

**LIDL UK GMBH
GEO-ENVIRONMENTAL INVESTIGATION**

**PIER ROAD, LITTLEHAMPTON
(NORTH SITE)**

SEPTEMBER 2008

OPUS JOYNES PIKE

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

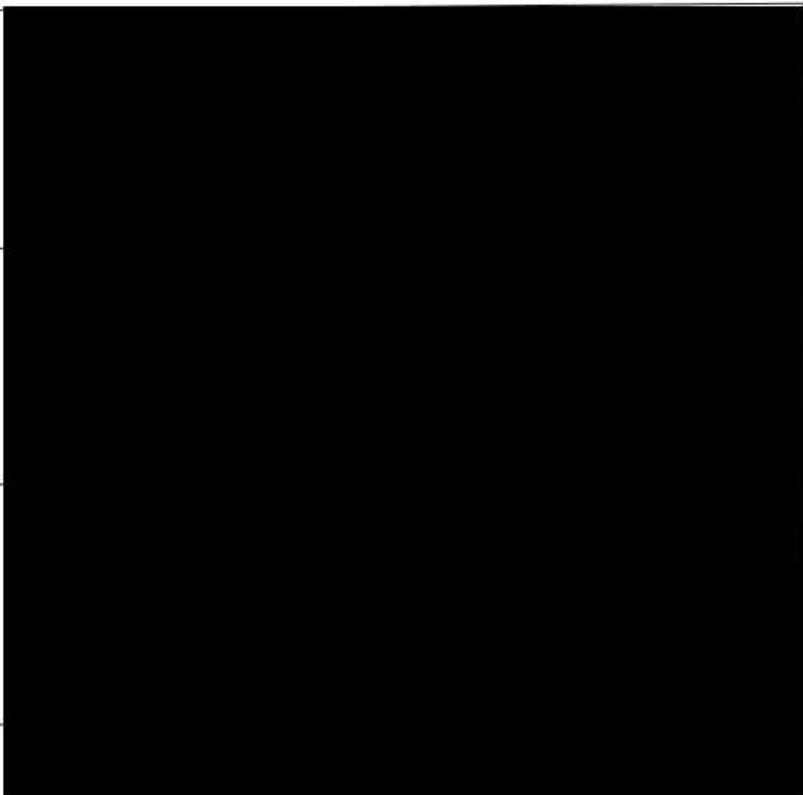
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A. FACTUAL INFORMATION

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 northern 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 redeveloped as a Lidl retail store with car parking. The southern half of the larger site is to be retained by Travis Perkins and redeveloped as a new building materials depot.
- 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 northern half of the larger site (the area to be redeveloped as a Lidl retail store) 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 (R002b)) has been compiled for the southern 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 both Pier Road and New Road at approximate National Grid Reference 502770, 101890. The site is situated to the south of Littlehampton town centre, which lies approximately 100m 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, and New Road, which is located to the north.

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-BK093/502A.
- 2.2.2 The site is currently occupied by a former saw mill, with external areas to the north and south, and the northernmost section of the existing Travis Perkins warehouse, with two adjoining workshops.
- 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 former sawmill is of traditional brick construction with a timber-framed roof of corrugated metal and slate. The floors of the saw mill comprise a mix of concrete, suspended timber and compacted soil. Several wood cutting machines are still present in the saw mill. A staff meeting room, kitchen, toilets and offices are contained in the southern section of the saw mill. The remainder of the saw mill is either empty or used for storage.
- 2.2.5 A plastic bunded above-ground diesel storage tank is present adjacent to the outside elevation of the eastern section of the saw mill. At the time of the site walkover, localised staining was observed directly below the fill nozzle of the tank.
- 2.2.6 A fuel flow meter is present on the outside elevation of the eastern section of the saw mill. A metal cover is also present on the ground surface near the meter. These may indicate the historical presence of nearby above-ground or underground storage tank(s).
- 2.2.7 The external area to the north has hardcore surfacing, with small areas of concrete surfacing, and is used for staff car parking and the storage of sacks of aggregates. An electricity substation is present in the extreme north of the site. The external area to the south forms part of the main sales yard. It has bitumen surfacing, also with small areas of concrete surfacing, and is used for customer parking and the storage of paving blocks and slabs.

- 2.2.8 The northern section of the existing Travis Perkins warehouse is of timber construction with a timber-framed roof of corrugated metal. The floor of the warehouse is concrete. The warehouse extends onto the adjoining proposed development site. The northern section of the warehouse is used for the storage of hardboard, insulation and worktops.
- 2.2.9 The two adjoining workshops are of traditional brick construction with timber roofs. These are used for the storage of discarded marketing materials. The southernmost workshop is contained within the warehouse.
- 2.2.10 The site is generally level, however, ground levels rise gently towards Pier Road along the western boundary of the site.
- 2.2.11 The site is bounded to the west by Pier Road, with modern apartments beyond; the north by New Road, with traditional terraced houses beyond; and the east by traditional terraced houses and Clifton Road. The site is bounded to the south 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 north of the site was occupied by Sawmills. The northern section of the existing former sawmill building is shown in the site centre. The south of the site was still undeveloped at this time.
- 3.2.2 The remainder of the existing former sawmill building is shown on the next plan dated **1898**. A large, rectangular structure is shown in the southwest of the site. The existing warehouse building, labelled as Norfolk Saw Mills, is also shown in the southeast of the site. The Norfolk Saw Mills extended into the adjoining proposed development site immediately to the south.
- 3.2.3 The large, rectangular structure in the southwest of the site is labelled as a 'Tank' on the **1912** and **1932** plans. It is no longer shown on the next available plan dated **1959**.
- 3.2.4 One of the Sawmills in the north of the site is no longer shown on the **1959** plan. The electricity substation is present in the area of the absent Sawmill on the **1968** plan.
- 3.2.5 There are no significant changes to the site on the **1970**, **1974** or **1984** plans.
- 3.2.6 The remainder of the Sawmills in the north of the site are no longer shown on the next available plan dated **1994**. The current site form and layout is present at this time.
- 3.2.7 The Norfolk Sawmills were located on the adjoining proposed development site immediately to the south between **1898** and **1959**. The area has been labelled as a Timber Yard since the **1968** 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 north, the east, and beyond the adjoining proposed development site to the south, 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 86m 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 892m 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 192m 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 historical contamination of the site from spillage and/or leakage of petroleum hydrocarbons (oils) and potentially timber preservatives from the above-ground tanks and/or underground storage tanks, including the tank present in the southwest of the site 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 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 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 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.

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 dust if any contamination is exposed in soft landscaped areas. Site construction workers may be susceptible as 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.

4.4 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 Eight window sample boreholes (WS1 to WS8) were advanced using a small tracked light percussion rig on 17th and 18th July 2008.

5.3.2 WS1 refused on brick cobbles at 0.50m bgl (below ground level), and was terminated at this depth. WS1 was replaced with WS1A, which achieved an investigation depth of 6.00m bgl. All other exploratory holes except WS7 achieved an investigation depth of 5.00m bgl. WS7 refused on brick cobbles at 1.00m bgl, and was terminated at this depth.

5.3.3 The rationale for the location of the exploratory holes was as follows:

Borehole	Location and Reason
WS1A	Staff Car Parking Area - Provide Site Coverage
WS2	Staff Car Parking Area - Adjacent to Electricity Substation
WS3	Access Road - Adjacent to Possible Storage Tank(s)
WS4	Main Sales Yard - Adjacent to Above-Ground Diesel Storage Tank and Area of Historical 'Tank'
WS5	Main Sales Yard - Up-gradient of Area of Historical 'Tank'
WS6	Main Sales Yard - Adjacent to Area of Historical 'Tank'
WS7	Main Sales Yard - Within Area of Historical 'Tank'
WS8	Main Sales Yard - Down-gradient of Historical 'Tank'

5.3.4 It was not possible to locate any exploratory holes within the former saw mill due to the lack of adequate access for the drilling rig at the time of our investigation.

- 5.3.5 The approximate locations of the exploratory holes are shown on the appended Drawing J-BK093/503A, 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 four exploratory holes (WS1A, WS2, WS7 and WS8) 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 four exploratory holes (WS1A, WS3, WS6 and WS8). 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 four 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 with Potential Contamination either by Potential Visual and Olfactory Evidence or Location relative to Potential Current or Historical Sources of Contamination

- Speciated Total Petroleum Hydrocarbons (TPH) - 5 samples
- Speciated Phenols - 5 samples
- Speciated Volatile Organic Compounds (VOC) - 2 samples
- Polychlorinated Biphenyls (PCB) - 1 sample

- 5.4.3 The following chemical testing of groundwater was carried out:

- Toxic Heavy Metals, Sulphur Compounds and pH - 4 samples
- Speciated Polycyclic Aromatic Hydrocarbons (PAH) - 4 samples
- Speciated Total Petroleum Hydrocarbons (TPH) - 4 samples
- Speciated Phenols - 3 samples
- 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 granular and cohesive soil 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) - 3 samples
- Water-Soluble Sulphate (BS1377; Part 3; 1990) - 3 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 four standpipes (WS1A, WS3, WS6 and WS8) 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 WS1A and WS2 penetrated gravelly brown grey black sand surface layers to depths of 0.40m and 0.30m bgl respectively. The sand was underlain by chalk and brick cobbles to a depth of 0.75m bgl in WS2.
- 6.1.2 WS3, WS5, WS6, WS7 and WS8 penetrated 50mm thick bituminous surfacing. 100mm thick concrete was present immediately beneath the bituminous surfacing in WS5 and WS7, and a 200mm thick layer of concrete gravel was present immediately beneath the bituminous surfacing in WS8. WS4 penetrated 150mm thick concrete surfacing.
- 6.1.3 The concrete/concrete gravel in WS4, WS5, WS7 and WS8 was underlain by a sub-base of brick cobbles to depths between 0.35m and 1.00m bgl. The base of the brick cobbles was not penetrated to the refusal depth of 1.00m bgl in WS7.
- 6.1.4 The bituminous surfacing in WS3 and WS6 and the brick cobbles in WS5 were underlain by a granular sub-base of ashy gravelly brown grey black sand to depths of 0.40m and 0.60m bgl. Chalk cobbles were present beneath the sand in WS5 and WS6 to depths of 0.65m and 0.80m bgl. The chalk cobbles in WS5 were further underlain by clayey silty brown grey black sand to 1.30m bgl.
- 6.1.5 Cohesive horizons of variably coloured clays were present beneath the sand and cobble layers in WS3, WS4 and WS8 to depths of 0.80m, 0.65m and 1.40m bgl respectively.
- 6.1.6 Deeper Made Ground of grey brown sand and then clayey silty brown grey black sand was present in WS4 to a depth of 2.00m bgl.
- 6.1.7 No further Made Ground was encountered in the eight exploratory holes.

Natural Deposits

- 6.1.8 Cohesive deposits comprising high plasticity light green brown clays with soft consistency and occasional gravel of mudstone and flint were encountered immediately beneath the Made Ground in all exploratory holes except WS7. The clays encountered in WS1A and WS2, and the shallower clays in WS8, were mottled orange. The clays encountered in WS3, WS4, WS5 and WS6, and the deeper clays in WS8, were mottled grey blue with an organic odour. The base of the light green brown clays deepened towards the south beneath the site (1.00m bgl in WS2 to 4.80m bgl in WS8).
- 6.1.9 Further cohesive deposits comprising high plasticity brown clays with very soft consistency and black mottling were encountered beneath the light green brown clays in WS2, WS3, WS4 and WS5. The base of the brown clays also deepened towards the south (2.00m bgl in WS2 to 4.40m bgl in WS5). The brown clays were absent in WS1A, WS6 and WS8.

- 6.1.10 The cohesive deposits abruptly changed to granular deposits comprising silty green, grey or orange brown medium sand with occasional gravel of flint in WS1A, WS3 to WS6 and WS8. This change in strata appeared to deepen towards the south-southwest (2.00m bgl in WS1A and 4.80m bgl in WS8). The green brown sands were absent in WS2, and the base encountered at depths between 3.20m bgl (WS3) and 4.90m bgl (WS5 and WS6), but not proven to 5.00m bgl in WS8, suggesting that the green brown sands deepen towards the south-southwest.
- 6.1.11 A horizon of silty yellow brown clay with chalk pebbles was encountered beneath the brown clays in WS2 to a depth of 2.75m bgl. Horizons of clayey yellow brown medium sand with chalk pebbles were encountered in WS3 to WS6. The base of the yellow brown sand was encountered at 4.00m bgl in WS3, but not proven to 5.00m bgl in WS4, WS5 and WS6, also suggesting that the yellow brown sands deepen towards the south-southwest.
- 6.1.12 Chalk bedrock, deepening towards the south-southwest, was struck in the exploratory holes in the north of the site at depths of 2.75m bgl in WS2, 4.00m bgl in WS3 and 4.80m bgl in WS1A.
- 6.1.13 No natural deposits were encountered in WS7 to the refusal depth of this exploratory hole of 1.00m bgl.

Standard Penetration Tests

- 6.1.14 Standard Penetration Tests (SPT's) were undertaken at 1.00m intervals within four exploratory holes (WS1A, WS2, WS7 and WS8).
- 6.1.15 SPT's taken within the cohesive deposits of light green brown clays and brown clays gave corrected 'N' values ranging between 'N' = 0 and 'N' = 6, indicating very soft cohesive soils. These deposits were broadly recorded to 2.00m bgl in the north of the site and 4.00m bgl in the south.
- 6.1.16 SPT's taken within the underlying granular deposits of grey, green or orange brown sands gave corrected 'N' values ranging between 'N' = 3 and 'N' = 5, indicating very loose granular soils. These deposits were broadly recorded to around 4.00m bgl in the north of the site and 5.00m bgl in the south.

N = 8 – 30 in Chalk (WS1A - 1WS2)

6.2 Groundwater Observations

- 6.2.1 Groundwater seepages were recorded at the following approximate depths during drilling (July 2008):

WS1A	= 2.50m bgl	WS5	= 2.00m bgl
WS2	= 2.00m bgl	WS6	= 2.00m bgl
WS3	= 3.00m bgl	WS8	= 2.50m bgl
WS4	= 2.00m bgl		

- 6.2.2 Groundwater rest levels were recorded in the four standpipes (WS1A, WS3, WS6 and WS8) between the following minimum and maximum depths during monitoring (July and August 2008):

WS1A = Minimum 1.95m bgl – Maximum 2.31m bgl
 WS3 = Minimum 1.93m bgl – Maximum 2.05m bgl
 WS6 = Minimum 1.81m bgl – Maximum 1.94m bgl
 WS8 = Minimum 1.19m bgl – Maximum 1.27m bgl

6.3 Evidence of Hydrocarbon Contamination

- 6.3.1 Hydrocarbon staining and diesel odour was noted within the sub-base horizons underlying the concrete surfacing in WS4 between 0.15m and 0.65m bgl.
- 6.3.2 No other visible or olfactory evidence of hydrocarbon contamination was noted beneath the site during the course of this investigation.
- 6.3.3 Grey blue mottling with an organic odour and black mottling was widely noted in the light green brown clays and the brown clays respectively encountered in WS3 to WS8. 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 A lead concentration of 1000mg/kg has been detected in the Made Ground sample taken from WS7 between depths of 0.60-0.90m bgl, which lies above the IHSL for a 'Commercial' site end use of 750mg/kg.
- 6.4.4 Concentrations of other metals and individual PAH's lie below their ISHL for a 'Commercial' site end use in these three samples.

TPH, BTEX and MTBE

- 6.4.5 Five soil samples have been analysed for speciated TPH including BTEX (Benzene, Toluene, Ethyl benzene and Xylene) and MTBE (Methyl Tertiary Butyl Ether). One of these samples represents the sub-base horizons in WS4 between depths of 0.30m and 0.65m bgl with diesel staining and odour.
- 6.4.6 Concentrations of each TPH fraction lie below their IHSL for a 'Commercial' site end use in these five samples. The TPH fractions in the Made Ground sample taken from WS4 between depths of 0.30-0.65m bgl essentially lie below the laboratory detection limits.

6.4.7 A notable TPH (C5-C35) concentration of 410mg/kg has been detected in the Made Ground sample taken from WS7 between depths of 0.60-0.90m bgl. The TPH (C5-C35) concentration essentially comprises the medium to heavy aromatic carbon bands C10-C35.

6.4.8 Concentrations of BTEX and MTBE lie below their laboratory detection limits in these five samples.

Speciated Phenols

6.4.9 Five soil samples have been analysed for speciated phenols.

6.4.10 Concentrations of individual phenol compounds lie below the IHSL for a 'Commercial' site end use in these five samples.

6.4.11 Total phenol concentrations are between 0.7mg/kg and 1.4mg/kg.

Speciated VOC

6.4.12 Two soil samples have been analysed for speciated VOC.

6.4.13 Concentrations of individual VOC compounds lie below their laboratory detection limits in these two samples.

PCB

6.4.14 A soil sample taken from WS2 between depths of 0.75-1.00m bgl has been analysed for PCB.

6.4.15 PCB concentrations lie below the laboratory detection limit in this sample.

Asbestos

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

6.4.17 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 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 (the sum of six individual 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 Four samples of groundwater (WS1A, WS3, WS6 and WS8) have been analysed for metals and speciated PAH.
- 6.5.5 Arsenic concentrations (28µg/l, 30µg/l, 45µg/l and 56µg/l respectively) lie marginally above the EQS for coastal and estuarine waters of 25µg/l in these four samples.
- 6.5.6 Concentrations of other metals lie below their EQS for coastal and estuarine waters in these four samples.
- 6.5.7 A total PAH concentration of 0.6µg/l is present in the sample of groundwater taken from WS6. However, the sum of the six individual PAH's is <0.1µg/l, and therefore, the total PAH concentration lies below the SWAD Imperative Value of 0.2µg/l.
- 6.5.8 Concentrations of PAH lie below the laboratory detection limit in the other three samples.

TPH, BTEX and MTBE

- 6.5.9 Four samples of groundwater (WS1A, WS3, WS6 and WS8) have been analysed for speciated TPH including BTEX and MTBE.
- 6.5.10 A TPH (C5-C35) concentration of 270µg/l is present in the sample of groundwater taken from WS6. The TPH (C5-C35) concentration lies marginally above the SWAD Imperative Value of 200µg/l for Class A2 surface waters, but considerably below the SWAD Imperative Value of 1000µg/l for Class A3 surface waters. The TPH (C5-C35) concentration comprises the medium to heavy aromatic carbon bands C10-C35.
- 6.5.11 Concentrations of TPH (C5-C35) lie below the laboratory detection limit in the other three samples.
- 6.5.12 Concentrations of BTEX and MTBE lie below their laboratory detection limits in the four samples.

Speciated Phenols

- 6.5.13 Three samples of groundwater (WS3, WS6 and WS8) have been analysed for speciated phenols.
- 6.5.14 Concentrations of individual phenol compounds lie below the laboratory detection limit in these three samples.

Speciated VOC

- 6.5.15 One sample of groundwater (WS8) has been analysed for speciated VOC.
- 6.5.16 Concentrations of individual VOC compounds lie below their laboratory detection limits in this sample.

6.6 Geotechnical TestingFoundation and Floor Slab Design

- 6.6.1 Two cohesive soil samples (WS1A 1.70-2.00m and WS8 1.70-2.00m) have been tested for Plasticity Index and Natural Moisture Content.
- 6.6.2 The Plasticity Index of the WS1A sample is 51 with a corresponding Natural Moisture Content of 40%.
- 6.6.3 The Plasticity Index of the WS8 sample is 29 with a corresponding Natural Moisture Content of 36%.

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 140mg/l and 570mg/l with corresponding pH values between 7.8 and 8.5.
- 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 30mg/l and 50mg/l with corresponding pH values of 7.6 and 7.8.
- 6.6.6 Four samples of groundwater (WS1A, WS3, WS6 and WS8) have been tested for total sulphate and pH. Total sulphate concentrations in these four samples range between 48mg/l and 100mg/l with corresponding pH values between 7.6 and 8.5.

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 four standpipes (WS1A, WS3, WS6 and WS8) on four occasions.

6.7.4 The gas monitoring results are summarised below:

- Methane concentrations were recorded between 3.8% v/v and 14.7% v/v in WS3 and between 0.9% v/v and 3.7% v/v in WS6. Methane concentrations were consistently recorded below the instrument detection limit (0.1% v/v) in WS1A and WS8. The maximum recorded methane concentration was 14.7% v/v.
- Carbon dioxide concentrations were consistently recorded above 1% v/v, but below 5% v/v, in WS3 and WS6. Carbon dioxide concentrations were generally recorded below 1% v/v in WS1A and WS8.
- Carbon monoxide concentrations were recorded up to 4ppm, while hydrogen sulphide concentrations were consistently recorded below the instrument detection limit (1ppm).
- The maximum recorded gas flow rate was a peak value of 8.6 l/hr in WS8, although the steady rate was 0.1 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 Lidl retail store with car parking. It is proposed to locate the retail store in the north of the site and the car parking area in the south. It is also proposed to include limited areas of soft landscaping around the perimeter of the car parking area. 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 contamination beneath the site is considered to be surface water in the River Arun.
- 7.4 Our intrusive investigation has been limited to the existing external areas of the site. It was not possible to investigate within the existing former saw mill. Hence, the ground conditions beneath the floor slab of the existing former saw mill have not been determined at this stage.

8.0 ENVIRONMENTAL ASSESSMENT

8.1 Environmental Summary

- 8.1.1 A lead concentration of 1000mg/kg has been detected in Made Ground within WS7, which lies above the IHSL for a 'Commercial' site end use of 750mg/kg.
- 8.1.2 A notable TPH (C5-C35) concentration of 410mg/kg has been detected in Made Ground within WS7. The TPH (C5-C35) concentration essentially comprises the medium to heavy aromatic carbon bands C10-C35.
- 8.1.3 A TPH (C5-C35) concentration of 270µg/l is present in groundwater within WS6, which lies between the SWAD Imperative Guideline Values of 200µg/l and 1000µg/l for Class A2 and A3 surface waters respectively. The TPH (C5-C35) concentration comprises the medium to heavy aromatic carbon bands C10-C35.
- 8.1.4 Arsenic concentrations of 28µg/l, 30µg/l, 45µg/l and 56µg/l are present in groundwater in WS1A, WS3, WS6 and WS8 respectively, which lie marginally above the EQS for coastal and estuarine waters of 25µg/l.
- 8.1.5 The minimum recorded groundwater rest levels in the four standpipes (which are considered to represent low tide levels) during the four monitoring visits indicate that groundwater appears to deepen in a south-southwest direction beneath the site. Groundwater flow beneath the site is therefore also considered to be in a south-southwest direction, towards the River Arun.
- 8.1.6 Significantly elevated methane concentrations have been recorded in WS3 and WS6. No volatile organic compounds have been recorded at the site.
- 8.1.7 The source of the lead and medium-heavy aromatic TPH contamination in the Made Ground in WS7 is not known with certainty. However, the contamination was noted at shallow depth (<1.00m bgl) and WS7 was located within the area of the historical large, rectangular tank present between 1912 and 1932. The Made Ground contamination recorded in WS7 may therefore be due to historical surface leaks/spills of fuel oils/timber preservatives from the tank, and subsequent percolation into the Made Ground beneath and around the tank.
- 8.1.8 The source of the medium-heavy aromatic TPH contamination in the groundwater in WS6 may be a direct result of the Made Ground contamination. WS6 is located immediately to the south (hydraulically down-gradient) of the Made Ground contamination. Dissolution of the TPH contamination from the Made Ground into the groundwater, and subsequent migration to the south, may therefore be responsible for the groundwater contamination recorded in WS6. In addition, the elevated methane concentrations in WS3 and WS6 may also be a direct result of degradation of the TPH contamination.

- 8.1.9 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.

8.2 Environmental Risk Assessments

Human Health

- 8.2.1 We understand that it is proposed to redevelop the site for a new Lidl retail store with car parking.
- 8.2.2 With the exception of the lead concentration in Made Ground within WS7, no soil contaminant concentrations exceed their IHSL for a 'Commercial' site end use.
- 8.2.3 The site redevelopment proposals include hard cover across the area of WS7 and the area of the historical tank (ie. concrete floor slab of the retail store and tarmac car parking area). The presence of hard cover will break any potential exposure pathways (ingestion, dermal contact and inhalation) between the lead contamination and future customers and staff. Hence, there are not assessed to be any future environmental risks to human health from the lead contamination. However, a suitable thickness of clean topsoil should be placed on the proposed limited areas of soft landscaping around the perimeter of the car parking area to provide a barrier to potential exposure pathways and a suitable growing medium for plants.

Controlled Waters

- 8.2.4 The primary sensitive 'controlled water' receptor is considered to be surface water in the River Arun.
- 8.2.5 With the exception of the TPH (C10-C35) concentration in groundwater within WS6 and the elevated arsenic concentrations, no groundwater contaminant concentrations exceed their EQS for coastal and estuarine waters or SWAD Imperative Guideline Values.
- 8.2.6 Based on the findings and results of the investigative work to date, TPH groundwater contamination beneath the site appears to be confined to the area of WS6, which is situated towards the southern site boundary. TPH (C5-C35) concentrations were not detected ($<10\mu\text{g/l}$) in groundwater within WS1A, WS3 or WS8, which are situated to the north and west of WS6. However, as no further standpipes are present to the south (hydraulically down-gradient) of WS6, it is not possible to confirm at this stage that the TPH groundwater contamination does not extend further towards, and potentially beyond, the southern site boundary.
- 8.2.7 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.

8.2.8 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 TPH or 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.

8.2.9 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.

8.2.10 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

8.2.11 The maximum detected methane concentration of 14.7% 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 Lidl retail store. The maximum detected gas flow rate is 8.6 l/hr.

8.2.12 The GSV is calculated as follows:

$$Q_{hg} = C_{hg} / 100 \times q$$

Where Q_{hg} = GSV (l/hr)
 C_{hg} = Maximum methane concentration (% v/v)
 q = Maximum gas flow rate (l/hr)

The GSV for the site is 1.2642 l/hr.

8.2.13 In accordance with Table 8.5 of C665, the GSV classifies the site as Characteristic Situation 3 where gas protection measures are required in new commercial developments. In this case, the peak methane concentration of 14.7% and the peak gas flow reading of 8.6 l/hr has been used in the initial assessment. However, the gas flow rate reduced to a steady reading of 0.1 l/hr, and hence, Characteristic Situation 3 is considered appropriate.

8.2.14 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 3 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.

- 8.2.15 For example, in accordance with Table 3 of BS8485:2007, the installation of a lapped, taped and sealed methane 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 existing buildings on the site. 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 the demolition of these buildings before the new building can be constructed. 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 demolition, we would recommend that an intrusive investigation of the ground conditions beneath the floor slab of the existing buildings 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 odourous 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, locally becoming cohesive with depth, to depths of between 0.40m bgl (WS1A) and 1.40m bgl (WS8). Deeper granular Made Ground is present immediately to the south of the existing former saw mill (WS4) to 2.00m bgl.
- 9.1.2 The Made Ground is underlain by cohesive deposits comprising highly plastic soft light green brown clays, becoming highly plastic very soft brown clays with depth. These clays are variably mottled orange, grey blue and black. The grey blue mottled clays also include an organic odour. The base of the cohesive deposits deepens towards the south beneath the site (2.00m bgl in WS2 and 4.80m bgl in WS8). These clays are interpreted as representing Alluvium associated with the River Arun.
- 9.1.3 The cohesive deposits seem to abruptly change to granular deposits comprising silty green, grey or orange brown sands. The base of the granular deposits deepens towards the south-southwest beneath the site (absent in WS2 and not proven to 5.00m bgl in WS8). These sands are interpreted as representing Raised Beach Deposits.
- 9.1.4 Yellow brown clays / sands with chalk pebbles were encountered beneath the northeast of the site, deepening towards the south-southwest (2.75m bgl in WS2 and not proven to 5.00m bgl in WS4, WS5 and WS6).
- 9.1.5 Chalk bedrock was struck beneath the north of the site and was shown deepening towards the south-southwest (2.75m bgl in WS2, 4.00m bgl in WS3 and 4.80m bgl in WS1A).
- 9.1.6 Corrected SPT 'N' values taken within the clays were between 'N' = 0 and 'N' = 6, indicating very soft cohesive soils, to general depths of 2.00m bgl in the north of the site and 4.00m bgl in the south. Those taken within the sands were between 'N' = 3 and 'N' = 5, indicating very loose granular soils, to general depths 4.00m bgl in the north of the site and 5.00m bgl in the south. The tests in the Chalk recorded N-values of between N = 8 and N=30.
- 9.1.7 The plasticity index results indicate that the cohesive soils are of medium to high volume change potential.

9.2 Foundation Design

- 9.2.1 The presence of very soft cohesive soils and very loose granular soils recorded beneath the site, coupled with their variability, are not considered to be suitable founding strata for traditional strip, pad, trench or raft foundations.
- 9.2.2 The foundations of the new Lidl retail store should bear upon competent Upper Chalk strata, which is potentially present at depths of around 5.00m, and deepening towards the south, beneath the area of the proposed building footprint. Driven or bored pile foundations are considered to be suitable foundation options in order to achieve such depths.

- 9.2.3 Consideration could be given to the use of vibro ground improvement techniques (ie stone or concrete columns) although the presence of very soft clays beneath the site may render the technique unsuitable.
- 9.2.4 We recommend that this report should be made available to specialist piling contractors allow the most appropriate and economic foundation solution to be adopted. Further intrusive investigation by cable percussion drilling techniques will be required by the specialist piling contractors to obtain additional information for pile design.
- 9.2.5 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 If an engineered capping to support the floor slab is adopted, 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 Any 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.
- 9.3.4 The gas screening value (GSV) classifies the site as Characteristic Situation 3 (CIRIA Report C665) where gas protection measures are required in new commercial developments. Details are presented in Section 8.2 of this report.
- 9.3.5 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 Although not strictly applicable to commercial developments, 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 medium to 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 The exposed formation should be proof rolled and 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 (<1.20m 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 (>1.20m bgl). Consideration should be given to the use of adequate groundwater control measures during excavation works.
- 9.6.4 If a piled solution is adopted, a suitably designed and engineered working platform will be required.

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 140mg/l and 570mg/l and pH values between 7.8 and 8.5. Natural deposits samples contain water-soluble sulphate concentrations of 30mg/l and 50mg/l and pH values of 7.6 and 7.8. Samples of groundwater contain total sulphate concentrations ranging between 48mg/l and 100mg/l and pH values between 7.6 and 8.5.
- 9.7.3 Based on the above parameters, the site is assigned a Design Sulphate Class DS-2 and an ACEC (Aggressive Chemical Environment for Concrete) Class AC-2.

- 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 existing former saw mill.
- (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.