GEOENVIRONMENTAL SITE INVESTIGATION REPORT

PHASE II SITE INVESTIGATION

OF LAND AT

SOLAR FARM,

WREXHAM

Prepared for:-

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1.0 INTRODUCTION

1.1 Instruction

1.1.1 GeoCon Site Investigations Ltd (GeoCon) have been commissioned by Innova Renewables Developments Limited to undertake a Phase II Geoenvironmental Site Investigation on land at Solar Farm, Wrexham.

1.1.2 It is understood that this is required following the results of a Phase I Preliminary Risk Assessment carried out by GeoCon Site Investigations in December 2023 referenced GSI 2006 MP PI Report V1 which should be referred to in conjunction with this report.

1.1.3 This report is therefore provided to establish the potential for contamination at the site as a result of current and historic land uses both on site and within influencing distance of the site, to understand the type nature and extent of contamination present, and, to identify the ground conditions and provide details of the engineering properties of the underlying soils and rocks encountered with subsequent recommendations on suitable foundation solutions for the proposed development.

1.1.4 This report is written in accordance with the guidance set out in Land Contamination Risk Management (LCRM), Guiding Principles for Land Contamination (GPLC) 1 – 3, and the National Planning Policy Framework (NPPF).

1.2 Scope of Works

1.2.1 Prior to commencing the site works the proposed scope of investigation was as follows, however the proposed scope will be subject to change dependent upon site conditions, access, restrictions and obstructions. The actual works undertaken following the completion of the site works and any on site amendments are detailed in section 3.0.

- Four days dynamic sample boreholes to a nominal depth of up to 5.00m bgl or refusal.
- Three days TRL DCP tests to provide CBR values for the proposed access roads and car parking areas at the site.
- Insitu environmental and geotechnical sampling, and insitu geotechnical testing.
- Full supervision of all works by engineering geologist including sampling and detailed geotechnical descriptions to BS5930, EN ISO 14688-1 EN ISO 14688-2 and EN ISO 14689 of all strata types encountered within the exploratory holes.
- A suite of chemical laboratory analysis.
- A suite of geotechnical laboratory analysis.
- Production of an interpretative report including Generic Quantitative Risk Assessment (GQRA) and updated Conceptual Site Model (CSM), and geotechnical assessment.

1.3 Previous Investigations

1.3.1 A Phase I Preliminary Risk Assessment referenced GSI 2006 MP PI Report V1, dated December 2023 was produced by GeoCon Site Investigations and the findings are summarised below.

1.3.2 The following preliminary risks were identified by GeoCon:

- Site end users from contaminated soils – Low Risk
- Site end users from inhalation of vapours – Low to Moderate Risk
- Site end users from inhalation of gas – Low to Moderate Risk

- Controlled waters – Low to Moderate Risk

1.3.3 The following assessment should be made in full reference to this report.

1.4 Reliance and Limitations

1.4.1 This report has been prepared using published information and information provided by the Client and their professional advisers which has been made available to GeoCon at the time of writing only. GeoCon accepts no liability for any changes resulting from new information which has become available since this time.

1.4.2 This report is provided for the sole use of the client and their professional advisors and is confidential to them unless agreed otherwise in writing. This report may only be used and relied on once the work has been paid for in full.

1.4.3 GeoCon owes no duty of care and has no liability to any third party who is not authorised by GeoCon to use this report. Any unauthorised third parties using information contained in this report do so at their own risk.

1.4.4 This assessment has been carried out to determine the potential risks posed to future end users, along with other key receptors, resulting from potential contamination at the site, based on the proposed development. Should any revisions in the development proposals result in a change any assessment parameters detailed in this report, a re-assessment of the risk should be carried out.

1.4.5 Whilst this report may reference observations made regarding the presence of features/ issues such as invasive species, ACM, site drainage and evidence of structural abnormalities, this report does not constitute specialist surveys on these matters. Should further specialist surveys be carried out in this regard, the findings of these should be reported to GeoCon so that we may determine if this has any impact on the findings of this report.

1.4.6 The assessment and interpretation of the factual data obtained as part of this Phase II Site Investigation has been undertaken in accordance with standard consulting practice and with current national and international guidance.

1.4.7 This report presents the observations made during the Phase II Site Investigation and the factual data obtained. The conclusions and recommendations in this report are limited to those which can be made based on the findings of the survey and information provided by third parties. GeoCon assumes all third party data to be true and correct. No responsibility can be accepted by GeoCon for inaccuracies in the information provided by any other party.

1.4.8 This report is written in the context of an agreed scope of works and should not be used in a different context. Furthermore, new information, improved practices, and changes in legislation may require the reinterpretation of the report in whole or in part after its original issue. GeoCon reserve the right to alter their conclusions and recommendations in the light of further information that may become available. This report is provided for the sole use of the client and their professional advisers and is confidential to them unless agreed otherwise in writing.

1.4.9 Ground conditions can be variable and change rapidly, especially in areas of Made Ground, however it is assumed that the ground conditions encountered and observed are typical and representative of the site as a whole. Most specifically with regard to this limited investigation, the ground conditions have been determined from a limited number of exploratory holes formed across the site, therefore only a small percentage of the total area of the site has been investigated. Interpolation between exploratory holes has enabled a general picture of the subsurface conditions to be produced. Conclusions drawn from the ground investigation should be read in this context. GeoCon cannot accept responsibility for any situations resulting from locally unforeseen ground conditions occurring between exploratory holes.

1.4.10 In addition, subsurface conditions including contaminant concentrations and groundwater levels may vary spatially with time. This factor should be given due consideration in the event that the information contained within this report is used after any significant period of time has elapsed.

2.0 SITE LOCATION AND DESCRIPTION

2.1 Site Location

2.1.1 The site is located at land adjacent to Williams Farm Solar, Wrexham, at approximate National Grid Reference NGR: 337930:348420 (centre of the site).

2.1.2 A site location plan is presented as Drawing No. GSI 2006/01 in Appendix A.

2.2 Site Description

2.2.1 The site is an irregular shaped piece of land with an approximate area of 9.63Ha. The site begins to the west with a narrow corridor of land stretching eastwards from the entrance of the site. The site become wider to the east and opens up to the north and east and south.

2.2.2 The topography of the site generally slopes towards the north and the river channel on the northern boundary with localised undulations present.

2.2.3 The site is predominantly undeveloped agricultural grazing land, with small derelict bricked buildings located in the eastern portion of the site which have become overgrown with vegetation and rubble. Small amounts of fly tipping is present in small localised areas on the site including timber, plastics and car tyres. The structures on site show evidence of connected electric and power, and manhole covers along the connecting perimeter of site. An electric substation is present on the site boundary to the adjacent Solar Farm. Overhead power lines are in the west of site. The access track in the east of site is of poor condition. Ground conditions during the site walkover indicated soft and boggy ground with the most impacted area identified in the north of site located closer to the River Clywedog. The river at the northern extents has mature trees present along the low banks of the river channel. Standing surface water was also present towards this area.

2.2.4 An approximate distribution of the surface covering is given below in Table 2.1: Site Surface Covering.

Table 2.1: Site Surface Covering

Type of Surface Cover	Distribution (%)
Soft Ground (grassed and landscaped areas)	85
Hardstanding	0
Roadways	5
Buildings	10
Water (ponds, streams)	0

2.2.5 The site is bound by the River Clywedog northwest, fence line, hedges and established trees to the east. The south and west of site is bound by the adjacent fence line of Williams Solar Farm.

2.2.6 Access to the site is via unnamed road off the east of Bedwell Road.

2.2.7 A selection of photographs from the site walkover are presented as GSI 2006/02 in Appendix A.

2.3 Surrounding Area

2.3.1 The current surrounding land use to the site is generally grassland and agricultural properties in all directions, with the solar farm present adjacent to the site to the immediate south, and the meandering River channel to the north.

2.3.2 The topography of the surrounding area is sloping down towards the north; contour maps show a slight decline in elevation to the west.

2.4 Future Site Usage

2.4.1 It is currently proposed to construct additional extension to the preexisting solar farm development adjacent to the site, referenced WR-EX-258-06-01 and contained with Appendix A. The development contains a number of structures in Field 1B and 1C, with access roadway infrastructure proposed and the open areas of the site populated with rows of solar panels installed.

2.4.2 This assessment has been carried out with reference to this proposed development plan as provided by the client, any changes to the proposed development may result in this assessment requirement updating.

3.0 GROUND INVESTIGATION

3.1 General

3.1.1 The intrusive investigation was carried out between 20th and 23rd February 2024.

3.1.2 The ground investigation has been carried out in accordance with BS5930 and the UK Specification for Ground Investigation Second Edition 2012.

3.1.3 All strata descriptions were undertaken in accordance with BS5930 Amendment 1; EN ISO 14688 -1; EN ISO 14688 -2; and EN ISO 14689.

3.1.4 The actual ground investigation comprised the formation of:

- 18 No. Dynamic sampling boreholes.
- Two days TRL DCP probe holes.
- UXO Borehole Clearance Specialist
- Insitu geotechnical and geoenvironmental testing and sampling.
- Full supervision of all works by engineering geologist including sampling and detailed geotechnical descriptions to BS5930, EN ISO 14688-1 EN ISO 14688-2 and EN ISO 14689 of all strata types encountered within the exploratory holes.
- A suite of geotechnical laboratory analysis.
- A suite of chemical laboratory analysis.
- Production of an interpretative report.

3.1.5 The ground investigation was carried out to determine the geotechnical and geoenvironmental properties of the soils and rock beneath the site for a proposed residential development at the site.

3.1.6 The locations of the exploratory holes were specified by GeoCon and were positioned to gain key information beneath the site in relation to the proposed development.

3.1.7 All locations were checked against buried service location plans and then scanned with a Cable Avoidance Tool (CAT) and Genny prior to excavation, and a permit to dig was then issued. Each location was then continued by hand down to a minimum of 1.20mbgl to clear any buried services or other subsurface obstructions. All locations were then checked again with a Cable Avoidance Tool (CAT) at the base of the hand excavated inspection pit by GeoCon prior to commencement of drilling.

3.1.8 All access permissions were arranged by Client prior to the ground investigation commencing.

3.1.9 An exploratory hole location plan is presented in Appendix A as drawing number GSI 2006/02.

3.2 Dynamic Sample Boreholes

3.2.1 Eighteen dynamic sample boreholes were drilled at the site, referenced WS01 – WS18, to depths of between 0.70m to 5.00mbgl.

3.2.2 The Dynamic sample boreholes were drilled using a tracked Dynamic sample rig in order to facilitate geoenvironmental sampling and to gain an understanding of the environmental and geotechnical properties of the soils and rock beneath the site.

3.2.3 The dynamic sample boreholes were drilled using 100mm diameter barrel reducing in size with depth. to achieve the target depths.

3.2.4 All dynamic sample borehole logs are presented in Appendix B.

3.3 CBR Testing (by TRL DCP method)

3.3.1 A series of TRL DCP probe holes were undertaken along the lines of the proposed roads. The TRL DCP consists of an 8kg mass falling through 575mm onto an anvil, which drives a 20mm diameter 60° cone into the ground. The number of blows required to drive the cone through measured increments are recorded. The results of the TRL DCP tests are presented as graphs of the number of blows and CBR values versus depth.

3.3.2 The TRL DCP testing results are presented in Appendix C.

3.4 UXO Borehole Clearance

3.4.1 All boreholes were surveyed by a UXO Borehole Specialist to assist with drilling by way of down-borehole clearance. No anomalies were detected on any of the exploratory hole locations and therefore the risk of encountering UXO is considered to have been reduced to low as reasonably practical.

3.4.2 The UXO Borehole Clearance Report is presented in Appendix D.

3.5 Sampling and Insitu Testing

3.5.1 The environmental and geotechnical sampling regime and insitu testing regime included the following:

- Environmental samples for subsequent chemical analysis were taken from each strata type, with a minimum of three samples taken from the upper 1.00 m, then at 1.00 m intervals in Made Ground with a minimum of one sample from the natural strata.
- Small disturbed samples taken from each strata type and then at 1.00 m intervals thereafter.
- Bulk disturbed samples taken at 1.00 m intervals to a depth of 5.00 mbgl, then 1.50 m intervals thereafter
- Insitu Standard Penetration Tests (SPTs) were carried out at 1.00 m intervals down to 5.00 mbgl and at 1.50 m intervals thereafter in granular soils to collate insitu strength information (relative density) for the soils beneath the site.

3.5.2 Soil samples were collected for environmental and geotechnical analysis by the engineering geologist on site based on physical and visual inspection in addition to standard sampling.

3.5.3 All samples were stored in pre-chilled cool-boxes prior to immediate dispatch to laboratory. Where there has been a delay in transporting the samples to the laboratory, samples have been kept in a cool dark storage unit inside cool boxes packed with ice, which is regularly replaced to maintain sample quality.

3.5.4 The environmental samples were subsequently transported to a chemical laboratory in plastic tubs, glass jars and soils vials. The geotechnical samples were subsequently transported to a geotechnical laboratory in prepared bulk bags and plastic tubs.

3.6 Backfill

3.6.1 All exploratory holes were backfilled with arisings and made level at the surface to a similar condition as prior to the work.

3.7 Groundwater

3.7.1 Where groundwater was encountered a waiting period of 20 minutes was allowed to monitor any change (rise or fall) in the levels of each groundwater strike.

3.8 Laboratory testing

3.8.1 Chemical laboratory testing was subsequently carried out on selected samples of soil. Further details of the chemical laboratory testing are given within section 5.0 – Chemical Testing and Results.

3.8.2 All chemical laboratory testing has been scheduled by GeoCon.

3.8.3 Geotechnical laboratory testing was subsequently carried out on selected samples of soil. Further details of the geotechnical laboratory testing are given within section 7.0 – Geotechnical Testing and Results.

3.8.4 All geotechnical laboratory testing has been scheduled by GeoCon.

3.9 Restrictions

3.9.1 It should be noted that a section of the northern area of the site, closest to the river, could not be access during this phase of exploratory works due to flooding from the river.

4.0 GROUND CONDITIONS

4.1 Published Geology

4.1.1 The British Geological Survey shows the site to be underlain by the geological succession outlined below.

Table 4.1: Published Geology

Geology	Description /strata	BGS General Description (Lexicon)
Artificial	Landscaped Ground	Artificially Modified Ground
Superficial	Till and Alluvium	Gravel, Sand, Clay and Silt
Bedrock	Kinnerton Sandstone Formation	Sandstone

4.2 General

4.2.1 A generalised summary of the ground conditions encountered, depths to base, and thickness recorded from the exploratory hole records is presented below in Table 4.2: Summary of Ground Conditions.

Table 4.2: Summary of Ground Conditions

Geology / Strata	Depth (mbgl)				Thickness (m)		Locations encountered
	Top		Base		Min	Max	
	Min	Max	Min	Max			
Topsoil	0.00	-	0.20	0.70	0.20	0.70	All locations
Made Ground	0.00	-	0.70	-	0.70	-	WS02 & WS16
Clay	0.20	3.40	1.10	5.00	0.90	4.80	All locations
Gravel	0.80	4.00	1.50	5.00	0.70	4.20	WS02, WS03, WS04, WS09, WS11, WS12, WS13, WS14, WS15, WS17 & WS18
Sand	1.80	3.90	2.40	5.00	0.60	3.20	WS02, WS07, WS14 & WS17
Groundwater	**Strike depth (mbgl)**		**Rest Level (mbgl)**		**Locations encountered**		
	Min	**Max**	**Min**	**Max**			
Strike	0.30	2.40	0.30	2.40	WS01, WS02, WS03, WS04, WS07, WS09, WS10, WS11, WS12, WS13, WS14, WS15, *WS17 & WS18*.		

4.2.2 The general ground conditions encountered have been summarised below.

4.2.3 Detailed strata descriptions are presented on the dynamic sample borehole logs, Appendix B.

4.3 Made Ground

4.3.1 Made Ground was encountered in WS02 and WS16 from ground level to a maximum depth of 0.70mbgl, and described as gravelly clay with fragments of glass, plastic, brick and concrete within WS02, and a concrete obstruction within WS16.

4.4 Topsoil

4.4.1 Topsoil was encountered in in all locations from ground level to a maximum depth of 0.70mbgl and generally comprised sandy gravelly clay with abundant rootlets.

4.5 Superficial Deposits

4.5.1 Clay deposits were encountered in WS01, and WS03 to WS18 directly beneath the topsoil to depths of between 1.10 and 5.00mbgl, and generally comprised firm sandy gravelly clay.

4.5.2 Gravel deposits were encountered underlaying the cohesive deposits in WS02 to WS04, WS09 to WS15, and WS17 to WS18 and were proven to depths of between 1.50 and 5.00mbgl, and generally comprised medium dense to dense clayey sandy gravel.

4.5.3 Sand deposits were encountered in WS02, WS07, WS14 and WS17 and were encountered to depths of between 2.40 and 5.00mbgl, and generally comprised medium dense to dense clayey gravelly sand.

4.5.4 These soils are considered to represent the Till and Alluvium superficial deposits.

4.6 Bedrock

4.6.1 Bedrock was not encountered during this ground investigation.

4.7 Groundwater

4.7.1 Groundwater was encountered in 14 of the 18 exploratory holes formed across the site. Further details are as follows:

- WS01 – strike at 1.70mbgl remaining stable after 20 minutes.
- WS02 – strike at 1.60mbgl remaining stable after 20 minutes.
- WS03 – strike at 1.50mbgl remaining stable after 20 minutes.
- WS04 – strike at 1.70mbgl remaining stable after 20 minutes.
- WS07 – strike at 2.40mbgl remaining stable after 20 minutes.
- WS09 – strike at 1.80mbgl remaining stable after 20 minutes.
- WS10 – strike at 1.00mbgl remaining stable after 20 minutes.
- WS11– strike at 1.70mbgl remaining stable after 20 minutes.
- WS12 – strike at 0.40mbgl remaining stable after 20 minutes.
- WS13 – strike at 0.40mbgl remaining stable after 20 minutes.
- WS14 – strike at 0.30mbgl remaining stable after 20 minutes.
- WS15 – strike at 0.40mbgl remaining stable after 20 minutes.
- WS17 – strike at 1.80mbgl remaining stable after 20 minutes.
- WS18 – strike at 1.60mbgl remaining stable after 20 minutes.

4.8 Groundwater Monitoring

4.8.1 GeoCon have not been commissioned to carry out any groundwater monitoring at the site.

4.9 Obstructions

4.9.1 It should be noted that WS16 could not be drilled due to a concrete obstruction at 0.70mbgl.

4.10 Contamination

4.10.1 No visual or olfactory evidence of contamination was encountered or observed during this ground investigation, in particular no obvious visual or olfactory evidence of mobile contamination was observed during the ground investigation.

5.0 CHEMICAL TESTING AND RESULTS

5.1 General

5.1.1 All samples were sent to a UKAS accredited chemical testing laboratory, and MCERTS were used where available. The analytical strategy focussed on a general suite of potential contaminants and the analytical suites are summarised in Table 5.1: Summary of Chemical Testing Suite. Chemical results have been screened against current guideline values where applicable for a commercial end use.

5.1.2 All chemical testing results are presented in Appendix E.

Table 5.1: Summary of Chemical Testing Suite

Testing	Comment	No. of soil samples analysed
General heavy metals and inorganics suite including: Arsenic, cadmium, chromium, copper, cyanide, lead, mercury, nickel, phenol, selenium, zinc, pH, and water soluble sulphate	General analysis of soils beneath the site to achieve general site coverage, and targeting former uses on site and off site within influencing distance	12
Speciated PAH	General analysis of soils beneath the site to achieve general site coverage, and targeting former uses on site and off site within influencing distance	8
TPH CWG	General analysis of soils beneath the site to achieve general site coverage, and targeting former uses on site and off site within influencing distance	8
VOC's	General analysis of soils beneath the site to achieve general site coverage, and targeting former uses on site and off site within influencing distance	8
SVOC's	General analysis of soils beneath the site to achieve general site coverage, and targeting former uses on site and off site within influencing distance	8
PCB's	General analysis of soils beneath the site to achieve general site coverage, and targeting former uses on site and off site within influencing distance	8
Asbestos Screen	General analysis of soils beneath the site to achieve general site coverage, and targeting former uses on site and off site within influencing distance	8
WAC	General analysis of soils beneath the site to achieve general site coverage, and targeting former uses on site and off site within influencing distance	4

5.2 Chemical Testing Results

5.2.1 Only detectable concentrations of contaminants reported above the laboratory detection limits are presented overleaf below in Total Organic Carbon (TOC) was analysed in all three samples from the site. The results of the TOC recorded values between 0.20 and 5.20%. From this Soil Organic Matter (SOM has been calculated at values of between 0.34 and 8.97. Therefore, a worst case scenario of 1% SOM has been used where appropriate in the chemical assessment overleaf.

5.2.2 Table 5.2: Summary of Soil Chemical Testing Results. All other samples recorded contaminant concentrations below laboratory detection limits.

5.2.3 Total Organic Carbon (TOC) was analysed in all three samples from the site. The results of the TOC recorded values between 0.20 and 5.20%. From this Soil Organic Matter (SOM has been calculated at values of between 0.34 and 8.97. Therefore, a worst case scenario of 1% SOM has been used where appropriate in the chemical assessment overleaf.

Table 5.2: Summary of Soil Chemical Testing Results

Determinand	No. Of samples analysed	Screening value (mg/kg) (where applicable)	Determinand concentration range (mg/kg)		No of Samples exceeding screening value
			Min	Max	
Cyanide (total)	12	373	BD	BD	0
Phenols - Total by HPLC	12	760	BD	BD	0
Arsenic	12	640	6.20	12.00	0
Cadmium	12	190	BD	3.60	0
Copper	12	68000	7.10	43.00	0
Chromium	12	8600	13.00	39.00	0
Hexvalent Chromium	12	33	BD	BD	0
Lead	12	6000	15.00	1000.00	0
Mercury	12	58	BD	BD	0
Nickel	12	980	15.00	43.00	0
Selenium	12	12000	BD	BD	0
Zinc	12	730000	39.00	730.00	0
Acenaphthene	12	84000	BD	BD	0
Acenaphthylene	12	83000	BD	BD	0
Anthracene	12	520000	BD	0.12	0
Benzo(a)anthracene	12	170	BD	BD	0
Benzo(a)pyrene	12	35	BD	0.27	0
Benzo(b)fluoranthene	12	44	BD	0.36	0
Benzo(ghi)perylene	12	3900	BD	0.19	0
Benzo(k)fluoranthene	12	1200	BD	0.11	0
Chrysene	12	350	BD	0.22	0
Dibenzo(ah)anthracene	12	3.5	BD	0.07	0
Fluoranthene	12	23000	BD	0.35	0
Fluorene	12	63000	BD	0.07	0
Indeno(123-cd)pyrene	12	500	BD	0.17	0
Naphthalene	12	190	BD	BD	0
Phenanthrene	12	2200	BD	0.12	0
Pyrene	12	54000	BD	0.33	0
TPH: Total Aliphatic	8	-	BD	29.27	0
TPH: Total Aromatic	8	-	BD	28.00	0

BD = Below Detection

5.2.4 Twelve samples were analysed for asbestos screen. No fibres were detected in any of the samples.

6.0 GENERIC QUANTITATIVE RISK ASSESSMENT (GQRA)

6.1 Criteria for interpretation

6.1.1 The regime for contaminated land was set out in Part IIA of the Environmental Protection Act (EPA) 1990, as inserted by S.57 of The Environment Act 1995 and came into effect in England on 1st April 2000 as The Contaminated Land (England) Regulations 2000 (SI 2000/227). These regulations were subsequently updated with the provision of The Contaminated Land (England) Regulations 2006 (SI 2006/1380), which consolidated the previous regulations and amendments and added in provisions regarding radioactive contaminated land. These regulations came into force on 4th August 2006. This modified the wording for "Contaminated Land" under Part IIA of the EPA. Section 78A (2) defines contaminated land as "land which appears to be in such a condition, by reason of substances in, on or under the land, that:

- significant harm is being caused, or there is a significant possibility of significant harm being caused (SPOSH);

Human Health Receptors

6.1.2 An initial Generic Quantitative Risk Assessment (GQRA) for human health has been undertaken by comparison of the soil analytical results with published guidance criteria. These can be classified as Generic Assessment Criteria (GAC) or Soil Screening Values (SSV's) and are widely referred to by consultants, Regulatory Authorities and other professionals within the industry and include the following:

- Land Quality Management (LQM) Chartered Institute of Environmental Health (CIEH) have published a series of GACs / SSV's via the CLEA v1.06 software which are applicable to the UK for common determinands.
- Defra Category 4 Screening Levels 2014 (C4SL's) for assessment of land affected by contamination.
- Current published Soil Guideline Values (SGVs) published by the Environmental Agency (EA).
- Contaminated Land: Applications in Real Environments (CL:AIRE) 'The Soil Generic Assessment Criteria for Human Health Risk Assessment' GAC's via the CLEA v1.06 software (updated version of the v1.04 update after the release of LQM GAC's).

6.1.3 It should be noted that the above guidance criteria are generally restricted with depth i.e. the values quoted with reference to human health are generally only applicable in the top 1.00m of soil and do not (dependant on the conceptual site model and conditions identified on site) necessarily identify significant harm.

6.2 Risk to Human Health

6.2.1 All chemical determinands recorded levels below the relevant screening criteria (where available) for a commercial end use.

6.2.2 It is understood that the proposed development comprises an extension of the pre-existing solar farm adjacent to the site.

6.2.3 Therefore, a pollutant linkage is not considered to be present and the risk to human end users are considered to be **very low** at this stage.

6.2.4 Risks to construction workers are considered to be **very low**. All construction workers should wear appropriate Personal Protective Equipment (PPE) including latex gloves and dust masks. Provisions should be made for water on site to 'damp down' any dust in dry conditions.

6.2.5 Risks to neighbours / general public are considered to be **very low**. Provisions should be made for water on site to 'damp down' any dust in dry conditions.

6.2.6 A watching brief should be maintained during construction to ensure that any unsuitable materials are removed at the time.

6.2.7 Should any erroneous materials or previously unidentified contamination be encountered during construction then further sampling and analysis may be required.

6.2.8 The above recommendations should be agreed in principle with the Local Planning Authority prior to development to avoid any delays or complications at a later stage.

6.3 Risk to Controlled Waters

Groundwater

6.3.1 The Environmental Agency aquifer classification scheme indicates that the superficial aquifers designation for the site are classed as Secondary A and Secondary A Undifferentiated Aquifers and the bedrock aquifer designation for the site is classed as a Principal Aquifer.

6.3.2 There are no public drinking water abstractions within 1000m of the site, but located within two Source Protection Zones (SPZ) – Zone II Outer Protection Zone, and a Zone III total catchment. Zone 1 Inner Protection Zone is indicated 308m northeast.

6.3.3 Therefore, based on the above information, the results of the soil testing, the generally permeable geology beneath the site, and considering that natural attenuation, dilution and dispersion will take place, the risks to groundwater and drinking waters are considered to be **Very low** at this stage.

Surface Water

6.3.4 The nearest surface watercourse to the site is the River Clywedog located adjacent to site along the northern boundary, flowing west to east.

6.3.5 Given the results of the soil testing, the distance of the surface water receptor to the site, and considering that natural attenuation, dilution and dispersion will take place, the risks to surface waters are considered to be **very low** at this stage.

6.4 Ground Gas Risk Assessment

General

6.4.1 There are no landfill sites or other waste associated sites within 250m of the site boundary. There are seventeen areas of potentially infilled land with the closest regarding a pond feature on site and potentially backfilled in 1961.

6.4.2 Made Ground was also encountered beneath the site in two localised areas and was encountered to depths of up to 0.70mbgl.

6.4.3 Considering the limited potential for ground gas generation identified, and the proposed use as a solar farm, the potential risk of ground gas is Very Low.

6.5 Plants and Native grasses

6.5.1 Any plants that may be grown at the site in areas of landscaping may potentially be at risk from phytotoxic elements in any artificial soils beneath the site. Guideline screening values are currently available for copper, nickel and zinc which are considered to be the most harmful to plant life.

6.5.2 All three chemical Determinands recorded levels below the relevant phytotoxic screening criteria. In addition, all plant growth appeared normal during the site walkover. Given the above and the generally low potential for contamination and the results of the wider soil analysis, the risks to plants and native grasses are considered to be very low.

6.6 Buried Services and Utilities

6.6.1 Any organic contamination present in the soils or groundwater beneath the site would pose a risk of premature failure to below ground services via chemical reaction. Based on the chemical analysis carried out during this ground investigation, the risks to buried services and pipelines are considered to be **low.**

6.6.2 It is the responsibility of the utility providers to confirm the risk status and determine what materials should be used in the provision of any newly proposed buried services and utilities based on the results of the chemical analysis with this report. A copy of this report should therefore be provided to the utility contractors.

6.6.3 It is recommended that prior to the placement of any newly proposed buried services, that adequate testing of the soils of which the pipes / cables will be laid in is carried out to determine the suitability of those soils for the utility provider's equipment.

6.7 Updated Conceptual Site Model (CSM)

6.7.1 Following the results of the site investigation and above assessment, an updated Conceptual Site Model (CSM) has been produced overleaf as Table 6.3: Updated Conceptual Site Model (CSM).

Table 6.3: Updated Conceptual Site Model (CSM)

Potential Sources	Contaminants of Concern	Potential Pathway	Potential Receptor	Potential Pollutant Linkage	Probability	Consequence	Risk Classification	Action / Mitigation / Justification
Made Ground both on site and within influencing distance of the site Current and former land uses both on site and within influencing distance of the site	Heavy metals, sulphates and inorganics PAH's Asbestos	Ingestion Inhalation Dermal Contact	**Human health** Including current site users, future site users	Considered potentially active	Unlikely	Mild	**Very Low**	Results of the site investigation confirm that all determinands analysed recorded levels below the relevant screening criteria. Therefore, no further action is required
			Human health Construction workers	Considered potentially active	Unlikely	Mild	**Very Low**	Construction personnel to adhere to standard PPE guidelines and hygienic site practices to control risk.
			Human health Neighbouring residents	Considered potentially active	Unlikely	Mild	**Very Low**	Results of the site investigation confirm that all determinands analysed recorded levels below the relevant screening criteria. Therefore, no further action is required.
Landfill sites Potentially infilled Land (ponds, quarries, reservoirs etc) Made Ground Natural organic soils Fuel Stations (on and off-site sources)	Hazardous ground gases including CO_2, CH_4 CO, H_2S Vapours	Inhalation Explosion	**Human health** Including current site users, future site users, neighbouring residents and constructions workers **Buildings** Confined Spaces	Considered inactive	Unlikely	Severe	**Very Low**	Given the proposed development consisting of an extension of the adjacent solar farm, with no enclosed or confined spaces being included, it is considered that there is no active pathway to suture site end users, and limited ground gas potential identified within these assessments. No further action required

Potential Sources	Contaminants of Concern	Potential Pathway	Potential Receptor	Potential Pollutant Linkage	Probability	Consequence	Risk Classification	Action / Mitigation / Justification
Made Ground on site Current and former land uses on site	Heavy metals, sulphates and inorganics	Lateral and vertical migration and leaching of contaminants into local groundwater	**Underlying Aquifer** (Potable water)	Considered potentially active	Unlikely	Mild	**Very low**	Given the encountered ground conditions, lack of made ground and the results of the chemical testing, it is considered a very low risk to the receptor.
Made Ground on site Current and former land uses on site	Heavy metals, sulphates and inorganics PAH's	Lateral and vertical migration and leaching of contaminants into surface water bodies via permeable strata and features.	Local **water courses** and associated flora and fauna	Considered potentially active	Unlikely	Mild	**Very Low**	Given the encountered ground conditions, lack of made ground and the results of the chemical testing, it is considered a very low risk to the receptor.
Made Ground beneath the site Current and former site uses	Phytotoxic elements	Plant uptake	**Plants and vegetation**	Considered potentially active	Unlikely	Minor	**Very low**	Results of the site investigation confirm that all determinands analysed recorded levels below the relevant phytotoxic screening levels. Therefore, no further action is required.

7.0 GEOTECHNICAL TESTING AND RESULTS

7.1 In-situ Testing

7.1.1 In-situ Standard Penetration Tests (SPTs) were undertaken in accordance with BS1377 (1990) within the window sample boreholes. A summary of the insitu testing is given below in Table 7.1: Insitu Geotechnical Testing:

Table 7.1: Insitu Geotechnical Testing

Strata	Depth Range (mbgl) vs SPT N Value	Locations Encountered
Clay	1.20 – 5.00: N = 1 – 50	All locations
Sand	2.00 – 5.00: N = 8 – 22	WS02, WS17 and WS18
Gravel	2.00 – 4.00: N = 12 – 22	WS09, WS10, WS12, WS13, WS14 and WS15

NR = Not Recorded In This Strata

7.2 Laboratory Testing

7.2.1 A programme of geotechnical laboratory testing was undertaken in accordance with BS1377 (1990) 'Methods of tests for soils for civil engineering purposes. All samples were sent to a UKAS accredited geotechnical testing laboratory. The geotechnical testing regime has been summarised below in Table 7.2: Geotechnical Laboratory Analysis.

Table 7.2: Geotechnical Laboratory Analysis

BS 1377 Test Number	Test Description	Quantity Analysed
BS 1377 1990: Part 2. Clause 3.2	Moisture content	12
BS 1377 1990: Part 2. Clause 4.3, 5.3 & 5.4	Atterberg Limits	12
BS 1377 1990: Part 3. Clause 5.3 & BRE CP2/79	BRE SD 1	12

7.2.2 The results of the geotechnical testing are presented in Appendix G.

Plasticity Index

7.2.3 Atterberg limit testing was carried out on selected samples of cohesive soils taken from the site to establish the plasticity index of the clay beneath the site. The results of this testing is presented below in Table 7.3: Atterberg Limits Testing Results.

Table 7.3: Atterberg Limits Testing Results

Test	Range
Moisture Content (%)	11 - 32
Liquid Limit (%)	23 - 46
Plastic Limit (%)	14 - 22
Plasticity Index (%)	9 - 24
Modified plasticity index (%)	7 - 23

7.2.4 Based on these results the clay beneath the site can be classed as low to intermediate plasticity.

7.2.5 Chapter 4.2 'Building near Trees' of the NHBC standards indicates that from the testing results, the modified plasticity index is between 7 and 23% and therefore, the clay beneath the site is of low to medium volume change potential.

BRE SD 1

7.2.6 12 soil samples were analysed for BRE SD 1 reduced suite to assess the risk to buried concrete at the site, which includes total sulphate, water soluble sulphate, pH and total sulphur. The results of the testing are summarised below.

Table 7.4: Summary of BRE SD 1 Results

Test	Soil Test - Results Range
Total sulphate (%)	<0.01 – 0.04
Water soluble sulphate (mg/l)	11 - 100
Total sulphur (%)	<0.01 – 0.08
pH	6.5 – 8.6
Total Potential Sulphate (%)	0.03 – 0.24
Potential amount of Oxidisable Sulphate Present (%)	0.01 – 0.04

7.2.7 Design/mix of buried concrete should be undertaken in accordance with the "Aggressive Chemical Environment for Concrete" (ACEC) classification, of BRE Special Digest 1:2005 (Concrete in Aggressive Ground).

7.2.8 The above results indicate that pyrite is likely to be present within the soils beneath the site.

8.0 GEOTECHNICAL ASSESSMENT

8.1 General

8.1.1 It is understood that the proposed development comprises an extension to the pre-existing solar farm development adjacent to the site with associated solar panels and access roadways. New buildings are proposed in the footprint of existing ruined structures on site (near locations WS04 to WS07 and WS11), with smaller ancillary buildings to the southeast of site (WS01 to WS03). Solar panels will be installed in rows across the open fields on site.

8.1.2 The recommendations given below assume that ground levels intended for the redevelopment will be similar to those existing at present. If ground levels are subject to significant change as part of the proposed development, then the recommendations in this report may require reinterpretation.

8.2 Geotechnical Model

8.2.1 Eighteen dynamic sample boreholes were advanced across the site on a basis of targeting proposed structures and as a general coverage assessment of the site as a whole.

8.2.2 The ground conditions encountered within the exploratory holes are summarised below.

Table 8.1: Summary of Ground Conditions

Stratum	Depth Range to Base of Stratum (mbgl) (Thickness Range)	Relative Density / Undrained Shear Strength	Notes
Made Ground and Topsoil			
Made Ground and Topsoil	0.00m to 0.70 (0.00 to 0.70)	None recorded	Made Ground was encountered in WS02 and WS16 comprising slightly gravelly sandy Clay and sandy Gravel. Topsoil was encountered in all boreholes, with topsoil reworked in WS02 and WS16
Natural Strata			
Cohesive Deposits (Clay)	0.20m to 5.00 (0.90 to 4.80))	<u>Strength from Field Description</u> Soft to Stiff <u>Strength from In-situ Field Testing</u> SPT 'N' values recorded: 1.20: N = 0 - 20 2.00: N = 2 - 41 3.00: N = 1 - 32 4.00: N = 18 - 26 5.00: N = 19 - 30	Clay was encountered within all locations across the site and mainly comprised slightly gravelly sandy Clay. Soil density is poor in the north nearest the River. Moisture Contents: 11 – 32% Liquid Limits: 23 – 46% Plastic Limits: 14 – 22% Plasticity Indices*: 9.00 – 24.00% Consistency Index: 0.20 – 1.3% The Atterberg Limit tests indicate that the cohesive soil is of low to intermediate plasticity, of medium volume change potential (NHBC classification), and on the basis of the consistency index has a range of very soft to very stiff consistency. Low SPT ranges are present in upper 2.0m in WS12, WS13, WS15, WS18 and are not representative of eastern / main site area ground conditions.

Granular Deposits (Sands and Gravel)	0.80m – 5.00 (0.7 to 4.20)	Strength from Field Description Loose to Medium Dense Strength from In-situ Field Testing SPT 'N' values recorded: 1.20: N = 3 - 8 2.00: N = 4 - 22 3.00: N = 8 - 22 4.00: N = 15 - 30 5.00: N = 16 - 30	Till and Alluvium deposits were encountered within WS02, WS03, WS04, and WS09 to WS15 and comprised clayey sandy Gravel.
* - Corrected for fines content in accordance with NHBC Chapter 4.2.			

NR = Not Recorded In This Strata

8.3 Foundations

Shallow Foundations

8.3.1 As per the proposed development plan, this foundation discussion relates to Field 1b and Field 1C where the new proposed structures reside. The site investigation locations within these areas have been used for the foundation discussion (WS01 – WS08).

8.3.2 Where Made Ground is either not present or present only at shallow depths, it would be possible to adopt strip or spread foundations in the underlying firm cohesive soils, which generally consists o*f* firm gravelly sandy Clay. It is considered that this material will provide a suitable bearing stratum, provided that the foundations are placed within a single soil type, and generally described as being present in a firm (or higher) insitu condition. It is considered that strip or spread foundations constructed within this material at a minimum depth of 1.20mbgl could be designed assuming an allowable increase in load given below in **Error! Reference source not found.**.

Table 8.2: Allowable increase in stress

Foundation Parameter	Strip Footings (m)			Spread Foundation (m)		
Foundation Width (m)	0.60	1.00	1.50	1.00	2.00	3.00
Foundation Depth (m)	1.20			1.20		
Allowable Increase in Stress (kN/m^2)	175	160	155	250	230	220

8.3.3 The allowable increase in stress given above assumes a factor of safety of 3 against general shear failure, with cohesion of 75kN/m^2 at the foundation depths. Settlements at the above loading intensities should remain within tolerable limits (<25mm) for the type of structure proposed provided that the underlying soils are carefully inspected immediately final trimming has taken place. Should any soft or weak material be encountered they should be locally removed and replaced with lean-mix concrete or compacted granular soil.

8.3.4 Once excavated, the formation may be subject to heave, which may result in settlement when the new foundation loads are applied. The designer should ensure that any settlement would remain within serviceable limits for the new and existing structures.

8.3.5 It is recommended that foundations are placed in one soil type to avoid any differential settlement. If this is not possible due to the varying depth of cohesive and granular soils, then foundations would need to be locally deepened and placed within the clays or suitably reinforced if spanning across soil types. Foundations would need to be designed by a suitably structural engineer.

8.3.6 Foundation depths may need to be increased where they are within influencing distance of trees. Heave precautions may also be required.

8.3.7 Areas of soft material may require ground improvement in the form of dynamic compaction or dig and replace to improve bearing capacity of shallow soils in locations along the northern boundary and

nearest the River (WS10, WS12 to WS16); or an alternative foundation solution may require consideration in these areas.

8.4 Floor Slabs

8.4.1 In accordance with BS 8103-1; and based on proven ground conditions it is recommended that suspended floor slabs are used at this site due to the potential for heave / shrinkage from the underlying cohesive soils immediately beneath the site.

8.5 Concrete

8.5.1 A review of the pH and sulphate concentrations indicates that all concrete used in the foundations at this site should be designed to "Design Sulphate Class" DS-1, and the "Aggressive Chemical Environment for Concrete" (ACEC) class AC-1.

8.6 Groundwater and Excavations

8.6.1 Groundwater is likely to represent a particular problem to the construction of the proposed development at this site. However, it should be recognized that slight seepages and minor water entries may combine in any long trench excavations to create a significant volume of water which may cause local problems during the construction phase. Any minor groundwater seepages or significant standing water within excavations made upon this site may be removed by using a simple form of de-watering. Such a system could include the excavation of sumps from which the water could be pumped. Advice on Groundwater Control is given in CIRIA Report No 515 – Groundwater Control Design and Practice.

8.6.2 Foundation excavations should be feasible using conventional plant.

8.6.3 The stability of the excavation faces cannot be guaranteed, thus temporary support to the excavation faces may become necessary. Alternatively, subject to space constraints, excavations could be battered back to a suitable angle of repose. However, if there is a requirement to protect nearby structures or services, appropriate supports may still be required. Advice on excavation support is given in CIRIA Report No 97 – Trenching Practice.

8.7 Road Pavement

8.7.1 Any new pavements will require assessment of the existing sub grade in terms of its California Bearing Ratio (CBR) to facilitate the actual pavement design.

8.7.2 TRL DCP testing has been undertaken on all proposed roadways and pathways. Results can be found in Appendix C.

8.8 Existing structures

8.8.1 Any existing structures and foundations if found should be grubbed up and replaced with a suitable engineered granular backfill and should be compacted in layers.

9.0 OTHER POTENTIAL DEVELOPMENT CONSIDERATIONS

9.1 Waste Soils Characterisation

9.1.1 Any excavation works may potentially produce waste soils for which appropriate waste management will be required. Any soils requiring removal and disposal from site would require appropriate classification testing prior to disposal and the results would need to be confirmed with the landfill operator. Isolated hotspots if encountered may need to be taken off as Non-Hazardous or Hazardous waste. Any off-site disposal of soil requires careful management and due consideration of appropriate legislation, guidance and Duty of Care responsibilities.

9.1.2 Waste Acceptance Criteria (WAC) testing has been carried out four samples of any materials requiring disposal from site. The results of the WAC testing should be presented to the landfill operator for their confirmation of waste category.

9.2 Imported Fill

9.2.1 Any imported fill will be subject to specific quality requirements, particularly in any proposed areas of landscaping. Allowance should be made for the testing of imported fill materials prior to emplacement to ensure suitability should the materials be delivered with no testing certification.

9.3 Construction Activities

9.3.1 Due consideration should be given to the suppression of noise, dust and vibration emissions from the site during construction.

9.4 Material Re-Use

9.4.1 Any site won soils / materials may be available for reuse across the site subject to the appropriate classification, analysis and engineered solution.

9.4.2 Any natural topsoil or Made Ground topsoil may be suitable for reuse across the site in any proposed landscaped areas subject to appropriate chemical testing.

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