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SITE INVESTIGATION REPORT

WITANHURST

41 HIGHGATE WEST HILL

LONDON N6

Report Reference No. C11681

DEWRACE MANAGEMENT SERVICES

MICHAEL BARCLAY PARTNERSHIP

CONSULTING ENGINEERS

REPORT ON A SITE INVESTIGATION

AT

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Report Reference No. C11681 **May 2009**

INTRODUCTION

Dewrace Management Services, the client, intends to have a 68m by 35m plan area, 10m deep basement, with no superstructure, constructed adjacent Witanhurst, 41 Highgate West Hill, London N6. Witanhurst is a Grade II* listed building.

Ground Engineering was instructed by Consulting Engineers Michael Barclay Partnership, on behalf of the client, to carry out a site investigation comprising a desk study into the former uses of the site and a ground investigation. The latter was to determine the nature and geotechnical properties of the underlying soils in relation to the foundation design and construction of the basement. In addition, the depth to groundwater was to be monitored and a contamination assessment was to be included within the scope of this investigation.

LOCATION, TOPOGRAPHY AND GEOLOGY OF THE SITE

Highgate West Hill, runs approximately south-west to north-east through a residential part of Highgate, London N6. Witanhurst (No.41) is a large detached residence set within extensive grounds on the north-western side of Highgate West Hill, some 200m north-west of the northern end of Highgate Cemetery. The irregularly-shaped, approximately 200m long (south-west to north-east) and 40m to 110m wide (north-west to south-east) site is centred at National Grid Reference TQ 2812 8717.

Witanhurst is a large L-shaped three-storey brick residential building, which is located within the central, eastern part of the grounds. The ground to the west of the building comprises extensive gardens/parkland, including tennis courts and walled gardens. The entrance to the site was off Highgate West Hill and was through a covered way within a two-storey brick gatehouse at the north-eastern corner of the site.

At the time of the investigation, the 55m by 35m approximately rectangular area of ground between the gatehouse and Witanhurst was predominantly surfaced with asphalt, used as an access road and car park, and was sub-divided by a 2.5m high, partially curvilinear, brick wall. The proposed basement structure is to be located beneath this currently vacant courtyard adjacent the eastern side of the main house (Site Plan).

The site is limited to the south-east by Highgate West Hill, from which it is separated by a 1.8m high brick retaining wall that steps down the hill towards the south-west; by a 1.0m high brick retaining wall to the north, which delineates the site's boundary with No.1 The Grove; to the north-west by a 2.8m high chain link fence beyond which were further gardens to the rear of properties facing onto Highfields Grove; and to the south-west by a group of two-storey dwellings.

A large number of mature trees were present within the grounds of Witanhurst, notably a row of Lime trees within the Highgate West Hill boundary; a single Lime tree within

the centre of the car park, and a row of Beech trees alongside the northern boundary of the site with the adjacent No.1 The Grove.

The main house stands at an approximate elevation of 125mOD at the south-western edge of the relatively flat top of Highgate Hill, beyond which the ground falls moderately steeply to the south-west (1 vertical in 8 horizontal) and west (1 vertical in 4 horizontal). These changes in ground level have historically been accommodated by terracing and remodelling of the slopes immediately to the west and south-west of the house. The existing car park slopes gently down south-westwards towards the main house from about 126mOD at the site entrance.

The 1934 geological map for this part of London, based on the 1920 Edition O.S. Sheet II SW at 1:10,560 scale, shows the site to be directly underlain by solid geology Bagshot Sand (buff coloured sand with ferruginous conglomerate) and then in turn underlain by the solid geology of the Claygate Beds and London Clay.

The 2006 geological map for the area at 1:50,000 scale, Sheet 256, shows the site to be near the edge of ground that is directly underlain by the solid geology of the Bagshot Formation, which caps Highgate Hill. The Bagshot Formation in turn is underlain by the Claygate Member of the London Clay Formation, and then the underlying undifferentiated London Clay Formation. These latter two strata directly underlie the lower slopes of Highgate Hill immediately to the west and south-west of the site.

A previous ground investigation, undertaken by others in 1999, comprised a single deep borehole and six shallow window sample holes which were positioned to the south, south-west and west of the main building. These 4.00m to 20.00m deep holes encountered 0.70m to 2.10m of made ground, which generally covered sandy clays but locally sand and gravel deposits. With increasing depth the boreholes entered clayey and silty sands with subordinate clay layers. Groundwater was not met in the shallow holes or recorded within the 6.00m deep standpipe installation in the 20.00m deep hole.

HISTORY OF THE SITE

Historical maps dating between 1747 and the present day have been reviewed as part of this desk study. Selected map sheets are reproduced in Appendix 1 with relevant descriptions given below.

John Rocque's 'Plan of the Cities of London and Westminster and the Country near ten miles round' was published in 1747 and has most of the modern day road network within the village of Highgate in place. Individual buildings cannot be identified on this small scale plan but several were present on what is today called Highgate West Hill.

Similarly, the 1807 Ordnance Survey (O.S.) map of Hampstead at the 2 inches to 1 mile scale shows the existing road system upon Highgate Hill and a number of buildings dotted along them. Again individual buildings cannot be identified on this map.

Stanford's 'Library Map of London and its Suburbs' was published in 1862 and shows the site on the north-western side of Highgate Hill to the west of St. Michael's Church (opened 1832) and Highgate Cemetery (opened 1839). The eastern end of the site was occupied by a pair of dwellings facing onto the western side of the southern end of The Grove; the centre of the present day basement site by an L-shaped building called Grove Bank; and the western side by an S-shaped range of buildings separated from Grove Bank by an open space or yard with access directly off Highgate Hill. Local history records indicate that the S-shaped range of buildings was called Parkfield, although on this map this name is ascribed to a building further down the hill to the south-west. The remainder of the site included several further dwellings to the south-west, one of which it is known was The Fox and Crown public house, several fields and Fitzroy Park to the west (Figure A). A covered reservoir was depicted to the north-north-east of the site at the northern end of Highgate Hill.

The 1st Edition Ordnance Survey (O.S.) map for the area was published in 1870 at the 1:2500 scale (London Sheet III). This shows the site (Figure B) in greater detail with the house within the centre of the site denoted as Parkfield and associated stables and outbuildings

lining the sides of a yard/open space separating it from the unnamed Grove Bank to the east. Both of these dwellings had associated gardens and some terracing of the sloping ground was depicted on this survey, as well as glasshouses within the gardens of Parkfield. At the eastern end of the site the pair of dwellings apparent on the 1862 map had apparently been reduced to a single building aligned parallel to West Hill. The public house was positioned across the site boundary within the south-western corner of the site and was marked (P.H.) but not named on this edition. Residential development of the surrounding area continued piecemeal, predominantly to the south and west.

The 1896, 2nd Edition O.S. map for the area (London Sheet XIX) at the same scale as the 1st, has Parkfield greatly extended to its north and rear, and the resultant removal of the former stables and two of the outbuildings (Figure C). The former open space between Parkfield and Grove Bank was now shown to contain trees. Another building and glasshouse had been added to Grove Bank and further earthworks were shown within the field to the west of the main house. Several nurseries were present to the south-east of West Hill and west of Highgate Cemetery on this map.

The 1916, 3rd Edition O.S. map (London Sheet II.9), shows Parkfield unchanged (Figure D) but the addition of further long and thin buildings (presumed stables) to the rear and north-east of Grove Bank extending to the south of No.1 The Grove. Elsewhere within the site the glasshouses to the south-west of Parkfield had been removed and a new T-shaped configuration of glasshouses constructed further from the building. The building within the south-western corner of the site was no longer denoted as a public house on this edition and had been reduced in size.

The 1939-45 Bomb Damage Map (Figure E) shows the site unaffected by World War II bomb damage and the nearest affected building as St. Michael's Church to the east. The site itself is shown to have altered significantly with the replacement of Parkfield with a larger building; the complete removal of the Grove Bank buildings from the eastern half of the site and the former public house from the south-western corner of the grounds. A building did remain at

the southern end of the site's frontage onto The Grove at the eastern end of the site. Local history records indicate that the replacement building was built between 1913 and 1920 for soap magnate Sir Arthur Crosfield, was called Witanhurst, and the Georgian-style mansion incorporated some elements of the former house.

The 1951, 1:10,560 scale sheet TQ 28 NE (Figure F) has the site and immediate surrounding area unchanged from the wartime survey. The gardens to the west and south of the new building are shown to have been extensively remodelled.

The 1952 edition of the 1:2500 scale maps TQ 2887 (Figure G) shows Witanhurst in detail and with a lodge at its eastern end with a covered way access off West Hill. The terraced gardens to the north-west of the main house included an enclosure (later named as tennis courts) and, to the north-west, a small pond. As before, the surrounding area was predominantly residential but included a nursery.

The site and immediate surrounding area remained unchanged on the 1968 edition of the 1:1250 scale sheet TQ 2887 SW (Figure H). The buildings at the eastern end of the site were now marked as North Lodge and South Lodge, on either side of the covered access.

The 1976, 1:10,000 scale map for the area, sheet TQ 28 NE (Figure I) has the site and surrounding area as it was in 1968.

The 1996 edition of the 1:10,000 scale sheet, TQ 28 NE, also has the site unchanged, and as it was at the time of this investigation (Figure J). West of the site Highfields Grove had been constructed and was lined by a number of large dwellings.

The undated location map included on page 4 of the Environmental Searches report presented in Appendix 2 shows the site as before, apart from the addition of a building at the northern end of the eastern site frontage associated with the entrance lodges, and as it was in early 2009.

In summary, this part of Highgate was already developed during the Eighteenth Century and by 1862 the site was occupied by dwellings called Parkfield and Grove Bank, and a public house called The Fox and Crown. The site was redeveloped between 1913 and 1920 when

Witanhurst was constructed and most of the other buildings removed. The site has remained largely unchanged from 1920 through to 2009.

ENVIRONMENTAL SEARCHES

Appendix 2 contains information derived from Environmental Databases for a radius of up to 250m from the site. The information contained includes data sets held by Landmark Information Group and contributors include the Environment Agency, British Geological Survey, Ordnance Survey, English Nature and the Coal Authority.

The results obtained are presented in summary form together with a detailed search on selected areas of inquiry based on the summary details.

Current Land Use

The following is a brief summary of the main points for the current land use:

Landfill Survey: There are no (0) recorded current or former landfills licensed, by the Environment Agency under Part II of the Environmental Protection Act 1990, on site or within 250m of the site.

Waste Treatment, Transfer and Disposal: There are no (0) recorded sites licensed by the Environment Agency under Part II of the Environmental Protection Act 1990, to transfer, dispose and treat controlled waste within 250m of the site.

Statutory Authorisations

Local Authority Pollution Prevention and Controls: There are no (0) recorded authorisations, by the Environment Agency under Part I of the Environmental Protection Act 1990, subjecting a site to Local Authority pollution prevention and controls within 250m of the site.

Contaminated Land Register Entries & Notices: There are no (0) entries or notices on the Contaminated Land Register recorded on, or within 250m of, the site.

Keeping of Radioactive Substances: There are no (0) recorded sites registered by the Environment Agency under the Radioactive Substances Act 1993, to keep or use radioactive materials within 250m of the site.

Discharge Consents

Discharges to Water: There is one (1) recorded consent issued by the Environment Agency to discharge water to water courses within 250m of the site. This licence was issued to Thames Water for the waterworks to the north-east of the site, but has been revoked.

Water Industry Act Referrals: There are no (0) recorded referrals under the Water Industry Act within 250m of the site.

Industrial Processes

IPC Regulations: There are no (0) recorded sites authorised by the Environment Agency, under Part I of the Environmental Protection Act 1990, to carry out processes subject to Integrated Pollution Control (IPC) or Integrated Pollution Prevention and Control (IPPC) within 250m of the site. Nor are there any recorded IPC Registered Waste Sites.

Storage of Hazardous Substances

Control of Major Accidents: There are no (0) recorded sites regulated by the Health and Safety Executive, under the Control of Major Accident Hazards (COMAH) regulations 1999, within 250m of the site.

Explosives Sites: There are no (0) recorded explosives sites within 250m of the site.

Storage of Dangerous Substances: There are no (0) recorded sites regulated, by the Health and Safety Executive for storing specific dangerous substances under the NIHHS regulations 1982, within 250m of the site.

Storage of Hazardous Substances: There are no (0) recorded sites subject to hazardous substances consents granted, by the relevant local authority under the Planning (Hazardous Substances) Act 1990, within 250m of the site.

Contraventions

Local Authority Pollution Prevention & Control Enforcements: There are no (0) recorded enforcements by the Local Authority under Part I of the Environmental Protection Act 1990.

Enforcement and Prohibition Notices: There are no (0) recorded enforcements and prohibition notices issued by the Environment Agency under Part I of the Environmental Protection Act 1990.

Pollution Incidents to Controlled Water: There are no (0) recorded incidents on or within 250m of the site.

Prosecutions: There are no (0) recorded prosecutions by the Environment Agency under Part I of the Environmental Protection Act 1990 relating to either authorised processes or controlled waters, within 250m of the site.

Potentially Contaminative Uses

Contemporary: There are no (0) recorded potentially contaminative uses listed for the site address. The two (2) recorded contemporary trade entries within 250m of the site are for hygiene and cleansing services, and an air conditioning supplier, to the south-west of the site. Both are listed as being inactive.

Fuel Station Entries: There are no (0) recorded fuel station sites within 250m of the site.

Miscellaneous

Mineral Sites: There are no (0) recorded mineral sites on the British Geological Survey database within 250m of the site.

Historical Land Use

The following is a brief summary of the main points for the historical land use:

Potentially Contaminative Uses

Historical Tanks and Energy Facilities: There are no (0) recorded historical tanks and energy uses listed for the site address. There are four (4) entries recorded for two (2) electricity sub-stations (one recorded twice) and one (1) potential tank site within 250m to the east, north-east and south-west of the site.

Past Land Use: There are no (0) recorded historical potentially contaminative uses listed for the site address and one (1) listed within 250m of the site. The latter is Highgate Cemetery.

Potentially Infilled Land

Former Marshes: There are no (0) recorded former marshes within 250m of the site.

Potentially Infilled Land: There are no (0) areas of potentially infilled land recorded within 250m of the site.

Site Sensitivity

The following is a brief summary of the main points for the sensitivity section:

Pathways

Groundwater Vulnerability: The site is designated as being underlain by a Minor Aquifer of variable permeability, the Bagshot Formation.

Drift Deposits: The site is recorded as not being covered by any drift deposits.

Flood Risk: The site is reported as not being within an area where flooding from rivers or sea occurs, and consequently is not within an area that benefits from flood defences.

Environmentally Sensitive Receptors

None of the information relating to the various environmental settings listed in the database indicates that the site lies within 250m of a sensitive area.

Nearest Surface Water Feature: The nearest recorded surface water feature within 250m of the site is the small pond in the gardens to the north-west of the site.

Abstraction Licences: There are no (0) recorded groundwater abstraction licences issued, by the Environment Agency in accordance with the Water Resources Act 1991, within 250m of the site.

Source Protection Zones: The site does not lie within 250m of source protection zone for groundwater.

Other Factors

The following is a brief summary of the main points for the other factors section:

Brine Compensation Area: The site is not within a Brine Compensation Area.

Coal Mining: The site is not within a coal mining area.

Natural and Mining Cavities/Instability: The site is not within an area affected by natural and mining cavities and instability.

Radon Affected Area: The site lies within an area where less than 1% of homes are above the BRE action level for radon.

Radon Protection Measures: The site lies within an area where basic radon protection measures are not required for new dwellings in accordance with BR211.

Natural Subsidence Risk: According to the British Geological Survey the on-site risk due to the natural subsidence hazard of Shrinking or Swelling Ground is rated as moderate; the risk of Running Sand is rated as low; Landslides is rated as very low; whilst Compressible Ground, Collapsible Ground, Ground Dissolution and Shallow Mining are recorded as 'No Hazard'.

PRELIMINARY RISK ASSESSMENT

In order to assess the risks associated with the presence of ground contamination the linkages between the sources and potential receptors to contamination need to be established and evaluated. This is in accordance with the Environmental Protection Act 1990, which provides a statutory definition of Contaminated Land. To fall within this definition it is necessary that, as a result of the condition of the land, substances may be present on or under the land such that

- *Significant harm is being caused or there is a significant possibility of such harm being caused; or*
- *Pollution of controlled waters is being, or is likely to be, caused*

There are three principal factors that are assessed whilst undertaking a qualitative risk assessment for any site. These are the presence of a contamination source, the existence of migration pathways and the presence of a sensitive target(s). It should be noted that it is necessary for each element of source, pathway and target to be present in order for exposure of a human or environmental receptor to occur.

UK Government guidance on the assessment of contaminated land, requires risk to human health and the environment to be reviewed using source – pathway – target relationships. If each of these elements is present, the linkage provides a potential risk to the identified targets. ***Contaminants or potential pollutants*** identified as ***sources*** in relation to the identified previous uses are listed below in Table 1.

Table 1: Identified Potential Contaminant Sources

Contaminant Source	*Comments*
Drainage	Effluent from existing drains could provide a contaminant source.
Soil Beneath Site	Contamination may be present within made ground beneath the site.
Soil Gas	Potential soil gas generated from the made ground or underlying strata.
Ground Contamination Outside Site Boundary	Ground contamination migrating from adjoining sites.

A ***Pathway*** is defined as one or more routes through which a receptor is being, or could be, exposed to, or affected by, a given contaminant.

Potential ***Target or Receptors*** fall within the categories of Human Health, Water Environment, Flora and Fauna, and Building Materials.

There are a number of possible pathways for the contaminants identified on the site to impact human and/or environmental receptors and these are summarised in Tables 2 and 3.

Table 2: Human Receptors and Pathways

Human Receptor-Mechanism	*Typical Exposure Pathway*
Human Inhalation	Breathing Dust and Fumes Breathing Gas emissions
Human Ingestion	Eating -contaminated soil, for example by small children -plants grown on contaminated soil Ingesting dust or soil on fruit or vegetables Drinking contaminated water
Human Contact	Direct skin contact with contamination Direct skin contact with contaminated liquids

Table 3: Water Receptors and Pathways

Receptor-Water Environment	*Typical Exposure Pathway*
Groundwater The site is underlain by a Minor Aquifer (Bagshot Formation) and at depth by a Non-Aquifer (London Clay).	Surface infiltration of atmospheric waters into the soils beneath the site could wash or dissolve potential contaminants and migrate to underlying groundwater. Contamination leads to restriction/prevention of use as a resource, for example, drinking water, and can have secondary impacts on other resources, which depend on it.
Surface Water The nearest surface water feature is the pond positioned within gardens some 80m north-west of Witanhurst.	Surface infiltration of atmospheric waters into the soils beneath the site could wash or dissolve potential contaminants and laterally migrate. Contamination leads to a restriction/prevention of use: -as drinking water resource -for amenity use Effects on aquatic life

Preliminary Conceptual Model

Assessment of the potential linkage between ground contamination sources, human and environmental receptors have been assessed based on the desk study research documented in the preceding sections of this report.

A generalised preliminary conceptual model relative to the construction phase and completed basement development is presented below in Table 4.

Table 4: Preliminary Conceptual Model Relative to Construction/Future Use of Basement

Receptors	Pathway	Estimated Potential for Linkage with Contaminant Sources			
		Drainage	Soil Beneath Site	Soil Gas	Ground Contamination Outside Site Boundary
Human Health – ground Workers	Ingestion and Inhalation of contaminated Soil, Dust and Vapour	Low likelihood	Low likelihood	Low likelihood	Low likelihood
Human Health – users of completed basement development	Ingestion and Inhalation of contaminated Soil, Dust and Vapour	Unlikely	Unlikely	Low likelihood	Unlikely
Water Environment	Migration through ground into surface water or groundwater	Low likelihood	Low likelihood	Unlikely	Low likelihood
Flora and Fauna	Vegetation on site growing on contaminated soil	Low likelihood	Low likelihood	Unlikely	Low likelihood
Building Materials	Contact with contaminated soil	Low likelihood	Low likelihood	Unlikely	Low likelihood

Key to Table 4

Estimated Potential for Linkage with Contaminant Source	Definition
High likelihood	There is a pollution linkage and an event that either appears very likely in the short term and almost inevitable over the long term, or there is evidence at the receptor of harm or pollution.
Likely	There is a pollution linkage and all the elements are present and in the right place, which means that it is probable that an event will occur. Circumstances are such that an event is not inevitable, but possible in the short term and likely over the long term.
Low likelihood	There is a pollution linkage and circumstances are possible under which an event could occur. However, it is by no means certain that even over a longer period such an event would take place, and is less likely in the shorter term.
Unlikely	There is a pollution linkage but circumstances are such that it is improbable that an event would occur even in the very long term.
N/A	Not Applicable

SITE WORK

Three cable percussive boreholes and three trial pits were undertaken on this site at the positions requested by the Engineer, amended to suit on site conditions, and as denoted on the site plan at the rear of this report.

The elevations of the exploratory holes were interpolated using the spot heights detailed on a survey drawing provided by the Engineer. The exploratory hole records are presented in Appendix 3.

Cable Percussive Boreholes

The three boreholes were undertaken by a standard (BHs 1 and 2) and restricted (BH 3) access cable percussive boring rigs between the 27th January and 3rd February 2009. Prior to boring, statutory service records were consulted, starter pits were broken out (BHs 1 and 2) using a hydraulic breaker and then dug to 1.20m depth using hand tools, in order to ensure the absence of buried services. The boreholes were then advanced using weighted claycutter and shell tools, initially working within casing.

Borehole BH 2 was commenced at 150mm diameter but could not be advanced beyond 16.50m depth where the hole was abandoned, short of the intended 20.00m depth, due to continued ingress of groundwater and 'blowing sand' conditions reported by the driller. Consequently a set of 200mm diameter drilling equipment was mobilised to site and BH 1 was completed at 25.00m after using 200mm diameter casing to 8.00m and then 150mm diameter casing to 18.70m depth. Borehole BH 3 was carried out by the restricted access rig once it had been taken through the building and into the rear garden of the main house. This hole was completed at 20.00m below ground level using only 150mm diameter equipment.

Standard penetration tests were undertaken in sand, silt and clay in order to give an indication of the in-situ relative density/shear strength of the soils encountered. The test was made by driving a split spoon sampler 50mm diameter and 35mm bore into the soil at the base of

the borehole by means of an automatic trip hammer weighing 63.50kg falling freely through 760mm. The penetration resistance was determined as the number of blows required to drive the tool the final 300mm of a total penetration of 450mm into the soil ahead of the borehole. The results have been tabulated following each of the borehole records.

Undisturbed samples 100mm diameter were taken in clay, where possible, at regular intervals. The ends of the samples were waxed to maintain them in as representative condition as possible during transit to the laboratory.

Representative small and bulk disturbed samples of soil were taken from the boring tools at regular intervals throughout the depth of the boreholes. Water samples were recovered from the boreholes once sufficient water had collected.

On completion of the three boreholes, 50mm diameter plastic standpipes were installed to 14.00m (BHs 1 and 3) and 15.00m (BH 2) depth, as instructed. Below these depths the remainder of the holes were backfilled with clean arisings. The annulus around the standpipe was backfilled with pea gravel with a bentonite seal placed around the top of the installation within 1.00m of ground level. A gas tap was installed in the top of each standpipe. A protective steel stopcock cover was concreted into the ground flush with the surface over the installation.

The borehole records give the descriptions and depths of the various strata encountered, details of all samples taken and the groundwater conditions observed during boring, on completion and subsequently in the standpipes.

Trial Pits

Three trial pits (TPs 1 to 3) were excavated on 2nd February 2009 by a JCB type machine. The trial pits were taken to depths between 4.00m and 4.70m below ground level. The exposed strata were logged and sampled by a Geotechnical Engineer. An archaeologist was in attendance whilst the pits were excavated.

Small disturbed samples of soil were taken at regular intervals throughout the surface layers of made ground within these pits and placed in polycarbonate pots pending

chemical testing. Representative bulk disturbed samples of soil were taken at regular intervals throughout the depth of each trial pit within natural ground.

The trial pit records give the descriptions and depths of the various strata encountered, details of all samples taken and the groundwater conditions observed during excavation. Following completion, the trial pits were backfilled in compacted layers with the excavated spoil.

Monitoring

Three scheduled return visits were made on 16th, 24th February and 16th March 2009 in order to monitor methane, carbon dioxide and oxygen gas levels in the borehole standpipes. Ambient pressures and flow rates were recorded on each occasion, together with the depth to groundwater. The latter has been added to the borehole records, whilst the gas results are presented in Appendix 4.

Following subsequent instruction, falling head permeability tests were undertaken in the three borehole standpipes on 16th March 2009. Water was poured into the top of the 50mm diameter pipes and the fall in water level recorded for a period of up to 200 minutes. In the BH 1 standpipe the extremely rapid fall in water level to equilibrium level meant that the test was repeated twice before an intermediate water level could be recorded. The results of the three tests are presented in Appendix 4.

In order to record fluctuations in the groundwater level beneath the site, the Engineer issued a subsequent instruction to install dataloggers (Mini-divers) that would periodically record the piezometric head every four hours. The mini-divers were installed at 11.10m, 13.00m and 13.00m depth in BHs 1, 2 and 3, respectively, on 1st April 2009. The data was downloaded during three monthly visits at the end of April, May and June 2009, and the results are presented in Appendix 4.

LABORATORY TESTING

The samples were inspected in the laboratory and assessments of the soil characteristics have been taken into account during preparation of the exploratory hole records. The soil sample descriptions are in accordance with BS5930:1999.

A geotechnical testing schedule was proposed and a schedule, amended and supplemented by the client's geotechnical consultant (Geotechnical Consulting Group - GCG), was undertaken. The chemical testing schedule was devised by Ground Engineering for a broad suite of potential contaminants, based on the known former and proposed residential site end use, and the likely need to dispose of material off-site from the envisaged basement excavation.

The geotechnical test results are presented in Appendix 5 and the results of the chemical tests are presented in Appendix 6.

Geotechnical Testing

The moisture contents and index properties of selected soil samples were determined as a guide to soil classification and behaviour. The liquid limit was determined by the cone penetrometer method.

Selected samples of soil and water were analysed to determine the concentration of soluble sulphates. The pH values were also determined using an electrometric method.

Test specimens were prepared at full diameter from selected undisturbed samples. Immediate undrained triaxial compression tests were made on each sample at full diameter at instructed (GCG) cell pressures. The moisture content and bulk densities of the specimens were also determined.

The particle size distributions of selected samples were obtained by sieve analysis. The particle size distribution passing the 63μm sieve was obtained for selected samples by pipette sedimentation. Results of these tests are given as particle size distribution curves at the end of

this report. Where sieve analysis and sedimentation were carried out on the same sample the results are presented as a single combined distribution curve.

An indication of the 'settlement' characteristics of selected undisturbed samples were obtained from tests in the consolidation apparatus or oedometer. These tests were performed on 75mm diameter samples, about 19mm thick, contained in steel rings following a loading regime specified by the client's geotechnical consultant (GCG). The samples were saturated and the swelling pressure balanced prior to applying a constant load with drainage at both ends. When primary compression was complete the load was reduced, and this was repeated for a further two increments of load. The sample was then unloaded. The rate and total amount of consolidation were continually monitored using a computer controlled E.L.E. Datasystem 7 Unit. The results were plotted and analysed by the computer for each increment of load to obtain the coefficients of compressibility (m_v), and of consolidation (c_v), which govern the amount and rate of movement, respectively.

Direct shear tests were undertaken on two undisturbed samples (BH 1, U2 and BH 3, U2) in order to determine the angle of shearing resistance of the soils at about 5.00m depth. The test apparatus consisted of a 60mm shear box. Three undisturbed specimens, at natural moisture content, were sheared at three different instructed normal pressures (50kPa, 100kPa and 200kPa) in order to determine the angle of shearing resistance.

In order to determine the effective stress parameters for the soils beneath this site five consolidated drained triaxial compression tests with volume change measurement were undertaken on selected undisturbed samples. Following testing, each of these samples was split, photographed and described. The photographs, results and values of effective shear strength (c') and angle of shearing resistance (ϕ') are presented at the rear of Appendix 5.