

Strata	Depth Range (Thickness Range)	Description and Comments
		thickness of mixed granular and cohesive fill, with recorded fill depths of between 3.30m and >3.40m bgl. During the excavation of TP1 and TP4, located within the south eastern and north eastern areas of the site, respectively, relic foundations and concrete obstructions were encountered. In the latter of the trial pits a large tree trunk (approx 900mm x 450mm) was encountered at the base of the excavation, 3.30m bgl. Within the western part of the site, made ground was encountered to a maximum proven depth of 2.60m bgl, and generally comprised granular fill, described as sandy gravel of limestone, brick, concrete, ash, clinker and red shale. Cohesive made ground comprising stiff sandy clay with gravel sized fractions of sandstone, brick and ash, was locally encountered within WS8. Window sample boreholes WS6, WS6A and WS6B, located within the north western part of the site, encountered obstructions within the made ground at depths of between 0.50m and 1.00m bgl, and subsequently did not prove the true thickness of the material.
Alluvial	2.20 to 3.30m (1.10 – 2.65m)	Alluvial deposits were encountered underlying the made ground within the north eastern (TP3, TP5, WS4, WS5), and south western (WS7) areas of the site, within the footprints of the former reservoirs. In addition alluvial deposits were encountered in the north western area of the site (WS6C), within the approximate vicinity of the former channel of Sough Dyke. The alluvial deposits were encountered to depths of between 3.60m and 5.15m bgl, and were generally described as very soft and soft, locally firm, organic clay and silt.

Strata	Depth Range (Thickness Range)	Description and Comments
		Within WS7 an upper layer (0.10m thick) of silty organic sand was noted. TP5 was terminated within the alluvial deposits at a depth of 4.10m bgl, and subsequently did not prove the true thickness of the material.
Residual Middle Coal Measures	1.50 to 5.15m (>0.20 – 2.35m)	The made ground, and alluvial deposits where present, were typically found to be underlain by natural cohesive material to depths of between 1.90m (TP1) and >5.45m bgl (WS5). The natural cohesive deposits were described as firm to very stiff sandy clay with occasional gravel sized fragments of mudstone and sandstone. The cohesive residual material ranged in thickness between >0.20m (not proven in TP3) and 1.10m (WS7). Within WS8 located in the western area of the site, slightly sandy, slightly clayey gravel of sandstone, siltstone and mudstone was encountered underlying the natural cohesive deposits between depths of 2.20 and 4.55m bgl (2.35m thickness). These natural cohesive and granular deposits are considered representative of completely weathered (residual) Middle Coal Measures strata. The residual Middle Coal Measures strata was not encountered within WS2 and WS3, located within the south eastern area of the site. This is assumed to be associated with the level of the south eastern area of the site being reduced and regraded as part of the previous development of the site.
Middle Coal Measures -	0.50 to 6.50m (NR)	Competent bedrock, comprising mudstone, siltstone and sandstone, was encountered at depths of between 0.50m and 6.50m bgl, within the trial pits, window samples and rotary

Strata	Depth Range (Thickness Range)	Description and Comments
Bedrock		probeholes. The depth to rockhead was generally shallower in the south eastern part of the site, becoming deeper towards the north. A coal seam, recorded to be between 2.00m and 2.30m thick, was encountered in rotary open-hole boreholes RO1, RO2 and RO3 at depths of between 6.70m and 14.50m bgl. Given that the rotary probe holes were located on a level concrete slab, and based on the assumption that the elevation (m AOD) of the rotary probeholes are equal, triangulation of the borehole data indicates that the seam is dipping at approximately 13° to the south east.

NR - not recorded

6.2. Material Properties

Made Ground

Highly variable SPT 'N' values of between 6 and 40 (generally in the range of 9 to 24) were recorded within the made ground deposits indicating generally loose/low strength through to dense/very high strength conditions within the granular/cohesive deposits, respectively. An SPT N value of 50 for 115mm penetration was recorded within the granular fill encountered in WS1. However, this is not considered representative of the made ground and is assumed to be the result of obstructions within the material.

Water soluble sulphate (SO₄) concentrations recorded from five samples taken in made ground soils recorded concentrations of between 0.086g/l and 0.38g/l, together with pH conditions of between 8.0 and 11.4.

These results indicate a design sulphate class of DS-1 and an ACEC class of AC-1, in accordance with BRE Special Digest 1 (2005) for the design of buried concrete in made ground soils, based on brownfield site designation and mobile groundwater conditions.

Alluvial Deposits

Atterberg Limit determinations undertaken on two samples of cohesive alluvial deposits, obtained from TP3 and WS4, indicate the material to be clay of intermediate plasticity, with Liquid Limits of 41% and 47%, Plastic Limits of 23% and 25%, and Plasticity Indices of 18% and 22%, respectively. Based on recorded natural moisture contents of 30% and 35% within the samples obtained from TP3 and WS4, respectively, calculation of the modified Plasticity Indices indicate the alluvial clay has a low volume change potential.

Consistency Indices (Ic) of the alluvial sandy clay indicate Ic values of 0.55 and 0.61, indicative of firm consistency.

An Atterberg Limit determination within a sample of alluvium obtained from WS5 indicated the material to be silt of extremely high plasticity, with a Liquid Limit of 98%, a Plastic Limit of 55% and a Plasticity Index of 43%. Based on a recorded moisture content of 88%, the Consistency Index of the sample tested indicates an Ic value of 0.23 (very soft consistency). The relatively high moisture content, plastic limit and liquid limit reported within this sample is assumed to be associated with a high organic content.

The results of hand shear vane tests undertaken in the cohesive alluvial deposits (sandy clay) within TP5, ranged between 10kPa and 19kPa, indicative of very low strength material.

Standard Penetration Tests (SPTs) undertaken within the cohesive alluvial soils, returned 'N' values of between 2 and 6. Indicative undrained shear strengths of cohesive soils can be derived by applying a correlation to SPT 'N' values according to the material's plasticity, after Stroud (1975)¹. Based on reported plasticity indices of 22% and 43% for the alluvial clay and silt, correlation factors of 5 and 4.5 can be derived, respectively. Using Stroud's correlation the SPT N values indicate undrained shear strengths of between 9kPa and 30kPa within the alluvial deposits, indicative of very low and low strength deposits.

Water soluble sulphate (SO₄) testing of four samples of the alluvial soils recorded concentrations of between 0.18g/l and 1.5g/l, together with pH conditions of between 6.9 and 9.2.

¹ Stroud, M. A. The standard penetration test in insensitive clays and soft rocks, *Proceedings of the European Symposium on Penetration Testing*, 2, 367 – 375 (1975)

These results indicate a design sulphate class of DS-2 and an ACEC class of AC-2, in accordance with BRE Special Digest 1 (2005) for the design of buried concrete, based on brownfield site designation and mobile groundwater conditions.

Residual Middle Coal Measures (MCM)

Atterberg Limit determinations undertaken on two samples of residual Middle Coal Measures strata (MCM), recovered as sandy, gravelly clay, indicate the material to be of intermediate plasticity, with Liquid Limits of 50% and 36%, Plastic Limits of 24% and 22% and Plasticity Indices of 26% and 14%, respectively. Calculation of the modified Plasticity Indices indicate the residual MCM soils have a low to medium volume change potential.

Consistency Indices (I_c) of the residual MCM material indicate I_c values of 1.23 and 1.36, indicative of very stiff material.

SPTs undertaken within the residual MCM, recovered as sandy, gravelly clay, returned 'N' values of between 14 (WS6C at 4m) and 34 (WS7 at 4m). Using Stroud's correlation, and based on plasticity indices of 26% and 14%, the SPT N values indicate undrained shear strengths of between 70kPa and 245kPa, representative of medium to very high strength material.

It was not possible to undertake hand shear vanes on excavated blocks of the residual MCM due to its friable nature.

Water soluble sulphate (SO₄) testing of a sample of residual MCM material recorded a concentration of 0.068g/l, together with a pH condition of 7.1. This result indicates a design sulphate class of DS-1 and an ACEC class of AC-1, in accordance with BRE Special Digest 1 (2005) for the design of buried concrete in natural soils, based on brownfield site designation and mobile groundwater conditions.

Middle Coal Measures (MCM) - Bedrock

SPTs undertaken within strata of the MCM (mudstone, siltstone and/or sandstone) returned 'N' values of between 50 for 200mm penetration (WS7 at 5.00m) and 50 for 50mm penetration (WS3 at 0.80m), indicative of extremely weak to very weak rock.

Water soluble sulphate (SO₄) testing of a sample of mudstone recorded a concentration of 0.053g/l, together with a pH condition of 6.9. This result indicates a design sulphate class of DS-1 and an ACEC class of AC-1, in accordance with BRE Special Digest 1 (2005) for the design of

buried concrete in natural soils, based on brownfield site designation and mobile groundwater conditions.

6.3. Stability

The majority of the trial pits were recorded as being stable in the short term within the made ground and natural deposits, with the exception of Trial pits TP3 and TP4 which were recorded as being unstable within the made ground and alluvial deposits, respectively.

6.4. Groundwater

Groundwater strikes encountered during the recent ground investigation are summarised in Table 6.2, below.

Table 6.2 Summary of Groundwater Encountered

Exploratory Hole	Depth Encountered (m bgl)	Description	Stratum
RO1	9.50	Groundwater strike	Middle Coal Measures
RO2	12.50	Groundwater strike	Middle Coal Measures
RO3	12.50	Groundwater strike	Middle Coal Measures
WS6C	1.50 2.70	Groundwater seepage Groundwater seepage	Made ground Alluvium
WS7	1.50	Groundwater seepage	Made ground
WS8	4.00	Groundwater seepage	Residual MCM (Granular)
TP1	1.40	Groundwater seepage	Made ground
TP3	2.10	Groundwater seepage	Made ground
TP4	2.70	Groundwater inflow (slight hydrocarbon odour)	Made ground
TP5	3.50	Groundwater seepage	Alluvium

Groundwater strikes were noted within the Middle Coal Measures strata within rotary probe holes RO1 and RO3, at depths of 9.50m and 12.50m bgl. However, due to the nature of the rotary drilling method (air mist), it is not possible to detect seepages or low flow water strikes.

Subsequent groundwater monitoring of the monitoring installations sealed within the MCM strata (Secondary A Aquifer) within the rotary boreholes, revealed the groundwater to be standing at between 1.24m and 1.74m bgl, indicating subartesian conditions.

6.5. Visual / Olfactory Evidence of Contamination

A slight hydrocarbon odour to the groundwater was noted within TP4 at 2.70m bgl. No other visual and/or olfactory evidence of organic contamination was noted during the fieldworks.

Made ground soils consisting of ash, clinker, coal, brick, concrete and red shale were encountered. These materials can often contain elevated metals and PAH.

6.6. Ground Gas

Ground gas monitoring has been carried out on one occasion to date, and the results are summarised in Table 6.3 below. Full details of ground gas monitoring results are included in Appendix D.

Table 6.3 Summary of Gas Monitoring (1 visit only)

Well	Methane %v/v (Peak – Constant)	Carbon Dioxide %v/v (Peak – Constant)	Oxygen %v/v (Min – Constant)	Flow l/hr (Peak – Constant)
RO1	ND – ND	ND – ND	21.0 – 21.0	ND – ND
RO2	ND – ND	0.4 – 0.3	20.7 – 20.8	ND – ND
RO3	ND - ND	2.3 – 2.3	16.2 – 16.3	ND - ND
WS1	ND – ND	ND – ND	20.7 – 20.7	ND - ND
WS4	ND – ND	ND – ND	20.9 – 21.0	ND - ND
WS5	ND – ND	ND – ND	20.9 – 20.9	ND - ND

ND Not Detected

In addition to the above, no significant VOC concentrations were detected in the ground gas.

The monitoring programme includes 4 visits over a 1 month period. However, on the second monitoring visit, five out of the six monitoring installations were found to have been either damaged or buried during the ongoing demolition works. Consequently, the monitoring wells are to be reinstated so that the gas monitoring programme can be completed.

On completion of the monitoring, a full set of results will be issued in an addendum letter.

7. RESULTS OF CHEMICAL TESTING

7.1. Assessment Methodology

The results of the laboratory testing have been compared against generic assessment criterion (GAC) values, the derivations of which are detailed in Appendix E.

Usually statistical testing is undertaken for the Planning Scenario by the methods described in CL:AIRE & CIEH “Guidance on Comparing Soil Contamination Data with a Critical Concentration”, May 2008. This statistical testing is undertaken to determine whether there was sufficient evidence that the true mean concentration of each determinand was less than the relevant critical concentration for that component.

As chemical test results relate to differing types of made ground soils, statistical assessment has not been carried out.

7.2. Soil Analysis

Results of chemical analysis are presented in full in Appendix C.

For this site, measured values were compared to Generic Assessment Criteria (GAC) derived for a commercial / industrial end use. Source data for all GACs are provided in Appendix E.

The chemical analysis results and screening criteria are summarised in Table 7.1.

Table 7.1 Summary of Total Soil Concentrations

Determinand	No. of Samples Tested	Range of Results (mg/kg unless specified)	GAC (1% SOM)	No. of Samples >GAC	Samples exceeding GAC
Metals					
Inorganic Arsenic	6	8.9 – 17	640	0	
Cadmium	6	0.5 – 0.8	230	0	
Chromium (III)	6	17 – 36	30000	0	
Lead	6	20 – 160	750	0	
Inorganic Mercury	6	<0.05 – 0.26	3600	0	
Selenium	6	<0.5 – 0.8	13000	0	
Copper	6	19 – 150	72000	0	
Nickel	6	11 – 29	1800	0	
Zinc	6	53 – 180	600000	0	
Inorganics					
pH	11	6.9 – 11.4	<5	0	

Determinand	No. of Samples Tested	Range of Results (mg/kg unless specified)	GAC (1% SOM)	No. of Samples >GAC	Samples exceeding GAC
Total Sulphate	6	300 - 1300	2400	0	
Water Sol. Sulphate	11	0.053 – 1.5	0.5 g/l	2	WS4 at 4.00m WS5 at 4.00m
Speciated PAH					
Acenaphthene	6	<0.1 – 1.2	77000	0	
Anthracene	6	<0.1 – 5.3	520000	0	
Acenaphthylene	6	<0.1 – 1.6	77000	0	
Benzo(a)anthracene	6	<0.1 – 18	91	0	
Benzo(b)fluoranthene	6	<0.1 – 12	100	0	
Benzo(k)fluoranthene	6	<0.1 – 6.8	140	0	
Benzo(g,h,i)perylene	6	<0.1 – 11	660	0	
Benzo(a)pyrene	6	<0.1 – 15	14	2	TP5 at 1.00m WS4 at 0.60m
Chrysene	6	<0.1 – 17	140	0	
Dibenzo(a,h)anthracene	6	<0.1 – 2.1	13	0	
Fluoranthene	6	<0.1 – 40	23000	0	
Fluorene	6	<0.1 – 3.8	61000	0	
Indeno(1,2,3-cd)pyrene	6	<0.1 – 11	61	0	
Naphthalene	6	<0.1 – 0.6	110	0	
Pyrene	6	<0.1 – 32	54000	0	
Phenanthrene	6	<0.1 – 21	22000	0	
TPH					
Aliphatic EC 5-6	1	<0.01	2500	0	
Aliphatic EC >6-8	1	0.01	5500	0	
Aliphatic EC >8-10	1	0.07	1300	0	
Aliphatic EC >10-12	1	<1.5	6400	0	
Aliphatic EC >12-16	1	1.7	44000	0	
Aliphatic EC >16-35	1	240	No GAC	0	
Aromatic EC 5-7	1	<0.01	16	0	
Aromatic EC >7-8	1	<0.01	35000	0	
Aromatic EC >8-10	1	0.06	2300	0	
Aromatic EC >10-12	1	<0.9	11000	0	
Aromatic EC >12-16	1	1.3	35000	0	
Aromatic EC >16-21	1	14	28000	0	
Aromatic EC >21-35	1	130	28000	0	
Others					
Phenol	6	<0.3	3200	0	
TOC	7	0.8 – 3.1w/w%	3 w/w%	1	WS4 at 0.60m
Calorific Value	4	<1 – 1.1 MJ/kg	2 MJ/kg	0	
Asbestos	2	Non detected	Fibres present	0	

Table based on a Commercial / Industrial end use.

US95 - 95th percentile estimate of the mean value; GAC -generic assessment criterion; NA - not applicable.

Metals and Metalloids

No metals recorded concentrations above the relevant GAC.

Organics

Marginally elevated concentrations of benzo(a)pyrene were detected in samples of made ground taken from TP5 and WS4 at depths of 1.00m and at 0.60-0.90m bgl, respectively. These samples of made ground were found to contain varying quantities of gravel sized fractions of ash, clinker and coal.

Total organic carbon (TOC) was recorded in one sample of made ground at a concentration slightly exceeding its relevant guideline value. The GAC is based on the Hazardous Waste (England and Wales) Regulations 2005. TOC content in itself does not represent a potential risk to human health. This GAC is provided for indicative assessment of disposal options; in the case that off-site landfill of soil is undertaken. This GAC is specified at the 'Inert' waste threshold and should therefore be considered as for information purposes only.

Although slight olfactory evidence of hydrocarbon contamination was noted within the made ground encountered in TP4 between 2.70 and 3.00m bgl; no TPH fractions recorded concentrations above the relevant GAC.

Other Inorganic Analytes

Water soluble sulphate, in two samples taken from within organic alluvial deposits, were found at concentrations exceeding the relevant guidelines. The reported concentrations of water soluble sulphate are not considered to pose a risk to human health and are discussed later as part of the risk to the built development.

No other inorganics recorded concentrations above the relevant GAC.

7.3. Leachability Testing

Analytical data from leachate testing have been evaluated against GAC values (based on Drinking Water Standards [DWS]) appropriate to the conceptual model for the site. Source data for all GACs are provided in Appendix E.

The results of the soil leachate analyses and the outcome of screening are summarised in Table 7.2 below.

Table 7.2 Summary of Leachate Analysis

Determinand	No. of Samples Tested	No. Samples Above Limit of Detection	Range of Results (µg/l unless specified)	GAC (µg/l unless specified)	No. of Samples >GAC
Metals					
Arsenic	2	0	<1	10	0
Cadmium	2	0	<2	5	0
Chromium	2	0	<5	50	0
Lead	2	0	<4	25	0
Mercury	2	0	<0.05	1	0
Selenium	2	0	<3	10	0
Copper	2	0	2, 4	2000	0
Nickel	2	0	<10	20	0
Zinc	2	0	17, 72	5000	0
Organics					
Naphthalene	2	0	<0.01	10	0
Benzo(a)pyrene	2	2	0.09, 0.17	0.01	2
Benzo(b)fluoranthene	2	2	0.12, 0.26	0.1	2
Benzo(k)fluoranthene	2	2	0.03, 0.08	0.1	0
Benzo(ghi)perylene	2	2	0.1, 0.2	0.1	1
Indeno(1,2,3-cd) pyrene	2	2	0.1, 0.21	0.1	1
Sum PAH-4	2	2	0.35, 0.75	0.1	2
Phenol	2	2	1.7, 2.8	0.5	2
Others					
pH	2	NA	7.8, 8.2	6-9 pH units	0

Based on Water Supply (Water Quality) Regulations 2001 and 2007, where available.

Metals and Metalloids

No leachable metals recorded concentrations above the relevant GAC.

Organics

Slightly elevated concentrations of leachable PAH species (including benzo(a)pyrene) were recorded from leachate obtained from samples of made ground, when compared to DWS thresholds. In addition elevated leachable phenol concentrations of 1.7 and 2.8µg/l were encountered in both samples tested.

However, on the basis that the majority of the site will be hardsurfaced, the made ground soils are predominantly underlain by impermeable cohesive strata, hence reducing surface water infiltration,

leachate generation and potential pathways, and the low environmental sensitivity of the site with regard to controlled waters, it is considered that the marginally elevated concentrations of leachable PAH and phenol detected are unlikely to pose a significant risk to controlled waters and are therefore not considered further.

7.4. Groundwater Analysis

Groundwater analytical data have been evaluated against GAC values appropriate to the conceptual model for the site, based on the Drinking Water Standards. Source data for all GACs are provided in Appendix E.

The analytical results for groundwater samples and the outcome of screening are summarised in Table 7.3. A total of four groundwater samples were tested, this included three groundwater samples obtained from the monitoring wells sealed within the Secondary A Aquifer, and a sample of perched groundwater encountered within made ground soils.

Table 7.3 Summary of Groundwater Analysis

Determinand	No. of Samples Tested	No. Samples Above Limit of Detection	Range of Results (µg/l unless specified)	GAC (µg/l unless specified)	No. of Samples >GAC
Metals					
Arsenic	3	0	<1	10	0
Cadmium	3	0	<2	5	0
Chromium	3	0	<5	50	0
Lead	3	0	<4	25	0
Mercury	3	0	<0.05	1	0
Selenium	3	0	<3	10	0
Copper	3	0	<2	2000	0
Nickel	3	0	<10	20	0
Zinc	3	3	30 - 32	5000	0
Inorganics					
Sulphate	3	3	180 – 320mg/l	250mg/l	1
Ammonium (as NH ₄ ⁺)	3	3	309 - 604	500	1
Organics					
Total TPH	4	2	<10 - 55	10	2
Naphthalene	3	2	<0.01 – 0.36	10	0
Benzo(a)pyrene	3	1	<0.01 – 0.01	0.01	0
Benzo(b)fluoranthene	3	1	<0.01 – 0.02	0.1	0
Benzo(k)fluoranthene	3	0	<0.01	0.1	0
Benzo(ghi)perylene	3	0	<0.01	0.1	0

Determinand	No. of Samples Tested	No. Samples Above Limit of Detection	Range of Results (µg/l unless specified)	GAC (µg/l unless specified)	No. of Samples >GAC
Indeno(1,2,3-cd)pyrene	3	0	<0.01	0.1	0
Sum PAH-4	3	1	<0.04 – 0.05	0.1	0
Phenol	3	0	<0.5	0.5	0
Others					
Electrical Conductivity	3	3	947 – 1400	2500 µS/cm	0
pH	3	NA	6.9 – 7.0	6-9 pH units	0

Based on Water Supply (Water Quality) Regulations 2001 and 2007, where available.

Metals and Metalloids

No metals recorded concentrations above the relevant GAC.

Other Inorganic Analytes

Locally elevated concentrations of sulphate (320mg/l) and ammonium (604µg/l) were recorded in the natural groundwater obtained from RO2.

Organics

A total TPH concentration of 27 and 55µg/l, above an adopted GAC of 10µg/l, was detected within a sample of perched groundwater and natural groundwater obtained from TP4 and RO1, respectively. Speciation of the TPH detected within the perched and natural groundwater samples indicate PRO (C₆ - C₁₀) concentrations of <1µg/l, DRO (C₁₀ - C₂₁) concentrations of 19 and 52µg/l, and Mineral Oil (>C₂₁) concentrations of 8 and 2µg/l, respectively.

No other organics recorded concentrations above the relevant GAC.

8. REVISED CONCEPTUAL MODEL AND GENERIC QUANTITATIVE RISK ASSESSMENT OF POLLUTANT LINKAGES

The preliminary combined conceptual site model and conceptual exposure model has been revised in light of this ground investigation and the chemical analysis results presented above.

The revised conceptual model has been developed for the proposed future land-use (commercial). This summarises the understanding of surface and sub-surface features, the potential contaminant sources, transport pathways and receptors.

The revised conceptual model is presented in schematic form in Appendix A, as Drawing No. C4013/06.

8.1. Summary of Identified Pollutant Linkages

In summary, the revised CSM has identified the following potential pollutant linkages which could result in an unacceptable risk to the proposed end-use, denoted as a moderate or higher likelihood on the CSM:

- Ingestion and dermal contact with benzo(a)pyrene in made ground soils.
- Possible asbestos containing materials (ACMs) within the demolition rubble stockpile.
- Locally marginally elevated concentrations of TPH, sulphate and ammonium detected within the shallow groundwater, both within made ground soils and natural strata, posing a potential risk to controlled waters, namely the underlying Secondary A Aquifer.
- Risk from hazardous gas sources, located both on and off site, associated with areas of deep made ground (namely the infilled reservoirs), alluvial deposits, and mines gas associated with the underlying Middle Coal Measures strata.

It should be noted that the revised conceptual site model does not take into consideration areas that were inaccessible during the Phase 1 intrusive works (namely the central area). The revised CSM detailed above should be amended following completion of the further intrusive ground investigation (post completion of the demolition works).

9. CONCLUSIONS AND RECOMMENDATIONS

9.1. General

This geoenvironmental appraisal has been undertaken for land off Peel Street, Barnsley.

It is understood that Lidl are in the process of redeveloping the property with two commercial units within the east of the site, associated car parking within the west, together with peripheral areas of soft landscaping. It is understood that one of the units (Unit 1), located in the south eastern area of the site will be occupied by Lidl, while the other proposed unit (Unit 2), located in the north eastern area, will be occupied by another party.

A proposed development layout plan (Humphreys Teal Partnership Drawing No. 747.19, rev. D, dated December 2010) was provided to Sirius by Lidl, and is presented as Drawing No. C4013/02, within Appendix A to this report.

It has been assumed in the production of this report that the site is to be redeveloped for a commercial end use. In addition, it has been assumed that ground levels will not change significantly from those described in this report. If this is not the case, amendments to the interpretation and conclusions in this report may be required.

Due to access restrictions associated with demolition works being undertaken at the site, the ground investigation works are to be undertaken in a phased approach. This phase of work comprised an initial stage of intrusive works (Phase 1) within areas accessible during the demolition works. A second phase of infill intrusive works is to be undertaken at a later date following completion of demolition works, when access to previously restricted areas will be available. The conclusions/recommendations given below may need to be revised/amended following completion of the further ground investigation (post demolition).

9.2. Flood Risk

According to the GroundSure Report, obtained as part of the previous Sirius desk study report (Report Ref: C3457), and the Environment Agency website, the site is not located in a fluvial indicative floodplain.

It is understood from information provided by Lidl that a redundant culvert is located beneath the site. It is advised that clarification be sought from the relevant drainage authority with regards the

status (live or dead) and location of the culvert and implication it may have to the proposed development.

The following recommendations assume that drainage easement will not affect the proposed development.

9.3. Geotechnical

Mining and Quarrying

Review of the BGS plans of the area indicate that the Kent's Thick and Kent's Thin coal seams outcrop, striking approximately north east/south west, within the central and south eastern areas of the site, respectively. The Kent's Thick and Kent's Thin coal seams are recorded to dip 5° to the south east, and to be between 0.91m and 1.22m, and 0.24m and 0.76m thick, respectively, with the Kent's Thin overlying the Kent's Thick by approximately 26m.

The rotary probeholes drilled as part of this intrusive investigation have identified an intact seam of coal, up to 2.30m thick, at depths of between 6.70m bgl in the north eastern area of the site and 14.50m bgl in the eastern area. This coal seam is considered likely to be representative of the Kent's Thick. Triangulation of the borehole data (assuming that the exploratory holes are positioned at the same elevation (m AOD)), indicates that the coal seam dips approximately 13° to the south east; suggesting that the coal seam may outcrop within the central area of the site. Due to access restrictions, this part of the site is yet to be investigated.

The Kent's Thin coal seam is shown on the BGS plans to outcrop within the south eastern area of the site. However, this seam has not been encountered as part of this intrusive investigation and it is assumed to outcrop further to the east of the site.

For typical Coal Measures bedrock, it is generally accepted that there is a risk of surface instability where the thickness of competent bedrock above the worked coal seam is less than 10x the seam thickness. Based on a maximum recorded seam thickness of 2.30m, a minimum rock cover of 23m would be required above the Kent's Thick in order to mitigate the potential for surface subsidence. The ground investigation has confirmed that insufficient rock cover exists and there is a risk of surface instability across the site.

Although no evidence of historic mining (broken ground/voids) was recorded, it is considered that the coal seam encountered is of a workable thickness, and the possibility that "pillars" were encountered during fieldwork cannot be discounted at this stage. It is therefore recommended that

the building footprint be proof drilled to confirm whether “pillars” were encountered, and to establish the need for ground stabilisation, i.e. drilling and pressure grouting.

No quarrying activities are known to have taken place on site; however, shallow pits cannot be discounted, nor can bell pits and or crop workings to/of shallow coal seams. Further trial pitting as part of the Phase 2 intrusive investigation is recommended within the central area of the site in order to confirm the presence/absence of the conjectured outcrop of the Kent's Thick seam.

No mine entries are known to exist on the site. However, the possibility of encountering unrecorded mine entries should not be discounted. It is recommended that all excavations are examined for evidence of mine entries. If a mine entry is suspected, advice should be sought immediately from a suitably qualified engineer.

Foundations

The recommendations below assume that mining will not affect surface stability. If this is not proven to be the case modification to foundation design may be required.

Given the variable ground profile encountered during this intrusive investigation, the proposed foundations for each of the commercial units, are discussed separately below.

Commercial Unit 1 (south eastern part of the site)

Beneath the footprint of the proposed commercial property (Unit 1) located within the south eastern area of the site, made ground ranging between 0.50m and >2.45m thick was encountered, and was generally seen to become thicker towards the north west. Within TP3, located in the north western area of the proposed footprint of Unit 1, the made ground was found to be underlain by soft, organic alluvial clay to a depth of 3.60m bgl. In addition the depth to rockhead was found to vary from 0.50m bgl in WS2 and WS3 to >3.80m bgl in TP3.

The made ground and soft, organic alluvial soils are considered unsuitable to support foundations in their present condition due to variability in strength, consistency and content. In addition, the geotechnical properties of residual soils and rock are different: a characteristic which could lead to differential settlements.

It is therefore recommended that structural loads are supported upon a competent and consistent stratum, in this case the Middle Coal Measures bedrock (MCM).

In the east and much of the central part of the unit, rockhead is sufficiently shallow to allow structural loads to be supported upon spread foundations such as strips or pads.

The load that can be applied to a foundation is dependent on its shape and size. However, by way of example, for a 1m square pad founded on shallow MCM bedrock (Class B 'partially weathered') at 0.90m bgl, a design load of 200kN could be assumed.

It is recommended a foundation schedule is completed once building foundation arrangements are known. In light of the nature of mudstone rock, which is generally weak and closely fractured, characteristics which are proportional to the load bearing capacity of the rock, it is recommended that a qualified engineer/engineering geologist inspects the formation to assess the weathering grade of the mudstone prior to casting the foundation.

Towards the western part of the unit, this investigation indicates competent strata at depths of >2.45m bgl (WS1). In this case it may be possible to consider a trench fill/mass concrete pier solution. However, the actual depth to bedrock is not proven. Consequently it may be prudent to utilise a piled foundation solution within this part of the unit.

Consideration must be given to abnormal costs associated with the removal and off site disposal of potentially contaminated arisings generated by foundation construction. This is likely to be greater where excavations for spread foundations are proposed.

Commercial Unit 2 (northern eastern part of the site)

Within the footprint of the proposed commercial property (Unit 2) located within the north eastern area of the site, made ground was encountered to depths of between 2.20m and >3.40m bgl, which in turn was underlain by soft and firm, generally low strength organic alluvial soils to a maximum depth of 5.15m bgl. The alluvial deposits were found to be underlain by residual Middle Coal Measures strata, described as firm and stiff, high strength clay, in WS4 and WS5.

The made ground and alluvial soils are considered unsuitable to support foundations due to the potential for excessive total and differential settlements and potentially low bearing resistance. Subsequently, owing to the excessive thicknesses of made ground and organic alluvial soils encountered across the majority of the proposed footprint of Unit 2, it is considered that foundations should therefore be extended through these soils to bear into the underlying competent strata, in particular Middle Coal Measures strata via end-bearing piles.

The design of the piles (for both unit 1 and 2) should be undertaken by a specialist contractor, using information obtained during this site investigation. Allowance should be made for potential obstructions in the fill where the full thickness of made ground is not re-engineered, and where buried structures may exist (i.e. former relic foundations/structures and the redundant culvert).

It should be noted that the very soft, low strength nature of the cohesive alluvial soils are likely to be considered unsuitable for effective treatment by ground improvement techniques, as lateral

migration of stone within the very soft clay/silt may occur. Consequently vibro-improvement techniques are discounted for supporting structural loads on this site.

If shallow abandoned mine workings are proven, they will be required to be drilled and pressure grouted. Foundation design will thus be subject to the thickness of competent cover above the treated workings. It is likely that if workings are proven, piles will need to be extended through the treated seam over some, if not all of the building footprint.

It must be ensured that piles do not introduce any preferential pathways for the migration of contaminants and the guidance given in the Environment Agency document 'Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention' should be followed and discussed with the Environment Agency prior to undertaking any piling operations.

The south eastern site boundary is formed by a sandstone block retaining wall, approximately 7m high, which retains Pitt Street. It would appear that in parts a reinforced concrete wall has been constructed against the original sandstone block retaining wall, in order to reinforce and stabilise the original structure. Where the original sandstone block retaining wall is exposed, spalling is evident locally with some sandstone blocks missing. It is recommended that a structural assessment of the existing retaining walls, forming the south eastern site boundary, be undertaken by a suitably qualified engineer.

Floors

Given the depth of the made ground encountered across the site and the presence of soft organic alluvial deposits, it is recommended that a fully suspended floor slab is adopted.

Sulphate Attack

With regard to the made ground and residual MCM strata, a Design Sulphate Class of DS-1 and an ACEC Class of AC-1 should be used for buried concrete structures, based on brownfield site designation and mobile groundwater conditions.

For buried concrete in contact with the alluvial soils a Design Sulphate Class of DS-2 and an ACEC Class of AC-2 should be used, based on brownfield site designation and mobile groundwater conditions.

Groundworks/Earthworks, Excavation Stability and Groundwater Dewatering

Excavation should be suitable for standard plant although the use of hydraulic or pneumatic breakers would be required for excavations extending into rock, and where existing foundations or other buried structures/obstructions are encountered.

Shallow excavations through the made ground should be assumed to be unstable and an allowance should be made for suitable temporary shoring. No man entry into unsupported excavations should be allowed without an appropriate risk assessment. Reference to CIRIA 97 Trenching Practice should be made to establish suitable means of support or battering of excavation sides during construction.

Based on the results of this investigation, groundwater seepages or minor inflows within shallow excavations (<2m) should be anticipated. It should be possible to deal with these seepages through normal site pumping practices for any shallow excavations open for short periods of time.

It is recommended that an adequate drainage system for surface water be installed by a competent contractor in order to prevent surface water ponding or collecting both during and post construction, as this may lead to deterioration of the founding stratum.

It is recommended that in order to reduce the possibility of softening or swelling of cohesive soils at the base of excavations/trenches, it should be suitably blinded with concrete.

Pavements and Highways

Based on a visual examination of the made ground and alluvial deposits, and Atterberg Limit determinations undertaken on the cohesive alluvial deposits, a preliminary CBR value of <2.5% is recommended for these materials. Highways Agency document HD25 Interim Advice Note 73/06 Revision 1 (2009) states that where a subgrade has a CBR lower than 2.5%, it is considered unsuitable support for a pavement foundation since it would tend to deform under construction traffic, and must be improved.

It is recommended that in-situ CBR testing is carried out following completion of the demolition package when final site levels will be known.

9.4. Asbestos-Containing Materials

Asbestos-containing materials were not observed within the soils encountered during this investigation. However, asbestos sheeting, used as shuttering, and/or fragments of asbestos-

containing materials within made ground or fill materials beneath concrete slabs cannot be entirely discounted.

In addition, a stockpile of demolition rubble is located on site which is to be recycled to form engineering fill materials. It is assumed that this material will be placed under future hardstand. However, if this is not the case and the material is to be left <1m below finished ground level in proposed soft landscaped areas, laboratory screening will be required to confirm that asbestos fibres are not present.

9.5. Soil and Groundwater Contamination

Risk Evaluation for the Proposed Land Use (commercial)

The revised conceptual site model confirms pollutant linkages may exist for end users, construction workers and controlled waters. Pollutant linkages assessed as a Low or Negligible risk are not considered significant or requiring remedial action, and are not considered further.

Human Health Receptors

Marginally elevated concentrations of benzo(a)pyrene were recorded in samples of made ground containing ash and clinker. These soils are considered to pose a potential risk to site end users in soft landscape areas only and require remedial action, as discussed below.

The risk to end users with regards to hazardous gas is discussed below.

Controlled Waters Receptors

Aromatic TPH within the diesel range (C₁₀ – C₃₅) was detected within groundwater samples obtained from RO1, sealed within natural strata of the Middle Coal Measures (Secondary A aquifer) and TP4, taken from perched groundwater within made ground soils.

In addition, locally marginally elevated concentrations of sulphate and ammonium were also recorded within the natural groundwater.

No significant sources of organic and inorganic contamination have been identified within the made ground and shallow natural soils during the Sirius site investigation and it is considered that the elevated concentration of TPH detected may be due to historical on-site and/or off-site activities.

Given the localised distribution and low concentrations of the determinands detected in the groundwater encountered, these components are considered to pose a **low** risk to controlled

waters and do not require remedial action. This conclusion may need to be revised if, during further site investigation works or enabling works, any visual/olfactory evidence of significant hydrocarbon contamination is detected.

Ecological Receptors

No potential pollutant linkages to ecological receptors have been identified for the site.

Utilities

It is recommended that the results of the chemical testing and details of the proposed remedial works are provided to the appropriate utility companies to determine the necessity for service protection.

Construction and Maintenance Workers

Contamination may pose a short-term (acute) or long-term (chronic) risk to workers during construction and maintenance. The potential risks must be specifically assessed as part of the health and safety evaluation for the works to be performed in accordance with prevailing legislation. Site practices must conform to the specific legislative requirements and follow appropriate guidance (e.g., HSE, 1991; CIRIA, 1996).

Outline Remediation Requirements

In view of the locally slightly elevated concentrations of benzo(a)pyrene within the made ground, it is considered that should the material be placed under areas of proposed hardstanding (whether it be buildings or car parking/roadways) no further remedial action is considered necessary to protect end users from direct contact with the identified contamination.

Where made ground is left in place in areas of soft landscaping, a subsoil/topsoil “cap” will be required to provide a suitable growing medium for shallow rooted plants; a capping thickness of 450mm is suggested, subject to regulatory approval. Deep rooted plants will need to be potted in a suitable depth of clean inert fill. It is recommended that a clean cap specification be agreed with the local authority before development begins.

It is possible that areas of more significant contamination not identified to date may be encountered onsite during redevelopment. If any areas of noxious odorous, brightly coloured, fibrous, liquid etc contamination are encountered further advice should be sought from a suitably qualified consultant. A contingency for removal/treatment of possible contamination should be included.

If more heavily contaminated groundwater than encountered during the ground investigation is observed during the enabling works, treatment or disposal from site should be considered.

The above recommendations comprise a general outline of possible or likely works. A separate remediation strategy report may be required by the regulators.

9.6. Ground Gas

Gas monitoring undertaken to date (one visit) has revealed no/low detectable concentrations of methane and carbon dioxide, coupled with no positive gas emission rates.

Based on the results of the initial gas monitoring visit, a worst case gas screening value (GSV) of 0.0023l/hr has been calculated for carbon dioxide.

Based on the monitoring data obtained to date, the ground gas regime for the proposed retail units has been provisionally assessed as Characteristic Situation (CS) 1, based on Situation A presented in CIRIA C665.

This interim categorisation indicates that, at this stage, no special precautions with regard to ground gas protection are required for the proposed development.

However, areas of deep made ground and organic, alluvial deposits were encountered on site during the intrusive works, and in addition the possibility of mines' gas associated with the underlying Middle Coal Measures strata, cannot be ruled out at this stage. Consequently, at this stage, it may be necessary to make an allowance for gas protection measures to be increased from CS 1 to CS 2.

A further three gas/groundwater monitoring visits are required prior to finalising gas protective measures. The full results will be issued as an addendum letter on completion of the monitoring programme.

Significant VOC concentrations were not detected in the ground gas. Therefore, based on the monitoring results to date, specific protective measures with regard to VOCs are not currently anticipated.

The above assessments should be regarded as interim only, pending completion of the gas monitoring programme.

Radon protection measures are not required for the proposed development on this site.

9.7. Invasive Plants

Invasive plant species were not observed on this site at the time of investigation.

9.8. Disposal of Soils

Any materials removed from site should be undertaken in accordance with the Duty of Care Regulations 1991. There will also be a requirement to classify the waste in accordance with the European Waste Catalogue. The waste should also be subject to Waste Acceptance Criteria (WAC) testing. In light of the new regulations it is recommended that discussion with landfill operators takes place at an early stage.

10. FURTHER WORKS/REGULATORY APPROVALS

The conclusions and recommendations presented above are considered reasonable based on the findings of the site investigation. However, these cannot be guaranteed to gain regulatory approval and, therefore, the report should be passed to the appropriate regulatory authorities and/or other organisations for their comment and approval prior to undertaking any works on site.

Following the completion of the demolition works at the site, it is recommended that an 'infill' intrusive investigation (Phase 2) be undertaken within previously inaccessible areas, namely the central area of the site where the stockpile of the demolition material is currently located. It is anticipated that this will comprise one day's trial pitting to investigate shallow ground conditions and the presence/absence of the Kent's Thick coal seam at shallow depth, which is conjectured to outcrop in this part of the site.

It is also recommended that the building footprint be proof drilled as part of the enabling works to confirm whether "pillars" were encountered as part of the previous intrusive investigation, and the need for ground stabilisation.



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16th June 2011

Ref. C4013/JW/4449

Dear Wayne

Re: Peel Street, Barnsley – Phase 2 “Infill” Ground Investigation / Mining Risk Assessment

1. Background

Sirius Geotechnical and Environmental Ltd (Sirius) were commissioned by Lidl UK GmbH (Lidl) to undertake a geoenvironmental appraisal of land off Peel Street, Barnsley (the “site”).

It is understood that Lidl are proposing to redevelop the site with two commercial units within the eastern area, associated car parking within the western area, and peripheral areas of soft landscaping, as shown on Humphreys Teal Partnership Drawing No. 747.19, rev D, dated December 2010. It is understood that one of the units (Unit 1), located in the south eastern area of the site will be occupied by Lidl, while the other proposed unit (Unit 2), located in the north eastern area, will be occupied by another party.

Sirius have previously completed a preliminary appraisal report (desk study) for the site (report ref. C3547, dated October 2009), on behalf of Opus Land (North) Ltd. It is understood that this report has subsequently been reassigned to Lidl. The desk study included an assessment of information provided by GroundSure Ltd, the British Geological Survey (BGS), the Coal Authority (CA) and the Environment Agency (EA).

Based on the findings of the desk study, an intrusive investigation was scoped and subsequently undertaken by Sirius.

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INVESTOR IN PEOPLE



At the time of this ground investigation, demolition/clearance works of an existing property were ongoing at the site. As such the central area of the property was occupied by a large stockpile of demolition rubble. Consequently the intrusive investigation has been undertaken in a phased approach, with the initial phase of intrusive works (Phase 1) undertaken pre-completion of the demolition works. In light of this, the Phase 1 intrusive investigation was restricted to the eastern and western parts of the site.

The Phase 1 Geoenvironmental Appraisal (Sirius Report Ref: C4013) was issued in February 2011, and included a discussion of the findings of the investigation, and provided foundation recommendations, and advice on contamination remediation measures (soils, water and gas).

The above referenced report recommended that an 'infill' intrusive investigation (Phase 2) be undertaken within previously inaccessible areas (namely the central area of the site where the stockpile of the demolition material was formerly located). It was also recommended that the building footprint be proof drilled as part of the enabling works to confirm the presence/absence of mine workings beneath the proposed buildings and the need for ground stabilisation.

This letter report presents the second phase of intrusive ground investigation works undertaken following completion of the demolition works, when access to previously restricted areas (principally the central area of the site) was available, and incorporates the further mine workings investigation.

This report should be read in conjunction with the Sirius desk study report, which contains the environmental setting and initial conceptual site model (CSM) from which the investigation rationale was derived, and the Phase 1 Geoenvironmental Appraisal Report.

2. Mining Investigation

During the Phase 1 site investigation works, a coal seam, recorded to be between 2.00m and 2.30m thick, was encountered at depths of between 6.70m (RO2) and 14.50m bgl (RO3), within rotary probeholes drilled beneath the footprint of the proposed retail units. The coal seam was considered to be representative of the Kent's Thick.

While no workings were encountered during the Phase 1 investigation works, the seam was considered to be of extractable thickness and may have been subject to bell pitting and/or pillar and stall workings.

Consequently it was recommended within the Phase 1 Geoenvironmental Appraisal Report that the building footprint be proof drilled as part of the enabling



works to confirm whether "pillars" were encountered as part of the Phase 1 intrusive investigation, and the need for ground stabilisation.

Proof drilling works were undertaken by Sirius Drilling Services (SDS) and supervised by Sirius on a part-time basis.

The programme of proof drilling works was carried out as a continuous operation between 23rd and 31st March 2011.

Drilling logs were provided daily by SDS to the Sirius Engineer and are attached to this letter report along with summary sheets prepared by Sirius.

A primary 6m grid was set out across the building footprint, extending up to 3m beyond this line with all boreholes extending 1m beyond the seam. A numbering system was established prior to the works commencing. Boreholes were drilled using openhole rotary drilling techniques utilising air mist.

The layout of boreholes is shown on Drawing No. C4013/P2/01, attached to this letter report.

The depth to rockhead varied between 0.30m and 6.00m bgl across the footprint of the buildings. The depth to the top of the coal seam was recorded as being between 8.60m and 15.60m bgl and was seen to dip to the south east at approximately 7°. The thickness of the seam was recorded as varying between 1.20m and 2.20m.

The borehole records obtained from the proof drilling exercise generally concur with the findings of the Phase 1 ground investigation works.

Broken ground was encountered in one rotary borehole (I9) between 10.00m and 15.20m bgl. Additional boreholes sunk locally to the borehole on a secondary (3m) grid encountered intact coal at corresponding depths. A further borehole drilled 300mm adjacent to borehole I9 encountered intact coal between 13.90m and 15.90m bgl.

Subsequently a trial trench (TT101) was excavated in the location of I9. Made ground was encountered to a depth of 2.70m bgl. Within the western part of the trial trench stiff, slightly sandy, slightly gravelly clay was encountered beneath the made ground, while in the eastern part, slightly sandy, slightly clayey gravel of sandstone, siltstone and mudstone was recovered overlying intact sandstone rockhead. No evidence of a mine entry was encountered.

It is considered that the broken ground recorded within borehole I9 may be the result of a fracture/fault zone within the bedrock, or a previous exploratory borehole.



Boreholes were injected with grout comprising a 1:15 ratio mixture of Ordinary Portland Cement (OPC) and Pulverised Fuel Ash (PFA), respectively, with 40 to 45% water. Grout uptake within the boreholes was minimal in each case, varying between 0.16 and 0.24 tonnes.

3. Phase 2 (Infill) Ground Investigation

The investigation, which was supervised by a Sirius Geoenvironmental Engineer, took place on 8th April 2011 and comprised:

- 8 No. trial pits (TP101 to TP105, TP105A, TP106 and TP106A) to a maximum depth of 4.70m bgl.

Detailed descriptions of strata and groundwater observations made during the Phase 2 ground investigation works, together with samples recovered, are presented on the engineer's exploratory hole records attached to this letter report.

Standard strata descriptions are compliant with BS EN ISO 14688:2002 and 2004 and BS EN ISO 14689:2003. The depths of strata on the record sheets are recorded from current ground levels at each location, unless indicated otherwise.

The exploratory hole locations were based on the findings of the preliminary conceptual site model, in order to target the areas of site inaccessible during the Phase 1 ground investigation works. Procedures and principals recommended in CLR4, BS EN ISO 1997-2: 2007 and BS 10175:2001 were followed when determining exploratory hole locations.

Exploratory hole locations are shown on Drawing No. C4013/P2/02, attached to this letter report.

Selected samples (3 No.) of the soils encountered were tested for a range of potential contaminants under subcontract with Derwentside Environmental Testing Services (DETS), a UCAS and MCERTS accredited laboratory.

The potential contaminants of concern identified by the preliminary conceptual site model were selected as the analytes for the samples recovered from the site. The results of soil analysis, as received from the laboratory, are attached to this letter report.

3.1 Recorded Ground Conditions

Trial pits encountered predominantly granular fill to depths of between 1.50 and 2.60m bgl. The granular fill was generally described as sandy gravel with occasional cobbles. The gravel and cobble sized fractions were recorded to include limestone, concrete, ash, clinker, brick and wood.



In TP101 sandy slightly gravelly silt with cobble sized fragments of brick, rubber and metal waste was encountered at a depth of 1.90m bgl. The trial pit was terminated on a concrete obstruction at 2.50m bgl.

Numerous relic foundations and structures were encountered during the excavation of the trial pits. Concrete obstructions were encountered within TP101 at 2.50m bgl and in TP106 at 1.50m bgl, and subsequently did not prove the true thickness of the fill. In TP105, an obstruction was encountered at 1.80m bgl and bituminous material was recovered. The trial pit was terminated at this depth.

Alluvial soils were encountered in the majority of trial pits, with the exception of TP103 located within the southern part of the Phase 2 investigation area, to depths of between 3.40m and 4.50m bgl. These soils generally comprised soft, slightly sandy, slightly organic clays. In TP104 and TP106A, located within the northern part of the Phase 2 investigation area, very soft, silt/clay was encountered underlying the soft clay deposits.

Residual Middle Coal Measures (MCM) soils were encountered underlying the made ground soils in TP103, and beneath the alluvial deposits in TP102 and TP106A. In TP102 and TP103, the residual rock comprised firm and stiff, slightly sandy, slightly gravelly clay with the gravel fraction comprising sandstone, mudstone and coal. In TP106A slightly clayey, sandy gravel of sandstone was encountered at 4.50m bgl.

Extremely weak mudstone was encountered within TP103, located within the southern part of the Phase 2 investigation area, at 3.10m bgl.

A tarry material with a hydrocarbon odour was recorded in TP102 between 1.20m and 2.00m bgl. No other visual and/or olfactory evidence of organic contamination was noted during the fieldworks.

Made ground soils consisting of ash, clinker, bituminous material, coal, brick and concrete were encountered. These materials can often contain elevated metals and PAH.

The majority of the trial pits were recorded as being stable in the short term within both the made ground and natural deposits.

Perched groundwater was encountered within the made ground soils at 1.80m bgl in TP101, 2.00m bgl in TP103 and 2.30m bgl in TP105A.



3.2 Chemical Test Results

The results of the laboratory testing have been compared against generic assessment criterion (GAC) values. Usually statistical testing is undertaken for the Planning Scenario by the methods described in CL:AIRE & CIEH "Guidance on Comparing Soil Contamination Data with a Critical Concentration", May 2008." This statistical testing is undertaken to determine whether there was sufficient evidence that the true mean concentration of each determinand was less than the relevant critical concentration for that component.

As chemical test results relate to differing types of made ground soils, statistical assessment has not been carried out in this instance.

Results of chemical analysis as received from the laboratory are attached to this letter report.

For this site, measured values were compared to Generic Assessment Criteria (GAC) derived for a commercial / industrial end use. Source data for all GACs can be provided on request.

The chemical analysis results and screening criteria are summarised below.

Determinand	No. of Samples Tested	Range of Results (mg/kg unless specified)	GAC (1% SOM)	No. of Samples >GAC	Samples exceeding GAC
Metals					
Inorganic Arsenic	2	12 – 20	640	0	
Cadmium	2	0.6 – 0.7	230	0	
Chromium (III)	2	21 – 26	30000	0	
Lead	2	63 – 75	750	0	
Inorganic Mercury	2	0.07 – 0.17	3600	0	
Selenium	2	0.7	13000	0	
Copper	2	63 – 75	72000	0	
Nickel	2	14 – 16	1800	0	
Zinc	2	51 – 81	600000	0	
Inorganics					
pH	2	11.1 – 11.3	<5	0	
Total Sulphate	2	1300 – 1600	2400	0	
Water Sol. Sulphate	2	0.28 – 0.39	0.5 g/l	0	
Speciated PAH					
Acenaphthene	2	0.2 – 1.9	77000	0	
Anthracene	2	2.1 – 9.9	520000	0	
Acenaphthylene	2	0.4 – 3.6	77000	0	
Benzo(a)anthracene	2	5.6 – 23	91	0	
Benzo(b)fluoranthene	2	3.2 – 15	100	0	



Determinand	No. of Samples Tested	Range of Results (mg/kg unless specified)	GAC (1% SOM)	No. of Samples >GAC	Samples exceeding GAC
Benzo(k)fluoranthene	2	1.9 – 8.6	140	0	
Benzo(g,h,i)perylene	2	3.2 – 11	660	0	
Benzo(a)pyrene	2	5.3 – 23	14	1	TP102 @ 0.30m
Chrysene	2	5.3 – 21	140	0	
Dibenzo(a,h)anthracene	2	<0.1 – 2.3	13	0	
Fluoranthene	2	9.3 – 35	23000	0	
Fluorene	2	0.9 – 5.5	61000	0	
Indeno(1,2,3-cd)pyrene	2	2.7 – 12	61	0	
Naphthalene	2	<0.1 – 5.5	110	0	
Pyrene	2	6.7 – 30	54000	0	
Phenanthrene	2	50 – 230	22000	0	
TPH					
Aliphatic EC 5-6	1	<0.01	2500	0	
Aliphatic EC >6-8	1	<0.01	5500	0	
Aliphatic EC >8-10	1	<0.01	1300	0	
Aliphatic EC >10-12	1	6.5	6400	0	
Aliphatic EC >12-16	1	48	44000	0	
Aliphatic EC >16-35	1	23.1	No GAC	0	
Aromatic EC 5-7	1	<0.01	16	0	
Aromatic EC >7-8	1	<0.01	35000	0	
Aromatic EC >8-10	1	<0.01	2300	0	
Aromatic EC >10-12	1	1	11000	0	
Aromatic EC >12-16	1	47	35000	0	
Aromatic EC >16-21	1	89	28000	0	
Aromatic EC >21-35	1	110	28000	0	
Others					
Phenol	2	<0.3	3200	0	
TOC	2	0.9 – 1.1w/w%	3 w/w%	0	

Table based on a Commercial / Industrial end use.

US95 - 95th percentile estimate of the mean value; GAC -generic assessment criterion; NA - not applicable.

Metals and Metalloids

No metals recorded concentrations above the relevant GAC.