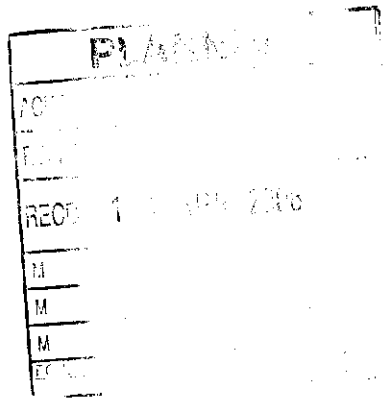
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Islington Wharf

Geotechnical and Geoenvironmental Report

ISSUE 1



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Geotechnical and Geoenvironmental Report

November 2004

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EXECUTIVE SUMMARY

The Islington Wharf site is currently a derelict site located adjacent to the Ashton canal, approximately 2 km to the east of Manchester city centre.

The proposed development involves the redevelopment of the site for a mixed-use retail and residential scheme with multi-storey high quality canal side apartments set in to five blocks, and constructed in three phases. There is a two-storey podium structure that lies between the four residential blocks located in the west of the site and contains car parking and a roof top landscaped area.

This report collates geotechnical and geo-environmental information from a variety of sources including previous desk study and site investigation works.

Arup conducted a desk study in 2003, which indicated the presence of significant historical development including a cotton mill, industrial school, paint works, toy balloon works, scrap yard, spindle works, chain works and residential dwellings.

Following the desk study, an intrusive site investigation was designed and supervised by Arup and conducted by contractor Ian Farmer Associates in March 2004. The purpose of this investigation was to provide preliminary geotechnical and geoenvironmental information relevant to the design of the development, focussing on the Phase 1 area.

This report details the findings of this recent site investigation and the previous site investigation works by others. This report also discusses potential development constraints and recommendations in terms of both the geotechnical design and environmental remediation works.

The site investigation confirmed the ground conditions to comprise a highly variable Made Ground (average 1.5m thick) overlying a firm to very stiff Glacial Till (average 17m thick) overlying a dense Glacial Sand and Gravel layer (11m to 17.7m thick where proven). The sandstone bedrock below this was only proven in limited positions. Ground water was found to be generally several metres below the top of the Glacial Sand and Gravel although small pockets of perched water were evident in the Made Ground Deposits.

A number of potential contamination sources have been identified from the desk study and site investigation. A qualitative and generic quantitative risk assessment has been undertaken which indicates some levels of contaminants above the initial screening levels for Antimony, Arsenic, Copper, Lead, Nickel and PAH. Recommendations have been made with regards to the remediation considerations and an outline strategy put forward.

Gas monitoring indicates that elevated Carbon Dioxide is present in both the deep and shallow deposits and the development will need adequate protection measures.

The earthworks requirements form part of the remediation strategy and it is evident that based on the current Broadway Malyan scheme, there is a net surplus of materials on site therefore off site disposal will be required. The works will include the following:

- Site strip – To remove vegetated deposits, needles and syringes.
- Removal of Japanese Knotweed deposits (if not eradicated by treatment by the time the works commence)
- Removal of contamination hotspots.
- Cut and fill to form platform – Including processing of materials to reduce the requirements for both off site disposal and importation of suitable fills.

Due to the high loadings from the main residential blocks, the foundations will need to be piled, with the piles installed in to the dense Sand and Gravel layer. Given the lower foundation loads imposed by the two-storey Podium structure, shallow spread foundations are likely to be acceptable.

Recommendations for further work have been made including the following:

- Additional assessment of the foundations as part of the detailed design
- Further gas monitoring, particularly of the shallow installations
- Further treatment of the Japanese Knotweed
- An assessment of the integrity of the canal structure
- Further discussions with the Environmental Health Officer (EHO) with a view to developing the Detailed Quantitative Risk Assessment, the Foundation Works Risk Assessment and the detailed remediation strategy.
- Given that the current SI was focussed on the Phase 1 development area and subject to the above EHO discussions, further site investigation may be required.

1. INTRODUCTION

Arup have been appointed by ISIS as civil, structural and geotechnical consultants for the proposed Islington Wharf development, adjacent to Great Ancoats Street in east Manchester.

The project involves the redevelopment of a derelict site, which is adjacent to the Ashton Canal. The proposed development is for a mixed-use retail and residential scheme with multi-storey high quality canal side apartments set into five blocks, and constructed in three phases. There is a two-storey podium structure that lies between the four residential blocks located in the west of the site and contains car parking and a roof top landscaped area.

This report collates geotechnical and environmental information from a variety of sources including previous desk study and site investigation works. This work builds upon a previous geotechnical desk study undertaken by Arup in November 2003, which discussed the site history and likely ground conditions (Islington Wharf, Desk Study Report, Arup, November 2003).

Following the desk study, an intrusive site investigation was designed and supervised by Arup and conducted by contractor Ian Farmer Associates. The purpose of this investigation was to provide preliminary geotechnical and geoenvironmental information relevant to the design of the development. This report details the findings of this recent site investigation.

This report also discusses potential development constraints and recommendations for geotechnical design and environmental remediation works as appropriate.

This report takes into account the particular instructions and requirements of our client, ISIS, in connection with the Islington Wharf project. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

2. THE SITE

2.1 Location and Topography

The site is located on the eastern edge of Manchester city centre and is centred on National Grid Reference SJ 853 983 (See Figures 1 and 2). The site is bounded by Great Ancoats Street to the west, Old Mill Street to the north, Vesta Street to the east and the Ashton Canal to the south. The eastern half of the site is crossed by the Islington Branch of the Ashton Canal. The site to the west of the Islington Branch is currently mainly vacant land, with insecure fencing and earth mounds on the boundaries. Adjacent to the Islington Branch there is a small depot occupied by British Waterways. The site to the east of the Islington Branch is also vacant land together with mounds of what is possibly demolition material. There are established areas of scrub vegetation over much of the site, particularly to the west of the Islington Branch. The site is currently unused except for recreational drug abuse.

The site slopes gently downwards from a level of 49.4mOD in the north eastern corner of the site to a level of 47.2mOD at the western boundary. There is little change in level from north to south. There are locks on the Ashton Canal both immediately to the east of Great Ancoats Street and also just to the east of the site. There is a grassy bank sloping up to the site from the canal towpath at a level of 47.6mOD. Canal water level between these locks is approximately 47.2mOD.

2.2 Surrounding Land Use

The site is located within mixed residential and light industrial area (comprising mainly textile manufacture, scrap metal works and vehicle maintenance facilities) to the east of Manchester City Centre. The nearest residential properties are located approximately 200 m north east of the site. Commercial premises in close vicinity to the site include a car servicing facility to the east, and a small retail park to the north of Old Mill Street. The former Ancoats Hospital, now under regeneration as New Islington, Britain's third Millennium Village, is located to the east of Vesta Street.

The Envirocheck report indicates that the site lies 500 m north west of a known construction waste landfill site (Palmerston Street / Great Ancoats Street), formerly registered to Peter Birse Ltd, although the license has now been surrendered. Several local authority air pollution control consents have been granted within the vicinity of the site, including a scrap metal furnace on Jersey Street, respraying of vehicles on Great Ancoats Street and a coppersmiths on Piercy Street.

2.3 Site History

An Envirocheck Report has been obtained for the site. This provides copies of the historical Ordnance Survey maps for the site together with environmental information obtained from a number of databases. The historical data has been supplemented by a review of available large scale pre-Ordnance survey maps of this area. A selection of historical maps is presented as Figures 3 to 7.

In summary, the history of the site is as follows:

Pre 1793 map

Green (1793) indicates that the earliest development of the site took place prior to 1793. This development appears to comprise dwellings and gardens, and a possible pond is also shown.

1831 map

By this date, the Ashton Canal had been constructed and the Islington Branch had been added to provide canal access to land north of the site. A cotton mill was present on the site on the west side of the Islington Branch canal. A further branch of the canal extended to the east towards Vesta Street from the main Islington Branch.

1850-1960's maps

Further development on the site occurred during the latter half of the nineteenth century and there are a number of recorded uses for the buildings on the site.

To the west of the Islington Branch the site has been used for residential development, a public house (on Great Ancoats Street) and an 'Industrial School' (on Mill Street). Parts of the residential development were demolished in the early 1950's. The Industrial School became a Technical School and then the 'Manchester School of Building'. Land alongside the canal branch is originally described as 'Wharf', later 'Paint Works' and 'Paint Warehouse'.

To the east of the canal branch, the Engineering Works is initially recorded as 'Spindle Works', later 'Metal Stamping' and 'Toy Balloon Works'.

Post 1960's maps

Site clearance took place in the 1970's and 1980's with the majority of buildings being demolished. The 'Works' adjacent to Vesta Street remained until the early 1990's. In 1989 the OS map identifies it as 'Oak House'. The existing British Waterways depot was constructed on the west side of the Islington canal basin in the late 1970's when a 'scrap works' was also located on this part of the site. The lock keepers cottage adjacent to the Ashton Canal site is still present.

2.4 Geology

The published 1:10,560 Geological Map of the area (Sheet SJ 89 NW) indicates that the site is underlain by Glacial Till, which in turn overlies Sherwood Sandstone. Manchester Marl is present at depth beneath the Sherwood Sandstone and is shown to subcrop just to the east of the site. The Sandstone and Marl are part of the Permo-Triassic series. It is expected that Made Ground will be present to varying depths on the site. No indication of the depth to bedrock is provided on the geological map.

The investigations have, however indicated the presence of a buried glacial Sand and Gravel valley feature between the Glacial Till and the bedrock (Refer to sections 4.1.2 and 5.1).

2.5 Mining

The site is close to a known coal mining area and coal mining is known to have taken place in the Westphalian D coal measures strata which sub outcrop about 400m to the east of the site, and dip to the west.

A coal mining search has been conducted in 1994 and reported in the Roscoe report [REF 11]. The report indicates that there are four mined coal seams at between 350 and 1100m depth below the site and were last worked in 1961. The workings therefore extend below the Permo-Triassic units which underlie the site. The Coal Authority state that ground movement from these past workings should by now have ceased. There are no shafts or adits indicated on the site.

2.6 Hydrogeology

The main groundwater table is expected to lie within the Sherwood Sandstone. The published hydrogeological data for the site indicate the groundwater level to be at approximately 29mOD.

The Environment Agency Groundwater Vulnerability Map for the area (1:100,000 Derbyshire and North Staffordshire, Sheet 17) indicates that the Sherwood Sandstone is a major aquifer. The map shows the aquifer to be overlain by soils of a high potential leachibility. This is a default classification for surface deposits in urban areas where a high degree of variability is likely to be present.

Data provided on the Environment Agency website indicates that the site is not within a flood plain however the site is located within the Source Protection Zone covering the Strangeways Brewery extraction wells.

2.7 Hydrology

The site is adjacent to the Ashton Canal to the south, and a canal arm bisects the site from north to south, classified as Canal Quality B. The River Medlock runs approximately 600 m south east of the site, and is classified as River Quality E.

The Envirocheck report contains references to several minor pollution incidents to controlled waters, including a spillage of tracing dye to the Ashton Canal in 1995, but little additional information on the nature of these spills is provided.

Two water abstractions are listed, one approximately 400 m north east of the site, licensed to British Waterways, and one approximately 400 m south of the site, used for cooling purposes by several industrial premises.

3. PROPOSED DEVELOPMENT

3.1 Proposed Development

The proposed development is to comprise mixed retail and residential buildings located at the junction of Great Ancoats Street and the Ashton Canal. The development is for multi-storey high quality canal side residential apartments set in to five blocks (Blocks A to E) with residential units located at ground floor level. There is a two-storey podium structure that lies between the four residential blocks located in the west of the site and contains car parking and a roof top landscaped area. The development proposals are shown on the Broadway Malyan General Site Drawing included as Figure 8

3.2 Landscaping

Landscaping proposals are currently being developed for the site. However it is understood that the landscaping design will include areas of both public and private realm. Landscaping will be included around the boundary of the site and in the central area over the podium car park.

3.3 Development Phasing

It is proposed to develop the site in three phases as shown on the Broadway Malyan Phasing Drawing included in Figure 9. Block A and B located in the western part of the site will form the first phase and will comprise approximately 200 residential units with about 150 car park spaces provided in the central podium car park. Phase 2 will comprise Blocks C and D with additional car parking and retail units fronting on to Old Mill Street. Block E located to the east of the canal arm will be constructed as part of the Phase 3 development.

4. SITE INVESTIGATION

4.1 Previous Investigations

Two sources of data are available for previous ground investigations undertaken on or close to the site. These are as follows:

- Edward Roscoe Associates, 1997. Assessment of Ground Conditions for Redevelopment for land at Great Ancoats Street, Manchester. Prepared for Peel Investments North Ltd.
- PB Kennedy & Donkin, 2000. Interpretative Report on Ground Investigation for Metrolink, Manchester. Prepared for Greater Manchester Passenger Transport Executive.

4.1.1 Edward Roscoe Associates, 1997

The report prepared by Edward Roscoe Associates refers to two phases of ground investigation on the site. The first of these was undertaken in 1994 and was limited to the area of the site to the west of the Islington Branch. The second phase of ground investigation covered the whole of the current development site and was undertaken in 1997. In total, seven boreholes have been sunk to a maximum depth of 10.5m below ground level and a total of thirty six trial pits have been excavated to a maximum depth of 3.3 m below ground level. The investigation also included sampling and testing of the mounds on the site, assumed to comprise fly tipped material together with sampling and testing of sediments from the base of the Islington Branch canal arm. Geotechnical and chemical testing was undertaken on samples recovered during the ground investigation. Gas and groundwater monitoring standpipes were installed in the boreholes.

The ground conditions were found to comprise Made Ground overlying Glacial Till. The depth of the Made Ground varied between 0.4m and 3.4m. The variable depth is attributed to the presence of backfilled cellars and basements on the site. The Made Ground is described as predominantly granular in nature, typically comprising sands and gravels with brick, concrete and ash. Some localised areas of clay were found.

The Glacial Till is described as a firm to very stiff brown and mottled brown/grey sandy clay with some gravel and occasional sand bands/pockets being encountered within the clay. The base of the Glacial Till was not encountered in the ground investigation with the boreholes terminating a maximum of 10.5m below ground level.

Groundwater levels were found to be at depths of between 0.7m and 2.7m below ground level. However, no long term groundwater monitoring was undertaken to establish seasonal variations in level.

A total of twenty seven solid samples were selected for chemical testing. No leachate testing was undertaken. Roscoe conclude that the chemical analyses do not indicate levels of contamination significantly above ICRCL [REF 35] threshold trigger concentrations for an industrial/retail end use. It should be noted that these guidelines are now superseded. Gas monitoring did not identify elevated levels of either methane or carbon dioxide. However, the report indicates that monitoring was extended after the date the report was issued. It has since been confirmed that no further monitoring was conducted.

4.1.2 PB Kennedy and Donkin

Although this investigation was not undertaken on the site itself, it does provide useful information on the deeper ground conditions in the vicinity of the site. The works were conducted to the south east of the proposed site.

The investigation was part of a wider investigation for the Ashton Line, proposed as part of the Phase 3 Metrolink Extension. A series of boreholes were sunk along the proposed

alignment. The borehole records reviewed include two boreholes just to the west of Great Ancoats Street and one located within the central reservation on Great Ancoats Street, together with four immediately to the south of the site between the Ashton Canal and Pollard Street. The boreholes encountered variable depths of Made Ground overlying Glacial Till and Glacial Sands and Gravel. Bedrock comprising Sherwood Sandstone was encountered in all boreholes. The depth to bedrock varied significantly between the boreholes. The closest holes to the site are near the south-eastern boundary (Boreholes B6 to B10). Within these 5 holes the rock depth varied from 25 to 35m (13.75 to 25.4mOD), depicting a valley feature with BH B8 at the deepest point. The highest rockhead recorded is 9.7m below ground level in the boreholes located to the west of Great Ancoats Street. In the boreholes immediately to the south of the Islington Wharf site, rockhead level is up to 35m below ground level. In two of these boreholes the base of the Glacial Till is at about 20m below ground level and this deposit is underlain by a significant depth of Glacial Sand and Gravel, which extends to rockhead. PB Kennedy & Donkin suggest that the boreholes may have identified a buried glacial outwash channel. If this conclusion is correct, then the feature is likely to cross the Islington Wharf site as well.

Groundwater levels recorded during this ground investigation indicate levels varying between 20mOD and 26mOD i.e. about 20-25m below ground level. Groundwater levels were lower in the areas of lower rockhead.

4.2 Current Investigation

Arup designed a ground investigation for an earlier iteration of the proposed development. The investigation was undertaken by Ian Farmers Associates between February and March 2004. The work was to focus primarily on the Phase 1 of the development.

The objectives of the investigation were to:

- Supplement the previous site investigations undertaken on the site
- Establish the ground conditions on the site
- Obtain parameters for geotechnical design
- Determine the nature and extent of any contamination present on site
- Establish a groundwater and gas monitoring programme.

The scope of the investigation comprised cable percussion boreholes, machine excavated trial pits and two hand dug pits. Representative disturbed and undisturbed samples were taken from the boreholes and trial pits. Both in situ and laboratory testing were undertaken.

4.2.1 Cable Percussive Boreholes

Eleven cable percussive boreholes (BH 1 to 11) were sunk to depths between 21.70 m and 40.00 m below ground level. In-situ Standard Penetration Tests (SPT's) were carried out in accordance with BS 1377 (1990).

Four additional shallow cable percussive boreholes (BH 12 to 15) were sunk to about 5 m depth after the main fieldwork period to allow additional gas monitoring of the shallow ground.

4.2.2 Trial Pits

Nineteen trial pits were mechanically excavated to depths between 0.7 m and 4.2 m below ground level.

4.2.3 Geotechnical Testing

Ian Farmer Associates undertook geotechnical testing of soil samples. The following tests were carried out:

- Laboratory Testing
- Moisture content
- Liquid and Plastic limits
- Total Organic Content
- Particle Size Distribution
- Sedimentation
- Bulk Density
- Compaction
- California Bearing Ratio
- Consolidation
- Triaxial Single Stage
- Hand Vane

4.2.4 Chemical Testing

Chemical testing was performed by Derwentside Environmental Testing Services Ltd. Soil and water samples were tested for the determinands listed in Appendix 1.

4.2.5 Instrumentation and Monitoring

Combined gas and groundwater monitoring standpipes were installed in nine of the original eleven boreholes and the four additional shallow boreholes.

Up to 12 rounds of groundwater level and gas monitoring were undertaken in the deep boreholes and 4 rounds in the shallow boreholes. The results are presented in Appendix 5 and graphically on Figures 15 and 16.

5. GROUND CONDITIONS

5.1 General Stratigraphy

The site investigation has revealed the generalised stratigraphy to be Made Ground over Glacial Till which overlies Sand and Gravel which sits on a Sandstone bedrock. A total of 78 investigation positions have been considered, of which 18 were light cable percussive boreholes, 58 mechanically excavated trial pits and 2 hand excavated trial pits. The maximum depth of the investigation was 40m below existing ground level (or 8.6m OD). A summary of the general stratigraphy of the site is given below.

Strata	Depth to Base of Stratum (m)	Thickness (m)	Reduced Level of Stratum Base (mOD)
Made Ground	0.4-3.7	0.4 - 3.7	43.4 - 49.4
Glacial Till	16.7 - 20.8	14 - 19.1	27.7 - 31.8
Glacial Sand and gravel	20.5 - 36.7 (where proven)	Min 11m thk where proven but max 23.2m penetrated without proving base	10.5 – 19.7 (where proven)
Rock	Unproven	1.3 – 1.7 (Not fully penetrated)	Unproven

5.2 Made Ground

Made Ground deposits were encountered in all exploratory locations on the site. The thickness of the deposits ranged from 0.4m to 3.7m with an average thickness, where proven of about 1.5m. It should be noted that the deposit was not fully proven in 11 of the 78 exploratory locations on account of the presence of buried obstructions, which prohibited penetration to the full depth. There is no obvious spatial pattern as to the Made Ground thickness on the site except that there appears to be a cluster of deeper deposits (over 2.5m thick) located in the northern section of the site.

It should be noted that the site contains high concentrations of needles/syringes associated with recreational drug usage and as it is not secure, the site continues to be used for these purposes.

The surface deposits forming the upper section of the Made Ground were found to be hard surfacing of either concrete slab or bitmac in 19 of the positions, probable remnants of the historical developments. The remaining positions were either loose Made Ground or gravel deposits or grass/topsoil deposits at ground level.

It is also noted that there are significant areas of fly tipped materials which appear to be above the levels indicated on the topographical survey. There is evidence that the fly tipping is ongoing.

There are several areas of the highly invasive plant species Japanese Knotweed on the site. It is recommended that this is investigated further by specialists who will also advise on the methods of treatment.

Below the surface deposits, the Made Ground can be described as highly variable, comprising crushed brick, concrete slabs, loose clayey sand, gravelly sand, gravel of ash and clinker, bricks, timber, rags, occasional domestic refuse and metal. The Made Ground was predominantly granular in nature.

There was evidence of remnant brick structures at several locations, probably relating to the presence of backfilled cellars and basements on the site.

The Made Ground deposits appeared to be mostly free from any obvious significant contamination with the exception of 7 positions which encountered oily or diesel type odours, one position encountering a black odourless liquid and one encountering domestic type waste which included asbestos tiles.

A total of 21 Standard Penetration Tests (SPT's) were performed in the Made Ground deposits (see Figure 13) and indicated a range of SPT 'N' values of 5 to 31, indicating a Loose to Dense (average Medium Dense) consistency. Typically the results generally indicated the deposit to be Loose ('N' value between 4 and 10 on 13 of tests).

A total of 19 particle size distribution tests were performed on the Made Ground and indicated a predominantly granular composition with a average of 31% sand sized and 45% gravel sized particles.

5.3 Glacial Till Deposits

Glacial Till deposits were found below the Made Ground in 67 of the exploratory locations, with the other 11 positions being terminated in the Made Ground on account of obstructions. The level of the top of the unit has been controlled by the historical development. The unit has been fully penetrated in only 11 of the positions, these being the most recent Ian Farmer Associates boreholes. The boreholes from earlier phases of work all terminated in the Glacial Till. Where proven, the base of the Glacial Till ranged from 16.7 to 20.8m depth (27.7 to 31.8mOD) giving proven thickness range of 14 to 19.1m.

The Glacial Till is described as a firm to very stiff brown and mottled brown/grey sandy clay with some gravel and occasional sand bands/pockets were encountered within the clay. The top of the unit was found to be fissured in several of the recent borehole positions. Deep sand bands were encountered in 4 of the recent boreholes (up to 2.5m thick) and a shallow sand band was found in BH8 between 2.8 and 4m depth. Elsewhere there are localised minor sand and silt lenses.

Atterberg Limit determinations were carried out on 63 samples of Glacial Till and the results are presented on Figure 12. The results indicate a Plastic Limit range between 11 and 30% (average 19%), Liquid Limit range of between 23 and 65 % (average 41 %) and Plasticity Index range of between 11 and 38 % (average 22 %). The natural moisture content of these samples ranged from 3 to 27 % (average 17 %). When plotted on a Casagrande Plasticity chart, the classification is generally within the range of a Clay of Low to Intermediate plasticity.

A total of 18 particle size distribution tests were performed on the Glacial Till deposits and indicated a cohesive composition with a average of 30% clay, 39% silt and 25% sand sized particles.

A total of 115 Standard Penetration Tests (SPT's) were performed on the Glacial Till (see Figure 13) and indicated a range of SPT 'N' values of 9 to 48 (average of 22). The results generally increased with depth. The undrained shear strength, C_u has been related to SPT 'N' value by the expression (Stroud 1988)

$C_u = f_1 \times N$ kN/m^2

Where f1 is a factor dependent upon plasticity.

For a plasticity index of 22% a value of $f_1 = 5$ is suggested.

Based on this correlation, a range of undrained shear strength of 45 to 240 kN/m^2 is suggested (average 110 kN/m^2).

In addition to these, a total of 46 laboratory undrained traixial tests have been conducted on the Glacial Till and indicated a range of undrained shear strength of 22 to 305 kN/m^2 (average 147 kN/m^2) and a set of 28 hand vane tests were performed on the U100 samples giving an undrained shear strength range of 91 to >240 kN/m2.

The results of all shear strength tests and SPT strength correlations for the Glacial Till are indicated on Figure 14.

A total of 8 California Bearing Ratio (CBR) tests have been performed on the upper portion of the Glacial Till. Two tests from Borehole 5 indicated low CBRs, between 0.7 and 1.1% however the 6 tests from three of the trial pits indicated a range of CBRs of 3.2 to 9.2% with average of 6%.

Fifteen samples of the material were tested using one-dimensional consolidation oedometer apparatus to determine the compressibility. For the effective overburden Po'+100 kN/m^2, the results range from 0.075 to 0.197m^2/MN with an average of 0.129m^2/MN. From Tomlinson, this indicates the material to be of Medium compressibility.

5.4 Glacial Sand and Gravel Deposits

Glacial Sand and Gravel deposits were encountered underlying the Glacial Till in all 11 of the exploratory holes from the recent phase of investigation. The unit is believed to extend down to rockhead however this was only proven in three of the positions. Where fully penetrated the base of the unit was at depths of 20.5, 27.8 and 36.7m (reduced levels of 28.3, 19.7 and 10.5mOD respectively). Information from the adjacent site investigation for Phase 3 of the Metrolink extension support the presence of a glacial valley feature trending to the north west although there is too little information from the current investigation to support this. In many cases it was not possible with the equipment used on the current investigation works to penetrate the gravel. If this is a future requirement, the use of a rotary cased system should be considered.

The borehole records indicate that the deposit is generally brown or mottled grey in colour and is generally described as gravelly sand or sandy gravel. There is a significant cobble content in the deposit and occasional boulders which prevented further progress with the cable percussive drilling equipment used.

A total of 76 Standard Penetration Tests (SPT's) were performed on the Glacial Sand and Gravel deposits (see Figure 13) and indicated a range of SPT 'N' values of 8 to 500 (average of 38). This indicates a loose to very dense consistency. The results were typically in the range of 10 to 50 indicating a Medium Dense to Dense consistency. The results generally increased with depth.

A total of 12 particle size distribution tests were performed on the Glacial Sand and Gravel deposits and indicated a composition with a average of 14% silt and clay, 38% sand and 49% gravel sized particles. The tests are not fully representative of insitu conditions as cobble and boulder sized particles cannot be recovered from boreholes.

5.5 Bedrock

Bedrock was encountered in 3 of the exploratory locations, BH1, BH6A and BH8 at depths of 36.7m, 20.5m and 27.8m respectively. The reduced levels at top of rock is 10.5, 28.3 and 19.7mOD respectively. The rock level could not be proven in the remaining boreholes of the

recent investigation due to budget constraints, obstructions in the gravel layer and other drilling constraints.

Where encountered the rockhead was found to be a red brown weathered sandstone. It was proven to a maximum penetration of 1.7m.

Four Standard Penetration Tests (SPT's) were performed on the Sandstone rockhead (see Figure 13) and indicated a range of extrapolated SPT 'N' values of 188 to 3000.

5.6 Ground Water

Ground water was encountered during construction of 21 of the exploratory points (27%). The remaining 57 positions (73%) were dry during construction.

Six of the Ian Farmer Associates boreholes encountered deep water inflows during construction at depths of 16.3 to 18.8m. Water seepages were encountered in 11 of the Ian Farmer Associates trialpits and 4 of the Roscoe Trialpits.

Upon completion of the latest Ian Farmer Associates boreholes, gas/groundwater monitoring standpipes were installed in thirteen of the holes and these have been monitored on up to ten occasions. Nine of the installations were in to the Glacial Sand and Gravel layer and four were installed to shallow depths to record water in the Made Ground and in the top of Glacial Till.

Four of the earlier Roscoe boreholes were installed with gas/ground water installations but these were only monitored on one occasion on 23rd September 1997 and gave variable water levels of between 0.7m depth and in excess of 5m depth.

The results of the monitoring of the deep installations indicate a static water level typically between 24 and 27m OD, which is generally several metres below the base of the Glacial Till layer. There are several anomalous results between April and June 2004 where the apparent water level is higher and it is not clear whether this is due to real changes in the gravel layer or an instrumental error due to rainfall infiltration into the well, artificially raising the levels.

With regards to the shallow wells, these were dry during the boring and now indicate water between 2.1 and 4.3m depth. However its possible that this is rainwater infiltration that has percolated into the well through the relatively permeable Made Ground. The water levels should continue to be monitored as part of the recommended gas monitoring (see section 8.4).

6. ENVIRONMENTAL RISK ASSESSMENT

6.1 Framework for Assessment

Current UK legislation on contaminated land is governed by Part IIA of the Environmental Protection Act (EPA) 1990, which was retrospectively inserted by Section 57 of the Environment Act 1995 [REF 12].

The legislation introduces the concept of a "suitable for use" approach to the re-use of contaminated sites, requiring remedial action where unacceptable risks to human health or the environment are identified, considering both the use of the land and its environmental setting, endorsing the principle of site-specific risk assessment.

The legislation provides a definition of "contaminated land" as:

> "any land which appears to the local authority in whose area it is situated to be in such a condition, by reason of substances in, on or under the land, that -
>
> "(a) *significant harm* is being caused or there is a *significant possibility* of such harm being caused; or
>
> "(b) pollution of controlled waters is being, or is likely to be, caused".

Further guidance is included within the legislation as to the nature of harm to be classified as significant, and what constitutes the significant possibility of significant harm. In order to prove that significant harm is being caused, a significant pollutant linkage must be established, using a source-pathway-receptor model. This model comprises three elements:

- ***Source*** - the key pollutant hazards associated with the site
- ***Receptor*** – the key targets at risk from the sources
- ***Pathway*** – the means by which the contaminant can cause harm to the receptor.

If a significant pollutant linkage is to be established, all three elements must be present, with a contaminant capable of causing harm, a receptor sensitive to that contaminant and a pathway linking them.

6.2 Assessment Approach

There are two principal types of risk assessment – qualitative and quantitative. Within a qualitative risk assessment, plausible pollutant linkages are determined by development of the source-pathway-receptor (the conceptual) model.

A quantitative risk assessment involves the estimation of risks via the comparison of representative site concentrations of contaminants with appropriate assessment criteria to identify unacceptable levels of risk. A generic quantitative risk assessment (GQRA) compares site data against generic assessment criteria (i.e. those derived or published by an authoritative body). A detailed quantitative risk assessment (DQRA) involves the derivation of site-specific assessment criteria using an appropriate modelling tool. Risks to human health may be assessed on a site-specific basis using models such as SNIFFER [REF 13], RISC-Human [REF 14] or RBCA [REF 15], whilst models to assess risks to controlled waters include the Environment Agency R & D 20 spreadsheets [REF 16] and CONSIM [REF 17].

At this stage of the development, a qualitative and generic quantitative risk assessment has been undertaken. The generic assessment criteria adopted for each assessment are discussed fully within each relevant section.

6.3 Conceptual Model

6.3.1 Introduction

The following sections set out a conceptual model of the site, as recommended in current good practice guidelines [REF 18 & 19] and the Environmental Protection Part IIA. The model identifies potential sources of contamination (such as those arising from previous industrial uses, waste disposal or spillages), possible receptors (e.g. humans, controlled waters and flora and fauna) and possible contaminant pathways (the ways in which the contamination can come into contact with the receptors e.g. ingestion, vegetation uptake). The purpose of this model is to highlight all potential risks to receptors from both on-site and off-site sources of contamination, and to identify pollutant linkages. Two cross sections through the site are presented as Figures 10 and 11, which indicates the typical ground conditions forming part of the conceptual model.

6.3.2 Potential Sources

On –Site

The site has been used for a range of industrial activities over the past 300 years, including a cotton mill, balloon manufacturing plant, a number of metal works and a paint works. Potential contaminants associated with these industries include heavy metals, dyes, acids and alkalis, fuels and solvents. Given the age of these industrial works, spillages and on-site disposal are likely to have occurred, and Made Ground deposits across the site may contain elevated levels of contaminants, which may extend to the natural strata below.

Many phases of demolition have occurred on site, and demolition materials and historic foundations are anticipated, which may include asbestos. There may be areas of infilled basements, which could contain demolition arisings or even ashes or other process wastes. Historical plans show the presence of a public house on the site, which is likely to have included a basement or cellar.

Also shown on historical plans is a pond feature, later presumed to be infilled. Such features often contain high levels of organic material, which may be a source of methane and carbon dioxide gas. Other potential sources of gas include any areas of gross hydrocarbon contamination.

In more recent years, British Waterways have used the centre of the site adjacent to the canal arm as a temporary holding facility for materials dredged from the canal. Items such as abandoned cars and other rubbish have been held on a short term basis on the site, and there may have been localised areas of fuel spillages associated with this activity, although much of this area comprises hardstanding.

The site has been extensively fly tipped with what, from the site walkover, appears to be largely domestic refuse material. This material may have a high organic content, and may be source for the generation of landfill gases. In addition, there may be hazardous materials such as old metal-acid car batteries or fuel cans. Also of note are the large numbers of used syringes on the site, which pose a biological hazard to site users and construction workers.

Off –Site

The site is located in the centre of a light industrial area, and nearby industrial premises include a textile manufacturers (likely to use dyes and acids as process materials), scrap metal merchants and metal works (potential sources of metal and acid contamination) and various car servicing and maintenance facilities (sources of contaminants such as hydrocarbons and degreasing agents). A landfill has also been identified within 500 m of the site boundary, which may be a source of landfill gas and leachate.

6.3.3 Potential Receptors and Pathways

Potential human exposure to contaminants is feasible through four principal pathways, as defined in the CLEA guidance [REF 20]:

- Ingestion of soils or dust
- Dermal contact with soil or dust
- Outdoor or indoor inhalation of dust and/or vapours
- Consumption of home grown vegetables, and any soils attached

The principal pathways will vary with each contaminant as a result of characteristic chemical properties and potential health effects.

Receptors at risk include construction workers, staff and residents of the Islington Wharf development and maintenance workers. Exposure will be increased in landscaped or unsurfaced areas, where direct contact is more probable. Given the proposed end-use of the site as residential apartments and commercial units, it is not envisaged that indirect ingestion of contaminants via the consumption of fruit and vegetables grown on the site will occur, as areas of landscaping are likely to be either hard landscaping or controlled planting.

Off-site receptors include residents of the adjacent terraced properties, to the north of the site, who would be at risk from any lateral migration of leachate or gas emanating from the site. The adjacent site, the ex-hospital site, is also currently being redeveloped as the New Islington Millennium Community, with over 1400 new residential properties. It is also believed that the drinking water for this development is to be provided by a refurbished groundwater well on the site, and therefore any mobile contamination arising from the Islington Wharf site may pose a potential risk to this potential potable water source.

Controlled Waters

Several surface waters are in the vicinity of the site, with the Ashton Canal immediately to the south, and a canal arm bisecting the site. The River Medlock runs approximately 600 m south east of the site. Two surface water abstractions are listed with 400 m of the site, one approximately 400 m north east of the site, licensed to British Waterways, and one approximately 400 m south of the site, used for cooling purposes by several industrial premises.

With respect to groundwater, the Sherwood Sandstone is classified as a major aquifer by the Environment Agency, and the site is partially located within the outer catchment of a groundwater Source Protection Zone. If, as previously discussed, a potable water abstraction well is to be constructed on the adjacent site, the groundwater within the Sandstone aquifer immediately below the Islington Wharf site would become a very sensitive receptor.

Structures and Services

Below-ground concrete structures are at risk in areas of elevated sulfates. Gross hydrocarbon contamination can also have an adverse impact on the setting of concrete, which may affect foundation construction and piling.

Plastic pipe materials are also vulnerable to attack from elevated levels of hydrocarbons, which can potentially lead to contamination of potable water supplies.

Ground gases generally migrate through areas of high relative permeability or along the length of man-made features such as pipes and backfill since these provide a preferential pathway.

Landscaped Areas

Planting is at risk from phytotoxic contaminants such as copper, zinc, nickel and boron. The pathway for phytotoxic contaminants is usually via uptake through plant root systems via

contact with contaminated groundwater. Hydrocarbons can also adversely affect plant growth.

6.4 Chemical Analysis

6.4.1 Made Ground Deposits

The chemical results for the soil analysis of the Made Ground deposits on the Islington Wharf site are summarised in **Table 6.1** and presented in **Appendix 1**. This includes the 95th percentile (US95) for each of the contaminants, calculated in accordance with the procedure outlined in CLR 7 [REF 20]. The US95 calculations are included in **Appendix 2**. Materials were generally shown to be moderately alkaline in nature, with some areas of high lead and hydrocarbons.

No asbestos was identified during the investigations.

6.4.2 Natural Ground Deposits

Chemical results for the natural soil deposits (i.e. Glacial Till) encountered beneath the Made Ground are summarised in **Table 6.2**. Testing of the underlying materials ie Glacial Sand and Gravel and Sandstone rock were not conducted on this visit.

6.5 Initial Human Health Risk Assessment

6.5.1 Introduction

To fully assess the risks to human health from contaminated soils on the site, it recommended that a detailed quantitative risk assessment (DQRA) be undertaken, to derive site-specific assessment criteria for the development. This assessment could include zoning the site, assessing materials to be used beneath the building footprint and within landscaped areas separately. Soil thresholds within the building footprint area would be considerably less stringent than for the landscaped areas for most non-volatile contaminants.

A DQRA can also be modified to include all the contaminants of concern for the site. Generic assessment criteria have only been issued by DEFRA for a limited number of contaminants for which guideline values have been published to date.

However, as an initial screen, a generic quantitative risk assessment (GQRA) has been undertaken for the site for those contaminants for which generic assessment criteria are available. In the following sections the assessment criteria selected are discussed, and the chemical analysis results of soil assessed.

Table 6.1: Soil Chemistry – Made Ground Deposits

Parameter	Unit	No. Samples	Minimum	Maximum	Mean	Standard Deviation	t	US95
Antimony	(mg/kg)	29	0.9	32	5.46	6.39	1.701	7.48
Arsenic	(mg/kg As)	54	4	170	28.45	27.75	1.676	34.78
Asbestos								
Benzene	(mg/kg)	29	0.1	0.1	0.10	0.00	1.701	0.10
Boron (water soluble)	(mg/kg)	54	0.13	4.7	1.29	1.01	1.676	1.52
Cadmium	(mg/kg Cd)	54	0.2	5.6	0.76	0.79	1.676	0.94
Chromium	(mg/kg Cr)	54	1	73	26.90	16.42	1.676	30.65
Chromium VI	(mg/kg Cr)	1	0.31	0.31	0.31			
Cobalt	(mg/kg)	29	0.1	5.7	1.87	2.26	1.701	2.59
Copper	(mg/kg Cu)	54	13	1800	228.37	392.97	1.676	318.00
Cyanide (free)	(mg/kg CN)	30	1	1	1.00	0.00	1.699	1.00
Cyanide (thiocyanate)	(mg/kg CN)	1	1	1	1.00			
Cyanide (total)	(mg/kg CN)	54	0.1	60	4.31	11.29	1.676	6.88
Ethylbenzene	(mg/kg)	29	0.1	0.1	0.10	0.00	1.701	0.10
Lead	(mg/kg Pb)	54	11	11000	586.91	1515.63	1.676	932.58
Mercury	(mg/kg Hg)	54	0.1	2.4	0.47	0.43	1.676	0.57
mp-xylene	(mg/kg)	29	0.1	0.1	0.10	0.00	1.701	0.10
Nickel	(mg/kg Ni)	54	2.5	81	25.56	14.21	1.676	28.80
o-xylene	(mg/kg)	29	0.1	0.1	0.10	0.00	1.701	0.10
PAH (total)	(mg/kg)	44	5	700	55.18	120.21	1.682	85.66
PCBs	(mg/kg)	26	0.01	0.01	0.01	0.00	1.708	0.01
pH		54	7	10.8	8.11	0.75	1.676	8.28
Phenols (monohydric)	(mg/kg)	1	0.3	0.3	0.30			
Phenols (total)	(mg/kg)	44	0.2	5.9	1.22	1.24	1.682	1.53
Selenium	(mg/kg Se)	54	0.1	1.5	0.40	0.26	1.676	0.45
Sulfate (2:1 extract)	(g/l SO_4)	41	0.06	1.656	0.53	0.47	1.684	0.66
Sulfate (total)	(% SO4)	15	0.1	17	1.29	4.35	1.761	3.27
Sulfide	(mg/kg S^{2-})	44	0.2	170	37.36	42.65	1.682	48.17
Sulfur (free)	(mg/kg S)	44	0.5	100	37.15	47.36	1.682	49.16
TEM	(mg/kg TEM)	10	10	3400	- 760.00	1260.29	1.833	1490.52
Toluene	(mg/kg)	29	0.1	0.1	0.10	0.00	1.701	0.10
Total organic carbon	(mg/kg)	5	14000	30900	23960.00	6767.79	2.132	30412.81
TPH	(mg/kg)	34	20	1600	291.44	401.31	1.693	407.96
Zinc	(mg/kg Zn)	54	26	1200	270.59	263.76	1.676	330.75

Table 6.2: Soil Chemistry – Natural Ground

Parameter	Unit	No. Samples	Minimum	Maximum	Mean	Standard Deviation	t	US95
Antimony	(mg/kg)	6	1.4	2.8	2.00	0.53	2.015	2.44
Arsenic	(mg/kg As)	11	4.1	8.3	6.78	1.59	1.812	7.65
Benzene	(mg/kg)	6	0.1	0.1	0.10	0.00	2.015	0.10
Boron (water soluble)	(mg/kg)	11	0.1	3.2	0.89	0.96	1.812	1.42
Cadmium	(mg/kg Cd)	11	0.2	0.74	0.38	0.22	1.812	0.49
Chromium	(mg/kg Cr)	11	6.4	37	21.99	13.12	1.812	29.16
Cobalt	(mg/kg)	6	0.1	4.9	1.27	1.91	2.015	2.84
Copper	(mg/kg Cu)	11	16	47	29.09	9.08	1.812	34.05
Cyanide (free)	(mg/kg CN)	6	1	1	1.00	0.00	2.015	1.00
Cyanide (total)	(mg/kg CN)	11	0.1	1	0.59	0.47	1.812	0.85
Ethylbenzene	(mg/kg)	6	0.1	0.1	0.10	0.00	2.015	0.10
Lead	(mg/kg Pb)	11	11	70	31.64	23.20	1.812	44.31
Mercury	(mg/kg Hg)	11	0.1	0.3	0.21	0.10	1.812	0.27
mp-xylene	(mg/kg)	6	0.1	0.1	0.10	0.00	2.015	0.10
Nickel	(mg/kg Ni)	11	1.1	40	21.74	13.16	1.812	28.93
o-xylene	(mg/kg)	6	0.1	0.1	0.10	0.00	2.015	0.10
PAH (total)	(mg/kg)	6	5	66	15.17	24.90	2.015	35.65
pH		11	6.95	8.2	7.61	0.38	1.812	7.82
Phenols (total)	(mg/kg)	6	0.2	0.5	0.25	0.12	2.015	0.35
Selenium	(mg/kg Se)	11	0.1	0.3	0.21	0.10	1.812	0.27
Sulfate (2:1 extract)	(g/l SO_4)	11	0.04	1.092	0.29	0.29	1.812	0.45
Sulfide	(mg/kg S^{2-})	6	10	28	14.67	7.66	2.015	20.97
Sulfur (free)	(mg/kg S)	6	0.5	1	0.58	0.20	2.015	0.75
TEM	(mg/kg TEM)	5	10	100	60.00	39.37	2.132	97.54
Toluene	(mg/kg)	6	0.1	0.1	0.10	0.00	2.015	0.10
TPH	(mg/kg)	6	20	140	47.17	48.62	2.015	87.16
Zinc	(mg/kg Zn)	11	13	85	42.36	22.77	1.812	54.80

6.5.2 Soil Assessment Thresholds – Human Health

Two main end-uses have been identified for the development – residential accommodation in apartment blocks, and landscaped areas. Both of these end-uses differ from the four standard land-uses identified in the CLEA model:- residential with and without plant uptake, allotments and commercial. The residential end-use identified in CLEA model considers a residential development with a garden. Potential exposure pathways included in this end-use scenario are:

- ingestion of soil and household dust
- dermal contact with soil and household dust
- inhalation of fugitive soil and household dust
- inhalation of indoor and outdoor vapours
- ingestion of contaminated vegetables or soil attached to vegetables (if vegetables are grown within the garden area)

No landscaping or public open space end-use is considered with the four CLEA standard end-uses.

For the Islington Wharf development, the residential units will be apartment blocks, without gardens, but with some areas of managed soft landscaping and hard landscaped external works. Residents could be exposed to contaminated soils in soft landscaping areas via:

- ingestion of soil
- dermal contact with soil
- inhalation of fugitive soil
- inhalation of outdoor vapours

Within the apartment blocks themselves, the key exposure pathway is via indoor inhalation of soil vapours, as direct contact with soil will be prevented by the ground slab of the building.

In the absence of a DQRA, an initial screen of the contamination data has been undertaken. As a conservative approach CLEA soil guideline values (SGVs) for residential developments without plant uptake (i.e. discounting the additional intake of contaminants via the consumption of home grown vegetables) have been used as initial screening levels (ISLs) to assess risks to human health in areas of soft landscaping. DEFRA have published SGVs for seven contaminants (arsenic, cadmium, nickel, lead, selenium, chromium and mercury). Generic assessment criteria (GACs) have been derived internally by Arup following the CLEA model [REF CLR 10] for zinc, benzene, benzo(a)pyrene, naphthalene, inorganic cyanide (used to assess total cyanide), and phenol (used to assess total phenols) for the four standard CLEA end-uses. Research reports [REF ARUP GAC reports] to support each of the threshold values can be made available to the local authority to support this assessment if required. The residential without plant uptake end-use GACs were used for these parameters.

The CLEA SGVs and Arup GACs for a commercial/industrial end-use have been used as initial thresholds for materials beneath the building footprint and hard landscaping. These guideline values are considered to be generally conservative, as the commercial end-use still considers ingestion of soil and building dust, dermal contact with soil and building dust, inhalation of fugitive soil and building dust and inhalation of indoor and outdoor vapours. It is therefore likely that any site-specific assessment criteria would be much less stringent than these thresholds for non-volatile contaminants, as ingestion can be discounted as a pathway in this area. For volatile contaminants, the critical receptor for a residential development, a 0 – 6 year old female child, will be more sensitive than the critical receptor for the commercial /

industrial end-use, and exposure duration may be longer. It is therefore possible that the site-specific assessment criteria for volatile contaminants may be more conservative than the commercial / industrial SGVS and GACs.

For other parameters, the initial screening levels (ISLs) are based in the Dutch Intervention Values [REF 23]. These guidelines assume a multi-purpose end-use for any site, which could range from housing to industrial use and take into account ecotoxicology in addition to human toxicology. A further, more detailed risk assessment is required for these parameters, as the Dutch model is based on different toxicological assumptions, soil types and exposure scenarios. However, the values are considered appropriate as a first level of screening for the development prior to completion of a DQRA.

6.5.3 Soil Assessment Results – Human Health

The full assessment of the soil results in comparison to the initial screening levels (ISLs) are presented in spreadsheet format in **Appendix 3**. Summaries of the results are presented in **Tables 6.3** and **6.4**.

In general, natural materials on the site were not in excess of the initial screening levels for landscaping or building footprint areas. Only one exception, a sample from TP15, contained elevated levels of polyaromatic hydrocarbons (PAH).

Made Ground deposits on the site contained levels of lead, antimony, arsenic, copper, PAH and nickel above the initial screening levels for landscaping, indicating that much of the Made Ground deposits across the site may pose a risk to human health in areas of open landscaping. The initial screening levels for underneath the building footprint were exceeded for copper, lead, nickel and PAH indicating that some areas of the Made Ground may require removal or treatment, although with a further site-specific risk assessment it is anticipated that these levels of contaminants will not pose a risk to human health underneath the building footprint as the ground slab will break the potential pollutant linkage.

6.5.4 Summary of Risks to Human Health

A site-specific detailed quantitative risk assessment is required to fully assess risks to human health for the Islington Wharf development, but the results of a preliminary screening exercise using generic assessment criteria has indicated that Made Ground deposits in the site may be unsuitable for use in open landscaping. Some Made Ground deposits may also be unsuitable to remain beneath the building footprint and treatment or removal may be required.

Some materials may pose a risk to construction workers, as they are in direct contact with excavated materials. This exposure is short-term, but should be controlled via the implementation of appropriate health and safety measures, such as PPE.

Risk control measures should be implemented during construction to minimise exposure of the workers and residents and occupiers of adjacent properties to fugitive dust.

Table 6.3: Summary of Soil Assessment - Landscaping

Parameter	Unit	ISL	Source	No Samples	No. in Excess of ISL
Antimony	(mg/kg)	15	Professional judgement	34	2
Arsenic	(mg/kg As)	20	CLEA Residential no plant uptake	67	10
Asbestos				0	
Benzene	(mg/kg)	2.7	Arup GAC Residential no plant uptake	34	
Boron (water soluble)	(mg/kg)	3	Professional judgement	67	
Cadmium	(mg/kg Cd)	30	CLEA Residential no plant uptake	67	
Chromium	(mg/kg Cr)	130	CLEA Residential no plant uptake	67	
Cobalt	(mg/kg)	240	Dutch Intervention Value	34	
Copper	(mg/kg Cu)	190	Dutch Intervention Value	67	5
Cyanide (free)	(mg/kg CN)	20	Dutch Intervention Value	38	
Cyanide (total)	(mg/kg CN)	136	Arup Residential no plant uptake	67	
Ethylbenzene	(mg/kg)	50	Dutch Intervention Value	34	
Lead	(mg/kg Pb)	450	CLEA Residential no plant uptake	67	7
Mercury	(mg/kg Hg)	15	CLEA Residential no plant uptake	67	
mp-xylene	(mg/kg)	25	Dutch Intervention Value	34	
Nickel	(mg/kg Ni)	75	CLEA Residential no plant uptake	67	1
o-xylene	(mg/kg)	25	Dutch Intervention Value	34	
PAH (total)	(mg/kg)	40	Dutch Intervention Value	52	7
PCBs	(mg/kg)	1	Dutch Intervention Value	26	
pH		5.5-9		67	
Phenols (monohydric)	(mg/kg)	15000	Arup GAC Residential no plant uptake	1	
Phenols (total)	(mg/kg)	15000	Arup GAC Residential no plant uptake	52	
Selenium	(mg/kg Se)	260	CLEA Residential no plant uptake	67	
Toluene	(mg/kg)	130	Dutch Intervention Value	51	
TPH	(mg/kg)	500	Professional Judgement	52	
Zinc	(mg/kg Zn)	10700	Arup GAC Residential no plant uptake	52	

Table 6.4: Summary of Soil Assessment – Building Footprint and Hardstanding

Parameter	Unit	ISL	Source	No Samples	No. in Excess of ISL
Antimony	(mg/kg)	15	Professional judgement	34	2
Arsenic	(mg/kg As)	500	CLEA Commercial	67	
Asbestos				0	
Benzene	(mg/kg)	15	Arup GAC Commercial	34	
Boron (water soluble)	(mg/kg)	3	Professional judgement	67	
Cadmium	(mg/kg Cd)	1400	CLEA Commercial	67	
Chromium	(mg/kg Cr)	5000	CLEA Commercial	67	
Cobalt	(mg/kg)	240	Dutch Intervention Value	34	
Copper	(mg/kg Cu)	190	Dutch Intervention Value	67	5
Cyanide (free)	(mg/kg CN)	20	Dutch Intervention Value	38	
Cyanide (total)	(mg/kg CN)	13900	Arup GAC Commercial	67	
Ethylbenzene	(mg/kg)	50	Dutch Intervention Value	34	
Lead	(mg/kg Pb)	750	CLEA Commercial	67	4
Mercury	(mg/kg Hg)	480	CLEA Commercial	67	
mp-xylene	(mg/kg)	25	Dutch Intervention Value	34	
Nickel	(mg/kg Ni)	5000	CLEA Commercial	67	
o-xylene	(mg/kg)	25	Dutch Intervention Value	34	
PAH (total)	(mg/kg)	40	Dutch Intervention Value	52	7
PCBs	(mg/kg)	1	Dutch Intervention Value	26	
pH		5.5 - 9.0	Professional judgement	67	
Phenols (monohydric)	(mg/kg)	59000	Arup GAC Commercial	1	
Phenols (total)	(mg/kg)	59000	Arup GAC Commercial	52	
Selenium	(mg/kg Se)	8000	CLEA Commercial	67	
Toluene	(mg/kg)	130	Dutch Intervention Value	51	
TPH	(mg/kg)	5000	Dutch Intervention Value for Mineral Oil	52	
Zinc	(mg/kg Zn)	257000	Arup GAC Commercial	52	

6.6 Risks to Controlled Waters

6.6.1 Introduction

Risks to controlled waters (groundwater and surface waters) are primarily assessed in accordance with the protocol outlined in the Environment Agency R & D 20 publication "Methodology for the Derivation of Remedial Targets for Soil and Groundwater to Protect Resources" [REF 16]. The R & D 20 report provides a tiered approach of risk assessment starting with an initial screen of leachate and groundwater data against drinking water limits or other appropriate threshold values, followed by basic calculations for each contaminant to modify the assessment criteria for site-specific ground conditions if required. If pollution of controlled waters is identified as a key concern, further detailed hydrological or hydrogeological modelling may be required to assess scenarios such as off-site migration of contaminants.

6.6.2 R&D Tier 1 Assessment

A Tier 1 assessment has been completed using leachate results from the current site investigation. The leachate data can be seen in **Appendix 4**. Values have been assessed against UK drinking water standards or the Dutch Intervention Values for groundwater [REF 23].

6.6.3 Results

The leachate quality thresholds (LQT) were exceeded for ammonia, antimony, benzene and lead, indicating that these contaminants may be potentially mobile within some of the Made Ground deposits. Infiltration passing through the Made Ground may therefore generate contaminated leachate.

6.6.4 Summary of Risks to Controlled Waters

An initial screen of the leachate results from the Made Ground deposits across the site indicate that some of the contaminants may be potentially mobile. The significant thicknesses of Glacial Till below the Made Ground will prevent vertical migration down into the underlying Sand and Gravels and Sandstone aquifer, however any lateral migration of perched waters within the Made Ground into the adjacent Ashton Canal, or surface runoff may pose a risk to surface waters. The proposed development will reduce infiltration across the site due to the increase in hardstanding, but care will need to be taken in areas of soft landscaping that surface materials do not pose a risk in terms of the generation of contaminated surface run-off. It is also believed that the canal is lined with puddle clay and therefore this would greatly reduce the risk of the infiltration of contaminated ground water into the canal.

A more detailed assessment of the risks to the adjacent Ashton Canal is required as part of the full environmental risk assessment to be undertaken for the site, in particular addressing the likelihood of lateral migration of perched waters in the Made Ground. It is suggested that further confirmation of the integrity of the canal walls are made. This could form part of the structural inspections of the canal wall which will be necessary for the proposed development, following the drawing down of the canal e.g. by checking for water inflows from the ground at this stage, combined with intrusive trial pit investigation behind the wall.

It is also recommended that a foundation works risk assessment be undertaken to determine whether the adoption of piled foundations pose any risk to the underlying sandstone aquifer, particularly given the possible construction of a potable water source on the adjacent New Islington site. Such an assessment should assess the suitability of foundation remediation options in terms of both buildability and environmental risk. Possible foundation techniques should be assessed against 'possible pollution scenarios' in accordance with the Environment

Agency's guidance document 'Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention' (NC/99/73).

6.7 Risks to Structures

The ground was assessed for chemical agents aggressive to concrete using BRE Special Digest 1. For the purpose of this analysis the site was classified as *brownfield*. The water within the soil was classified as *static*.

There are 51 sulfate results from the site. The maximum sulfate (2:1 extract) was 1.66g/l and the characteristic value was 1.3 g/l. This indicates a Design Sulfate class of **DS-1**.

There are 67 pH test results, the minimum value being 6.95 and the characteristic value being 7.5

The samples indicated an aggressive chemical environment for concrete (ACEC) classification of **AC-1s**. The suffix s indicates that, as the water has been classified as static, no additional protective measures are generally necessary.

[REF 26 & 27]

6.8 Risks to Services

The soil chemical data has been compared with the Water Regulations Advisory Service [24] (WRAS) material selection threshold levels. The thresholds were exceeded for arsenic, cadmium, mercury, lead, phenols, TPH and PAH. It is therefore likely that special consideration of pipe materials will be required, and/or protective measures such as the use of trenches backfilled with clean imported fill material.

6.9 Risks to Landscaping

The results of the chemical analyses indicate that elevated levels of phytotoxic elements such as copper and nickel are present. It is therefore recommended that the chemical data should be reviewed by the landscape architect where soft landscaping at ground level is planned, as this can be dependent upon the planting strategy and plant species adopted.

Quality criteria should be set for imported topsoil, to ensure that this material does not pose a risk to planting.

6.10 Initial Gas Assessment

6.10.1 Sources and Pathways

Material with organic or biodegradable content e.g. organic clays, coal seams and domestic refuse, will have the potential for the generation of the landfill gases, methane, carbon dioxide and hydrogen sulfide (H_2S) and for the displacement of oxygen, with associated hazards of explosion or asphyxiation.

Potential sources of gas that have been identified on site are Made Ground deposits, fly tipping and any hydrocarbon contamination across the site. Gas may migrate through the permeable deposits on site; either through the Made Ground, or along service trenches or bedding.

6.10.2 Receptors

Potential receptors include humans and buildings. If methane or carbon dioxide collects within an enclosed area, it can cause asphyxiation and explosion, therefore causing death or injury to humans and destruction of the building.

Gas	Hazard Concentrations	
	Toxicity of asphyxiation % by volume in air[1]	Explosive limits in air % by volume in air (LEL)[2] (UEL)[3]
Methane	30	5.0 - 15.0
Carbon Dioxide	0.5	n/a
Carbon Monoxide	0.005	12.5 - 74.2
Hydrogen Sulfide	0.001	4.3 - 45.5
Hydrogen	30	4.0 - 74.0

[1] 8 hour long-term exposure limit (HSE, 1991)

[2] lower explosive limit

[3] upper explosive limit

Table taken from CIRIA R149 (1996) [REF 25]

6.10.3 Monitoring Data

Gas monitoring has been undertaken in both deep and shallow installations across the site, and results are included in **Appendix 5**. Monitoring of the deep installations within the sand and gravel layers recorded concentrations of carbon dioxide gas up to 13% (by volume) at total gas flow rates up to 30 l/h. Monitoring of the shallow installations recorded concentrations of carbon dioxide gas up to 4.9% (by volume) and total gas flow rates of 0.3 l/h.

The maximum level of methane recorded during monitoring of both the shallow and deep installations was 0.1% (by volume).

6.10.4 Initial Data Assessment

According to CIRIA R149 gas protection measures are required when the concentration of methane and carbon dioxide exceed 1% and 1.5% by volume in air respectively. In most natural UK soils methane concentrations fall well below 0.1%. The CIRIA R149 Report has been used to preliminarily assess the gas regime at the site. The criteria used take into consideration the maximum gas concentration recorded and do not consider gas flow rates, and therefore it is often deemed to provide unnecessarily high classifications.

Elevated levels of carbon dioxide (up to 13% concentration) were measured at depth in the sand and gravel layers, but monitoring of the shallow wells indicates that concentrations within the Made Ground deposits on the site are lower, with the maximum concentration of carbon dioxide recorded as 4.9%, typical of many Made Ground deposits. Comparison of the shallow gas monitoring results with CIRIA R149 classifies the site as Characteristic Situation 2, which requires ventilation of confined spaces within the building, installation of a well constructed ground slab, installation of a low permeability gas membrane and minimum penetration of the ground slab by services.

6.10.5 Summary of Gas Risks

The gas monitoring programme on the site has recorded high gas flow rates and carbon dioxide concentrations at depth within the sand and gravel layers, but shallow gas monitoring has shown that these flow rates and concentrations are not detected in the Made Ground deposits across the site. It is likely that the significant thicknesses of Glacial Till across the site are acting as a barrier to gas migration.

Slightly elevated levels of carbon dioxide gas were detected within the Made Ground deposits, and appropriate gas protection measures will be required within the final development to address this risk.

7. DEVELOPMENT CONSIDERATIONS AND STRATEGY

7.1 Proposed Development

7.1.1 Potential Earthworks Strategy

A programme of earthworks will be required to form an earthworks profile suitable for the proposed development levels and to treat geotechnically and chemically unsuitable materials. A preliminary assessment has been made to determine approximate quantities and material types to be excavated. The earthworks assessment and estimation of quantities is based on a comparison of the ground surface derived from the topographical survey and the formation level assumed to be 0.5m below the slab levels indicated on the Architects drawing No GSD-02-101. This is to allow for the construction thickness of the ground floor slab and car park with granular stone below. Additional allowance has been made for dealing with soft and hard areas below the buildings outside the Podium areas to allow the use of a ground bearing slab. A summary of the estimated earthworks quantities is given below:

Item	Phase 1	Phase 2	Phase 3	Total
Excavation	3,200	5,150	4,000	12,350
Fill	3,150	2,000	900	6,050
Off Site Disposal	2,200	3,150	2,400	7,750
Process On site for re use	1,000	2,000	1,800	4,800
Import of granular fill	2,150	0	0	2,150

The earthworks assessment indicates that there will be a net surplus of excavated arisings which will require disposal from site. Also it is estimated that about 2,150m^3 of imported granular fill will be required for the Phase 1 area. There is significantly more cut than fill required in the Phase 2 and 3 areas and it is assumed that the majority of the fill requirement for these phases can be sourced from the excavated arisings. It is assumed that each phase will be developed separately and therefore there will be little opportunity to share and balance materials across each phase of development.

The preliminary assessment indicates that excavation will predominantly be in Made Ground deposits with Glacial Till locally encountered in the Phase 2 and 3 areas. The Made Ground deposits, described in details in Section 5, are variable in composition and consistency and generally will be unsuitable for direct reuse as engineering fill. A proportion of these materials including hard materials should be suitable for processing by screening and crushing to generate suitable granular fill for use on the site. There is also a small quantity of Glacial Till which could also be used as general fill on site. The following construction sequence is proposed to help maximise the reuse potential of the excavated arisings:

- Site strip – Remove vegetated upper material say 100mm across the site. To included removal of needles and syringes.
- Removal of Japanese Knotweed – excavation is likely to be required up to a 7m radius and to 2m depth at each stand location.
- Removal of identified contamination hotspots.

- Cut and fill to form earthworks platform at structural slab level less 0.5m.
- Process suitable excavated arising by screening and crushing to form granular fill for reuse on site.
- Remove soft and hard areas below building footprint and car park areas. Backfill with granular fill.
- Place granular fill to underside of ground floor slab and car park.
- Remove unsuitable and surplus arisings from site.

It is suggested that a range of +/- 10 % is given on the bulk earthworks quantities and a range of up to 20% on the individual volumes from the Made Ground components to reflect the typical variability. The estimated quantities could vary beyond these ranges following the detailed risk assessments and the development and approval of a remediation strategy for the site.

The earthworks activities are highly influenced by seasonal conditions and periods of extended rain could result in further degradation of materials and decrease in their reuse potential. Conversely, periods of very dry weather combined with the already low natural moisture content of the clay may mean that additional wetting down is required prior to compaction. Ideally the earthworks should be carried out between April and October to minimise this risk.

The site remediation targets will govern the classification of material which is unsuitable for use on account of its chemical properties. These targets will need to be developed following detailed risk assessment which has not yet been fully undertaken... Any changes to the preliminary generic targets assumed may alter the quantity of U2 material present.

There will be further materials generated from site in the form of substructure excavations, pad excavations and pile arisings which have not been included in the above calculations. From our experience it is difficult to retain these materials for use on site and at this stage an allowance should be made for additional off site disposal.

7.2 Remediation

7.2.1 Objectives

In general terms the objectives of any remediation works proposed are to ensure the site is 'suitable for use' in accordance with Part IIA of the Environmental Protection Act, i.e. contamination remaining on site:

- Does not present a significant risk of significant harm to identified receptors
- Does not cause significant pollution of controlled waters.

The environmental risk assessment identified the following potential pollutant linkages that should be addressed during remediation and enabling works on the site:

	Source	Pathway	Receptor
Construction	Fugitive dust	Inhalation and ingestion	Adjacent residents, construction workers
Construction	Made Ground deposits	Ingestion, dermal contact, inhalation	Construction workers

	deposits	of contaminant vapours	
Construction	Made Ground deposits and perched waters	Surface water runoff Lateral migration	Ashton Canal
Construction & Post Construction	Made Ground deposits and perched waters	Vertical migration of leachate and perched groundwater	Sandstone aquifer
Construction & Post Construction	Ground gas	Migration	Residents and site users, construction workers
Post Construction	Made Ground	Vapour and leachates	Services
Post Construction	Topsoil and surface landscaping materials	Ingestion, dermal contact, inhalation of contaminant vapours, plant uptake	Site users, maintenance workers, landscaping

7.2.2 Outline Strategy

Derivation of detailed remediation targets and completion of a detailed environmental risk assessment has yet to be undertaken for the development, but the preliminary assessment undertaken to date has indicated that a proportion of the Made Ground deposits on the site will be unsuitable for use in landscaped areas, and hotspots of contamination beneath the building footprint will require removal as they pose unacceptable risks to human health. Remediation targets will be set for both landscaping and building footprint areas, allowing some flexibility for material movement across the site, and minimising the need for off-site disposal of materials suitable for use under hardstanding.

The results of the preliminary earthworks modelling exercise indicates that there will be a net surplus of materials requiring removal from site. It is intended to retain, process and reuse as much of the better quality Made Ground deposits as possible subject to environmental and geotechnical suitability. These materials should generate suitable granular engineering fill following screening and crushing.

For the first phase of soil remediation works, soils known to contain contaminants significantly exceeding the site remediation criteria on the site, i.e. contamination "hotspots", will be excavated. These areas will be identified in the detailed remediation statement to be developed. Such soils will be classified as U2, 'Unacceptable Contaminated' Material, as defined in the Department of Transportation Specification 1991, and treated on-site or disposed of appropriately off site.

General excavation arisings will be processed by screening and crushing, and a suitable materials testing designed and approved with the regulatory authorities to enable materials suitable for re-use both chemically and geotechnically to be identified.

7.2.3 Site Chemist

It is recommended that a full time independent qualified site chemist should be appointed for overseeing all excavation, delineation and removal from site of all Class U2 material, to be responsible for all chemical sampling and scheduling of analysis. The chemist would ensure that samples are prepared and preserved in accordance with the guidance provided by the appointed laboratory. Methods of analysis for each determinant will need to be agreed between the site chemist, the remediation designer and the laboratory prior to the scheduling of any chemical analysis.

7.2.4 Hotspot Removal

It is envisaged that known areas of significantly elevated contaminants will be excavated to the proven depth of contamination or the top of Glacial Till, and then chased out by visual or olfactory means where feasible, supervised by the site chemist. This could be assisted by use of a PID meter for hydrocarbon contamination. Validation samples will be taken for chemical analysis from excavations to ensure that all contamination has been removed. Five samples would normally be anticipated, four from the sides of the excavation and one from the base.

Depth of excavations will be limited to the Glacial Till, as this stratum is assumed to be 'clean'. Such areas will however be marked on the validation drawing.

If any potentially significantly contaminated materials, in addition to those identified from the investigations to date, are uncovered during any phase of the earthworks they will either be removed for off site disposal, or stockpiled pending analysis to determine their suitability to remain on site.

7.2.5 Imported Fill Materials

Imported fill materials on the site should comply with the chemical criteria to be derived as part of the detailed remediation strategy.

Imported recycled fill materials should be produced in compliance with the Quality Protocol for the production of aggregates from inert waste [REF 30], and appropriate documentation (as detailed in the protocol) must be provided for all materials.

7.2.6 Topsoil

Landscaped areas will require an appropriate combined thickness of sub/top soil and trees will be planted in appropriate trenches or pits.

Copies of the environmental risk assessment, remediation strategy and chemical testing data will be issued to the landscape architect prior to detailed design of the landscaping works.

The chemical quality criteria for topsoil should be defined by the landscape architect appointed for the development, to ensure healthy plant growth. These criteria must not exceed the imported fill criteria. It is recommended that once the topsoil criteria have been established they are reviewed by the Engineer to ensure that they are in accordance with the environmental risk assessment, and may require review and approval by Environmental Health.

7.2.7 Fly Tipping

Site visits indicate the presence of fly-tipped materials which appear to be above the levels indicated on the topographic survey. These will need to be quantified and removed from site prior to commencement of the main enabling works. These materials appear to be variable and include domestic refuse. It is recommended that these be removed from site.

7.2.8 Syringes

The site contains high concentrations of needles/syringes associated with recreational drug usage. Once the site has been secured, a thorough search and removal process will need to be undertaken as these pose a high risk to construction workers. It may be necessary to remove the surface layer from site as an advance operation to ensure the risk is minimised.

7.2.9 Construction Method Statement

Prior to commencement of the site enabling works, including the remediation works, the Contractor appointed will be required to submit a detailed Construction Method Statement to include proposals for the health and safety of all site staff and the storage, treatment and disposal of any excavated material and groundwater from the site. This will ensure that all works are carried out in accordance with the Construction (Design and Management) Regulations 1994 [REF 31], together with all relevant health and safety legislation.

All staff working on the site will be made aware of the potential hazards from any residual or unidentified contamination, including asbestos, and the procedures to be followed if any such material is uncovered during later stages of the development works.

As discussed previously, the statement should also include details of all dust control measures to be implemented for the works.

7.3 Waste Management Licensing

The earthworks strategy for the site requires levels of site to be regraded and development platforms to be constructed prior to construction. The environmental risk assessment for the site concludes that Made Ground and natural deposits on site are suitable for the proposed end-use. However, due to the nature of the earthworks to be undertaken, it may be necessary to apply for a Waste Management License exemption. It is considered that the works will be eligible for exemption under Paragraph 19 Schedule 3 of the Waste Management Regulations 1994 [REF 32].

With regards to imported materials, there is a risk that recycled fill materials from other sources may be subject to a waste management licence unless they are aggregates recycled in accordance with the WRAP quality protocol [REF 24].

It is recommended that clarification be sought from the Environment Agency in respect to both issues.

7.4 Waste Classification

Under the requirements of the Landfill Regulations 2002 [REF 29], the 'co-disposal' of hazardous and non-hazardous waste in the same landfill is prohibited. The regulations (or Landfill Directive, as they are more commonly known) introduced a new system for the classification of waste materials, defining them as inert, non-hazardous and hazardous. Hazardous wastes identified in the European Waste Catalogue must be pre-treated, according to a three-point test, to reduce their quantity and hazard before they are sent to landfill. Also defined are Waste Acceptance Criteria, "limit values" for certain parameters obtained from standard leaching tests for different categories of waste going to landfill.

Inert materials are defined in two ways. Some materials are defined as automatically inert (e.g. concrete, brick and glass) in the Regulations themselves. Alternatively, material can be stringently tested in accordance with BSEN 12457 Part 3 [REF 33], and compared against the Waste Acceptance Criteria for inert wastes.

Soils from contaminated sites are included in the European Waste Catalogue as "mirror entries". This means that they are classified as hazardous waste if an assessment of their

hazardous properties indicates that they are in excess of specified threshold values. The protocol for assessing these materials and the appropriate threshold values are discussed in the Environment Agency's "Technical Guidance *WM2* Hazardous Waste – Interpretation of the Definition and Classification of Hazardous Waste" [REF 34]. If a waste is classified as neither inert nor hazardous, then it is by default non-hazardous.

7.5 Foundations

7.5.1 Apartments

The proposed multi-storey residential blocks are significant structures that will impose very large loading, both in terms of the vertical static load, lateral loading and rotational moments, into the ground. The structures will require piled foundations to support the localised structural columns. The piles should be socketted into the dense Sand and Gravel layer between the base of Till and Rockhead.

The following preliminary working loads for piles founded in the Sand and Gravel unit are suggested but it should be noted that these are for individual piles and the group effects are more likely to govern the design on this type of foundation and should be carefully considered in the detailed design:

750mm diameter pile to 17.5m (toe level 27mOD) : 1950 kN

1200mm diameter pile to 21m (toe level 23.5mOD) : 4275 kN

It is assumed that the above piles would be installed using conventional bored or continuous flight auger methods.

The above recommendations are preliminary and it is recommended that detailed foundation designs be undertaken to suit individual structures and their location on the site.

7.5.2 Podium Structure

The site investigation has encountered Glacial Till at generally shallow depths, typically less than 1.5m and up to 4m. Conventional strip or trench-fill type foundations are therefore likely to be suitable for the anticipated loads from this low-rise structure. Detailed design has not been undertaken at this stage. However for preliminary scheme purposes an allowable bearing pressure for individual pad foundations on the firm Glacial Till of 80 kN/m^2 can be taken.

The detailed assessment should include an assessment of the effects of load interaction between the individual pads as this may significantly increase the likely settlements.

Due to the variability of the Made Ground deposits it is not recommended that the shallow foundations are constructed on the Made Ground. However it may be permissible to construct the lower deck of the Podium as a ground bearing unit, following the site strip, removal of unsuitable materials and soft spots and proof rolling.

7.6 Ground Gases

The gas monitoring programme on the site has recorded high gas flow rates and carbon dioxide concentrations at depth within the Sand and Gravel layers, but shallow gas monitoring has shown that these flow rates and concentrations are not detected in the Made Ground deposits across the site. It is likely that the significant thicknesses of Glacial Till across the site are acting as a barrier to gas migration.

Elevated levels of carbon dioxide gas were detected within the Made Ground deposits, and appropriate gas protection measures will be required within the final development to address this risk. We would recommend that further monitoring is conducted to establish the shallow gas regime and allow the detailed design of gas protection measures.

8. CONCLUSIONS AND RECOMMENDATIONS

8.1 Foundations

Due to the high loadings anticipated, the foundations to the main residential blocks will be piled. The piles will need to be extended into the dense Glacial Sand and Gravel layer located about 16 to 20 m below ground level. Further detailed design of these foundations will be required once the final loadings have been developed.

For the podium, which is currently a two-storey car park structure with roof garden, it is anticipated that shallow spread foundations on to the Glacial Till will be acceptable. Further assessment of the likely settlements and load interactions will be required as part of the detailed design.

8.2 Earthworks

A programme of earthworks will be required to form an earthworks profile suitable for the proposed development levels and to treat geotechnically and chemically unsuitable materials. A preliminary assessment has been made to determine approximate quantities and material types to be excavated which indicates that there will be a net surplus of excavated arisings which will require disposal from site. The excavated arisings will predominantly be in Made Ground deposits with Glacial Till locally encountered in the Phase 2 and 3 areas. The Made Ground deposits are variable in composition and consistency and generally will be unsuitable for direct reuse as engineering fill. A proportion of these materials including hard materials should be suitable for processing by screening and crushing to generate suitable granular fill for use on the site.

A quantity of granular import will be required to supplement the materials processed on site. All imported materials should comply with the chemical criteria derived as part of the detailed remediation strategy.

It is assumed that each phase will be developed separately and therefore there will be little opportunity to share and balance materials across each phase of development. Off site disposal and import could be reduced if an earthworks strategy was developed and implemented for the whole site.

The site contains high concentrations of needles/syringes associated with recreational drug usage. Once the site has been secured, a thorough search and removal process will need to be undertaken as these pose a high risk to construction workers. It may be necessary to remove the surface layer from site as an advance operation to ensure the risk is minimised.

8.3 Contamination

At this stage of the development process, a qualitative and generic quantitative risk assessment has been undertaken to assess risks to human health and controlled waters which have indicated that there are areas of Made Ground deposits which may be unsuitable for use in landscaped areas and below building footprints. Also the assessment indicates that some of the contaminants present in the Made Ground may be potentially mobile and possibly present a risk to the Ashton Canal.

An outline draft strategy is presented in Section 7.2 and is aimed to address the above risks and provide a site which is 'suitable for use' in accordance with Part IIA of the Environmental Protection Act. A detailed Remediation Strategy will be required including site specific quantitative risk assessment. The Strategy should be submitted to Manchester City Council Environmental Health for approval prior to the commencement of construction works on site.

Elevated levels of carbon dioxide gas were detected within the Made Ground deposits, and appropriate gas protection measures will be required within the final development to address this risk. We would recommend that further monitoring is conducted to establish the shallow gas regime and allow the detailed design of gas protection measures.

The presence of Japanese Knotweed has been confirmed, by others, on site. It is understood that a programme of spraying was undertaken in Autumn 2004. It is envisaged that further treatment will be required prior to construction works commencing. Treatment by excavation may be required if the treatment has not fully eradicated the plants prior to construction.

8.4 Recommendations for Further Investigation

It is recommended that further gas monitoring is conducted in order to establish the shallow gas regime.

We would recommend a further meeting with the Environmental Health Officer to discuss the findings of the works thus far and the additional works required in the development of the Detailed Quantitative Risk Assessment (DQRA) and the detailed remediation strategy. Further Site Investigation may be required following this, particularly as the recent investigation was focussed primarily on the Phase 1 area.

A detailed remediation strategy will need to be prepared and approved by Manchester City Council Environmental Health prior to commencement of the works. This should include Further environmental risk assessment and the derivation of site-specific remediation levels following DQRA.

It is also recommended that a foundation works risk assessment is undertaken to determine the suitability of the foundation proposals in relation to the risk to controlled waters.

The proposed works are located in close proximity to the canal structure. It is therefore recommended that a pre construction condition survey is undertaken with the canal drawn down. We would recommend that this is conducted in conjunction with British Waterways.

Further treatment of the Japanese Knotweed and pre construction survey is required to establish the performance of the treatment programme.

9. REFERENCES

[1] Envirocheck, Report on Manchester, Grid Ref 385550:398200, Reference 54619-1-1, February 2001

[2] Arup, Islington Wharf, Desk Study Report, 112354/REP/GEO/001, November 2003

[3] Ian Farmers Associates, Islington Wharf, Phase 1 Ste Investigation – Factual Report (Draft Issue), Ref. 4394, April 2004

[4] Arup, Structural Design Philosophy, April 2004

[5] Environment Agency, Landfill Directive Regulatory Guidance Note 2 (version 4.0, November 2002), Interim Waste Acceptance Criteria and Procedures

[6] Environment Agency, Guidance on Sampling and Testing of Wastes to Meet Landfill Waste Acceptance Procedures, Version 4.3a, December 2003

[7] BS EN 12457 Part 3, Characterisation of waste – Leaching – Compliance test for leaching granular waste materials and sludge, 2002

[8] Environment Agency, Groundwater Vulnerability 1:100,000 Map Series Sheet 17, Derbyshire and North Staffordshire, 1996.

[9] Geotechnics Ltd, Ground Investigation at Manchester Metro Phase 3 Extension to Commonwealth Games Stadium for GMPTE Project 00-C1848 February 2001.

[10] PB Kennedy & Donkin, Manchester Metrolink Phase 3 Piccadilly to Eastlands Interpretative Report on Ground Investigation (First Issue), November 2000

[11] Edward Roscoe Associates, Assessment of Ground Conditions for Redevelopment for land at Great Ancoats Street Manchester, Reference M11740J, October 1997

[12] DETR Circular 02/2000, Environmental Protection Act 1990: Part IIA

[13] SNIFFER, Framework for Deriving Numeric Targets to Minimise the Adverse Human Health Effects of Long-term Exposure to Contaminants in Soil, April 2000

[14] Environment Agency, Contaminated Land Exposure Model Fact Sheet for RISC-HUMAN (3.1), NGWCLC Fact Sheet FS-03 , 2003

[15] Environment Agency, Contaminated Land Exposure Model Fact Sheet for the RBCA Tool Kit for Chemical Releases, NGWCLC Fact Sheet FS-02 , 2003

[16] Environment Agency, R & D 20, Methodology for the Derivation of Remedial Targets for Soil and Groundwater to Protect Resources, 1999

[17] Golder Associates (UK) Ltd & Environment Agency, CONSIM: Contamination Impact on Groundwater: Simulation by Monte Carlo Method, Environment Agency R & D Project P2-007, 1999

[18] Rudland, D J, Lancefield, R M, Mayell, P N, Contaminated Land Risk Assessment – A Guide to Good Practice, CIRIA C552, CIRIA, 2001

[19] DETR, Guidelines for Risk Assessment and Management – Revised Departmental Guidance, HMSO, 2000

[20] Environment Agency, Assessment of Risks to Human Health from Land Contamination: an Overview of the Development of Guideline Values and Related Research, R & D Publication CLR 7, 2002

[21] DEFRA/Environment Agency, The Contaminated Land Exposure Assessment (CLEA) Model: Technical Basis and Algorithms, R & D Publication CLR 10, 2002

[22] Ove Arup and Partners Ltd, CLEA Generic Assessment Criteria for Benzo(a)pyrene, Research Report, Ref. REP/BaP001, March 2004
Ove Arup and Partners Ltd, CLEA Generic Assessment Criteria for Zinc, Research Report, Ref. REP/001, March 2004

Ove Arup and Partners Ltd, CLEA Generic Assessment Criteria for Phenol, Research Report, Ref. REP/001, February 2004

Ove Arup and Partners Ltd, CLEA Generic Assessment Criteria for Napthalene, Research Report, Ref. REP/C10H8-001, March 2004

Ove Arup and Partners Ltd, CLEA Generic Assessment Criteria for Inorganic Cyanide, Research Report, Ref. REP/CN-D1`, March 2004

Ove Arup and Partners Ltd, CLEA Generic Assessment Criteria for Benzene, Research Report, Ref. REP/001, March 2004

[23] Dutch Ministry of Housing, Spatial Planning and the Environment, Circular on Target Values and Intervention Values for Soil Remediation, 2000

[24] Water Regulations Advisory Service, The Selection of Materials for Water Supply Pipes to be Laid in Contaminated Land, No. 9-04-03, October 2002

[25] CIRIA Report 149, 1996

[26] BRE, Special Digest 1, Concrete in Aggressive Ground, Part 1: Assessing the Aggressive Chemical Environment, 2001

[27] BRE, Special Digest 1, Concrete in Aggressive Ground, Part 2: Specifying Concrete and Additional Protection Measures, 2001

[28] Card, G. B., Protecting Development from Methane, CIRIA Report 149, 1996.

[29] The Landfill (England and Wales) Regulations, SI 2002 No. 1559

[30] Waste and Resources Action Programme, Quality Protocol for the Production of Aggregates from Inert Waste, June 2004, ISBN 1-88405-119-6

[31] The Construction (Design and Management) Regulations 1994, SI 1994 No. 3140

[32] The Waste Management Licensing Regulations 1994, SI 1994 No. 1056

[33] BS EN 12457 Part 3, Characterisation of Waste – Leaching – Compliance Test for Leaching for Granular Waste Materials and Sludges, 2002

[34] Environment Agency, Technical Guidance *WM2* Hazardous Waste – Interpretation of the Definition and Classification of Hazardous Waste, 2003

[35] Interdepartmental Committee on the Redevelopment of Contaminated Land, ICRCL 59/83, Second Edition, 1987