**INTERPRETIVE REPORT**

**on**

**GROUND INVESTIGATION**

**at**

**DUNHAMS COURTYARD,**

**HATFIELD**

**FEBRUARY 2008**

**REPORT NO: 720858**

# STRUCTURAL SOILS

# GASCOYNE CECIL ESTATES LTD.

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# 1 INTRODUCTION

This investigation was carried out on the instructions of Brooks/Murry Architects (the 'Engineer') on behalf of Gascoyne Cecil Estates Ltd (the 'Client'). The purpose of the work was to investigate ground conditions and provide information for the design of foundations for a number of residential properties with associated garages and to assess the contamination status of the site.

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 dynamic sampling techniques of soft ground boring and trial pitting techniques, in general accordance with the recommendations of BS5930: 1999 *Code of Practice for Site Investigations* and with BS10175 *Investigation of Potentially Contaminated Sites: Code of Practice* (2001). 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.

A comprehensive desk study, other than an inspection of geological maps, has not been requested or undertaken as part of this investigation. However a desk study has been carried out by Hyder Consulting (Report No: 0001-LN00855) dated July 2005, a copy of which was provided by the Engineer and which is discussed in this report.

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 which 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.

This report does not consider ecological impacts (eg bats) or botanical risks (eg Japanese knotweed). It is recommended that these are considered as part of the assessment of development constraints for the site.

This report was prepared by Structural Soils Ltd for the sole and exclusive use of Gascoyne Cecil Estates Ltd. 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.

# 2 SITE DESCRIPTION

## 2.1 Location and Topography

The site is located between Great North Road and Park Street in 'Old Hatfield', to the east of Hatfield town centre in the county of Hertfordshire. The British National Grid Reference of the site is TL 235 087 (see Site Location Plan in Appendix A).

The site is irregularly shaped occupying an area approximately 100m x 50m in size. The surface of the site is level and covered by a reinforced concrete pavement bounded by 33 no. lock up garages (see Exploratory Hole Location Plan in Appendix A).

The site lies within a predominantly residential area with a number of local businesses close by. Hatfield Park lies approximately 50m to the east of the site, access to which is over a viaduct running west to east approximately 15m to the south of the site. The viaduct is supported on earth embankments orientated north-south which rise approximately 10-15m above the general level of the site. The northern edge of the closest earth embankment to the site slopes gradually down to meet the rear of the garages that line the southern edge of the site. There are a number of large trees (approximately 10-20m high) to the south of the site on the viaduct embankment. A small (5m x 5m) grassed area exists at the entrance to the garages accessed off Park Street. There is also a large tree within this grassed area.

Buried services on site include a storm water drain located to the west of the site orientated northwest-southeast.

In addition to the main area of investigation, one exploratory hole was located at the foot of the viaduct embankment on the southern side of the viaduct (TP5 – see Exploratory Hole Location Plan in Appendix A). Immediately to the south and east of this are small commercial premises believed to contain a metal workshop and a builders yard.

The nearest surface water feature is the River Lee approximately 1.25km to the northeast

## 2.2 Geology

The Geological Survey Map of Great Britain (sheet 239, scale 1:50,000) shows the site to be underlain by Glacial Gravel (with Bunter Pebbles) of Pleistocene age. These deposits are underlain by the Upper Chalk Formation of Palaeocene age, which is typically soft white chalk with many flints. Approximately 600m to the northwest the Glacial Gravel is absent and the chalk is overlain by Boulder Clay. The Upper Chalk Formation is noted to outcrop approximately 250m to the southeast. From cross sections on the map for a point approximately

4km to the north, the superficial deposits in the area are thought to be relatively thin and chalk to be at between 10-15m depth.

## 2.3 Hydrogeology

The Environment Agency's Groundwater Vulnerability Map of West London (sheet 39, scale 1:100,000) shows the site to lie on a major aquifer (highly permeable). These are highly permeable formations usually with a known or probable presence of significant fracturing. They may be highly productive and able to support large abstractions for public supply and other purposes.

The soils on this site have been classified as having a high (urban) leaching potential (HU), as soil information for urban areas is based on fewer observations than elsewhere. Therefore a worst-case vulnerability classification is assumed (HU) until proved otherwise.

## 2.4 Summary of Desk Study

A desk study was carried out in July 2005 (Report no: 0001-LN00855) by Hyder Consulting, a copy of which has been supplied by the Engineer. The desk study covers both the site and some of the surrounding area.

The desk study shows no significant land use change to the site or the immediate surrounding area from the date of the earliest historical map obtained, 1879, up until the present day, except as follows. Initially shown to be fields, the site was developed at some point between 1961 and 1971 with the 33 no lockup garages that remain present today.

Other information supplied revealed that "localised hydrocarbon staining was noted" within an archaeological trial pit recently excavated down the centre of the hard standing area on site. The trench log shows a "contaminated Topsoil" layer beneath the pavement to 0.58m depth over "glacial deposits" to the final depth of 0.9m.

## 2.5 Initial Contamination Conceptual Model

### 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.

The risk assessment uses a 'Source-Pathway-Receptor' methodology for assessing whether a source of contamination could potentially lead to harmful consequences. This means that there needs to be a pollutant linkage from source to receptor for harm to be caused, this linkage consisting of:

- a source of pollution;
- a pathway for the pollutant to move along;
- a receptor that is affected by the pollutant.

As an example, the pollutant source could be an identified leak of oil or area of dumped waste.

The pathways could include transport of the contaminant by groundwater, surface water, windblown dust, or vapours, and for human receptors will include the means by which contaminants enter the body, for example skin contact, ingestion and inhalation.

Receptors include people, other living organisms, the built environment and groundwater and surface waters (these latter two also being contaminant pathways).

The source-pathway-receptor methodology relationship allows an assessment of the environmental risk to be determined, based on the nature of the source, the degree of exposure of the receptor to the source and the sensitivity of the receptor.

This section of the report is based on the information set out in the previous sections of the report and should not be read independently of such sections.

### 2.5.2 Potential Sources

Potential sources of contamination on site are the material used to build the embankment which meets the southern site boundary and any other made ground on the site. Other sources of contamination on site may come from the lock up garages, "localised hydrocarbon staining" reported in the archaeological trench and a firm of metal workers located adjacent to the smaller area of investigation that lies south of the viaduct. Off-site sources of contamination may come from the railway (220m W), metal processing plant (240m SW), the garage (150m S) and historic gas works (440m SW).

### 2.5.3 Potential Contaminants

The potential primary contaminants associated with the sources identified above include:

| **Potential on site sources** | **Likely contaminants** |
|---|---|
| Lock up garages | Hydrocarbons and various. |
| Staining | Hydrocarbons. |
| **Potential off site sources** | **Likely contaminants** |
| None close to site | |
| Firm of metal workers | Metals & asbestos. |
| Embankment and other made ground | Heavy metals, hydrocarbons, ground gases & possible asbestos. |

### 2.5.4 Receptors

The main receptors include:

- Future site users
- Maintenance workers
- Construction workers
- Vegetation
- Buildings, structures and services

- Groundwater (major aquifer)

### 2.5.5 Pathways

The potential pathways that could connect sources and receptors include the following:

- Direct dermal contact with contaminated soil or groundwater
- Inhalation of vapours/gases/dust
- Ingestion of contaminated soil or vegetables
- Flow of gases/vapours into buildings
- Sulphate attack of concrete foundations and structures
- Leaching of contaminants to underlying groundwater

## 2.6 Initial Environmental Risk Assessment

### 2.6.1 General

It is accepted that an environmental risk assessment can be based on a source-pathway-receptor model. We examine whether a receptor (a future resident for example) will be at risk from a contamination source (such as methane gas). First we determine whether the methane gas is present or not, then we consider whether there are any pathways (routes of exposure) which might actually link the future resident to the methane hazard.

Environmental risk assessments rely heavily on numerical trigger concentrations or guidelines because exposure of targets to contamination is difficult to quantify directly. Quantification of risk is therefore mainly undertaken for general scenarios in order to derive trigger levels. These are derived for various contaminants for particular targets and routes of exposure. An example of a fairly sensitive target would be users of a domestic back garden, where routes of exposure might be skin contact, dust inhalation, direct ingestion and indirect ingestion via cultivation and consumption of fruit and vegetables.

In March 2002 the first parts of the new CLEA risk assessment guidance were released by DEFRA/Environment Agency.

The risk assessment approach is an extension of the 'fit for use' concept whereby land is cleaned up to a standard fit for the proposed use, that is, so all remaining risks are acceptable. But as well as being 'fit for use', the environment risk assessment approach also addresses the soil and

water environment so that these are also safeguarded where necessary. For example if a site was contaminated with heavy metals and the development comprised the proposed construction of hard standings and buildings only, the fit-for-use approach might require no remediation for the site. However, consideration of the wider environment leads us to question whether groundwater is being contaminated, and if so whether remediation is required for this reason instead.

Clean-up of sites is only generally affordable if funded by a proposed development, although it is sometimes necessary to safeguard the environment from a site which poses an acute risk but which is not scheduled for development. This appears to be the purpose of the Part IIA contaminated land regime, whereas development sites are regulated by the planning process.

### 2.6.2 Source-Pathway-Receptor Linkages

The current potential risks to the receptors arising from the various source-pathway-receptor linkages are assessed on the basis that the site is to be redeveloped into three-story residential dwellings with associated garages. This initial assessment was made by Hyder Consulting in July 2005 (Report no: 0001-LN00855) and a summary of this is presented below:

| Source | Pathway | Receptor | Potential Risk |
|---|---|---|---|
| Any contaminated soil present including any contaminated material from spillage/ leakage | Direct dermal contact/ inhalation/ ingestion | Current site users | **Low** – limited contact due to site predominantly being covered in buildings and hardstanding. |
| | | Future site residents | **Medium** - in its current state. Assess risk by a detailed ground investigation. |
| | | Maintenance and construction workers | **Low** – likely to come into direct contact with ground. Manage with appropriate PPE. |
| | Leaching of contaminants | Groundwater under the site (major aquifer). | **Medium** – leaching of contaminants through the glacial gravel overlying the chalk aquifer is likely. Assess risk by detailed ground investigation. |
| | Uptake through root systems. | Current and future vegetation and soft landscaping | **Low to medium** – assess risk by a detailed ground investigation. |
| | Direct contact or via groundwater | Current buildings and services | **Medium** – substances that can be involved in chemical attack of buildings may be present on site (e.g. sulphates, chlorides and possible fuels and oils). Assess risk by detailed ground investigation. |
| | | Future residential properties | **Medium** – assess risk by detailed ground investigation. |
| Vapours/ gases associated with contaminants | Inhalation | Site construction workers and maintenance workers. | **Low** – manage with appropriate PPE. |
| | | Future residents | **Low to medium** - assess risk by a detailed ground investigation. |
| Unexploded ordnance | Explosion | Current and future site users, construction workers and future residents. | **Low** – no records of unexploded bombs found at Hertfordshire Records Office. |

In this qualitative risk assessment a low risk implies that remedial action is unlikely to be required at the site, where any higher degree of risk is likely to require further assessment and possibly remediation.

This study has found potential low to medium risks, therefore a contamination investigation, including the installation of gas monitoring wells, should be undertaken to assess the risk to human health and groundwater.

## 3 FIELDWORK

3 no. machine dug trial pits (TP1 to TP3), 2 no. hand dug trial pits (TP4 to TP5) and 4 no. percussive window sample exploratory holes (WS1 to WS4) were completed on 18 December 2007 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 Ltd, in conjunction with the Engineer and the Client. The positions were selected by Structural Soils Ltd in conjunction with the Client and mostly set out by the Client.

All trial pits and concrete excavation/reinstatement at the borehole and trial pit locations was carried out by a workforce supplied and directed by the Client.

The hand dug trial pits were approximately 2.0m x 0.6m in plan and up to 1.20m deep. The other trial pits were excavated using a wheeled mechanical excavator and were approximately 2.3m x 1.0m in plan area and up to 1.75m deep. The trial pits encountered made ground and possible made ground comprising clays, gravels and silts. Trial pits TP1 to TP4 were excavated against the existing garages to expose the foundations. Logs for the pits which show the details exposed are contained in Appendix B. TP5 was located to the south of the main site to provide preliminary information on ground conditions at that location. The log is also included in Appendix B. Hand vane tests were carried out in the cohesive strata in the trial pits and disturbed samples were taken and returned to the laboratory for testing.

The percussive window sampler exploratory holes were 86mm in diameter at the surface reducing in diameter with depth and were between 3.0m and 5.0m deep. The holes encountered made ground over natural superficial and glacial deposits. Samples were taken and returned to the laboratory for testing. Standard Penetration Tests were carried out at 1.0m intervals in accordance with BS1377: Part 9: 1990: 3.3. Test results are given in detail in Appendix B and summarised on the borehole logs. Undrained shear strengths of the cohesive strata encountered within the boreholes were measured directly using a hand penetrometer. The results are given in detail on the borehole logs contained in Appendix B.

On completion 40mm diameter combined gas/groundwater monitoring wells complete with flush fitting protective covers were installed in WS1 and WS3, the design having been decided by Structural Soils Ltd. Details of the monitoring wells are given on the logs in Appendix B.

2 no. return monitoring visits were made on 17 January and 7 February 2008 to monitor groundwater levels and the presence of gas within the standpipes. The results are contained in Appendix E.

On completion WS2 and WS4 were backfilled with bentonite pellets and all trial pits were backfilled with arisings. As previously noted, the hard cover was reinstated by the Client where necessary.

# 4 LABORATORY TESTING

The following laboratory tests were carried out on samples unless indicated otherwise generally in accordance with BS1377: 1990, *Methods of test for soils for civil engineering purposes*, parts 1 to 8. Where non-standard procedures have been undertaken, this will be recorded on the report sheet. The results are reported in tabular and/or graphical form included as Appendices C and D of this report.

Samples for geotechnical testing were returned to the company's laboratory in Bristol and those for contamination testing were sent to an approved chemical testing laboratory. Geotechnical and contamination tests were scheduled by Structural Soils Ltd.

## 4.1 Moisture Content

3 no. moisture contents were undertaken using the oven-drying method in accordance with BS1377: Part 2: 1990. The results are tabulated in an A Line Plot (in accordance with BS5930: 1999).

## 4.2 Liquid Limit, Plastic Limit and Plasticity Index

3 no. liquid and plastic limit tests were performed in accordance with BS1377: Part 2: 1990. The results are tabulated in an A Line Plot (in accordance with BS5930: 1999).

## 4.3 Particle Size Distribution

2 no. particle size distribution tests were undertaken by sieving in accordance with BS1377: Part 2: 1990. The results are represented graphically as particle size distribution curves and in tabular format.

## 4.4 Unconsolidated Undrained Triaxial Compressive Shear Strength Tests (without the measurement of pore pressure)

3 no. single stage unconsolidated undrained triaxial compression tests without the measurement of pore pressure were undertaken in accordance with BS1377: Part 7: 1990. Each test was carried out on a single specimen between 51mm and 75mm in diameter and between 100mm and 161mm in length. These confining pressures ranged between 35 and 60kPa.

The results are tabulated in the Summary of Undrained Triaxial Compression Tests.

## 4.5 Chemical Analyses

3 no. samples of soils were tested to determine their pH values and soluble sulphate ($SO_4$) contents in accordance with BS1377:Part 3:1990 clause 5.

The results are tabulated in the Summary of Chemical Analysis.

### 4.6 Contamination

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

The results are tabulated in Appendix D.

# 5 GROUND CONDITIONS

## 5.1 General

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

## 5.2 Made Ground

Made ground was encountered within all exploratory holes on site and proven to a maximum depth of 1.60m in TP3, in which the base of the made ground was not found. Possible made ground was proven to a maximum 1.75m depth in TP2 which terminated in this unit. The made ground varied across the site, consisting of predominantly sandy gravelly clays. The gravel within this layer consists of predominantly flint and brick fragments. The possible made ground encountered in TP1 and TP2 consisted of sandy clay and silt respectively.

## 5.3 Glacial Deposits

Directly beneath the made ground in the window sample exploratory holes lies soft typically varying to firm slightly gravelly clay. This becomes stiff below about 2.5m depth with the exception of WS1 in which the soft or firm clay extends to 4.0m depth. The gravel consisted of predominantly fine to medium flint. Beneath this layer in WS4 (to the east of the site) at 2.60m depth lies dense slightly sandy silty gravel which was proven to 3.0m depth.

Beneath about 2.50m in WS2 and WS3 was stiff slightly sandy slightly gravelly clay which was proven to a maximum of 5.0m depth in WS3. In WS1 the clay soils were underlain by dense clayey gravelly sand at 4.0m depth which were proven to the base of the borehole at 5.0m.

As the shear strength values within the cohesive material vary greatly throughout the stratum, the very soft clays directly beneath the made ground in WS1 may be indicative of some form of infilled glacial channel or similar feature.

## 5.4 Groundwater

Groundwater was encountered at 3.5m depth in WS1. The other exploratory holes remained dry. Groundwater levels in the monitoring wells installed in WS1 and WS3 were measured on 17 January and 7 February 2008 and were dry on both occasions.

## 5.5 Existing Foundations

Hand dug trial pits excavated against the existing garages showed their foundations to be set at between 1.10m and 1.30m depth within the made ground and to consist of a concrete footing 200mm thick. The foundations typically projected by approximately 150mm to 200mm from the wall of the garages although in some cases the foundation concrete extended further (at least 700mm in TP1). This is considered to probably be over-spill of excess concrete during construction and not part of the original design.

# 6 DISCUSSION AND RECOMMENDATIONS

## 6.1 General

The proposed development is understood to comprise the demolition of the existing garages and the construction of new three-storey residential dwellings with associated garages and access road. The proposed three storey building is to be built on the northern half of the site (from borehole WS3 to the northern boundary) with the garages being built along the southern boundary. No design foundation loads have been provided.

## 6.2 Site Preparation and Excavation

The soils encountered at the site are considered to be suitable for excavation using standard mechanical plant such as a wheeled backhoe excavator. Groundwater was encountered at 3.5m depth during the site works at one location only (WS1). The monitoring wells installed in boreholes WS1 and WS3, which were 1.50m and 2.50m deep were found to be dry during two subsequent monitoring visits. Based on these findings, groundwater is unlikely to be encountered in shallow foundation or service excavations.

Based on observations made during the site works, excavations in the cohesive soils and medium dense/dense gravels encountered at anticipated foundation depths (see section 6.3 below) will probably remain stable in the short term which should be sufficient for construction of trench fill foundations. However the made ground encountered across the majority of the site may be unstable and could require support, especially where granular in nature.

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* (Ref 8.8).

## 6.3 Foundations

It is recommended that conventional strip foundations be adopted for the proposed development. These may possibly be founded at 1.50m depth on the natural clays encountered, however these offer low allowable bearing capacities and deeper foundations may be required. It may also be necessary to deepen foundations in the south-western corner of the site where clay soils may occur close to mature trees. All foundations should be designed in accordance with the NHBC Standards (see also Section 6.6).

In-situ tests carried out within the dynamic sample exploratory holes and SPT's carried out within all exploratory holes have indicated the natural clay to be predominantly soft with a

typical minimum recorded undrained shear strength of 30kN/m$^2$ in the upper part of the unit. Based on these findings, a minimum net allowable bearing capacity of 65kN/m$^2$ is available for conventional strip foundations up to 1.00m wide set on the natural clay soils which underlie the made ground. These occur between 1.0m and 1.5m depth and a minimum foundation depth of 1.5m is recommended to take foundations below the softest deposits increasing to 2.0m depth in the vicinity of WS1.

The total long term settlement of foundations exerting the above bearing pressures should not exceed 25mm. For example, a 1.00m wide foundation set at 2.0m depth in the vicinity of WS1 should be in the order of 15-20mm. This is based on an estimated coefficient of volume compressibility, $m_v$, of 0.3m$^2$/MN, and a geological factor, $\mu_g$, of 0.8 for the natural clay soils.

A minimum net allowable bearing capacity of 100kN/m$^2$ may be assumed for square pad foundations up to 2.0m wide set at the same depth, for which total long term settlement should not exceed 25mm.

Higher allowable bearing capacities are available in the vicinity of borehole WS2, WS3 and WS4. At these locations the clay soils become noticeably more stiff at around 2.0-2.5m depth, or, in the case of borehole WS4, passed into dense gravel at 2.60m depth.

Assuming a slight decrease in the coefficient of volume change ($m_v$) for the clay soils with depth to, say, 0.25m$^2$/MN below 2.5m, a minimum net allowable bearing capacity of 125kN/m$^2$ may be assumed for a 1.0m wide strip foundation set at 2.0m depth or greater in the vicinity of WS2, 3 and 4, for which the total long term settlement should not exceed 25mm.

In WS1 the soft clays extended to 4.0m depth where the borehole passed into dense clayey gravelly sand. To obtain increased minimum allowable bearing capacities at this location it would be necessary to take foundations down to the sand. Given the depth of excavation required in such cases a beam and base foundation solution might be practicable, or, alternatively, a piled foundation solution. In either case it would be recommended that a deeper (say 15m cable percussion) borehole be sunk at the location to obtain additional information for design purposes.

As there is noticeable variation in shear strength in the clays across the site consideration should be given to reinforcing strip foundations to limit differential settlement.

## 6.4 Floor Slabs

The made ground, which typically comprised loose rubble and reworked soft soils was encountered to 1.0m depth toward the south of the site and 1.5m depth toward the north. The made ground is not considered suitable for supporting ground bearing floor slabs.

NHBC guidelines suggest that suspended floor slabs be utilised where the made ground exceeds 600mm or where required foundation depths are in excess of 1.5m due to shrinkage and swelling issues (see section 6.5 below). Suspended floor slabs are therefore recommended for use across the site.

## 6.5 Shrinkage and Swelling

Atterberg Limits tests performed on samples taken from the window samples showed them to be of groups CI and CH as defined in BS 5930:1999. After correction where necessary for their >0.425mm fraction, these samples show medium volume change potentials with changes in moisture content, according to the criteria of NHBC Standards, Chapter 4.2 (2007) *Building Near Trees*. A medium volume change potential should therefore be assumed for all cohesive soils on the site.

Foundations should be designed in accordance with the NHBC standards to take account of existing trees, whether retained or removed, and possible future plantings. Mature trees are present immediately beyond the western edge of the site and foundation depths here should take account of the potential depth of influence of the roots from these trees on the clay soils. Foundations may need to be deepened below the minimum depth of 1.5m discussed in Section 6.3 in this area.

## 6.6 Protection of Buried Concrete

The water-soluble sulphate results for soil fall into Design Sulphate Class DS-1 in Table C2 of BRE Special Digest 1 (Ref 8.5). The site is classed as brownfield and groundwater is mobile. pH values varying from 7.8 to 10.6 were recorded indicating alkaline soil pH conditions. Therefore according to Table C2 the Aggressive Chemical Environment for Concrete (ACEC) class is AC-1 and the designer should utilise this classification in order to produce the concrete specification.

## 6.7 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 BRE report indicates that no radon protection is necessary.

## 6.8 Contamination

### 6.8.1 General

In March 2002 DEFRA (Department of the Environment, Food and Rural Affairs) and the Environment Agency released the CLEA (Contaminated Land Exposure Assessment) model and the first tranche of Soil Guideline Values (SGV) covering 7 contaminants. There will eventually be SGV's for 55 contaminants, but the timescale is not known.

Generally there will be SGV's for each contaminant, for several different uses of land. Currently the land-uses are limited to residential (with and without plant uptake), allotments and commercial. These standard SGV's are derived in such a way as to be conservative and are tabulated with the results.

There is also an interactive CLEA computer model which is intended to allow the standard values to be adjusted for soil type, pH and organic matter content. At present however, these adjustments tend to be of insignificant magnitude. Therefore it is usually appropriate to assess the results for the site against the standard values; provided that the exposure assumptions used to derive the SGV's are relevant to the site. The interactive model also allows an insight into the process which is followed in order to derive an SGV for a given contaminant and land-use.

The CLEA system also introduces some statistical testing of the test results. In principle, the mean (average) of the results for a given contaminant could be compared with the SGV. However, the measured mean could differ significantly from the true mean if only a limited number of results were available. Therefore in the *mean value test* the upper 95$^{th}$ percentile of the mean measured concentration ($US_{95}$) is calculated for each contaminant and this is compared to the SGV. This test calculates the upper bound, below which 95% of the results would be expected to lie. If the mean value exceeds the SGV then this may indicate a requirement for remediation or further investigation.

If the mean value lies below the SGV, then remediation is not likely to be required: this may be the case even if some individual results exceed the SGV, as long as the high results fall within the same sample population, as discussed below.

There is also a *maximum value test* and this determines whether results which exceed the SGV fall within the range that can be expected from the sample population, or whether they are indicative of an area of higher contaminant concentrations and hence are called "outliers". If outliers are present, then again this may indicate a requirement for remediation or further investigation.

Until recently the assessment of contamination was based upon ICRCL Guidance Note 59/83. In December 2002 DEFRA withdrew ICRCL 59/83 because it was thought that its inconsistency with CLEA would cause confusion. The withdrawal of ICRCL Guidance Note 59/83 prior to the publication of CLEA guidelines for most contaminants has meant that there is at present no UK guidance for some contaminants. In the absence of CLEA guidelines reference can be made to the generic assessment criteria (GAC) derived using the Risk-Based Corrective Action (RBCA) model by RSK. The GACs and the methodology used to derive them are shown with the results.

### 6.8.2 Contaminants Which May Pose Hazards To Human Health (arsenic, cadmium, chromium, lead, mercury, nickel, selenium, copper, nickel, zinc, Polycyclic Aromatic Hydrocarbons (PAH), benzo(a)pyrene (BaP), Total Petroleum Hydrocarbons (TPH)

Except as follows the mean value test ($US_{95}$) results for these contaminants were below the CLEA SGVs for residential use with and without plant uptake. There were no outliers above the guidelines.

The mean value for nickel was below the SGV for residential with plant uptake, but TP2 at 0.4-0.6m showed 55mg/kg which slightly exceeds the SGV of 50mg/kg with plant uptake, although it is below the SGV without plant uptake of 75mg/kg.

### 6.8.3 Contaminants in Soil Which May Pose a Hazard to Plantings

Copper, nickel and zinc are all potentially phytotoxic in high enough concentrations. Guidance on the levels has been utilised from the Code of Practice for Agricultural Use of Sewerage Sludge, 1996.

The concentrations determined of these contaminants were below the stated guidelines for these contaminants affecting plants.

### 6.8.4 Contaminants Which May Pose Hazards to Groundwater

No samples of groundwater were analysed as potential contamination is considered to be low and therefore testing was not deemed necessary (as mentioned in Section 2.6.2).

### 6.8.5 Summary of Contamination

The analyses undertaken on the samples tested suggest that the site is not contaminated for the proposed end-use.

There was one slightly elevated nickel result in TP2 but this is located under a proposed hard surfaced area and not near any gardens, so it is not likely to be significant. Furthermore the mean value was below the relevant SGV.

## 6.9 Methane and Carbon Dioxide

Gases were monitored on 17 January and 7 February 2008 and the results are contained in Appendix E.

There are no historical potential sources of land gas generation within 250 metres of the site. Therefore in general accordance with CIRIA 659 the potential for gas generation is considered to be low. The sensitivity of the development is deemed to be high (houses).

In accordance with the approach proposed by CIRIA 659 (Ref 8.14) the worst-case gas screening values have been calculated for each visit as shown in the table below.

| Visit | Flow | Methane ($CH_4$) | | Carbon Dioxide ($CO_2$) | |
|---|---|---|---|---|---|
| | | Maximum Concentration | Gas Screening Value | Maximum Concentration | Gas Screening Value |
| 17 Jan 2008 | 0.2 | 0 | 0 | 1.3 | 0.0026 |
| 7 Feb 2008 | 0.4 | 0 | 0.0016 | 0.1 | 0.0004 |

The highest gas screening values were 0.0016 l/h for methane and 0.0026 l/h for carbon dioxide. Theses values are below the 0.16 l/h and 0.78 l/h upper thresholds for the green classification in the 'traffic light' system for low rise housing with suspended floors in CIRIA 659. Table 8.4 of CIRIA 659 states that for this classification gas protection measures are not considered necessary.

This assessment is only valid if the development conforms reasonably to the house model stated in CIRIA 659 which includes a 150mm vented subfloor void. If this is not the case then the development should be assessed using the modified Wilson and Card approach also detailed in CIRIA 659. This would also classify the site as not requiring precautions.

The site is classed as having a low gassing potential but a high risk end use and CIRIA 659 conservatively calls for 9 visits over 6 months. Therefore the local authority might require further monitoring on this site.

## 6.10 Final Contamination Conceptual Model

### 6.10.1 General

This section of the report aims to clarify 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.

### 6.10.2 Sources, Pathways & Receptors

The potential sources of contamination (which have been outlined in section 2.5.3 of this report) are considered to have not changed from the 'Initial Contamination Conceptual Model'. The potential receptors and pathways are considered to have not changed. No significant soil or gas contamination was encountered in the investigation.

## 6.11 Final Environmental Risk Assessment

### 6.11.1 General

This section reassesses likely risks to the identified receptors, arising from potential contamination sources. It provides a final qualitative assessment of the risks involved, indicating whether (where appropriate) any immediate action is required to mitigate certain risks. It also discusses (where appropriate) what longer term measures or remedial works may be required in the future if the site were to be developed.

Significant points to be considered have not changed from the 'Initial Environmental Risk Assessment'.

It is considered that the site would not be assessed by the local authority as a contaminated site under the terms of the Environmental Protection Act 1990 Part IIa.

### 6.11.2 Environmental Risk Assessment

| Source | Pathway | Receptor | Potential Risk | Linkage Number | Action Required |
|---|---|---|---|---|---|
| Any contaminated soil present including any contaminated material from spillage/ leakage | Direct dermal contact/ inhalation/ ingestion | Current site users | Low - Limited contact due to site predominantly being covered in buildings and hardstanding. | 1a | None |
| | | Future site residents | Low - no significant contamination found and no gardens proposed only soft landscaping. | 1b | None |

| | | | | | |
|---|---|---|---|---|---|
| | | Maintenance and construction workers | **Low** – no significant contamination found. | 1c | Excessive dust generation should be avoided. Basic PPE should be worn and general hygiene procedures should be followed. |
| | Leaching of contaminants | Groundwater under the site (major aquifer). | **Low** – no significant contamination found. | 1d | None |
| | Uptake through root systems. | Current and future vegetation and soft landscaping | **Low** – no significant contamination found. | 1e | None |
| | Direct contact or via groundwater | Current buildings and services | **Low** – no significant contamination found. | 1f | None |
| | | Future residential properties | **Low** – no significant contamination found. | 1g | None |
| Vapours/ gases associated with contaminants | Inhalation | Site construction workers and maintenance workers. | **Low** – site classed as having a low gassing potential | 2a | Local authority may require further monitoring due to high risk end use. |
| | | Future residents | **Low** - site classed as having a low gassing potential | 2b | Local authority may require further monitoring due to high risk end use. |
| Unexploded ordnance | Explosion | Current and future site users, construction workers and future residents. | **Low** – no records of unexploded bombs found at Hertfordshire Records Office. | 3a | None |

Some of the information given above has been adapted from the desk study carried out by Hyder Consulting.

Following the ground investigation the risks have been assessed as being potentially low.

## 6.12 Outline Strategy for Risk Reduction

Given the existence of made ground on the site it would be prudent to maintain vigilance during site clearance and construction, in case any areas of suspected contamination are encountered. If areas are found then a suitably qualified person should undertake appropriate sampling, testing and further risk assessment.

Site, 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.

## 6.13 Off-site Disposal of Surplus Soil

The disposal of waste (including surplus soils and contaminated soils) to landfill sites is governed by the *Landfill (England & Wales) Regulations 2002*, the *Hazardous Waste Technical Guidance document WM2 (2003)* and associated legislation.

One of the aims of the above legislation is to encourage waste producers (including developers disposing of surplus soils etc) to reduce their waste (and not just discard and disown it). This can be achieved by recycling or reusing the waste. In the case of contaminated sites where leaving contaminated material in-situ poses a risk to a potential receptor such as groundwater resources, further testing and assessment for such risk could reduce the quantities requiring disposal. If there is still unacceptable risk from contaminated soil being left in place, then it may be possible to reduce the risk to an acceptable level (such that the material can be left in place) by in-situ or ex-situ clean up of the soils.

Before waste can be disposed of, the producer of the waste must undertake a number of steps. '*Initial Waste Testing and Characterisation*' is firstly undertaken to determine whether the waste is non-hazardous or hazardous. The exceptions are that some wastes such as coal tars, 'tank bottom sludges', etc are immediately classed as hazardous, regardless of any testing or threshold concentrations.

Any inert or hazardous waste destined for landfill must undergo '*Compliance Testing*' using the Waste Acceptance Criteria (WAC). There are different inert and hazardous WAC limits relating to landfill sites that are correspondingly licensed to accept inert or hazardous waste.

If the '*Initial Waste Testing and Characterisation*' shows a waste to be hazardous, then it is a requirement that the material be tested against the WAC-hazardous suite of tests. If it *passes* the WAC-hazardous testing, then it can be taken to a hazardous waste landfill site. If the material *fails* the WAC-hazardous testing, then the material must be treated before undergoing re-characterisation, further WAC-hazardous testing and then potential disposal at a hazardous waste disposal site.

If the '*Initial Waste Testing and Characterisation*' shows a waste not to be hazardous, then it can be taken to a non-hazardous waste landfill site, without further testing. The producer may however decide to undertake WAC-inert testing, in an attempt to reclassify the waste as inert, in which case the waste could then go to an inert landfill site.

The volumes of soils associated with potential hotspots on a site (be they hazardous or non-hazardous) which might require off-site disposal, could potentially be reduced by further on-site sampling and subsequent testing.

The 'Initial Waste Characterisation' has been undertaken using CAT-WASTE$^{SOIL}$ (a commercially available assessment tool) and this shows that all of the samples tested are not classed as hazardous.

With regard to the *Compliance Testing*, it should be noted that some landfill sites are permitted to increase the standard WAC-hazardous/inert limit concentrations, such that they might accept waste that would normally fail such limits.

It is recommended that the exploratory hole logs and the results of the *Initial Waste Testing and Characterisation* (including the history of the site) be presented to the proposed landfills, to obtain their acceptance of the information to date and to determine the actual WAC limits used by them.

Attention is drawn to the landfill tax and the fact that waste (soils and other materials) arising from the remediation/reclamation of contaminated land (but excluding spoil from foundation excavations, or similar) is usually exempt from such tax. Exemption must be applied for 30 days before it is intended to start removing remediation waste to landfill (HM Customs and Excise document LFT2 refers. For advice telephone 0845 010 9000).

### 6.13.1 Safety of Site Workers

Site workers should wear gloves, boots and overalls and wash their hands before eating, drinking and smoking. Excessive dust generation should be avoided.

## 7 SUMMARY

**7.1** The proposed development is understood to comprise a number of residential properties with associated garages in an area currently occupied by lock up garages.

**7.2** The site is underlain by made ground to a maximum proven depth of 1.60m in TP3. Beneath the made ground lies soft/firm slightly gravelly clay (Glacial Deposits). This typically becomes stiff below 2.0m depth with the exception of WS1 where soft clay was present to 4.0m depth. In WS1 and WS4 the clays were underlain by sand and gravel at 4.0m and 3.0m depth respectively. In WS2 and WS3 stiff clay was proven to the base of the holes at 4.0-5.0m depth.

**7.3** Existing foundations for the garages were found to be between 0.9m and 1.1m depth with a concrete footing 200mm thick. The foundations typically project 150-200mm from the walls of the garages.

**7.4** Groundwater was struck in WS1 at 3.50m depth. All other exploratory holes remained dry. Two groundwater monitoring wells were installed during the works to a maximum depth of 2.50m and these were also found to be dry when monitored on two subsequent occasions.

**7.5** The soils encountered are considered suitable for excavation using standard mechanical plant such as a wheeled backhoe excavator. Excavations to anticipated foundation depths should remain dry.

**7.6** A net allowable bearing capacity of 65kN/m$^2$ is recommended for conventional strip foundations up to 1.00m set on the natural clay soils at 1.5m depth directly beneath the made ground. The estimated long term foundation settlement will be in the order or 15-20mm.

**7.7** In WS1 the soft clays extended to 4.0m depth where the borehole passed into dense gravelly sand. To increase minimum allowable bearing capacities at this location it would be necessary to take foundations down to the sand. In such cases a beam and base foundation solution might be practicable; alternatively a piled foundation solution may be favourable. In either case, further investigation is recommended

**7.8** Samples of cohesive soils tested showed modified plasticity indices of equal or greater than 20% and may therefore be considered to be of medium volume change potential according to the criteria of NHBC Standards, Chapter 4.2.

**7.9** The Aggressive Chemical Environment for Concrete (ACEC) class for the site is AC-1.

**7.10** BRE Report 211 indicates that no radon protection is required.

**7.11** The investigation has shown contaminant levels to be below the assessment criteria, which indicates that no risks to health have been identified.

**7.12** When applied to the guidelines contained within CIRIA report 665 the gas monitoring results obtained for this site suggest that no special precautions are required for this gas regime. However, the local authority might require further monitoring on this site as CIRIA 665 calls for 9 visits over 6 months.

**7.13** The 'Initial Waste Characterisation' has been undertaken using CAT-WASTE$^{SOIL}$ and shows that all of the samples tested are not classed as hazardous.

**STRUCTURAL SOILS LIMITED**

G Griffiths BSc (Hons) FGS

A R Handcock MA CEng MICE CGeol FGS

S Pond BSc CChem MRSC

# 8 REFERENCES


**8.1** BS 5930:1999 *Code of Practice for Site Investigations*

**8.2** BS 1377:1990 *Methods of Test for Soils for Civil Engineering Purposes*

**8.3** Geological Survey of Great Britain sheet 239 scale 1:50,000

**8.4** Hyder Consulting Desk Study: *Dunhams Courtyard, Park Street, Old hatfield.* Report no: 0001-LN00855 (July 2005)

**8.5** EA Groundwater Vulnerability Map of the West London sheet 39, scale 1:100,000

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

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

**8.8** Building Research Establishment Report 211 (2007) Radon: *Guidance on Protective Measures for New Dwellings*

**8.9** *Health and Safety in Construction*, HSG150, HSE, 1996

**8.10** R & D Publication CLR 10 (March 2002) *The Contaminated Land Exposure Assessment Model (CLEA): Technical basis and algorithms, Environment Agency*

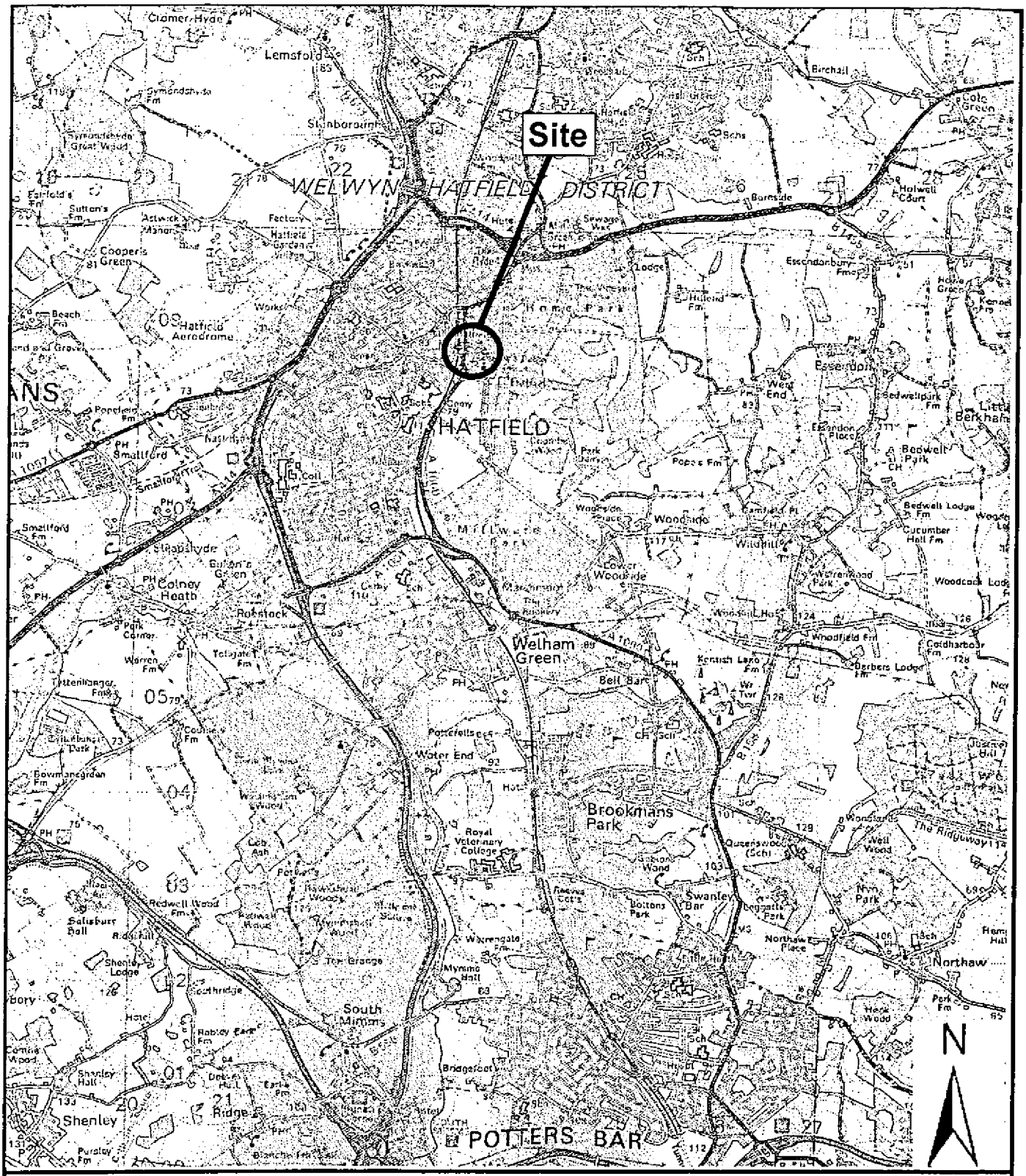
**8.11** R & D Publication CLR 7 (March 2002) *Assessment of Risks to Human Health from Land Contamination: An Overview of the Development of Soil Guideline Values and Related Research, Environment Agency*

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

**8.13** Landfill (England & Wales) Regulations 2002.

**8.14** CIRIA Report 659 (2006) *Assessing risks posed by hazardous gases to buildings*

Appendix 1

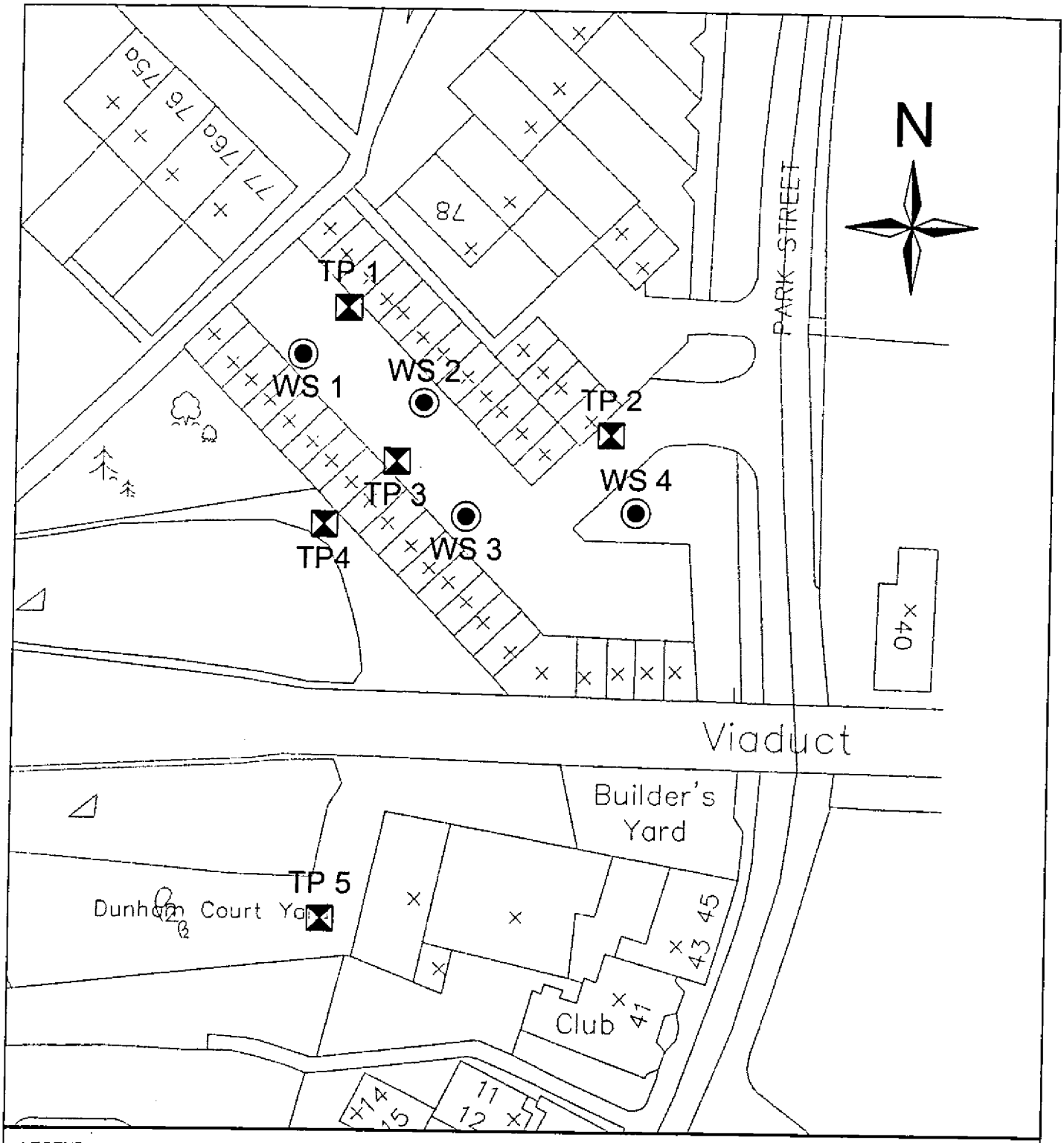





# SITE INVESTIGATION LOCATION MAP

**Structural Soils Limited**
**The Old School**
**Stillhouse Lane**
**Bedminster**
**BS3 4EB**

| | |
|---|---|
| Site | **Dunhams Courtyard Hatfield** |
| Job no. | 720858 |
| Drawing no. | 01 |
| Date | Feb-08 |
| Client | **Gascoyne Cecil Estates Ltd.** |
| Drawn by | GG |




LEGEND

WINDOW SAMPLE POSITION

TRIAL PIT POSITION

**STRUCTURAL SOILS LIMITED**

The Old School
Stillhouse Lane
Bedminster
Bristol BS3 4EB

Tel: 0117 947 1000
Fax: 0117 947 1004
admin@soils.co.uk
www.soils.co.uk

Client: GASCOYNE CECIL ESTATES LTD

Project: DUNHAMS COURTYARD HATFIELD

Title: EXPLORATORY HOLE LOCATION PLAN

| Drawn | Date | Checked: | Date | Approved | Date | Contract REF: | Drawing REF: |
|---|---|---|---|---|---|---|---|
| SM | 28.02.2008 | GG | 28.02.2008 | -- | | 720858 | ---------- |

| Scale | Orig Size | Dimensions | Drawing Status | Rev. |
|---|---|---|---|---|
| 1:500 | A4 | m | FINAL | --- |

## APPENDIX B

(i) Key to Exploratory Hole Logs

(ii) Dynamic Sample Logs

(iii) Standard Penetration Test (SPT) Summary Sheet

(iv) Trial Pit Logs

# STRUCTURAL SOILS

## KEY TO EXPLORATORY HOLE LOGS

### SAMPLING

| | |
|---|---|
| B | Bulk disturbed sample. |
| BLK | Block sample. |
| C | Core run. |
| CBR | CBR mould sample. |
| CS | Core sample taken from rotary core for laboratory testing. |
| D | Small disturbed sample. |
| J | Glass jar sample. |
| LB | Large bulk disturbed sample (for earthworks testing). |
| P | Undisturbed pushed piston sample - 102 mm diameter, 1000 mm long. |
| TW | Thin walled push in sample. |
| U | Undisturbed driven tube sample - 102 mm diameter, 450 mm long. Number of blows indicated in brackets i.e. (10). |
| VL | Vial sample. |
| W | Water sample. |
| U+, P+ | No recovery in undisturbed sample. |

### IN-SITU TESTING

| | |
|---|---|
| SPT | Standard Penetration Test using split spoon sampler. ($SPT_{(NR)}$ indicates 'No Sample Recovery'). |
| $SPT_{(c)}$ | Standard Penetration Test using a solid 60 degree cone. |

The N Value is the number of blows required to complete a test drive of 300 mm after a seating drive of 150 mm or 25 blows.
Where the full test drive is not completed, a linearly extrapolated N value is given and suffixed by a '*' character.
'NP' denotes No Penetration in the Test Drive.

| | |
|---|---|
| HP | Hand Penetrometer Test. Value given as shear strength cu, in kPa. |
| $V_{(Cu)}$ | Field Vane Test. Peak value given as shear strength cu, in kPa. |
| $V_{(Cr)}$ | Field Vane Test. Residual value given as shear strength cr, in kPa. |
| G | Gas Test |
| PID | Photo Ionisation Detector Results, in ppm. |

### DRILLING RECORDS

| | |
|---|---|
| W | Water flush returns. |
| TCR | Total Core Recovery, %. |
| SCR | Solid Core Recovery, %. |
| RQD | Rock Quality Designation, %. |
| If | Fracture spacing, mm. Where variable, the minimum, average and maximum spacing may be quoted.<br>'NI' denotes non intact core.<br>'NA' denotes not applicable. |

### WATER COLUMN SYMBOLS

First water strike, second water strike etc.

Standing water level following first strike, standing water level following second strike etc.

Seepage.

Standing water level recorded at documented date.

### INSTRUMENTATION SYMBOLS

Arisings

Gravel filter

Sand filter

Bentonite seal

Bentonite cement grout

Concrete

Solid pipe

Slotted pipe

Stopcock cover

Upstand cover

**NOTES:**

1. All soil and rock descriptions and legends in general accordance with BS5930:1999.
2. All lengths used to determine rock core mechanical properties taken along the centre line of the core. Obvious induced fractures have been ignored.
3. The assessment of solid core is based on lengths that show a full diameter and not necessarily a full circumference.
4. Material types divided by a broken line (- - -) indicates an unclear boundary.

The data on any sheet showing the AGS icon is available in the AGS format.

STRUCTURAL SOILS

# WINDOW SAMPLE LOG

| Contract | Client | Window Sample No |
|---|---|---|
| **Dunhams Courtyard, Hatfield** | **Gascoyne Cecil Estates Ltd.** | **WS1** |

| Job No | Date | Ground Level (m) | Local Grid Co-Ordinates | Sheet |
|---|---|---|---|---|
| **720858** | **18.12.07** | **---** | **---** | **1 of 1** |

| Progress | Samples / Tests | | | | Water | Instrumentation | Description of Strata | Depth (Thickness) | Legend |
|---|---|---|---|---|---|---|---|---|---|
| Window Run (size (mm)) | Depth | No | Type | Results | | | | | |
| | | | | | | | MADE GROUND: Reinforced Concrete | 0.20 | |
| 0.20 - 1.00 (86) 70 % rec | 0.20-1.00 | 1 | D | | | | MADE GROUND: Soft light brown mottled grey green slightly gravelly very sandy CLAY. Gravel is subangular to subrounded fine to coarse flint with some fine brick fragments. | (1.30) | |
| 1.00 - 2.00 (76) 60 % rec | 1.00-1.45 | 101 | CPT | N=5 | | | | | |
| | 1.50 | | HP | $c_u$=45 | | | | 1.50 | |
| | 1.60-1.80 | 2 | U | | | | Very soft to soft locally firm light grey slightly gravelly, slightly sandy CLAY. Gravel is subangular fine to medium flint. Sand occurs as coarse grained orange pockets. (Glacial Deposits) | | |
| | 1.80-2.00 | 3 | D | | | | | | |
| | 2.00-2.45 | 201 | CPT | N=6 | | | | | |
| | 2.00 | | HP | $c_u$=50 | | | . . . Soft varying to firm below approximately 2.0m depth. | | |
| | 2.50 | | HP | $c_u$=40 | | | | | |
| | 2.60-2.80 | 4 | U | | | | | (2.50) | |
| | 2.80-3.00 | 5 | U | | | | | | |
| 3.00 - 4.00 (66) 50 % rec | 3.00-3.45 | 301 | CPT | N=16 | | | | | |
| | 3.00-4.00 | 6 | D | | ▼ | | | | |
| | 3.50 | | HP | $c_u$=30 | | | | | |
| | | | | | | | | 4.00 | |
| 4.00 - 5.00 (56) 70 % rec | 4.00-4.45 | 401 | CPT | N=35 | | | Dense becoming very dense with depth light brown orange gravelly clayey SAND. Gravel is subangular fine to coarse flint. (Glacial Deposits) | | |
| | 4.00-5.00 | 7 | D | | | | | (1.00) | |
| | 5.00-5.39 | 501 | CPT | N=62* | | | | 5.00 | |
| | | | | | | | Exploratory hole complete at 5.0m depth. | | |

## General Remarks

1. Groundwater encountered at 3.50m depth.
2. 40mm diameter combined gas/groundwater monitoring well installed to 1.50m depth (response zone 0.5-1.5m).

| All dimensions in metres Scale 1:30 | Method **Tracked Window Sampling** | Logged By **GG** | Checked By | AGS |
|---|---|---|---|---|

# STRUCTURAL SOILS

# WINDOW SAMPLE LOG

| Contract | Client | Window Sample No |
|---|---|---|
| **Dunhams Courtyard, Hatfield** | **Gascoyne Cecil Estates Ltd.** | **WS2** |

| Job No | Date | Ground Level (m) | Local Grid Co-Ordinates | Sheet |
|---|---|---|---|---|
| **720858** | **18.12.07** | --- | --- | **1** of **1** |

| Progress | Samples / Tests | | | | Water | Instrumentation | Description of Strata | Depth (Thickness) | Legend |
|---|---|---|---|---|---|---|---|---|---|
| Window Run (size (mm)) | Depth | No | Type | Results | | | | | |
| | | | | | | | MADE GROUND: Reinforced Concrete | 0.20 | |
| 0.20 - 1.00 (96) 100 % rec | 0.20-1.00 | 1 | D | | | | MADE GROUND: Soft locally firm brown mottled red/orange slightly sandy gravelly CLAY. Gravel is subangular to subrounded fine to coarse flint with many brick fragments. | (1.20) | |
| 1.00 - 2.00 (86) 80 % rec | 1.00-1.45 | 101 | CPT | N=9 | | | | 1.40 | |
| | 1.50 | | HP | $c_u$=70 | | | Firm becoming stiff dark brown slightly gravelly CLAY. Gravel is subangular to subrounded fine flint. With some roots (8-10mm diamter). (Glacial Deposits) | | |
| | 1.60-1.90 | 2 | U | | | | | (1.10) | |
| 2.00 - 3.00 (76) 50 % rec | 2.00-2.45 | 201 | CPT | N=8 | | | | | |
| | 2.00 | | HP | $c_u$=80 | | | | 2.50 | |
| | 2.50-2.80 | 3 | U | | | | Stiff orange brown slightly gravelly sandy CLAY. Gravel is subrounded to rounded medium to coarse flint. (Glacial Deposits) | | |
| | 2.50 | | HP | $c_u$=90 | | | | | |
| | 2.80-3.00 | 4 | D | | | | | | |
| 3.00 - 4.00 (66) 50 % rec | 3.00-3.45 | 301 | CPT | N=21 | | | | | |
| | 3.00-3.50 | 5 | D | | | | | (1.50) | |
| | 3.00 | | HP | $c_u$=100 | | | | | |
| | 3.50-4.00 | 6 | D | | | | | | |
| | 4.00-4.45 | 401 | CPT | N=39 | | | | 4.00 | |
| | | | | | | | Exploratory hole complete at 4.0m depth. | | |

## General Remarks

1. No groundwater encountered
2. Exploratory hole backfilled on completion with bentonite pellets.

| All dimensions in metres | Method | Logged | Checked |
|---|---|---|---|
| 1:20 | **Tracked Window** | GC | DCL |

# STRUCTURAL SOILS

# WINDOW SAMPLE LOG

| Contract | Client | Window Sample No |
|---|---|---|
| **Dunhams Courtyard, Hatfield** | **Gascoyne Cecil Estates Ltd.** | **WS3** |

| Job No | Date | Ground Level (m) | Local Grid Co-Ordinates | Sheet |
|---|---|---|---|---|
| **720858** | **18.12.07** | **---** | **---** | **1 of 1** |

| Progress | Samples / Tests | | | | Water | Instrumentation | Description of Strata | Depth (Thickness) | Legend |
|---|---|---|---|---|---|---|---|---|---|
| Window Run (size (mm)) | Depth | No | Type | Results | | | | | |
| | | | | | | | MADE GROUND: Reinforced Concrete | 0.20 | |
| 0.20 - 1.00 (86) 100 % rec | 0.20-0.80 | 1 | D | | | | MADE GROUND: Light brown silty sandy GRAVEL. Gravel is subangular to subrounded fine to coarse flint with some brick fragments. | (0.80) | |
| 1.00 - 2.00 (76) 65 % rec | 1.00-1.45 | 101 | CPT | N=6 | | | | 1.00 | |
| | 1.25 | | HP | $c_u$=25 | | | Soft dark brown mottled orange, slightly sandy slightly gravelly CLAY. Gravel is subangular to rounded fine flint. (Glacial Deposits) | | |
| | 1.30-1.50 | 2 | D | | | | | | |
| | 1.50-1.80 | 3 | U | | | | | | |
| | 1.50 | | HP | $c_u$=30 | | | | | |
| | 1.75 | | HP | $c_u$=40 | | | | (1.60) | |
| | 1.80-2.00 | 4 | D | | | | | | |
| 2.00 - 3.00 (76) 70 % rec | 2.00-2.45 | 201 | CPT | N=6 | | | | | |
| | 2.00-2.50 | 5 | D | | | | | | |
| | 2.60-3.00 | 6 | D | | | | | 2.60 | |
| | | | | | | | Firm light brown mottled orange slightly sandy slightly gravelly CLAY. Gravel is subangular fine to medium flint. (Glacial Deposits) | (0.40) | |
| 3.00 - 4.00 (66) 70 % rec | 3.00-3.45 | 301 | CPT | N=15 | | | | 3.00 | |
| | 3.20-3.50 | 7 | U | | | | Stiff dark brown slightly sandy, slightly gravelly CLAY. Gravel is subrounded medium to coarse chert. (Glacial Deposits) | | |
| | 3.50-3.80 | 8 | U | | | | | | |
| | 3.80-4.00 | 9 | D | | | | | | |
| 4.00 - 5.00 (66) 65 % rec | 4.00-4.45 | 401 | CPT | N=20 | | | . . . Becoming very gravelly below 3.9m depth. | (2.00) | |
| | 4.00-5.00 | 10 | D | | | | | | |
| | 5.00-5.45 | 501 | CPT | N=37 | | | | 5.00 | |
| | | | | | | | Exploratory hole complete at 5.0m depth. | | |

## General Remarks

1. No groundwater encountered
2. 40mm combined gas/groundwater monitoring well installed to 2.50m depth (response zone 0.5-2.5m).

| All dimensions in metres | Method | Logged By | Checked By |
|---|---|---|---|
| Scale **1:30** | **Tracked Window Sampling** | **GG** | |

STRUCTURAL SOILS

# WINDOW SAMPLE LOG

| Contract | Client | Window Sample No |
|---|---|---|
| **Dunhams Courtyard, Hatfield** | **Gascoyne Cecil Estates Ltd.** | **WS4** |

| Job No | Date | Ground Level (m) | Local Grid Co-Ordinates | Sheet |
|---|---|---|---|---|
| **720858** | **18.12.07** | --- | --- | **1** of **1** |

| Progress | Samples / Tests | | | | Water | Instrumentation | Description of Strata | Depth (Thickness) | Legend |
|---|---|---|---|---|---|---|---|---|---|
| Window Run (size (mm)) | Depth | No | Type | Results | | | | | |
| | | | | | | | MADE GROUND: Reinforced Concrete. | 0.20 | |
| 0.20 - 1.00 (86) 90 % rec | 0.20-0.40 | 1 | D | | | | MADE GROUND: Dark brown slightly gravelly slighty sandy SILT. Gravel is subangular fine flint. | 0.40 | |
| | 0.40-0.65 | 2 | D | | | | MADE GROUND: Dark brown, orange slightly sandy gravelly CLAY. Gravel is subangular to subrounded fine to coarse flint with some brick fragments and fine white chalk clasts. | 0.65 | |
| | 0.65-1.00 | 3 | D | | | | MADE GROUND: Dark brown slightly gravelly sandy CLAY. Gravel is subangular fine to medium flint with many fine to medium brick fragments. | (0.35) 1.00 | |
| 1.00 - 2.00 (76) 60 % rec | 1.00-1.45 | 101 | CPT | N=7 | | | Soft locally firm dark brown slightly gravelly CLAY. Gravel is subangular fine flint with many black silt pockets and roots. (Glacial Deposits) | (1.00) | |
| | 1.00-2.00 | 4 | D | | | | | 2.00 | |
| 2.00 - 3.00 (66) 70 % rec | 2.00-2.45 | 201 | CPT | N=46 | | | Very stiff dark brown slightly sandy very gravelly CLAY. Gravel is angular to rounded fine to coarse flint. (Glacial Deposits) | (0.60) | |
| | 2.00-2.60 | 5 | D | | | | | 2.60 | |
| | 2.60-3.00 | 6 | D | | | | Dense becoming very dense light brown slightly sandy silty GRAVEL. Gravel is subangular to subrounded fine to coarse flint. (Glacial Deposits) | (0.40) | |
| | 3.00-3.35 | 301 | CPT | N=75* | | | Exploratory hole complete at 3.0m depth. | 3.00 | |

## General Remarks

1. No groundwater encountered
2. Exploratory hole backfilled on completion with bentonite pellets.

| All dimensions in metres | Method | Logged By | Checked By |
|---|---|---|---|
| | **Tracked Window** | CC | AML |

# STRUCTURAL SOILS

## STANDARD PENETRATION TEST SUMMARY SHEET

| Contract: | | | | | | | Client: | | | | Job No: |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dunhams Courtyard, Hatfield | | | | | | | Gascoyne Cecil Estates Ltd. | | | | 720858 |
| BH | Depth (m) | Dia (mm) | Casing Depth (m) | Water Depth (m) | Seating Drive | | Test Drive | | | | Comments |
| | | | | | Blows | Pen (mm) | Blows | R (mm) | N | N* | |
| WS1 | 1.00 | | | Dry | 1,1 | 150 | 1,1,1,2 | | 5 | | SPT(c) |
| WS1 | 2.00 | | | Dry | 1,2 | 150 | 1,2,1,2 | | 6 | | SPT(c) |
| WS1 | 3.00 | | | Dry | 2,2 | 150 | 3,4,4,5 | | 16 | | SPT(c) |
| WS1 | 4.00 | | | Dry | 2,3 | 150 | 6,7,9,13 | | 35 | | SPT(c) |
| WS1 | 5.00 | | | Dry | 4,5 | 150 | 12,18,17,3+ | 240 | | 62* | SPT(c) |
| WS2 | 1.00 | | | Dry | 2,1 | 150 | 3,2,2,2 | | 9 | | SPT(c) |
| WS2 | 2.00 | | | Dry | 2,3 | 150 | 2,2,2,2 | | 8 | | SPT(c) |
| WS2 | 3.00 | | | Dry | 2,5 | 150 | 4,6,5,6 | | 21 | | SPT(c) |
| WS2 | 4.00 | | | Dry | 2,7 | 150 | 6,11,9,13 | | 39 | | SPT(c) |
| WS3 | 1.00 | | | Dry | 1,1 | 150 | 2,2,1,1 | | 6 | | SPT(c) |
| WS3 | 2.00 | | | Dry | 1,1 | 150 | 1,2,1,2 | | 6 | | SPT(c) |
| WS3 | 3.00 | | | Dry | 3,2 | 150 | 3,4,3,5 | | 15 | | SPT(c) |
| WS3 | 4.00 | | | Dry | 2,4 | 150 | 4,6,4,6 | | 20 | | SPT(c) |
| WS3 | 5.00 | | | Dry | 2,6 | 150 | 7,10,9,11 | | 37 | | SPT(c) |
| WS4 | 1.00 | | | Dry | 2,1 | 150 | 2,2,2,1 | | 7 | | SPT(c) |
| WS4 | 2.00 | | | Dry | 3,5 | 150 | 6,13,14,13 | | 46 | | SPT(c) |
| WS4 | 3.00 | | | Dry | 3,7 | 150 | 11,19,20+ | 200 | | 75* | SPT(c) |

**Notes:**
1. Tests carried out in accordance with BS1377: Part 9: 1990: 3.3.
2. Reported blows are for 75mm penetration unless indicated "+".
3. Where full test drive was not achieved, actual penetration (R) and extrapolated N value (N*) reported.
4. Tests carried out using a split spoon sampler unless noted as SPT(c) in comments column.

AGS

# STRUCTURAL SOILS

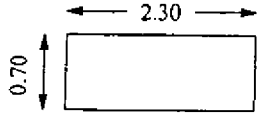
# TRIAL PIT LOG

| Contract | Client | Trialpit No |
|---|---|---|
| **Dunhams Courtyard, Hatfield** | **Gascoyne Cecil Estates Ltd.** | **TP1** |

| Job No | Date | Ground Level (m) | Local Grid Co-Ordinates | Sheet |
|---|---|---|---|---|
| **720858** | **18.12.07** | **---** | **---** | **1 of 1** |

| Samples and In-situ Tests | | | | Water | Description of Strata | Depth (Thickness) | Legend |
|---|---|---|---|---|---|---|---|
| Depth | No | Type | Results | | | | |
| | | | | | BRICK | | |
| | | | | | MADE GROUND: Reinforced concrete. | 0.20 | |
| 0.50<br>0.50 | 1 | D<br>V | $c_u$=80 | | MADE GROUND: Medium dense orange brown sandy clayey GRAVEL. Gravel is subangular to subrounded fine to coarse flint. With some brick and brick fragments. | (0.80) | |
| | | | | | 0.70m<br>CONCRETE | 1.00 | |
| 1.20<br>1.20 | 2 | D<br>V | $c_u$=60 | | POSSIBLE MADE GROUND: Firm dark grey slightly sandy CLAY. | (0.40) | |
| | | | | | Trial pit complete at 1.40m depth. | 1.40 | |

Plan (Not to Scale)




No Bearing Taken

## General Remarks

1. No groundwater encountered.
2. Excavation backfilled with arisings on completion.

All dimensions in metres | Method | Logged | Checked

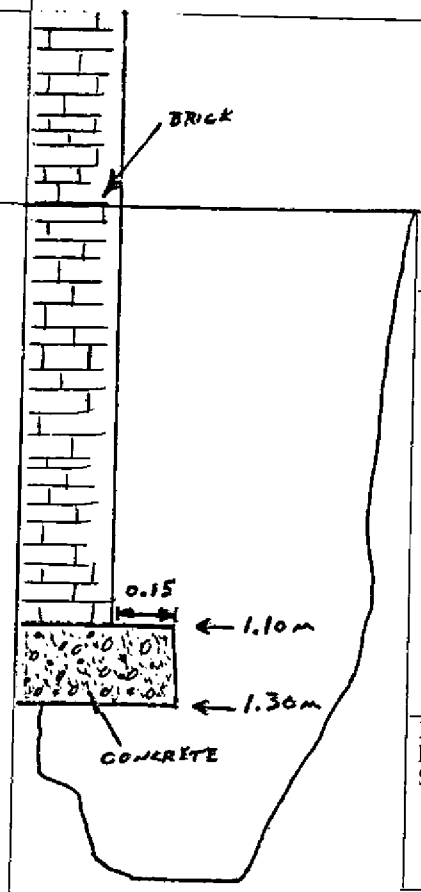
# STRUCTURAL SOILS

# TRIAL PIT LOG

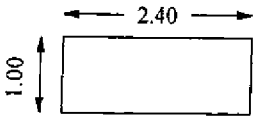
| Contract | Client | Trialpit No |
|---|---|---|
| Dunhams Courtyard, Hatfield | Gascoyne Cecil Estates Ltd. | TP2 |

| Job No | Date | Ground Level (m) | Local Grid Co-Ordinates | Sheet |
|---|---|---|---|---|
| 720858 | 18.12.07 | --- | --- | 1 of 1 |

| Samples and In-situ Tests | | | | Water | Description of Strata | Depth (Thickness) | Legend |
|---|---|---|---|---|---|---|---|
| Depth | No | Type | Results | | | | |
| | | | | | MADE GROUND: Reinforced concrete. | 0.20 | |
| 0.40-0.60 | 1 | D | | | MADE GROUND: Firm red grey/brown slightly sandy gravelly CLAY. Gravel is subangular to subrounded fine to coarse brick fragments, concrete clasts and flint. | (1.10) | |
| 1.00 | | V | $c_u$=70 | | | 1.30 | |
| 1.50-1.70 | 2 | D | | | POSSIBLE MADE GROUND: Light grey brown slightly sandy SILT. With many roots. | (0.45) | |
| | | | | | Trial pit complete at 1.75m depth. | 1.75 | |




Plan (Not to Scale)




No Bearing Taken

## General Remarks

1. No groundwater encountered.
2. Excavation backfilled with arisings on completion.

| All dimensions in metres | Method | Logged By | Checked By |
|---|---|---|---|
| Scale 1:20 | Machine & Hand Dug | GG | |

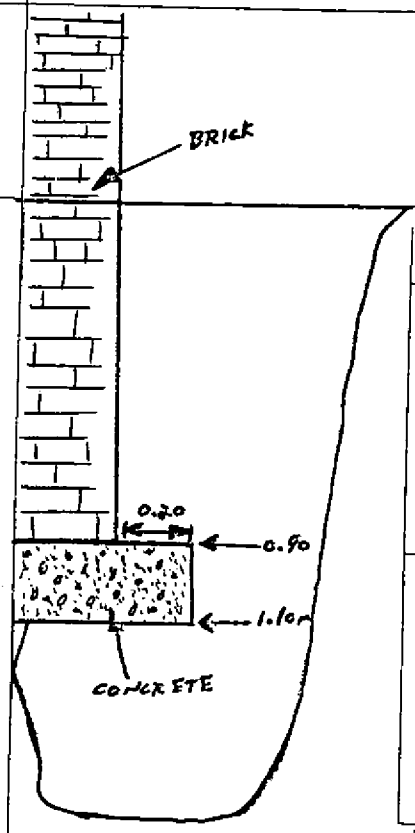
# STRUCTURAL SOILS

# TRIAL PIT LOG

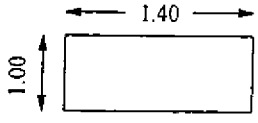
| Contract | Client | Trialpit No |
|---|---|---|
| **Dunhams Courtyard, Hatfield** | **Gascoyne Cecil Estates Ltd.** | **TP3** |

| Job No | Date | Ground Level (m) | Local Grid Co-Ordinates | Sheet |
|---|---|---|---|---|
| **720858** | **18.12.07** | --- | --- | **1** of **1** |

| Samples and In-situ Tests | | | | Water | Description of Strata | Depth (Thickness) | Legend |
|---|---|---|---|---|---|---|---|
| Depth | No | Type | Results | | | | |
| | | | | | MADE GROUND: Reinforced concrete. | 0.20 | |
| 0.70-0.90 | 1 | D | | | MADE GROUND: Red brown grey slightly sandy clayey GRAVEL. Gravel is angular to subrounded fine to coarse brick fragments concrete clasts and flint. With many whole bricks. | (0.70) | |
| 1.00 | | V | $c_u$=70 | | MADE GROUND: Firm dark brown gravelly sandy CLAY. Gravel is angular to subrounded fine to coarse concrete clasts and flint. | (0.70) | |
| | | | | | Trial pit complete at 1.60m depth. | 1.60 | |




Plan (Not to Scale)




No Bearing Taken

## General Remarks

1. No groundwater encountered.
2. Excavation backfilled with arisings on completion.

| All dimensions in metres | Method | Logged | Checked |
|---|---|---|---|
| | | | |

# STRUCTURAL SOILS

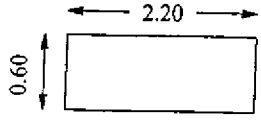
# TRIAL PIT LOG

| Contract | Client | Trialpit No |
|---|---|---|
| **Dunhams Courtyard, Hatfield** | **Gascoyne Cecil Estates Ltd.** | **TP4** |

| Job No | Date | Ground Level (m) | Local Grid Co-Ordinates | Sheet |
|---|---|---|---|---|
| **720858** | **18.12.07** | **---** | **---** | **1 of 1** |

| Samples and In-situ Tests | | | | Water | Description of Strata | Depth (Thickness) | Legend |
|---|---|---|---|---|---|---|---|
| Depth | No | Type | Results | | | | |
| | | | | | BRICK | | |
| 0.50 | | V | $c_u$=70 | | MADE GROUND: Firm dark brown slightly gravelly sandy SILT. Gravel is subangular to subrounded fine to coarse brick fragments concrete clasts and flint. With many fine rootlets and roots. | (1.20) | |
| 1.00-1.20 | 1 | D | | | 0.15m, 0.90m, 1.60m, CONCRETE | | |
| 1.00 | | V | $c_u$=60 | | | | |
| | | | | | Trial pit complete at 1.20m depth. | 1.20 | |

Plan (Not to Scale)




No Bearing Taken

## General Remarks

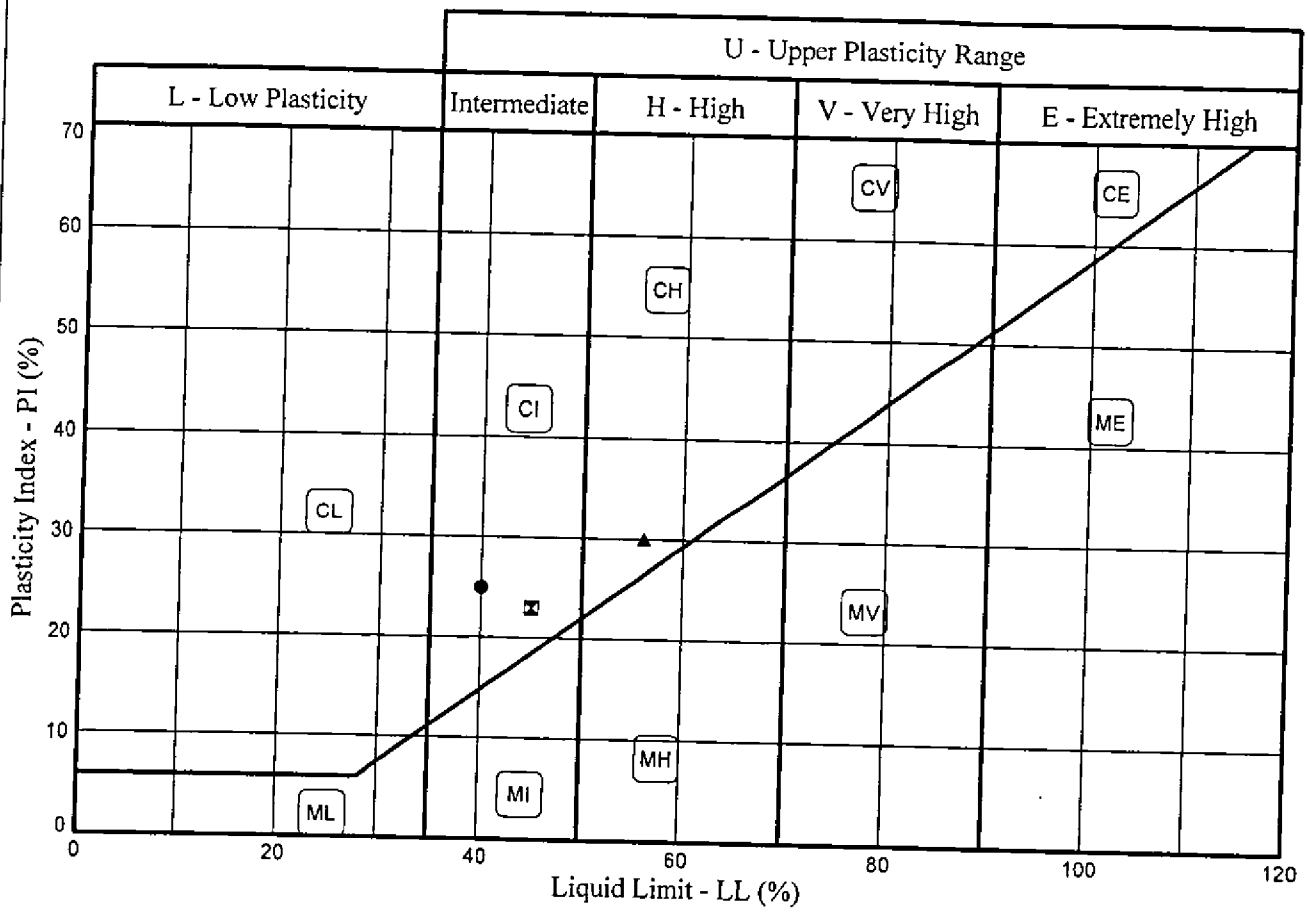
1. No groundwater encountered.
2. Excavation backfilled with arisings on completion.

| All dimensions in metres | Method | Logged | Checked |
|---|---|---|---|

Appendix C

# PLASTICITY CHART - PI Vs LL

In accordance with clause 42.3 of BS5930:1981
Testing in accordance with clauses 3.2,4.3,4.4,5.3,5.4 of BS1377:Part 2:1990




| Sample Identification | | | | MC | LL | PL | PI | <425um | Specimen Description | |
|---|---|---|---|---|---|---|---|---|---|---|
| HoleID | Sample | | Depth | % | % | % | % | % | | |
| ● WS1 | 2U | | 1.60 | 25 | 40 | 15 | 25 | 85 | Brown mottled black slightly gravelly CLAY. | * |
| ⊠ WS3 | 4D | | 1.80 | 30 | 45 | 22 | 23 | 86 | Brown slightly gravelly CLAY. | |
| ▲ WS4 | 4D | | 1.00 | 26 | 56 | 26 | 30 | 90 | Brown slightly gravelly CLAY. | |

* Non-standard test  Approved Signatories: D. TROWBRIDGE A. FROST F. HAMILTON L. MARTIN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Bristol BS3 4EB


| Compiled By | Date | Checked By | Date |
|---|---|---|---|
| A.D. Te | 29/01/08 | D Trowbridge | 29/1/08 |

Contract: **Dunhams Courtyard, Hatfield**

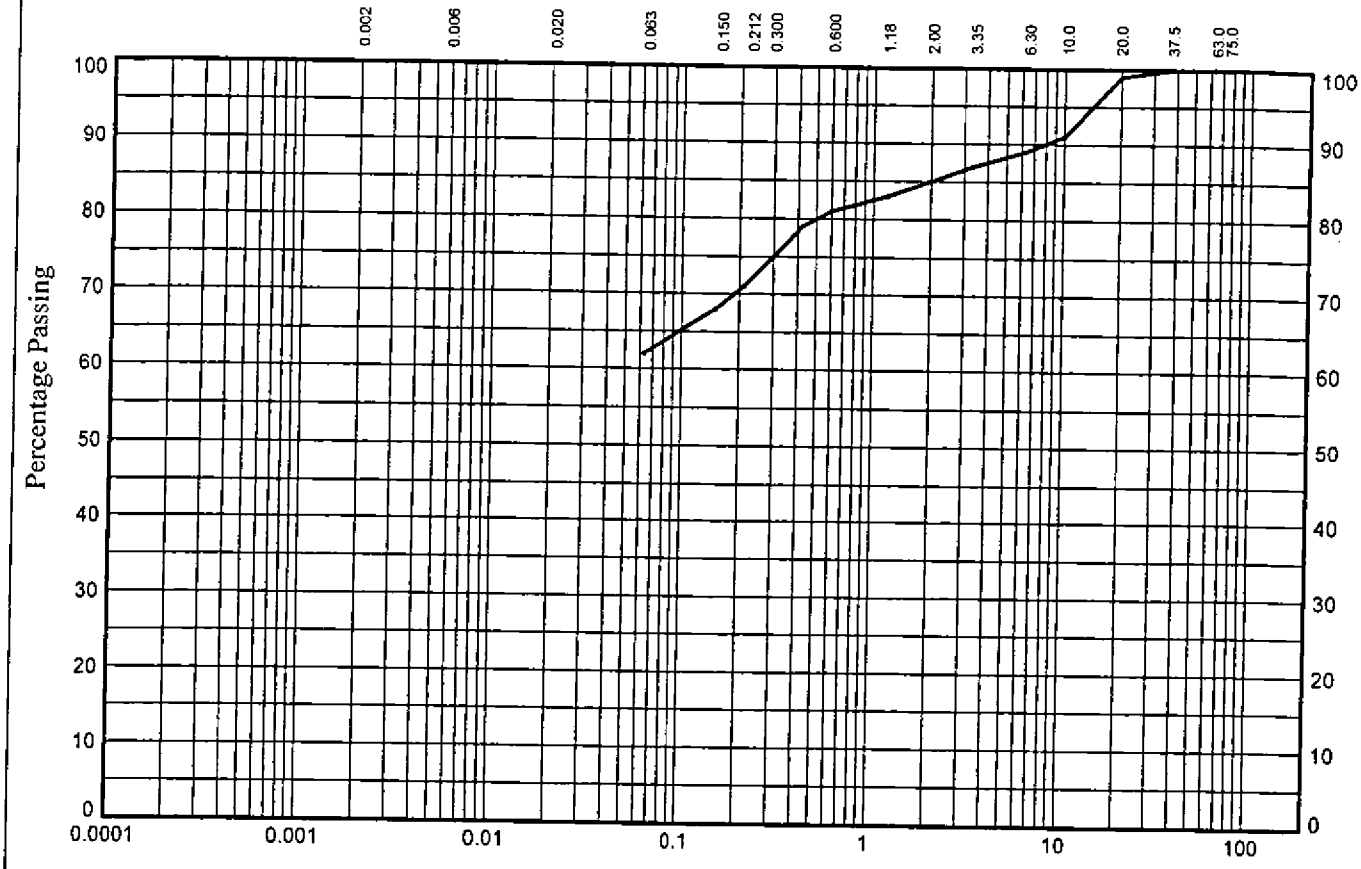
Job No: **720858**

AGS

# PARTICLE SIZE DISTRIBUTION TEST

In accordance with clauses 9.2,9.3 of BS1377:Part 2:1990

Window Sample : **WS1** Sample Ref : **3** Sample Type : **D** Depth (m) : **1.80**




| CLAY | fine | medium | coarse | fine | medium | coarse | fine | medium | coarse | COBBLES |
|---|---|---|---|---|---|---|---|---|---|---|
| | SILT | | | SAND | | | GRAVEL | | | |

| BS Test Sieve (mm) | Percentage Passing |
|---|---|
| 125.0 | 100 |
| 75.0 | 100 |
| 63.0 | 100 |
| 37.5 | 100 |
| 20.0 | 99 |
| 10.0 | 91 |
| 6.30 | 89 |
| 5.00 | |
| 3.35 | 87 |
| 2.00 | 85 |
| 1.18 | 83 |
| 0.600 | 81 |
| 0.425 | 79 |
| 0.300 | |
| 0.212 | 71 |
| 0.150 | 68 |
| 0.063 | 62 |

| Particle Diameter | Percentage Passing |
|---|---|
| | |

| Soil Fraction | Sieve Percentage |
|---|---|
| GRAVEL | 15 |
| SAND | 23 |
| SILT/CLAY | 62 |

Soil Description:
Grey mottled orangish brown slightly gravelly slightly sandy CLAY.

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| Compiled By | Date | Checked By | Date |
|---|---|---|---|
| A.D | 21/01/08 | | 29/1/08 |

Contract: **Dunhams Courtyard, Hatfield**

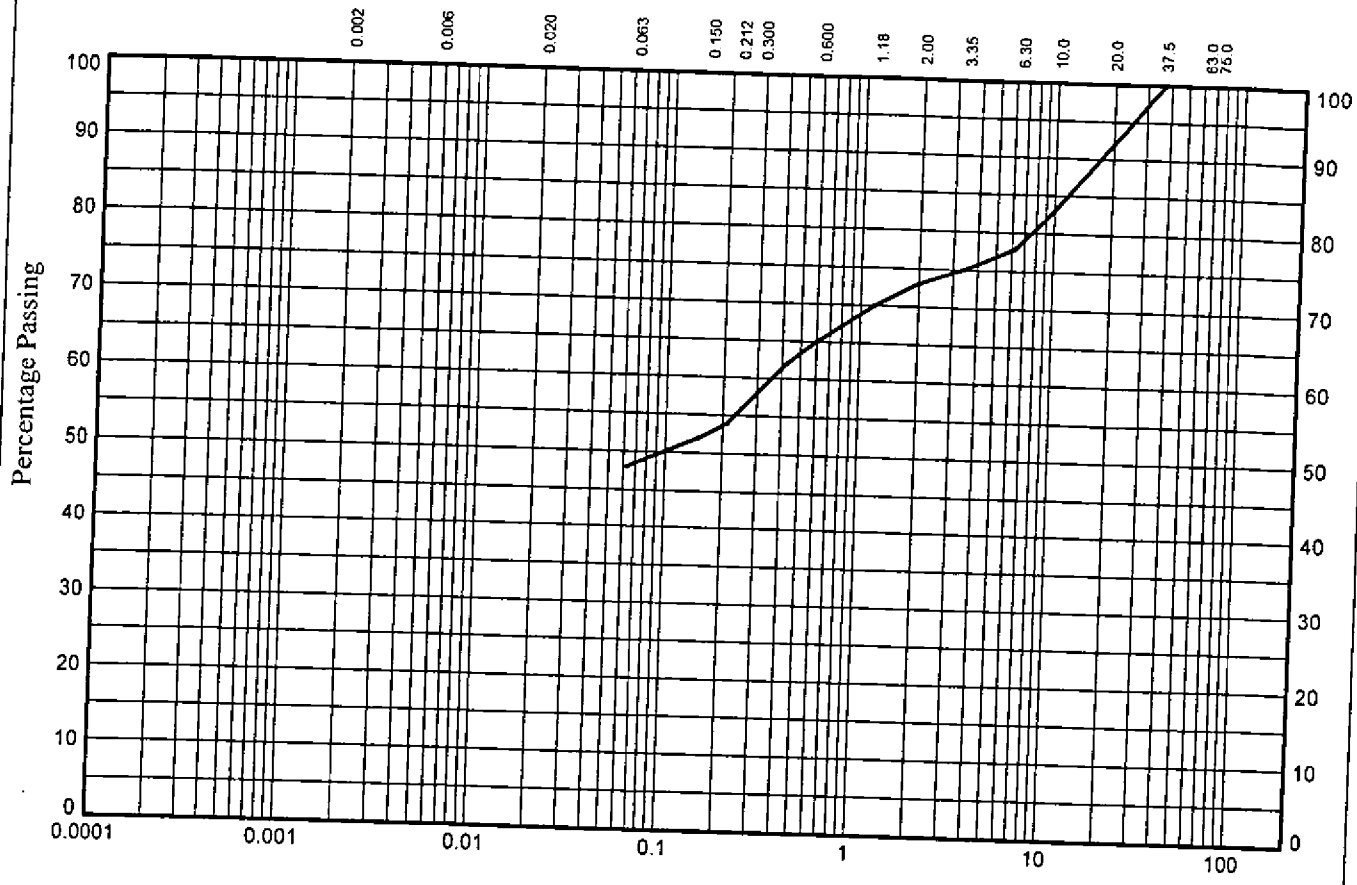
Job No: **720858**

AGS

# PARTICLE SIZE DISTRIBUTION TEST

In accordance with clauses 9.2,9.3 of BS1377:Part 2:1990

Window Sample : **WS3** Sample Ref : **6** Sample Type : **D** Depth (m) : **2.60**




| CLAY | fine | medium | coarse | fine | medium | coarse | fine | medium | coarse | COBBLES |
|---|---|---|---|---|---|---|---|---|---|---|
| | SILT | | | SAND | | | GRAVEL | | | |

| BS Test Sieve (mm) | Percentage Passing |
|---|---|
| 125.0 | 100 |
| 75.0 | 100 |
| 63.0 | 100 |
| 37.5 | 100 |
| 20.0 | 92 |
| 10.0 | 83 |
| 6.30 | 78 |
| 5.00 | |
| 3.35 | 75 |
| 2.00 | 73 |
| 1.18 | 70 |
| 0.600 | 65 |
| 0.425 | 62 |
| 0.300 | |
| 0.212 | 54 |
| 0.150 | 52 |
| 0.063 | 48 |

| Particle Diameter | Percentage Passing |
|---|---|
| | |

| Soil Fraction | Sieve Percentage |
|---|---|
| GRAVEL | 27 |
| SAND | 25 |
| SILT/CLAY | 48 |

Soil Description:
Brown mottled orangish brown slightly sandy slightly gravelly CLAY.

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| Compiled By | Date | Checked By | Date |
|---|---|---|---|
| A.D. | 21/01/08 | | 29/1/08 |

| Contract | Job No |
|---|---|
| **Dunhams Courtyard, Hatfield** | **720858** |

AGS

# SUMMARY OF UNDRAINED SHEAR STRENGTH TESTS IN TRIAXIAL COMPRESSION

BS1377:Part 7:1990

| Hole Reference | Sample No | Depth m | Moisture Content % | Bulk Density Mg/m³ | Dry Density Mg/m³ | Undrained Triaxial Compression Tests (Total Stress) | | | | | | | Description of Sample |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Size mm | Cell Pressure kPa | Corrected Max kPa | Shear Strength ($C_u$) kPa | Average ($C_u$) kPa | % Strain at Failure | Failure Type | |
| WS1 | 2 | 1.66 | 21 | 2.11 | 1.74 | 51 x 100 | 35 | 31 | 15 | | 19.5 | P | Brown mottled black slightly gravelly CLAY. |
| WS1 | 5 | 2.80 | 25 | 1.98 | 1.59 | 64 x 145 | 60 | 53 | 27 | | 14.0 | C | Light grey slightly gravelly CLAY. |
| WS3 | 3 | 1.50 | 32 | 1.79 | 1.35 | 75 x 161 | 35 | 56 | 28 | | 10.3 | C | Brown slightly gravelly CLAY. |

Key : MS = Multi-stage, RM = Remoulded, B = Brittle, P = Plastic, C = Compound.

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| Compiled By | Date | Checked By | Date | Job No |
|---|---|---|---|---|
| A.D.Te | 21.01.08 | D Trowbridge | 29/1/08 | 720858 |

Contract: **Dunhams Courtyard, Hatfield**

# SUMMARY OF CHEMICAL ANALYSES

**In accordance with clauses 5, 9 of BS1377:Part 3:1990.**

| Hole Reference | Sample No | Sample Type | Depth m | Sulphate ($SO_4$) Content # | | | Chloride Content | | pH Value | Percent Passing 2 mm % | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Acid Soluble Sulphate as % $SO_4$ | Aqueous Extract as g/l $SO_4$+ | Ground-water as g/l $SO_4$ | Soluble Chloride as g/l Cl | Ground-water as g/l Cl | | | |
| TP2 | 2 | D | 1.50 | | 0.14 | | | | 8.4 | 98 | Brown slightly gravelly CLAY. |
| WS1 | 3 | D | 1.80 | | 0.08 | | | | 7.8 | 85 | Grey mottled orangish brown slightly gravelly slightly sandy CLAY. |
| WS3 | 6 | D | 2.60 | | 0.03 | | | | 7.8 | 73 | Brown mottled orangish brown slightly sandy slightly gravelly CLAY. |

NOTES : + In 2:1 water:soil extract
# Calculated as $SO_3$ to BS1377:Part 3:1990, reported as $SO_4$ ($SO_4 = SO_3 \times 1.2$)
All chemical tests were undertaken by an external laboratory.
$SO_4$ results for soil are for material <2mm

Approved Signatories: D. TROWBRIDGE A. FROST F. HAMILTON L. MARTIN

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| Compiled By | Date | Checked By | Date | Job No |
|---|---|---|---|---|
| LW | 28.01.08 | A. D. T | 29/01/08 | 720858 |

Contract: **Dunhams Courtyard, Hatfield**

## APPENDIX D

(i) Contamination Test Results

(ii) CAT-WASTE$^{SOIL}$ Results Input and Output Sheets

(iii) Generic Assessment Criteria for Human Health – Residential Scenario

STRUCTURAL SOILS LTD

## SUMMARY OF CONTAMINATION ANALYSIS: SOIL

**SITE:** HATFIELD
**REF:** 720858
**DATE:** JANUARY 2008

| SAMPLE LOCATION | WS1 | WS3 | WS4 | TP2 | TP3 |
|---|---|---|---|---|---|
| **DEPTH (m)** | **0.2-1.0** | **1.3-1.5** | **0.65-1.00** | **0.4-0.6** | **0.7-0.9** |
| Arsenic | 10 | 6 | 10 | 9 | 10 |
| Cadmium | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 |
| Chromium (total) | 25 | 21 | 20 | 23 | 23 |
| Copper | 14 | 34 | 37 | 45 | 17 |
| Mercury | <0.6 | <0.6 | <0.6 | <0.6 | <0.6 |
| Nickel | 23 | 20 | 19 | 55 | 16 |
| Lead | 16 | 85 | 150 | 160 | 65 |
| pH (units) | 8.06 | 8.17 | 8.17 | 9.74 | 10.63 |
| Selenium | <3 | <3 | <3 | <3 | <3 |
| Sulphate (SO4 in 2:1 extract g/l) | 0.036 | 0.007 | 0.006 | 0.079 | 0.067 |
| Zinc | 51 | 83 | 140 | 72 | 72 |
| Total Organic Matter (%) | 0.75 | 1.8 | 2.9 | 18 | 1.9 |
| **PAHs** | | | | | |
| Naphthalene | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Acenaphthylene | <0.01 | <0.01 | 0.03 | <0.01 | <0.01 |
| Acenaphthene | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Fluorene | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Phenanthrene | <0.01 | <0.01 | 0.10 | <0.01 | 0.04 |
| Anthracene | <0.01 | <0.01 | 0.06 | 0.01 | 0.02 |
| Fluoranthene | <0.01 | <0.01 | 0.62 | 0.11 | 0.14 |
| Pyrene | <0.01 | <0.01 | 0.58 | 0.11 | 0.13 |
| Benzo (a) anthracene | 0.01 | 0.03 | 0.43 | 0.09 | 0.08 |
| Chrysene | 0.01 | 0.01 | 0.51 | 0.12 | 0.11 |
| Benzo (b) fluoranthene<br>Benzo (k) fluoranthene | <0.01 | <0.01 | 0.36 | <0.01 | <0.01 |
| Benzo (a) pyrene | <0.01 | <0.01 | 0.43 | 0.08 | 0.08 |
| Indeno (1,2,3-cd) pyrene | <0.01 | <0.01 | 0.31 | 0.03 | <0.01 |
| Dibenzo (ah) anthracene | <0.01 | <0.01 | 0.05 | 0.02 | <0.01 |
| Benzo (g,h,i) perylene | <0.01 | <0.01 | 0.77 | 0.14 | 0.13 |
| **VOLATILE PETROLEUM HYDROCARBONS** | | | | | |
| MTBE | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Benzene | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Toluene | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Ethyl Benzene | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Total Xylene | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Aliphatics C5-C6 | <0.01 | <0.01 | 0.01 | 0.01 | 0.01 |
| Aliphatics >C6-C8 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Aliphatics >C8-C10 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Aromatics C5-C6 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Aromatics >C6-C8 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Aromatics >C8-C10 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| **EXTRACTABLE PETROLEUM HYDROCARBONS** | | | | | |
| EPH C10-C12 | <10 | <10 | <10 | <10 | <10 |
| EPH C12-C16 | <10 | <10 | <10 | <10 | <10 |
| EPH C16-C21 | <10 | <10 | <10 | <10 | <10 |
| EPH C21-C36 | <10 | <10 | <10 | <10 | <10 |

Results are expressed as mg/kg unless otherwise stated
Any outlier values which exceed relevant guidelines are shown in bold.

Checked by/Date:

GG 27.02.09

STRUCTURAL SOILS LTD

## SUMMARY OF CONTAMINATION ANALYSIS: SOIL

**SITE:** HATFIELD
**REF:** 720858
**DATE:** JANUARY 2008

| | Mean Value Test * | CLEA Guidelines For Residential use (mg/kg) | | GAC Guidelines for Residential Scenario - Private Gardens (mg/kg) |
|---|---|---|---|---|
| | $US_{95}$ | With plant uptake | Without plant uptake | |
| Arsenic | 10.65 | 20 | 20 | - |
| Cadmium | 0.30 | 1 (pH 6)<br>2 (pH 7)<br>8 (pH 8) | 30 | - |
| Chromium (total) | 24.26 | 130 | 200 | - |
| Copper | 42.13 | - | - | 440 |
| Mercury | 0.60 | 8 | 15 | - |
| Nickel | 41.92 | 50 | 75 | - |
| Lead | 152.59 | 450 | 450 | - |
| Selenium | 3.00 | 35 | 260 | - |
| Zinc | 115.63 | - | - | 880 |
| **PAHs** | | | | |
| Naphthalene | 0.01 | - | - | 6.6 |
| Acenaphthylene | 0.02 | - | - | 1.3 |
| Acenaphthene | 0.01 | - | - | 15 |
| Fluorene | 0.01 | - | - | 6500 |
| Phenanthrene | 0.07 | - | - | 1900 |
| Anthracene | 0.04 | - | - | 51000 |
| Fluoranthene | 0.42 | - | - | 93 |
| Pyrene | 0.39 | - | - | 930 |
| Benzo (a) anthracene | 0.29 | - | - | 9.3 |
| Chrysene | 0.35 | - | - | 5.4 |
| Benzo (b) fluoranthene | 0.23 | - | - | 9.3 |
| Benzo (k) fluoranthene | | - | - | 9.3 |
| Benzo (a) pyrene | 0.29 | - | - | 1.1 |
| Indeno (1,2,3-cd) pyrene | 0.20 | - | - | 9.3 |
| Dibenzo (ah) anthracene | 0.04 | - | - | 0.93 |
| Benzo (g,h,i) perylene | 0.52 | - | - | 1400 |
| **VOLATILE PETROLEUM HYDROCARBONS** | | | | |
| MTBE | 0.01 | - | - | 19 |
| Benzene | 0.01 | - | - | 0.17 |
| Toluene | 0.01 | 3, 7, $14_A$ | 3, 8, $150_A$ | - |
| Ethyl Benzene | 0.01 | 9, 21, $41_A$ | 16, 41, $80_A$ | - |
| Total Xylene | 0.01 | - | - | 11 |
| Aliphatics C5-C6 | 0.01 | - | - | 93,000 |
| Aliphatics>C6-C8 | 0.01 | - | - | 170,000 |
| Aliphatics >C8-C10 | 0.01 | - | - | 53 |
| Aromatics C5-C6 | 0.01 | - | - | $0.31_B$ |
| Aromatics >C6-C8 | 0.01 | - | - | $0.31_B$ |
| Aromatics >C8-C10 | 0.01 | - | - | 11 |
| **EXTRACTABLE PETROLEUM HYDROCARBONS** | | | | **Aliphatic** / **Aromatic** |
| EPH C10-C12 | 10.00 | - | - | 5,500 / 31 |
| EPH C12-C16 | 10.00 | - | - | 5,500 / 160 |
| EPH C16-C21 | 10.00 | - | - | 110,000 / 1,400 |
| EPH C21-C36 | 10.00 | - | - | 110,000 / 1,700 |

* - The calculations for the mean value test include outliers
A: for 1.0%, 2.5% and 5.0% SOM respectively
B: Guideline given is for aromatics C5-C7
GACs given assume 1% SOM for metals and 2.5% SOM for hydrocarbons
SOM: Soil organic matter
Hydrocarbon GACs assumes free phase contamination is not present.
Checked by/Date:

GE 27.02.08

STRUCTURAL SOILS LTD

## SUMMARY OF CONTAMINATION ANALYSIS: SOIL

**SITE:** HATFIELD
**REF:** 720858
**DATE:** JANUARY 2008

| | Mean Value Test * | CLEA Commercial Guidelines | GAC Guidelines for Commercial Scenario | |
|---|---|---|---|---|
| | US$^{95}$ | | | |
| Arsenic | 10.65 | 500 | - | |
| Cadmium | 0.30 | 1400 | - | |
| Chromium (total) | 24.26 | 5000 | - | |
| Copper | 42.13 | - | 110,000 | |
| Mercury | 0.60 | 480 | - | |
| Nickel | 41.92 | 5000 | - | |
| Lead | 152.59 | 750 | - | |
| Selenium | 3.00 | 8000 | - | |
| Zinc | 115.63 | - | 810,000 | |
| **PAHs** | | | | |
| Naphthalene | 0.01 | - | 68 | |
| Acenaphthylene | 0.02 | - | 11 | |
| Acenaphthene | 0.01 | - | 130 | |
| Fluorene | 0.01 | - | 104,000 | |
| Phenanthrene | 0.07 | - | 30,000 | |
| Anthracene | 0.04 | - | 820,000 | |
| Fluoranthene | 0.42 | - | 1,500 | |
| Pyrene | 0.39 | - | 15,000 | |
| Benzo (a) anthracene | 0.29 | - | 150 | |
| Chrysene | 0.35 | - | 1,500 | |
| Benzo (b) fluoranthene | 0.23 | - | 150 | |
| Benzo (k) fluoranthene | | - | 150 | |
| Benzo (a) pyrene | 0.29 | - | 18 | |
| Indeno (1,2,3-cd) pyrene | 0.20 | - | 150 | |
| Dibenzo (ah) anthracene | 0.04 | - | 15 | |
| Benzo (g,h,i) perylene | 0.52 | - | 22,000 | |
| **VOLATILE PETROLEUM HYDROCARBONS** | | | | |
| MTBE | 0.01 | - | 2000 | |
| Benzene | 0.01 | - | 3.6 | |
| Toluene | 0.01 | 150 | - | |
| Ethyl Benzene | 0.01 | 48000 | - | |
| Total Xylene | 0.01 | - | 240 | |
| Aliphatics C5-C6 | 0.01 | - | NA | |
| Aliphatics>C6-C8 | 0.01 | - | NA | |
| Aliphatics >C8-C10 | 0.01 | - | 90,000 | |
| Aromatics C5-C6 | 0.01 | - | 6.8B | |
| Aromatics >C6-C8 | 0.01 | - | 6.8B | |
| Aromatics >C8-C10 | 0.01 | - | 230 | |
| **EXTRACTABLE PETROLEUM HYDROCARBONS** | | | **Aliphatic** | **Aromatic** |
| EPH C10-C12 | 10.00 | - | 90,000 | 36,000 |
| EPH C12-C16 | 10.00 | - | 90,000 | 36,000 |
| EPH C16-C21 | 10.00 | - | ** | 27,000 |
| EPH C21-C36 | 10.00 | - | ** | 27,000 |

* - The calculations for the mean value test include outliers
B: Guideline given is for aromatics C5-C7
GACs given assume 1% SOM for metals and 2.5% SOM for hydrocarbons
SOM: Soil organic matter
Hydrocarbon GACs assumes free phase contamination is not present.
NA - Modelling indicates that the compound will not pose a risk to human health at any concentration below 1.0E+06 mg/kg.
** - Value not applicable due to low volatility of substance.
Checked by/Date:

27.02.08

CAT-WASTE

Classification Assessment Tool of Soil Wastes - Hazard Summary Sheet

Ardle ATKINS

| | |
|---|---|
| Site Name | HATFIELD |
| Location | HATFIELD |
| Site ID | GG |
| Job Number | 720858 |
| Date | 1/24/2008 10:44:35 AM |
| User Name | Enviro@soils.co.uk |
| Company Name | Structural Soils Ltd |

| Hole ID | Sample Depth | Hazardous Waste Y/N | H1 | H2 | H3A | H3B | H4 | H5 | H6 | H7 | H8 | H9 | H10 | H11 | H12 | H13 | H14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WS1 | 0.2-1.0m | N | False | False | False | False | False | False | False | False | False | False | False | False | False | False | False |
| WS3 | 1.3-1.5m | N | False | False | False | False | False | False | False | False | False | False | False | False | False | False | False |
| WS4 | 0.65-1.0m | N | False | False | False | False | False | False | False | False | False | False | False | False | False | False | False |
| TP2 | 0.4-0.6m | N | False | False | False | False | False | False | False | False | False | False | False | False | False | False | False |
| TP3 | 0.7-0.9m | N | False | False | False | False | False | False | False | False | False | False | False | False | False | False | False |
| | | | | | | | | | | | | | | | | | |

CAT-WASTE

Classification Assessment Tool of Soil Wastes - Individual Compound Information

ArdleATKINS

| | |
|---|---|
| Site Name | HATFIELD |
| Location | HATFIELD |
| Site ID | GG |
| Job Number | 720858 |
| Date | 1/24/2008 10:44:35 AM |
| User Name | Enviro@soils.co.uk |
| Company Name | Structural Soils Ltd. |

| Hole ID | Sample Depth | Contaminant | Contaminant Concentration (%) | Hazardous Waste Y/N | Hazard Class | Risk Phrases Exceeded | Additive Risk Phrases Exceeded | Additional Risk Phrases (see notes section) |
|---|---|---|---|---|---|---|---|---|
| WS1 | 0.2-1.0m | Benzene | 1E-06 | N | | | | R11 test |
| WS1 | 0.2-1.0m | Toluene | 1E-06 | N | | | | R11 test |
| WS1 | 0.2-1.0m | Ethylbenzene | 1E-06 | N | | | | R11 test |
| WS1 | 0.2-1.0m | m,p-xylene | 1E-06 | N | | | | R10 test flash point |
| WS1 | 0.2-1.0m | o-xylene | 1E-06 | N | | | | R10 test flash point |
| WS1 | 0.2-1.0m | Chromium (Total) when no | 0.0155376 | N | | | | R43 see comment |
| WS1 | 0.2-1.0m | Nickel | 0.006063802 | N | | | | R42 see comment, R43 see comment |
| WS1 | 0.2-1.0m | Zinc | 0.01414702 | N | | | | R43 see comment |
| WS3 | 1.3-1.5m | Benzene | 1E-06 | N | | | | R11 test |
| WS3 | 1.3-1.5m | Toluene | 1E-06 | N | | | | R11 test |
| WS3 | 1.3-1.5m | Ethylbenzene | 1E-06 | N | | | | R11 test |
| WS3 | 1.3-1.5m | m,p-xylene | 1E-06 | N | | | | R10 test flash point |
| WS3 | 1.3-1.5m | o-xylene | 1E-06 | N | | | | R10 test flash point |
| WS3 | 1.3-1.5m | Chromium (Total) when no | 0.01305159 | N | | | | R43 see comment |
| WS3 | 1.3-1.5m | Nickel | 0.005272671 | N | | | | R42 see comment, R43 see comment |
| WS4 | 0.65-1.0m | Benzene | 1E-06 | N | | | | R11 test |
| WS4 | 0.65-1.0m | Toluene | 1E-06 | N | | | | R11 test |
| WS4 | 0.65-1.0m | Ethylbenzene | 1E-06 | N | | | | R11 test |
| WS4 | 0.65-1.0m | m,p-xylene | 1E-06 | N | | | | R10 test flash point |
| WS4 | 0.65-1.0m | o-xylene | 1E-06 | N | | | | R10 test flash point |
| WS4 | 0.65-1.0m | Chromium (Total) when no | 0.01243008 | N | | | | R43 see comment |
| WS4 | 0.65-1.0m | Nickel | 0.005009227 | N | | | | R42 see comment, R43 see comment |
| TP2 | 0.4-0.6m | Benzene | 1E-06 | N | | | | R11 test |
| TP2 | 0.4-0.6m | Toluene | 1E-06 | N | | | | R11 test |
| TP2 | 0.4-0.6m | Ethylbenzene | 1E-06 | N | | | | R11 test |
| TP2 | 0.4-0.6m | m,p-xylene | 1E-06 | N | | | | R10 test flash point |
| TP2 | 0.4-0.6m | o-xylene | 1E-06 | N | | | | R10 test flash point |
| TP2 | 0.4-0.6m | Chromium (Total) when no | 0.01429459 | N | | | | R43 see comment |
| TP2 | 0.4-0.6m | Nickel | 0.0145004 | N | | | | R42 see comment, R43 see comment |
| TP3 | 0.7-0.9m | Benzene | 1E-06 | N | | | | R11 test |
| TP3 | 0.7-0.9m | Toluene | 1E-06 | N | | | | R11 test |
| TP3 | 0.7-0.9m | Ethylbenzene | 1E-06 | N | | | | R11 test |
| TP3 | 0.7-0.9m | m,p-xylene | 1E-06 | N | | | | R10 test flash point |
| TP3 | 0.7-0.9m | o-xylene | 1E-06 | N | | | | R10 test flash point |
| TP3 | 0.7-0.9m | Chromium (Total) when no | 0.01429459 | N | | | | R43 see comment |
| TP3 | 0.7-0.9m | Nickel | 0.004218297 | N | | | | R42 see comment, R43 see comment |

CAT-WASTE

Ardle ATKINS

## Notes - Additional Information on Risk Phrases

| | | |
|---|---|---|
| R1 to R6 | Test for explosives except when the waste is covered by the Explosives Act 1875 | Test to establish whether a substance or preparation presents a danger of explosion when submitted to the effect of a flame (thermal sensitivity), impact or friction. Undertake Test Method A14 from EC Directive 92/62/EEC |
| R7, R8 and R9 | Test/calculation for oxides | Applicable to solid compounds that are not explosive, highly flammable, organic peroxides or combustible. A test for the compounds oxidising properties as described in Directive 92/69/EEC, Test Method A17. For organic peroxides calculate the available oxygen content (%). For liquids and oxidising materials not covered by those previously listed no testing available. |
| R10 | R10 test flash point | Flashpoint test as per Directive 92/62/EEC, Test Method A9 |
| R11 | R11 test flash point | For liquid substances, undertake the flashpoint test as per Directive 92/62/EEC, Test Method A9. For solid substances undertake flammability test as per directive 92/62/EEC, Test Method A10 |
| R12 | R12 test flammability | Flammability of gasses test as per Directive 92/62/EEC Test Method A11. |
| R15 | R15 test flammability | To test the flammability of a substance when in contact with water test as per Directive 92/62/EEC, Test Method A12. |
| R16 | R16 test for explosives | Test to establish whether a substance or preparation present a danger of explosion when submitted to the effect of a flame (thermal sensitivity), impact or friction. Undertake Test Method A14 from EC Directive 92/62/EEC |
| R17 | R17 pyrophoric test | To test the pyrophoric properties of solids and liquids test as per Directive 92/62/EEC, Test Method A13. |
| R18 | R18 test for flammable explosive vapour air mixture | Test to establish whether a substance or preparation presents a danger of explosion when submitted to the effect of a flame (thermal sensitivity), impact or friction. Undertake Test Method A14 from EC Directive 92/62/EEC |
| R19 | R19 test for flammable explosive peroxides | Test to establish whether a substance or preparation present a danger of explosion when submitted to the effect of a flame (thermal sensitivity), impact or friction. Undertake Test Method A14 from EC Directive 92/62/EEC |
| R29 | R29 test or calculation | Undertake test as per Directive 92/62/EEC, Test Method A12. |
| R31 | R31 test or calculation | Undertake testing as per Directive 92/62/EEC, Test Method A12 modified to replace water with an acid which will not cause a displacement reaction to occur. Method to measure SO2 evolved when a waste is in contact with an acid (see Environment Agency SWEN 068). |
| R32 | R32 test or calculation | Undertake testing as per Directive 92/62/EEC, Test Method A12 modified to replace water with an acid which will not cause a displacement reaction to occur). |
| R42 and R43 | No test available | No test available for sensitisation |
| R44 | R44 test for explosives | Test to establish whether a substance or preparation present a danger of explosion when submitted to the effect of a flame (thermal sensitivity), impact or friction. Undertake Test Method A14 from EC Directive 92/62/EEC |
| R54 to R58 | see comment | Classification of waste as ecotoxic (on the basis of terrestrial non-aquatic toxicity) is not applicable due to the lack of detailed information. Until more data becomes available R54 to R58 should not be considered when assessing the ecotoxic hazard of wastes and classifications should be based upon aquatic toxicity data. Where there is reason to believe that a waste contains substances that only have effects on the terrestrial environment, guidance on the approapriate test method should be obtained from the Environment Agency. |

**Notes:**

Testing of compounds which would be classified under H14 should only be undertaken where the hazards cannot be adequately identified. (i.e. where the waste contains a substance/s for which there is no aquatic toxicity data and/or where the waste is an uncharacterised mixture and/or there is the potential that the waste may contain unknown substances or breakdown products.

Aquatic toxicity testing should be undertaken in accordance with the Environmental Health and Safety Publication, series on Testing and Assessment No. 23 ENV/JM/MONO(2000) 6 June 2000

## Generic Assessment Criteria for Human Health
## Residential Scenario – Private Gardens

*1. Model Selection*

The Generic Assessment Criteria (GAC) were calculated using Risk-Based Corrective Action (RBCA) and Risk-Integrated Software for Clean-ups (RISC). RBCA was chosen for two reasons. Firstly, it uses the Johnson and Ettinger (J&E) model, which has been incorporated into the current beta version of the UK Contaminated Land Exposure Assessment (CLEA) model and secondly, RBCA accounts for differential pressure in the indoor air inhalation pathway from both soil and groundwater. RISC only accounts for differential pressure for indoor air inhalation from soil. However, it is the only model available to generate values for the vegetable ingestion pathway and was used for this pathway. One disadvantage is that the model only accounts for dissolved phase hydrocarbons. CLEA was not used following the Environment Agency's Frequently Asked Question Number 26 regarding the suitability of the Briggs et al algorithm for chemicals with a log Kow >5.

*2. Pathway Selection*

Pathways considered in the residential end use include indoor air inhalation from soil and groundwater, ingestion of soil/indoor dust, dermal contact with soil and ingestion of vegetables. CLEA also includes the outdoor air inhalation and soil attached to vegetables pathways. Outdoor air inhalation was not modelled, as the indoor air pathway is typically more conservative. Soil attached to vegetables was not included owing to a calculation method not being available within RISC. A conceptual model illustrating the linkages modelled is included in Figure 1.

Within the model, the solubility limit of the determinant limits the extent of volatilisation, which in turn drives the indoor air inhalation pathway. In cases where the contaminant solubility is exceeded, a reliable method to derive GAC has not been determined, and the values calculated for the soil ingestion and dermal contact pathways are selected as the GAC.

*3. Input Selection*

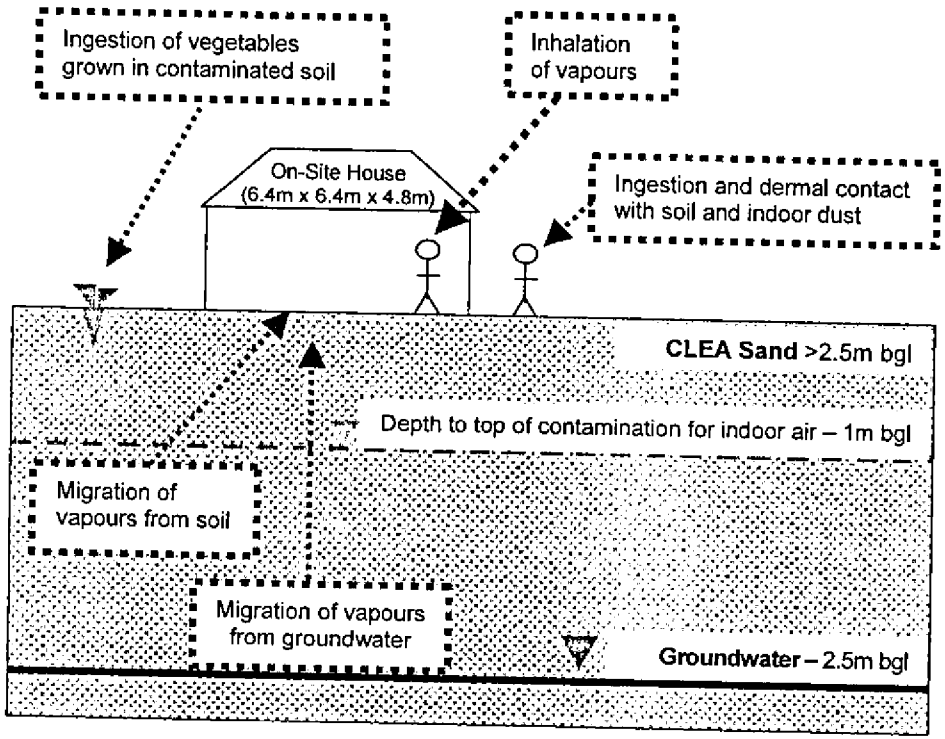
Where available, the published UK toxicity data has been used. For compounds where Tolerable Daily Soil Intakes (TDSI) for both a child and an adult are published, the value for the child was used in line with CLEA. For Total Petroleum Hydrocarbons (TPH), toxicity and chemical specific parameters from the TPH Criteria Working Group (TPHCWG) were used. Due to the lack of UK-specific data, default information in the RBCA model was used to evaluate MTBE. No published UK toxicity data was available for 1,2,4- and 1,3,5-trimethylbenzene. Data was collected from Syracuse Research Corporation database (http://www.syrres.com/esc/physdemo.htm) and the Risk Assessment Information System (http://risk.lsd.ornl.gov/cgi-bin/tox/). Toxicity reports have been generated by RSK in line with guidance in CLR9 for 14 of the 16 USEPA Polycyclic Aromatic Hydrocarbons (PAHs). The chemical and toxicity data used to generate the GAC was derived from these reports.

Building size, particularly height, is a sensitive parameter when considering the indoor air pathway. Building parameters for a CLEA house (two floors) and a sand soil type were used in line with published SGVs. An average groundwater depth of 2.5m was assumed based on typical UK conditions. This is also a sensitive parameter for the indoor air pathway. If groundwater is shallower than 2.0m bgl or deeper than 3.0m bgl, the GAC should be used with caution since they could be over or under conservative.

*4. GAC*

The GAC were produced using the input parameters in Tables 1 to 3 and the GAC are presented by pathway in Table 4. The final selected GAC are presented in Table 5.

**Figure 1**
**Conceptual Model for Residential Scenario – Private Gardens**




Note: Exposure parameters shown on Table 1.

**Table 1**
**Exposure Assessment Parameters for Residential Scenario - Private Gardens – Inputs for RBCA Model**

| Parameter | Value | Justification |
|---|---|---|
| Averaging time | 6 years | Equals exposure duration for residential use in line with Table 3.2, CLR10 |
| Body weight | 14.5kg | Average 0-6 year old female child in line with Table 5.6, CLR10 for residential use |
| Exposure frequency | 365 days | In line with Tables 3.2, 4.3, 4.4, CLR10 for a residential end use. |
| Exposure duration | 6 years | |
| Ingestion rate for soil | 100mg/day | Table 6.1, CLR10 value for a 0-6 year old ingesting soil and indoor dust. |
| Total exposed skin surface area | 1634cm$^2$ | Equation: Total skin area (6167cm$^2$) x max fraction skin exposed outdoors (0.265)<br><br>Mean of total skin area for 0-6 year old female, calculated from Appendix 1, BN 1 and mean of max fraction for outdoor exposure of a 0-6 year old female taken from Table 2, BN 1.<br><br>Indoor exposure fraction is 0.33 but was not selected since a lower adherence factor is relevant for indoor exposure. This value is within the range of indoor and just above that for outdoor exposed skin in Appendix 1, BN1 and therefore is considered appropriate for use. |
| Soil/skin adherence factor | 1mg/cm$^2$ | In line with recommendations for a child resident for outdoor exposure. Table 3, BN1. Note indoor adherence factor is 0.06mg/cm$^2$, but 1mg/cm$^2$ is considered more conservative. |

Note: Briefing Notes (BN) are CLEA publications. BN1, Version 1.1, (March 2005).

**Table 2**
**Additional Exposure Parameters used in the RISC Model – Ingestion of Vegetable Pathway**

| Parameter | Value | Justification |
|---|---|---|
| Exposure frequency | 365 No. | In line with paragraph 4.34, CLR10 for a residential end use. |
| Ingestion rate for root veg | 61.7g/day | In line with CLR10 for a 1–4 year old, averaged for 1–4 year old age from Tables 6.3 and 5.6 as the 1–4 year age group is nearest to 0–6 year old used in CLEA to assess residential end use. |
| Ingestion rate for above ground veg | 16.5g/day | |
| Fraction of veg grown in contaminated soil | 0.28 [-] | Average home-grown fraction calculated from Table 6.4, CLR10. |
| Fraction of organic carbon | 0.0058 [-] | Published SGVs use a soil organic matter of 1%. This is the equivalent of 0.58% TOC. |

Note: Fraction of vegetables grown in contaminated soil is taken from CLR10 that CLAN6/06 recognises as being overly conservative.

**Table 3**
**Additional Parameters for Residential Scenario - Private Gardens - Inputs for RBCA Model**

| Parameter | Value | Justification |
|---|---|---|
| Depth to water bearing unit | 2.5m | Assumed typical depth to groundwater based on RSK experience. |
| Depth to top of affected soil | 1m | Default from BN 2 for the depth to impacted soil. |
| Depth to base of affected soil | 2.5m | Taken equal to depth to water-bearing unit to reflect unsaturated zone thickness. |
| Affected soil area | 40.96m$^2$ | Taken equal to foundation area (6.4m x 6.4m) of CLEA house. BN 3. |
| **Soil type – Sand in line with CLEA** | | |
| Total porosity | 0.46 [-] | CLEA sand from Table 3, BN2 as this is the most permeable CLEA soil and was used to produce the published SGVs. |
| Volumetric water content | 0.15 [-] | |
| Dry bulk density | 1.6 | |
| Vertical hydraulic conductivity | 5.6m/d | |
| Vapour permeability | 7.20E-12m$^2$ | Calculated for a CLEA sand using equations in Appendix 2, BN 2. |
| Capillary zone thickness | 0.05m | Default value for sand from RBCA as RBCA sand is similar to CLEA sand and value is not included in BN 2. |
| Fraction of organic carbon | 0.0058 | Modelling used 1% SOM (0.58% TOC) in line with the published CLEA SGVs. |
| Soil/water pH | 6.8 | Taken as model default, which is considered reasonably conservative for UK. |
| Groundwater plume width at source | 6.4m | Equal to width of CLEA house (6.4m x 6.4m). Appendix 1, BN 3. |
| Foundation area | 40.96m$^2$ | CLEA house dimensions used (6.4m x 6.4m). Appendix 1, BN 3. |
| Foundation perimeter | 25.6m | |
| Building volume/area ratio | 4.8m | CLEA house. Appendix 1, BN 3. |
| Building air exchange rate | 12 No./day | CLEA BN 3 for a residential property. |
| Depth to slab base | 0.15m | CLEA house. Appendix 1, BN 3 for foundation or slab thickness. |
| Foundation crack fraction | 0.00125 | Calculated using building perimeter and foundation area in line with last paragraph of BN 3 (0.002m x perimeter/area). |
| Volumetric air content of cracks | 0.31 [-] | Assumed equal to underlying soil type in assumption that cracks become filled with soil over time. Discussion for Equation 6 - BN 2. Underlying soil is assumed to be CLEA sand. |
| Volumetric water content of cracks | 0.15 [-] | |
| Indoor/outdoor differential pressure | 30g/cm/s$^2$ | CLEA house, Appendix 1, BN 3. |

Note: Briefing Notes (BN) are CLEA publications. BN2, Version 1.1 (July 2004), BN3, Version 1.1 (July 2004).

Table 4
Human Health Generic Assessment Criteria by Pathway for Residential Scenario - Private Gardens

| Compound | GAC for Inhalation of Indoor Air from Groundwater (a) (mg/l) | SSV Appropriate to Pathway | | | Selected SSV for Soil with Vegetable Uptake (c) (mg/kg) |
|---|---|---|---|---|---|
| | | Soil Ingestion/ Dermal Contact (mg/kg) | Inhalation of Indoor Air (mg/kg) | SSV for Vegetable Uptake (b) (mg/kg) | |
| **Metals** | | | | | |
| Arsenic | - | NC | NC | NC | 2.00E+01 (d) |
| Cadmium (pH 6 - see note k) | - | NC | NC | NC | 1.00E+00 (d,k) |
| Chromium (total) | - | NC | NC | NC | 1.30E+02 (d) |
| Copper (b) | - | 5.80E+03 | - | 4.40E+02 | 4.40E+02 |
| Lead | - | NC | NC | NC | 4.50E+02 (d) |
| Mercury | - | NC | NC | NC | 8.00E+00 (d) |
| Nickel | - | NC | NC | NC | 5.00E+01 (d) |
| Selenium | - | NC | NC | NC | 3.50E+01 (d) |
| Zinc (b) | - | 4.40E+04 | - | 8.80E+02 | 8.80E+02 |
| **Volatile Organic Compounds (f)** | | | | | |
| Benzene | 7.39E-02 | 1.60E+01 | 1.67E-01 | 2.00E+00 | 1.67E-01 |
| Toluene (1% SOM - see note e) (g) | 5.15E+00 | NC | NC | NC | 3.00E+00 (d) |
| Ethylbenzene (1% SOM - see note e) (g) | 1.16E+01 | NC | NC | NC | 9.00E+00 (d) |
| Xylene (g) | 3.50E+00 | 9.80E+03 | 1.10E+01 | 2.50E+03 | 1.10E+01 |
| Methyl t-Butyl ether (h) | 3.66E+02 | 4.77E+02 | 1.58E+02 | 1.90E+01 | 1.90E+01 |
| Trichloroethene | 2.20E-01 | 2.86E+02 | 9.57E-01 | 4.30E+01 | 9.57E-01 |
| Tetrachloroethene | 1.41E+00 | 7.71E+02 | 1.21E+01 | 1.40E+02 | 1.21E+01 |
| 1,1,1-Trichloroethane | 1.75E+01 | 9.49E+03 | 1.09E+02 | 5.80E+03 | 1.09E+02 |
| 1,1,1,2 & 1,1,2,2-Tetrachloroethane | 1.11E+01 | 9.17E+01 | 6.84E+00 | 5.20E+01 | 6.84E+00 |
| Carbon Tetrachloride | 4.18E-02 | 2.21E+01 | 3.68E-01 | 1.70E+01 | 3.68E-01 |
| 1,2-Dichloroethane | 4.40E-02 | 1.90E+00 | 2.21E-02 | 4.00E-01 | 2.21E-02 |
| Vinyl Chloride | 4.03E-03 | 2.21E-01 | 5.52E-02 | 4.80E-02 | 4.80E-02 |
| 1,2,4-Trimethylbenzene (i) | 8.07E-02 | 2.75E+03 | 3.13E-01 | 6.70E+02 | 3.13E-01 |
| 1,3,5-Trimethylbenzene (i) | 5.93E-02 | 2.75E+03 | 3.13E-01 | 8.00E+02 | 3.13E-01 |
| **Semi-Volatile Organic Compounds (j)** | | | | | |
| Acenaphthene | 7.59E-01 | 9.28E+02 | 1.53E+01 | 1.00E+03 | 1.53E+01 |
| Acenaphthylene | 1.08E-01 | 9.28E+01 | 1.27E+00 | 7.00E+01 | 1.27E+00 |
| Anthracene | ND | 5.11E+04 | ND | 9.50E+04 | 5.11E+04 |
| Benzo(a)anthracene | ND | 9.28E+00 | ND | 8.00E+01 | 9.28E+00 |
| Benzo(b)fluoranthene | ND | 9.28E+00 | ND | 4.40E+01 | 9.28E+00 |
| Benzo(g,h,i)perylene | ND | 1.39E+03 | ND | 1.70E+03 | 1.39E+03 |
| Benzo(k)fluoranthene | ND | 9.28E+00 | ND | 6.70E+01 | 9.28E+00 |
| Chrysene | ND | 9.28E+01 | ND | 5.40E+00 | 5.40E+00 |
| Dibenzo(a,h)anthracene | ND | 9.28E-01 | ND | 6.40E+00 | 9.28E-01 |
| Fluoranthene | ND | 9.28E+01 | ND | 2.40E+02 | 9.28E+01 |
| Fluorene | ND | 6.45E+03 | ND | 9.10E+03 | 6.45E+03 |
| Indeno(1,2,3-cd)pyrene | ND | 9.28E+00 | ND | 6.80E+01 | 9.28E+00 |
| Phenanthrene | ND | 1.86E+03 | ND | 2.90E+03 | 1.86E+03 |
| Pyrene | ND | 9.28E+02 | ND | 2.40E+03 | 9.28E+02 |
| Benzo(a)pyrene (f) | ND | 1.10E+00 | ND | 5.50E+00 | 1.10E+00 |
| Naphthalene (f,g) | 1.68E+00 | 1.10E+03 | 6.56E+00 | 4.70E+02 | 6.56E+00 |
| Phenol (d) | - | NC | NC | NC | 7.80E+01 (d) |

Table 4
Human Health Generic Assessment Criteria by Pathway for Residential Scenario - Private Gardens

| Compound | GAC for Inhalation of Indoor Air from Groundwater (a) (mg/l) | SSV Appropriate to Pathway | | | Selected SSV for Soil with Vegetable Uptake (c) (mg/kg) |
|---|---|---|---|---|---|
| | | Soil Ingestion/ Dermal Contact (mg/kg) | Inhalation of Indoor Air (mg/kg) | SSV for Vegetable Uptake (b) (mg/kg) | |
| Table 4 Continued | | | | | |
| | | | | | |
| **Total Petroleum Hydrocarbons (h)** | | | | | |
| Aliphatic Hydrocarbons $EC_5$-$EC_6$ | 1.39E+00 | 2.75E+05 | ND | 9.30E+04 | 9.30E+04 |
| Aliphatic Hydrocarbons >$EC_6$-$EC_8$ | 9.39E-01 | 2.75E+05 | ND | 1.70E+05 | 1.70E+05 |
| Aliphatic Hydrocarbons >$EC_8$-$EC_{10}$ | 3.13E-02 | 5.50E+03 | 5.26E+01 | 7.30E+03 | 5.26E+01 |
| Aliphatic Hydrocarbons >$EC_{10}$-$EC_{12}$ | 2.01E-02 | 5.50E+03 | ND | 1.50E+04 | 5.50E+03 |
| Aliphatic Hydrocarbons >$EC_{12}$-$EC_{16}$ | ND | 5.50E+03 | ND | 3.80E+04 | 5.50E+03 |
| Aliphatic Hydrocarbons >$EC_{16}$-$EC_{21}$ | - | 1.10E+05 | - | - | 1.10E+05 |
| Aliphatic Hydrocarbons >$EC_{21}$-$EC_{35}$ | - | 1.10E+05 | - | - | 1.10E+05 |
| Aromatic Hydrocarbons $EC_5$-$EC_7$ | 6.29E-02 | 1.65E+02 | 3.13E-01 | 1.20E+03 | 3.13E-01 |
| Aromatic Hydrocarbons >$EC_7$-$EC_8$ | 3.54E+00 | 1.10E+04 | 2.10E+01 | 2.10E+03 | 2.10E+01 |
| Aromatic Hydrocarbons >$EC_8$-$EC_{10}$ | 1.02E+00 | 2.20E+03 | 1.05E+01 | 9.80E+02 | 1.05E+01 |
| Aromatic Hydrocarbons >$EC_{10}$-$EC_{12}$ | 3.63E+00 | 2.20E+03 | 3.07E+01 | 1.30E+03 | 3.07E+01 |
| Aromatic Hydrocarbons >$EC_{12}$-$EC_{16}$ | ND | 2.20E+03 | 1.61E+02 | 1.70E+03 | 1.61E+02 |
| Aromatic Hydrocarbons >$EC_{16}$-$EC_{21}$ | - | 1.65E+03 | - | 1.40E+03 | 1.40E+03 |
| Aromatic Hydrocarbons >$EC_{21}$-$EC_{35}$ | - | 1.65E+03 | - | 3.70E+04 | 1.65E+03 |

Notes:
"-" - GAC or SSV not calculated owing to low volatility of substance and therefore an absence of toxicity data for this pathway.
EC - Equivalent Carbons.
GAC - Generic Assessment Criteria.
NC - Not calculated as published screening value exists.
ND - Not determined. Calculated screening value exceeded the solubility limit used in RBCA. Theoretically, these compounds could not dissolve into a solution with high enough concentrations to pose a risk as the solubility limit is exceeded and the RBCA model cannot consider free phase.
RBCA - Risk-Based Corrective Action model, Version 1.3b (2000), (ASTM, 1998).
RISC - Risk-Integrated Software for Clean-ups, Version 4.03a (BP, 2003).
SGV - Soil Guideline Values.
SSV - Soil Screening Values.
(a) Unless otherwise noted, values were calculated by the RBCA model using default values shown in Table 1, Table 2 and Table 3 of this Appendix.
(b) Toxicity data taken from the RISC model.
(c) Value selected is the lowest calculated from the soil ingestion/dermal contact, inhalation of indoor air and vegetable uptake pathways.
(d) GAC taken as published residential with plant uptake SGV.
(e) The SGVs for toluene and ethylbenzene are dependent on Soil Organic Matter (SOM) (%) content. To obtain SOM from total organic carbon (TOC) (%) divide by 0.58%. 1% SOM is 0.58% TOC. DL Rowell Soil Science: Methods and Applications, Longmans, 1994.
(f) Unless otherwise noted toxicity information and chemical parameters obtained from Environment Agency publications.
(g) Child values for Total Daily Soil Intake were used for both the oral and inhalation pathways (oral values substituted for dermal pathway in absence of dermal values).
(h) RBCA default values used for MTBE and hydrocarbon fractions. Hydrocarbons consistent with TPH Criteria Working Group (TPHCWG).
(i) No UK data available, see Input Selection section for references.
(j) Unless otherwise noted RSK toxicity values used. These were derived following the CLR9 hierarchy in absence of UK data. Toxicity reports available upon request.
(k) Cadmium is dependent on soil pH, 1 mg/kg is the SGV at a pH of 6, 2 mg/kg is the SGV at a pH of 7, and 8 mg/kg is the SGV at a pH of 8.

Table 5
**Selected Human Health Generic Assessment Criteria for Residential Scenario - Private Gardens**

| Compound | GAC for Groundwater (a) (mg/l) | GAC for Soils (a) (mg/kg) |
|---|---|---|
| **Metals** | | |
| Arsenic | - | 20 |
| Cadmium (pH 6, 7, 8) | - | 1,2,8 |
| Chromium (total) | - | 130 |
| Copper | - | 440 |
| Lead | - | 450 |
| Mercury | - | 8 |
| Selenium | - | 35 |
| Nickel | - | 50 |
| Zinc | - | 880 |
| **Volatile Organic Compounds** | | |
| Benzene | 0.074 | 0.17 |
| Toluene (SOM 1%, 2.5%, 5%) | 5.2 | 3.0, 7.0, 14 |
| Ethylbenzene (SOM 1%, 2.5%, 5%) | 12 | 9.0, 21, 41 |
| Xylene | 3.5 | 11 |
| Methyl t-Butyl ether | 370 | 19 |
| Trichloroethene | 0.22 | 0.96 |
| Tetrachloroethene | 1.4 | 12 |
| 1,1,1-Trichloroethane | 18 | 110 |
| 1,1,1,2 & 1,1,2,2-Tetrachloroethane | 11 | 6.8 |
| Carbon Tetrachloride | 0.042 | 0.37 |
| 1,2-Dichloroethane | 0.044 | 0.022 |
| Vinyl Chloride | 0.0040 | 0.048 |
| 1,2,4-Trimethylbenzene | 0.081 | 0.31 |
| 1,3,5-Trimethylbenzene | 0.059 | 0.31 |
| **Semi-Volatile Organic Compounds** | | |
| Acenaphthene | 0.76 | 15 |
| Acenaphthylene | 0.11 | 1.3 |
| Anthracene | ND | 51,000 |
| Benzo(a)anthracene | ND | 9.3 |
| Benzo(b)fluoranthene | ND | 9.3 |
| Benzo(g,h,i)perylene | ND | 1,400 |
| Benzo(k)fluoranthene | ND | 9.3 |
| Chrysene | ND | 5.4 |
| Dibenzo(a,h)anthracene | ND | 0.93 |
| Fluoranthene | ND | 93 |
| Fluorene | ND | 6,500 |
| Indeno(1,2,3-cd)pyrene | ND | 9.3 |
| Phenanthrene | ND | 1,900 |
| Pyrene | ND | 930 |
| Benzo(a)pyrene | ND | 1.1 |
| Naphthalene | 1.7 | 6.6 |
| Phenol | - | 78 |
| **Total Petroleum Hydrocarbons** | | |
| Aliphatic Hydrocarbons $EC_5$-$EC_6$ | 1.4 | 93,000 |
| Aliphatic Hydrocarbons >$EC_6$-$EC_8$ | 0.9 | 170,000 |
| Aliphatic Hydrocarbons >$EC_8$-$EC_{10}$ | 0.031 | 53 |
| Aliphatic Hydrocarbons >$EC_{10}$-$EC_{12}$ | 0.020 | 5,500 |
| Aliphatic Hydrocarbons >$EC_{12}$-$EC_{16}$ | ND | 5,500 |
| Aliphatic Hydrocarbons >$EC_{16}$-$EC_{21}$ | - | 110,000 |
| Aliphatic Hydrocarbons >$EC_{21}$-$EC_{35}$ | - | 110,000 |
| Aromatic Hydrocarbons $EC_5$-$EC_7$ | 0.063 | 0.31 |
| Aromatic Hydrocarbons >$EC_7$-$EC_8$ | 3.5 | 21 |
| Aromatic Hydrocarbons >$EC_8$-$EC_{10}$ | 1.0 | 11 |
| Aromatic Hydrocarbons >$EC_{10}$-$EC_{12}$ | 3.6 | 31 |
| Aromatic Hydrocarbons >$EC_{12}$-$EC_{16}$ | ND | 160 |
| Aromatic Hydrocarbons >$EC_{16}$-$EC_{21}$ | - | 1,400 |
| Aromatic Hydrocarbons >$EC_{21}$-$EC_{35}$ | - | 1,700 |

Notes:
"-" Value not applicable due to low volatility of substance. No value in table as groundwater ingestion not considered a plausible pathway.
GAC - Generic Assessment Criteria.
ND - Not determined. Value exceeded solubility limit used in RBCA. Theoretically these compounds could not dissolve into a solution with high enough concentrations to pose a risk, as solubility limit is exceeded the potential pathway is incomplete.
RBCA - Risk-Based Corrective Action model, Version 1.3b (2000), (ASTM, 1998).
(a) See Table 4 for calculation notes, values shown rounded to two significant figures.

# APPENDIX E

(i) Gas and Groundwater Monitoring Results

## GAS MONITORING RESULTS

**Contract No: 720858**
**Contract Name: DUNHAMS COURTYARD, HATFIELD**

**Contract Engineer: GG**
**Date: 17/01/08**

Weather Conditions: OVERCAST
Atmospheric Wind Conditions: Light
ALM Pressure: Falling

Equipment used: LMSxi

Data Collected By: IAN WARNE

Ground Conditions (eg dry, flooded, frost, snow etc): DAMP

Input Checked by (sign):

| Location | Well depth (mbgl) Current and [as installed] | Top of Response zone (m bgl) | Depth to water (m bgl) (start and finish) | Flow (l/hr) (peak and residual) | Atmospheric Pressure (mb) | BH Pressure (mb) | Time | | % by volume in air | | | LEL (%) | (ppm) | | | Notes (eg dual installation, odours, sheens, broken leadworks). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | hours mins | secs | Methane | Carbon Dioxide | Oxygen | | H2S | CO | PID | |
| WS1 | 1.38 | - | DRY | 0.2<br>0.0 | 988 | 988 | | 0 (initial) | 0.0 | 0.0 | 20.8 | | | | | |
| | | | | | | | | 15 | 0.0 | 0.0 | 19.2 | | | | | |
| | | | | | | | | 30 | 0.0 | 0.0 | 18.9 | | | | | |
| | | | | | | | | 60 | 0.0 | 0.0 | 18.7 | | | | | |
| | | | | | | | | 90 | 0.0 | 0.0 | 18.7 | | | | | |
| | | | | | | | | 120 | - | - | - | | | | | |
| | | | | | | | | 180 | - | - | - | | | | | |
| WS3 | 3.33 | - | DRY | 0.2<br>0.0 | 987 | 987 | | 0 | 0.0 | 0.0 | 20.8 | | | | | |
| | | | | | | | | 15 | 0.0 | 0.5 | 18.0 | | | | | |
| | | | | | | | | 30 | 0.0 | 0.8 | 17.5 | | | | | |
| | | | | | | | | 60 | 0.0 | 1.3 | 16.8 | | | | | |
| | | | | | | | | 90 | 0.0 | 1.2 | 16.8 | | | | | |
| | | | | | | | | 120 | - | - | - | | | | | |
| | | | | | | | | 180 | - | - | - | | | | | |

## GAS MONITORING RESULTS

**Contract No: 720858**
**Contract Name: DUNHAMS COURTYARD, HATFIELD**

**Contract Engineer: GG**
**Date: 07/02/08**

Weather Conditions: OVERCAST
Atmospheric Wind Conditions: Light
ALM Pressure: Falling

Equipment used: LMSxi

Data Collected By: IAN WARNE/BOB DAVIES

Ground Conditions (eg dry, flooded, frost, snow etc):

Input Checked by (sign):

| Location | Well depth (mbgl) Current and [as installed] | Top of Response zone (m bgl) | Depth to water (m bgl) (start and finish) | Flow (l/hr) (peak and residual) | Atmospheric Pressure (mb) | BH Pressure (mb) | Time | | % by volume in air | | | LEL (%) | (ppm) | | | Notes (eg dual installation, odours, sheens, broken leadworks). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | hours mins | secs | Methane | Carbon Dioxide | Oxygen | | H2S | CO | PID | |
| WS1 | 1.37 | | DRY | -0.4 | 1025 | 1025 | | 0 (initial) | 0.0 | 0.0 | 20.8 | | | | | |
| | | | | 0.0 | 1025 | 1025 | | 15 | 0.0 | 0.0 | 17.7 | | | | | |
| | | | | | | | | 30 | 0.0 | 0.0 | 17.5 | | | | | |
| | | | | | | | | 60 | 0.0 | 0.0 | 17.5 | | | | | |
| | | | | | | | | 90 | - | - | - | | | | | |
| | | | | | | | | 120 | - | - | - | | | | | |
| | | | | | | | | 180 | - | - | - | | | | | |
| WS3 | 3.34 | | DRY | 0 | 1025 | 1025 | | 0 | 0.0 | 0.0 | 20.8 | | | | | |
| | | | | | | | | 15 | 0.0 | 0.0 | 20.6 | | | | | |
| | | | | | | | | 30 | 0.0 | 0.0 | 20.4 | | | | | |
| | | | | | | | | 60 | 0.0 | 0.1 | 20.4 | | | | | |
| | | | | | | | | 90 | 0.0 | 0.1 | 20.3 | | | | | |
| | | | | | | | | 120 | - | - | - | | | | | |
| | | | | | | | | 180 | - | - | - | | | | | |