Report type:	Phase II Site Appraisal
Site:	Island Road South, Garston, Liverpool
Client:	Lovell Partnership Ltd
Client's Agent:	The Alan Johnston Partnership
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ISLAND ROAD SOUTH, GARSTON, LIVERPOOL

PHASE II SITE APPRAISAL FOR THE ALAN JOHNSTON PARTNERSHIP

Project Ref:
P6547

Date:
May 2014

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This report has been prepared in accordance with GRM's Accredited Quality Procedures

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Site Appraisal for Island Road South, Garston, Liverpool

SUMMARY OF RECOMMENDATIONS

Where further assessment is required it is indicated with a "Y" in the right hand column		
Proposed Development	Two blocks of six, 2-storey, terrace houses.	
CONTAMINATION ASSESSMENT - REMEDIATION / WASTE DISPOSAL		
End Users	Remove made ground A from beneath gardens and soft landscaped areas. Treatment of hotspots around WS1 and WS7.	
Site Workers	None required.	
Construction Materials	Possible upgrade of plastic water pipes and clean inert backfill to service trenches following consultation with water supply company.	Y
Groundwater	None required.	
Surface Water	None required.	
Waste Disposal (may include soils, asbestos, oil drums, chemical containers, etc)	Client has a duty of care to ensure that all waste is disposed appropriately to a licensed landfill. The landfill receiving the waste may request additional 'WAC' testing analysis. Waste characterisation can only be confirmed by the landfill site.	
GEOTECHNICAL ASSESSMENT – FOUNDATIONS		
Ground Treatment Required	None required.	
Main Bearing Strata	Cohesive Glacial Till.	
Nett Allowable Bearing Pressure	110kN/m^2 (Clay).	
Tree Influence	None.	
Volume Change Potential	Low to Medium – recommend medium be used for design purposes.	
Likely Foundation Types	100% Strip/Trench Fill.	
Likely Foundation Depth Range	0.9m begl minimum, 1.6m begl maximum depths; average depth 1.2m begl.	
Excavation Hazards	Remnant floorslabs, buried foundations.	
Floor Slab Types	100% voided suspended (beam and block).	
Gas Protection Requirements Radon and/or Landfill	Gas protection due to carbon dioxide. No radon protection.	
GEOTECHNICAL ASSESSMENT - GENERAL		
Slope Stability Risk	Low.	
Soakaways Potential	Not suitable.	
New Access Roads	Observational CBRs 1% to 2% in granular made ground, 2% to 4% in natural cohesive soils.	
Buried Concrete Class	DS - 3; AC- 3	
Retaining Walls	None existing, unlikely as part of proposed development.	
Other Comments		

This summary is based on the full report that provides the detailed assessment of the ground risks affecting the development and how to manage them. It should not be used in isolation.

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APPENDICES

1 INTRODUCTION

1.1 PREAMBLE

GRM Development Solutions Limited (GRM) has been appointed by The Alan Johnston Partnership (Client's Agent) on behalf of Lovell Partnership Limited (Client) to undertake a Phase II Site Appraisal. A previous desk study by GRM (Phase I Desk Study Assessment, Island Road South, Garston, Liverpool, P6547 / DS / F.1, April 2014) formed Phase I of the assessment and allowed the geotechnical and geo-environmental setting of the site to be determined and the identification of areas of particular concern that required targeted investigation. The Phase II works reported within this document comprise the intrusive ground investigation, geotechnical testing and chemical analysis. The information gained from the Phase II works will be used to refine the conceptual model for the site and determine the most cost effective development solutions for the site.

This site appraisal is intended to provide information that will assist decision making by identifying and recommending solutions to ground engineering and contamination issues.

GRM Standard Limitations of Reporting are provided in Appendix A of this report.

The Client proposes to develop the site with twelve residential properties comprising two rows of six terrace houses and associated infrastructure. The proposed end use includes gardens. The outline development proposals provided by the Client are presented in Appendix B.

The Client has informed GRM of the following potential development hazards:

- Existing hardstanding.
- Former site use as a market.
- Live services.

1.2 OBJECTIVES OF THE SITE APPRAISAL

The Client's specific requirements were to undertake a Phase II intrusive investigation in accordance with the supplied quotation.

The principal aims of the Phase II Site Appraisal are as follows:

a) Obtain information, from easily accessible sources, about the soil and groundwater conditions within the area of the site.

b) Determine the possible ground related geotechnical and contamination hazards within the site boundaries that may affect the proposed development.

c) Provide preliminary development recommendations.

d) Provide advice on further works required for the cost-effective reduction of risks to the development and procedures likely to satisfy regulators.

Whilst every effort has been made to pre-empt the likely requirements of the Local Authority and the Environment Agency, they are likely to have specific requirements that will need to be discussed and addressed at a later date.

2 PHASE I DESK STUDY DESK STUDY SUMMARY

The findings of the Phase I – Desk Study and Site Walkover have been used to formulate the site setting; the main features are summarised below. It should be noted that the following information should not be read in isolation and for full details reference should be made to the original report.

- The site is located 9km south east of Liverpool city centre. The National Grid Reference (NGR) for the approximate centre of the site is SJ406846. Site Location and Site Boundary Plans are provided in Appendix C.
- The site forms a rectangle of land, which covers an area of approximately 0.25 hectares and is surrounded on all sides by a 2m high single skin brick wall. The northern boundary is formed by the aforementioned brick wall fronting on to Island Road South, the western boundary by residential properties along Island Road South, the southern boundary by the rear gardens of residential properties along Condor Close beyond and the eastern boundary by a residential property situated at the junction of Island Road South and Horrocks Road.
- The site is first recorded to be developed in 1927 and recorded as a market in 1937. Additional structures were added to the market site, but not demolished, up to 1993 when construction ended. The OS maps still recorded the site as a market in 2012. Between 2012 and the present day all above ground structures were demolished leaving only the remnant floorslabs.
- The geology is recorded to comprise Glacial Till deposits of over a solid geology of Chester Beds Formation.
- The Environment Agency has classified the Glacial Till as non-productive strata and the Chester Beds Formation as a Principal aquifer.
- The site is not in area affected by coal mining activity.
- No significant environmental factors considered likely to have seriously impacted the site have been identified.
- The site is not in an area requiring radon gas precautions.

In summary the desk study by GRM revealed the following significant features.

Significant Features Identified:
Underground services – likely to require disconnection/diversion. Former buildings and sub-structures (remnant floorslabs) – deepened foundations, possible asbestos containing materials within building fabric. Variable strata – deepened foundations. Made ground (associated with the demolition of former structures and development of the site) – deepened foundations, potential source of contamination and ground gas. Principal aquifer – potential receptor (low risk due to anticipated overlying cohesive strata).

From this an initial conceptual model has been formulated for the site, which is presented on the following page.

2.1 PHASE I CONCEPTUAL SITE MODEL

HUMAN HEALTH			
Source	**Pathway**	**Receptor**	**Solution**
Potentially contaminated made ground associated with previous development.	Indoor and outdoor inhalation of ground gas and soil vapours, the ingestion of contaminated soil and soil dust, and dermal contact with contaminated soil and soil dust.	End users and construction workers.	Soil capping or removal of contaminated soils.
Potential ground gases (methane/ carbon dioxide) from made ground.	Inhalation.	End users.	Gas protection measures.
Potential asbestos containing materials mixed with soils following demolition of buildings.	Inhalation.	Construction workers.	Removal or burial of contaminated soils.

CONTROLLED WATERS			
Potentially contaminated made ground associated with previous development.	Leaching of contaminants and vertical migration to the groundwater.	Principal aquifer – risk reduced due to anticipated cohesive superficial strata.	Assessment of groundwater quality and, if required, subsequent risk assessment and remediation.

CONSTRUCTION MATERIALS			
Potentially contaminated made ground associated with previous development.	Migration of contamination through leaks and joints, degradation of pipe materials.	Water pipes.	Upgraded water pipes/clean backfill material.
Elevated levels of sulphate and/or acidic ground conditions.	Direct contact.	Buried concrete.	Appropriate concrete specification.

3 PHASE II GROUND INVESTIGATION

3.1 FIELDWORK

The ground investigation has been designed in accordance with the general comments outlined in Appendix A (iv).

A total of nine exploratory holes were undertaken, to a maximum depth of 3m begl. The exploratory hole location plan and exploratory hole logs are presented in Appendix D and Appendix E respectively.

The ground investigation fieldwork was conducted on 23rd April 2014 with groundwater/gas monitoring visits continuing after that period. The positioning of individual exploratory holes was designed to target the location of the former site structures and determine the presence / absence of significant thicknesses of made ground and potential substructures.

Samples not used for testing will be stored for a month after issue of this report and then disposed of, unless the client requests in writing that they be kept.

Six gas and water monitoring standpipes were installed during the site works, the rationale for these works are discussed fully in Section 5.

3.2 PROVEN GROUND

The following ground conditions were encountered during the investigation fieldwork:

- Made ground
- Glacial Till (Superficial Deposits)
- Chester Beds Formation (Solid Strata)

3.2.1 Made Ground

Various types of made ground were observed:

Made ground A generally consists of a black clayey sandy gravel of tarmacadam and was found across the site with the exception of the northern central and north western areas (WS4 and WS9), to depths of up to 0.3m begl and was generally 0.2m thick. This made ground is likely to comprise the surface cover material from previous site use.

Made ground B generally consists of a grey-brown or red-brown clayey gravelly sand of quartzite, sandstone, brick and locally concrete and was found in all areas of site, to depths of up to 0.8m begl and was generally 0.3m thick. This made ground is likely to comprise sub-base materials from former structures.

Made ground C generally consists of a black slightly gravelly sand of tarmac and building materials and was only found in the extreme eastern part of the site (WS2 and WS3), to depths of 0.6m begl and 0.7m begl respectively. This made ground is likely to comprise construction materials from former structures.

Made ground D consists of an orange-brown very gravelly sand with gravel of sandstone, limestone and concrete and was only found in WS1 located in the south eastern part of the site, to a depth of 1.45m. This made ground is likely to comprise construction materials from former structures mixed with natural soils.

Overall the made ground varied in thickness from 0.3m (WS6) to 1.45 (WS1) with an average thickness of 0.66m. The greatest thickness was recorded in the south west and generally reduced in thickness towards the north.

3.2.2 Glacial Till

These deposits were encountered across the site in all of the exploratory holes to depths of up to 3.7m begl (WS1); with the exception of WS1 all of the exploratory holes were terminated at 3m begl within the cohesive Glacial Till deposits. The material generally comprised red-brown mottled grey and locally orange-brown sandy gravelly CLAY with gravel of sandstone, quartz, quartzite and limestone. Strengths varied from locally soft to hard, but were generally firm to stiff between 1m begl and 2m begl and stiff to very stiff below 2m begl.

Granular horizons within the Glacial Till was observed in WS2 (0.6m-0.9m begl, WS3 (0.7m-0.95m begl), WS4 (0.4m-0.6m and 1.35m-2.4m begl), WS5 (0.6m-1.1m begl), WS7 (0.7m-1.4m begl) and WS8 (0.8m-1.5m begl). The material comprised grey-brown slightly gravelly clayey SAND with gravel consisting of sandstone, quartz and mudstone. Strengths within the granular horizons were generally medium dense

3.2.3 Solid Strata

In terms of geotechnical behaviour most solid strata are rocks, although some have remained as, or have become, soil (the latter as part of the weathering process). The solid strata at shallow depths beneath this site are representative of a soil (of weathered rock), becoming less weathered with depth until they are a rock. The weathered rock will have the geotechnical characteristics of a soil.

Chester Pebble Beds Formation
These deposits were only encountered in WS1 (3.7m-4m begl) located in the south east and generally comprised a weak red SANDSTONE recovered as a slightly gravelly SAND.

3.3 GROUNDWATER

Groundwater not observed in any of the exploratory holes. However, the exploratory techniques used were rapid and may have masked small water seepages.

The results of monitoring are reported in Appendix F. In summary standing water was recorded at depths of 0.81m begl to 3.1m begl.

The groundwater encountered during the investigation is considered to be from perched volumes within the Glacial Till and not representative of the regional groundwater table. The groundwater in the underlying aquifer is not likely to be in hydraulic continuity with the observed groundwater due to the presence of cohesive strata.

Long term monitoring of groundwater levels has not been conducted as part of this investigation and interpreted levels are approximate and will be dependent on seasonal variations.

It has not been possible to accurately determine the groundwater flow direction beneath the site. However, the groundwater flow is considered to be to the west following the local topography.

3.4 CONTAMINATION OBSERVATIONS

No visual or olfactory evidence of potential contamination was encountered during the fieldwork and monitoring.

3.5 GROUND GAS

Ground gases are discussed in full in Section 4, in summary no elevated concentrations of methane have been recorded, carbon dioxide of up to 6.1%v/v and oxygen as low as 13.7%v/v have been recorded. No flow was noted during the monitoring completed to date.

3.6 SUMMARY OF FIELDWORK OBSERVATIONS

The fieldwork has revealed/confirmed the following potential hazards, receptors and sources that were not identified during the desk study, but which should be included when assessing the site.

Significant Features identified during fieldwork
Made ground – source of contamination Shrinkable strata – geotechnical hazard Variable strata – geotechnical hazard

3.7 LABORATORY ANALYSES RATIONALE

3.7.1 Chemical Laboratory Analysis

Chemical laboratory analyses were selected to provide the parameters necessary to make an initial assessment of potentially contaminated soils and/or waters, for the budgetary design of the development. The choice of contamination testing was based on the Phase I assessment, identified past uses of the site and site observations. The chemical analysis comprised:

- Eight soil samples for a general suite of contaminants (metals, inorganics and speciated PAH).
- Four soil samples for banded aliphatic and aromatic hydrocarbons (TPHCWG).
- Four soils leachate samples for a general suite of contaminants.
- Eight of samples have been screened for the presence of asbestos.

pH and water soluble sulphate testing was conducted as part of the chemical analysis suite to determine how aggressive the ground and/or waters are to buried concrete.

The chemical analysis results are presented in Appendix G.

3.7.2 Geotechnical Laboratory Testing

Geotechnical soils testing has been undertaken as part of the ground investigation including the following:

- Three Atterberg Limits (PI) classification tests.
- Three pH and water soluble sulphate testing.

Geotechnical tests were selected to provide the parameters necessary for the budgetary design of the development including foundations and infrastructure. The geotechnical test results are presented in Appendix H.

4 QUANTITATIVE RISK ASSESSMENT – HUMAN HEALTH (GROUND GAS)

The gas risk assessment methodology used by GRM is outlined in Appendix A (v).

As the proposed land use is classed as high (residential with gardens) sensitivity, five number gas/water monitoring standpipes have been installed across the site (WS1, WS3, WS4, WS8 and WS9). The 35mm standpipes have been installed in window sampling boreholes.

As the gas hazard is considered very low (limited made ground) the monitoring programme will comprise six visits over three months. Therefore, only an initial assessment of the local gas regime has been undertaken at this stage and further visits will be required to complete the monitoring program. A separate gas addendum letter report will be issued following the completion of the full monitoring program.

The gas monitoring has been undertaken using a LMSxi Multifunction Gas Analyser. The gas monitoring results to date, are presented in Appendix F. In summary, no elevated methane concentrations have been recorded, carbon dioxide of up to 6.1%v/v and oxygen as low as 13.7%v/v have been recorded. No flow was noted during the monitoring completed to date

The results suggest that locally slightly elevated concentrations of carbon dioxide are being generated probably by made ground materials. No obvious deleterious material was noted within the made ground and only in WS1 was the made ground observed to exceed 1m in thickness.

For this site, as the development is residential and is likely to include a number of different floor types, the risk from ground gases has been assessed using both ‘Situation A’ and ‘Situation B’.

Using the default borehole flow rate of 0.1l/hr and the maximum carbon dioxide concentration of 6.1%v/v, a GSV of 0.0061l/hr has been calculated for carbon dioxide. No elevated concentrations of methane have been recorded. Therefore, the site has been assessed as ‘Characteristic Situation 1’ or ‘Traffic Light Green’ as outlined CIRIA C665. However, because the level of carbon dioxide is above 5% consideration should be increasing the level of protection to that of ‘Characteristic Situation 2’ or ‘Traffic Light Amber 1’.

Therefore, it is considered that gas protection measures are required for the proposed development; these should comprise:

- Reinforced cast in situ floor slab (suspended, ground bearing or raft), low permeability gas membrane, under floor venting (pipes) and sealed joints/service entries.

OR

- Pre-cast (beam and block) concrete floor, low permeability gas membrane, underfloor venting and sealed joints/service entries.

In addition to the above recommendations all gas protection measures should be designed in accordance with BS8485 'Code of practice for the characterisation and remediation from ground gas affected developments'.

The desk study risk assessment determined that no radon protection measures are required. Observations during fieldwork confirm that this assessment does not need be altered.

5 QUANTITATIVE RISK ASSESSMENT – HUMAN HEALTH (SOIL)

5.1 INTRODUCTION

The proposed development comprises twelve residential properties including two rows of six terrace houses and associated infrastructure.

Various sources of contamination have been put forward in earlier text and summarised in the Phase I conceptual model. The material on site identified as being the most likely to be contaminated is the made ground.

Representative samples of all strata and those considered to be potentially contaminated by virtue of the desk study and/or based on site observations were collected for further examination and/or potential testing.

The rationale for the end use specific SGV/TAC used by GRM is outlined in Appendix A (vi) for this site the chemical analysis results are being compared against the TAC for residential end use with plant uptake with a Soil Organic Matter content of 6%.

5.2 RISK TO END USERS

The chemical analysis results are presented in Appendix G.

Statistical analysis in accordance with the principles outlined in the CIEH document *Guidance on Soil Contamination Data with a Critical Concentration* (May 2008) has been used to assess the chemical analysis test results; the accompanying reports are presented in Appendix I.

Five samples of made ground type B were selected for chemical analysis as this was the material with the widest distribution and statistical analysis has been carried out on the data set. A single sample of made ground A was also analysed to better determine the risk posed to end users from this material.

5.2.1 Analysis of Soil Contamination Data – Made Ground B

Statistical analysis of the chemical assessment data reports that the true mean value of potential contaminants of concern, with the exception of benzo(a)pyrene, are below their respective SGV/TACs.

The 95% upper confidence limit (UCL) of the true mean of benzo(a)pyrene concentrations present in the shallow soils at the site is 3.35mg/kg against the SGV/TAC of 1.0mg/kg. However, this is considered to be due to a hotspot around WS7 of 4.3mg/kg. Removal of the outlier shows that the true mean reduces to below 0.3g/kg.

It is considered that the elevated concentration of benzo(a)pyrene in WS7 is a result of tarmacadam within the sample. Limited remedial works with respect to benzo(a)pyrene contamination are considered to be necessary.

5.2.2 Analysis of Other Contamination Data

The single sample of made ground A from WS1 (0.1m) was submitted for chemical analysis and the results compared directly against the TAC for residential end use with plant uptake with a Soil Organic Matter content of 6%.

Nearly of the contaminants tested for were below the relevant TAC with the exception of:

- Benzo(a)anthracene of 30.6mg/kg exceeds the TAC of 5.9mg/kg.
- Bezo(a)pyrene of 40.9mg/kg exceeds the TAC of 1mg/kg.
- Benzo(b)fluoranthene of 46.4mg/kg exceeds the TAC of 7mg/kg.
- Benzo(k)fluoranthene of 16.6mg/kg exceeds the TAC of 10mg/kg.
- Chrysene of 26.3mg/kg exceeds the TAC of 9.3mg/kg.
- Dibenzo(a,h)anthracene of 5.1mg/kg exceeds the TAC of 0.9mg/kg.
- Indeno(1,2,3,-cd)pyrene of 32.4mg/kg exceeds the TAC of 4.2mg/kg.

The elevated PAH results are considered likely to be the result of tarmacadam fragments within the sample. Remediation of made ground A will be required to protect end users.

5.2.3 Analysis of Petroleum Hydrocarbon Contamination Data

No evidence of petroleum hydrocarbon contamination was observed in exploratory holes. However, four samples of the shallow made ground materials were tested for banded TPH so that the risk to end users could be assessed.

The sample analysis did not reveal elevated concentrations of petroleum hydrocarbons in excess of the relevant TAC. It is therefore considered that the identified petroleum hydrocarbon contamination does not pose a risk to end-users.

5.2.4 Analysis of Asbestos Contamination Data

No evidence of asbestos was observed during the fieldworks. However, with cognisance of the sites history of development eight samples of the made ground were submitted for an asbestos screen. None of the samples reported the presence of asbestos.

Accordingly, the risk posed to end users from asbestos is assessed as negligible and no remediation is required.

5.2.5 Summary of Risk to End Users

In summary the risk to end users from soil contamination is considered to be low to moderate.

As outlined in Section 4 there is considered to be a moderate risk to end users from carbon dioxide.

5.3 RISK TO SITE WORKERS

The investigation has not revealed any specific risk to site workers; however, the general comments outlined in Appendix A (vii) should be considered when site specific risk assessments are completed.

6 QUANTITATIVE RISK ASSESSMENT - CONTROLLED WATERS

The methodology, rationale and guidance GRM have used to assess the risk to controlled waters is set out in Appendix A (viii).

6.1 ASSESSMENT OF THE CHEMICAL ANALYSIS RESULTS

The results of the soil leachate are presented in Appendix G; these have been compared against the UKDWS values presented in Appendix J.

Recorded concentrations of almost all contaminants are below the relevant threshold; however, the following were recorded at levels in excess of the relevant UKDWS values:

- Arsenic - Recorded concentration of 18µg/l in WS3 at 0.2m exceeds the UKDWS of 10µg/l.
- Phenols – Recorded concentrations of 1.7µg/l in WS3 at 0.2m, 6.3µg/l in WS5 at 0.3m and 1.4µg/l in WS8 at 0.4m exceed the UKDWS of 0.5µg/l.

Elevated concentrations of arsenic and phenols were not reported in the soil results. In addition, the underlying geology (Glacial Till) is considered likely to be predominately cohesive in nature and so it is considered highly unlikely that a clearly identifiable and consistent pathway between the site and the Principal aquifer (Chester Pebble Beds Formation).

6.2 SUMMARY OF RISK TO CONTROLLED WATERS

The risk to the aquifer below the site is low.

No viable surface water receptors have been identified.

7 QUANTITATIVE RISK ASSESSMENT - CONSTRUCTION MATERIALS

The methodology, rationale and guidance GRM have used to assess the risk to construction materials is set out in Appendix A (ix).

7.1 WATER SUPPLY PIPES

Generally the recorded concentrations of organic contaminants do not exceed the acceptable levels listed in the UKWIR Documentation (extract included in Appendix J). Elevated concentrations of C12-C35 were recorded in the shallow made ground material around WS1. However as previously reported in section 5.2.2, the elevated concentrations are likely to be a result of tarmacadam fragments within the sample. Following the removal of the shallow made ground materials, recommended to protect end users, standard PE/PVC pipes in clean inert backfill will be suitable.

The local utility should be contacted to determine its exact requirements in respect of the levels of contamination encountered.

7.2 BURIED CONCRETE

Based on the recorded water soluble sulphate and pH levels in the soils below the site and assuming mobile groundwater conditions, in accordance with requirements of BRE Special Digest 1 (2005), 'Concrete in Aggressive Ground', the Design Sulphate Class for buried concrete at the site should be assumed as DS-3 and the ACEC Class as AC-3.

For unreinforced trench-fill foundations with a width of greater than 450mm, the classifications above equate to a concrete designated as GEN1 in BS8500 and RC35 for reinforced foundations.

The results of the water soluble sulphate and pH testing of are presented in Appendices G and H.

8 PHASE II CONCEPTUAL MODEL

8.1 SOURCE – PATHWAY – RECEPTOR

The intrusive investigation has revealed that the single sample of made ground A material was contaminated with PAH's. As made ground A was encountered across the site the contamination is considered to be pervasive, although the contamination is likely to be a result of tarmacadam fragments in the sample. A hotspot of benzo(a)pyrene contamination has been reported in WS7 at 0.4m begl. Gas monitoring and has been undertaken and elevated concentrations of carbon dioxide has been recorded.

Development proposals have been confirmed as two rows of six 2-storey terrace houses with areas of hardstanding (e.g. car parking) and domestic gardens.

The primary human health receptors are end users of the completed development and construction workers. The pathways of concern include dermal contact with contaminated soil and soil dust, the ingestion of contaminated soil and soil dust, ingestion of vegetables that have taken up the contamination, indoor and outdoor inhalation of ground gas and soil vapours.

For controlled waters, the primary receptor for the site has been confirmed as the underlying Principal aquifer (Chester Pebble Beds Formation). The presence of perched groundwater has been confirmed. Soil leachate test results confirm contamination (arsenic and phenols) of the shallow made ground B material.

Predominantly clay soils below the site should prevent the migration of contaminants to the Principal aquifer.

The concentrations of petroleum hydrocarbons present in made ground deposits do not generally exceed the thresholds for plastic water pipes and following the removal of the made ground A material plastic water pipes are anticipated, depending on the local water authority's specific criteria, to be appropriate. Specifications for buried concrete have been made in light of the reported pH and water soluble sulphate concentrations.

Considering the above, it is considered that the site poses a low to moderate risk to end users and construction materials and a low risk to controlled waters.

The pollutant linkage model is illustrated on the following page.

8.2 PHASE II CONCEPTUAL SITE MODEL

HUMAN HEALTH			
Source	**Pathway**	**Receptor**	**Solution**
Elevated PAH's in made ground A. Hotspot of benzo(a)pyrene in WS7 (made ground B).	Indoor and outdoor inhalation of ground gas and soil vapours, the ingestion of contaminated soil and soil dust, and dermal contact with contaminated soil and soil dust.	End users and construction workers.	Removal of made ground A. Removal of hotspot around WS7. Importation of topsoil.
Elevated levels of carbon dioxide.	Inhalation.	End users.	Gas protection measures.

CONTROLLED WATERS			
Slightly elevated arsenic and phenols.	Leaching of contaminants and vertical migration to the groundwater. Risk reduced due to largely cohesive strata.	Principal aquifer.	None considered to be required.

CONSTRUCTION MATERIALS			
Hotspot of elevated petroleum hydrocarbons in WS1 (made ground A).	Migration of contamination through leaks and joints, degradation of pipe materials.	Water pipes.	Removal of contamination hotspot.
Elevated levels of sulphate.	Direct contact.	Buried concrete.	Appropriate concrete specification.

9 REMEDIATION

9.1 RECOMMENDED RISK REDUCTION AND REMEDIAL MEASURES

9.1.1 Protection of End Users

Based on the recorded levels of contamination across the site remediation will be required to protect end users of the proposed residential development. It is assumed in the following recommendations that site levels will remain similar to existing.

Made ground A should be removed from beneath all garden areas. In addition, the two hotspots of contamination noted in WS1 and WS7 should be remediated and an area measuring approximately 5m by 5m, from the centre of the exploratory hole, should be excavated. The sides and base of the excavations should be sampled for validation testing, to ensure no residual contaminated made ground remains.

The volume of made ground A material is considered likely to be in the region of 500m^3 and together with the material excavated from the WS7 hotspot could be stored beneath areas of hardstanding. The material excavated from WS1 should be removed to a suitable waste facility.

The made ground B material is unlikely to be acceptable to the NHBC due the presence of bricks, therefore, there will be a requirement to treat (riddle and sort) the top 500mm of remaining made ground beneath garden areas. From site observations the site will be deficient in topsoil. Accordingly, a suitable clean inert growing medium will be needed to be imported to form the garden areas of the proposed plots.

Remediation recommendations in respect of the identified gas hazard are outlined in Section 4; in summary gas protection measures are required.

Should any material suspected of being significantly contaminated be encountered during the redevelopment of the site, GRM can be contacted to undertake additional investigation if necessary. The local Environmental Health Officer should be contacted and informed of any additional remedial work required.

9.1.2 Protection of Site Workers

The risk to site workers from the soil contamination is negligible. No remedial measures are required. However, the use of suitable PPE should be enforced during the ground works stage.

9.1.3 Protection of Controlled Waters

The risk to controlled waters is currently assessed as low. Adoption of either Option 1 or Option 2 above would remove the source of contamination (made ground A) and reduced the risk to controlled waters to negligible levels and no additional remedial measures are considered to be required.

9.1.4 Protection of Construction Materials

Following the removal of the made ground A materials from garden areas and the treatment of the contamination hotspots the risk to construction materials is likely to be low. However, as some made ground will remain it would be prudent to allow for the upgrading of water pipes and the use of clean inert backfill within service trenches. Accordingly, early consultation with the local water company is recommended to determine their exact requirements.

Elevated sulphate was recorded in WS9 and the recommended concrete specification is made accordingly.

9.2 POST REMEDIATION VALIDATION

The recommended remedial methods should avoid the need for monitoring after validation; however, validation of any remedial measures will be required. Validation will comprise laboratory analysis of the growing medium to confirm it is suitable for its intended end-use; at this stage it is anticipated that three chemical validations would be sufficient.

Validation analysis of the growing medium is best conducted prior to importing the material. If subsoil/topsoil is to be imported with an existing test certificate, then it is recommended that this be forwarded to GRM to ensure that the material is suitable for use. The test certificate should be for the same suite of contaminants as the GRM soils testing suite, details of which are presented in Appendix G, plus total hydrocarbon concentration, which is now required by the NHBC.

Details of the validation testing of the imported growing medium will be required by the local Environmental Health Officer and the NHBC.

Additionally, the validation will include confirmation that no made ground remains present beneath gardens and soft landscaped areas. This confirmation should take the form of hand dug trial pits within each plot. In addition, it is strongly advised that a photographic record is taken showing the garden areas having been stripped of made ground prior to the placement of the growing medium.

9.3 REMEDIATION METHOD STATEMENT

As the remedial works are limited to the stripping of made ground from beneath garden and soft landscaped areas and the excavation of hotspots this report should be suitable for submission as a Remediation Method Statement.

Following your review of this document, we would recommend that a copy of it be forwarded to the Local Authority for comment and approval, prior to commencing development of the site. The Local Authority may choose to include other consultees as part of the planning process (such as the Environment Agency).

Consultation should be undertaken at the earliest possible opportunity to avoid abortive or delayed works.

9.4 DISPOSAL AND CLASSIFICATION

Based on the chemical analysis results currently available it is considered the any material removed from site will be classed as Non Hazardous; however, this assessment will need to be confirmed by the receiving landfill and reference should be made to the relevant notes presented in Appendix A (x).

10 GEOTECHNICAL ASSESSMENT

10.1 INTRODUCTION

The client has indicated that the proposed development consists of twelve residential properties comprising two rows of six terrace houses and associated infrastructure Finished floor levels and the levels of any underground engineering works have not been provided.

Detailed development plans were not available at the time of report preparation so it has been assumed in the following assessment that the development will be in line with current planning guidance and comprise two to three storey residential housing and three to four storey apartment blocks.

In addition to the site specific comments below reference should be made to the general comments relating to the Geotechnical Assessment listed in Appendix A (xi to xvi).

10.2 ENGINEERING GROUND TREATMENT

Engineering ground treatment is not considered necessary.

10.3 EXCAVATION CONDITIONS

Excavation of the materials encountered during the ground investigation should be easily achieved using conventional hydraulic excavation techniques. A breaker or similar plant will be required as the sites surface largely comprises remnant floorslabs and the likelihood of encountering buried foundations is considered high. A breaker may also be required should deeper excavations into the less weathered Chester Pebble Beds Formation be required as the window sampler refused at 4m.

From the ground investigation undertaken, it is likely that excavations will be generally stable in the short term. Some materials such as granular soils and made ground are liable to collapse without warning. This situation is likely to be exacerbated by water ingress.

It is considered unlikely that dewatering will be required for shallow short-term excavations. The observed groundwater conditions suggest that only simple dewatering techniques (e.g. sump pumping) will be needed to control water ingress to dewater deeper excavations. Care should be taken to ensure that dewatering does not lead to settlement of soils below existing structures or services on or off-site.

10.4 EXISTING STRUCTURES / SUBSTRUCTURES

The sites surface largely comprises remnant floorslabs from its previous site use as a market. Additionally, there are known lives services beneath the site and there may also be old foundations or other buried structures from the previous site use (e.g. associated with demolished buildings), that have not been identified from this investigation.

10.5 FOUNDATIONS

Foundations must not be founded in made ground, buried topsoil or soft natural strata, all of which should be fully penetrated by all new foundations.

The shallow strata noted during the investigation are considered suitable in their current condition for the proposed structures to found on. The natural cohesive soils encountered, at anticipated foundation depths, were generally at least firm. It is anticipated that a nett allowable bearing pressure of at least 110kN/m^2 should be available for conventional strip or trench fill footings. This will allow line loads up to 49kN/m to be taken on footings 450mm wide and 66kN/m on footings 600mm wide. This should result in total settlements of not more than 20mm, keeping differential settlements within acceptable limits.

In the south western site area it would be possible to found in the granular Glacial Till (minimum depth of 0.6m would be applicable), which were loose to medium dense at anticipated foundation depth. However, given the nature of the proposed construction (terrace housing) it would be preferable to deepen foundations in this area to a consistent clay stratum.

Wider footings may be required for higher point/line loads such as at party walls etc. Should wider footings be required for higher point/line loads, GRM should be contacted for further advice.

The soils below the site are of low to medium volume change potential (see Appendix H). As a result foundations will need to be designed accordance with NHBC Standards Chapter 4.2 'Building near trees'. However, with the exception of a small number of self-seeded buddleia bushes no trees were observed within the site boundary. Accordingly, deepening of foundations for trees is not anticipated.

At this stage, it is considered that deep strip or trench fill foundations 150mm into the Glacial Till will be suitable for the proposed development. Minimum foundation depths of 0.90m (cohesive soils) will be applicable.

Due to the presence of made ground, foundation depths of up to 1.6m should be expected. However, the general depth of foundations is likely to be 1.2m bgl.

Once the development plan and levels have been finalised, consideration should be given to the most appropriate foundation solution, taking into account removal of old substructures, stability of the strata and proximity to boundaries/services/roads/ existing structures.

10.6 FLOOR SLABS

Gas protection measures are required for the proposed development. These could comprise ground bearing/cast in situ floor slabs with a granular venting layer/pipework dependant on the depth of unsuitable material. However, in GRM's experience the use of suspended floor slabs incorporating a sub-floor void such as beam and block, is likely to prove more cost effective and practicable. Accordingly, it is recommended that allowance be made for such floors through the development.

See section 4 for full details of the required gas precautions. It should be noted that further monitoring is required to complete the gas monitoring program.

Old substructures should be removed to at least 0.5m below any new floor slabs to prevent the formation of 'hard spots'.

Gas protection measures are required for the proposed development. These could comprise ground bearing/cast in situ floor slabs with a granular venting layer/pipework dependant on the depth of unsuitable material. However, in GRM's experience the use of suspended floor slabs incorporating a sub-floor void such as beam and block is likely to prove more cost effective and practicable. Accordingly, it is recommended that allowance be made for such floors through the development. See section 5 for full details of the required gas precautions. It should be noted that further monitoring is required to complete the gas monitoring program.

No radon protection measures are required.

10.7 SLOPE STABILITY AND RETAINING STRUCTURES

The site is generally flat lying with only minor variations in surface level created by the remnant floorslabs; the area surrounding the site is similarly flat-lying. Therefore, there is no significant risk of slope instability occurring on the site.

There are no current retaining walls on site. Although the present gradients on site are likely to be adjusted by minor earthworks future ground profiles are considered unlikely to require earth retaining structures.

10.8 SOAKAWAY DRAINAGE

The strata encountered during the investigation are considered unsuitable for soakaway drainage and an alternative drainage system should be considered for the disposal of surface water.

It is recommended that the Local Authority and Environment Agency be consulted with regards to the use of soakaways.

10.9 NEW ACCESS ROADS

Site observations suggest that natural cohesive materials will have CBR values of between 2% and 4% and the granular made ground materials will have CBR values of between 1% and 2%, when suitably drained. Proof rolling and the improvement of soft spots may result in increased CBR values and the incorporation of a geotextile grid into sub-base layers may allow for reduced capping thickness.

Site observations should be confirmed by in situ or laboratory testing in accordance with the adopting Local Authority's preference.

11 FURTHER INVESTIGATION

Further investigation is not considered necessary.

- A copy of this report should be submitted to the Planning Department of the Local Authority/Local Authority EHO for review, if planning conditions exist for this site. A copy should also be sent to the NHBC for their records.

12 CONCLUSIONS

This Site Appraisal has shown the site is suitable for the proposed development, assuming compliance with all the recommendations contained within this report (for abridged version see 'Summary of Recommendations' table at the beginning of the report).

APPENDIX A

GRM Development Solutions provides multi-disciplinary consultancy services, UK-wide:

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- Construction Management
- Site Services

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GENERAL APPRAISAL COMMENTS

i INFORMATION SOURCES

Where available the following sources have been used for the identification and assessment of potential ground hazards:

- Relevant British Standards
- British Geological Survey (BGS) Geology Map Scale 1:10,000 for local area
- British Geological Survey (BGS) Geology Map Scale 1:50,000/1:63,320
- BGS Memoir
- BGS Borehole Records
- Environment Agency Groundwater Vulnerability Maps
- Historical Ordnance Survey (OS) Maps
- Environmental Data Report
- Environment Agency Website: http://www.environment-agency.gov.uk/
- Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites, UKWIR, 2010.
- Coal Authority Records / Coal Mining Report
- DEFRA/Environment Agency Contaminated Land publications and DoE Industry Profiles
- BRE Guide BR211 (2007), 'Radon: Guidance on protective measures for new buildings'
- HPA-RPD-033 (2007), 'Indicative Atlas of Radon in England and Wales'
- NRPB Publication W26 (2002), 'Radon Atlas of England and Wales'
- CIRIA C665 'Assessing risks posed by hazardous ground gases to buildings'
- Other technical references used throughout this document are detailed in the text.

ii CONTAMINANTS OF CONCERN

The DoE Industry Profiles are normally used to assess likely contaminants from past land use and potential nearby industrial sources. For land uses where no profile is available, likely contaminants of concern are selected by GRM based on past experience of similar sites, a general screening suite of contaminants covered by CLEA and common contaminants from the Industry Profiles.

- Arsenic
- Cadmium
- Chromium
- Lead
- Mercury
- Selenium
- Copper
- Nickel
- Zinc
- Phenols
- cyanide (total)
- pH
- Water soluble sulphate
- PAH (polycyclic aromatic hydrocarbons)

Asbestos and PCBs are listed in the vast majority of profiles. PCBs are listed as the profiles expect electricity substations and switch boxes on all industrial sites. There is the potential for asbestos containing material to be mixed up with made ground, following any demolition works.

iii CONCEPTUAL MODEL METHODOLOGY

The consideration of contamination is based upon the principles of risk assessment, using the 'source-pathway-receptor' model in order to establish the presence, or potential presence, of a pollutant linkage.

To create a risk, contamination must have the potential to cause harm to susceptible targets or receptors such as humans, the water environment or the built environment. The potential for harm to occur requires three conditions to be satisfied to form a pollutant linkage:

- The presence of substances that may cause harm (SOURCE).
- The presence of a target which may be harmed (RECEPTOR).
- The existence of a plausible migration route between the source and the receptor (PATHWAY).

In the absence of a plausible pollutant linkage there is no risk. Where a potential linkage is identified in order for it not to pose a risk to the identified receptor it must be broken.

iv INTRUSIVE INVESTIGATION SAMPLING METHODOLOGY

The ground investigation (including fieldwork, sampling, monitoring and laboratory analyses) has been designed to identify and assess potential ground related problems and to allow cost effective solutions to be advised. It has been planned on the basis of the desk study, site inspection and the proposed development layout (where available). All fieldwork and soil descriptions were carried out in general accordance with relevant British Standards.

The exploratory holes have been positioned and advanced to depths to determine the general ground/groundwater/gas conditions below the site. A general grid pattern has been adopted, where possible, to provide sufficient information based on the current proposed layout scheme. Some holes have been targeted at particular hazards identified in the Phase I assessment. The resultant exploratory hole density is considered to be commensurate with the complexity of the site conditions and detail of information required for this phase of the investigation.

v GROUND GAS RISK ASSESSMENT METHODOLOGY

Gas monitoring programmes undertaken by GRM are designed to broadly comply with the recommendations outlined in CIRIA Report C665 'Assessing risks posed by hazardous ground gas to buildings' (2007).

To assess the risks posed by ground gases such as radon, carbon dioxide and methane, the relevant current guidance has been used. For radon the site has been assessed following the guidelines in 'Radon: guidance on protective measures for new dwellings (BR211: 2007)'. For methane and carbon dioxide the primary guidance document used to determine if protection measures are required is CIRIA Report C665 'Assessing risks posed by hazardous ground gases to buildings' (2007). This uses Gas Screening Values (GSVs), which are gas concentrations multiplied by borehole flow rate, along with additional limiting factors (such as maximum methane concentrations) to classify the gas regime of a site.

The guidance document includes two methods of characterising a site. The main method 'Situation A' is based on work by Wilson and Card and is used for all types of development except low rise housing that meets the assumptions of 'Situation B'. The 'Situation B' method proposed by Boyle and Witherington for the NHBC assumes all properties have pre-cast suspended floors (beam and block) with ventilated underfloor voids.

Where flow is not recorded during the monitoring a default flow rate of 0.1l/hr will be used in the assessment to produce a positive result.

vi HUMAN HEALTH RISK ASSESSMENT METHODOLOGY

Guidance contained in the Environment Agency's CLEA Report has been used to assess the risks posed to human health.

For residential developments that include domestic gardens the default Tier 1 Assessment Criteria (TAC) for 'residential land with plant uptake' are used, i.e. a female with a start age class of one and an end age class of six. All pathways are considered including the consumption of home-grown vegetables.

For residential developments that do not include domestic gardens the default Tier 1 Assessment Criteria (TAC) for 'residential land without plant uptake' are used, i.e. a female with a start age class of one and an end age class of six. All pathways are considered except the consumption of home-grown vegetables.

For commercial/industrial developments the default Tier 1 Assessment Criteria (TAC) for 'commercial/industrial' are used, i.e. a female with a start age class of sixteen and an end age class of eighteen. All pathways are considered except the consumption of home-grown vegetables.

The TAC used by GRM include Soil Guideline Values (SGV) published by the EA, values calculated by GRM using the CLEA v1.06 risk assessment and values and chemical data developed by LQM/CIEH. The TAC used in the assessment are selected based on the lowest site specific SOM values returned as part of the chemical analysis.

Where soil chemical analysis results are found to exceed the TAC, Site-Specific Risk Assessments may be undertaken using the CLEA v1.06 risk assessment software using the age classes and pathways described above.

vii RISK TO SITE WORKERS – GENERAL COMMENTS

The risks to site workers are similar to those posed to site end users, although likely to be less severe due to the site workers' shorter exposure to the identified contamination. However, site workers (particularly groundworkers) are more likely to come into direct contact with contaminated soils due to the nature of their work. On this basis ground and construction workers should be provided with basic Personal Protective Equipment based on the site's general health and safety risk assessment, but including as a minimum safety footwear, gloves and overalls.

A site specific risk assessment should be carried out for all hazards identified within the ground investigation in accordance with current health and safety legislation. This assessment should identify any measures required to further reduce risks i.e. providing further Personal Protective Equipment, welfare facilities and if necessary preventing access to certain areas.

Demolition and dismantling of existing structures on the site must be carried out to a safe and acceptable standard, in accordance with current UK guidance and best practice. Whilst not ground related, asbestos and hazardous substances surveys should be conducted prior to any demolition.

Any unusual colours, odours and suspicious ground should be reported immediately to site management and then GRM.

Whilst this appraisal has considered the long-term effects of contamination, GRM can also help during the formulation of Health and Safety documentation, if required.

viii CONTROLLED WATERS RISK ASSESSMENT METHODOLOGY

Where the desk study and fieldwork do not reveal a potential source of contamination no leachate or groundwater testing will be performed. Where a potential source is identified the testing will comprise leachate testing on the material considered most likely to pose a risk, groundwater testing will be undertaken if water is present at shallow depth.

The UK Drinking Water Standards (UKDWS) or Environmental Quality Standards (EQS) are usually adopted for comparison with the leachate/groundwater test results. When the most sensitive receptor is considered to be the an aquifer (groundwater) UKDWS will be adopted as the Initial Tier 1 screening values. Where the most sensitive receptor is a surface water feature the EQS values will be used as Initial Tier I Screening values.

ix CONSTRUCTION MATERIALS RISK ASSESSMENT METHODOLOGY

The 'screening levels' adopted for the assessment of risk to construction materials are taken from the following documents:

- UK Water Industry Research (UKWIR) Contamination thresholds for sub-surface water pipes, for the protection of buried pipes.
- Building Research Establishment (BRE) Special Digest SD1 (2005), 'Concrete in Aggressive Ground', for the protection of buried concrete.

x WASTE DISPOSAL AND SITE WASTE MANAGEMENT PLANS

Under current Waste Management Regulations, waste soil materials produced from the site will require characterisation to enable it to be disposed of correctly.

The chemical analysis results included in this report should be provided to the relevant landfill operators to establish the characterisation of the waste, confirm its suitability for landfill disposal and provide estimated costings. If material is classified as hazardous, then the site will need to be registered with the Environment Agency prior to the movement of the waste. Depending on the receiving landfill's current permit, further chemical analysis, incorporating Waste Acceptance Criteria (WAC) leachate analysis, may be required.

All materials removed from the site will be classified as 'waste' and therefore must be removed by a suitably licensed carrier of waste. This applies whether or not the waste is contaminated. All waste removed to landfill will attract Landfill Tax.

The developer/builder is likely to be classed as the waste producer and therefore, has a duty of care to ensure that all waste is disposed of appropriately. This includes ensuring the waste carrier is licensed and disposes of the waste to a suitably licensed landfill site. They are also required to keep a paper trail from 'cradle to grave' including copies of the waste disposal tickets.

Efficient materials management on site is recommended as it can lead to significant cost savings when compared to the traditional side casting or single stockpile of arisings. Likewise making the site as volume neutral as possible will reduce the costs of development.

Site Waste Management Plans allow better waste management practices, help to reduce the amount of waste produced and identify best environmental disposal options. Implementing a Site Waste Management Plan (SWMP) can reduce costs (increasing business profits) and maximise resource efficiency.

SWMPs are a legal requirement for all projects with an overall development cost of over £300k. GRM can assist in the production of SWMPs which comply with the Code of Practice and identify best environmental disposal options when dealing with waste.

xi GEOTECHNICAL ASSESSMENT GENERAL COMMENTS

Where finished floor levels of proposed structures have not been provided by the Client, then for the purposes of initial assessment, GRM will assume that finished levels will not vary appreciably from the existing ground levels. If the depths of any underground engineering works (i.e. sewers, pumping stations etc.) are unknown they will not be taken in to account in the assessment and it will be assumed that any such works will not compromise foundation or ground stability.

Should the development proposals or finished levels be different from these assumptions then the comments/recommendations in the Geotechnical Assessment may require revising.

It should be noted that the results of window sampling and/or cable percussive boreholes may not give a true indication of a soils actual engineering properties (i.e. stability, mass structure etc). GRM consider that that prior to development trial pitting should be undertaken to confirm the recommendations in the Geotechnical Assessment.

xii GEOTECHNICAL ASSESSMENT – ENGINEERING GROUND TREATMENT

Near surface soils have the potential to be disturbed by weathering and site traffic. Precautions should always be taken to avoid this, as excessive disturbance may leads to more onerous floor slab designs, road cap thickness and increased amounts of off site disposal etc.

Near surface soils may need treatment or reinforcing to allow safe movement of construction plant and labour. An assessment by the contractor should be undertaken once the type of machinery/plant needed to complete the development is known.

xiii GEOTECHNICAL ASSESSMENT – EXCAVATIONS

Excavation instability (over-break) can result in damage to existing services or structures (e.g. foundations, roads or boundary walls/fences) both on and off-site, as well as increased foundation concrete costs. In order to minimise this, all excavations deeper than 1.2m deep (or any excavation within 1.5m of any existing structure or service) should be supported. Full support should be provided to the full depth of all near vertically sided excavations in made ground, soft and very soft clays and granular soils. A reduction to intermediate support should be acceptable within firm and stiffer natural clays.

Wherever possible, man entry into excavations should be prevented; however, where this is not possible, entry to, and time spent in, excavations should be kept to a minimum.

The build program should be tailored to reflect the impact that deep excavations through potentially unstable strata can have on adjacent properties, so that they are not undermined.

All excavations on site should be in accordance with HSE guidelines and stability should be practically maintained at all times. Reference should be made to HSE construction information sheet No. 8 (Revision 1) 'Safety in Excavations'.

Care should be taken to ensure that falls from excavation faces do not adversely affect the integrity of foundation concrete.

If contaminated water enters excavations it should be removed and transported to an appropriate treatment facility by a suitably licensed carrier before construction begins.

xiv GEOTECHNICAL ASSESSMENT – SUBSTRUCTURES

Where practicable, existing buried construction should be fully removed; however, if this is not practicable all new foundations should be carried down to fully penetrate it and it should be broken well away from all new structures.

There may be existing structures and/or infrastructure in close proximity to the proposed development. New build foundations may be constructed next to pavements with existing underground services beneath them, or excavations may be required near existing footings associated with adjacent properties. These potential hazards need to be taken into consideration when designing foundations and the groundworker needs to be made aware of their potential impact during the redevelopment works. Foundations close to existing underground services or buildings may require alternative foundation techniques (such as piling) to protect the integrity of these structures.

The contractor for the works should carry them out in such a fashion so as to not cause excessive overbreak, concrete usage or undermine existing buildings/roads/ services that are to be retained.

xv GEOTECHNICAL ASSESSMENT – SOAKAWAYS

Soakaway testing in trial pits by GRM is broadly carried out in accordance with BRE 365 (1991). The testing comprises the excavation of a test pit to a suitable depth, and the placement of water into the pit. The level of water present is then monitored over time. For borehole installations, the permeability testing (falling head/rising head) is undertaken in accordance with BS5930.

If it is decided to proceed with the use of soakaway drainage, then the following general points should be noted:

- Soakaways should not be placed so that water can be discharged through potentially contaminated made ground.
- The Environment Agency may require soakaways to be sealed systems such that only roof run off falls to soakaway.
- Interceptors are likely to be required for soakaways for highway drainage. The adopting authority for the highways should be consulted at the earliest opportunity regarding the use of soakaways for highways drainage.
- Consideration of site levels and slopes should be taken into account during the design.
- The construction of all soakaways should be in accordance with the current building regulations.
- Soakaways should not be placed within 5m of a proposed building.
- Placement of soakaways needs to be considered so as to avoid ponding of water down slope.
- The base of a soakaway should not be below the highest recorded water level.
- The Environment Agency prefer 1m of dry soil to be present between the base of a soakaway and the water table to provide attenuation for contamination.

xvi GEOTECHNICAL ASSESSMENT – FOUNDATIONS

If soft or hard spots are encountered during foundation excavation then they should be replaced with suitably compacted material or the footings deepened to suitable strata, to avoid differential settlement.

If strata of differing bearing character (e.g. sand and clay) are encountered at foundation levels within the excavations for a single plot then the excavation depths should be altered as appropriate to ensure the foundations rest on a single stratum, or strata that will not induce differential settlement. Where this is impractical then GRM should be contacted to assess a reinforced concrete detail or an alternative foundation solution (e.g. piles or vibro-replacement).

NOTES ON LIMITATIONS

General

GRM Development Solutions Limited has prepared this report solely for the use of the Client and those parties with whom a warranty agreement had been executed, or with whom an assignment had been agreed. Should any third party wish to use or rely upon the contents of the report, written approval must be sought from GRM Development Solutions Limited; a charge may be levied against such approval.

GRM Development Solutions Limited accepts no responsibility or liability for:

a) the consequences of this document being used for any purpose or project other than for which it was commissioned, and

b) the consequences of this document being used by any third party with whom an agreement has not been executed.

Phase I Environmental Audits/ Desk Studies

The work undertaken to provide the basis of this report comprised a study of available documented information from a variety of sources (including the Client), together with (where appropriate) a brief walk over inspection of the site and meetings and discussions with relevant authorities and other interested parties. The opinions given in this report have been dictated by the finite data on which they are based and are relevant only to the purpose for which the report was commissioned. The information reviewed should not be considered exhaustive and has been accepted in good faith as providing true and representative data pertaining to site conditions. Should additional information become available which may affect the opinions expressed in this report, GRM Development Solutions Limited reserves the right to review such information and, if warranted, to modify the opinions accordingly. It should be noted that any risks identified in a Phase 1 report are perceived risks based on the information reviewed; actual risks can only be assessed following a physical investigation of the site.

Phase II Environmental Audits (Contamination Investigations)

The investigation of the site has been carried out to provide sufficient information concerning the type and degree of contamination, ground and groundwater conditions to allow a reasonable risk assessment to be made. The objectives of the investigation have been limited to establishing the risks associated with potential human targets, building materials, and controlled waters.

The amount of exploratory work and chemical testing undertaken has necessarily been restricted by the short timescale available, and the locations of exploratory holes have been restricted to the areas unoccupied by the building(s) on the site and by buried services. A more comprehensive investigation may be required if the site is to be redeveloped as, in addition to risk assessment, a number of important engineering and environmental issues need to be resolved.

For these reasons if costs have been included in relation to site remediation these must be considered as tentative only and must, in any event, be confirmed by a commercial adviser.

The exploratory holes undertaken, which investigate only a small volume of the ground in relation to the size of the site, can only provide a general indication of site conditions. The number of sampling points and methods of sampling and testing do not preclude the existence of localised “hotspots” of contamination where concentrations may be significantly higher than those actually encountered.

The risk assessment and opinions provided, inter alia, take in to consideration currently available guidance relating to acceptable contamination concentrations; no liability can be accepted for the retrospective effects of any future changes or amendments to these values.

Phase II Geo-environmental Investigations (Combined Geotechnical and Contamination Investigations)

The investigation of the site has been carried out to provide sufficient information concerning the type and degree of contamination, geotechnical characteristics, and ground and groundwater conditions to provide a reasonable assessment of the environment risks together with engineering and development implications. If costs have been included in relation to site development a commercial adviser must confirm these.

The exploratory holes undertaken, which investigate only a small volume of the ground in relation to the size of the site, can only provide a general indication of site conditions. The opinions provided and recommendations given in this report are based on the ground conditions apparent at the site for each of the exploratory holes. There may be exceptional ground conditions elsewhere on the site which have not been disclosed by this investigation and which have therefore not been taken into account in this report.

The comments made on groundwater conditions are based on observations made at the time the site work was conducted. It should be noted that groundwater levels will vary owing to seasonal, tidal and weather related effects.

The scope of the investigation was selected on the basis of the specific development proposed by the Client and may be inappropriate to another form of development or scheme.

The risk assessment and opinion provided, inter alia, take into consideration currently available guidance relating to acceptable contamination concentrations; no liability can be accepted for the retrospective effects of any future changes or amendments to these values.

APPENDIX B

GRM Development Solutions provides multi-disciplinary consultancy services, UK-wide:

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DO NOT SCALE

NOTES:

Approximate Site Boundary

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CLIENT:
The Alan Johnston Partnership

PROJECT:
Island Road South, Garston, Liverpool

TITLE:
Outline Development Plan

SCALE@SIZE :	ISSUE:
NTS	FINAL
DESIGN/DRAWN :	DATE:
PW	04/2014
PROJECT No:	DRAWING No:
P6547	Figure 1

APPENDIX C

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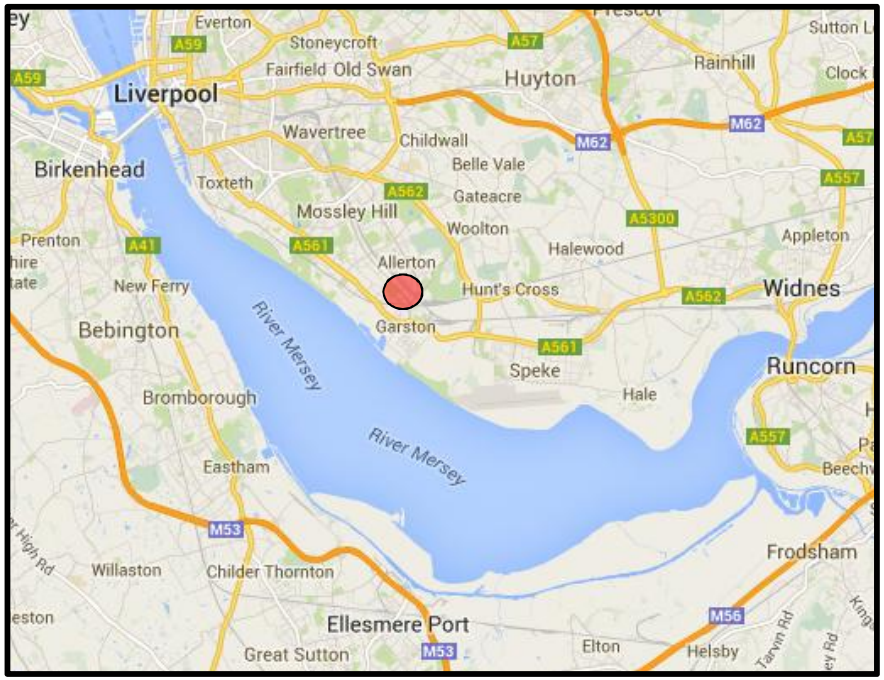

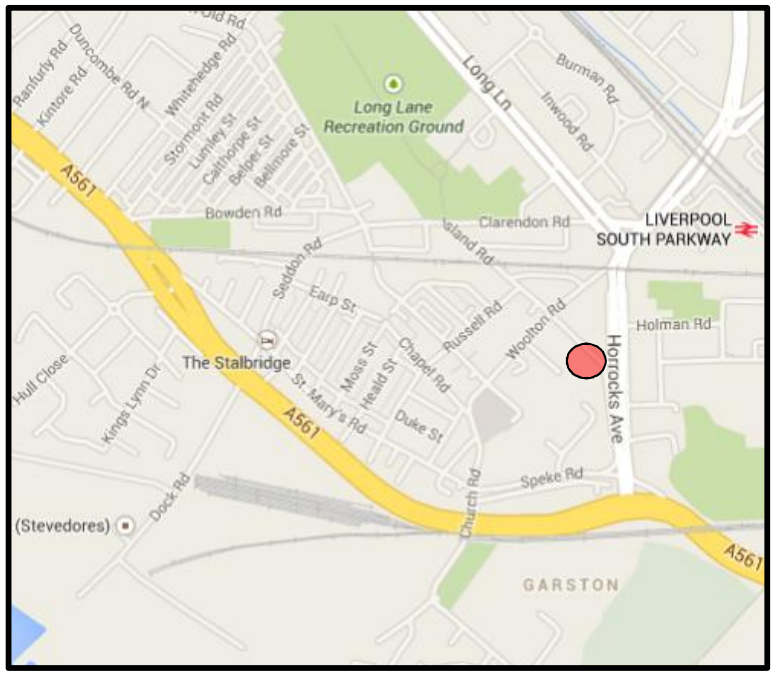

DO NOT SCALE

NOTES:

Approximate Site Locations

Approximate Site Boundary

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CLIENT:
The Alan Johnston Partnership

PROJECT:
Island Road South, Garston, Liverpool

TITLE:
Site Location Plan

SCALE@SIZE :	ISSUE:
NTS	FINAL
DESIGN/DRAWN :	DATE:
PW	04/2014
PROJECT No:	DRAWING No:
P6547	Figure 2

APPENDIX D

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- Structural Engineering Services
- Construction Management
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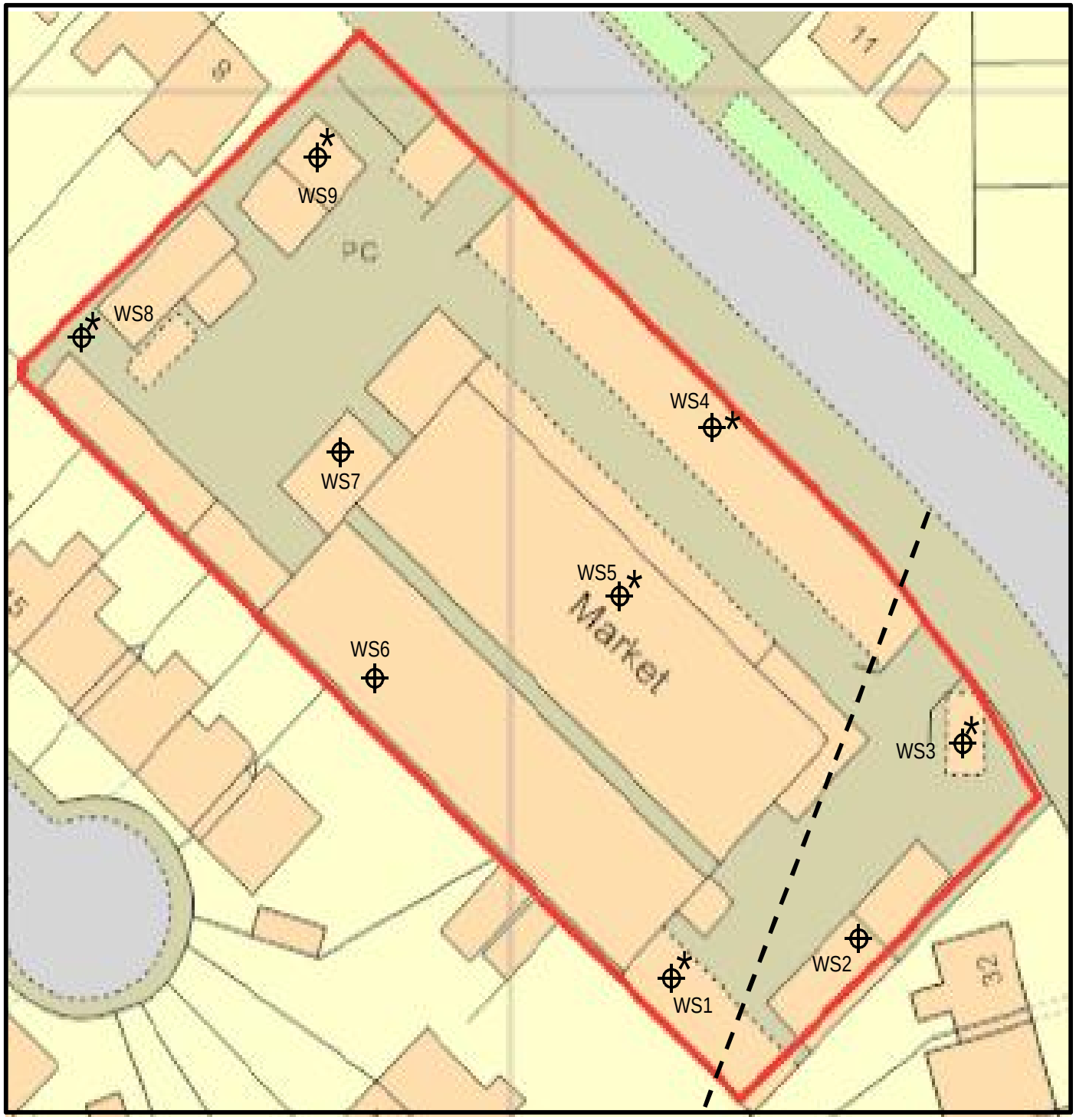

DO NOT SCALE

NOTES:

WS* Window sample hole location (* denotes monitoring installation)

Approximate location of known buried electricity cable.

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CLIENT:
The Alan Johnston Partnership

PROJECT:
Island Road South, Garston, Liverpool

TITLE:
Exploratory Hole Location Plan

SCALE@SIZE :	ISSUE:
NTS	FINAL
DESIGN/DRAWN :	DATE:
PW	05/2013
PROJECT No:	DRAWING No:
P6547	Figure 5

APPENDIX E

GRM Development Solutions provides multi-disciplinary consultancy services, UK-wide:

- Geotechnical and Geo-environmental Services
- Civil and Infrastructure Services
- Structural Engineering Services
- Construction Management
- Site Services

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Window Sample

Borehole Number **WS1**

Ground Level mAOD

Site:	Island Road South, Garston, Liverpool	GRM Project ref:	**P6547**
Client:	The Alan Johnston Partnership	Equipment:	Competitor
		Crew: White Rose Drilling	Logger: AS

Coordinates: 340614E 384642N

Groundwater		Samples	Insitu Tests		Strata				
Installation/ Backfill	Depth (m)	Depth/Type (m)	Depth/Type (m)	N Value (Sample Blows)	Casing Depth (m)	Depth (m)	Level (m AOD)	Key	Description
		0.10/D 0.10/ES				0.20			Black clayey sandy gravel. Gravel is fine to coarse subangular to subrounded tarmac fragments (medium dense). (Made ground)
		0.40/D 0.40/ES				0.30			Brick fragments. (Made ground)
		0.80/D 0.80/ES				0.55			Grey brown clayey gravelly sand. Gravel is fine to coarse subangular to subrounded quartzite, sandstone and brick (medium dense). (Made ground)
	1		1.00	N=19 (7,7/2,6,6,5)					Orange brown very gravelly sand. Gravel is varied fine to coarse angular to subrounded sandstone, limestone and concrete (loose). (Made ground)
		1.60/D				1.45			Brown slightly gravelly very sandy CLAY. Gravel is fine to coarse subangular to rounded chert and quartzite (soft to firm). (Glacial Till)
	2		2.00	N=9 (2,2/2,2,2,3)					
		2.50/D				2.10			Brown to orange brown sandy gravelly CLAY. Gravel is fine to coarse subangular to subrounded sandstone and mudstone (soft). (Glacial Till)
						2.30			Red brown slightly sandy slightly gravelly CLAY. Gravel is fine to coarse subangular to subrounded sandstone, quartzite and very weak siltstone (firm to stiff). (Glacial Till)
	3		3.00	N=27 (5,5/7,7,7,6)					
		3.40/D				3.10			Red very sandy CLAY. Sand is fine to coarse (firm). (Glacial Till)
						3.70			Red slightly gravelly SAND. Gravel is fine to coarse subangular to subrounded sandstone (medium dense). (Chester Pebble Bed Formation)
		3.90/D	3.80	50 (25 for 5mm/50 for 10mm)					
	4					4.00			End of borehole at 4.00 m
	5								

Hole Started 23/04/2014 | Hole Complete

Remarks:

Test Type: S = Standard Penetration Test, C = Cone Penetration Test. N values reported are uncorrected. N value 50/275 = 50 blows in 275mm.

Scale: 1:25

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Window Sample

Borehole Number **WS2**

Ground Level mAOD

Site:	Island Road South, Garston, Liverpool	GRM Project ref: **P6547**	Coordinates:
Client:	The Alan Johnston Partnership	Equipment: Competitor	340625E
		Crew: White Rose Drilling / Logger: AS	384647N

Groundwater		Samples	Insitu Tests		Strata				
Installation/ Backfill	Depth (m)	Depth/Type (m)	Depth/Type (m)	N Value (Sample Blows)	Casing Depth (m)	Depth (m)	Level (m AOD)	Key	Description
		0.10/ES				0.20			Black clayey sandy gravel. Gravel is fine to coarse subangular to subrounded tarmac fragments (medium dense). (Made ground)
		0.30/D 0.30/ES				0.40			Red brown mottled yellow and black slightly clayey gravelly SAND. Gravel is fine to coarse subangular to rounded sandstone, quartzite, quartz and brick (medium dense to dense). (Made ground)
		0.50/D 0.50/ES				0.60			Black slightly gravelly sand. Gravel is fine to coarse subangular to subrounded tarmac and building material (very dense). (Made ground)
		0.80/D				0.90			Grey brown slightly gravelly clayey SAND. Gravel is fine to coarse subangular to subrounded quartzite and sandstone. Rare carbonaceous fragments (medium dense to dense). (Glacial Till)
	1		1.00	N=5 (1,1/1,1,1,2)					
		1.20/D				1.60			Red brown mottled grey slightly gravelly very sandy CLAY. Gravel is fine to coarse subangular to subrounded sandstone and quartzite (firm). (Glacial Till)
		1.80/D							
	2		2.00	N=18 (2,2/3,4,5,6)		2.10			Red brown mottled grey slightly gravelly sandy CLAY. Gravel is fine to coarse subangular to subrounded sandstone. Locally a sand (stiff to very stiff). (Glacial Till)
		2.50/D							Red brown slightly sandy slightly gravelly CLAY. Gravel is fine to coarse subangular to subrounded sandstone, quartz, quartzite and limestone (stiff becoming very stiff at 2.3m). (Glacial Till)
	3		3.00	N=36 (4,6/7,7,10,12)		3.00			End of borehole at 3.00 m
	4								
	5								

Hole Started 23/04/2014 | Hole Complete

Remarks:

Test Type: S = Standard Penetration Test, C = Cone Penetration Test. N values reported are uncorrected. N value 50/275 = 50 blows in 275mm.

Scale: 1:25

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Window Sample

Borehole Number **WS3**

Ground Level mAOD

Site:	Island Road South, Garston, Liverpool	GRM Project ref:	**P6547**
Client:	The Alan Johnston Partnership	Equipment:	Competitor
		Crew: White Rose Drilling	Logger: AS

Coordinates: 340632E 384659N

Groundwater		Samples	Insitu Tests		Strata				
Installation/ Backfill	Depth (m)	Depth/Type (m)	Depth/Type (m)	N Value (Sample Blows)	Casing Depth (m)	Depth (m)	Level (m AOD)	Key	Description
		0.05/ES				0.10			Black clayey sandy gravel. Gravel is fine to coarse subangular to subrounded tarmac fragments (medium dense). (Made ground)
		0.20/ES				0.30			Grey brown clayey gravelly sand. Gravel is fine to coarse subangular to subrounded quartzite, sandstone and brick (medium dense). (Made ground)
		0.80/D				0.70			Black slightly gravelly sand. Gravel is fine to coarse subangular to subrounded tarmac and building material (very dense). (Made ground)
	1		1.00	N=12 (1,2/3,3,3,3)		0.95			Grey brown slightly gravelly clayey SAND. Gravel is fine to coarse subangular to subrounded quartzite and sandstone. Rare carbonaceous fragments (medium dense to dense). (Glacial Till)
		1.20/D							Red sandy gravelly CLAY. Gravel is fine to coarse subangular to subrounded sandstone and mudstone (firm to stiff). (Glacial Till)
						1.60			Red brown mottled grey slightly gravelly sandy CLAY. Gravel is fine to coarse subangular to subrounded sandstone. Locally a sand. Becomes stiff at 1.3m. Becomes very stiff at 1.5m (firm to stiff). (Glacial Till)
	2		2.00	N=18 (2,3/3,4,5,6)					
	3		3.00	N=46 (6,7/9,9,13,15)		3.00			End of borehole at 3.00 m
	4								
	5								

Hole Started 23/04/2014 | Hole Complete

Remarks:

Test Type: S = Standard Penetration Test, C = Cone Penetration Test. N values reported are uncorrected. N value 50/275 = 50 blows in 275mm.

Scale: 1:25

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Window Sample

Borehole Number **WS4**

Ground Level mAOD

Site:	Island Road South, Garston, Liverpool	GRM Project ref:	**P6547**
Client:	The Alan Johnston Partnership	Equipment:	Competitor
		Crew: White Rose Drilling	Logger: AS

Coordinates: 340614E 384679N

Groundwater		Samples	Insitu Tests		Strata				
Installation/ Backfill	Depth (m)	Depth/Type (m)	Depth/Type (m)	N Value (Sample Blows)	Casing Depth (m)	Depth (m)	Level (m AOD)	Key	Description
		0.10/ES							Grey brown clayey gravelly sand. Gravel is fine to coarse subangular to subrounded quartzite, sandstone and brick (medium dense). (Made ground)
		0.50/D				0.40			Grey brown slightly gravelly clayey SAND. Gravel is fine to coarse subangular to subrounded quartzite and sandstone. Rare carbonaceous fragments (medium dense to dense). (Glacial Till)
	1		1.00	N=20 (2,4/4,6,5,5)		0.60			Red brown mottled grey slightly gravelly sandy CLAY. Gravel is fine to coarse subangular to subrounded sandstone and mudstone. Locally a sand (firm to stiff). (Glacial Till)
						1.35			Red brown mottled grey brown clayey SAND. Sand is fine to medium (medium dense to dense). (Glacial Till)
	2		2.00	N=14 (2,2/2,3,4,5)					
		2.20/D				2.10			Red clayey gravelly SAND. Gravel is fine to coarse subangular to subrounded sandstone (medium dense to dense). (Glacial Till)
		2.60/D				2.40			Red mottled grey sandy gravelly CLAY. Gravel is fine to coarse subangular to subrounded sandstone and quartzite (very stiff). (Glacial Till)
	3		3.00	N=42 (5,6/7,10,11,14)		3.00			End of borehole at 3.00 m
	4								
	5								

Hole Started 23/04/2014 | Hole Complete

Remarks:

Test Type: S = Standard Penetration Test, C = Cone Penetration Test. N values reported are uncorrected. N value 50/275 = 50 blows in 275mm.

Scale: 1:25

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Window Sample

Borehole Number **WS5**

Ground Level mAOD

Site:	Island Road South, Garston, Liverpool	GRM Project ref:	**P6547**
Client:	The Alan Johnston Partnership	Equipment:	Competitor
		Crew: White Rose Drilling.	Logger: AS

Coordinates: 340604E 384671N

Groundwater		Samples	Insitu Tests		Strata				
Installation/ Backfill	Depth (m)	Depth/Type (m)	Depth/Type (m)	N Value (Sample Blows)	Casing Depth (m)	Depth (m)	Level (m AOD)	Key	Description
						0.10			Black clayey sandy gravel. Gravel is fine to coarse subangular to subrounded tarmac fragments (medium dense). (Made ground)
		0.30/D 0.30/ES							Grey brown clayey gravelly sand. Gravel is fine to coarse subangular to subrounded quartzite sandstone and brick (medium dense). (Made ground)
		0.70/D				0.60			Red mottled orange brown slightly gravelly SAND. Gravel is fine to coarse subangular to subrounded sandstone and quartz. Locally lithified to a sandstone (dense). (Glacial Till)
	1		1.00	N=9 (1,2/2,2,2,3)					
		1.50/D				1.10			Red brown mottled orange brown and grey slightly gravelly very sandy CLAY. Gravel is fine to coarse subangular to subrounded sandstone and mudstone. Local pockets of sand. Becomes firm at 1.5m and becoming firm to stiff at 1.7m (soft to firm). (Glacial Till)
		1.90/D							
	2		2.00	N=16 (3,3/2,3,5,6)					
		2.70/D				2.50			Red mottled grey sandy gravelly CLAY. Gravel is fine to coarse subangular to subrounded sandstone and quartzite (stiff to very stiff). (Glacial Till)
	3		3.00	N=36 (5,6/6,8,9,13)		3.00			End of borehole at 3.00 m
	4								
	5								

Hole Started 23/04/2014 | Hole Complete

Remarks:

Test Type: S = Standard Penetration Test, C = Cone Penetration Test. N values reported are uncorrected. N value 50/275 = 50 blows in 275mm.

Scale: 1:25

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Window Sample

Borehole Number **WS6**

Ground Level mAOD

Site:	Island Road South, Garston, Liverpool	GRM Project ref:	**P6547**
Client:	The Alan Johnston Partnership	Equipment:	Competitor
		Crew: White Rose Drilling	Logger: AS

Coordinates: 340592E 384663N

Groundwater		Samples	Insitu Tests		Strata				
Installation/ Backfill	Depth (m)	Depth/Type (m)	Depth/Type (m)	N Value (Sample Blows)	Casing Depth (m)	Depth (m)	Level (m AOD)	Key	Description
		0.15/D 0.15/ES				0.05			Black clayey sandy gravel. Gravel is fine to coarse subangular to subrounded tarmac fragments (medium dense). (Made ground)
						0.30			Grey brown clayey gravelly sand. Gravel is fine to coarse subangular to subrounded quartzite sandstone and brick (medium dense). (Made ground)
		0.80/D							Red mottled grey sandy gravelly CLAY. Gravel is fine to coarse subangular to subrounded mudstone, sandstone and quartzite. Occasional carbonaceous fragments. Local pockets of red sand. Lens of very dense slightly gravelly very clayey sand 2.2-2.6m (firm to stiff and locally firm). (Glacial Till)
	1		1.00	N=9 (1,2/2,2,2,3)					
		1.40/D							
	2		2.00	N=22 (2,3/4,6,6,6)					
		2.40/D							
		2.80/D							
	3		3.00	N=48 (6,6/9,10,13,16)		3.00			End of borehole at 3.00 m
	4								
	5								

Hole Started 23/04/2014 | Hole Complete

Remarks:

Test Type: S = Standard Penetration Test, C = Cone Penetration Test. N values reported are uncorrected. N value 50/275 = 50 blows in 275mm.

Scale: 1:25

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Window Sample

Borehole Number **WS7**

Ground Level mAOD

Site:	Island Road South, Garston, Liverpool	GRM Project ref: **P6547**	Coordinates:
Client:	The Alan Johnston Partnership	Equipment: Competitor	340587E
		Crew: White Rose Drilling. Logger: AS	384680N

Groundwater		Samples	Insitu Tests		Strata				
Installation/ Backfill	Depth (m)	Depth/Type (m)	Depth/Type (m)	N Value (Sample Blows)	Casing Depth (m)	Depth (m)	Level (m AOD)	Key	Description
		0.10/ES				0.25			Black clayey sandy gravel. Gravel is fine to coarse subangular to subrounded tarmac fragments (medium dense). (Made ground)
		0.40/D				0.70			Grey brown sandy gravelly clay. Gravel is fine to coarse angular to subrounded building material and concrete (soft). (Made ground)
		0.90/D							Grey brown mottled orange clayey gravelly SAND. Gravel is fine to coarse subangular to subrounded sandstone (medium dense). (Glacial Till)
	1		1.00	N=15 (3,4/4,4,4,3)		1.40			
		1.60/D							Red mottled grey sandy gravelly CLAY. Gravel is fine to coarse subangular to subrounded mudstone, sandstone and quartzite. Occasional carbonaceous fragments. Local pockets of red sand. Becomes very stiff at 2.4m. Signs of lithification at base (2.95-3.0m) (firm to stiff and locally firm). (Glacial Till)
	2		2.00	N=25 (6,9/4,7,7,7)					
		2.60/D	2.60	N=50 (7,7/9,11,14,16)					
		2.90/D							
	3					3.00			End of borehole at 3.00 m
	4								
	5								

Hole Started 23/04/2014 | Hole Complete

Remarks:

Test Type: S = Standard Penetration Test, C = Cone Penetration Test. N values reported are uncorrected. N value 50/275 = 50 blows in 275mm.

Scale: 1:25

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Window Sample

Borehole Number **WS8**

Ground Level mAOD

Site:	Island Road South, Garston, Liverpool	GRM Project ref:	**P6547**
Client:	The Alan Johnston Partnership	Equipment:	Competitor
		Crew: White Rose Drilling.	Logger: AS

Coordinates: 340571E 384685N

Groundwater		Samples	Insitu Tests		Strata				
Installation/ Backfill	Depth (m)	Depth/Type (m)	Depth/Type (m)	N Value (Sample Blows)	Casing Depth (m)	Depth (m)	Level (m AOD)	Key	Description
						0.30			Black clayey sandy gravel. Gravel is fine to coarse subangular to subrounded tarmac fragments (medium dense). (Made ground)
		0.40/D 0.40/ES							Grey brown slightly gravelly very clayey sand. Gravel is fine to coarse subangular to subrounded quartzite sandstone and brick (medium dense). (Made ground)
						0.80			
		0.90/D 0.90/ES	1.00	N=8 (3,3/3,3,1,1)					Grey mottled orange brown slightly gravelly clayey SAND. Gravel is fine to coarse subangular to subrounded sandstone and mudstone (medium dense). (Glacial Till)
	1					1.50			
		1.60/D							Red mottled grey sandy gravelly CLAY. Gravel is fine to coarse subangular to subrounded mudstone, sandstone and quartzite. Occasional carbonaceous fragments. Local pockets of red sand (firm to stiff and locally firm). (Glacial Till)
	2		2.00	N=28 (2,3/7,7,7,7)					
		2.40/D							
			2.60	N=34 (4,5/7,7,9,11)					
	3					3.00			End of borehole at 3.00 m
	4								
	5								

Hole Started 23/04/2014 | Hole Complete

Remarks:

Test Type: S = Standard Penetration Test, C = Cone Penetration Test. N values reported are uncorrected. N value 50/275 = 50 blows in 275mm.

Scale: 1:25

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Window Sample

Borehole Number **WS9**

Ground Level mAOD

Site:	Island Road South, Garston, Liverpool	GRM Project ref:	**P6547**
Client:	The Alan Johnston Partnership	Equipment:	Competitor
		Crew: White Rose Drilling.	Logger: AS

Coordinates: 340585E 384700N

Groundwater		Samples	Insitu Tests		Strata				
Installation/ Backfill	Depth (m)	Depth/Type (m)	Depth/Type (m)	N Value (Sample Blows)	Casing Depth (m)	Depth (m)	Level (m AOD)	Key	Description
		0.10/D 0.10/ES							Grey brown slightly gravelly very clayey sand. Gravel is fine to coarse subangular to subrounded quartzite sandstone and brick (medium dense). (Made ground)
						0.40			
		0.80/D							Red mottled grey sandy gravelly CLAY. Gravel is fine to coarse subangular to subrounded mudstone, sandstone and quartzite. Occasional carbonaceous fragments. Local pockets of red sand below 1.3m. Becomes very stiff at 0.9m (firm to stiff and locally firm). (Glacial Till)
	1		1.00	N=12 (2,2/3,2,3,4)					
		1.50/D							
		1.90/D							
	2		2.00	N=20 (2,3/4,5,5,6)					
		2.50/D							
			2.70	N=33 (4,6/6,8,9,10)					
		2.90/D							
	3					3.00			End of borehole at 3.00 m
	4								
	5								

Hole Started 23/04/2014 | Hole Complete

Remarks:

Test Type: S = Standard Penetration Test, C = Cone Penetration Test. N values reported are uncorrected. N value 50/275 = 50 blows in 275mm.

Scale: 1:25

APPENDIX F

GRM Development Solutions provides multi-disciplinary consultancy services, UK-wide:

- Geotechnical and Geo-environmental Services
- Civil and Infrastructure Services
- Structural Engineering Services
- Construction Management
- Site Services

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MONITORING OF SOIL GASES & GROUNDWATER

PROJECT NO. P6547

SITE. Island Road South, Garston, Liverpool

CLIENT. The Alan Johnston Partnership

DATE. 09-May-14

CONDITIONS.

WEATHER:	CLOUDY / WET / WINDY
ATMOSPHERIC PRESSURE:	1004 mb
PRESSURE TREND:	Steady

OPERATOR. Alex Smith

EQUIPMENT. LMXSi Gas Data Recorder

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Burton-upon-Trent
Staffordshire
DE14 2WH

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Facsimile: (01283) 211 968
Email: mail@grm-uk.com

RESULTS

Borehole/ Well Ref. No.	Methane (CH_4) %v/v	Carbon Dioxide (CO_2) %v/v	Oxygen (O_2) %v/v	Flow (l/hr)	L.E.L (%)	Depth to Groundwater (mbegl)	Total Depth (mbegl)
WS1	0.0	6.1	13.7	0	0	2.5	3.1
WS3	0.0	3.8	14.7	0.0	0.0	3.10	3.10
WS4	0.0	0.9	20.2	0.0	0.0	0.81	2.60
WS5	0.0	1.2	20.0	0.0	0.0	0.91	3.10
WS8	0.0	1.7	17.8	0.0	0.0	DRY	0.80
WS9	0.0	1.7	19.5	0.0	0.0	1.09	2.80

Notes

L.E.L.	Lower Explosive Limit (100% L.E.L.'= 5% Flammable Gas)
N.D.	Not Detected
N.R.	Not Recorded
%	By Volume

MONITORING OF SOIL GASES & GROUNDWATER

PROJECT NO. P6547

SITE. Island Road South, Garston, Liverpool

CLIENT. The Alan Johnston Partnership

DATE. 19-May-14

CONDITIONS.

WEATHER:	Sunny / Cloudy
ATMOSPHERIC PRESSURE:	997 mb
PRESSURE TREND:	Steady

OPERATOR. Alex Smith

EQUIPMENT. LMXSi Gas Data Recorder

GRM Development Solutions Limited
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Telephone: (01283) 551 249
Facsimile: (01283) 211 968
Email: mail@grm-uk.com

RESULTS

Borehole/ Well Ref. No.	Methane (CH_4) %v/v	Carbon Dioxide (CO_2) %v/v	Oxygen (O_2) %v/v	Flow (l/hr)	L.E.L	Depth to Groundwater (mbegl)	Total Depth (mbegl)
WS1	0.0	7.2	11.7	0.0	0.0	2.50	3.00
WS3	0.0	4.7	12.9	0.0	0.0	2.20	3.00
WS4	0.0	1.2	20.0	0.0	0.0	0.84	2.50
WS5	0.0	1.4	19.8	0.0	0.0	0.84	3.00
WS8	0.0	2.4	18.4	0.0	0.0	0.74	2.80
WS9	0.0	1.5	19.6	0.0	0.0	1.16	2.80

Notes

L.E.L.	Lower Explosive Limit (100% L.E.L.'= 5% Flammable Gas)
N.D.	Not Detected
N.R.	Not Recorded
%	By Volume

APPENDIX G

GRM Development Solutions provides multi-disciplinary consultancy services, UK-wide:

- Geotechnical and Geo-environmental Services
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DE14 2WH

Analytical Test Report: L14/0858/GRM/001

Your Project Reference:	**Island Road South, Garston**	Samples Received on:	26.04.2014
Your Order Number:	P6547	Testing Instruction Received:	26.04.2014
Report Issue Number:	1	Sample Tested :	26.04 to 07.05.2014
Samples Analysed	11 Soils 4 Leachates	Report issued:	08.05.2014

Signed

James Gane
Manager - Data Logistics
Nicholls Colton Analytical

Notes:

General

Please refer to Methodologies tab for details pertaining to the analytical methods undertaken.

Samples will be retained for 14 days after issue of this report with the exception of the abestos test portion which is held for 6 months unless otherwise requested.

Moisture Content was determined in accordance with NCA method statement MS - CL - Sample Prep, oven dried at <30˚C.

Moisture Content is reported as a percentage of the dry mass of soil, this calculation is in accordance with BS1377, Part 2, 1990, Clause 3.2

Stone Content was determined in accordance with NCA method statement MS - CL - Sample Prep and refers to the percentage of stones retained on a 10mm BS test sieve.

With the exception of Sulphate, which is crushed over the 2mm test sieve, concentrations are reported as a percentage mass of the dry soil passing the 10mm BS test sieve. As received samples have been corrected for moisture content but not stone content.

Samples were supplied by customer.

Deviant Samples

Samples were received in suitable containers	**Yes**
A date and time of sampling was provided	**Yes**
Sample handling times were exceeded prior to analysis of determinants	**No**

Where samples do not meet one or more of the above criteria they will be classed as deviant, this means data may not be representative of the sample at the time of sampling and it is possible that results provided may be compromised.

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L14/0858/GRM/001

Project Reference - Island Road South, Garston

Analytical Test Results - GRM Soil Suite

NCA Reference			14-12414	14-12415	14-12416	14-12417	14-12418	14-12419
Client Sample Reference			S1	S2	S1	S1	S1	S2
Client Sample Location			WS1	WS3	WS4	WS5	WS6	WS7
Depth (m)			0.10	0.20	0.10	0.30	0.15	0.40
Date of Sampling			23.04.2014	23.04.2014	23.04.2014	23.04.2014	23.04.2014	23.04.2014
Time of Sampling			Not provided	Not provided	Not provided	Not provided	Not provided	Not provided
Sample Matrix			Clay	Sand	Clay	Clay	Clay	Clay
Determinant	**Units**	**Accreditation**						
Arsenic	(mg/kg)	MCERTS	18.4	26.5	17.1	13.0	< 10	18.7
Cadmium	(mg/kg)	MCERTS	2.2	0.7	0.6	0.6	0.3	1.0
Chromium (Total)	(mg/kg)	MCERTS	< 1	3.3	4.5	1.7	3.5	< 1
Copper	(mg/kg)	MCERTS	67.4	215	66.2	50.2	14.5	97.2
Lead	(mg/kg)	MCERTS	94.5	83.4	183	95.3	20.1	303
Mercury	(mg/kg)	UKAS	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5
Nickel	(mg/kg)	MCERTS	26.8	27.8	26.6	24.7	14.2	30.3
Selenium	(mg/kg)	None	< 8	< 8	< 8	< 8	< 8	< 8
Zinc	(mg/kg)	MCERTS	900	492	89.7	64.4	30.0	462
Total Phenols	(mg/kg)	MCERTS	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
Cyanide (Total)	(mg/kg)	MCERTS	<1.2	<1.2	<1.2	2.2	1.7	<1.2
Chromium (Hexavalent)	(mg/kg)	None	1.4	1.2	<1.2	1.3	<1.2	<1.2
pH	pH Units	MCERTS	8.1	7.9	7.1	6.6	7.6	7.5
SOM	(%)	MCERTS	10.0	12.2	5.1	5.4	2.6	10.2
Sulphate	(mg/l)	None	33	77	35	200	47	37
Acenaphthene	(mg/kg)	MCERTS	<1.0	<1.0	<0.1	<0.1	<0.1	<0.1
Acenaphthylene	(mg/kg)	UKAS	<1.0	<1.0	<0.1	<0.1	<0.1	<0.1
Anthracene	(mg/kg)	UKAS	5.5	<1.0	<0.1	<0.1	<0.1	0.8
Benzo (a) anthracene	(mg/kg)	MCERTS	30.6	<1.0	0.1	0.2	0.3	3.8
Benzo (a) pyrene	(mg/kg)	MCERTS	40.9	<1.0	0.1	0.2	0.4	4.3
Benzo (b) fluoranthene	(mg/kg)	MCERTS	46.4	<1.0	0.1	0.2	0.4	5.0
Benzo (g, h, i) perylene	(mg/kg)	MCERTS	27.7	<1.0	<0.1	0.1	0.3	2.8
Benzo (k) fluoranthene	(mg/kg)	MCERTS	16.6	<1.0	<0.1	<0.1	<0.1	1.8
Chrysene	(mg/kg)	MCERTS	26.3	<1.0	0.2	0.2	0.3	3.6
Dibenzo (a,h) anthracene	(mg/kg)	MCERTS	5.1	<1.0	<0.1	<0.1	<0.1	0.5
Fluoranthene	(mg/kg)	MCERTS	51.9	<1.0	0.4	0.5	0.5	8.0
Fluorene	(mg/kg)	MCERTS	<1.0	<1.0	<0.1	<0.1	<0.1	<0.1
Indeno (1, 2, 3,-cd) pyrene	(mg/kg)	MCERTS	32.4	<1.0	<0.1	0.1	0.3	3.1
Naphthalene	(mg/kg)	MCERTS	<1.0	<1.0	<0.1	<0.1	<0.1	0.2
Phenanthrene	(mg/kg)	MCERTS	17.9	<1.0	0.2	0.3	0.2	3.1
Pyrene	(mg/kg)	MCERTS	59.0	<1.0	0.4	0.5	0.6	8.2
Total PAH (Sum of USEPA 16)	(mg/kg)	UKAS	364	<16	2.4	2.9	3.9	45.4
Asbestos	-	UKAS	No asbestos detected	No asbestos detected	No asbestos detected	No asbestos detected	No asbestos detected	No asbestos detected

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Project Reference - Island Road South, Garston

Analytical Test Results - GRM Soil Suite

NCA Reference			14-12420	14-12421	14-12422	14-12423	14-12425
Client Sample Reference			S1	S1	S4	S2	S2
Client Sample Location			WS8	WS9	WS1	WS5	WS9
Depth (m)			0.40	0.10	1.60	0.70	0.80
Date of Sampling			23.04.2014	23.04.2014	23.04.2014	23.04.2014	23.04.2014
Time of Sampling			Not provided	Not provided	Not provided	Not provided	Not provided
Sample Matrix			Clay	Clay	Clay	Sand	Clay
Determinant	**Units**	**Accreditation**					
Arsenic	(mg/kg)	MCERTS	19.8	< 10	-	-	-
Cadmium	(mg/kg)	MCERTS	0.6	0.4	-	-	-
Chromium (Total)	(mg/kg)	MCERTS	1.5	3.7	-	-	-
Copper	(mg/kg)	MCERTS	84.0	21.8	-	-	-
Lead	(mg/kg)	MCERTS	137	38.5	-	-	-
Mercury	(mg/kg)	UKAS	< 2.5	< 2.5	-	-	-
Nickel	(mg/kg)	MCERTS	24.3	20.1	-	-	-
Selenium	(mg/kg)	None	< 8	< 8	-	-	-
Zinc	(mg/kg)	MCERTS	110	35.0	-	-	-
Total Phenols	(mg/kg)	MCERTS	<1.2	<1.2	-	-	-
Cyanide (Total)	(mg/kg)	MCERTS	<1.2	<1.2	-	-	-
Chromium (Hexavalent)	(mg/kg)	None	1.8	<1.2	-	-	-
pH	pH Units	MCERTS	6.5	7.4	7.0	6.2	6.9
SOM	(%)	MCERTS	7.0	2.8	-	-	-
Sulphate	(mg/l)	None	73	<10	630	<10	2200
Acenaphthene	(mg/kg)	MCERTS	<0.1	<0.1	-	-	-
Acenaphthylene	(mg/kg)	UKAS	<0.1	<0.1	-	-	-
Anthracene	(mg/kg)	UKAS	<0.1	<0.1	-	-	-
Benzo (a) anthracene	(mg/kg)	MCERTS	0.3	<0.1	-	-	-
Benzo (a) pyrene	(mg/kg)	MCERTS	0.3	<0.1	-	-	-
Benzo (b) fluoranthene	(mg/kg)	MCERTS	0.4	<0.1	-	-	-
Benzo (g, h, i) perylene	(mg/kg)	MCERTS	0.2	<0.1	-	-	-
Benzo (k) fluoranthene	(mg/kg)	MCERTS	<0.1	<0.1	-	-	-
Chrysene	(mg/kg)	MCERTS	0.4	<0.1	-	-	-
Dibenzo (a,h) anthracene	(mg/kg)	MCERTS	<0.1	<0.1	-	-	-
Fluoranthene	(mg/kg)	MCERTS	0.8	<0.1	-	-	-
Fluorene	(mg/kg)	MCERTS	<0.1	<0.1	-	-	-
Indeno (1, 2, 3,-cd) pyrene	(mg/kg)	MCERTS	0.2	<0.1	-	-	-
Naphthalene	(mg/kg)	MCERTS	<0.1	<0.1	-	-	-
Phenanthrene	(mg/kg)	MCERTS	0.4	<0.1	-	-	-
Pyrene	(mg/kg)	MCERTS	0.9	<0.1	-	-	-
Total PAH (Sum of USEPA 16)	(mg/kg)	UKAS	4.5	<1.6	-	-	-
Asbestos	-	UKAS	No asbestos detected	No asbestos detected	-	-	-

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Project Reference - Island Road South, Garston

Analytical Test Results - TPH CWG

NCA Reference			14-12414	14-12416	14-12418	14-12421
Client Sample Reference			S1	S1	S1	S1
Client Sample Location			WS1	WS4	WS6	WS9
Depth (m)			0.10	0.10	0.15	0.10
Date of Sampling			23.04.2014	23.04.2014	23.04.2014	23.04.2014
Time of Sampling			Not provided	Not provided	Not provided	Not provided
Sample Matrix			Clay	Clay	Clay	Clay
Determinant	**Units**	**Accreditation**				
Aliphatics						
$>C_5$ to C_6	(mg/kg)	None	0.06	0.03	<0.04	<0.03
$>C_6$ to C_8	(mg/kg)	None	0.06	<0.03	<0.04	0.12
$>C_8$ to C_{10}	(mg/kg)	None	<0.03	<0.03	<0.04	<0.03
$>C_{10}$ to C_{12}	(mg/kg)	None	<12	<12	<12	<11
$>C_{12}$ to C_{16}	(mg/kg)	None	16	<12	<12	<11
$>C_{16}$ to C_{21}	(mg/kg)	None	46	<12	<12	<11
$>C_{21}$ to C_{35}	(mg/kg)	None	115	15	<12	<11
Aromatics						
$>C_5$ to C_7	(mg/kg)	None	<0.03	<0.03	<0.04	<0.03
$>C_7$ to C_8	(mg/kg)	None	<0.03	<0.03	<0.04	<0.03
$>C_8$ to C_{10}	(mg/kg)	None	<0.03	<0.03	<0.04	<0.03
$>C_{10}$ to C_{12}	(mg/kg)	None	<12	<12	<12	<11
$>C_{12}$ to C_{16}	(mg/kg)	None	14	<12	<12	<11
$>C_{16}$ to C_{21}	(mg/kg)	None	136	<12	<12	<11
$>C_{21}$ to C_{35}	(mg/kg)	None	808	<12	<12	<11

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Project Reference - Island Road South, Garston

Analytical Test Results - GRM Leachate Suite

NCA Reference			14-12415	14-12417	14-12419	14-12420
Client Sample Reference			S2	S1	S2	S1
Client Sample Location			WS3	WS5	WS7	WS8
Depth (m)			0.20	0.30	0.40	0.40
Date of Sampling			23.04.2014	23.04.2014	23.04.2014	23.04.2014
Time of Sampling			Not provided	Not provided	Not provided	Not provided
Sample Matrix			Leachate	Leachate	Leachate	Leachate
Determinant	**Units**	**Accreditation**				
Arsenic	(µg/l)	None	18	< 2.5	< 2.5	3
Cadmium	(µg/l)	None	< 2.5	< 2.5	< 2.5	< 2.5
Chromium (Total)	(µg/l)	None	< 2.5	< 2.5	< 2.5	< 2.5
Copper	(µg/l)	None	3	3	5	23
Lead	(µg/l)	None	< 1	< 1	2	< 1
Mercury	(µg/l)	None	< 1	< 1	< 1	< 1
Nickel	(µg/l)	None	< 2.5	< 2.5	< 2.5	< 2.5
Selenium	(µg/l)	None	< 1	< 1	< 1	< 1
Zinc	(µg/l)	None	< 1	< 1	13	< 1
Phenol (Total)	(µg/l)	None	1.7	6.3	0.3	1.4
Cyanide (Total)	(mg/l)	None	<0.5	<0.5	<0.5	<0.5
pH	pH Units	UKAS	7.7	7.3	7.7	7.2
Sulphate	(mg/l)	None	<10	30	<10	<10
Ammonical Nitrogen	(mg/l)	None	<0.5	<0.5	<0.5	1.7
Benzo (a) pyrene	(µg/l)	None	<0.01	<0.01	<0.01	<0.01
Benzo (b) fluoranthene	(µg/l)	None	<0.01	<0.01	<0.01	<0.01
Benzo (g, h, i) perylene	(µg/l)	None	<0.01	<0.01	<0.01	<0.01
Benzo (k) fluoranthene	(µg/l)	None	<0.01	<0.01	<0.01	<0.01
Indeno (1, 2, 3,-cd) pyrene	(µg/l)	None	<0.01	<0.01	<0.01	<0.01
Naphthalene	(µg/l)	None	0.08	0.09	0.05	0.08

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Project Reference - Island Road South, Garston

Sample Descriptions

NCA Reference	Client Sample Reference	Sample Location	Description	Moisture Content (%)	Stone Content (%)
14-12414	S1	WS1	Dark brown silty clay with organic matter.	19	0
14-12415	S2	WS3	Dark brown slightly gravelly sand.	15	0
14-12416	S1	WS4	Brown sandy clay.	20	0
14-12417	S1	WS5	Brown sandy slightly gravelly clay.	18	0
14-12418	S1	WS6	Brown slightly sandy clay.	16	0
14-12419	S2	WS7	Brown slightly sandy silty clay.	23	0
14-12420	S1	WS8	Brown slightly gravelly sandy clay.	17	0.5
14-12421	S1	WS9	Brown sandy clay.	1.0	0

NCA Reference	Client Sample Reference	Sample Location	Description	% Passing 2mm BS test sieve
14-12422	S4	WS1	Brown slightly gravelly slightly silty clay	93
14-12423	S2	WS5	Brown sand.	99
14-12425	S2	WS9	Brown clay	99

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Project Reference - Island Road South, Garston

Analysis Methodologies

Matrix	Determinant	Sample condition for analysis	Test Method used
Soil	Metals	Air Dried	In house method statement - MS - CL - ICP metals
Soil	PAH	Air Dried	In house method statement - MS - CL - PAH
Soil	Phenols	As Received	In house method statement - MS - CL - Phenols (Skalar)
Soil	Chromium (hexavalent)	As Received	In house method statement - MS - CL - Chromium (Hexavalent)
Soil	Cyanide	As Received	In house method statement - MS - CL - Cyanide by Skalar
Soil	pH	As Received	In house method statement - MS - CL - pH (Soil)
Soil	SOM	Air Dried	In house method statement - MS - CL - TOC
Soil	Sulphate	Air Dried	In house method statement - MS - CL - Anions (Aquakem)
Soil	CWG	As Received	In house method statement - MS - CL - EPH and VPH
Soil	Asbestos	As Received	Tested in accordance with in house documented method MS - AS - Asbestos based on HSG 248 using stereo-microscopy, polarised light microscopy and dispersion staining
Soil	Leaching	As Received	NRA R&D note 301 using a 10 : 1 by wet mass of sample extraction ratio
Leachate	Metals	As Received	In house method statement - MS - CL - ICP Metals Water
Leachate	PAH	As Received	In house method statement - MS - CL - PAH Water
Leachate	Phenol	As Received	In house method statement - MS - CL - Phenols (HPLC)
Leachate	pH	As Received	BS 1377, Part 3, 1990
Leachate	Cyanide	As Received	In house method statement - MS - CL - Cyanide
Leachate	Sulphate	As Received	In house method statement - MS - CL - Anions (Aquakem)
Leachate	Ammonia	As Received	In house method statement - MS - CL - Ammonia

APPENDIX H

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TEST REPORT

BS 1377 PLASTICITY INDEX AND MOISTURE CONTENT

Island Road South, Garston

Report no. L14/0858/GRM/002			
Order reference: P6547	Date of receipt: 26/04/2014	Date of testing: 03/05/2014 to 08/05/2014	Date of issue: 08/05/2014

NCA Sample reference	Client sample reference	Sample type	Depth (m)	Sample description	Fines passing 425µm (%)	**Liquid limit (%)**	**Plastic limit (%)**	**Plasticity index (%)**	**Moisture content (%)**
14-12426	WS1 S4	Disturbed	1.60	Brown slightly gravelly slightly silty clay	96	**22**	**13**	**9**	**15**
14-12427	WS5 S4	Disturbed	1.50	Brown slightly sandy slightly silty clay	99	**26**	**13**	**13**	**17**
14-12428	WS9 S2	Disturbed	0.80	Brown clay	100	**50**	**22**	**28**	**25**

NOTES:
1. Sample preparation was in accordance with BS 1377 : Part 1 : 1990.
2. Plasticity index testing was in accordance with BS 1377 : Part 2 : 1990 Clauses 3, 4.4 (one-point) & 5.
3. Moisture content testing was in accordance with BS 1377 : Part 2 : 1990 Clause 3.2.3.1 .
4. The material was prepared from its natural state.
5. Some information required by BS 1377 : Part 1 : 1990 Clause 9 is not included in the report. The information will be provided if requested.

.....
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Manager – Data Logistics
Nicholls Colton Analytical

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APPENDIX I

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	GRM TIER 1 ASSESSMENT CRITERIA		
LAND USE	Residential with Plant Uptake		
CONTAMINANT	**1%**	**2.50%**	**6%**
a **Arsenic**	32	32	32
a **Cadmium**	10	10	10
b **Chromium III**	614	614	614
b **Chromium VI**	4.15	4.15	4.15
c **Lead**	450	450	450
d **Mercury**	170	170	170
a **Selenium**	350	350	350
a **Nickel**	130	130	130
b **Phenols**	184	290	415
b **Copper**	2330	2330	2330
b **Zinc**	3,750	3750	3750
e **Cyanide**	34	34	34
b **Benzene**	0.08	0.157	0.332
b **Toluene**	119	270	611
b **Ethylbenzene**	65	154	354
b ***o* - xylene**	45	106	246
b ***m* - xylene**	44	103	240
b ***p* - xylene**	42	98.2	228
b/f **Acenaphthene**	210(326)	480	1000
b/f **Acenaphthylene**	168	400	850
b/f **Anthracene**	2300	4900	9200
b **Benzo(a)anthracene**	3.1	4.7	5.9
b **Benzo(a)pyrene**	0.83	0.94	1
b **Benzo(b)fluoranthene**	5.6	6.5	7
b **Benzo(ghi)perylene**	40	46	47
b **Benzo(k)fluoranthene**	8.5	9.6	10
b **Chrysene**	6	8	9.3
b **Dibenzo(ah)anthracene**	0.76	0.86	0.9
b **Fluoranthene**	260	460	670
b/f **Fluorene**	160	380	780
b **Ideno(1,2,3-cd)pyrene**	3.2	3.9	4.2
b **Napthalene**	1.5	3.7	8.7
b/f **Phenanthrene**	92	200	380
b **Pyrene**	560	1000	1600
ALIPHATIC HYDROCARBONS			
b/f **C5-C6**	30	55	110
b/f **C6-C8**	73	160	370
b/f **C8-C10**	19	46	110
b/f **C10-C12**	93(48)	230(118)	540(283)
b/f **C12-C16**	740(24)	1700(59)	3000(142)
f **C16-35**	45,000	64,000	76,000
AROMATIC HYDROCARBONS			
b/f **C5-7 (benzene)**	65	130	280
b/f **C7-8 (toluene)**	120	270	611
b/f **C8-C10**	27	65	151
b/f **C10-C12**	69	160	346
b/f **C12-C16**	140	310	593
f **C16-C21**	250	480	770
f **C21-C35**	890	1110	1230

Notes

a SGV (2009)
b LQM/CIEH values or derived using CLEAv1.06 with LQM/CIEH Data.
c 2002 SGV values used until further guidance is pubished
d SGV for inorganic Hg used (ref.2009 SGV, Pg5, Para.4)
e Atkins ATRISKsoil Value
f Oral, dermal and inhalation exposure compared with Oral HCV
Values in brackets present TAC exceeding solubility & vapour saturation limits

GRM.TAC.03.11

	GRM TIER 1 ASSESSMENT CRITERIA		
LAND USE	Residential without Plant Uptake		
CONTAMINANT	**% Soil Organic Matter**		
	1%	**2.50%**	**6%**
a **Arsenic**	35	35	35
a **Cadmium**	17.7	17.7	17.7
b **Chromium III**	620	620	620
b **Chromium VI**	4.17	4.17	4.17
c **Lead**	450	450	450
d **Mercury**	170	170	170
a **Selenium**	595	595	595
a **Nickel**	786	786	786
b **Phenols**	310	418	519
b **Copper**	6200	6200	6200
b **Zinc**	40,500	40,500	40,500
e **Cyanide**	34	34	34
b **Benzene**	0.266	0.49	0.998
b **Toluene**	607	1290	2710
b **Ethylbenzene**	167	381	843
b ***o* - xylene**	59.5	139	321
b ***m* - xylene**	55.4	130	302
b ***p* - xylene**	53.3	125	288
b/f **Acenaphthene**	2020(57)	3090(141)	3910(336)
b/f **Acenaphthylene**	1950(86)	3020(212)	3870(506)
b/f **Anthracene**	20,100(1.84)	22,400	23,400
b **Benzo(a)anthracene**	3.71	5.23	6.22
b **Benzo(a)pyrene**	1	1.03	1.04
b **Benzo(b)fluoranthene**	6.99	7.25	7.36
b **Benzo(ghi)perylene**	43	43.6	43.8
b **Benzo(k)fluoranthene**	10.1	10.3	10.4
b **Chrysene**	8.84	9.74	10.1
b **Dibenzo(ah)anthracene**	0.865	0.91	0.928
b **Fluoranthene**	972	993	1000
b/f **Fluorene**	1850(30)	2480(76)	2870(183)
b **Ideno(1,2,3-cd)pyrene**	4.17	4.35	4.43
b **Napthalene**	1.64	3.92	9.22
b/f **Phenanthrene**	731(16)	872	943
b **Pyrene**	2330	2380	2400
ALIPHATIC HYDROCARBONS			
b/f **C5-C6**	30	55	113
b/f **C6-C8**	73	162	371
b/f **C8-C10**	19	46	110
b/f **C10-C12**	93(48)	230(118)	540(283)
b/f **C12-C16**	745(23.7)	1700(59.1)	3040(142)
f **C16-35**	89,000	89,000	89,000
AROMATIC HYDROCARBONS			
b/f **C5-7 (benzene)**	263	483	978
b/f **C7-8 (toluene)**	607	1290	2710
b/f **C8-C10**	33.2	80.7	189
b/f **C10-C12**	177	417	866
b/f **C12-C16**	1250(169)	1590(419)	1710
f **C16-C21**	1340	1340	1340
f **C21-C35**			

Notes

a SGV (2009)
b LQM/CIEH values or derived using CLEAv1.06 with LQM/CIEH Data.
c 2002 SGV values used until further guidance is pubished
d SGV for inorganic Hg used (ref.2009 SGV, Pg5, Para.4)
e Atkins ATRISKsoil Value
f Oral, dermal and inhalation exposure compared with Oral HCV
Values in brackets present TAC exceeding solubility & vapour saturation limits

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	GRM TIER 1 ASSESSMENT CRITERIA		
LAND USE	Commercial & industrial		
CONTAMINANT	**1%**	**2.50%**	**6%**
a **Arsenic**	640	640	640
a **Cadmium**	230	230	230
b **Chromium III**	8,790	8,790	8,790
b **Chromium VI**	34.5	34.5	34.5
c **Lead**	750	750	750
d **Mercury**	3600	3600	3600
a **Selenium**	13,000	13, 000	13,000
a **Nickel**	1800	1800	1800
b **Phenols**	1,100,000	1,100,000	1,200,000
b **Copper**	71,700	71,700	71,700
b **Zinc**	667,000	667,000	667,000
e **Cyanide**	34	34	34
b **Benzene**	28	50	95
b **Toluene**	869	1,920	4400
b **Ethylbenzene**	518	1,220	2800
b ***o* - xylene**	4,780	1,120	2600
b ***m* - xylene**	625	1,470	3500
b ***p* - xylene**	576	1,350	3200
b/f **Acenaphthene**	85000(57)	98000(141)	100,000
b/f **Acenaphthylene**	84,000	97000(212)	100,000
b/f **Anthracene**	530,000	540,000	540,000
b **Benzo(a)anthracene**	90	95	97
b **Benzo(a)pyrene**	14	14	14
b **Benzo(b)fluoranthene**	100	100	100
b **Benzo(ghi)perylene**	650	660	660
b **Benzo(k)fluoranthene**	140	140	140
b **Chrysene**	140	140	140
b **Dibenzo(ah)anthracene**	13	13	13
b **Fluoranthene**	23,000	23,000	23,000
b/f **Fluorene**	64,000	69,000	71,000
b **Ideno(1,2,3-cd)pyrene**	60	61	62
b **Napthalene**	200(76)	480(183)	1100(432)
b/f **Phenanthrene**	22,000	22,000	23,000
b **Pyrene**	54,000	54,000	54,000
ALIPHATIC HYDROCARBONS			
b/f **C5-C6**	3339(304)	6200(558)	13,000(1150)
b/f **C6-C8**	8300(144)	18,000(322)	42,000(736)
b/f **C8-C10**	2130(78)	5100(190)	12,000(451)
b/f **C10-C12**	10,000(48)	24,000(118)	49,300(283)
b/f **C12-C16**	61,000(24)	83,000(59)	91,000(142)
f **C16-35**	1,600,000	1,800,000	1,800,000
AROMATIC HYDROCARBONS			
b/f **C5-7 (benzene)**	28,000(1220)	49,000(2260)	90,000(4710)
b/f **C7-8 (toluene)**	59,000(869)	110,000(1920)	190,000(4360)
b/f **C8-C10**	3670(613)	8560(1500)	18,000(3580)
b/f **C10-C12**	17,000(364)	29,000(899)	34,500(2150)
b/f **C12-C16**	36,000(169)	37,000	37,800
f **C16-C21**	28,000	28,000	28,000
f **C21-C35**			

Notes

a SGV (2009)
b LQM/CIEH values or derived using CLEAv1.06 with LQM/CIEH Data.
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Line through middle?

UKDWS			Groundwater Q	Surface Water Q	EQS for List 1 & 2 Dangerous Substances (µg/l)	WRAS Values (mg/kg)
Parameter	Concentration	Units		Conc/unit		
Acrylamide	0.1	µg/l				
Aluminium	200	µgAl/l				
Ammonium	0.5	mgNH4/l		4 mg NH4/l	15 (NH3)	
Antimony	5	µgSb/l				10
Arsenic	10	µgAs/l		DW1: 0.05 mg As/l DW2: 0.05 mg As/l DW3: 0.1 mg As/l		10*
Benzene	1	µg/l		Inland surface waters MAC-EQS: 50 ug/l Other surface waters MAC-EQS: 50 ug/l	30	
Benzo(a)pyrene	0.01	µg/l		Inland surface waters AA-EQS: 0.05 ug/l Other surface waters AA-EQS: 0.05 ug/l Inland surface waters MAC-EQS: 0.1 ug/l Other surface waters MAC-EQS: 0.1 ug/l		
Boron	1	mgB/l	under investigation		2000	
Bromate	10	µgBrO3/l				
Cadmium	5	µgCd/l	low risk	DW1: 0.005 mg Cd/l DW2: 0.005 mg Cd/l DW3: 0.005 mg Cd/l	5	3
Chromium	50	µgCr/l	under investigation	DW1: 0.05 mg Cr/l DW2: 0.05 mg Cr/l DW3: 0.05 mg Cr/l	32.8	25/ 600 (CrVI/Total)
Chloride (i)	250	mgCl/l				
Conductivity (i)	2500	µS/cm at 20°C				
Copper(ii)	2	mg/l	under investigation	DW1: 0.05 mg Cu/l		
Cyanide	50	µgCN/l	low risk	DW1: 0.05 mg CN/l DW2: 0.05 mg CN/l DW3: 0.05 mg CN/l		25/ 250 (Free/Complex)
1, 2 dichloroethane	3	µg/l		Inland surface waters AA-EQS: 10 ug/l Other surface waters AA-EQS: 10 ug/l		
Epichlorohydrin	0.1	µg/l				
Fluoride	1.5	mgF/l	under investigation	DW1: 1.5 mg F/l		
Hydrogen ion	10	pH value				
Iron	200	µgFe/l		DW1: 0.3 mg Fe/l DW2: .2 mg Fe/l	1000	
Lead (ii)	10	µgPb/l	under investigation	DW1: 0.05 mg Pb/l DW2: 0.05 mg Pb/l DW3: 0.05 mg Pb/l		500
Manganese	50	µgMn/l				
Mercury	1	µgHg/l	low risk	DW1: 0.001 mg Hg/l DW2: 0.001 mg Hg/l DW3: 0.001 mg Hg/l	1	1
Mineral Oil (TPH)	10	µg/l	low risk			100/10/1000 (diesel/petrol/mineral)
Nitrate (iii)	50	mgNO3/l		DW1: 50 mg NO3/l DW2: 50 mg NO3/l DW3: 50 mg NO3/l		
Nitrite (iii)	0.5 (0.1 at treatment works)	mgNO2/l	under investigation			
Phenol	0.5	µg/l				5
Polycyclic Aromatic Hydrocarbons (vii) *	0.1	µg/l		DW1: 0.0002 mg/l DW2: 0.0002 mg/l DW3: 0.001 mg/l	10 (Naphtahlene)	50
Selenium	10	µgSe/l	under investigation	DW1: 0.01 mg Se/l DW2: 0.01 mg Se/l DW3: 0.01 mg Se/l		3
Sodium	200	mgNa/l				
Sulphate (i)	250	mgSO4/l		DW1: 250 mg SO4/l DW2: 250 mg SO4/l (1) DW3: 250 mg SO4/l (1)		2000
Tetrachloroethene and Trichloroethene (viii)	10	µg/l		10 ug/l		
Tetrachloromethane	3	µg/l		Inland surface waters AA-EQS: 12 ug/l Other surface waters AA-EQS: 12 ug/l		
Toluene/Xylene (m, p, o)		µg/l		Inland surface freshwaters AA-EQS: 30 ug/l Coastal waters and relevant territorial waters AA-EQS: 30 ug/l	50/30	50
Vinyl chloride	0.5	µg/l				
Zinc	5000	µg/l	under investigation	DW1: 3 mg Zn/l DW2: 5 mg Zn/l DW3: 5 mg Zn/l		

3 types

other types

Pesticides				
Aldrin	0.03	µg/l	Inland surface waters AA-EQS: 0.01 ug/l (1) Other surface waters AA-EQS: 0.005 ug/l (1)	0.01
Dieldrin	0.03	µg/l	DW1: 0.001 mg/l DW2: 0.0025 mg/l DW3: 0.005 mg/l	0.01
Heptachlor	0.03	µg/l		
Heptachlor epoxide	0.03	µg/l		
other pesticides	0.1	µg/l		Endrin 0.005, Total'drins (0.03)
Pesticides: Total (vi)	0.5	µg/l		

Reference

UK Water Supply (Water Quality) Regulations 2000

* PAHs - sum of specified compounds:
- benzo(b)fluoranthene
- benzo(k)fluoranthene
- benzo(ghi)perylene
- indeno(1,2,3-cd)pyrene

Surface Waters (Abstraction for Drinking Water) (Classification) Regulations 1996

Groundwater Regulations 1998

Council Directive on the quality of fresh waters needing protection or improvement in order to support fish life (Freshwater Fish Directive)

DW1, DW2 and DW3, in order of decreasing water quality

EQS for Hardness Related List 2 Dangerous Substances

Substance	EQS type	EQS (ug/l) for Hardness bands (mg/l CaCO3)					
		0-50	>50-100	>100-150	>150-200	>200-250	>250
Freshwaters, suitable for all fishlife							
Copper (dissolved)	Annual average	1	6	10	10	10	28
Copper (dissolved)	95th percentile	5	22	40	40	40	112
Nickel (dissolved)	Annual average	50	100	150	150	200	200
Vanadium (dissolved)	Annual average	20	20	20	20	60	60
Freshwaters, suitable for Salmonid (game) fish							
Chromium (dissolved)	Annual average	5	10	20	20	50	50
Lead (dissolved)	Annual average	4	10	10	20	20	20
Zinc (total)	Annual average	8	50	75	75	75	125
Zinc (total)	95th percentile	30	200	300	300	300	500
Freshwaters, suitable for Cyprinid (coarse) fish							
Chromium (dissolved)	Annual average	150	175	200	200	250	250
Lead (dissolved	Annual average	50	125	125	250	250	250
Zinc (total)	Annual average	75	175	250	250	250	500
Zinc (total)	95th percentile	300	700	1000	1000	1000	2000

Cadmium??

Boron??

Pipe Selection Table[2]

		Pipe material					
		All threshold concentrations are in mg/kg					
	Parameter group	**PE**	**PVC**	**Barrier pipe (PE-Al-PE)**	**Wrapped Steel**	**Wrapped Ductile Iron**	**Copper**
1	Extended VOC suite by purge and trap or head space and GC-MS with TIC	0.5	0.125	Pass	Pass	Pass	Pass
1a	+ BTEX + MTBE	0.1	0.03	Pass	Pass	Pass	Pass
2	SVOCs TIC by purge and trap or head space and GC-MS with TIC (aliphatic and aromatic C5-C10)	2	1.4	Pass	Pass	Pass	Pass
2e	+ Phenols	2	0.4	Pass	Pass	Pass	Pass
2f	+ Cresols and chlorinated phenols	2	0.04	Pass	Pass	Pass	Pass
3	Mineral oil C11-C20	10	Pass	Pass	Pass	Pass	Pass
4	Mineral oil C21-C40	500	Pass	Pass	Pass	Pass	Pass
5	Corrosive (Conductivity, Redox and pH)	Pass	Pass	Pass	Corrosive if pH <7 and conductivity >400µS/cm	Corrosive if pH <5, Eh not neutral and conductivity >400µS/cm	Corrosive if PH <5 or >8 and Eh positive
	Specific suite identified as relevant following site investigation						
2a	Ethers	0.5	1	Pass	Pass	Pass	Pass
2b	Nitrobenzene	0.5	0.4	Pass	Pass	Pass	Pass
2c	Ketones	0.5	0.02	Pass	Pass	Pass	Pass
2d	Aldehydes	0.5	0.02	Pass	Pass	Pass	Pass
6	Amines	Fail	Pass	Pass	Pass	Pass	Pass

[2] *Taken from the UKWIR publication '26HGuidance for the selection of water supply pipes to be used in Brownfield sites'*