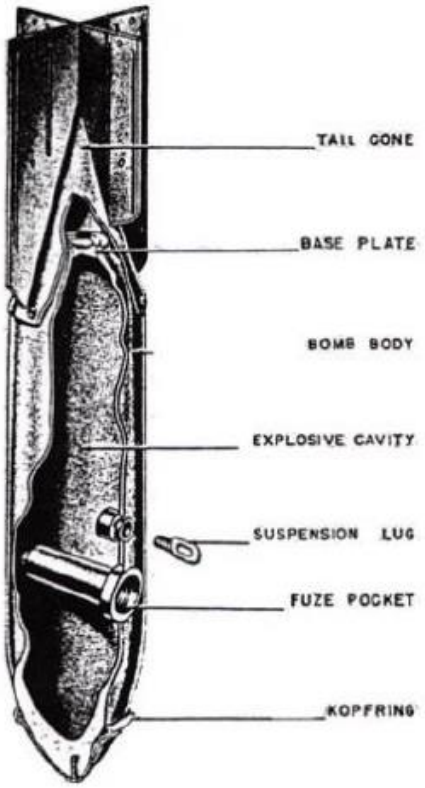
## Appendix 1 Anticipated Ordnance Types

The probability of encountering UXO on the Site is considered to be low. As with any similar site in the UK, there is always a background risk of finding ordnance and potential types to be encountered are detailed below. For a more comprehensive set of ordnance data sheets, see http://zeticauxo.com/downloads-and-resources/ordnance-data-sheets/.

### Information Data Sheet

**Category** Bomb (Luftwaffe)
**Type** Sprengbombe-Cylindrisch (SC) 50kg

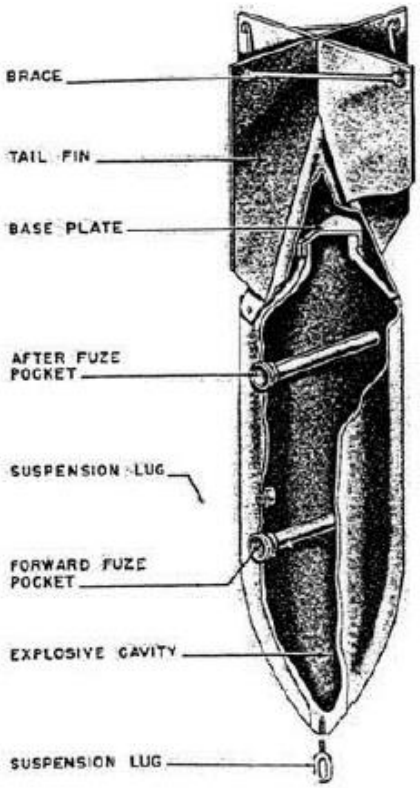
| | |
|---|---|
| **Variants** | 8 |
| **Body Dimensions** | 762 x 200mm (30" x 7.9") |
| **Weight** | 55kg (122lbs) |
| **Charge Weight** | 25kg (54lbs) |
| **Fuze** | Single electric impact fuze. Some have short time delay |
| **Composition** | Sheet steel |
| **Description** | Thick nose welded to a steel body. Nose may be attached to Kopfring (a triangular section steel ring) or spike. Suspension bolt in eye/body and sheet metal tail attached to body with rivets/screws. Originally painted green-grey with a yellow stripe on the tail. Cast TNT, Amatol or Trialen filling. |
| **Function** | Designed to maximise shock waves through air, water and earth and for general demolition. Used against easily damageable targets, including roads, aircraft hangars, rolling stock and small buildings. Spike bombs/ 'Stabo' (SC 50 with spikes attached to nose) were used against rail lines and country roads, with Kopfring used against naval targets. |



## Information Data Sheet

**Category** Bomb
**Type** Sprengbombe-Cylindrisch (SC) 250kg

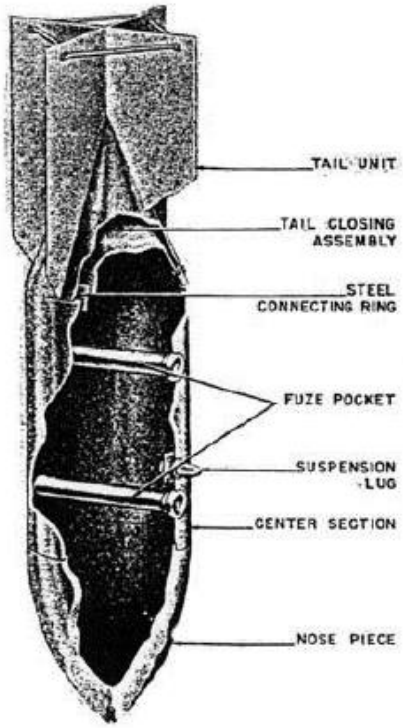
| | |
|---|---|
| **Variants** | 8 |
| **Body Dimensions** | 1194mm x 368mm (47" x 14.5") |
| **Weight** | 249-264 kg (548-582lbs) |
| **Charge Weight** | 130-145 kg (287-320lbs) |
| **Fuze** | Electric impact fuze/electric clockwork time fuse & electric anti-disturbance fuze |
| **Composition** | Sheet steel with stays |
| **Description** | Thick nose welded to steel body. Nose may be attached to Kopfring (triangular section steel ring) or spike. Sheet metal tail attached to body with rivets/ screws. Suspension eye bolt in the nose/body. Originally painted green-grey with a yellow stripe on the tail. TNT; amatol; TNT and aluminium powder, naphthalene, ammonium nitrate and wax/ wood meal filling. |
| **Function** | Designed to maximise shock waves through air, water and earth and general demolition. Used against railway installations, large buildings, ammunition depots and below-ground installations (to 8m). Spike bombs/ 'Stabo' (SC 50 with spikes attached to nose) used against rail lines and country roads. |



## Information Data Sheet

**Category** Bomb
**Type** Sprengbombe-Cylindrisch (SC) 500kg

| | |
|---|---|
| **Variants** | - |
| **Body Dimensions** | 1414–1486mm x 470mm (55.7-58.5" x 18.5") |
| **Weight** | 500kg (1,100lbs) |
| **Charge Weight** | 220kg (484lbs) |
| **Fuze** | Electric impact fuze/electric clockwork time fuse & electric anti-disturbance fuze. |
| **Composition** | Sheet steel with stays or drum |
| **Description** | Thick nose welded to steel body. Nose may be attached to Kopfring (triangular section steel ring). Tail either steel sheet or drum-shaped. Suspension band. Originally painted green-grey/ buff (some later versions sky blue) with yellow stripe on tail. Filled with amatol, TNT or trialen. |
| **Function** | Designed to maximise shock waves through air, water and earth and for general demolition. Used against railway property, large buildings, shipping and below-ground installations. |



## Information Data Sheet

**Category** Bomb
**Type** Sprengbombe-Cylindrisch (SC) 1,000kg (HERMANN)

**Variants** 3

**Body Dimensions** 1742-1905mm x 648–660mm (68.6-75" x 25.5-26")

**Weight** 1,000-1,088kg (2,204-2,398lbs)

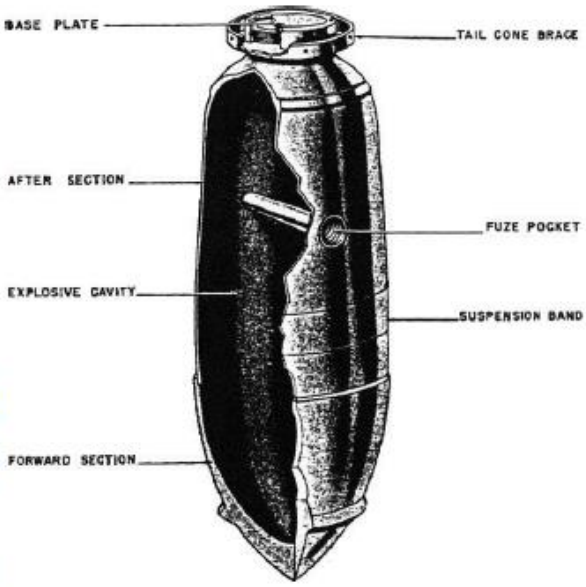
**Charge Weight** 529-619kg (1,166-1,364lbs)

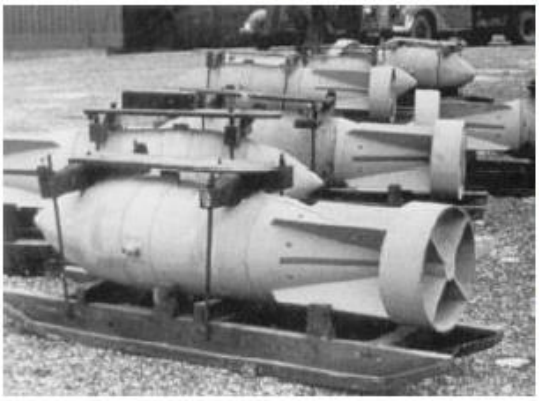
**Fuze** Electric impact fuze/ electric clockwork time fuze & electric anti-disturbance fuze

**Composition** Magnesium alloy with drum

**Description** Thick nose welded to steel body. Nose attached to Kopfring (triangular section steel ring). Drum-shaped tail made of magnesium alloy. Suspension band. Originally painted sky-blue. Filled with amatol, TNT/aluminium/wood meal or trialen.

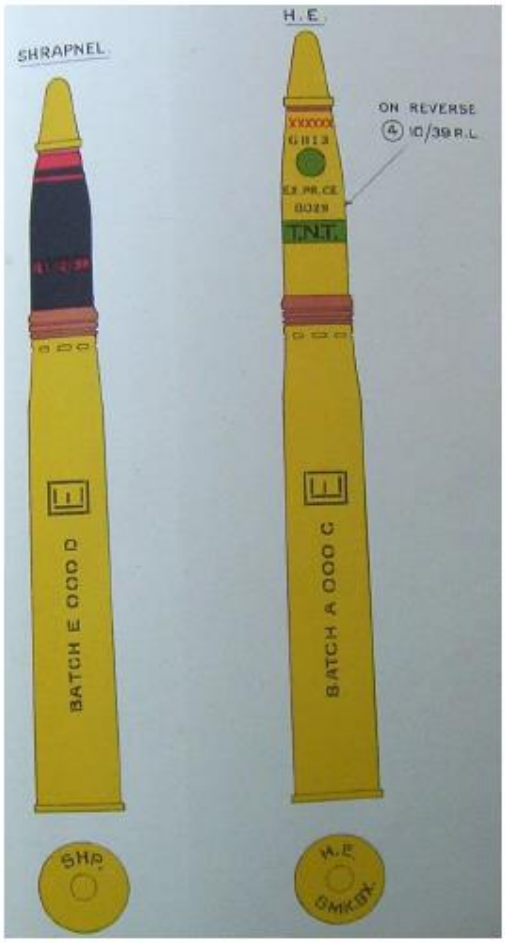
**Function** Designed to maximise shock waves through air, water and earth and for general demolition.



## Information Data Sheet

**Category** Projectile
**Type** 3.7" Anti-Aircraft Shell




| | |
|---|---|
| **Variants** | 6 |
| **Body Dimensions** | 94mm x 360mm (3.7 x 14.7") |
| **Weight** | 12.7kg (28lb) |
| **Fuze** | Mechanical time fuze |
| **Composition** | Cast steel |
| **Description** | Brass cartridge case. Square-based shell with tapered nose, filled with Amatol, TNT or RDX/TNT. MK6 had forward centring bands and a wider driving band. |
| **Function** | Used as a defence against enemy aircraft, fired from fixed batteries and mobile mountings. Could fire approximately 20 rounds per minute with a maximum ceiling of 41,000ft and horizontal range of 20,600 yards. |

## Information Data Sheet

**Category** Projectile
**Type** 4.5" Shell (Mark II – Anti-Aircraft)

**Variants** -

**Body Dimensions** 114mm x 566mm (4.5" x 21.9")

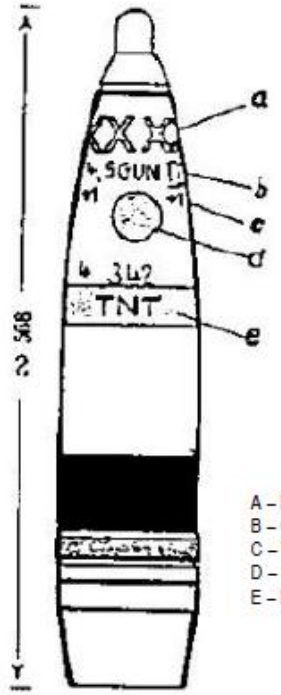
**Weight** 24.9kg (55lb)

**Fuze** Mechanical time fuze

**Composition** Cast steel

**Description** Square-based, tapered-nosed shell filled with TNT or Amatol. Steel casing, rotating band of either copper or gilding metal located 3.5" in front of the base end with single groove.

**Function** Used as field artillery and adapted for use in anti-aircraft defence from fixed batteries. Rate of fire of 8 rounds per minute, maximum ceiling of 44,000ft and horizontal range of 22,800 yards.



## Appendix 2 Sources of UXO Hazard

The sections below provide background information on the potential sources of UXO hazard (albeit low) affecting the Site. For a more comprehensive set of UXO information sheets, see http://zeticauxo.com/downloads-and-resources/uxo-information-sheets/.

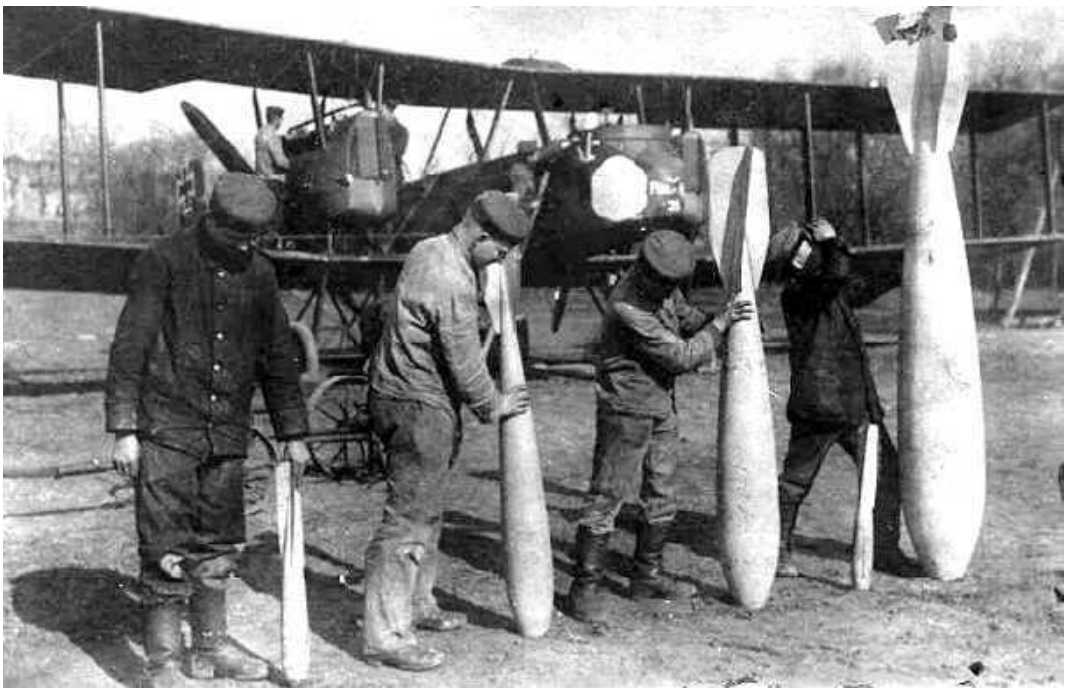
### Appendix 2.1 WWI Bombing

It is not generally realised that during World War One (WWI) significant bombing took place across some areas of the UK. An estimated 9,000No. German bombs were dropped on Britain during the course of 51No. airship and 52No. aircraft raids. It was the first time that strategic aerial bombardment had been used. More than 1,400No. people were killed during these raids.

Most air raids were carried out on London and Southeast England. Areas along the East Coast were also targeted regularly due to their proximity to the European continent. Bombing raids further inland were rare and West England and Wales were out of reach for German aircraft of the time.

Aerial bombing during WWI initially relied on visual aiming, with bombsights not developed until later in the war. The inaccuracy inherent in this method meant that bombs often fell some way from their intended targets.

The first recorded raid against England occurred on the 21st December 1914 when 2No. high explosive bombs fell near the Admiralty Pier at Dover. Zeppelin raids intensified during 1915 and 1916, with aircraft raids becoming more frequent after 1917. The last raid of WWI took place on the 19th May 1918, when 38 Gotha and 3 Giant aircraft bombed London and surrounding districts, dropping a total of more than 2,500lbs of bombs.



The potential of coming across an Unexploded Bomb (UXB) from WWI is far less likely than a WWII UXB given the lower bombing densities during raids in the Great War.

Some areas which were subjected to sustained bombing raids, such as parts of London and coastal towns, recorded a higher number of UXB. In these areas, where there has been no significant development for the last century, the potential of a UXB remaining from WWI cannot be totally discounted.

## Appendix 2.2 WWII Bombing

Bombing raids began in the summer of 1940 and continued until the end of WWII. Bombing densities generally increased towards major cities or strategic targets such as docks, harbours, industrial premises, power stations and airfields. In addition to London, industrial cities and ports, including Birmingham, Coventry, Southampton, Liverpool, Hull and Glasgow, were heavily targeted, as well as seaside towns such as Eastbourne and cathedral cities such as Canterbury.

The German bombing campaign saw the extensive use of both High Explosive (HE) bombs and Incendiary Bombs (IBs). The most common HE bombs were the 50kg and 250kg bombs, although 500kg were also used to a lesser extent. More rarely 1,000kg, 1,400kg and 1,800kg bombs were dropped.

The HE bombs tended to contain about half of their weight in explosives and were fitted with one or sometimes two fuzes. Not all HE bombs were intended to explode on impact. Some contained timing mechanisms where detonation could occur more than 70 hours after impact.

Incendiary devices ranged from small 1kg thermite filled, magnesium bodied Incendiary Bombs (IBs) to a 250kg 'Oil Bomb' (OB) and a 500kg 'C300' IB. In some cases the IBs were fitted with a bursting charge. This exploded after the bomb had been alight for a few minutes causing burning debris to be scattered over a greater area. The C300 bombs were similar in appearance to 500kg HE bombs, although their design was sufficiently different to warrant a specially trained unit of the Royal Engineers to deal with their disposal.

Anti-Personnel (AP) bombs and Parachute Mines (PMs) were also deployed. 2No. types of anti-personnel bombs were in common use, the 2kg and the 12kg bomb. The 2kg bomb could inflict injury across an area up to 150m away from the impact. PMs (which were up to 4m in length) could be detonated either magnetically or by noise/vibration.

Anti-shipping parachute mines were commonly dropped over navigable rivers, dockland areas and coastlines. The Royal Navy was responsible for ensuring that the bombs were made safe. Removal and disposal was still the responsibility of the Bomb Disposal Unit of the Royal Engineers.

In 1944, the Germans introduced new weapons; the V1, a 'flying bomb' and guided missile, and the V2, a ballistic missile rocket that travelled at such speed that no one could see or hear its approach. London was the main target for these attacks.

WWII bomb targeting was inaccurate, especially in the first year of the war. A typical bomb load of 50kg HE bombs mixed with IBs which was aimed at a specific location might not just miss the intended target but fall some considerable distance away.

It is understood that the local Civil Defence authorities in urban areas had a comprehensive system for reporting bomb incidents and dealing with any Unexploded Bombs (UXB) or other UXO. In more rural areas, fewer bombing raids occurred. It is known that Air Raid Precaution (ARP) records under-represent the number and frequency of bombs falling in rural and coastal areas. Bombs were either released over targets or as part of 'tip and run' raids where bomber crews would drop their bombs to avoid anti-aircraft fire or Allied fighter aircraft on the route to and from other strategic targets. Bombs dropped as a result of poor targeting or 'tip and run' raids on rural and coastal areas often went unrecorded or entered as 'fell in open country' or 'fell in the sea'. The Luftwaffe are thought to have dropped approximately 75,000 tons of bombs on Britain throughout the Second World War and an estimated 11% of all bombs dropped during the war failed to detonate.

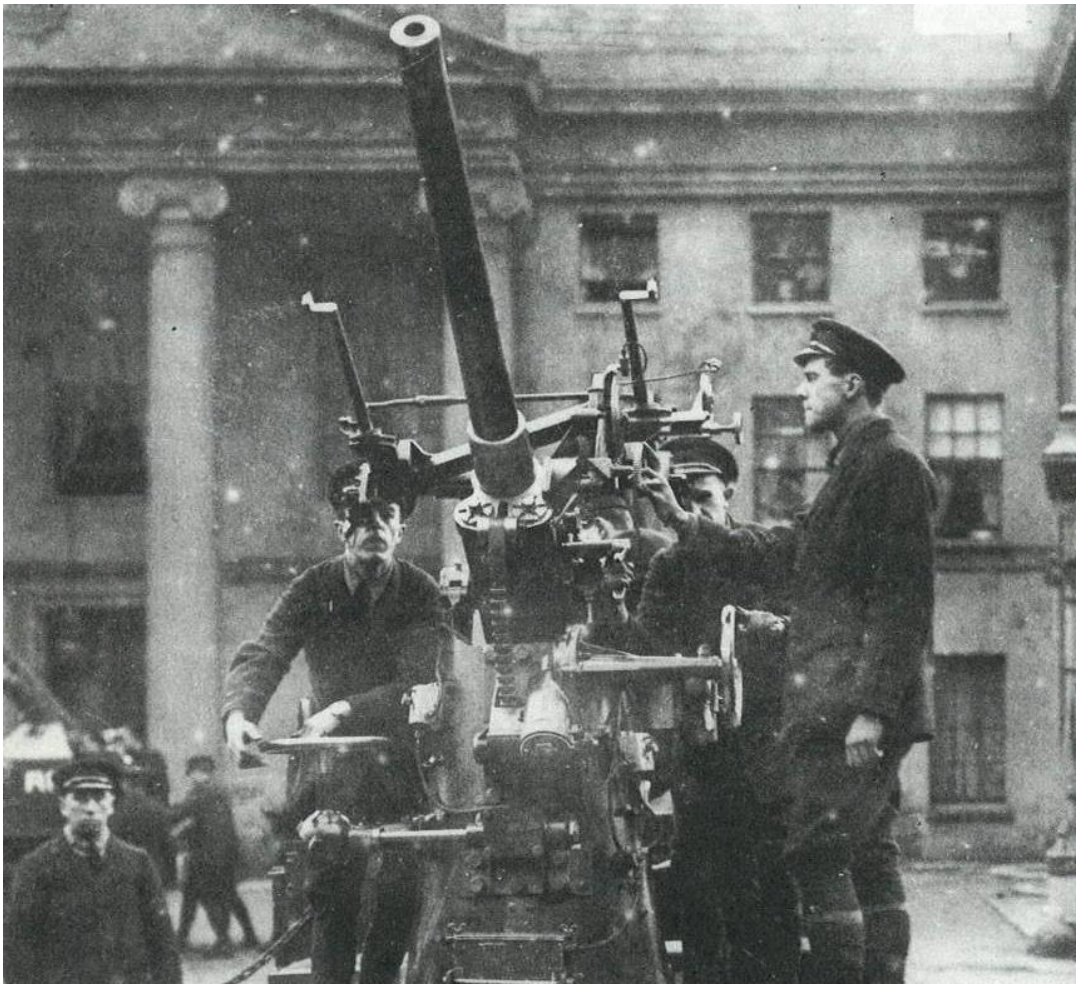
The potential for a UXB hazard to exist on a site depends on a variety of factors. Were there strategic targets in the surrounding area? Was the site bombed? Could a UXB impact have been missed? Even in rural areas, the potential for UXB cannot be totally discounted and therefore it is essential that detailed local bombing records are obtained when assessing the UXB hazard on any site.

## Appendix 2.3 Anti-Aircraft Guns

As aerial bombardment first began during WWI, Anti-Aircraft (AA) gun batteries were established were gradually established throughout much of England to counter German bombing raids. By June 1916, there were approximately 271No. AA guns and 258No. searchlight installations defending London alone.

Common AA defences during WWI included 3-inch, 75 millimetre, 6-pounder and 1-pounder guns. Many of these guns were mobile, being mounted on lorry chassis. They were driven about following the course of an airship and fired from any area of open land.

During WWI, Unexploded AA (UXAA) shells, could land up to 13km from the firing point, although more typically fell within 10km.



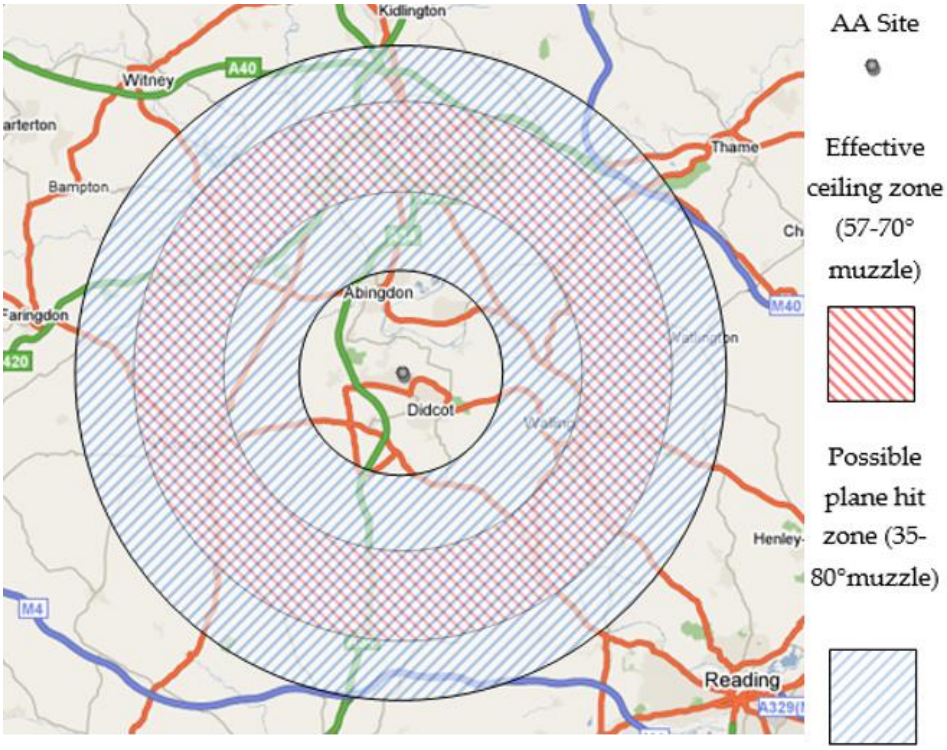
AA gun batteries were used extensively during WWII to counter the threat posed by enemy aircraft. In many instances, AA shells caused damage to Allied territory and in some areas caused significant numbers of civilian fatalities.

During WWII, AA shells could land up to 27km from the firing point, although more typically fell within 15km. These could be distributed over a wide area.

3No. types of AA batteries existed:

- **Heavy Anti-Aircraft (HAA)** batteries of large guns (typically 3.7", 4.5" and 5.25" calibre) designed to engage high flying bomber aircraft. These tended to be relatively permanent gun emplacements.
- **Light Anti-Aircraft (LAA)** weaponry, designed to counter low flying aircraft. These were often mobile and were moved periodically to new locations around strategic targets such as airfields. They typically fired 40mm shells and machine gun ammunition.
- **Rocket batteries (ZAA)** firing 3" or 3.7" AA rockets with a maximum altitude of 5,800m and a ground range of 9km were typically permanent emplacements.

Unexploded AA (UXAA) shells were a common occurrence during WWII. As the figure below demonstrates, shells were unlikely to fall in the immediate vicinity of a gun battery but in the surrounding area. This would be dependent upon the angle of fire and the flight height of the attacking aircraft.




AA batteries were deliberately targeted by the Luftwaffe and therefore areas surrounding a gun battery may have a greater risk of UXB being present.

Munitions stores were also established around AA batteries. These stored the shells for the batteries and small arms ammunition for troops manning the position. Such stores were typically removed at the end of WWII, although some disposal may have occurred in the immediate vicinity of the gun battery.

## Appendix 3 Recent UXO Finds

UXO finds in the UK are a regular occurrence, although they almost never result in an accidental detonation.

It is still important to note that explosives rarely lose effectiveness with age. In some instances, mechanisms such as fuzes and gaines can become more sensitive and more prone to detonation, regardless of whether the device has been submersed in water or embedded in silt, clay or similar materials.

The effects of an accidental UXO detonation are usually extremely fast, often catastrophic and invariably traumatic to any personnel involved. Such occurrences are largely restricted to current theatres of war and overseas minefields, with occasional events in mainland Europe.

Zetica, and other commercial EOD companies, uncover and make safe thousands of items of UXO each year, though details are rarely made public knowledge.

Publicly-recorded discoveries do also occur regularly, as demonstrated by the list of recent significant UXO finds in the UK below. To keep up to date with the latest UXO finds, visit http://zeticauxo.com/news/.

On the 3rd February 2020, a 500kg German UXB was found on a building site in Soho, London. It was removed by an EOD team.

On the 18th April 2020, a 500lb British UXB was discovered by a farmer near Drayton in Oxfordshire. The area had been used as an RAF practice bombing range during WWII and after an in-situ disposal was completed the item was found to have contained no explosives.

On the 4th May 2020, a UXB was discovered by builders at Kings Hill on the former RAF West Malling airfield, the fourth found since 2017. It was destroyed in a controlled explosion.

On the 1st December 2020, a research vessel discovered an unexploded marine mine containing 350kg of explosives in Wemyss Bay in the Firth of Clyde. RN divers investigated the item and destroyed it.

On the 4th February, 2No. anti-tank mines were discovered on Slapton Sands in Devon. They had been uncovered by recent storms and were destroyed.

On the 26th February 2021, a 1,000kg German “Hermann” UXB was discovered by builders at Exeter University campus (see plate below). It was investigated and detonated in-situ following the evacuation of nearby properties and University halls of residence.

On the 29th March 2021, 1No. 250lb UXB was discovered on the seabed near Hinkley Point C harbour, Bristol. A maritime exclusion was imposed while the item was investigated and then destroyed in a controlled explosion.

On the 10th May 2021, 1No. Anti-Aircraft shell dating from WWII was found by a member of the public in Horsham, Surrey. It was destroyed in-situ by a bomb disposal unit.

On the 17th May 2021, 1No. Sea Wolf missile was brought onboard a fishing vessel near Brixham in Devon. A Royal Navy EOC team destroyed the missile in a controlled explosion.

On the 1st June 2021, a cache of approximaetly 100No. hand grenades dating from WWII were found in a Nottinghamshire forest, a possible relic from nearby wartime camps. They were destroyed.

On the 23rd July 2021, 1No. 18lb artillery shell dating from WWI was discovered in a private garden in Bloxham, Oxfordshire. It was transported to a nearby field where it was destroyed in a controlled explosion.

On the 24th July 2021, 1No. 500lb British UXB was uncovered during construction works in Goole, East Yorkshire. Reports indicated that the UXB had been jettisoned by a Lancaster bomber aircraft prior to crashing nearby in WWII. The item was investigated and then destroyed.

On the 18th August 2021, 1No. UXB was found by construction workers on a Site in Earl Sterndale, Derbyshire. Upon inspection the UXB was deemed to be dangerous and a controlled detonation was undertaken.

On the 10th September 2021, EOD teams destroyed 25No. mortars which had been washed up onto beaches around Nairn and Ardersier in Morayshire. These beaches had been used during WWII for training prior to the D-Day landings in Normandy.

On the 18th October, 1No. 18.5lb artillery shell was discovered during the clearing-out of a farmyard barn near Aberfeldy in Perthshire. The shell dated from WWI and was removed.

On the 12th November 2021, 1No. unexploded artillery shell was found on a housing development site in Wrexham, Wales. It was detroyed in controled explosion.

On the 15th December 2021, approximately 200No. artillery shells were discovered at a construction site located within the former Royal Ordnance Factory at Swynnerton in Staffordshire. The shells were removed and destroyed.

On the 15th December 2021, 1No. apparent UXB was snagged by a fishing trawler off the Norfolk Coast and then detonated, causing significant damage to the vessel. Upon further investigation, it was concluded that the UXB had been dropped in the water during WWII.

On the 2nd January 2022, 1No. heavily deteriorated 105mm artillery shell was discovered by dogwalkers on a beach in Cumbria. This may have originated on one of the several offshore ranges which have been operational along the nearby coastline since WWII.

Between the 24th and 27th January 2022, 5No. empty artillery shells were uncovered at a construction site in Manchester. These were likely linked to a shell-production factory which had been active on the site during WWII.

On the 17th February 2022, 1No. WWI-era Mk1 Mills hand grenade was found in the River Frome in Dorset by magnet fishermen. This was the third grenade to be pulled from the same stretch of the river over the past year. After an inspection by local police, the grenade was removed by an EOC team and destroyed.

## Appendix 4 Glossary and Definitions

| | |
|---|---|
| **Abandoned Explosive Ordnance (AXO)** | Abandoned Explosive Ordnance is explosive ordnance that has not been used during an armed conflict, that has been left behind or disposed of by a party to an armed conflict, and which is no longer under control of that party. Abandoned explosive ordnance may or may not have been primed, fuzed, armed or otherwise prepared for use. |
| **Close Combat Munitions** | Items of ordnance thrown, propelled or placed during land warfare, to include grenades, mortars, projectiles, rockets and land mines. |
| **Demil** | Derived from the term 'Demilitarisation', it refers to the break down and the recycling or disposal of ordnance components. |
| **Detonation** | The high-speed chemical breakdown of an energetic material producing heat, pressure, flame and a shock wave. |
| **Device** | This term is used for any component, sub-assembly or completed ordnance, which may or may not have an explosive risk. It can apply to detonators, primers, gaines, fuzes, shells or bombs. |
| **Explosive** | The term explosive refers to compounds forming energetic materials that under certain conditions chemically react, rapidly producing gas, heat and pressure. Obviously, these are extremely dangerous and should only be handled by qualified professionals. |
| **Explosive Ordnance (EO)** | Explosive Ordnance is all munitions containing explosives, nuclear fission or fusion materials and biological and chemical agents. This includes bombs and warheads, guided and ballistic missiles, artillery, mortar, rocket, small arms ammunition, mines, torpedoes, depth charges, pyrotechnics, cluster bombs & dispensers, cartridge & propellant actuated devices, electro-explosive devices, clandestine & improvised explosive devices, and all similar or related items or components explosive in nature. |
| **Explosive Ordnance Clearance (EOC)** | Explosive Ordnance Clearance is a term used to describe the operation of ordnance detection, investigation, identification and removal, with EOD being a separate operation. |
| **Explosive Ordnance Disposal (EOD)** | Explosive Ordnance Disposal is the detection, identification, on-site evaluation, rendering safe, recovery and final disposal of unexploded explosive ordnance. |
| **Explosive Ordnance Reconnaissance (EOR)** | Explosive Ordnance Reconnaissance is the detection, identification and on-site evaluation of unexploded explosive ordnance before Explosive Ordnance Disposal. |
| **Explosive Remnants of War (ERW)** | Explosive Remnants of War are Unexploded Ordnance (UXO) and Abandoned Explosive Ordnance (AXO), excluding landmines. |

**Explosive Substances and Articles (ESA)**

Explosive substances are solid or liquid substances (or a mixture of substances), which are either:

- capable by chemical reaction in itself of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings.
- designed to produce an effect by heat, light, sound, gas or smoke, or a combination of these as a result of a non-detonative, self-sustaining, exothermic reaction.

Explosive article is an article containing one or more explosive substances.

**Fuze**

A fuze is the part of an explosive device that initiates the main explosive charge to function. In common usage, the word fuze is used indiscriminately, but when being specific (and in particular in a military context), fuze is used to mean a more complicated device, such as a device within military ordnance.

**Gaine**

Small explosive charge that is sometimes placed between the detonator and the main charge to ensure ignition.

**Geophysical survey**

A geophysical survey is essentially a range of methods that can be used to detect objects or identify ground conditions without the need for intrusive methods (such as excavation or drilling). This is particularly suited to ordnance as disturbance of ordnance items is to be avoided where ever possible.

**Gold line**

This is the estimated limit of blast damage from an explosive storage magazine. It usually means that development within this zone is restricted.

**High Explosive**

Secondary explosives (commonly known as High Explosives (HE)) make up the main charge or filling of an ordnance device. They are usually less sensitive than primary explosives. Examples of secondary explosives are: Nitro glycerine (NG), Trinitrotoluene (TNT), AMATOL (Ammonia nitrate + TNT), Gunpowder (GP), and Cyclotrimethylenetrinitramine (RDX).

**Munition**

Munition is the complete device charged with explosives, propellants, pyrotechnics, initiating composition, or nuclear, biological or chemical material for use in military operations, including demolitions. This includes those munitions that have been suitably modified for use in training, ceremonial or non-operational purposes. These fall into three distinct categories:-

- inert - contain no explosives whatsoever.
- live - contain explosives and have not been fired.
- blind - have fired but failed to function as intended.

| | |
|---|---|
| **Primary Explosive** | Primary explosives are usually extremely sensitive to friction, heat, and pressure. These are used to initiate less sensitive explosives. Examples of primary explosives are: Lead Azide, Lead Styphnate, and Mercury Fulminate. Primary explosive are commonly found in detonators. |
| **Propellants** | Propellants provide ordnance with the ability to travel in a controlled manner and deliver the ordnance to a predetermined target. Propellants burn rapidly producing gas, pressure and flame. Although usually in solid form they can be produced in liquid form. Examples of propellants are: Ballistite often found in a flake form and Cordite used in small arms ammunition. |
| **Pyrotechnic** | A pyrotechnic is an explosive article or substance designed to produce an effect by heat, light, sound, gas or smoke, or a combination of any of these, as a result of non-detonative, self-sustaining, exothermic chemical reactions. |
| **Small Arms Ammunition (SAA)** | SAA includes projectiles around 12mm or less in calibre and no longer than approximately 100mm. They are fired from a variety of weapons, including rifles, pistols, shotguns and machine guns. |
| **Unexploded Anti-Aircraft (UXAA) Shell** | UXAA shells are army ordnance commonly containing HE, though they can also contain pyrotechnic compounds that produce smoke.<br>Most commonly, these were 3.7” and 4.5” HE shells, although they ranged from 2” to 5.25” calibre. |
| **Unexploded Bomb (UXB)** | UXB is a common term for unexploded air-dropped munitions. |
| **Unexploded Ordnance (UXO)** | UXO is explosive ordnance that has been either primed, fuzed, armed or prepared for use and has been subsequently fired, dropped, launched, projected or placed in such a manner as to present a hazard to operations, persons or objects and remains unexploded either by malfunction or design. |
| **V1** | The Vergeltungswaffe-1, V-1, also designated Fieseler Fi 103/FZG-76, known colloquially in English as the Flying Bomb, Buzz Bomb or Doodlebug, was the first guided missile used in WWII and the forerunner of today's cruise missile. |
| **V2** | The Vergeltungswaffe 2 (V-2) (‘Reprisal Weapon 2’) was the first ballistic missile. It was used by the German Army primarily against Belgian and British targets during the later stages of WWII. The V-2 was the first man-made object launched into space, during test flights that reached an altitude of 189km (117 miles) in 1944. |

## Appendix 5 WWII Bombing Incident List

**29th August 1940**

1No. HE bomb fell on Cavendish Street, approximately 0.4km northwest of the Site.

9th October 1940

1No. IB fell on the junction of Coupland Street and Malcolm Square, approximately 0.2km southwest of the Site.

1No. IB fell on Cecil Street, approximately 0.5km south-southeast of the Site.

**10th October 1940**

1No. HE bomb fell on Welbeck Street, approximately 0.2km west of the Site.

**11th October 1940**

1No. IB fell on Bridge Street, approximately 20m northeast of the Site.

1No. IB fell on Coupland Street, approximately 0.1km south-southwest of the Site.

6No. IBs fell on the junction of Booth Street West and Higher Chatham Street, approximately 0.2km northwest of the Site.

1No. HE bomb fell on the Park Street Drill Hall, approximately 0.3km southwest of the Site.

4No. IBs fell on the junction of Rosamund Street West and Higher Chatham Street, approximately 0.3km northwest of the Site.

1No. IB fell on Rosamond Street West, approximately 0.4km north of the Site.

1No. IB fell on Jenkinson Street, approximately 0.4km north of the Site.

1No. IB fell on Baptist Church, Upper Brook Street, approximately 0.5km northeast of the Site.

**22nd – 25th October 1940**

1No. HE bomb fell between 98 and 104 Higher Cambridge Street, approximately 0.4km northwest of the Site.

1No. HE bomb fell on the Royal Oak Inn, 30 Higher Cambridge Street, approximately 0.5km north-northeast of the Site.

**22nd - 24th December 1940**

1No. HE bomb fell on St. Ambrose Church, Higher Chatham Street, approximately 60m north-northwest of the Site.

1No. HE bomb fell on the Turner Dental School on the corner of Bridge Street and Higher Chatham Street, approximately 60m west-southwest of the Site.

1No. HE bomb fell on 93 Higher Cambridge Street, approximately 0.2km northwest of the Site.

1No. HE bomb fell on 29 Jenkinson Street, approximately 0.2km north of the Site.

1No. HE bomb fell on Burlington Street, approximately 0.2km south of the Site.

1No. HE bomb fell on the junction of Boundary Lane and Bridge Street, approximately 0.3km west-southwest of the Site.

1No. IB fell on 30 New York Street, approximately 0.3km northeast of the Site.

1No. PM fell on Ducie Street, approximately 0.4km south-southwest of the Site.

1No. HE bomb fell on Salutation Hall, 12 Higher Chatham Street, approximately 0.4km north-northwest of the Site.

1No. PM fell on warehouses on Rumford Street, approximately 0.4km east-southeast of the Site.

1No. PM fell on Dover Street, approximately 0.4km east of the Site.

1No. IB fell on the School of Art, Cavendish Street, approximately 0.4km north-northwest of the Site.

1No. IB fell on Upper Wilmott Street Drill Hall/University Barracks, approximately 0.4km northwest of the Site.

1No. HE bomb fell on All Saints Church, Cavendish Street, approximately 0.5km north-northwest of the Site.

1No. PM fell on the corner of Oxford Road and Ducie Street, approximately 0.5km southeast of the Site.

1No. IB fell on Mill Street, approximately 0.5km northwest of the Site.

1No. IB fell on All Saints Church, Cavendish Street, approximately 0.5km north-northwest of the Site.

1No. IB fell on the corner of Dover Street and Upper Brook Street, approximately 0.5km east of the Site.

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## Established for over 30 years, Zetica's services include

- ☑ Desk studies
- ☑ Unexploded ordnance risk assessments and risk mitigation
- ☑ Utility services detection
- ☑ Environmental and engineering geophysical surveys
- ☑ Transport infrastructure surveys
- ☑ Pipeline & cable route surveys
- ☑ Intrusive ground investigations

More details are available at

www.zetica.com

zeticauxo

# APPENDIX III

# EXPLORATORY HOLE LOGS

| | | | |
|---|---|---|---|
| clancy consulting | Project Title: Martin Harris New Music Block, University of Manchester | | **WS1** |
| | Project Number: 10/2084 | Client: University of Manchester | Sheet 1 Of 1 |
| | GL (mAOD): | N Coord: 53.465926 | E Coord: -2.236205 |
| Date: 21/06/2022 | Method: Window Sampler | Driller: Exploration Ltd | Logged By: SP |

| Depth (m) | Type | Test Result | Level | Legend | Depth (m) | Description | Water | Standpipe |
|---|---|---|---|---|---|---|---|---|
| | | | | | 0.25 | MADE GROUND: Tarmac and subbase. | | |
| 0.65 | ES | | | | 0.70 | MADE GROUND: Light brown sandy gravel with a low cobble content. Gravel is angular to subrounded, fine to coarse of sandstone, concrete, brick, coal and clinker. Cobbles are subangular of brick. 0.60 - 0.70 Mild hydrocarbon contamination. Visible black staining. | | |
| 0.90 | ES | N=8 | | | 0.85 | | | |
| 1.20 | D | | | | 1.00 | | | |
| 1.20 - 1.65 | SPT | | | | | | | |
| 2.00 - 2.45 | SPT | N=9 | | | 1.90 | MADE GROUND: Dark brown mottled green slightly gravelly clay. Gravel is angular to subrounded, fine to coarse of brick and clinker. | | |
| | | | | | 2.00 | | | |
| 2.50 | D | | | | 2.30 | Light brown slightly gravelly SAND. Gravel is subrounded to rounded, fine to coarse sandstone. (Glaciofluvial Sheet Deposits) | | |
| 3.00 - 3.45 | SPT | N=23 | | | 3.00 | | | |
| | | | | | 3.70 | Light brown very gravelly SAND. Gravel is subrounded to rounded, fine to coarse sandstone. (Glaciofluvial Sheet Deposits) | | |
| 3.90 - 4.19 | SPT | pp 50/145mm | | | 4.00 | Firm to stiff dark brown slightly gravelly CLAY. Gravel is subangular to rounded, fine to medium of mudstone, siltstone and sandstone. (Till, Devensian ) | | |
| | | | | | 4.19 | | | |
| | | | | | 5.00 | Weathered SANDSTONE recovered as red slightly gravelly fine to medium SAND. Gravel is subangular to subrounded, fine to coarse of sandstone. (Chester Formation ) | | |
| | | | | | | End Of Borehole At 4.19 m | | |
| | | | | | 6.00 | | | |
| | | | | | 7.00 | | | |
| | | | | | 8.00 | | | |

## KEY

D - Disturbed Sample
B - Bulk Sample
U - Undisturbed
W - Water Sample
S - Standard Penetration Test
C - Cone Penetration Test
N - Penetration Test 'N' Value
V - Hand Shear Vane kPa
▽ - Groundwater Strike
▼ - Groundwater Level

AGS

## REMARKS

Borehole terminated due to SPT refusal. Borehole backfilled with arisings. Groundwater seepage at 1.50m.

Scale: 1:50

**Water Strikes**

| Date | Strike | Level | Minutes | Casing | Sealed |
|---|---|---|---|---|---|
| 03/08/2022 | 0 | | | | |
| | | | | | |
| | | | | | |

**Daily Log Of Depths**

| Date | Casing | Water |
|---|---|---|
| | | |
| | | |

**Chiselling**

| From | To | Hours |
|---|---|---|
| | | |
| | | |

| | | | |
|---|---|---|---|
| clancy consulting | Project Title: Martin Harris New Music Block, University of Manchester | | **WS2** |
| | Project Number: 10/2084 | Client: University of Manchester | Sheet 1 Of 1 |
| | GL (mAOD): | N Coord: 53.46584 | E Coord: -2.236125 |
| Date: 21/06/2022 | Method: Window Sampler | Driller: Exploration Ltd | Logged By: SP |

| Depth (m) | Type | Test Result | Level | Legend | Depth (m) | Description | Water | Standpipe |
|---|---|---|---|---|---|---|---|---|
| | | | | | 0.20 | MADE GROUND: Tarmac and subbase. | | |
| 0.70 | ES | | | | 0.60 | MADE GROUND: Light brown sandy gravel. Gravel is angular to subrounded, fine to coarse of sandstone, concrete and limestone. | | |
| 1.20 - 1.65 | SPT | N=8 | | | 1.00 | MADE GROUND: Dark greyish brown slightly gravelly clay with a low cobble content. Gravel is angular to subrounded, fine to coarse of brick, clinker, slag, concrete, mudstone and wood fragments. Cobbles are angular to subangular of brick. | | |
| 1.70 | ES | | | | 1.65 | | | |
| 2.00 - 2.45 | SPT | N=6 | | | 1.90<br>2.00 | 0.60 - 1.65 Strong hydrocarbon odour. Visible black staining. | | |
| 2.40 | ES | | | | | MADE GROUND: Dark grey slightly gravelly fine to medium sand. Gravel is subangular to rounded, fine to coarse of sandstone and rare concrete. | | |
| 3.00 - 3.45<br>3.00 - 3.45 | D<br>SPT | N=18 | | | 3.00 | 1.65 - 1.90 Moderate hydrocarbon odour. Visible sheen. | | |
| 3.90<br>4.00 - 4.40 | D<br>SPT | pp 50/250mm | | | 4.00<br>4.15 | Light brown slightly gravelly fine to medium SAND. Gravel is subrounded to rounded, fine to medium of sandstone. (Glaciofluvial Sheet Deposits) | | |
| | | | | | 4.40 | Firm becoming firm to stiff slightly gravelly CLAY. Gravel is subangular to rounded, fine to medium of mustone, siltstone and sandstone. (Till, Devensian ) | | |
| | | | | | 5.00 | 2.00 - 2.30 Poor recovery | | |
| | | | | | 6.00 | Weathered SANDSTONE recovered as red slightly gravelly fine to medium SAND. Gravel is subangular to subrounded, fine to coarse of sandstone. | | |
| | | | | | | End Of Borehole At 4.40 m | | |
| | | | | | 7.00 | | | |
| | | | | | 8.00 | | | |

## KEY

D - Disturbed Sample
B - Bulk Sample
U - Undisturbed
W - Water Sample
S - Standard Penetration Test
C - Cone Penetration Test
N - Penetration Test 'N' Value
V - Hand Shear Vane kPa
▽ - Groundwater Strike
▼ - Groundwater Level

AGS

## REMARKS

Borehole terminated due to SPT refusal. Borehole installed with ground gas and water monitoring well. Seepage at 1.65m.

Scale: 1:50

**Water Strikes**

| Date | Strike | Level | Minutes | Casing | Sealed |
|---|---|---|---|---|---|
| 03/08/2022 | 0 | | | | |
| | | | | | |
| | | | | | |

**Daily Log Of Depths**

| Date | Casing | Water |
|---|---|---|
| | | |
| | | |

**Chiselling**

| From | To | Hours |
|---|---|---|
| | | |
| | | |

Printed By GeoLogs (www.GeoLogs.com)

| | | | |
|---|---|---|---|
| clancy consulting | Project Title: Martin Harris New Music Block, University of Manchester | | **WS3** |
| | Project Number: 10/2084 | Client: University of Manchester | Sheet 1 Of 1 |
| | GL (mAOD): | N Coord: 53.465886 | E Coord: -2.235991 |
| Date: 21/06/2022 | Method: Window Sampler | Driller: Exploration Ltd | Logged By: SP |

| Depth (m) | Type | Test Result | Level | Legend | Depth (m) | Description | Water | Standpipe |
|---|---|---|---|---|---|---|---|---|
| | | | | | 0.20 | MADE GROUND: Tarmac and subbase. | | |
| 0.65 | ES | | | | 0.60 | MADE GROUND: Light greyish brown sandy gravel with a low cobble content. Gravel is angular to subrounded, fine to coarse of sandstone, clinker, brick, concrete and timber. Cobbles are angular to subrounded of cobblestone and brick. | | |
| 1.20 - 1.65 | SPT | N=4 | | | 1.00 | | | |
| 1.35 | ES | | | | 1.40 | | | |
| 1.60 | ES | | | | 1.50 | MADE GROUND: Dark brown sandy gravel. Gravel is angular to subrounded, fine to coarse of slag, ash, sandstone, concrete and brick. Cobbles are angular to subangular of brick. 0.60 - 1.40 Strong hydrocarbon odour. Visible black staining. | | |
| 1.80 | D | | | | | | | |
| 2.00 - 2.45 | D | N=15 | | | 2.00 | | | |
| 2.00 - 2.45 | SPT | | | | | MADE GROUND: Dark brown slightly gravelly clay. Gravel is angular to subrounded, fine to coarse of slag, clinker, brick and concrete. | | |
| 3.00 - 3.45 | SPT | N=40 | | | 3.00 | MADE GROUND: Light brown fibrous peat with rare ceramic gravels. | | |
| 3.60 - 3.92 | SPT | pp 50/170mm | | | 3.60 | Soft to firm greenish grey slightly gravelly slightly sandy CLAY with relict plant remains. Gravel is subangular to rounded, fine to medium of mudstone and sandstone. (Glaciofluvial Sheet Deposits) 1.50 - 2.00 Mild humic odour. | | |
| | | | | | 3.92 | | | |
| | | | | | 4.00 | | | |
| | | | | | 5.00 | Firm becoming firm to stiff light brown slightly gravelly CLAY. Gravel is subangular to rounded, fine to medium of mudstone and sandstone. (Till, Devensian ) 2.60 - 3.80 Becoming stiff | | |
| | | | | | 6.00 | Weathered SANDSTONE recovered as red slightly gravelly fine to medium SAND. Gravel is subangular to subrounded, fine to coarse of sandstone. (Chester Formation ) | | |
| | | | | | 7.00 | End Of Borehole At 3.92 m | | |
| | | | | | 8.00 | | | |

## KEY

D - Disturbed Sample
B - Bulk Sample
U - Undisturbed
W - Water Sample
S - Standard Penetration Test
C - Cone Penetration Test
N - Penetration Test 'N' Value
V - Hand Shear Vane kPa
▽ - Groundwater Strike
▼ - Groundwater Level

AGS

## REMARKS

No Groundwater Encountered
Borehole terminated due to SPT refusal. Borehole used to facilitate falling head infiltration test between 1.5-2.00m. Borehole installed with ground gas and water monitoring well.

Scale: 1:50

Water Strikes

| Date | Strike | Level | Minutes | Casing | Sealed |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |

Daily Log Of Depths

| Date | Casing | Water |
|---|---|---|
| | | |
| | | |

Chiselling

| From | To | Hours |
|---|---|---|
| | | |
| | | |

| | | | |
|---|---|---|---|
| clancy consulting | Project Title: Martin Harris New Music Block, University of Manchester | | **WS4** |
| | Project Number: 10/2084 | Client: University of Manchester | Sheet 1 Of 1 |
| | GL (mAOD): | N Coord: 53.465966 | E Coord: -2.236057 |
| Date: 21/06/2022 | Method: Window Sampler | Driller: Exploration Ltd | Logged By: SP |

| Depth (m) | Type | Test Result | Level | Legend | Depth (m) | Description | Water | Standpipe |
|---|---|---|---|---|---|---|---|---|
| | | | | | 0.25 | MADE GROUND: Tarmac and subbase. | | |
| 0.40 | ES | | | | | MADE GROUND: Light yellowish brown sandy gravel. Gravel is subangular to subrounded, fine to coarse of concrete, sandstone and limestone. | | |
| 0.70 | ES | | | | 0.65 | | | |
| | | | | | 1.00 | | | |
| 1.20 - 1.65 | SPT | N=2 | | | 1.30 | MADE GROUND: Dark brown becoming light brown slightly gravelly slightly sandy clay. Gravel is angular to subrounded, fine to coarse of concrete, brick, sandstone, glass, slag and clinker. | | |
| | | | | | 1.70 | | | |
| 1.80 | ES | | | | | | | |
| 2.00 - 2.45 | D | N=22 | | | 2.00 | MADE GROUND: Light bluish grey slightly gravelly clay. Gravel is angular to subrounded, fine to coarse of sandstone, mudstone and rare brick. 1.30 - 1.70 Mild humic odour. | | |
| 2.00 - 2.45 | SPT | | | | | | | |
| 3.00 - 3.45 | D | N=43 | | | 3.00 | Firm to stiff becoming stiff light brown slightly gravelly CLAY. Gravel is subangular to rounded, fine to coarse of sandstone, siltstone and mudstone. (Till, Devensian ) | | |
| 3.00 - 3.45 | SPT | | | | | | | |
| 3.50 - 3.80 | SPT | pp 50/150mm | | | 3.45 | | | |
| | | | | | 3.80 | | | |
| | | | | | 4.00 | Weathered SANDSTONE recovered as red slightly gravelly fine to medium SAND. Gravel is subangular to subrounded, fine to coarse of sandstone. (Chester Formation ) | | |
| | | | | | 5.00 | End Of Borehole At 3.80 m | | |
| | | | | | 6.00 | | | |
| | | | | | 7.00 | | | |
| | | | | | 8.00 | | | |

## KEY

D - Disturbed Sample
B - Bulk Sample
U - Undisturbed
W - Water Sample
S - Standard Penetration Test
C - Cone Penetration Test
N - Penetration Test 'N' Value
V - Hand Shear Vane kPa
▽ - Groundwater Strike
▼ - Groundwater Level

AGS

## REMARKS

No Groundwater Encountered
Borehole terminated due to SPT refusal. Borehole used facilitate falling head infiltration test between 1.5-2.00m. Borehole installed with ground gas and water monitoring well.

Scale: 1:50

Water Strikes

| Date | Strike | Level | Minutes | Casing | Sealed |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |

Daily Log Of Depths

| Date | Casing | Water |
|---|---|---|
| | | |
| | | |

Chiselling

| From | To | Hours |
|---|---|---|
| | | |
| | | |

# APPENDIX IV

# CHEMICAL LABORATORY TEST RESULTS

envirolab
Units 7 & 8 Sandpits Business Park
Mottram Road, Hyde, Cheshire, SK14 3AR

# FINAL ANALYTICAL TEST REPORT
## SUPPLEMENT TO TEST REPORT 22/06213/1

**Amendments:** Request for Additional Analysis

**Envirolab Job Number:** 22/06213
**Issue Number:** 2 **Date:** 04 August, 2022

**Client:**
Clancy Consulting
Dunham Court
2 Dunham Road
Altrincham
Cheshire
UK
WA14 4NX

**Project Manager:** Desy Korai/Sean Pilling
**Project Name:** Martin Harris Building Uni of Manchester
**Project Ref:** 10 2084
**Order No:** 31215
**Date Samples Received:** 24/06/22
**Date Instructions Received:** 24/06/22
**Date Analysis Completed:** 04/08/22

**Approved by:**

Richard Wong
Client Manager

mCERTS THE ENVIRONMENT AGENCY'S MONITORING CERTIFICATION SCHEME
UKAS TESTING 1247

Envirolab Job Number: 22/06213

Client Project Name: Martin Harris Building Uni of Manchester

Client Project Ref: 10 2084

| Lab Sample ID | 22/06213/1 | 22/06213/2 | 22/06213/3 | 22/06213/4 | 22/06213/5 | 22/06213/6 | 22/06213/7 | Units | Limit of Detection | Method ref |
|---|---|---|---|---|---|---|---|---|---|---|
| Client Sample No | | | | | | | | | | |
| Client Sample ID | WS1 | WS2 | WS3 | WS3 | WS2 | WS2 | WS3 | | | |
| Depth to Top | 0.65 | 0.70 | 0.65 | 1.35 | 1.70 | 2.40 | 1.60 | | | |
| Depth To Bottom | | | | | | | | | | |
| Date Sampled | 21-Jun-22 | 21-Jun-22 | 21-Jun-22 | 21-Jun-22 | 21-Jun-22 | 21-Jun-22 | 21-Jun-22 | | | |
| Sample Type | Soil - ES | Soil - ES | Soil - ES | Soil - ES | Soil - ES | Soil - ES | Soil - ES | | | |
| Sample Matrix Code | 5AB | 6A | 4AB | 5AB | 4A | 5A | 5A | | | |
| % Stones >10mm$_{A}$ | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | % w/w | 0.1 | A-T-044 |
| pH$_{D}^{M\#}$ | 8.67 | 7.11 | 8.40 | 8.06 | 6.76 | 8.19 | 7.44 | pH | 0.01 | A-T-031s |
| Sulphate (water sol 2:1)$_{D}^{M\#}$ | - | <0.01 | 0.15 | 0.12 | - | <0.01 | <0.01 | g/l | 0.01 | A-T-026s |
| Total Organic Carbon$_{D}^{M\#}$ | - | 5.14 | 5.58 | 5.15 | 0.24 | - | - | % w/w | 0.03 | A-T-032s |
| Arsenic$_{D}^{M\#}$ | 7 | 13 | 19 | 13 | 2 | <1 | 3 | mg/kg | 1 | A-T-024s |
| Beryllium$_{D}$ | 1.0 | 1.3 | 0.8 | 0.9 | <0.5 | 1.1 | 1.4 | mg/kg | 0.5 | A-T-024s |
| Boron (water soluble)$_{D}$ | 1.1 | 1.5 | <1.0 | 1.7 | <1.0 | <1.0 | 1.7 | mg/kg | 1 | A-T-027s |
| Cadmium$_{D}^{M\#}$ | 0.7 | 0.8 | 1.2 | 0.8 | <0.5 | 0.9 | 0.7 | mg/kg | 0.5 | A-T-024s |
| Copper$_{D}^{M\#}$ | 37 | 50 | 62 | 83 | 12 | 24 | 63 | mg/kg | 1 | A-T-024s |
| Chromium (hexavalent)$_{D}$ | <1 | <1 | <1 | <1 | <1 | <1 | <1 | mg/kg | 1 | A-T-040s |
| Lead$_{D}^{M\#}$ | 102 | 155 | 636 | 565 | 10 | 12 | 75 | mg/kg | 1 | A-T-024s |
| Mercury$_{D}$ | 0.76 | 0.62 | 1.65 | 1.13 | <0.17 | <0.17 | 0.30 | mg/kg | 0.17 | A-T-024s |
| Nickel$_{D}^{M\#}$ | 21 | 28 | 23 | 31 | 15 | 38 | 30 | mg/kg | 1 | A-T-024s |
| Selenium$_{D}^{M\#}$ | <1 | <1 | <1 | <1 | <1 | <1 | 1 | mg/kg | 1 | A-T-024s |
| Vanadium$_{D}^{M\#}$ | 27 | 41 | 24 | 27 | 18 | 32 | 48 | mg/kg | 1 | A-T-024s |
| Zinc$_{D}^{M\#}$ | 56 | 60 | 125 | 43 | 24 | 56 | 60 | mg/kg | 5 | A-T-024s |

**Envirolab Job Number: 22/06213**

**Client Project Name: Martin Harris Building Uni of Manchester**

**Client Project Ref: 10 2084**

| Lab Sample ID | 22/06213/1 | 22/06213/2 | 22/06213/3 | 22/06213/4 | 22/06213/5 | 22/06213/6 | 22/06213/7 | Units | Limit of Detection | Method ref |
|---|---|---|---|---|---|---|---|---|---|---|
| Client Sample No | | | | | | | | | | |
| Client Sample ID | WS1 | WS2 | WS3 | WS3 | WS2 | WS2 | WS3 | | | |
| Depth to Top | 0.65 | 0.70 | 0.65 | 1.35 | 1.70 | 2.40 | 1.60 | | | |
| Depth To Bottom | | | | | | | | | | |
| Date Sampled | 21-Jun-22 | 21-Jun-22 | 21-Jun-22 | 21-Jun-22 | 21-Jun-22 | 21-Jun-22 | 21-Jun-22 | | | |
| Sample Type | Soil - ES | Soil - ES | Soil - ES | Soil - ES | Soil - ES | Soil - ES | Soil - ES | | | |
| Sample Matrix Code | 5AB | 6A | 4AB | 5AB | 4A | 5A | 5A | | | |
| **Asbestos in Soil (inc. matrix)** | | | | | | | | | | |
| Asbestos in soil$_{D}$$^{\#}$ | NAD | NAD | - | NAD | - | NAD | NAD | | | A-T-045 |
| Asbestos Matrix (visual)$_{D}$ | - | - | - | - | - | - | - | | | A-T-045 |
| Asbestos Matrix (microscope)$_{D}$ | - | - | - | - | - | - | - | | | A-T-045 |
| Asbestos ACM - Suitable for Water Absorption Test?$_{D}$ | N/A | N/A | - | N/A | - | N/A | N/A | | | A-T-045 |

envirolab

**Envirolab Job Number: 22/06213**

**Client Project Name: Martin Harris Building Uni of Manchester**

**Client Project Ref: 10 2084**

| Lab Sample ID | 22/06213/1 | 22/06213/2 | 22/06213/3 | 22/06213/4 | 22/06213/5 | 22/06213/6 | 22/06213/7 | Units | Limit of Detection | Method ref |
|---|---|---|---|---|---|---|---|---|---|---|
| Client Sample No | | | | | | | | | | |
| Client Sample ID | WS1 | WS2 | WS3 | WS3 | WS2 | WS2 | WS3 | | | |
| Depth to Top | 0.65 | 0.70 | 0.65 | 1.35 | 1.70 | 2.40 | 1.60 | | | |
| Depth To Bottom | | | | | | | | | | |
| Date Sampled | 21-Jun-22 | 21-Jun-22 | 21-Jun-22 | 21-Jun-22 | 21-Jun-22 | 21-Jun-22 | 21-Jun-22 | | | |
| Sample Type | Soil - ES | Soil - ES | Soil - ES | Soil - ES | Soil - ES | Soil - ES | Soil - ES | | | |
| Sample Matrix Code | 5AB | 6A | 4AB | 5AB | 4A | 5A | 5A | | | |
| **PAH-16MS** | | | | | | | | | | |
| Acenaphthene$_{A}^{M\#}$ | 0.48 | 0.15 | 0.90 | 0.01 | 0.05 | <0.01 | <0.01 | mg/kg | 0.01 | A-T-019s |
| Acenaphthylene$_{A}^{M\#}$ | 0.35 | 0.06 | 0.18 | <0.01 | <0.01 | <0.01 | <0.01 | mg/kg | 0.01 | A-T-019s |
| Anthracene$_{A}^{M\#}$ | 1.22 | 0.32 | 1.29 | 0.04 | <0.02 | <0.02 | <0.02 | mg/kg | 0.02 | A-T-019s |
| Benzo(a)anthracene$_{A}^{M\#}$ | 4.23 | 0.71 | 3.80 | 0.20 | 0.09 | <0.04 | <0.04 | mg/kg | 0.04 | A-T-019s |
| Benzo(a)pyrene$_{A}^{M\#}$ | 3.31 | 0.48 | 3.14 | 0.19 | 0.08 | <0.04 | <0.04 | mg/kg | 0.04 | A-T-019s |
| Benzo(b)fluoranthene$_{A}^{M\#}$ | 3.39 | 0.57 | 3.45 | 0.21 | 0.09 | <0.05 | <0.05 | mg/kg | 0.05 | A-T-019s |
| Benzo(ghi)perylene$_{A}^{M\#}$ | 1.49 | 0.25 | 1.65 | 0.12 | <0.05 | <0.05 | <0.05 | mg/kg | 0.05 | A-T-019s |
| Benzo(k)fluoranthene$_{A}^{M\#}$ | 1.14 | 0.20 | 1.12 | <0.07 | <0.07 | <0.07 | <0.07 | mg/kg | 0.07 | A-T-019s |
| Chrysene$_{A}^{M\#}$ | 4.07 | 0.77 | 3.77 | 0.21 | 0.10 | <0.06 | <0.06 | mg/kg | 0.06 | A-T-019s |
| Dibenzo(ah)anthracene$_{A}^{M\#}$ | 0.40 | <0.04 | 0.31 | <0.04 | <0.04 | <0.04 | <0.04 | mg/kg | 0.04 | A-T-019s |
| Fluoranthene$_{A}^{M\#}$ | 6.79 | 1.50 | 7.99 | 0.23 | 0.17 | <0.08 | <0.08 | mg/kg | 0.08 | A-T-019s |
| Fluorene$_{A}^{M\#}$ | 0.85 | 0.23 | 0.92 | 0.03 | 0.06 | <0.01 | <0.01 | mg/kg | 0.01 | A-T-019s |
| Indeno(123-cd)pyrene$_{A}^{M\#}$ | 1.58 | 0.26 | 1.69 | 0.12 | 0.06 | <0.03 | <0.03 | mg/kg | 0.03 | A-T-019s |
| Naphthalene $_{A}^{M\#}$ | 0.57 | 0.20 | 0.44 | <0.03 | <0.03 | <0.03 | <0.03 | mg/kg | 0.03 | A-T-019s |
| Phenanthrene$_{A}^{M\#}$ | 6.14 | 1.50 | 5.64 | 0.13 | <0.03 | <0.03 | <0.03 | mg/kg | 0.03 | A-T-019s |
| Pyrene$_{A}^{M\#}$ | 7.86 | 1.66 | 8.10 | 0.23 | 0.19 | <0.07 | <0.07 | mg/kg | 0.07 | A-T-019s |
| Total PAH-16MS$_{A}^{M\#}$ | 43.9 | 8.86 | 44.4 | 1.72 | 0.89 | <0.08 | <0.08 | mg/kg | 0.01 | A-T-019s |

envirolab

**Envirolab Job Number: 22/06213**

**Client Project Name: Martin Harris Building Uni of Manchester**

**Client Project Ref: 10 2084**

| Lab Sample ID | 22/06213/1 | 22/06213/2 | 22/06213/3 | 22/06213/4 | 22/06213/5 | 22/06213/6 | 22/06213/7 | Units | Limit of Detection | Method ref |
|---|---|---|---|---|---|---|---|---|---|---|
| Client Sample No | | | | | | | | | | |
| Client Sample ID | WS1 | WS2 | WS3 | WS3 | WS2 | WS2 | WS3 | | | |
| Depth to Top | 0.65 | 0.70 | 0.65 | 1.35 | 1.70 | 2.40 | 1.60 | | | |
| Depth To Bottom | | | | | | | | | | |
| Date Sampled | 21-Jun-22 | 21-Jun-22 | 21-Jun-22 | 21-Jun-22 | 21-Jun-22 | 21-Jun-22 | 21-Jun-22 | | | |
| Sample Type | Soil - ES | Soil - ES | Soil - ES | Soil - ES | Soil - ES | Soil - ES | Soil - ES | | | |
| Sample Matrix Code | 5AB | 6A | 4AB | 5AB | 4A | 5A | 5A | | | |
| **TPH CWG with Clean Up** | | | | | | | | | | |
| Ali >C5-C6$_{A}^{\#}$ | <0.01 | <0.01 | - | <0.01 | <0.05 | <0.01 | <0.01 | mg/kg | 0.01 | A-T-022s |
| Ali >C6-C8$_{A}^{\#}$ | <0.01 | 0.06 | - | <0.01 | <0.05 | <0.01 | <0.01 | mg/kg | 0.01 | A-T-022s |
| Ali >C8-C10$_{A}$ | 1 | 165 | - | <1 | 59 | <1 | <1 | mg/kg | 1 | A-T-055s |
| Ali >C10-C12$_{A}^{M\#}$ | 5 | 435 | - | <1 | 412 | <1 | <1 | mg/kg | 1 | A-T-055s |
| Ali >C12-C16$_{A}^{M\#}$ | 26 | 658 | - | <1 | 1110 | <1 | <1 | mg/kg | 1 | A-T-055s |
| Ali >C16-C21$_{A}^{M\#}$ | 24 | 35 | - | 1 | 61 | <1 | <1 | mg/kg | 1 | A-T-055s |
| Ali >C21-C35$_{A}^{M\#}$ | 67 | 204 | - | 13 | 35 | 4 | 3 | mg/kg | 1 | A-T-055s |
| Total Aliphatics$_{A}$ | 123 | 1500 | - | 15 | 1680 | 4 | 3 | mg/kg | 1 | A-T-055s |
| Aro >C5-C7$_{A}^{\#}$ | <0.01 | <0.01 | - | <0.01 | <0.05 | <0.01 | <0.01 | mg/kg | 0.01 | A-T-022s |
| Aro >C7-C8$_{A}^{\#}$ | <0.01 | <0.01 | - | <0.01 | <0.05 | <0.01 | <0.01 | mg/kg | 0.01 | A-T-022s |
| Aro >C8-C10$_{A}$ | 2 | 62 | - | <1 | 17 | <1 | <1 | mg/kg | 1 | A-T-055s |
| Aro >C10-C12$_{A}$ | 6 | 145 | - | <1 | 183 | <1 | <1 | mg/kg | 1 | A-T-055s |
| Aro >C12-C16$_{A}$ | 36 | 260 | - | 4 | 566 | 1 | <1 | mg/kg | 1 | A-T-055s |
| Aro >C16-C21$_{A}^{M\#}$ | 103 | 92 | - | 12 | 61 | 1 | <1 | mg/kg | 1 | A-T-055s |
| Aro >C21-C35$_{A}^{M\#}$ | 255 | 179 | - | 56 | 33 | 4 | 3 | mg/kg | 1 | A-T-055s |
| Total Aromatics$_{A}$ | 402 | 738 | - | 72 | 861 | 6 | 3 | mg/kg | 1 | A-T-055s |
| TPH (Ali & Aro >C5-C35)$_{A}$ | 526 | 2230 | - | 86 | 2540 | 10 | 5 | mg/kg | 1 | A-T-055s |
| BTEX - Benzene$_{A}^{\#}$ | <0.01 | <0.01 | - | <0.01 | <0.05 | <0.01 | <0.01 | mg/kg | 0.01 | A-T-022s |
| BTEX - Toluene$_{A}^{\#}$ | <0.01 | <0.01 | - | <0.01 | <0.05 | <0.01 | <0.01 | mg/kg | 0.01 | A-T-022s |
| BTEX - Ethyl Benzene$_{A}^{\#}$ | <0.01 | <0.01 | - | <0.01 | <0.05 | <0.01 | <0.01 | mg/kg | 0.01 | A-T-022s |
| BTEX - m & p Xylene$_{A}^{\#}$ | <0.01 | <0.01 | - | <0.01 | <0.05 | <0.01 | <0.01 | mg/kg | 0.01 | A-T-022s |
| BTEX - o Xylene$_{A}^{\#}$ | <0.01 | <0.01 | - | <0.01 | <0.05 | <0.01 | <0.01 | mg/kg | 0.01 | A-T-022s |
| MTBE$_{A}^{\#}$ | <0.01 | <0.01 | - | <0.01 | <0.05 | <0.01 | <0.01 | mg/kg | 0.01 | A-T-022s |

envirolab

**Envirolab Job Number: 22/06213**

**Client Project Name: Martin Harris Building Uni of Manchester**

**Client Project Ref: 10 2084**

| Lab Sample ID | 22/06213/8 | 22/06213/9 | | | | | | Units | Limit of Detection | Method ref |
|---|---|---|---|---|---|---|---|---|---|---|
| Client Sample No | | | | | | | | | | |
| Client Sample ID | WS3 | WS2 | | | | | | | | |
| Depth to Top | 2.00 | 3.80 | | | | | | | | |
| Depth To Bottom | 2.45 | | | | | | | | | |
| Date Sampled | 21-Jun-22 | 21-Jun-22 | | | | | | | | |
| Sample Type | Soil - D | Soil - D | | | | | | | | |
| Sample Matrix Code | 3A | 3A | | | | | | | | |
| % Stones >10mm$_{A}$ | <0.1 | <0.1 | | | | | | % w/w | 0.1 | A-T-044 |
| Sulphate (water sol 2:1)$_{D}^{M\#}$ | 0.02 | 0.01 | | | | | | g/l | 0.01 | A-T-026s |

## REPORT NOTES

**General**

This report shall not be reproduced, except in full, without written approval from Envirolab.
The results reported herein relate only to the material supplied to the laboratory.
The residue of any samples contained within this report, and any received with the same delivery, will be disposed of six weeks after initial scheduling. For samples tested for Asbestos we will retain a portion of the dried sample for a minimum of six months after the initial Asbestos testing is completed.
Analytical results reflect the quality of the sample at the time of analysis only.
Opinions and interpretations expressed are outside the scope of our accreditation.
If results are in italic font they are associated with an AQC failure, these are not accredited and are unreliable.
A deviating samples report is appended and will indicate if samples or tests have been found to be deviating. Any test results affected may not be an accurate record of the concentration at the time of sampling and, as a result, may be invalid.
The Client Sample No, Client Sample ID, Depth to Top, Depth to Bottom and Date Sampled were all provided by the client.

**Soil chemical analysis:**

All results are reported as dry weight (<40°C).
For samples with Matrix Codes 1 - 6 natural stones, brick and concrete fragments >10mm and any extraneous material (visible glass, metal or twigs) are removed and excluded from the sample prior to analysis and reported results corrected to a whole sample basis. This is reported as '% stones >10mm'.
For samples with Matrix Code 7 the whole sample is dried and crushed prior to analysis and this supersedes any “A” subscripts
All analysis is performed on the sample as received for soil samples which are positive for asbestos or the client has informed asbestos may be present and/or if they are from outside the European Union and this supersedes any "D" subscripts.

**TPH analysis of water by method A-T-007:**

Free and visible oils are excluded from the sample used for analysis so that the reported result represents the dissolved phase only.

**Electrical Conductivity of water by Method A-T-037:**

Results greater than 12900µS/cm @ 25°C / 11550µS/cm @ 20°C fall outside the calibration range and as such are unaccredited.

**Asbestos:**

Asbestos in soil analysis is performed on a dried aliquot of the submitted sample and cannot guarantee to identify asbestos if only present in small numbers as discrete fibres/fragments in the original sample.
Stones etc. are not removed from the sample prior to analysis.
Quantification of asbestos is a 3 stage process including visual identification, hand picking and weighing and fibre counting by sedimentation/phase contrast optical microscopy if required. If asbestos is identified as being present but is not in a form that is suitable for analysis by hand picking and weighing (normally if the asbestos is present as free fibres) quantification by sedimentation is performed. Where ACMs are found a percentage asbestos is assigned to each with reference to 'HSG264, Asbestos: The survey guide' and the calculated asbestos content is expressed as a percentage of the dried soil sample aliquot used.

**Predominant Matrix Codes:**

1 = SAND, 2 = LOAM, 3 = CLAY, 4 = LOAM/SAND, 5 = SAND/CLAY, 6 = CLAY/LOAM, 7 = OTHER, 8 = Asbestos bulk ID sample, 9 = INCINERATOR ASH.
Samples with Matrix Code 7 & 8 are not predominantly a SAND/LOAM/CLAY mix and are not covered by our BSEN 17025 or MCERTS accreditations, with the exception of bulk asbestos which are BSEN 17025 accredited.

**Secondary Matrix Codes:**

A = contains stones, B = contains construction rubble, C = contains visible hydrocarbons, D = contains glass/metal,
E = contains roots/twigs.

**Key:**

IS indicates Insufficient Sample for analysis.
US indicates Unsuitable Sample for analysis.
NDP indicates No Determination Possible.
NAD indicates No Asbestos Detected.
N/A indicates Not Applicable.
Superscript # indicates method accredited to ISO 17025.
Superscript "M" indicates method accredited to MCERTS.
Subscript "A" indicates analysis performed on the sample as received.
Subscript "D" indicates analysis performed on the dried sample, crushed to pass a 2mm sieve
Subscript "^" indicates analysis has dependant options against results. Testing dependant on results appear in the comments area of your sample receipt.
EPH CWG results have humics mathematically subtracted through instrument calculation
TPH results "with Cleanup" indicates results cleaned up with Silica during extraction

**EPH CWG GCxGC ID from TPH CWG**

Where we have identified humic substances in any ID's from TPH CWG with Clean Up please note that the concentration of these humic substances is not included in the quantified results and are included in the ID for information.

Please contact us if you need any further information.

v2

# Envirolab Deviating Samples Report

Units 7&8 Sandpits Business Park, Mottram Road, Hyde, SK14 3AR
Tel. 0161 368 4921 email. ask@envlab.co.uk

**Client:** Clancy Consulting, Dunham Court, 2 Dunham Road, Altrincham, Cheshire, UK, WA14 4NX

**Project:** Martin Harris Building Uni of Manchester

**Clients Project No:** 10 2084

**Project No:** 22/06213

**Date Received:** 24/06/2022 (am)

**Cool Box Temperatures (°C):** 18.2

| | |
|---|---|
| **Lab Sample ID** | 22/06213/6 |
| **Client Sample No** | |
| **Client Sample ID/Depth** | WS2 2.40m |
| **Date Sampled** | 21/06/22 |
| **Deviation Code** | |
| F | ✓ |

*Key*

*F* *Maximum holding time exceeded between sampling date and analysis for analytes listed below*

## HOLDING TIME EXCEEDANCES

| | |
|---|---|
| **Lab Sample ID** | 22/06213/6 |
| **Client Sample No** | |
| **Client Sample ID/Depth** | WS2 2.40m |
| **Date Sampled** | 21/06/22 |
| EPHCWG | ✓ |
| VPHCWG | ✓ |

Note: If, at any point before reaching the laboratory, the temperature of the samples has breached those set in published standards, e.g. BS-EN 5667-3 (for water samples 5 ± 3°C), ISO 18400-105:2017, then the concentration of any affected analytes may differ from that at the time of sampling.

# Envirolab Analysis Dates

| Lab Sample ID | 22/06213/1 | 22/06213/2 | 22/06213/3 | 22/06213/4 | 22/06213/5 | 22/06213/6 | 22/06213/7 | 22/06213/8 | 22/06213/9 |
|---|---|---|---|---|---|---|---|---|---|
| **Client Sample No** | | | | | | | | | |
| **Client Sample ID/Depth** | WS1 0.65m | WS2 0.70m | WS3 0.65m | WS3 1.35m | WS2 1.70m | WS2 2.40m | WS3 1.60m | WS3 2.00-2.45m | WS2 3.80m |
| **Date Sampled** | 21/06/22 | 21/06/22 | 21/06/22 | 21/06/22 | 21/06/22 | 21/06/22 | 21/06/22 | 21/06/22 | 21/06/22 |
| A-T-019s | 01/07/2022 | 01/07/2022 | 01/07/2022 | 01/07/2022 | 01/07/2022 | 01/07/2022 | 01/07/2022 | | |
| A-T-022s | 01/07/2022 | 01/07/2022 | | 01/07/2022 | 04/07/2022 | 04/08/2022 | 01/07/2022 | | |
| A-T-024s | 30/06/2022 | 30/06/2022 | 30/06/2022 | 30/06/2022 | 30/06/2022 | 30/06/2022 | 30/06/2022 | | |
| A-T-026s | | 30/06/2022 | 30/06/2022 | 30/06/2022 | | 30/06/2022 | 30/06/2022 | 30/06/2022 | 30/06/2022 |
| A-T-027s | 30/06/2022 | 30/06/2022 | 30/06/2022 | 30/06/2022 | 30/06/2022 | 30/06/2022 | 30/06/2022 | | |
| A-T-031s | 30/06/2022 | 30/06/2022 | 30/06/2022 | 30/06/2022 | 30/06/2022 | 30/06/2022 | 30/06/2022 | | |
| A-T-032s | | 30/06/2022 | 30/06/2022 | 30/06/2022 | 30/06/2022 | | | | |
| A-T-040s | 30/06/2022 | 30/06/2022 | 30/06/2022 | 30/06/2022 | 30/06/2022 | 30/06/2022 | 30/06/2022 | | |
| A-T-044 | 28/06/2022 | 28/06/2022 | 28/06/2022 | 28/06/2022 | 28/06/2022 | 28/06/2022 | 28/06/2022 | 28/06/2022 | 28/06/2022 |
| A-T-045 | 28/06/2022 | 28/06/2022 | | 28/06/2022 | | 28/06/2022 | 28/06/2022 | | |
| A-T-055s | 01/07/2022 | 01/07/2022 | | 01/07/2022 | 04/07/2022 | 04/08/2022 | 01/07/2022 | | |

The above dates are the analysis completion dates, please note that these are not necessarily the date that the analysis was weighed/extracted.

**End of Report**

# APPENDIX V

# GEOTECHNICAL LABORATORY TEST RESULTS

# LABORATORY REPORT

4043

**Contract Number: PSL22/4295**

Report Date: 08 July 2022

Client's Reference: 10 2084

Client Name: Clancy Consulting
Dunham Court
2 Dunham Road
Altrincham
Cheshire
WA144NX

**For the attention of: Sean Pilling**

Contract Title: Martin Harris UoM

Date Received: 23/6/2022
Date Commenced: 23/6/2022
Date Completed: 07/07/2022

**Notes: Opinions and Interpretations are outside the UKAS Accreditation**

A copy of the Laboratory Schedule of accredited tests as issued by UKAS is attached to this report. This certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service. The results reported herein relate only to the material supplied to the laboratory. This certificate shall not be reproduced other than in full, without the prior written approval of the laboratory.

Checked and Approved Signatories:

| | | |
|---|---|---|
| A Watkins<br>(Director) | R Berriman<br>(Quality Manager) | S Royle<br>(Laboratory Manager) |
| L Knight<br>(Assistant Laboratory Manager) | S Eyre<br>(Senior Technician) | M Fennell<br>(Senior Technician) |



**5 – 7 Hexthorpe Road, Hexthorpe,**
**Doncaster DN4 0AR**
**tel: +44 (0)844 815 6641**
**fax: +44 (0)844 815 6642**
**e-mail: rberriman@prosoils.co.uk**
**awatkins@prosoils.co.uk**

# SUMMARY OF LABORATORY SOIL DESCRIPTIONS

| Hole Number | Sample Number | Sample Type | Top Depth m | Base Depth m | Description of Sample |
|---|---|---|---|---|---|
| WS1 | | D | 2.50 | | Brown sandy CLAY. |
| WS2 | | D | 3.00 | 3.45 | Brown sandy CLAY. |
| WS3 | | D | 1.70 | | Brown slightly sandy CLAY. |
| WS4 | | D | 2.00 | 2.45 | Brown sandy CLAY. |

| | | | |
|---|---|---|---|
| UKAS TESTING 4043 | PSL Professional Soils Laboratory | Martins Harris UoM | Contract No: PSL22/4295 |
| | | | Client Ref: 10 2084 |

# SUMMARY OF SOIL CLASSIFICATION TESTS

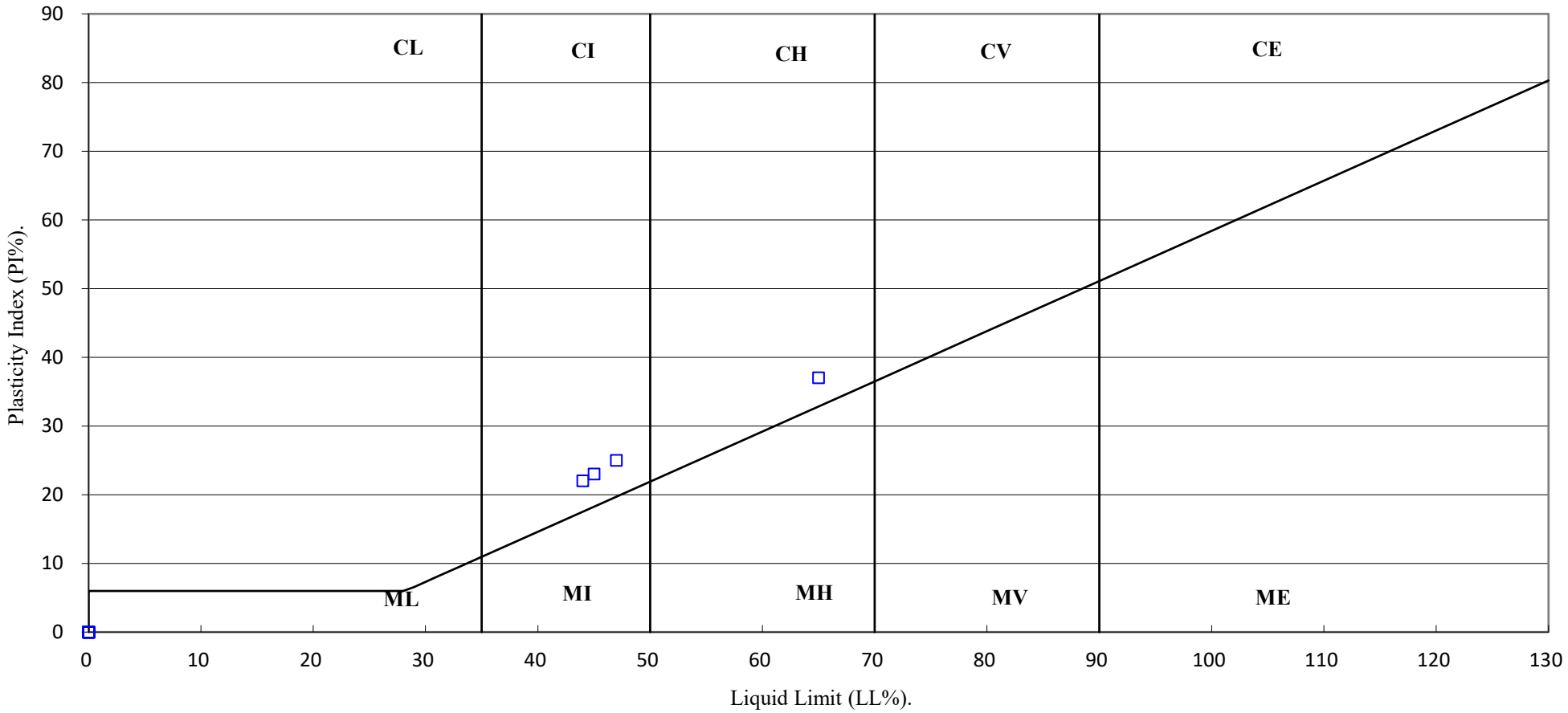
**(BS1377 : PART 2 : 1990)**

| Hole Number | Sample Number | Sample Type | Top Depth m | Base Depth m | Moisture Content % Clause 3.2 | Linear Shrinkage % Clause 6.5 | Particle Density $Mg/m^3$ Clause 8.2 | Liquid Limit % Clause 4.3/4 | Plastic Limit % Clause 5.3 | Plasticity Index % Clause 5.4 | Passing .425mm % | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WS1 | | D | 2.50 | | 17 | | | 44 | 22 | 22 | 100 | Intermediate Plasticity CI |
| WS2 | | D | 3.00 | 3.45 | 18 | | | 45 | 22 | 23 | 100 | Intermediate Plasticity CI |
| WS3 | | D | 1.70 | | 33 | | | 65 | 28 | 37 | 100 | High Plasticity CH |
| WS4 | | D | 2.00 | 2.45 | 23 | | | 47 | 22 | 25 | 100 | Intermediate Plasticity CI |

**SYMBOLS : NP : Non Plastic** *** : Liquid Limit and Plastic Limit Wet Sieved.**

| | | | |
|---|---|---|---|
| UKAS TESTING 4043 | PSL Professional Soils Laboratory | Martins Harris UoM | Contract No: PSL22/4295 |
| | | | Client Ref: 10 2084 |

# PLASTICITY CHART FOR CASAGRANDE CLASSIFICATION.




| | | | |
|---|---|---|---|
| UKAS TESTING 4043 | PSL Professional Soils Laboratory | Martins Harris UoM | Contract No: PSL22/4295 |
| | | | Client Ref: 10 2084 |

# APPENDIX VI

# GAS MONITORING RESULTS

# MONITORING RESULTS

| | | | |
|---|---|---|---|
| **CLIENT:** | University of Manchester | **JOB NO:** | 10/2084 |
| **SITE:** | Martin Harris New Music Block, University of Manchester | **SHEET:** | 1 of 4 |
| **DATE:** | 30/06/2022 | | |

**Ambient Concentration (% Volume)** **CH4** 0.0 **CO2** 0.0

**O2** 20.8

| Monitoring Point | | | Gas Concentration | | | | | | | | Gas Flow Rate | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Highest | | | Steady | | | Lowest | H2S | | |
| Ref | GWL | Depth | CH4 | | CO2 | CH4 | | CO2 | O2 | | | |
| | (m)BGL | (m) BGL | % LEL | % v/v | (%) | % LEL | % v/v | (%) | (%) | ppm | l/hr | |
| WS2 - #New# | Dry | 1.9 | 0.00 | 0.00 | 1.60 | 0.00 | 0.00 | 1.60 | 18.50 | 0 | 0.00 | |
| WS3 - #New# | 1.33 | 3.5 | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 | 0.00 | 20.50 | 0 | 0.00 | |
| WS4 - #New# | Dry | 3.5 | 0.00 | 0.00 | 6.00 | 0.00 | 0.00 | 5.90 | 12.60 | 0 | 0.00 | |

| | | | |
|---|---|---|---|
| **Barometric Pressure (mb):** | 1005 | **Monitoring Equipment:** | GFM436 |
| **Barometric Trend:** | Rising | **Date Of Last Calibration:** | 09/11/2021 |
| **Weather:** | Overcast | **Operator:** | SP |
| **Ground Condition:** | Dry | | |

| KEY | Remarks |
|---|---|
| **ND - None Detected**<br>**NR - Not Recorded**<br>**POS - Positive Flow**<br>**NEG - Negative Flow** | |

**Checked:** DK **Approved:** DK

# MONITORING RESULTS

| | | | |
|---|---|---|---|
| **CLIENT:** | University of Manchester | **JOB NO:** | 10/2084 |
| **SITE:** | Martin Harris New Music Block, University of Manchester | **SHEET:** | 2 of 4 |
| **DATE:** | 08/07/2022 | | |

| **Ambient Concentration (% Volume)** | **CH4** | 0.0 | **CO2** | 0.0 |
|---|---|---|---|---|
| | **O2** | 20.7 | | |

| **Monitoring Point** | | | **Gas Concentration** | | | | | | | | **Gas Flow Rate** | **Remarks** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Highest** | | | **Steady** | | | **Lowest** | **H2S** | | |
| **Ref** | **GWL** | **Depth** | **CH4** | | **CO2** | **CH4** | | **CO2** | **O2** | | | |
| | **(m)BGL** | **(m) BGL** | **% LEL** | **% v/v** | **(%)** | **% LEL** | **% v/v** | **(%)** | **(%)** | **ppm** | **l/hr** | |
| WS2 - #New# | Dry | 1.9 | 0.00 | 0.00 | 2.10 | 0 | 0.00 | 1.80 | 17.20 | 0 | 0.00 | |
| WS3 - #New# | 1.48 | 3.5 | 0.00 | 0.00 | 0.50 | 0 | 0.00 | 0.20 | 21.40 | 0 | 0.00 | |
| WS4 - #New# | Dry | 3.5 | 0.00 | 0.00 | 2.00 | 0 | 0.00 | 0.10 | 18.90 | 0 | 0.00 | |

| | | | |
|---|---|---|---|
| **Barometric Pressure (mb):** | 998 | **Monitoring Equipment:** | GFM436 |
| **Barometric Trend:** | Rising | **Date Of Last Calibration:** | 07/11/2021 |
| **Weather:** | Sunny | **Operator:** | TB |
| **Ground Condition:** | Dry | | |

| **KEY** | **Remarks** |
|---|---|
| **ND - None Detected**<br>**NR - Not Recorded**<br>**POS - Positive Flow**<br>**NEG - Negative Flow** | |

| | | | |
|---|---|---|---|
| **Checked:** | DK | **Approved:** | DK |

# MONITORING RESULTS

| | | | |
|---|---|---|---|
| **CLIENT:** | University of Manchester | **JOB NO:** | 10/2084 |
| **SITE:** | Martin Harris New Music Block, University of Manchester | **SHEET:** | 3 of 4 |
| **DATE:** | 21/07/2022 | | |

**Ambient Concentration (% Volume)** **CH4** 0.0 **CO2** 0.0

**O2** 20.8

| Monitoring Point | | | Gas Concentration | | | | | | | | Gas Flow Rate | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Highest | | | Steady | | | Lowest | H2S | | |
| Ref | GWL | Depth | CH4 | | CO2 | CH4 | | CO2 | O2 | | | |
| | (m)BGL | (m) BGL | % LEL | % v/v | (%) | % LEL | % v/v | (%) | (%) | ppm | l/hr | |
| WS2 - #New# | Dry | 1.9 | 0.00 | 0.00 | 1.30 | 0.00 | 0.00 | 0.40 | 18.70 | 0.00 | 0.10 | |
| WS3 - #New# | 1.40 | 3.5 | 0.00 | 0.00 | 2.10 | 0.00 | 0.00 | 0.10 | 18.20 | 0.00 | 0.10 | |
| WS4 - #New# | Dry | 3.5 | 0.00 | 0.00 | 3.20 | 0.00 | 0.00 | 1.20 | 17.40 | 0.00 | 0.10 | |

| | | | |
|---|---|---|---|
| **Barometric Pressure (mb):** | 1008 | **Monitoring Equipment:** | GA94a Gas Analyser |
| **Barometric Trend:** | Rising | **Date Of Last Calibration:** | 07/11/2021 |
| **Weather:** | Overcast | **Operator:** | TB |
| **Ground Condition:** | Dry | | |

| KEY | Remarks |
|---|---|
| **ND - None Detected**<br>**NR - Not Recorded**<br>**POS - Positive Flow**<br>**NEG - Negative Flow** | - |

**Checked:** DK **Approved:** DK

# MONITORING RESULTS

| | | | |
|---|---|---|---|
| **CLIENT:** | University of Manchester | **JOB NO:** | 10/2084 |
| **SITE:** | Martin Harris New Music Block, University of Manchester | **SHEET:** | 4 of 4 |
| **DATE:** | 28/07/2022 | | |

**Ambient Concentration (% Volume)** **CH4** 0.0 **CO2** 0.0 **O2** 20.7

| Monitoring Point | | | Gas Concentration | | | | | | | | Gas Flow Rate | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Highest | | | Steady | | | Lowest | H2S | | |
| Ref | GWL | Depth | CH4 | | CO2 | CH4 | | CO2 | O2 | | | |
| | (m)BGL | (m) BGL | % LEL | % v/v | (%) | % LEL | % v/v | (%) | (%) | ppm | l/hr | |
| WS2 - #New# | Dry | 1.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 21.20 | 0.00 | 0.00 | - |
| WS3 - #New# | 1.63 | 3.5 | 0.00 | 0.00 | 1.10 | 0.00 | 0.00 | 0.10 | 18.60 | 0.00 | 0.10 | - |
| WS4 - #New# | Dry | 3.5 | 0.00 | 0.00 | 1.60 | 0.00 | 0.00 | 0.70 | 19.30 | 0.00 | 0.10 | - |

| | | | |
|---|---|---|---|
| **Barometric Pressure (mb):** | 997 | **Monitoring Equipment:** | GA94a Gas Analyser |
| **Barometric Trend:** | Rising | **Date Of Last Calibration:** | 07/11/2021 |
| **Weather:** | Raining | **Operator:** | TB |
| **Ground Condition:** | Wet | | |

| KEY | Remarks |
|---|---|
| **ND - None Detected**<br>**NR - Not Recorded**<br>**POS - Positive Flow**<br>**NEG - Negative Flow** | - |

**Checked:** DK **Approved:** DK

# APPENDIX VII

# INFILTRATION TEST SHEETS

# Permeability Determination

**ws3**

| | | | | |
|---|---|---|---|---|
| | **Borehole dimension** | Dimensions (m) | 0.1 | |
| | | Response Zone (m) | 0.5 | |
| | 0.952380952 | Perimeter (m) | 0.314159 | |
| | | Area (m2) | 0.164934 | |
| | | h1 | 2 | |
| | | h2 | 1.95 | |
| | **depth hole (m)** | h | 2 | m |
| | **depth at 30sec BGL** | | 0 | m |
| | **depth at 1800 sec BGL** | | 0.05 | m |

k/l *(t2t1)= log (h1/h20 - log (ah1 +1/ ah2+1)

| | |
|---|---|
| k/l(t2-t1) | 0.0038168 |
| l= (h1-h2)/2 | |
| Average head l (m) | 1.975 |
| k | **0.00000419** |

| | | |
|---|---|---|
| **time** | t1 (sec) | 30 |
| | t2(sec) | 1800 |

Permeability k **4.19E-06**

# Permeability Determination

**ws4**

| | | | | |
|---|---|---|---|---|
| | **Borehole dimension** | Dimensions (m) | 0.1 | |
| | | Response Zone (m) | 0.5 | |
| | 0.952380952 | Perimeter (m) | 0.314159 | |
| | | Area (m2) | 0.164934 | |
| | | h1 | 1.63 | |
| | | h2 | 1.55 | |
| | **depth hole (m)** | h | 2 | m |
| | **depth at 30sec BGL** | | 0.37 | m |
| | **depth at 1800 sec BGL** | | 0.45 | m |

k/l *(t2t1)= log (h1/h20 - log (ah1 +1/ ah2+1)

| | |
|---|---|
| k/l(t2-t1) | 0.00869446 |
| l= (h1-h2)/2 | |
| Average head l (m) | 1.59 |
| k | **0.00000768** |

| | | |
|---|---|---|
| **time** | t1 (sec) | 30 |
| | t2(sec) | 1800 |

Permeability k **7.68E-06**