

OPUS JOYNES PIKE

ARUN DISTRICT COUNCIL				
No.	W	384	08	

Lidl UK GmbH
Geo-Environmental Investigation
Pier Road, Littlehampton (South Site)

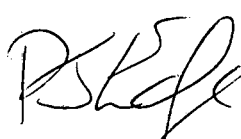
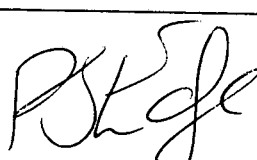
September 2008

Opus Joynes Pike Limited
3800 Parkside
Birmingham Business Park
Birmingham
B37 7YG

Telephone: 0121 329 1560
Facsimile: 0121 788 0757

Date: September 2008
Reference: CAB/J-BK093(R002b)
Status: Final

Client: Lidl UK GmbH
Site Name: Pier Road, Littlehampton
Document: Geo-Environmental Investigation Report
Reference: CAB/J-BK093
Date: September 2008
Status: R002b

Originated:	 Craig Bulga - Senior Geo-Environmental Engineer
Reviewed:	 PP Paul Palgrave - Associate Director
Approved:	 Phil Edge - Principal Geo-Environmental Engineer

CONTENTS

A.	FACTUAL INFORMATION	1
1.0	INTRODUCTION	1
2.0	THE SITE	3
2.1	Location & Access	
2.2	Site Description	
3.0	DESK STUDY	4
3.1	Sources of Information	
3.2	Site History	
3.3	Geology, Hydrogeology and Hydrology	
3.4	Mineral Extraction	
3.5	Radon	
3.6	Environmental Considerations	
4.0	CONCEPTUAL SITE MODEL.....	7
4.1	Introduction	
4.2	Potential Sources of Contamination	
4.3	Potential Contaminant Pathways	
4.4	Potential Receptors of Contamination	
5.0	INVESTIGATION METHODOLOGY	10
5.1	Objectives	
5.2	Clearance of Underground Services	
5.3	Site Works	
5.4	Chemical Testing	
5.5	Geotechnical Testing	
5.6	Ground Gas Monitoring	
6.0	RESULTS OF THE INVESTIGATION.....	13
6.1	Ground Conditions Encountered	
6.2	Groundwater Observations	
6.3	Evidence of Hydrocarbon Contamination	
6.4	Chemical Testing – Soils	
6.5	Chemical Testing – Groundwater	
6.6	Geotechnical Testing	
6.7	Gas Monitoring	
B.	ASSESSMENT & RECOMMENDATIONS.....	18
7.0	INTRODUCTION	18
8.0	ENVIRONMENTAL ASSESSMENT.....	19
8.1	Environmental Summary	
8.2	Environmental Risk Assessments	
8.3	Further Investigation / Remediation	
8.4	Health & Safety	
8.5	Waste Disposal	
8.6	Liaison with Regulators	
8.7	Liaison with Water Supply Authority	
8.8	Environmental Protection	
9.0	GEOTECHNICAL ASSESSMENT	23
9.1	Geotechnical Summary	
9.2	Foundation Design	
9.3	Floor Slab Design	
9.4	Building Near Trees	
9.5	Pavement Design	
9.6	Construction	
9.7	Concrete Specification	
9.8	Soakaways	

10.0 RECOMMENDATIONS 27

DRAWINGS

J-BK093/501	Site Location Plan
J-BK093/502B	Site Features Plan
J-BK093/503B	Exploratory Hole Location Plan

APPENDICES

APPENDIX A	Historical Maps
APPENDIX B	Environmental Database Report
APPENDIX C	Exploratory Hole Records
APPENDIX D	Chemical Testing Results and Assessment Criteria
APPENDIX E	Monitoring Results

A. FACTUAL INFORMATION

1.0 INTRODUCTION

- 1.1 This report describes a Geo-Environmental Investigation undertaken on behalf of Lidl UK GmbH (The 'Client') on a site at Pier Road, Littlehampton.
- 1.2 The subject site comprises the southern half of a larger site. The larger site is currently entirely occupied by Travis Perkins, and used as a building materials depot. We understand that the subject site is to be retained by Travis Perkins and redeveloped as a new building materials depot. The northern half of the larger site is to be redeveloped as a Lidl retail store with car parking.
- 1.3 The larger site has been the subject of a Phase 1 Geo-Environmental Desk Study by Opus Joynes Pike (OJP) produced on behalf of Lidl (UK) GmbH. The findings of the desk study, which are presented within the OJP report (Ref: JH/AS/J-BK093 (R001)) dated June 2008, have been used to design the ground investigation for the site.
- 1.4 The findings of the following report cover the southern half of the larger site (the area to be retained by Travis Perkins and redeveloped as a new building materials depot) only, and in the context of this report, the 'site' refers to the above area only. A separate Geo-Environmental Investigation report (Ref: CAB/J-BK093 (R002a)) has been compiled for the northern half of the larger site.
- 1.5 This report has been prepared by Opus Joynes Pike (OJP) with all reasonable skill, care and diligence within the terms of the Contract with The Client (Lidl UK GmbH), and taking account of the information made available by the client, as well as the manpower and resources devoted to it by agreement with the client. Opus Joynes Pike disclaims any responsibility to the client and others in respect of any matters outside the scope of the above Contract.
- 1.6 The objectives of this Geo-Environmental Investigation are as follows:
- Obtain information relating to ground and groundwater conditions beneath the site in order to enable an assessment of ground contamination;
 - Provide a preliminary assessment of foundation design and construction options, floor slab design and road pavement design;
 - Identify any potential constraints to redevelopment of the site resulting from difficult ground conditions;
 - Identify any potential risks associated with site ownership resulting from ground contamination; and
 - Enable formulation of an appropriate remediation strategy as necessary.

- 1.7 This report has been produced on behalf of The Client (Lidl UK GmbH), and no responsibility is accepted to any Third Party for all or any part. This report should not be relied upon or transferred to any other parties without the express written authorisation of Opus Joynes Pike. If any unauthorised Third Party comes into possession of this report, they rely on it at their own risk and the authors owe them no duty of care or skill.
- 1.8 The findings and opinions conveyed via the desk study are based on information obtained from a variety of sources, as detailed, which Opus Joynes Pike believes are reliable. Nevertheless, Opus Joynes Pike cannot and does not guarantee the authenticity or reliability of the information it has relied upon from these sources.
- 1.9 Whilst this report may express an opinion on the possible configuration of strata, contaminants or ground gases between or beyond exploratory hole positions, or on the possible presence of features based on either visual, verbal or published evidence, this is for guidance only, and no liability can be accepted for its accuracy.
- 1.10 The comments on groundwater and ground gases are based on observations made at the time of the investigation. It should be noted, however, that groundwater levels and ground gas concentrations may vary from those reported due to seasonal or other effects.
- 1.11 Although every effort has been made to position exploratory holes in the least sensitive areas of the site, exploratory hole positions were located approximately as part of this investigation and no guarantee can be given as to their accuracy on the drawing.
- 1.12 Existing manhole covers were not lifted and drainage runs were not inspected during the course of this investigation.
- 1.13 It is advised that the site plans enclosed in this report should not be used for scaling purposes.

2.0 THE SITE

2.1 Location & Access

2.1.1 The site is approximately 0.5 hectares in area and is roughly L-shaped. The site is located off Pier Road at approximate National Grid Reference 502770, 101890. The site is situated to the south of Littlehampton town centre, which lies approximately 175m to the north, as shown on the appended Drawing J-BK093/501.

2.1.2 The site is currently accessed from Pier Road, which is located to the west.

2.2 Site Description

2.2.1 As part of the desk study, a site walkover was undertaken on 28th May 2008. The findings of the site walkover are detailed below and summarised on the appended Drawing J-BK093/502B.

2.2.2 The site is currently occupied by the existing Travis Perkins warehouse, with external areas to the northwest and southwest.

2.2.3 We understand from consultation with site staff that timber treatment does not appear to have been undertaken at the site, and that historical, as well as current, site processes have essentially comprised the cutting, storage and selling of timber.

2.2.4 The northern section of the existing Travis Perkins warehouse is of timber construction with a timber-framed roof of corrugated metal. The southern section is of steel and timber construction with a timber-framed roof of corrugated metal. The floors are concrete. The warehouse extends onto the adjoining proposed development site.

2.2.5 The warehouse is divided into five areas. The northwest of the warehouse is a hire shop, the west is used for the storage of small wood products, the centre is the sales floor, sales counter and offices, the east is used for the storage of large wood products and the southeast is used for the storage of plasterboard.

2.2.6 The external area in the northwest of the site has concrete surfacing, and is used for the storage of bricks and blocks. The external area in the southwest has concrete surfacing, and is used for the storage of timber.

2.2.7 The site is generally level, however, ground levels rise gently towards Pier Road along the western boundary of the site.

2.2.8 The site is bounded to the west by Pier Road, with modern apartments beyond, the south by traditional terraced houses and the east by Clifton Road, with traditional terraced houses beyond. The site is bounded to the north by the adjoining proposed development site, which comprises the remainder of the Travis Perkins depot.

3.0 DESK STUDY

3.1 Sources of Information

- 3.1.1 The larger site has been the subject of a Phase 1 Geo-Environmental Desk Study by Opus Joynes Pike (OJP) produced on behalf of Lidl (UK) GmbH. The findings of the desk study are presented within the OJP report (Ref: JH/AS/J-BK093 (R001)) dated June 2008.
- 3.1.2 The main findings identified in the above report are summarised below, and copies of the historical maps and environmental database report included as Appendices 'A' and 'B' respectively.

3.2 Site History

- 3.2.1 The site is shown to have been partially developed since the earliest available plan dated **1876**. The northwest of the site was occupied by two residential properties with backyards and outbuildings, and two separate unidentified buildings. The east and south of the site was still undeveloped at this time.
- 3.2.2 The existing warehouse building, labelled as Norfolk Saw Mills, is shown on the next available plan dated **1898**. This comprised three adjoining buildings. The Norfolk Saw Mills extended into the adjoining proposed development site immediately to the north.
- 3.2.3 The Norfolk Saw Mills buildings merged into a single building and extended further to the west on the **1912** and **1932** plans. Two further residential properties are present on a pocket of land between the site and Pier Road on the **1932** plan.
- 3.2.4 The site is labelled as a Timber Yard on the next available plan dated **1959**. The two original residential properties are no longer present at this time.
- 3.2.5 There are no significant changes to the site on the **1970** or **1974** plans.
- 3.2.6 The western section of the existing warehouse building is no longer shown on the next available plan dated **1984**. The current site form and layout is present at this time.
- 3.2.7 Sawmills were located on the adjoining proposed development site immediately to the north between **1876** and **1984**. A large, rectangular 'Tank' was also present immediately beyond the northern site boundary on the **1912** and **1932** plans. One Sawmill has remained since the **1994** plan.
- 3.2.8 Three wharfs (Timber 'Norfolk' Wharf, Coal 'Dukes' Wharf and Ballast 'County' Wharf) were located beyond Pier Road to the southwest of the site between **1876** and **2000**. We understand that all three wharfs have been closed, demolished and redeveloped into modern apartment block complexes in the last three to five years.
- 3.2.9 Areas to the south, the east, and beyond the adjoining proposed development site to the north, were undeveloped on the **1876** plan. Residential properties were developed on these areas between **1876** and **1912**. There have been no significant changes to these areas since the **1912** plan.

3.3 Geology, Hydrogeology and Hydrology

- 3.3.1 According to the British Geological Survey map (Sheet 332), the site is recorded as being underlain by superficial Raised Beach Deposits comprising sands and gravels. The solid stratum of the Cretaceous Upper Chalk is anticipated to underlie the Raised Beach Deposits. Alluvium associated with the River Arun is recorded to the west of the site.
- 3.3.2 According to the Environment Agency Groundwater Vulnerability map (Sheet 45), the site is recorded as being underlain by a Major Aquifer with overlying soils of Unclassified, assumed High, vulnerability. The Major Aquifer is considered to represent the Upper Chalk.
- 3.3.3 Major Aquifers are highly permeable formations that may support large groundwater abstractions for potable (ie. drinking water) supplies and other purposes.
- 3.3.4 Soils underlying urban areas are assigned an 'Unclassified' vulnerability as soil information is based on fewer observations than those in rural areas. A worst case classification of High vulnerability is assumed for such areas until proven otherwise. Soils of High vulnerability have little ability to attenuate pollutants, and as such, pollutants may rapidly migrate downwards into underlying strata and groundwater.
- 3.3.5 The nearest surface watercourse to the site is the River Arun. The River Arun lies approximately 54m to the southwest of the site at its closest point.
- 3.3.6 The River Arun has a General Quality Assessment Grade of 'Unclassified' as it is a tidal river along this stretch.
- 3.3.7 The site lies within Flood Zone 3, which is an area at risk of flooding from rivers or seas without flood defences. The site lies within the tidal influence of the River Arun. It is recommended that a flood risk assessment is undertaken into the potential risk of flooding at the site.

3.4 Mineral Extraction

- 3.4.1 Littlehampton is not listed within the Law Society's Guidance Notes and Directory for Coal Mining Searches as requiring a Coal Mining Report.
- 3.4.2 Littlehampton is not indicated as an area of intensive mineral extraction. The closest mineral extraction sites are located approximately 750m to the southwest of the site and are related to the production of crushed rock and marine sand and gravel. However, the presence of sand and gravel deposits beneath the site, which may have been used as aggregates, indicates that the unrecorded mineral extraction cannot be entirely discounted.
- 3.4.3 An enquiry was made to West Sussex County Council regarding the presence of both chalk mining and aggregate extraction in the area of Littlehampton. Nick Bainton responded on behalf of West Sussex County Council confirming that Littlehampton was not in an area of chalk mining or aggregate extraction. The wharfs at Littlehampton were however involved with the export of aggregates.

3.5 Radon

- 3.5.1 The site lies within an area affected by radon gas, as between 1% and 3% of homes are above the action levels.
- 3.5.2 A review of BR211 'Guidance on the protective measures for new buildings' states that the site lies within an area where no radon protection is required in the construction of new dwellings or extensions.

3.6 Environmental Considerations

- There are no registered landfill sites within 250m of the site.
- There are three Category 3 (Minor) Pollution Incidents recorded within 250m of the site. These involved spillages of oils, tar and petrol into the River Arun.
- There are no licensed water abstractions within 500m of the site. The nearest water abstraction is held by Arc Ltd (Solent Aggregates), located 962m from the site, and is for the abstraction of water for general washing and process washing.
- There is one discharge consent recorded within 250m of the site. This is held by Arun Yacht Club, located 131m from the site, and is for the discharge of final/treated effluent.
- There are no Control of Major Accident Hazard Sites (COMAH) or Notification of Installations Handling Hazardous Substances (NIHHS) sites registered within 500m of the site.

4.0 CONCEPTUAL SITE MODEL

4.1 Introduction

- 4.1.1 A **Site Conceptual Model** is a simplified representation of the ground conditions beneath the site that enables risk assessments to be carried out. The Site Conceptual Model identifies the potential sources of contamination, the potential contaminant migration pathways and the potential receptors of contamination.
- 4.1.2 **Sources** include contaminating current or historical uses, activities, events or substances at the site or within the surrounding area that may impact on underlying soils or groundwater.
- 4.1.3 **Pathways** are the routes that contaminants follow from sources to receptors.
- 4.1.4 **Receptors** include human and non-human organisms, controlled waters (groundwater or surface water) and building materials (concrete or plastic) that experience adverse effects on exposure to contaminated materials.
- 4.1.5 A **Pollutant Linkage** occurs when a contaminant is able to travel from a source, via a pathway, to a receptor. Each element may exist in isolation and pose no environmental risk. It is only when all three elements are linked to each other that a pollutant linkage exists, and poses an environmental risk.

4.2 Potential Sources of Contamination

- 4.2.1 The following potential **on-site** sources have been identified:
- Imported contaminated fill materials beneath existing floor slabs and hardstanding surfaces. Contaminants typically associated with fill materials include toxic heavy metals and Polycyclic Aromatic Hydrocarbons (PAH).
 - Potential ground gas generation from decomposition of biodegradable materials present within fill materials. Ground gases include methane, carbon dioxide, carbon monoxide and hydrogen sulphide.
 - Potential contamination of soils with asbestos during the demolition of historical buildings and other structures.
- 4.2.2 The following potential **off-site** sources have been identified:
- Potential cross-boundary migration of historical contamination from spillage and/or leakage of hydrocarbons (oils) and potentially timber preservatives from the tank present immediately beyond the northern site boundary between 1912 and 1932. Contaminants typically associated with petroleum hydrocarbons and timber preservatives include Total Petroleum Hydrocarbons (TPH), phenols and Volatile Organic Compounds (VOC).
 - Potential ground gas generation from the historical infilled docks within the wharfs to the southwest of the site.

4.3 Potential Contaminant Pathways

4.3.1 The following potential **on-site** contaminant pathways have been identified:

Inhalation

- Future customers and staff may be susceptible to breathing contaminated dust or hydrocarbon vapours in outdoor or indoor air.

Ingestion

- Future customers and staff may be susceptible to swallowing contaminated soils or dust if any contamination is exposed in soft landscaped areas. Contaminants may enter the human body either directly by deliberate consumption or indirectly by eating, smoking or wiping mouths with dirty hands.

Dermal Contact

- Future customers and staff may be susceptible to touching contaminated soils or dust if any contamination is exposed in soft landscaped areas. Contaminants may enter the human body by sorption through skin tissue or open wounds.

Migration of Ground Gases and Hydrocarbon Vapours

- Ground gases and hydrocarbon vapours may migrate laterally and/or vertically through Made Ground and along preferential pathways such as buried utility service trenches and basements. The gases and vapours may eventually ingress the future retail store, and potentially existing neighbouring properties, and accumulate within confined or poorly ventilated spaces.

Aggressive Attack

- Future buried building materials may be susceptible to damage by direct contact with aggressive ground conditions such as hydrocarbon attack on plastic water supply pipes and sulphate attack on concrete foundations.

4.3.2 The following potential **off-site** contaminant pathways have been identified:

Leaks and Spills

- Hydrocarbons may spill during the emptying and refilling of tanks and leak through cracks or holes in tanks, pipes and drains. These may penetrate hardstanding surfaces and Made Ground, leading to significant contamination of underlying soils and groundwater.

Leaching and Dissolution

- Rainwater percolation through any contaminated Made Ground may leach and dissolve hydrocarbons into groundwater.

Migration of Contaminated Groundwater

- Periodic flushing of any contaminated groundwater from a combination of rainwater infiltration and groundwater flow may promote lateral and/or vertical migration through surrounding Made Ground and into the underlying superficial deposits. Significant contaminant migration may ultimately reach the Major Aquifer of the Upper Chalk or the River Arun and impact their water quality.

4.4 Potential Receptors of Contamination

4.4.1 The following potential human health and environmental receptors have been identified:

- Surface water in the River Arun
- Groundwater in the Upper Chalk (Major Aquifer)
- Future retail store customers and staff
- Demolition, construction and maintenance workers
- Neighbouring occupants
- Buried concrete and plastic water supply pipes

4.4.2 Bearing in mind the information contained within the Desk Study, the primary sensitive 'controlled water' receptor in relation to potential contamination beneath the site is considered to be surface water in the River Arun.

4.4.3 The shallow groundwater in the superficial deposits is anticipated to be in direct hydraulic continuity with both the surface water in the adjacent River Arun and the deeper groundwater in the underlying Upper Chalk. However, lateral movement of the shallow groundwater towards the River Arun is likely to significantly outweigh vertical movement towards the Upper Chalk due to the tidal influence on the local hydrogeological regime. Any potential contamination in the shallow groundwater beneath the site is therefore likely to migrate laterally through the superficial deposits towards the River Arun, with no significant vertical migration towards the Upper Chalk.

4.4.4 Based on the above observations, groundwater in the Upper Chalk (Major Aquifer) is considered to be a secondary 'controlled water' receptor.

5.0 INVESTIGATION METHODOLOGY

5.1 Objectives

5.1.1 The objectives of this Geo-Environmental Investigation are as follows:

- Obtain information relating to ground and groundwater conditions beneath the site in order to enable an assessment of ground contamination;
- Provide a preliminary assessment of foundation design and construction options, floor slab design and road pavement design;
- Identify any potential constraints to redevelopment of the site resulting from difficult ground conditions;
- Identify any potential risks associated with site ownership resulting from ground contamination; and
- Enable formulation of an appropriate remediation strategy as necessary.

5.2 Clearance of Underground Services

5.2.1 All exploratory hole locations were scanned by an OJP Geo-Environmental Engineer using a CAT (Cable Avoidance Tool) on the day of the intrusive investigation to avoid striking buried services.

5.3 Site Works

5.3.1 Four window sample boreholes (WSA to WSD) were advanced using a small tracked light percussion rig on 18th July 2008. All four exploratory holes achieved an investigation depth of 5.00m bgl (below ground level).

5.3.2 The desk study identified no potential point sources of contamination at the site. Hence, the rationale for the location of the exploratory holes was simply to provide the maximum possible coverage of the site.

5.3.3 The locations of the exploratory holes were as follows:

Borehole	Location
WSA	Brick and Block Storage Yard
WSB	Large Wood Products Storage Warehouse
WSC	Plasterboard Storage Warehouse
WSD	Timber Storage Yard

5.3.4 It was not possible to locate any exploratory holes within the hire shops, small wood products storage warehouse or sales floor, sales counter and offices due to the lack of adequate access for the drilling rig, the likely disruption to site operations and general health and safety implications at the time of our investigation.

5.3.5 The approximate locations of the exploratory holes are shown on the appended Drawing J-BK093/503B, and the exploratory hole logs are presented in Appendix 'C'.

- 5.3.6 Disturbed soil samples were taken at selected intervals from the encountered strata during the intrusive investigation and submitted for geotechnical and chemical testing.
- 5.3.7 Standard Penetration Tests (SPT's) were undertaken at 1.00m intervals within two exploratory holes (WSB and WSC) to provide 'N' values for empirical assessment of strength and density parameters of the underlying strata.
- 5.3.8 Combined ground gas and groundwater monitoring standpipes were installed within two exploratory holes (WSB and WSD). The standpipes were constructed using 35mm plain pipe within a bentonite seal from ground level to 1.00m bgl and 35mm slotted pipe within a gravel surround below 1.00m bgl. These were fitted with a gas tap assembly at ground level suitable for connection to propriety gas monitoring equipment. A stopcock cover was placed at ground level to provide protection.
- 5.3.9 Groundwater samples were taken from the two standpipes on 30th July 2008 and submitted for chemical testing.
- 5.4 Chemical Testing**
- 5.4.1 Selected soil and groundwater samples were subjected to appropriate chemical testing at the MCERTS and UKAS accredited laboratory of i2 Analytical, Watford for a suite of potential contaminants taking account of the Conceptual Site Model presented in Section 4.0.
- 5.4.2 The following chemical testing of soils was carried out:
- Made Ground
- Toxic Heavy Metals, Sulphur Compounds and pH - 3 samples
 - Speciated Polycyclic Aromatic Hydrocarbons (PAH) - 3 samples
 - Asbestos - 3 samples
- Made Ground and Natural Soils
- Speciated Total Petroleum Hydrocarbons (TPH) - 2 samples
 - Speciated Phenols - 2 samples
- 5.4.3 The following chemical testing of groundwater was carried out:
- Toxic Heavy Metals, Sulphur Compounds and pH - 2 samples
 - Speciated Polycyclic Aromatic Hydrocarbons (PAH) - 2 samples
 - Speciated Total Petroleum Hydrocarbons (TPH) - 2 samples
 - Speciated Phenols - 1 sample
 - Speciated Volatile Organic Compounds (VOC) - 1 sample
- 5.4.4 Results of the chemical testing are presented in Appendix 'D'.
- 5.5 Geotechnical Testing**
- 5.5.1 Selected cohesive soil samples were subjected to appropriate geotechnical testing to determine soil properties relating to foundation and floor slab design at the UKAS accredited laboratory of Terra Tek, Birmingham.

5.5.2 The following geotechnical testing was carried out:

- Natural Moisture Content (BS1377; Part 2; 1990) - 2 samples
- Plasticity Index (BS1377; Part 2; 1990) - 2 samples

5.5.3 Selected Made Ground and natural deposits samples were also subjected to appropriate geotechnical testing to determine soil properties relating to the classification of buried concrete at the MCERTS and UKAS accredited laboratory of i2 Analytical, Watford.

5.5.4 The following geotechnical testing was carried out:

- pH (BS1377; Part 3; 1990) - 5 samples
- Water-Soluble Sulphate (BS1377; Part 3; 1990) - 5 samples

5.5.5 Results of the geotechnical testing are presented in Appendix 'E', and the pH and sulphate determinations included in Appendix 'D'.

5.6 Ground Gas Monitoring

5.6.1 Ground gas monitoring has been undertaken within the two standpipes (WSB and WSD) on four occasions (30th July and 6th, 13th and 20th August 2008).

5.6.2 Methane, carbon dioxide, oxygen, carbon monoxide and hydrogen sulphide concentrations have been measured using a calibrated Geotechnical Instruments (UK) Limited GA2000 Infra Red Gas Analyser.

5.6.3 Atmospheric pressure and gas flow rates have also been recorded on these four occasions.

5.6.4 Results of the ground gas monitoring are presented in Appendix 'F'.

6.0 RESULTS OF THE INVESTIGATION

6.1 Ground Conditions Encountered

Made Ground

- 6.1.1 WSA penetrated 200mm thick concrete surfacing underlain by a 450mm thick sub-base of brick cobbles. The brick cobbles were underlain by clayey silty brown grey black sand to a depth of 1.30m bgl.
- 6.1.2 WSB, WSC and WSD penetrated 150mm thick concrete surfacing underlain by a 200-350mm thick sub-base of sandy grey black, cream or brown gravel including clinker, coal, chert, flint, slag, brick and concrete.
- 6.1.3 The sub-base in WSB was underlain by chalk cobbles to a depth of 0.60m bgl. Coarse brown sand was present beneath the sub-base to a depth of 0.65m bgl in WSC. The sub-base in WSD was underlain by clayey silty brown grey black sand to a depth of 0.55m bgl.
- 6.1.4 No further Made Ground was encountered in the four exploratory holes.

Natural Deposits

- 6.1.5 A horizon of silty clayey green brown medium sand with occasional black mottling was encountered immediately beneath the Made Ground in WSA and WSD to depths of 1.45m and 0.65m bgl respectively.
- 6.1.6 Cohesive deposits comprising high plasticity light green brown clays with soft consistency and orange mottling was encountered immediately beneath the Made Ground in WSB and WSC and beneath the green brown sand horizon in WSA and WSD. The base of these clays was recorded at 1.00m bgl in WSD, 2.00m bgl in WSC and WSB and 2.45m bgl in WSA.
- 6.1.7 Further cohesive deposits comprising high plasticity light green brown clays with very soft consistency and occasional gravel of chalk, mudstone and flint were encountered beneath the light green brown clays in all four exploratory holes. These clays were mottled grey blue with an organic odour. The base of these clays was encountered at 4.70m bgl in WSC, but not proven to 5.00m bgl in WSA, WSB or WSD.
- 6.1.8 A horizon of orange brown coarse sand was encountered in WSC from a depth of 4.70m bgl to the proven depth of 5.00m bgl.

Standard Penetration Tests

- 6.1.9 Standard Penetration Tests (SPT's) were undertaken at 1.00m intervals within two exploratory holes (WSB and WSC).
- 6.1.10 SPT's taken within the cohesive deposits of light green brown clays gave corrected 'N' values of 'N' = 0 between 1.00m and 4.00m bgl, indicating very soft cohesive soils. A corrected 'N' value of 'N' = 3, indicating very soft cohesive soils, was also recorded in WSB at 5.00m bgl.
- 6.1.11 An SPT taken within the horizon of orange brown coarse sand in WSC at 5.00m bgl gave a corrected 'N' value of 'N' = 20, indicating medium dense granular soils.

6.2 Groundwater Observations

- 6.2.1 Groundwater seepages were recorded at an approximate depth of 2.50m bgl within all four exploratory holes during drilling (July 2008).
- 6.2.2 Groundwater rest levels were recorded in the two standpipes (WSB and WSD) between the following minimum and maximum depths during monitoring (July and August 2008):
- WSB = Minimum 0.93m bgl – Maximum 1.07m bgl
 WSD = Minimum 0.48m bgl – Maximum 0.73m bgl

6.3 Evidence of Hydrocarbon Contamination

- 6.3.1 No visible or olfactory evidence of hydrocarbon contamination was noted beneath the site during the course of this investigation.
- 6.3.2 Grey blue mottling with an organic odour was widely noted in the light green brown clays encountered in WSA to WSD. However, this mottling and odour appeared to represent natural 'organic' materials rather than hydrocarbon contamination.

6.4 Chemical Testing – Soils

- 6.4.1 DEFRA and the Environment Agency have withdrawn the use of Soil Guideline Values (SGV's) for the assessment of soil contaminant concentrations with respect to human health. In the current absence of existing UK soil screening levels, chemical testing results for soil samples have been compared to the appropriate OJP In-House Screening Levels (IHSL's) for a 'Commercial' site end use to be protective of human health (currently Version 2008.2 dated August 2008).

Metals and PAH

- 6.4.2 Three Made Ground samples have been analysed for metals and speciated PAH.
- 6.4.3 Concentrations of metals and individual PAH's lie below their ISHL for a 'Commercial' site end use in these three samples.

TPH, BTEX and MTBE

- 6.4.4 Two soil samples have been analysed for speciated TPH including BTEX (Benzene, Toluene, Ethyl benzene and Xylene) and MTBE (Methyl Tertiary Butyl Ether).
- 6.4.5 Concentrations of each TPH fraction lie below their IHSL for a 'Commercial' site end use in these two samples.
- 6.4.6 BTEX and MTBE concentrations lie below their laboratory detection limits in these two samples.

Speciated Phenols

- 6.4.7 Two soil samples have been analysed for speciated phenols.
- 6.4.8 Concentrations of individual phenol compounds lie below the IHSL for a 'Commercial' site end use in these two samples.

6.4.9 The total phenol concentrations are 0.3mg/kg and 3.4mg/kg.

Asbestos

6.4.10 Three Made Ground samples have been screened for asbestos fibres.

6.4.11 No asbestos fibres were detected in these three samples.

6.5 Chemical Testing – Groundwater

6.5.1 As detailed in the Conceptual Site Model in Section 4.0 of this report, the primary sensitive 'controlled water' receptor in relation to potential contamination beneath the site is considered to be surface water in the River Arun. On this basis, chemical testing results for samples of groundwater have initially been compared to the Environmental Quality Standards (EQS's) for List 1 and List 2 dangerous substances in coastal and estuarine waters defined in the EC Dangerous Substances Directive (76/464/EEC) to be protective of the River Arun.

6.5.2 As no EQS is available for TPH, the testing results for the samples of groundwater have been compared to the Imperative Guideline Values for dissolved and emulsified hydrocarbons defined in the Surface Water Abstraction Directive (75/440/EEC) (SWAD). These are a TPH (total of all fractions) concentration of 50µg/l for Class A1 (Untreated) surface waters, 200µg/l for Class A2 (Partially Treated) surface waters and 1000µg/l for Class A3 (Fully Treated) surface waters.

6.5.3 As no EQS is available for PAH, the testing results for the samples of groundwater have been compared to the Imperative Guideline Value for Total PAH defined in the SWAD. This is a Total PAH concentration (sum of six PAH's only) of 0.2µg/l for Class A1, A2 and A3 surface waters. The six individual PAH's are benzo(a)pyrene, benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, fluoranthene and indeno(123cd)pyrene.

Metals and PAH

6.5.4 Two samples of groundwater (WSB and WSD) have been analysed for metals and speciated PAH.

6.5.5 Arsenic concentrations (73µg/l and 67µg/l respectively) lie marginally above the EQS for coastal and estuarine waters of 25µg/l in these two samples.

6.5.6 Concentrations of other metals lie below their EQS for coastal and estuarine waters in these two samples.

6.5.7 Concentrations of PAH lie below the laboratory detection limit in these two samples.

TPH, BTEX and MTBE

6.5.8 Two samples of groundwater (WSB and WSD) have been analysed for speciated TPH including BTEX and MTBE.

6.5.9 Concentrations of TPH (C5-C35), BTEX and MTBE lie below their laboratory detection limits in these two samples.

Speciated Phenols

- 6.5.10 One sample of groundwater (WSD) has been analysed for speciated phenols.
- 6.5.11 Concentrations of individual phenol compounds lie below the laboratory detection limit in this sample.

Speciated VOC

- 6.5.12 One sample of groundwater (WSD) has been analysed for speciated VOC.
- 6.5.13 Concentrations of individual VOC compounds lie below their laboratory detection limits in this sample.

6.6 Geotechnical Testing

Foundation and Floor Slab Design

- 6.6.1 Two cohesive soil samples (WSB 1.70-2.00m and WSC 2.70-3.00m) have been tested for Plasticity Index and Natural Moisture Content.
- 6.6.2 The Plasticity Index of the WSB sample is 36 with a corresponding Natural Moisture Content of 47%.
- 6.6.3 The Plasticity Index of the WS8 sample is 38 with a corresponding Natural Moisture Content of 49%.

Buried Concrete Classification

- 6.6.4 Three Made Ground samples have been tested for water-soluble sulphate and pH. Water-soluble sulphate concentrations in these samples range between 210mg/l and 4,700mg/l with corresponding pH values between 7.4 and 7.6.
- 6.6.5 Two natural deposits samples have also been tested for water-soluble sulphate and pH. Water-soluble sulphate concentrations in these samples are 180mg/l and 1,900mg/l with corresponding pH values of 7.9 and 8.0.
- 6.6.6 Two samples of groundwater (WSB and WSD) have been tested for total sulphate and pH. Total sulphate concentrations in these two samples are 1,300mg/l and 170mg/l with corresponding pH values of 8.1 and 8.6.

6.7 Gas Monitoring

- 6.7.1 Gas monitoring results have been compared to guidance presented in the recently published CIRIA Report C665, Assessing Risks Posed by Hazardous Ground Gases to Buildings, 2007.
- 6.7.2 The above guidance indicates that gas protection measures may be necessary in new buildings on sites where methane concentrations exceed 1% v/v and/or where carbon dioxide concentrations exceed 5% v/v. The gas flow rate is also considered in the required level of protection.

- 6.7.3 Maximum methane (CH₄) and carbon dioxide (CO₂) concentrations, as percentage volume in air (%v/v), maximum carbon monoxide (CO) and hydrogen sulphide (H₂S) concentrations, as parts per million (ppm), oxygen (O₂) concentrations (%v/v) and gas flow rates in litres per hour (l/hr), have been monitored within the two standpipes (WSB and WSD) on four occasions.
- 6.7.4 The gas monitoring results are summarised below:
- Methane concentrations were consistently recorded below the instrument detection limit (0.1% v/v) in WSB and WSD.
 - Carbon dioxide concentrations were consistently recorded below 1% v/v in WSB and WSD. The maximum recorded carbon dioxide concentration was 0.9% v/v.
 - Carbon monoxide concentrations were recorded up to 6ppm, while hydrogen sulphide concentrations were consistently recorded below the instrument detection limit (1ppm).
 - The maximum recorded gas flow rate was a peak value of 12.0 l/hr in WSD, although the steady rate was 1.2 l/hr.

B. ASSESSMENT & RECOMMENDATIONS

7.0 INTRODUCTION

- 7.1 This report has been prepared on the understanding that the site is to be redeveloped for a new Travis Perkins building materials depot. It is proposed to locate a combined retail and warehousing building in the south of the site and a storage yard in the north. If the proposed site layout or end use should change significantly from the above, the contents of this report will require review and amendment as appropriate.
- 7.2 Based on the above, the proposed redevelopment of the site is considered to correspond to the '**Commercial**' site end use model.
- 7.3 As detailed in the Conceptual Site Model in Section 4.0 of this report, the primary sensitive 'controlled water' receptor in relation to potential contamination beneath the site is considered to be surface water in the River Arun.
- 7.4 Our intrusive investigation has been limited to the accessible warehousing areas of the existing depot and the existing external areas of the site. It was not possible to investigate within the retail areas of the existing depot. Hence, the ground conditions beneath the floor slab of the retail areas of the existing depot have not been determined at this stage.

8.0 ENVIRONMENTAL ASSESSMENT

8.1 Environmental Summary

- 8.1.1 No significant soil or groundwater contaminant concentrations have been detected beneath the site.
- 8.1.2 No soil contaminant concentrations exceed their IHSL for a 'Commercial' site end use.
- 8.1.3 Arsenic concentrations of 73µg/l and 67µg/l are present in groundwater in WSB and WSD respectively, which lie marginally above the EQS for coastal and estuarine waters of 25µg/l.
- 8.1.4 The source of the elevated arsenic concentrations in groundwater samples is not clear. Water-based Copper-Chromium-Arsenic (CCA) solutions are one of several types of solution used for timber preservation. Although, through consultation with site staff, it appears that timber treatment has not been undertaken at the site, this cannot be ruled out. Hence, CCA solutions may be a potential source for the elevated arsenic concentrations in groundwater beneath the site. No notable copper or chromium concentrations have been recorded in the groundwater samples.
- 8.1.5 No groundwater TPH or PAH concentrations exceed their SWAD Imperative Guideline Values.
- 8.1.6 No elevated methane and carbon dioxide concentrations, and no volatile petroleum hydrocarbons, have been recorded at the site.

8.2 Environmental Risk Assessments

Human Health

- 8.2.1 We understand that it is proposed to redevelop the site for a new Travis Perkins building materials depot.
- 8.2.2 No soil contaminant concentrations exceed their ISHL for a 'Commercial' site end use. Hence, there are not assessed to be any future environmental risks to human health from site contamination.

Controlled Waters

- 8.2.3 The primary sensitive 'controlled water' receptor is considered to be surface water in the River Arun.
- 8.2.4 With the exception of the elevated arsenic concentrations, no groundwater contaminant concentrations exceed their EQS for coastal and estuarine waters or SWAD Imperative Guideline Values.
- 8.2.5 The elevated arsenic concentrations appear to be widespread beneath the site, and there are no obvious point sources to justify the presence of these elevated concentrations.

- 8.2.6 Bearing in mind that the primary sensitive 'controlled water' receptor is considered to be surface water in the River Arun, there are not assessed to be any current or future environmental risks to the water quality of the River Arun from the arsenic. However, given the proximity of the River Arun, it is recommended that a quantitative groundwater risk assessment be carried out utilising the existing data to derive site specific target levels for soil and leachates for metals and speciated petroleum hydrocarbons.
- 8.2.7 The site is underlain by a Major Aquifer (the Chalk) however the presence of significant proportions of cohesive material in the superficial deposits is likely to inhibit downward migration of contaminants.
- 8.2.8 The EA should be consulted at the earliest opportunity to determine whether or not they are satisfied with the scope of this investigation and the environmental assessment and recommendations in this report.
- Gas Protection Measures
- 8.2.9 The maximum detected carbon dioxide concentration of 0.9% v/v has been selected to calculate a Gas Screening Value (GSV) for the site in accordance with CIRIA Report C665 to determine the required level of gas protection measures for the new combined Travis Perkins retail and warehousing building. The maximum detected gas flow rate is 12.0 l/hr.
- 8.2.10 The GSV is calculated as follows:
- $$Q_{hg} = C_{hg} / 100 \times q$$
- Where
- Q_{hg} = GSV (l/hr)
 C_{hg} = Maximum carbon dioxide concentration (% v/v)
 q = Maximum gas flow rate (l/hr)
- The GSV for the site is 0.108 l/hr.
- 8.2.11 In accordance with Table 8.5 of C665, the GSV classifies the site as Characteristic Situation 2 where gas protection measures are required in new commercial developments. In this case, the peak carbon dioxide concentration of 0.9% and the peak gas flow reading of 12.0 l/hr has been used in the initial assessment. However, the gas flow rate reduced to a steady reading of 1.2 l/hr, and hence, Characteristic Situation 2 is considered appropriate.
- 8.2.12 In accordance with BS8485:2007, the required gas protection can be calculated from the site characteristic situation category and the type of building. For a commercial development with a Characteristic Situation 2 classification, the required gas protection value is '2' in accordance with Table 2 of BS8485:2007. The gas protection value is a combination of different elements which include the type of membrane and floor slab construction, workmanship and integrity testing. One protection element of each type can be combined in order to achieve the required gas protection.

- 8.2.13 For example, in accordance with Table 3 of BS8485:2007, the installation of a lapped, taped and sealed carbon dioxide proof membrane to reasonable levels of workmanship and validation could provide a solution score of 0.5 and a reinforced cast in-situ suspended slab with minimal service penetrations could provide a solution score of 1.5. Hence, these two elements coupled together would provide adequate gas protection.

8.3 Further Investigation / Remediation

- 8.3.1 Our intrusive investigation has been limited to the accessible warehousing areas of the existing depot and the existing external areas of the site. It was not possible to investigate within the retail areas of the existing depot. However the main issues of concern appear to be the arsenic contamination of the groundwater across the site and possible isolated hotspots of petroleum hydrocarbon contamination in the near surface soils.
- 8.3.2 The proposed redevelopment of the site requires a section of the existing building to be demolished and the new building to be constructed prior to demolition of the remaining structures. Hence, given the close proximity of the River Arun, it is recommended that a quantitative groundwater risk assessment be carried out utilising the existing data to derive site specific target levels for soil and leachates for individual metals and speciated petroleum hydrocarbons. This will allow a remediation method statement to be formulated for the whole site containing site specific target levels for soil and groundwater which are protective of human health and the aquatic environment.
- 8.3.3 Following the different phases of demolition, we would recommend that an intrusive investigation of the ground conditions beneath the floor slab of the retail areas of the existing depot be combined with further investigation of the site as a whole to determine whether or not the arsenic concentrations pose an environmental risk to 'controlled waters'.
- 8.3.4 However we would recommend that the Local Authority and Environment Agency be contacted to ascertain whether they require any specific issues to be addressed.
- 8.3.5 In addition, it is recommended that an asbestos survey is undertaken prior to demolition of the existing site buildings and other structures.
- ### **8.4 Health & Safety**
- 8.4.1 The Principal Contractor should provide an assessment of the appropriate procedures required to protect site workers from potentially contaminated materials beneath the site.
- 8.4.2 Health and safety measures should be adopted during the site redevelopment works as follows:
- Basic Personal Protective Equipment (PPE) including hard hats, gloves, coveralls and steel toe-capped boots to be worn at all times;
 - Eating, drinking and smoking to be forbidden at all times except in designated mess areas; and

- Breathing equipment to be available for those working in confined or unventilated spaces.

8.4.3 If ground conditions should differ significantly from those encountered during the intrusive investigation, including the discovery of any visible or odorous contamination, the Principal Contractor should suspend site redevelopment works within the subject area immediately and inform Lidl (UK) GmbH. The suspect material should then be inspected and assessed by a Geo-Environmental Engineer.

8.5 Waste Disposal

8.5.1 Made Ground and demolition arisings should, where possible, be reused on-site as engineered fill in accordance with the Waste Management Licensing Regulations.

8.5.2 Representative samples of any materials to be removed off-site for disposal as part of the site redevelopment works should be subjected to Waste Acceptance Criteria (WAC) testing in accordance with the Landfill Regulations.

8.6 Liaison with Regulators

8.6.1 As recommended in Section 8.2, this report should be submitted to the Environment Agency for their review and comment of the issues relevant to 'controlled waters' prior to any irrevocable action taking place. This report should also be submitted to the Local Authority Environmental Health Officer for review and comment of the issues relevant to human health.

8.7 Liaison with Water Supply Authority

8.7.1 Hydrocarbons, particularly aromatic TPH fractions, may permeate plastic water pipes and taint water supplies. Although no significant hydrocarbon contamination has been detected beneath the site, it is recommended that this report be submitted to the relevant Water Supply Authority to confirm the required level of protection for future plastic water supply pipes.

8.8 Environmental Protection

8.8.1 Environmental protection measures should be adopted during the site redevelopment works as follows:

- The covering or dampening of spoil to prevent the spread of dust;
- The containment of surface water runoff to prevent the pollution of surface water drains and sewers; and
- The cleaning and washing of boots, vehicle wheels and other equipment at site entry and exit points to prevent the spread of mud.

9.0 GEOTECHNICAL ASSESSMENT

9.1 Geotechnical Summary

- 9.1.1 The exploratory hole logs indicate that the sequence of strata beneath the site essentially comprises granular Made Ground to depths between 0.55m bgl (WSD) and 1.30m bgl (WSA).
- 9.1.2 The Made Ground is locally underlain beneath the southwest of the site by granular deposits comprising silty clayey green brown sand to depths of 1.45m bgl in WSA and 0.65m bgl in WSD.
- 9.1.3 The Made Ground in WSB and WSC and the granular deposits in WSA and WSD are underlain by cohesive deposits comprising highly plastic soft light green brown clays, becoming very soft clays with depth. The soft clays are mottled orange and the very soft clays are mottled grey blue. The grey blue mottled clays also include an organic odour, suggesting the presence of a significant proportion of organic matter. The base of the cohesive deposits was encountered at 4.70m bgl in WSC, but not proven to 5.00m bgl in WSA, WSB or WSD. These clays are interpreted as representing Alluvium associated with the River Arun.
- 9.1.4 The cohesive deposits in WSC are further underlain by orange brown sand to a proven depth of 5.00m bgl. These sands interpreted as representing the recorded Raised Beach Deposits.
- 9.1.5 The chalk bedrock was not struck during our intrusive investigation. However, it is anticipated to be present at depths exceeding the proven investigation depth of 5.00m bgl beneath the site.
- 9.1.6 SPT 'N' values taken within the clays were 'N' = 0, indicating very soft cohesive soils, to depths of 4.00m bgl. The SPT 'N' value taken within the orange brown sand was 'N' = 20, indicating medium dense granular soils.
- 9.1.7 The plasticity index results indicate that the cohesive soils are of high volume change potential.

9.2 Foundation Design

- 9.2.1 The very soft cohesive soils recorded beneath the site are not considered to be suitable founding strata for traditional strip, pad, trench or raft foundations.
- 9.2.2 The foundations of the new combined Travis Perkins retail and warehousing building should bear upon competent Upper Chalk strata, which is potentially present at depths of around 10.00m bgl, and deepening towards the south, beneath the area of the proposed building footprint. Driven or bored pile foundations are considered to be suitable foundation option in order to achieve such depths. The presence of very soft clays beneath the site renders vibro-stone columns as unsuitable for the foundations.
- 9.2.3 We recommend that this report should be made available to specialist piling contractors to assist in the design of the pile foundations. Further intrusive investigation by cable percussion drilling techniques will be required by the specialist piling contractors to obtain additional information for the design.

- 9.2.4 In accordance with the guidance presented in CIRIA Report C574, 'Engineering in Chalk', consideration has been given to the potential for in-filled solution features in the Chalk. However, discussion with Building Control has established that the Chalk deposits in the area are not associated with solution features. However, a careful watch should be kept for variations in the upper surface of the chalk which may indicate the presence of such features.

9.3 Floor Slab Design

- 9.3.1 A suspended floor slab should be appropriate for the new Lidl retail store. If site levels are to be raised significantly, and the floor slabs are to be lightly loaded, it may be possible to design an engineered capping of granular material to support the floor slab, although consideration will need to be given to potential settlements.
- 9.3.2 Care should be taken to ensure that historical and current building foundations and any other structures are broken out to avoid the creation of hard spots.
- 9.3.3 The re-laid Made Ground should be compacted to a specification suitable to provide a working platform for the piling rig.
- 9.3.4 The stripped Made Ground should be screened, sorted and reused beneath the proposed car parking areas. Any stripped cohesive soils are likely to require off-site disposal.
- 9.3.5 The GSV classifies the site as Characteristic Situation 2 (CIRIA Report C665) where gas protection measures are required in new commercial developments. Details are presented in Section 8.2 of this report.
- 9.3.6 Reference to the 'Envirocheck' report and BR211 indicates that the site lies in an area where no radon protection measures are required in new building developments.

9.4 Building Near Trees

- 9.4.1 Consideration should be given in foundation and floor slab design to the influence of nearby trees, shrubs and hedges, whether former, existing or proposed, in accordance with NHBC Standards Chapter 4.2.
- 9.4.2 The plasticity index results indicate that the cohesive soils are of high volume change potential. Hence, the risk of shrinkage and heave is considered to be medium to high, and shrinkage/heave protection measures should be incorporated into ring beams.

9.5 Pavement Design

- 9.5.1 Made Ground is likely to be present at pavement formation level (450mm below finished level). If the finished site levels are similar to existing levels, granular materials are anticipated to be present at formation. However, the soft cohesive soils are likely to be present immediately below this level. The Design CBR value for roads should be restricted to 2%.

- 9.5.2 Any Made Ground / soft cohesive soils beneath pavement formation level should be excavated, sorted, re-laid and compacted to a suitable specification. The exposed formation prior to relaying the Made Ground should be inspected and assessed by a competent engineer and any soft spots removed and replaced with granular fill material or lean mix concrete. Design CBR values should be confirmed by in-situ testing at pavement formation level to confirm a suitable sub-base thickness.

9.6 Construction

- 9.6.1 Shallow excavation depths should be readily achieved using conventional plant (JCB 3CX or similar). Heavier duty plant is likely to be required for breaking out the foundations and floor slabs of the historical and current buildings and any other structures.
- 9.6.2 Shallow excavations (<0.60m bgl) across the site should remain stable for short periods of time. Deeper excavations are likely to require shoring and dewatering. Excavation support or battered sides should be provided for all excavations requiring entry by site workers in accordance with CIRIA Report 97 'Trenching Practice'.
- 9.6.3 Significant ingress of groundwater is likely to occur within excavations (>0.60m bgl). Consideration should be given to the use of adequate groundwater control measures during excavation works.

9.7 Concrete Specification

- 9.7.1 The ground conditions, pH values and water-soluble sulphate concentrations have been assessed for potential aggressive attack on concrete in accordance with BRE Special Digest 1 'Concrete in Aggressive Ground (2005)'.
- 9.7.2 The site is considered to be a 'Brownfield' site. Made Ground samples contain water-soluble sulphate concentrations ranging between 210mg/l and 4,700mg/l and pH values between 7.4 and 7.6. Natural deposits samples contain water-soluble sulphate concentrations of 180mg/l and 1,900mg/l and pH values of 7.9 and 8.0. Samples of groundwater contain total sulphate concentrations of 1,300mg/l and 170mg/l and pH values between 8.1 and 8.6.
- 9.7.3 Based on the above parameters, the site is assigned a Design Sulphate Class DS-3 and an ACEC (Aggressive Chemical Environment for Concrete) Class AC-3.
- 9.7.4 The specific concrete mixes for the DS Class to be used at the site will be determined, mindful of the ACEC Class, by the site-specific concrete requirements in terms of the required durability and structural performance. These are assessed in terms of the Structural Performance Level (SPL) and any Additional Protection Measures (APM).

9.8 Soakaways

- 9.8.1 The use of conventional soakaways for surface water drainage is not considered to be a feasible option due to the presence of impermeable clays and a shallow water table beneath the site. Consideration should be given to other forms of Sustainable Urban Drainage Systems (SUDS) to attenuate flows and provide storage.

10.0 RECOMMENDATIONS

10.1 The following further works have been recommended prior to the redevelopment of the site:

- (a) Further intrusive investigation to determine whether or not the TPH and arsenic concentrations pose an environmental risk to 'controlled waters'.
- (b) Submission of this report to the Environment Agency, and the Local Authority Environmental Health Officer, for their review and comment prior to any irrevocable action taking place.
- (c) Further intrusive investigation of the ground conditions beneath the floor slab of the retail areas of the existing depot.
- (d) Completion of an asbestos survey.
- (e) Submission of this report to the relevant Water Supply Authority to confirm the required level of protection for plastic water supply pipes.
- (f) Waste Acceptance Criteria (WAC) testing of representative samples of any materials deemed for off-site disposal as part of the redevelopment works.
- (g) Submission of this report to specialist piling contractors to assist in the design of the pile foundations.
- (h) Completion of a flood risk assessment.