COMBINED PHASE 1 AND 2 GEO-ENVIRONMENTAL AND GEOTECHNICAL SITE ASSESSMENT REPORT

LAND AT CEDAR DRIVE,

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EXECUTIVE SUMMARY

EnviroSolution Ltd was commissioned to undertake a combined Phase 1 and Phase 2 geo-environmental and geotechnical site assessment at a site located at Cedar Drive in Wrexham. This work is required to inform development proposals for residential land use at the site.

The recent intrusive ground investigation has shown that the development is directly underlain by natural diamicton deposits. The recent intrusive ground investigation has shown that the development site has no Made Ground within the shallow soils.

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A total of 5 no. soil samples were collected and analysed for a range of chemical parameters. Low level soil contaminants (e.g. heavy metals) have been detected the shallow soils beneath the site. However, generic quantitative risk assessments have proven that they will not present a risk to any of the receptors identified in the preliminary conceptual site model, if they remain present beneath the site following redevelopment.

The conceptual site model identified that the site lies within a high probability area for naturally occurring radon gas. No further sources of contamination have been identified. Full radon protective measures would be required for any future development.

Further guidance can be found in BR 211 (2015) 'Radon: Guidance on protective measures for new buildings'.

It is recommended that discussions are undertaken with the water supply company to confirm their requirements for water supply pipes.

The underlying diamicton deposits are considered to be adequate bearing material. It is considered that conventional shallow spread foundations can be used with an allowable bearing pressure of 85kN/m^2 can be adopted for foundation design assuming a foundation width of 1m and that the water table is below the base of the foundation.

Foundation excavations should be checked by an experienced ground worker prior to placing concrete. Any soft spots or unsuitable founding materials (very loose sands and gravels) should be removed if encountered and replaced with compacted granular fill or lean mix concrete. Should both granular and cohesive material be present at the proposed formation level, it is recommended that excavations are locally deepened, or foundations appropriately reinforced to span material with different settlement properties.

Initial designs may consider the use of ground bearing floor slabs.

The results from the chemical laboratory sulphate and pH analysis for the site indicate a Design Sulphate Class of DS-1 and an Aggressive Chemical Environment for Concrete (ACEC) class of AC-1.

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1 Introduction

1.1 Background

EnviroSolution Ltd was commissioned to undertake a combined Phase 1 and Phase 2 geo-environmental and geotechnical site assessment at a site located at Cedar Drive in Wrexham, North Wales. This work is required to inform development proposals for residential land use at the site.

1.2 Objectives

The objectives of the preliminary environmental site assessment were:

1. To provide a summary of the environmental setting and historical land use of the site and immediate surrounding area.
2. To obtain information on the ground conditions present beneath the site.
3. To develop a conceptual site model and complete and generic quantitative risk assessment in order to identify any environmental risks and liabilities associated with ground conditions at the site.
4. To obtain information to inform foundation design.
5. To identify the requirements for any additional works prior to site development (e.g. ground remediation).

1.3 Scope of Work

In order to achieve the objectives, the following scope of work was completed:

1. A desk-based study (Phase 1) of the site comprising a review of available environmental information for the site such as geological and hydrogeological data and historical land use information.
2. A site walkover survey to assess on-site ground conditions, vegetation and signs of previous contamination.
3. An intrusive ground investigation (Phase 2).
4. A generic quantitative risk assessment in accordance with industry approved standards.
5. A geotechnical appraisal of the ground conditions.

The scope of work was developed in accordance with the Environment Agency of England and Wales Environment Agency (2020) Land Contamination Risk Management Report LCRM “How to assess and manage the risks from land contamination” and BS10175:2011+A2:2017 ‘Investigation of Potentially Contaminated Sites – Code of Practice’.

1.4 Information Sources

Historical Ordnance Survey maps have been obtained from historical records, ranging from 1873 to 2021. These maps provide high quality information on historical site uses.

The British Geological Survey Geoindex database has been used to gain information on geo-environmental aspects of the site and the immediate surrounding area, including geological, hydrogeological and hydrological data.

The Environment Agency website (www.gov.uk/government/organisations/environment-agency) and Magic website (www.magic.gov.uk) was also used to gain information on the environmental context of the site and surroundings.

Industry Profiles, produced by the Department of the Environment, were utilised to obtain information on processes, materials and wastes along with associated potential contaminative land uses in the vicinity of the site.

Readily available information sources have been used to produce this desk-based study. Additional information may be requested by the Local Planning Authority (e.g. local authority environmental information request).

2 The Site

2.1 Site Location

The site is located at Cedar Drive, Gwersylly, Wrexham, Wales, LL11 4HW. The British National Grid Reference for the approximate site centre is GR: 331367 353898.

The site location is shown on **Figure 1** in **Appendix A**.

2.2 Site Description

The site description is aided by the completion of a site walkover survey conducted by EnviroSolution on the 2nd February 2021. The site photographs are included in **Appendix B**.

The site is irregular in shape and covers an approximate area of 570 square meters.

The site is currently vacant and forms a fenced-off section of a larger field. The plot appears to be used as a car park with gravel hardstanding present across the majority of the site area.

The topography of the site is generally flat with little change in elevation.

The site is bounded by residential houses to the west and south, and open fields to the north and east. The site boundaries consist of wooden panel fencing to the west and metal fencing to the north.

A row of mature trees divide the site from the fields to the east.

Former industrial/ commercial land is located 100m southeast of the site.

The nearest petrol filling station is located 280m east of the site.

The existing site plan is shown on **Figure 2** which is included in **Appendix A**.

2.3 Development Proposals

It is understood that the proposed development proposal includes the construction of two new residential dwellings. Final development plans include vehicle parking and areas of soft landscaping to be used as gardens.

The final proposed development plans are shown on **Figure 3** which is included in **Appendix A**.

2.4 Site History

The development site and surrounding area has been reviewed with reference to historical Ordnance Survey (OS) maps. The history of the site and immediate surrounding area is summarised in Table 1. Copies of the historical OS maps are included in **Appendix C**. A search buffer of 250m has been used.

Table 1 - Historic Mapping Review

Date	Scale	On Site	Off Site
1873	1:2,500	The site is undeveloped and lies within an open agricultural field.	Surrounding land largely undeveloped open fields. Small pond 150m east of the site. Railway 220m east of the site. Gwersyllt Colliery and two mine shafts located 250m southeast of the site.
1899	1:2,500	No significant change.	Gwersyllt Colliery expanded to 200m southeast of the site.
1912	1:2,500	No significant change.	Gwersyllt Colliery expanded to 140m southeast of the site.
1939	1:10,560	No significant change.	Gwersyllt Colliery expanded to 100m southeast of the site and now disused.
1962	1:2,500	No significant change.	Gwersyllt Colliery dismantled and converted to club. Residential development 190m southwest of the site.
1970	1:2,500	No significant change.	Residential development 50m south and 90m west of the site. Disused unlicensed tip located 200m southeast of the site.
1976	1:2,500	No significant change.	Residential development directly west and south of the site and 70m north. Council depot 100m southeast of the site. Engineering works 140m southeast. Pond no longer marked on map.
1986	1:2,500	No significant change.	No significant change.
1996	1:2,500	No significant change.	No significant change.
2021	1:10,000	No significant change.	Council depot disused.

3 Environmental Setting

3.1 Geology

Geological maps of the area indicate the site is directly underlain by superficial diamicton deposits of the which are of Quaternary age. The diamicton deposits generally consist of over-consolidated, unsorted clays, silts, sands and gravels.

The underlying bedrock geology consists of the Cefn Rock Member of the Pennine Lower/Middle Coal Measures Formation (undifferentiated) which is of Carboniferous age. The Cefn Rock generally consists of massive quartzose sandstone with subordinate and impersistent beds of mudstone and coal.

A BGS borehole log (Ref: SJ35SW765) has been obtained from BGS online records 80m east of the site. The borehole shows 3.0m of generally cohesive glacial diamicton comprising firm to stiff brown/ grey clay overlying light grey sandstone.

The nearest geological fault is located 620m east of the site.

A copy of the geological maps is included in **Appendix D.** A copy of the BGS borehole logs are included in **Appendix D**.

3.2 Radon

The site lies within an elevated band of radon potential where it is estimated that between 10-30% of the properties are above the action level (high probability). Full radon protective measures would be required for any future development.

Further guidance can be found in BR 211 (2015) 'Radon: Guidance on protective measures for new buildings'.

3.3 Coal Mining Activity

The site lies within a coal mining area described as having minable coal deposits but does not lie within a 'Development High Risk Area' for coal mining, as defined by the Coal Authority. As such, it is considered that there are no coal mining related hazards which could affect the site.

A copy of the coal mining summary map is included in **Appendix D**.

3.4 Hydrogeology

The superficial deposits are designated as a Secondary Undifferentiated Aquifer. This is defined as cases where it has not been possible to assign either A or B to a soil type due to variability in lithology.

The underlying Cefn Rock is designated as a Secondary A Aquifer, defined as; permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.

The site is not located within a Source Protection Zone and there are no records of sites that hold groundwater abstraction licences held within a 1km radius of the site.

A copy of the hydrogeological maps is included in **Appendix D**.

3.5 Hydrology

There are no significant surface water features (lakes, rivers, reservoirs) located within a 1km radius of the site.

There are no minor surface water features located within a 250m radius of the site.

3.6 Flood Risk

The site lies within a Flood Zone 1, land assessed as having less than a 1 in 1,000 annual probability of river flooding (0.01%) in any year (low risk). The completion of a detailed Flood Risk Assessment is not deemed necessary for this site.

3.7 Waste Management Facilities

There are no records of historic or currently authorised landfill sites located within a 1km radius of the site.

There are no sites located within a 1km radius of the site operating under an environmental permit for waste operations.

3.8 Environmental Permits, Incidents and Registers

There are no records of sites located within a 1km radius of the development site operating under an environmental permit for discharges to water and groundwater.

There are no records of any pollution events having occurred within a 1km radius of the site.

3.9 Designated Environmentally Sensitive Sites

There are no records of designated environmentally sensitive sites located within a 1km radius of the site.

4 Preliminary Conceptual Site Model

4.1 Introduction

In order to assess the environmental risks present, a preliminary conceptual model has been developed for the site. This model has been developed using best practice guidelines in conjunction with the current assessment framework taking into account the development proposals. This preliminary conceptual model is based on the gathered desk-based information (e.g. historical OS data and data sourced from the EA, Geoindex and Magic databases).

The conceptual site model is a representation of the hypothesised relationships between sources, pathways and receptors which allows the identification of potential pollutant linkages and whether these linkages have the potential to comprise significant harm and/or pollution of controlled waters in relation to the site. This model comprises three elements:

Source – the key pollutant hazards associated with the site

Receptor – the key targets at risk from the sources

Pathway – the means by which the contaminant can cause harm to the receptor

If all three elements are present, then a potential pollutant linkage exists, and this may require further assessment.

4.2 Potential Contamination Sources

The site has remained undeveloped since as far back as 1873 and is unlikely to have been developed previously. The site forms part of a open field. This land use is unlikely to have directly resulted in the contamination of the shallow soils.

Several off-site land uses have been identified in the surrounding area which have the potential to contaminate the shallow soils at the site. The land uses and their associated contaminants are summarised in Table 2 below:

Table 2 – Potential contaminants

Land Use	**Potential Contaminants**
Council Depot	Heavy metals, solvents, PAHs
Engineering Works	Heavy metals, PAHs
Railway	Heavy metals, hydrocarbon fuels
Tip	Heavy metals, PAHs, asbestos, ground gases
Colliery Spoil	Heavy metals, ash, sulphates

A number of off-site features identified have the potential to generate ground gases (methane and carbon dioxide). These include an infilled pond, disused tip and mine shafts. However, it is considered that these sources present a low risk to the site. All features are located between 150m and 250m from the site. The natural soils in the area have been shown to be cohesive in nature and will limit gas migration towards the site. Additionally, the tip was disused in the 1960s and is therefore unlikely to present a significant ground gas risk.

The site does, however, lie within a high probability for naturally occurring radon gas at potentially harmful levels. This can be readily mitigated through the incorporation of gas protection measures.

4.3 Receptors

The potential receptors considered to be at risk from soil and groundwater contamination associated with the site are summarised in Table 3 below:

Table 3 - Receptor Description

Receptor	Details
Human (On Site)	- Construction workers - Future site users - Site visitors
Human (Off Site)	- Adjacent site users
Controlled Waters	- Secondary Undifferentiated Aquifer - Secondary A Aquifer
Building/ construction materials	- Foundations and buried services

4.4 Pathways

The potential exposure pathways linking contamination with the receptors identified above are summarised in Table 4 below:

Table 4 - Exposure Pathways Summary

Receptor	Details of Exposure Pathway
Human (on-site)	- Direct ingestion of contaminated soil/groundwater - Dermal contact with soil/groundwater - Inhalation of gases and vapours
Human (off-site)	- Inhalation of fibres and particulates - Inhalation of migrating gases and vapours
Controlled waters	- Vertical and lateral migration of dissolved phase contaminants via preferential pathways to groundwater aquifers

Receptor	Details of Exposure Pathway
	- Direct surface water run-off to surface water features
Building/construction	- Buried materials/services - Contact with contaminated soil and/or groundwater

4.5 Potential Pollution Linkages

4.5.1 Human Health

The development plans include the construction of two residential dwellings. Proposals include areas of soft landscaping to be used as gardens and areas for vehicle parking.

The presence of any proposed buildings and hardstanding would eliminate the risk of exposure, via the dermal contact and ingestion pathways to future site users to any ground contamination that may remain following development.

There could be a potential risk of exposure to any ground contamination that remains following redevelopment in any proposed areas of soft landscaping (i.e. gardens), to future site users, via all possible exposure pathways.

Any ground gases (i.e. methane and carbon dioxide) and vapours that are present within the soils beneath the site could potentially ingress into any future buildings at the site through preferential pathways (e.g. service entry points). Therefore, there would be a risk of exposure via inhalation to future site users.

There is the potential for construction workers and adjacent land users to be exposed to soil and groundwater contamination during future site redevelopment. However, the use of appropriate PPE and the adoption of suitable Health and Safety methods will help to reduce the risks posed to human health during this work.

4.5.2 Controlled Waters

The site is directly underlain by superficial diamicton deposits which are of low permeability and do not form a significant groundwater aquifer. It is considered that the diamicton will act as an impermeable barrier, preventing any migration of potential contaminants to the underlying groundwater aquifers. Local borehole information confirms the diamicton deposits are generally cohesive in nature.

There are no surface water features identified in the surrounding area.

The site is not located within a Source Protection Zone and there are no groundwater abstraction licences held within a 1km radius of the site. The risk to controlled waters is deemed to be low.

4.5.3 Building/ Construction Materials/ Buried Services

The presence of any soil and groundwater contaminants beneath the site could potentially impact on construction materials, such as below ground structures and services. Concrete foundations are particularly sensitive to aggressive ground conditions, i.e. sulphate attack.

If ground gases and vapour are present in the soil beneath the site, then there would be the potential risk of ingress into any future properties which could present a risk of explosion.

4.6 Preliminary Hazard Assessment

A preliminary hazard assessment is presented in Table 5. The preliminary hazard assessment is a qualitative assessment of the risks posed by each potential pollutant linkage described above and is used to identify the requirement for additional work (e.g. intrusive ground investigation).

Table 5 – Preliminary Hazard Assessment

Source 1	Pathway	Receptor	Likelihood	Effect	Risk	Assessment
Contaminated soil	Ingestion (via soil dust), inhalation (via soil dust and vapours), ingestion through dirty hands, dermal contact with soil/water.	Future site users Adjacent site users Construction workers	2	3	Moderate	On-site source potential identified.
Contaminated soil groundwater	Direct contact	Buildings/ services	2	3	Moderate	On-site source potential identified. Made Ground in direct contact with potential future building foundations.
Contaminated groundwater	Downward or lateral migration Surface water run-off	Secondary Aquifers	1	3	Low	On-site contamination source identified. Impermeable diamicton will act as a barrier.
Ground gas / vapours Radon	Inhalation, ingress into buildings	Buildings / services Future site users Adjacent site users Construction workers	3	4	High	No significant on-site or off-site ground gas source identified. Site located within a high probability area for radon gas.

Using Risk Matrix (Table 6) Degree of Risk (R) = Likelihood (L) x Effect (E)

Table 6 - Risk Matrix, Degree of Risk (R) = Likelihood (L) x Effect (E)

Likelihood	Description	Probability	Effect (E)	Description
5	Almost certain	>70%		
4	Probable	50-70%	4	Severe
3	Likely	30-50%	3	Medium
2	Unlikely	10-30%	2	Mild
1	Negligible	<10%	1	Minor
Risk (R)	**Risk Level**	**Action**		
1-5	Low	None required		
6-10	Moderate	Further assessment via Phase 2 intrusive ground investigation.		
>10	High	Further assessment via Phase 2 intrusive ground investigation.		

5 Ground Investigation Methodology

5.1 Intrusive Field Works

The intrusive investigation works were undertaken by EnviroSolution Ltd on the 10th of February 2021. The work comprised the following:

- The drilling of 3 no. window sample boreholes (designated as WS1 – WS5) to depths of up to 4.0m below ground level (bgl).
- Geological logging of ground conditions at each location.
- Collection of representative soil samples from all boreholes for subsequent chemical and geotechnical laboratory analysis.

The exploratory hole locations are shown on **Figure 4** in **Appendix A**. The exploratory holes were spaced on an even grid to ensure full site coverage and to ensure a minimum 25m^2 grid was achieved.

5.2 Soil Sampling Methodology

The exploratory holes were logged in accordance with the requirements of BS5930: 2015 and BSEN14688 Part 1&2.

Visual and olfactory evidence of contamination was noted if encountered. These observations were used to aid scheduling of samples for chemical laboratory analysis.

Soil samples were collected at distinct changes in lithology, or on the basis of field observations.

Samples were collected with a clean trowel or by hand (using dedicated nitrile gloves for each sampling location). Samples were placed immediately into laboratory supplied sampling containers, specific to the type of analyses required.

All sample containers were sealed and labelled with a unique location identity, depth and date of sampling.

5.3 Laboratory Analysis

5.3.1 Chemical Analysis

All soil samples were transported in cool boxes at the end of the day under a chain of custody regime to Chemtest, who are a UKAS accredited laboratory. Analyses were conducted to MCerts standards where applicable.

Chemical analysis was scheduled on a total of 5 no. soil samples between the depths of 0.30m and 1.2m bgl for a range of chemical parameters including: Toxic 9 metals, pH, asbestos ID, volatile and semi-volatile organic compounds (VOCs and SVOCs) and TPH criteria working group.

5.3.2 QA/QC

Field methods and procedures complied with accepted industry standards (BS10175:2011 & A2:2017). These standards include the use of specified sample pot types and agreed sampling decontamination procedures.

All samples were transported from the site to the analytical laboratory under a chain of custody regime within cool boxes containing ice packs. All analytical results were subjected to a QA/QC validation check to ensure they met the Laboratory's target criteria.

5.3.3 Geotechnical Analysis

The following in-situ and laboratory testing outside the scope of BS1377 was also undertaken:

Table 6 – BS:1377 Testing

BS Test No.	Test Description
Part 3:5, 9	Sulphate content, pH value
Part 2:5, 3	Atterberg limits
Part 2:9, 2	Particle Size Distribution

Table 7 - Non-BS:1377 Testing

Standard or Methodology	Test Description
BRE Special Digest 1	Total Sulphate, Aqueous Extract Sulphate, Total Sulphur, pH

6 Ground Conditions

6.1 Topsoil

Topsoil was encountered at the surface beneath a layer of grass/turf in all exploratory holes. The topsoil generally consists of brown loamy clayey soil.

6.2 Diamicton

Natural superficial deposits were encountered in all boreholes beneath the topsoil. The diamicton deposits ranged in thickness from 1.70m and 2.80m with the thickness increasing towards the south.

The diamicton generally consists of firm to stiff brown slightly sandy slightly gravelly clay with bands of sandy gravel. Gravel layers were encountered in WS2 and WS3 only with a maximum thickness of 0.80m.

Uncorrected SPT N values for the cohesive diamicton deposits range between 4 and 17 which indicates a low to high strength clay with an approximate undrained shear strength range of between 20kN/m^2 and 85kN/m^2 using the general approximation of:

Undrained shear strength = N x 5 (after Stroud, 1974).

Based on these results, then it is considered that a Characteristic Shear Strength of 50kN/m^2 can be adopted for foundation design.

6.3 Bedrock

Bedrock deposits of the Pennine Lower Coal Measures Formation were encountered at depths of between 1.90m and 3.0m bgl.

The bedrock was recovered as weakly cemented extremely weak to very weak weathered brown sandstone.

Uncorrected SPT N values recorded blows in excess of 50 within the sandstone material where testing was terminated.

Borehole logs are included in **Appendix E**.

6.4 Groundwater

Groundwater inflows were not recorded during the investigation.

6.5 Visual/Olfactory Evidence of Contamination

6.6 Chemical Analysis

A copy of the laboratory test certificates is included in **Appendix F**. The results of the chemical analysis are assessed in Section 8.

7 Geotechnical Test Results and Appraisal

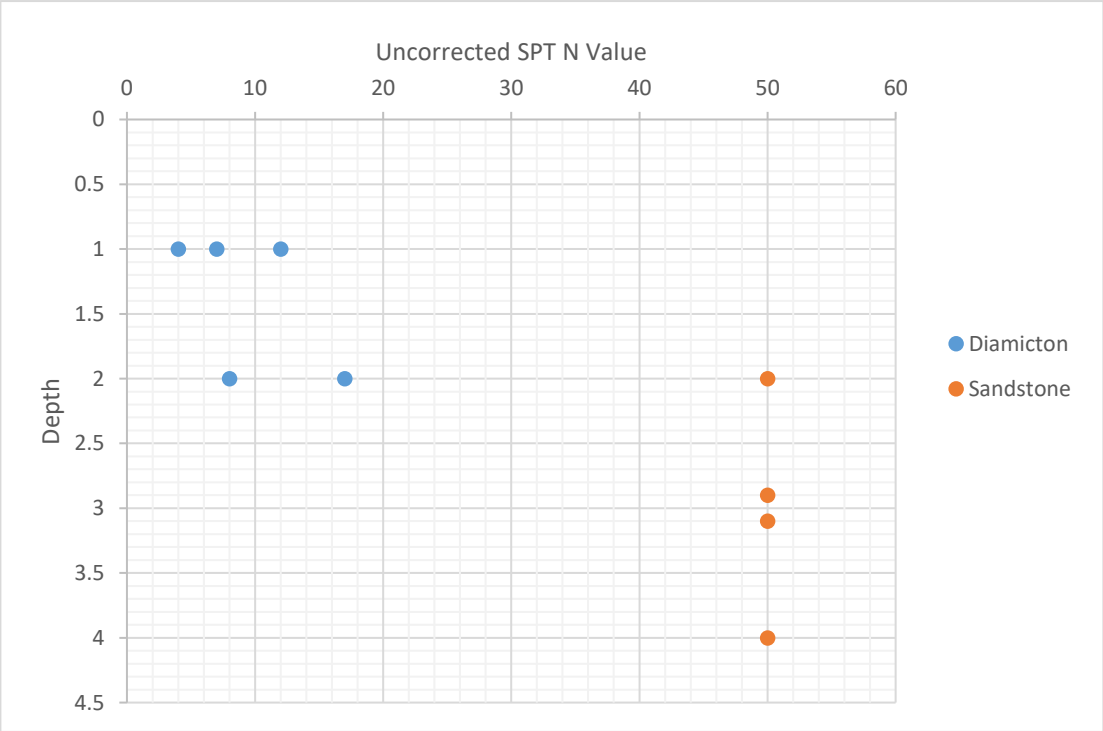
7.1 Geotechnical Model

Table 8 - Geotechnical Model

Stratum	Depth to Base (m bgl)	Parameters/ Comments	
		Strength Parameters	Other Parameters/ Notes
Topsoil	0.20m	None Recorded	Brown loamy clayey topsoil
Diamicton	1.90m – 3.0m	SPT N values 4 – 17	Firm to stiff brown slightly sandy slightly gravelly clay with bands of sandy gravel
Pennine Lower Coal Measures (Sandstone)	Not Proven	SPT N values >50	Weakly cemented extremely weak to very weak weathered brown sandstone

A total of 9 no. Standard Penetration Tests (SPTs) were performed during the drilling works. The results are recorded on the borehole logs at the appropriate depths and are displayed on the graph below.

SPT – Depth Plot



7.2 Laboratory Test Results

7.2.1 Chemical Results

The results of chemical testing carried out in accordance with BRE Special Digest 1:2005 Concrete in Aggressive Ground are summarised as follows: (See **Appendix G**).

Table 9 - Laboratory Test Data

Material	Property	No. of Tests	Range of Results	Characteristic Values (BRE Special Digest 1)	Design Sulphate Class and ACEC Class
Diamicton	Sulphate (SO_4) by 2:1 water soil extract (mg/l)	2	54 – 243	243	**DS-1** **AC-1**
	pH	2	8.7 – 8.9	8.7	
	Total Sulphur %	2	<0.02 – 0.05	0.05	
	Chloride by 2:1 water soil extract (mg/l)	2	11 – 15	N/a	N/a
	Nitrate by 2:1 water soil extract (mg/l)	2	4.5 – 6.4	N/a	N/a

7.2.2 Plasticity Results

The results of the plasticity testing are included in **Appendix G** and summarised below:

Table 10 - Plasticity Results

Sample	Plastic Limit	Plasticity Index	Modified Plasticity Index	Volume Change Potential
WS1 at 1.50m	12	12	9	Low
WS3 at 2.0m	13	12	9	Low

The above results indicate a low plasticity clay soil with a low volume change potential.

7.2.3 Moisture Content

The results of the moisture content testing are included in **Appendix G**. The results show a range in moisture content from 7.6% to 14.2%.

7.3 Appraisal

7.3.1 Foundations

The underlying natural diamicton deposits are considered to be adequate bearing material. It is considered that conventional shallow spread foundations can be used with an allowable bearing pressure of 85kN/m^2 can be adopted for foundation design assuming a foundation width of 1m and that the water table is below the base of the foundation.

Foundation excavations should be checked by an experienced ground worker prior to placing concrete. Any soft spots or unsuitable founding materials (very loose sand and gravel) should be removed if encountered and replaced with compacted granular fill or lean mix concrete. Should both granular and cohesive material be present at the proposed formation level, it is recommended that excavations are locally deepened, or foundations appropriately reinforced to span material with different settlement properties.

Initial designs may consider the use of ground bearing floor slabs.

7.3.2 Excavations and Groundwater

Groundwater was not recorded during the ground investigation.

Sump pumps should be adequate for dewatering shallow excavations if required. Advice on groundwater control in construction is given in CIRIA Report C515: Groundwater Control Design and Practice.

Shallow foundation excavations within the sand would not remain stable in the short-term. Excavations would need to be either be fully supported or battered back to a safe angle of repose.

Further advice on excavation support is given in CIRIA Document 97: Trenching Practice.

7.3.3 Concrete Design

The results from the chemical laboratory sulphate and pH analysis for the site indicate a Design Sulphate Class of DS-1 and an Aggressive Chemical Environment for Concrete (ACEC) class of AC-1.

8 Generic Quantitative Risk Assessment

8.1 Introduction

The quantitative risk assessment has been undertaken in general accordance with guidance issued by the Environment Agency and comprises a Generic Quantitative Risk Assessment (GQRA) which screens site concentrations against Generic Assessment Criteria (GAC) based on the Preliminary Risk Assessment (PRA) and associated Preliminary Conceptual Site Model in Section 4. Where a concentration exceeds the GAC, the substance is confirmed as a Contaminant of Concern (CoC).

8.2 Human Health Assessment

8.2.1 Long Term Human Health Risks

Taking into account the proposed land use at the site (residential) GAC for residential land use with plant uptake has been adopted as the GAC for this assessment as it is considered feasible that private garden areas may be used to grow homegrown produce (see **Appendix H**).

The source of the GAC utilised for this assessment comprise the CLEA Soil Guideline Values (SGVs) and LQM 'Suitable 4 Use Levels' and Category 4 Screening Levels'.

All substances detected in the soil beneath the site were at concentrations below the GAC (see **Appendix H)**, thus indicating a low risk to future site users from the identified substances in the shallow soils beneath the site.

Asbestos was not detected in any of the exploratory borehole locations, thus indicating a low risk to future site users from asbestos in the shallow soils beneath the site.

8.2.2 Short Term Risks

During the redevelopment of the site, it will be necessary to implement measures to protect construction workers, and adjacent site users from the soil contaminants identified at the site. In addition, to ensure that they do not come into contact with contaminated soils and / or groundwater, construction workers and site visitors should wear appropriate personal protective equipment (PPE). Health and safety procedures would ensure that ingestion of contaminated soils and / or groundwater is avoided (e.g. by washing hands prior to eating, drinking and smoking).

8.3 Buildings and Buried Services

It is considered that the foundations for the proposed development could be at risk of attack from any aggressive chemicals contained within the ground. In line with the recommendations with BRE Special Digest 1 (2005) "Concrete in Aggressive Ground", the Design Sulphate Class for the site is likely DS-1 and AC-1 as previously detailed in Section 7.2.1.

Plastic pipe materials are potentially vulnerable to attack from elevated levels of hydrocarbons, which can potentially lead to contamination of potable water supplies, and water supply companies require the risk to their workers from other contaminants in the ground to be assessed. Therefore, if new water supply pipes are to be installed on site, it is

recommended that discussions are undertaken with the water supply company to confirm their requirements.

8.4 Controlled Waters

The site is directly underlain by superficial diamicton deposits which are of low permeability and do not form a significant groundwater aquifer. It is considered that the diamicton will act as an impermeable barrier, preventing any migration of potential contaminants to the underlying groundwater aquifers. Local borehole information confirms the diamicton deposits are generally cohesive in nature.

There are no surface water features identified in the surrounding area.

The site is not located within a Source Protection Zone and there are no groundwater abstraction licences held within a 1km radius of the site. The risk to controlled waters is deemed to be low.

8.5 Ground Gas

The conceptual site model identified that the site lies within a high probability area for naturally occurring radon gas. No further sources of contamination have been identified. Full radon protective measures would be required for any future development.

Further guidance can be found in BR 211 (2015) 'Radon: Guidance on protective measures for new buildings'.

9 Conclusions and Recommendations

9.1 Contaminated Land

The recent intrusive ground investigation has shown that the development site has no Made Ground within the shallow soils.

A total of 5 no. soil samples were collected and analysed for a range of chemical parameters. Low level soil contaminants (e.g. heavy metals) have been detected the shallow soils beneath the site. However, generic quantitative risk assessments have proven that they will not present a risk to any of the receptors identified in the preliminary conceptual site model, if they remain present beneath the site following redevelopment.

The conceptual site model identified that the site lies within a high probability area for naturally occurring radon gas. No further sources of contamination have been identified. Full radon protective measures would be required for any future development.

Further guidance can be found in BR 211 (2015) 'Radon: Guidance on protective measures for new buildings'.

It is recommended that discussions are undertaken with the water supply company to confirm their requirements for water supply pipes.

9.2 Geotechnical

The underlying diamicton deposits are considered to be adequate bearing material. It is considered that conventional shallow spread foundations can be used with an allowable bearing pressure of 85kN/m^2 can be adopted for foundation design assuming a foundation width of 1m and that the water table is below the base of the foundation.

Foundation excavations should be checked by an experienced ground worker prior to placing concrete. Any soft spots or unsuitable founding materials (very loose sands and gravels) should be removed if encountered and replaced with compacted granular fill or lean mix concrete. Should both granular and cohesive material be present at the proposed formation level, it is recommended that excavations are locally deepened, or foundations appropriately reinforced to span material with different settlement properties.

Initial designs may consider the use of ground bearing floor slabs.

The results from the chemical laboratory sulphate and pH analysis for the site indicate a Design Sulphate Class of DS-1 and an Aggressive Chemical Environment for Concrete (ACEC) class of AC-1.

REFERENCES

1. Environment Agency (2020) Land Contamination Risk Management Report LCRM "How to assess and manage the risks from land contamination".
2. BS10175:2011 & A2:2017: Investigation of Potentially Contaminated Sites – Code of Practice.
3. British Standard BS 5930:2015: Code of Practice for Site Investigations. British Standards Institute (2015).
4. BS EN ISO 14688-1:2002+A1:2013: Geotechnical Investigation and Testing. Identification and Classification of Soil. Identification and Description.
5. BS 1377-2:1990**:** Methods of Test for Soils for Civil Engineering Purposes. Classification Tests.
6. BRE Special Digest 1: Concrete in Aggressive Ground (2005).
7. NHBC Technical Standards, Part 4 Foundations, Chapter 4.2 Building Near Trees.
8. CIRIA Report 97: Trenching Practice (1992).
9. CIRIA Report C515: Groundwater Control Design and Practice.
10. Environment Agency: Contaminated Land Exposure Assessment - Soil Guideline Values for Human Health Risk Assessment.
11. LQM/CIEH: S4ULS for Human Health Risk Assessment. Land Quality Press (2015). (Copyright Land Quality Management Limited reproduced with permission, publication number S4UL3505. All rights reserved).
12. SP1010: Category 4 Screening Levels for Assessment of Land Affected by Contamination. DEFRA (2014).
13. The Chartered Institute of Environmental Health. The Local Authority Guide to Ground Gas (2008).
14. CIRIA 665: Assessing Risks posed by Hazardous Ground Gases to Buildings (2007).
15. BS8485: Code of Practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings (2015).