

Report No. 9507/1
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GEOENVIRONMENTAL APPRAISAL
of land at
LESLIE ROAD, BARNSELY

Prepared for
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LESLIE ROAD, BARNSELY (HASLAM HOMES LIMITED)

- SUMMARY OF GEOENVIRONMENTAL ISSUES

The site is located off Leslie road, Kendray, Barnsley, approximately 3.5km south east of Barnsley town centre (NGR SE 368 054). The site occupies an area of approximately 2.5 hectares (6.17 acres). Historically the site comprised open fields until the construction of housing between 1938 and 1955. This housing has recently been demolished.

Encia were commissioned by Haslam Homes Limited to provide a geoenvironmental appraisal of the site. It is understood that the site is to be redeveloped with two to three storey domestic dwellings; a proposed layout is available. Encia's investigation included a review of historical plans and search information from statutory bodies together with a ground investigation comprising 22 trial pits, with soakaway tests in 5 of the pits, and 10 window sample boreholes.

A summary of salient geoenvironmental issues is provided in the Table below.

Summary of Geoenvironmental Issues

Issue	Remarks
History	The site comprised open fields until construction of housing between 1938 and 1955. This housing has recently been demolished.
Made Ground	Made ground (typically Cohesive Made Ground comprising reworked clay with gravel of brick etc) encountered across the majority of the site to typically <1.0m depth. Locally deep made ground, to >3.0m, identified beneath the existing highway, possibly associated with a drainage trench.
Natural Ground	Natural strata generally comprised a sequence of Completely Weathered Sandstone (sandy gravelly Clay) over Weathered Sandstone (clayey Sand, Gravel and Cobbles). Rockhead comprising Sandstone (Coal Measures strata) typically encountered from 2.0m depth. In south and east (TP's 4, 8, 9 and 10), rockhead encountered between 0.8m and 1.5m depth.
Contamination	No elevated concentrations of inorganic or organic contamination identified at the site.
Hazardous Gas	Site not located in radon affected area. No additional hazardous gas protection measures considered necessary.
Mining & Quarrying	The surface stability of the site is unlikely to be affected by shallow underground coal mining. No quarrying is shown at or adjacent to the site on historical plans.
Foundations	Conventional reinforced strip/trenchfill foundations placed in natural cohesive or granular strata will be suitable for the proposed two to three storey residential dwellings. Where rockhead is encountered, foundations should be placed entirely in rock and not partially in rock and partially in residual soil. This may necessitate the overdeepening of foundations.
Groundwater & Excavations	Significant inflows of groundwater are not anticipated. Excavations likely to remain stable in the short term although shoring may be required in the long term, most notably within the made ground. Localised cobbles encountered in the trial pits (Weathered Sandstone), consequently, some overbreak should be anticipated during excavation of foundation/service trenches in this strata. Excavations in rock (greater than around 2m depth) may prove difficult with localised breaking out required.
Flooding & Drainage	The site does not lie within a flood risk area; however, site is >1ha therefore Flood Risk Assessment required under PPS25. In-situ testing has shown that soakaways will not be suitable for disposal of surface water run-off.
Highways	Existing highway generally comprises a concrete pavement of up to 200mm thickness with localised sub-base, but typically lying directly on the natural soils. Based on visual inspection of the natural materials and the recorded plasticity indices the natural cohesive deposits encountered will have a CBR value of at least 3%. These values should be verified prior to or during construction.

Developer abnormalities relating to geoenvironmental issues at the site are:

- Provision of minimum 150mm topsoil in garden and landscaped areas to facilitate plant growth
- Increase of cover to 300mm where localised unsuitable materials (bricks etc) remain, or, excavation and screening of such materials from the upper 300mm (from finished levels) of garden/landscaped areas
- Localised overdeepening of foundations where rock encountered
- Resurfacing of existing highway (as a minimum), possible grubbing up and re-construction to allow adoption by Local Highways Authority

This brief summary should not be assumed to represent a complete account of all the potential geo-environmental issues that may exist at the site. As such it is strongly recommended that the report be read in its entirety.

TABLE OF CONTENTS

1	INTRODUCTION.....	1
1.1	The Commission and Brief	1
1.2	The Proposed Development	1
1.3	Report Format and Limitations	1
2	SITE DESCRIPTION	2
2.1	General	2
2.2	Site Features.....	2
2.3	Japanese Knotweed.....	2
3	SITE HISTORY	3
4	ENVIRONMENTAL SETTING	4
4.1	General	4
4.2	Landfills.....	5
5	GROUND INVESTIGATION DESIGN	5
5.1	Anticipated Ground Conditions & Potential Issues.....	5
5.2	Preliminary Conceptual Site Model	6
5.3	Ground Investigation Design & Strategy	6
6	FIELDWORK	7
6.1	Objectives.....	7
6.2	Exploratory Hole Location Constraints	7
6.3	Scope of Works.....	7
7	GROUND CONDITIONS	8
7.1	General	8
7.2	Made Ground.....	8
7.3	Obstructions.....	9
7.4	Natural Ground	9
7.5	Groundwater	9
7.6	Stability.....	9
7.7	Revised Conceptual Ground Model (Ground Conditions)	12
8	CONTAMINATION (ANALYSIS)	12
8.1	General	12
8.2	Testing Scheduled.....	12
8.3	Soil Contamination Results	12
9	CONTAMINATION (QUALITATIVE RISK ASSESSMENT & REMEDIATION)	18
9.1	Assessment of Contamination Test Results	18
9.2	Revised Conceptual Ground Model (Contamination).....	18
9.3	Site Preparatory Works	18
9.4	Summary of Potential Pollutant Linkages & Mitigation	19
10	HAZARDOUS GAS.....	19

11 GEOTECHNICAL TESTING	20
11.1 General	20
11.2 Atterberg Limits.....	20
11.3 Soluble Sulphate and pH	20
11.4 Soakaway Tests.....	21
12 GEOTECHNICAL ISSUES.....	22
12.1 Conceptual site Model.....	22
12.2 Mining & Quarrying	22
12.3 Foundation Recommendations	22
12.4 Designated Concrete Mixes.....	25
12.5 Excavations.....	25
12.6 Drainage.....	26
12.7 Highways.....	26
12.8 External Works	26
13 REDEVELOPMENT ISSUES.....	26
13.1 General	26
13.2 Remedial Strategy.....	27
13.3 Health & Safety Issues - Construction Workers.....	27
13.4 Control of Excavation Arisings.....	27
13.5 New Utilities	28
14 SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS.....	28
14.1 General	28
14.2 Hazardous Gas	28
14.4 Contamination & Remediation	28
14.5 Foundations	29
14.6 Flooding	29
14.7 Highways & Drainage	29

APPENDICES

Appendix A – General Notes

01	Environmental Setting
02	Ground Investigation Fieldwork
03	Geotechnical Testing
04	Contamination Laboratory Analysis & Interpretation (including WAC)
05	Soakaways

Appendix B – Drawings

Drawing No.	Title
9507/1	Site Location Plan
9507/2	Proposed Site Layout
9507/3	Existing Site Features & Site Photographs
9507/4	Preliminary Conceptual Site Model
9507/5	Exploratory Hole Location Plan
9507/6	Revised Conceptual Site Model

Appendix C – Commission

Appendix D – Historical OS Plans

Appendix E – Search Responses (Only on accompanying CD)

From	To	Date	Content
Coal Authority	Encia	28 th February 2008	Mining Report
Barnsley Metropolitan Borough Council	Encia	13 th March 2008	Environmental Information
Environment Agency	Encia	11 th April 2008	Environmental Information

Appendices F and G – Exploratory Hole Records

Appendix F	TP's 1 to 20, 5a and 7a
Appendix G	WS's 1 to 10

Appendix H – Chemical Test Results (Only on accompanying CD)

Appendix I – Geotechnical Test Results (Only on accompanying CD)

FOREWORD (Geoenvironmental Investigation Report)

This report has been prepared for the sole internal use and reliance of the Client named on page 1. This report shall not be relied upon or transferred to any other parties without the express written authorisation of Encia Consulting Limited (Encia); such authorisation not to be unreasonably withheld. If any unauthorised third party comes into possession of this report, they rely on it at their peril and the authors owe them no duty of care and skill.

The report presents observations and factual data obtained during our site investigation, and provides an assessment of geoenvironmental issues with respect to information provided by the Client regarding the proposed development. Further advice should be sought from Encia prior to significant revision of the development proposals.

The report should be read in its entirety, including all associated drawings and appendices. Encia cannot be held responsible for any misinterpretations arising from the use of extracts that are taken out of context. However, it should be noted that in order to keep the number of sheets of paper in the hard copy to a minimum, some information (e.g. laboratory test certificates) is only included within the "electronic", PDF Report on the accompanying CD.

The findings and opinions conveyed in this report (including review of any third party reports) are based on information obtained from a variety of sources as detailed within this report, and which Encia believes are reliable. All reasonable care and skill has been applied in examining the information obtained. Nevertheless, Encia cannot and does not guarantee the authenticity or reliability of the information it has relied upon.

The report represents the findings and opinions of experienced geo-environmental consultants. Encia does not provide legal advice and the advice of lawyers may also be required.

Intrusive investigation can only investigate shallow ground beneath a small proportion of the total site area. It is possible therefore that the intrusive investigation undertaken by Encia, whilst fully appropriate, may not have encountered all significant subsurface conditions. Consequently, no liability can be accepted for conditions not revealed by the exploratory holes. Any opinion expressed as to the possible configuration of strata between or below exploratory holes is for guidance only and no responsibility is accepted as to its accuracy

It should be borne in mind that the timescale over which the investigation was undertaken may not allow the establishment of equilibrium groundwater levels. Particularly relevant in this context is that groundwater levels are susceptible to seasonal and other variations and may be higher during wetter periods than those encountered during this commission.

Where the report refers to the potential presence of invasive weeds such as Japanese Knotweed, or the presence of asbestos containing materials, it should be noted that the observations are for information only and should be verified by a suitably qualified expert.

This report assumes that ground levels will not change significantly from those existing at present and that houses will be of two to three storey construction. If this is not to be the case, then some modification to this report may be required.

Encia Consulting Limited cannot be responsible for the consequences of changing practices, revisions to waste management legislation etc that may affect the viability of proposed remedial options.

Encia reserve the right to amend their conclusions and recommendations in the light of further information that may become available.

GEOENVIRONMENTAL APPRAISAL

of land at

LESLIE ROAD, BARNLSLEY

1 INTRODUCTION

1.1 The Commission and Brief

1.1.1 Encia Consulting Limited (Encia), were commissioned by Haslam Homes Limited (Haslam Homes) to carry out a geoenvironmental appraisal of land at Leslie Road, Barnsley.

1.1.2 Correspondence regarding Encia's appointment, including the brief for this investigation, is included in Appendix C. The agreed scope of works included:

- a site walkover and inspection
- an assessment of the land use history
- determination of the site's environmental setting
- an intrusive ground investigation comprising 22 trial pits with soakaways in 5 of the pits and 10 window sample boreholes
- assessment of the geotechnical properties of the near surface deposits to enable provision of foundation and highway recommendations
- a qualitative assessment of contamination risks, with respect to potential receptors
- the provision of recommendations with respect to site preparatory and remedial works

1.2 The Proposed Development

1.2.1 It is understood that consideration is being given to redevelopment of the site with two to three storey domestic dwellings, associated gardens, POS and adoptable roads and sewers. A provisional sketch site layout has been provided by Haslam Homes (Drawing reference Leslie Road, dated January 08) which is reproduced as Drawing No. 9507/2 in Appendix B to this report.

1.3 Report Format and Limitations

1.3.1 All standard definitions, procedures and guidance are contained within Appendix A, which includes background, generic information on:

- Assessment of the site's environmental setting
- Ground investigation fieldwork (including techniques, in-situ testing and sampling)
- Geotechnical Testing
- Contamination Testing (including current guidance, notes about organics analyses, and WAC)
- Soakaways

1.3.2 General notes and limitations relevant to all Encia geoenvironmental investigations are described in the Foreword and should be read in conjunction with this report. The text of the report draws specific attention to any modification to these procedures and to any other special techniques employed.

1.3.3 Primary aims of this investigation were to identify salient geoenvironmental issues affecting the site to enable the Client to obtain budget costs for the necessary site preparatory and remedial works.

2 SITE DESCRIPTION

2.1 General

2.1.1 The site location is shown on Drawing No. 9507/1 presented in Appendix B to this report. Site details are summarised in the Table below.

Detail	Remarks
Location	3.5 km south east of Barnsley town centre
NGR	SE 368 054
Approximate Area	2.0ha (6.17 acres)
Known services	Underground gas, electric overhead telecom & sewer all within the existing road. Underground drainage noted on eastern site boundary.

2.2 Site Features

2.2.1 An Encia Engineer completed a walkover survey of the site on 7th February 2008.

2.2.2 At the time of the walkover the site comprised areas of waste ground with several derelict houses currently under demolition. Stockpiles of demolition rubble are located to the west of Leslie Road with crushing of demolition materials in the north-west. At the time of the fieldwork all of the former houses at the site had been demolished.

2.2.3 Leslie Road which is generally unused currently divides the site from north to south.

2.2.4 Existing salient features together with a photographic record of the site at the time of the walkover survey are presented on Drawing No. 9507/3 in Appendix B to this report.

Feature	Remarks
Current Access	Off Leslie Road
Topography	Slope down from west to east
Approximate areas	1.8ha – former housing with gardens 0.2ha – existing highway
Nature of boundaries	Open to north, south and west, palisade fencing to the east
Surrounding land uses	North and west – residential East – Railway line on raised embankment South – children’s play area with residential beyond

2.3 Japanese Knotweed

2.3.1 During the site walkover, we did not notice the presence of any Japanese Knotweed. However, it should be noted that we are not qualified ecologists and as such cannot guarantee the absence of Knotweed or other invasive vegetation.

3 SITE HISTORY

3.1.1 In order to investigate the development history and previous land uses at the site and immediate surrounding land, site centred extracts from Ordnance Survey (OS) plans dating back to 1854 were examined. These plans are presented in Appendix D to this report.

3.1.2 The Table below provides a summary of the salient points relating to the history of the site with respect to the proposed end use. It is not the intention of this report to describe in detail all the changes that have occurred on or adjacent to the site. Significant former uses/operations are highlighted in bold text for ease of reference.

Date(s)	Site	Surrounding Land
1854	Open fields.	Oaks Colliery approximately 400m to north.
1894	No change.	Oaks Colliery now labelled as 'Old Oaks Colliery'. Majority of quarries to north-west now absent. New Oaks Colliery approximately 700m to east.
1907	No change.	Railway line adjacent to eastern boundary.
1938	Road marked on plan in location of Leslie Road.	Urbanisation of the area to the east of the railway line. Housing within 300m to the west and south-west. New Oaks Colliery labelled as Oaks Chemical Plant. Barnsley Main Colliery approximately 500m to the north.
1955	Site now comprises housing.	Housing immediately to the north, west and south. Mill and Builders Yard located to the north-east of the site beyond the railway.
1961	No change.	Housing to the east beyond the railway line.
1974	No change.	Builders Yard to north-east now comprises housing. Mill labelled as Coal Yard. Spoil Tips adjacent to Barnsley Main Colliery labelled as 'disused'.

3.1.3 No further significant changes are shown on subsequent plans at or near to the site, however, since the publication of the latest OS plan the housing at the site has been demolished.

4 ENVIRONMENTAL SETTING

4.1 General

4.1.1 Notes describing how the site's environmental setting has been assessed are included in Appendix A to this report. The responses received from the Coal Authority, Barnsley Metropolitan Borough Council, the BGS and the Environment Agency are presented in Appendix E.

Issue	Data reviewed	Summary
Geology	1:50,000 BGS map (Sheet 87) 1:10,000 BGS map (Sheet SE 30NE)	Drift – None recorded Solid – Upper Carboniferous Middle Coal Measures (Oaks Sandstones Rock) Shallowest coal seam – Low Beamshaw Coal (0.53m to 0.90m thick) at around 100m depth Strata Dip – not recorded Faults - 70m NE of site with a NW-SE trend and a downthrow to NE 650m SW of site with a NNW-SSE trend and a downthrow to NE
Mining	Coal Authority Report BGS maps	Past and present workings – Site is within the zone of likely influence from workings in eleven seams of coal at depths of between 150m to 600m, the last date of working being 1983. Mine entries – None within 200m Opencast – None within 200m Subsidence claim made by residents of 60 Reginald Road in 1993
Quarrying	Local Authority search Historical OS Plans	None at or adjacent to the site
Radon	BRE Report BR211	No radon protection measures required
Hydrogeology	Environment Agency Groundwater Vulnerability map (Sheet 11)	Source Protection Zone – No Minor Aquifer (Oaks Rock Sandstone) Soil leaching potential – high Groundwater abstractions – Nearest located 660m NE for general washing and process washing (Industrial / Commercial) Pollution incidents - None at or adjacent to the site
Hydrology	Environment Agency Landmark Report	Nearest watercourse – Stream 'Dob Sike' 600m SE Water quality – Not available Pollution incidents – None at or near to the site Abstractions – None at or near to the site Discharge consents – None at or near to the site
Flood Risk	Environment Agency	Not in a flood risk area; however, Flood Risk Assessment required under PPS25 as site > 1ha.

- 4.1.2 The report received from the Coal Authority (Appendix E) states that a subsidence claim was made by residents of 60 Reginald Road in 1993, a telephone conversation with the Coal Authority suggests this claim was rejected. However, in the 1970's claims were made by almost every house on Leslie Road.
- 4.1.3 The coal underlying the site was last worked in 1983. Workings of this age and depth were by the 'longwall method'. On cessation of mining, support would be withdrawn under license and the workings allowed to collapse in their entirety. Minor subsidence at the surface would be instantaneous but potentially cause very minor damage (slight cracking) to structures in the affected area. The Coal Authority settled these claims by repair.
- 4.1.4 As noted in the Coal Authority report, settlement from these workings will by now have ceased.

4.2 Landfills

- 4.2.1 Known or suspected areas of landfill within 250m of the proposed development site are summarised below:

Landfill Sites

Location	NGR (proximity to site)	Remarks	Source of data
School Street	SE 369 056 (200m north-east)	Deposited Inert and Commercial Waste between 1977 and 1984.	Landmark

- 4.2.2 The above site is recorded on the Envirocheck data sheets, however, the landfill is not recorded by BMDC or the EA. Historical OS Plans show the area of landfill to comprise a garage, haulage yard, builders yard and transport depot between the dates of landfilling provided above. Consequently the area infilled with waste is likely to have been small (around 2,000m²) as the remainder of the site was occupied by buildings etc.
- 4.2.3 Based on the above and given the age of the site together with the nature of material deposited it is considered unlikely that any significant volumes of hazardous gas will be generated from the landfill.

5 GROUND INVESTIGATION DESIGN

5.1 Anticipated Ground Conditions & Potential Issues

- 5.1.1 Based on the data reviewed in Sections 3 (Site History) and 4 (Environmental Setting), anticipated ground conditions are expected to comprise:-

Anticipated Condition	Remarks
Made Ground	Sub-base below existing road. Reworked materials associated with former housing
Natural Soils	No drift anticipated, weathered rock anticipated (clays, sands & gravels)
Bedrock	Carboniferous Middle Coal Measures (Oaks Rock Sandstone)
Groundwater	Unlikely at shallow depth. Possible deep groundwater in the Coal Measures

5.1.2 Based on the data above and that in Sections 2 (Site Description) and 3 (History), potential ground-related issues associated with this site are likely to include:

Type of Issue	Specific Issue	Remarks
Potential on-site contamination sources	1. Existing highway	1. Possible fuel leaks and spillages
Potential off-site contamination sources	1. Adjacent railway	1. Possible fuel leaks and spillages
Potential geotechnical hazards	1. Relict buried obstructions 2. Made ground	1. Former housing across site 2. Reworked materials from former footings
Other potential constraints	1. Existing services in road	1. Diversion and/or replacement

5.1.3 A railway line on a raised embankment is located adjacent to the eastern site boundary. Although contamination from oil/diesel spillage/leakage can occur in marshalling yards, significant contamination associated with running lines is considered unlikely.

5.1.4 Therefore contamination of the site from the railway line is considered unlikely and as such is deemed to pose negligible risk to the site.

5.2 Preliminary Conceptual Site Model

5.2.1 A preliminary conceptual site model, presented as Drawing No 9507/4 in Appendix B, has been prepared after consideration of all the data presented in Sections 2 to 5.1 inclusive, of this report.

5.2.2 Potential pollutant linkages are shown on the preliminary conceptual site model.

Plausible pathways include

- Inhalation, ingestion
- Dermal contact
- Uptake by plants
- Migration of mobile / leachable contaminants.

Receptors include

- End users (residents)
- Site workers
- Environment (plants, groundwater – minor aquifer)

5.3 Ground Investigation Design & Strategy

5.3.1 The preliminary conceptual site model was used as a basis for design of an appropriate ground investigation, the scope of which is summarised below.

Initial Ground Investigation Strategy

Exploratory Holes	Purpose
TPs 1 to 20	To determine the general nature of soils underlying the site, including the: <ul style="list-style-type: none"> • nature, distribution and thickness of made ground • nature, degree and extent of contamination, if any • proportion of undesirable elements e.g. biodegradable matter, foundations etc • suitability of the ground for founding structures and highways • Identify any below ground obstructions (eg relict foundations) • Allow soakaway testing in selected pits depending on ground conditions encountered
WS's 1 to 10	To determine the construction of the existing highway

- 5.3.2 Proposed exploratory hole locations have been selected to provide a representative view of the strata beneath the site and to target potential areas of interest identified in Section 5.1 above. Additional exploratory locations will probably be scheduled by the site engineer in light of the ground conditions actually encountered.
- 5.3.3 The number of representative samples taken will be reflective of the geological complexity actually encountered. However, in general about 3 samples will be taken from most trial pits.
- 5.3.4 An assessment of potential contaminants associated with the former uses has been undertaken. As a consequence of this assessment, anticipated potential contaminants, within soil and/or groundwater include:
- Metals (Made Ground associated with former housing)
 - Hydrocarbons (Minor spillage/leakage of fuel/oil on existing highway)

6 FIELDWORK

6.1 Objectives

- 6.1.1 The original investigation strategy is outlined in Section 5.3 above.
- 6.1.2 The additional exploratory holes listed below were advanced in light of ground conditions actually encountered.

Additional Exploratory Holes

Exploratory Holes	Purpose
TPs 5a and 7a	To undertake additional soakaway testing.

6.2 Exploratory Hole Location Constraints

- 6.2.1 Access was restricted along the existing highway (Leslie Road) due to services. Concrete coring of the surface hardstand with window sampling of the underlying sub-base was carried out within the highway to determine the existing road construction.
- 6.2.2 It should be noted that window sampling allows only a limited inspection of the ground (especially made ground with a significant proportion of coarse material). Furthermore, assessment of the strength of cohesive soils, via hand vane tests, is difficult due to disturbance caused by drilling.
- 6.2.3 Access was restricted in the east of the site due to boggy ground conditions and in the centre of the site where crushing and screening of demolition rubble was taking place, including the stockpiling of materials as shown on Drawing No 9507/5 in Appendix B.

6.3 Scope of Works

- 6.3.1 Fieldwork was supervised by Encia between 28th March and 1st April 2008 and comprised the exploratory holes listed below.

Scope of Ground Investigation Works

Technique	Exploratory holes	Final depth(s)	Remarks
Trial pitting (machine dug)	TP's 1 to 20, 5a and 7a.	1m to 3.5m	5a and 7a excavated for Soakaway testing
Soakaway Tests	TP's 5a, 7a, 14, 15 and 18	1m to 2.5m	
Window Sample Boreholes	WS's 1 to 10	0.85m to 3m	Concrete coring of surface hardstand.

- 6.3.2 Notes describing ground investigation techniques, in-situ testing and sampling are included in Appendix A to this report.
- 6.3.3 Exploratory hole logs are presented in Appendices F and G to this Report. These logs include details of the:
 - Samples taken
 - Descriptions of the solid strata, and any groundwater encountered.
- 6.3.4 Exploratory hole locations are shown on Drawing No. 9507/5 presented in Appendix B.

7 GROUND CONDITIONS

7.1 General

- 7.1.1 A complete record of strata encountered beneath the proposed development site is given on the various exploratory hole records, presented in Appendices F and G. However, a summary of the ground conditions is provided in the tables on pages 10 and 11.
- 7.1.2 Typical ground conditions encountered at the site are described below in Sections 7.2 (made ground) and 7.4 (natural ground).

7.2 Made Ground

- 7.2.1 Made ground was encountered across the site to typically <1m, and can generally be classified as one of two broad types as summarised in the table below. An area of localised deep made ground, to >3.0m depth, was identified beneath Leslie Road, possibly associated with a drainage trench.

Made Ground

Strata	Typical Composition	Distribution & Typical depth (m)
Cohesive Made Ground	Typically reworked clay with gravel size fragments of sandstone, ceramics and other anthropogenic materials such as brick.	Identified across the majority of the site between 0.40m to >1.5m, typically to <1m.
Granular Made Ground	Gravel of brick, sandstone with locally wood, metal wire fragments.	Identified in TP11, TP20 and WS3.

- 7.2.2 During the trial pitting, Brick Fill was identified in TP15 to a depth of 0.3m. This is likely to be from the demolition rubble stockpiles at the site. This material was not identified in any other exploratory holes.
- 7.2.3 Relict Topsoil was also identified in three of the trial pits between 0.4m and 1.3m depth.
- 7.2.4 Window sampling was undertaken in the highway to determine the existing construction to allow adoption by the Local Authority Highways Department.

Highway Construction

Strata	Typical Composition	Distribution & Typical depth (m)
Concrete	Unreinforced concrete	Comprising the majority of the surface running layer, varying in depth from 0.07m to 0.2m, typically 0.15m
Tarmac	Aggregate of limestone bound in tarmac	Identified in one hole, WS1, to 0.1m depth overlying the concrete
Sub-base	Gravel size fragments of limestone	Underlying the concrete to 0.35m and 0.4m depth respectively in two of the holes (WS6 & WS9). Identified to >3.0m depth in WS1

Strata	Typical Composition	Distribution & Typical depth (m)
Ash & Clinker	Gravel size fragments of clinker with brick fragments and sand of ash	Identified in WS10 to 0.8m depth underlying the concrete
Cohesive Made Ground	Typically reworked clay with gravel size fragments of sandstone, ceramics and other anthropogenic materials such as brick.	Identified in WS5 to 0.4m depth underlying the concrete
Granular Made Ground	Gravel of brick, sandstone	Identified in one hole (WS3) to 0.85m depth

7.2.5 Typically, the concrete pavement was underlain by in-situ natural deposits (clay, sand and gravel) with no sub-base materials.

7.2.6 Whilst not encountered during this investigation, the possibility of asbestos sheeting, used as shuttering, and/or fragments of asbestos sheeting within the hardcore beneath concrete slabs, cannot be entirely discounted.

7.3 Obstructions

7.3.1 Historically the site has been occupied by housing which has recently been demolished.

7.3.2 As part of the demolition works it is understood that the foundations of the former houses have been grubbed up by the demolition contractor.

7.3.3 During the recent intrusive works no substantial obstructions were encountered, consequently the risk of encountering significant obstructions during redevelopment of the site is considered low.

7.4 Natural Ground

7.4.1 Natural ground was encountered in the majority of the exploratory holes, and typically comprised Weathered Sandstone.

Summary of Natural Ground Conditions

Strata and Depth	Typical Composition	Typical Distribution
Completely Weathered Sandstone	Sandy gravelly CLAY	Identified across the site at depths of up to 2.7m.
Weathered Sandstone	Clayey SAND, GRAVEL and COBBLES.	Identified across the site at depths of 0.8m to 3.0m.
Coal Measures Sandstone	Orange and brown fine to coarse grained sandstone recovered as angular tabular cobbles.	Identified at depths between 0.8m and 3.0m.

7.5 Groundwater

7.5.1 Groundwater seepages were encountered in TP11 at 1.1m depth and in TP19 at 2.4m depth within the Weathered Sandstone.

7.6 Stability

7.6.1 Stability of excavations within both the made ground and natural ground was generally good, with the exception of TP20, where collapse occurred at 1.5m in the Granular Made Ground.

7.6.2 Some localised overbreak occurred in excavation trenches where cobbles were encountered.

Summary of Ground Conditions – Trial Pits.

Hole ID	Final Depth (m)	Depth to Base of Made Ground (m)	Depth to Base of Made Ground (m)				Depth to Base of Natural Ground (m)			Depth to rock head and penetration (m)	
			Cohesive Made Ground	Relict Topsoil	Brick Fill	Granular Made Ground	Completely Weathered Sandstone (CLAY)	Weathered Sandstone (SAND/ GRAVEL/ COBBLES)	Completely Weathered Sandstone (CLAY)		
TP1	2.90	0.80	0.40	0.80				1.40	2.50	>2.90	Coal Measures SANDSTONE
TP2	1.90	1.20	0.70	1.20				>1.90			
TP3	1.90	1.00	1.00						>1.90		
TP4	1.60	0.90	0.90						1.50		1.50 (0.10)
TP5	1.80	0.50	0.50						1.30		1.30 (0.50)
TP5a	2.50	0.50	0.50					0.80	2.10	>2.50	2.10 (0.40)
TP6	1.70	0.80						>1.70			
TP7	2.00	1.30						2.00			2.00 (0.00)
TP7a	1.50	1.00	1.00					>1.50			
TP8	1.00	0.30	0.30					0.80			0.80 (0.20)
TP9	1.70							1.50			1.50 (0.20)
TP10	1.30	0.20						1.10			1.10 (0.20)
TP11	1.60	1.40	0.30			1.40		>1.60			
TP12	2.20	1.30	1.30					1.30			2.10 (0.10)
TP13	2.70	1.30	1.30	1.50				2.70			2.70 (0.00)
TP14	2.70	0.20	0.20						2.00		2.00 (0.00)
TP15	2.40	0.10			0.10				0.50, 2.40	1.90	2.40 (0.00)
TP16	2.60	0.90	0.90					>2.60			2.60 (0.00)
TP17	2.60	1.00	1.00						>2.60		2.60 (0.00)
TP18	3.00	1.50	1.50					2.10	3.00		3.00 (0.00)
TP19	2.40	0.60	0.60					1.80	>2.40		2.40 (0.00)
TP20	1.50	>1.50	0.60				>1.50				

Summary of Ground Conditions – Window Sample Holes

Hole ID	Final Depth (m)	Depth to Base of Made Ground (m)	Depth to Base of Made Ground (m)							Depth to Base of Natural Ground (m)		
			Tarmac	Concrete	Sub-base	Ash & Clinker	Granular Made Ground	Cohesive Made Ground	Weathered Sandstone (SAND/GRAVEL)	Completely Weathered Sandstone (CLAY)		
WS1	3.00	>3.00	0.10	0.20	>3.00							
WS2	1.83	0.17		0.17								>1.80
WS3	0.85	0.30		0.20			0.30				>0.85	
WS4	1.10	0.19		0.19							0.90	>1.10
WS5	1.10	0.40		0.20					0.40			>1.10
WS6	2.00	0.35		0.15	0.35							>2.00
WS7	1.90	0.17		0.17								>1.90
WS8	0.90	0.16		0.16								>0.90
WS9	1.00	0.40		0.15	0.40							>1.00
WS10	1.50	0.80		0.07		0.80						>1.50

7.7 Revised Conceptual Ground Model (Ground Conditions)

- 7.7.1 The Preliminary Conceptual Site Model has been revised in light of data obtained during the ground investigation, most notably with respect to:
- The nature and distribution of made ground
 - The strength, nature and depth of underlying natural strata
- 7.7.2 The revised Conceptual Site Model is presented in Appendix B, as Drawings 9507/6
- 7.7.3 Further refinement of the Conceptual Site Model is presented in Section 9.2, where the results of laboratory testing for contaminants have been considered.

8 CONTAMINATION (ANALYSIS)

8.1 General

- 8.1.1 Notes outlining current guidance with respect to the interpretation of analytical data are included in Appendix A to this report.
- 8.1.2 The site has been formerly occupied by residential housing.
- 8.1.3 The site's former usage may have given rise to some ground contamination, furthermore, made ground to typically <1.0m depth was identified across the site, locally to >3.0m depth.
- 8.1.4 An assessment of potential contaminants associated with the former uses has been undertaken; see Section 5.2.

8.2 Testing Scheduled

- 8.2.1 Based on the above assessment, an Encia Engineer submitted a test schedule (summarised in the table below) to a UKAS accredited laboratory.

Type of Sample	No. of Samples	Determinands
Made Ground	19	pH, water soluble boron, and total metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc)
	11	Water soluble sulphate, chloride, nitrate and magnesium
	10	Leachable metals: arsenic, boron, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc
	1	Total PAH, Total TPH, Speciated TPH
	2	Speciated PAH
	4	Total Organic Carbon
	1	Calorific Value
	5	Asbestos Screen
Natural Ground	2	Total PAH, Total TPH, Speciated PAH

- 8.2.2 Notes describing the various organics analyses are included in Appendix A to this report.

8.3 Soil Contamination Results

- 8.3.1 The soil contamination test results are summarised in the Tables on pages 13 to 15.
- 8.3.2 Laboratory test certificates as received from the laboratory are presented in Appendix H to this report.

Summary of Degree of Ground Contamination (Inorganics) at Leslie Road, Barnsley.

Hole ID	Depth (m)	Material	Concentrations in mg/kg unless otherwise stated. Results are quoted to 1 decimal place if <10, and whole numbers if >10. Trigger Level Concentrations are Shown in Brackets and assume a residential with gardens end-use.													Calorific Value (2MJ/kg)		
			pH#	As (20)\$	Cd ♣ \$	Cr (130)\$	Pb (450)\$	Hg (8)\$	Se (35)\$	B (3)*	Cu ♣ x	Ni (50)\$	Zn ♣ x	Sol SO ₄ (0.5 g/l) ◇	Asbestos Screen			
WS10	0.50	Ash & Clinker	8.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TP1	0.30	Cohesive Made Ground	7.9	-	-	-	-	-	-	-	-	-	-	-	-	0.6	-	-
TP2	0.30	Cohesive Made Ground	8.0	-	-	-	-	-	-	-	-	-	-	-	-	0.6	-	-
TP3	0.50	Cohesive Made Ground	7.9	-	-	-	-	-	-	-	-	-	-	-	-	0.6	-	-
TP4	0.50	Cohesive Made Ground	8.0	-	-	-	-	-	-	-	-	-	-	-	-	1.5	-	-
TP5	0.40	Cohesive Made Ground	8.0	-	-	-	-	-	-	-	-	-	-	-	-	1.5	-	-
TP6	0.20	Cohesive Made Ground	8.1	-	-	-	-	-	-	-	-	-	-	-	-	1.5	-	-
TP10	0-0.2	Cohesive Made Ground														1.8		
TP11	0-0.3	Cohesive Made Ground	8.5	-	-	-	-	-	-	-	-	-	-	-	-	0.6	-	-
TP19	0.20	Cohesive Made Ground	7.9	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TP20	0.40	Cohesive Made Ground	8.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TP1	0.70	Relict Topsoil	7.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TP2	0.80	Relict Topsoil	7.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TP8	0-0.4	Relict Topsoil	7.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TP14	0.10	Relict Topsoil	7.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TP15	0.30	Brick Fill	7.4	-	-	-	-	-	-	-	-	-	-	-	-	-	NFD	-
TP20	1.10	Granular Made Ground	7.9	-	-	-	-	-	-	-	-	-	-	-	-	0.7	NFD	-
TP16	0.50	Granular Made Ground	7.9	-	-	-	-	-	-	-	-	-	-	-	-	1.2	NFD	-
TP17	0.30	Granular Made Ground	9.8	-	-	-	-	-	-	-	-	-	-	-	-	1.4	NFD	-
TP18	0.80	Granular Made Ground	8.3	-	-	-	-	-	-	-	-	-	-	-	-	-	NFD	-

Key	Source of Guidance Trigger Level	
	\$	
-	Parameter tested for but not found to be in excess of trigger concentration	DEFRA and the EA Contaminated Land Exposure Assessment (CLEA) – March '02
	Parameter not tested for	MAFF – The Soil Code (Rev. 1998)
NFD	No Fibres Detected	BRE Special Digest 1, Concrete in aggressive ground (2005)
#	All pH results listed to confirm which soil guideline values are to be used in CLEA assessment	Dutch Intervention Levels
♣	Tier 1 Value is pH dependent	ICRCL Guidance Note 59/83, Second Edition (1987) – (Boron Phytotoxic only)

Summary of the Leachability Testing on samples from Leslie Road, Barnsley

Hole ID	Depth (m)	Material	Concentration in µg/litre unless otherwise Shown. Results are quoted to 1 decimal place if <10, and whole numbers if >10. Trigger Level Concentrations are Shown in Brackets.												
			pH	As (10)*	Cd (5)*	Cr (50)*	Cu (2000)*	Pb (25)*	Hg (1)*	Ni (20)*	Zn (5,000)*	Se (10)*	B (1000)*		
TP1	0.30	Cohesive Made Ground	7.7	-	-	-	-	-	-	-	-	-	-	-	-
TP4	0.80	Cohesive Made Ground	7.9	-	-	-	-	-	-	-	-	-	-	-	-
TP11	0.0-0.30	Cohesive Made Ground	7.7	-	-	-	-	-	-	-	-	-	-	-	-
TP2	0.80	Relict Topsoil	8.0	-	-	-	-	-	-	-	-	-	-	-	-
TP14	0.10	Relict Topsoil	7.3	-	-	-	-	-	-	-	-	-	-	-	-
TP15	0.10	Brick Fill	8.0	-	-	-	-	-	-	-	-	-	-	-	-
TP16	0.50	Granular Made Ground	7.9	-	-	56	-	-	-	-	-	-	-	-	-
TP17	0.30	Granular Made Ground	8.8	-	-	-	-	-	-	-	-	-	-	-	-
TP18	0.80	Granular Made Ground	8.0	-	-	-	-	-	-	-	-	-	-	-	-
TP20	1.10	Granular Made Ground	7.9	-	-	-	-	-	-	-	-	-	-	-	-

Key		Source of Guidance Trigger Level
-	Parameter tested for but not found to be in excess of trigger concentration	* Water Supply (Water Quality) Regulations 1989, as amended in 2000
	Parameter not tested for	

Summary of Degree of Ground Contamination (Organics) at Leslie Road, Barnsley.

Hole ID	Depth (m)	Material	Concentrations in mg/kg. Results are quoted to 1 decimal place if <10, and whole numbers if >10. Trigger Level Concentrations are shown in brackets and assume a residential with gardens and 600mm cover end use											
			Benzene (0.3) ~	Toluene (38) ~	Ethyl Benzene (78) ~	Xylenes (86) ~	Total PAH (23) ~ ◇	Naphthalene (23) ~	GRO C ₅ to C ₁₀ (0.3) ~ ◇	DRO C ₁₀ to C ₂₀ (330) ~	LRO C ₂₀ to C ₄₀ (5,000) ~			
WS3	0.50	Weathered Sandstone					-							
WS5	0.30	Cohesive Made Ground					120							
WS8	0.50	Completely Weathered Sandstone					26							
WS10	0.50	Ash & Clinker	-	-	-	-	27					-*	-*	-*

Key

- Contaminant tested for but not found to be in excess of threshold concentration

Contaminant not tested for

Source of Guidance Trigger Level

♣ CLEA SGV is dependent on Soil Organic Matter content. The Tier 1 values used here are the most conservative and assume no plant uptake. In the event of exceedances, reference should be made to TOC analysis.

~ Encia risk-derived Tier 1 screening values. (Assumes isolation beneath a **minimum 600mm thickness of soil cover**, see Generic Notes 04 in Appendix A)

◇ Conservative value – assumes all C₆ to C₁₀ is benzene, or all PAH is naphthalene.

Inorganic Determinands

- 8.3.3 Of the nineteen samples of natural and made ground analysed for inorganic parameters, eighteen of the samples can be classified as uncontaminated and one could be classified as contaminated.
- 8.3.4 These samples are classified by comparison of parameters concentrations with the relevant current UK guidance threshold value for an end use including domestic gardens and any area where plants are to be grown (the most sensitive of the proposed end-uses).
- 8.3.5 The only contaminant identified was arsenic in one sample of Cohesive Made Ground.
- 8.3.6 Statistical analysis of the results has been carried out in general accordance with the methods outlined in CLR7 (see comments in Appendix A, Contamination Testing) and the results are summarised below. None of the determinands failed the outlier test in the Cohesive Made Ground.

Results of Statistical Analysis of Soil Contamination Data

Stratum	US ₉₅ Values for Contaminants that have yielded one or more Tier 1 exceedances for a given made ground type
	Arsenic (20)
Cohesive Made Ground	12

- 8.3.7 This statistical analysis indicates that the upper 95th percentile bound values (US₉₅) for arsenic in the Cohesive Made Ground is not elevated in comparison with the relevant current UK guidance threshold value for residential with gardens end use.

Calorific Value

- 8.3.8 The calorific value of one sample of Ash & Clinker has yielded a CV of 0.8MJ/kg. Materials whose CV's exceed 10MJ/kg are almost certainly combustible, while those with values below 2MJ/kg are unlikely to burn.

Asbestos

- 8.3.9 No asbestos fibres were identified in any of the samples of Brick Fill or Granular Made Ground screened.

Leachables

- 8.3.10 Of the leachability tests conducted on ten samples of made ground, one had a concentration of leachable Cadmium above the maximum permissible concentrations as defined in the Water Supply (Water Quality) Regulations 1989, as amended in 2000.
- 8.3.11 However, this is not considered significant given:
- Only one determinand in one sample was slightly elevated
 - The proposed development comprises significant areas of hardstand with an enclosed drainage system, which will reduce infiltration
 - The underlying stratum is classified as a minor aquifer
 - Soakaway testing has shown the shallow natural strata at the site to be of low permeability

Organic Determinands

- 8.3.12 In the absence of UK guidance values for many organic determinands, samples have been classified by comparison with Encia risk-derived Tier 1 screening values (see Generic Notes 04B in Appendix A).
- 8.3.13 Given that the existing highway will be retained in its current location, the samples recovered from beneath the highway have been assessed against the Tier 1 screening values for a residential end use with a 600mm cover.

Total Petroleum Hydrocarbons (TPH)

- 8.3.14 With respect to aliphatic and aromatic TPH fractions (C₅ to C₃₅), Encia have derived risk based screening values in accordance with the methodology detailed by the TPHCWG, and recently reviewed by a UK workshop of experts in respect to UK adoption of the method. All default parameters and conclusions are detailed in Appendix A.
- 8.3.15 These "Tier 1" TPH screening concentrations have been derived using the RISC model adapted to reflect current UK scenarios and assumptions. With respect to remediation, a higher "target" concentration might be acceptable, but this would normally be subject to the results of a Quantitative Risk Assessment (QRA).
- 8.3.16 The concentrations of GRO/DRO/LRO do not exceed their respective Tier 1 values presented in the Table on page 15, therefore further assessment (a 3-step approach, outlined in Generic Notes 04B in Appendix A) has been undertaken.
- 8.3.17 The first two steps involve review of speciated results. The third step assesses cumulative effects.
- 8.3.18 As TPH fractions are made up of a range of different substances it is possible that a number of these can affect the same 'target organ' (i.e. cause skin irritation or affect the liver), resulting in cumulative effects.
- 8.3.19 The cumulative effect, associated with each source material, has been assessed via calculation of a Hazard Index (HI); HI < 1 indicates no cumulative effects; HI > 1, cumulative risk requires further consideration via a detailed QRA.
- 8.3.20 The HI calculation for this site is contained in Appendix H. The HI is <1, therefore cumulative risks need not be considered further.

Polycyclic Aromatic Hydrocarbons (PAH)

- 8.3.21 Total PAH testing has identified elevated concentrations of PAH in samples recovered from beneath the existing highway. Speciated analysis has confirmed the absence of naphthalene in these soils.
- 8.3.22 The next most volatile PAH's are the three benzene ring compounds fluorene, phenanthrene and anthracene. However, due to their relatively low volatility these PAH's will not pose a potential risk to future end users, provided the PAH contaminated material remains beneath the highway where it will be suitably isolated from end-users of the site.
- 8.3.23 Given the absence of any significant visual or olfactory evidence of contamination, the elevated results of PAH identified may be the result of localised fragments of tarmac within the samples.

9 CONTAMINATION (QUALITATIVE RISK ASSESSMENT & REMEDIATION)

9.1 Assessment of Contamination Test Results

- 9.1.1 Notes outlining current guidance with respect to the interpretation of analytical data are included in Appendix A to this report.
- 9.1.2 Made ground underlies the majority of the site, which is typically less than 1.0m thick and comprises of predominantly Cohesive Made Ground (clay with gravel of sandstone, brick and concrete). Granular Made Ground, Relict Topsoil and Brick Fill were also identified with Sub-base and Ash & Clinker identified underlying the existing highway.
- 9.1.3 This made ground does not contain elevated concentrations of inorganic determinands; however, materials (eg brick, concrete), which would generally be considered undesirable as a near-surface material in garden areas were identified locally.
- 9.1.4 No areas of organic contamination have been identified underlying the existing highway based on Encia's laboratory test results and the fact that the soils will remain isolated beneath hardstand.
- 9.1.5 No visual or olfactory evidence of gross organic contamination was noted during sampling.

9.2 Revised Conceptual Ground Model (Contamination)

- 9.2.1 The Preliminary Conceptual Site Model has been amended in light of data obtained during the ground investigation, most notably with respect to the distribution of made ground and contaminants.
- 9.2.2 A revised Conceptual Site Model is presented as Drawing No. 9507/6 in Appendix B. The Model includes the contaminant sources described in Section 5.2 above, and potential pollutant linkages to receptors.

9.3 Site Preparatory Works

General

- 9.3.1 Approval of the recommendations given below should be sought from the appropriate regulatory authorities prior to commencement of site redevelopment.
- 9.3.2 It is recommended that a 150mm cover of 'clean' topsoil is placed in all garden and landscaped areas to facilitate plant growth.

Contamination

- 9.3.3 No significant contamination was identified at the site; however, locally the made ground contains materials (eg brick etc) considered undesirable near surface in garden and landscaped areas.
- 9.3.4 It is therefore recommended that unsuitable materials (bricks etc) are isolated beneath a 300mm 'clean' soil cover.
- 9.3.5 Alternatively, given that unsuitable materials were encountered locally and are not widespread across the site, these materials could be removed, through excavation and screening, from the upper 300mm (from final levels) in garden and landscaped areas where encountered.
- 9.3.6 With regards to the concentrations of PAH identified beneath the existing highway it should be ensured that these materials remain isolated from end-users beneath the highway.

9.3.7 Careful control of excavation arisings will be required during redevelopment of the site (see Section 13.4) to prevent contamination of essentially 'clean' materials.

Waste Classification

9.3.8 Disposal of the made ground off site is not considered appropriate, economically viable, nor in line with current Government philosophy regarding sustainable development. However, some excess arisings may be generated by excavations for foundations, sewers etc. Disposal to landfill may be the most practical solution, if redistribution and retention on site is not feasible.

9.3.9 Notes outlining the interpretation of analytical data with respect to waste classification are included in Appendix A to this report, together with notes about Waste Acceptance Criteria (WAC).

9.3.10 Soil arisings generated by excavations at this site are likely to be classified as follows:

Soil Type	Waste Classification	Remarks
Fuel contamination	Hazardous	Maximum TPH concentration > 1,000mg/kg (LRO) in WS5, however, average concentration <1,000mg/kg; therefore, likely to be downgraded to Non-Hazardous
Made Ground	Inert	
Natural Soils	Inert	

9.4 Summary of Potential Pollutant Linkages & Mitigation

9.4.1 In terms of the proposed redevelopment plausible pollutant linkages, and feasible remediation options, can be summarised as follows:

Receptors	Pathways	Contaminants	Remediation Options
Human Health (Future residents) ◇	Consumption of contaminated vegetables	TPH & PAH beneath highway	Organic contaminated materials should remain below the existing highway, or if excavated during redevelopment works, be isolated beneath areas of hardstand. It is recommended that 150mm of topsoil is placed in garden areas to facilitate plant growth, increased to 300mm where unsuitable materials (bricks etc) remain.
	Ingestion		
	Inhalation (dust and/or vapours)		
	Dermal contact		
Buildings	Contact with "aggressive" soil and/or groundwater	Sulphate in the made ground	Sub-surface concrete in contact with the made ground of Design Sulphate Class DS-2, ACEC Classification of AC-2.
Controlled Waters	Leaching, surface water run-off	TPH & PAH beneath highway	Isolation beneath hardstand, use of enclosed drainage system as part of the redevelopment.

◇ transient risks to construction workers will be addressed by the adoption of appropriate health and safety measures in accordance with the Health and Safety at Work Act 1974 and regulations made under the Act including for example the COSHH Regulations.

10 HAZARDOUS GAS

10.1.1 The site is not in an area susceptible to radon emissions and as such no radon protection measures are required for new dwellings at the site.

10.1.2 Information from Historical OS Plans, the Environment Agency and Local Authority indicates that there are no known former landfill sites at or within 250m of the site. However, an Historical Landfill site is recorded on Envirocheck records approximately 200m to the north-east of the site.

- 10.1.3 Given the age of the site, the nature of the materials deposited and the size of the site it is considered unlikely that this landfill site will be capable of generating significant volumes of hazardous gas.
- 10.1.4 The development site is neither underlain by shallow mineworkings nor located in an area considered susceptible to mines gas emissions.
- 10.1.5 Therefore, the risk to the development site from hazardous gas is considered negligible.

11 GEOTECHNICAL TESTING

11.1 General

- 11.1.1 Seven samples of natural soil were delivered to a suitably accredited laboratory with a schedule of geotechnical testing drawn up by Encia.
- 11.1.2 The geotechnical laboratory test results are presented in Appendix J to this report.

11.2 Atterberg Limits

- 11.2.1 Results are summarised below.

Soil type	Range of Plasticity Indices* (Average)	Shrinkability
Completely Weathered Sandstone	9-23 (17.5)	Medium

* Modified where appropriate in accordance with revised Chapter 4.2 of the NHBC Standards (April 2003).

Note. The term Shrinkability is equivalent to the term Volume Change Potential used in Chapter 4.2.

- 11.2.2 For the purposes of foundation design, it is recommended that all cohesive soils be regarded as being of medium shrinkability.

11.3 Soluble Sulphate and pH

- 11.3.1 In accordance with BRE Special Digest 1:2005, this site has been classified as brownfield with a mobile groundwater regime.
- 11.3.2 It is envisaged foundations will extend to depths of about 1m through made ground and natural strata and samples taken from this depth range have been submitted for pH and water-soluble sulphate (2:1 soil/water extract).
- 11.3.3 The concentrations of sulphate in the aqueous natural soil extracts of eight samples were determined using the gravimetric method. In addition, seventeen samples of made ground were tested using ion chromatography as part of the contamination suite. The pH value of each sample was determined by the electrometric method.
- 11.3.4 The highest water-soluble sulphate concentration and the lowest pH value for each soil type analysed are shown in the Table on page 21. The values of pH were all above 5.5, therefore concentrations of chloride and nitrate are considered insignificant.

Summary of Sulphate and pH results

Soil type	Lowest pH values	Highest Soluble Sulphate Concentration (g/l)
Cohesive Made Ground	7.9	1.8 (typically <1.6)
Relict Topsoil	7.2	0.4
Granular Made Ground	7.9	1.4
Brick Fill	7.4	0.2
Completely Weathered Sandstone (Clay)	7.2	0.1
Weathered Sandstone (Sand/Gravel)	7.6	0.2

- 11.3.5 Elevated concentrations of soluble sulphate were identified within the eight samples of Cohesive Made Ground tested. Characteristic results for soluble sulphate were below 1.6mg/l with only one sample recording a concentration of 1.8mg/l.
- 11.3.6 Elevated concentrations of soluble sulphate (>0.5g/l but <1.6g/l) were also identified within the Granular Made Ground.
- 11.3.7 Therefore, in accordance with Tables C1 and C2 of SD1, sub-surface concrete in contact with the made ground should be Design Sulphate Class DS-2, with the site allocated an ACEC Classification of AC-2.
- 11.3.8 Sub-surface concrete in contact with the natural ground should be Design Sulphate Class DS-1, with the site allocated an ACEC Classification of AC-1.

11.4 Soakaway Tests

- 11.4.1 General notes about soakaways, including their location, design, and Encia's test methodology are presented in Appendix A.
- 11.4.2 Soakaway tests were carried out in five of the trial pits at the site in accordance with BRE Digest 365 "Soakaway Design". The locations of the soakaways are shown on Drawing No. 9507/5 presented in Appendix B to this report. Records of the soakaway tests are appended to the appropriate trial pit log in Appendix F to this report.
- 11.4.3 The soakaway pits were excavated across the site to a maximum depth of 3m using a JCB 3CX backactor with a 0.6m wide bucket. Each pit was then rapidly filled with water to the top of the test section.

Infiltration Rates

- 11.4.4 The soakaway test strata are summarised in the Table below. It was not possible to calculate infiltration rates for any of the tests as the water did not drain from the pits.

Summary of Soakaway Infiltration Rates

Soakaway	Test Section	Stratum	Infiltration Rate
TP5a	1.20m to 2.50m	Weathered Sandstone (Gravel & Cobbles) and Completely Weathered Sandstone (Clay)	no calculation possible
TP7a	1.30m to 2.60m	Completely Weathered Sandstone (Clay)	no calculation possible
TP14	1.10m to 2.00m	Weathered Sandstone (Gravel)	no calculation possible
TP15	1.50m to 2.40m	Completely Weathered Sandstone (Clay) and Weathered Sandstone (Gravel)	no calculation possible
TP18	1.60m to 3.00m	Completely Weathered Sandstone (Clay) and Weathered Sandstone (Gravel)	no calculation possible

- 11.4.5 Based on the above it is therefore considered that soakaways will not be a suitable drainage solution for surface water run-off at the site.

12 GEOTECHNICAL ISSUES

12.1 Conceptual site Model

- 12.1.1 The preliminary Conceptual Site Model has been revised in light of data obtained during the ground investigation, most notably with respect to the distribution of made ground.
- 12.1.2 A revised Conceptual Site Model is presented in Appendix B as drawing 9507/6.

12.2 Mining & Quarrying

- 12.2.1 The Coal Authority Mining Report states that the site is within the zone of likely influence from workings in eleven seams of coal at depths of between 150m to 600m, the last date of working being 1983.
- 12.2.2 It is therefore considered unlikely that the surface stability of the site will be affected by underground coal mining.

12.3 Foundation Recommendations

General

- 12.3.1 It is understood that consideration is being given to redevelopment of the site with domestic dwellings with associated gardens, POS and adoptable roads and sewers. A provisional sketch site layout has been provided by Haslam Homes (Drawing reference Leslie Road, dated January 08) which is reproduced as Drawing No. 9507/2 in Appendix B to this report.
- 12.3.2 Foundation recommendations assume that development will be two to three storey and that line loads will not exceed 80kN/m run. If this is not the case significant alteration to these recommendations will be required.
- 12.3.3 We have also assumed that final development levels will not differ significantly from ground levels existing at the time of investigation. Any digital terrain modelling undertaken, or commissioned by Haslam Homes should consider implications for the foundation recommendations outlined below.
- 12.3.4 Made ground was encountered across the majority of the site to typically <1.0m depth. Locally deep made ground, to >3.0m, was identified beneath the existing highway, possibly associated with a drainage trench.
- 12.3.5 Made ground is not considered a suitable foundation material and foundations should therefore be taken through these materials into underlying strata of adequate bearing capacity.
- 12.3.6 A suspended floor construction should be used wherever the depth of made ground or infill beneath a plot exceeds 600mm. This is likely to affect around 60% of the site.
- 12.3.7 Natural strata at the site generally comprised a sequence of Completely Weathered Sandstone (sandy gravelly Clay) over Weathered Sandstone (clayey Sand, Gravel and Cobbles).
- 12.3.8 Assuming a strip foundation of 10m length and 600mm width, founding at 0.9m depth, the Completely Weathered Sandstone deposits are generally considered to have a safe bearing capacity >120kN/m².
- 12.3.9 With respect to the above foundation geometry and a maximum line load of 80kN/m run, settlements of less than 25mm would be anticipated. This is considered likely to be acceptable; however, further advice should be sought from the Structural Engineer responsible for design.

- 12.3.10 Granular deposits generally make good founding strata if they are in a medium dense or denser state of compaction. Loose or very loose granular soils; however, have low safe bearing capacities and excessive settlements can occur on loading, especially in wet ground.
- 12.3.11 No in-situ test results are available for the granular deposits, however, the granular strata at the site comprises in-situ weathered rock which was generally stable during excavation, locally proving difficult to penetrate with the plant type used. This suggests the granular soils are medium dense and for a 600mm wide footing will provide a safe bearing capacity of at least 120kN/m² with settlements less than 25mm.
- 12.3.12 Therefore, assuming line loads do not exceed 80kN/m², two to three storey dwellings could be built on 600mm wide strip footings founded in granular soils.
- 12.3.13 The sandstone rockhead is considered to have a safe bearing capacity of at least 200kN/m². Sandstone was encountered in fifteen of the exploratory holes from 0.8m depth, typically from >2.0m depth.
- 12.3.14 Haslam Homes or their groundworker should seek further advice from Encia if unexpected ground conditions are encountered in foundation or sewer excavations, including any conflict between soft ground associated with a backfilled trial pit excavation and the line of a proposed footing.
- 12.3.15 Excavations at the site were generally stable in both the made ground and the natural strata.
- 12.3.16 No significant inflows of groundwater were encountered during the investigation.
- 12.3.17 Sub-surface concrete in contact with the made ground should be Design Sulphate Class DS-2, with the site allocated an ACEC Classification of AC-2. Sub-surface concrete in contact with the natural ground should be Design Sulphate Class DS-1, with the site allocated an ACEC Classification of AC-1.
- 12.3.18 Where existing buildings have been demolished, it is assumed that that all concrete slabs and service ducts have been broken out. However, should further relict foundations be encountered then these too should be broken out prior to re-development. Alternatively, if encountered, relict foundations could probably be left in-situ and an allowance made for local breaking out where these conflict with new foundations.
- 12.3.19 Foundations of plots placed over relict foundations should be taken to greater depth than the relict foundations and into natural ground of adequate bearing capacity.
- 12.3.20 Overdeepened foundations should be stepped in accordance with NHBC Standards, Chapter 4.4.
- 12.3.21 Foundations will be required to be placed below a line drawn up at 45° from the base of any service or similar excavation.
- 12.3.22 Strip/trench fill foundations are considered the most suitable option for two and three storey residential properties constructed on this site and these are discussed below.
- Strip/Trench Fill Footings**
- 12.3.23 It is considered that strip footings/trench fill will be the most suitable foundation solution for the two or three storey houses constructed at the site. This solution is viable where the made ground is less than about 2.5m thick, and firm clay, medium dense sands and gravels, or competent rock is the founding material.

- 12.3.24 Where the ground is found to comprise varying and significant amounts of coarse granular (cobbly/bouldery) weathered rock or varying soil types, reinforcement of footings is recommended as a precaution against differential settlement.
- 12.3.25 For a standard 600mm wide, 225mm thick footing, a suitable reinforcement would be one layer of A393 mesh placed 75mm above the base of the footing. For other footing dimensions further advice should be sought from Encia.
- 12.3.26 Reinforcement, as a precaution against differential settlement, is recommended only where foundation excavations encounter significant lateral and vertical variations in strata. Given the ground conditions at the site an allowance should be made for the use of reinforcement in all of the plots.
- 12.3.27 Where rock is encountered at shallow depth foundations on rock should be placed entirely on rock and not partially on rock and partially on residual soil. This may, depending on surface gradient, necessitate significant overdeepening of foundations.
- 12.3.28 Foundations in rock could be placed at a minimum depth of 450mm; however, rockhead was typically encountered from 2.0m depth although in the south and east of the site (TP's 4, 8, 9 and 10), rockhead was encountered between 0.8m and 1.5m depth.
- 12.3.29 Clay classification tests suggest that natural cohesive soils at the site should be regarded as being of medium shrinkability. A minimum founding depth of 900mm is therefore recommended for all natural cohesive soils on the site where strip footings are proposed.
- 12.3.30 Where plots are founded in natural granular soils the minimum founding depth can be reduced to 600mm provided that clay does not lie below the base of the footing at a depth equal to the width of the footing or a depth less than three quarters that which would be calculated for a clay soil. However, natural granular soils were generally identified at depths of >1m.
- 12.3.31 To prevent differential settlement, where granular and cohesive soils are encountered within the same footing, the foundation should be taken to the minimum foundation depth required for cohesive soils. This may necessitate overdeepening of foundations through the granular material.
- 12.3.32 In order to minimise softening and swelling of cohesive soils or loosening of granular soils, it is recommended that as soon as formation level is reached, it should be blinded. The blinding should consist of concrete with as low water: cement ratio as possible.
- 12.3.33 Whilst strip or trench fill footings generally represent a simple and inexpensive foundation solution, there are a number of potential disadvantages associated with their use on this site:
- The made ground will need at least 150mm thick cover of clean topsoil (see Section 9.6) to facilitate plant growth, increased to 300mm where unsuitable materials (eg brick) remain. Subject to final remediated development levels, this cover is likely to increase footing depth/under build
 - Disposal of arisings will be required
 - Foundation and drainage excavations may encounter significant obstructions resulting in significant overbreak, such as cobbles and boulders of sandstone within the natural strata
 - Foundation and drainage excavations are likely to require shoring in made ground over the long term

12.3.34 In addition to the above, Haslam Homes should review proposed plot designs and layouts, since deeper excavations for trench fill are likely to be unstable where the centre-lines of parallel trenches are closer than about 2m (assuming 600mm widths). Haslam Homes should supervise their ground worker to ensure footings are excavated in a controlled and safe manner.

Summary of Foundation Recommendations

12.3.35 In summary, the following foundation solutions are likely to be most appropriate (subject to Client preferences regarding site preparatory works, final levels & costs associated with each foundation option).

Plot Nos	Foundation Solution(s)	Remarks (influencing factors)
All plots	Strip/trenchfill from 0.9m depth (cohesive soils), 0.6m depth (granular soils) & 0.45m depth (rockhead)	Medium shrinkability clays, granular deposits and locally shallow rock

12.3.36 The foundation solutions outlined in the above table assume that ground levels will not change significantly from those existing at present. If this is not to be the case, further advice should be sought from Encia Consulting.

12.4 Designated Concrete Mixes

12.4.1 The following designated mixes in accordance with BRE Special Digest SD1 and BS 8500: Part1: 2006 will be suitable for use on this site.

Application	DS-1 conditions (natural ground) ACEC Class AC-1	DS-2 conditions (made ground) ACEC Class AC-2
Unreinforced strip/trench fill footings	GEN1	FND2
Reinforced strip/ trench fill footings (mesh reinforcement)	RC25/30	FND2
Reinforced strip/ trench fill footings (rebar etc)	RC25/30* ¹	FND2
Unreinforced concrete floor slabs	GEN2	GEN2
In situ reinforced concrete floor slabs	RC28/35	RC28/35

Note. *¹Although RC25/30 is in line with BS8500, Encia recommend the use of RC28/35 for concrete used in structurally sensitive works, to provide greater certainty of compliance with strength verification tests, enhanced durability and compliance with accepted NHBC practice.

The use of an FND mix imposes a strength class of C28/35 on the structural designer; if this is not acceptable a designed mix in accordance with BS8500-1:2006 should be specified.

12.5 Excavations

12.5.1 Based on the results of the investigation it is unlikely that major groundwater flows will be encountered in shallow excavations.

12.5.2 Excavations should remain stable in the short term but if left open for any significant period of time, may require shoring most notably in granular soils and made ground.

12.5.3 Some overbreak can be anticipated in foundation/service excavations where cobbles of sandstone are encountered.

12.5.4 Rockhead was encountered in fifteen exploratory locations at the site, typically from 2.0m depth. Shallow rock, between 0.8m and 1.5m depth was encountered in the south and east of the site. Based on the exploratory hole logs, excavation greater than around 2.0m is likely to prove difficult across the site. It would therefore be prudent to allow for excavation of hard rock in any deep excavations such as those that may be required for service trenches etc.

12.6 Drainage

- 12.6.1 Based on the results of in-situ testing, soakaways are not considered a suitable drainage solution for surface water run-off at the site.
- 12.6.2 Any damage to the existing land drainage system caused by foundation or sewer excavations should be made good; this may require diversion and re-connection.
- 12.6.3 It is recommended that the developer contact Yorkshire Water Services with respect to capacity in existing foul and surface water sewers in the vicinity of the development area.

12.7 Highways

- 12.7.1 As part of the redevelopment of the site it is understood that Haslam Homes propose to utilise the existing highway (Leslie Road) at the site.
- 12.7.2 Investigation of the existing highway identified a concrete pavement, between 0.07m and 0.2m thick, typically around 0.17m thick generally overlying the natural Completely Weathered and Weathered Sandstone strata.
- 12.7.3 Sub-base, generally comprising limestone gravel, was identified in two of the window sample boreholes to <0.4m depth, with sub-base recorded to >3m in one hole.
- 12.7.4 The surface of the existing road is in a generally poor condition, with several areas of former repairs to holes and service excavation trenches. It is therefore considered likely that at least some remedial works to the surface of the road such as a new running layer will be required.
- 12.7.5 However, further information regarding the adoption of the existing highway should be sought from the Local Authority (Highways Department). The Local Authority may request that the road is grubbed p and reconstructed prior to adoption.
- 12.7.6 Should a new road be constructed then based on visual inspection of the natural materials and the recorded plasticity indices at the site, published tables (Design Manual for Roads and Bridges – Volume 7, Section 2 – January 1999) indicate that the natural cohesive deposits encountered will have a CBR value of at least 3%. These values should be verified prior to or during construction.

12.8 External Works

- 12.8.1 Any digital terrain modelling undertaken, or commissioned by Haslam Homes should be made available to their Engineering Designer prior to issue of an External Works Drawing.

13 REDEVELOPMENT ISSUES

13.1 General

- 13.1.1 This report has presented options with respect to foundation solutions, remediation of the site etc that are considered technically feasible and in line with current good practice. Consequently, we would expect to obtain regulatory approval for whichever option is adopted, although this cannot be guaranteed. Copies of this report should be forwarded to the relevant regulatory authorities (NHBC & Local Authority) for their comment/approval.

13.2 Remedial Strategy

- 13.2.1 Based on the findings of the investigation it is considered unlikely that the local Planning Authority and NHBC will require a Remediation Strategy document for the site.
- 13.2.2 All demolition works were complete at the time of the investigation with site clearance works (of the remaining stockpiles) underway.
- 13.2.3 Minor organic contamination identified beneath the existing highway is not considered a risk to end users of the site provided it remains isolated beneath the highway. The risks to construction workers can be addressed through simple Health & Safety precautions as detailed in Section 13.3.

13.3 Health & Safety Issues - Construction Workers

- 13.3.1 The bulk of the made ground has been retained on site. This made ground is essentially clean. However, the made ground beneath the existing highway contains contaminants at concentrations slightly above the guidance threshold values for an end use that includes domestic gardens. Workers involved in excavations for new highways, drainage, utilities etc are likely to come into direct contact with the organic contamination in the made ground.
- 13.3.2 Although workers will only be exposed to the contaminated soil for a relatively short time, the contaminants represent a risk, and simple precautionary measures are required, i.e. good personal hygiene and basic personnel protective equipment.
- 13.3.3 Consequently, during the remediation and construction phases of the site development, most notably any works within the existing highway, it will be necessary to protect the health and safety of site personnel. General guidance on these matters is given in the Health and Safety Executive (HSE) document "Protection of Workers and the General Public during the Redevelopment of Contaminated Land". In summary, the following measures are suggested to provide a minimum level of protection:
- All ground workers should be issued with protective clothing, footwear and gloves. Personnel should be instructed in why and how they are to be used.
 - Hand-washing and boot-washing facilities.
 - Care should be taken to minimise the potential for off-site migration of contamination by the provision of dust suppression control and wheel cleaning equipment during the construction works.
 - Good practices relating to personal hygiene should be adopted on the site.
 - The contractor should satisfy the Health & Safety Executive with regard to any other matters concerning the health, safety and welfare of persons on the site.
- 13.3.4 Access into excavations etc. must be controlled. The atmosphere in shored trenches in excess of 1.2m should be monitored for oxygen and hazardous gas (methane & carbon dioxide), prior to personnel entering such excavations. Monitoring should continue whilst personnel are working in deep excavations.
- 13.3.5 Before site operations are started, the necessary COSHH statements and Health & Safety Plan should be drafted in accordance with the CDM regulations.

13.4 Control of Excavation Arisings

- 13.4.1 Excavations into the made ground underlying the existing highway are likely to yield contaminated arisings. The groundworker should carefully segregate (and stockpile separately) made ground arisings from arisings of "clean" natural soils, in order that an excessive volume of unsuitable material is not generated.

13.4.2 Made ground arisings recovered from beneath the highway could be:

- redistributed beneath concrete oversite, or areas of hardstanding, where they would be satisfactorily isolated from end users.
- exported from site to a suitably licensed landfill facility

13.5 New Utilities

13.5.1 It is recommended that trenches for services including site drainage and water supply are cut over size in order to isolate pipe materials from potential contaminants and to enable maintenance to be conducted in "clean" material.

13.5.2 It is strongly recommended that all statutory service bodies are consulted at an early stage with respect to the ground conditions within which they will lay services in order to enable them to assess at an early stage any potential abnormal costs.

13.5.3 It is likely that the Water Company will request the use of ductile iron mains, with plastic coated copper house connections, given that residual organic contaminants will still be present beneath the highway post-remediation, albeit at trace concentrations.

14 SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

14.1 General

14.1.1 It is understood that consideration is being given to redevelopment of the site with two to three storey domestic dwellings, associated gardens, POS and adoptable roads and sewers. A provisional sketch site layout has been provided by Haslam Homes (Drawing reference Leslie Road, dated January 08) which is reproduced as Drawing No. 9507/2 in Appendix B to this report.

14.1.2 Made ground was encountered across the majority of the site to typically <1.0m depth. Locally deep made ground, to >3.0m, was identified beneath the existing highway, possible associated with a drainage trench.

14.1.3 Natural strata at the site generally comprised a sequence of Completely Weathered Sandstone (sandy gravelly Clay) over Weathered Sandstone (clayey Sand, Gravel and Cobbles).

14.1.4 Rockhead comprising Sandstone (Coal Measures strata) was typically encountered from 2.0m depth, however, in the south and east of the site in TP's 4, 8, 9 and 10, rockhead was encountered between 0.8m and 1.5m depth.

14.2 Hazardous Gas

14.2.1 The site is not in an area affected by radon and no hazardous gas protection measures are required for new dwellings at the site.

14.2.2 The historical landfill located approximately 200m to the north-east of the site is considered unlikely to be capable of producing significant quantities of hazardous gas.

14.3 Mining

14.3.1 The surface stability of the site is unlikely to be affected by underground coal workings.

14.4 Contamination & Remediation

14.4.1 It is recommended that a minimum 150mm capping of 'clean' topsoil be placed in garden and landscaped areas to facilitate plant growth.

- 14.4.2 No significant contamination was identified at the site, consequently no remediation will be required.
- 14.4.3 However, the groundworker should carefully segregate (and stockpile separately) arisings recovered from beneath the existing highway from arisings of "clean" soils, in order that an excessive volume of unsuitable material is not generated given that concentrations of PAH considered unsuitable near surface (upper 600mm) in garden and landscaped areas were identified in materials underlying the highway.
- 14.4.4 In garden and landscaped areas it should be ensured that no undesirable materials (bricks etc) remain in the upper 300mm of soil in garden and landscaped areas.
- 14.4.5 Where identified, these materials should be isolated beneath an increased thickness (300mm) of "clean" cover or alternatively, given that bricks etc were not extensive at the site, removed through excavation and screening.

14.5 Foundations

- 14.5.1 It is considered that strip footings/trench fill founded in the Completely Weathered Sandstone (Clay) or the Weathered Sandstone (Sand, Gravel and Cobbles) will be the most suitable foundation solution for the two or three storey houses constructed at the site at a minimum depth of 0.9m.
- 14.5.2 Where plots are founded in natural granular soils the minimum founding depth can be reduced to 600mm provided that clay does not lie below the base of the footing at a depth equal to the width of the footing or a depth less than three quarters that which would be calculated for a clay soil. However, natural granular soils were generally identified at depths of >1m.
- 14.5.3 Where rock is encountered at shallow depth foundations on rock should be placed entirely on rock and not partially on rock and partially on residual soil. This may, depending on surface gradient, necessitate significant overdeepening of foundations.
- 14.5.4 Sub-surface concrete in contact with the natural ground should be Design Sulphate Class DS-1, with the site allocated an ACEC Classification of AC-1.
- 14.5.5 Sub-surface concrete in contact with the made ground should be Design Sulphate Class DS-2, with the site allocated an ACEC Classification of AC-2.

14.6 Flooding

- 14.6.1 The EA indicate that the site is not located within an indicative floodplain. Given that the site occupies an area >1ha a Flood Risk Assessment will be required under PPS25.

14.7 Highways & Drainage

- 14.7.1 As part of the redevelopment of the site it is understood that Haslam Homes propose to utilise the existing highway (Leslie Road) at the site.
- 14.7.2 Further information regarding the adoption of the existing highway based on the findings of the investigation should be sought from the Local Authority (Highways Department).
- 14.7.3 Should a new road be constructed then based on visual inspection of the natural materials and the recorded plasticity indices at the site, published tables (Design Manual for Roads and Bridges – Volume 7, Section 2 – January 1999) indicate that the natural cohesive deposits encountered will have a CBR value of at least 3%. These values should be verified prior to or during construction.
- 14.7.4 In-situ testing has shown that soakaways will not be a suitable drainage solution for surface water run-off at this site.