



Geo-Environmental Report

Marston's lodge Plas Coch Road, Wrexham, LL11 2BW
For
Marston's Group plc

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For:	Marston's Group Plc
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Executive Summary

Proposed Development

A lodge development and associated car parking is proposed.

Investigation

Site works were undertaken by Enzygo Geoenvironmental Ltd. in February 2018, together with monitoring visits and Soakaway testing.

Ground Conditions

Ground conditions comprise variable Topsoil and Made Ground up to 4.45mbgl, over firm locally soft sandy gravelly clays and medium dense becoming very dense, rarely becoming loose from 5.00mbgl clayey gravelly sands and gravels. This is underlain by sandstone at 9.00mbgl. Groundwater was encountered below 4.45mbgl.

Contamination

No GAC exceedances have been encountered, however Asbestos has been encountered and remediation is recommended.

Foundations

Piled foundations are considered suitable socketed into the underlying sandstone below 9.00mbgl. Suspended floor slabs are recommended given the thickness of the Made Ground.

Re-use of Materials

Made Ground is not considered suitable for re-use as general fill.

Pavement Design

An equilibrium CBR of 3% is recommended following proof rolling and removal of loose material. Soils are considered to be frost susceptible.

Buried Concrete

It is considered that Class AC-1s conditions of Special Digest 1 can be used.

Drainage

Based on a BRE soakaway test undertaken at SA1 and within the Made Ground to 3.00mbgl a soil infiltration rate of 5.5×10^{-4} m/s has been calculated.

Chemical results have been compared with the screening values provided by Water UK. The Water UK Individual PAH and TPH threshold value for potable water supply pipes has not been exceeded and as such, barrier pipes are not anticipated.

Gas and Radon

Full Radon protection measures are recommended, and no gas risk has been identified.

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1.0 INTRODUCTION

Background

- 1.1 Enzygo Geoenvironmental Limited has been commissioned by Simpson Associates on behalf of Marstons Plc to prepare a Geo-Environmental Report for a proposed Marstons lodge at Plas Coch Road, Wrexham, LL11 2BW.

Proposed Development

- 1.2 The proposed development is shown on the Drawing 3381_P104 which has been incorporated into the site plan presented as Drawing CRM.427.008.GE.D.001.

Objectives

- 1.3 The objectives of the study are to:
- Obtain desk study information pertaining to the proposed development and the surrounding area. The Desk study information is included within Appendix A;
 - Review any available ground investigation data;
 - Undertake a targeted ground investigation for the proposed development;
 - Assess the implications of any potential environmental risks, liabilities and development constraints associated with the site in relation to the future use of the site and in relation to off-site receptors; and
 - Provide a factual and interpretative report relating to the desk study and site investigations. Provide a revised conceptual model and recommendations on any potential development issues and mitigation measures, where appropriate.
 - Provide geotechnical recommendations in relation to foundations and infrastructure.

Risk Classification

- 1.4 Enzygo Geoenvironmental Limited has utilised the available information, together with our experience to assess the likely risks to development from land quality issues. Definitions of the risk terms used are provided on the following table.

Risk	Description
Negligible	No contamination risk has been identified which is likely to affect development.
Low	No significant contaminated land risks have been encountered affecting development and a low risk that remediation will be required.
Low-Moderate	There are unlikely to be significant contaminated land issue associated with the site which will adversely affect its re-development. However, minor or localised contamination may be present requiring remediation. Remediation should be possible under a discovery strategy and with a call out service.
Moderate	Some potential contaminated land risks have been encountered or identified which may affect re- development. The risks identified are unlikely to affect the entire site or preclude development. Remediation is considered feasible as part of the development process and no further investigation is considered necessary.
Moderate-High	Some potentially significant contaminated land risks have been identified at the property that requires remediation. It is recommended that a separate remedial methodology is prepared supported by a site specific risk assessment
High	Significant potential contaminated land risks have been identified and remediation is required supported by further intrusive ground investigation, risk assessment and remedial design.

- 1.5 Where adverse risks from ground instability are identified these are discussed within the report.

2.0 SITE SETTING

Site Description

Item	Description
Site Address	Marstons lodge at Plas Coch Road, Wrexham, LL11 2BW
National Grid Reference	332635, 351401
Approximate Site Area	0.22 Ha

Current Site Description

- 2.1 The following site description has been compiled from the site inspection undertaken in February 2017 by an experienced environmental consultant, together with current maps and aerial photographs.
- 2.2 At the time of the inspection the site was occupied a play area and pub garden and car parking to the south with the existing Plas Coch Pub/Restaurant to the east of the site and a car parking to the south.
- 2.3 There are no buildings on the lodge site.
- 2.4 The site is accessed off the existing Plas Coch car park to the south west of the site and through a wooden fencing which had to be dismantled to gain access with the rig.
- 2.5 The site is generally level.
- 2.6 Trees form the eastern and southern boundary of the site.
- 2.7 A electrical main is supposed to be located within the northern part of the site. However, on site inspection this is located to the west of the site and in a different route.
- 2.8 There was no visual evidence of contamination on the site.

Surrounding Area

- 2.9 Land uses surrounding the site are summarised as follows:

Direction	Land Use
South	Road, Car parking, Road and commercial units.
East	Road open landscaping and student accommodation and Tennis courts
North	Aldi Wrexham and car parking with commercial units beyond.
West	Plas Coch Pub restaurant, Car parking road, Car parking and Sainsbury Petrol Station

- 2.10 No significant contamination risks are identified on or adjacent to the site. The garage is of new construction and is not considered a risk to the site given the distance to the site.

3.0 SITE HISTORY

- 3.1 A review of historical Ordnance Survey maps and information pertinent to the entire site and within a 250m radius is summarised below:

Potentially Contaminative Historical Land Use		
Map Edition	Site	Surrounding Area
1872	Site is covered with trees within garden.	Plas Coch house is shown 10m W. A road is shown 0m E with a canal the eastern side of the road. The canal route is shown by the road indicating the road used the route of the canal. Ashfield House is shown 200m NE. Pond 200m N. Area to the SE of the road is referenced as Race Course.
1939	No changes.	Road is shown as Plas Coch Road. A Recreation ground is shown 10m NE.
1957	Pond is shown in the centre of the site.	College buildings 100m S. Playing field with associated levelling 10m SE.
1968	No changes.	College is reference Denbighshire Technical college and has enlarged. Building shown within former Recreation ground 20m SE.
1975	Pond not shown.	A41 shown 220m NW and W in cutting.
1992	Site shown as open development site.	Roundabout and road network 0m S. Plas Coch house and buildings 10m W not shown. Tennis courts shown 20mNE. Commercial development (Sainsbury) 80m N and 70m NW. Car Parking 80m W. Garage 120m NW.
1994	Pub gardens and car parking and associated paths for Plas Coch Pub restaurant.	Plas Coch Pub restaurant 0mW.
2002-2010	No significant changes.	No significant changes.

- 3.2 It is considered that the former use of the gardens will have no effect of the proposed scheme.
- 3.3 The canal is a negligible risk to the site based on the distance and the presence of the road in the same alignment as the canal post 1874.
- 3.4 The pond within the site has been backfilled by 1975. Given the date of infilling there is a risk of Made Ground infill on the site which will be investigated as part of the investigation. Gas monitoring which also be undertaken as part of the investigation.
- 3.5 No other significant risks are identified at or near to the site from the historical maps.

4.0 ENVIRONMENTAL SETTING

Ground Conditions

- 4.1 The British Geological Survey (BGS) indicates that the site is underlain by the following geological sequence:

Geological Unit	Type	Description	Aquifer Classification
Drift	Glacial Till - Diamicton	Diamicton	Unproductive Aquifer.
Solid	Etruria Formation Mudstone	Mudstone	Secondary (A) Aquifer.
	Lower and Middle Coal Measures (1m east)	Mudstone. Sandstone and siltstone	Secondary (A) Aquifer

- 4.2 No Made Ground is identified on the site by the BGS.
- 4.3 There are no landslips shown near to the site.
- 4.4 Background soil chemistry for the site shows no exceedances above Public Open Space and commercial GAC values.
- 4.5 There are no BGS Borehole records for the site or the surrounding areas.

Groundwater

- 4.6 Permeability of the drift geology is low to very high reflecting the mixed and granular nature of the underlying materials. Permeability of the solid geology is low to moderate and is based on the fractures within the underlying materials.
- 4.7 The Ground Sure Report shows that the site is not located within a Source Protection Zone.
- 4.8 There are no licensed groundwater abstractions within 500m of the site.
- 4.9 BGS records show the site is moderate at risk of groundwater flooding, this is not considered a risk as no basements are proposed as part of the development. However should deep excavations be required these could contain groundwater.

Coal Mining

- 4.10 Coal mining activities have been identified within 1000m of the site. The Coal mining report indicates that the site is not at risk from shallow coal mining and there are 2 seams of coal at 270m to 360m depth which were last worked in 1921. Any movement from these should

have ceased. There are no coal mining shafts within 20m of the site. A copy of the coal mining report is given in Appendix A. In addition, based on the Coal Authorities Interactive map the site is not shown in a development high risk area, an area where coal outcrops occur, probable shallow coal mining working area or past shallow coal mining workings area.

Non Coal Mining and Cavities

- 4.11 No significant non coal mining activities have been identified within 1000m of the site.

Ground Workings

- 4.12 A historical canal is shown 3m to the east of the site. This has been backfilled and is currently a road. Road cutting are also shown 223m west of the site. The canal has been infilled with a road, given its likely construction of engineering fill it is therefore not considered a risk to the site. The closest colliery site is located 669m north of the site.
- 4.13 No new risks are identified from the ground workings.

Hydrology

- 4.14 No open water courses are present on site or within 500m of the site.
- 4.15 Given the distance of the water coarse this is not considered to be viable receptor.
- 4.16 There are no surface water abstractions within 1000m of the site.
- 4.17 Environment Agency records show that the site is not located within a flood risk zone.

Radon Risk Potential

- 4.18 The Groundsure GeolInsight Report indicates that the site is located within an area where Radon protection measures are required and Full Radon Protection are necessary and will be discussed in Section 10.

Natural Hazards Finding

- 4.19 BGS information presented within the Groundsure Geo Insight report identifies the following ground conditions:

Hazard	Risk Designation (Groundsure)
Coal Mining	None identified
Collapsible Ground	Very Low
Compressible Ground	Negligible
Ground Dissolution	Negligible
Landslide	Very Low
Running Sand	Very Low
Swelling / Shrinking Clay	Negligible

4.20 There are no significant ground risks identified for the site.

Sensitive Land Uses

4.21 The site is currently a recreation ground/park. This is considered to have a moderate sensitivity.

4.22 English Heritage identifies no historical features on the site.

Environmental Sensitivity

4.23 Overall the site is currently considered to be of **Low** sensitivity due to the following:

- Site is currently a pub restaurant garden;
- There are no open surface water courses on or near to the site;
- The site is underlain by a Secondary Aquifer and there are no shallow abstractions nearby;
- There are no ecological designations identified in the Enviro Insight Report on or adjacent to the site;
- Site is not within a Source Protection Zone

4.24 The sensitivity for end users will be moderate for the Proposed development.

Industrial Land Uses

- 4.25 Industrial uses surrounding the site comprise light industrial uses. There are no new potential contaminative industrial uses identified within the Groundsure Enviro Insight Report which are considered to pose a significant risk to the site identified within 250m.
- 4.26 The Groundsure EnviroInsight Report shows one fuel stations within 250m of the site. This is located 144m west of the suite and is associated with Sainsbury Garage. No enforcements have been recorded and it is of modern construction. Given the distance this is not considered a risk to the site.
- 4.27 There are no oil or gas pipelines within 500m of the site.
- 4.28 No new significant risks are identified from the register of industrial land uses.

5.0 CONSULTATIONS

Regulatory Database

- 5.1 The following information has been obtained from a commercially available environmental database.

Environmental Permits, Incidents and Registers	0 -250m	250-500m	Details
Site determined as contaminated land	0	0	Not applicable
Authorised industrial processes	0	0	Not applicable
Registered radioactive substances	0	0	Not applicable
Enforcements, prohibitions or prosecutions	0	0	Not applicable
Pollution Incidents	0	0	Not applicable
Consents issued under the Planning (Hazardous Substances) Act 1990	0	0	Not applicable
Control of Major Accident Hazard (COMAH)/ Notification of Installations Handling Hazardous Substances (NIHHS) sites	0	0	Not applicable
Records of Licensed Discharge Consents	0	1	1 expired consent 495m South of the site. No risk to the site.

- 5.2 No significant risks are identified from the regulatory data base.

Landfill Sites and Waste Treatment Sites

- 5.3 There are no operational or historical landfill sites within 500m.
- 5.4 There are no waste treatment, transfer or management sites within 500m site.
- 5.5 No significant risks are identified from waste activities.

6.0 PRELIMINARY CONCEPTUAL MODEL

Source	Location	Exposure Pathway	Potential Receptor	Probability of Exposure	Details
Human Health					
Asbestos, hydrocarbons and metals.	Potential Made Ground	Ingestion dermal and inhalation.	Construction Workers.	Dismissed.	Normal construction PPE will address risk under CDM.
			Site users.	Negligible.	Significant contamination unlikely.
Hydrocarbon and metals.	Migration from off-site sources.	Ingestion dermal and inhalation.	Construction Workers.	Dismissed.	No source identified.
			Site users.		
Ground Gas.	Historic Landfills.	Inhalation & Explosive.	Construction Workers.	Dismissed.	Backfilled canal is not recorded as a landfill and is considered to be backfilled with Engineered materials which is likely to be inert.
	Potential Made Ground.		Site users.		Significant putrescible material unlikely.
			Construction Workers.		
			Site users.		
Groundwater					
Hydrocarbon and metals.	Potential spillage on site.	Vertical Migration.	Groundwater.	Negligible.	Site underlain by Secondary Aquifer. No source.
Surface Water					
Hydrocarbon and metals.	Potential spillage on site.	Horizontal Migration.	River Network.	Dismissed.	No open receptor.
Environmental Receptors					
On site contaminants		Ingestion dermal and inhalation.	Ecology.	Dismissed.	No sensitive ecology designation.
		Direct.	Archaeology.	Dismissed.	None present.
		Direct.	Geology.	Dismissed.	None present.
		Phytotoxic.	Woodland.	Dismissed.	No receptor.
		Phytotoxic.	Crops.	Dismissed.	No receptor.
		Ingestion dermal and inhalation.	Livestock.	Dismissed.	No source identified.
Building Services					
On site contaminants		Direct.	Historic Buildings.	Dismissed.	No receptors
		Direct.	Proposed Buildings.	Dismissed.	No source identified.
		Permeate into pipework.	Water Pipes.	Dismissed.	No source identified.

6.1 There is a negligible risk of contamination affecting the groundwater as the site is underlain by a secondary aquifer, however there are no local abstractions and there are no sources reducing the risk.

6.2 No other risks are identified.

7.0 SITE INVESTIGATION

General

- 7.1 A ground investigation was undertaken by Enzygo Limited in February 2017.
- 7.2 Locations of exploratory holes advanced by Enzygo Limited are presented on Drawing CRM.427.008.GE.D.001. Locations were selected for the proposed lodge together with associated car parking.
- 7.3 Site works were undertaken using window sampler boreholes (WS01 to WS05), a hand dug pit (HP1) and Deep Borehole (BH01). The scope of the investigation works is outlined below:

Rational	Exploratory Holes	Notes
Groundwater and gas	WS05.	Installation.
Soil infiltration.	WS05.	Preliminary soakaway.
Foundations	WS01 to WS05 and BH01.	Below proposed building
Car parking.	HP01.	Proposed car parking.
General coverage.	WS01 to WS05, HP01 and BH01.	General coverage.
Service investigations.	HP01.	Service Investigations to locate electric main.

- 7.4 The density of granular soils and shear strength of the cohesive soils was measured using a Standard Penetration Tests (SPT). Results are included on the logs presented in Appendix B.
- 7.5 Representative soil samples were collected for chemical and geotechnical testing. Soil samples destined for chemical analysis were collected in appropriate containers provided by the analytical laboratory. Samples were stored in cool boxes prior to dispatch to the laboratory for analysis. All samples were collected using appropriate sampling equipment that was cleaned at each sampling location.
- 7.6 Generally samples were collected from Made Ground, which may contain potential inclusions of contaminating materials and also materials displaying evidence of potential contamination.
- 7.7 In the absence of any evidence of contamination samples were collected near surface as this material is more likely to be contaminated by surface spillages and also will potentially be in contact with future residents. No spillages were noted.

Laboratory Testing

- 7.8 Samples for geotechnical testing were sent to the laboratories of I2 Ltd, which is UKAS accredited, for the following analysis:
- California Bearing Ratio (CBR) undertaken on a re-compacted sample;

- Moisture Content;
- Atterberg Limits Determinations;
- PSD (Particle Size Distribution); and
- Soluble sulphate and pH.

7.9 Samples for chemical analysis were sent to the I2 Laboratories Ltd who are NAMAS and MCERTS accredited. Samples were tested for the CLEA metal suite, pH, sulphate, cyanide, phenols, speciated Polycyclic Aromatic Hydrocarbons (PAH), organic carbon, banded Total Petroleum Hydrocarbon (TPH) and asbestos screen. Two stage WAC tests were also undertaken to assist with waste classification.

7.10 No historical contamination has been encountered and therefore the standard sampling and testing has been undertaken.

8.0 GROUND AND GROUNDWATER CONDITIONS

Summary of Ground and Groundwater Conditions

8.1 Ground and groundwater conditions have been assessed by Enzygo Limited investigation.

The investigation undertaken identify the following strata across the site:

Strata	Summary Description	Thickness (m)
Made Ground.	Grass over topsoil comprising dark brown dark brown slightly gravelly slightly sandy CLAY with frequent rootlets.	0.10
	Firm brown locally greyish slightly gravelly slightly sandy CLAY. Gravel is subangular, fine to coarse bricks, limestone, and sandstone	0.45 to 1.55
	Light grey slightly sandy GRAVEL of angular, fine to coarse limestone.	0.15
Made Ground possible backfilled Pond materials	Topsoil like material (100mm thick) over 3 layers of firm locally soft dark brown grey becoming brown mottled grey slightly gravelly slightly sandy CLAY with low cobble content of angular bricks and concrete, and ceramic fragments. Gravel is subangular, fine to coarse bricks, limestone, mudstone, sandstone, quartzite, bricks and concrete with gravel of chert, and mudstone at depth.	3.50 to 4.45
Diamicton.	Up to three layers of firm locally becoming soft at 2.00mbgl and stiff with depth dark brown mottled black slightly gravelly slightly sandy CLAY. Gravel is subangular, fine to coarse mudstone, sandstone coal, and quartz.	0.95 to 2.60
	Up to three layers of medium dense orange brown slightly clayey slightly gravelly medium to coarse SAND. Gravel is subangular, fine to medium, mudstone, sandstone and coal and medium dense becoming dense below 8.30mbgl brown mottled grey slightly clayey slightly sandy GRAVEL. Gravel is subangular, fine to coarse coal, sandstone, mudstone, chert and quartzite. Locally interbedded with firm grey silt and clay (7.30mbgl to 8.30mbgl).	5.5
Etruria Formation Mudstone	Medium strong greyish brown fine and medium grained SANDSTONE. (Recovered as angular medium and coarse gravel sized fragments of sandstone.	In excess of 0.1
Groundwater.	Seepages at 4.45 to 5.00mbgl.	n/a

8.2 Details of the ground and groundwater conditions encountered are given on the exploratory hole records included in Appendix B and are summarised in the sections below:

Made Ground

8.3 Made Ground was encountered across the site and comprised Grass over topsoil comprising dark brown dark brown slightly gravelly slightly sandy clay with frequent rootlets. These materials from part of the topsoil like materials are were 100mm thick. These materials were underlain by firm brown locally greyish slightly gravelly slightly sandy clay. Gravel is

subangular, fine to coarse bricks, limestone, and sandstone. These materials were encountered to depths ranging from 0.50mbgl to 1.50mbgl and thickening towards the south.

- 8.4 In Borehole WS03 these materials were underlain by a thin layer of light grey slightly sandy gravel of angular, fine to coarse limestone.
- 8.5 In Borehole BH01 and WS04 deep Made Ground was encountered this is thought to be associated with the backfill of the historical pond identified in the historical plans from 1957 to 1975. These materials comprised topsoil like material (100mm thick) over 3 layers of firm locally soft dark brown grey becoming brown mottled grey slightly gravelly slightly sandy clay with low cobble content of angular bricks and concrete, and ceramic fragments. Gravel is subangular, fine to coarse bricks, limestone, mudstone, sandstone, quartzite, bricks and concrete with gravel of chert, and mudstone at depth and were proved to depths ranging from 3.50mbgl to 4.45mbgl.

Services

- 8.6 Enzygo Geoenvironmental Ltd were instructed to excavate a service hand pit (HP01) to identify a possible electricity main located on the service plans which crosses the proposed lodge site. This was located as hand pit HP01. No trace of this cable was encountered using a CAT, however a hand pit was undertaken at the required position. Whilst excavating this pit a discussion with the site workers working on the site as part of the refurbishment indicated there was no service in this area and based on a hand annotated plan this service was located in the car park to the west of the Plas Coch restaurant. The new area was subsequently scanned using the CAT and confirmed its location, however could not be excavated due to cars parking over the position of the handstanding.

Diamicton

- 8.7 Diamicton was encountered across the site and comprised cohesive and granular materials. These materials were encountered to a depth of 9.00mbgl in Borehole BH01.

Cohesive materials

- 8.8 The cohesive materials were encountered above the granular materials and to depths up to 4.10mbgl in Borehole WS05 to the south of the site. These materials generally comprised up to three layers of firm locally becoming soft at 2.00mbgl and stiff with depth dark brown

mottled black slightly gravelly slightly sandy clay. Gravel is subangular, fine to coarse mudstone, sandstone coal, and quartz. These materials were locally soft below 2.00mbgl.

Granular materials

- 8.9 The granular materials were encountered below the cohesive materials and to depths of 9.00mbgl in Borehole BH01. These materials generally comprised up to three layers of medium dense orange brown slightly clayey slightly gravelly medium to coarse sand. Gravel is subangular, fine to medium, mudstone, sandstone and coal and medium dense becoming dense below 8.30mbgl brown mottled grey slightly clayey slightly sandy gravel. Gravel is subangular, fine to coarse coal, sandstone, mudstone, chert and quartzite.
- 8.10 In Borehole BH01 and from 7.30mbgl to 8.30mbgl the gravel was interbedded with firm grey silt and clay.
- 8.11 The upper granular material was generally underlain by a second layer of granular material, which was proven in all borehole locations with the exception Boreholes of WS1 and WS4. The lower granular material comprises orange brown mottled clayey and very clayey fine and medium sand and was proven to depths of up to 5.45mbgl and thickness up to 5.15m.

Etruria Formation Mudstone

- 8.12 The Etruria Formation was encountered below 9.00mbgl in Borehole BH01 and comprised medium strong greyish brown fine and medium grained sandstone recovered as angular medium and coarse gravel sized fragments of sandstone.

Visual and Olfactory Evidence of Contamination.

- 8.13 No visual or olfactory evidence of contamination was encountered during the site works.

Soil Strength

- 8.14 The Diamicton ranged in strength from soft to firm for the cohesive materials with shear strengths ranging from 27kN/m² to 67kN/m² and loose to medium dense for the granular materials with SPT N values of 3 to 18. Below 8.00mbgl the granular materials became dense and very dense with SPT N values ranging from 42 to >50.

Groundwater

- 8.15 Groundwater was encountered in Borehole WS1 and WS2 to the north of the site and BH01 to the south of the site as seepages and damp conditions at depths ranging from 4.45m bgl to 5.00mbgl.
- 8.16 Results of subsequent monitoring rounds are summarised below:

Exploratory Hole	Depth m(bgl)			
	Siteworks	13.02.18	22.02.18	28.02.18
WS5	Dry	Dry	Dry	Dry

Ground Gas

- 8.17 Ground gas was monitored during the return visit and the results are summarised on the table below:

Exploratory Hole	Atmos pressure (Mb)	Flow (l/hr)	CH4		CO2		O2
			Concentration (%)	GSV (l/hr)	Concentration (%)	GSV (l/hr)	Concentration (%)
13-02-18							
WS5	987	<0.1	<0.1	<0.0001	<0.1	<0.0001	21.5
22-02-18							
WS5	1014	<0.1	<0.1	<0.0001	<0.1	<0.0001	21.4
28-02-18							
WS5	1008	<0.1	<0.1	<0.0001	4.8	<0.0048	16.6

- 8.18 Where gas concentrations exceed 1% by volume methane or 5% by volume Carbon Dioxide the concentrations are coloured yellow. If concentrations are lower the values are coloured green. Where gas flux meets characteristic situation 1 the GSV is coloured green. The GSV is coloured yellow for Characteristic Situation 2 and red for Characteristic Situation 3 and above.

Soil Infiltration

- 8.19 A Full BRE soakaway test was undertaken (SA1) to a depth of 3.00mbgl. The Soakaway test provided a soil infiltration value of 5.5×10^{-4} m/s. This was undertaken within the Made Ground.

9.0 CONTAMINATION ASSESSMENT

General

- 9.1 A Tier I risk assessment has been undertaken using available and current screening values for human health and where appropriate controlled waters. The risk assessment is undertaken based on the findings of the preliminary conceptual model presented in Section 6. Based on the contamination testing and Tier I assessment a revised Conceptual Model has been prepared, which is presented later in this section.
- 9.2 Where significant risks are identified remedial measures are recommended.

Human Health

- 9.3 Assessment of the risks to human health has been undertaken by comparing the soil quality data with reference values obtained from the Contaminated Land Exposure Assessment (CLEA), Soil Guideline Values (SGV) and General Acceptance Criteria (GAC) published by LQM/CIEH. The LQM/CIEH S4ULs values are used and summary tables of the reference values are included in Appendix C.
- 9.4 Where an exceedance is identified the risk is assessed by considering the sensitivity of the proposed development and the potential pathway. The proposed development is for lodge and soft landscaping and as such the GAC values for Residential public open space are considered suitable.
- 9.5 Results of the chemical testing are included in Appendix C. In addition to the laboratory sheets there is a sheet with the results coloured. Where results are coloured green these are below the GAC. Values coloured red exceed the GAC.
- 9.6 The soil quality analysis shows no exceedances of the GAC values for commercial or residential public open space.
- 9.7 Asbestos has been encountered in one sample Borehole WS04 (0.20 to 1.00mbgl) and comprised Chrysotile -loose fibres.

Controlled Waters

- 9.8 Where groundwater samples have been analysed the results are compared against reference values. These reference values are summarised in Appendix C and are taken from

Fresh Water Environmental Quality Standards (EQS), UK Drinking Water Standards and World Health Organisation (WHO) values for Drinking Water.

- 9.9 Where the controlled waters receptor is a surface water course then the EQS are used as the primary reference value. Drinking Water Standards and WHO values are used where EQS values are not available. An assessment of likely risk is then made based on a source-pathway-receptor model. Where the receptor is potable groundwater resources the Drinking Water Standards and WHO values are used.
- 9.10 Risk to groundwater is assessed based on the chemical analysis results for the soils. The risk was negligible in the preliminary risk assessment and no exceedance above GAC values were measured. As groundwater at the site is not used for potable supply and there are no nearby abstractions the risk to groundwater resources is dismissed.
- 9.11 Risk to surface waters was dismissed within the Preliminary Conceptual Model and no new risks are identified.

Ground Gas

- 9.12 Following the guidance provided in CIRIA C665 an initial assessment is undertaken to determine if there are any significant sources of potential ground gas. Such sources include landfills, organic clays and made ground incorporating putrescible materials such as rags, paper and wood. Where no significant source is identified no further assessment is necessary.
- 9.13 Where significant potential risk from ground gas has been identified from the Initial Conceptual Model and the intrusive ground investigation works ground gas monitoring is undertaken and the results of the monitoring are compared against the Gas Screening Values given in CIRIA Report 665. From this the Characteristic Situation is identified and remedial measures proposed.
- 9.14 When assessing the risk and type of remedial measures appropriate consideration is given to the likely construction of the development, the nature of the gas posing a risk and the nature of the likely source. The use of engineering judgement when determining risk from ground gas is consistent with the recommendations given in CIRIA C665. No significant sources of ground gas were noted from the desk study. A quarry was noted as part of the desk study to the north of the site in 1895. This had been infilled by 1914. Given the date of infilling and the distance from the site the risk associated with the gravel pit has been dismissed. Made Ground was encountered on site but this did not include significant

putrescible materials. However, gas monitoring has been undertaken as a precaution and to check the gas levels across the site.

- 9.15 Gas monitoring was undertaken during return visits to monitor groundwater levels. Ground gas has not recorded significant elevated concentrations of Methane or Carbon Dioxide and no detectable gas flow rates have been measured.
- 9.16 Based on the gas monitoring undertaken it is considered that Characteristic Situation 1 applies and no gas protective measures are required.

Revised Conceptual Model

- 9.17 The Initial Conceptual Model presented in Section 6 has been revised based on the findings of the ground investigation and the revised Conceptual Model is presented below:

Source	Location	Exposure Pathway	Potential Receptor	Probability of Exposure	Details
Human Health					
Asbestos	Borehole WS4	Ingestion dermal and inhalation.	Construction Workers.	Low	Management measures.
			Site users.	Moderate	Remediation.
Metals and hydrocarbons.	Unforeseen Contamination.	Ingestion dermal and inhalation.	Construction Workers.	Dismissed..	Normal construction PPE will address risk under CDM.
			Site users.		Dismissed no contamination identified or likely.
Metals and hydrocarbons.	Made Ground.	Ingestion dermal and inhalation.	Construction Workers.	Dismissed.	No exceedance of GAC.
			Site users.		
Hydrocarbon and metals.	Migration from off-site sources.	Ingestion dermal and inhalation.	Construction Workers.	Dismissed.	No Source.
			Site users.		
Ground Gas.	Made Ground.	Inhalation & Explosive.	Construction Workers.	Dismissed.	Characteristic situation 1 proposed.
			Site users.		
	Landfill	Inhalation & Explosive.	Construction Workers.	Dismissed.	
			Site users.		
Groundwater					
Hydrocarbon and metals.	Potential spillage on site.	Vertical Migration.	Groundwater.	Dismissed.	No source.
Surface Water					
Hydrocarbon and metals.	Potential spillage on site.	Horizontal Migration.	River Network.	Dismissed.	No receptor.
Environmental Receptors					
On site contaminants.		Ingestion dermal and inhalation.	Ecology.	Dismissed.	No sensitive ecology designation.
		Direct.	Archaeology.	Dismissed.	None present.
		Direct.	Geology.	Dismissed.	None present.
		Phytotoxic.	Woodland.	Dismissed.	None present.
		Phytotoxic.	Crops.	Dismissed.	None present.
		Ingestion dermal and inhalation.	Livestock.	Dismissed.	None present.
Building Services					
On site contaminants.		Direct.	Historic Buildings.	Dismissed.	No receptors.
		Direct.	Proposed Buildings.	Dismissed.	No sources identified.
		Permeate into pipework.	Water Pipes.	Dismissed.	No sources identified.

Remediation and Verification Strategy

- 9.18 The ground investigation has identified elevated concentrations of Asbestos.
- 9.19 Based on the site investigation it is considered that remediation is required to safely allow redevelopment of the site for residential use.
- 9.20 Following the guidance given in British Standards BS10175, consideration has been given to whether further investigation is appropriate. The options available are either to:
1. Undertake further investigation in the hope that contamination hotspots can be delineated and the remediation works undertake to address these areas only; or
 2. Undertake robust site wide remediation, including a discovery strategy.
- 9.21 It is considered that Asbestos contamination has been identified within Made Ground is likely to be associated with the Made Ground across the site and as such may be present across the entire site. Site wide remediation is therefore proposed taking account of the proposed development works and construction requirements. The proposed remedial works are outlined below:

Proposed Remediation

- 9.22 It is considered that hardstanding to pavement areas and buildings will provide a suitable barrier to prevent potential risk to end users. Within areas of the soft landscaping it is proposed that clean cover soils are provided. Soils should comprise 600mm of cover with a geotextile separator below. Clean cover soils could comprise imported materials with 150mm of clean Topsoil on top.
- 9.23 Use of an encapsulation system is a recognised and widely used remediation approach which breaks the potential pollutant linkages. As such encapsulation also allows unforeseen contamination to be addressed thereby providing a robust strategy for the site. Cover soils proposed are the default thickness given in 'Cover Systems for Land Remediation' prepared by Building Research Establishment.
- 9.24 When considering the remedial approach consideration was given to the nature of the development and other construction constraints. Specifically, 50% of the site will be covered by hardstanding effectively providing encapsulation through design mitigation measures. Within soft landscape areas it is considered that the use of clean cover soils will be required regardless of the soil quality impacts identified to provide a suitable planting medium.

- 9.25 Cover soils will be validated. It is proposed to undertake validation using hand pits to confirm the thickness of cover soils, presence of a geotextile and also collect samples for chemical analysis of the clean cover soils. The number and location of validation pits and number of chemical samples analysed will be in accordance with guidance developed by the NHBC in consultation with the Environment Agency.
- 9.26 On completion of the site works a Verification Report will be prepared and submitted for approval to the Local Planning Authority.

Unforeseen Contamination

- 9.27 Regardless of any investigation works undertaken there is a residual risk that unforeseen contamination may be encountered at the site during the preparation and construction works. As such a discovery strategy is proposed.
- 9.28 If unforeseen contamination is encountered during construction works such as localised spillage outside the areas investigated an Environmental consultant will be available on a 'call out' basis to undertake an assessment of risk. If 'unforeseen contamination' is encountered such as hydrocarbon contamination or solvent odours the discovery strategy will be to remove the source as it is likely to be very limited in extent or encapsulate it on site as appropriate and the Local Planning Authority advised.

Asbestos Management

- 9.29 End users of the site will be protected against asbestos risk through the use of a cover system to break the pollutant linkage.
- 9.30 To protect construction worker's measures should to be incorporated in to the Contractors Construction Stage Health and Safety Plan as required under the Construction Design and Management (CDM) Regulations to mitigate risk to construction works. Measures may include:
- Designing temporary works to minimise disturbance of the backfill material;
 - Separating material and disposal of soils containing asbestos;
 - Wetting down during excavation;
 - Sheeting of stockpiles where asbestos is suspected;
 - Testing of soils and off-site disposal of any soils found or suspected of containing asbestos;
 - Preventing access to the construction site by members of the public;

- Use of good hygiene measures, including washing down of plant; and
- Use of appropriate PPE, including face masks.

Waste Classification

- 9.31 A two part WAC test was undertaken for the Made Ground which recorded no exceedances of leachable concentrations above the inert threshold values and the values of pH are not less than 6.
- 9.32 It is considered that Made Ground is likely to be classified as inert.
- 9.33 Asbestos quantification indicates a value of 0.01%, which indicates that the site is likely to be classified as inert, however this will require the landfill to confirm waste classification and acceptability based on their specific intake allowances.
- 9.34 The Waste Management paper 3 requires the landfill to make an appropriate assessment of the waste classification. As such final assessment will be undertaken by the receiving landfill based on the requirements of their permit. Given this should any materials be required to be disposed of off site sampling and testing should be undertaken from the stockpile heap to confirm waste classification.

10.0 GEOTECHNICAL ASSESSMENT

Proposed Development

- 10.1 The proposed development will comprise a two-storey building (lodge). No structural loadings are available and therefore a provisional loading of 50kN per metre run is used for assessment purposes.
- 10.2 It is considered that the scheme meets the criteria of Geotechnical Category 1 of Eurocode 7.

Ground Conditions

- 10.3 Ground conditions comprise variable Topsoil and Made Ground up to 4.45m bgl over firm locally soft clay over medium dense locally very loose around the groundwater level at 5.00mbgl over dense gravel below 8.00mbgl and sandstone at 9.00mbgl. Groundwater was encountered below 4.45mbgl.

Site Preparation

- 10.4 The site should be cleared and any vegetation below areas of proposed development stripped in accordance with Series 200 of the Specification for Highway Works. This should include:
- Any redundant services should be sealed off and grubbed out and replaced with suitable compacted engineered fill; and
 - Any buried structures and old foundations should be excavated from below the proposed structures. (none encountered).

Foundations

- 10.5 It is considered that conventional strip foundations are unsuitable as Deep Made Ground has been encountered to the south of the site to a depth of 4.45mbgl. Vibro compaction has been considered at the site however given the presence of soft alluvial materials it is considered that this is not appropriate.
- 10.6 A preliminary pile design has been undertaken based on the following parameters:
- Resistance and also negative skin friction within the desiccated materials to 4.45mbgl has been ignored. It is recommended that piles are sleeved through these materials.

- For the purposes of this preliminary assessment the Diamicton is considered to be below 4.45mbgl and the sandstone below 9.00mbgl.
- A global factor of safety of 2.5 has been used. In addition, an assessment using a factor of safety of 1.5 on shaft resistance and 3 on end bearing has also been undertaken
- Groundwater is assumed at 4.45mbgl.

A typical pile depth of up to 9.10m below ground level is recommended, this is based on the borehole BH1.

The following preliminary pile working loads have been calculated and are given below. The pile depths are based on Borehole BH1.

Depth bgl	Working Load kN		
	200mm	300mm	450mm
7m	80	180	350
9m	134	250	500

- 10.7 Given a refusal has been encountered at 9.00mbgl. it is likely that the piles will be socketed into the sandstone at 9.10mbgl. and therefore the working loads will be a reflection the sandstone refusal.
- 10.8 Final pile design should be undertaken by a specialist contractor who can use pile test records to agree lower factors of safety and thereby generate a more cost effective pile design.
- 10.9 Modified Plasticity Index values confirm that the cohesive element of the Diamicton considered to be of moderate shrinkage potential in accordance with Chapter 4.2 of NHBC.
- 10.10 Foundations should be designed assuming soils of moderate shrinkage potential. Given that minimal trees have been encountered within the footprint of the proposed buildings it is unlikely that heave will be a significant issue for foundations.

Ground Floor Slab

- 10.11 Given the substantial thickness of Made Ground suspended floor slabs are recommended.
- 10.12 Full radon protection measures are required which will require the installation of full radon barrier to be installed with sealed and lapped joints.

Pavement Construction

10.13 An assessment of the likely California Bearing Ratio (CBR) has been assessed from the following sources:

- Description of the materials encountered in the exploratory holes, and;
- Guidance given in HD25/94 and 73/06.

10.14 Based on this it is recommended that an equilibrium CBR of 3.0 %. The formation should be proof rolled and any areas of loose material excavated and removed. It is further recommended that formations are checked and insitu CBR tests and carried out to confirm suitability before placement of any pavement design. Shallow soils are considered to be frost susceptible.

Materials Re-use

10.15 An assessment of the shallow soils suitability for re-use has been undertaken using the following parameters:

- Laboratory CBR tests undertaken on re-compacted samples to mimic proof rolling.
- Grading analysis; and
- Description of the soils.

10.16 It is considered that Made Ground/topsoil is not suitable for re-use as engineered fill.

10.17 The underlying gravelly clay is considered suitable for general fill.

Drainage

10.18 A soil infiltration value of was undertaken in the Soakaway test (SA1) which provided a soil infiltration value of $5.5E^{-06}$ m/s. Based on this and the presence of existing soakaway drainage on the adjacent site, soakaway tests should be acceptable however this was undertaken within the Made Ground.

10.19 Chemical results have been compared with the screening values provided by Water UK. The Individual PAH and TPH threshold value has not been exceeded and it is likely that barrier pipes will not be required.

- 10.20 Final selection of potable water supply pipes will be determined by the water authority and it is recommended that the chemical results are be provided to them so that they can specify pipework accordingly.

Buried Concrete

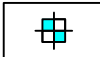
- 10.21 Results of the sulphate testing indicate that soils have soluble sulphate concentrations of less than 0.5 g/l it is therefore considered that DS1 Conditions of BRE Special Digest 1 and as such shallow buried concrete may be designed in accordance with ACEC Class AC-1s.

Excavation

- 10.22 Based on the various site observations it is considered that excavations should be feasible with normal construction plant.
- 10.23 Groundwater was encountered below 4.45mbgl, however given that groundwater levels vary according to the season it is recommended that the groundwater levels are checked before any construction excavations are undertaken.
- 10.24 It is recommended that deep excavations are avoided where possible. Excavations where access is required should be supported in accordance with CIRIA RR97.



Key

-  Site Boundary
-  Window Sampler Boreholes (WS)
(WS1-WS5)
-  Cable Percussion Borehole (BH)
(BH01)
-  Hand Pit (HP)
(HP1)
-  Soakaway Position (SA)
(SA1)



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SCALE: NTS PROJECT REF: CRM.427.008

DRAWN: NP CHECKED: RH DATE: Feb 2018

PROJECT: Plas Coch, Wrexham

TITLE: Location Plan

FIGURE NO: CRM.427.008.GE.D.001