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INTERPRETIVE REPORT
on
SITE INVESTIGATION
at
WYETH PHARMACEUTICALS
HAVANT

NOVEMBER 2010
REPORT NO: 725013

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1 INTRODUCTION

This investigation was carried out on the instructions of Rushby Brewster Associates on behalf of Wyeth Pharmaceuticals. The purpose of the work was to investigate ground conditions, assess the contamination status of the site and provide information for the design of foundations for a new 12-14m high steel framed chill store. The work included a Preliminary Risk Assessment (formerly called Desk Study/Phase 1 Investigation), intrusive investigation, laboratory testing, a quantitative risk assessment and the preparation of a report.

A previous report was carried out by Structural Soils Ltd in January 2001 at Wyeth Laboratories. Report no. 01113 (Ref 8.6).

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, settlement, etc. 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. This report does not consider ecological impacts (e.g. bats) or botanical risks (e.g. Japanese Knotweed). It is recommended that these be considered as part of the assessment of development constraints for the site.

The ground investigation has been carried out using cable percussion techniques of soft ground boring, in general accordance with the recommendations of BS5930: 1999 *Code of Practice for Site Investigations*. Whilst every attempt is made to record full details of the strata encountered in the exploratory holes, techniques of hole formation and sampling will inevitably lead to disturbance, mixing or loss of material in some soils and rocks. The investigation has also been carried out in accordance with BS10175 *Investigation of Potentially Contaminated Sites: Code of Practice* (2001).

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



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

This report was prepared by Structural Soils Ltd for the sole and exclusive use of Wyeth Pharmaceuticals 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 within an existing factory complex which is situated roughly 1km to the north east of Havant town centre in the county of Hampshire (see Site Location Plan in Appendix A).

The British National Grid Reference of the site is SU 725 027.

The site of the proposed building is approximately 50m by 40m in size (see site plan in Appendix A) and is bounded to the north west and south by existing factory buildings of the same complex. To the east is the access road.

The site is predominantly flat and level and is asphalt covered. The northern half of site is currently used for access to a loading bay for the adjacent building, and for storage of recyclable materials either as bundles (e.g. card board) or in dedicated skips (e.g. metal and wood). The southern half of the site is currently surrounded by a palisade fence which marks the boundary of a contractors store which was being re-located at the time of the site works. Buildings that remained in situ included a pre-fabricated concrete garage, a toilet block and a porta-cabin.

Services on the site include surface water drainage, electricity and telecoms. Service plans were provided by the client on site.

2.2 Geology

The British Geological Survey map (sheet 316, scale 1:50,000) shows the site to be underlain by aeolian Brickearth deposits underlain by Head Gravel and then by the Eocene London Clay Formation.

Brickearth is usually a silt which can be locally contaminated with sand and gravel. The underlying Head Gravel is recorded as being typically a clayey flint gravel and the London Clay is a stiff grey fissured clay which may become sandy at some levels.

2.3 Hydrogeology and Hydrology

The Environment Agency (EA) groundwater vulnerability maps (West Sussex and Surrey, sheet 45, scale 1:100,000) and the EA website show the site location as overlying a Secondary 'A' Aquifer (variably permeable). We interpret this as referring to the Recent Head and Brickearth deposits as the underlying London Clay is recorded as unproductive strata.



'Secondary' aquifers include a wide range of rock layers or drift deposits with an equally wide range of water permeability and storage. Secondary 'A' Aquifers are permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers.

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

The nearest surface water to the site is small stream lying approximately 280m to the NW. Groundwater contained within the Recent Head Deposits is likely to be in potential continuity with this feature.

The EA defines zones around groundwater abstractions used for public water supply as being Source Protection Zones (SPZ). The Zones are defined by the estimated travel time of potential contaminants to the abstractions. This travel time can be influenced by factors such as the underlying geology or the volume of groundwater being abstracted. Source Protection Zones are therefore areas that may be particularly sensitive to groundwater impact. The site does not lie within a currently defined SPZ.

The groundwater beneath the site is anticipated to lie at about 2-3m below ground level and is likely to be flowing in a south westerly direction.

2.4 Preliminary Risk Assessment (formerly called Desk Study/Phase I Investigation)

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

The site lies close to a county boundary and is covered by both 'Sussex' and 'Hampshire & Isle of Wight' county series maps.



Dates	Scale	Significant features, changes and developments:	
		On site	In surroundings [distance(m)]
1866-1870	1:10,560 & 1:2,500	The site is shown as part of an open field.	- South Western Railway 195m E, trending N-S. - Leigh Lane 350m SE. - New Lane 175m NW. - Gas Works 550m SW. - Havant 800m SW.
1897-1899	1:10,560 & 1:2,500	No significant changes.	- Allotment Gardens 300m SW. - Residential development 150m SE. - Old Gravel Pit 520m SW and 500m N & W. - Clay Pit 500m SE.
1909-1914	1:10,560 & 1:2,500	No significant changes.	Old Gravel Pit 500m SW and 400m N no longer shown.
1932-1933	1:10,560 & 1:2,500	No significant changes.	- Gas Works 550m SW no longer labelled. - Some residential development 250m radius and beyond.
1938-1942 & 1953	1:10,560 & 1:2,500	No significant changes.	- Nursery buildings 130m S. - Houses 130m W.
1960-1972	1:10,560 & 1:2,500 & 1:10,000	No significant changes.	- Works 100m SW and 195m S. - Factory 50m N, 190m N and 50m W. - Houses 200m NW and 250m SW. - Plastics Factory 30m SW. - Several Above-ground Storage Tanks (ASTs) shown from 100m WNW. - Gas holder 500m N. Those 550m SE no longer recorded
1969-1973 & 1975	1:10,560 & 1:2,500 & 1:1,250 & 1:10,000	The site is shown as a vacant plot surrounded by factory buildings, possibly now a car park.	- The site is now bordered by soft landscaping. - Significant residential and commercial development in surroundings.
1978-1992	1:10,560 & 1:2,500	No significant changes.	- Building 15m E. - The site is part of an industrial estate.
1993-2006	1:1,250 & 1:10,000	No significant changes.	No significant changes.
2010	1:10,000	No significant changes.	Building immediately N.

2.4.1 Environmental Data

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



Data Types Showing <u>Notable</u> Issues	No. of <u>Notable</u> Listings (or Yes/No) and Distance (m) from Site				Details of <u>Notable</u> Listings
	On site	0-250	250-500	>500	
GENERAL					
Nitrate Vulnerable Zones	1		1		- Eutrophic Water – DEFRA (on site) - Eutrophic Water – DEFRA (415m E)
Local Authority Pollution Prevention and Controls		2	2	3	Thermofil Polymers (UK) Ltd, New Lane, Havant. Havant Borough Council (Factory located to SW of site).
Local Authority Pollution Prevention and Control Enforcements		1			New Lane, Havant – Air Pollution Control Enforcement (105m W).
Integrated Pollution Prevention and Controls		3			Sumika Polymer Compounds (UK) Ltd – Havant Plastics Compounder: New Lane, Havant. Environment Agency, Inorganic Chemicals (101m W).
Integrated Pollution Controls		5			Asahi Thermofil (UK) Ltd – New Lane, Havant. Environment Agency (97m W).
Control of Major Accident Hazards Sites (COMAH)			1		Transco Plc – Leigh Holder Station, Leigh Park, Havant. Active (496m N).
Planning Hazardous Substance Consents			2	1	British Gas Plc – Gas Holder Station, New Lane, Havant. Havant Borough Council (495m N).
Notifications of Installations Handling Hazardous Substances			1		Transco - Leigh Holder Station, Leigh Park, Havant. Active (493m N).
WATER RELATED					
Discharge Consents			1	5	Mr K Harvey – Maintenance Manager: New Lane, Havant. Environment Agency (320m N)
Nearest Surface Waters			Yes		Stream 281m NW.
Controlled Waters (Pollution Incidents)			4	4	Industrial: Other – Eastern Road, Havant. Environment Agency. Stream Polluted, chemical Industry (274m SW).
Water Industry Act Referrals	Yes				Ac Stubbings – Wyeth Laboratories, New Lane, Havant. Environment Agency
Groundwater Vulnerability	Yes	n/a	n/a	n/a	The site is classified as a Secondary Aquifer (Formerly classed as a Minor Aquifer)
Water Abstractions (Licensed)				(3*)	No significant listings - * Listings located over 1km from site.
WASTE					
Licensed Waste Management Facilities (Locations)	Yes			1	New Lane, Havant – John Wyeth and Brother Ltd. Environment Agency



Data Types Showing <u>Notable</u> Issues	No. of <u>Notable</u> Listings (or Yes/No) and Distance (m) from Site				Details of <u>Notable</u> Listings
	On site	0-250	250-500	>500	
Registered Waste Transfer Sites	Yes			1	John Wyeth and Brother Ltd – New Lane, Havant. Environment Agency. Degradable household, commercial, industrial waste.
Registered Waste Treatment and Disposal Sites	Yes		1		Wyeth Laboratories – New Lane, Havant. Environment Agency.
GEOLOGICAL					
Potential for Collapsible Ground Stability Hazards	Yes				A low hazard is given for the site.
Radon Protection Measures	Yes	n/a	n/a	n/a	- The property is in a radon affected area, as between 1 and 3% of properties are above the action level. - No radon protection measures are required for new homes.
INDUSTRIAL LAND USE					
Contemporary Trade Directory Entries	Yes	7	32	39	- Pfizer/Wyeth pharmaceutical company on site. - Sumika Polymer Compounds (UK) Ltd – New Lane, Havant: Plastics, raw materials (101m W).

2.4.2 Summary of Desk Study

Our earliest maps which date back to 1866 show the site as part of an open field, which remains the case until the late 1960's when the Wyeth pharmaceuticals factory is developed. By 1972 the site appears to be a car park and this use has remained unchanged until the cordoning off of part of the site to form a yard for the on-site contractors. The immediate surroundings were developed into factories, laboratories and work shops from the middle of the last century onwards, with the most recent development being the structure that bounds the north and west of the site. During the construction of this building the northern half of the site was re-surfaced.

The property is in a radon affected area as between 1 and 3% of properties are above the action level. No radon protection measures are required in the construction of new dwellings or extensions.

2.5 Outline Conceptual Model and Risk Assessment

2.5.1 General

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



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

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

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

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

2.5.2 Risk Assessment Methodology

CLR11 outlines the framework to be followed for risk assessment in the UK. The framework is designed to be consistent with UK legislation and policies including planning. Under CLR11, three stages of risk assessment exist: Preliminary, Generic Quantitative and Detailed Quantitative. An Outline Conceptual Model should be formed at the preliminary risk assessment stage. This identifies potentially complete (termed *possible*) pollutant linkages (source–pathway–receptor) and is used as the basis for design of the site investigation. The Outline Conceptual Model is updated as further information becomes available, for example as a result of the site investigation.

2.5.3 Potential Sources and Contaminants

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



Potential Sources: On site	Possible contaminants
Made Ground	Heavy metals, asbestos, hydrocarbons
Pharmaceutical Processes	Heavy metals, asbestos, PCB, hydrocarbons – including VOCs
Potential Sources: Off site	Likely contaminants
Surrounding industrial processes	Heavy metals, hydrocarbons

2.5.4 Outline Conceptual Site Model

The information presented in previous sections has been used to compile an Outline Conceptual Model. The identified potential contaminants and potential receptors have been considered, along with any possible pathways that may link them.

The resulting pollutant linkages are considered in the table below:



Potential Source	Potential Pathway	Potential Receptor	Potential Complete Linkage?	Comments (e.g. regarding pathways, impermeable strata, site upstream of source, etc)
Soil contaminants in any Made Ground	Ingestion/ Dermal Contact	Future on-site users (commercial)	Yes	Dermal contact and ingestion through areas of possible soft landscaping.
		Construction workers	Yes	Dermal contact and inhalation during construction work.
		Maintenance workers	Yes	Dermal contact through areas of soft landscaping.
		Adjacent commercial/ residential land users	Yes	Potential for dust generation during construction works
	Permeation	Subsurface plastic water pipes	Yes	
	Leaching	Groundwater in Secondary Aquifer	Yes	Through areas of soft landscaping
	Direct contact/Root uptake	Soft landscaping on-site (phytotoxicity)	Yes	
Groundwater contaminants in area of site (i.e. Hydrocarbons)	Ingestion/ Dermal Contact	Future on-site users (commercial)	No	Groundwater is anticipated to be within a few meters of the surface but no direct contact is envisaged, nor is significant volatile contamination anticipated.
		Adjacent commercial/ residential land users		
		Construction workers		
		Maintenance workers		
	Permeation	Subsurface plastic water pipes	No	No likely source of significant contamination that could pose a risk to groundwater is likely to be present on the site.
	Lateral Groundwater migration	Groundwater in stream 281m NW.		
Vapours associated with soil and groundwater contaminants	Vapour migration and inhalation	Future on-site users (commercial)	No	Significant volatile hydrocarbon contamination of the soil/groundwater is not anticipated.
		Construction/ Maintenance workers	No	Significant volatile hydrocarbon contamination of the soil/groundwater is not anticipated.
Natural radon gas	Flow through ground	End users	No	Below action levels for residential use.



2.5.5 Outline Risk Assessment Conclusions

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

2.6 Recommendations

Intrusive investigation is required to assess any significant contaminant sources, pathways and receptors. The commercial land use will require consideration of the former use of the site in terms of any potentially contaminative processes that may have caused contamination of the ground and/or groundwater.

The objectives of an investigation are to:

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

To achieve these objectives, an investigation was undertaken comprising 2 no. exploratory holes. Where possible the exploratory holes passed through all made ground and into underlying natural soils.



3 FIELDWORK

2 no. cable percussion boreholes (BH6 and BH7) were completed on 5 October 2010 at locations shown on the Exploratory Hole Location Plan in Appendix A. The scope of investigation and choice of investigation equipment was decided by Structural Soils Limited. The positions were selected and set out by Structural Soils Limited. Inspection pits were excavated by hand to 1.20m depth at the exploratory hole locations prior to the commencement of drilling.

The boreholes were drilled using a cable tool percussion drilling rig and were 150mm diameter. The depths of the boreholes were 9.0m to 12.0m and they encountered made ground over superficial deposits over stiff to very stiff London Clay Formation. 100mm diameter undisturbed samples were recovered from the cohesive strata in the boreholes. Standard Penetration Tests were carried out at regular intervals in accordance with BS1377: Part 9: 1990: 3.3. Test results are given in detail in tabular format on the Summary of Standard Penetration Tests in Appendix B, and also summarised on the borehole logs.

On completion the exploratory holes were backfilled with arisings and reinstated.



4 LABORATORY TESTING

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

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

Contamination testing was carried out in accordance with MCERTs/UKAS standards. The results are reported in Appendix D of this report, along with the accreditation certificate for the laboratory.

4.1 Moisture Content

5 no. moisture content tests were undertaken using the oven-drying method in accordance with BS1377: Part 2: 1990. The results are tabulated in the Summary of Soil Classification Tests and below the Plasticity Chart (see Section 4.2, below).

4.2 Liquid Limit, Plastic Limit and Plasticity Index

5 no. liquid and plastic limit tests were performed in accordance with BS1377: Part 2: 1990. The results are plotted on the Plasticity Chart (in accordance with BS5930: 1999) and tabulated below the chart, and in the Summary of Soil Classification Tests.

4.3 Particle Size Distribution

2 no. particle size distribution tests were undertaken by sieving and 2 no. tests were extended by sedimentation analysis using the hydrometer method. All tests were 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 nominally 100mm in diameter and 200mm in length. The confining pressures ranged between 150kPa and 200kPa.



4.5 Contamination

4 no. soil samples were analysed for arsenic, cadmium, chromium (total), lead, mercury, selenium, copper, nickel, zinc, speciated polycyclic aromatic hydrocarbons (PAH), total petroleum hydrocarbons (banded TPH), organic matter, soluble sulphate and pH (SSL Soil 1 suite).



5 GROUND CONDITIONS

5.1 General

The exploratory holes were logged by an engineer and the ground conditions encountered are detailed on the logs contained in Appendix B and are summarised below. The log for BH5 from our investigation in November 2000 is also included as the location for this falls within the footprint of the new structure.

5.2 Made Ground

Made ground was encountered in both boreholes to depths of between 0.35 and 0.45m. This consisted of asphalt over brown grey sandy gravel of fine to coarse subangular flint.

5.3 Brickearth

Soils considered to represent the Brickearth were encountered in both of the boreholes from the base of the made ground to between 1.60m (BH6) and 2.10m depth (BH7). These soils were encountered as firm, becoming stiff, orange brown sandy clayey silts or gravelly clayey silts, with the gravel content increasing with depth. In BH5 this material was recorded as slightly sandy gravelly clay from 0.40m to 1.25m depth.

5.4 Head Deposits

Head gravels were proven in all boreholes from the base of the Brickearth at between 1.25m and 2.10m to a depth of between 3.60m (BH5) and 4.30m (BH7). These gravels were initially medium dense very clayey or silty sandy gravels passing into dense generally very sandy gravels from 3.00m depth in all holes.

5.5 Superficial Deposits

Soft orange brown and grey very thinly laminated clays were encountered below the base of the Head Gravel from 4.10m and 4.30m in BH6 and BH7 respectively. In BH5 this stratum was recorded as soft silty clay and was encountered from 3.60m depth.

This clay was proven to depth of 5.20m (BH7) and 5.45m (BH6) where they were underlain by a grey very silty fine sand in BH7 and an orange brown clayey very silty fine sand in BH6. In BH5 the soft clay was proven to 6.00 depth where it was underlain by a stiff brown grey sandy clay with bands of grey clayey sand to a depth of 8.00m, and which was considered to be a part of the London Clay Formation.



The orange brown fine sand in BH6 became coarser with depth and contained fine shell fragments from 6.50m depth, before passing into a brown grey very silty fine sand with occasional very thin laminae of brown clay at around 6.90m depth. This brown grey sand also contained occasional fine to medium rounded gravel of chalk and rare medium to coarse rounded tabular gravel of a fine grained calcareous sandstone. This stratum was proven to a depth of 8.00m.

In BH7 the grey very silty fine sand was underlain by a grey mottled orange brown slightly sandy silty clay from 6.50m depth, which passed into a firm to stiff grey slightly gravelly sandy clay at 7.40m depth, which was proven to 8.50m depth.. The gravel within this stratum was fine to coarse subrounded flint.

The presence of the chalk and calcareous sandstone gravel within these deposits is not something recorded in the literature for the London Clay Formation within this locality. As mentioned above, the presence of laminations within the soft orange brown and grey clay lying beneath the Head Gravel suggest that these soils may not be contemporaneous with the those gravels. Consideration of the PI results for the deeper London Clay shows a marked change into the basal stratum of this material, a change that would not be expected if these soils were a part of the London Clay Formation. On balance these soils are considered to be superficial deposits rather than a part of the London Clay Formation.

5.6 London Clay Formation

Soils considered to be of the London Clay Formation were encountered from 8.00m in BH6 and BH5 and from 8.50m depth in BH7 as generally very stiff slightly sandy clay with occasional sandy partings. SPT N- value was seen to increase in depth within this strata though they were notably higher in BH5 with an N-value of 41, 44 and 50 at 9.00m, 10.50m and 12.00m respectively compared to values of 25 and 29 at 9.5m and 11.5m respectively in BH6.

5.7 Groundwater

Groundwater strikes were masked in the Head Gravel as water was being added to assist drilling, though it is considered likely that these were water bearing as standing water levels of 2.00 were recorded during the SPT tests undertaken in both boreholes at 2.00m depth.

A single strike was recorded in BH6 at 6.80m depth within the Superficial Deposits, with a corresponding rise to 4.70m depth. A seepage was recorded in BH5 at 6.00m depth and no groundwater was recorded in BH7, possibly due to the likely slow inflow rates that would be expected in the fine sand at this depth.



No groundwater was recorded within the underlying London Clay Formation.



6 DISCUSSION AND RECOMMENDATIONS

6.1 Proposed Development

The proposed development will, it is understood, comprise a new 12-14m high steel framed chill store.

6.2 Site Preparation and Excavation

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

Based on our site works, groundwater ingress into excavations to the recommended founding depths (or services excavations, etc) is likely where the excavations extend into the Head Gravel. This should be controllable by sump pumping. Advice on suitable dewatering techniques is given in CIRIA Report C515 *Groundwater Control – design and practice*. Inflows could, however, be greater around periods of heavy rain.

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

6.3 Shrinkage and Swelling

Atterberg Limits tests performed on samples taken from the superficial deposits and the London Clay Formation. The tests undertaken on the soils of the superficial deposits and the London Clay formation showed them to be of groups CI and CH respectively as defined in BS 5930:1999, however these are of too great a depth to influence foundation design.

6.4 Foundations

This investigation has revealed firm to stiff clay and silt deposits (Brickearth) to depths of 1.6m-2.1m, underlain by sandy gravel deposits (Head Deposits) to depths of between 4.1m and 4.3m. This is in turn underlain by a layer of soft sandy clay and medium dense silty sand and stiff sandy clay (Superficial Deposits) to a maximum depth of 8.5m. The London Clay Formation, comprising stiff slightly sandy to sandy clay, was proven to a maximum depth of 12.0m.

It is considered that pad and/or strip foundations may be used, taken through the Brickearth deposits and placed within the medium dense gravel deposits encountered from depths of 1.6m and 2.1m.



An allowable bearing capacity of 400kN/m^2 is calculated for the gravel deposits. This figure is based on a conservative SPT N-value of 20, corrected to allow for overburden pressure and assuming a potentially shallow water table. The allowable bearing capacity in granular soils is defined as that causing 25mm of settlement, assuming a depth of granular soil beneath the foundation of at least twice the foundation width. For lower bearing pressures the settlements will be proportionally less.

To support a column load of 300kN pad foundations would need to be in the order of 0.85m by 0.85m in size. The total long term settlement of foundations exerting the above bearing pressures should not exceed 25mm. For example, a 1.0m square pad foundation set at 1.6m depth exerting a foundation pressure of 300kN/m^2 should be in the order of 20mm. Settlements within the granular deposits are likely to occur almost immediately upon loading.

If larger column loads are imposed, and increased size pad foundations need to be adopted, i.e. greater than 1.25m by 1.25m, consideration will need to be given to the soft to firm superficial clay deposits that underlie the gravel deposits, as the zone of influence beneath the foundations will increase, and as a result begin to exert an effect on the underlying clay. Increased settlement should be expected if larger loads and larger pads are used in the proposed development. Settlement within the granular deposits will likely be immediate, whereas any settlement within the clay will be long term as the increase in porewater pressure dissipates.

If therefore, given the potential loading and settlement limitations as indicated above, it is considered that pad foundations are not deemed appropriate for the development then piled foundations may be adopted.

The following ultimate values for skin friction and end bearing, based on the profile of BH6, may be used to carry out a preliminary design for bored piles.

Depth (m bgl)	Ultimate Skin Friction (kN/m^2)	Ultimate End Bearing (kN/m^2)	Description
0.0m-0.45m	N/A	N/A	Made Ground
0.45m-1.6m	65 ²	N/A	Firm to Stiff SILT (Brickearth)
1.6m-4.1m	20 ¹	Not Recommended	Medium Dense GRAVEL (Head Deposits)
4.1m-5.5m	20	Not Recommended	Soft Clay (Superficial Deposits)
5.5m-8.0m	40 ¹	1500 ⁵	Medium Dense silty SAND (Superficial Deposits)
8.0m-12.0m	50 ⁴	1040 ³	Stiff sandy CLAY (London Clay Formation)

Notes:

1. Coefficient of horizontal soil stress, K_s , of 0.85, and angle of pile/soil friction, δ , of $1.0 \times \phi'$ used to derive this value.



2. Soil adhesion factor, α , of 0.6 used to derive these values.
3. Bearing capacity factor, N_c , of 9.0 used to derive these values.
4. Soil adhesion factor, α , of 0.45 used to derive these values.
5. The ultimate end bearing should be limited to that of the underlying stiff clay for any piles that terminate within five pile diameters of the base of the medium dense sand.

The following ultimate values for skin friction and end bearing, based on the profile of BH6, may be used to carry out a preliminary design for driven piles.

Depth (m bgl)	Ultimate Skin Friction (kN/m ²)	Ultimate End Bearing (kN/m ²)	Description
0.0m-0.45m	N/A	N/A	Made Ground
0.45m-1.6m	70 ²	N/A	Firm to Stiff SILT (Brickearth)
1.6m-4.1m	40 ¹	Not Recommended	Medium Dense GRAVEL (Head Deposits)
4.1m-5.5m	20	Not Recommended	Soft Clay (Superficial Deposits)
5.5m-8.0m	45 ¹	1700 ⁵	Medium Dense silty SAND (Superficial Deposits)
8.0m-12.0m	70 ⁴	1040 ³	Stiff sandy CLAY (London Clay Formation)

Notes:

1. Coefficient of horizontal soil stress, K_s , of 1.25, and angle of pile/soil friction, δ , of $0.8 \times \phi'$ used to derive this value.
2. Soil adhesion factor, α , of 1.0 used to derive these values.
3. Bearing capacity factor, N_c , of 9.0 used to derive these values.
4. Soil adhesion factor, α , of 0.6 used to derive these values.
5. The ultimate end bearing should be limited to that of the underlying stiff clay for any piles that terminate within five pile diameters of the base of the medium dense sand.

When calculating the allowable working load of piles, a factor of safety of 2.5 should be applied to the above ultimate values for skin friction and end bearing. As the capacity of piles can vary depending on the type and method of installation, we recommend that the advice of specialist piling contractors be sought with regard to the final design of piles. Consideration should also be given to undertaking loading tests on selected piles.

6.5 Floor Slabs

We understand that the uniformly distributed floor slab load will be in the order of 35kN/m², with point loads up to a maximum of 120kN. The exploratory holes indicate a variable thickness of Brickearth deposits across the site, with a variable thickness and density of gravel deposits underlying this. Based on these exploratory hole profiles for the site, settlements for a uniform load of 35kN/m² would be in the order of 50mm. Within the areas of increased point loading settlement would be up to the order of 180mm, and as such differential settlement will occur across the ~35m wide floor slab.



Any ground bearing floor slab design will therefore need to be adequately reinforced to resist this settlement due to the variation in uniform and point loads that are applied, or a piled floor slab design should be adopted for the development.

6.6 Protection of Buried Concrete

The site is classed as brownfield and groundwater is assumed to be static above about 2.0m depth and mobile below. Soil pH values varying from 7.9 to 8.4 were recorded for the near surface soils. The water-soluble sulphate results range from 10mg/l to 30mg/l. The 'Characteristic Value' is therefore 30mg/l and this falls into Design Sulphate Class DS-1 in Table C2 of BRE Special Digest 1 (SD1).

The underlying geology (London Clay Formation) at the site is potentially pyritic. However, buried concrete is unlikely to be exposed to disturbed ground in which pyrite may oxidize to sulphate (e.g. the pyritic strata are too deep, or if piles are used then they will not cause disturbed ground that could oxidise) and so the concrete classification need not be based on any pyrite test results.

Therefore according to Table C2 the Aggressive Chemical Environment for Concrete (ACEC) class is AC-1. The designer should utilise this class 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 Human Health Risks: General

To determine whether contaminants are present at levels that may be deemed to pose a significant hazard to human health, measured contamination levels in soil at the site are compared against derived guideline values ('Tier 2' soil screening), either directly or following statistical analysis. Where contaminants are present near, or above, the screening values it is



probable that site-specific information will be required to further examine the potential risk of harm arising from such contamination.

The Soil Guideline Values (SGVs) derived from the CLEA model and published by DEFRA provide initial screening criteria to establish whether sources of contamination are significant. These can then be compared with the site-specific analytical data to establish whether the hazards have the potential to cause unacceptable health risks.

In August 2008 the Environment Agency and the Department of Environment, Food and Rural Affairs (Defra) withdrew Contaminated Land Reports CLR7 to CLR10, together with the previously published Soil Guideline Values (SGVs) and CLEA UK software. In September 2009 version 1.06 of the CLEA model was issued and in May 2010 RSK released screening values (Generic Assessment Criteria (GAC)) derived in accordance with this model. RSK Group Plc has followed the same approach as CLEA to derive GAC for relevant contaminants for which SGVs are as yet not published. The rationale behind the derivation of these values is presented in Appendix D.

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 value below which the true mean value for the site lies (US_{95}) is calculated at the 95% confidence limit. Therefore if the US_{95} is below the SGV then there is 95% confidence that the true mean is below the SGV and that there is no significant risk to health. 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 elevated results fall within the same sample population, as discussed below. There is also a maximum value test and this determines whether individual results which exceed a SGV fall within the range that can be expected from the sample population, or whether they are indicative of an area of greater contaminant concentrations (e.g. a hotspot). In this latter case such elevated results are called “outliers” and such outliers may indicate a requirement for remediation or further investigation.

The end-use of the site is commercial and thus the commercial guidelines have been used to assess the results.



6.8.2 Human Health Risks: Contaminants arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, zinc, Polycyclic Aromatic Hydrocarbons (PAH) & Total Petroleum Hydrocarbons (TPH).

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

The mean value test (US₉₅) results and all of the individual results were all below the GAC/CLEA SGV's for a commercial end-use. There were no outliers exceeding the SGVs.

6.8.3 Risks to Plants (phytotoxicity): Contaminants copper, nickel and zinc

Copper, nickel and zinc can inhibit plant growth. The GAC for this pollutant linkage (see Appendix D) have been taken from Department of the Environment Publication, *Code of Practice for Agricultural Use of Sewage Sludge*, 1996.

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

6.8.4 Risks to Water Supply Pipes: Various contaminants

Risks to water supply pipes have been assessed in accordance with guidance from the Water Regulations Advisory Scheme (WRAS) and the flow chart used is included in Appendix 6.6.

3 no. of the samples have marginally exceeded the pH GAC of 8, whilst 2 no. samples have exceeded the TPH GAC of 50mg/kg for TPH. It should be noted that the local water supply companies occasionally do not strictly adhere to the WRAS guidelines and thus they should be contacted in this respect as they may not require the use of barrier pipe for any new water supply pipes lain on the site.

6.8.5 Other Contaminants

Further testing was undertaken to determine concentrations of pH, water soluble sulphate.

The sulphate and pH results do not pose significant risk to human health, but sulphates can pose a risk to concrete in the ground and this is discussed in Section 6.6.

6.8.6 Summary of Contamination

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



6.9 Final Conceptual Site Model & Risk Assessment

6.9.1 General

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

6.9.2 Sources, Pathways & Receptors

The potential sources and receptors of contamination (which have been outlined in Section 2.5.3 of this report) are considered to have changed from the 'Outline Contamination Conceptual Model'. The changes are that the made ground on the site does not appear to be contaminated from either the past use of the site, or from industrial processes in the surrounding area.

6.9.3 Risk Assessment Methodology

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

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

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

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



- **Severe:** Short term (acute) risk to human health likely to result in 'significant harm' as defined by the Environment Protection Act 1990, Part IIA. Short-term risk of pollution of sensitive water resources. Catastrophic damage to buildings or property. Short term risk to an ecosystem or organism forming part of that ecosystem (note definition of ecosystem in 'Draft Circular on Contaminated Land', DETR 2000);
- **Medium:** Chronic damage to human health ('significant harm' as defined in 'Draft Circular on Contaminated Land', DETR 2000), pollution of sensitive water resources, significant change in an ecosystem or organism forming part of that ecosystem (note definition of ecosystem in 'Draft Circular on Contaminated Land', DETR 2000);
- **Mild:** Pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services ('significant harm' as defined in 'Draft Circular on Contaminated Land', DETR 2000). Damage to sensitive buildings, structures or the environment; and
- **Minor:** Harm, not necessarily significant, but that could result in financial loss or expenditure to resolve. Non-permanent human health effects easily prevented by use of personal protective clothing. Easily repairable damage to buildings, structures and services.

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

Risk Classification System (CIRIA 552)					
		Consequence			
		Severe	Medium	Mild	Minor
Probability	Highly likely	Very high	High	Moderate	Moderate/Low
	Likely	High	Moderate	Moderate/Low	Low
	Low likelihood	Moderate	Moderate/Low	Low	Very Low
	Unlikely	Moderate/Low	Low	Very Low	Very Low

6.9.4 Final Conceptual Site Model

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



Final Conceptual Model					
Potential Source	Potential Pathway	Potential Receptor	Potential Probability & Consequence	Potential Risk	Comments #
Soil contaminants	Ingestion/ Dermal Contact	Future on-site users (residents/ commercial)	Unlikely/ Medium	Low	No contamination identified that poses an unacceptable risk to human health
		Construction workers			
		Maintenance workers			
		Adjacent commercial/ residential land users			
	Permeation	Subsurface plastic water pipes	Low Likelihood / Medium	Moderate / Low	Confirmation of required pipe material to be sought from local water supply company
Groundwater contaminants	Leaching	Groundwater in Secondary A Aquifer	Unlikely/ Medium	Low	No significant contamination identified.
	Root uptake	Soft landscaping on-site (e.g. phytotoxicity)	Unlikely/ Mild	Very Low	
	Ingestion/ Dermal Contact	Future on-site users (residents/commercial)	Unlikely/ Medium	Low	No significant groundwater contamination identified. No pathway for groundwater contact
		Adjacent commercial/ residential land users			
		Construction workers			
		Maintenance workers			
Vapours associated with soil and groundwater contaminants	Vapour migration and inhalation	Subsurface plastic water pipes	Unlikely/ Medium	Low	No significant groundwater contamination identified.
		Groundwater in Secondary A Aquifer/ surface watercourse			
Vapours associated with soil and groundwater contaminants	Vapour migration and inhalation	Future on-site users (residents/commercial)	Unlikely/ Medium	Low	No volatile contamination identified.
		Construction/ Maintenance workers			

This Generic Quantitative Risk Assessment (GQRA) indicates that complete pollutant linkages are generally unlikely to be present. The exception to this is the risk posed by the soils on the site to any new plastic water supply pipes. The remaining linkages are considered to be low and very low risks and therefore the site is suitable for the proposed end use without significant remediation or other risk reduction measures.

The risk to the water supply pipe is only relevant if new water supply pipes are to be laid as a part of the development. If this is so the risk can be overcome by selection of a suitable pipe material for any new pipes on the site. The local water supply company will need to be consulted on this matter and proof of this consultation and subsequent selection and installation of suitable pipe material may be required by the local authority to satisfy any contaminated land planning condition relating to the site.



6.10 Further Data and Investigation

No further data acquisition or investigation is likely to significantly alter these contamination risk findings. However, given the existence of made ground on the site it would be prudent to maintain vigilance during site clearance and construction, in case any further areas of suspected contamination are encountered. If areas are found then a suitably qualified person should undertake appropriate sampling, testing and further risk assessment.

6.11 Off-site Disposal of Surplus Soil

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

- ‘inert’, or
- ‘non-hazardous’, or
- ‘hazardous’.

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

Samples classified as ‘hazardous’ wastes must be disposed of at a suitably licensed ‘hazardous’ waste landfill. It should be noted that if more than 200kg of hazardous waste is to be removed from the site within a 12 month period, the site is required to notify the Environment Agency under the Hazardous Waste Regulations 2005 and obtain a premise code/registration number for use on Hazardous Waste Consignment notes.

Samples classified as ‘inert’ waste must be disposed of at a landfill licensed solely for ‘inert’ waste or a site that has a valid exemption from the Waste Management Licensing Regulations 1994 (as amended) registered with the Environment Agency (some non-hazardous landfills will also accept inert waste).

‘Stable non-reactive hazardous’ waste is not discussed herein (suffice to say that asbestos is classified as a ‘stable non-reactive hazardous’ waste and, as such, can be disposed of within a ‘stable non-reactive hazardous’ waste cell in a ‘non-hazardous’ waste landfill).

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



A complication to the entire system of classification is that landfills, although placed into broad categories, will ultimately be restricted by the details of their licences, and to a degree the loadings of contaminants that they have accepted during their operation. We therefore recommend that a number of potential landfill sites are approached to determine their ability to accept any waste from a site. Information should be presented to them as soon as possible and should include: the contamination test results (total solid testing), exploratory hole logs, site history and any waste assessments (see below).

Initial Waste Characterisation

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

Any samples that are classed as hazardous will have light cells with bold text, in the respective sample columns (assuming results are in black & white, otherwise yellow cells on a colour copy). The results show that none of the samples analysed would be classed as hazardous waste for off site disposal purposes. This indicates that the soils are suitable to be disposed of directly as non-hazardous waste or that it may be possible to obtain an inert classification subject to further analysis.

It is important to note that whilst we believe our in-house assessment tool to be an accurate interpretation of the requirements of WM2, thereby producing initial classifications in accordance with it, landfill operators often have their own assessment tools and can often come to a different conclusion. As a result, some landfill operators could even refuse to take apparently suitable waste.

Using WM2, further testing (Waste Acceptance Criteria (WAC)) is normally required to allow the soils to be accepted by landfills, but not all landfills will require such testing.

WAC testing is not required by WM2 where the waste contaminated soils have an initial waste characterisation of 'not being hazardous', and the soils are clearly not inert (e.g. contain peat, much organic matter, etc), thus meaning they can only therefore be non-hazardous.



WAC testing is also not required by WM2 where the waste contaminated soils have an initial waste characterisation of 'not being hazardous' and it is intended that such soil be disposed of as non-hazardous at an appropriate landfill anyway.



7 SUMMARY

- 7.1** The proposed development is to comprise a new 12-14m high steel framed chill store.
- 7.2** The preliminary risk assessment has identified that the site was open land before being incorporated into the grounds of a factory. Initially remaining open land the site was then used for car parking and latterly the southern half of the site was used as a contractor's store.
- 7.3** A site investigation covering the area was carried out by ourselves in 2000. The later phase of works described here comprised the formation of two additional cable percussion boreholes. These proved very similar ground conditions to the earlier work, namely Brickearth, over Head Gravel, over Superficial Deposits over the London Clay Formation.
- 7.4** According to Table C2 the Aggressive Chemical Environment for Concrete (ACEC) class is AC-1.
- 7.5** Preliminary foundation design information is contained in Section 6.4.
- 7.6** Based on these exploratory hole profiles for the site, settlements for a uniformly distributed floor slab load of 35kN/m^2 would be in the order of 50mm. Within the areas of increased point loading settlement would be up to the order of 180mm, and as such differential settlement will occur across the ~35m wide floor slab. Any ground bearing floor slab design will therefore need to be adequately reinforced to resist this settlement due to the variation in uniform and point loads that are applied, or a piled floor slab design should be adopted for the development.
- 7.7** Chemical analysis has not identified contamination present which would pose a risk to human health.
- 7.8** Levels of pH and TPH have been recorded that exceed the WRAS guidelines for plastic water supply pipes and consultation with the local water supply company should be undertaken to ensure the selection of appropriate pipe materials, if new water pipes are to be laid in this ground.
- 7.9** None of the soil samples analysed would be classed as hazardous waste for off site disposal purposes. These soils may be disposed of directly to a non-hazardous waste landfill, or if further analysis were undertaken, potentially an inert landfill.



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8 REFERENCES

- 8.1 BS 5930:1999 Code of Practice for Site Investigations
- 8.2 BS 5930:1999 *Code of Practice for Site Investigations: including amendment 1* (2007)
- 8.3 BS 10175: 2001 *Investigation of potentially contaminated sites: Code of practice*
- 8.4 Geological Survey of Great Britain sheet 316 scale 1:50,000
- 8.5 NRA Groundwater Vulnerability Map sheet 45 scale 1:100,000
- 8.6 *Report on Ground Investigation* at Wyeth Laboratories, January 2001, Report no. 01113
- 8.7 BS 1377:1990 *Methods of Test for Soils for Civil Engineering Purposes*
- 8.8 *Health and Safety in Construction*, HSG150, HSE, 1996
- 8.9 NHBC Standards, Chapter 4.2, 2010 *Building Near Trees*
- 8.10 BRE Special Digest 1 (SD1)(2005) *Concrete in Aggressive Ground Part 1: Assessing the aggressive chemical environment*. Third Edition
- 8.11

APPENDIX A

- (i) Site Location Plan
- (ii) Exploratory Hole Location Plan

APPENDIX B

- (i) Key to Exploratory Hole Logs
- (ii) Borehole Logs
- (iii) Standard Penetration Test (SPT) Summary Sheet

APPENDIX C

(i) Geotechnical Test Results

APPENDIX D

- (i) Contamination Laboratory Test Results
- (ii) Initial Waste Characterisation

APPENDIX E

- (i) Environmental Data Sheets
- (ii) Historical Mapping