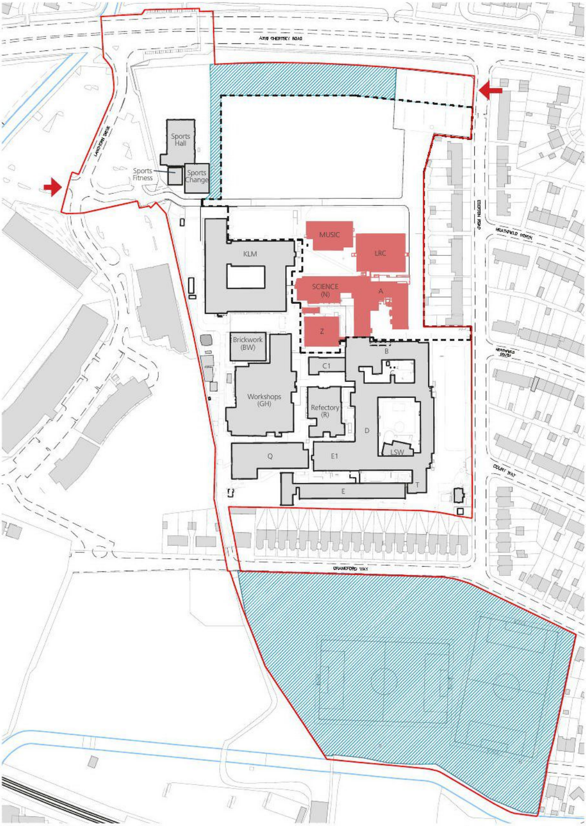
Appendix 6.4: Indicative Construction Phasing Plans



ENABLING WORKS

PHASE 1a

Existing rooms to be taken out of use for Decant

PHASE 1b

Existing rooms to be refurbished to accommodate new curriculum

Line out 2nr pitches to playing fields

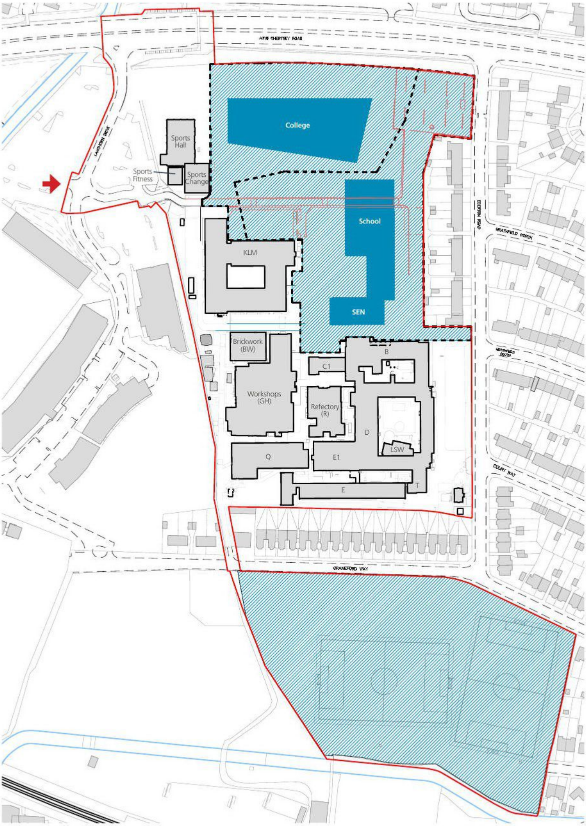
College move into decant area

Creation of haul road & preparation of access off Langhorn Drive and Egerton Road

Demolition of existing buildings (Music, LRC, Science and A block (part) and Z block)

Weatherproofing to the end of open end of Block A

- Existing Buildings
- Buildings to be Demolished
- Buildings under Construction
- New Buildings
- Construction Area
- Construction Hoarding
- Construction Vehicle Access



PHASE 1c

Construction of College main building

Construction of Secondary School and Special School

Removal of hardstanding and seeding to playing fields

Existing Buildings

Buildings to be Demolished

Buildings under Construction

New Buildings

Construction Area

Construction Hoarding

Construction Vehicle Access

PHASE 1d

Phased move of KLM, remaining A block, refectory and E block into new College building

Construct Temporary Changing facilities for Sports Hall

Schools open

PHASE 1e

Demolition of KLM

Demolition of remaining A block, refectory and E block (B, C, C1, D, E, E1, R, T, LSW)

Demolition of out buildings and pumping station

Demolition of Changing facilities for Sports Hall

Existing Buildings

Buildings to be Demolished

Buildings under Construction

New Buildings

Construction Area

Construction Hoarding

Construction Vehicle Access

PHASE 2a

Construction of Sports and STEM buildings & vehicle movement temporarily altered

Completion of Schools external area (except works shown in Phase 3b)

Creation of 3G pitch and grass pitch during summer holidays

Marsh Farm Lane upgrade up to cross over point

Existing Buildings

Buildings to be Demolished

Buildings under Construction

New Buildings

Construction Area

Construction Hoarding

Construction Vehicle Access

PHASE 2b

Phase 1 of the residential starts on site.

Access to Phase 1 residential site controlled and managed by contractor.

- Existing Buildings
- Buildings to be Demolished
- Buildings under Construction
- New Buildings
- Construction Area
- Construction Hoarding
- Construction Vehicle Access

Phase 2c
Decant into Sports and STEM building

Phase 2d
Demolition of Sports building and temporary changing building
Demolition of Brick, Conc, Engine, E Block and Q Block
Temporary route for residential site established and controlled by contractor

Existing Buildings
Buildings to be Demolished
Buildings under Construction
New Buildings
Construction Area
Construction Hoarding
Construction Vehicle Access

Phase 3a

Construction of Haymarket

Upgraded junction on to A316

Langhorn Drive road widening and realignment & Marsh Farm Lane from STEM to Sports, including SEN MUGA and Sports car park

Existing Buildings

Buildings to be Demolished

Buildings under Construction

New Buildings

Construction Area

Construction Hoarding

Construction Vehicle Access

Phase 3b

Construction of Phase 2 residential.

Permanent residential access established.

Phase 3c

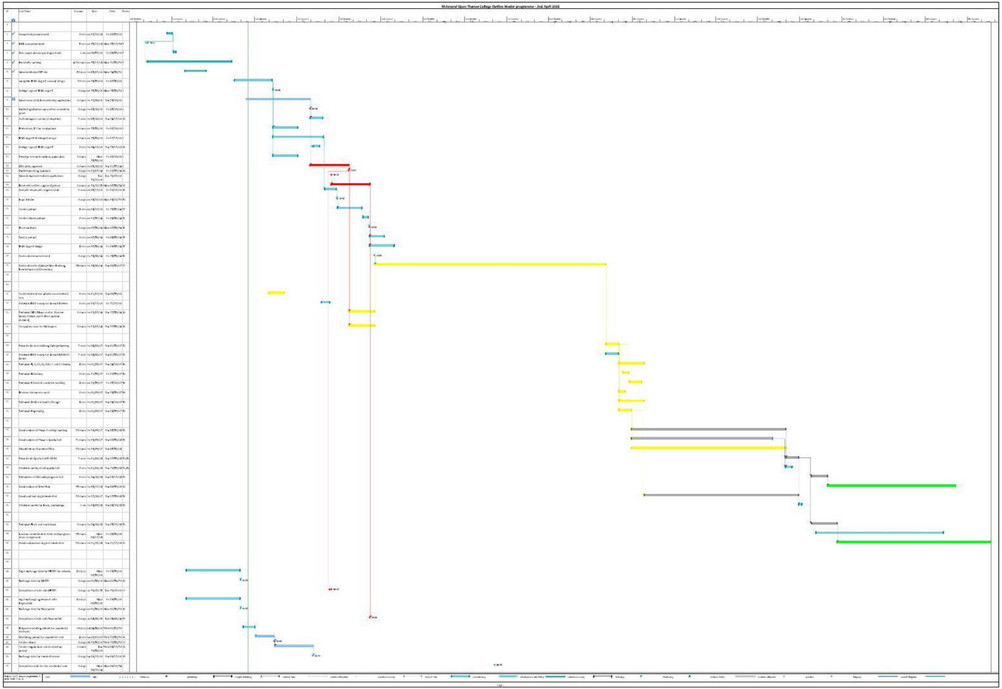
Marsh Farm Lane (playing fields to sports centre)

- Existing Buildings
- Buildings to be Demolished
- Buildings under Construction
- New Buildings
- Construction Area
- Construction Hoarding
- Construction Vehicle Access

A316 CHERTSEY ROAD
HUB
College
STEM
Sports
School
SEN
Residential
Residential
Residential
Residential
Residential
Residential
Residential
HEATHFIELD NORTH
HEATHFIELD SOUTH
COURT WAY
CRANEFORD WAY

Appendix 6.5: Indicative Demolition and Construction Programme

Richmond Upon Thames College Outline Master programme – 2nd April 2015



Appendix 6.6: 2008 Soiltechnics Ground Investigation Report

Proposed Redevelopment of Richmond Upon Thames College Egerton Road Twickenham

GROUND INVESTIGATION REPORT

Soiltechnics Ltd. Cedar Barn, White Lodge, Walgrave, Northampton. NN6 9PY.
Tel: (01604) 781877 Fax: (01604) 781007 E-mail: mail@soiltechnics.net

Report Reference: STE1297R

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Report Issue					
Company	Name	Paper		Electronic	
		Issue	Date	Issue	Date
AKT	Joyce Ferng	Final Draft	21.07.08	Final Draft	21.07.08

Aerial photograph of site

Report status and format

Report section	Principal coverage	Report status		
		First draft	Final draft	Comments
1	Executive summary		21.07.08	
2	Introduction		21.07.08	
3	Desk study information and site observations		21.07.08	
4	Fieldwork		21.07.08	
5	Ground conditions encountered		21.07.08	
6	Laboratory testing		21.07.08	
7	Engineering assessment	30.06.08	21.07.08	Preliminary Engineering assessment issued to AKT
8	Chemical contamination		21.07.08	
9	Gaseous contamination		21.07.08	
10	Effects of ground conditions on building materials		21.07.08	
11	Landfill issues		21.07.08	
12	Further investigations		21.07.08	
13	Remediation statement		21.07.08	
14	Drawings		21.07.08	

Note: A separate report has been produced on classification of soils for off site disposal.

List of drawings

Drawing	Title	Revision
STE1297R-01	Site location plan	
STE1297R-02	Plan showing existing site features and approximate location of exploratory points.	
STE1297R-03a	Plots summarising insitu density testing from Standard Penetration Testing (SPT) and triaxial laboratory test data in boreholes BH01 to BH06	
STE1297R-03b	Plots summarising insitu density testing from Standard Penetration Testing (SPT) in Kempton Park Gravels only	
STE1297R-03c	Plots summarising undrained shear strength derived from Standard Penetration Test (SPT) N values and triaxial laboratory test data in London Clay deposits.	
STE1297R-04a	Plot summarising insitu density testing from Dynamic Cone Penetration testing (DCP) across the site.	
STE1297R-04b	Plot summarising insitu density testing from Dynamic Cone Penetration testing (DCP) in tennis courts to the south of Cranford Way.	
STE1297R-05	Section showing construction of combined water & gas monitoring standpipe installed in boreholes BH01 to BH06.	

List of appendices

Appendix	Contents
A	Definitions of geotechnical terms used in this report.
B	Definitions of geo-environmental terms used in this report.
C	Trial pit records.
D	Records of soil infiltration tests and calculation of infiltration rate.
E	Borehole records (cable and tool percussion drilling).
F	Borehole records (driven tube sampler).
G	Copies of laboratory test result certificates – classification testing.
H	Copies of laboratory test result certificates – physical testing.
I	Copies of laboratory test result certificates – concentrations of chemical contaminants.
J	Statistical and comparative analysis of test data in relation to concentrations of chemical contaminants.
K	Record of in-situ gas monitoring results and groundwater levels.
L	Copies of Statutory Undertakers replies.
M	Copy of desk study information produced by Envirocheck

1 Executive Summary

General

We recommend the following executive summary is not read in isolation to the main report which follows.

Site description, history and development proposals

The site is located towards the centre of Twickenham and is occupied by Richmond-Upon-Thames College. Prior to development of the college in the 1930s old Ordnance Survey maps record the site to be undeveloped although a tramway was recorded run across the southern half of the site.

At this stage, the proposals are being developed however we understand that the existing buildings are to be demolished to make way for the new college buildings.

Ground conditions encountered

Exploratory excavations generally encountered between 0.3-1.0m of topsoil or made ground grading into orange brown clays becoming sand and gravel considered to be Kempton Park Gravel to depths of between 4.2-5.3m and locally 9.3m. Stiff grey dark grey clay considered to be London Clay was encountered underlying the Kempton Park Gravel. Groundwater was encountered at between 1.1-3.5m in exploratory excavations and water levels of between 1.33-2.54m have been observed in standpipes installed across the site.

Soil infiltration tests indicate that the near surface Kempton Park Gravel exhibit some permeability.

Foundation solution

We consider that spread type foundations will be suitable option for the proposed buildings located on the upper horizons of the Kempton Park Gravels. A piled foundation solution providing end bearing in the London Clay could also be considered. Ground bearing floor slabs can be adopted however a suspended floor may be required for low rise buildings.

Chemical and gaseous contamination

Elevated concentration of benzo(a)pyrene was measured in one location presumably associated with ash and clinker contained in the soil. Some hydrocarbon contamination also measured in two locations in the near surface soils. Further supplementary investigations recommended in these locations to determine extent and risks (if any) to groundwater.

Based on gas monitoring undertaken to date, the site is classified as characteristic gas situation two requiring some gas protective measures for new buildings subject to further monitoring. Based on desk study information, Radon protective measures are not necessary.

SECTION 2 - CONTENTS

2	**Introduction**
2.1	Objectives
2.2	Client instructions and confidentiality
2.3	Site location and redevelopment proposals
2.4	Report format and investigation standards
2.5	Status of this report

2 Introduction

2.1 Objectives

2.1.1 This report describes a ground investigation carried out for the propsed redevelopment of Richmond-Upon-Thames College, Twickenham.

2.1.2 The principal objective of the ground investigation was to establish ground conditions at the site, sufficient to identify possible foundation solutions for the development and provide parameters necessary for the design and construction of foundations.

2.1.3 The investigation included an evaluation of potential chemical and gaseous contamination of the site leading to the production of a risk assessment in relation to contamination.

2.1.4 Our brief also included investigations and testing to allow classification of soils at the site to be disposed of to landfill.

2.2 Client Instructions and Confidentiality

2.2.1 The investigation was carried out in May 2008 and reported in July 2008 acting on instructions received from Adams Kara Taylor (Consulting Civil and Structural Engineers), on behalf of our mutual client Richmond-Upon-Thames College.

2.2.2 This report has been prepared for the sole benefit of our above named instructing client, but this report, and its contents, remains the property of Soiltechnics Limited until payment in full of our invoices in connection with production of this report.

2.2.3 The scope of the investigation was defined by Adams Kara Taylor in their briefing document ref. **A041826** dated April 2008. The investigation generally followed the briefing document. The investigation process was also determined to maintain as far as possible the original investigation budget costs.

2.3 Site Location and Redevelopment Proposals

2.3.1 The National Grid reference for the site is 515350,173810. A plan showing the location of the site is presented on Drawing STE1297R-01.

2.3.2 We understand the project will consist of the phased demolition of the existing buildings at Richmond Upon Thames College in combination with and followed by:-

- Construction of temporary accommodation block to the south of the existing campus
- A new four to five storey "L" shaped building approximately 250m long by 40m extending to playing fields to the north of the site and within the footprint of the existing college buildings, and
- A potential residential development in the southern part of the site.

2.3.3 At this stage the layout and position of the buildings is being developed, and no plans are currently available.

2.4 Report Format and Investigation Standards

2.4.1 Sections 2 to 6 of this report describe the factual aspects of the investigation with Section 7 presenting an engineering assessment of the investigatory data. Section 8 provides a risk assessment of chemical contamination based on readily available historic records, inspection of the soils and laboratory testing. Section 9 provides a similar risk assessment in relation to gaseous contamination with Section 10, a risk assessment relating to construction materials likely to be in contact with the ground. Section 11 discusses issues related to landfill.

2.4.2 This investigation integrates both contamination and geotechnical aspects. The investigation was carried out generally, and where practical following the recommendations of BS5930: 1999 '*Code of Practice for Site Investigations*'. The investigation process also followed the principles of BS10175: 2001 '*Investigation of potentially Contaminated Sites – Code of Practice*'. In view of the client's requirement for rapid implementation of the investigation, the following elements, defined in BS10175, have been completed and incorporated in this report.

a) Phase I Preliminary investigation (desk study and site reconnaissance)

b) Phase II Exploratory and main (intrusive) investigations

2.4.3 The extent and result of the preliminary investigation (desk study) is reported in Section 3. Fieldwork combined the exploratory investigation and main investigation stages into one phase with the extent of these works described in Sections 4 and 6 of this report. Any supplementary investigations deemed necessary as a result of deficient information obtained by investigations, completed to date, are identified in Section 12. Section 13 provides information on any remedial strategy and specification if required.

2.4.4 Our investigations included testing to allow classification of soils at the site for potential disposal to landfill. Our report on this aspect is separately presented.

2.5 Status of this Report

2.5.1 This report is final based on our current instructions.

2.5.2 This investigation has been carried out and reported based on our understanding of best practice. Improved practices, technology, new information and changes in legislation may necessitate an alteration to the report in whole or part after publication. Hence, should the development commence after expiry of one year from the publication date of this report then we would recommend the report be referred back to Soiltechnics for reassessment. Equally, if the nature of the development changes, Soiltechnics should be advised and a reassessment carried out if considered appropriate.

2.6 Report Distribution

2.6.1 This report has been prepared to assist in the design and planning process of the development and normally will require distribution to the following parties, although this list may not be exhaustive:

Party	Reason
Client	For information / reference and cost planning
Developer / Contractor / project manager	To ensure procedures are implemented, programmed and costed
Planning department	Potentially to discharge planning conditions
Environment Agency	If ground controlled waters are affected, and obtain approvals to any remediation strategies
Independent inspectors such as NHBC / Building Control	To ensure procedures are implemented and compliance with building regulations
Project design team	To progress the design
CDM Coordinator	To advise in construction risk identification and management under the Construction (design and management) regulations

SECTION 3 - CONTENTS

3	**Desk Study Information and site observations**
3.1	General
3.2	Description of the site
3.3	Injurious and invasive weeds and asbestos.
3.4	History of the site
3.5	Geology and geohydrology of the area
3.6	Environmental study
3.7	Coal mining records
3.8	Radon
3.9	Enquiries with Statutory Undertakers
3.10	Flood risk
3.11	Shallow mining and natural subsidence hazards
3.12	Borehole records
3.13	Mining and dissolution hazards

3 Desk study information and site observations

3.1 General

3.1.1 We have carried out a desk study which was limited to the collection of readily available information. This included:

a) Retrieval of published Ordnance Survey maps dating back to 1871 at 1:1250, 1:2500, 1:10000 and 1:10560 scales where applicable.

b) Inspection of geological maps produced by the British Geological Survey together with relevant geological memoirs.

c) Consultation with Statutory Undertakers.

d) Site reconnaissance

e) Other relevant published documents

3.1.2 Section a) was carried out by Envirocheck. The report prepared by Envirocheck is presented in Appendix M. In addition to retrieval of historical and current Ordnance Survey data, Envirocheck provide information compiled from outside agencies including: -

Environment Agency
Institute of Hydrology
British Geological Survey
Countryside Council for Wales
Scottish National Heritage
English Nature

3.1.3 The study did not extend to research of meteorological information or consultation with other interested parties such as English Heritage (ancient monuments), Ordnance Survey (survey control points), Planning Authorities or Archaeological Units.

3.2 Description of the Site

3.2.1 The site is positioned on the floor of a wide and flat bottomed valley carrying the River Crane, the channel of which is located about 75m to the south of the site and the Duke of Northumberland's River which is located 300m to the west of the southern end of the site and 20m to the west of the northern end of the site.

3.2.2 The site is occupied by Richmond-Upon-Thames College and can be separated into three distinct areas as follows:-

Northern - Playing Field and Car Park

The northern area of the site is predominantly flat and occupied by open space surfaced in bituminous bound materials and laid to grass, forming a car park and playing field respectively. One masonry building is present in this area and is currently utilised as a sports hall.

Central – College Buildings

The central area of the site slopes gently to the south (~1:250) and is occupied by numerous buildings of varying age predominantly between one and four stories in height with a six storey tower located to the south of the main building. The college buildings are occupied by numerous departments broadly covering science, arts, social science and vocational disciplines. Ancillary facilities are also present within this area of the site including chemical stores located to the central eastern area of the site.

Southern – Tennis Court and Playing Fields

The southern area of the site slopes gently to the south (~1:150) and is separated from the central area of the site by Craneford Way and a row of residential properties. This area is occupied by playing fields, laid to grass, and tennis courts surfaced in bituminous bound materials.

3.2.3 **College environs**

The northern boundary of the college campus is defined by Chertsey Road with a residential development beyond. Chertsey Road is constructed on a shallow embankment reaching some 2m in height in the north eastern part of the site as the road approaches a bridge to carry it over the Duke of Northumberland River. Much of the eastern boundary of the college is marked by Egerton Road, serving residential properties to the east. Blocks of residential properties are located to the west together with a rugby ground with associated car parking. The southern boundary of the site is defined by residential properties off Craneford Way. Playing fields are located to the south of Craneford Way.

3.2.4 A plan showing the observed site features and location of exploratory points is presented on Drawing STE1297R-02.

3.3 Injurious and invasive weeds and asbestos.

3.3.1 Injurious and invasive weeds

3.3.1.1 Our investigations exclude surveys to identify the presence injurious and invasive weeds. Under the Weeds Act 1959, the Secretary of State may serve an enforcement notice on the occupier of land on which injurious weeds are growing, requiring the occupier to take action to prevent the spread of injurious weeds. The Weeds Act specifies five Injurious weeds: Common Ragwort, Spear Thistle, Creeping of Field Thistle, Broad leaved Dock and Curled Dock. The Wildlife and Countryside act 1981 provides the primary controls on the release of non native species into the wild in Great Britain. It is an offence under section 14(2) of the act to 'plant or otherwise cause to grow in the wild' any plants listed in schedule 9, part II. The only flowering plants currently listed are Japanese Knotweed and Giant Knotweed. We recommend specialists in the identification and procedures to deal with injurious and invasive weeds are appointed prior to commencement of any works on site or if appropriate purchase of the site. The presence of such weeds on site may have considerable effects on the cost / timescale in developing the site.

3.3.1.2 Good guidance on injurious and invasive weeds is provided on DEFRA and Environment Agency web sites

3.3.2 Asbestos

3.3.2.1 Our investigations exclude surveys to identify the presence or indeed absence of asbestos on site. We recommend specialists in the identification and control / disposal of asbestos are appointed prior to commencement of any works on site or, if appropriate, purchase of the site. The presence of asbestos on site may have considerable effects on the cost / timescale in developing the site. There is good guidance in relation to Asbestos available on the Health and Safety Executive (HSE) web site

3.4 History of the Site

3.4.1 An attempt to trace the history of the site has been carried out by obtaining copies of old Ordnance Survey maps provided by Envirocheck. These maps are presented in Appendix M, but have been reduced from sizes ranging from A1-A3 to A4 for ease of presentation. This size reduction affects the scale recorded on the maps. We can provide A3 copies if required.

3.4.2 The recent history of the site based on published Ordnance Survey maps is summarised on the following table: -

Dates	Historical Usage	Comments
1871	Open space	Agricultural land with orchards to the north of the site Marsh Farm located to the south of the site Railway land located 200m to south
1874	As above	As above Pond recorded to the centre of the central area of the site
1896	Open Space & tramway	Tramway located across the southern central area of the site, linking to a sewage works located 400m to the south west Gravel pit located 225m to the south Pond no longer recorded As above
1898	As above	As above
1915	As above tramway not recorded	Expansion of the sewage works including filter and sludge beds within 100m of the eastern site boundary. Football ground located to the north. As above
1920	As above	As above
1934	As above	Further expansion of the sewage works including filter and sludge beds within 50m of the eastern site boundary. As above
1938	Central area of site occupied building	Residential development underway to north and east of the site As above
1949	As above	As above
1961	Site recorded as Twickenham Technical College	Playing fields to north of the site with five suspected air raid shelters. Buildings to the central area of the site Tennis courts located in the southern area of the site
1966	As above recorded as College	Sewage works recorded as depot
1973	As above additional buildings	As above
1974	As above	As above Air raid shelters no longer recorded
1975	As above additional building and playing fields recorded	As above Sports stadium recorded to west Football ground located to the north recorded as rugby ground
1982	As above	As above Building present in area of former air raid shelter
1992	As above	As above
1999	As above	As above
2008	As above	As above

Table 3.4.2

3.5 Geology and Geohydrology of the Area

3.5.1 Geology of the Area

3.5.1.1 Inspection of the geological map of the area (at 1:50,000 scale) published by the British Geological Survey indicates the topography local to the site (based on borehole/observations recorded on the map) is formed in the following sequence of soils.

Strata	Approximate thickness (m)	Typical soil type	Likely permeability
Kempton Park Gravel	Not recorded	Silt, sand and Gravel	Moderate
London Clay	50m	Clay	Low
Lambeth Group	50m	Clay sands, and gravels	Low – Moderate
Upper Chalk	>50m	Chalk	High

Table 3.5.1

The soil types and assessment of permeability's are based on geological memoirs, in combination of our experience of investigations in these soil types.

3.5.2 Geohydrology – aquifer designation and groundwater vulnerability

3.5.2.1 Envirocheck reports the site is located in an area designated a major aquifer probably reflecting the deep geology comprising Upper Chalk, which are likely to be reasonably permeable deposits containing chalk deposits. A major aquifer is defined by the Environment Agency in their publication *'policy and practice for the protection of groundwater'* on highly permeable formations. They are highly productive and able to support large abstractions for public water supply and other purposes.

3.5.2.2 In addition, Envirocheck provide an extract of the groundwater vulnerability map recording the soils containing the aquifer is a high leaching potential. These soils have little ability to attenuate diffuse source pollutants. Non-absorbed diffuse source pollutants and liquid discharges will percolate rapidly through them. The groundwater vulnerability map also records a sub class of soil type U, (undifferentiated). In such a case there is insufficient information to classify the soils accurately and generally a default class of H1 is adopted. A sub class of H1 is defined as a soil which readily transmits liquid discharges because they are either shallow or susceptible to rapid by-pass flow directly to rock, gravel or groundwater.

3.5.3 Geohydrology – water abstractions

3.5.3.1 Envirocheck report five abstraction points within 2000m of the site. The closes abstraction point lies 859m to the north-west of the site and is recorded as water supply related: General use at a Thames Water Sewage Treatment Works. The remaining abstraction points are located in excess of 1500m and thus are not considered further.

3.5.4 Geohydrology – source protection zone

3.5.4.1 Envirocheck does not record the site is located within a zone protecting a potable water supply abstracting from a major aquifer (i.e. a source protection zone).

3.6 Environmental Study

3.6.1 We have instructed Envirocheck to carry out a search of their records and report on the following aspects: -

Agency and Hydrological

Air Pollution Controls ("APC")
Discharge Consents to Controlled Waters
Enforcement and Prohibition Notices
Integrated Pollution Controls ("IPC")
Nearest Surface Water Feature
Pollution Incidents to Controlled Waters
Prosecutions relating to Authorised Processes
Prosecutions to Controlled Waters
Red List Discharge Consents
Radioactive Substance Authorisations ("RSA")
River Quality Data
Water Abstractions
Groundwater Vulnerability
Drift Deposits
Fluvial Indicative Flood Plain
Tidal Indicative Flood Plain
Source Protection Zones

Waste

BGS Recorded Landfill Sites
Integrated Pollution Control registered Waste Sites
Registered Waste Transfer Sites
Registered Waste Treatment or Disposal Sites
Registered Landfill Sites

Hazardous Substances

Planning Hazardous Substance Consents
Planning Hazardous Substance Enforcements
COMAH Sites
Explosive Sites
NIHHS Sites

Geological

BGS Boreholes
BGS Recorded Mineral Sites
BGS 1:625,000 Surface Geology
Coal Mining Affected Areas
Shallow Mining Hazards
Natural Subsidence Hazard
Radon Affected Area
Radon Protection Measures

Industrial Land Use

Contemporary Trade Directory Entries (of possible contaminative use)
Fuel Station Entries
Post 1995 Planning Applications (of possible contaminative use)
Potentially Contaminative Uses (Past Use)
Potentially Contaminative Uses (Non-Water Related)
Potentially Contaminative Uses (Water Related)
Nearest Overhead Transmission Line

Sensitive Land Use

Adopted Green Belt
Unadopted Green Belt
Areas of Outstanding Natural Beauty
Environmentally Sensitive Areas
Forest Parks
Local Nature Reserves
Marine Nature Reserves
National Nature Reserves
National Parks
National Scenic Areas
Nitrate Sensitive Areas
Nitrate Vulnerable Zones
RAMSAR Sites
Sites of Special Scientific Interest ("SSSI")
Special Areas of Conservation
Special Protection Areas

3.6.2 A copy of records produced by Envirocheck is presented in Appendix M.

3.6.3 Envirocheck produce a wealth of factual database information. Although we can provide a discussion on each of the database topics, this would produce a very lengthy document, but some of these discussions would not be relevant to the aims of this report. As a consequence we have extracted some of the relevant geotechnical topics (including flood risk) and discussed them in this section of the report. Key environmental issues from the Envirocheck database are discussed in Section 7.

3.7 Coal Mining Records

3.7.1 With reference to *The Coal Mining Searches Law Society Guidance and Directory 1994*, the site **is not recorded** as being within an area, which has been affected by past or present coal mining, or minerals worked in association with coal.

3.8 Radon

3.8.1 With reference to the Building Research Establishment (BRE) publication *"Radon: guidance on protective measures for new dwellings", (2007)* the site is located where **no protection** is considered necessary. In addition, Envirocheck use the British Geological Survey database to review reported radon levels in the area in which the site is located to establish recommended radon protection levels for new dwellings. The database confirms the BRE recommendations.

3.8.2 The Building Research Establishment publication has not been prepared for non-domestic buildings, however, protection from radon at work is specified in the Ionising Radiations Regulations 1985, legislation made under the Health and Safety at Work Act administered by the Health and Safety Executive (HSE). The technical guidance contained in the present report may be of use to designers and builders of new structures whose form of construction and compartmentation is similar to housing and where the heating and ventilation regime is similar to that used in housing. This is likely to include small office buildings and primary schools. Further information is contained in the HSE/BRE guide *"Radon in the Workplace"*.

3.9 Enquiries with Statutory Undertakers

3.9.1 We have contacted the following Statutory Undertakers (SUs) to obtain copies of their records in order to avoid damaging their apparatus during our fieldwork activities: -

a) British Telecommunications plc
b) Transco
c) Thames Water
d) EDF energy
e) Virgin Media

Copies of responses received prior to publication of this report are presented in Appendix L. These records have been obtained solely for the purposes described above. Some of these records have been obtained from the Internet and from our database without contacting the statutory undertaker direct. Occasionally, SU information is recorded on drawings larger than A3, and thus cannot be easily presented in this report. In such cases we will copy the correspondence but not incorporate the drawing in this report, and maintain the records on our office file.

3.9.2 Normally Statutory Undertakers drawings record the approximate location of their services. We recommend further on site investigations be undertaken to confirm the position of the apparatus and thus establish the effect on the proposed development and the necessity or otherwise for the permanent or temporary diversion of the service to allow the construction of the development to safely and successfully proceed.

3.9.3 It should be noted that statutory undertakers' records normally exclude private services. We were however provided with plans of the site which included private services prior to our investigations.

3.10 Flood Risk

3.10.1 The Envirocheck report indicates that the southern, northern and areas of the eastern and western boundaries of the site **are located** within a fluvial flood plain. We would recommend that clarification of flood risk and its implications be sought with the Environment Agency.

3.11 Shallow mining and natural subsidence hazards

3.11.1 Envirocheck use the British Geological Survey database to establish hazard ratings for shallow minings and natural subsidence hazards. The database indicates the following ratings for the site.

a)	Shallow mining hazard rating:	**No hazard**
b)	Potential for collapsible ground stability hazard	**No hazard**
c)	Potential for compressible ground stability hazard:	**No hazard**
d)	Potential for ground dissolution stability hazard:	**Very Low**
e)	Potential for landslide ground stability hazard	**Very Low**
f)	Potential for running sand ground stability hazard:	**Very Low**
g)	Potential for shrinking or swelling clay ground stability hazard:	**Moderate**

3.12 Borehole Records

3.12.1 The British Geological Survey (BGS) retain records of boreholes formed from ground investigations carried out on a nationwide basis. A plan showing the location of the boreholes within 1000m of the site is produced in the Envirocheck Report presented in Appendix M.

3.12.2 We do not normally obtain copies of these records but can do on further instructions. There is normally a charge made by the BGS for retrieving and copying these records.

3.13 Mining and dissolution hazards

3.13.1 Envirocheck's database indicates two BGS recorded Mineral Sites, Mogden Sand and Ballast Works, located 539m and 740m to the north-east of the site excavating Sand and Gravel by opencast methods from the Kempton Park Gravels. Both of the sites are recorded as no longer active.

3.13.2 Numerous local excavations both on and adjacent to the site are recorded on the historic maps produced by Envirocheck dating between 1874 and 1963, with excavations recorded as sand and gravel pits, ponds and sewage works.

SECTION 4 – CONTENTS

4	**Fieldwork**
4.1	General
4.2	Site restrictions
4.3	Exploratory trial pits
4.4	Light cable percussion boring
4.5	Driven tube sampling
4.6	Dynamic probing
4.7	Measurement of landfill type gases in gas monitoring standpipes
4.8	Sampling strategy

4 Fieldwork

4.1 General

4.1.1 Fieldwork comprised the following activities:-

- Excavation of twenty six exploratory trial pits using hand tools with soil infiltration tests undertaken in eight if these
- Excavation of six exploratory boreholes using cable and tool percussion drilling techniques
- Excavation of twenty one exploratory boreholes formed using driven tube sampling equipment with infiltration tests undertaken in two of these
- Dynamic cone penetration testing in thirteen locations

4.1.2 A plan of the site showing observed/existing site features (including site reconnaissance notes) and position of exploratory points is presented on Drawing STE1297R-02. The position of exploratory points shown on these plans is approximate only and confirmation of these positions is subject to dimensional surveys, which is considered outside our brief.

4.1.3 The extent of fieldwork activities and position of exploratory points were defined by the Client's Engineer, and were subsequently amended on site to account for access restrictions.

4.1.4 Exploratory points were positioned to avoid known locations of underground services, to avoid possible location of proposed foundations but were also positioned to provide a reasonable coverage of the site.

4.1.5 Prior to commencement of exploratory excavations an electronic cable locating tool was used to scan the area of the excavation. If we received a response to this equipment then the excavation would be relocated.

4.1.6 All soils/rocks exposed in excavations were described in accordance with BS5930: 1999 "*Code of Practice for Site Investigations*".

4.2 Site Restrictions

The site is occupied by a active sixth form college, because of this the majority of the intrusive investigations were carried out during the half term week including a bank holiday to minimise disturbance to the normal operation of the college. It should be noted however, that access was restricted to certain areas due to ongoing examinations. The method of investigation was also restricted to small diameter equipment to minimise surface damage which would have been caused by machine dug trial pits although trial pits would have produced the most information.

4.3 Exploratory Trial Pits

4.3.1 Trial pits SA01 to SA10 were excavated using hand tools to a maximum depth of 1.5m to undertake infiltration tests. Trial Pits TP01 to TP14 were excavated using hand tools to a maximum depth of 2m to expose existing foundation arrangements to existing buildings within the site. Trial pits TP14 to TP16 were excavated using hand tools to a maximum depth of 0.7m to sample the near surface soils.

4.3.2 The trial pit excavations were backfilled with excavated material, which was compacted using hand held ramming tools. The surface was reinstated to match the original surroundings. A Geotechnical Engineer supervised the excavations.

4.3.3 Sampling and logging was carried out as trial pit excavations proceeded. The density of granular soils encountered in excavations was gauged by the ease of excavation.

4.3.4 Soil samples for subsequent laboratory determination of concentration of chemical contaminants were taken from the sides of trial pits using clean stainless steel equipment and stored in new plastic containers, which were labelled and sealed. The stainless steel sampling equipment was cleaned with deionised water between sampling points Samples from below access depth into trial pits were taken as a sub sample from soil contained in the excavator bucket, discarding any soil, which may have been in contact with the bucket. If as a consequence of visual or olfactory evidence, a sample was suspected to be contaminated by organic material, the sample was stored in an amber glass jar with a PTFE sealing washer.

4.3.4 Soil samples for subsequent 'physical and classification' laboratory testing were taken from the side of trial pits. The sample was placed in a plastic bag and subsequently sealed and labelled. Samples for moisture content determination were placed in sealable tins and appropriately labelled. Moisture content samples were taken to the laboratory for testing within 24 hours of sampling.

4.3.5 Soil samples were taken to meet the requirements of class 3, 4 or 5 as described in BS5930: 1999 (table 2) with the sample sizes in accordance with Table 3 of the same standard. Sample sizes were appropriate for the laboratory test being considered.

4.3.6 Soil infiltration tests were carried out in trial pits SA01 to SA10 at depths of between approximately 0.6m and 1.0m. The infiltration tests were carried out following the procedures described in the Building Research Establishment (BRE) Digest 365 (2007) "*Soakaway Design*". In addition, variable head tests were undertaken in driven tube sampler boreholes DTS08 and DTS17 at depths of between 0.5-2.0m following methods described in *BS 5930: 1999 'Code of Practice for Site Investigations' (section 25)*. Records of the test results and calculations to determine the soil infiltration rate are presented in Appendix D. The rate at which water placed in each trial pit, dissipated was relatively slow and only one test cycle (the BRE Digest recommends three) could only be carried out in one day's fieldwork. The test results have been used to produce a soil infiltration rate for each test cycle, using the methods described in the BRE Digest.

4.4 Light Cable and Tool Percussion Boring

4.4.1 Boreholes BH01 to BH06 were excavated using light cable percussion boring techniques as described in BS5930: 1999 forming 150mm diameter holes. Temporary casing was advanced within the borehole excavation to maintain the stability of the hole. When groundwater was encountered the excavation was temporarily halted to allow for groundwater observations to be made. Following groundwater observations the casing was advanced within the hole and the location/locations of the water strikes recorded. The casing was subsequently advanced to maintain the stability of the borehole and seal off the water to prevent further ingress. Additional records were taken when (and if) the casing produced a seal against water ingress. When obstructions were encountered a chisel was employed to break through the obstruction. Time taken to progress the excavation using the chisel is recorded on the borehole logs.

4.4.2 On completion of excavations the boreholes were backfilled with excavated soils compacted using drilling tools.

4.4.3 Soil samples for subsequent laboratory determination of concentration of chemical contaminants were taken from 'intact' bulk disturbed samples obtained in the cutting shoe of the drilling rig. A sub sample was obtained discarding soil, which would have been in contact with the drilling rig cutting shoe with the subsamples taken using clean stainless steel equipment. In all cases the stainless steel equipment was cleaned with deionised water between sampling with samples stored in new plastic containers, which were labelled and sealed.

4.4.4 Water samples collected for laboratory determination of concentration of chemical contaminants was taken from the borehole using new proprietary plastic bailing equipment. The samples were placed in a new green bottle, quickly sealed with a screw cap with a PTFE washer and subsequently labelled.

4.4.5 Bulk soil samples for identification or subsequent 'classification' laboratory testing were taken from borehole cutting equipment. The sample were placed in a plastic bag and subsequently sealed and labelled. Bulk soil samples were taken to meet the requirements of class 3, 4 or 5 as described in BS5930: 1999 with the sample sizes in accordance with Table 1 of the same standard. Sample sizes were appropriate for the laboratory test being considered.

4.4.6 'Undisturbed' 100mm diameter samples were taken in cohesive soils when considered appropriate using a general-purpose open tube sampler. Whilst we tried to obtain class 1 samples to BS5930 (1999) class 2 samples were more likely (refer BS5930: 1999 for an explanation). The undisturbed sample was obtained in a plastic liner and sealed with wax prior to labelling. The number of blows of the standard driving hammer is required to obtain the sample is recorded on borehole records.

4.4.7 Standard Penetration Testing (SPT) was carried out at regular frequencies in the borehole. The test was carried out in accordance with BS1377: 1990 Part 9 *'Method of Test for soils for Civil Engineering Purposes'* (method 3.3). Details of the test, as required by BS1377: 1990 are recorded in borehole records. The drive rods were type AW up to 20m depth and type BW for depths in excess of 20m. Samples taken from the open sampler (SPT) were placed in a plastic bag, sealed and labelled. In coarse granular soils, a solid 60° cone may have been used to replace the SPT cutting shoe. This test is reported as SPT(C). A graphical summary of standard penetration testing is presented on Drawings STE1297R-03a, -03b and -03c.

4.4.8 The borehole excavations were formed by drillers accredited by the British Drilling Association with samples relogged by an experienced Geotechnical Engineer.

4.4.9 Records of boreholes formed by light cable and tool percussion drilling techniques are presented in Appendix E.

4.4.10 Gas and water monitoring standpipes were installed in boreholes BH01 to BH06. The standpipes were installed following the recommendations of BS5930: 1999 *'Code of Practice for Site Investigations'* figure F1. Details of the standpipe installation are recorded on Drawing STE1297R-05.

4.4.11 Water levels in the standpipes have been measured during two return visits to the site (monitoring scheduled for a further 4 months). Water levels were measured using a measuring tape calibrated in 1mm intervals with an electronic end piece, which emits an alarm sound in contact with water. Water levels are measured from ground levels at the borehole position. Records of water levels are presented in Appendix K.

4.5 Driven Tube Sampling

4.5.1 Boreholes DTS01 to DTS21 were formed using driven tube sampling equipment. Driven tube sampling comprises driving 1m long steel sample tubes, which are screw coupled together or coupled to extension rods and fitted with a screw on cutting edge. The sample tubes are of various diameters, generally commencing with 100mm and reducing, with depth, to 50mm, and include a disposable plastic liner which is changed between sampling locations in order to limit the risk of cross contamination. On completion of excavation the liner containing the sample is cut open and the soil sample logged by a geo-environmental engineer. Borehole records are presented in Appendix F.

4.5.2 Samples for determination concentration of chemical contaminants are taken from samples obtained in the disposable tubes as sub-samples, using stainless steel sampling equipment, which is cleaned with de-ionised water.

4.5.3 The driven tube sampler obtains samples of quality class 3 or class 4 in accordance with Table 2 of BS5930: 1999 *'Code of Practice for Site Investigations'*.

4.5.5 Records of boreholes formed using driven tube sampling techniques are presented in Appendix F.

4.6 Dynamic Cone Penetration testing

4.6.1 Dynamic Cone Penetration (DCP) testing was carried out in twelve locations. Dynamic Cone Penetration testing consists of driving a 50mm diameter, 90° cone into the ground, via an anvil and extension rods with successive blows of a freefall hammer. The number of blows required to drive the cone each successive 100mm (N100) is recorded.

4.6.2 *Dynamic Cone Penetration testing was carried out following BS1377: 1990: Part 9 'Methods of test for soils for Civil Engineering Purposes'* (method 3.2) and the apparatus used was categorised as 'Super heavy' (DPSH) in accordance with the standard.

4.6.3 Equivalent Standard Penetration Test N value derived from Dynamic Cone Penetration test data is presented in graphical format on Drawings STE1297R-04a and b.

4.7 Measurement of Landfill Type Gases in gas monitoring standpipes

4.7.1 The concentrations of landfill type gases collected within gas monitoring standpipes installed in boreholes BH 01 to BH06 was measured using a portable infra-red gas analyser (model GA2000 plus, manufactured by Geotechnical Instruments). Initially the gas analyser was connected to the gas valve on the top of the standpipe to allow the flow rate to be measured. Essentially this is a measurement of gas pressure produced in the standpipe, which is compared with atmospheric pressure at the time of measurement to produce an equivalent gas 'flow' in l/hr. The equipment used is capable of measuring to an accuracy of 0.1l/hr; below this the gas analyser records zero flow. Following BS8485:2007 '*British Standard Code of Practice for the Characterisation and remediation from ground gas in affected developments*',(clause 6.1), we assume flows of 0.1l/hr when the gas analyser reads zero, thus producing a pessimistic gas flow rate in our assessment of ground gasses.

4.7.2 Following measurement of 'flow' the gas analyser pumps gases contained in the standpipe through the analyser for a period of about 30 seconds to allow a continuous measurement of landfill type gases. The analyser then measures 'peak' and 'steady' concentrations of the following gases.

- Methane (CH_4)
- Carbon dioxide (Co_2)
- Oxygen (O_2)
- Nitrogen (N_2)

4.7.3 The ambient atmospheric temperature and barometric pressure was also recorded at the site. To determine if the atmospheric pressure is rising or falling we interrogate the internet on a daily basis.

4.7.4 Methane in concentrations of between 5 to 15% in air is potentially explosive. The 5% methane concentration in air is defined as the Lower Explosive Limited (LEL). The gas analyser measures a percentage of the LEL. For example, 10% LEL equates to 10% of 5%, i.e. 0.5% methane concentration in air.

4.7.5 Records of gas monitoring data are presented in Appendix K.

4.8 Sampling Strategy

4.8.1 In general we adopted a judgemental sampling strategy in relation to potential chemical contamination. The location and frequency of sampling was carried out in consideration of the following:-

i) Location of potential contamination sources
ii) Topography
iii) Geology (including Made Ground)
iv) Nature of development proposals

Sampling for physical/classification testing was also judgemental with the frequency and location of sampling relating to: -

i) Geology
ii) Topography
iii) Nature of development proposals

4.8.2 Samples are stored for a period of one month following issue of this report unless otherwise required.

SECTION 5 - CONTENTS

5	**Ground Conditions Encountered**
5.1	Soils
5.2	Topsoil
5.3	Groundwater
5.4	Existing foundations

5 Ground conditions encountered

5.1 Soils

5.1.1 The exploratory excavations encountered soils, which, in our opinion, were identified as follows in order of superposition:-

either

- Dark to light brown grey and orange sandy silt or silty clays with gravels and cobbles of brick and flint gravels, between ground level and average depth of 1m and locally 1.9m adjacent to existing foundations.

or

- Brown grey and orange gravelly sand and sandy clay or light to dark brown sandy silt between ground level to between 0.3-1.0m considered to be made ground or topsoil these deposits graded into:-
- Loose becoming medium dense orange brown clays and silts becoming sands, sands and gravels to an average depth of 5m, locally to a depth of 9.3m considered to be Kempton Park Gravels.
- Stiff becoming very stiff blue grey clay considered to be London Clay to a depth in excess of 25m.

With the exception of Made Ground, the investigation generally confirmed published geological records.

5.2 Topsoil

5.2.1 As a practice we have adopted the following policy for description of topsoil. If the surface soil exhibits a visually significant organic content and darker colour than the soils it overlies (which are considered to be naturally deposited) then we will describe the soil as topsoil. In some cases it is difficult to visually distinguish the interface between topsoil and subsoils below, which may also exhibit an organic content, and in such cases we will adopt an estimate of the interface but may also use the terms 'grading into' with some defining depths.

5.2.2 If 'topsoil' deposits include materials such as ash, brick and other man made materials, or the topsoil overlies made ground deposits we will term the material 'made ground', even though it may still be able to support vegetable growth, and potentially reused as topsoil.

5.2.3 Topsoil can be classified following a number of test procedures as described in BS3882: 1994 *'Specification for Topsoil'*, to allow its uses to be determined. We do not carry out such testing unless specifically instructed to do so.

5.3 Groundwater

5.3.1 Groundwater inflows were observed in most of the exploratory excavations. A summary of our observations is tabulated below:

Exploratory point	Depth (m) below ground levels	Observations
BH01	3.5	Steady
BH02	3.0	Steady
BH03	2.5	Steady
BH04	2.5	Steady
BH05	2.5	Steady
BH06	2.8	Steady
DTS02	1.1	After 5 min
DTS05	1.55	After 5 min
DTS06	1.34	After 5 min
DTS07	1.05	After 5 min
DTS08	1.09	Standing water level on commencement of infiltration test
DTS09	1.17	After 5 min
DTS10	0.87	After 5 min
DTS11	2.0	Rose to 1.5m in 10 min
DTS12	1.8	Steady
DTS13	2.45	Standing water level on completion of borehole
DTS14	2.5	Rose to 1.3m on completion of boreholes
DTS16	1.2	After 5 min
DTS17	1.41	Standing water level on commencement of infiltration test
DTS18	2.3	After 5 min
DTS20	2.0	After 5 min

Table 5.3.1

5.3.2 It should be noted that water levels will vary depending generally on recent weather conditions and only long term monitoring of levels in standpipes will provide a measure of seasonal variations in groundwater levels. We are scheduled to monitor the boreholes over a 6 month period following the investigation. We have undertaken two of the scheduled visits to date with the measured water levels provided in Appendix K. We will provide the remaining depths on completion of the monitoring.

5.4 Existing foundations

5.4.1 Generally, and where possible trial pit excavations exposed existing (seemingly spread) foundations located on the upper (granular) horizons of the Kempton Park Gravels.

SECTION 6 - CONTENTS

6	**Laboratory testing**
6.1	Classification and physical testing
6.2	Chemical testing

6 Laboratory testing

6.1 Classification and physical testing

6.1.1 Laboratory testing was carried out as deemed necessary and limited to the following: -

- In accordance with BS1377: 1990 *"Methods of Test for Soils for Civil Engineering Purposes"*.

a) Classification tests: (to part 2)
   - i) Determination of moisture content (method 3)
   - ii) Determination of the liquid limit – one point cone penetrometer method (method 4.4)
   - iii) Determination of the plastic limit and plasticity index (method 5)
   - iv) Determination of particle size distribution – wet sieving (method 9.2)

b) Compressibility, permeability and durability tests (to part 5).
   - i) Determination of one-dimensional consolidation properties.

c) Shear strength tests (total stress) (to part 7).
   - i) Determination of undrained shear strength in triaxial compression without measurement of pore pressure (method 8).

d) Compaction related tests (to part 4)
   - i) Determination of the California Bearing ratio (CBR) (test 7).

6.1.2 Laboratory testing was carried out by an independent specialist testing house, which operates a quality assurance scheme.

6.1.3 Copies of laboratory test result certificates are presented in Appendices G and H.

6.2 Chemical testing

6.2.1 Laboratory testing was carried out as deemed necessary and carried out using the following techniques:

- Using inductively coupled plasma – optical emission spectrometry (ICP-OES), determination of concentration of
  - i) Metals
  - ii) Soluble sulphate content
- Using gas chromatography – mass spectrometry, determination of the concentration of
  - i) Polycyclic aromatic hydrocarbons (PAH)
- Using electromagnetic measurement, determination of pH
- Using gas chromatography – flame ionisation detection methods, determination of concentration of Total petroleum hydrocarbons and speciation of the same.
- Determination of concentration of leachable contaminants

6.2.1 Laboratory testing was carried out by an independent specialist testing house, which operates a quality assurance scheme.

6.2.2 Copies of laboratory test result certificates are presented in Appendix I.

SECTION 7 - CONTENTS

7	**Engineering Assessment**
7.1	General description of the development
7.2	Building foundation design and construction
7.3	Influence of trees and hedges
7.4	Ground floor construction
7.5	Service trench excavations
7.6	Infiltration potential
7.7	Pavement foundations

7 Engineering Assessment

7.1 General Description of the Development

7.1.1 The following assessments are made on the investigatory data presented in the preceding sections of this report and are made with reference to specific nature of the development.

7.1.2 We understand the project will consist of the phased demolition of the existing buildings at the College in combination with and followed by:-

- Construction of temporary accommodation block to the south of the existing campus
- A new four to five storey "L" shaped building approximately 250m long by 40m extending to playing fields to the north of the site and within the footprint of the existing college buildings, and
- A potential residential development in the southern part of the site.

7.1.3 At this stage the layout and position of the buildings is being developed, and no plans are currently available.

7.1.4 Should the development proposals change then it may be necessary to review the investigation and report.

7.2 Building Foundation, Design and Construction

7.2.1 Definitions of geotechnical terms used in the following paragraphs are provided in Appendix A.

7.2.2 In our opinion the naturally deposited Kempton Park Gravels will adequately support low rise buildings on spread type foundations. The Kempton Park Gravels generally below 1m are granular and thus their volume will not be influenced by changes water content due to demands of major vegetation at the site. Based on the above, in combination with ground conditions encountered on site, we recommend foundations extend a minimum of 1m, below existing or proposed ground levels whichever provides the deeper foundation with all foundations penetrating any made ground deposits by at least 0.3m subject to an overall foundation depth of 1m. It should be noted at this stage that demolition of existing buildings in combination with removal of foundations will cause disturbance of near surface soils thus requiring deeper new foundations where new buildings intercept footprints of existing.

7.2.3 We consider it likely there are some air raid shelters on site, based on our interpretation of Ordnance Survey maps and from knowledge of members of the college estates department. The approximate location of the air raid shelters is shown on drawing STE1297R-02. Some of these shelters would have been removed as part of the construction of the music building but an earthworks mound remains on site in the area of the former shelters outside footprints of existing buildings. Borehole DTS15 formed in this area encountered concrete at shallow depths potentially confirming an underground structure in this area. Clearly there is a risk of encountering underground structures in this area, requiring removal in areas of new build and consequential increase in foundation depths. At this stage and due to time restrictions associated with our fieldwork activities insufficient information is available to clearly define the lateral and vertical extent of these potential former air raid shelters.

7.2.4 Essentially, in our opinion, the Kempton Park Gravels deposits will behave as a granular material. Calculations based on an angle of shearing resistance of 33°, a foundation depth of 1m with groundwater levels located at the base of foundations, indicate following bearing values for pad type foundations.

Plan size of pad (m)	Ultimate bearing value (KN/m^2)	Presumed bearing value (KN/m^2)	Allowable bearing pressure (KN/m^2)
1.5 x 1.5	750	260	260
2.0 x 2.0	810	280	235
2.5 x 2.5	870	300	200
3.0 x 3.0	930	320	175
3.5 x 3.5	990	340	160
4.5 x 4.5	1110	380	135

Table 7.2.4

The presumed bearing value has been derived from the ultimate bearing value by applying a factor of safety of 3, and the allowable bearing pressure derived to limit total settlement. The allowable bearing pressure for a concrete strip foundation located at the same formation level as the pad foundation would be identical to that described above for a 1.5m square pad foundation.

7.2.5 It is difficult to accurately predict the amount of total and differential movement caused by consolidation of the foundations supporting subsoils, however, providing foundation stresses do not exceed allowable bearing pressures provided in the preceding paragraph, it is suggested that total settlement would be small and probably less than 25mm. Differential settlement is totally dependant upon the variation of foundation loads and consistency of the supporting ground. Assuming the foundation loads are reasonably uniform, we suggest that differential settlement is unlikely to exceed say 15mm between adjacent pads. It is likely settlement will be fully achieved within say 5 years of construction.

7.2.6 The Kempton Park Gravels deposits encountered in exploratory excavations are consistent and will provide uniform support to foundations. In the unlikely event foundation excavations encounter clay deposits, we recommend foundation excavations continue to locate granular soils.

7.2.7 It is difficult to predict the stability of trench sides from borehole investigations. Generally we anticipate some overbreak/instability in more granular (loose) deposits of the made ground and Kempton Park Gravels producing a wider than planned trench widths resulting in an increase in the quantity of foundation concrete to fill voids produced by instability of trench sides. The risks of encountering groundwater increase significantly at depths below 1.3m with groundwater inflows promoting collapse of trench sides and the construction of a successful spread type foundation difficult.

7.2.8 Although it is likely that a spread foundation solution will be sufficient for the proposed building, piled or raft foundation solutions could also be adopted and the following paragraphs provide information relating to these solutions.

7.2.9 Piled Foundations

7.2.9.1 A piled foundation would transmit superstructural loads down through the Made Ground into the Kempton Park Gravels and London Clay at depth to obtain end bearing and shaft adhesion support. The difficulty of driving or boring piles through these deposits will need to be considered by any specialist piling company and will affect the method of pile installation. It is important to note that the Kempton Park Gravel deposits include groundwater which will affect the method of pile installation.

7.2.9.2 For the purposes of producing a preliminary pile design foundation scheme, we have produce the following report paragraphs based on the following idealised soil profile:

1 to 6m Kempton Park Gravels
6 to 23m+ London Clays

7.2.10 Preliminary pile design parameters – (Kempton Park Gravel)

7.2.10.1 Ultimate shaft adhesion values for bored piles in the granular Kempton Park Gravel deposits are derived using the following relationship

$$Qsu = ks \times \sigma v \times \tan \delta$$

7.2.10.2 We have assumed loose density parameters taking into account the likelihood of soil disturbance during excavation of pile bores (refer Tomlinson – *'Foundation design and construction'* – seventh edition) The following parameters must be considered estimates only. Detailed pile design must be undertaken by a specialist piling contractor who is familiar with installation of piles in this geology.

for loose conditions let $\phi = 30°$ (angle of shearing resistance)

Let $\sigma v = 19kN/m^3$ x depth and assume $\delta = 20°$ (soil pile friction angle)

Where, $ks = 0.8ko$ Tomlinson, 2001 (p206) $ko = 1 - \sin\phi = 0.5$, then $ks = 0.4$

Then $Qs = 0.4 \times \tan 20o \times \sigma v \times As = 0.145 As \times \sigma v$

Where, σv = average effective overburden pressure over depth of soil layer and As = area of pile shaft.
Utilising the above we can provide the following information for preliminary pile design purposes based on the bored pile solution through the granular Kempton Park Gravel deposits

Strata	Depth (m)	Shaft adhesion factors (kN/m²)	End bearing factor (kN/m²)
Kempton Park Gravel deposits	1.0 to 6m	Increase linearly from 2.755 x As (@1m) to 16.53 x As (@6m)	NA
Table 7.2.10			

A factor of safety of 2.5 on the ultimate load as given by the sum of the base resistance and skin friction should limit settlement at the working load to tolerable values although we recommend settlement should be verified by load testing in advance of main piling.

7.2.11 Preliminary pile design parameters (London Clays)

7.2.11.1 The ultimate shaft adhesion for bored piles in London Clays is determined by the following relationship.

$$Qsu = \overline{Cu} \times \alpha \times As$$

Where α = adhesion factor and $\overline{Cu}$ = average undrained shear strength (kN/m²).

7.2.11.2 Measured undrained shear strength determinations have been used to 'calibrate' the conversion of standard penetration test data to undrained shear strength with a summary of undrained shear strength data in the London Clay shown on Drawings STE1297R-03a and -03c. A suggested relationship between undrained shear strength and penetration into the London Clays is shown on Drawing STE1297R-03c based primarily on shear strength determinations. This relationship can be used to determine $\overline{Cu}$.

7.2.11.3 With reference to '*Guidance notes for the design of straight shafted bored piles in London Clay*' produced by the London District Surveyors Association, the $\overline{Cu} \times \alpha$ value is limited to 140 KN/m², (approximately equates to a maximum undrained shear strength of 235KN/m²) unless it can be demonstrated that higher values can be adopted by pile testing.

7.2.11.4 It is important to exclude water from pile bores in the London Clays to avoid further softening of these soils which would reduce the shaft adhesion support to the pile.

7.2.11.5 The ultimate end bearing capacity for bored piles terminating in the London Clays is derived from the following relationship.

$$Qbu = Nc \times Cu \times Ab$$

Where Nc = end bearing capacity factor = 9
Cu = undrained shear strength (kN/m²) at the pile toe.
Again, Cu can be obtained from Drawing STE1297R-03c.

7.2.11.6 Utilising the above we can provide the following information for preliminary pile design purposes based on the bored pile solution in the London Clays.

Strata	Depth (m)	Shaft adhesion factors (kN/m²)	End bearing factor (kN/m²)
London Clay (α = 0.6)	6 to 23m	Increase linearly from 39 x As (@5m) to 90 x As (@23m)	Increase linearly from 585 x Ab (@6m) to 1350 x Ab (@23m)
Table 7.2.11.6			

Where As = Area of the pile shaft (m²)
Ab = Area of the pile base (m²)

The adhesion factor, α of 0.6 in the London Clays has been obtained from guidance provided in '*Guidance notes for the design of straight shafted bored piles in London Clay*' produced by the London District Surveyors Association, and assumes the following:

- There are no water seepages in the London Clays

- Piles are not constructed using drilling fluid (eg bentonite) or continuous flight auger
- The pile design is dictated by vertical compressive loads
- The piles are concreted within 12 hours of start of boring in the London Clays (or 12 hours below casing depth)

The published guidance recommends the adhesion is limited to 140KN/m^2 which equates to limit on the undrained shear strength of the clays of about 235KN/m^2. This limit could be reconsidered if pile testing is carried out to demonstrate higher values of shaft adhesion.

7.2.11.7 The sum of shaft adhesion and end bearing will need to divided by a factor of safety ranging from 3 to 2 subject to testing of installed piles. The following is taken from guidance in the publication described above:

Pile testing		Factor of safety
Preliminary pile load test to confirm design	**Load testing on working piles to 1.5 x working load**	
none	none	3
none	1% of working piles	2.5
Constant rate of penetration test	1% of working piles	2.25
Maintained load test	1% of working piles	2.0

Table 7.2.11.7

7.2.12 Pile Design and Installation

7.2.12.1 We have endeavoured to provide sufficient information to allow detailed design of piles to be completed. The above pile design guidelines have been produced in good faith based on our current understanding of design procedures for the purposes of producing a preliminary foundation layout by a Structural Engineer. We recommend the design and installation of the piles are determined by a specialist piling contractor who has experience in pile installation in these or similar ground conditions, and may be able to interpret the observed ground conditions in a different and potentially more beneficial manner. We recommend the specialist piling contractor assumes responsibility for the choice, design and installation of the piles.

7.2.12.2 We recommend piling be carried out following the *"Specification for Piling and Embedded Retaining Walls"* produced by the Institution of Civil Engineers.

7.2.12.3 Methods for load testing of piles including the constant rate of penetration test and maintained load test are described in BS 8004:1986 *'British Standard Code of practice for Foundations'*.

7.2.12.4 It is likely that a 'piling mat' will have to be constructed in advance of piling operations. This will be designed following the Building Research Establishment publication *'Working Platforms for tracked plant: good practice guide to the design, installation, maintenance and repair of ground supported working platforms'*. We will be pleased to assist in the design and specification of such a platform on further instructions.

7.2.13 Raft Foundations

7.2.13.1 Raft foundations have the ability to spread superstructural loads over the footprint of the building thus substantially reducing stresses imparted to the ground compared with isolated spread foundations. The bearing capacity of a raft foundation is not typically critical, but levels of settlement need to be established. In order to determine likely levels of settlement we will require likely stress levels generated by the raft and indeed the area of the raft. We will be pleased to carry out settlement calculations on receipt of the above data and on further instructions. For a shallow raft, then we recommend made ground deposits are removed and replaced where appropriate with an imported well graded durable granular fill compacted to an end point specification.

7.3 Influence of Trees and other major vegetation

7.3.1 The results of plastic and liquid limit determinations performed on samples of the Kempton Park Gravel (generally below 1m) indicate the deposits are non-plastic when classified in accordance with National House Building Council (NHBC) Standards, Chapter 4.2 and thus not affected by the moisture demand of trees and other major vegetation.

7.4 Ground Floor Construction

7.4.1 College buildings (large floor areas)

7.4.1.1 Ground bearing floor slabs can be adopted at this site where Made Ground and Topsoil deposits are fully removed within the footprint of the building. We recommend a blanket of good quality compacted granular material be placed prior to construction of the floor slabs.

7.4.1.2 Following completion of excavations to formation levels we recommend where possible the formation is rolled using a heavy roller to identify any soft areas and indeed compact near surface soils which may have been disturbed by excavation processes. Any 'soft' areas will require excavation to locate more stable soils. We recommend a blanket of good quality compacted granular material be placed prior to construction of the floor slabs.

7.4.1.3 Where floor slabs are not required to support settlement sensitive equipment and with reference to *'Concrete industrial ground floors'* (Technical Report no. 34 – third edition) produced by the Concrete Society, the modulus of subgrade reaction (k) supporting the floor slab has only a minor effect on the slab design thickness for flexural stresses and does not therefore have to be estimated with great accuracy.

7.4.1.4 The modulus of subgrade reaction is a measure of the elastic properties of near surface soils. Plate bearing tests provide the most accurate measure of elastic modulus and we can carry this out on further instructions. California Bearing Ratio (CBR) test data be converted to an equivalent modulus of subgrade reaction (see Technical Report 34), but CBRs are not a direct measure of modulus. Again, we can carry out CBR testing on further instructions. Technical report 34, provides typical values of modulus of subgrade reaction based on soil descriptions, and using this guidance we estimate the modulus subgrade reaction in the range of 0.015 to 0.03 N/mm^3.

7.4.1.5 In addition to elastic deformation of soils (estimated from *k* values described above), some long-term settlement of the floor slab will occur under applied loads, particularly uniformly distributed loads. It is difficult to accurately predict levels of settlement, as the applied load pattern is not known. Assuming a constantly applied uniformly distributed load of say 50kN/m^2, settlements in the order of 10mm could occur within 5 to 10 years. Some differential settlement will occur in the long term, if the floor slab is not uniformly loaded.

7.4.1.6 If ground floors to college buildings are required to support settlement sensitive equipment then the amount of allowable settlement will dictate the floor construction and indeed the method of support. At this stage we do not know if any settlement sensitive equipment is planned or indeed if such equipment is planned then the levels of settlement, but we will be pleased to advise further on this item at a future date once further details are known.

7.4.2 Residential buildings

7.4.2.1 We assume residential developments will comprise low rise housing. Although ground bearing floors could be adopted supported on the naturally deposited Kempton Park Gravels, BS8103-1:1995 '*Structural design of low rise buildings – code of practice for stability, site investigation, foundations and floor slabs for housing*' limits the depth of filling below floors to 600mm, thus if this cannot be achieved then a suspended floor construction will be required.

7.5 Service Trench Excavations

7.5.1 Generally we anticipate some overbreak/instability in more granular (loose) deposits of made ground producing a wider than planned trench widths The risks of encountering groundwater increase significantly at depths below 1.3m with groundwater inflows promoting collapse of trench sides requiring continuous shoring and indeed significant pumping to maintain an open excavation. On this basis it is important to minimise where possible depths of excavations.

7.5.2 We recommend any trench excavation requiring human entry is shored as necessary to conform with current best practice, and accepted by the Health and safety Executive (HSE) and in particular, following guidance provided in the HSE construction information sheet No 8 (revision 1) *"Safety in excavations"*.

7.6 Infiltration Potential

7.6.1 The Kempton Park Gravel deposits and Made Ground generally exhibit some permeability varying across the site. The permeability of these soils was measured in ten trial pits generally following the procedures described in Building Research Establishment (BRE) Digest 365 (2007) *"Soakaway Design"*. These tests produced infiltration rates of between 5 $\times 10^{-6}$ ms^{-1} to 5.2 $\times 10^{-5}$ ms^{-1}. In addition, variable head tests were undertaken in two of the driven tube sampler boreholes following methods described in *BS 5930: 1999 'Code of Practice for Site Investigations'* (section 25). The variable head tests produced infiltration rates of 3 $\times 10^{-6}$ ms^{-1} and 8.4 $\times 10^{-7}$ ms^{-1}. Records of the testing and calculations are presented in Appendix D. It should be noted that the rate of water dissipating in the trial pits and boreholes was in general relatively slow and we were not able to carry out three cycles of the test procedures described in the published methods with one day's fieldwork. Further on site testing with observations made over a period of days may allow the production of more accurate infiltration rates and allowing three cycles of the test procedure. We can carry out such testing on further instructions.

7.6.2 If infiltration systems are adopted as a means of stormwater disposal (including permeable pavement construction), we recommend approval for the use of soakaways is sought from the Environment Agency. It should be noted that the Groundwater Regulations 1998 require that list 1 substances (e.g. Hydrocarbons) are to be prevented from entering groundwater receptors and list 2 substances (e.g. metals) are also restricted. Typically, the Environment Agency will require details of the proposed soakaway systems, showing pollution prevention measures. They will also require geological and geo-hydrological information, (contained in this report) as well as the risks of chemical contaminants in the ground affecting water resources. It is also typical requirement that there is an 'unsaturated zone' between the base of the soakaway system and the groundwater table (saturated zone) providing attenuation capacity.

7.7 Pavement Foundations

7.7.1 It is anticipated that proposed access roads and associated hardstanding areas will be located at or about existing ground levels with formation located on Made Ground and Kempton Park Gravel deposits.

7.7.2 Five bulk samples were submitted to the laboratory to determine the California bearing ratio, three of these were combined samples from a selection of sampling locations. Based on these, we have derived an average CBR of 2%. Laboratory results are presented in Appendix G.

7.7.3 We can also derive an 'equilibrium' CBR (California Bearing Ratio) values (with reference to Transport and Road Research Laboratory (TRRL) Report LR1132 *'Structural design of Bituminous Roads'*) are from a knowledge of subgrade classification data (plasticity index for soils exhibiting cohesion) the location of the water table below formation levels, pavement thickness, and weather conditions at the time of construction. The plasticity index of near surface Kempton Park Gravel deposits was measured at an average of 15 and with the water table located in excess of 600mm below assumed formation levels, and assuming a 'thin' pavement and average construction conditions a CBR of 4% is derived. This value should be compared with CBR derived from undrained shear strength data discussed in the following paragraph.

7.7.4 It is possible to derive the 'insitu' CBR value at formation from undrained shear strength data by applying a conversion factor of 23. Thus adopting pessimistic undrained shear strength of say 70kN/m^2 (firm category) at formation level then an equivalent CBR value can be obtained i.e.

$$\text{Insitu CBR} = \frac{\text{undrained shear strength (70)}}{23} = 3\%$$

The 'insitu' CBR derived above, is susceptible to change dependent upon weather conditions during construction. The equilibrium CBR value derived in paragraph 7.7.3 above is an estimate of the CBR value, which will predominate during the life of the pavement. We recommend the insitu CBR of 3% derived from shear strength data be utilised for design purposes and reassessed during construction. The fact that clay subgrade soils are likely to be deemed frost susceptible will probably be the overriding criteria for pavement foundation design purposes.

7.7.5 Made Ground deposits at the site exhibit a degree of variation in compactness. Some long term settlement of hardstandings will occur due to consolidation of the Made Ground deposits and from applied loads, particularly uniformly distributed loads. It is difficult to accurately predict levels of settlement, as potentially applied loading patterns are not known. Assuming a constantly applied uniformly distributed load of say 10kN/m^2, settlement in the order of 10mm could occur within 5 to 10 years of construction. Equally, some differential settlement could occur in the long term, if hardstandings are not uniformly loaded. We suggest that pavements under transient (vehicular) loads are unlikely to generate significant levels of settlement.

7.7.4 Once formation levels have been established it is recommended that the formation be trimmed and rolled following current requirements of the Highways Agency Specification for Highways Works (clause 616) (refer www.specificationforhighways.co.uk) Such a process will identify any soft areas, which we recommend be either excavated out and backfilled with a suitable well compacted material similar to those exposed in the sides of the resulting excavation, or large cobbles of a good quality stone rolled into the formation to stabilise the 'soft' area.

7.7.5 The silty nature of the Kempton Park Gravel will render them moisture susceptible with small increases in moisture content giving rise to a rapid loss of support to construction plant. We therefore recommend, as soon as formation is trimmed and rolled, that sub-base is laid in order to avoid deterioration of the subgrade in wet or frosty conditions.

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8 Chemical contamination (Part A – Regulation, liabilities and procedures)

8.1 Contaminated land, regulation and liabilities.

8.1.1 Statute

8.1.1.1 Part IIA of the Environment Protection Act 1990 became statute in April 2000. The principal feature of this legislation is that the hazards associated with contaminated land should be evaluated in the context of a site-specific risk based framework. More specifically contaminated land is defined as:

"any land which appears to the local authority in whose area it is situated to be in such a condition, by reasons of substances in, on or under the land, that:

a) Significant harm is being caused or there is a significant possibility of such harm being caused; or

b) Pollution of controlled waters is being or is likely to be caused".

8.1.1.2 Central to the investigation of contaminated land and the assessment of risks posed by this land is that:

i) There must be contaminants(s) at concentrations capable of causing health effects *(Sources)*.

ii) There must be a human or environmental receptor present, or one which makes use of the site periodically *(Receptor)*; and

iii) There must be an exposure pathway by which the receptor comes into contact with the environmental contaminant *(Pathway)*.

8.1.1.3 In most cases the Act is regulated by Borough or District Councils and their role is as follows:

Inspect their area to identify contaminated land

i) Establish responsibilities for remediation of the land

ii) See that appropriate remediation takes place

- through agreement with those responsible, or if not possible
  - by serving a remediation notice, or
  - in certain cases carrying out the works themselves, or
  - in certain cases by other powers
- keep a public register detailing the regulatory action which they have taken

8.1.1.4 For "special" sites the Environment Agency will take over from the Council as regulator. Special sites typically include:-

- Contaminated land which affects controlled water and their quality
- Oil refineries
- Nuclear sites
- Waste management sites

8.1.2 Liabilities under the Act

8.1.2.1 Liability for remediation of contaminated land would be assigned to persons, organisations or businesses if they caused, or knowingly permitted contamination, or if they own or occupy contaminated land in a case where no polluter can be found.

8.1.3 Relevance to predevelopment conditions

8.1.3.1 For current use, Part IIA of the Environmental Protection Act 1990 provides the regulatory regime. The presence of harmful chemicals could provide a 'source' in a 'pollutant linkage' allowing the regulator (local authority or Environment Agency) to determine if there is a significant possibility of harm being caused to humans, buildings or the environment. Under such circumstances the regulator would determine the land as 'contaminated' under the provision of the Act requiring the remediation process to be implemented.

8.1.4 Relevance to planned development

8.1.4.1 With regards to planned future use, Planning and Policy Statement 23 (PPS23) '*Planning and pollution control – Annex 2 – Development on land affected by contamination*' requires land owners / developers to ensure the proposed development is safe and suitable for use for the purpose for which it is intended. The developer is thus responsible for determining whether land is suitable for a particular development or can be made so by remedial action. In particular, the developer should carry out an adequate investigation to inform a risk assessment to determine:

a) Whether the land in question is already affected by contamination through source – pathway – receptor pollutant linkages and how those linkages are represented in a conceptual model

b) Whether the development proposed will create new linkages create new linkages e.g. new pathways by which existing contaminants might reach existing or proposed receptors and whether it will introduce new vulnerable receptors, and

c) What action is needed to break those linkages and avoid new ones, deal with any unacceptable risks and enable safe development and future occupancy of the site and neighbouring land.

8.1.4.2 Building control bodies enforce compliance with the Building Regulations. Practical guidance is provided in Approved documents, one of which is Part C, '*Site preparation and resistance to contaminants and moisture*' which seeks to protect the health, safety and welfare of people in and around buildings, and includes requirements for protection against harm from chemical contaminants.

8.1.5 Further Information

8.1.5.1 The above provides a brief outline as regards current statute and planning controls. Further information can be obtained from the Department for the Environment, Food and Rural Affairs (DEFRA) and their Web site www.defra.gov.uk.

8.2 Objectives, procedures and report format

8.2.1 This report section discusses investigations carried out with respect to chemical contamination issues relating to the site. The investigations were carried out with the aim of satisfying the requirements of PPS 23 in relation to the proposed development and indeed determine if there are any liabilities with respect to Part IIA of the Environment Protection Act. As stated in Section 2.4.2, the investigation process followed the principles of BS10175: 2001 *'Investigation of potentially contaminated sites – Code of Practice'*, with the investigation combining a desk study (preliminary investigation) together with the exploratory and main investigations (refer BS10175: 2001 for an explanation).

8.2.2 This section of the report produces a *'Conceptual model'* based on investigatory data obtained to date. The conceptual model is constructed by identification of *contaminants* and establishment of feasible *pathways* and *receptors*. The conceptual model allows a *risk assessment* to be derived. Depending upon the outcome of the risk assessment it may be necessary to carry out remediation and/or further investigations with a view to eliminating, reducing or refining the risk of damage to identified receptors. If appropriate, our report will provide recommendations in this respect.

8.2.3 Definition of terms used in the preceding paragraph and subsequent parts of this section of the report are presented in Appendix B.

8.2.4 Procedure to assess risks of chemical contamination

8.2.4.1 For the purposes of presenting this section of this report, we have adopted the following sequence in relation to chemical contamination.

Conceptual model element	Contributory information	Outcome
Receptor	Development categorisation	- identification of receptors at risk of being harmed - method of analysing test data - criteria for risk assessment modelling
Pathways	- geology and ground conditions - development proposals	- identification of critical pathways from source to receptor
Source	- previous site history - desk study information - site reconnaissance - fieldwork observations	- testing regime - Identification of a chemical source - by-analysis of test data and other evidence

Table 8.2.4.1

8.2.5 We have adopted, in general, the procedures described in CIRIA C552 *'Contaminated land risk assessment - a guide to good practice'* in deriving a risk assessment. Initially we have carried out a 'phase 1 assessment' based on desk study information and site reconnaissance, to produce a preliminary conceptual model and thus a preliminary risk assessment. This model / assessment is then used to target fieldwork activities and laboratory testing, with the results of this part of the investigation used to allow a phase 2 assessment to be produced by updating the conceptual model and refining the risk assessment.

8.2.6 Report format

8.2.6 For ease of reporting we have split the remaining section of this report into three, considering individually the principle receptors potentially exposed to any chemical contaminants at the site: with the final part (part D) providing conclusions and recommendations ie

Part B	Human receptors
Part C	Water resource receptors (controlled waters)
Part D	Summary and recommendations

8 Chemical contamination (Part B – Human Receptors)

8.3 Development Categorisation and Identified Human Receptors

8.3.1 Identified human receptors

8.3.1.1 The principal receptors subject to harm caused by any contamination of the proposed development site are as follows.

a) End users of the developed site (Humans)

b) Construction operatives and other site investigators (Humans)

8.3.1.2 We are aware that there are other receptors such as ecological systems and other non human living organisms and building materials. This section of the report deals with the receptors listed in paragraph 8.3.1.1 above.

8.3.2 Human Receptors – End Users of the Site

8.3.2.1 The critical human 'receptor' used in the analysis of test data (refer CLR publications listed in Section 8.8.2 below) is a child under the age of 6 years. This takes into account the inquisitive nature of children (i.e. an amenable means of direct soil ingestion) and their relative body mass. Such a receptor is critical for residential developments particularly those including gardens where both direct (hand to mouth and breathable soil dusts) and indirect ingestion (via consumption of home grown vegetables) of contaminated soils is feasible. For industrial/commercial developments, the adult becomes the critical receptor, exposed in the long term, where applicable, to breathable airborne contaminated soil dusts. These pathways (inhalation/ingestion) for source contamination to reach the human receptor can be eliminated, depending upon the development proposals, or by remediation, or indeed if the source is not evident then the source-pathway-receptor model is not relevant. Further, more detailed information on the exposure assessment model for human receptors is described in CLR 10 (refer report Section 8.8.2 for references).

8.3.3 Human Receptors – Construction Operatives and other site investigators.

8.3.3.1 Typically, construction operatives and other site investigators (such as archaeologists) will be exposed to the development site for relatively short timescales. Operatives however, are subject to contaminated soils/waters through the ingestion/inhalation pathway route. Exposure risks can be substantially reduced by various means described in the recommendations Section 8.19 of this report.

8.3.4 Development Categorisation

8.3.4.1 The nature of the development will have a significant influence on the ease or difficulty of how human receptors can access any contaminated soils at the site. Clearly, a site developed for industrial usage is likely to be ultimately covered in hardstandings and buildings thus effectively eliminating human end user access to any chemically impacted soils, whereas a residential development which includes gardens provides easy human (end user) access to soils in garden areas via direct contact or indeed indirect contact by consumption of soils on vegetables or inhalation of soil dust. On this basis, the type of planned development will significantly influence the conceptual model and analysis of any test data.

8.3.4.2 It is understood the site will be redeveloped but remain as a college facility (educational) thus we have assumed an equivalent commercial land use with the site substantially covered in buildings and hardstanding areas. This criterion has been used in the construction of the conceptual model, and ultimately in the evaluation of test data (refer following report sections). We are aware, that part of the site could be developed for residential end use, although the location and nature of such a development is currently not known, thus at this stage we have limited our considerations of chemical contamination to the equivalent 'commercial (educational) end use'. Once the location / nature of the residential development is known, we will be pleased to review test data in this location, and advise accordingly.

8.4 Identification of Pathways

8.4.1 Pathways to Human Receptors (end users)

8.4.1.1 CLR10 (refer report Section 8.8.2 for references), provides a very detailed assessment of pathways and assessment and human exposure rates to source contaminants. In summary, the principal pathways of contamination to the human receptor are as follows:-

- Ingestion of contaminated soil dusts
- Ingestion by incidental or deliberate hand to mouth contact
- Ingestion of contaminated fruit/vegetables
- Skin contact with soils (working or at play)
- Inhalation of vapours

Clearly some of these pathways can be eliminated depending upon the end use of the site, for instance ingestion of fruit/vegetables sourced from an industrial development is unlikely, and child receptors would not be considered for an industrial development.

8.4.2 Pathways to Human Receptors (end users) - Elemental Risk Assessment

8.4.2.1 Based on our understanding of development proposals (as described in 8.3.4. above), we can provide the following elemental risk evaluation of possible pathways to end users of the site.

Assessment of possible pathways to site end user receptors		
Receptor	**Type (position in conceptual model)**	**Probability of a chemical source causing harm**
End users (children)	Pathway – ingestion of contaminated soils	**Unlikely**
End users (children)	Pathway – inhalation of contaminated soil dusts	**Unlikely**
End users (adults)	Pathway – ingestion of contaminated soils	**Likely**
End users (adults)	Pathway – inhalation of contaminated soil dusts	**Likely**
Table 8.4.2		

8.5 Assessment of Sources of Chemical Contamination

8.5.1 Initially, potential sources of contamination are assessed using the following elements of the investigation process.

- History of the site
- Desk study information
- Site reconnaissance

These elements will dictate a relevant soil/water testing regime to quantify possible risks of any identified contaminative processes/events which may harm identified receptors.

8.5.2 Source Assessment – History of the Site

8.5.2.1 The history of the site and its immediate surroundings based on published Ordnance Survey maps is described in Section 3.

8.5.2.2 Based on published historical maps, there is no evidence to indicate the site, or its immediate surroundings, has been subject to activities, which could produce a source of chemical contamination. The following table summarises this elemental source assessment.

Table summarising results of source assessment based on historical data		
Source	**Possible contaminant which could cause harm to human receptors**	**Likely extent of contamination on site**
On site and adjacent sites No recorded land uses which are likely to provide a contaminative source	No evidence available	Not applicable
Table 8.5.2		

8.5.3 Source Assessment – Desk Study Information.

8.5.3.1 Envirocheck presents a detailed database of environmental information in relation to the site including;

- Pollution incidents
- Landfill sites
- Trading activities

Based on the Envirocheck data (refer Appendix M) the site has no recorded history of any pollution events, or trading activities which could generate a source of contamination, or is located in close proximity to a landfill site. The following table summarises this elemental source assessment.

Table summarising results of source assessment based on desk study information		
Source	**Possible contaminant which could cause harm to human receptors**	**Likely extent of contamination on site**
On site and adjacent sites No recorded pollution events, trading activities etc, likely to provide a contaminative source	No evidence available	Not applicable
Table 8.5.3		

8.5.4 Source Assessment – Site Reconnaissance

8.5.4.1 A full description of the site and observed adjacent land uses is provided in Section 3 of this report. A plan summarising observations made on site during our site reconnaissance visit is presented on Drawing STE1297R-02.

8.5.4.2 As a result of our site reconnaissance, a 'porta cabin' type building was observed along the eastern boundary utilised as a chemical store, presumably storing chemicals used by the science faculty in the college laboratories. In our opinion, the chemicals are stored in small quantities and well managed and thus considered unlikely to produce a contaminative source likely to affect the near surface soils. On this basis, we are of the opinion that there is not any obvious evidence of any current or recent activities on site or adjacent sites which provide a potential source of chemical contamination. The following table summarises this elemental source assessment.

Table summarising results of source assessment based on historical data		
Source	**Possible contaminant which could cause harm to human receptors**	**Likely extent of contamination on site**
On site and adjacent sites No observed onsite activities or activities on adjacent sites which are likely to provide a contaminative source	No potential contaminative sources observed	Not applicable
Table 8.5.4		

8.5.5 **Source Assessment – Summary**

Table summarising results of source assessment			
Source	**Origin of information**	**Possible contaminant which could cause harm to humans / water receptors**	**Likely extent of contamination on site**
On site and adjacent sites No observed or recorded onsite activities or activities on adjacent sites which are likely to provide a contaminative source	Site reconnaissance, historical maps and desk study information	No potential contaminative sources observed	Not applicable
Table reference 8.5.5			

8.6 Phase 1 Assessment and initial conceptual model

8.6.1 Based on desk study information and site observations we can produce the following initial conceptual model with respect to human receptors which requires on site investigation to produce a qualitative risk assessment.

Initial conceptual model		
Potential source origin	**Potential pathway**	**Human Receptors at risk**
On site No positive identification of potential contaminative source based on desk study information and site reconnaissance	No pathway analysis required (no source identified)	Not applicable
Table 8.6.1		

8.7 Fieldwork observations

8.7.1 Continuation of Source Assessment based on Fieldwork Activities

8.7.1.1 Near surface soils exposed in trial pits TP14 and TP09 were observed to exhibit a hydrocarbon type odour. Trial pit TP14 was excavated adjacent to the chemical store, with TP09 exposing foundations to a building.

8.7.1.2 We obtained samples of the potentially chemically impacted soils for subsequent laboratory testing. On this basis, the source assessment requires amendment and is summarised in the table below.

Table summarising results of source assessment			
Source	**Origin of information**	**Possible contaminant which could cause harm to humans / water receptors**	**Likely extent of contamination on site**
On site Hydrocarbon impacted soils	Fieldwork observations	Unknown and subject to testing	Around trial pit TP14 at 0.0-0.2m and TP09 at 0.1-0.2m depth
Table reference 8.7.2			

8.8 Laboratory Testing

8.8.1 Testing Regime – Human receptors

8.8.1.1 Based on our source assessment reported in Section 8.5 and the preliminary conceptual model (section 8.6 above), we have no evidence to identify any past or recent uses of the site which may have generated specific contamination. On this basis, we have scheduled testing to measure the concentration of inorganic contaminants listed in table 2.1 of the Contaminated Land Report (CLR) no. 8 *'Potential Contaminants for the assessment of contaminated land'* produced by the Department for Environment, Food and Rural Affairs (DEFRA) in conjunction with the Environment Agency (EA), when they are considered a risk to harm human receptors.

8.8.1.2 With reference to Section 8.7 and our source assessment based on fieldwork observations (refer table 8.7.2 above we have scheduled testing to measure concentrations of total petroleum hydrocarbons with speciation (TPH-CWG) on a sample taken from each location. In addition, although we have no obvious evidence of organic contamination across the remainder of the site, we have scheduled testing to include more common organic compounds forming polycyclic aromatic hydrocarbons (PAH) typically derived from a variety of combustion and pyrolytic sources.

8.8.1.2 Twelve samples from across the site were submitted for measurement of inorganic contaminants and PAH described above. The quantity is considered a minimum to allow a meaningful statistical analysis of test data to be carried out and a risk assessment to be made. Obviously, additional testing (quantity and types) would allow a more accurate risk assessment to be made.

8.8.1.3 The results of laboratory determination of concentration of chemical contaminants are presented in Appendix I.

8.8.2 Criteria for assessment of test data – Human receptors

8.8.2.1 Assessment of laboratory test data has been carried out using the following documents published by the DEFRA in conjunction with the EA

- *Assessment of Risks to Human Health from Land Contamination: An overview of the development of soil guideline values and related research'* (R & D Publication, Contaminated Land Report **(CLR 7).**
- *'Contaminants of Soil: Collation of Toxicological Data and Intake Values for Humans'* (R & D Publication, Contaminated Land Report **(CLR 9).**
- *'The Contaminated Land Exposure Assessment Model'* (CLEA): *Technical basis and algorithms'* (R & D Publication, Contaminated Land Report **(CLR 10).**
- Model Procedures for the Management of Land Contamination (Contaminated Land Report **(CLR 11)**
- *'Contaminants in Soil: Collection of Toxicological data and intake values for Human Values'* (R & D Publications Tox 1, 2, 3, 4, 5, 6, 7, 8, & 10).
- *'Soil Guideline Values for Contamination'* (R & D Publication SGV1, 3, 4, 5, 7, 9, & 10).

These documents form part of the Contaminated Land Report (CLR) some of which remains unpublished. The above publications do provide soil guideline values (SGVs) in relation to the following chemical contaminants.

Arsenic	Mercury
Cadmium (total)	Selenium
Chromium (total)	Nickel
Lead	Ethylbenzene
	Toluene

8.8.2.2 Soil guideline values (SGVs) referred to in Contaminated Land Reports (CLR) are used as a screening tool to assess the risks posed to health of humans from exposure to soil contamination in relation to land uses. They represent 'intervention values'; indications to an assessor that soil concentrations above these levels might present an unacceptable risk to the health of site users. These soil guideline values have been produced using conceptual exposure models, which use assumptions and are applied to differing end uses of land. If the SGVs are exceeded it does not necessarily imply there is an actual risk to health and site-specific circumstances should be taken into account. Conversely, where a critical pathway or chemical form of the contaminant has not been evaluated by the CLR then, potentially, a significant risk may be present even if the SGV has not been exceeded.

8.8.2.3 Where published soil guidelines are not available for a contaminant we have adopted Generic Assessment Criteria (GAC). These values have been derived by Land Quality Management (LQM) and the Chartered Institute of Environmental Health (CIEH) and presented in *'Generic Assessment Criteria for Human Health Risk Assessment'*. GACs have been prepared for a number of metals and polycyclic aromatic hydrocarbons (PAH) following the CLR guidance and using the CLEA UK (beta) software.

8.8.2.4 Sulphur is listed in table 2.1 of CLR8 as a chemical which may be considered a risk to human health. Currently there is no SGV, GAC or indeed a toxicity report for this contaminant. Having carried out a significant amount of in house research, we have not been able to produce any criteria which would allow us to determine a concentration for sulphur which may be considered a risk to human health. According to the United States Environmental Protection Agency (USEPA), *'sulphur poses very little if any risk to human health'*. Contact with natural sulphur at low levels over many years is generally recognised as safe. Health studies of mineworkers exposed to sulphur dust and sulphur dioxide throughout their lives show that they often had eye and respiratory disturbances including bronchitis and chronic sinus effects. These effects, however, relate to continued exposure to high concentrations of sulphur dust. On this basis, unless the site is clearly significantly contaminated with sulphur relating to past use of the site which used/manufactured sulphur, we would not consider this element further.

8.8.2.5 Currently there is a toxicity report for inorganic cyanide but not organic cyanides. In the absence of both an SGV and GAC for this contaminant we are researching this potential contaminant with respect to risks to human health. Pending completion of our research we have adopted a potentially conservative approach of considering a risk to human health on the concentration of cyanides (free and total) above detectable limits.

8.8.3 Statistical analysis of test data – Human Receptors

8.8.3.1 Following CLR7, we have carried out a statistical analysis of test data for each chemical contaminant considered in this investigation. Initially, the maximum value test is carried out to provide an indication of results, which could be considered 'statistical outliers', and thus not part of the general population of results. The maximum test value is described in detail in CLR7. If outliers are clearly identified, then these may represent an area of contamination considered worthy of further investigation.

8.8.3.2 Following completion of the maximum value test procedure, then the mean value test is carried out on test data. If a "statistical outlier' is identified as part of the maximum value test, then the outlier result is ignored in the subsequent mean value test, to avoid distortion of the general population of results. The mean value test determines the 95th percentile value for appropriate test data for individual contaminants, which is also related to the number of test values under consideration. The resulting 95th percentile values are then compared with soil guideline values or site specific assessment criteria.

8.8.3.3 Following paragraph A8 of CLR7, any concentrations of contaminants that are below the analytical detection limit are assigned a value equal to the detection limit for the purposes of carrying out the statistical analysis. In some cases where a small proportion of results marginally exceed detection limits, with the remaining results at or below detection limits, then statistically these 'higher' results could be deemed statistical outliers. Providing these results are below SGVs or GACs then further investigations are not considered necessary.

8.8.3.4 The above statistical analysis of test data is tabulated in Appendix J.

8.8.3.5 As always, statistical tests are an aid to decision making, but are not a substitute for professional judgement.

8.8.4 Evaluation of test data (inorganic contaminants) - Human Receptors

8.8.4.1 In consideration of the results of the maximum value test (refer Appendix I), statistical analysis highlighted outliers potentially suggesting further investigations for arsenic, cadmium, cyanide, nickel, sulphur and vanadium. With the exception of cyanide and sulphur which do not have published assessment criteria, the outlier concentrations associated with these metals fall well below soil guideline values for the end use of the site. With reference to paragraph 8.8.2.4, we do not consider the measured concentration of sulphur to present a risk to end users of the site.

8.8.4.2 The maximum value test compares an outlier test statistic to a critical value. CLR7 gives two different critical values; one for a 5% chance of wrongly identifying an outlier, and one for a 10% chance. In contaminated soil analyses we are concerned about wrongly accepting a value; therefore, 10% values are more stringent (i.e. human health protective). In the case of arsenic and vanadium, the outlier test statistic lies between the 5% and 10% critical values. Now, considering the mean value test with the potential outlier value removed from the population of results, the resulting 95th percentile value falls below the SGV (or GAC) for this contaminant (refer Appendix J). Considering, then, the 95th percentile value for the whole population of results, (including the potential outliers) then this value again falls below the

SGV (or GAC) for this contaminant. On this basis we do not consider this potential outlier values for arsenic and vanadium worthy of further investigation.

8.8.4.3 With respect to cyanide, in our opinion, the outlier concentration did not represent a true outlier but due to a quirk in the statistical analysis. When values are measured to be below detectable limits it is assumed, for the purposes of statistical testing, that these concentrations are equal to detectable limits. This can have the effect of erroneously highlighting values as outliers. Based on these observations we are of the opinion the outlier concentration is not worthy of further investigation.

8.8.4.4 In consideration of the mean value test (95th Percentile values – refer Appendix J), none of the 95th Percentile values exceed the relevant SGV or GAC. It should be noted that test data indicates the concentration of cyanides are below or marginally above detectable limits and on this basis cyanides are not considered to potentially pose a significant risk causing significant harm to human end users of the site.

8.8.4.9 Based on the above evaluation, we are of the opinion that the near surface soils do not exhibit any significant inorganic contamination from a perspective of human end use and thus, in conclusion, are not considered to present a significant possibility of causing significant harm to human health.

8.8.5 Evaluation of test data (organic contaminants) – Human Receptors

8.8.5.1 Polycyclic aromatic hydrocarbons

8.8.5.1.1 For evaluation of test data in relation to polycyclic aromatic hydrocarbon (PAH) contamination we have used benzo(a)pyrene, dibenzon(a,h)anthracene, fluorene and naphthalene as indicators of prevalent organic contamination. These indicators have been chosen as they have corresponding GACs. The GAC fractions are dependent on the Soil Organic Matter (SOM) content of the soils. We have adopted the lowest measured SOM as an initial screening value.

8.8.5.1.2 With respect to the maximum value test (refer Appendix J), outliers were produced for benzo(a)pyrene, dibenzo(a,h)anthracene and fluorene, with measured at a concentrations of 18-58mg/kg, 0.12-6.4mg/kg and 0.14-24mg/kg respectively. None of the results exceed our site specific assessment criteria with the exception of one result for benzo(a)pyrene measured at a concentration of 58mg/kg on a sample taken from borehole DTS05 at 0.2-0.35m.

8.8.5.1.3 With respect to dibenzo(a,h)anthracene, fluorene and naphthalene, in our opinion, the outlier concentrations do not represent outliers but due to a quirk in the statistical analysis. When values are measured to be below detectable limits it is assumed, for the purposes of statistical testing, that these concentrations are equal to detectable limits. This can have the effect of erroneously highlighting values as outliers. Based on these observations we are of the opinion the outlier concentrations associated with these contaminants are not worthy of further investigation.

8.8.5.1.4 In consideration of the mean value test (95th percentile values – refer Appendix J) for benzo(a)pyrene, dibenzon(a,h)anthracene, fluorene and naphthalene none of the results exceed the relevant GAC values.

8.8.5.1.5 Based on the above evaluation, only one sample taken from borehole DTS05 at 0.2 to 0.35m produced elevated concentration of benzo(a)pyrene, (a sample of ash / clinker) which could pose a risk of causing harm to end users of the site. Recommended remedial action is described in section D below.

8.8.5.2 Total Petroleum hydrocarbons

8.8.5.2.1 For evaluation of total petroleum hydrocarbon contamination (measured on the two samples taken from trial pits TP9 and TP14, which exhibited some hydrocarbon odours) we have followed the principles described in the EA publication '*The UK Approach for evaluating Human Health Risks from Petroleum Hydrocarbons in Soils*'. We have adopted a first stage approach of comparing measured concentrations of indicator compounds with soil guideline values (SGV) or site specific assessment criteria (GAC). We have adopted the following indicator compounds based on currently available GACs and SGVs.

Indicator compounds for TPH evaluation	
None threshold indicators	**Threshold indicators**
• Benzo(a)pyrene (GAC) • Dibenz(a,h)anthracene (GAC)	• Toluene (SGV) • Ethylbenzene (SGV) • Naphthalene (GAC)

Table 8.8.5a

Threshold indicators are contaminants for which there is tolerable human intake, whereas for non threshold contaminants, human exposure should be kept to a level as '*low as reasonably practicable*' (ALARP)

8.8.5.2.2 Comparison of measured concentrations of the above indicator compounds with GACs and (refer appendix I) indicates petroleum hydrocarbon contamination is unlikely to pose a significant risk of causing harm to end users of the site.

8.8.5.2.3 The second stage of TPH analysis considers individual fractions of the TPH concentration. We have adopted the published GAC values for each hydrocarbon fraction. The GAC fractions are dependent on the Soil Organic Matter (SOM) content of the soils. We have adopted the lowest measured SOM as an initial screening value. Based on conservative GAC values, none of the fractions are above the relevant GAC, and therefore unlikely to pose a significant risk of causing harm to end users of the site. The comparison of measured values with GAC values is presented in appendix I)

8 Chemical contamination (part C – Water Receptors)

8.9 Location and sensitivity of water receptors

8.9.1 Groundwater receptors

8.9.1.1 With reference to section 3.5, the following table summarises the environmental setting of the site with respect to groundwater receptors.

Table summarising criteria defining sensitivity of the site with respect to groundwater receptors

Criterion	Status
Aquifer potential	Major Aquifer within Upper Chalk
Abstractions	Closest 859m north west for Sewage Treatment works
Source protection zone	Remote from source protection zone
Fieldwork observations	Reasonably consistent deposit of permeable Kempton Park Gravels containing groundwater overlying impermeable London Clay

Table 8.9.1

Based on the above, although the site is considered to be a major aquifer, this is likely to refer to the Upper Chalk underlying the London Clay. The London Clay is considered to be effectively impermeable and thus we do not consider there to be a high risk of chemical contaminants migrating vertically into the major aquifer. However, in consideration of the high water table, we consider the site to be relatively sensitive to any chemical contamination affecting groundwater resources, and thus worthy of appropriate investigations to determine risks.

8.9.2 Surface water receptors

8.9.2.1 With reference to section 3.2, the following table summarises the environmental setting of the site with respect to surface water receptors.

Table summarising criteria defining sensitivity of the site with respect to surface water receptors

Criterion	Status
Location of surface watercourse	Channel of River Crane 75m south of site. Channel of the Duke of Northumberlands River 20 to 300m to the west of the site.
Abstractions	None within 2000m of the site
Fieldwork observations	Reasonably consistent deposits of reasonably permeable Kempton Park Gravel containing groundwater

Table 8.9.2

Based on the above, and in consideration of the close proximity of a watercourse in combination with the permeable nature of the near surface soils, we are of the opinion the site is sensitive to any chemical contamination affecting surface water resources, and thus worthy of investigations to establish risks.

8.10 Source assessment – Water receptors

8.10.1 The source of potential contaminants at the site has been established in section 8.7 above and summarised in table 8.7.2 which is repeated below. These sources each have a potential to affect ground / surface water receptors.

Table summarising results of source assessment			
Source	**Origin of information**	**Possible contaminant which could cause harm to humans / water receptors**	**Likely extent of contamination on site**
On site Hydrocarbon impacted soils	Fieldwork observations	Unknown and subject to testing	Around trial pit TP14 at 0.0-0.2m and TP09 at 0.1-0.2m depth
Table reference 8.7.2			

8.11 Pathway assessment – Water receptors

8.11.1 Groundwater receptors

8.11.1.1 Based on the sensitivity analysis described in section 8.9 above the site is considered relatively sensitive to any chemical contamination affecting groundwater resources. In addition, and with reference to section 3.5 above, the site is directly underlain by some 4 to 9m of Kempton Park Gravels comprising sands and gravels which exhibit some permeability and contains groundwater thus poses a risk of vertical migration of leachable contaminants to groundwater resources.

8.11.2 Surface water receptors

8.11.2.1 Based on the sensitivity analysis described in section 8.9 above the site is considered sensitive to any chemical contamination affecting Surface water resources. With the site being principally underlain with permeable deposits of Kempton Park Gravels which extend to the watercourses identified in table 8.9.2 above there is a feasible lateral migration pathway from the subject site to nearby watercourses.

8.12 Phase 1 Assessment and initial conceptual model relating to water receptors.

8.12.1 Based on sections 8.9 to 8.11 above we can produce the following initial conceptual model with respect to water resource receptors which requires on site investigation to produce a qualitative risk assessment.

Initial conceptual model		
Potential source origin	**Potential pathway**	**Water Receptors at risk**
On site Hydrocarbon impacted soils	Vertical and horizontal migration of hydrocarbons through permeable soils on site	Groundwater / surface waters
Table 8.12.1		

8.13 Testing regime – Water Receptors

8.13.1 With reference to CLR8 and in the absence of any knowledge of historical site uses which may have generated specific contamination and based on observations during our fieldwork activities, we have scheduled testing to measure the leachability / concentrations of inorganic contaminants listed in table 2.1 (of CLR8) where they are considered a risk to water resources. In addition, we have scheduled testing to include the common organic compounds forming polycyclic aromatic hydrocarbons (PAH).

8.13.2 It should be noted that we have only scheduled six water samples taken from each of the six deeper boreholes (where monitoring standpipes were installed) some 3 weeks after completion of drilling operations. These samples were scheduled for determination of concentrations of contaminants described in paragraph 8.13.1 above.

8.14 Assessment Criteria - Water Receptors

8.14.1 For interpretation of test data in relation to water receptors we have directly compared measured values with the Environmental Quality Standards (EQS) produced by the Environment Agency in their publication, 'Environment Agency technical advice to third parties on Pollution of Controlled Waters for Part 11A of the Environmental Protection Act 1990.

8.14.2 In the absence of EQS values we have adopted UK Drinking Water Standards published in the Water Supply (Water Quality) Regulations.

8.15 Evaluation test data – Water Receptors

8.15.1 Inorganic contaminants

8.15.1.1 Acceptable EQS values for freshwater is dictated by the hardness of the receiving watercourse. The hardness of water is a measure of the concentration of calcium carbonate in the water. Although we have not sampled water from nearby watercourses, we have contacted the Environment Agency and have been advised that there is some test data for hardness in the River Crane, which is an ultimate receiving watercourse from surface waters downstream of the site. We are advised that over a two year monitoring period, the River Crane produced an average hardness of 280mg/l at Duke of Northumberland's

River (downstream of the subject site). Using this information for List II substances (DOE Circular 7/89) we have added the EQS values relative to the hardness of the receiving watercourse to the above table assuming a worst case scenario of the watercourse supporting 'sensitive' aquatic life.

8.15.1.2 Based on this comparison the measured concentration of inorganic contaminants in six water samples taken across the college campus fall below the EQS values for the hardness of the receiving watercourse exceeding 250mg/l, and thus considered unlikely to pose a significant risk of causing significant harm to water resources.

8.15.2 Organic contaminants.

8.15.3.1 With respect to assessing Polycyclic aromatic hydrocarbons (PAH) concentrations, EQS have only been published for naphthalene. All measured concentrations of naphthalene fall well below the EQSvalue for this contaminant.

8.15.2.1 For analysis of measured concentrations of polycyclic aromatic hydrocarbon (PAH) contamination we have compared results with maximum allowable concentrations in the Water Supply (Water Quality) Regulations 2000 (UK Drinking Water Standards). There specified compounds forming the Polycyclic aromatic hydrocarbon 'suite' are

- Benzo(b)fluoranthene
- Benzo(k)fluoranthene
- Benzo(ghi)perylene
- Indeno(1,2,3-cd)pyrene

Summation of the measured concentration of these compounds should not exceed 0.1µg/l. The summed concentration of the PAH 'suite' measured on all of these specified compounds produced measured concentrations below detectable limits, and as such, the concentrations of PAH on water samples taken across the site as part of this suite of analysis, are not considered to pose a significant risk of causing significant harm to groundwater or off-site receptors.

8.15.4 Based on the above evaluation of test data from groundwater samples, the results indicate there unlikely to be a significant possibility of significant harm being caused to water resources from chemical contamination at the site. There are some hydrocarbon impacted soils observed in trial pits TP09 and TP14, which may have locally impacted ground waters in this area, but have not seemingly affected groundwater sampled in borehole BH04, located some 50m from these trail pits. At this stage we cannot confirm whether or not this hydrocarbon contamination is migrating into groundwater. There is therefore a potential risk to groundwater that requires further investigations to eliminate or quantify this risk and identify appropriate remedial action (if any)

8 Chemical contamination (Part D – Summary and Recommendations)

8.16 Phase 2 Assessment and conceptual model

8.16.1 By considering the sources, pathways and receptors reported in parts B and C of this report section an assessment of risks to human health, and water receptors is made with reference to the significance and degree of risk. This assessment is based on consideration of whether the source contamination can reach a receptor and hence whether it is of major or minor significance. As potential sources of contamination have been identified it is necessary evaluate the risks to each possible receptor. This is tabulated on the following page.

Risk Evaluation

Phase 2 updated conceptual model							
Condition status: Existing conditions							
Source	**Contaminant**	**Pathway**	**Receptor**	**Consequence of risk being realised.**	**Probability of risk being realised**	**Risk Classification**	**Risk management action taken**
Polycyclic aromatic Hydrocarbons (PAH) probably from ash containing soils	PAH	Direct contact Inhalation and ingestion of dusts	Future end users of the site and construction operatives	Medium	Likely	Moderate	• Introduction of hardstanding and building to sever pathway to receptors. Or • If landscaped, introduction of a capping layer (refer to paragraph 8.17 below) Or • Remove off site • Further investigations using hand dug trial pits in area of DTS05 to establish extent
Hydrocarbon impacted soils around TP09 and TP14	Hydrocarbons	Leaching to groundwater	Groundwater	Medium	Likely	Moderate	• Further investigations to eliminate or quantify risk to groundwater and remedial action, and determine extent of soil contamination.
Table reference 8.16.1.							

8.17 Remediation proposals

8.17.1 Based on the above some further investigations are recommended in the areas of TP14, TP09, and borehole DTS05, before a remedial strategy (if any) can be established. Recommendations for further investigations are provided in section 12.

8.18 Chemical contamination - Risk assessment in relation to use of infiltration systems

8.18.1 The permeability of the near surface Kempton Park Gravel in combination with the site located over a minor aquifer suggests the site is sensitive to migration of contaminants. We have carried out leachate testing of a suite of contaminants with our assessment provided in Section 8.15 above. Essentially, measured concentrations of leachable contaminants fall below EQS values for the local environment and on this basis the risk of infiltration systems promoting mobilisation of contaminants is considered unlikely except potentially in the areas around TP14, TP09 and DTS05, which would be more fully assessed based on the results of further investigations.

8.19 Chemical contamination – risk assessment summary and recommendations

8.19.1 Based on our assessments described above, we can provide the following summary and recommendations for each identified receptor.

8.19.2 End users

8.19.2.1 Elevated concentrations of benzo(a)pyrene were identified in one location (borehole DTS05) considered to be related to ash in the Made Ground. If this area is to be landscaped then we would recommend removal of soils which contain the ash type material or provision of a capping layer. The extent of the soils exhibiting elevated concentrations of benzo(a)pyrene, could potentially established by further on site investigations.

8.19.3 Construction operatives and other site investigators

8.19.3.1 The risk of damage to health of construction operatives and other site investigators is, in our opinion, low (given the concentration and seemingly isolated locations of identified contamination, and the relatively short exposure times) and would be minimised by taking adequate hygiene precautions on site. Such precautions would be:-

- Wearing protective clothing particularly gloves to minimise ingestion from soil contaminated hands.
- Avoiding dust by dampening the soils during the works.

- Wearing masks if processing produce dust.

Guidance on safe working practices can be obtained from the following documents

- The Health and Safety Executive Publication *"Protection of Workers and the General Public during the Development of Contaminated Land"* (HMSO) and
- *"A Guide to Safer Working on Contaminated Sites"* (CIRIA Report 132).

In addition, reference should be made to the Health and Safety Executive. In all cases work shall be undertaken following the requirements of the Health and Safety at Work Act 1974 and regulations made under the Act including the COSHH regulations.

If during the course of excavations hydrocarbon type odours become evident we recommend works are halted, and the air quality measured to determine if the excavation can be safely entered. If the air quality is unacceptable then appropriate personal protective equipment, will be required for human entry into the excavation. If elevated concentrations of airborne hydrocarbons / vapours are detected on site, we recommend Soiltechnics are advised to determine an appropriate course of action with respect to building construction.

8.19.4 Off Site Receptors

8.19.4.1 Although groundwater samples taken from six boreholes across the campus did not indicate any evidence of significant chemical contamination, we have identified hydrocarbon impacted soils in two locations which are remote from borehole water sampling locations. At this stage, we recommend further sampling and laboratory testing in the vicinity of the contamination to eliminate or quantify the risk to groundwater.

8.20 Statement with respect to PPS23 annex 2

8.20.1 With reference to paragraph 8.1.4 above we consider investigations completed to date, and providing the recommendations described above are satisfactorily completed, then we are of the opinion the proposed development (subject to the results of further localised investigations) can be made safe and suitable for use for the purpose for which it is intended, thus meeting the requirements of Planning and Policy Statement 23 (PPS23) '*Planning and pollution control – Annex 2 – Development on land affected by contamination*' , and compliant with the Building Regulations Part C, '*Site preparation and resistance to contaminants and moisture*'.

8.21 On Site Monitoring

8.21.1 We have attempted to identify the potential for chemical contamination on the site, however, areas, which have not been investigated at this stage, may exhibit higher levels of contamination. If such areas are exposed at any time during construction we recommend investigation and testing be carried out accordingly.

SECTION 9 – CONTENTS

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9 Gaseous contamination

9.1 Legislative framework

9.1.1 There is currently a complex mix of documentation relating to legislative and regulatory procedures on the issue of contamination, and it is not considered a purpose of this report to discuss the detail of these regulations. Essentially, Government Policy is based on *'suitable for use approach'*, which is relevant to both the current and proposed future use of land. For current use Part IIA of the Environmental Protection Act 1990 provides the regulatory regime (see section 8.1 above). The presence of harmful soil gasses could provide a 'source' in a 'pollutant linkage' allowing the regulator (local authority or Environment Agency) to determine if there is a significant possibility of harm being caused to humans, buildings or the environment. Under such circumstances the regulator would determine the land as 'contaminated' under the provision of the Act requiring the remediation process to be implemented.

9.1.2 With regards to planned future use, Planning and Policy statement 23 (PPS23) requires developers to undertake appropriate risk assessments to demonstrate to the local planning authority that proposals adequately mitigate any potential hazards associated with ground contamination including soil gas. The Town and Country Planning (General Development Procedure) Order 1995, requires the planning authority to consult with the Environment Agency before granting planning permission for development on land within 250metres of land which is being used for deposit of waste, (or has been at any time in the last 30 years) or has been notified to the planning authority for the purposes of that provision

9.1.3 Building control bodies enforce compliance with the Building Regulations. Practical guidance is provided in Approved documents, one of which is Part C, '*Site preparation and resistance to contaminants and moisture*' which seeks to protect the health, safety and welfare of people in and around buildings, and includes requirements for protection against harm from soil gas.

9.2 General

9.2.1 The following assessment relates to the potential for, and the effects of, gasses generated by biodegradable matter. A separate, but related class of problem involves migration of vapour phase of hydrocarbons resulting from spillages of petroleum and solvents, but this is addressed under organic contamination in section 7 above. The potential for the development to be affected by Radon Gas is considered in Section 3 above. The principal ground gasses are carbon dioxide (CO_2) and methane (CH_4). The following table provides a summary of the effects of these gases when mixed with air.

Significant Gas concentrations in air		
Gas	**Concentration by volume**	**Consequence**
Methane	0.25% 5% 30%	Ventilation required in confined spaces Potentially explosive when mixed with air Asphyxiation
Carbon Dioxide	0.5% 1.5% >3%	8 hour exposure limit (WEL) (HSE) 15 min exposure limit (WEL) Breathing difficulties

Table.9.1

9.2.2 Following the current Building Regulations Approved Document C1, Section 2 '*Resistance to Contaminates*' (2004) a risk assessment approach is required in relation to gaseous contamination based on the source-pathway-receptor conceptual model procedure. We have adopted procedures described in the following reference documents for investigation and assessments of risk of the development being affected by landfill type gases and if appropriate the identification of mitigation measures.

- BS8485: 2007 '*British Standard Code of practice for the characterisation and remediation from ground gas in affected developments*'
- CIRIA Report C665 '*Assessing risks posed by hazardous ground gases to buildings*' (2007).

9.2.3 An assessment of the risk of the site being affected by ground gases is based on the following aspects.

a) Source of the gas
b) Investigation information
c) Migration feasibility
d) Sensitivity of the development and its location relative to the source

9.3 Assessment of source of gases

9.3.1 General sources

9.3.1.1 The following table summarises the source of gasses and parameters for producing gasses

Source and control of gasses	
Type	**Parameters affecting the rate of gassing**
Landfills	Portion of biodegradable material, rate reduces with time.
Mineworkings	Flooding reduces rate of gassing
Docksilt	Portion of organic matter
Carbonate deposits	Ground / rainwater (acidic) reacts with some carbonates to produce carbon dioxide.
Soils / rocks	Portion of organic matter

Table 9.3.1

The rate of decomposition in gas production is also related to atmospheric conditions, pH, temperature, and water content / infiltration.

9.3.1.2 As the site is not within a dockland environment, or area affected by mineworkings, and near surface soils do not exhibit high carbonate content, then potential gas sources are limited to landfills and /or soils with a high proportion of organic matter.

9.3.2 Landfill sources

9.3.2.1 Waste Management Paper 27 (1991) produced by the Department of the Environment *'Control of Landfill Gases'* contains the strong recommendation to avoid building within 50m of a new landfill site and to carry out site investigations within a zone 250m beyond the boundary of a landfill site. No distinction is made between sites of differing ground conditions, but the paper does not advocate the site is safe beyond the 250m zone, dependant, of course, upon the type of landfill and potential for migration of landfill gasses.

9.3.2.2 Envirocheck reports five historical landfill sites within 1000m of the subject site all located in the north, north west and north east of the site. The closest is recorded to be 339m north east of the site. Records indicate the sites were licensed for receipt of wastes which included inert and industrial wastes with the exception of the historical landfill site furthest from the site. Such materials are unlikely to generate any significant quantities of landfill type gasses however we cannot confirm that these were licensed for the receipt of these wastes exclusively. There is no record of the type of backfill material used to restore the historical landfill located 893m north east of the site.

9.3.2.3 In addition, inspection of old Ordnance Survey maps indicates some localised quarrying activities 539m and 740m to the north east of the site, this is concurrent with the closest recorded historical landfill sites. Operations have now ceased and more recent OS maps indicate they have been restored and subsequently developed with buildings recorded in the locations. We have no records of the type of fills used to restore these former workings however the record of the historical landfill site in this location specifies the waste to include inert waste. We cannot conclude from this that the wastes used to restore these workings and historical landfill sites were exclusively inert and industrial waste therefore on this basis, consider there to be a risk of a potential source of landfill gasses in the area worthy of further consideration.

9.3.3 Soil conditions

9.3.3.1 None of the soils observed in exploratory excavations, in our opinion exhibit significant concentrations of organic matter, which are likely to produce significant quantities of carbon dioxide and / or methane gas.

9.3.3.2 Based on an assessment of 'deep' geological conditions we are of the opinion that it is unlikely that the subject site would be affected by significant quantities of carbon dioxide and methane generated by soils/rocks at depth.

9.3.4 Source assessment summary

9.3.4.1 The following table summarises the possibility of a source of landfill type gasses.

Source assessment summary

Potential source origin	Viability of source	Evidence
Landfills	Possible	Desk study information Historical landfill sites and restored opencast quarries – closest 339m north east of site
Mineworkings	Unlikely	Desk Study information Geological conditions not amenable
Dock silt	Unlikely	Site remote from dockland environment
Carbonate deposits	Unlikely	Recorded and observed soil conditions do not indicate high concentrations of carbonates
Soils / rocks	Unlikely	Soils exposed in exploratory excavations do not exhibit high concentrations of organic matter

Table 9.3.4

9.3.4.2 Based on the above it there is a possibility of a source of potential landfill gasses which may affect the subject site. On this basis, it is considered necessary to consider possible pathways for migration of ground gasses, from this potential source to the site.

9.4 Gas migration

9.4.1 Exploratory excavations encountered a reasonably consistent deposit of Kempton Park Gravel to depths of between 4-9m, which in our opinion are relatively permeable and would provide little resistance to lateral migration of landfill type gasses. In addition, based on published geological records the Kempton Park Gravel extends from the subject site to the historical landfill sites and former quarry. On this basis it is considered possible that the potential source of landfill type gasses (identified in section 9.2 above) would feasibly migrate to the subject site.

9.5 Conceptual model

9.5.1 Based on the above, there is a potential source of landfill type gases, and a feasible migration pathway to the site via potentially permeable Kempton Park Gravels. Our conceptual model is tabled below. On this evidence we are of the opinion that the site is at risk of being affected by ground gasses (carbon dioxide / methane) sufficient to potentially cause harm to human end users of the site, construction operatives or indeed buildings. On this basis, we have installed monitoring standpipes in boreholes, and implemented a monitoring regime, generally following procedures described in CIRIA report C665, to quantify the risk, and if appropriate, identify mitigation measures.

Conceptual model		
Potential source origin	**Potential pathway**	**Receptors at risk**
Landfills Historical landfill sites, closest 339m north east of site	Via Kempton Park Gravels	• End users • Construction operatives • Buildings

Table 9.5.1

9.6 Development Categorisation

9.6.1 With reference to BS 8485:2007 (table 2), the proposed development would be classified as *'Public building (which includes managed apartments, schools and hospitals)'*.

9.7 Initial Monitoring observations.

9.7.1 Six standpipes have been installed at the site to depths between 4m and 6m (refer Drawing STE1297R-06). Following CIRIA Report C665 (tables 5.5a, and 5.4b) we have provisionally assessed the site as moderate risk of generation potential of source ideally requiring 6 monitoring visits over a 3 month period. This initial assessment will be reviewed pending the results of further monitoring observations.

9.7.2 We have returned to site for two of the six proposed monitoring visits to obtain measurements of landfill type gases at atmospheric conditions in the range of 1003 to 1013mb and temperatures in the range of 16°C to 18°C. Our observations/measurements to date are recorded in

Appendix K. Essentially we did not detect any methane but concentrations of carbon dioxide measured in the range of 0.1 to 6.1%. If flows were detected during our monitoring visits then these are recorded, but where no flow is detected then, following BS8485:2007, we have assumed flow at the detection limit of the monitoring equipment at 0.1l/s.

9.8 Interim classification of site characteristic gas situation.

9.8.1 Using test data obtained to date, and with reference to table 1 of BS8485:2007, the site would be classified as characteristic gas situation two. Clearly this is an interim classification based on observations to date and can only be confirmed following additional monitoring visits. It should be noted however, that there is a significant possibility of higher flow measurements being recorded during low atmospheric conditions, which may increase the classification of the site requiring more onerous gas protective measures.

9.9 Interim assessment of gas protective measures.

9.9.1 Based on monitoring observations to date, development categorisation (section 8.6 above), and the interim site characteristic gas situation (section 8.8 above) and with reference to table 2 of BS8485:2007, the development requires gas protective measures which would achieve a '*solution score*' of 3. Lists of protective measures which each produce a score value are produced in table 3 of BS8485:2007. A copy of table 3 is presented as Appendix B. Clearly this is an interim assessment based on observations to date and can only be confirmed following additional monitoring visits. It should be noted however, that there is a significant possibility of higher flow measurements being recorded during low atmospheric conditions, which may increase the classification of the site requiring more onerous gas protective measures.

9.11 Effect of gasses on existing buildings

9.11.1 With respect to any existing buildings that may remain, we do not know if gas protection has been installed, and unless it can be demonstrated that appropriate levels of protection are available, we recommend gas monitoring is carried out within the building to determine if there is a problem, and if necessary, install protection using active venting systems. We can carry out such investigations on further instructions.

9.12 Gas protective measures - construction operatives

9.12.1 Areas near landfill sites, underground coal strata or in carbonate rich deposits (such as limestone and chalk) have the potential to generate both harmfully low oxygen levels and high carbon dioxide levels in confined spaces. The assessment for such situations may therefore require using gas monitors to warn of significant leaks of gas into confined spaces to minimise the risks associated with an oxygen-deficient atmosphere which could lead to asphyxiation, and/or a toxic atmosphere due to high levels of carbon dioxide.

9.12.2 During construction, we recommend any excavations/confined spaces are well ventilated and human entry is avoided. The Workplace Exposure Limits (WELs) for carbon dioxide are 5000 parts per million (ppm by volume), which is equivalent to 0.5%, for the 8-hour time-weighted average (TWA); and 15000 ppm (1.5%) for the 15-minute short-term exposure limit (STEL). Typically, oxygen deficiency alarms on gas detectors are set at 19% volume ratio (v/v). Normal air contains 20.9% oxygen. Therefore should human entry be necessary then we recommend excavations/confined spaces are monitored over short- and long-term exposure periods for both oxygen and carbon dioxide gases prior to entry to ensure levels are within acceptable concentrations or suitable breathing equipment adopted.

9.12.3 We recommend further reference is made to the following documents to minimise the risks to construction workers from ground gases:

- Health and Safety Executive Publication *"Protection of Workers and the General Public during the Development of Contaminated Land"* (HMSO)
- *"A Guide to Safer Working on Contaminated Sites"* (CIRIA Report 132)
- Health and Safety Executive Publication EH40/2005 *"Workplace Exposure Limits"*

9.13 Statement with respect to PPS 23 annex 2

9.13.1 With reference to paragraph 9.9 above, and subject to completion of further monitoring which is likely to indicate some measures to protect buildings against ingress of landfill type gasses, then we are of the opinion the proposed development can be made safe and suitable for use for the purpose for which it is intended, thus meeting the requirements of Planning and Policy Statement 23 (PPS23) '*Planning and pollution control – Annex 2 – Development on land affected by contamination*' , and compliant with the Building Regulations Part C, '*Site preparation and resistance to contaminants and moisture*'.

SECTION 10 – CONTENTS

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10 Effects of ground conditions on building materials.

10.1 General

10.1.1 Building materials are often subjected to aggressive environments which cause them to undergo chemical or physical changes. These changes may result in loss of strength or other properties that may put at risk their structure integrity or ability to perform to design requirements. Aggressive conditions include:-

-
- Severe climates
- Coastal conditions
- Polluted atmospheres
- Aggressive ground conditions

This report section only considers aggressive ground conditions, with other items considered outside our brief and scope of investigations.

10.1.2 In aggressive ground conditions, the potential for contaminant attack depends on the following:-

- The presence of water as a carrier of chemical contaminants, (except free phase organic contamination)
- The availability of the contaminant in terms of solubility, concentration and replenishment rate
- Contact between the contaminant and the building material
- The nature of the building materials and its capability of being attacked by contaminants

In general the thicker the building material the less likelihood there is for contaminant attack to cause damage to the integrity of the structure.

10.2 Reference Documents

10.2.1 Following the Environment Agency publication *'Model Procedures for the Management of Land Contamination'* (Contaminated Land Report 11) the following documents have been referred to in production of the following report paragraphs.

- *'Performance of Building Materials in Contaminated Land'* report BR255 (Building Research Establishment 1994).
- *'Risks of Contaminated Land to Buildings, Building Materials and Services. A Literature Review'* - Technical Report P331 (Environment Agency 2000).

- *'Guidance on assessing and managing risks to buildings from land contamination'* - Technical Report P5 035/TR/01).

- Building Regulations Approved document C - site preparation and resistance to contaminants and moisture (Office of the Deputy Prime Minister, 2004).

- *'Concrete in aggressive ground'* Special Digest 1: 2005 (Building Research Establishment).

10.3 Hazard Identification and Assessment

10.3.1 The identification of hazards is based on the findings of this investigation primarily relating to former land uses (potential for chemical contamination, and likely type of contamination) and laboratory determination of concentration of chemical contaminants. Clearly, the scope of laboratory testing is determined with respect to former land uses, contaminants which may cause harm to human health and water resources, based on CLR 8 *'Potential contaminants for the Assessment of Contaminated Land'*.

10.3.2 Based on the above, the scope of our testing regime is described in Sections 8b (human receptors) and 8c (water receptors). We have utilised this test data in production of the following risk assessments in relation to building materials, in conjunction with test data targeting the effects of chemical attack on concrete in contact with the ground, as described in BRE Special Digest 1.

10.3.3 The identification of hazards from contamination and subsequent assessment of risks is based on the following:-

- The contaminants present on site.

- The nature of the contaminant (i.e. calcium sulphate is much less soluble than sodium or magnesium sulphate and is, therefore, less of a concern with regards sulphate attack).

- The concentration of contaminants - in general the higher the concentration the greater the hazard.

- The solubility of the contaminants - contaminants which are not soluble will not generally react with materials.

- The permeability of the soils - i.e. case by which fluids can transport contaminants to the building.

10.3.4 The process of risk assessment for building materials is concerned with identification of the hazard (contaminants at the site - a source) and subsequently how the contaminants can reach the building (pathway) and how they can react with the building (receptor). Thus the risk assessment is produced based on the source - pathway - receptor model.

10.4 Provision of test data to specifiers/manufacturer/installer

10.4.1 The following risk assessments are based on current published data. We strongly recommend, however, that information gained from this investigation are provided to specifiers/manufacturers/installers of building materials/service ducts/apparatus who may have more up to date research to confirm the ability of the product to resist the effects of chemical contaminants at the site for the desired lifespan of the product.

10.5 Risks Assessments for Individual Building Materials

10.5.1 The following/typical sections contain risk assessments for various building materials likely to be incorporated in developments. Other materials which we are not aware of may also be used in developments and in contact with the ground and, therefore, recommend the suppliers are consulted with respect to ground conditions at this site and their opinion sought as to the ability of the product to resist chemical conditions determined at the site.

10.6 Concrete - General Mechanisms of Attack

10.6.1 There are a number of mechanisms by which contaminants attack concrete including the following:-

- Hydrolysis of the hardened concrete.
- Degradation as a result of exchange reactions between calcium in calcium hydroxide (free lime hydrate) and ions in aggressive solutions.
- Expansive reactions as a result of chemical reaction or salt crystallisation.

10.7 Concrete - Sulphate Attack

10.7.1 Hazard

10.7.1.1 Sulphate attack on concrete is characterised by expansion, leading to loss of strength, cracking, spalling and eventual disintegration. There are three principal forms of sulphate attack, as follows:-

- Formation of gypsum through reaction of calcium hydroxide and sulphate ions.

- Ettringite formation through reaction of tricalcium alluminate and sulphite irons.

- Thaumasite formation as a result of reactions between calcium silicate hydrates, carbonate ions (from aggregates) and sulphate ions.

10.7.2 Assessment

10.7.2.1 The hazard of sulphide attack is addressed by reference to procedures described in Building Research Establishment (BRE) Special Digest 1: 2005 '*Concrete in Aggressive Ground*' to establish a design sulphate class (DS) and the '*aggressive Chemical Environment for Concrete*' (ACEC). These procedures have been followed during our investigation and are described in the following paragraphs.

10.7.3 Desk Study Information

10.7.3.1 The first step in the procedure is to consider specific elements of the desk study. These are tabulated below.

Element	Interrogation	Outcome	SD1: 2005 reference
Geology	Likelihood of soils containing pyrites		Box C6
	Kempton Park Gravel	Unlikely	
	London Clay	Likely	
Past industrial uses	Brownfield site?	Yes	C2.1.2

Table 10.7

A brownfield site is defined in SD1: 2005 as a site, or part of a site which has been subject to industrial development, storage of chemicals (including for agricultural use) or deposition of waste, and which may contain aggressive chemicals in residual surface materials, or in ground penetrated by leachates. Where the history of the site is not known, it should be treated as brownfield until there is evidence to classify it as natural.

10.7.3.2 For spread type foundations which will extend into the Kempton Park Gravels and based on the above it is necessary to follow the procedures described in figure C8 ('*locations on brownfield sites except where soils may contain pyrite*').

10.7.3.2 For a piled foundation solution which will extend into the London Clay and based on the above it is necessary to follow the procedures described in Section C5.1.4 ('*Brownfield locations that contain pyrite*').

10.7.4 Assessment of Design Sulphate Class

10.7.4.1 For spread type foundations which will extend into the Kempton Park Gravel.

10.7.4.1.1 The sulphate concentration in a 2:1 water/soil extract was measured on 13 soil samples and 2 groundwater samples the mean of the 3 highest sulphate results from soil samples was calculated at 1110mg/l (characteristic value). On this basis and with reference to table C2 of SD1I: 2005, the design sulphate class is **DS-2**.

10.7.4.1.2 The concentration of sulphate was measured at less than 3000mg/l and thus the concentration of magnesium was not measured.

10.7.4.2 For piled type foundations which will extend into the London Clay

10.7.4.2.1 The sulphate concentration in a 2:1 water/soil extract was measured on 18 soil samples and two groundwater samples the mean of the 3 highest sulphate results from soil samples was calculated at 846mg/l (characteristic value). On this basis and with reference to table C2 of SD1l: 2005, the design sulphate class is **DS -2**.

10.7.4.2.2 We assume foundations will not be in contact with disturbed ground (as defined in BRE SD:1). We, therefore, have not considered Oxidisable Sulphates or Total Potential Sulphate content. On this basis and with reference to SD1: 2005, derived design sulphate class is **DS-2**.

10.7.5 Assessment of groundwater mobility

10.7.5.1 With reference to SD1: 2005, Section C3.2, we are of the opinion that ground and site characteristics suggest 'mobile groundwater' conditions.

10.7.6 Assessment of pH

10.7.6.1 Following SD1: 2005, Section C5.1.1 (step 4) the characteristic value of pH is 5.9, derived by taking the mean of the lowest 3 of the pH results.

10.7.6.2 None of the measured pH values were below 5.5, thus the concentration of chlorides and nitrates was not measured.

10.7.7 Assessment of Aggressive Chemical Environment for Concrete (ACEC)

10.7.7.1 Based on the design sulphate class, characteristic value of pH and assessment of groundwater mobility, and with reference to table C2 of SDI: 2005, we are of the opinion that the ACEC class for a pad foundation solution is **AC-3z** and for a piled foundation solution is also **AC-3z**

10.8 Concrete - Chloride Attack

10.8.1 Hazards

10.8.1.1 There are a number of ways in which chlorides can react with hydrated cement compounds in concrete. These are as follows:-

- Chlorides react with calcium hydroxide in the cement binder to form soluble calcium chloride. This reaction increases the permeability of the concrete reducing its durability.

- Calcium and magnesium chlorides can react with calcium aluminate hydrates to form chloroaluminates which result in low to medium expansion of the concrete.

- If concrete is subject to wetting and drying cycles caused by groundwater fluctuations, salt crystallisation can form in concrete pores. If pressure produced by crystal growth is greater than the tensile strength of the concrete, the concrete will crack and eventually disintegrate.

10.8.2 Risk Assessment

10.8.2.1 Chlorides of sodium, potassium, and calcium are generally regarded as being non-aggressive towards mass concrete; indeed brine containers used in salt mines have been known to be serviceable after 20 years service. Depending upon the type of concrete, and the cement used up to 0.4% chloride is allowed in BS8110: Part 1.

10.8.2.2 In view of the past use of the site we consider the likelihood of elevated concentrations of chlorides in the ground is not likely to occur and on this basis have not specifically measured concentrations of chlorides and, in our opinion, the risk of buried concrete being affected by chlorides is considered low.

10.9 Concrete - Acid Attack

10.9.1 Hazards

10.9.1.1 Concrete being an alkaline material is vulnerable to attack by acids. Prolonged exposure of concrete structures to acidic solutions can result in complete disintegration.

10.9.2 Risk Assessment

10.9.2.1 The rate of acid attack on concrete depends upon the following:-

- The type of acid
- The acid concentration (pH)
- The composition of the concrete (cement/aggregate)
- The soil permeability
- Groundwater movement

British Standard BS8110: Part 1 classifies extreme environment as one where concrete is exposed to flowing groundwater that has a pH<4.5. The standard also warns that Portland Cement is not suitable for acidic conditions with a pH of 5.5 or lower.

10.9.2.2 The pH of the soil/groundwater was measured exceeding 5.5 and on this basis the risk of concrete being affected by acidic conditions is considered low.

10.10 Concrete - Magnesium Attack

10.10.1 Hazards

10.10.1.1 Magnesium salts (excepting magnesium hydrogen carbonate) are destructive to concrete. Corrosion of concrete occurs from cation exchange reactions where calcium in the cement paste hydrates and is replaced with magnesium. The cement looses binding power and eventually the concrete disintegrates.

10.10.2 Risk Assessment

10.10.2.1 In practise 'high' concentrations of magnesium will be found in the UK only in ground having industrial residues. Following BRE Special Digest 1:2005, measurement of the concentration of magnesium is recommended if sulphate concentrations in water extract or groundwater exceed 3000mg/l. Once measured the concentration of magnesium is considered further in BRE Special Digest in establishing the concrete mix to resist chemical attack.

10.10.2.2 We are not aware the site has been subject to any manufacturing processes which would have included magnesium containing compounds, and in addition sulphate concentrations did not exceed 3000mg/l, on this basis we have not measured the concentration of magnesium in soils at the site, and would consider the risk of soils at the site promoting attack on concrete is considered low.

10.10.2.3 BS EN 206-1:2000 *'Concrete - Part 1: Specification, performance, production and conformity'* does, however, provide exposure classes for concrete in contact with water, with varying concentrations of magnesium for the design/specification for concrete mixes. As there is a possibility that concrete for the building may be in contact with groundwater during its life, then we have measured the concentration of magnesium in groundwater samples.

10.10.2.4 We have measured the concentration of magnesium in two groundwater samples from the site which produced results of 11mg/l and 14mg/l. This result falls well below the criteria for the exposure classes as outlined in Table 1 of BS EN206-1:2000. Sulphate concentrations in water samples produced a result in the range of >200 but <600 thus indicating an exposure class of XA1

10.11 Concrete - Ammonium Attack

10.11.1 Hazards

10.11.1.1 Ammonium salts, like magnesium salts act as weak acids and attack hardened concrete paste resulting in softening and gradual decrease in strength of the concrete.

10.11.2 Risk Assessment

10.11.2.1 UK guidance is not available on the concentration of ammonium which may affect concrete. BS EN 206-1: 2000 *'Concrete - Part 1: Specification, performance, production and conformity'* does, however, provide exposure classes for concrete in contact with water with varying concentrations of ammonia for the design/specification for concrete mixes.

10.11.2.2 We have measured the concentration of ammonia in two groundwater samples at the site, and there is a potential possibility that concrete for the building may be in contact with groundwater during its life. The concentrations of ammonia were measured at 0.13mg/l and 0.22mg/l. This result falls well below the criteria for the exposure classes as outlined in Table 1 of BS EN206-1:2000. Sulphate concentrations in water samples produced a result in the range of >200 but <600 thus indicating an exposure class of XA1

10.12 Concrete Blocks

10.12.1 Hazards

10.12.1.1 Precast aggregate concrete blocks and autoclaved aerated concrete blocks are commonly used in the construction of shallow foundations. Concrete blocks are potentially attacked by the same contaminants and ground conditions which affect dense concrete.

10.12.2 Risk Assessment

10.12.2.1 In general, the mechanism of attack on concrete blocks is the same for hardened concrete. We recommend parameters for ground conditions for concrete described in the preceding paragraphs for concrete blockwork in contact with the ground/groundwater and the blockwork manufacturers confirmation sought for applicability of their product.

10.13 Clay Bricks/Pipes

10.13.1 Clay Bricks are highly durable materials which have been used in buildings for many centuries. Fire clay pipe material can also be considered similarly resistant to contaminants.

10.13.2 Hazards

10.13.2.1 Dissolution of clay brick in a potentially serious cause of deterioration. The extent of dissolution depends upon the solubility of the glassy material (produced by firing of the clay) contained in the brick. The acidic nature of the glass phase will produce low solubility in a neutral and acidic environment, but can be soluble in a basic environment.

10.13.2.2 A potentially more serious hazard for brickwork is the crystallisation of soluble salts within the brick pore structure. Salts are transported by water to the interior of the brick originating from the external environment or by rehydration, however, are only likely to occur when there is a gradient from a wet interior to a drying surface. The potential, therefore, for salt crystallisation in the ground is, therefore, low.

10.13.3 Risk Assessment

10.13.3.1 There seems to be little published information as regards the resistance to clay bricks/pipes in aggressive ground conditions, however, clay bricks are generally considered very durable. As no significant concentrations of chemical contaminants have been identified at this site in combination with near neutral pH conditions it is considered unlikely that ground conditions are sufficiently aggressive to cause damage to brickwork/clay pipes.

10.13.3.2 Some basic guidance is provided in BS5628-3: 2005 *'Code of Practice for the Use of Masonry - Part 3: Materials and components, design and workmanship'* with regards to resistance of masonry to resist the effects of sulphate attack.

10.14 Mortar

10.14.1 Mortars are based on building sands mixed with cement and/or lime as a binder. In the UK Portland cements and masonry cement are commonly used. Masonry cements are a mixture of Portland Cements and fine mineral filler (i.e. Limestone) with an air entraining agent.

10.14.2 Hazards

10.14.2.1 Mortar is subject to the same agents for deterioration as concrete with the major cause of deterioration being sulphate attack.

10.14.3 Risk Assessment

10.14.3.1 Sulphates can originate from soils/groundwater or from the bricks themselves. Calcium, magnesium, sodium and potassium sulphates are present in almost all fired-clay bricks. Water can dissolve a fraction of these sulphates and transport them to the mortar.

10.14.3.2 Currently, we are not aware of any guidance on the resistance of mortars to sulphate attack. The Building Research Establishment report that the sulphate resistance of mortar was improved by the use of sulphate resisting Portland cements and lime. Some guidance is also provided in BS5628-3: 2005 *'Code of Practice for the use of Masonry - Part 3: Materials and components, design and workmanship'*.

10.14.3.2 Based on ground conditions determined at the site the risk of significant sulphate attack on mortars (Based on testing/analysis of sulphates in relation to concrete - refer Section 10.7) is considered low.

10.15 Metals - general

10.15.1 There are a number of metals which are used in buildings either as piles, services, non structural and, indeed, structural components. The most common metals used in buildings are steel, stainless steel, copper, lead, zinc, aluminium and cast iron. All these metals can deteriorate through corrosion process. Corrosion can affect metals in a variety of ways depending upon the nature of the metal and the environment to which it is subjected. In most common forms of corrosion are:-

- Electrochemical - the most common form of corrosion in an aqueous solution
- Chemical corrosion - occurs when there is a direct charge transfer between the metal and the attacking medium (examples are oxidation, attack by acids, alkalis and organic solvents)
- Microbial induced corrosion

10.16 Metals - Cast Iron

10.16.1 Cast iron is a term to describe ferrous metals containing more than 1.7% carbon and is used extensively in the manufacture of pipes.

10.16.2 Hazards

10.16.2.1 Generally, cast iron has a good resistance to corrosion by soils, however, corrosion can occur due to the following mechanisms:-

1) Generation of large scale galvanic cells caused by differences in salt concentrations, oxygen availability or presence of stray electrical currents.

2) Hydrochloric acid will cause corrosion at any concentration and temperature. Dilute sulphuric, nitric and phosphoric acids are also aggressive as also are well aerated organic acids.

10.16.3 Risk Assessment

10.16.3.1 Testing can be carried out on site to measure the resistivity and redox potential of soils which can assist in deriving recommendations for protection of cast iron components using coatings, burial trenches, or isolation techniques. Currently, however, there is no specific guidance and we recommend advice is sought from manufacturers.

10.16.3.2 Guidelines produced by the Water Research Centre (WRc) on the use of ductile iron pipes, state that highly acidic soils (pH <5) are corrosive to cast iron pipe even when protected by a zinc coating or polythene sleeving. WRc also indicate that groundwater containing >300ppm chloride may corrode even protected cast iron pipes.

10.16.3.3 On the basis that the pH of soils at the site are not less than 5, and groundwater is unlikely to be in contact with cast iron elements, then the risk of ductile cast iron pipes being affected by acid/chloride attack is considered low. We have not carried out any redox/resistivity testing (considered outside our brief) and thus we cannot comment further with regards to the risks of galvanic action.

10.17 Metals - Steel Piles

10.17.1 Hazards

10.17.1.1 The corrosion of steel requires the presence of both oxygen and water. In undisturbed natural soils the amount of corrosion of driven steel piles is generally small. In disturbed soils (made ground) however, corrosion rates can be high and normally twice as high as those for undisturbed natural soils.

10.17.2 Risk Assessment

10.17.2.1 Guidance on the use of steel piles in different environments is provided in British Steel's piling handbook which includes calculating the effective life of steel piles. There is no specific guidance, however, for contaminated soils in this publication. Coatings can be provided to the pile surface but experience has shown that some coatings can be damaged during driving, particularly in ground which can contain hard materials such as brick/concrete/stone.

10.18 Metals - Stainless Steel

10.18.1 Hazards

10.18.1.1 Stainless steel is used in a number of building components including services, pipework, reinforcement bars and wall ties. There is little knowledge, however, of the performance of stainless steel in aggressive environments.

10.18.2 Risk Assessment

10.18.2.1 Stainless steel can withstand pH of 6.5 to 8.5, but the chlorine content of a soil increases the risk of corrosion. At concentrations of 200mg/l type 304 stainless steel can be used, but for concentrations of 200 to 1000mg/l type 316 should be used in preference to type 304, but for concentrations greater than 1000mg/l type 316 should always be used.

10.18.2.2 At this site the pH of the soils was generally near neutral (within the range of 6.5 to 8.5) and it is considered unlikely that groundwater will be in contact with stainless steel components (unless we are advised otherwise) thus the risk of ground conditions at the site affecting stainless steel is considered low.

10.19 Metals - Galvanised Steel

10.19.1 Hazards

10.19.1.1 Galvanising steel is a means of protecting steel from aggressive environments, however, zinc galvanising can be corroded by salts and acids.

10.19.2 Risk Assessment/Remedial Action

10.19.2.1 There is no current specific guidance on the effects of aggressive ground conditions on galvanised steel, however, some research indicates zinc alloys are generally more resistant than pure zinc coatings in aggressive conditions.

10.20 Metals - Copper

10.20.1 Hazards

10.20.1.1 Copper is commonly used for gas and water supplies. Copper is generally resistant to corrosion in most natural environments, but in contaminated ground copper can be subject to corrosion by acids, sulphates, chlorides and ground containing cinders/ash. Wet peat (pH 4.6) and acid clays (pH 4.2) are considered aggressive conditions to promote corrosion to copper.

10.20.2 Risk Assessment

10.20.2.1 There is no specific published guidance on what constitutes aggressive conditions to copper except very acid/peaty conditions.

10.20.2.2 Although there are no significantly acidic or peaty conditions at the site, there are significant concentrations of ash/cinders in come areas of the site which may lead to the risk of corrosion. We recommend manufacturers are consulted possibly to provide a coating to the pipe or possibly installation of the pipe in a trench with clean backfill.

10.21 Metals - Lead

10.21.1 Hazards

10.21.1.1 Lead is used in tanking, flashings, damp proof courses, etc. Lead is a durable material which is resistant to corrosion in most environments. Lead damp proof courses can be subject to attach from the lime released by Portland Cement based mortar and concrete. In the presence of moisture, a slow corrosive attack is initiated on lead sheet. In such cases a thick coat of bitumen should be used to protect the lead damp proof course.

10.21.2 Risk Assessment

10.21.2.1 There is no current guidance on the performance of lead in contact with contaminated soils, however, acids and alkalis (lime) could be aggressive towards lead.

10.21.2.2 At the site pH conditions are not considered significantly extreme and this it is considered unlikely that ground conditions at the site would significantly affect lead.

10.22 Plastics - general

10.22.1 The range of plastics in construction is wide and increasing. The deterioration of plastics varies with the individual material and the environment to which it is exposed. In general, plastics deteriorate through degradation of their polymer constituent, but loss of plasticizer and other additives can render plastics ultimately unserviceable.

10.23 Plastic Membranes and Geotextiles

10.23.1 Plastic membranes and textiles are used in the construction industry as damp proof courses, gas resistant membranes, cover systems and liners. They are typically used to restrict the movement of gas or water into buildings, building materials or components or to separate differing soil types. Typically materials used for membranes are polyethylene (PE) and poly vinyl chloride (PVC).

10.23.2 Hazards

10.23.2.1 Membranes of PE and PVC are attacked by a variety of acids and solvents. PE has a poor corrosion resistance to oxidising acids (nitric and sulphuric) at high concentrations. Hydrochloric acid (HCl) does not chemically attack PE but can have a detrimental effect on its mechanical properties. Alkalis, basic salts, ammonia solutions and bleaching chemicals such as chlorine will cause deterioration of PE. PE is resistant to non oxidising salt solutions.

10.23.2.2 PVC is degraded by the action of oxidising acids. Nitric acid is particularly aggressive towards PVC. PVC does not deteriorate under the action of neutral or alkaline solutions.

10.23.3 Risk Assessment

10.23.3.1 There is no published guidance on quantitative assessment of the risks to PE or PVC although there is a lot of advice on how contaminants react with these plastics. In general, the more concentrated the contamination the greater the risk to plastic membranes/geotextiles.

10.23.3.2 Based on the investigatory data obtained to date, and in consideration of the hazards described above, there is no evidence of significant concentrations of acids or alkalis, indicating the risks of ground conditions at the site affecting PE and PVC materials are considered low.

10.24 Plastic Pipes

10.24.1 Hazards

10.24.1.1 Plastic pipes are predominantly manufactured from PVC and PE but other materials can be used. In general they perform well but it is known that chemical attack and permeation of contaminants through the pipes can result from use in contaminated land. A published review on plastic pipes reports the following:-

- Polyethylene (PE) - good resistance to solvents, acids and alkalis
- Poly vinyl chloride (PVC) - most common form of pipe. Good general resistance to chemical attack but can be attacked by solvents such as ketones, chlorinated hydrocarbons and aromatic polypropylene (PP) - chemically resistant to acids, alkalis and organic solvents but not recommended for use with storing oxidising acids, chlorinated hydrocarbons and aromatics.
- Poly vinylidene fluoride (PVDF) - inert to most solvents, acids and alkalis as well as chlorine, bromide and other halogens
- Polytetrafluoroethylene (PTFE) - one of the most inert thermoplastics available. PTFE has good chemical resistance to solvents, acids and alkalis

A survey carried out by the Water Research Centre (WRc) on reported incidents of permeation (more than 25), only two involved PVC with these incidents relating to spillages of fuel.

10.24.2 Risk Assessment

10.24.2.1 Plastic pipe performance has been the subject of a WRc report. The report risk ranks differing previous site uses in relation to the use of plastic pipes which is summarised in the following table.

Type A = High Risk
Asbestos works, chemical works, gasworks, hazardous waste treatment, wood preservative use/manufacture, landfill sites, metal mines, smelters, foundries, steel works, munitions production/testing sites, oil and fuel production / storage / use, paper and printing works, pesticide manufacture, pharmaceutical manufacture, scrap yards, sewage works, tanneries.
Type B = Suspect Sites
Dry cleaners, electric/electrical equipment manufacture, fertiliser storage, garage/filling stations, mechanical engineering works, metal finishing installations, paint and ink manufacture, railway land, textile production, research laboratories, road haulage yards.
Type C = Low Risk
Agriculture, brewing and distilleries, food preparation and storage.
Table 9.24.2. Risk ranking of former land use with respect to use of plastic pipes.

10.24.2.2 The WRc report also provides advices on the type of pipe material appropriate for the type of contamination present. An extract is provided below.

Material Groups

Group 1. Organic Contamination

- PE sleeved ductile iron.
- Tape wrapped or coated steel.
- Sheathed copper.
- Wrapped metal fittings.
- Protection for joints and seals.
- Clean suitable backfill.
- Seek specialist advice on use of PVC-U or GRP pipes.

Group 2. Mixed Contamination

- Plastic-coated or wrapped metal pipes.
- Cathodic protection (coated metal and pre-stressed concrete pipes only)
- Protection for joints and seals.
- Clean suitable backfill.

Group 3. Inorganic Contamination

- Plastic pipes.
- Plastic-coated metal pipes.
- Cathodic protection (coated metal and pre-stressed concrete pipes only)
- Clean suitable backfill.
- Seek specialist advice on use of GRP pipes.

Group 4. No Significant Organic or Inorganic Contamination

- Material of Choice.

For all material groups, good pipe laying practice must be followed.

10.24.2.3 The WRc report also refers to testing suites in relation to both inorganic and organic contamination. With respect to inorganic contamination, the WRc report acknowledges the purposes of this is for a risk assessment in relation to human health for construction operatives with the effects of such contaminants affecting plastic drinking water pipes limited.

10.24.2.4 The WRc report indicates that permeation of plastic pipes by organic solvents and substances was a major problem. The WRc report produces the following groups of compounds to which trigger concentrations were assigned.

Group 1(a) Compounds:
Carbon tetrachloride
Trichloreothane
Tetrachloroethane
Benzene
Toluene
Xylenes
Chlorobenzene

Group 1 (b) Compounds:
Dichloromethane
1,2-dichloroethane
1,1,1-trichloroethane
1,2-dichloropropane
vinyl chloride
methyl bromide
dichlorobenzenes

Trichlorobenzenes
Ethylbenzene

The above chemicals relate to fuels and volatile organic compounds.

10.24.2.5 We are aware that water companies have their own testing regime to assist in selection of an appropriate material supply of drinking water to the site and would, therefore, recommend a copy of this report is provided to the water company to allow them to specify the appropriate pipeline material.

10.24.2.6 We would only carry out laboratory testing to measure concentrations of organic contaminants listed in the WRc report (refer 9.24.2.4 above) if the site is known to or is suspected of using/processing these chemicals and at this site we have no evidence to suspect the use of such chemicals.

10.25 Electrical Cables

10.25.1 Hazards

10.25.1.1 Electrical cables are generally protected by plastic sleeves. These sleeves are potentially subject to chemical and permeation in similar modes as plastic pipes. Medium and low voltage cables are often laid directly into the ground and are thus at risk of attack by contaminants. High voltage cables tend to be laid in trenches backfilled with 'clean' materials.

10.25.2 Risk Assessment/Remedial Action

10.25.2.1 The selection of appropriate sheathing material is important to provide resistance to ground conditions at the site and recommend manufacturers advices are sought.

10.26 Rubbers

10.26.1 Hazards

10.26.1.1 Rubbers are crosslinked polymeric materials containing a number of additives such as carbon black, fillers, antioxidant and vulcanising agents. The corrosion resistance of rubber is dependant upon the polymeric constituent. The mechanisms by which rubbers deteriorate when placed in aggressive chemical environments are similar to those described for plastics. Oxidation is the principal form of degradation. Whilst rubbers are resistant to strong acids and alkalis, they are rapidly attacked by oxidising agents such as nitric acid and oxidising salts such as copper, manganese and iron.

10.26.1.2 Rubber is also susceptible to attack by certain hydrocarbons and oils. The absorption of these liquids causes the rubber to smell.

10.26.2 Risk Assessment/Remedial Action

10.26.2.1 Information on the effect of a range of chemicals on the physical properties of various rubbers has been produced by the Rubber and Plastics Research Association. This was based on observations carried out following immersion tests using undiluted chemicals, but this has limitations such as the effects of combined chemicals and the effects of dilution.

10.26.2.2 We recommend manufacturers of the rubber materials likely to be in contact with the ground at the site are consulted to confirm, or otherwise, the applicability of their product.

SECTION 11 - CONTENTS

11	**Landfill issues**
11.1	Disposal of soils off site
11.2	Landfill tax

11 Landfill Issues

11.1 Disposal of Soils off Site

11.1.1 Using available investigatory data we have produced a separate report to classify soils likely to be excavated at the site for off site disposal.

11.2 Landfill tax

11.2.1 Disposal of soils to landfill sites is normally subject to landfill tax with rates varying from year to year based on government policy. Current information on rates of landfill tax can be obtained from H M Customs and Excise (HMCE) Office (leaflet notice LFT 1) with a lower rate applied to inactive (or inert) wastes and the standard rate to all other taxable wastes.

11.2.2 Landfill tax exemption can be obtained providing the following conditions can be satisfied.

a) Reclamation must involve clearing the land of pollutants that are causing harm or have the potential to cause harm, demonstrating that the pollutants are or potentially:

   i) Polluting ground or surface water or
   ii) Harming the health of people or animals or plants on
   iii) Damaging the fabric of structures or services

b) The cause of the pollution must have ceased

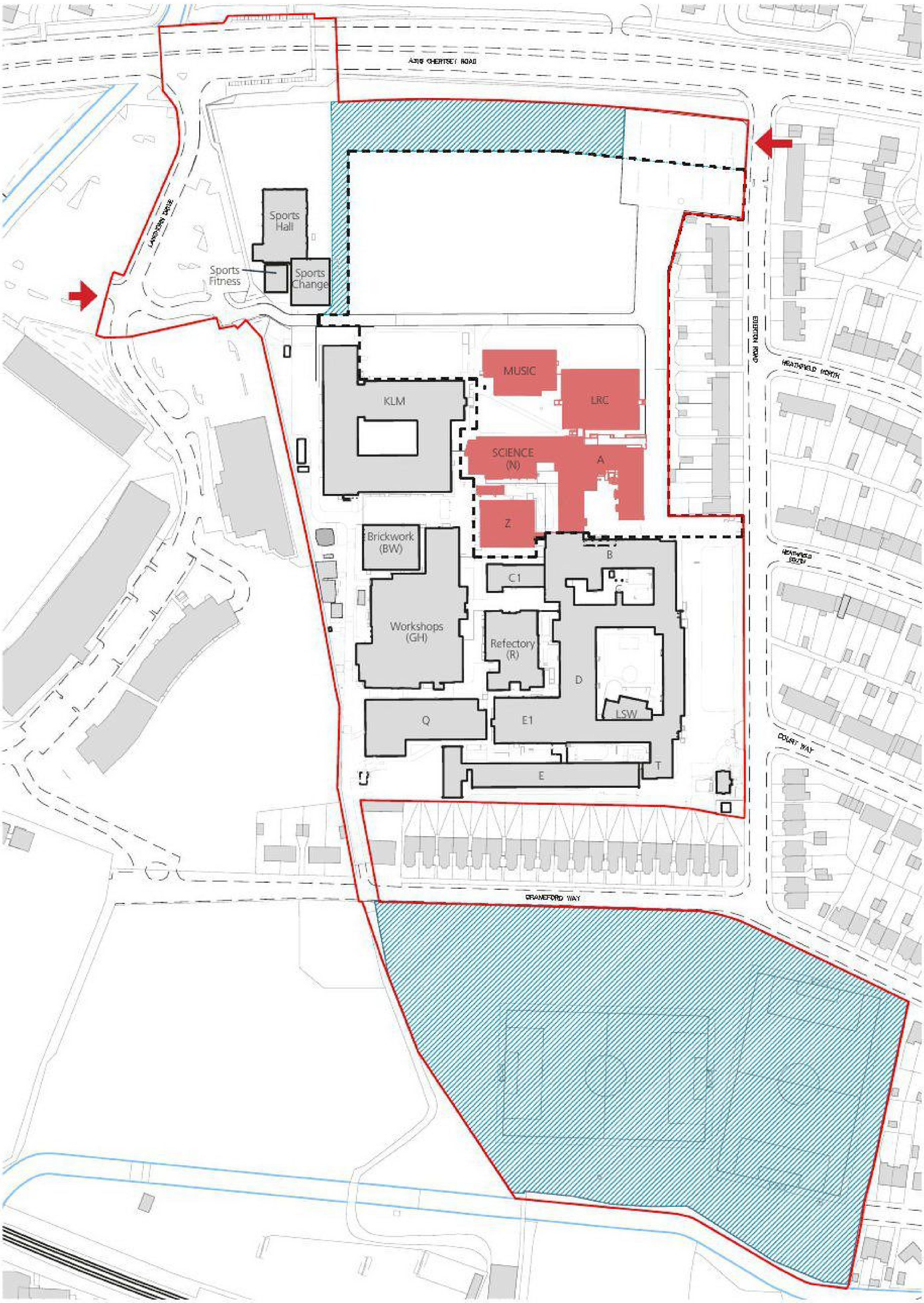
c) The land is not subject to the works or remediation notice

d) The reclamation constitutes or includes clearing the land of pollutants which would (unless cleared) prevent the land being put to intended use

11.2.3 Details of the above are produced in the HMCE Leaflet LFT2. Applications for landfill tax exemption must be submitted to HMCE at least 30 days before the intention to start removing waste to landfill.

11.2.4 Based on ground conditions determined at this site and development proposals it is unlikely that landfill tax exemption would be obtained as item a) above is unlikely to be satisfied, however we would recommend an application be made to HMCE to obtain their ruling on this matter. We would be pleased to assist on this aspect on further instructions.

Appendix 6.4: Indicative Construction Phasing Plans



ENABLING WORKS

PHASE 1a

Existing rooms to be taken out of use for Decant

PHASE 1b

Existing rooms to be refurbished to accommodate new curriculum

Line out 2nr pitches to playing fields

College move into decant area

Creation of haul road & preparation of access off Langhorn Drive and Egerton Road

Demolition of existing buildings (Music, LRC, Science and A block (part) and Z block)

Weatherproofing to the end of open end of Block A

Existing Buildings

Buildings to be Demolished

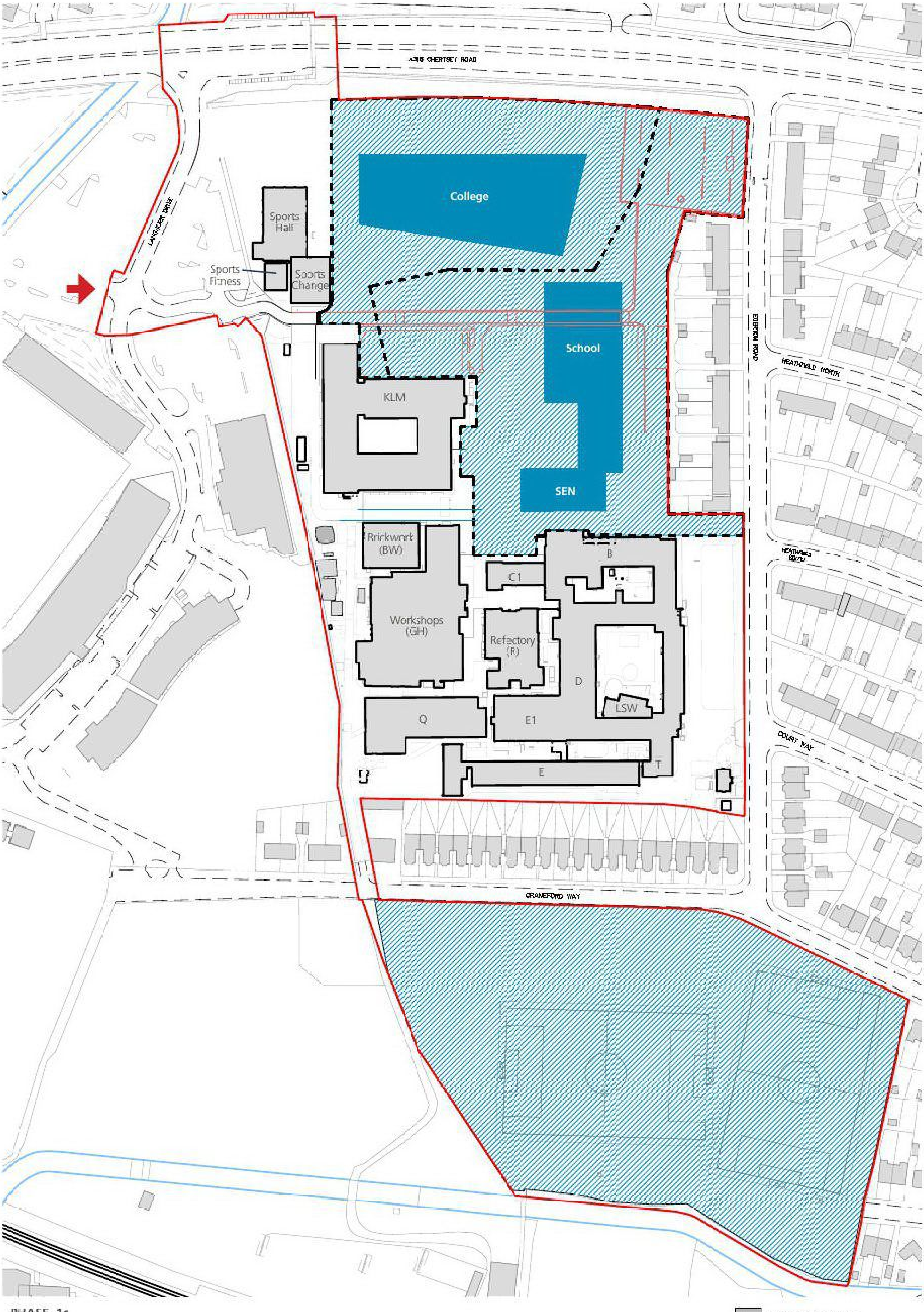
Buildings under Construction

New Buildings

Construction Area

Construction Hoarding

Construction Vehicle Access



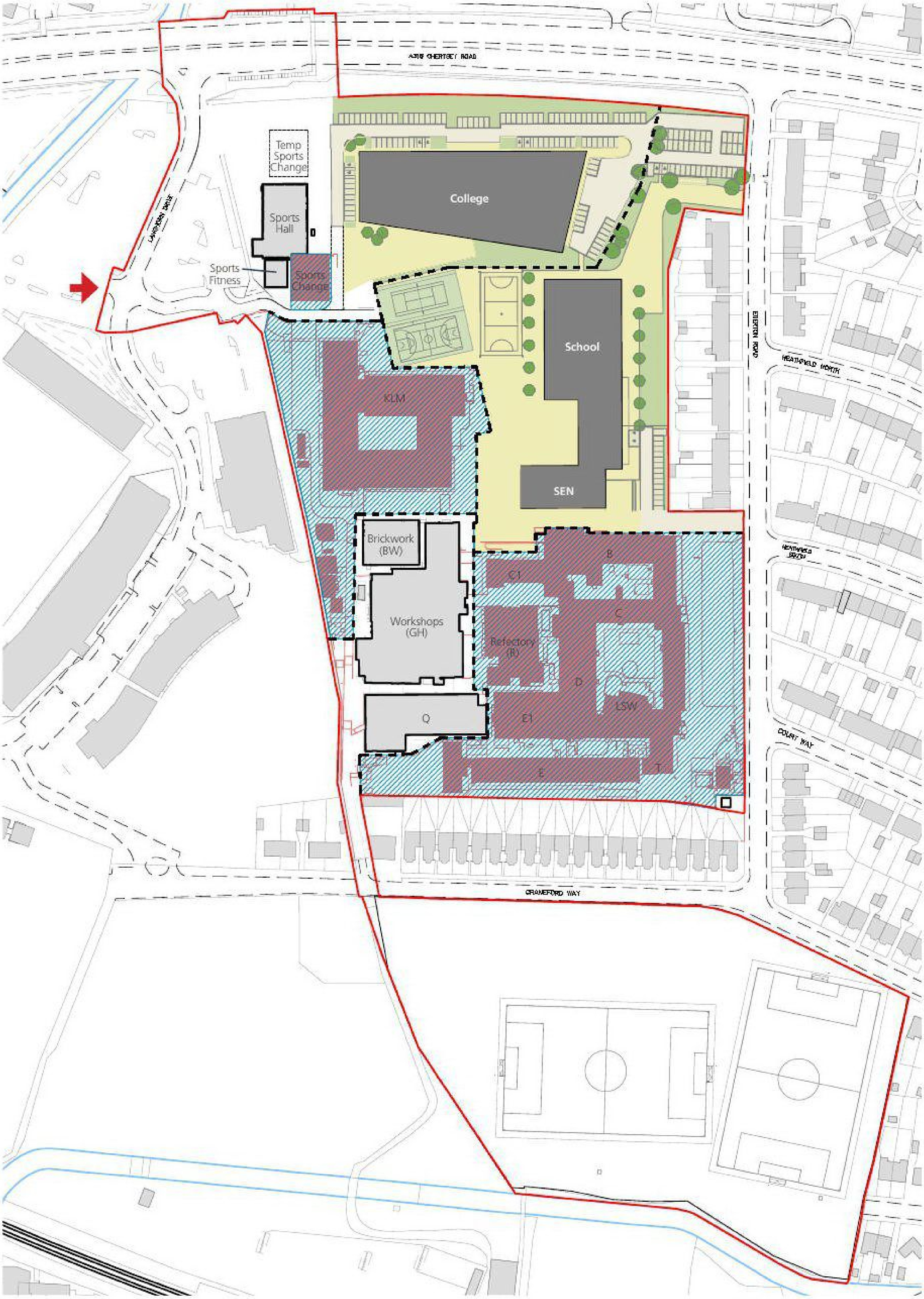
PHASE 1c

Construction of College main building

Construction of Secondary School and Special School

Removal of hardstanding and seeding to playing fields

- Existing Buildings
- Buildings to be Demolished
- Buildings under Construction
- New Buildings
- Construction Area
- Construction Hoarding
- Construction Vehicle Access



PHASE 1d

Phased move of KLM, remaining A block, refectory and E block into new College building

Construct Temporary Changing facilities for Sports Hall

Schools open

PHASE 1e

Demolition of KLM

Demolition of remaining A block, refectory and E block (B, C, C1, D, E, E1, R, T, LSW)

Demolition of out buildings and pumping station

Demolition of Changing facilities for Sports Hall

Existing Buildings

Buildings to be Demolished

Buildings under Construction

New Buildings

Construction Area

Construction Hoarding

Construction Vehicle Access

PHASE 2a

Construction of Sports and STEM buildings & vehicle movement temporarily altered

Completion of Schools external area (except works shown in Phase 3b)

Creation of 3G pitch and grass pitch during summer holidays

Marsh Farm Lane upgrade up to cross over point

- Existing Buildings
- Buildings to be Demolished
- Buildings under Construction
- New Buildings
- Construction Area
- Construction Hoarding
- Construction Vehicle Access

PHASE 2b

Phase 1 of the residential starts on site.

Access to Phase 1 residential site controlled and managed by contractor.

- Existing Buildings
- Buildings to be Demolished
- Buildings under Construction
- New Buildings
- Construction Area
- Construction Hoarding
- Construction Vehicle Access

Phase 2c

Decant into Sports and STEM building

Phase 2d

Demolition of Sports building and temporary changing building

Demolition of Brick, Conc, Engine, E Block and Q Block

Temporary route for residential site established and controlled by contractor

- Existing Buildings
- Buildings to be Demolished
- Buildings under Construction
- New Buildings
- Construction Area
- Construction Hoarding
- Construction Vehicle Access

Phase 3a

Construction of Haymarket

Upgraded junction on to A316

Langhorn Drive road widening and realignment & Marsh Farm Lane from STEM to Sports, including SEN MUGA and Sports car park

Phase 3b

Construction of Phase 2 residential.

Permanent residential access established.

Phase 3c

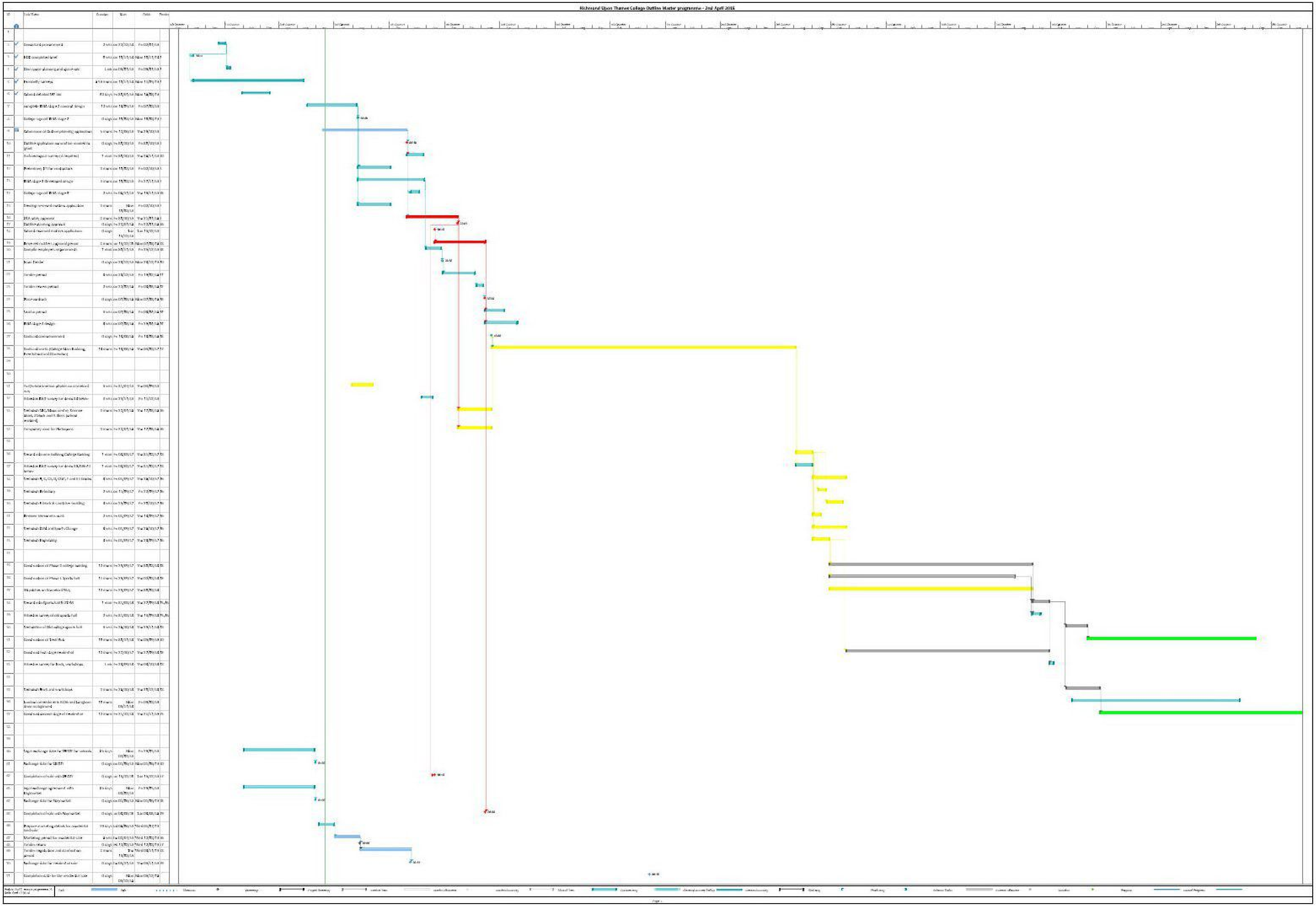
Marsh Farm Lane (playing fields to sports centre)

- Existing Buildings
- Buildings to be Demolished
- Buildings under Construction
- New Buildings
- Construction Area
- Construction Hoarding
- Construction Vehicle Access

A316 CHERTSEY ROAD
HUB
College
STEM
Sports
School
SEN
Residential
Residential
Residential
Residential
Residential
Residential
EGERTON ROAD
HEATHFIELD NORTH
HEATHFIELD SOUTH
COURT WAY
CRANEFORD WAY

Appendix 6.5: Indicative Demolition and Construction Programme

Richmond Upon Thames College Outline Master programme - 2nd April 2016



Appendix 6.6: 2008 Soiltechnics Ground Investigation Report

Proposed Redevelopment of Richmond Upon Thames College Egerton Road Twickenham

GROUND INVESTIGATION REPORT

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Report Reference: STE1297R

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Report Issue					
Company	Name	Paper		Electronic	
		Issue	Date	Issue	Date
AKT	Joyce Ferng	Final Draft	21.07.08	Final Draft	21.07.08

Aerial photograph of site

Report status and format

Report section	Principal coverage	Report status		
		First draft	Final draft	Comments
1	Executive summary		21.07.08	
2	Introduction		21.07.08	
3	Desk study information and site observations		21.07.08	
4	Fieldwork		21.07.08	
5	Ground conditions encountered		21.07.08	
6	Laboratory testing		21.07.08	
7	Engineering assessment	30.06.08	21.07.08	Preliminary Engineering assessment issued to AKT
8	Chemical contamination		21.07.08	
9	Gaseous contamination		21.07.08	
10	Effects of ground conditions on building materials		21.07.08	
11	Landfill issues		21.07.08	
12	Further investigations		21.07.08	
13	Remediation statement		21.07.08	
14	Drawings		21.07.08	

Note: A separate report has been produced on classification of soils for off site disposal.

List of drawings

Drawing	Title	Revision
STE1297R-01	Site location plan	
STE1297R-02	Plan showing existing site features and approximate location of exploratory points.	
STE1297R-03a	Plots summarising insitu density testing from Standard Penetration Testing (SPT) and triaxial laboratory test data in boreholes BH01 to BH06	
STE1297R-03b	Plots summarising insitu density testing from Standard Penetration Testing (SPT) in Kempton Park Gravels only	
STE1297R-03c	Plots summarising undrained shear strength derived from Standard Penetration Test (SPT) N values and triaxial laboratory test data in London Clay deposits.	
STE1297R-04a	Plot summarising insitu density testing from Dynamic Cone Penetration testing (DCP) across the site.	
STE1297R-04b	Plot summarising insitu density testing from Dynamic Cone Penetration testing (DCP) in tennis courts to the south of Cranford Way.	
STE1297R-05	Section showing construction of combined water & gas monitoring standpipe installed in boreholes BH01 to BH06.	

List of appendices

Appendix	Contents
A	Definitions of geotechnical terms used in this report.
B	Definitions of geo-environmental terms used in this report.
C	Trial pit records.
D	Records of soil infiltration tests and calculation of infiltration rate.
E	Borehole records (cable and tool percussion drilling).
F	Borehole records (driven tube sampler).
G	Copies of laboratory test result certificates – classification testing.
H	Copies of laboratory test result certificates – physical testing.
I	Copies of laboratory test result certificates – concentrations of chemical contaminants.
J	Statistical and comparative analysis of test data in relation to concentrations of chemical contaminants.
K	Record of in-situ gas monitoring results and groundwater levels.
L	Copies of Statutory Undertakers replies.
M	Copy of desk study information produced by Envirocheck

1 Executive Summary

General

We recommend the following executive summary is not read in isolation to the main report which follows.

Site description, history and development proposals

The site is located towards the centre of Twickenham and is occupied by Richmond-Upon-Thames College. Prior to development of the college in the 1930s old Ordnance Survey maps record the site to be undeveloped although a tramway was recorded run across the southern half of the site.

At this stage, the proposals are being developed however we understand that the existing buildings are to be demolished to make way for the new college buildings.

Ground conditions encountered

Exploratory excavations generally encountered between 0.3-1.0m of topsoil or made ground grading into orange brown clays becoming sand and gravel considered to be Kempton Park Gravel to depths of between 4.2-5.3m and locally 9.3m. Stiff grey dark grey clay considered to be London Clay was encountered underlying the Kempton Park Gravel. Groundwater was encountered at between 1.1-3.5m in exploratory excavations and water levels of between 1.33-2.54m have been observed in standpipes installed across the site.

Soil infiltration tests indicate that the near surface Kempton Park Gravel exhibit some permeability.

Foundation solution

We consider that spread type foundations will be suitable option for the proposed buildings located on the upper horizons of the Kempton Park Gravels. A piled foundation solution providing end bearing in the London Clay could also be considered. Ground bearing floor slabs can be adopted however a suspended floor may be required for low rise buildings.

Chemical and gaseous contamination

Elevated concentration of benzo(a)pyrene was measured in one location presumably associated with ash and clinker contained in the soil. Some hydrocarbon contamination also measured in two locations in the near surface soils. Further supplementary investigations recommended in these locations to determine extent and risks (if any) to groundwater.

Based on gas monitoring undertaken to date, the site is classified as characteristic gas situation two requiring some gas protective measures for new buildings subject to further monitoring. Based on desk study information, Radon protective measures are not necessary.

SECTION 2 - CONTENTS

2	**Introduction**
2.1	Objectives
2.2	Client instructions and confidentiality
2.3	Site location and redevelopment proposals
2.4	Report format and investigation standards
2.5	Status of this report

2 Introduction

2.1 Objectives

2.1.1 This report describes a ground investigation carried out for the propsed redevelopment of Richmond-Upon-Thames College, Twickenham.

2.1.2 The principal objective of the ground investigation was to establish ground conditions at the site, sufficient to identify possible foundation solutions for the development and provide parameters necessary for the design and construction of foundations.

2.1.3 The investigation included an evaluation of potential chemical and gaseous contamination of the site leading to the production of a risk assessment in relation to contamination.

2.1.4 Our brief also included investigations and testing to allow classification of soils at the site to be disposed of to landfill.

2.2 Client Instructions and Confidentiality

2.2.1 The investigation was carried out in May 2008 and reported in July 2008 acting on instructions received from Adams Kara Taylor (Consulting Civil and Structural Engineers), on behalf of our mutual client Richmond-Upon-Thames College.

2.2.2 This report has been prepared for the sole benefit of our above named instructing client, but this report, and its contents, remains the property of Soiltechnics Limited until payment in full of our invoices in connection with production of this report.

2.2.3 The scope of the investigation was defined by Adams Kara Taylor in their briefing document ref. **A041826** dated April 2008. The investigation generally followed the briefing document. The investigation process was also determined to maintain as far as possible the original investigation budget costs.

2.3 Site Location and Redevelopment Proposals

2.3.1 The National Grid reference for the site is 515350,173810. A plan showing the location of the site is presented on Drawing STE1297R-01.

2.3.2 We understand the project will consist of the phased demolition of the existing buildings at Richmond Upon Thames College in combination with and followed by:-

- Construction of temporary accommodation block to the south of the existing campus
- A new four to five storey "L" shaped building approximately 250m long by 40m extending to playing fields to the north of the site and within the footprint of the existing college buildings, and
- A potential residential development in the southern part of the site.

2.3.3 At this stage the layout and position of the buildings is being developed, and no plans are currently available.

2.4 Report Format and Investigation Standards

2.4.1 Sections 2 to 6 of this report describe the factual aspects of the investigation with Section 7 presenting an engineering assessment of the investigatory data. Section 8 provides a risk assessment of chemical contamination based on readily available historic records, inspection of the soils and laboratory testing. Section 9 provides a similar risk assessment in relation to gaseous contamination with Section 10, a risk assessment relating to construction materials likely to be in contact with the ground. Section 11 discusses issues related to landfill.

2.4.2 This investigation integrates both contamination and geotechnical aspects. The investigation was carried out generally, and where practical following the recommendations of BS5930: 1999 '*Code of Practice for Site Investigations*'. The investigation process also followed the principles of BS10175: 2001 *'Investigation of potentially Contaminated Sites – Code of Practice'*. In view of the client's requirement for rapid implementation of the investigation, the following elements, defined in BS10175, have been completed and incorporated in this report.

a) Phase I Preliminary investigation (desk study and site reconnaissance)

b) Phase II Exploratory and main (intrusive) investigations

2.4.3 The extent and result of the preliminary investigation (desk study) is reported in Section 3. Fieldwork combined the exploratory investigation and main investigation stages into one phase with the extent of these works described in Sections 4 and 6 of this report. Any supplementary investigations deemed necessary as a result of deficient information obtained by investigations, completed to date, are identified in Section 12. Section 13 provides information on any remedial strategy and specification if required.

2.4.4 Our investigations included testing to allow classification of soils at the site for potential disposal to landfill. Our report on this aspect is separately presented.

2.5 Status of this Report

2.5.1 This report is final based on our current instructions.

2.5.2 This investigation has been carried out and reported based on our understanding of best practice. Improved practices, technology, new information and changes in legislation may necessitate an alteration to the report in whole or part after publication. Hence, should the development commence after expiry of one year from the publication date of this report then we would recommend the report be referred back to Soiltechnics for reassessment. Equally, if the nature of the development changes, Soiltechnics should be advised and a reassessment carried out if considered appropriate.

2.6 Report Distribution

2.6.1 This report has been prepared to assist in the design and planning process of the development and normally will require distribution to the following parties, although this list may not be exhaustive:

Party	Reason
Client	For information / reference and cost planning
Developer / Contractor / project manager	To ensure procedures are implemented, programmed and costed
Planning department	Potentially to discharge planning conditions
Environment Agency	If ground controlled waters are affected, and obtain approvals to any remediation strategies.
Independent inspectors such as NHBC / Building Control	To ensure procedures are implemented and compliance with building regulations
Project design team	To progress the design
CDM Coordinator	To advise in construction risk identification and management under the Construction (design and management) regulations

SECTION 3 - CONTENTS

3	**Desk Study Information and site observations**
3.1	General
3.2	Description of the site
3.3	Injurious and invasive weeds and asbestos.
3.4	History of the site
3.5	Geology and geohydrology of the area
3.6	Environmental study
3.7	Coal mining records
3.8	Radon
3.9	Enquiries with Statutory Undertakers
3.10	Flood risk
3.11	Shallow mining and natural subsidence hazards
3.12	Borehole records
3.13	Mining and dissolution hazards

3 Desk study information and site observations

3.1 General

3.1.1 We have carried out a desk study which was limited to the collection of readily available information. This included:

a) Retrieval of published Ordnance Survey maps dating back to 1871 at 1:1250, 1:2500, 1:10000 and 1:10560 scales where applicable.

b) Inspection of geological maps produced by the British Geological Survey together with relevant geological memoirs.

c) Consultation with Statutory Undertakers.

d) Site reconnaissance

e) Other relevant published documents

3.1.2 Section a) was carried out by Envirocheck. The report prepared by Envirocheck is presented in Appendix M. In addition to retrieval of historical and current Ordnance Survey data, Envirocheck provide information compiled from outside agencies including: -

Environment Agency
Institute of Hydrology
British Geological Survey
Countryside Council for Wales
Scottish National Heritage
English Nature

3.1.3 The study did not extend to research of meteorological information or consultation with other interested parties such as English Heritage (ancient monuments), Ordnance Survey (survey control points), Planning Authorities or Archaeological Units.

3.2 Description of the Site

3.2.1 The site is positioned on the floor of a wide and flat bottomed valley carrying the River Crane, the channel of which is located about 75m to the south of the site and the Duke of Northumberland's River which is located 300m to the west of the southern end of the site and 20m to the west of the northern end of the site.

3.2.2 The site is occupied by Richmond-Upon-Thames College and can be separated into three distinct areas as follows:-

Northern - Playing Field and Car Park

The northern area of the site is predominantly flat and occupied by open space surfaced in bituminous bound materials and laid to grass, forming a car park and playing field respectively. One masonry building is present in this area and is currently utilised as a sports hall.

Central – College Buildings

The central area of the site slopes gently to the south (~1:250) and is occupied by numerous buildings of varying age predominantly between one and four stories in height with a six storey tower located to the south of the main building. The college buildings are occupied by numerous departments broadly covering science, arts, social science and vocational disciplines. Ancillary facilities are also present within this area of the site including chemical stores located to the central eastern area of the site.

Southern – Tennis Court and Playing Fields

The southern area of the site slopes gently to the south (~1:150) and is separated from the central area of the site by Craneford Way and a row of residential properties. This area is occupied by playing fields, laid to grass, and tennis courts surfaced in bituminous bound materials.

3.2.3 **College environs**

The northern boundary of the college campus is defined by Chertsey Road with a residential development beyond. Chertsey Road is constructed on a shallow embankment reaching some 2m in height in the north eastern part of the site as the road approaches a bridge to carry it over the Duke of Northumberland River. Much of the eastern boundary of the college is marked by Egerton Road, serving residential properties to the east. Blocks of residential properties are located to the west together with a rugby ground with associated car parking. The southern boundary of the site is defined by residential properties off Craneford Way. Playing fields are located to the south of Craneford Way.

3.2.4 A plan showing the observed site features and location of exploratory points is presented on Drawing STE1297R-02.

3.3 Injurious and invasive weeds and asbestos.

3.3.1 Injurious and invasive weeds

3.3.1.1 Our investigations exclude surveys to identify the presence injurious and invasive weeds. Under the Weeds Act 1959, the Secretary of State may serve an enforcement notice on the occupier of land on which injurious weeds are growing, requiring the occupier to take action to prevent the spread of injurious weeds. The Weeds Act specifies five Injurious weeds: Common Ragwort, Spear Thistle, Creeping of Field Thistle, Broad leaved Dock and Curled Dock. The Wildlife and Countryside act 1981 provides the primary controls on the release of non native species into the wild in Great Britain. It is an offence under section 14(2) of the act to 'plant or otherwise cause to grow in the wild' any plants listed in schedule 9, part II. The only flowering plants currently listed are Japanese Knotweed and Giant Knotweed. We recommend specialists in the identification and procedures to deal with injurious and invasive weeds are appointed prior to commencement of any works on site or if appropriate purchase of the site. The presence of such weeds on site may have considerable effects on the cost / timescale in developing the site.

3.3.1.2 Good guidance on injurious and invasive weeds is provided on DEFRA and Environment Agency web sites

3.3.2 Asbestos

3.3.2.1 Our investigations exclude surveys to identify the presence or indeed absence of asbestos on site. We recommend specialists in the identification and control / disposal of asbestos are appointed prior to commencement of any works on site or, if appropriate, purchase of the site. The presence of asbestos on site may have considerable effects on the cost / timescale in developing the site. There is good guidance in relation to Asbestos available on the Health and Safety Executive (HSE) web site

3.4 History of the Site

3.4.1 An attempt to trace the history of the site has been carried out by obtaining copies of old Ordnance Survey maps provided by Envirocheck. These maps are presented in Appendix M, but have been reduced from sizes ranging from A1-A3 to A4 for ease of presentation. This size reduction affects the scale recorded on the maps. We can provide A3 copies if required

3.4.2 The recent history of the site based on published Ordnance Survey maps is summarised on the following table: -

Dates	Historical Usage	Comments
1871	Open space	Agricultural land with orchards to the north of the site Marsh Farm located to the south of the site Railway land located 200m to south
1874	As above	As above Pond recorded to the centre of the central area of the site
1896	Open Space & tramway	Tramway located across the southern central area of the site, linking to a sewage works located 400m to the south west Gravel pit located 225m to the south Pond no longer recorded As above
1898	As above	As above
1915	As above tramway not recorded	Expansion of the sewage works including filter and sludge beds within 100m of the eastern site boundary. Football ground located to the north. As above
1920	As above	As above
1934	As above	Further expansion of the sewage works including filter and sludge beds within 50m of the eastern site boundary. As above
1938	Central area of site occupied building	Residential development underway to north and east of the site As above
1949	As above	As above
1961	Site recorded as Twickenham Technical College	Playing fields to north of the site with five suspected air raid shelters. Buildings to the central area of the site Tennis courts located in the southern area of the site
1966	As above recorded as College	Sewage works recorded as depot
1973	As above additional buildings	As above
1974	As above	As above Air raid shelters no longer recorded
1975	As above additional building and playing fields recorded	As above Sports stadium recorded to west Football ground located to the north recorded as rugby ground
1982	As above	As above Building present in area of former air raid shelter
1992	As above	As above
1999	As above	As above
2008	As above	As above

Table 3.4.2

3.5 Geology and Geohydrology of the Area

3.5.1 Geology of the Area

3.5.1.1 Inspection of the geological map of the area (at 1:50,000 scale) published by the British Geological Survey indicates the topography local to the site (based on borehole/observations recorded on the map) is formed in the following sequence of soils.

Strata	Approximate thickness (m)	Typical soil type	Likely permeability
Kempton Park Gravel	Not recorded	Silt, sand and Gravel	Moderate
London Clay	50m	Clay	Low
Lambeth Group	50m	Clay sands, and gravels	Low – Moderate
Upper Chalk	>50m	Chalk	High

Table 3.5.1

The soil types and assessment of permeability's are based on geological memoirs, in combination of our experience of investigations in these soil types.

3.5.2 Geohydrology – aquifer designation and groundwater vulnerability

3.5.2.1 Envirocheck reports the site is located in an area designated a major aquifer probably reflecting the deep geology comprising Upper Chalk, which are likely to be reasonably permeable deposits containing chalk deposits. A major aquifer is defined by the Environment Agency in their publication *'policy and practice for the protection of groundwater'* on highly permeable formations. They are highly productive and able to support large abstractions for public water supply and other purposes.

3.5.2.2 In addition, Envirocheck provide an extract of the groundwater vulnerability map recording the soils containing the aquifer is a high leaching potential. These soils have little ability to attenuate diffuse source pollutants. Non-absorbed diffuse source pollutants and liquid discharges will percolate rapidly through them. The groundwater vulnerability map also records a sub class of soil type U, (undifferentiated). In such a case there is insufficient information to classify the soils accurately and generally a default class of H1 is adopted. A sub class of H1 is defined as a soil which readily transmits liquid discharges because they are either shallow or susceptible to rapid by-pass flow directly to rock, gravel or groundwater.

3.5.3 Geohydrology – water abstractions

3.5.3.1 Envirocheck report five abstraction points within 2000m of the site. The closes abstraction point lies 859m to the north-west of the site and is recorded as water supply related: General use at a Thames Water Sewage Treatment Works. The remaining abstraction points are located in excess of 1500m and thus are not considered further.

3.5.4 Geohydrology – source protection zone

3.5.4.1 Envirocheck does not record the site is located within a zone protecting a potable water supply abstracting from a major aquifer (i.e. a source protection zone).

3.6 Environmental Study

3.6.1 We have instructed Envirocheck to carry out a search of their records and report on the following aspects: -

Agency and Hydrological

Air Pollution Controls ("APC")
Discharge Consents to Controlled Waters
Enforcement and Prohibition Notices
Integrated Pollution Controls ("IPC")
Nearest Surface Water Feature
Pollution Incidents to Controlled Waters
Prosecutions relating to Authorised Processes
Prosecutions to Controlled Waters
Red List Discharge Consents
Radioactive Substance Authorisations ("RSA")
River Quality Data
Water Abstractions
Groundwater Vulnerability
Drift Deposits
Fluvial Indicative Flood Plain
Tidal Indicative Flood Plain
Source Protection Zones

Waste

BGS Recorded Landfill Sites
Integrated Pollution Control registered Waste Sites
Registered Waste Transfer Sites
Registered Waste Treatment or Disposal Sites
Registered Landfill Sites

Hazardous Substances

Planning Hazardous Substance Consents
Planning Hazardous Substance Enforcements
COMAH Sites
Explosive Sites
NIHHS Sites

Geological

BGS Boreholes
BGS Recorded Mineral Sites
BGS 1:625,000 Surface Geology
Coal Mining Affected Areas
Shallow Mining Hazards
Natural Subsidence Hazard
Radon Affected Area
Radon Protection Measures

Industrial Land Use

Contemporary Trade Directory Entries (of possible contaminative use)
Fuel Station Entries
Post 1995 Planning Applications (of possible contaminative use)
Potentially Contaminative Uses (Past Use)
Potentially Contaminative Uses (Non-Water Related)
Potentially Contaminative Uses (Water Related)
Nearest Overhead Transmission Line

Sensitive Land Use

Adopted Green Belt
Unadopted Green Belt
Areas of Outstanding Natural Beauty
Environmentally Sensitive Areas
Forest Parks
Local Nature Reserves
Marine Nature Reserves
National Nature Reserves
National Parks
National Scenic Areas
Nitrate Sensitive Areas
Nitrate Vulnerable Zones
RAMSAR Sites
Sites of Special Scientific Interest ("SSSI")
Special Areas of Conservation
Special Protection Areas

3.6.2 A copy of records produced by Envirocheck is presented in Appendix M.

3.6.3 Envirocheck produce a wealth of factual database information. Although we can provide a discussion on each of the database topics, this would produce a very lengthy document, but some of these discussions would not be relevant to the aims of this report. As a consequence we have extracted some of the relevant geotechnical topics (including flood risk) and discussed them in this section of the report. Key environmental issues from the Envirocheck database are discussed in Section 7.

3.7 Coal Mining Records

3.7.1 With reference to *The Coal Mining Searches Law Society Guidance and Directory 1994*, the site **is not recorded** as being within an area, which has been affected by past or present coal mining, or minerals worked in association with coal.

3.8 Radon

3.8.1 With reference to the Building Research Establishment (BRE) publication *"Radon: guidance on protective measures for new dwellings", (2007)* the site is located where **no protection** is considered necessary. In addition, Envirocheck use the British Geological Survey database to review reported radon levels in the area in which the site is located to establish recommended radon protection levels for new dwellings. The database confirms the BRE recommendations.

3.8.2 The Building Research Establishment publication has not been prepared for non-domestic buildings, however, protection from radon at work is specified in the Ionising Radiations Regulations 1985, legislation made under the Health and Safety at Work Act administered by the Health and Safety Executive (HSE). The technical guidance contained in the present report may be of use to designers and builders of new structures whose form of construction and compartmentation is similar to housing and where the heating and ventilation regime is similar to that used in housing. This is likely to include small office buildings and primary schools. Further information is contained in the HSE/BRE guide *"Radon in the Workplace"*.

3.9 Enquiries with Statutory Undertakers

3.9.1 We have contacted the following Statutory Undertakers (SUs) to obtain copies of their records in order to avoid damaging their apparatus during our fieldwork activities: -

a) British Telecommunications plc
b) Transco
c) Thames Water
d) EDF energy
e) Virgin Media

Copies of responses received prior to publication of this report are presented in Appendix L. These records have been obtained solely for the purposes described above. Some of these records have been obtained from the Internet and from our database without contacting the statutory undertaker direct. Occasionally, SU information is recorded on drawings larger than A3, and thus cannot be easily presented in this report. In such cases we will copy the correspondence but not incorporate the drawing in this report, and maintain the records on our office file.

3.9.2 Normally Statutory Undertakers drawings record the approximate location of their services. We recommend further on site investigations be undertaken to confirm the position of the apparatus and thus establish the effect on the proposed development and the necessity or otherwise for the permanent or temporary diversion of the service to allow the construction of the development to safely and successfully proceed.

3.9.3 It should be noted that statutory undertakers' records normally exclude private services. We were however provided with plans of the site which included private services prior to our investigations.

3.10 Flood Risk

3.10.1 The Envirocheck report indicates that the southern, northern and areas of the eastern and western boundaries of the site **are located** within a fluvial flood plain. We would recommend that clarification of flood risk and its implications be sought with the Environment Agency.

3.11 Shallow mining and natural subsidence hazards

3.11.1 Envirocheck use the British Geological Survey database to establish hazard ratings for shallow minings and natural subsidence hazards. The database indicates the following ratings for the site.

a) Shallow mining hazard rating: **No hazard**

b) Potential for collapsible ground stability hazard **No hazard**

c) Potential for compressible ground stability hazard: **No hazard**

d) Potential for ground dissolution stability hazard: **Very Low**

e) Potential for landslide ground stability hazard **Very Low**

f) Potential for running sand ground stability hazard: **Very Low**

g) Potential for shrinking or swelling clay ground stability hazard: **Moderate**

3.12 Borehole Records

3.12.1 The British Geological Survey (BGS) retain records of boreholes formed from ground investigations carried out on a nationwide basis. A plan showing the location of the boreholes within 1000m of the site is produced in the Envirocheck Report presented in Appendix M.

3.12.2 We do not normally obtain copies of these records but can do on further instructions. There is normally a charge made by the BGS for retrieving and copying these records.

3.13 Mining and dissolution hazards

3.13.1 Envirocheck's database indicates two BGS recorded Mineral Sites, Mogden Sand and Ballast Works, located 539m and 740m to the north-east of the site excavating Sand and Gravel by opencast methods from the Kempton Park Gravels. Both of the sites are recorded as no longer active.

3.13.2 Numerous local excavations both on and adjacent to the site are recorded on the historic maps produced by Envirocheck dating between 1874 and 1963, with excavations recorded as sand and gravel pits, ponds and sewage works.

SECTION 4 – CONTENTS

4	**Fieldwork**
4.1	General
4.2	Site restrictions
4.3	Exploratory trial pits
4.4	Light cable percussion boring
4.5	Driven tube sampling
4.6	Dynamic probing
4.7	Measurement of landfill type gases in gas monitoring standpipes
4.8	Sampling strategy

4 Fieldwork

4.1 General

4.1.1 Fieldwork comprised the following activities:-

- Excavation of twenty six exploratory trial pits using hand tools with soil infiltration tests undertaken in eight if these
- Excavation of six exploratory boreholes using cable and tool percussion drilling techniques
- Excavation of twenty one exploratory boreholes formed using driven tube sampling equipment with infiltration tests undertaken in two of these
- Dynamic cone penetration testing in thirteen locations

4.1.2 A plan of the site showing observed/existing site features (including site reconnaissance notes) and position of exploratory points is presented on Drawing STE1297R-02. The position of exploratory points shown on these plans is approximate only and confirmation of these positions is subject to dimensional surveys, which is considered outside our brief.

4.1.3 The extent of fieldwork activities and position of exploratory points were defined by the Client's Engineer, and were subsequently amended on site to account for access restrictions.

4.1.4 Exploratory points were positioned to avoid known locations of underground services, to avoid possible location of proposed foundations but were also positioned to provide a reasonable coverage of the site.

4.1.5 Prior to commencement of exploratory excavations an electronic cable locating tool was used to scan the area of the excavation. If we received a response to this equipment then the excavation would be relocated.

4.1.6 All soils/rocks exposed in excavations were described in accordance with BS5930: 1999 "*Code of Practice for Site Investigations*".

4.2 Site Restrictions

The site is occupied by a active sixth form college, because of this the majority of the intrusive investigations were carried out during the half term week including a bank holiday to minimise disturbance to the normal operation of the college. It should be noted however, that access was restricted to certain areas due to ongoing examinations. The method of investigation was also restricted to small diameter equipment to minimise surface damage which would have been caused by machine dug trial pits although trial pits would have produced the most information.

4.3 Exploratory Trial Pits

4.3.1 Trial pits SA01 to SA10 were excavated using hand tools to a maximum depth of 1.5m to undertake infiltration tests. Trial Pits TP01 to TP14 were excavated using hand tools to a maximum depth of 2m to expose existing foundation arrangements to existing buildings within the site. Trial pits TP14 to TP16 were excavated using hand tools to a maximum depth of 0.7m to sample the near surface soils.

4.3.2 The trial pit excavations were backfilled with excavated material, which was compacted using hand held ramming tools. The surface was reinstated to match the original surroundings. A Geotechnical Engineer supervised the excavations.

4.3.3 Sampling and logging was carried out as trial pit excavations proceeded. The density of granular soils encountered in excavations was gauged by the ease of excavation.

4.3.4 Soil samples for subsequent laboratory determination of concentration of chemical contaminants were taken from the sides of trial pits using clean stainless steel equipment and stored in new plastic containers, which were labelled and sealed. The stainless steel sampling equipment was cleaned with deionised water between sampling points Samples from below access depth into trial pits were taken as a sub sample from soil contained in the excavator bucket, discarding any soil, which may have been in contact with the bucket. If as a consequence of visual or olfactory evidence, a sample was suspected to be contaminated by organic material, the sample was stored in an amber glass jar with a PTFE sealing washer.

4.3.4 Soil samples for subsequent 'physical and classification' laboratory testing were taken from the side of trial pits. The sample was placed in a plastic bag and subsequently sealed and labelled. Samples for moisture content determination were placed in sealable tins and appropriately labelled. Moisture content samples were taken to the laboratory for testing within 24 hours of sampling.

4.3.5 Soil samples were taken to meet the requirements of class 3, 4 or 5 as described in BS5930: 1999 (table 2) with the sample sizes in accordance with Table 3 of the same standard. Sample sizes were appropriate for the laboratory test being considered.

4.3.6 Soil infiltration tests were carried out in trial pits SA01 to SA10 at depths of between approximately 0.6m and 1.0m. The infiltration tests were carried out following the procedures described in the Building Research Establishment (BRE) Digest 365 (2007) "*Soakaway Design*". In addition, variable head tests were undertaken in driven tube sampler boreholes DTS08 and DTS17 at depths of between 0.5-2.0m following methods described in *BS 5930: 1999 'Code of Practice for Site Investigations' (section 25)*. Records of the test results and calculations to determine the soil infiltration rate are presented in Appendix D. The rate at which water placed in each trial pit, dissipated was relatively slow and only one test cycle (the BRE Digest recommends three) could only be carried out in one day's fieldwork. The test results have been used to produce a soil infiltration rate for each test cycle, using the methods described in the BRE Digest.

4.4 Light Cable and Tool Percussion Boring

4.4.1 Boreholes BH01 to BH06 were excavated using light cable percussion boring techniques as described in BS5930: 1999 forming 150mm diameter holes. Temporary casing was advanced within the borehole excavation to maintain the stability of the hole. When groundwater was encountered the excavation was temporarily halted to allow for groundwater observations to be made. Following groundwater observations the casing was advanced within the hole and the location/locations of the water strikes recorded. The casing was subsequently advanced to maintain the stability of the borehole and seal off the water to prevent further ingress. Additional records were taken when (and if) the casing produced a seal against water ingress. When obstructions were encountered a chisel was employed to break through the obstruction. Time taken to progress the excavation using the chisel is recorded on the borehole logs.

4.4.2 On completion of excavations the boreholes were backfilled with excavated soils compacted using drilling tools.

4.4.3 Soil samples for subsequent laboratory determination of concentration of chemical contaminants were taken from 'intact' bulk disturbed samples obtained in the cutting shoe of the drilling rig. A sub sample was obtained discarding soil, which would have been in contact with the drilling rig cutting shoe with the subsamples taken using clean stainless steel equipment. In all cases the stainless steel equipment was cleaned with deionised water between sampling with samples stored in new plastic containers, which were labelled and sealed.

4.4.4 Water samples collected for laboratory determination of concentration of chemical contaminants was taken from the borehole using new proprietary plastic bailing equipment. The samples were placed in a new green bottle, quickly sealed with a screw cap with a PTFE washer and subsequently labelled.

4.4.5 Bulk soil samples for identification or subsequent 'classification' laboratory testing were taken from borehole cutting equipment. The sample were placed in a plastic bag and subsequently sealed and labelled. Bulk soil samples were taken to meet the requirements of class 3, 4 or 5 as described in BS5930: 1999 with the sample sizes in accordance with Table 1 of the same standard. Sample sizes were appropriate for the laboratory test being considered.

4.4.6 'Undisturbed' 100mm diameter samples were taken in cohesive soils when considered appropriate using a general-purpose open tube sampler. Whilst we tried to obtain class 1 samples to BS5930 (1999) class 2 samples were more likely (refer BS5930: 1999 for an explanation). The undisturbed sample was obtained in a plastic liner and sealed with wax prior to labelling. The number of blows of the standard driving hammer is required to obtain the sample is recorded on borehole records.

4.4.7 Standard Penetration Testing (SPT) was carried out at regular frequencies in the borehole. The test was carried out in accordance with BS1377: 1990 Part 9 *'Method of Test for soils for Civil Engineering Purposes'* (method 3.3). Details of the test, as required by BS1377: 1990 are recorded in borehole records. The drive rods were type AW up to 20m depth and type BW for depths in excess of 20m. Samples taken from the open sampler (SPT) were placed in a plastic bag, sealed and labelled. In coarse granular soils, a solid 60° cone may have been used to replace the SPT cutting shoe. This test is reported as SPT(C). A graphical summary of standard penetration testing is presented on Drawings STE1297R-03a, -03b and -03c.

4.4.8 The borehole excavations were formed by drillers accredited by the British Drilling Association with samples relogged by an experienced Geotechnical Engineer.

4.4.9 Records of boreholes formed by light cable and tool percussion drilling techniques are presented in Appendix E

4.4.10 Gas and water monitoring standpipes were installed in boreholes BH01 to BH06. The standpipes were installed following the recommendations of BS5930: 1999 '*Code of Practice for Site Investigations*' figure F1. Details of the standpipe installation are recorded on Drawing STE1297R-05.

4.4.11 Water levels in the standpipes have been measured during two return visits to the site (monitoring scheduled for a further 4 months). Water levels were measured using a measuring tape calibrated in 1mm intervals with an electronic end piece, which emits an alarm sound in contact with water. Water levels are measured from ground levels at the borehole position. Records of water levels are presented in Appendix K.

4.5 Driven Tube Sampling

4.5.1 Boreholes DTS01 to DTS21 were formed using driven tube sampling equipment. Driven tube sampling comprises driving 1m long steel sample tubes, which are screw coupled together or coupled to extension rods and fitted with a screw on cutting edge. The sample tubes are of various diameters, generally commencing with 100mm and reducing, with depth, to 50mm, and include a disposable plastic liner which is changed between sampling locations in order to limit the risk of cross contamination. On completion of excavation the liner containing the sample is cut open and the soil sample logged by a geo-environmental engineer. Borehole records are presented in Appendix F.

4.5.2 Samples for determination concentration of chemical contaminants are taken from samples obtained in the disposable tubes as sub-samples, using stainless steel sampling equipment, which is cleaned with de-ionised water.

4.5.3 The driven tube sampler obtains samples of quality class 3 or class 4 in accordance with Table 2 of BS5930: 1999 '*Code of Practice for Site Investigations*'.

4.5.5 Records of boreholes formed using driven tube sampling techniques are presented in Appendix F.

4.6 Dynamic Cone Penetration testing

4.6.1 Dynamic Cone Penetration (DCP) testing was carried out in twelve locations. Dynamic Cone Penetration testing consists of driving a 50mm diameter, 90° cone into the ground, via an anvil and extension rods with successive blows of a freefall hammer. The number of blows required to drive the cone each successive 100mm (N100) is recorded.

*4.6.2 Dynamic Cone Penetration testing was carried out following BS1377: 1990: Part 9 '*Methods of test for soils for Civil Engineering Purposes*'* (method 3.2) and the apparatus used was categorised as 'Super heavy' (DPSH) in accordance with the standard.

4.6.3 Equivalent Standard Penetration Test N value derived from Dynamic Cone Penetration test data is presented in graphical format on Drawings STE1297R-04a and b.

4.7 Measurement of Landfill Type Gases in gas monitoring standpipes

4.7.1 The concentrations of landfill type gases collected within gas monitoring standpipes installed in boreholes BH 01 to BH06 was measured using a portable infra-red gas analyser (model GA2000 plus, manufactured by Geotechnical Instruments). Initially the gas analyser was connected to the gas valve on the top of the standpipe to allow the flow rate to be measured. Essentially this is a measurement of gas pressure produced in the standpipe, which is compared with atmospheric pressure at the time of measurement to produce an equivalent gas 'flow' in l/hr. The equipment used is capable of measuring to an accuracy of 0.1l/hr; below this the gas analyser records zero flow. Following BS8485:2007 '*British Standard Code of Practice for the Characterisation and remediation from ground gas in affected developments*',(clause 6.1), we assume flows of 0.1l/hr when the gas analyser reads zero, thus producing a pessimistic gas flow rate in our assessment of ground gasses.

4.7.2 Following measurement of 'flow' the gas analyser pumps gases contained in the standpipe through the analyser for a period of about 30 seconds to allow a continuous measurement of landfill type gases. The analyser then measures 'peak' and 'steady' concentrations of the following gases.

- Methane (CH_4)
- Carbon dioxide (Co_2)
- Oxygen (O_2)
- Nitrogen (N_2)

4.7.3 The ambient atmospheric temperature and barometric pressure was also recorded at the site. To determine if the atmospheric pressure is rising or falling we interrogate the internet on a daily basis.

4.7.4 Methane in concentrations of between 5 to 15% in air is potentially explosive. The 5% methane concentration in air is defined as the Lower Explosive Limited (LEL). The gas analyser measures a percentage of the LEL. For example, 10% LEL equates to 10% of 5%, i.e. 0.5% methane concentration in air.

4.7.5 Records of gas monitoring data are presented in Appendix K.

4.8 Sampling Strategy

4.8.1 In general we adopted a judgemental sampling strategy in relation to potential chemical contamination. The location and frequency of sampling was carried out in consideration of the following:-

i) Location of potential contamination sources
ii) Topography
iii) Geology (including Made Ground)
iv) Nature of development proposals

Sampling for physical/classification testing was also judgemental with the frequency and location of sampling relating to: -

i) Geology
ii) Topography
iii) Nature of development proposals

4.8.2 Samples are stored for a period of one month following issue of this report unless otherwise required.

SECTION 5 - CONTENTS

5	**Ground Conditions Encountered**
5.1	Soils
5.2	Topsoil
5.3	Groundwater
5.4	Existing foundations

5 Ground conditions encountered

5.1 Soils

5.1.1 The exploratory excavations encountered soils, which, in our opinion, were identified as follows in order of superposition:-

either

- Dark to light brown grey and orange sandy silt or silty clays with gravels and cobbles of brick and flint gravels, between ground level and average depth of 1m and locally 1.9m adjacent to existing foundations.

or

- Brown grey and orange gravelly sand and sandy clay or light to dark brown sandy silt between ground level to between 0.3-1.0m considered to be made ground or topsoil these deposits graded into:-
- Loose becoming medium dense orange brown clays and silts becoming sands, sands and gravels to an average depth of 5m, locally to a depth of 9.3m considered to be Kempton Park Gravels.
- Stiff becoming very stiff blue grey clay considered to be London Clay to a depth in excess of 25m.

With the exception of Made Ground, the investigation generally confirmed published geological records.

5.2 Topsoil

5.2.1 As a practice we have adopted the following policy for description of topsoil. If the surface soil exhibits a visually significant organic content and darker colour than the soils it overlies (which are considered to be naturally deposited) then we will describe the soil as topsoil. In some cases it is difficult to visually distinguish the interface between topsoil and subsoils below, which may also exhibit an organic content, and in such cases we will adopt an estimate of the interface but may also use the terms 'grading into' with some defining depths.

5.2.2 If 'topsoil' deposits include materials such as ash, brick and other man made materials, or the topsoil overlies made ground deposits we will term the material 'made ground', even though it may still be able to support vegetable growth, and potentially reused as topsoil.

5.2.3 Topsoil can be classified following a number of test procedures as described in BS3882: 1994 '*Specification for Topsoil*', to allow its uses to be determined. We do not carry out such testing unless specifically instructed to do so.

5.3 Groundwater

5.3.1 Groundwater inflows were observed in most of the exploratory excavations. A summary of our observations is tabulated below:

Exploratory point	Depth (m) below ground levels	Observations
BH01	3.5	Steady
BH02	3.0	Steady
BH03	2.5	Steady
BH04	2.5	Steady
BH05	2.5	Steady
BH06	2.8	Steady
DTS02	1.1	After 5 min
DTS05	1.55	After 5 min
DTS06	1.34	After 5 min
DTS07	1.05	After 5 min
DTS08	1.09	Standing water level on commencement of infiltration test
DTS09	1.17	After 5 min
DTS10	0.87	After 5 min
DTS11	2.0	Rose to 1.5m in 10 min
DTS12	1.8	Steady
DTS13	2.45	Standing water level on completion of borehole
DTS14	2.5	Rose to 1.3m on completion of boreholes
DTS16	1.2	After 5 min
DTS17	1.41	Standing water level on commencement of infiltration test
DTS18	2.3	After 5 min
DTS20	2.0	After 5 min
Table 5.3.1		

5.3.2 It should be noted that water levels will vary depending generally on recent weather conditions and only long term monitoring of levels in standpipes will provide a measure of seasonal variations in groundwater levels. We are scheduled to monitor the boreholes over a 6 month period following the investigation. We have undertaken two of the scheduled visits to date with the measured water levels provided in Appendix K. We will provide the remaining depths on completion of the monitoring.

5.4 Existing foundations

5,4.1 Generally, and where possible trial pit excavations exposed existing (seemingly spread) foundations located on the upper (granular) horizons of the Kempton Park Gravels.

SECTION 6 - CONTENTS

6	**Laboratory testing**
6.1	Classification and physical testing
6.2	Chemical testing

6 Laboratory testing

6.1 Classification and physical testing

6.1.1 Laboratory testing was carried out as deemed necessary and limited to the following: -

- In accordance with BS1377: 1990 *"Methods of Test for Soils for Civil Engineering Purposes"*.

a) Classification tests: (to part 2)

i) Determination of moisture content (method 3)

ii) Determination of the liquid limit – one point cone penetrometer method (method 4.4)

iii) Determination of the plastic limit and plasticity index (method 5)

iv) Determination of particle size distribution – wet sieving (method 9.2)

b) Compressibility, permeability and durability tests (to part 5).

i) Determination of one-dimensional consolidation properties.

c) Shear strength tests (total stress) (to part 7).

i) Determination of undrained shear strength in triaxial compression without measurement of pore pressure (method 8).

d) Compaction related tests (to part 4)

i) Determination of the California Bearing ratio (CBR) (test 7).

6.1.2 Laboratory testing was carried out by an independent specialist testing house, which operates a quality assurance scheme.

6.1.3 Copies of laboratory test result certificates are presented in Appendices G and H.

6.2 Chemical testing

6.2.1 Laboratory testing was carried out as deemed necessary and carried out using the following techniques:

- Using inductively coupled plasma – optical emission spectrometry (ICP-OES), determination of concentration of
  - i) Metals
  - ii) Soluble sulphate content
- Using gas chromatography – mass spectrometry, determination of the concentration of
  - i) Polycyclic aromatic hydrocarbons (PAH)
- Using electromagnetic measurement, determination of pH
- Using gas chromatography – flame ionisation detection methods, determination of concentration of Total petroleum hydrocarbons and speciation of the same.
- Determination of concentration of leachable contaminants

6.2.1 Laboratory testing was carried out by an independent specialist testing house, which operates a quality assurance scheme.

6.2.2 Copies of laboratory test result certificates are presented in Appendix I.

SECTION 7 - CONTENTS

7	**Engineering Assessment**
7.1	General description of the development
7.2	Building foundation design and construction
7.3	Influence of trees and hedges
7.4	Ground floor construction
7.5	Service trench excavations
7.6	Infiltration potential
7.7	Pavement foundations

7 Engineering Assessment

7.1 General Description of the Development

7.1.1 The following assessments are made on the investigatory data presented in the preceding sections of this report and are made with reference to specific nature of the development.

7.1.2 We understand the project will consist of the phased demolition of the existing buildings at the College in combination with and followed by:-

- Construction of temporary accommodation block to the south of the existing campus
- A new four to five storey "L" shaped building approximately 250m long by 40m extending to playing fields to the north of the site and within the footprint of the existing college buildings, and
- A potential residential development in the southern part of the site.

7.1.3 At this stage the layout and position of the buildings is being developed, and no plans are currently available.

7.1.4 Should the development proposals change then it may be necessary to review the investigation and report.

7.2 Building Foundation, Design and Construction

7.2.1 Definitions of geotechnical terms used in the following paragraphs are provided in Appendix A.

7.2.2 In our opinion the naturally deposited Kempton Park Gravels will adequately support low rise buildings on spread type foundations. The Kempton Park Gravels generally below 1m are granular and thus their volume will not be influenced by changes water content due to demands of major vegetation at the site. Based on the above, in combination with ground conditions encountered on site, we recommend foundations extend a minimum of 1m, below existing or proposed ground levels whichever provides the deeper foundation with all foundations penetrating any made ground deposits by at least 0.3m subject to an overall foundation depth of 1m. It should be noted at this stage that demolition of existing buildings in combination with removal of foundations will cause disturbance of near surface soils thus requiring deeper new foundations where new buildings intercept footprints of existing.

7.2.3 We consider it likely there are some air raid shelters on site, based on our interpretation of Ordnance Survey maps and from knowledge of members of the college estates department. The approximate location of the air raid shelters is shown on drawing STE1297R-02. Some of these shelters would have been removed as part of the construction of the music building but an earthworks mound remains on site in the area of the former shelters outside footprints of existing buildings. Borehole DTS15 formed in this area encountered concrete at shallow depths potentially confirming an underground structure in this area. Clearly there is a risk of encountering underground structures in this area, requiring removal in areas of new build and consequential increase in foundation depths. At this stage and due to time restrictions associated with our fieldwork activities insufficient information is available to clearly define the lateral and vertical extent of these potential former air raid shelters.

7.2.4 Essentially, in our opinion, the Kempton Park Gravels deposits will behave as a granular material. Calculations based on an angle of shearing resistance of 33°, a foundation depth of 1m with groundwater levels located at the base of foundations, indicate following bearing values for pad type foundations

Plan size of pad (m)	Ultimate bearing value (KN/m^2)	Presumed bearing value (KN/m^2)	Allowable bearing pressure (KN/m^2)
1.5 x 1.5	750	260	260
2.0 x 2.0	810	280	235
2.5 x 2.5	870	300	200
3.0 x 3.0	930	320	175
3.5 x 3.5	990	340	160
4.5 x 4.5	1110	380	135

Table 7.2.4

The presumed bearing value has been derived from the ultimate bearing value by applying a factor of safety of 3, and the allowable bearing pressure derived to limit total settlement. The allowable bearing pressure for a concrete strip foundation located at the same formation level as the pad foundation would be identical to that described above for a 1.5m square pad foundation.

7.2.5 It is difficult to accurately predict the amount of total and differential movement caused by consolidation of the foundations supporting subsoils, however, providing foundation stresses do not exceed allowable bearing pressures provided in the preceding paragraph, it is suggested that total settlement would be small and probably less than 25mm. Differential settlement is totally dependant upon the variation of foundation loads and consistency of the supporting ground. Assuming the foundation loads are reasonably uniform, we suggest that differential settlement is unlikely to exceed say 15mm between adjacent pads. It is likely settlement will be fully achieved within say 5 years of construction.

7.2.6 The Kempton Park Gravels deposits encountered in exploratory excavations are consistent and will provide uniform support to foundations. In the unlikely event foundation excavations encounter clay deposits, we recommend foundation excavations continue to locate granular soils.

7.2.7 It is difficult to predict the stability of trench sides from borehole investigations. Generally we anticipate some overbreak/instability in more granular (loose) deposits of the made ground and Kempton Park Gravels producing a wider than planned trench widths resulting in an increase in the quantity of foundation concrete to fill voids produced by instability of trench sides.. The risks of encountering groundwater increase significantly at depths below 1.3m with groundwater inflows promoting collapse of trench sides and the construction of a successful spread type foundation difficult.

7.2.8 Although it is likely that a spread foundation solution will be sufficient for the proposed building, piled or raft foundation solutions could also be adopted and the following paragraphs provide information relating to these solutions.

7.2.9 Piled Foundations

7.2.9.1 A piled foundation would transmit superstructural loads down through the Made Ground into the Kempton Park Gravels and London Clay at depth to obtain end bearing and shaft adhesion support. The difficulty of driving or boring piles through these deposits will need to be considered by any specialist piling company and will affect the method of pile installation. It is important to note that the Kempton Park Gravel deposits include groundwater which will affect the method of pile installation.

7.2.9.2 For the purposes of producing a preliminary pile design foundation scheme, we have produce the following report paragraphs based on the following idealised soil profile:

1 to 6m Kempton Park Gravels
6 to 23m+ London Clays

7.2.10 Preliminary pile design parameters – (Kempton Park Gravel)

7.2.10.1 Ultimate shaft adhesion values for bored piles in the granular Kempton Park Gravel deposits are derived using the following relationship

$$Qsu = ks \times \sigma v \times \tan \delta$$

7.2.10.2 We have assumed loose density parameters taking into account the likelihood of soil disturbance during excavation of pile bores (refer Tomlinson – *'Foundation design and construction'* – seventh edition) The following parameters must be considered estimates only. Detailed pile design must be undertaken by a specialist piling contractor who is familiar with installation of piles in this geology.

for loose conditions let $\phi = 30\,°$ (angle of shearing resistance)

Let $\sigma v = 19kN / m^3$ x depth and assume $\delta = 20\,°$ (soil pile friction angle)

Where, $ks = 0.8ko$ Tomlinson, 2001 (p206) $ko = 1 - \sin\phi = 0.5$, then $ks = 0.4$

Then $Qs = 0.4 \times \tan 20\text{o} \times \sigma v \times As = 0.145 As \times \sigma v$

Where, $\sigma v =$ average effective overburden pressure over depth of soil layer and $As =$ area of pile shaft.
Utilising the above we can provide the following information for preliminary pile design purposes based on the bored pile solution through the granular Kempton Park Gravel deposits

Strata	Depth (m)	Shaft adhesion factors (kN/m²)	End bearing factor (kN/m²)
Kempton Park Gravel deposits	1.0 to 6m	Increase linearly from 2.755 x As (@1m) to 16.53 x As (@6m)	NA
Table 7.2.10			

A factor of safety of 2.5 on the ultimate load as given by the sum of the base resistance and skin friction should limit settlement at the working load to tolerable values although we recommend settlement should be verified by load testing in advance of main piling.

7.2.11 Preliminary pile design parameters (London Clays*)*

7.2.11.1 The ultimate shaft adhesion for bored piles in London Clays is determined by the following relationship.

$$Qsu = \overline{Cu} \times \alpha \;\; x\, As$$

Where α = adhesion factor and $\overline{Cu}$ = average undrained shear strength (kN/m^2).

7.2.11.2 Measured undrained shear strength determinations have been used to 'calibrate' the conversion of standard penetration test data to undrained shear strength with a summary of undrained shear strength data in the London Clay shown on Drawings STE1297R-03a and -03c. A suggested relationship between undrained shear strength and penetration into the London Clays is shown on Drawing STE1297R-03c based primarily on shear strength determinations. This relationship can be used to determine $\overline{Cu}$.

7.2.11.3 With reference to '*Guidance notes for the design of straight shafted bored piles in London Clay*' produced by the London District Surveyors Association, the $\overline{Cu} \times \alpha$ value is limited to 140 KN/m^2, (approximately equates to a maximum undrained shear strength of 235KN/m^2) unless it can be demonstrated that higher values can be adopted by pile testing.

7.2.11.4 It is important to exclude water from pile bores in the London Clays to avoid further softening of these soils which would reduce the shaft adhesion support to the pile.

7.2.11.5 The ultimate end bearing capacity for bored piles terminating in the London Clays is derived from the following relationship.

$$Qbu = Nc \times Cu \text{ x } Ab$$

Where Nc = end bearing capacity factor = 9
Cu = undrained shear strength (kN/m^2) at the pile toe.
Again, Cu can be obtained from Drawing STE1297R-03c.

7.2.11.6 Utilising the above we can provide the following information for preliminary pile design purposes based on the bored pile solution in the London Clays.

Strata	Depth (m)	Shaft adhesion factors (kN/m²)	End bearing factor (kN/m²)
London Clay (α = 0.6)	6 to 23m	Increase linearly from 39 x As (@5m) to 90 x As (@23m)	Increase linearly from 585 x Ab (@6m) to 1350 x Ab (@23m)

Table 7.2.11.6

Where As = Area of the pile shaft (m²)
Ab = Area of the pile base (m²)

The adhesion factor, α of 0.6 in the London Clays has been obtained from guidance provided in '*Guidance notes for the design of straight shafted bored piles in London Clay*' produced by the London District Surveyors Association, and assumes the following:

- There are no water seepages in the London Clays

- Piles are not constructed using drilling fluid (eg bentonite) or continuous flight auger
- The pile design is dictated by vertical compressive loads
- The piles are concreted within 12 hours of start of boring in the London Clays (or 12 hours below casing depth)

The published guidance recommends the adhesion is limited to 140KN/m^{2,} which equates to limit on the undrained shear strength of the clays of about 235KN/m^2. This limit could be reconsidered if pile testing is carried out to demonstrate higher values of shaft adhesion.

7.2.11.7 The sum of shaft adhesion and end bearing will need to divided by a factor of safety ranging from 3 to 2 subject to testing of installed piles. The following is taken from guidance in the publication described above:

Pile testing		**Factor of safety**
Preliminary pile load test to confirm design	**Load testing on working piles to 1.5 x working load**	
none	none	3
none	1% of working piles	2.5
Constant rate of penetration test	1% of working piles	2.25
Maintained load test	1% of working piles	2.0

Table 7.2.11.7

7.2.12 Pile Design and Installation

7.2.12.1 We have endeavoured to provide sufficient information to allow detailed design of piles to be completed. The above pile design guidelines have been produced in good faith based on our current understanding of design procedures for the purposes of producing a preliminary foundation layout by a Structural Engineer. We recommend the design and installation of the piles are determined by a specialist piling contractor who has experience in pile installation in these or similar ground conditions, and may be able to interpret the observed ground conditions in a different and potentially more beneficial manner. We recommend the specialist piling contractor assumes responsibility for the choice, design and installation of the piles.

7.2.12.2 We recommend piling be carried out following the *"Specification for Piling and Embedded Retaining Walls"* produced by the Institution of Civil Engineers.

7.2.12.3 Methods for load testing of piles including the constant rate of penetration test and maintained load test are described in BS 8004:1986 '*British Standard Code of practice for Foundations*'.

7.2.12.4 It is likely that a 'piling mat' will have to be constructed in advance of piling operations. This will be designed following the Building Research Establishment publication '*Working Platforms for tracked plant: good practice guide to the design, installation, maintenance and repair of ground supported working platforms*'. We will be pleased to assist in the design and specification of such a platform on further instructions.

7.2.13 Raft Foundations

7.2.13.1 Raft foundations have the ability to spread superstructural loads over the footprint of the building thus substantially reducing stresses imparted to the ground compared with isolated spread foundations. The bearing capacity of a raft foundation is not typically critical, but levels of settlement need to be established. In order to determine likely levels of settlement we will require likely stress levels generated by the raft and indeed the area of the raft. We will be pleased to carry out settlement calculations on receipt of the above data and on further instructions. For a shallow raft, then we recommend made ground deposits are removed and replaced where appropriate with an imported well graded durable granular fill compacted to an end point specification.

7.3 Influence of Trees and other major vegetation

7.3.1 The results of plastic and liquid limit determinations performed on samples of the Kempton Park Gravel (generally below 1m) indicate the deposits are non-plastic when classified in accordance with National House Building Council (NHBC) Standards, Chapter 4.2 and thus not affected by the moisture demand of trees and other major vegetation.

7.4 Ground Floor Construction

7.4.1 College buildings (large floor areas)

7.4.1.1 Ground bearing floor slabs can be adopted at this site where Made Ground and Topsoil deposits are fully removed within the footprint of the building. We recommend a blanket of good quality compacted granular material be placed prior to construction of the floor slabs.

7.4.1.2 Following completion of excavations to formation levels we recommend where possible the formation is rolled using a heavy roller to identify any soft areas and indeed compact near surface soils which may have been disturbed by excavation processes. Any 'soft' areas will require excavation to locate more stable soils. We recommend a blanket of good quality compacted granular material be placed prior to construction of the floor slabs.

7.4.1.3 Where floor slabs are not required to support settlement sensitive equipment and with reference to '*Concrete industrial ground floors*' (Technical Report no. 34 – third edition) produced by the Concrete Society, the modulus of subgrade reaction (k) supporting the floor slab has only a minor effect on the slab design thickness for flexural stresses and does not therefore have to be estimated with great accuracy.

7.4.1.4 The modulus of subgrade reaction is a measure of the elastic properties of near surface soils. Plate bearing tests provide the most accurate measure of elastic modulus and we can carry this out on further instructions. California Bearing Ratio (CBR) test data be converted to an equivalent modulus of subgrade reaction (see Technical Report 34), but CBRs are not a direct measure of modulus. Again, we can carry out CBR testing on further instructions. Technical report 34, provides typical values of modulus of subgrade reaction based on soil descriptions, and using this guidance we estimate the modulus subgrade reaction in the range of 0.015 to 0.03 N/mm^3.

7.4.1.5 In addition to elastic deformation of soils (estimated from *k* values described above), some long-term settlement of the floor slab will occur under applied loads, particularly uniformly distributed loads. It is difficult to accurately predict levels of settlement, as the applied load pattern is not known. Assuming a constantly applied uniformly distributed load of say $50kN/m^2$, settlements in the order of 10mm could occur within 5 to 10 years. Some differential settlement will occur in the long term, if the floor slab is not uniformly loaded.

7.4.1.6 If ground floors to college buildings are required to support settlement sensitive equipment then the amount of allowable settlement will dictate the floor construction and indeed the method of support. At this stage we do not know if any settlement sensitive equipment is planned or indeed if such equipment is planned then the levels of settlement, but we will be pleased to advise further on this item at a future date once further details are known.

7.4.2 Residential buildings

7.4.2.1 We assume residential developments will comprise low rise housing. Although ground bearing floors could be adopted supported on the naturally deposited Kempton Park Gravels, BS8103-1:1995 '*Structural design of low rise buildings – code of practice for stability, site investigation, foundations and floor slabs for housing*' limits the depth of filling below floors to 600mm, thus if this cannot be achieved then a suspended floor construction will be required.

7.5 Service Trench Excavations

7.5.1 Generally we anticipate some overbreak/instability in more granular (loose) deposits of made ground producing a wider than planned trench widths The risks of encountering groundwater increase significantly at depths below 1.3m with groundwater inflows promoting collapse of trench sides requiring continuous shoring and indeed significant pumping to maintain an open excavation. On this basis it is important to minimise where possible depths of excavations.

7.5.2 We recommend any trench excavation requiring human entry is shored as necessary to conform with current best practice, and accepted by the Health and safety Executive (HSE) and in particular, following guidance provided in the HSE construction information sheet No 8 (revision 1) *"Safety in excavations"*.

7.6 Infiltration Potential

7.6.1 The Kempton Park Gravel deposits and Made Ground generally exhibit some permeability varying across the site. The permeability of these soils was measured in ten trial pits generally following the procedures described in Building Research Establishment (BRE) Digest 365 (2007) "*Soakaway Design*". These tests produced infiltration rates of between 5 $\times 10^{-6}$ ms^{-1} to 5.2 $\times 10^{-5}$ ms^{-1}. In addition, variable head tests were undertaken in two of the driven tube sampler boreholes following methods described in *BS 5930: 1999 'Code of Practice for Site Investigations' (section 25).* The variable head tests produced infiltration rates of 3 $\times 10^{-5}$ ms^{-1} and 8.4 $\times 10^{-7}$ ms^{-1}. Records of the testing and calculations are presented in Appendix D. It should be noted that the rate of water dissipating in the trial pits and boreholes was in general relatively slow and we were not able to carry out three cycles of the test procedures described in the published methods with one day's fieldwork. Further on site testing with observations made over a period of days may allow the production of more accurate infiltration rates and allowing three cycles of the test procedure. We can carry out such testing on further instructions.

7.6.2 If infiltration systems are adopted as a means of stormwater disposal (including permeable pavement construction), we recommend approval for the use of soakaways is sought from the Environment Agency. It should be noted that the Groundwater Regulations 1998 require that list 1 substances (e.g. Hydrocarbons) are to be prevented from entering groundwater receptors and list 2 substances (e.g. metals) are also restricted. Typically, the Environment Agency will require details of the proposed soakaway systems, showing pollution prevention measures. They will also require geological and geo-hydrological information, (contained in this report) as well as the risks of chemical contaminants in the ground affecting water resources. It is also typical requirement that there is an 'unsaturated zone' between the base of the soakaway system and the groundwater table (saturated zone) providing attenuation capacity.

7.7 Pavement Foundations

7.7.1 It is anticipated that proposed access roads and associated hardstanding areas will be located at or about existing ground levels with formation located on Made Ground and Kempton Park Gravel deposits

7.7.2 Five bulk samples were submitted to the laboratory to determine the California bearing ratio, three of these were combined samples from a selection of sampling locations. Based on these, we have derived an average CBR of 2%. Laboratory results are presented in Appendix G.

7.7.3 We can also derive an 'equilibrium' CBR (California Bearing Ratio) values (with reference to Transport and Road Research Laboratory (TRRL) Report LR1132 *'Structural design of Bituminous Roads'*) are from a knowledge of subgrade classification data (plasticity index for soils exhibiting cohesion) the location of the water table below formation levels, pavement thickness, and weather conditions at the time of construction. The plasticity index of near surface Kempton Park Gravel deposits was measured at an average of 15 and with the water table located in excess of 600mm below assumed formation levels, and assuming a 'thin' pavement and average construction conditions a CBR of 4% is derived. This value should be compared with CBR derived from undrained shear strength data discussed in the following paragraph.

7.7.4 It is possible to derive the 'insitu' CBR value at formation from undrained shear strength data by applying a conversion factor of 23. Thus adopting pessimistic undrained shear strength of say $70kN/m^2$ (firm category) at formation level then an equivalent CBR value can be obtained i.e.

$$\text{Insitu CBR} = \frac{\text{undrained shear strength (70)}}{23} = 3\%$$

The 'insitu' CBR derived above, is susceptible to change dependent upon weather conditions during construction. The equilibrium CBR value derived in paragraph 7.7.3 above is an estimate of the CBR value, which will predominate during the life of the pavement. We recommend the insitu CBR of 3% derived from shear strength data be utilised for design purposes and reassessed during construction. The fact that clay subgrade soils are likely to be deemed frost susceptible will probably be the overriding criteria for pavement foundation design purposes.

7.7.5 Made Ground deposits at the site exhibit a degree of variation in compactness. Some long term settlement of hardstandings will occur due to consolidation of the Made Ground deposits and from applied loads, particularly uniformly distributed loads. It is difficult to accurately predict levels of settlement, as potentially applied loading patterns are not known. Assuming a constantly applied uniformly distributed load of say $10kN/m^2$, settlement in the order of 10mm could occur within 5 to 10 years of construction. Equally, some differential settlement could occur in the long term, if hardstandings are not uniformly loaded. We suggest that pavements under transient (vehicular) loads are unlikely to generate significant levels of settlement.

7.7.4 Once formation levels have been established it is recommended that the formation be trimmed and rolled following current requirements of the Highways Agency Specification for Highways Works (clause 616) (refer www.specificationforhighways.co.uk) Such a process will identify any soft areas, which we recommend be either excavated out and backfilled with a suitable well compacted material similar to those exposed in the sides of the resulting excavation, or large cobbles of a good quality stone rolled into the formation to stabilise the 'soft' area.

7.7.5 The silty nature of the Kempton Park Gravel will render them moisture susceptible with small increases in moisture content giving rise to a rapid loss of support to construction plant. We therefore recommend, as soon as formation is trimmed and rolled, that sub-base is laid in order to avoid deterioration of the subgrade in wet or frosty conditions.

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8 Chemical contamination (Part A – Regulation, liabilities and procedures)

8.1 Contaminated land, regulation and liabilities.

8.1.1 Statute

8.1.1.1 Part IIA of the Environment Protection Act 1990 became statute in April 2000. The principal feature of this legislation is that the hazards associated with contaminated land should be evaluated in the context of a site-specific risk based framework. More specifically contaminated land is defined as:

"any land which appears to the local authority in whose area it is situated to be in such a condition, by reasons of substances in, on or under the land, that:

a) Significant harm is being caused or there is a significant possibility of such harm being caused; or

b) Pollution of controlled waters is being or is likely to be caused".

8.1.1.2 Central to the investigation of contaminated land and the assessment of risks posed by this land is that:

i) There must be contaminants(s) at concentrations capable of causing health effects (*Sources*).

ii) There must be a human or environmental receptor present, or one which makes use of the site periodically *(Receptor)*; and

iii) There must be an exposure pathway by which the receptor comes into contact with the environmental contaminant *(Pathway)*.

8.1.1.3 In most cases the Act is regulated by Borough or District Councils and their role is as follows:

Inspect their area to identify contaminated land

i) Establish responsibilities for remediation of the land

ii) See that appropriate remediation takes place

- through agreement with those responsible, or if not possible
  - by serving a remediation notice, or
  - in certain cases carrying out the works themselves, or
  - in certain cases by other powers
- keep a public register detailing the regulatory action which they have taken

8.1.1.4 For "special" sites the Environment Agency will take over from the Council as regulator. Special sites typically include:-

- Contaminated land which affects controlled water and their quality
- Oil refineries
- Nuclear sites
- Waste management sites

8.1.2 Liabilities under the Act

8.1.2.1 Liability for remediation of contaminated land would be assigned to persons, organisations or businesses if they caused, or knowingly permitted contamination, or if they own or occupy contaminated land in a case where no polluter can be found.

8.1.3 Relevance to predevelopment conditions

8.1.3.1 For current use, Part IIA of the Environmental Protection Act 1990 provides the regulatory regime. The presence of harmful chemicals could provide a 'source' in a 'pollutant linkage' allowing the regulator (local authority or Environment Agency) to determine if there is a significant possibility of harm being caused to humans, buildings or the environment. Under such circumstances the regulator would determine the land as 'contaminated' under the provision of the Act requiring the remediation process to be implemented.

8.1.4 Relevance to planned development

8.1.4.1 With regards to planned future use, Planning and Policy Statement 23 (PPS23) '*Planning and pollution control – Annex 2 – Development on land affected by contamination*' requires land owners / developers to ensure the proposed development is safe and suitable for use for the purpose for which it is intended. The developer is thus responsible for determining whether land is suitable for a particular development or can be made so by remedial action. In particular, the developer should carry out an adequate investigation to inform a risk assessment to determine:

a) Whether the land in question is already affected by contamination through source – pathway – receptor pollutant linkages and how those linkages are represented in a conceptual model

b) Whether the development proposed will create new linkages create new linkages e.g. new pathways by which existing contaminants might reach existing or proposed receptors and whether it will introduce new vulnerable receptors, and

c) What action is needed to break those linkages and avoid new ones, deal with any unacceptable risks and enable safe development and future occupancy of the site and neighbouring land.

8.1.4.2 Building control bodies enforce compliance with the Building Regulations. Practical guidance is provided in Approved documents, one of which is Part C, '*Site preparation and resistance to contaminants and moisture*' which seeks to protect the health, safety and welfare of people in and around buildings, and includes requirements for protection against harm from chemical contaminants.

8.1.5 Further Information

8.1.5.1 The above provides a brief outline as regards current statute and planning controls. Further information can be obtained from the Department for the Environment, Food and Rural Affairs (DEFRA) and their Web site www.defra.gov.uk.

8.2 Objectives, procedures and report format

8.2.1 This report section discusses investigations carried out with respect to chemical contamination issues relating to the site. The investigations were carried out with the aim of satisfying the requirements of PPS 23 in relation to the proposed development and indeed determine if there are any liabilities with respect to Part IIA of the Environment Protection Act. As stated in Section 2.4.2, the investigation process followed the principles of BS10175: 2001 *'Investigation of potentially contaminated sites – Code of Practice'*, with the investigation combining a desk study (preliminary investigation) together with the exploratory and main investigations (refer BS10175: 2001 for an explanation).

8.2.2 This section of the report produces a *'Conceptual model'* based on investigatory data obtained to date. The conceptual model is constructed by identification of *contaminants* and establishment of feasible *pathways* and *receptors.* The conceptual model allows a *risk assessment* to be derived. Depending upon the outcome of the risk assessment it may be necessary to carry out remediation and/or further investigations with a view to eliminating, reducing or refining the risk of damage to identified receptors. If appropriate, our report will provide recommendations in this respect.

8.2.3 Definition of terms used in the preceding paragraph and subsequent parts of this section of the report are presented in Appendix B.

8.2.4 Procedure to assess risks of chemical contamination

8.2.4.1 For the purposes of presenting this section of this report, we have adopted the following sequence in relation to chemical contamination.

Conceptual model element	Contributory information	Outcome
Receptor	Development categorisation	- identification of receptors at risk of being harmed - method of analysing test data - criteria for risk assessment modelling
Pathways	- geology and ground conditions - development proposals	- identification of critical pathways from source to receptor
Source	- previous site history - desk study information - site reconnaissance - fieldwork observations	- testing regime - Identification of a chemical source - by-analysis of test data and other evidence
Table 8.2.4.1		

8.2.5 We have adopted, in general, the procedures described in CIRIA C552 *'Contaminated land risk assessment - a guide to good practice'* .in deriving a risk assessment. Initially we have carried out a 'phase 1 assessment' based on desk study information and site reconnaissance, to produce a preliminary conceptual model and thus a preliminary risk assessment. This model / assessment is then used to target fieldwork activities and laboratory testing, with the results of this part of the investigation used to allow a phase 2 assessment to be produced by updating the conceptual model and refining the risk assessment.

8.2.6 Report format

8.2.6 For ease of reporting we have split the remaining section of this report into three, considering individually the principle receptors potentially exposed to any chemical contaminants at the site: with the final part (part D) providing conclusions and recommendations ie

Part B Human receptors

Part C Water resource receptors (controlled waters)

Part D Summary and recommendations

8 Chemical contamination (Part B – Human Receptors)

8.3 Development Categorisation and Identified Human Receptors

8.3.1 Identified human receptors

8.3.1.1 The principal receptors subject to harm caused by any contamination of the proposed development site are as follows.

a) End users of the developed site (Humans)

b) Construction operatives and other site investigators (Humans)

8.3.1.2 We are aware that there are other receptors such as ecological systems and other non human living organisms and building materials. This section of the report deals with the receptors listed in paragraph 8.3.1.1 above.

8.3.2 Human Receptors – End Users of the Site

8.3.2.1 The critical human 'receptor' used in the analysis of test data (refer CLR publications listed in Section 8.8.2 below) is a child under the age of 6 years. This takes into account the inquisitive nature of children (i.e. an amenable means of direct soil ingestion) and their relative body mass. Such a receptor is critical for residential developments particularly those including gardens where both direct (hand to mouth and breathable soil dusts) and indirect ingestion (via consumption of home grown vegetables) of contaminated soils is feasible. For industrial/commercial developments, the adult becomes the critical receptor, exposed in the long term, where applicable, to breathable airborne contaminated soil dusts. These pathways (inhalation/ingestion) for source contamination to reach the human receptor can be eliminated, depending upon the development proposals, or by remediation, or indeed if the source is not evident then the source-pathway-receptor model is not relevant. Further, more detailed information on the exposure assessment model for human receptors is described in CLR 10 (refer report Section 8.8.2 for references).

8.3.3 Human Receptors – Construction Operatives and other site investigators.

8.3.3.1 Typically, construction operatives and other site investigators (such as archaeologists) will be exposed to the development site for relatively short timescales. Operatives however, are subject to contaminated soils/waters through the ingestion/inhalation pathway route. Exposure risks can be substantially reduced by various means described in the recommendations Section 8.19 of this report.

8.3.4 Development Categorisation

8.3.4.1 The nature of the development will have a significant influence on the ease or difficulty of how human receptors can access any contaminated soils at the site. Clearly, a site developed for industrial usage is likely to be ultimately covered in hardstandings and buildings thus effectively eliminating human end user access to any chemically impacted soils, whereas a residential development which includes gardens provides easy human (end user) access to soils in garden areas via direct contact or indeed indirect contact by consumption of soils on vegetables or inhalation of soil dust. On this basis, the type of planned development will significantly influence the conceptual model and analysis of any test data.

8.3.4.2 It is understood the site will be redeveloped but remain as a college facility (educational) thus we have assumed an equivalent commercial land use with the site substantially covered in buildings and hardstanding areas. This criterion has been used in the construction of the conceptual model, and ultimately in the evaluation of test data (refer following report sections). We are aware, that part of the site could be developed for residential end use, although the location and nature of such a development is currently not known, thus at this stage we have limited our considerations of chemical contamination to the equivalent 'commercial (educational) end use'. Once the location / nature of the residential development is known, we will be pleased to review test data in this location, and advise accordingly.

8.4 Identification of Pathways

8.4.1 Pathways to Human Receptors (end users)

8.4.1.1 CLR10 (refer report Section 8.8.2 for references), provides a very detailed assessment of pathways and assessment and human exposure rates to source contaminants. In summary, the principal pathways of contamination to the human receptor are as follows:-

- Ingestion of contaminated soil dusts
- Ingestion by incidental or deliberate hand to mouth contact
- Ingestion of contaminated fruit/vegetables
- Skin contact with soils (working or at play)
- Inhalation of vapours

Clearly some of these pathways can be eliminated depending upon the end use of the site, for instance ingestion of fruit/vegetables sourced from an industrial development is unlikely, and child receptors would not be considered for an industrial development.

8.4.2 Pathways to Human Receptors (end users) - Elemental Risk Assessment

8.4.2.1 Based on our understanding of development proposals (as described in 8.3.4. above), we can provide the following elemental risk evaluation of possible pathways to end users of the site.

Assessment of possible pathways to site end user receptors		
Receptor	**Type (position in conceptual model)**	**Probability of a chemical source causing harm**
End users (children)	Pathway – ingestion of contaminated soils	**Unlikely**
End users (children)	Pathway – inhalation of contaminated soil dusts	**Unlikely**
End users (adults)	Pathway – ingestion of contaminated soils	**Likely**
End users (adults)	Pathway – inhalation of contaminated soil dusts	**Likely**

Table 8.4.2

8.5 Assessment of Sources of Chemical Contamination

8.5.1 Initially, potential sources of contamination are assessed using the following elements of the investigation process.

- History of the site
- Desk study information
- Site reconnaissance

These elements will dictate a relevant soil/water testing regime to quantify possible risks of any identified contaminative processes/events which may harm identified receptors.

8.5.2 Source Assessment – History of the Site

8.5.2.1 The history of the site and its immediate surroundings based on published Ordnance Survey maps is described in Section 3.

8.5.2.2 Based on published historical maps, there is no evidence to indicate the site, or its immediate surroundings, has been subject to activities, which could produce a source of chemical contamination. The following table summarises this elemental source assessment.

Table summarising results of source assessment based on historical data		
Source	**Possible contaminant which could cause harm to human receptors**	**Likely extent of contamination on site**
On site and adjacent sites No recorded land uses which are likely to provide a contaminative source	No evidence available	Not applicable
Table 8.5.2		

8.5.3 Source Assessment – Desk Study Information.

8.5.3.1 Envirocheck presents a detailed database of environmental information in relation to the site including;

- Pollution incidents
- Landfill sites
- Trading activities

Based on the Envirocheck data (refer Appendix M) the site has no recorded history of any pollution events, or trading activities which could generate a source of contamination, or is located in close proximity to a landfill site. The following table summarises this elemental source assessment.

Table summarising results of source assessment based on desk study information		
Source	**Possible contaminant which could cause harm to human receptors**	**Likely extent of contamination on site**
On site and adjacent sites No recorded pollution events, trading activities etc, likely to provide a contaminative source	No evidence available	Not applicable
Table 8.5.3		

8.5.4 Source Assessment – Site Reconnaissance

8.5.4.1 A full description of the site and observed adjacent land uses is provided in Section 3 of this report. A plan summarising observations made on site during our site reconnaissance visit is presented on Drawing STE1297R-02.

8.5.4.2 As a result of our site reconnaissance, a 'porta cabin' type building was observed along the eastern boundary utilised as a chemical store, presumably storing chemicals used by the science faculty in the college laboratories. In our opinion, the chemicals are stored in small quantities and well managed and thus considered unlikely to produce a contaminative source likely to affect the near surface soils. On this basis, we are of the opinion that there is not any obvious evidence of any current or recent activities on site or adjacent sites which provide a potential source of chemical contamination. The following table summarises this elemental source assessment.

Table summarising results of source assessment based on historical data		
Source	**Possible contaminant which could cause harm to human receptors**	**Likely extent of contamination on site**
On site and adjacent sites No observed onsite activities or activities on adjacent sites which are likely to provide a contaminative source	No potential contaminative sources observed	Not applicable
Table 8.5.4		

8.5.5 **Source Assessment – Summary**

Table summarising results of source assessment			
Source	**Origin of information**	**Possible contaminant which could cause harm to humans / water receptors**	**Likely extent of contamination on site**
On site and adjacent sites No observed or recorded onsite activities or activities on adjacent sites which are likely to provide a contaminative source	Site reconnaissance, historical maps and desk study information	No potential contaminative sources observed	Not applicable
Table reference 8.5.5			

8.6 Phase 1 Assessment and initial conceptual model

8.6.1 Based on desk study information and site observations we can produce the following initial conceptual model with respect to human receptors which requires on site investigation to produce a qualitative risk assessment.

Initial conceptual model		
Potential source origin	**Potential pathway**	**Human Receptors at risk**
On site No positive identification of potential contaminative source based on desk study information and site reconnaissance	No pathway analysis required (no source identified)	Not applicable
Table 8.6.1		

8.7 Fieldwork observations

8.7.1 Continuation of Source Assessment based on Fieldwork Activities

8.7.1.1 Near surface soils exposed in trial pits TP14 and TP09 were observed to exhibit a hydrocarbon type odour. Trial pit TP14 was excavated adjacent to the chemical store, with TP09 exposing foundations to a building.

8.7.1.2 We obtained samples of the potentially chemically impacted soils for subsequent laboratory testing. On this basis, the source assessment requires amendment and is summarised in the table below.

Table summarising results of source assessment

Source	Origin of information	Possible contaminant which could cause harm to humans / water receptors	Likely extent of contamination on site
On site Hydrocarbon impacted soils	Fieldwork observations	Unknown and subject to testing	Around trial pit TP14 at 0.0-0.2m and TP09 at 0.1-0.2m depth

Table reference 8.7.2

8.8 Laboratory Testing

8.8.1 Testing Regime – Human receptors

8.8.1.1 Based on our source assessment reported in Section 8.5 and the preliminary conceptual model (section 8.6 above), we have no evidence to identify any past or recent uses of the site which may have generated specific contamination. On this basis, we have scheduled testing to measure the concentration of inorganic contaminants listed in table 2.1 of the Contaminated Land Report (CLR) no. 8 *'Potential Contaminants for the assessment of contaminated land'* produced by the Department for Environment, Food and Rural Affairs (DEFRA) in conjunction with the Environment Agency (EA), when they are considered a risk to harm human receptors.

8.8.1.2 With reference to Section 8.7 and our source assessment based on fieldwork observations (refer table 8.7.2. above we have scheduled testing to measure concentrations of total petroleum hydrocarbons with speciation (TPH-CWG) on a sample taken from each location. In addition, although we have no obvious evidence of organic contamination across the remainder of the site, we have scheduled testing to include more common organic compounds forming polycyclic aromatic hydrocarbons (PAH) typically derived from a variety of combustion and pyrolytic sources.

8.8.1.2 Twelve samples from across the site were submitted for measurement of inorganic contaminants and PAH described above. The quantity is considered a minimum to allow a meaningful statistical analysis of test data to be carried out and a risk assessment to be made. Obviously, additional testing (quantity and types) would allow a more accurate risk assessment to be made.

8.8.1.3 The results of laboratory determination of concentration of chemical contaminants are presented in Appendix I.

8.8.2 Criteria for assessment of test data – Human receptors

8.8.2.1 Assessment of laboratory test data has been carried out using the following documents published by the DEFRA in conjunction with the EA

- *Assessment of Risks to Human Health from Land Contamination: An overview of the development of soil guideline values and related research'* (R & D Publication, Contaminated Land Report **(CLR 7).**
- *'Contaminants of Soil: Collation of Toxicological Data and Intake Values for Humans'* (R & D Publication, Contaminated Land Report **(CLR 9).**
- *'The Contaminated Land Exposure Assessment Model' (*CLEA): *Technical basis and algorithms'* (R & D Publication, Contaminated Land Report **(CLR 10).**
- Model Procedures for the Management of Land Contamination (Contaminated Land Report **(CLR 11)**
- *'Contaminants in Soil: Collection of Toxicological data and intake values for Human Values'* (R & D Publications Tox 1, 2, 3, 4, 5, 6, 7, 8, & 10).
- *'Soil Guideline Values for Contamination'* (R & D Publication SGV1, 3, 4, 5, 7, 9, & 10).

These documents form part of the Contaminated Land Report (CLR) some of which remains unpublished. The above publications do provide soil guideline values (SGVs) in relation to the following chemical contaminants.

Arsenic	Mercury
Cadmium (total)	Selenium
Chromium (total)	Nickel
Lead	Ethylbenzene
	Toluene

8.8.2.2 Soil guideline values (SGVs) referred to in Contaminated Land Reports (CLR) are used as a screening tool to assess the risks posed to health of humans from exposure to soil contamination in relation to land uses. They represent 'intervention values'; indications to an assessor that soil concentrations above these levels might present an unacceptable risk to the health of site users. These soil guideline values have been produced using conceptual exposure models, which use assumptions and are applied to differing end uses of land. If the SGV's are exceeded it does not necessarily imply there is an actual risk to health and site-specific circumstances should be taken into account. Conversely, where a critical pathway or chemical form of the contaminant has not been evaluated by the CLR then, potentially, a significant risk may be present even if the SGV has not been exceeded.

8.8.2.3 Where published soil guidelines are not available for a contaminant we have adopted Generic Assessment Criteria (GAC). These values have been derived by Land Quality Management (LQM) and the Chartered Institute of Environmental Health (CIEH) and presented in *'Generic Assessment Criteria for Human Health Risk Assessment'*. GACs have been prepared for a number of metals and polycyclic aromatic hydrocarbons (PAH) following the CLR guidance and using the CLEA UK (beta) software.

8.8.2.4 Sulphur is listed in table 2.1 of CLR8 as a chemical which may be considered a risk to human health. Currently there is no SGV, GAC or indeed a toxicity report for this contaminant. Having carried out a significant amount of in house research, we have not been able to produce any criteria which would allow us to determine a concentration for sulphur which may be considered a risk to human health. According to the United States Environmental Protection Agency (USEPA), *'sulphur poses very little if any risk to human health'*. Contact with natural sulphur at low levels over many years is generally recognised as safe. Health studies of mineworkers exposed to sulphur dust and sulphur dioxide throughout their lives show that they often had eye and respiratory disturbances including bronchitis and chronic sinus effects. These effects, however, relate to continued exposure to high concentrations of sulphur dust. On this basis, unless the site is clearly significantly contaminated with sulphur relating to past use of the site which used/manufactured sulphur, we would not consider this element further.

8.8.2.5 Currently there is a toxicity report for inorganic cyanide but not organic cyanides. In the absence of both an SGV and GAC for this contaminant we are researching this potential contaminant with respect to risks to human health. Pending completion of our research we have adopted a potentially conservative approach of considering a risk to human health on the concentration of cyanides (free and total) above detectable limits.

8.8.3 Statistical analysis of test data – Human Receptors

8.8.3.1 Following CLR7, we have carried out a statistical analysis of test data for each chemical contaminant considered in this investigation. Initially, the maximum value test is carried out to provide an indication of results, which could be considered 'statistical outliers', and thus not part of the general population of results. The maximum test value is described in detail in CLR7. If outliers are clearly identified, then these may represent an area of contamination considered worthy of further investigation.

8.8.3.2 Following completion of the maximum value test procedure, then the mean value test is carried out on test data. If a "statistical outlier' is identified as part of the maximum value test, then the outlier result is ignored in the subsequent mean value test, to avoid distortion of the general population of results. The mean value test determines the 95th percentile value for appropriate test data for individual contaminants, which is also related to the number of test values under consideration. The resulting 95th percentile values are then compared with soil guideline values or site specific assessment criteria.

8.8.3.3 Following paragraph A8 of CLR7, any concentrations of contaminants that are below the analytical detection limit are assigned a value equal to the detection limit for the purposes of carrying out the statistical analysis. In some cases where a small proportion of results marginally exceed detection limits, with the remaining results at or below detection limits, then statistically these 'higher' results could be deemed statistical outliers. Providing these results are below SGVs or GACs then further investigations are not considered necessary.

8.8.3.4 The above statistical analysis of test data is tabulated in Appendix J.

8.8.3.5 As always, statistical tests are an aid to decision making, but are not a substitute for professional judgement.

8.8.4 Evaluation of test data (inorganic contaminants) - Human Receptors

8.8.4.1 In consideration of the results of the maximum value test (refer Appendix I), statistical analysis highlighted outliers potentially suggesting further investigations for arsenic, cadmium, cyanide, nickel, sulphur and vanadium. With the exception of cyanide and sulphur which do not have published assessment criteria, the outlier concentrations associated with these metals fall well below soil guideline values for the end use of the site. With reference to paragraph 8.8.2.4, we do not consider the measured concentration of sulphur to present a risk to end users of the site.

8.8.4.2 The maximum value test compares an outlier test statistic to a critical value. CLR7 gives two different critical values; one for a 5% chance of wrongly identifying an outlier; and one for a 10% chance. In contaminated soil analyses we are concerned about wrongly accepting a value; therefore, 10% values are more stringent (i.e. human health protective). In the case of arsenic and vanadium, the outlier test statistic lies between the 5% and 10% critical values. Now, considering the mean value test with the potential outlier value removed from the population of results, the resulting 95th percentile value falls below the SGV (or GAC) for this contaminant (refer Appendix J). Considering, then, the 95th percentile value for the whole population of results, (including the potential outliers) then this value again falls below the

SGV (or GAC) for this contaminant. On this basis we do not consider this potential outlier values for arsenic and vanadium worthy of further investigation.

8.8.4.3 With respect to cyanide, in our opinion, the outlier concentration did not represent a true outlier but due to a quirk in the statistical analysis. When values are measured to be below detectable limits it is assumed, for the purposes of statistical testing, that these concentrations are equal to detectable limits. This can have the effect of erroneously highlighting values as outliers. Based on these observations we are of the opinion the outlier concentration is not worthy of further investigation.

8.8.4.4 In consideration of the mean value test (95th Percentile values – refer Appendix J), none of the 95th Percentile values exceed the relevant SGV or GAC. It should be noted that test data indicates the concentration of cyanides are below or marginally above detectable limits and on this basis cyanides are not considered to potentially pose a significant risk causing significant harm to human end users of the site.

8.8.4.9 Based on the above evaluation, we are of the opinion that the near surface soils do not exhibit any significant inorganic contamination from a perspective of human end use and thus, in conclusion, are not considered to present a significant possibility of causing significant harm to human health.

8.8.5 Evaluation of test data (organic contaminants) – Human Receptors

8.8.5.1 Polycyclic aromatic hydrocarbons

8.8.5.1.1 For evaluation of test data in relation to polycyclic aromatic hydrocarbon (PAH) contamination we have used benzo(a)pyrene, dibenzon(a,h)anthracene, fluorene and naphthalene as indicators of prevalent organic contamination. These indicators have been chosen as they have corresponding GACs. The GAC fractions are dependent on the Soil Organic Matter (SOM) content of the soils. We have adopted the lowest measured SOM as an initial screening value.

8.8.5.1.2 With respect to the maximum value test (refer Appendix J), outliers were produced for benzo(a)pyrene, dibenzo(a,h)anthracene and fluorene, with measured at a concentrations of 18-58mg/kg, 0.12-6.4mg/kg and 0.14-24mg/kg respectively. None of the results exceed our site specific assessment criteria with the exception of one result for benzo(a)pyrene measured at a concentration of 58mg/kg on a sample taken from borehole DTS05 at 0.2-0.35m.

8.8.5.1.3 With respect to dibenzo(a,h)anthracene, fluorene and naphthalene, in our opinion, the outlier concentrations do not represent outliers but due to a quirk in the statistical analysis. When values are measured to be below detectable limits it is assumed, for the purposes of statistical testing, that these concentrations are equal to detectable limits. This can have the effect of erroneously highlighting values as outliers. Based on these observations we are of the opinion the outlier concentrations associated with these contaminants are not worthy of further investigation.

8.8.5.1.4 In consideration of the mean value test (95th percentile values – refer Appendix J) for benzo(a)pyrene, dibenzon(a,h)anthracene, fluorene and naphthalene none of the results exceed the relevant GAC values.

8.8.5.1.5 Based on the above evaluation, only one sample taken from borehole DTS05 at 0.2 to 0.35m produced elevated concentration of benzo(a)pyrene, (a sample of ash / clinker) which could pose a risk of causing harm to end users of the site. Recommended remedial action is described in section D below.

8.8.5.2 Total Petroleum hydrocarbons

8.8.5.2.1 For evaluation of total petroleum hydrocarbon contamination (measured on the two samples taken from trial pits TP9 and TP14, which exhibited some hydrocarbon odours) we have followed the principles described in the EA publication '*The UK Approach for evaluating Human Health Risks from Petroleum Hydrocarbons in Soils'.* We have adopted a first stage approach of comparing measured concentrations of indicator compounds with soil guideline values (SGV) or site specific assessment criteria (GAC). We have adopted the following indicator compounds based on currently available GACs and SGVs.

Indicator compounds for TPH evaluation	
None threshold indicators	**Threshold indicators**
• Benzo(a)pyrene (GAC) • Dibenz(a,h)anthracene (GAC)	• Toluene (SGV) • Ethylbenzene (SGV) • Naphthalene (GAC)
Table 8.8.5a	

Threshold indicators are contaminants for which there is tolerable human intake, whereas for non threshold contaminants, human exposure should be kept to a level as '*low as reasonably practicable'* (ALARP)

8.8.5.2.2 Comparison of measured concentrations of the above indicator compounds with GACs and (refer appendix I) indicates petroleum hydrocarbon contamination is unlikely to pose a significant risk of causing harm to end users of the site.

8.8.5.2.3 The second stage of TPH analysis considers individual fractions of the TPH concentration. We have adopted the published GAC values for each hydrocarbon fraction. The GAC fractions are dependent on the Soil Organic Matter (SOM) content of the soils. We have adopted the lowest measured SOM as an initial screening value. Based on conservative GAC values, none of the fractions are above the relevant GAC, and therefore unlikely to pose a significant risk of causing harm to end users of the site. The comparison of measured values with GAC values is presented in appendix I)

8 Chemical contamination (part C – Water Receptors)

8.9 Location and sensitivity of water receptors

8.9.1 Groundwater receptors

8.9.1.1 With reference to section 3.5, the following table summarises the environmental setting of the site with respect to groundwater receptors.

Table summarising criteria defining sensitivity of the site with respect to groundwater receptors	
Criterion	**Status**
Aquifer potential	Major Aquifer within Upper Chalk
Abstractions	Closest 859m north west for Sewage Treatment works
Source protection zone	Remote from source protection zone
Fieldwork observations	Reasonably consistent deposit of permeable Kempton Park Gravels containing groundwater overlying impermeable London Clay
Table 8.9.1	

Based on the above, although the site is considered to be a major aquifer, this is likely to refer to the Upper Chalk underlying the London Clay. The London Clay is considered to be effectively impermeable and thus we do not consider there to be a high risk of chemical contaminants migrating vertically into the major aquifer. However, in consideration of the high water table, we consider the site to be relatively sensitive to any chemical contamination affecting groundwater resources, and thus worthy of appropriate investigations to determine risks.

8.9.2 Surface water receptors

8.9.2.1 With reference to section 3.2, the following table summarises the environmental setting of the site with respect to surface water receptors.

Table summarising criteria defining sensitivity of the site with respect to surface water receptors	
Criterion	**Status**
Location of surface watercourse	Channel of River Crane 75m south of site Channel of the Duke of Northumberlands River 20 to 300m to the west of the site.
Abstractions	None within 2000m of the site
Fieldwork observations	Reasonably consistent deposits of reasonably permeable Kempton Park Gravel containing groundwater
Table 8.9.2	

Based on the above, and in consideration of the close proximity of a watercourse in combination with the permeable nature of the near surface soils, we are of the opinion the site is sensitive to any chemical contamination affecting surface water resources, and thus worthy of investigations to establish risks.

8.10 Source assessment – Water receptors

8.10.1 The source of potential contaminants at the site has been established in section 8.7 above and summarised in table 8.7.2 which is repeated below. These sources each have a potential to affect ground / surface water receptors.

Table summarising results of source assessment			
Source	**Origin of information**	**Possible contaminant which could cause harm to humans / water receptors**	**Likely extent of contamination on site**
On site Hydrocarbon impacted soils	Fieldwork observations	Unknown and subject to testing	Around trial pit TP14 at 0.0-0.2m and TP09 at 0.1-0.2m depth
Table reference 8.7.2			

8.11 Pathway assessment – Water receptors

8.11.1 Groundwater receptors

8.11.1.1 Based on the sensitivity analysis described in section 8.9 above the site is considered relatively sensitive to any chemical contamination affecting groundwater resources. In addition, and with reference to section 3.5 above, the site is directly underlain by some 4 to 9m of Kempton Park Gravels comprising sands and gravels which exhibit some permeability and contains groundwater thus poses a risk of vertical migration of leachable contaminants to groundwater resources.

8.11.2 Surface water receptors

8.11.2.1 Based on the sensitivity analysis described in section 8.9 above the site is considered sensitive to any chemical contamination affecting Surface water resources. With the site being principally underlain with permeable deposits of Kempton Park Gravels which extend to the watercourses identified in table 8.9.2 above there is a feasible lateral migration pathway from the subject site to nearby watercourses.

8.12 Phase 1 Assessment and initial conceptual model relating to water receptors.

8.12.1 Based on sections 8.9 to 8.11 above we can produce the following initial conceptual model with respect to water resource receptors which requires on site investigation to produce a qualitative risk assessment.

Initial conceptual model		
Potential source origin	**Potential pathway**	**Water Receptors at risk**
On site Hydrocarbon impacted soils	Vertical and horizontal migration of hydrocarbons through permeable soils on site	Groundwater / surface waters
Table 8.12.1		

8.13 Testing regime – Water Receptors

8.13.1 With reference to CLR8 and in the absence of any knowledge of historical site uses which may have generated specific contamination and based on observations during our fieldwork activities, we have scheduled testing to measure the leachability / concentrations of inorganic contaminants listed in table 2.1 (of CLR8) where they are considered a risk to water resources. In addition, we have scheduled testing to include the common organic compounds forming polycyclic aromatic hydrocarbons (PAH).

8.13.2 It should be noted that we have only scheduled six water samples taken from each of the six deeper boreholes (where monitoring standpipes were installed) some 3 weeks after completion of drilling operations. These samples were scheduled for determination of concentrations of contaminants described in paragraph 8.13.1 above.

8.14 Assessment Criteria - Water Receptors

8.14.1 For interpretation of test data in relation to water receptors we have directly compared measured values with the Environmental Quality Standards (EQS) produced by the Environment Agency in their publication, 'Environment Agency technical advice to third parties on Pollution of Controlled Waters for Part 11A of the Environmental Protection Act 1990.

8.14.2 In the absence of EQS values we have adopted UK Drinking Water Standards published in the Water Supply (Water Quality) Regulations.

8.15 Evaluation test data – Water Receptors

8.15.1 Inorganic contaminants

8.15.1.1 Acceptable EQS values for freshwater is dictated by the hardness of the receiving watercourse. The hardness of water is a measure of the concentration of calcium carbonate in the water. Although we have not sampled water from nearby watercourses, we have contacted the Environment Agency and have been advised that there is some test data for hardness in the River Crane, which is an ultimate receiving watercourse from surface waters downstream of the site. We are advised that over a two year monitoring period, the River Crane produced an average hardness of 280mg/l at Duke of Northumberland's

River (downstream of the subject site). Using this information for List II substances (DOE Circular 7/89) we have added the EQS values relative to the hardness of the receiving watercourse to the above table assuming a worst case scenario of the watercourse supporting 'sensitive' aquatic life.

8.15.1.2 Based on this comparison the measured concentration of inorganic contaminants in six water samples taken across the college campus fall below the EQS values for the hardness of the receiving watercourse exceeding 250mg/l, and thus considered unlikely to pose a significant risk of causing significant harm to water resources.

8.15.2 Organic contaminants.

8.15.3.1 With respect to assessing Polycyclic aromatic hydrocarbons (PAH) concentrations, EQS have only been published for naphthalene. All measured concentrations of naphthalene fall well below the EQSvalue for this contaminant.

8.15.2.1 For analysis of measured concentrations of polycyclic aromatic hydrocarbon (PAH) contamination we have compared results with maximum allowable concentrations in the Water Supply (Water Quality) Regulations 2000 (UK Drinking Water Standards). There specified compounds forming the Polycyclic aromatic hydrocarbon 'suite' are

- Benzo(b)fluoranthene
- Benzo(k)fluoranthene
- Benzo(ghi)perylene
- Indeno(1,2,3-cd)pyrene

Summation of the measured concentration of these compounds should not exceed 0.1µg/l. The summed concentration of the PAH 'suite' measured on all of these specified compounds produced measured concentrations below detectable limits, and as such, the concentrations of PAH on water samples taken across the site as part of this suite of analysis, are not considered to pose a significant risk of causing significant harm to groundwater or off-site receptors.

8.15.4 Based on the above evaluation of test data from groundwater samples, the results indicate there unlikely to be a significant possibility of significant harm being caused to water resources from chemical contamination at the site. There are some hydrocarbon impacted soils observed in trial pits TP09 and TP14, which may have locally impacted ground waters in this area, but have not seemingly affected groundwater sampled in borehole BH04, located some 50m from these trail pits. At this stage we cannot confirm whether or not this hydrocarbon contamination is migrating into groundwater. There is therefore a potential risk to groundwater that requires further investigations to eliminate or quantify this risk and identify appropriate remedial action (if any)

8 Chemical contamination (Part D – Summary and Recommendations)

8.16 Phase 2 Assessment and conceptual model

8.16.1 By considering the sources, pathways and receptors reported in parts B and C of this report section an assessment of risks to human health, and water receptors is made with reference to the significance and degree of risk. This assessment is based on consideration of whether the source contamination can reach a receptor and hence whether it is of major or minor significance. As potential sources of contamination have been identified it is necessary evaluate the risks to each possible receptor. This is tabulated on the following page.

Risk Evaluation

Phase 2 updated conceptual model							
Condition status: Existing conditions							
Source	**Contaminant**	**Pathway**	**Receptor**	**Consequence of risk being realised.**	**Probability of risk being realised**	**Risk Classification**	**Risk management action taken**
Polycyclic aromatic Hydrocarbons (PAH) probably from ash containing soils	PAH	Direct contact Inhalation and ingestion of dusts	Future end users of the site and construction operatives	Medium	Likely	Moderate	• Introduction of hardstanding and building to sever pathway to receptors. Or • If landscaped, introduction of a capping layer (refer to paragraph 8.17 below) Or • Remove off site • Further investigations using hand dug trial pits in area of DTS05 to establish extent
Hydrocarbon impacted soils around TP09 and TP14	Hydrocarbons	Leaching to groundwater	Groundwater	Medium	Likely	Moderate	• Further investigations to eliminate or quantify risk to groundwater and remedial action, and determine extent of soil contamination.
Table reference 8.16.1.							

8.17 Remediation proposals

8.17.1 Based on the above some further investigations are recommended in the areas of TP14, TP09, and borehole DTS05, before a remedial strategy (if any) can be established. Recommendations for further investigations are provided in section 12.

8.18 Chemical contamination - Risk assessment in relation to use of infiltration systems

8.18.1 The permeability of the near surface Kempton Park Gravel in combination with the site located over a minor aquifer suggests the site is sensitive to migration of contaminants. We have carried out leachate testing of a suite of contaminants with our assessment provided in Section 8.15 above. Essentially, measured concentrations of leachable contaminants fall below EQS values for the local environment and on this basis the risk of infiltration systems promoting mobilisation of contaminants is considered unlikely except potentially in the areas around TP14, TP09 and DTS05, which would be more fully assessed based on the results of further investigations.

8.19 Chemical contamination – risk assessment summary and recommendations

8.19.1 Based on our assessments described above, we can provide the following summary and recommendations for each identified receptor.

8.19.2 End users

8.19.2.1 Elevated concentrations of benzo(a)pyrene were identified in one location (borehole DTS05) considered to be related to ash in the Made Ground. If this area is to be landscaped then we would recommend removal of soils which contain the ash type material or provision of a capping layer. The extent of the soils exhibiting elevated concentrations of benzo(a)pyrene, could potentially established by further on site investigations.

8.19.3 Construction operatives and other site investigators

8.19.3.1 The risk of damage to health of construction operatives and other site investigators is, in our opinion, low (given the concentration and seemingly isolated locations of identified contamination, and the relatively short exposure times) and would be minimised by taking adequate hygiene precautions on site. Such precautions would be:-

- Wearing protective clothing particularly gloves to minimise ingestion from soil contaminated hands.
- Avoiding dust by dampening the soils during the works.

- Wearing masks if processing produce dust.

Guidance on safe working practices can be obtained from the following documents

- The Health and Safety Executive Publication *"Protection of Workers and the General Public during the Development of Contaminated Land"* (HMSO) and
- *"A Guide to Safer Working on Contaminated Sites"* (CIRIA Report 132).

In addition, reference should be made to the Health and Safety Executive. In all cases work shall be undertaken following the requirements of the Health and Safety at Work Act 1974 and regulations made under the Act including the COSHH regulations.

If during the course of excavations hydrocarbon type odours become evident we recommend works are halted, and the air quality measured to determine if the excavation can be safely entered. If the air quality is unacceptable then appropriate personal protective equipment, will be required for human entry into the excavation. If elevated concentrations of airborne hydrocarbons / vapours are detected on site, we recommend Soiltechnics are advised to determine an appropriate course of action with respect to building construction.

8.19.4 Off Site Receptors

8.19.4.1 Although groundwater samples taken from six boreholes across the campus did not indicate any evidence of significant chemical contamination, we have identified hydrocarbon impacted soils in two locations which are remote from borehole water sampling locations. At this stage, we recommend further sampling and laboratory testing in the vicinity of the contamination to eliminate or quantify the risk to groundwater.

8.20 Statement with respect to PPS23 annex 2

8.20.1 With reference to paragraph 8.1.4 above we consider investigations completed to date, and providing the recommendations described above are satisfactorily completed, then we are of the opinion the proposed development (subject to the results of further localised investigations) can be made safe and suitable for use for the purpose for which it is intended, thus meeting the requirements of Planning and Policy Statement 23 (PPS23) *'Planning and pollution control – Annex 2 – Development on land affected by contamination'* , and compliant with the Building Regulations Part C, *'Site preparation and resistance to contaminants and moisture'.*

8.21 On Site Monitoring

8.21.1 We have attempted to identify the potential for chemical contamination on the site, however, areas, which have not been investigated at this stage, may exhibit higher levels of contamination. If such areas are exposed at any time during construction we recommend investigation and testing be carried out accordingly.

SECTION 9 – CONTENTS

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9 Gaseous contamination

9.1 Legislative framework

9.1.1 There is currently a complex mix of documentation relating to legislative and regulatory procedures on the issue of contamination, and it is not considered a purpose of this report to discuss the detail of these regulations. Essentially, Government Policy is based on *'suitable for use approach'*, which is relevant to both the current and proposed future use of land. For current use Part IIA of the Environmental Protection Act 1990 provides the regulatory regime (see section 8.1 above). The presence of harmful soil gasses could provide a 'source' in a 'pollutant linkage' allowing the regulator (local authority or Environment Agency) to determine if there is a significant possibility of harm being caused to humans, buildings or the environment. Under such circumstances the regulator would determine the land as 'contaminated' under the provision of the Act requiring the remediation process to be implemented.

9.1.2 With regards to planned future use, Planning and Policy statement 23 (PPS23) requires developers to undertake appropriate risk assessments to demonstrate to the local planning authority that proposals adequately mitigate any potential hazards associated with ground contamination including soil gas. The Town and Country Planning (General Development Procedure) Order 1995, requires the planning authority to consult with the Environment Agency before granting planning permission for development on land within 250metres of land which is being used for deposit of waste, (or has been at any time in the last 30 years) or has been notified to the planning authority for the purposes of that provision

9.1.3 Building control bodies enforce compliance with the Building Regulations. Practical guidance is provided in Approved documents, one of which is Part C, '*Site preparation and resistance to contaminants and moisture*' which seeks to protect the health, safety and welfare of people in and around buildings, and includes requirements for protection against harm from soil gas.

9.2 General

9.2.1 The following assessment relates to the potential for, and the effects of, gasses generated by biodegradable matter. A separate, but related class of problem involves migration of vapour phase of hydrocarbons resulting from spillages of petroleum and solvents, but this is addressed under organic contamination in section 7 above. The potential for the development to be affected by Radon Gas is considered in Section 3 above. The principal ground gasses are carbon dioxide (CO_2) and methane (CH_4). The following table provides a summary of the effects of these gases when mixed with air.

Significant Gas concentrations in air		
Gas	**Concentration by volume**	**Consequence**
Methane	0.25% 5% 30%	Ventilation required in confined spaces Potentially explosive when mixed with air Asphyxiation
Carbon Dioxide	0.5% 1.5% >3%	8 hour exposure limit (WEL) (HSE) 15 min exposure limit (WEL) Breathing difficulties
Table.9.1		

9.2.2 Following the current Building Regulations Approved Document C1, Section 2 '*Resistance to Contaminates*' (2004) a risk assessment approach is required in relation to gaseous contamination based on the source-pathway-receptor conceptual model procedure. We have adopted procedures described in the following reference documents for investigation and assessments of risk of the development being affected by landfill type gases and if appropriate the identification of mitigation measures.

- BS8485: 2007 '*British Standard Code of practice for the characterisation and remediation from ground gas in affected developments*'
- CIRIA Report C665 '*Assessing risks posed by hazardous ground gases to buildings*' (2007).

9.2.3 An assessment of the risk of the site being affected by ground gases is based on the following aspects.

a) Source of the gas
b) Investigation information
c) Migration feasibility
d) Sensitivity of the development and its location relative to the source

9.3 Assessment of source of gases

9.3.1 General sources

9.3.1.1 The following table summarises the source of gasses and parameters for producing gasses

Source and control of gasses	
Type	**Parameters affecting the rate of gassing**
Landfills	Portion of biodegradable material, rate reduces with time.
Mineworkings	Flooding reduces rate of gassing
Docksilt	Portion of organic matter
Carbonate deposits	Ground / rainwater (acidic) reacts with some carbonates to produce carbon dioxide.
Soils / rocks	Portion of organic matter
Table 9.3.1	

The rate of decomposition in gas production is also related to atmospheric conditions, pH, temperature, and water content / infiltration.

9.3.1.2 As the site is not within a dockland environment, or area affected by mineworkings, and near surface soils do not exhibit high carbonate content, then potential gas sources are limited to landfills and /or soils with a high proportion of organic matter.

9.3.2 Landfill sources

9.3.2.1 Waste Management Paper 27 (1991) produced by the Department of the Environment *'Control of Landfill Gases'* contains the strong recommendation to avoid building within 50m of a new landfill site and to carry out site investigations within a zone 250m beyond the boundary of a landfill site. No distinction is made between sites of differing ground conditions, but the paper does not advocate the site is safe beyond the 250m zone, dependant, of course, upon the type of landfill and potential for migration of landfill gasses.

9.3.2.2 Envirocheck reports five historical landfill sites within 1000m of the subject site all located in the north, north west and north east of the site. The closest is recorded to be 339m north east of the site. Records indicate the sites were licensed for receipt of wastes which included inert and industrial wastes with the exception of the historical landfill site furthest from the site. Such materials are unlikely to generate any significant quantities of landfill type gasses however we cannot confirm that these were licensed for the receipt of these wastes exclusively. There is no record of the type of backfill material used to restore the historical landfill located 893m north east of the site.

9.3.2.3 In addition, inspection of old Ordnance Survey maps indicates some localised quarrying activities 539m and 740m to the north east of the site, this is concurrent with the closest recorded historical landfill sites. Operations have now ceased and more recent OS maps indicate they have been restored and subsequently developed with buildings recorded in the locations. We have no records of the type of fills used to restore these former workings however the record of the historical landfill site in this location specifies the waste to include inert waste. We cannot conclude from this that the wastes used to restore these workings and historical landfill sites were exclusively inert and industrial waste therefore on this basis, consider there to be a risk of a potential source of landfill gasses in the area worthy of further consideration.

9.3.3 Soil conditions

9.3.3.1 None of the soils observed in exploratory excavations, in our opinion exhibit significant concentrations of organic matter, which are likely to produce significant quantities of carbon dioxide and / or methane gas.

9.3.3.2 Based on an assessment of 'deep' geological conditions we are of the opinion that it is unlikely that the subject site would be affected by significant quantities of carbon dioxide and methane generated by soils/rocks at depth.

9.3.4 Source assessment summary

9.3.4.1 The following table summarises the possibility of a source of landfill type gasses.

Source assessment summary		
Potential source origin	**Viability of source**	**Evidence**
Landfills	Possible	Desk study information Historical landfill sites and restored opencast quarries – closest 339m north east of site
Mineworkings	Unlikely	Desk Study information Geological conditions not amenable
Dock silt	Unlikely	Site remote from dockland environment
Carbonate deposits	Unlikely	Recorded and observed soil conditions do not indicate high concentrations of carbonates
Soils / rocks	Unlikely	Soils exposed in exploratory excavations do not exhibit high concentrations of organic matter
Table 9.3.4		

9.3.4.2 Based on the above it there is a possibility of a source of potential landfill gasses which may affect the subject site. On this basis, it is considered necessary to consider possible pathways for migration of ground gasses, from this potential source to the site.

9.4 Gas migration

9.4.1 Exploratory excavations encountered a reasonably consistent deposit of Kempton Park Gravel to depths of between 4-9m, which in our opinion are relatively permeable and would provide little resistance to lateral migration of landfill type gasses. In addition, based on published geological records the Kempton Park Gravel extends from the subject site to the historical landfill sites and former quarry. On this basis it is considered possible that the potential source of landfill type gasses (identified in section 9.2 above) would feasibly migrate to the subject site.

9.5 Conceptual model

9.5.1 Based on the above, there is a potential source of landfill type gases, and a feasible migration pathway to the site via potentially permeable Kempton Park Gravels. Our conceptual model is tabled below. On this evidence we are of the opinion that the site is at risk of being affected by ground gasses (carbon dioxide / methane) sufficient to potentially cause harm to human end users of the site, construction operatives or indeed buildings. On this basis, we have installed monitoring standpipes in boreholes, and implemented a monitoring regime, generally following procedures described in CIRIA report C665, to quantify the risk, and if appropriate, identify mitigation measures.

Conceptual model		
Potential source origin	**Potential pathway**	**Receptors at risk**
Landfills Historical landfill sites, closest 339m north east of site	Via Kempton Park Gravels	• End users • Construction operatives • Buildings
Table 9.5.1		

9.6 Development Categorisation

9.6.1 With reference to BS 8485:2007 (table 2), the proposed development would be classified as *'Public building (which includes managed apartments, schools and hospitals)'*.

9.7 Initial Monitoring observations.

9.7.1 Six standpipes have been installed at the site to depths between 4m and 6m (refer Drawing STE1297R-06). Following CIRIA Report C665 (tables 5.5a, and 5.4b) we have provisionally assessed the site as moderate risk of generation potential of source ideally requiring 6 monitoring visits over a 3 month period. This initial assessment will be reviewed pending the results of further monitoring observations.

9.7.2 We have returned to site for two of the six proposed monitoring visits to obtain measurements of landfill type gases at atmospheric conditions in the range of 1003 to 1013mb and temperatures in the range of 16°C to 18°C. Our observations/measurements to date are recorded in

Appendix K. Essentially we did not detect any methane but concentrations of carbon dioxide measured in the range of 0.1 to 6.1%. If flows were detected during our monitoring visits then these are recorded, but where no flow is detected then, following BS8485:2007, we have assumed flow at the detection limit of the monitoring equipment at 0.1l/s.

9.8 Interim classification of site characteristic gas situation.

9.8.1 Using test data obtained to date, and with reference to table 1 of BS8485:2007, the site would be classified as characteristic gas situation two. Clearly this is an interim classification based on observations to date and can only be confirmed following additional monitoring visits. It should be noted however, that there is a significant possibility of higher flow measurements being recorded during low atmospheric conditions, which may increase the classification of the site requiring more onerous gas protective measures.

9.9 Interim assessment of gas protective measures.

9.9.1 Based on monitoring observations to date, development categorisation (section 8.6 above), and the interim site characteristic gas situation (section 8.8 above) and with reference to table 2 of BS8485:2007, the development requires gas protective measures which would achieve a '*solution score*' of 3. Lists of protective measures which each produce a score value are produced in table 3 of BS8485:2007. A copy of table 3 is presented as Appendix B. Clearly this is an interim assessment based on observations to date and can only be confirmed following additional monitoring visits. It should be noted however, that there is a significant possibility of higher flow measurements being recorded during low atmospheric conditions, which may increase the classification of the site requiring more onerous gas protective measures.

9.11 Effect of gasses on existing buildings

9.11.1 With respect to any existing buildings that may remain, we do not know if gas protection has been installed, and unless it can be demonstrated that appropriate levels of protection are available, we recommend gas monitoring is carried out within the building to determine if there is a problem, and if necessary, install protection using active venting systems. We can carry out such investigations on further instructions.

9.12 Gas protective measures - construction operatives

9.12.1 Areas near landfill sites, underground coal strata or in carbonate rich deposits (such as limestone and chalk) have the potential to generate both harmfully low oxygen levels and high carbon dioxide levels in confined spaces. The assessment for such situations may therefore require using gas monitors to warn of significant leaks of gas into confined spaces to minimise the risks associated with an oxygen-deficient atmosphere which could lead to asphyxiation, and/or a toxic atmosphere due to high levels of carbon dioxide.

9.12.2 During construction, we recommend any excavations/confined spaces are well ventilated and human entry is avoided. The Workplace Exposure Limits (WELs) for carbon dioxide are 5000 parts per million (ppm by volume), which is equivalent to 0.5%, for the 8-hour time-weighted average (TWA); and 15000 ppm (1.5%) for the 15-minute short-term exposure limit (STEL). Typically, oxygen deficiency alarms on gas detectors are set at 19% volume ratio (v/v). Normal air contains 20.9% oxygen. Therefore should human entry be necessary then we recommend excavations/confined spaces are monitored over short- and long-term exposure periods for both oxygen and carbon dioxide gases prior to entry to ensure levels are within acceptable concentrations or suitable breathing equipment adopted.

9.12.3 We recommend further reference is made to the following documents to minimise the risks to construction workers from ground gases:

- Health and Safety Executive Publication *"Protection of Workers and the General Public during the Development of Contaminated Land"* (HMSO)
- *"A Guide to Safer Working on Contaminated Sites"* (CIRIA Report 132)
- Health and Safety Executive Publication EH40/2005 *"Workplace Exposure Limits"*

9.13 Statement with respect to PPS 23 annex 2

9.13.1 With reference to paragraph 9.9 above, and subject to completion of further monitoring which is likely to indicate some measures to protect buildings against ingress of landfill type gasses, then we are of the opinion the proposed development can be made safe and suitable for use for the purpose for which it is intended, thus meeting the requirements of Planning and Policy Statement 23 (PPS23) *'Planning and pollution control – Annex 2 – Development on land affected by contamination'* , and compliant with the Building Regulations Part C, *'Site preparation and resistance to contaminants and moisture'.*

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10 Effects of ground conditions on building materials.

10.1 General

10.1.1 Building materials are often subjected to aggressive environments which cause them to undergo chemical or physical changes. These changes may result in loss of strength or other properties that may put at risk their structure integrity or ability to perform to design requirements. Aggressive conditions include:-

- Severe climates
- Coastal conditions
- Polluted atmospheres
- Aggressive ground conditions

This report section only considers aggressive ground conditions, with other items considered outside our brief and scope of investigations.

10.1.2 In aggressive ground conditions, the potential for contaminant attack depends on the following:-

- The presence of water as a carrier of chemical contaminants, (except free phase organic contamination)
- The availability of the contaminant in terms of solubility, concentration and replenishment rate
- Contact between the contaminant and the building material
- The nature of the building materials and its capability of being attacked by contaminants

In general the thicker the building material the less likelihood there is for contaminant attack to cause damage to the integrity of the structure.

10.2 Reference Documents

10.2.1 Following the Environment Agency publication *'Model Procedures for the Management of Land Contamination'* (Contaminated Land Report 11) the following documents have been referred to in production of the following report paragraphs.

- *'Performance of Building Materials in Contaminated Land'* report BR255 (Building Research Establishment 1994).
- *'Risks of Contaminated Land to Buildings, Building Materials and Services. A Literature Review'* - Technical Report P331 (Environment Agency 2000).

- *'Guidance on assessing and managing risks to buildings from land contamination'* - Technical Report P5 035/TR/01).

- Building Regulations Approved document C - site preparation and resistance to contaminants and moisture (Office of the Deputy Prime Minister, 2004).

- *'Concrete in aggressive ground'* Special Digest 1: 2005 (Building Research Establishment).

10.3 Hazard Identification and Assessment

10.3.1 The identification of hazards is based on the findings of this investigation primarily relating to former land uses (potential for chemical contamination, and likely type of contamination) and laboratory determination of concentration of chemical contaminants. Clearly, the scope of laboratory testing is determined with respect to former land uses, contaminants which may cause harm to human health and water resources, based on CLR 8 *'Potential contaminants for the Assessment of Contaminated Land'*.

10.3.2 Based on the above, the scope of our testing regime is described in Sections 8b (human receptors) and 8c (water receptors). We have utilised this test data in production of the following risk assessments in relation to building materials, in conjunction with test data targeting the effects of chemical attack on concrete in contact with the ground, as described in BRE Special Digest 1.

10.3.3 The identification of hazards from contamination and subsequent assessment of risks is based on the following:-

- The contaminants present on site.

- The nature of the contaminant (i.e. calcium sulphate is much less soluble than sodium or magnesium sulphate and is, therefore, less of a concern with regards sulphate attack).

- The concentration of contaminants - in general the higher the concentration the greater the hazard.

- The solubility of the contaminants - contaminants which are not soluble will not generally react with materials.

- The permeability of the soils - i.e. case by which fluids can transport contaminants to the building.

10.3.4 The process of risk assessment for building materials is concerned with identification of the hazard (contaminants at the site - a source) and subsequently how the contaminants can reach the building (pathway) and how they can react with the building (receptor). Thus the risk assessment is produced based on the source - pathway - receptor model.

10.4 Provision of test data to specifiers/manufacturer/installer

10.4.1 The following risk assessments are based on current published data. We strongly recommend, however, that information gained from this investigation are provided to specifiers/manufacturers/installers of building materials/service ducts/apparatus who may have more up to date research to confirm the ability of the product to resist the effects of chemical contaminants at the site for the desired lifespan of the product.

10.5 Risks Assessments for Individual Building Materials

10.5.1 The following/typical sections contain risk assessments for various building materials likely to be incorporated in developments. Other materials which we are not aware of may also be used in developments and in contact with the ground and, therefore, recommend the suppliers are consulted with respect to ground conditions at this site and their opinion sought as to the ability of the product to resist chemical conditions determined at the site.

10.6 Concrete - General Mechanisms of Attack

10.6.1 There are a number of mechanisms by which contaminants attack concrete including the following:-

- Hydrolysis of the hardened concrete.
- Degradation as a result of exchange reactions between calcium in calcium hydroxide (free lime hydrate) and ions in aggressive solutions.
- Expansive reactions as a result of chemical reaction or salt crystallisation.

10.7 Concrete - Sulphate Attack

10.7.1 Hazard

10.7.1.1 Sulphate attack on concrete is characterised by expansion, leading to loss of strength, cracking, spalling and eventual disintegration. There are three principal forms of sulphate attack, as follows:-

- Formation of gypsum through reaction of calcium hydroxide and sulphate ions.
- Ettringite formation through reaction of tricalcium alluminate and sulphite irons.
- Thaumasite formation as a result of reactions between calcium silicate hydrates, carbonate ions (from aggregates) and sulphate ions.

10.7.2 Assessment

10.7.2.1 The hazard of sulphide attack is addressed by reference to procedures described in Building Research Establishment (BRE) Special Digest 1: 2005 '*Concrete in Aggressive Ground*' to establish a design sulphate class (DS) and the '*aggressive Chemical Environment for Concrete*' (ACEC). These procedures have been followed during our investigation and are described in the following paragraphs.

10.7.3 Desk Study Information

10.7.3.1 The first step in the procedure is to consider specific elements of the desk study. These are tabulated below.

Element	Interrogation	Outcome	SD1: 2005 reference
Geology	Likelihood of soils containing pyrites		Box C6
	Kempton Park Gravel	**Unlikely**	
	London Clay	**Likely**	
Past industrial uses	Brownfield site?	**Yes**	C2.1.2

Table 10.7

A brownfield site is defined in SD1: 2005 as a site, or part of a site which has been subject to industrial development, storage of chemicals (including for agricultural use) or deposition of waste, and which may contain aggressive chemicals in residual surface materials, or in ground penetrated by leachates. Where the history of the site is not known, it should be treated as brownfield until there is evidence to classify it as natural.

10.7.3.2 For spread type foundations which will extend into the Kempton Park Gravels and based on the above it is necessary to follow the procedures described in figure C6 ('*locations on brownfield sites except where soils may contain pyrite*').

10.7.3.2 For a piled foundation solution which will extend into the London Clay and based on the above it is necessary to follow the procedures described in Section C5.1.4 ('*Brownfield locations that contain pyrite*').

10.7.4 Assessment of Design Sulphate Class

10.7.4.1 For spread type foundations which will extend into the Kempton Park Gravel.

10.7.4.1.1 The sulphate concentration in a 2:1 water/soil extract was measured on 13 soil samples and 2 groundwater samples the mean of the 3 highest sulphate results from soil samples was calculated at 1110mg/l (characteristic value). On this basis and with reference to table C2 of SD1l: 2005, the design sulphate class is **DS-2**.

10.7.4.1.2 The concentration of sulphate was measured at less than 3000mg/l and thus the concentration of magnesium was not measured.

10.7.4.2 For piled type foundations which will extend into the London Clay

10.7.4.2.1 The sulphate concentration in a 2:1 water/soil extract was measured on 18 soil samples and two groundwater samples the mean of the 3 highest sulphate results from soil samples was calculated at 846mg/l (characteristic value). On this basis and with reference to table C2 of SD1l: 2005, the design sulphate class is **DS -2**.

10.7.4.2.2 We assume foundations will not be in contact with disturbed ground (as defined in BRE SD:1). We, therefore, have not considered Oxidisable Sulphates or Total Potential Sulphate content. On this basis and with reference to SD1: 2005, derived design sulphate class is **DS-2**.

10.7.5 Assessment of groundwater mobility

10.7.5.1 With reference to SD1: 2005, Section C3.2, we are of the opinion that ground and site characteristics suggest 'mobile groundwater' conditions.

10.7.6 Assessment of pH

10.7.6.1 Following SD1: 2005, Section C5.1.1 (step 4) the characteristic value of pH is 5.9, derived by taking the mean of the lowest 3 of the pH results.

10.7.6.2 None of the measured pH values were below 5.5, thus the concentration of chlorides and nitrates was not measured.

10.7.7 Assessment of Aggressive Chemical Environment for Concrete (ACEC)

10.7.7.1 Based on the design sulphate class, characteristic value of pH and assessment of groundwater mobility, and with reference to table C2 of SDI: 2005, we are of the opinion that the ACEC class for a pad foundation solution is **AC-3z** and for a piled foundation solution is also **AC-3z**

10.8 Concrete - Chloride Attack

10.8.1 Hazards

10.8.1.1 There are a number of ways in which chlorides can react with hydrated cement compounds in concrete. These are as follows:-

- Chlorides react with calcium hydroxide in the cement binder to form soluble calcium chloride. This reaction increases the permeability of the concrete reducing its durability.
- Calcium and magnesium chlorides can react with calcium aluminate hydrates to form chloroaluminates which result in low to medium expansion of the concrete.

- If concrete is subject to wetting and drying cycles caused by groundwater fluctuations, salt crystallisation can form in concrete pores. If pressure produced by crystal growth is greater than the tensile strength of the concrete, the concrete will crack and eventually disintegrate.

10.8.2 Risk Assessment

10.8.2.1 Chlorides of sodium, potassium, and calcium are generally regarded as being non-aggressive towards mass concrete; indeed brine containers used in salt mines have been known to be serviceable after 20 years service. Depending upon the type of concrete, and the cement used up to 0.4% chloride is allowed in BS8110: Part 1.

10.8.2.2 In view of the past use of the site we consider the likelihood of elevated concentrations of chlorides in the ground is not likely to occur and on this basis have not specifically measured concentrations of chlorides and, in our opinion, the risk of buried concrete being affected by chlorides is considered low.

10.9 Concrete - Acid Attack

10.9.1 Hazards

10.9.1.1 Concrete being an alkaline material is vulnerable to attack by acids. Prolonged exposure of concrete structures to acidic solutions can result in complete disintegration.

10.9.2 Risk Assessment

10.9.2.1 The rate of acid attack on concrete depends upon the following:-

- The type of acid
- The acid concentration (pH)
- The composition of the concrete (cement/aggregate)
- The soil permeability
- Groundwater movement

British Standard BS8110: Part 1 classifies extreme environment as one where concrete is exposed to flowing groundwater that has a $pH<4.5$. The standard also warns that Portland Cement is not suitable for acidic conditions with a pH of 5.5 or lower.

10.9.2.2 The pH of the soil/groundwater was measured exceeding 5.5 and on this basis the risk of concrete being affected by acidic conditions is considered low.

10.10 Concrete - Magnesium Attack

10.10.1 Hazards

10.10.1.1 Magnesium salts (excepting magnesium hydrogen carbonate) are destructive to concrete. Corrosion of concrete occurs from cation exchange reactions where calcium in the cement paste hydrates and is replaced with magnesium. The cement looses binding power and eventually the concrete disintegrates.

10.10.2 Risk Assessment

10.10.2.1 In practise 'high' concentrations of magnesium will be found in the UK only in ground having industrial residues. Following BRE Special Digest 1:2005, measurement of the concentration of magnesium is recommended if sulphate concentrations in water extract or groundwater exceed 3000mg/l. Once measured the concentration of magnesium is considered further in BRE Special Digest in establishing the concrete mix to resist chemical attack.

10.10.2.2 We are not aware the site has been subject to any manufacturing processes which would have included magnesium containing compounds, and in addition sulphate concentrations did not exceed 3000mg/l, on this basis we have not measured the concentration of magnesium in soils at the site, and would consider the risk of soils at the site promoting attack on concrete is considered low.

10.10.2.3 BS EN 206-1:2000 '*Concrete - Part 1: Specification, performance, production and conformity*' does, however, provide exposure classes for concrete in contact with water, with varying concentrations of magnesium for the design/specification for concrete mixes. As there is a possibility that concrete for the building may be in contact with groundwater during its life, then we have measured the concentration of magnesium in groundwater samples.

10.10.2.4 We have measured the concentration of magnesium in two groundwater samples from the site which produced results of 11mg/l and 14mg/l. This result falls well below the criteria for the exposure classes as outlined in Table 1 of BS EN206-1:2000. Sulphate concentrations in water samples produced a result in the range of >200 but <600 thus indicating an exposure class of XA1

10.11 Concrete - Ammonium Attack

10.11.1 Hazards

10.11.1.1 Ammonium salts, like magnesium salts act as weak acids and attack hardened concrete paste resulting in softening and gradual decrease in strength of the concrete.

10.11.2 Risk Assessment

10.11.2.1 UK guidance is not available on the concentration of ammonium which may affect concrete. BS EN 206-1: 2000 '*Concrete - Part 1: Specification, performance, production and conformity*' does, however, provide exposure classes for concrete in contact with water with varying concentrations of ammonia for the design/specification for concrete mixes.

10.11.2.2 We have measured the concentration of ammonia in two groundwater samples at the site, and there is a potential possibility that concrete for the building may be in contact with groundwater during its life. The concentrations of ammonia were measured at 0.13mg/l and 0.22mg/l. This result falls well below the criteria for the exposure classes as outlined in Table 1 of BS EN206-1:2000. Sulphate concentrations in water samples produced a result in the range of >200 but <600 thus indicating an exposure class of XA1

10.12 Concrete Blocks

10.12.1 Hazards

10.12.1.1 Precast aggregate concrete blocks and autoclaved aerated concrete blocks are commonly used in the construction of shallow foundations. Concrete blocks are potentially attacked by the same contaminants and ground conditions which affect dense concrete.

10.12.2 Risk Assessment

10.12.2.1 In general, the mechanism of attack on concrete blocks is the same for hardened concrete. We recommend parameters for ground conditions for concrete described in the preceding paragraphs for concrete blockwork in contact with the ground/groundwater and the blockwork manufacturers confirmation sought for applicability of their product.

10.13 Clay Bricks/Pipes

10.13.1 Clay Bricks are highly durable materials which have been used in buildings for many centuries. Fire clay pipe material can also be considered similarly resistant to contaminants.

10.13.2 Hazards

10.13.2.1 Dissolution of clay brick in a potentially serious cause of deterioration. The extent of dissolution depends upon the solubility of the glassy material (produced by firing of the clay) contained in the brick. The acidic nature of the glass phase will produce low solubility in a neutral and acidic environment, but can be soluble in a basic environment.

10.13.2.2 A potentially more serious hazard for brickwork is the crystallisation of soluble salts within the brick pore structure. Salts are transported by water to the interior of the brick originating from the external environment or by rehydration, however, are only likely to occur when there is a gradient from a wet interior to a drying surface. The potential, therefore, for salt crystallisation in the ground is, therefore, low.

10.13.3 Risk Assessment

10.13.3.1 There seems to be little published information as regards the resistance to clay bricks/pipes in aggressive ground conditions, however, clay bricks are generally considered very durable. As no significant concentrations of chemical contaminants have been identified at this site in combination with near neutral pH conditions it is considered unlikely that ground conditions are sufficiently aggressive to cause damage to brickwork/clay pipes.

10.13.3.2 Some basic guidance is provided in BS5628-3: 2005 '*Code of Practice for the Use of Masonry - Part 3: Materials and components, design and workmanship*' with regards to resistance of masonry to resist the effects of sulphate attack.

10.14 Mortar

10.14.1 Mortars are based on building sands mixed with cement and/or lime as a binder. In the UK Portland cements and masonry cement are commonly used. Masonry cements are a mixture of Portland Cements and fine mineral filler (i.e. Limestone) with an air entraining agent.

10.14.2 Hazards

10.14.2.1 Mortar is subject to the same agents for deterioration as concrete with the major cause of deterioration being sulphate attack.

10.14.3 Risk Assessment

10.14.3.1 Sulphates can originate from soils/groundwater or from the bricks themselves. Calcium, magnesium, sodium and potassium sulphates are present in almost all fired-clay bricks. Water can dissolve a fraction of these sulphates and transport them to the mortar.

10.14.3.2 Currently, we are not aware of any guidance on the resistance of mortars to sulphate attack. The Building Research Establishment report that the sulphate resistance of mortar was improved by the use of sulphate resisting Portland cements and lime. Some guidance is also provided in BS5628-3: 2005 '*Code of Practice for the use of Masonry - Part 3: Materials and components, design and workmanship*'.

10.14.3.2 Based on ground conditions determined at the site the risk of significant sulphate attack on mortars (Based on testing/analysis of sulphates in relation to concrete - refer Section 10.7) is considered low.

10.15 Metals - general

10.15.1 There are a number of metals which are used in buildings either as piles, services, non structural and, indeed, structural components. The most common metals used in buildings are steel, stainless steel, copper, lead, zinc, aluminium and cast iron. All these metals can deteriorate through corrosion process. Corrosion can affect metals in a variety of ways depending upon the nature of the metal and the environment to which it is subjected. In most common forms of corrosion are:-

- Electrochemical - the most common form of corrosion in an aqueous solution
- Chemical corrosion - occurs when there is a direct charge transfer between the metal and the attacking medium (examples are oxidation, attack by acids, alkalis and organic solvents)
- Microbial induced corrosion

10.16 Metals - Cast Iron

10.16.1 Cast iron is a term to describe ferrous metals containing more than 1.7% carbon and is used extensively in the manufacture of pipes.

10.16.2 Hazards

10.16.2.1 Generally, cast iron has a good resistance to corrosion by soils, however, corrosion can occur due to the following mechanisms:-

1) Generation of large scale galvanic cells caused by differences in salt concentrations, oxygen availability or presence of stray electrical currents.

2) Hydrochloric acid will cause corrosion at any concentration and temperature. Dilute sulphuric, nitric and phosphoric acids are also aggressive as also are well aerated organic acids.

10.16.3 Risk Assessment

10.16.3.1 Testing can be carried out on site to measure the resistivity and redox potential of soils which can assist in deriving recommendations for protection of cast iron components using coatings, burial trenches, or isolation techniques. Currently, however, there is no specific guidance and we recommend advice is sought from manufacturers.

10.16.3.2 Guidelines produced by the Water Research Centre (WRc) on the use of ductile iron pipes, state that highly acidic soils (pH <5) are corrosive to cast iron pipe even when protected by a zinc coating or polythene sleeving. WRc also indicate that groundwater containing >300ppm chloride may corrode even protected cast iron pipes.

10.16.3.3 On the basis that the pH of soils at the site are not less than 5, and groundwater is unlikely to be in contact with cast iron elements, then the risk of ductile cast iron pipes being affected by acid/chloride attack is considered low. We have not carried out any redox/resistivity testing (considered outside our brief) and thus we cannot comment further with regards to the risks of galvanic action.

10.17 Metals - Steel Piles

10.17.1 Hazards

10.17.1.1 The corrosion of steel requires the presence of both oxygen and water. In undisturbed natural soils the amount of corrosion of driven steel piles is generally small. In disturbed soils (made ground) however, corrosion rates can be high and normally twice as high as those for undisturbed natural soils.

10.17.2 Risk Assessment

10.17.2.1 Guidance on the use of steel piles in different environments is provided in British Steel's piling handbook which includes calculating the effective life of steel piles. There is no specific guidance, however, for contaminated soils in this publication. Coatings can be provided to the pile surface but experience has shown that some coatings can be damaged during driving, particularly in ground which can contain hard materials such as brick/concrete/stone.

10.18 Metals - Stainless Steel

10.18.1 Hazards

10.18.1.1 Stainless steel is used in a number of building components including services, pipework, reinforcement bars and wall ties. There is little knowledge, however, of the performance of stainless steel in aggressive environments.

10.18.2 Risk Assessment

10.18.2.1 Stainless steel can withstand pH of 6.5 to 8.5, but the chlorine content of a soil increases the risk of corrosion. At concentrations of 200mg/l type 304 stainless steel can be used, but for concentrations of 200 to 1000mg/l type 316 should be used in preference to type 304, but for concentrations greater than 1000mg/l type 316 should always be used.

10.18.2.2 At this site the pH of the soils was generally near neutral (within the range of 6.5 to 8.5) and it is considered unlikely that groundwater will be in contact with stainless steel components (unless we are advised otherwise) thus the risk of ground conditions at the site affecting stainless steel is considered low.

10.19 Metals - Galvanised Steel

10.19.1 Hazards

10.19.1.1 Galvanising steel is a means of protecting steel from aggressive environments, however, zinc galvanising can be corroded by salts and acids.

10.19.2 Risk Assessment/Remedial Action

10.19.2.1 There is no current specific guidance on the effects of aggressive ground conditions on galvanised steel, however, some research indicates zinc alloys are generally more resistant than pure zinc coatings in aggressive conditions.

10.20 Metals - Copper

10.20.1 Hazards

10.20.1.1 Copper is commonly used for gas and water supplies. Copper is generally resistant to corrosion in most natural environments, but in contaminated ground copper can be subject to corrosion by acids, sulphates, chlorides and ground containing cinders/ash. Wet peat (pH 4.6) and acid clays (pH 4.2) are considered aggressive conditions to promote corrosion to copper.

10.20.2 Risk Assessment

10.20.2.1 There is no specific published guidance on what constitutes aggressive conditions to copper except very acid/peaty conditions.

10.20.2.2 Although there are no significantly acidic or peaty conditions at the site, there are significant concentrations of ash/cinders in come areas of the site which may lead to the risk of corrosion. We recommend manufacturers are consulted possibly to provide a coating to the pipe or possibly installation of the pipe in a trench with clean backfill.

10.21 Metals - Lead

10.21.1 Hazards

10.21.1.1 Lead is used in tanking, flashings, damp proof courses, etc. Lead is a durable material which is resistant to corrosion in most environments. Lead damp proof courses can be subject to attach from the lime released by Portland Cement based mortar and concrete. In the presence of moisture, a slow corrosive attack is initiated on lead sheet. In such cases a thick coat of bitumen should be used to protect the lead damp proof course.

10.21.2 Risk Assessment

10.21.2.1 There is no current guidance on the performance of lead in contact with contaminated soils, however, acids and alkalis (lime) could be aggressive towards lead.

10.21.2.2 At the site pH conditions are not considered significantly extreme and this it is considered unlikely that ground conditions at the site would significantly affect lead.

10.22 Plastics - general

10.22.1 The range of plastics in construction is wide and increasing. The deterioration of plastics varies with the individual material and the environment to which it is exposed. In general, plastics deteriorate through degradation of their polymer constituent, but loss of plasticizer and other additives can render plastics ultimately unserviceable.

10.23 Plastic Membranes and Geotextiles

10.23.1 Plastic membranes and textiles are used in the construction industry as damp proof courses, gas resistant membranes, cover systems and liners. They are typically used to restrict the movement of gas or water into buildings, building materials or components or to separate differing soil types. Typically materials used for membranes are polyethylene (PE) and poly vinyl chloride (PVC).

10.23.2 Hazards

10.23.2.1 Membranes of PE and PVC are attacked by a variety of acids and solvents. PE has a poor corrosion resistance to oxidising acids (nitric and sulphuric) at high concentrations. Hydrochloric acid (HCl) does not chemically attack PE but can have a detrimental effect on its mechanical properties. Alkalis, basic salts, ammonia solutions and bleaching chemicals such as chlorine will cause deterioration of PE. PE is resistant to non oxidising salt solutions.

10.23.2.2 PVC is degraded by the action of oxidising acids. Nitric acid is particularly aggressive towards PVC. PVC does not deteriorate under the action of neutral or alkaline solutions.

10.23.3 Risk Assessment

10.23.3.1 There is no published guidance on quantitative assessment of the risks to PE or PVC although there is a lot of advice on how contaminants react with these plastics. In general, the more concentrated the contamination the greater the risk to plastic membranes/geotextiles.

10.23.3.2 Based on the investigatory data obtained to date, and in consideration of the hazards described above, there is no evidence of significant concentrations of acids or alkalis, indicating the risks of ground conditions at the site affecting PE and PVC materials are considered low.

10.24 Plastic Pipes

10.24.1 Hazards

10.24.1.1 Plastic pipes are predominantly manufactured from PVC and PE but other materials can be used. In general they perform well but it is known that chemical attack and permeation of contaminants through the pipes can result from use in contaminated land. A published review on plastic pipes reports the following:-

- Polyethylene (PE) - good resistance to solvents, acids and alkalis
- Poly vinyl chloride (PVC) - most common form of pipe. Good general resistance to chemical attack but can be attacked by solvents such as ketones, chlorinated hydrocarbons and aromatic polypropylene (PP) - chemically resistant to acids, alkalis and organic solvents but not recommended for use with storing oxidising acids, chlorinated hydrocarbons and aromatics.
- Poly vinylidene fluoride (PVDF) - inert to most solvents, acids and alkalis as well as chlorine, bromide and other halogens
- Polytetrafluoroethylene (PTFE) - one of the most inert thermoplastics available. PTFE has good chemical resistance to solvents, acids and alkalis

A survey carried out by the Water Research Centre (WRc) on reported incidents of permeation (more than 25), only two involved PVC with these incidents relating to spillages of fuel.

10.24.2 Risk Assessment

10.24.2.1 Plastic pipe performance has been the subject of a WRc report. The report risk ranks differing previous site uses in relation to the use of plastic pipes which is summarised in the following table.

Type A = High Risk
Asbestos works, chemical works, gasworks, hazardous waste treatment, wood preservative use/manufacture, landfill sites, metal mines, smelters, foundries, steel works, munitions production/testing sites, oil and fuel production / storage / use, paper and printing works, pesticide manufacture, pharmaceutical manufacture, scrap yards, sewage works, tanneries.
Type B = Suspect Sites
Dry cleaners, electric/electrical equipment manufacture, fertiliser storage, garage/filling stations, mechanical engineering works, metal finishing installations, paint and ink manufacture, railway land, textile production, research laboratories, road haulage yards.
Type C = Low Risk
Agriculture, brewing and distilleries, food preparation and storage.
Table 9.24.2. Risk ranking of former land use with respect to use of plastic pipes.

10.24.2.2 The WRc report also provides advices on the type of pipe material appropriate for the type of contamination present. An extract is provided below.

Material Groups

Group 1. Organic Contamination

- PE sleeved ductile iron.
- Tape wrapped or coated steel.
- Sheathed copper.
- Wrapped metal fittings.
- Protection for joints and seals.
- Clean suitable backfill.
- Seek specialist advice on use of PVC-U or GRP pipes.

Group 2. Mixed Contamination

- Plastic-coated or wrapped metal pipes.
- Cathodic protection (coated metal and pre-stressed concrete pipes only)
- Protection for joints and seals.
- Clean suitable backfill.

Group 3. Inorganic Contamination

- Plastic pipes.
- Plastic-coated metal pipes.
- Cathodic protection (coated metal and pre-stressed concrete pipes only)
- Clean suitable backfill.
- Seek specialist advice on use of GRP pipes.

Group 4. No Significant Organic or Inorganic Contamination

- Material of Choice.

For all material groups, good pipe laying practice must be followed.

10.24.2.3 The WRc report also refers to testing suites in relation to both inorganic and organic contamination. With respect to inorganic contamination, the WRc report acknowledges the purposes of this is for a risk assessment in relation to human health for construction operatives with the effects of such contaminants affecting plastic drinking water pipes limited.

10.24.2.4 The WRc report indicates that permeation of plastic pipes by organic solvents and substances was a major problem. The WRc report produces the following groups of compounds to which trigger concentrations were assigned.

Group 1(a) Compounds:
Carbon tetrachloride
Trichloreothane
Tetrachloroethane
Benzene
Toluene
Xylenes
Chlorobenzene

Group 1 (b) Compounds:
Dichloromethane
1,2-dichloroethane
1,1,1-trichloroethane
1,2-dichloropropane
vinyl chloride
methyl bromide
dichlorobenzenes

Trichlorobenzenes
Ethylbenzene

The above chemicals relate to fuels and volatile organic compounds.

10.24.2.5 We are aware that water companies have their own testing regime to assist in selection of an appropriate material supply of drinking water to the site and would, therefore, recommend a copy of this report is provided to the water company to allow them to specify the appropriate pipeline material.

10.24.2.6 We would only carry out laboratory testing to measure concentrations of organic contaminants listed in the WRc report (refer 9.24.2.4 above) if the site is known to or is suspected of using/processing these chemicals and at this site we have no evidence to suspect the use of such chemicals.

10.25 Electrical Cables

10.25.1 Hazards

10.25.1.1 Electrical cables are generally protected by plastic sleeves. These sleeves are potentially subject to chemical and permeation in similar modes as plastic pipes. Medium and low voltage cables are often laid directly into the ground and are thus at risk of attack by contaminants. High voltage cables tend to be laid in trenches backfilled with 'clean' materials.

10.25.2 Risk Assessment/Remedial Action

10.25.2.1 The selection of appropriate sheathing material is important to provide resistance to ground conditions at the site and recommend manufacturers advices are sought.

10.26 Rubbers

10.26.1 Hazards

10.26.1.1 Rubbers are crosslinked polymeric materials containing a number of additives such as carbon black, fillers, antioxidant and vulcanising agents. The corrosion resistance of rubber is dependant upon the polymeric constituent. The mechanisms by which rubbers deteriorate when placed in aggressive chemical environments are similar to those described for plastics. Oxidation is the principal form of degradation. Whilst rubbers are resistant to strong acids and alkalis, they are rapidly attacked by oxidising agents such as nitric acid and oxidising salts such as copper, manganese and iron.

10.26.1.2 Rubber is also susceptible to attack by certain hydrocarbons and oils. The absorption of these liquids causes the rubber to smell.

10.26.2 Risk Assessment/Remedial Action

10.26.2.1 Information on the effect of a range of chemicals on the physical properties of various rubbers has been produced by the Rubber and Plastics Research Association. This was based on observations carried out following immersion tests using undiluted chemicals, but this has limitations such as the effects of combined chemicals and the effects of dilution.

10.26.2.2 We recommend manufacturers of the rubber materials likely to be in contact with the ground at the site are consulted to confirm, or otherwise, the applicability of their product.

SECTION 11 - CONTENTS

11	**Landfill issues**
11.1	Disposal of soils off site
11.2	Landfill tax

11 Landfill Issues

11.1 Disposal of Soils off Site

11.1.1 Using available investigatory data we have produced a separate report to classify soils likely to be excavated at the site for off site disposal.

11.2 Landfill tax

11.2.1 Disposal of soils to landfill sites is normally subject to landfill tax with rates varying from year to year based on government policy. Current information on rates of landfill tax can be obtained from H M Customs and Excise (HMCE) Office (leaflet notice LFT 1) with a lower rate applied to inactive (or inert) wastes and the standard rate to all other taxable wastes.

11.2.2 Landfill tax exemption can be obtained providing the following conditions can be satisfied.

a) Reclamation must involve clearing the land of pollutants that are causing harm or have the potential to cause harm, demonstrating that the pollutants are or potentially:

   i) Polluting ground or surface water or
   ii) Harming the health of people or animals or plants on
   iii) Damaging the fabric of structures or services

b) The cause of the pollution must have ceased

c) The land is not subject to the works or remediation notice

d) The reclamation constitutes or includes clearing the land of pollutants which would (unless cleared) prevent the land being put to intended use

11.2.3 Details of the above are produced in the HMCE Leaflet LFT2. Applications for landfill tax exemption must be submitted to HMCE at least 30 days before the intention to start removing waste to landfill.

11.2.4 Based on ground conditions determined at this site and development proposals it is unlikely that landfill tax exemption would be obtained as item a) above is unlikely to be satisfied, however we would recommend an application be made to HMCE to obtain their ruling on this matter. We would be pleased to assist on this aspect on further instructions.