Phase II Ground Investigation Report

Selwyn Primary School
Cavendish Road
Highams Park
London
E4 9NG

Prepared for:
Mace Group
155 Moorgate
London
EC2M 6XB

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SELWYN PRIMARY SCHOOL, HIGHAMS PARK

NON TECHNICAL SUMMARY

This report presents the findings of a Ground Investigation undertaken to identify the ground conditions as well as provide a geotechnical appraisal of the ground conditions encountered. Pertinent findings and conclusions may be summarised as follows:

- The intrusive investigation comprised the forming of six boreholes to depths of up to 3m which found the ground conditions to comprise of a consistent thickness of made ground overlying cohesive London Clay.
- Made ground materials were found to comprise asphalt, thought to have resulted in elevated concentrations of contaminants of concern which could pose an unacceptable risk to future site users.
- To protect future site users, control measures have been recommended for any proposed areas of soft landscaping or recreational playing fields comprising the provision of 600mm of clean soils or removal of existing made ground materials .
- For the purposes of off-site disposal, made ground should be classified and disposed of as Non-Hazardous material with natural soils being Inert.
- A previous unexploded ordnance survey (UXO) has indicated a moderate risk and a further more detailed study will be required.

ENGINEERING SUMMARY

- The ground conditions are considered suitable for the use of conventional spread foundations, bearing on the London Clay, adopting allowable bearing pressures ranging from 75kN/m^2 to 125kN/m^2.
- It is strongly recommended that a full tree survey is undertaken to establish the impact of these on foundations (both those to be retained and removed as part of the proposed development).
- Given the presence of trees and the plasticity of the soils encountered, suspended ground floor construction is recommended incorporating a sub-floor void suitable for a high volume change potential soil.
- A design sulphate class of DS-3 together with an aggressive chemical environment for concrete classification of AC-2s is recommended.

The above points represent a simplified summary of the findings of this assessment and should not form the basis for key decisions for the proposed development. A thorough review of the details contained within the following report, or discussion with EPS is recommended.

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1 INTRODUCTION

In December 2013, Environmental Protection Strategies Ltd (EPS) was commissioned by Mace Group to undertake a Phase II Ground Investigation at Selwyn Primary School, Cavendish Road, Highams Park, London, E4 9NG (the 'site'); see Figure 1. A current site layout plan and an aerial photograph are included as Figure 2 and 3 respectively. Selected photographs and a photograph location plan are included in Appendix A.

This report presents the findings, conclusions, and recommendations of the investigation.

The development proposals are likely to include the demolition of the existing school teaching block and erection of a new school building on site.

1.1 Background and Previous Report

Following an initial Phase I Desk Study produced by EPS in January 2014, an environmental / geotechnical site investigation was undertaken by EPS on 13th February 2014. The works were carried out in order to characterise the nature and extent of any impacts to soil by contaminants of concern, which may have arisen either through the site's historic / current and surrounding land uses, and to collect information to assist geotechnical design.

The original Phase I Desk Study identified a number of plausible contaminant linkages including the interaction between made ground materials potentially to be found on site and construction workers through the proposed development and site users. It was recommended that a number of boreholes be drilled on site in order to undertake a combined environmental / geotechnical investigation.

Additionally, the desk study identified a moderate unexploded ordnance (UXO) risk and a more detailed assessment was recommended.

It is recommended that the previous report (referenced below) is reviewed before the reader examines the content of this document:

- *UK13.1429 Phase I Geo-Environmental Assessment, Selwyn Primary School (Final)*, Selwyn Primary School, Cavendish Road, Highams Park, London, E4 9NG, January 2014.

1.2 Objectives

The objectives of this investigation were as follows:

a) To investigate contaminant linkages identified through the Phase I Desk Study and determine the potential risks posed by the site and make recommendations for further work that may be required, to ensure safe development in accordance with the Model Procedures for the Management of Land Contamination - Contaminated Land Report 11.
b) To collect information on ground conditions and strength in order to make appropriate recommendations for future geotechnical design.

1.3 Scope of Work

To perform an exploratory assessment of the site in accordance with the principles and requirements of DEFRA Circular 01/2006, BS10175 –'Investigation of Potentially Contaminated Sites' and BS EN 1997 'Geotechnical Design' the following tasks were undertaken:

Intrusive Investigation:

- Site walkover and obtaining photographic records.
- Health and safety briefing / site supervision.
- Drilling of window sampling boreholes to a maximum depth of 3.0m below ground level (bgl) at six locations.
- Recording of ground conditions including in-situ testing as well as inspection of samples for visual and olfactory contamination.

Reporting:

- Data collection and interpretation
- Reporting

The findings of these investigations and their conclusions are presented in the following sections.

1.4 Limitations and Constraints

The purpose of this report is to present the findings of a soil and water sampling investigation conducted at the location(s) specified. When examining the data collected from the investigations made during the assessment, Environmental Protection Strategies Ltd (EPS) makes the following statements.

No investigation method is capable of completely identifying all ground conditions that might be present in the soil or groundwater under a site. Where outlined in our report, we have examined the ground beneath a site by constructing a number of boreholes and/or trial pits to recover soil and/or groundwater samples. The locations of these excavations and sampling points are considered to be representative of the condition of the whole site subsurface. However, ground conditions are naturally variable and it may be possible that the ground conditions encountered may differ to those encountered during the investigation.

No visible evidence of Japanese Knotweed was identified during the site walkover, however this plant can be difficult to identify in the early stages of growth and therefore it is not always possible to identify its presence at certain times of the year. For this reason EPS cannot confirm that Japanese Knotweed rhizomes do not exist and it is recommended that if it is suspected that this species, or other similarly invasive plants are present at the site, a specialist contractor should be commissioned to make a detailed assessment.

If third parties have been contracted / consulted during compilation of this report, the validity of any data they may have supplied, and which are included in the report, have been assessed as far as possible by EPS. However, EPS cannot guarantee the validity of these data.

The report has been prepared for the client(s) listed on the report title page and has been subject to standard internal EPS review procedures. EPS accepts no liability or responsibility for use of, or reliance upon, this report and or the information contained within it by third parties.

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This report and its contents, together with any supporting correspondence or other documentation, remain the property of Environmental Protection Strategies Ltd until paid for in full.

2 SUMMARY OF INTRUSIVE INVESTIGATIONS

The intrusive ground investigation was undertaken on the 13th February 2014 in accordance with EPS standard operating procedures, copies of which will be made available on request. A summary of all site activities is presented in the following sections:

2.1 Site Description

The site is located to the north of Cavendish Road, to the south and east of Selwyn Avenue and to the west of Haldan Road. The school grounds are roughly rectangular in shape, with dimensions of around 160m (north to south) by 60m (east to west) covering and area of approximately 9600m^2. It lies at an approximate elevation of 21m above ordnance datum (AOD) with the surrounding area being generally flat in nature. To the south western corner of the site is a small area of undeveloped land, containing mature vegetation. It is understood that this is also an area of the overall school site, although it is not known whether development is considered for this area.

Metal fencing surrounds the school, with the main buildings occupying north eastern, north western and central southern areas, with hard play areas and associated play equipment located between them. The existing structures are generally single storey in height with pitched roofs. Helwys Court along with the area of undeveloped land lies beyond the western boundary of the school, with residential properties and their associated gardens lying to the south, north and east.

During the initial walkover a number of semi-mature and mature tree species such as Birch were highlighted across the site particularly centred on hard play areas.

2.2 Borehole Locations

Borehole locations were selected through consideration of the proposed development layout, the location of below ground utilities as well as operational and health & safety considerations.

A total of six window-sampling boreholes (WS1 – WS6) were formed to assess the nature and quality of underlying soils to depths of up to 3.0m below ground level (bgl) using a track-mounted window sampling rig.

The overall objective in terms of borehole location was to provide an appropriate lateral and vertical coverage of the site with regard to the proposed development in order to provide information relating to the ground conditions and strength.

The boreholes were drilled in accordance with standard EPS drilling methodologies, and subcontractors were supervised at all times by an EPS engineer. After completion, each borehole was backfilled to ground level using suitable material and reinstated at the surface with turf and topsoil or concrete depending upon location. A detailed site layout plan showing the locations of the boreholes drilled during the investigation is presented as Figure 4.

2.3 Soil Sampling

Each borehole was logged for ground conditions encountered and inspected for any physical evidence of contamination, such as soil staining, odour and the presence of separate phase liquids on a precautionary basis.

At least three soil samples were obtained from every window sample location. Both environmental and geotechnical samples were obtained for laboratory analysis.

Where clay soils were encountered, Hand Shear Vane tests (indicated as IVN on the window sampler records) were carried out within the sampling tubes. The peak undrained shear strength for each test is presented in kN/m^2 on the window sampler records.

A laboratory testing schedule is included as Table 1.

2.4 Laboratory Testing

2.4.1 Chemical Analysis

Samples obtained for analysis of identified contaminants of concern were submitted to Chemtest Ltd of Newmarket, who hold appropriate UKAS/ MCERT accreditation for the required testing. Samples were transported in laboratory supplied containers and delivered to the laboratory by approved courier.

2.4.2 Geotechnical Testing

Geotechnical testing was undertaken by Soil Property Testing, Huntingdon, a UKAS accredited laboratory.

Copies of chain of custody documentation are held by EPS and will be made available on request.

3 FINDINGS OF THE INVESTIGATION

This section of the report provides a summary of the findings of the various aspects of the ground investigation.

3.1 Ground Conditions

A total of six boreholes were formed at the site and the ground conditions encountered, from ground level, were found to comprise:-

- Made Ground
- Alluvium
- London Clay Formation

A summary of the strata encountered across the site is provided below.

Geological Strata	Maximum Depth to Base of Strata(m bgl)	Strata Thickness (m)
Made Ground	0.45	0.25 – 0.45
Alluvium	2.35	1.90
London Clay Formation	>3.00	>2.55 – 2.75

3.1.1 Made Ground

Made ground generally comprising a thin layer of concrete overlying dark brownish grey silty sandy gravel/ gravelly sand with common fine to coarse brick fragments, crushed concrete and broken up asphalt was recorded in each location to a maximum depth of 0.45m below ground level (bgl).

3.1.2 Alluvium

Materials interpreted as Alluvium were only recorded in WS1, formed in the most south easterly corner of the site. These comprised soft becoming firm to stiff sandy, silty Clays.

3.1.3 London Clay Formation

Materials interpreted as London Clay Formation comprising generally firm orangey brown and grey slightly sandy silty clay was recorded in each location. This stratum was identified to underlie made ground materials and continued to beyond the formation depth of the borehole in each location.

3.1.4 Groundwater

Groundwater was not identified within borehole locations WS2 – WS6; to a maximum depth of 3.0m. However, slow groundwater seepage was encountered within a clayey sand layer recorded in WS1 (described in section 3.1.2 above) and groundwater was found at a rest level of approximately 2.0mbgl upon completion of drilling activities.

3.1.5 Borehole Records

Site specific borehole records are included as Appendix B and give descriptions and depths of strata encountered as well as presenting the results of in-situ testing.

3.2 Physical Evidence of Contamination

A notable thickness of made ground was identified in each of the borehole locations generally 0.25-0.45m thick. This material was found to comprise mostly inert building materials such as fine to coarse brick and concrete fragments; however significant evidence of broken up asphalt was also noted in each location. No further visual or olfactory evidence of contaminated materials were identified in field analysis including the presence of waste or putrefiable material.

3.3 Laboratory Analysis

3.3.1 Chemical Analysis-Soils

A laboratory analysis testing schedule is presented as Table 1 and environmental sample results obtained from the laboratory are included as AppendixC.

The key results of laboratory testing on environmental soil samples are summarised as follows:

Contaminant	No. of Samples	No of Detections	Range of Detections (mg/kg)		Highest Location & Depth (m bgl)
			Min	Max	
Arsenic	6	6	13	62	WS6 / 0.1-0.3
Cadmium	6	6	0.13	1.60	WS1 / 0.1-0.3
Chromium	6	6	21	200	WS6 / 0.1-0.3
Copper	6	6	24	110	WS6 / 0.1-0.3
Mercury	6	5	0.10	0.34	WS6/ 0.1-0.3
Nickel	6	6	13	58	WS2/ 0.5-1.0
Lead	6	6	23	390	WS1 / 0.1-0.3
Selenium	6	4	0.45	1.2	WS6 / 0.1-0.3
Zinc	6	6	52	300	WS1 / 0.1-0.3
Benzo[a]pyrene (BaP)	6	6	2.1	120	WS2 / 0.1-0.3
PAH (Total of 16)	6	6	54	1,900	WS2 / 0.1-0.3
TPH	2	1	4,800	4,800	WS2 / 0.1-0.3
SOM (%)	4	4	2.2	22	WS6 / 0.1-0.3
Asbestos Screening	4	-	-	-	-
pH	11	11	7.4	10.5	WS1 / 0.1-0.3
Water Soluble Sulphate (g/l)	9	9	0.03	2.02	WS5 / 2.0-2.2

Notes: - Contaminant not found above laboratory detection limits
PAH Polycyclic Aromatic Hydrocarbons
TPH Total Petroleum Hydrocarbons
SOM Soil Organic Matter

- Detectable concentrations of Heavy Metals were identified in the majority of locations across the site with the most significant impacts consistently identified within the shallow samples obtained from WS1 and WS6 (both formed within the south eastern area of the site).
- Detectable concentrations of selected PAH compounds, particularly Benzo[a]pyrene (BaP), were encountered in shallow soils across the entire site with the majority of greatest impacts identified within the sample obtained from WS2 (0.1-0.3m).
- Total PAH (sum of 16 compounds) concentrations ranged from 54 (WS2 / 0.5-1.0m) to 1,900mg/kg (WS2 / 0.1-0.3m).
- Total TPH concentrations were found to vary significantly between the two samples submitted from WS2. TPH concentration within made ground materials (WS2 / 0.1-0.3m) was found at 4,800mg/kg with natural materials (WS2 / 0.5-1.0m) recording no detectable impacts.
- No trace of Asbestos Containing Material (ACM) was identified within either of the made ground samples submitted for laboratory analysis with a minimum detection limit of 0.001%.
- The average organic matter content of the shallow samples submitted was calculated as approximately 9%.

3.3.2 Waste Analysis

Waste Acceptance Criteria (WAC) testing was undertaken on representative samples of both made ground (WS2 0.1-0.3m) and natural clays (WS2 0.5-1.0m) encountered across the site which included total concentrations of heavy metals, hydrocarbons as well as Inert WAC analysis.

On the basis of these samples, made ground materials across the site should be classified as stable, non-reactive **Hazardous Waste** for disposal in a **Non-Hazardous landfill**. This material cannot be treated as a Non-Hazardous waste due to the concentration of TPH analysed (approximately 5,000mg/kg) which is well above Non-Hazardous limit of 1,000mg/kg and is anticipated to be due to the presence of asphalt.

However, natural clays, indicative of the material recovered and analysed from WS2 (0.5-1.0m) should be classified as **Non-Hazardous, Inert Waste** for disposal in an **Inert Waste landfill**.

No trace of ACM was identified within either of the WAC samples submitted for laboratory analysis with a minimum detection limit of 0.001%.

WAC testing results are included as Appendix D.

3.3.3 Geotechnical Testing

The results of geotechnical laboratory testing are summarised in the table below.

Strata	Range of Parameters					
	Moisture Content (%)		Plasticity Index (%)		Undrained Shear Strength (kPa)	
	Min	Max	Min	Max	Min	Max
Alluvium	21	-	27	-	13	111
London Clay	21	35	34	48	40	143

(*) = Indicates plasticity modified for granular content of sample.

The natural moisture content was established for five samples of cohesive soil in accordance with BS1377 Part 1:7.3 and BS1377: Part 2:3.2.

Atterberg limit tests were undertaken on five samples of cohesive soils in accordance with BS1377: Part 1:7.4 and BS1377: Part 2:3.2&4.2.

A California Bearing Ratio (CBR) test was scheduled for two samples of natural material in accordance with BS 1377: Part1, 4:1990:7.2.

Sulphate contents and pH values determinations were also carried out by the analytical laboratory, the results of which are summarised in section 6.6 below.

A laboratory analysis testing schedule is presented as Table 1 and all geotechnical sample results obtained from the laboratory are included as Appendix E.

4 TIER 1 QUALITATIVE RISK ASSESSMENT

4.1 Tier 1 Screening – Generic Assessment Criteria (GAC)

4.1.1 Tier 1 Screening - Soils

In order to screen laboratory data for concentrations of contaminant in soil with potential to cause harm to human health in a school setting (seen as a conservative representation of the site based on the likely child/young adult receptor), UK Soil Guideline Values (SGVs) and an In-House Generic Assessment Criteria (GACs) for contaminants in soil have been used. The technical framework used to derive the assessment criteria and the documents in which they are published are summarised as follows:

- EA Science Reports (SC050021/SR2, SC050021/SR3, and SC050021/SR7)
- EA Soil Guideline Value Science Reports
- Generic Assessment Criteria for Human Health Risk Assessment – LQM and CIEH 2nd edition (2009).

For concentrations of Lead in soil, there are currently no published human health screening criteria available and EPS has used the previously withdrawn SGV for lead as an appropriate guide for professional judgement with respect to reasonable 'minimal risk' levels in the context of this site.

In addition to screening the concentrations of contaminant in soil for risks to human health, EPS has also screened the concentrations for potential to cause harm to water resources. The criteria used for this process were derived by EPS using the following technical guidance:

- Environment Agency Remedial Targets Methodology: Hydrogeological Risk Assessment for Land Contamination.

Tier 1 Risk Screening criteria for Low Groundwater Resource Potential (LGwRP) have been adopted for this site due to the underlying Unproductive Aquifer.

Tier 1 guideline values for a 3% Soil Organic Matter (SOM) content have been adopted as analysed values ranged between 2.2 and 22% with a calculated average of approximately 9%.

A summary of the screening criteria, including the derivation of In-House Generic Assessment Criteria for schools, and the methodology used to derive them is included in Appendix F.

4.2 Assessment of Soil Results

The results of the screening process for on-site human receptors show that Generic Assessment Criteria, representative of minimal risk values for a school setting were exceeded for a number of significant PAH compounds and are summarised in the table below:

Contaminant	Tier 1 Screening Criteria (mg/kg) (SOM 3%)	No. of Exceedances	Highest Exceedance (mg/kg) & Sampling Location
Benzo[a]anthracene	24.7	4	140 / WS2 0.1-0.3m
Chrysene	35.4	4	140 / WS2 0.1-0.3m
Benzo[a]pyrene (BaP)	3.77	5	120 / WS2 0.1-0.3m
Dibenzo[a,h]anthracene	3.47	4	22 / WS2 0.1-0.3m

Furthermore, screening criteria representative of minimal risk to the underlying groundwater were exceeded at five locations for a number of contaminants of concern including the concentrations of BaP which has a Tier 1 screening value of 10mg/kg.

4.3 Environmental Conclusions

The Phase II investigation identified ground conditions to comprise a fairly consistent thickness of made ground overlying Alluvium and London Clay generally comprising firm orangey brown and grey slightly sandy silty clay. Although the thickness of made ground materials was found to be relatively shallow (between 0.25 – 0.45m across the site) the material was identified to contain a significant proportion of asphalt which is likely to have resulted in the elevated concentrations of contaminants of concern observed; namely TPH and PAH compounds.

Tier 1 screening criteria, representative of minimal risk at a school setting, were exceeded for a number of PAH compounds within each of the samples submitted for laboratory analysis. The preliminary risk driver for the site is considered as BaP due to its frequency and level of exceedance relative to the Tier 1 screening criteria (3.77mg/kg) with concentrations of up to 140mg/kg recorded. Due to the level and consistency of impacts, statistical analysis has not been considered appropriate to calculate a U95 value for BaP. As a result, further action or control measures have been recommended within section 6 below, to ensure that risks associated with impacted made ground materials do not affect future site users throughout development works and post completion.

Screening criteria representative of minimal risk to groundwater resources were exceeded for a number of PAH compounds (including BaP) at five locations. However, where made ground materials were identified to be most severely impacted (WS2 0.1-0.3m), a sample of directly underlying natural material recovered from the same location (WS2 0.5-1.0m) found significantly reduced concentrations of contaminants of concern, none of which pose a significant risk to groundwater. Given the permeability of the underlying geology and the lack of environmental mobility of PAH compounds, substantiated within laboratory testing of underlying natural soils, no unacceptable risk to groundwater is recognised.

Results of waste analysis indicate that a sample representative of shallow made ground materials across the site should be classified as stable, non-reactive **Hazardous Waste** for disposal in a **Non-Hazardous landfill**. A sample representative of shallow natural materials across the site should be classified as **Non-Hazardous, Inert** waste for disposal into an **Inert landfill**.

In accordance with the Model Procedures for Management of Land Contamination (Contaminated Land Report 11), risks have been identified by this work which will require further assessment. A summary of the approach outlined in CLR11, marking the work completed under the risk assessment phase, is presented as a flow diagram in Figure 5 of this report.

4.4 Environmental Recommendations

Given that ground impacts are considered to potentially pose an unacceptable or ongoing risk to future site users, recommendations are made below with respect to necessary control measures during the forthcoming site redevelopment works to ensure that any potential risks are evaluated and appropriately controlled.

Elevated concentrations of PAHs were detected in the near-surface soils above minimum risk levels which have the potential to pose a risk to future site users. It is understood that the proposed development plan is under constant review but it is likely that some small scale landscaping areas may be included. Given the nature of the site and the nature of the contaminants identified, the following control measures could be applied to adequately control potential risks to future site users posed by near-surface soils in any proposed areas of soft landscaping.

a) A clean soil cover system
b) An impermeable capping system

If Option A were to be selected, clean soil would replace shallow made ground materials order to limit the level of interaction between future site users and underlying material which has been found to contain asphalt. Guidance presented within the BRE publication *Cover Systems for Land* Regeneration*: Thickness Design of Cover Systems for Contaminated Land (BRE, Mar 2004)* would indicate that a simple cover system involving **600mm** clean soil cover, or removal of the made ground, is likely to be appropriate given that landscaped areas are likely to be minimal. If installed, it is recommended that the thickness and quality of imported materials is validated to ensure suitability for use within a school setting.

It should be noted that some of the contaminants of concern are known to be phytotoxic and so it may be prudent to consider the use of deep planters for any new trees / deep-rooted shrubs etc.

Alternatively, the use of permanent hardstanding (Option B above) such as asphalt or paving could also be used to effectively cap the area and prevent physical interaction. These features would need to be designed to remain as permanent hardstanding (i.e. cemented in) and should not be able to be converted easily.

Additional precautionary measures to reduce the risk of exposure to contamination are detailed below:-

a) All construction workers operating at the site should be advised of the potential for contact with PAH compounds within shallow made ground materials. Appropriate health and safety precautions should also be adopted during any excavation works to avoid exposure to soils.

Reference should be made to the following HSE document *Protection of Workers and the General Public during Development of Contaminated Land*.

b) Should any palpable evidence of unexpected contamination be encountered during the redevelopment work, it should be reported to EPS so that an inspection can be made and appropriate sampling and assessment work carried out. A method statement for encountering any unexpected contamination is included as Appendix G of this report.

c) In order to reduce potential risks from linkages associated with ingress of contaminants to underground water supply pipework, aluminium barrier pipework meeting Water Industry Standard 4-32-19 and associated fittings can be used subject to agreement with the local water company. If other pipe work is preferable, more detailed testing may be required in accordance with UK Water Industry Research Report 10/WM/03/21 - "Guidance For The Selection Of Water Supply Pipes To Be Used In Brownfield Sites" (2010).

5 GEOTECHNICAL APPRAISAL

The ground conditions have been found to comprise made ground overlying London Clay.

5.1 Structural Foundations

The ground conditions are considered suitable for the use of conventional spread foundations, either strip footings or pad foundations bearing on the London Clay, subject to the required structural loading and depending upon the influence of trees, as outlined below.

Allowable bearing capacities for the London Clay are provided in the table below. The allowable bearing capacity is the permissible increase in vertical stress at the level of the underside of the foundation, above existing overburden pressure, which may be calculated on the basis of a soil density of 19kN/m³.

Depth (m bgl)	Allowable Bearing Capacity (kN/m^2)
1.0	75
1.5	105
2.0	125

It should be noted that these bearing capacities relate to natural London Clay and not shallow made ground materials which have been identified up to 0.45mbgl at each window sampler location or soft Alluvium recorded in WS1.

At the above bearing pressure total settlements are unlikely to exceed approximately 20mm. Settlements in cohesive (clay) soils will comprise both immediate and long term (consolidation) settlement and will take place over a long period of time.

A minimum foundation depth of 1.0m, below existing or proposed ground, level is considered suitable for the site, subject to the following provisos:-

a) The London Clay is a cohesive soil and will be subject to volume change (subsidence and/or heave) due to the presence of trees. Foundation design will therefore need to take in to account the presence of trees, both those to remain and those to be planted as well as to be removed from site. The London Clay should be considered as having a high volume change potential in accordance with NHBC Standards Chapter 4.2 'Building Near Trees'.

   A number of semi-mature and mature, low water demand trees have been noted in a number of areas across the site, including species such as Birch. As a guide, foundations formed roughly 3m from a mature Birch would need to be in excess of 1.50m in depth. It is strongly recommended that a full tree survey is undertaken to establish the impact of these on foundations.

b) Foundations should also fully penetrate any made ground and disturbed ground arising from the removal of existing foundations and should extend a minimum of 150mm in to undisturbed natural strata.

c) Foundation should also penetrate any soft areas, such as encountered in WS1, and should be extended to bear in soils with an undrained shear strength of at least 45kN/m^2.

Anti-heave precautions will be required when foundation depths exceed 1.5m due to the presence of trees to control the effects of potential future ground movements.

5.2 Ground Floor Construction

Given the presence of trees and the cohesive encountered, suspended ground floor construction is recommended incorporating a sub-floor void suitable for a high volume change potential soil.

5.3 External Works

5.3.1 Pavement Design

The subgrade across the site is likely to comprise either Made Ground or London Clay.

The site is considered suitable for the use of flexible, composite or rigid pavement construction, subject to the approval of the Local Authority for adoptable areas.

Laboratory CBR testing has been undertaken on a mixture of natural clays recovered from shallow depths. The testing gave results ranging from 2.9% to 3.9%.

Given the nature of the cohesive shallow soils encountered a design CBR value of 3% is considered appropriate providing proof rolling is undertaken using a heavy roller once the formation level for the new pavement has been achieved. Furthermore any soft areas revealed should be excavated and a greater depth of sub-base provided.

Exposed subgrades will likely deteriorate rapidly on exposure to wet weather and should be shaped to shed water. Sub-base should be placed as soon as possible to minimise the exposure of the subgrade to adverse weather conditions.

5.4 Groundworks

Shallow excavations formed within the London Clay may be stable for short periods but should not be relied upon over longer periods. The stability of made ground or disturbed ground arising from foundation removal should not be relied upon in unsupported excavations.

Heavy plant and stockpiles of materials should not be permitted close to the edges of unsupported excavations.

Further reference may be made to CIRIA Report No. 97 'Trenching Practice' 1992.

On the basis of the findings of the ground investigation, groundwater is unlikely to be encountered within shallow excavations for foundations or drainage.

5.5 Drainage

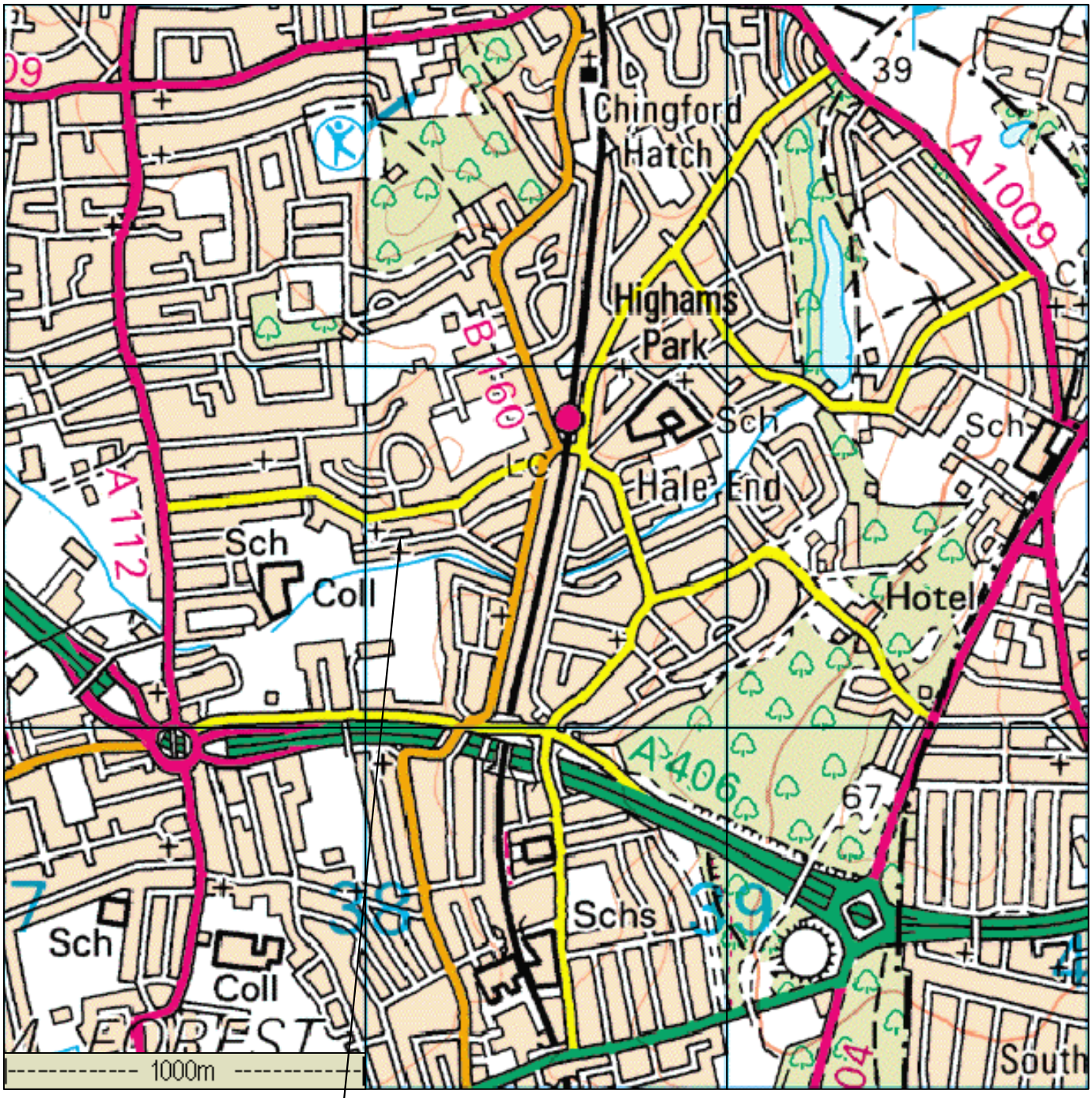
Due to the anticipated low permeability of the underlying cohesive soils, use of infiltration type drainage systems such as soakaways are not likely to be suitable and alternative disposal will need to be considered.

5.6 Concrete Grade

Sulphate contents and pH values determinations were carried out by both the analytical and chemical laboratories. Sulphate contents were recorded between 0.03g/l SO_4 to 2.02g/l SO_4 and the pH values ranged from 7.4 to 10.5. Furthermore, total Sulphur and Sulphate analysis was undertaken within three samples of natural materials recovered and found total Sulphur to range from 0.012 – 0.039% with total Sulphate identified between 0.07 - 0.14%.

In accordance with Part 1 of the BRE Special Digest 1 'Concrete in Aggressive Ground' 2005, a design sulphate class of DS-3 is considered suitable for the site, with an aggressive chemical environment for concrete (ACEC) of AC-2s.

FIGURES



Approximate Site Location

Title:	**Site Location Plan**
Project:	Selwyn Primary School, Cavendish Road, E4 9NG
Client:	Mace Group
Fig No:	1

Scale:	As Shown		
Drawn By:	BV	Approved By:	SB
Job No:	UK13.1429		
Dwg No:	Mace/Selwyn/0314/01		
Date:	March 2014		

Approximate Site Boundary

Title: Current Site Layout Plan

Project: Selwyn Primary School, Cavendish Road, E4 9NG

Client: Mace Group

Fig No: 2

Scale:	Not to Scale
Drawn By:	BV
Approved By:	SB
Job No:	UK13.1429
Dwg No:	Mace/Selwyn/0314/02
Date:	March 2014

N

Approximate Site Boundary

eps

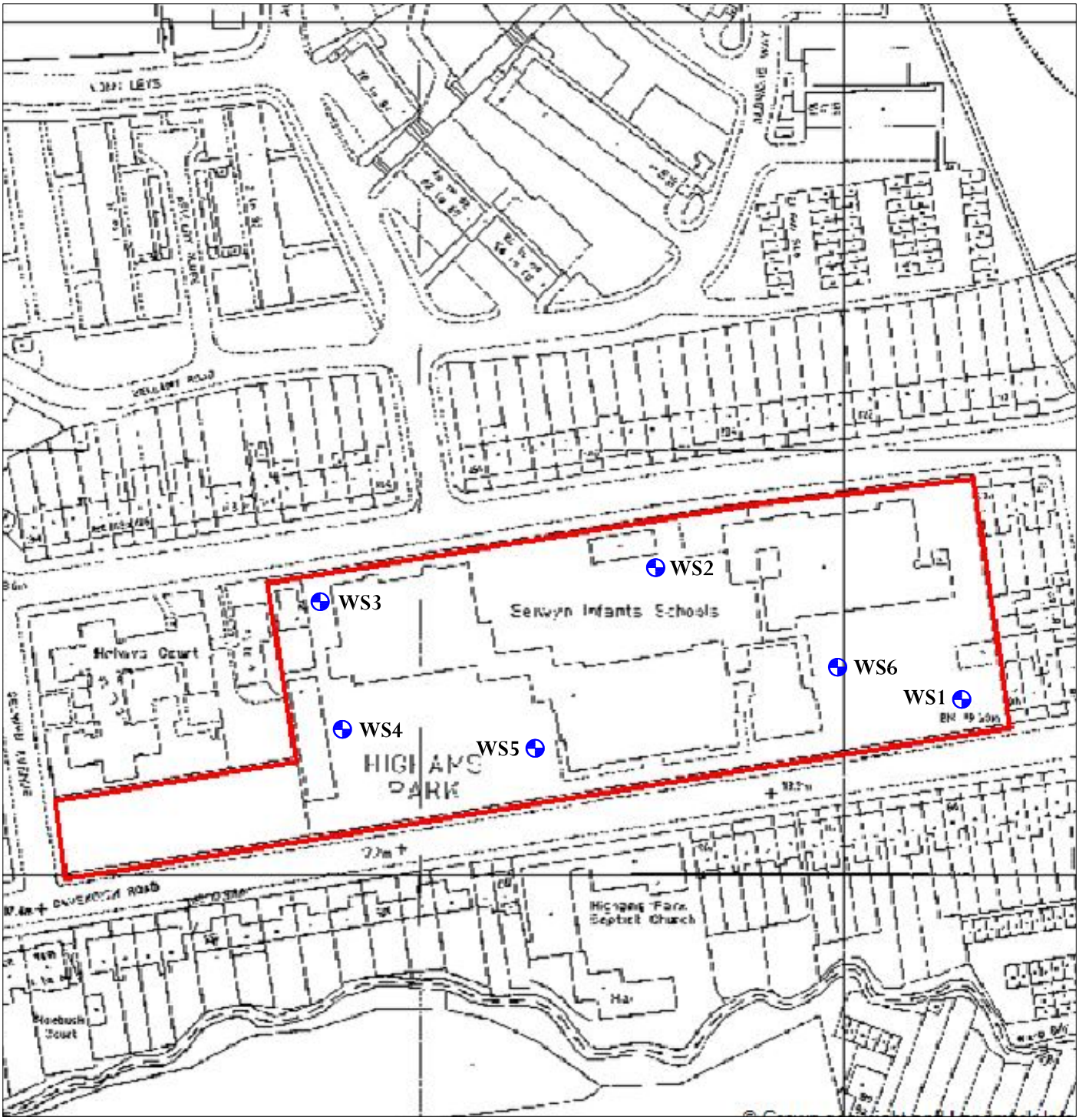
Title: Aerial Photograph

Project: Selwyn Primary School, Cavendish Road, E4 9NG

Client: Mace Group

Fig No: 3

Scale:	Not to Scale		
Drawn By:	BV	Approved By:	SB
Job No:	UK13.1429		
Dwg No:	Mace/Selwyn/0314/03		
Date:	March 2014		



Key:

Approximate Site Boundary

Approximate Borehole Locations

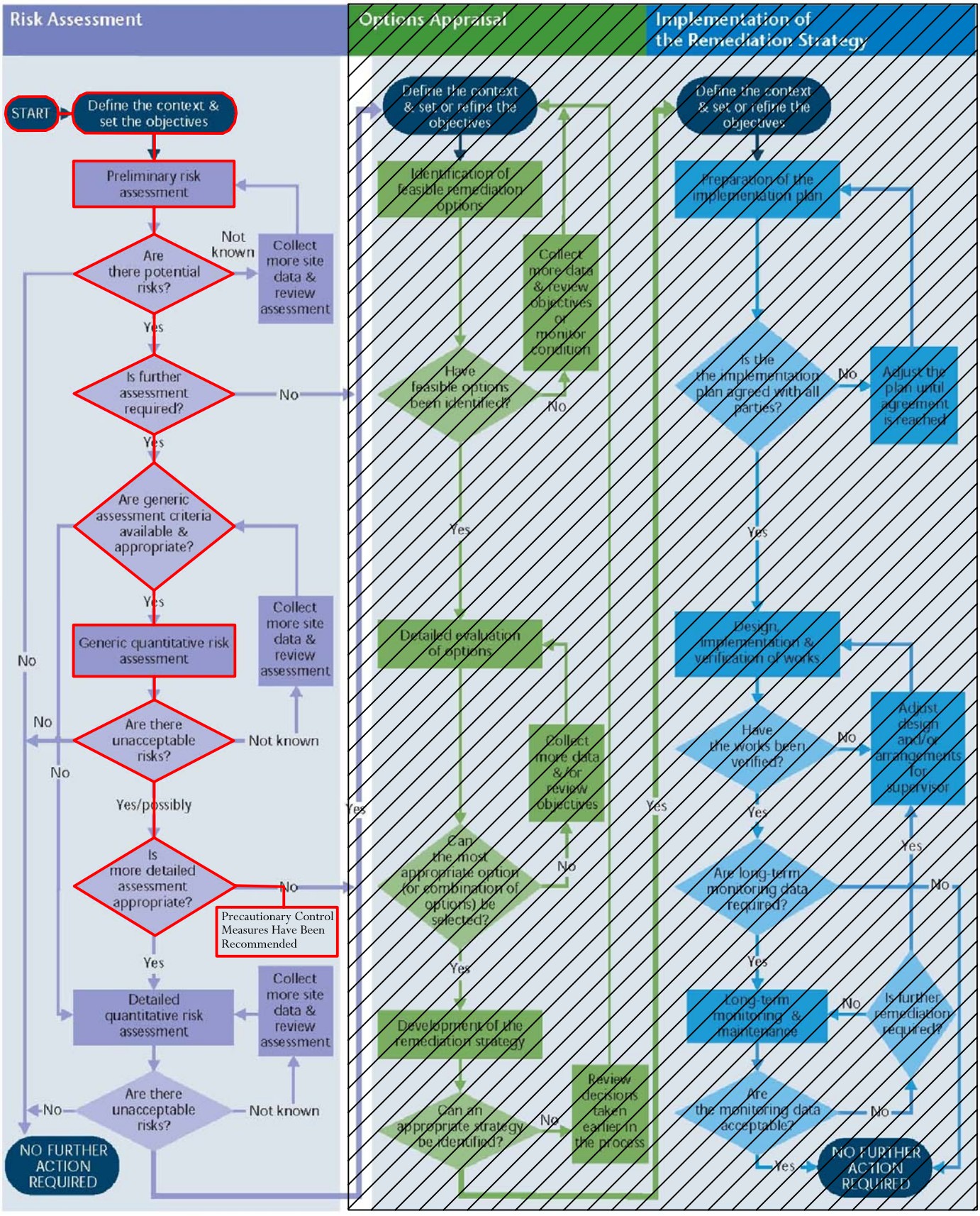
Title: Borehole Location Plan

Project: Selwyn Primary School, Cavendish Road, E4 9NG

Client: Mace Group

Fig No: 4

Scale:	Not to Scale
Drawn By:	BV
Approved By:	SB
Job No:	UK13.1429
Dwg No:	Mace/Selwyn/0314/04
Date:	March 2014



Assessment Pathway for Site

Title:	**Site Context - CLR11**		
Project:	Selwyn Primary School, Cavendish Road, E4 9NG	Scale:	n/a
		Drawn By: BV	Approved By: SB
Client:	Mace Group	Job No:	UK13.1429
Fig No:	**5**	Dwg No:	Mace/Selwyn/0314/05
		Date:	March 2014

TABLES

Table 1 – Laboratory Testing Schedule

Sample ID	Sample Depth (mbgl)	Traditionals	WAC	EPS Mini Suite	Liquid/ Plastic Limits	Moisture Content	Pyritic Ground Suite	CBR
WS1 (soil)	0.1-0.3	1	-	1	-	-	-	-
WS1 (soil)	0.8-1.0	1	-	-	1	1	1	-
WS2 (soil)	0.1-0.3	-	1	-	-	-	-	-
WS2 (soil)	0.5-1.0	-	1	-	-	-	1	-
WS4 (soil)	0.1-0.3	1	-	1	-	-	-	-
WS4 (soil)	0.5-1.5	-	-	-	1	1	-	1
WS5 (soil)	0.1-0.3	1	-	1	-	-	-	-
WS5 (soil)	1.0-1.2	1	-	-	1	1	-	-
WS5 (soil)	2.0-2.2	1	-	-	1	1	1	-
WS6 (soil)	0.1-0.3	1	-	1	-	-	-	-
WS6 (soil)	0.5-1.5	-	-	-	1	1	-	1

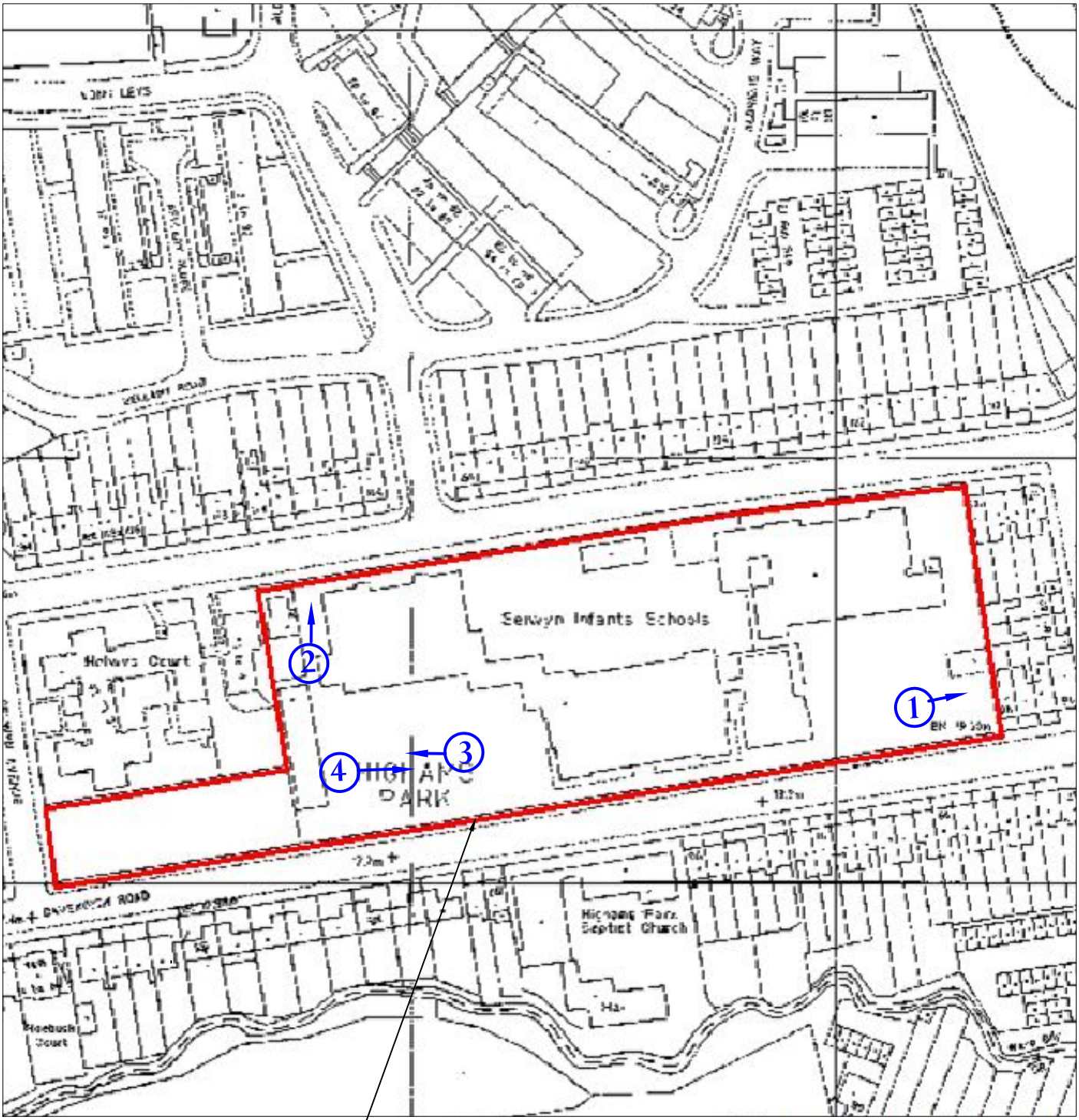
Notes:

mbgl	meters below ground level
1	Sample Taken
-	Sample Not Analysed
Traditionals	Include soil organic matter and/ or pH and water soluble sulphate analysis
WAC	Waste Acceptance Criteria
EPS Mini Suite	Organic Matter, Cyanide, Metals, Polycyclic Aromatic Hydrocarbons and Phenols
Pyritic Ground Suite	Analysis including pH, Total Sulphur, Total Sulphate and Water Soluble Sulphate
CBR	California Bearing Ratio

APPENDICES

APPENDIX A

Selected Site Photographs



Title:	**Photo Location Plan**
Project:	Selwyn Primary School, Cavendish Road, E4 9NG
Client:	Mace Group
Appendix: A	

Scale:	Not to Scale	
Drawn By:	BV	Approved By: SB
Job No:	UK13.1429	
Dwg No:	Mace/Selwyn/0314/A	
Date:	March 2014	

Photo 1: View looking at the materials recovered from WS1.	Photo 2: View looking approximately north at the location of WS3.
	
Photo 3: View looking approximately west at the location of WS4.	Photo 4: View looking approximately east at the location of WS5.
	

APPENDIX B

Site Specific Borehole Logs

Environmental Protection Strategies
Tel: 01954 710666
email: info@epstrategies.co.uk
www.epstrategies.co.uk

Borehole No **WS1**
Sheet 1 of 1

Project Name	Project No.	Co-ords: -	Hole Type
Selwyn Primary School	UK13.1429		WLS
Location: Selwyn Primary School, Cavendish Road, Highams Park, London, E4 9NG		Level: -	Scale 1:25
Client: Mace Group		Dates: 13/02/2014	Logged By BV

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
					0.05			CONCRETE.
		0.10-0.30	D					MADE GROUND: Dark brownish grey silty sandy gravel with common fine to coarse brick fragments and crushed concrete as well as borken up asphalt noted. Brick cobbles noted
					0.45			Slightly soft to firm light orangey brown slightly sandy silty CLAY. Material slightly soft-very silty
		0.80	IVN 1	13				
		0.80-1.00	D					
		1.30	IVN 2	89				
		1.20-1.40	D					
		1.50	IVN 3	111				
		1.80	IVN 4	85				
	▽				2.00			Light orangey brown fine to coarse SAND.
		2.00-2.20	D					
					2.35			Firm light orangey brown and grey slightly sandy silty CLAY.
		2.50	IVN 5	117				
		2.80	IVN 6	127				
					3.00			End of Borehole at 3.00 m
			Type	Results				

1 2 3 4

Remarks:

AGS

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Borehole No
WS2
Sheet 1 of 1

Project Name	Project No.	Co-ords: -	Hole Type
Selwyn Primary School	UK13.1429		WLS
Location: Selwyn Primary School, Cavendish Road, Highams Park, London, E4 9NG		Level: -	Scale 1:25
Client: Mace Group		Dates: 13/02/2014	Logged By BV

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
					0.05			CONCRETE.
		0.10-0.30	D					MADE GROUND: Dark brownish grey silty sandy gravel with common fine to coarse brick fragments and crushed concrete noted. Broken up asphalt noted
					0.30			Firm light orangey brown slightly sandy silty CLAY.
		0.50	IVN 1	76				
		0.50-1.00	D					
		0.80	IVN 2	42				
		1.30	IVN 3	43				
		1.50	IVN 4	73				
		1.80	IVN 5	114				
		2.30	IVN 6	99				
		2.50	IVN 7	115				
		2.80	IVN 8	107				
					3.00			End of Borehole at 3.00 m
			Type	Results				

1
2
3
4

Remarks: Groundwater not encountered.

AGS

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Borehole No
WS3
Sheet 1 of 1

Project Name	Project No.	Co-ords: -	Hole Type
Selwyn Primary School	UK13.1429		WLS
Location: Selwyn Primary School, Cavendish Road, Highams Park, London, E4 9NG		Level: -	Scale 1:25
Client: Mace Group		Dates: 13/02/2014	Logged By BV

Well	Water Strikes	Samples & In Situ Testing			Depth (m)	Level (m AOD)	Legend	Stratum Description
		Depth (m)	Type	Results				
					0.05			CONCRETE.
		0.10-0.30	D		0.25			MADE GROUND: Dark brownish grey silty gravelly sand with common fine to coarse brick fragments and broken up asphalt noted. Recently active fine rootlets noted
		0.50	IVN 1	48				Firm light orangey brown slightly sandy silty CLAY.
		0.80	IVN 2	49				
		1.00-1.20	D					
		1.30	IVN 3	59				
		1.50	IVN 4	65				
		1.80	IVN 5	73				
		2.00-2.20	D					
		2.30	IVN 6	85				
		2.50	IVN 7	84				
		2.80	IVN 8	89				
					3.00			End of Borehole at 3.00 m
			Type	Results				

1
2
3
4

Remarks: Groundwater not encountered.

AGS

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Borehole No
WS4
Sheet 1 of 1

Project Name	Project No.	Co-ords: -	Hole Type
Selwyn Primary School	UK13.1429		WLS
Location: Selwyn Primary School, Cavendish Road, Highams Park, London, E4 9NG		Level: -	Scale 1:25
Client: Mace Group		Dates: 13/02/2014	Logged By BV

Well	Water Strikes	Samples & In Situ Testing			Depth (m)	Level (m AOD)	Legend	Stratum Description
		Depth (m)	Type	Results				
					0.05			CONCRETE.
								MADE GROUND: Dark brownish grey silty sandy gravel with common fine to coarse brick fragments and broken up asphalt noted.
					0.45			Firm light orangey brown and grey slightly sandy silty CLAY.
		0.50-1.00	B					
		1.00-1.20	D					
		1.80-2.00	D					
		2.30	IVN 1	143				
		2.50	IVN 2	101				
		2.80	IVN 3	112				
					3.00			End of Borehole at 3.00 m
			Type	Results				

1
2
3
4

Remarks: Groundwater not encountered.

AGS

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Borehole No
WS5
Sheet 1 of 1

Project Name	Project No.	Co-ords: -	Hole Type
Selwyn Primary School	UK13.1429		WLS
Location: Selwyn Primary School, Cavendish Road, Highams Park, London, E4 9NG		Level: -	Scale 1:25
Client: Mace Group		Dates: 13/02/2014	Logged By BV

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
					0.05			CONCRETE.
					0.30			MADE GROUND: Dark brownish grey silty sandy gravel with common fine to coarse brick fragments and broken up asphalt noted.
		0.50	IVN 1	46				Firm light orangey brown and grey slightly sandy silty CLAY. Slight grey staining anticipated to be from overlying made ground materials.
		0.30-1.00	D					
		0.80	IVN 2	40				
		1.00-1.20	D					
		1.30	IVN 3	62				
		1.50	IVN 4	61				
		1.80	IVN 5	82				
		2.00-2.20	D					
		2.30	IVN 6	102				
		2.50	IVN 7	101				
		2.80	IVN 8	105				
					3.00			End of Borehole at 3.00 m
			Type	Results				

1
2
3
4

Remarks: Groundwater not encountered.

AGS

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email: info@epstrategies.co.uk
www.epstrategies.co.uk

Borehole No
WS6
Sheet 1 of 1

Project Name	Project No.	Co-ords: -	Hole Type
Selwyn Primary School	UK13.1429		WLS
Location: Selwyn Primary School, Cavendish Road, Highams Park, London, E4 9NG		Level: -	Scale 1:25
Client: Mace Group		Dates: 13/02/2014	Logged By BV

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Legend	Stratum Description
					0.05			CONCRETE.
								MADE GROUND: Dark brownish grey silty sandy gravel with common fine to coarse brick fragments, crushed concrete and broken up asphalt noted.
					0.45			Firm light orangey brown and grey slightly sandy silty CLAY.
		0.50-1.00	B					
		1.00-1.20	D					
		1.30	IVN 1	86				
		1.50	IVN 2	95				
		1.80	IVN 3	112				
		2.00-2.20	D					
		2.30	IVN 4	114				
		2.50	IVN 5	131				Slightly sandy lens noted
		2.80	IVN 6	135				
		2.80-3.00	D					
					3.00			End of Borehole at 3.00 m
			Type	Results				

1
2
3
4

Remarks: Groundwater not encountered.

AGS