HARRIS CARS PLC

INTERPRETIVE REPORT

on

SITE INVESTIGATION

at

GROVEFIELD WAY

CHELTENHAM

JULY 2014

REPORT NO: 729381R2

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1 INTRODUCTION

This investigation was carried out on the instructions of Emmaus Consulting Ltd on behalf of Harris Cars plc. This report is an update of our November 2008 report and incorporates additional gas monitoring. The purpose of the work was to determine ground conditions and provide information for the design of foundations of a car showroom and to assess the contamination status of the site. The original proposal was for three storey office blocks.

This report details the work carried out both on site and in the geotechnical and chemical testing laboratories; it contains the exploratory hole logs and laboratory testing results, and it gives recommendations relating to foundation design and settlement. It presents an appraisal of environmental aspects and gives recommendations on risk reduction. It should not be assumed that these would meet the requirements of the local authority, whose advice should be sought regarding planning permission.

The ground investigation has been carried out using cable percussive techniques of soft ground boring and trial pitting, in general accordance with the recommendations of BS5930: 1999 *Code of Practice for Site Investigations.* Whilst every attempt is made to record full details of the strata encountered in the exploratory holes, techniques of hole formation and sampling will inevitably lead to disturbance, mixing or loss of material in some soils and rocks. The investigation has also been carried out in accordance with BS10175 *Investigation of Potentially Contaminated Sites: Code of Practice* (2011).

All information, comments and opinions given in this report are based on the ground conditions encountered during the site work, and on the results of laboratory and field tests performed during the investigation. However, there may be conditions at the site that have not been taken into account, such as unpredictable soil strata, contaminant concentrations, and water conditions between or below exploratory holes. It should be noted that groundwater levels usually vary due to seasonal and/or other effects and may at times differ to those measured during the investigation.

All information, comments and opinions given in the desk study in this report are based on the information obtained. The information search cannot be exhaustive and there may be records that have not come to light. There may also be circumstances at the site that are not documented.

While this report has been compiled in general accordance with best practice it should not be assumed that it is sufficient to discharge any planning conditions and it is recommended that the local planning authority be consulted in this regard prior to progressing the development.

This report was prepared by Structural Soils Ltd for the sole and exclusive use of Harris Cars plc in response to particular instructions. Any other parties using the information contained in this report do so at their own risk and any duty of care to those parties is excluded. No liability will be accepted after a period of 6 years from the date of the report.

2 SITE DESCRIPTION

2.1 Location and Topography

Grovefield Way lies approximately 4km to the west of Cheltenham town centre, and 1km east of junction 11 of the M5. The British National Grid Reference of the site is SO 906 214.

The site is a triangular area of fields, bounded by Grovefield Way to the east, the A40 trunk round to the north and a minor road to the south. It is 350m from east to west and 200m wide at its eastern end. The fields are currently used for rough grazing for horses, and are divided by hedgerows in which are set small trees, including fruit trees. Other trees are also present towards the northern boundary and in the north-east part of the site. In 2014 the site was found to be overgrown.

The site slopes down very slightly to the north west, by approximately 1 in 30. A drainage ditch runs along the eastern two thirds of the northern boundary and is then culverted under the A40, which passes the site on an embankment.

A park and ride facility is located to the northeast, and housing the east. There are fields and scattered housing to the north and south, while to the west there are plant nurseries.

2.2 Geology

The Geological Survey map of Tewkesbury (sheet 216, scale 1:50,000) shows the site to be underlain by the Charmouth Mudstone Formation (formerly the Lower Lias Clay) which consists of mudstone with occasional beds of limestone. The mudstone weathers in the near surface to plastic clays. The Charmouth Mudstone Formation is underlain by the Blue Lias Formation which consists of clays interbedded with limestones.

No superficial deposits are mapped on the site.

2.3 Hydrogeology and Hydrology

The Environment Agency (EA) website (www.maps.environment-agency.gov.uk/wiyby/) has classified the geological units underlying the site as follows:

- Bedrock (Charmouth Mudstone Formation) as Unproductive Strata

'Unproductive Strata' are rock layers or superficial deposits with low permeability that have negligible significance for water supply or river base flow.

The site is not located with a Source Protection Zone (SPZ).

The closest down hydraulic gradient surface water body to the site is a drain running along the eastern two thirds of the site's northern boundary. Rainfall on the site is likely to flow into this drain.

2.4 Desk Study

2.4.1 Site History from Ordnance Survey Maps

A search of Ordnance Survey maps was undertaken to establish the land-use history of the site and surroundings. Extracts of the maps that are discussed below can be found in Appendix E of this report. Unless otherwise stated, all quoted distances are measured from the site boundary that is marked on the maps.

Dates	Scale	Significant features, changes and developments:	
		On site	**In surroundings [distance(m)]**
1884	1:10,560	- The site occupies several small fields with orchards in the north-east and central areas. - *Stone Cottage* is situated to the north of the site - Stream running along northern boundary flowing to the west - Road forms southern boundary	- Ponds 370m N, 150m W, 300m NE, 10m N, 150m S, 150m SW, 550m E and 350m NW - Elm cottages 150m W - The Elms 250m SW - Wells 300m SE and 400m S - Pump 400m S
1887	1:2,500	- Orchards extended in centre of site.	- Smithy 250m SW - Pump 210m S
1901-1903	1:10,560	- Stone cottage now *Middle Reddings Farm*	- No significant change
1923-1924	1:2,500	- No significant change on site	- Semi detached housing 140m SE and 20m S
1938	1:10,560	- No significant change on site	- No significant change
1949	1:10,560	- No significant change on site	- Some development
1972	1:2,500	- Middle Reddings Farm has been demolished - Small building present on northern boundary	- A40 trunk road 0-30m N - Some residential development - Poultry houses 140m E
1974-1976	1:10,000	- No significant change on site	Engineering Works 400m E - Nurseries 300m W and 450m S - Government Communications Headquarters 800m NE - Poultry Houses 700m SE - Depot 570m W
1984-1989	1:10,000	- No significant change on site	- Some residential development
1996	1:1,250	- No significant change on site	- New Road 10m E - Residential development to E
2002	1:10,000	- No significant change on site	- Hospital 300m E - Works 400m E
2005-2007	1:10,000 1:1,250	- Orchards not shown in 2005	- Nursery 180m NE - Park and ride 30m NE

2.4.1 Summary of Historical Data

Since 1884 the site has been small fields and orchards. Stone Cottage, which became Middle Reddings Farm between 1887 and 1901 lies on the northern part of the site. Later between 1949 and 1972 Middle Reddings Farm was demolished leaving a small rectangular building close to the northern boundary of the site. The site remained the same until between 2002 and 2005 the remaining building was removed, and the orchards uprooted.

Within the vicinity of the site there are numerous surface water features including the Hatherley Brook and a stream which runs along the northern boundary of the site. Little development occurred in the surrounding area until between 1949 and 1972 when the A40 trunk road was constructed 30m north of the site and residential developments occurred. Between 1972 and 1974 numerous industrial businesses were constructed, they included nurseries, poultry farms, engineering works and depots. Later between 1996 and 2002 a hospital was constructed 300m to the east of the site.

2.4.2 Environmental Data

Environmental features such as landfills, groundwater abstraction points, etc, are detailed on data sheets that can be found in Appendix E of this report. 'Notable' features in these data sets are listed below.

Data Types Showing Notable Issues	**No. of Notable Listings (or Yes/No) and Distance (m) from Site**				**Details of Notable Listings**
	On site	**0-250**	**250-500**	**>500**	
GENERAL					
Dangerous Substances Inventory Sites			5		270m SE; Lucas Aerospace, Arle Court, Cheltenham
WATER RELATED					
Discharge Consents			3		270m SE; Woodward Aircraft Controls, Arle Court, Cheltenham; discharge cooling water; Arle Court brook is the receiving water 367m E; Delphi Diesel Systems Ltd, Hatherley Lane, Cheltenham; trade discharges
Water Abstraction				1	809m NE; Dust suppression; Surface water Midlands Region; Tributary of Hatherley Brook
WASTE					
Historic Landfill Sites		1		1	5m NE; Land off Hatherley Lane, Hatherley

Data Types Showing Notable Issues	No. of Notable Listings (or Yes/No) and Distance (m) from Site				Details of Notable Listings
	On site	0-250	250-500	>500	
Non-Operational Landfill Sites		1		1	221m NE; Hatherley Lane, Arle Court Roundabout; Inert Waste landfill
Waste Treatment, transfer & Disposal Sites			1		350m N; Cotswold View, Golden Valley, Gloucester Road; Non-hazardous scrapyard
Non-Operational Waste Treatment, Transfer & Disposal Sites			1		354m N; Cotswold View, Golden Valley, Gloucester Road; Non-hazardous scrapyard
REGIS Waste Sites		1	2	3	198mNE; Shurdington, Gloucestershire; Landfill taking non-biodegradable wastes (not construction) 441m N; Golden Valley, Gloucester Road, Cheltenham; metal recycling sites
GEOLOGICAL					
Shrinking and Swelling Clay	Yes				0m on site: Low
Landslides	Yes				0m on site: Low; Possibility of slope instability problems after major changes in ground conditions. 23m W; Low 27m N; Low
Radon					The property is not in a radon affected area, as less than 1% of properties are above the action level
BGS Recorded Borehole	1				0m on site (S): 10m deep, A40 Improvement 19
LAND USE					
Current Industrial Sites		2	29		78m SE; Electricity sub station 238m NE depot; container and storage 254m SE; Tanks generic
Sites of Special Scientific Interest				1	684m S; Badgeworth

2.4.3 Summary of Desk Study

There are no significant industrial sites in close vicinity to the site. There is however an old area of landfill near the north eastern boundary of the site. The licence for this dates from 1994 so it likely relates to the building of the new A40 road and park and ride, rather than being a

putrescible landfill which could pose the risk of ground gases. The Environment Agency website show the licence was active from 21 April to 6 October 1994.

The site is not in a radon affected area as less than 1% of homes are above the action level and therefore no radon protection measures are necessary in the construction of new dwellings or extensions.

All geological hazards either pose low or no risk to the site.

2.5 Outline Contamination Conceptual Model and Preliminary Risk Assessment

2.5.1 General

This section of the report aims to identify land which could potentially be affected by contamination, such that it could affect the value or re-use of the land, or such that mitigation would be required for certain proposed end uses of the land.

The assessment also aims to identify land which would be regarded as 'contaminated land' under the terms of the Environmental Protection Act 1990, Part IIa. This act includes a stricter test for contaminated land than that outlined above. Land is considered to be contaminated if either:

- the land is causing significant harm to people, ecosystems or infrastructure; or
- there is a significant possibility that such harm could be caused; or
- pollution of controlled waters is being, or is likely to be, caused.

The following situations are defined as being where harm is to be regarded as significant:

- chronic or quite toxic effect, serious injury or death to humans;
- irreversible or other adverse harm to the ecological system;
- substantial damage to or failure of buildings;
- death of, or disease or other physical damage affecting, livestock or crops;

pollution of controlled waters.

2.5.2 Risk Assessment Methodology

CLR11 outlines the framework to be followed for risk assessment in the UK. The framework is designed to be consistent with UK legislation and policies including planning. Under CLR11,

three stages of risk assessment exist: Preliminary, Generic Quantitative and Detailed Quantitative. An Outline Conceptual Model should be formed at the preliminary risk assessment stage. This identifies potentially complete (termed *possible*) pollutant linkages (source–pathway–receptor) and is used as the basis for design of the site investigation. The Outline Conceptual Model is updated as further information becomes available, for example as a result of the site investigation.

2.5.3 Potential Sources

Some small farm buildings were present before 1972 but apart from these the site is greenfield.

The potential primary contaminants associated with the sources identified in the desk study are discussed in more detail below:

Potential Sources: On site	**Likely contaminants**
Possible Made Ground by former buildings Rest of site greenfield	Heavy metals, asbestos, hydrocarbons
Potential Sources: Off site	**Likely contaminants**
None identified	

There is an old area of landfill near the north eastern boundary of the site. The licence for this dates from 1994 so it probably relates to the building of the new A40 road and park and ride, rather than being a putrescible landfill which could pose the risk of ground gases.

2.5.4 Receptors

The main receptors are the future users of the site. Future plantings in gardens are also receptors, as are buildings and underground services. Construction workers are short-term receptors. Similar receptors in the vicinity are also potential targets.

Another potential receptor is the water environment, but below the site lies a non-aquifer and so groundwater is unlikely to be a receptor as there would be no plausible pathway for impact. The nearest surface water is a drain on the northern boundary of the site.

2.5.5 Preliminary Risk Assessment

The information presented in previous sections has been used to compile a Preliminary Risk Assessment. The identified potential contaminants and potential receptors have been considered, along with any possible pathways that may link them.

The resulting pollutant linkages are considered in the table below:

Potential Source	Potential Pathway	Potential Receptor	Potential Complete Linkage?	Comments (e.g. regarding pathways, impermeable strata, site upstream of source, etc)
Soil contaminants	Ingestion/ Dermal Contact	Future on-site users (commercial)	Yes	Via soft landscaping
		Construction workers	Yes	Appropriate PPE should be worn
		Maintenance workers	Yes	Appropriate PPE should be worn
		Adjacent commercial/residential land users	Yes	
	Permeation	Subsurface plastic water pipes	Yes	
	Leaching	Groundwater in Non Aquifer/ surface watercourse	No	
	Root uptake	Soft landscaping on-site (e.g. phytotoxicity)	Yes	
Groundwater contaminants (i.e. arsenic, lead)	Ingestion/ Dermal Contact	Future on-site users (residents)	No	
		Adjacent commercial/ residential land users		
		Construction workers		
		Maintenance workers		
	Permeation	Subsurface plastic water pipes		
	Lateral Groundwater migration	Groundwater in Minor Aquifer/ surface watercourse		
Vapours associated with	Migration along backfill	Future on-site users (residents)	Yes	Through the ground from landfill site to the north east of the site (but

soil and groundwater contaminants and/or bulk ground gases (e.g. methane/carbon dioxide)	around services, more permeable strata inhalation/ explosion	Construction/ Maintenance workers		landfill is not likely to be putrescible material)
Natural radon gas	Flow through ground	End users	No	There are less than 1% of homes above the action level; therefore no protection measures are necessary

2.5.6 Preliminary Risk Assessment Conclusions

The review of information and the construction of the Outline Conceptual Model highlights potential pollutant linkages. In order to investigate any unacceptable risk presented by these, intrusive investigation is recommended. An intrusive investigation will be able to provide further information on actual contaminants present and viable pathways to sensitive receptors.

2.6 Recommendations

Intrusive investigation is required to assess any significant contaminant sources, pathways and receptors. The change of land use from green field site to residential properties and private gardens will require consideration of the former use of the site in terms of any potentially contaminative processes that may have caused contamination of the ground and groundwater.

The objectives of an investigation are to:

- Clarify the 'Outline Contamination Conceptual Model'
- Clarify the Outline Risk Assessment
- Provide data for the design of any remedial works that may be required
- Benchmark the contamination status of the site

To achieve these objectives, an investigation is recommended, and should comprise of cable percussion drilling and trial pitting. Where possible the exploratory trial pits passed through all made ground and into underlying natural soils. Also where possible, the holes extended beyond the base of any obvious soil contamination and where groundwater could be at risk, the holes attempted to reach groundwater level.

3 FIELDWORK

2008

8 no. cable percussion boreholes (BH1 to BH8), 14 no. machine dug trial pits (TP1 to TP14), 7 no. California Bearing Ratio (CBR) tests (CBR1 to CBR7) and 3 no. soakaway tests (SA1-SA3) were completed between 31 June and 8 July 2008 at locations shown on the Exploratory Hole Location Plan in Appendix A.

The scope of investigation and choice of investigation equipment was decided by Structural Soils Limited. The positions were selected and set out by Structural Soils Limited.

The positions of exploratory holes BH1-BH8 were selected to target the main areas of construction and the trial pits TP1-TP14 were selected to provide general site coverage. Trial pits TP6 and TP7 were positioned to target the location of the farm buildings, which had been present on the northern part of the site until between 1949 and 1972, which could be a potential area of made ground and source of contamination. The CBRs were placed down the main spine of the proposed access road for the site, and its junction with Grovefield Way. Soakaway tests were carried out around the periphery of the site.

Sampling and in-situ testing details were specified by Structural Soils Limited. Geotechnical samples were taken and returned to the laboratory for classification and potential testing. Samples for contamination testing were placed in appropriate ‘contamination sample containers’ (supplied by the laboratory and with preservatives for waters, where required). They were then kept in cool boxes with ice packs and were transported to the laboratories (under Chain of Custody documentation) as promptly as possible to maintain sample integrity. Contamination sampling was specified by Structural Soils Limited.

Inspection pits were excavated by hand to 1.20m depth at the cable percussion hole locations prior to the commencement of drilling. The boreholes were drilled using a cable tool percussion drilling rig and were 150mm diameter. The depths of the boreholes were 5.00m to 11.85m. 100mm diameter undisturbed samples were recovered from the cohesive strata in the boreholes and Standard Penetration Tests were carried out at regular intervals in accordance with BS1377: Part 9: 1990: 3.3. Test results are given in detail in tabular format on the Summary of Standard Penetration Tests in Appendix B, and also summarised on the borehole logs.

The trial pits were excavated using a mechanical excavator and were approximately 0.80m x 3.00m in plan area and up to 3.65m deep. Hand vane and hand penetrometer tests were carried out in the cohesive strata in the trial pits.

On completion single standpipes were installed in holes BH1, 2, 4, 5, 7 and BH8 the design having been decided by Structural Soils Limited, and all other exploratory holes were backfilled. The site owner must ensure that the monitoring wells are not damaged/destroyed/covered until such time as Structural Soils no longer require information from them. Any damaged/destroyed/covered wells may necessitate further drilling work to form new replacement wells.

The in-situ CBR tests were undertaken using conventional test equipment mounted on a 4 wheel drive vehicle in accordance with BS1377 Part 4: 1990. The results are contained in Appendix C.

The soakaway tests were undertaken in general accordance to recommended practice given in BRE Digest 365. The results are contained in Appendix C.

On completion of the works, a survey of the exploratory hole locations was undertaken by a specialist surveyor using Global Positioning System (GPS) equipment. The coordinates and elevation of each exploratory hole were measured relative to British National Grid, and these are shown on the exploratory hole logs contained in Appendix B which have been printed with a reduced level column.

Ground gas monitoring was carried out over 4 no. monitoring rounds (as considered the minimum for an end-use of residential properties with gardens, in line with the CIRIA 665).

An infrared gas meter was used to measure concentrations of carbon dioxide (CO_2), methane (CH_4) and oxygen (O_2) in percentage by volume. Initial and steady state concentrations were recorded, as well as borehole flow rates (initial and steady state) in litres per hour (l/hr). In addition the atmospheric pressure before monitoring, together with the weather conditions were recorded.

In addition the atmospheric pressure before and during monitoring, together with the weather conditions were recorded.

2014

In June 2014 a further 4 no. gas monitoring visits were undertaken. The site was heavily vegetated but 4 no. of the 6 no. boreholes were located.

4 LABORATORY TESTING

Samples for potential geotechnical testing were returned to the company's laboratory in Bristol and those for potential contamination testing were sent to accredited chemical testing laboratories.

Geotechnical and contamination tests were scheduled by Structural Soils Limited. Geotechnical laboratory testing was generally carried out in accordance with BS1377: 1990, *Methods of Test for Soils for Civil Engineering Purposes*, Parts 1 to 8, unless indicated otherwise. Where non-standard procedures have been undertaken, this is recorded on the report sheet. The results are reported in tabular and/or graphical form and included as Appendix C of this report.

Contamination testing was carried out in accordance with MCERTs/UKAS standards. The results are reported in Appendix D of this report.

4.1 Moisture Content

22 no. moisture content tests were undertaken using the oven-drying method in accordance with BS1377: Part 2: 1990. The results are tabulated in the Summary of Classification Tests above the A-Line Plot (see Section 4.2, below).

4.2 Liquid Limit, Plastic Limit and Plasticity Index

22 no. liquid and plastic limit tests were performed in accordance with BS1377: Part 2: 1990. The results are tabulated above the A Line Plot (in accordance with BS5930: 1999) and the Summary of Classification Tests.

4.3 Dry Density/Moisture Content Relationship

2 no. dry density/moisture content relationship tests were undertaken in accordance with BS1377: Part 4: 1990 to determine the maximum dry density and optimum moisture content. Tests were carried out in a standard California Bearing Ratio (CBR) mould, using a 2.5kg rammer and 4.5kg rammer. The results are presented graphically as dry density/moisture content curves together with values of maximum dry density and optimum moisture content identified from the plot.

4.4 One-Dimensional Consolidation Test

4 no. one-dimensional consolidation tests were undertaken in accordance with BS1377: Part 5: 1990. 4 no. loading and 1 no. unloading stages were undertaken on each sample with pressures of between 40 and 320kPa.

The results are represented as voids ratio e/log pressure together with values of the coefficients of compressibility (m_v) and consolidation (c_v).

4.5 Chemical Analyses

18 no. soil samples were tested to determine their pH values and water soluble sulphate contents in accordance with BS1377:Part 3:1990 clause 5.

4.6 Contamination

21 no. soil samples were analysed in accordance with UKAS/MCERTS standards for arsenic, cadmium, chromium (total), lead, mercury, selenium, copper, nickel, zinc, speciated polycyclic aromatic hydrocarbons (PAH), organic matter, soluble sulphate and pH.

5 no. samples were also analysed for total petroleum hydrocarbons (banded TPH and for speciated TPH (TPHCWG)).

2 no. water samples were analysed for similar contaminants (except TPH was replaced by Extractable Petroleum Hydrocarbons (EPH)).

5 GROUND CONDITIONS

5.1 General

The exploratory holes were logged by an engineer in general accordance with the recommendations of BS5930: 1999 including amendment 1 (2007). Detailed descriptions, together with relevant comments, are given in the logs included in Appendix B.

5.2 Made Ground

All exploratory holes encountered grass over made ground between depths of 0.25m and 1.40m. The thickness of made ground was greatest in the vicinity of TP9, which was sited close to the former Middle Reddings Farm.

The composition of made ground was consistent across the site with slight variation within trial pits TP6 and TP7. Made ground generally consisted of brown mottled grey slightly sandy slightly gravelly clay. The gravel consisted of fine to medium subangular to subrounded brick, charcoal, limestone, chert and ceramics. The gravel uncovered in TP6 and TP7 close to the former farm buildings was coarse gravel with occasional cobbles of brick and various building stones.

The topmost layer of made ground comprises topsoil.

5.3 Superficial Deposits

Superficial deposits were encountered by all exploratory holes except for trial pits TP1, TP6, TP7, TP9 and TP10, and borehole BH8. The deposits were encountered between 0.20m and 2.70m depth. They consisted of firm to stiff brown mottled grey slightly sandy slightly gravelly clay; the gravel was fine to medium subrounded limestone and mudstone.

5.4 Charmouth Mudstone Formation

The Charmouth Mudstone Formation was encountered by all exploratory holes except for shallow CBR test pits, either directly beneath the made ground or beneath superficial deposits. It was encountered from depths of 0.45m to 2.70m and generally consisted of three layers.

The upper consisted of firm grey mottled brown slightly sandy clay with decomposing rootlets. The middle layer consisted of stiff to very stiff dark blue grey slightly sandy thinly laminated clay with occasional gypsum crystals and fine shell fragments. The lower layer consisted of either very weak dark grey mudstone with occasional shell fragments or hard dark grey clay interbedded with very weak mudstone. Very weak mudstone was encountered from depths of

3.30m in TP11 to 11.10m in BH2. The depth at which mudstone is reached generally decreases to the west.

The strength of the clays increased with depth, generally becoming very stiff from approximately 2.00m depth as indicated by the increasing SPT N values which ranged from N=6 in BH5 at 1.20m depth to N=20 in BH2 at 2.00m depth in the superficial deposits, increasing to SPT values of N=55 in BH8 at 4.00m depth and N=333 in BH2 at 11.80m depth in the very weak mudstone.

5.5 Groundwater

Groundwater was not encountered by any of the exploratory holes during the intrusive investigation.

5.6 Gas and Groundwater Monitoring

4 no. gas and groundwater monitoring visits were completed between the 21 August 2008 and 8 September 2008. During the monitoring visits groundwater water was present in boreholes BH1-BH8 between depths of 0.19m and 5.76m.

In 2014 a further 4 no. gas and groundwater monitoring visits were completed between the 3 and 26 June. During the monitoring visits groundwater water was present in boreholes BH1, BH4, BH5 and BH7 between depths of 0.24m and 1.65m.

6 DISCUSSION AND RECOMMENDATIONS

6.1 Proposed Development

Grovefield Way, Cheltenham is the proposed site for the construction of three storey blocks of offices with access roads and parking facilities. We have not been given any details of the proposed structures.

6.2 Site Preparation and Excavation

The soils encountered at the site are considered suitable for excavation by standard mechanical plant such as a wheeled backhoe excavator.

Where trees are removed to facilitate construction, the root boles should be grubbed out to prevent re-growth. Any resulting voids from this operation should be backfilled with an acceptable, adequately compacted fill. Also, our site works revealed that unsupported excavations to the recommended founding depths (or services excavations, etc) are likely to be stable in the short term. Groundwater entry into excavations should be anticipated, however inflow rates are likely to be minimal and controllable via sump-pumping from the base of excavations.

All excavations should be planned and due consideration should be given to providing temporary support or suitable battering. Excavations should be regularly inspected by a competent person to ensure continued safety. Further advice on the safety of excavations is given in *Health and Safety in Construction.*

6.3 Shrinkage and Swelling

Atterberg Limits tests performed on samples taken from slightly gravelly clay between 0.50m and 3.25m deep showed them to be generally of groups CI and CH as defined in BS 5930:1999. After correction where necessary for their >0.425mm fraction, these samples show medium to high volume change potentials with changes in moisture content, and we recommend assuming a high volume change potential in foundation design. Therefore according to the criteria of NHBC Standards, Chapter 4.2 (2007) *Building Near Trees,* foundations should be taken to a minimum depth of 1.00m. Where buildings are to be in proximity to existing, proposed, or recently felled trees, foundations should be deepened in accordance with the NHBC Standards.

6.4 Foundations

The proposed three storey office blocks can be constructed on conventional strip and pad foundations. The foundations should be taken down through any made ground to a minimum depth of 1.00m in accordance with NHBC Standards.

Assuming a conservative undrained shear strength of 75kPa, the allowable bearing capacity for a 1.00m wide strip foundation at 1.00m depth or for a 2.00m by 2.00m pad at the same depth would be of the order of 160kPa, which should be adequate for the type of development proposed. However, settlement of a 1.00m wide strip foundation at 1.00m depth loaded to a line load of 160kN/m^2 run, would be of the order of 25-30mm, using a coefficient of volume compressibility (m_v) of 0.2m^2/MN (based on an assessment of the consolidation test results) and a geological factor (μ_g) of 0.70. Therefore the allowable bearing pressure should be reduced to 140kN/m^2 to keep settlements below the generally accepted value of 25mm.

6.5 Floor Slabs

Lightly loaded ground bearing, floor slabs may be used at this site (designed in accordance with NHBC Standards). For ground bearing slabs the formation must be proof-rolled and any soft spots must be excavated and replaced with suitably compacted granular fill. However where made ground in excess of 600mm was encountered, NHBC Standards requires the use of suspended slabs as a precaution against differential settlement.

6.6 Pavement Design

In-situ CBR tests were carried out using conventional vehicle mounted equipment, at depths of between 0.50m and 0.70m in made ground consisting of firm slightly sandy slightly gravelly clay. Based on these test results we recommend using a CBR value of 2.0% for pavement design provided any soft spots are replaced with a suitably compacted granular fill. It should be noted that the CBR tests were carried out on cohesive soils that were dry and stiff when tested, and lower CBR values would be obtained during wetter weather.

6.7 Soakaway Design

Three soakaway tests were completed in trial pits SA1, SA2 and SA3. Infiltration rates could not be calculated, as none of the water drained away, indicating that the site is not suitable for shallow soakaways. Similar soils are found over the entire site and therefore the same can be assumed for other locations. Soakaways are therefore considered not practical at this site.

6.8 Protection of Buried Concrete

The site is classed as brownfield and groundwater is mobile. pH values varying from 8.1 to 8.6 were recorded indicating alkaline soil pH conditions. Groundwater pH results ranged from 8.2 to 8.7. The water-soluble sulphate results range from 3mg/l to 320mg/l. The 'Characteristic Value' is therefore <500mg/l and this falls into Design Sulphate Class DS-1 in Table C2 of BRE Special Digest 1 (SD1). The groundwater sulphate results range from 3200mg/l to 3800mg/l and the maximum result falls into Class DS-4.

From consideration of the sulphate, sulphur, pH and groundwater conditions it is concluded that the Aggressive Chemical Environment for Concrete (ACEC) class is AC-4 where concrete could be contact with groundwater and AC-1 if there is no risk of concrete being in contact with groundwater. The designer should utilise these classifications in order to produce the concrete specification.

6.9 Earthworks

Compaction tests, using 2.5kg and 4.5kg rammer, were undertaken on samples of superficial clay from 1.10m depth in TP1 to test for possible reuse of excavated clays. The natural moisture content was identical to the optimum moisture content in the 2.5kg test and inevitably therefore wet of the optimum in the 4.5kg test. The soils would be suitable for use as cohesive fill, with the provision that they should not be used in areas where heave might be a problem, since nearly all the tested samples have liquid limits in excess of 50%. The soils should no be used as fill beneath floor slabs.

6.10 Radon

BRE Report 211 is the current guidance to the building industry and is referred to in the Building Regulations. The report applies to residential development. New residential buildings in certain areas may require basic or full radon protection. Basic protection consists of a radon-proof barrier across the ground floor. Full radon protection consists of a radon proof barrier across the ground floor supplemented by either a radon sump or a ventilated subfloor void**.** For this site the desk study (see Section 2.4) indicates that no radon protection is necessary.

7 GEOENVIRONMENTAL SITE ASSESSMENT

7.1.1 Risk to Human Health

General

To determine whether contaminants are present at levels that may be deemed to pose a significant hazard to human health, measured contamination levels in soil at the site are compared against derived guideline values ('Tier 2' soil screening), either directly or following statistical analysis. Where contaminants are present above the screening values it is probable that site-specific information will be required to further examine the potential risk of harm arising from such contamination.

The background to the assessment is contained in Appendix F and the findings are summarised in the following pages.

The proposed used of the site is a car showroom and so the commercial guidelines have been used to assess the results. Since all bar one of the results are below the GAC it is not considered necessary to use statistics to assess the results.

Results

There were no olfactory or visual indications of contamination in any of the holes.

Contaminants assessed against the GAC are: arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, zinc, Polycyclic Aromatic Hydrocarbons (PAH) & Total Petroleum Hydrocarbons (TPH).

Except as follows all the results were below the GAC.

TP12 at 0.15m showed 5000mg/kg lead which exceeds the GAC of 2330mg/kg. This sample was in made ground (topsoil) which comprised dark brown slightly gravelly friable clay, the gravel being charcoal, brick, ceramic and limestone. The ceramic may explain the lead result since lead compounds have been used in pottery glazes.

7.1.2 Risks to Water Supply Pipes (Non-Brownfield)

General

Given that the site is not brownfield and is unlikely to be at risk from organic contaminants, then specific testing was not required, nor undertaken, for water supply pipe assessment. Accordingly

normal PE pipe materials should be suitable for the site, but this should be confirmed with the local water company.

7.1.3 Risks to Groundwater

General

The site lies over unproductive strata, but a drain runs along the northern boundary. The respective GAC are presented in Appendix D. The assessment below treats the water encountered as groundwater but in fact it is probably surface water which has seeped into the boreholes.

In line with the Environment Agency's Remedial Targets Methodology, the GAC for controlled waters are termed 'Target Concentrations'(TC).

Results

A few of the results exceeded the Target Concentrations as summarised below. Generally the Freshwater Environmental Quality Standards are relevant to surface waters and the Drinking Water Standards are relevant to groundwater. Two water samples from BH5 and BH8 were analysed.

- The chromium results of 7ug/l and 8ug/l chromium exceed the EQS of 4.7ug/l but are below the DWS of 50ug/l.
- The copper results of 7.5ug/l and 8.1ug/l cannot be assessed against the current EQS because water hardness was not measured, but they are below the DWS of 2000ug/l
- The nickel results of 30ug/l and 23ug/l slightly exceed the EQS and DWS of 20ug/l
- The BH5 selenium result of 31ug/l exceeds the DWS of 10ug/l (there is no EQS)
- The sulphate results of 3200ug/l and 3800ug/l exceed the EQS of 400ug/l and the DWS of 250ug/l.

7.1.4 Ground Gases

General

In order to assess the significance of ground gases at the site, measured concentrations (by volume in air) and flow rates have been used to generate Gas Screening Values (GSVs). These

have then been compared to the Revised Wilson and Card Classification) presented within CIRIA Report 665.

It is recommended that the gas risk should be assessed by the consideration of pathways to human receptors as follows:

- Gas entering the building through the substructure and building up to hazardous levels.

Results

The following ground gas parameters have been recorded over the 8 no. gas monitoring rounds:

- A maximum 'initial' methane concentration of 28.5%;
- A maximum 'steady state' carbon dioxide concentration of 3.4%;
- A maximum 'initial' flow rate of 4.5 l/hr; and
- A maximum 'steady state' flow rate of 0.1 l/hr.

The worst case Gas Screening Values (GSV) for both methane and carbon dioxide have been calculated. In accordance with NHBC guidance for methane the GSV is calculated using the peak concentration and flow and for carbon dioxide the residual concentrations and flow rates are used. The gas results have been assessed on a hole by hole basis in accordance with BS 8485.

Some initial high flow rates from BH7 and BH8 have been discounted because the very shallow water level on these occasions was within the unperforated top section of the standpipe, causing a pressure imbalance which is released during monitoring.

The high methane concentration in BH7 only occurred once and is not readily explainable. There is no apparent source of gas here, or anywhere on the site, in terms of the desk study or the borehole logs. BH7 lies just off the western boundary of the site plan supplied by the client, as shown in Appendix A. As such it is unlikely to be located under any proposed buildings, and the potential for gas migration is low due to the likely low permeability clay geology.

Conclusion

GSVs for methane and carbon dioxide have been calculated to be 0.26 l/hr and 0.0 l/hr respectively.

Therefore the site falls into 'Characteristic Situation' 2 (low hazard) in Table 8.5 of CIRIA 665.

The type of building proposed is commercial and for this Table 8.6 of CIRIA 665 indicates that the following special protection measures are required in the new buildings.

- Reinforced cast insitu floor slab with at least 1200 gauge DPM
- Beam block or precast concrete slab and at least 2000 gauge DPM/reinforced gas membrane
- Underfloor venting
- All joints and penetrations sealed

Underfloor venting is not required in large spaces such as warehouse but it is required where smaller rooms such as offices are present.

7.1.5 Conclusion on Contamination

The investigation has generally shown contaminant levels in the soil to be below the assessment criteria, which indicates that no risks to health have been identified. TP12 showed 5000mg/kg lead which exceeds the human health guideline of 750mg/kg. This could be due, for instance, to a fragment of lead-glazed pottery (ceramics were logged in this sample).

There are a few exceedances of groundwater guidelines, but these sampled were obtained using a bailer and it is likely that if low-flow sampling were carried out lower results would be returned. In additions the geology is classed as unproductive strata with low presumed permeability. Therefore the site is considered unlikely to pose a risk to water resources.

One instance of an elevated methane concentration was encountered in BH7 (28.5%).

7.2 Final Conceptual Site Model & Risk Assessment

7.2.1 General

This section of the report aims to refine the 'Initial Contamination Conceptual Model', in the light of the findings of the ground investigation. Furthermore, this section of the report is based on the information set out in the previous sections, and should not be read independently of the other sections of the report.

7.2.2 Risk Assessment Methodology

Risk is a combination of the 'likelihood' of an even occurring and the magnitude of its 'consequences'. Therefore, in order to assess risk, both the likelihood and the consequences of an event must be taken into account. RSK Group Plc has adopted guidance provided in CIRIA C552 for use in the production of risk assessments.

The likelihood of an event can be classified on a four point system using the following terms and definitions based on CIRIA C552:

- **Highly likely**: The event appears very likely in the short term and almost inevitable over the long term, or there is evidence at the receptor of harm or pollution;
- **Likely**: It is probable that an event will occur, or circumstances are such that the event is not inevitable, but possible in the short term and likely over the long term;
- **Low likelihood**: Circumstances are possible under which an event could occur, but it is not certain even in the long term that an event would occur and it is less likely in the short term;
- **Unlikely**: Circumstances are such that it is improbably the event would occur even in the long term.

The severity can be classified using a similar system also based on CIRIA C552. The terms and definitions relating to severity are:

- **Severe**: Short term (acute) risk to human health likely to result in 'significant harm' as defined by the Environment Protection Act 1990, Part IIA. Short-term risk of pollution of sensitive water resources. Catastrophic damage to buildings or property. Short term risk to an ecosystem or organism forming part of that ecosystem (note definition of ecosystem in 'Draft Circular on Contaminated Land', DETR 2000);
- **Medium**: Chronic damage to human health ('significant harm' as defined in 'Draft Circular on Contaminated Land', DETR 2000), pollution of sensitive water resources, significant change in an ecosystem or organism forming part of that ecosystem (note definition of ecosystem in 'Draft Circular on Contaminated Land', DETR 2000);

- **Mild**: Pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services ('significant harm' as defined in 'Draft Circular on Contaminated Land', DETR 2000). Damage to sensitive buildings, structures or the environment; and

- **Minor**: Harm, not necessarily significant, but that could result in financial loss or expenditure to resolve. Non-permanent human health effects easily prevented by use of personal protective clothing. Easily repairable damage to buildings, structures and services.

Once the likelihood of an event occurring and its severity have been classified, a risk category can be assigned the table below.

		Consequence			
		Severe	**Medium**	**Mild**	**Minor**
Probability	**Highly likely**	Very high	High	Moderate	Moderate/Low
	Likely	High	Moderate	Moderate/Low	Low
	Low likelihood	Moderate	Moderate/Low	Low	Very Low
	Unlikely	Moderate/Low	Low	Very Low	Very Low

7.2.3 Final Conceptual Site Model

The complete linkages and resulting risks have been identified and are presented in the table below:

Potential Source	Potential Pathway	Potential Receptor	Probability	Consequence	Risk	Comments
Soil contaminants (lead in TP12)	Ingestion/ Dermal Contact	Future on-site users (residents)	Low likelihood	Medium	Moderate/Low	Replace made ground/topsoil (0.3m thick) if soft landscaping proposed in vicinity of TP12
	Permeation	Subsurface plastic water pipes	Low likelihood	Medium	Moderate/Low	Consult water company as to whether alternative pipes are required
Ground gases (e.g. methane/carbon dioxide)	Migration along backfill around services, more permeable strata inhalation/ explosion	Future on-site users (residents)	Low likelihood	Severe	Moderate	Provide gas protection to CS2 of CIRIA C665
		Maintenance workers		Severe	Moderate	

This Generic Quantitative Risk Assessment (GQRA) indicates that complete and significant pollutant linkages exist at the site that require further action (e.g. remediation or other risk reduction measures).

7.3 Risk Reduction

7.3.1 Human Health

TP12 at 0.15 m showed elevated lead in the made ground. Therefore the made ground (0.3m thick) should be replaced in vicinity of TP12 if soft landscaping is proposed in this area. Further testing might be required to delineate the area.

7.3.2 Water Pipes

Normal polythene water supply pipes should be suitable for the site, but this should be confirmed with the local water company.

7.3.3 Ground Gas

GSVs for methane and carbon dioxide have been calculated to be 0.26 l/hr and 0.0 l/hr respectively. Therefore the site falls into 'Characteristic Situation' 2 (low hazard) in Table 8.5 of CIRIA 665.

The type of building proposed is commercial and for this Table 8.6 of CIRIA 665 indicates that the following special protection measures are required in the new buildings.

- Reinforced cast insitu floor slab with at least 1200 gauge DPM
- Beam block or precast concrete slab and at least 2000 gauge DPM/reinforced gas membrane
- Underfloor venting
- All joints and penetrations sealed

Underfloor venting is not required in large spaces such as a warehouse but it is required where smaller rooms such as offices are present.

7.3.4 Unforeseen Risks During Development

The site contains made ground/possible made ground in some areas and thus landscape and maintenance workers should wear gloves, boots and overalls and wash their hands before eating, drinking and smoking. Excessive dust generation should be avoided.

Given the existence of made ground on the site it would be prudent to maintain vigilance during site clearance and construction, in case any further areas of suspected contamination are

encountered. If areas are found then a suitably qualified person should undertake appropriate sampling, testing and further risk assessment.

Excavations or below ground voids should be checked for the presence of harmful gases prior to personnel entry.

7.4 Off-site Disposal of Surplus Soil

7.4.1 General

All excavated material and excess spoil must be classified for waste disposal purposes prior to disposal at landfill. Under the Landfill (England and Wales) Regulations 2002 (as amended), prior to disposal all wastes must be classified as:

- 'inert', or
- 'non-hazardous', or
- 'hazardous'.

The Environment Agency's *Hazardous Waste* (*Technical Guidance WM2*) document outlines the methodology for classifying wastes.

Currently all wastes may require pre-treatment prior to disposal at landfill.

7.4.2 Initial Waste Characterisation

Envirolab have produced an assessment tool, 'Haswaste', that characterises contaminated waste soil by following the guidance within WM2. The 'total solid testing' results from this investigation have been run through this assessment tool to aid potential future off-site disposal of materials. This assessment produces an 'initial' characterisation of the waste which determines if it is hazardous or not (if it is 'not' hazardous, then it may be either inert (insoluble and inorganic) or non-hazardous. However, due to complications with the terminology of 'inert waste' it is best not to refer to it as such until after Waste Acceptance Criteria testing).

The initial waste characterisation shows that the samples tested are not classed as hazardous, except for TP12 at 0.15m which is classed as hazardous due to its high lead result. The assessment is included in Appendix D.

It is important to note that whilst we believe our in-house assessment tool to be an accurate interpretation of the requirements of WM2, thereby producing initial classifications in

accordance with it, landfill operators often have their own assessment tools and can often come to a different conclusion. As a result, some landfill operators could even refuse to take apparently suitable waste.

8 SUMMARY

8.1 Grovefield Way, Cheltenham is the proposed location for a new car showroom.

8.2 A desk study completed prior to the commencement of site works indicated that the site has predominantly been fields since 1884. However there was a cottage present from 1884 until 1887 when it became a farm and later demolished between 1949 and 1972. The A40 trunk road was constructed to the north of the site between 1949 and 1972 and residential and industrial estates were established to the east of the site during this period also. Orchards on the site were felled between 2002 and 2005. The environmental data identified a historic landfill site to the north east of the site of unknown age.

8.3 A site investigation was completed between the 31 July 2008 and 6 August 2008. The investigation consisted of 8 no. cable percussion boreholes, 14 no. trial pits, and 7 no. Californian Bearing Ratio tests and 3 no. soakaway tests. The boreholes and trial pits encountered made ground up to 1.4m thick overlying superficial clays, beneath which stiff to hard grey clay and very weak mudstone of the Charmouth Mudstone Formation were encountered.

8.4 Tested samples show medium to high volume change potentials with changes in moisture content, according to the criteria of NHBC Standards, Chapter 4.2 (2003) *Building Near Trees*. We recommend that A high volume change potential be assumed for foundation design at this site.

8.5 The proposed buildings can be constructed on conventional strip or pad foundations. The foundations should be taken down through the made ground and upper superficial clays to a minimum depth of 1.00m depth. The allowable bearing pressure should be restricted to 140kN/m^2 to keep settlements below the generally accepted value of 25mm.

8.6 Lightly loaded ground bearing, floor slabs may be used at this site (designed in accordance with NHBC Standards). For ground bearing slabs the formation must be proof-rolled and any soft spots must be excavated and replaced with suitably compacted granular fill. However where made ground in excess of 600mm deep was encountered, NHBC Standards requires the use of suspended slabs as a precaution against differential settlement.

8.7 We recommend using a CBR value of 2.0% for pavement design provided any soft spots are replaced with a suitably compacted granular fill. It should be noted that the CBR tests were carried out on cohesive soils that were dry and stiff when tested, and lower CBR values would be obtained during wetter weather.

8.8 Shallow soakaways are not practical at this site.

8.9 The Aggressive Chemical Environment for Concrete (ACEC) class is AC-4 where concrete could be contact with groundwater and AC-1 if there is no risk of concrete being in contact with groundwater. The designer should utilise these classifications in order to produce the concrete specification.

8.10 No radon protection is necessary for this site as less than 1% of homes are above the action level.

8.11 TP12 at 0.15 m showed elevated lead in the made ground. Therefore the made ground (0.3m thick) should be replaced in the vicinity of TP12 if soft landscaping is proposed in this area. Further testing might be required to delineate the area.

8.12 Normal polythene water supply pipes should be suitable for the site, but this should be confirmed with the local water company

8.13 The gas monitoring results suggest that gas protection to CS2 of C665 should be provided. This requires a gas resistant membrane, sealed around service entries, and a vented underfloor void. Underfloor venting may not be required for large spaces such as warehouse.

8.14 All samples, except for TP12 at 0.15m depth, have not been classed as hazardous for disposal. Trial pit TP12 however was classed as hazardous.

STRUCTURAL SOILS LIMITED

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9 REFERENCES

9.1 BS 5930:1999 Code of Practice for Site Investigations

9.2 BS 5930:1999 *Code of Practice for Site Investigations:* including amendment 2 (2010)

9.3 BS 10175:2011 *Investigation of potentially contaminated sites: Code of practice*, including amendment A1 (2013)

9.4 Geological Survey of Great Britain for *Tewkesbury,* sheet 216, scale 1:50,000

9.5 Environment Agency website, www.environment–agency.gov.uk

9.6 CIRIA Report C552 (2001), *Contaminated Land Risk Management*; A Guide to Good Practice

9.7 BRE Report 279 *Sulphate and acid attack on concrete in the ground*: recommended procedures for soil analysis

9.8 Health and Safety in Construction, HSG150, HSE, 1996

9.9 NHBC Standards, Chapter 4.2, 2007 *Building Near Trees*

9.10 BRE Digest 365 (1991) *Soakaway Design*

9.11 BRE Special Digest 1 (SD1)(2005) *Concrete in Aggressive Ground Part 1*: Assessing the aggressive chemical environment. Third Edition

9.12 Environment Agency Policy. Part IIA – *Detailed Quantitative Assessment of Chronic Risks to Human Health from Contaminated Soils.* Policy Number 199_04, dated 9 March 2004.

9.13 R & D Publication CLR 11 (September 2004). *Model Procedures for the Management of Contaminated Land*. Contaminated Land. Environment Agency.

9.14 The Water Supply (Water Quality) Regulations 2000, DoE

9.15 CIRIA Report C665 *Assessing risks posed by hazardous ground gases to buildings, London*, 2007

9.16 *Hazardous Waste: Interpretation of the Definition and Classification of Hazardous Waste*, Environment Agency, WM2 Version 1.0, June 2003

9.17 *Landfill (England & Wales) Regulations* 2002

9.18 N. A. Tranter (2001) *Earthworks*: A guide published by Thomas Telford Limited

APPENDIX A

(i) Site Location Plan

(ii) Exploratory Hole Location Plan

(iii) Current Plan of Development Site