



**NHS Property Services Ltd**

**The Former Clitheroe Hospital,  
Chatburn Road, Clitheroe**

**Draft Factual and Interpretative Ground  
Investigation Report**

**A094939 – February 2017**

Manchester Quay West at MediaCityUK, Trafford Wharf Road, Trafford Park, Manchester, M17 1HH  
Tel: +44 (0)161 872 3223 Fax: +44 (0)161 872 3193  
Email: [info@wyg.com](mailto:info@wyg.com) Website: [www.wyg.com](http://www.wyg.com)

WYG Environment Planning Transport Limited. Registered in England & Wales Number: 03050297  
Registered Office: Arndale Court, Otley Road, Headingley, Leeds, LS6 2UJ



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Prepared by	Checked by	Approved by
Sara Hegewald BSc (Hons) MSc FGS Senior Environmental Consultant	Caroline Martin BSc (Hons) MSc CSci FGS Principal Geo-Environmental Engineer	Richard Jarrett BSc (Hons) MSc EurIng. CEng. MICE UK Registered Ground Engineering Adviser
<i>S. Hegewald</i>	<i>CMartin</i>	



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Appendix B – Exploratory Hole Logs

Appendix C – Geo-chemical Laboratory Test Results

Appendix D – Geo-technical Laboratory Test Results (PENDING)

Appendix E – Gas and Groundwater Level Monitoring Results

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## 1. Executive Summary

Current Site Status	The site is located on Chatburn Road, approximately 1.5km north-east of Clitheroe town centre and covers approximately 2 hectares. The site is currently a disused former hospital; three bunded oil tanks are also present adjacent to a former boiler room on the eastern boundary of the site. Surrounding the site, commercial properties lie to the south-east, beyond which is Clitheroe Auction Mart. Immediately to the east and north-east is the new Clitheroe Community Hospital, to the north is Chatburn Road with agricultural land beyond. Agricultural land is also located to the west.
Geology	The site is underlain by Made Ground which in turn is predominantly underlain by Glacial Till (Secondary Undifferentiated Aquifer) and bedrock of the Clitheroe Limestone Formation and Hodder Mudstone Formation (Secondary A Aquifer).
Site Investigation	<p>The WYG investigation works were undertaken between 01<sup>st</sup> and 02<sup>nd</sup> February 2017 with follow up monitoring of installations on 10<sup>th</sup> and 14<sup>th</sup> February 2017. The scope of works was as follows:</p> <ul style="list-style-type: none"> <li>• Six dynamic sample boreholes (WS101 to WS106);</li> <li>• Standard Penetration Tests (SPTs) within the dynamic sample holes;</li> <li>• Six trial pits (TP101, TP101A, TP103 to TP106);</li> <li>• Full-time supervision by a WYG consultant, to record the ground conditions and obtain soil samples;</li> <li>• Chemical laboratory testing, including soil-leachate testing and asbestos screening;</li> <li>• Geotechnical laboratory testing of soils; and,</li> <li>• Two visits to site to monitor for ground gas and groundwater levels (10<sup>th</sup> and 14<sup>th</sup> February 2017).</li> </ul>
Ground Contamination Assessment	The soil chemical test results have been screened against residential with plant uptake values as this is considered to be the most appropriate to the proposed end-use. The results of the soil-leachate analysis were assessed against DWS values. Elevated concentrations of lead in soils were reported in specific locations within the central and southern locations of the site. Elevated concentrations of benzo(a)pyrene, EPH (C12-C40), TPH Aromatic (EC16-EC35) and SVOCs were reported in soil at shallow depth within WS106. No elevated soil-leachate results were reported. Ground gas results were not elevated across the site. Radon protection measures are not required at the site.
Encountered Ground Conditions	Made Ground was encountered in all exploratory hole locations with exception of WS104 and WS105. It generally consisted of slightly silty gravelly sandy Clay with gravel of brick, ceramic and timber. The Made Ground is in turn underlain by slightly silty slightly gravelly or sandy Clay. Gravelly Sand was encountered beneath the Clay in TP102 and TP104 which was further underlain by sandy Gravel in TP102. Possible bedrock was encountered in WS101, WS105, TP101A, TP102, TP104 and TP106 due to refusals during the investigation. Grey Limestone was encountered at 2.85m bgl in TP105 and brown Mudstone was encountered in WS101 at 3.70m bgl. These hard strata may represent bedrock, but could also be boulders/cobbles.
Refined Risk Assessment	The risk from on-site contamination sources is generally considered to pose a <b>low to moderate</b> risk to on-site receptors. The risk to future site users and pipework is <b>moderate</b> from elevated lead, benzo(a)pyrene, EPH (C12-C40), TPH Aromatic (EC16-EC35) and SVOCs within soils and would require mitigation during development. The risk to future site users and buildings/installations is <b>low to moderate</b> from the generation and accumulation of vapours in the vicinity of the former boiler room/above ground tank area.
Recommendations for remediation	It is recommended that a 600mm thick cover system of clean soil be placed over areas of elevated lead concentrations in the central and southern parts of the site or the soil could be placed beneath hardstanding if possible. Further delineation and validation of soils is required within the vicinity of the former boiler house and above ground tanks in order to determine the extent of risk to human health at the site.
<i>This sheet is intended as a summary of the assessment of the site. It does not provide a definitive analysis.</i>	



## **2. Introduction**

### **2.1 Instruction**

WYG Environment Planning Transport Limited (WYG) was commissioned by NHS Property Services Ltd to undertake a ground investigation and report the findings for a site known as the Former Clitheroe Hospital, Chatburn Road, Clitheroe. A site location plan is enclosed as Drawing No. A094939-MAN-N-01.

### **2.2 Objectives**

The principal objective of the report is to present a general assessment of land quality with respect to geo-environmental issues.

### **2.3 Scope of Services**

The scope of investigation has been determined based on the information obtained to date and our understanding of the current development proposals. In order to achieve the above objectives, the following scope of works was determined:

- A review of historical information pertinent to the site;
- A ground investigation to obtain preliminary geo-environmental and geotechnical information;
- Reporting of factual information gathered;
- Interpretation of results including a Tier 1 risk assessment and updated conceptual site model/ risk assessment and;
- a preliminary geotechnical assessment.

### **2.4 Proposed Development**

It is understood that present proposals include the construction of up to 50 houses with associated infrastructure and soft landscaping.



## 2.5 Report Conditions

Attention is drawn to the report conditions included in Appendix A.

This report should be read in conjunction with the following:

- Phase I Geo-Environmental Desk Study, Former Clitheroe Hospital, WYG, December 2016 (prepared for NHS Property Services Ltd).



## 3. Site Details

### 3.1 Site Description

The site is currently occupied by the disused former Clitheroe Hospital located on Chatburn Road, approximately 1.5km north-east of Clitheroe town centre. The site coverage is approximately 50% soft landscaping, 25% building cover and 25% hardstanding (asphalt). Three bunded fuel oil tanks are present adjacent to a former boiler room on the eastern boundary of the site.

Key details for the site are provided in Table 3.1 below.

**Table 3.1 Phase 1 Area Details**

<b>Site Address</b>	Land at the former Clitheroe Hospital, Chatburn Road, Clitheroe, Lancashire, BB7 4JX (nearest postcode).
<b>Grid Reference</b>	Site is centered upon 375458, 443007
<b>Site Area</b>	~ 2 ha
<b>Elevation</b>	97 mAOD approx.

Surrounding the site, commercial properties lie to the south-east, beyond which is Clitheroe Auction Mart. Immediately to the east and north-east is the new Clitheroe Community Hospital, to the north is Chatburn Road with agricultural land beyond. Agricultural land is also located to the west.





## 4. Desk Study Summary

A Desk Study report was produced by WYG in December 2016. A summary of the pertinent findings of the desk study is given in Table 4.1 below.

**Table 4.1 – Summary of Desk Study Information**

<b>Environmental Setting</b>	The environmental database did not highlight any significant issues which may affect the site. In the surrounding area there are a number of former quarries, some of which have been later infilled. There is one upper tier COMAH site located 625m west of the site.
<b>History</b>	The earliest historical maps show the site to be occupied by fields. The 1886 map shows the site developed as the Clitheroe Union Workhouse, with a site layout similar to the current one. A number of quarries surrounded the site, some of which were later in-filled. The nearest quarry to the site was unnamed and was located 100m west. In recent years, much development of the surrounding area has occurred, including the Tarmac works to the north-west, an unnamed works to the west, a further works and conveyors to the north and Salthill industrial estate to the south.
<b>Geology</b>	Made Ground associated with previous development may be present. The superficial deposits underlying the site comprise Devensian Till, in turn, underlain by solid geology of the Clitheroe Limestone Formation and the Hodder Mudstone Formation. The Peach Quarry Limestone Member is shown to be present on the southern part of the site. From the information reviewed there are conflicting views on the requirement for radon protection measures within new builds at the site. This requires further investigation.
<b>Hydrogeology</b>	<ul style="list-style-type: none"> <li>• Devensian Till (Secondary Undifferentiated Aquifer);</li> <li>• Clitheroe Limestone Formation and Hodder Mudstone Formation (Secondary A Aquifer);</li> <li>• Peach Quarry Limestone Member (Secondary A Aquifer);</li> </ul>
<b>Hydrology</b>	The nearest surface water feature is a pond located 75m south-east of site. The Mearley Brook is located approximately 100m north-west of site. The site is not located within a Source Protection Zone (SPZ).
<b>Preliminary Assessment Risk</b>	The contamination risk posed by off-site and on-site sources to all receptors was considered to be generally <b>low</b> with exception to the risk posed to controlled waters from on-site fuel tanks to the east and ground gas migration from on-site Made Ground deposits which pose a <b>low to moderate</b> risk. The risk from natural ground sources of gas is considered to pose a <b>moderate</b> risk to human health.
<b>Recommendations</b>	The following recommendations were made: <ul style="list-style-type: none"> <li>• in order to refine the Preliminary Risk Assessment (PRA) a ground investigation should be carried out.</li> <li>• A bespoke report should be obtained from the British Geological Survey (BGS) to determine the risk posed to future site users from radon.</li> </ul>



## 5. WYG Investigation

### 5.1 Fieldworks Undertaken

The WYG investigation works were undertaken on 01<sup>st</sup> and 02<sup>nd</sup> February 2017 with follow-up monitoring of borehole installations on 10<sup>th</sup> and 14<sup>th</sup> February 2017. The works were undertaken in general accordance with BS 10175: Code of Practice for Site Investigations of Potentially Contaminative Sites, BS5930, BS EN1997-2, BS EN ISO 14688 and BS 8576.

The works comprised the following:

- Six dynamic sample holes (WS101 to WS106) drilled to a maximum depth of 4.45m bgl with the installation of gas and groundwater monitoring wells in all boreholes;
- Standard Penetration Tests (SPTs) within the dynamic sampling holes;
- Six machine excavated trial pits (TP101, TP101A, TP102, TP104 to TP106) to a maximum depth of 3.10m bgl;
- Full-time supervision by a WYG consultant, to record the ground conditions and obtain soil samples;
- Chemical laboratory testing, including asbestos screening;
- Geotechnical laboratory testing of soils; and,
- Two visits to site to monitor for ground gas and groundwater levels (10<sup>th</sup> and 14<sup>th</sup> February 2017).

Dynamic sample holes (WS101 and WS105) and trial pit locations (TP101A, TP102 and TP104 to TP106) were terminated at depths where hard strata were encountered.

TP101 was terminated at 1.50m bgl due to the identification of a land drain in this area. The trial pit was subsequently backfilled and relocated away from this area as TP101A. TP103 was not excavated.

A National Grid engineer visited the site to determine the location of a medium pressure gas main. Planned exploratory holes in close proximity to the gas main could not be undertaken (i.e. east of boiler room and above ground tanks) and were relocated to a safe location.

An exploratory hole location plan is enclosed as Drawing No. A094939-MAN-N-02.

Detailed engineering logs are presented as Appendix B; they will be updated for the final report once the geotechnical laboratory results have been received. A summary of the ground conditions is provided in Section 6.



## **5.2 Laboratory Analysis**

### **5.2.1 Soils Chemical Testing**

Soil samples underwent testing at Jones Environmental Laboratory, an MCERTS/UKAS accredited laboratory in Deeside, Flintshire, as follows:

- Twelve soil suites which included the following determinands: arsenic, water soluble boron, cadmium, total chromium, hexavalent chromium, copper, free cyanide, lead, mercury, nickel, selenium, zinc, pH, cyanide, water soluble sulphate, phenol, 16 Polycyclic Aromatic Hydrocarbons (PAHs) and Extractable Petroleum Hydrocarbons (EPH) (C8-C40).
- Three Semi Volatile Organic Carbons (SVOCs) and Volatile Organic Carbons (VOCs);
- Three Total Petroleum Hydrocarbons – Criteria Working Group (TPH-CWG);
- Three Poly-Chlorinated Biphenyls (PCBs) -WHO 12 Congeners;
- Six Fraction Organic Carbon (FOC);
- Eight asbestos screens; and,
- Three soil-leachate tests for pH, ammoniacal nitrogen, arsenic, boron, cadmium, copper, lead, mercury, nickel, selenium, zinc, mercury, chromium, sulphate and total cyanide.

Copies of the chemical laboratory test results and the accreditation details for each determinand analysed are included in Appendix C.

### **5.2.2 Geotechnical Testing**

Geotechnical samples underwent the following testing at Geotechnics Ltd, a UKAS accredited laboratory in Coventry, as follows:

- Nine Moisture Contents;
- Nine Atterberg limits; and,
- Nine Water Soluble Sulphate (2:1 water: soil extract) and pH value.

The geotechnical laboratory test results will be presented within the final report.



## 6. Encountered Ground Conditions

A summary of the ground conditions encountered is presented below, with detailed information presented on the exploratory hole logs included within Appendix B.

**Table 6.1 Summary of Encountered Ground Conditions**

Stratum	Depth Encountered (m bgl)	Depth to Base (m bgl)	Thickness (m)
Asphalt and gravel (sub-base) (WS106)	Ground Level	0.40	0.40
Grass over Topsoil: dark brown slightly sandy Clay (WS104 & WS105)	Ground Level	0.30	0.30
Made Ground: Grass over brown slightly silty slightly gravelly sandy Clay with gravel of brick, ceramic and timber (TP101, TP101A, TP102, TP104 to TP106, WS101, WS102 & WS103)	Ground Level – 1.50	0.36 - 1.50	0.36 - 1.50
Natural Ground: Orangish brown slightly silty slightly sandy gravelly Clay (TP101A, TP102, TP104, TP105, TP106, WS101 to WS106)	0.30 – 0.50	2.10 – 4.45*	1.72 – 4.05*
Natural Ground: Brown clayey gravelly Sand or Gravel (TP102 & TP104)	2.30 – 2.80	2.60 – 3.10	0.30 – 0.50
Possible Bedrock: Grey Limestone (TP105)	2.85	2.90*	0.05*
Possible Bedrock: Brown Mudstone (WS101)	3.70	3.72*	0.02*

\*total depth/thickness not proven.

### 6.1 Surface Cover

At the time of the current investigation, the surface cover was a mixture of hardstanding and grass land.

### 6.2 Made Ground

Made Ground was encountered in all exploratory hole locations with the exception of WS104 and WS105. It generally consisted of slightly silty slightly gravelly sandy Clay with gravel of brick, ceramic and timber up to depths of between 0.36m and 0.50m bgl. In one location (TP101) Made Ground was encountered much deeper to a depth of 1.50m bgl where a drain pipe was encountered.



## 6.3 Superficial Deposits

Superficial deposits comprised slightly silty, slightly gravelly or sandy Clay to depths of between 2.10m and 4.45m bgl. Underlying this was gravelly Sand between 2.30m and 2.80m bgl in TP102 and between 2.30m and 2.60m bgl in TP104. Sandy Gravel was encountered in TP102 between depths of 2.80m to 3.10m bgl.

## 6.4 Bedrock

During the advancement of TP105 and WS101 possible bedrock was encountered at 2.85m bgl (grey Limestone) and 3.70m bgl (brown Mudstone), respectively.

WS105 was terminated at 2.82m bgl due to SPT refusal which may be indicative of bedrock and/or boulders/cobbles. TP101A, TP102, TP104 and TP106 were all terminated at depths of between 2.10 - 3.10m bgl on possible bedrock and/or boulders/cobbles.

## 6.5 Groundwater

During the investigation, groundwater was encountered in TP101A, TP102, TP104 to TP106 and WS101 to WS104 at depths of between 1.50m bgl (TP101A) and 2.85m bgl (TP105) during excavation and drilling. Groundwater was not encountered in other exploratory locations during the main investigation.

### 6.5.1 Monitoring Well Installations

All drilled exploratory locations were installed with standpipes/monitoring wells into the superficial deposits, as summarised in the tables below.

**Table 6.2 – Groundwater and Gas Monitoring Installations**

Exploratory Hole	Groundwater Level (during drilling)	Installation Response Zone
		Depth Range
	m bgl	m bgl
WS101	2.20	0.50 – 3.50
WS102	1.80	0.50 – 3.00
WS103	2.20	0.50 – 3.50
WS104	2.20	1.00 – 4.00
WS105	-	0.50 – 2.50
WS106	-	0.50 – 2.50



Groundwater levels were monitored on 10<sup>th</sup> and 14<sup>th</sup> February 2017. Table 6.3 below summarises the levels monitored, with results presented in Appendix E.

**Table 6.3 – Summary of Monitored Groundwater Levels**

Exploratory Hole	Monitored Groundwater Level (Range)		Strata Installed Into
	m bgl		
	From	To	
WS101	1.20	1.22	NG: Slightly gravelly sandy Clay
WS102	1.60	1.61	NG: Slightly gravelly sandy Clay
WS103	3.36	3.38	NG: Slightly gravelly sandy Clay
WS104	2.73	2.75	NG: Slightly gravelly sandy Clay
WS105	Dry	Dry	NG: Slightly gravelly sandy Clay
WS106	2.42	2.45	NG: Slightly gravelly sandy Clay

Notes: Natural Ground (NG)

Based on the topography of the area, it is anticipated that groundwater will flow towards the Mearley Brook located approximately 100m north west.

## 6.6 Observed Contamination

No visual or olfactory evidence of contamination was noted during the investigation. The highest PID reading was recorded at WS102 in soil at 1.50m bgl (4.4ppm). This value is not considered to pose a risk to human health.



## 7. Ground Gas Results and Assessment

### 7.1 Ground Gas Results

Two gas monitoring visits were undertaken on 10<sup>th</sup> and 14<sup>th</sup> February 2017. Visits were conducted during steady and rising barometric pressures.

Table 7.1 below summarises the ground gas results and full results are presented in Appendix E.

**Table 7.1 Summary of Ground Gas Results**

Location	Response Zone (m bgl) & Strata	Max. Methane Conc. %	Max. Carbon Dioxide Conc. %	Min. Oxygen conc. %	Max. Flow Rate (l/hr)	Water Level Range (m bgl)
WS101	0.50 – 3.50	<0.1	0.7	20.6	0.3	1.20 – 1.22
WS102	0.50 – 3.00	<0.1	2.1	20.1	0.3	1.60 – 1.61
WS103	0.50 – 3.50	<0.1	0.3	21.2	0.2	3.36 – 3.38
WS104	1.00 – 4.00	<0.1	1.6	20.1	0.3	2.73 – 2.75
WS105	0.50 – 2.50	<0.1	1.4	20.5	<0.1	Dry
WS106	0.50 – 2.50	<0.1	0.4	20.9	0.3	2.42 – 2.45

Based on peak readings.

Semi-quantitative analysis of concentrations of VOCs was obtained using a PID. No significantly elevated concentrations were recorded with all values reported as <0.1ppm.

The maximum methane concentration recorded during ground gas monitoring was <0.1% in all monitoring wells. The maximum carbon dioxide concentration was 2.1% in WS102.

Concentrations of hydrogen sulphide and carbon monoxide were generally not reported above the detection limit (1ppm) with the exception of up to 3ppm of carbon monoxide measured in WS106.

### 7.2 Ground Gas Assessment

Ground gas results have been assessed using CIRIA C665 *Assessing Risks posed by Hazardous Ground Gases to Buildings* (2007). The CIRIA C665 assessment methodology is based on both volume percentages and volume flow rate of gases. In accordance with the CIRIA methodology, a conservative Gas Screening Value (GSV) has been calculated using a worst case scenario (i.e. highest gas concentration combined with highest flow rate). Where readings are not recorded above the instrument detection limit, the value of the instrument detection limit is used to calculate the GSV.



The calculation of the GSV is as follows:

Gas Screening Value = Gas Concentration in % divided by 100 then multiplied by flow rate in l/h.

$$0.1\% \text{ CH}_4 \times 0.3 \text{ l/hr} = \mathbf{0.0003 \text{ l/hr CH}_4} \text{ and } 2.1\% \text{ CO}_2 \times 0.3 \text{ l/hr} = \mathbf{0.0063 \text{ l/hr CO}_2}$$

Based on the above, the site currently equates to a land gas Characteristic Situation 1 (very low risk). BS 8485:2015 indicates that no special gas protection measures would be required for residential properties at this stage.

A bespoke Radon Report was procured for the site and this confirms that no radon protective measures are required for the proposed development. A copy of this report is presented in Appendix F.





## **8. Contamination Assessment**

### **8.1 Soils Contamination Assessment Methodology**

Soil contaminant concentrations have been screened against WYG Tier 1 soil screening values (TSVs). These principally comprise CIEH/LQM S4ULs, DEFRA with Contaminated Land: In Real Environments (CL:AIRE) published Category 4 Screening Levels (C4SLs). Contaminant concentrations below C4SLs are considered to pose an acceptably low risk to human health. In order to use benzo(a)pyrene as a surrogate marker of PAH, the profile of the genotoxic PAHs relative to benzo(a)pyrene must be calculated and compared to the 'Culp Study'.

The derivation of TSVs is an ongoing development process and as such, methodologies and input parameter values may alter as new guidance is published. This may result in temporary inconsistencies in the TSVs and regular updates as research and development work progresses.

The screening value used and its source are colour coded for the above TSV sources on the soil screening sheet provided in Appendix G.

Contaminant concentrations below the TSVs are considered not to warrant further risk assessment. Concentrations of potential contaminants above the TSVs require further consideration of the potential pollutant linkages. It should be noted that exceedance of the TSVs does not necessarily mean that the site requires remediation.

It is considered that at depths greater than 1m, the probability of human exposure via the direct contact pathways is significantly reduced, leaving inhalation of volatile compounds as the dominant pathway with regard to human health risks. Typically, volatile compounds only significantly affect the indoor inhalation pathway.

### **8.2 Statistical Analysis**

Should exceedances of the TSV occur, guidance for statistical analysis for assessments has been published by CL:AIRE stating that for each contaminant, the upper 95th percentile of the mean measured concentration should be calculated and this value should be compared to the TSV.

Maximum value tests can also be performed in accordance with the method outlined in Annex 1 of CLR7. The objective of these tests is to decide whether the maximum concentration observed should be treated as an outlier or whether it can reasonably be considered to come from the same underlying population as the other samples.



Constituent non-detects are assigned a value equal to the reported analytical laboratory limit of detection, considered reasonably conservative in accordance with CLR principles or where a significant number of non-detects are reported CL:AIRE guidelines are utilised to limit over conservatism. Any identified outliers are excluded from the datasets used in calculation of the 95%UCL value.

### **8.3 Controlled Waters Contamination Assessment Methodology**

The results of the soil leachate analysis have been assessed by direct comparison against The River Basin Districts Typology, Standards and Groundwater threshold values Water Framework Directive (England and Wales) 2010. For the purposes of the assessment data has been compared against Drinking Water Standard (DWS) screening. The following receptors have been included within this assessment:

- Secondary A Aquifer (bedrock of the Clitheroe Limestone Formation and Hodder Mudstone Formation) – DWS values.

The screening value used and its source are colour coded for the above TSV sources on the groundwater screening sheet provided in Appendix G.

Although the Mearley Brook is located approximately 100m north west of the site, due to the likely shallow nature of the bedrock, it is considered that the Secondary A Aquifer is the most sensitive receptor to potential on-site and off-site pollution sources.

### **8.4 Soil Contamination Assessment**

An assessment of the chemical results reported has been undertaken in accordance with the methodology described above. The soil results have been screened against published residential with plant uptake criteria as this is considered most pertinent to the proposed development. These are summarised in Table 8.1.

In instances where the laboratory Limit of Detection (LOD) exceeds the applicable screening value these determinands have been discounted from further consideration.



**Table 8.1 Summary of Soil Screening Exceedances**

Determinand	TSV (mg/kg)	Total no. of tests	Conc. Range (mg/kg)	No. elevated above TSV	Location of exceedance
Lead	200	12	32-546	5	TP104 at 0.20m bgl (409 mg/kg) WS101 at 0.40m bgl (546mg/kg) WS102 at 0.20m bgl (250 mg/kg) WS103 at 0.20m bgl (250 mg/kg) WS106 at 0.20m bgl (440 mg/kg)
Benzo(a)pyrene	5	12	<0.04-116.55	1	WS106 at 0.20m bgl (116.55mg/kg)
EPH (>C12-C16)	660	12	<10-727	1	WS106 at 0.20m bgl (727mg/kg)
EPH (>C16-C21)	930	12	<10-3891	1	WS106 at 0.20m bgl (3891mg/kg)
EPH (>C21-C40)	1700	12	<10-9577	1	WS106 at 0.20m bgl (9577mg/kg)
TPH Aromatic (EC16-EC21)	930	3	<7-1214	1	WS106 at 0.20m bgl (1214mg/kg)
TPH Aromatic (EC21-EC35)	1700	3	<7-4224	1	WS106 at 0.20m bgl (4224mg/kg)

Concentrations of SVOCS (2-methylnaphthalene, carbazole and dibenzofuran) were reported above the laboratory detection limit; screening criteria for these determinands are not available.

Asbestos was not detected in any of the soil samples that were screened for it.

The chemical analysis results are included within Appendix C. Tier 1 screening tables and assessment are included in Appendix G.

## 8.5 Soil Leachate Assessment

An assessment of the soil-leachate chemical results has been undertaken in accordance with the methodology described above. No determinands exceeded the DWS screening criteria.

## 8.6 Discussion of Results

### Human Health

Elevated lead concentrations in soil were reported above the screening criteria of 200mg/kg in a number of samples taken from shallow depth. Marginal exceedances were reported in WS102 and WS103 (250mg/kg), however, greater exceedances were reported in the south eastern corner of the site in TP104, WS101 and WS106.

Elevated concentrations of benzo(a)pyrene, EPH (C12-C40) and TPH Aromatic (EC16-EC35) in soil were reported above the relevant screening criteria for the proposed end-use at WS106 at 0.20m bgl.



The sample was taken from the strata encountered beneath the existing hardstanding (the depth range being 0.15m to 0.40m bgl). At this location, concentrations of SVOCs (2-methylnaphthalene, carbazole and dibenzofuran) were also reported above the laboratory detection limit. These elevated concentrations may correlate with substances that may have discoloured the limestone to greyish black, or the adjacent former boiler room and/or above ground tanks. The greyish black colour may also be discoloured from overlying asphalt layer above.

Concentrations of carbazole were reported above the laboratory detection limit in WS101 at 0.40m bgl (25µg/kg). A risk to human health is considered unlikely in this location as the concentration is minimal.

#### Controlled Waters

The soil-leachate results show that the metals within the soils are not at leachable concentrations and therefore a risk to controlled waters is considered unlikely.

## **8.7 Refined Conceptual Site Model (CSM)**

Based on the ground investigation data, the preliminary CSM produced at desk study stage has been refined. The development area is underlain by Made Ground generally consisting of slightly silty, gravelly sandy Clay with gravel of brick, ceramic and timber. Elevated concentrations of lead were reported in a number of locations, with elevated benzo(a)pyrene, EPH (C12-C40) and TPH Aromatic (EC16-EC35) and 2-methylnaphthalene, carbazole and dibenzofuran reported in soil in WS106.

The Made Ground is in turn underlain by slightly silty slightly gravelly or sandy Clay (Secondary Undifferentiated Aquifer) with gravelly Sand beneath this in locations TP102 and TP104, further underlain by sandy Gravel in TP102 up to 4.45m bgl. Beneath this is the bedrock of the Clitheroe Limestone Formation and Hodder Mudstone Formation (Secondary A Aquifer), which may have been encountered in the bases of some of the exploratory holes. Groundwater is present within the superficial deposits at varying depths across the site. The nearest surface water features are a pond located 75m south-east and the Mearley Brook approximately 100m north west of the site. Ground gases were not reported at elevated levels. Off-site sources identified within the desk top study report for the site, such as ground gases from possible in-filled quarries have been discounted from further consideration due to elevated gas concentrations not being reported from the ground investigation.



## 9. Refined Contamination Risk Assessment

### 9.1 Potential On-Site Sources

On site sources of contamination for a residential with plant uptake end use include those listed below:

- Elevated lead in soil (TP104 at 0.20m bgl, WS101 at 0.40m bgl, WS102 at 0.20m bgl, WS103 at 0.20m bgl and WS106 at 0.20m bgl); and,
- Elevated benzo(a)pyrene, EPH (C12-C40), TPH Aromatic (EC16-EC35) and SVOCs in soil (WS106 at 0.20m bgl).

### 9.2 Potential Off-Site Sources

Based on the available information, there are a limited number of contaminative sources in close proximity to the site. It is considered unlikely that off-site sources would be the contributing factor to elevated concentrations of concern reported on site.

### 9.3 Contamination Pathways

Potential contamination pathways which may still be applicable for the proposed development are listed below:

- Dermal contact;
- Inhalation of vapours or dust;
- Ingestion of soils and dusts;
- Ingestion of home grown produce (fruit and vegetable);
- Leaching to surface run-off/drainage;
- Leaching to groundwater;
- Lateral and vertical migration of groundwater; and,
- Migration along/into service conduits and pipework.

### 9.4 Contamination Receptors

Receptors that may be affected by potential contamination are:

- Future site users (occupants & visitors);



- Construction/maintenance workers
- Buildings / Services; and,
- Secondary A Aquifer.

## 9.5 Ground Contamination Risk Assessment

By considering the sources, pathways and receptors, a refined assessment of the environmental risk is made with reference to the significance and degree of the risk. This assessment is based on consideration of whether the source contamination can reach a receptor and hence whether it is of major or minor significance.

The risk assessment has been carried out by assessing the severity of the potential consequence, the sensitivity of the target and the likelihood of occurrence, based on the categories given below (Tables 9.1 to 9.3). A summary of the refined risk assessment of on-site sources is given in Table 9.4.

**Table 9.1: Potential Hazard Severity Definition**

Category	Definition
Severe	Acute risks to human health, catastrophic damage to buildings/property, major pollution of controlled waters
Medium	Chronic risk to human health, pollution of sensitive controlled waters, significant effects on sensitive ecosystems or species.
Mild	Pollution of non-sensitive waters, significant damage to buildings or structures
Minor	Requirement for protective equipment during site works to mitigate health effects, damage to non-sensitive ecosystems or species, minor damage to buildings or structures

The likelihood of an event (probability) takes into account both the presence of the hazard and target and the integrity of the pathway and has been assessed based on the categories given below.

**Table 9.2: Probability of Risk Definition**

Category	Definition
High likelihood	Pollutant linkage may be present, and risk is almost certain to occur in long term, or there is evidence of harm to the receptor
Likely	Pollutant linkage may be present, and it is probable that the risk will occur over the long term
Low likelihood	Pollutant linkage may be present, and there is a possibility of the risk occurring, although there is no certainty that it will do so
Unlikely	Pollutant linkage may be present, but the circumstances under which harm would occur are improbable

The potential severity of the risk and the probability of the risk occurring have been combined in accordance with the following matrix in order to give a level of risk for each potential hazard.



**Table 9.3: Level of Risk for Potential Hazard Definition**

		Potential Severity			
		Severe	Medium	Mild	Minor
Probability of Risk	High Likelihood	High	High	Moderate	Low/Moderate
	Likely	High	Moderate	Low/Moderate	Low
	Low Likelihood	Moderate	Low/Moderate	Low	Low
	Unlikely	Low/Moderate	Low	Low	Low

## 9.6 Summary of Refined Risk Assessment

The risk assessment is summarised as Table 9.4. The risk assessment is based on the currently notified development proposals.

Overall, the site is considered to pose a **low to moderate** risk.

The risk to future site users and future pipework from elevated lead, benzo(a)pyrene, EPH (C12-C40), TPH Aromatic (EC16-EC35) and SVOCs within the soils is **moderate** and would require mitigation during development. The risk to future site users and buildings/installations from the generation and accumulation of vapours in the vicinity of the former boiler room/above ground tank area is **low to moderate**.



**Table 9.4 - Refined Contamination Risk Assessment**

Source	Pathway	Receptor	Severity	Probability	Risk	Justification
Elevated lead (TP104, WS101, WS102, WS103 & WS106) within soils	Dermal contact, ingestion and/or inhalation of vapours or dust	Human Health – Future site users	Medium	Likely	Moderate	Elevated lead found in soil at shallow depth should be placed beneath hard standing or beneath a cover system (up to 600mm depth) with associated break layer to restrict any potential pathway to the contaminants.
		Human Health – Construction Workers	Minor	Likely	Low	It is assumed that, in line with good practice, appropriate working procedures and PPE will be adopted during construction works to mitigate this risk.
	Leaching and lateral and vertical migration of groundwater	Controlled Waters (Secondary A Aquifer)	Mild	Unlikely	Low	The risk rating is based on soil – leachate results from the WYG investigation. No elevated levels were reported and therefore a risk to controlled waters receptors is considered unlikely. Groundwater migration within the superficial deposits will be limited by the presence of low permeable Clay.
Elevated benzo(a)pyrene, EPH (C12-C40), TPH Aromatic (EC16-EC35) and SVOCs within soils in WS106	Direct contact, ingestion, and or inhalation of dust	Human Health – Future site users	Medium	Likely	Moderate	Do to elevated concentrations of EPH, TPH CWG Aromatics and SVOCs in shallow soils it is recommended that during construction, further delineation and validation of soils in this area be carried out. Following this, remediation of the soils maybe required or the soil placed beneath a cover system of 600mm or beneath hard standing.
		Human Health – Construction Workers	Minor	Likely	Low	It is assumed that, in line with good practice, appropriate working procedures and PPE will be adopted during construction works to mitigate this risk.
	Leaching and lateral and vertical migration of groundwater	Controlled Waters (Secondary A Aquifer)	Mild	Unlikely	Low	Heavy end hydrocarbon impact has been reported within shallow soils in one location on site. The mobility of these contaminants is low and also groundwater migration within the superficial deposits will be limited by the presence of low permeable Clay. Further delineation and validation is required in order to determine the extent of hydrocarbon impact to the east of the site.
		Service conduits and pipework	Medium	Likely	Moderate	Upgraded water supply pipelines (barrier pipe) will be required if the hydrocarbon impacted material is not removed from site. Further delineation and validation is required to determine this.
Elevated SVOCs / hydrocarbon impact in soil in WS106	Generation and migration / accumulation of vapours	Human Health – Future Site Users	Medium (asphyxiation)	Likely	Low to Moderate	Elevated gas concentrations were not reported and therefore gas mitigation measures are not required at the site. Shallow hydrocarbon impacted soil has been identified. Further delineation and validation of soils is required in order to fully determine the potential vapour risk at the site.
		Future Buildings and installations	Medium (explosion)	Likely	Low to Moderate	





## **10. Geotechnical Assessment**

### **10.1 Proposed Development**

It is understood that present proposals include the construction of up to 50 houses with associated infrastructure and soft landscaping.

This section of the report will be completed and included in the final report following receipt of the geotechnical test results.

## **11. Conclusions and Recommendations**

Overall, the site is considered to pose a low to moderate risk.

The risk to future site users and future pipework from elevated lead, benzo(a)pyrene, EPH (C12-C40), TPH Aromatic (EC16-EC35) and SVOCs within the soils is moderate and would require mitigation during development. The risk to future site users and buildings/installations from the generation and accumulation of vapours in the vicinity of the former boiler room/above ground tank area is low to moderate.

Where elevated concentrations of lead in soil have been reported, a 600mm thick cover system of clean soil with associated break layer should be placed where soft standing is proposed or the soil at these locations should be placed beneath hardstanding / buildings to prevent any plausible contamination pathways to future receptors.

Where elevated concentrations of benzo(a)pyrene, EPH (C12-C40), TPH Aromatic (EC16-EC35) and SVOCs within the soils have been reported, during the demolition and removal of the boiler room and above ground storage tanks the excavation of shallow soils should be undertaken. The resultant excavations should be validated by a suitably qualified Environmental Consultant to confirm that any associated contamination has been removed.



## Drawings

DO NOT SCALE: CONTRACTOR TO CHECK ALL DIMENSIONS AND REPORT ANY OMISSIONS OR ERRORS



THE SITE

Contains Ordnance Survey data ©  
Crown copyright and database right 2016

QUAY WEST at MediaCity UK  
TRAFFORD WHARF ROAD  
TRAFFORD PARK  
MANCHESTER  
M17 1HH  
TEL: +44 (0)161 872 3223  
FAX: +44 (0)161 872 3193  
e-mail: manchester@wyg.com



Client: **NHS PROPERTY SERVICES LTD**

Project: A094939  
**FORMER CLITHEROE HOSPITAL**

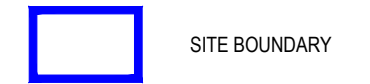
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REV	DESCRIPTION	BY	CHK	APP	DATE

Scale @ A4 1:20,000	Drawn CM	Date 06.02.17	Checked SH	Date 08.02.17	Approved 	Date 
Project No. <b>A094939</b>	Office <b>MAN</b>	Type <b>N</b>	Drawing No. <b>01</b>	Revision 		



**KEY**



SITE BOUNDARY

**WYG SITE INVESTIGATION**



TRIAL PIT



DYNAMIC SAMPLE (ALL LOCATIONS INSTALLED AS MONITORING WELLS)



REV	DESCRIPTION	BY	CHK	APP	DATE
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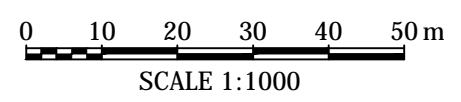
Client:  
NHS PROPERTY SERVICES LTD

QUAY WEST at MediaCity UK  
TRAFFORD WHARF ROAD  
TRAFFORD PARK  
MANCHESTER  
M17 1HH  
TEL: +44 (0)161 872 3223  
FAX: +44 (0)161 872 3193  
e-mail: manchester@wyg.com



Project: A094939  
FORMER CLITHEROE HOSPITAL

Drawing Title:  
EXPLORATORY HOLE LOCATION PLAN



Scale @	A3	Drawn	Date	Checked	Date	Approved	Date
1:1,000		CM	06.02.17	SH	08.02.17		
Project No.	Office	Type	Drawing No.		Revision		
A094939	MAN	N	02				



## **Appendices**



## **Appendix A – Report Conditions**



## **APPENDIX A - REPORT CONDITIONS GROUND INVESTIGATION**

This report is produced solely for the benefit of **NHS Property Services Ltd** and no liability is accepted for any reliance placed on it by any other party unless specifically agreed in writing otherwise.

This report refers, within the limitations stated, to the condition of the site at the time of the inspections. No warranty is given as to the possibility of future changes in the condition of the site.

This report is based on a visual site inspection, reference to accessible referenced historical records, information supplied by those parties referenced in the text and preliminary discussions with local and Statutory Authorities. Some of the opinions are based on unconfirmed data and information and are presented as the best that can be obtained without further extensive research. Where ground contamination is suspected but no physical site test results are available to confirm this, the report must be regarded as initial advice only, and further assessment should be undertaken prior to activities related to the site. Where test results undertaken by others have been made available these can only be regarded as a limited sample. The possibility of the presence of contaminants, perhaps in higher concentrations, elsewhere on the site cannot be discounted.

Whilst confident in the findings detailed within this report because there are no exact UK definitions of these matters, being subject to risk analysis, we are unable to give categorical assurances that they will be accepted by Authorities or Funds etc. without question as such bodies often have unpublished, more stringent objectives. This report is prepared for the proposed uses stated in the report and should not be used in a different context without reference to WYG Environment Planning Transport Ltd. In time improved practices or amended legislation may necessitate a re-assessment.

The assessment of ground conditions within this report is based upon the findings of the study undertaken. We have interpreted the ground conditions in between locations on the assumption that conditions do not vary significantly. However, no investigation can inspect each and every part of the site and therefore changes or variances in the physical and chemical site conditions as described in this report cannot be discounted.

The report is limited to those aspects of land contamination specifically reported on and is necessarily restricted and no liability is accepted for any other aspect especially concerning gradual or sudden pollution incidents. The opinions expressed cannot be absolute due to the limitations of time and resources imposed by the agreed brief and the possibility of unrecorded previous use and abuse of the site and adjacent sites. The report concentrates on the site as defined in the report and provides an opinion on surrounding sites. If migrating pollution or contamination (past or present) exists further extensive research will be required before the effects can be better determined.



## **Appendix B – Exploratory Hole Logs**





Project: **Former Clitheroe Hospital**  
 Location: **Clitheroe**  
 Client: **NHS Property Services Ltd**

Location Details  
 Easting:                      Northing:  
 Level:                         Depth: 1.50m  
 Logger: NS                    Type: TP

Status  
**DRAFT**

Pit Number  
**TP101**  
 Sheet 1 of 1

Pit Dimensions 	Hole Information			Groundwater				Scale: 1:25
	Orientation: 90°	Strike (m)	Rose To (m)	After (mins)	Remarks	Checked By: SH		
	Shoring: Not required					Approved By: RAJ		
	Stability: Stable					Start Date: 01/02/2017		
	Plant: Tracked Excavator					Finish Date: 01/02/2017		

Strata Description	Legend	Depth (m)	Reduced Level (mAOD)	Water Level (m)	Backfill	Samples and Testing		
						Depth (m)	Ref	Tests / Results
MADE GROUND: Grass over dark brown slightly silty slightly gravelly sandy CLAY with rootlets. Sand is fine to medium. Gravel is sub-angular to sub-rounded fine to medium coal, sandstone and shale.		0.30				0.20	ES	PID 0.20m, 0.0ppm
0.25						D		
0.40						D	PID 0.50m, 0.0ppm	
0.50						ES		
MADE GROUND: Firm orangish brown slightly silty slightly gravelly sandy CLAY. Sand is fine to medium. Gravel is sub-angular to sub-rounded fine to coarse sandstone, mudstone, coal and shale.						0.70	D	
						1.00	ES	PID 1.00m, 0.0ppm
EOH at 1.50m - Terminated due to land drain encountered		1.50						

Observations / Remarks  
 1. Groundwater was not observed. 2. On completion excavation was backfilled with arisings. 3. Land drain encountered at 1.50m bgl. Terminated excavation and backfilled.

Project Number  
**A094939**



Project: **Former Clitheroe Hospital**  
 Location: **Clitheroe**  
 Client: **NHS Property Services Ltd**

Location Details  
 Easting: Northing:  
 Level: Depth: 2.10m  
 Logger: NS Type: TP

Status  
**DRAFT**

Pit Number  
**TP101A**  
 Sheet 1 of 1

Hole Information		Groundwater				Scale: 1:25
Pit Dimensions 	Orientation: 90°	Strike (m)	Rose To (m)	After (mins)	Remarks	Checked By: SH
	Shoring: Not required Stability: Stable to 2.10m bgl. Unstable below. Plant: Tracked Excavator	1.50	1.50	20		Approved By: RAJ
						Start Date: 01/02/2017
						Finish Date: 01/02/2017

Strata Description	Legend	Depth (m)	Reduced Level (mAOD)	Water Level (m)	Backfill	Samples and Testing		
						Depth (m)	Ref	Tests / Results
MADE GROUND: Grass over dark brown slightly silty slightly gravelly sandy CLAY. Gravel is of sub-angular to sub-rounded fine to medium coal, sandstone and shale. Sand is fine to medium.		0.36				0.20	D	PID 0.20m, 0.0ppm
	0.20					ES		
	0.40					D	PID 0.50m, 0.0ppm	
	0.50					ES		
		0.70	D					
		1.50					D	
		2.00					D	
EOH at 2.10m - Terminated as possible bedrock encountered.		2.10						

Observations / Remarks  
 1. Groundwater seepage at 1.50m bgl. 2. On completion excavation was backfilled with arisings. 3. Trial pit unstable below 2.10m bgl.

Project Number  
**A094939**