

HPHA Ltd

PHASE 2 SITE INVESTIGATION, HYDE PARK,
HAYES, HPH4-6

October 2012



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- Final
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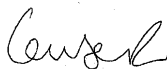
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Executive Summary

Aspect	Description		
Background	In May 2012, SKM Enviros were commissioned to undertake a Phase 2 site investigation for three separate areas at the Hyde Park, Hayes business park (referred to as HPH4-6, "the site") for HPHA Ltd, a subsidiary of Melford Capital Partners LLP. The building areas HPH1-3 and car park to the east are also under the ownership of HPHA Ltd but are considered offsite for the purposes of this assessment. Our previous commission in May 2011 was to undertake one round of groundwater monitoring on existing wells across the HPH area and to undertake a Phase 1 environmental assessment for HPH4-6. In March 2012 SKM updated the Phase 1 environmental assessment and provided it in a suitable form for submission to the London Borough of Hillingdon (LBH) as part of planning applications for HPH4 and 5..		
Development	The Hyde Park, Hayes business park contains a number of existing multi-storey buildings with hard and soft landscaping (HPH1-3) with a separate car parking area, as shown in the site layout plan below. The proposals are for development of three areas of the Hyde Park, Hayes business park (HPH4-6) which will be considered for a planning permission with the LBH. The areas outside of the three areas of the planning application are referred to as off site for the purposes of this assessment. The development is for creation of a three storey office with basement for HPH4 and a four storey office with basement for HPH5. The proposals for HPH6 are yet to be determined but are likely to include commercial development. The landscaping master plan is contained in Appendix 1.		
Objectives	■ To provide further information on ground / groundwater conditions and the environmental setting with respect to groundwater and soil quality and potential impacts on the proposed development in order to discharge likely soil and groundwater planning conditions. A separate factual report has been prepared by third parties with respect to geotechnical findings for design of foundations; ■ To assess risks relating to the proposed development (mainly vapour / gas risk into buildings from volatile organic compounds in groundwater and any made ground on site) and the implications for the proposed development; and, ■ To supply information to support two full planning applications with LBH for office buildings on HPH4 and 5 (for which full applications have been submitted), and to pave the way for future development (in a currently unspecified use) at HPH6. ■ To submit findings to the Environment Agency (EA) as part of planning applications for the respective areas.		
Receptor Sensitivity to Contamination	Principal Aquifer (Lynch Hill Gravels)	Future site users	Surface Water
	Moderately High	Moderate	Low
Assessed Risks Prior to Mitigation Measures	Moderate	Moderate / Low	n/a

Aspect	Description
Conclusions:	
Soil Contamination	There was no evidence of widespread contamination in soils across HPH4-6. Metal contamination was isolated at one location each in HPH5 and HPH6. There was no evidence of elevated chlorinated hydrocarbons in soil from the former Fairey Aviation Works.
Groundwater	- There was no evidence of groundwater contamination within the Lynch Hill Gravels with respect to stringent UK Drinking Water Standard (UKDWS). - Trichloroethene (TCE) and Vinyl Chloride (VC) was elevated above these standards outside the planning application area to the east. This is potentially from the Westlands site which was also part of the former Fairey Aviation works. - VC was elevated above UKDWS in the underlying London Clay beneath HPH5. This is a non-aquifer with over 20m of clay overlying the chalk below so we have not identified a requirement for remediation.
Ground Gas	- There was no evidence of putrescible material that would give rise to ground gas hazards from carbon dioxide or methane. The assessment against CIRIA C665 determined that no special protective measures were required with a CS1 classification. - Across HPH4-6 the concentrations of vapours from TCE and VC from groundwater within the Lynch Hill Gravels were below the long term and short term EALs. As a consequence no special protection measures would be required in buildings. - The concentrations of vapours from VC within groundwater in the London Clay at HPH5 were several times higher than both the long term and short term EALs. The risk to future users of the site was assessed to be Moderate requiring consideration for the design for piled foundations to prevent migration into buildings.
Soil Disposal	Screening against Environment Agency WM2 guidelines determined that a localised area of Made Ground within HPH5 would be considered as hazardous waste should offsite disposal of soils be required.
Recommendations	- Clean top soil materials should be used in areas of soft landscaping to act as a barrier to prevent contact with future site users. - Basement areas would require appropriate water proofing treatments to prevent groundwater ingress due to the relatively high water table,. - No requirement for groundwater remediation within the Lynch Hill Gravels has been identified on HPH4-6 since the concentrations are below stringent UKDWS. Since the London Clay is a non-aquifer, no remediation requirement has been identified. - Further testing, particularly of shallow Made Ground would need to be undertaken in the area of TP03 on HPH5. This would be to determine which material should be segregated for pre-treatment prior to disposal, or which material should remain within the site to avoid hazardous waste disposal charges - The pile design must incorporate mitigation measures to prevent the migration of VC vapours from the London Clay into proposed buildings.

1. Introduction

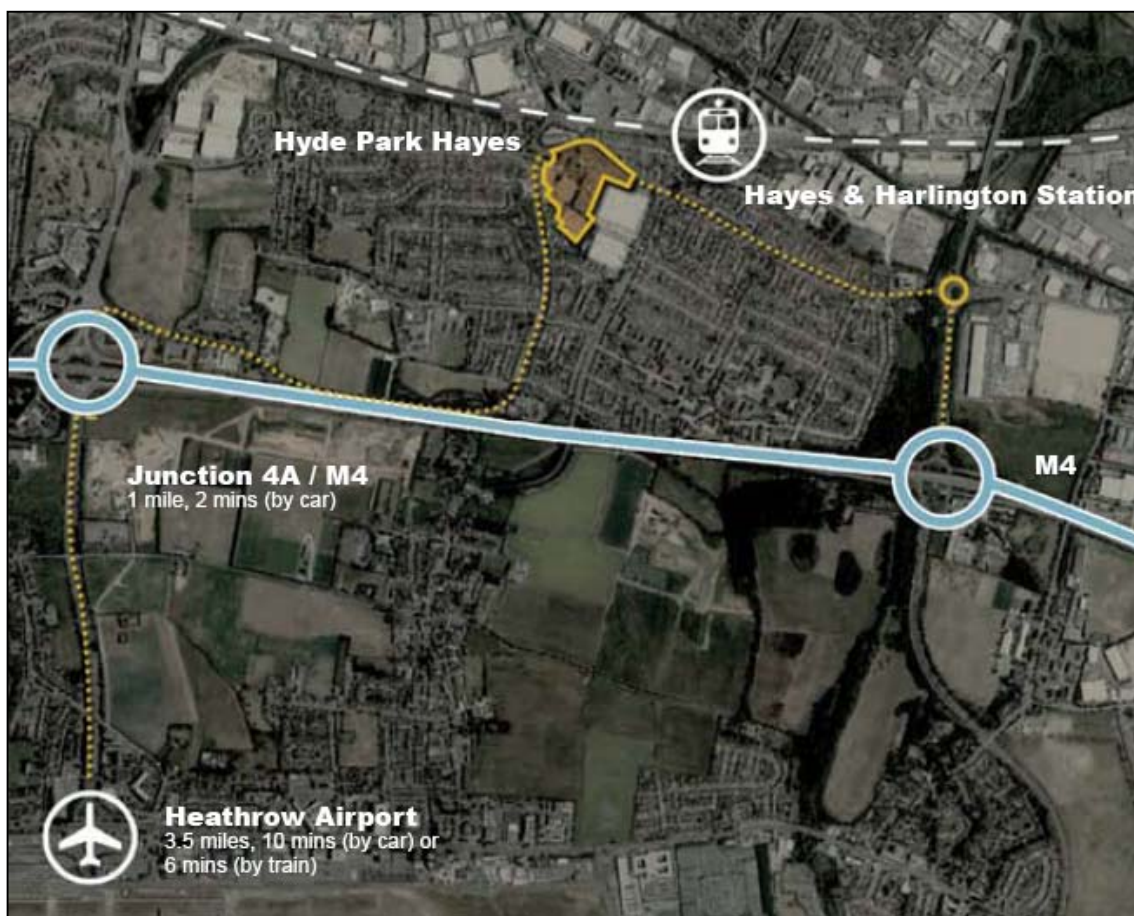
Background information regarding the site and the objectives of works are summarised in Table 1.

Table 1. Site Details and Project Objectives

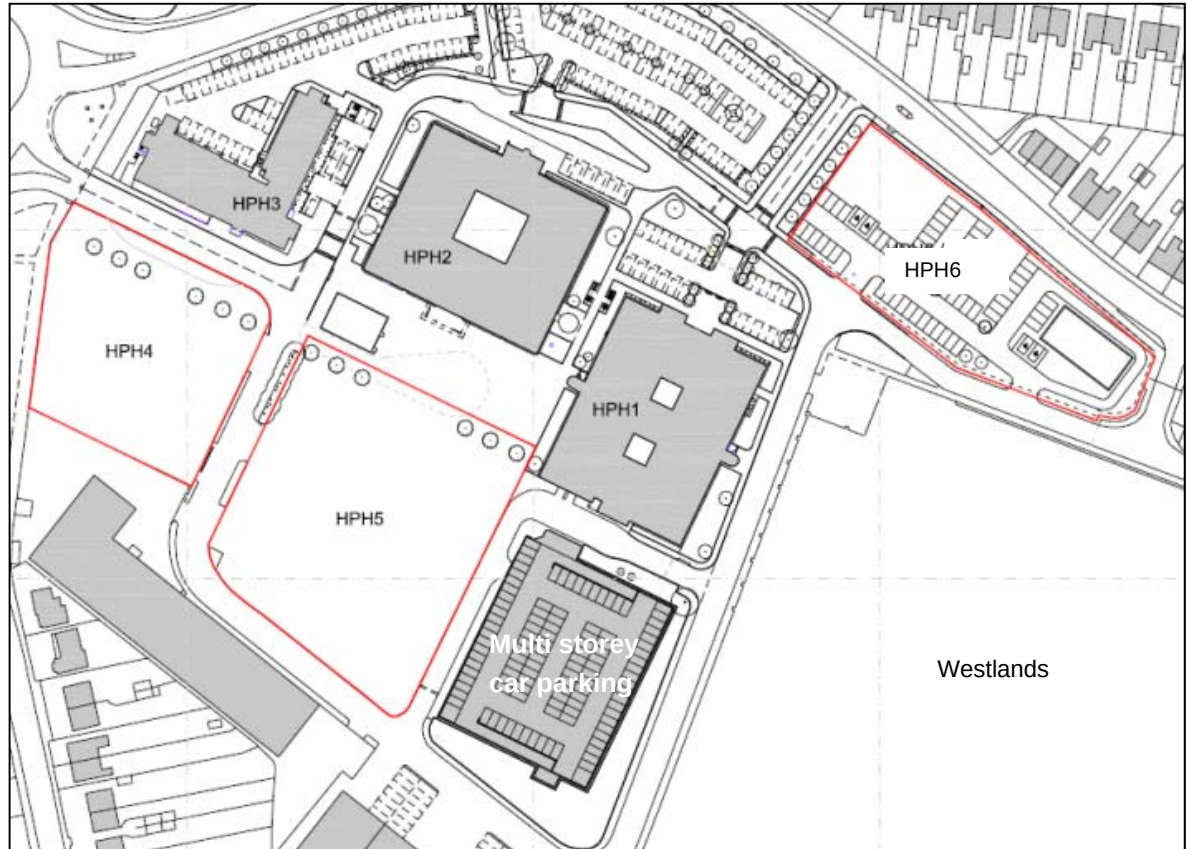
Aspect	Description
Site Address	Hyde Park, Millington Road, Hayes, UB3 4AZ
Grid Ref	509210 179260
Site Area	HPH4 – 3,585m ² HPH5 – 5,580 m ² HPH6 – 3,903 m ²
Background	In May 2012, SKM Enviros were commissioned to undertake a Phase 2 site investigation for three separate areas at the Hyde Park, Hayes business park (referred to as HPH4-6, “the site”) for HPHA Ltd, a subsidiary of Melford Capital Partners LLP. The building areas HPH1-3 and car park to the east are also under the ownership of HPHA Ltd but are considered offsite for the purposes of this assessment. Our previous commission in May 2011 was to undertake one round of groundwater monitoring on existing wells across the HPH area and to undertake a Phase 1 environmental assessment for HPH4-6. In March 2012 SKM updated the Phase 1 environmental assessment and provided it in a suitable form for submission to the London Borough of Hillingdon (LBH) as part of planning applications for HPH4 and 5.
Development	The Hyde Park, Hayes business park contains a number of existing multi-storey buildings with hard and soft landscaping (HPH1-3) with a separate car parking area, as shown in the site layout plan below. The proposals are for development of three areas of the Hyde Park, Hayes business park (HPH4-6) which will be considered for a planning permission with the LBH. The areas outside of the three areas of the planning application are referred to as off site for the purposes of this assessment. The development is for creation of a three storey office with basement for HPH4 and a four storey office with basement for HPH5. The proposals for HPH6 are yet to be determined but are likely to include commercial development. The landscaping master plan is contained in Appendix 1.
Local Authority Planning Conditions	This report is submitted to LBH to part discharge planning conditions for planning application for HPH5 and to support an outline planning application for HPH4. The information for HPH6 is submitted should there be a future application for this site.
Conclusions From Desk Study	The historic use of the site and the surrounding area has the potential to impact sensitive receptors on and in the vicinity of the site. The risks to human health receptors from historic use of the site are assessed as Moderate/Low for construction workers and Moderate/Low for future site users. The risks to controlled waters are assessed as Moderate. This reflects: ■ The historic use of the site and surrounding area; ■ The presence of localised elevated concentrations of lead, cadmium and copper as well as slightly elevated SVOCs, VOCs and TPH were identified in localised soil samples when compared to guidelines for commercial use; ■ Groundwater sampling in May 2011 confirmed the presence of elevated concentrations of VOC and metals in up gradient boreholes; and, ■ The proposed redevelopment of the site for low sensitivity office / commercial use.

Aspect	Description
Regulatory Consultation	SKM Enviros wrote to the Environment Agency (EA) and LBH on 21 March 2012 to confirm whether the proposed scope of works was acceptable. On 3 April LBH responded to confirm that the scope of works was acceptable. On 17 April the EA responded, confirming that they required three additional boreholes offsite to the east.
Objectives	■ To provide further information on ground / groundwater conditions and the environmental setting with respect to groundwater and soil quality and potential impacts on the proposed development in order to discharge likely soil and groundwater planning conditions. A separate factual report has been prepared by third parties with respect to geotechnical findings for design of foundations; ■ To assess risks relating to the proposed development (mainly vapour / gas risk into buildings from volatile organic compounds in groundwater and any made ground on site) and the implications for the proposed development; and, ■ To supply information to support two full planning applications with LBH for office buildings on HPH4 and 5 (for which full applications have been submitted), and to pave the way for future development (in a currently unspecified use) at HPH6. ■ To submit findings to the Environment Agency (EA) as part of planning applications for the respective areas.

Site Location Plan



Site Layout Plan



2. Site Investigation and Monitoring

2.1. Objectives and Strategy

2.1.1. Background

The broad objectives of the site investigation strategy were set out in our desk study report (Ref 2) and were subsequently modified in response to correspondence received from LBH and EA. These were primarily to assess the risks relating to the proposed development (mainly vapour / gas risk into buildings from volatile organic compounds in groundwater and any Made Ground on site) and the implications for the proposed development.

The methodology of the investigation is in accordance with the Environment Agency Model Procedures for Management of Land Contamination (CLR11) (Ref. 1). Details of the locations investigated and number of inspection points completed in each area are summarised in Table 2.

Table 2. Method And Location Of Investigation Points

Aspect	Description
Dates Main Site Works Undertaken	The main site works were undertaken between 2nd July 2012 and 21st July 2012 inclusive of geotechnical and land quality assessment. The locations of exploratory locations are shown in Figure 1. In all cases the work was undertaken to establish ground conditions and obtain samples for chemical analysis. During drilling of cable percussion boreholes, soil samples were obtained for geotechnical laboratory analysis and SPT's were undertaken at regular depth intervals. Upon completion, boreholes were installed for groundwater and gas monitoring as detailed below. Borehole logs are supplied in Appendix 2. Borehole logs BH2, 6, 8 and 9 from a previous investigation by Delta Simmons in 2005 are also included in Appendix 2. These four locations are outside the red line planning application boundaries for the HPH4-6. Two rounds of groundwater monitoring were undertaken on 26 July and 9 August 2012. A total of six rounds of ground gas monitoring were undertaken between 26 July and 27 September 2012.
HPH4	Two trial pits, referenced TP1 and TP2 were excavated to a maximum depth of 2.9mbgl using a JCB 3CX. Two boreholes, referenced BH11 and BH12 were advanced to depths of between 29.5mbgl and 30mbgl using cable percussion techniques. BH11 was screened within the Lynch Hill Gravels and BH12 screened within the London Clay deposits.
HPH5	Two trial pits, referenced TP3 and TP4 were excavated to a maximum depth of 3 mbgl using a JCB 3CX. Two boreholes, referenced BH13 and BH14 were advanced to depths of between 30 mbgl and 40mbgl using cable percussion techniques. BH13 was screened within the Lynch Hill Gravels and BH14 screened within the London Clay deposits.
HPH6	Four trial pits, referenced TP5-TP9 were excavated to a maximum depth of 3.2mbgl using a JCB 3CX. Four boreholes, referenced BH15 to BH18 were advanced to depths of between 6.1mbgl and 30mbgl using cable percussion techniques. Boreholes were screened as follows: BH15, Lynch Hill Gravels; BH16, Lynch Hill Gravels; BH17, London Clay and BH18, Lynch Hill Gravels.



Aspect	Description
Off Site	Groundwater and ground gas monitoring was also undertaken from offsite locations, BH2 located on HPH3; BH8 located north of HPH2; and BH8 and BH9 located to the east of the multi storey car parking. These locations were all installed by Delta Simmons in September 2005.
Exploratory Hole Surveying	Upon completion of site works, all boreholes and trial pit locations were surveyed relative to Ordnance Datum.

2.2. Laboratory Analytical Schedules

2.2.1. Soil Sampling and Analysis

Soil samples from each exploratory hole were carefully examined and logged in accordance with BS5930 and recorded by an experienced SKME engineer with respect to trial pits and by engineer with Endeavour Drilling with respect to boreholes.

Soil samples were collected using a stainless steel trowel. All sampling equipment was cleaned between samples to minimise the potential for cross-contamination.

Soil samples were collected from the exploratory hole arisings and placed in clean sample containers provided by the laboratory, appropriate to the analysis suite. Samples were then dispatched to 12 laboratories by same-day courier.

12 is a UKAS accredited laboratory and soil samples were tested to MCERTS standards where applicable. The analytical suite included:

- Toxic and phytotoxic metals;
- Volatile Organic Compounds (VOC);
- Semi Volatile Organic Compounds (SVOC);
- Speciated Polyaromatic Hydrocarbons (PAH);
- Speciated Petroleum Hydrocarbons (Banded TPH or TPHCWG);
- Waste Acceptance Criteria (WAC) testing suite;
- Soil Organic Matter (SOM); and,
- Asbestos.

The certificates of soil analysis are presented in Appendix 3 and the results are compared to human health criteria in Section 5 and are also shown in tabular form compared against human health screening values in Appendix 4.

2.2.2. Water Sampling and Analysis

Groundwater samples were collected from newly and previously installed groundwater monitoring wells. Prior to sampling the depth of groundwater in each well was measured and an interface meter was used to assess the presence of Dense Non Aqueous Phase (DNAPL). All water samples were collected using independent sampling bailers to prevent cross-contamination. These bailers were weighted with double valves to allow for collection of suspected DNAPL chlorinated solvents within sumps created within the London Clay for boreholes screened within the Lynch Hill



Gravels. Dissolved phase samples were taken within boreholes screened within the London Clay at depths of 8-9mbgl. An interphase probe was also used to assess the presence of DNAPL during monitoring. Water samples were placed in clean sample containers provided by the laboratory, appropriate to the analysis suite. Samples were then dispatched to 12 laboratories by same-day courier.

The analytical suite included:

- Volatile Organic Compounds (VOC);
- Benzene, toluene, ethylbenzene and xylene (BTEX);
- Methyl Tertiary Butyl Ether (MTBE);
- Semi Volatile Organic Compounds (SVOC); and,
- Speciated Petroleum Hydrocarbons (Banded TPH or TPHCWG);

The full analytical results along with certificates of analysis are presented in Appendix 3. The results are compared with controlled water quality standards in Section 3.

2.2.3. Ground Gas Analysis

Passive diffusion tubes were installed into the gas monitoring wells at BH11-16 between 4 September and 12 September 2012. This was to assess whether volatile vapours of trichloroethene and vinyl chloride in the groundwater may be migrating through permeable strata to the atmosphere. The tubes were despatched to Gradko International Laboratories for analysis.

2.3. Ground Conditions

2.3.1. Background

The ordnance datum levels for the London Clay shown in Figure 2 indicate a depression in the surface of the London Clay in the centre of the site which slopes between HPH4 and HPH5. The Lynch Hill Gravels are in part overlaid by Langley Silts to the north west and south east but are absent from the central part of the site between HPH4 and HPH5 where the Made Ground tends to be thickest. This is shown in the cross section north-west to south-east across HPH4 and HPH5 in Figure 3. The ground conditions encountered during the Phase 2 investigation are summarised Table 3. The exploratory hole logs from the investigation are presented in Appendix 1.

Table 3. Summary Of Ground Conditions

Strata	Material Type	Depth Encountered and Thickness
HPH4		
Made Ground	Variable in composition comprising sandy gravelly clays and sandy gravels with brick, rare clinker, concrete, and flint. Likely to be from demolition of former buildings on the site	Between 1.5m and 1.8m thick.
Lynch Hill Gravels	Comprised very dense sandy gravels with gravel of flint and quartz. Langley Silt not present in this area of the site confirming the findings of our desk study (Ref. 2)	Encountered between 1.5mbgl and 1.8mbgl with a thickness of between 2.7m and 2.8m.
London Clay	Medium strength to high strength stiff brown clay with	Encountered 4.3mbgl and 4.5mbgl. Depth not fully proven

Strata	Material Type	Depth Encountered and Thickness
Formation	fissures appearing from 8mbgl to 10mbgl.	at maximum drilling depth of 30m but likely to be greater than 50m (Ref. 2). The surface of the London Clay appears to slope toward the centre of the area between HPH4 and HPH5.
HPH5		
Made Ground	Variable in composition comprising gravelly cobbles of brick and concrete and sandy gravel with brick, rare clinker, concrete and flint. Likely to be from demolition of former buildings on the site	Between 0.5m and 1.5m thick.
Langley Silt	Silty gravelly clay. Present only at one location, TP4 on the eastern side of HPH5.	1.1m thick.
Lynch Hill Gravels	Comprised very dense sandy gravels with gravel of flint and quartz.	Encountered between 0.9mbgl and 7mbgl with a thickness of between 3.2m and 5.7m with the greater depth of London Clay toward the north of HPH5.
London Clay Formation	Medium strength to high strength stiff brown clay with fissures appearing from 6.5mbgl to 7.3mbgl.	Encountered 5.3mbgl and 7.0mbgl. As shown by Fig 2, the surface of the London Clay is deepest at BH13 at 24.9mAOD compared to shallower depths of 27.1mAOD at HPH4 and HPH6 as indicated by the contour lines. The thickness is not fully proven at maximum drilling depth of 40m but likely to be greater than 50m (Ref. 2).
HPH6		
Made Ground	Variable in composition comprising gravel of brick, tarmac and concrete.	Between 0.3m and 2.1m thick.
Langley Silt	Silty gravelly clay. Present within all trial pits and boreholes except BH16 and BH17.	Encountered between 0.3mbgl and 1.5mbgl with a thickness of between 0.5m and 2.4m
Lynch Hill Gravels	Comprised very dense sandy gravels with gravel of flint and quartz.	Encountered between 1.5mbgl and 2.1mbgl with a thickness of between 2.8m and 4.1m.
London Clay Formation	Medium strength to high strength stiff brown clay with fissures appearing from 6.5mbgl to 7.3mbgl.	Encountered 4.8mbgl and 5.6mbgl. Depth not fully proven at maximum drilling depth of 30m but likely to be greater than 50m (Ref. 2).



2.4. Groundwater Monitoring

Groundwater observations are recorded in cable percussion boreholes and trial pits in Appendix 2. Due to the permeability of the Lynch Hill Gravels, there were no appreciable groundwater strikes recorded and rest ground water levels were recorded at the start of drilling on the borehole logs. Groundwater monitoring was undertaken during 26 July and 9 August 2012 and is summarised in Table 4 below.

Table 4. Summary Of Post Fieldwork Groundwater Monitoring Data

Location	Monitoring Round	Groundwater Depth (mbgl)	Groundwater Level (mAOD)	Standpipe Response Zone (mbgl)	Strata Screened	Zone of Site
BH2	1	2.79	28.71	1 - 6	Lynch Hill Gravels	Outside red line boundary
	2	2.79	28.71			
BH6	1	2.97	28.99	1 - 6	Lynch Hill Gravels	
	2	3.18	28.78			
BH8	1	-	-	1 - 6	Lynch Hill Gravels	
	2	3.48	28.72			
BH9	1	3.06	28.92	1 - 6	Lynch Hill Gravels	
	2	3.26	28.72			
BH11	1	2.39	29.22	1 - 6	Lynch Hill Gravels	HPH4
	2	1.65	29.96			
BH12	1	1.74	29.85	7 - 30	London Clay	
	2	2.86	28.73			
BH13	1	1.44	30.48	1 - 8	Lynch Hill Gravels	HPH5
	2	2.02	29.90			
BH14	1	1.74	30.04	7 - 40	London Clay	
	2	1.76	30.02			
BH15	1	3.38	28.95	1 - 7	Lynch Hill Gravels	HPH6
	2	3.55	28.78			
BH16	1	3.51	28.95	7 - 30	London Clay	
	2	3.71	28.75			
BH17	1	3.29	28.97	6 - 30	London Clay	
	2	3.49	28.77			
BH18	1	2.89	28.97	1 - 6	Lynch Hill Gravels	
	2	3.09	28.77			

For comparison groundwater levels from monitoring conducted in 2005, 2011 and 2012 have been compared below in Table 5. It can be seen that groundwater levels dropped on average by 0.13m between 2005 and 2011 probably due to lower rainfall during this period. This average is skewed by BH9 which rose by 0.73m and if this point is removed, the average decrease in groundwater levels for BH2, BH6 and BH8 was 0.42m. In contrast groundwater levels rose on average by 0.48m between May 2011 and August 2012 probably due to greater than average rainfall.

Table 5. Comparison of Groundwater Levels Between 2005 and 2012 in Delta Simmons Boreholes

Location	Groundwater Level (mAOD)	Difference Between 2012 and 2011 (m)	Groundwater Level (mAOD)	Difference Between 2011 and 2005 (m)	Groundwater Level (mAOD)
	August 2012		May 2011		2005
BH2	28.71	+0.73	27.98	-0.63	28.61
BH6	28.78	+0.45	28.33	-0.36	28.69
BH8	28.72	+0.28	28.44	-0.27	28.71
BH9	28.72	+0.45	28.27	0.73	27.54
Average Change		+0.48		-0.13	

2012 monitoring from Round 2

2.4.1. Groundwater Assessment Summary

Groundwater levels in the Lynch Hill Gravels are generally shallow across the entire HPH area ranging from 2.79mbgl to 3.55mbgl during the second round of monitoring in August. There are relatively small differences in groundwater levels between boreholes screened in the London Clay and Lynch Hill Gravels. For example groundwater in BH14 screened in London Clay on HPH5 is 0.13m higher than groundwater in BH13 screened in the Lynch Hill Gravels during the second monitoring round. Groundwater in BH12 screened in the London Clay on HPH4 is the same height as groundwater in BH2 further to the north on HPH3. Groundwater in all boreholes on HPH6 are at the same height as shown on Figure 4. This may be due to fissuring of the London Clay (noted in Table 4 above) which may allow for preferential groundwater migration.

Over the two rounds of groundwater monitoring water levels decreased on average in the Lynch Hill Gravels by 9cm from the monitoring on 26 July and 9 August. This may have been due to the stabilisation in groundwater levels following the site investigation. Groundwater levels in the London Clay decreased on average by 40cm, with the greatest decrease in levels at BH12 of 1.12m from Round 1 to Round 2.

The overall trend of groundwater movement was largely static across the three areas of the site but with locally high groundwater in the northern part of HPH4 and HPH5. The ordnance datum levels in the Lynch Hill Gravels have been plotted on Figure 4 and show that groundwater levels on the periphery have a narrow range between 28.71mAOD and 28.78mAOD. However the two northern boreholes on HPH4 (BH11) and HPH5 (BH13) show groundwater levels that are over three meters higher than surrounding boreholes. There are several possible explanations for this trend:

- 1) The influence of subsurface obstructions from demolished buildings on the site which could interfere with groundwater flow.
- 2) The presence of Langley Silts on the periphery of HPH4 and HPH5 which may limit infiltration compared with the central area between HPH4 and HPH5 where Langley Silts are absent. Infiltration into the Lynch Hill Gravels through Made Ground in this central area would be maximised possibly leading to locally high groundwater levels.
- 3) The influence of the underlying London Clay which is lower in the centre of the site (24.92mAOD, BH13) compared to the periphery (29mAOD, BH2) which would retard the flow of groundwater downwards and restrict the flow of groundwater outward (See Figure 2). A profile A-A" from the north west to south east across HPH4 and HPH5 is shown on Figure 4.



The static groundwater in 2012 is in contrast with groundwater monitoring undertaken on 19th May 2011 by SKM Enviros which showed a west south westerly direction of groundwater flow which was consistent with the regional distribution of surface water features, i.e. River Thames and reservoirs to southwest. This information was obtained from four boreholes (BH2, BH6, BH8 and BH9) previously installed by Delta Simmons in 2005. The difference in groundwater flow patterns may be related to higher groundwater levels between 2011 and 2012 which increased on average by 0.48m.



3. Water Environment Risk Assessment

3.1. Background

As stated in the SKM Enviro desk study (Ref.3), the Environment Agency (EA) classify the Langley Silt as unproductive strata and groundwater was not found within the silt deposits. The Lynch Hill Gravels are classified as a Principal Aquifer (Ref.3). Within boreholes screened within the Lynch Hill Gravels, the saturated zone was within the permeable gravel materials at HPH4-6.

The underlying London Clay Formation is classified as unproductive strata. As indicated in Section 2.4.1 above, groundwater levels within boreholes screened within the London Clay rose to similar levels to groundwater within boreholes screened within the Lynch Hill Gravels.

The site is not located within a groundwater source protection zone (Ref. 3). The closest groundwater abstraction to the site is indicated to be located approximately 140m north of the site and is licensed to Thorn Emi Electronic Ltd. The groundwater is indicated to be abstracted from the Chalk for manufacturing purposes (See Ref. 2 Appendix A). Shallow groundwater was recorded at between 3.6 to 3.78 mbgl in 2011 and with a west south-westerly flow direction in contrast to more static groundwater on the periphery in August 2012.

The Water Framework Directive River Basin Management Plans for Groundwater in the area (Ref. 3) indicate the groundwater chemical quality is 'Poor' and is predicted to continue to be 'Poor' in 2015.

The site has been classified as Moderately High (M1) Sensitivity. The western portion of the site is directly underlain by a Principal Aquifer. The site is not located in a groundwater source protection zone and there are no known abstractions from the aquifer within 1km of the site.

3.2. Groundwater Quality Analysis

As there are no UK standards specifically for groundwater resources the Environmental Quality Standards (EQS) annual average for freshwater have been used for the initial comparison to analysis data. Where there are no EQS the UK Drinking Water Standards 2000 and 1989 (UKDWS 1989) are used.

Two rounds of groundwater monitoring were completed during 26 July and 9 August 2012. It should be noted that none of the boreholes sampled were above laboratory detection limits for the following compounds: BTEX, MTBE, SVOC and TPHCWG.

For brevity the tables below show VOC results which are above laboratory detection limits compared to UKDWS and to EQS. These were primarily chlorinated hydrocarbons: Trichloroethene (TCE); 1,1,1-Trichloroethane (1,1,1-TCA); 1,2-dichloroethene (1,2 DCE); and Vinyl Chloride (VC). Please note that in some cases the UKDWS and UK EQS was lower than available laboratory detection limits. No free phase DNAPL or Light Non Aqueous Phase (LNAPL) was detected from the interphase probe or from groundwater samples collected using the bottom weighted double valve disposable bailers.

The full analytical results for groundwater are presented in Appendix 3.

3.2.1. Boreholes Screened in Lynch Hill Gravels

During the first round of monitoring within the Lynch Hill Gravels (shown in Table 6 below), trace concentrations of TCE were above laboratory detection limits but below UKDWS and UK EQS of 10 µg/l at the following locations: BH15 at the western side of HPH6; at BH6 located east of HPH5 near the multi storey parking and at BH13 at on the northern side of HPH5. During the second round of monitoring (Table 7), the only two locations with elevated results were located outside the planning application area at BH6 and BH9 to the east bordering on the Westlands site. At both these locations TCE was 15 µg/l and 10 µg/l which was marginally above the stringent UKDWS of 10 µg/l. The slightly higher levels during the second round may be due to collection of dissolved solvents within sumps created within the London Clay.

Table 6. Round 1 Laboratory Analysis Results Above Detection Limits in Lynch Hill Gravels. 26 July 2012

Building Area	HPH6	Offsite multi storey parking	Offsite multi storey parking	HPH5	UK DWS	UK EQS
Sample Reference	BH15	BH6	BH9	BH13		
VOCs						
Trichloroethene (TCE)	1.8	4	< 1.0	6.8	10	10
1,1,1-Trichloroethane (1,1,1 TCA)	2.8	< 1.0	< 1.0	< 1.0		100
Cis-1,2-dichloroethene (1,2, DCE)	< 1.0	4.9	245	< 1.0		
Vinyl Chloride (VC)	<10	<10	43.6	<10	0.5	

All units µg/l. Laboratory detection limits were 1 µg/l apart from vinyl chloride which was 10 µg/l

	Above laboratory detection limits
	Above UKDWS or EQS

Trace concentrations of 2.8 µg/l of 1,1,1-TCA were found at BH15 during the first round of monitoring which was substantially below the EQS of 100 µg/l. None was found above laboratory detection limits in the second rounds of monitoring.

During the first round of monitoring, 1,2 DCE which is a breakdown product of TCE was found at BH6 (4.9 µg/l) and BH9 (245 µg/l) offsite, bordering the Westlands site. Concentrations during the second round increased to 33 µg/l and 530 µg/l respectively. There is no UKDWS or EQS for this compound. All other locations were below laboratory detection limits of 1 µg/l.

VC was found within the Lynch Hill Gravels at BH9 during the first round at concentrations of 43.6 µg/l which were 87 times higher than stringent UKDWS. Higher concentrations of 80 µg/l of VC were recorded at the same location during the second round of monitoring. This is a break down product of TCE.

Cholormethane was only detected in the second round of groundwater monitoring in the Lynch Hill gravels at BH9 at 6.5 µg/l, there was no UKDWS or EQS for comparison.

Table 7. Round 2 Laboratory Analysis Results Above Detection Limits in Lynch Hill Gravels. 9 August 2012

Building Area	Offsite multi storey parking	Offsite multi storey parking	UK DWS	UK EQS
Sample Reference	BH6	BH9		
VOCs				
Trichloroethene (TCE)	15	10	10	10
1,1-dichloroethane (1,1 DCA)	< 1.0	5.7	-	100
Cis-1,2-dichloroethene (1,2, DCE)	33	530	-	-
Vinyl Chloride (VC)	< 1.0	80	0.5	-
Chloromethane	< 1.0	6.5	-	-

All units µg/l. Laboratory detection limits 1 µg/l

	Above laboratory detection limits
	Above UKDWD or EQS

3.2.2. Boreholes Screened in London Clay

The highest concentrations of TCE were found at BH14 (1,340 µg/l) located in the southern part of HPH5 during the first monitoring round in July 2012 (Table 8). This maximum concentration of TCE in boreholes screened in the London Clay was 89 times higher than in boreholes screened within the Lynch Hill Gravels. Concentrations at BH12 (HPH4) and BH16 (HPH6) were above laboratory detection limits but below UKDWS and EQS. During Round 2, concentrations of TCE at BH14 were halved and TCE was not above laboratory detection limits at BH16. Concentrations of TCE at BH12 were similar in both rounds of monitoring (Table 9).

Table 8. Round 1 Laboratory Analysis Results Above Detection Limits in London Clay. 26 July 2012

Building Area	HPH6	HPH5	HPH4	UK DWS	UK EQS
Sample Reference	BH16	BH14	BH12		
VOCs					
Trichloroethene (TCE)	1.9	1,340	5.4	10	10
Cis-1,2-dichloroethene (1,2, DCE)	< 1.0	1,040	4.6	-	-

All units µg/l. Laboratory detection limits were 1 µg/l.

	Above laboratory detection limits
	Above UKDWD or EQS

1,2 DCE, which is a breakdown product of TCE, was highest at 1,040 µg/l at BH14 located in HPH5. This was nearly double the highest concentrations of 530 µg/l found in BH9 which is screened in Lynch Hill Gravels. Low levels of 1,2 DCE (4.6 µg/l) were found at BH12 located in HPH4 during the first round of monitoring, however in the second round none was detected above 1 µg/l.

No VC was found above laboratory detection limits in any of the boreholes screened in London Clay.

Table 9. Round 2 Laboratory Analysis Results Above Detection Limits in London Clay. 9 August 2012

Building Area	HPH5	HPH4	UK DWS	UK EQS
Sample Reference	BH14	BH12		
VOCs				
Trichloroethene (TCE)	620	6.1	10	10
Cis-1,2-dichloroethene (1,2, DCE)	600	< 1.0	-	-

All units µg/l. Laboratory detection limits 1 µg/l

	Above laboratory detection limits
	Above UKDWD or EQS

3.3. Solubility of Chlorinated Solvents in Water and Specific Density

Chlorinated solvents are characterised by a low solubility as indicated by Table 10 below. The concentrations found at HPH are several orders of magnitude below the concentrations at which these solvents become free phase DNAPL in groundwater. At the concentrations recorded at HPH, these chlorinated solvents would be present in the dissolved phase rather than free phase product. However as a general rule, detecting chlorinated solvents in groundwater at concentrations exceeding 1% of their solubility suggests the presence of DNAPL or residuals (Ref 4). This suggests that TCE may still be present as DNAPL within the London Clay as the maximum concentration is 12% of its solubility. The specific density of all the chlorinated solvents that were detectable in groundwater at HPH are greater than 1 so would tend to sink in the water column as DNAPL when present in a free phase product, apart from VC.

Table 10. Maximum Concentrations of Chlorinated Solvents in Groundwater at HPH Compared with Library Values for Solubility in Water and Specific Density

VOCs	Maximum Concentration HPH	Solubility in Water	Percentage of Solubility	Specific Density
Trichloroethene (TCE)	1,340	1,080,000	12.4%	1.4
1,1,1-Trichloroethane (1,1,1 TCA)	2.8	4,400,000	0.01%	1.3
1,1-dichloroethane (1,1 DCA)	5.7	5,500,000	0.01%	1.1
Cis-1,2-dichloroethene (1,2, DCE)	1,040	8,690,000	1.2%	1.2
Vinyl Chloride (VC)	80	2,700,000	0.3%	0.9

All units µg/l.

Comparison with library values of solubility and specific density values, see Ref. 5

Solubility and density quoted at 20°C



3.4. TCE Daughter Products

The presence of TCE as well as daughter products such as DCE and VC suggest that reductive dechlorination has been occurring in groundwater. This process refers to the degradation of chlorinated organic compounds by chemical reduction under anoxic conditions leading to the release of inorganic chloride ions and the gradual degradation of these compounds. This is a natural process that usually occurs at a slow rate due to the availability of electron donors.

In the Lynch Hill Gravels the concentration of TCE in groundwater is relatively low compared to the concentration of 1,2 DCE which is 35 times higher (Table 11). The presence of VC indicates that reductive dechlorination has been occurring. Both the SVOC and VOC suite used did not include ethane which would indicate the breakdown of VC.

The concentrations of TCE in groundwater in the London Clay is similar to the concentrations of 1,2 DCE indicating that some reductive dechlorination is occurring (Table 11). This process may be limited in the more anaerobic conditions and no VC was detected.

Table 11. Comparison of Maximum Concentrations of TCE to DCE and VC in Lynch Hill Gravels and London Clay.

	TCE	1,2,DCE	VC
Lynch Hill Gravel	15	530	80
London Clay	1,340	1,040	-

All units µg/l

3.5. Potential Source-Pathway-Receptors

The above chlorinated solvents compounds and their daughter compounds are likely to have been used as degreasers from use at the former Fairey

Aviation Works and leakage/spillage into the ground and migration through groundwater.

Chlorinated aliphatic hydrocarbons are listed as potential contaminants of concern for aircraft manufacturing

works in R&D66 (Ref 6) and the Department of Environment industry profiles (Ref 7). See box.

Solvent degreasing is widely carried out in engineering industries, as dedicated processes, or by manual wiping. Larger scale processes include ultrasonic baths and vapour degreasing, in which the solvents are distilled and reused. Historically, thinners and tetrachloroethane were widely used for degreasing. Materials currently used for degreasing include trichloroethylene, trichloroethane, perchloroethylene, ketones, alcohols and esters. The current trend is to use water-based cleaning systems instead of organic solvents. Department of Environment, Industry Profile, Aircraft Manufacturing Works

Areas likely to be affected by solvent contamination include storage areas for virgin and waste solvents, particularly around the cleaning and degreasing plant, and the paint shop where large volumes of solvents are held, and to a lesser extent the assembly plant.

Releases may occur during the filling and emptying of storage tanks and as a result of leaks from storage tanks and drums, accidental spillages and the on-site disposal of cleaning solvents or paint sludges. Department of Environment, Industry Profiles: Aircraft Manufacturing Works



It should be noted that the Fairey Aviation works incorporated the footprint of the HPH office complex as well as the adjacent Westlands site to the east. The LBH confirmed that a planning application had been submitted for the Westlands site to the east (Planning Ref: 32157/APP/2011/8721, for a new ASDA supermarket). This planning application included information indicating the potential for offsite groundwater contamination. A desk study for the Westlands site (Ref. 8) includes only limited chemical analysis from one borehole BH4 located to the north east of that site. This confirms that elevated aliphatic hydrocarbons were present in groundwater as follows:

- C10-C12: 6.43mg/l
- C12-C16: 37.2mg/l
- C16-C21: 17.39mg/l
- C21-C36: 11.2mg/l

In addition free product was encountered between 3.66m and 3.7m at the Westlands site with a hydrocarbon / white spirits odour. This is in contrast to monitoring at HPH4-6 where speciated hydrocarbons were all below laboratory detection limits and no free phase hydrocarbons were detected. Analysis for VOC compounds in groundwater at BH4 at the Westlands site showed they were all below laboratory detection limits. It is not stated in the Southern Testing desk study report whether groundwater monitoring was undertaken at the base of the borehole to detect potential DNAPL. Groundwater monitoring undertaken by SKM Enviros in 2011 indicated a more definitive east to west migration of groundwater in contrast to the monitoring undertaken in 2012 where groundwater levels had risen on average by 0.48m and resulted in more static groundwater.

Potential routes of exposure of site workers and site users to chlorinated solvents would be through the absorption of solvents, through inhalation and skin contact. Inhalation is the most common form of workplace exposure, because the solvents can readily evaporate. Skin contact and ingestion are unlikely in this case as site workers and site users would not be in contact with groundwater or drinking groundwater.

3.6. Summary of Findings

The findings of groundwater analysis results can be summarised as following:

- Chlorinated solvents are the main contaminant of concern in groundwater rather than SVOC, BTEX, MTBE and petroleum hydrocarbons.
- Within the planning application area of HPH4-6, there was no evidence of elevated concentrations of TCE or VC above UKDWS within the Lynch Hill Gravels. Elevated concentrations of TCE and VC were found in the Lynch Hill Gravels outside the planning application area to the east, adjacent to the Westlands site.
- Elevated concentrations of VC, several times above the UKDWS and EQS were found within the unproductive strata of the London Clay at HPH5. This is probably due a local depression in the surface of the clay in this area which tend to pool DNAPL, with likely preferential migration due to fissuring of the London Clay shown in the borehole logs.

1 Mixed use development comprising 7,310 sqm (gea) industrial/warehousing unit (Use Classes B1c, B2, B8); 7998 sqm (gea) retail store (Use Class A1) and petrol filling station, together with associated car parking, landscaping and alterations to adjacent highway. Refused 04-04-2012, appeal lodged 17-05-2012.



- The relatively low concentrations of chlorinated solvents when compared against their solubility in water indicate that these compounds are likely to be present as dissolved phase rather than insoluble DNAPL. It should be noted that DNAPL can be difficult to detect especially with their tendency to sink downwards through preferential pathways such as may be found within the fissures of the London Clay. As a result DNAPL may still be present in localised areas within the London Clay, however this is classified by the EA as a non productive strata for groundwater.
- The highest concentrations of TCE and DCE were found in boreholes screened within the London Clay rather than boreholes screened with the Lynch Hill Gravels. This may be due to the previous physical migration processes of DNAPL through fissures in the London Clay owing to their specific density which is greater than 1.
- The concentrations of TCE in groundwater within the Lynch Hill Gravels are at or just above stringent EQS or UKDWS compared with groundwater in the London Clay which is 89 times higher. The concentrations of DCE in groundwater in the London Clay were nearly double that of DCE in the Lynch Hill Gravels, there is no UKDWS or EQS for comparison.
- VC which is a breakdown product of TCE is only present in the Lynch Hill Gravels (outside the planning application areas) and was not present in the London Clay. It was 160 times higher than the stringent UKDWS in boreholes to the east of the site near the multi-storey car parking.
- Naturally occurring reductive dechlorination would appear to be occurring in groundwater to break down TCE to less complex daughter products. The presence of breakdown products 1,2 DCE and VC in the Lynch Hill Gravels indicates that this process may be more prevalent than in groundwater in the London Clay where only 1,2 DCE is present. The presence of greater concentrations of TCE in groundwater in the London Clay may also be due to its propensity to sink in groundwater when present as a DNAPL.
- The definitive source of the chlorinated solvents is not known, however given their use as metal degreasers it is likely that the source was the former Fairey Aviation works which incorporated both the wider area of the HPH business park and the adjacent Westlands site to the east. Previously in 2011 groundwater migration showed a west south westerly groundwater migration on contrast to largely static groundwater in 2012, possibly due to a rise in groundwater levels of nearly half a meter due to higher than average rainfall in 2012.

4. Ground Gas Assessment

4.1. Assessment Criteria

In order to assess the risk to the proposed built development on site associated with soil gas, reference has been made to the Construction Industry Research Information Association (CIRIA) Report C665 (Ref. 9). The classification system described within this report is an updated version of the classification scheme by Wilson and Card (1999). For all development sites, with the exception of low rise residential, the system classifies sites into one of six standard classes, referred to as Characteristic Situations (CS), by the concentrations of methane and carbon dioxide multiplied by the flow rate, expressed as the Gas Screening Value (GSV) (formerly limiting borehole gas flow volume). The guidance also lists standard construction practices for each Characteristic Situation.

The above classification system is considered to be the most appropriate guidance for assessing risks to the proposed development. The CIRIA C665 classification scheme is summarised in Table 12 below.

Table 12. CIRIA C665 Classification with Scope of Gas Protection Measures after Wilson & Card (1999)

Characteristic Situation	GSV (l/hr)	Typical Protection Measures
1	<0.07	No special precautions.
2	<0.7	a) Reinforced concrete cast <i>in situ</i> floor slab (suspended, non-suspended or raft) with at least 1200 g DPM. b) Beam and block or pre cast concrete and minimum 2000g DPM/reinforced gas membrane. Possibly under floor venting or pressurisation in combination with a) and b) depending on use. All joints and penetrations sealed.
3	<3.5	All types of floor slab as above. All joints and penetrations sealed. Minimum 2000 g/reinforced gas proof membrane and passively ventilated under floor sub-space or positively pressurised under floor sub-space.
4	<15	All types of floor slab as above. All joints and penetrations sealed. Proprietary gas resistant membrane and passively ventilated or positively pressurised under floor sub-space with monitoring facility.
5	<70	Reinforced concrete cast in situ floor slab (suspended, non-suspended or raft) All joints and penetrations sealed. Proprietary gas resistant membrane and passively ventilated or positively pressurised under floor sub-space with monitoring facility. In ground venting wells or barriers.
6	>70	Reinforced concrete cast in situ floor slab (suspended, non-suspended or raft) All joints and penetrations sealed. Proprietary gas resistant membrane and actively ventilated or positively pressurised under floor sub-space with monitoring facility, with monitoring. In ground venting wells and reduction of gas regime.



- The following strategy has been adopted for monitoring of ground gases beneath the site and is consistent with guidance contained in CIRIA C665.
- Development of a conceptual site model identifying potential sources of gas and migration pathways based on ground investigation findings.
- Targeted monitoring from a total of 8 individual locations².
- Monitoring during six discrete intervals over a range of pressures. This is based on CIRIA C665 Moderate sensitivity and Low gas risk.

4.2. Conceptual Site Model for Gas Risk

The conceptual site model for the planning application area of HPH4-6 for assessment of gas risks are summarised below and are based on the findings of our intrusive investigations.

4.2.1. Potential Sources of Soil Gas

The potential on-sources of soil gas include

- Carbon dioxide and methane from thin deposits of Made Ground associated with historical development at the site for warehousing and office buildings.
- Chlorinated hydrocarbon vapours from dissolved phase compounds in groundwater within the Lynch Hill Gravels and London Clay. Indicator compounds TCE and VC.

There are no potential off-site sources of soil gas within 1km of the site.

Where Made Ground was encountered on site, it almost, without exception, comprised of granular materials with no evidence of gas generating putrescible materials found. Reference to CIRIA C665 indicates that Made Ground deposits such as those identified on the site are typically characterised by methane concentrations that are not highly elevated but that carbon dioxide levels typically range to higher values.

Underlying Lynch Hill Gravels were granular in nature followed by cohesive London Clay formation which exclusively comprised cohesive clay deposits. No potentially gas generating peaty or organic rich horizons were found.

For the purposes of assessing the data, the site has been divided into three distinct areas comprising: HPH4, HPH5 and HPH6. This relates to the separate planning applications required for each area rather than differences in the gas regime or geology.

² Although gas monitoring comprised boreholes outside the red line boundary areas, only those boreholes within the red line boundary for the purposes of this planning application are considered further.



4.2.2. Potential Soil Gas Migration Pathways

The Made Ground and Lynch Hill Gravels beneath the site are predominantly granular in nature and would act as a potential migration pathway. However The Lynch Hill Gravels are in part overlaid by Langley Silts to the north west and south east which would tend to limit ground gas migration. The Langley Silts are absent from the central part of the site between HPH4 and HPH5 where the Made Ground tends to be thickest.

In addition, it should be noted that groundwater levels in the Lynch Hill Gravels are generally shallow across the site ranging from 2.79mbgl to 3.55mbgl during the second round of monitoring in August. The presence of shallow groundwater beneath the site throughout the year will serve to limit the potential for generation and migration of gases within and through the shallow subsurface. It should be noted that BH12 and BH14 were boreholes screened within the London Clay and as a result the slotted area of the borehole was below the water table.

4.3. Identified Receptors

Receptors potentially affected by soil gas identified at the site are:

- Future site users (i.e. occupants of the office and commercial development and maintenance workers);
- Future buildings and structures.

Without any specific gas protection measures, it is possible that soil gas could accumulate beneath building footprints via vertical migration through service corridors and permeable strata. Flammable or explosive hazards will occur when methane accumulates at concentrations of between 5 and 15% in normal air (20.9% oxygen). Concentrations above these limits detected within the ground can still be hazardous, as dilution in air can easily reduce methane concentrations to within flammable limits during ingress into buildings.

4.4. Gas monitoring results

Six rounds of gas monitoring were undertaken on 26 July, 9 August, 20 August, 4 September, 20-21 September and 27 September 2012 and the results are presented in Appendix 7 which includes information on steady state flows and concentrations.

For the purposes of this assessment we have used peak flows and gas concentration data.

The results from Gradko International Laboratories for dissolved phase chlorinated hydrocarbons, TCE and VC are contained in Appendix 8.

Methane concentrations were recorded below the detection limit of the instrument in the majority of borehole locations monitored during each visit. Occasionally, marginal methane concentrations of 0.3% were recorded.

Steady state carbon dioxide concentrations were generally low with maximum concentrations of 1.3% at HPH4, 0.7% at HPH5 and 1.7% at HPH6.

Gas flow rates were generally low during each of the monitoring visits within the majority of boreholes ranging from 0.1 l/hr to a maximum of 0.2 l/hr.



4.5. Interpretation of Gas Monitoring Data

In accordance with the guidance detailed above, an interpretation of the results is presented in Table 13, based on the Wilson and Card model in CIRIA C665.

Table 13. Gas Characteristic Situations based on Building areas

Zone	Borehole	Peak Flow Rate (l/hr)	Peak methane concentrations (%)	Peak carbon dioxide concentrations (%)	Methane GSV (l/hr)	Carbon Dioxide GSV (l/hr)	Characteristic Situation (CS)
HPH4	BH11	0.1	0.1	1.3	0.0004	0.0026	1
	BH12	0.2	0.2	1.2			
HPH5	BH13	0.1	0.1	0.7	0.0004	0.0014	1
	BH14	0.2	0.2	0.1			
HPH6	BH15	0.1	0.3	1.6	0.0003	0.0017	1
	BH16	0.1	0.2	0.5			
	BH17	0.1	0.3	0.9			
	BH18	0.1	0.2	1.7			

CS1 is GSV <0.07 l/hr.

GSV calculated for peak flow rate and concentrations which are highlighted in orange.

If the flow rate is <0.1 l/hr then the default of 0.1 l/hr has been used in the calculation of GSV

To assess the potential impact of vapour phase chlorinated hydrocarbons contained within groundwater on human receptors on site, the concentrations of VC and TCE in the soil gas from boreholes on HPH4-6 have been compared against the Environment Agency Long Term Environmental Assessment Levels For Air (EAL) (Ref. 10) as shown in Table 14 below.

Table 14. Comparison of Indicator Chlorinated Hydrocarbons in the Air in Boreholes against Environment Agency Long and Short Term Environmental Assessment Levels.

Zone		TCE	TCE Long Term EAL	TCE Short Term EAL	VC	VC Long Term EAL	VC Short Term EAL
HPH4	BH11	*	1,100	1,000	1.32	159	1,851
	BH12#	68.05			105		
HPH5	BH13	882			4.75		
	BH14#	4,543			11.62		
HPH6	BH15	9.82			58.05		
	BH16	*			38.64		

All units µgm-3

TCE -Trichloroethylene

VC - Vinyl Chloride

* Sample damaged on arrival, no analysis possible.

Borehole screened in London Clay.

TCE short term EAL derived over 24 hour period



- Our conceptual model has not identified a source of carbon dioxide or methane gas beneath the proposed building footprints and no evidence of putrescible material.
- Monitoring indicated no evidence of methane beneath the site.
- Carbon dioxide concentrations were generally low with corresponding flow rates generally very low suggesting limited potential driving force.
- As a result of the conservative calculation of GSV using peak flows and concentrations, the GSV for each of the three building areas is less than 0.07 l/hr and would therefore be classified as CS1, not requiring special protective measures for ground gas generation.
- There is no evidence of a long or short term risk to human health from vapour phase TCE and VC derived from chlorinated hydrocarbons in groundwater across HPH4-6. Soil gas from all boreholes screened within the permeable Lynch Hill Gravel deposits had concentrations substantially below the EAL.
- The concentrations of TCE within soil gas derived from groundwater in the London Clay were elevated against both long and short term EAL. Ordinarily there would be no pathway for TCE within groundwater within fissures of the London Clay which is a non aquifer. There is however, a potential pathway to the surface from driven piles for foundations into the London Clay. This risk would need to be managed with appropriate pile design.

5. Human Health Risk Assessment

5.1. Division of Data and Sampling Strategy

The areas of HPH which are under consideration for a planning application have been divided into three zones HPH4, HPH5 and HPH6. An initial assessment of the data determined that there were only a few exceedences of metals and these were limited to one or two of the above areas rather than being widespread across the site. This initial split in the data was also undertaken on the basis that separate planning applications would be submitted for each area. Additionally the data was split between Made Ground and natural ground. There were no exceeded results in natural ground and the analytical results shown in Table 15 below only show Made Ground data.

5.2. Assessment Methodology

The soil data have been assessed against generic assessment criteria (GAC), which include Soil Guideline Values (SGVs) published by the Environment Agency and other screening criteria derived by SKM for substances that do not have an SGV. SGVs are available for a limited number of contaminants, and where published they apply to a limited range of land uses and soil organic matter (SOM) content. For contaminants with no SGV, and selected SOM contents and land-uses not covered by the SGV reports, GACs have been calculated using the current version of the Environment Agency CLEA model (version 1.06). A detailed description of the methodology used to derive GACs is provided in Appendix 4, together with model output and references.

Before any statistical assessment is undertaken, it is important to have a good understanding of variation in the soil data and the conceptual model is understood. This ensures that the appropriate data set is assessed. Once the correct data has been identified and is understood, the probability and likelihood of potential receptors coming into contact with contaminants represented by the data set can be analysed statistically.

As the risks are associated with long term risks to human health, it is the average (or mean) concentrations which is of concern. To ensure that uncertainty is included in the assessment the 95% upper confidence limit (UCL) on the sample mean is calculated. The true soil mean has a 95% chance of being below this value. To undertake such a calculation, sufficient samples are required to ensure statistical power. Where the number of samples is less than six then calculation of the UCL95 has not been undertaken and reference has been made to the number of sample exceeding the GAC.

5.3. Land Use Designation

Owing to the proposed use of the site for offices for HPH4 and HPH5 and probably commercial end use for HPH6 we have undertaken our assessment based on commercial/industrial criteria. 1% organic matter content has been used for assessment of all three areas.

5.1. Data analysis

Toxic and phytotoxic metals, speciated TPH and speciated PAH were assessed against GACs and where the maximum value was above the GAC this is highlighted in the tables in Appendix 4. Laboratory analysis certificates are included in Appendix 3.



Where contaminants were above the GAC they were assessed with histograms to check the distribution and normality of data assessed using the Shapiro Wilks test. Assessment of TPH CWG data can be found in Appendix 6. In Table 15 below, only two metals contaminants exceeded the GAC, all other contaminants (toxic and phytotoxic metals, speciated TPH, speciated PAH, SVOC, VOC) were all below the GACs or have no GAC criteria and are not shown in the main text. No asbestos was found in any of the samples. None of the assessed determinants were above the commercial/industrial GAC in HPH4. A full data set is shown in Appendix 5.

Table 15 Analytical results exceeding GACs

Results – Metals in Made Ground		
Determinant	Cadmium	Lead
GAC	230 mg/kg	450 mg/kg
HPH5 Max Value (number exceeded / number assessed)	450 mg/kg at TP3 0.5mbgl (1/4)	2,400 mg/kg at TP3 0.5mbgl (1/4)
HPH6 Max Value (number exceeded / number assessed)	-	1,400 mg at BH18 0.5mbgl (1/9)
HPH5 UCL95	Not calculated due to small sample size for cadmium and lead (n<6)	
HPH6 UCL95	-	909 mg/kg
HPH6 Data Distribution	Chebychev (non normal)	

5.2. Summary

- Across HPH4-6 there no evidence of soil contamination from VOC or SVOC which would indicate a source for the dissolved chlorinated solvents found in groundwater. No asbestos was found in any of the samples. No elevated determinants were found in natural ground in HPH4-6.
- There were no exceeded contaminants in HPH4 indicating that the soil is suitable for use in the proposed office development.
- The only exceeded contaminants in soil in HPH5 were one elevated result for cadmium and lead which were two and five times above the commercial/industrial GAC respectively at TP03 at 0.5mbgl in Made Ground. All other determinants were below applicable GAC or laboratory detection limits.
- At HPH6, one location out of nine exceeded the GAC for lead by three times (BH18 at 0.5mbgl in Made Ground). Based on this one location the UCL95 was 909mg/kg which is above the GAC for lead of 450mg/kg. All other determinants were below applicable GAC or laboratory detection limits.
- Across the site, elevated hotspots for lead and cadmium were detected with no clear source for the contamination other than Made Ground from the area of the former Fairey Aviation works. It should be noted that on HPH4 and HPH5, a high proportion the area will be the office building footprint and hard landscaping with limited areas of soft landscaping. Development plans have yet to be finalised for HPH6.

6. Waste Acceptance Criteria

6.1. Procedure for Classification of Soil for disposal

When classifying soil destined for disposal, the first stage following development of the conceptual model and identification of material type and source areas as appropriate, is to determine if the waste is hazardous or non-hazardous. This is carried out using Environment Agency Guidance WM2.

Once a material is classified as hazardous or non-hazardous, if it is to be disposed to landfill, assessment must be made against waste acceptance criteria to determine whether it is acceptable to dispose of it to landfill and if so which landfills can accept it.

For hazardous waste, all the waste material must be treated prior to disposal at landfill.

6.2. Classification of Waste under WM2

A Technical Guidance document, WM2 "Hazardous waste: Interpretation of the definition and classification of hazardous waste" (Ref. 11) has been developed to provide guidance on the assessment and classification of hazardous waste based on the Hazardous Waste Directive definition of hazardous waste.

WM2 is intended:

- To provide guidance to all involved in the production, management and control of hazardous waste; and,
- To be a reference document for all legislation related to hazardous waste and its management.

The European Waste Catalogue (EWC) provides codes for classification of all wastes. In the European Waste classification, soil from construction sites can fall under two related ("mirror") entries:

- 17 05 03: Soil and stones containing dangerous substances;
- 17 05 04: Soil and stones other than those mentioned in 17 05 03.

The first entry is considered to be hazardous waste and the second is non-hazardous waste. There are three stages in the process of classification:

- 1) Determination of the dangerous substances likely to be present from the desk study knowledge of the site history and activities (i.e. conceptual model).
- 2) Derivation of hazardous waste criteria.
- 3) Comparison of sampling and analysis data against criteria.

6.2.1. Stage 1: Determination of Potentially Dangerous Substances

The dangerous substances that might be present on this site must be determined from the history of the site and the ground conditions encountered. This has been undertaken in the SKM EnviroS desk study to identify potential contaminants of concern.



6.2.2. Stage 2: Derivation of Hazardous Waste Criteria

In order to determine if the concentration of these substances are sufficiently high for the soil to contain “dangerous substances”, the maximum concentrations for each inorganic chemical parameter for each of the three areas HPH4-6 analysed have been compared with our in-house threshold for hazardous waste derived from the hazardous waste technical guidance WM2.

A screening tool has been devised by SKM EnviroS to assist with classification of soil as hazardous or non-hazardous waste. The tool assesses the identified contaminant concentrations against thresholds derived using the Approved Supply List and the WM2 guidance. This screening tool assesses the additivity of certain chemical properties (such as irritant and ecotoxic classification) as well as identifying individual compounds causing materials to be hazardous.

The results of the screening contained in Appendix 9 confirm that surface soils in HPH5 would be classified as hazardous waste when considered for offsite disposal. Currently the guidance appears to indicate that if the maximum value of any parameter exceeds the threshold then the material as a whole is considered to fail the waste acceptance criteria.

The data indicates that this is due to locally high concentrations at one location in HPH5 rather than widespread exceedences. This relates to copper, nickel and zinc at TP03 in Made Ground (0.5m) which is elevated above WM2 screening criteria as shown in Table 16 below.

Table 16. Summary of WM2 Screening for Classification of Hazardous Waste

Sample Reference	TP03
Depth (m)	0.5
Ground Type	MG
Area of Site	HPH5
Copper	2,800
Nickel	550
Zinc	1,900
WM2 Classification	Hazardous by H5: Harmful
	Hazardous by H7: Carcinogenic
	Hazardous by H14: Ecotoxic

MG - Made Ground

6.2.3. Stage 3: Comparison of data against hazardous waste criteria

Three soil samples were taken for Waste Acceptance Criteria (WAC) testing with I2 Laboratories, BH11 (1m); TP4 (0.5m) and TP8 (0.6m). The analysis results (Appendix 9) were compared with EA criteria for inert waste landfill; stable non reactive stable non-reactive hazardous waste in non-hazardous Landfill and hazardous waste landfill. All the results were below the criteria for hazardous and hazardous waste landfill.



It should be noted that the screening results from the WM2 would still apply for HPH5 and Made Ground from this location would be classified as hazardous. Further testing, particularly of shallow Made Ground would need to be undertaken. This would be to determine which material should be segregated for pre-treatment prior to disposal or which material should remain within the site to avoid hazardous waste disposal charges. The cut and fill model would be particularly important with respect to knowing which soil would be surplus to site requirements in the area of the proposed basements.

All data classification requires confirmation with the receiving landfill to determine acceptability.

7. Conceptual Site Model

7.1. Conceptual Site Model

In order for land contamination risk to be realised, a 'pollutant linkage' must exist. A pollutant linkage requires the presence of:

- a source of contamination;
- a receptor capable of being harmed; and,
- a pathway capable of exposing a receptor to the contaminant.

Should S-P-R linkages be identified, then there is a requirement to use remedial measures to reduce or remove the risk. For further information on the methodology of risk assessment see Appendix 10.

A conceptual site model (CSM) for the site was defined within the Preliminary Risk Assessment completed by SKM Enviro in March 2012. The CSM and Preliminary Risk Assessment assess the potential risks taking into account the future use of the site for commercial offices.

Potential pollutant linkages and environmental risks are being assessed against the proposed office / commercial development. Potential sources, pathways and receptors are considered below and have been used to complete the risk assessment which is included in Table 19.

7.1.1. Potential Contaminant Sources

Potential contamination sources at HPH4-6 have been listed below in Table 17 based on the site investigation findings after assessment against relevant guidance criteria. Only identified sources have been taken forward for further assessment.

Table 17. Potential Contamination Sources at HPH4-6

Zone	Dates	Potential Source	Potential Contaminants	Source to be considered further? <i>Reasons</i>
Onsite / Offsite ³	1930s to 1970	Aircraft manufacturing, Fairey Aviation Works.	Soil: VOC, SVOC, PAHs, asbestos and petroleum hydrocarbons. Toxic and phytotoxic metals (HPH4).	No. Determinants below GAC or laboratory detection limits
			Soil: cadmium and lead in Made Ground at HPH5 and HPH6.	Yes. Hotspots above GAC.
			Groundwater: SVOC, petroleum hydrocarbons.	No. Determinants below EQS or UK DWS / laboratory detection limits.
			Groundwater: toxic and phytotoxic metals.	No. Not detected at elevated concentrations during 2011 SKM Enviro monitoring.
			Groundwater: chlorinated hydrocarbons (TCE, VC)	Yes. TCE and VC above UKDWS in Lynch Hill

³ Incorporates Westland's site to the East including HPH4-6.

Zone	Dates	Potential Source	Potential Contaminants	Source to be considered further? Reasons
				Gravels VC above UKDWS in the London Clay.
Onsite	1970 to 2006	Warehousing, storage not determined.	Metals, hydrocarbons, PAHS.	No. Lack of information on previous uses
Offsite	1975 ⁴	Petrol filling station	Petroleum hydrocarbons, diesel / petrol.	No. No elevated TPH detected in groundwater.
	Estimated 2006 to present	Diesel storage tanks associated with HPH1	Diesel.	No. No elevated TPH detected in groundwater.

7.1.2. Potential Receptors and Pathways for Proposed Development

The sources identified above are considered with respect to the potential pathways to receptors in Table 18 below.

Table 18. Potential Receptors and Pathways at HPH4-6

Receptor	Pathway	Is pathway capable of exposing a receptor to the contaminant
People (users of office space / maintenance workers). ⁵	Dermal absorption	Yes
	Inhalation of dust/vapours	Yes
	Ingestion of home grown produce	N/a
	Soil ingestion	Yes
	Migration of hazardous gases via permeable strata	No. Concentrations of carbon dioxide and methane do not require special protection measures. Concentrations of TCE and VC are below long term and short term EAL values.
	Migration of vapours via driven piles into the London Clay	Yes
Controlled waters Groundwater – Principal Aquifer (Lynch Hill Gravels) ⁶	Spillage/loss direct to groundwater	No. No TCE/VC source remaining on site. No evidence of elevated concentrations in soil.
	Migration via permeable strata	Yes
	Run off via drainage /sewers	No. Drains likely to be located above groundwater table.
Controlled waters	Spillage/run off/loss direct to receiving waters	No

⁴ Decommissioning date not given in trade directory, see Section 2.4 SKM Enviros desk study.

⁵ Please note that short term risks to human health of site workers have not been assessed. It would be the responsibility of the Client as part of the Construction Design Management Regulations to alert contractors to the potential hazards.

⁶ The London Clay has been excluded as a receptor as this is unproductive strata rather than an aquifer



Receptor	Pathway	Is pathway capable of exposing a receptor to the contaminant
surface water – Grand Union Canal		
	Migration from groundwater via permeable strata	No
	Run off via drainage / sewers	No
Flora (plants)	Direct contact with contaminated soils	No contamination relevant to flora
	Uptake via root system	No contamination relevant to flora
	Migration of hazardous gases/vapours via permeable strata	No contamination relevant to flora
Buildings and services	Direct contact with contaminated soils	n/a, see Endeavour Drilling factual report
	Migration of explosive / corrosive gases/vapours via permeable strata	No. Concentrations of carbon dioxide and methane do not require special protection measures.

Table 19. Risk Assessment Before Mitigation Measures For Proposed Offices At HPH4 And HPH5 And Commercial Development At HPH6

Source	Pollutant	Receptors	Pathways to Receptor	Associated Hazard [Severity]	Likelihood of Occurrence	Potential Risk
On Site: Previous historic use (including aeronautical works)	Cadmium and lead in soil at HPH5 and HPH6	Human health (future site users of offices / commercial space) ⁷	Direct contact, inhalation, ingestion	Health hazard [Medium]	Low Localised contamination hotspots in Made Ground for cadmium and lead. Due to extensive hard landscaping across the proposed development there is unlikely to be a source-pathway-receptor linkage for contamination in the soil. Potential areas for contact with future site users would be subject to confirmation of cut/fill plan and landscaping details.	Moderate/Low
		Principal Aquifer (Lynch Hill Gravels)	Migration via permeable strata	Contamination of controlled waters [Medium]	Unlikely Previous data indicates that metal compounds in groundwater were not detected at elevated concentration and are not the primary contaminants of concern.	Low
	TCE and VC in Lynch Hill Gravels	Human health (future site users of offices / commercial space) ⁷	Inhalation via permeable strata from groundwater	Health hazard [Medium]	Unlikely No hazard present after comparison with EALs for short and long term exposure.	Low

⁷ Please note that short term risks to human health of site workers have not been assessed. It would be the responsibility of the Client as part of the Construction Design Management Regulations to alert contractors to the potential hazards.

Source	Pollutant	Receptors	Pathways to Receptor	Associated Hazard [Severity]	Likelihood of Occurrence	Potential Risk
		Principal Aquifer (Lynch Hill Gravels)	Migration via permeable strata	Contamination of controlled waters [Medium]	Likely TCE and VC have been detected in dissolved phase above UKDWS and EQS, however this is outside the planning application area of HPH4-6 and is located offsite adjacent to the Westlands site to the east. Horizontal migration would tend to be retarded by the locally depressed London Clay in the vicinity of HPH5 and largely static groundwater levels. Vertical migration would be limited by low permeability underlying London Clay.	Moderate
	TCE in London Clay	Human health (future site users of offices / commercial space) ⁷	Migration of vapours via driven piles into the London Clay at HPH5	Health hazard [Medium]	Likely The concentrations of TCE vapours in boreholes screened within the London Clay at HPH5 were above the long and short term EAL. The potential use of driven piles into the London Clay for foundations could create a potential pathway for inhalation without appropriate pile foundation design.	Moderate

8. Conclusions and Recommendations

8.1. HPH4

- **Soil contamination:** there was no evidence of elevated concentrations of metals, SVOC, VOC or PAH in shallow soils and therefore no special protection measures would be required.
- **Groundwater:** there was no evidence of elevated SVOC or VOC in the Lynch Hill Gravels and therefore no special protection measures would be required. The risk to the Lynch Hill Gravels as a Principal Aquifer was assessed as Moderate due to elevated concentrations of VC and TCE outside the planning application area to the east.
- **Ground gases:** there was no evidence of putrescible material that would give rise to ground gas hazards from carbon dioxide or methane. The assessment against CIRIA C665 determined that no special protective measures were required with a CS1 classification. The concentrations of vapours from TCE and VC from groundwater within the Lynch Hill Gravels and London Clay were below the long term and short term EALs so no special protection measures would be required in buildings.

Recommendations:

- Ensure that “clean” soil forming materials are used to provide a growing medium for areas of soft landscaping. Sufficient depth of soil to provide a growing medium for plants should be allowed in these areas.
- Due to the relatively high water table, basement areas would require appropriate water proofing treatments to prevent groundwater ingress.

8.2. HPH5

- **Soil contamination:** concentrations of lead and cadmium were locally elevated at one location requiring consideration in terms of protective measures for human health of future site users. The risk is assessed as Moderate/Low. There was no evidence of elevated concentrations of other metals, SVOC, VOC or PAH in shallow soils. Despite this, Made Ground would be classified as hazardous waste if disposed off site by virtue of one location which had elevated copper, nickel and zinc when compared with the EA WM2 screening tool.
- **Groundwater:** there was no evidence of elevated SVOC or VOC in the Lynch Hill Gravels and therefore no special protection measures would be required. The risk to the Lynch Hill Gravels as a Principal Aquifer was assessed as Moderate due to elevated concentrations of VC and TCE outside the planning application area to the east. Whilst elevated concentrations of VC were recorded within the London Clay, this is a non-aquifer with over 20m of clay overlying the chalk below.
- **Ground gases:** there was no evidence of putrescible material that would give rise to ground gas hazards from carbon dioxide or methane. The assessment against CIRIA C665 determined that no special protective measures were required with a CS1 classification.
- The concentrations of vapours from VC within groundwater in the London Clay were several times higher than both the long term and short term EALs. The risk to future users of the site was assessed to be Moderate.

Recommendations:

- Ensure that “clean” soil forming materials are used to provide a growing medium for areas of soft landscaping. An appropriate thickness of imported soil greater than 300mm should be used as a barrier to contact with underlying elevated lead and cadmium in localised areas.
- Further testing, particularly of shallow Made Ground would need to be undertaken in the area of TP03. This would be to determine which material should be segregated for pre-treatment prior to disposal, or which material should remain within the site to avoid hazardous waste disposal charges. The cut and fill model would be particularly important with respect to knowing which soil would be surplus to site requirements in the area of the proposed basements.
- The pile design must incorporate mitigation measures to prevent the migration of VC vapours from the London Clay into the building. This should be also considered for piled foundations at HPH4 and HPH6 due to the presence of trace chlorinated hydrocarbons on site and the potential for localised accumulation of DNAPL within the London Clay.
- Due to the relatively high water table, basement areas would require appropriate water proofing treatments to prevent groundwater ingress.

8.3. HPH6

- **Soil contamination:** concentrations of lead were locally elevated at one location requiring consideration in terms of protective measures for human health of future site users. The risk is assessed as Moderate/Low. There was no evidence of elevated concentrations of other metals, SVOC, VOC or PAH in shallow soils.
- **Groundwater:** there was no evidence of elevated SVOC or VOC in the Lynch Hill Gravels and therefore no special protection measures would be required. The risk to the Lynch Hill Gravels as a Principal Aquifer was assessed as Moderate due to elevated concentrations of VC and TCE outside the planning application area to the east.
- **Ground gases:** there was no evidence of putrescible material that would give rise to ground gas hazards from carbon dioxide or methane. The assessment against CIRIA C665 determined that no special protective measures were required with a CS1 classification. The concentrations of vapours from TCE and VC from groundwater were below the long term and short term EALs so no special protection measures would be required in buildings.

Recommendations:

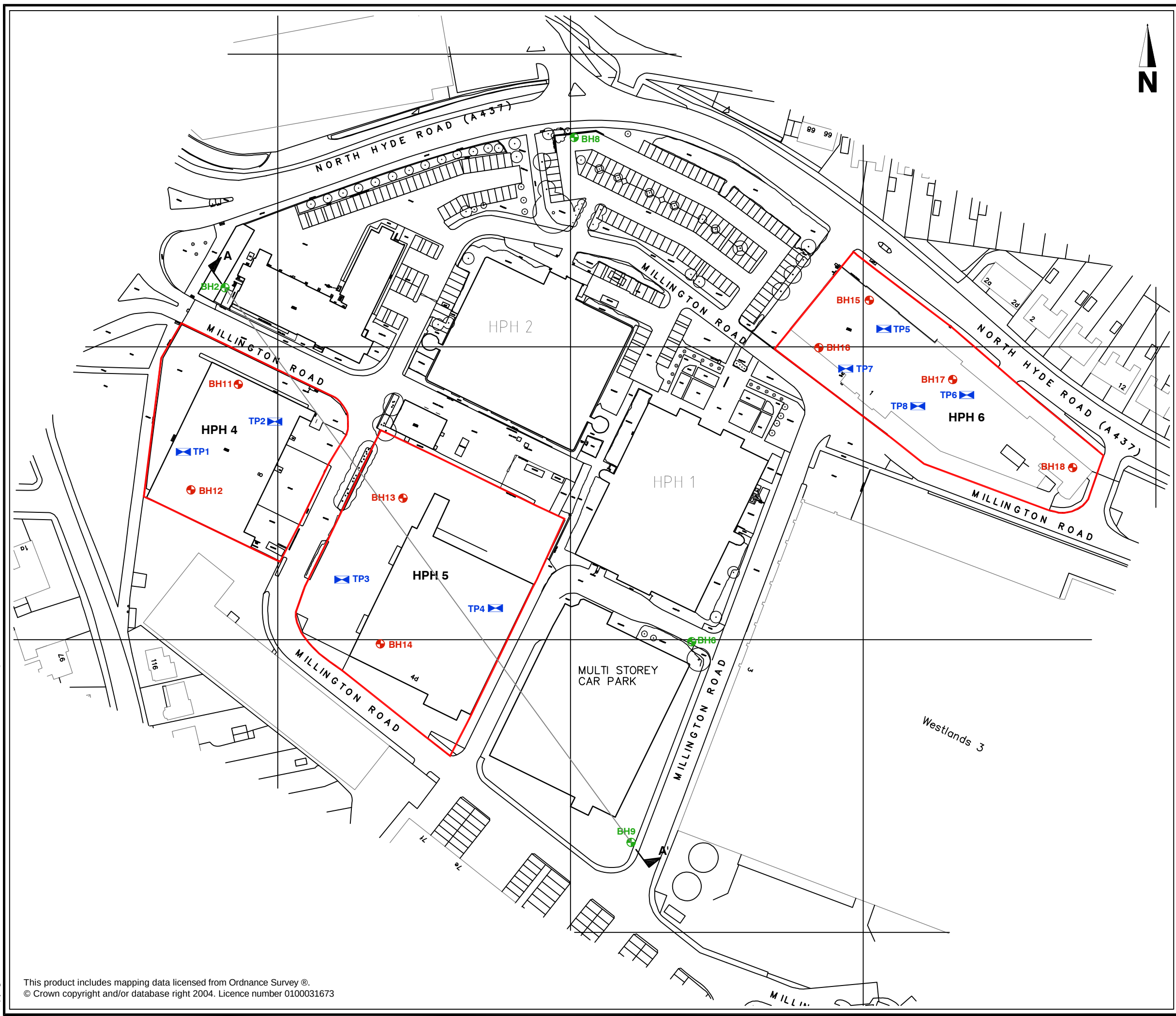
- Ensure that “clean” soil forming materials are used to provide a growing medium for areas of soft landscaping. An appropriate thickness of imported soil greater than 300mm should be used as a barrier to contact with underlying elevated lead in localised areas.
- Due to the relatively high water table, basement areas would require appropriate water proofing treatments to prevent groundwater ingress.



FIGURES

- Figure 1 Exploratory Location Plan**
- Figure 2 Levels at the Surface of the London Clay and Contours**
- Figure 3 Cross Section A – A”**
- Figure 4 Groundwater Levels and Contours from Boreholes Screened within the Lynch Hill Gravels**

File name: AJR9837.dwg
Plot date: Oct 11, 2012 - 9:22am
Ref: \\Enviros\Design\PROJECTS\JLW\JL30529\Figures\



KEY:

- SKME Percussion Boreholes
- Delta Simons Boreholes
- SKME Trial Pits
- Section Line A - A' (BH2 to BH9)
(For Detail, See Figure 3)

HPHA LTD

PHASE 2
SITE INVESTIGATION

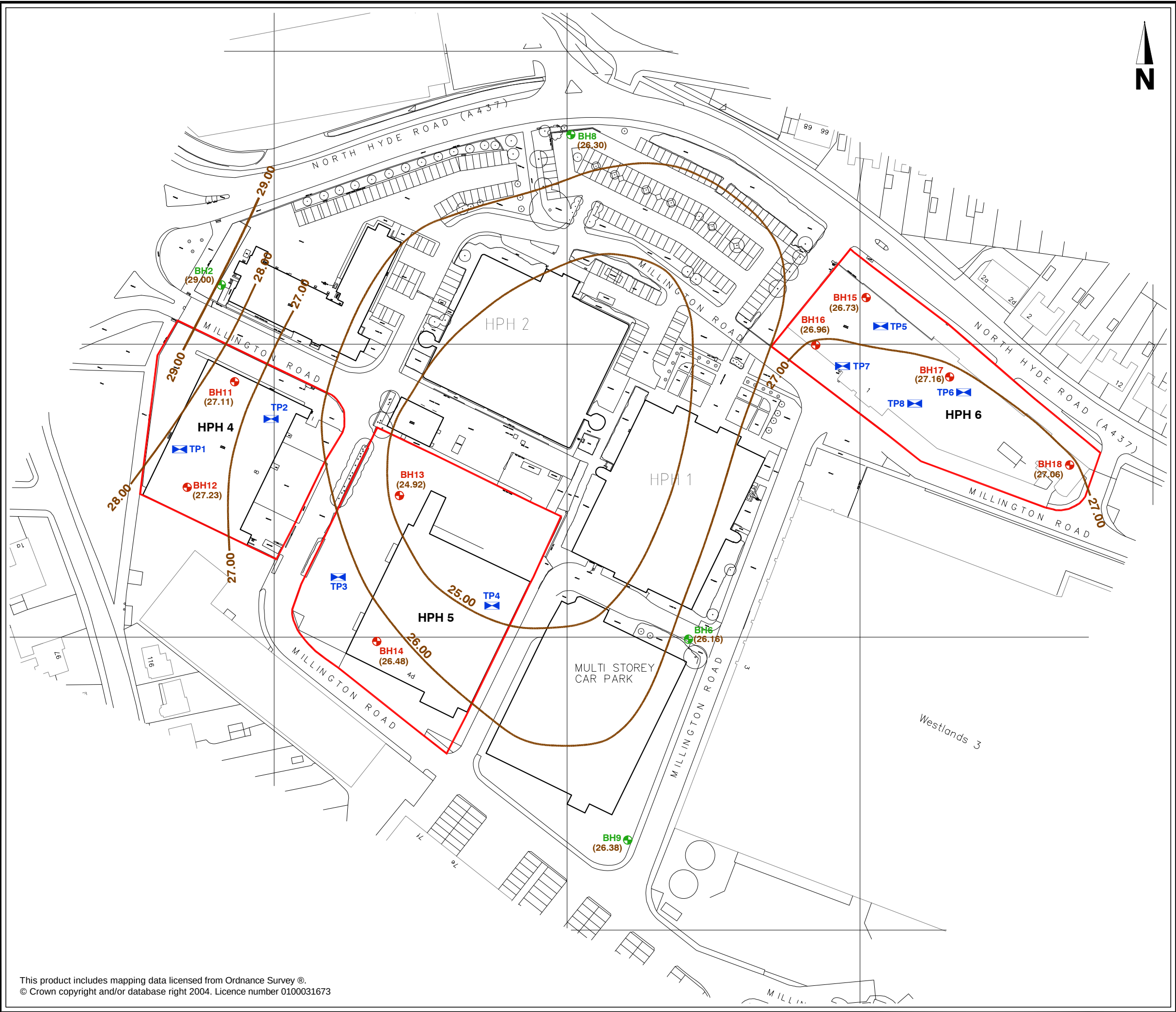
FIGURE 1
EXPLORATORY HOLE
LOCATION PLAN

SCALE	1:1250 @ A3	PROJECT No.	JL30529
CONTENT	RLP	DRAWN	AJR
CHECKED	RLP	DATE	AUGUST 2012



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KEY:

- SKME Percussion Boreholes
- Delta Simons Boreholes
- SKME Trial Pits
- Top of London Clay Contours mAO
- Top of London Clay Levels mAO

HPHA LTD

PHASE 2
SITE INVESTIGATION

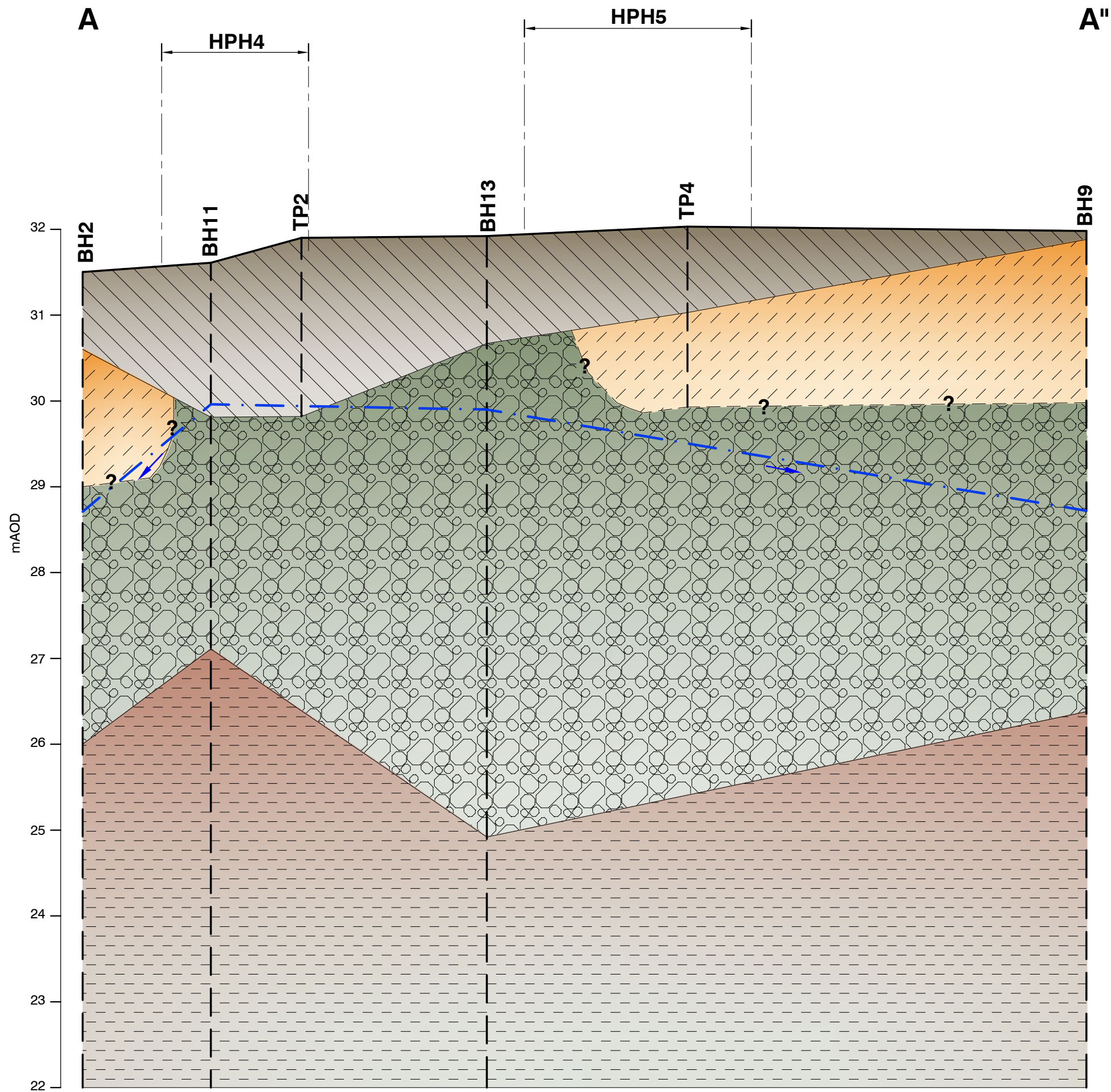
FIGURE 2
ORDNANCE DATUM LEVELS AT THE
TOP OF THE LONDON CLAY
FORMATION

SCALE	1:1250 @ A3	PROJECT No.	JL30529
CONTENT	RLP	DRAWN	AJR
CHECKED	RLP	DATE	AUGUST 2012



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File name: AJR9844.dwg
Plot date: Oct 11, 2012 - 9:26am
Ref: I:\Enviros\Design\PROJECTS\JLWM\JL30529\Figures\



- KEY:
- Made Ground
 - Langley Silts
 - Lynch Hill Gravels
 - London Clay
 - Groundwater (2nd Round 9/8/12)

HPHA LTD

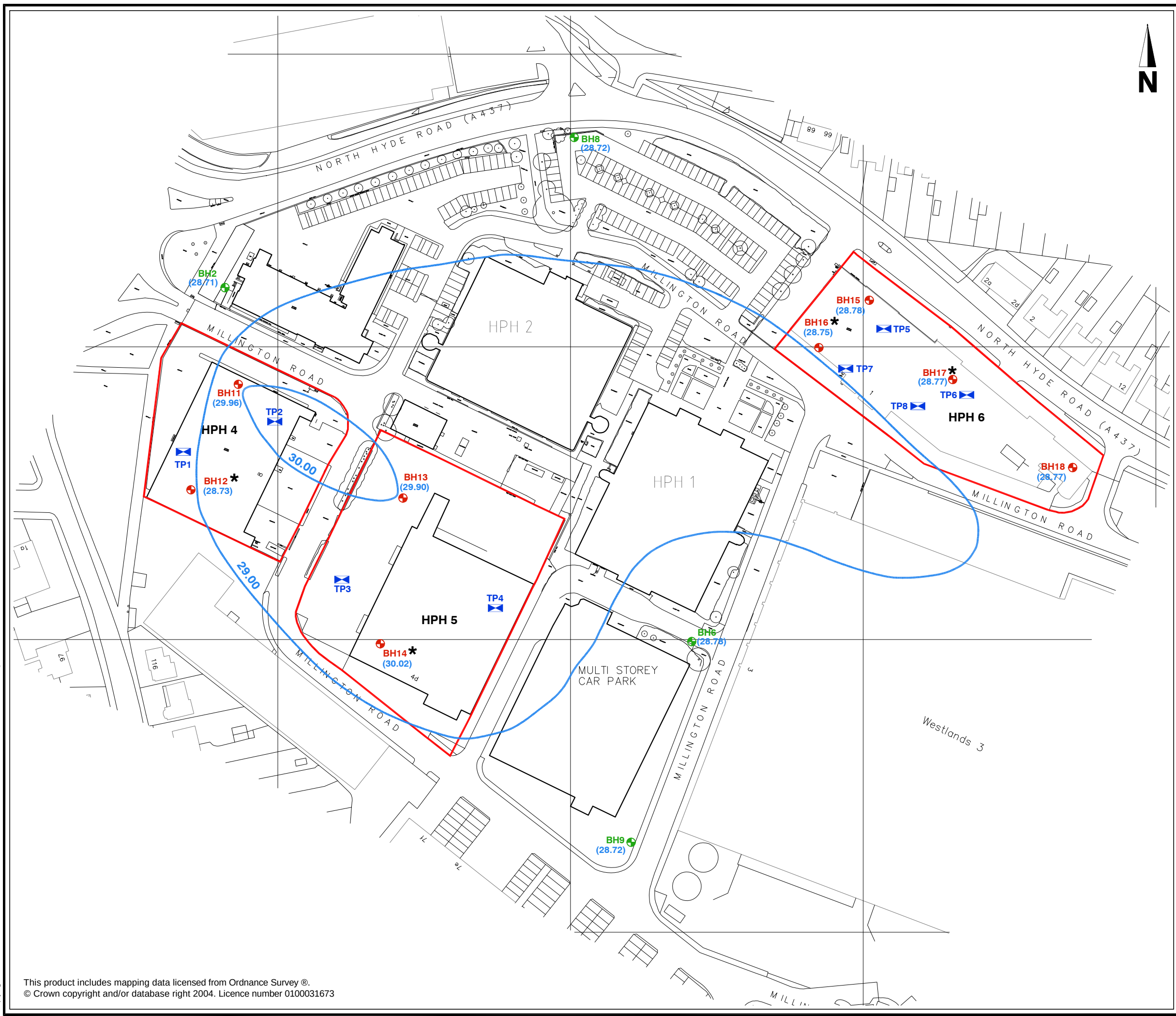
PHASE 2
SITE INVESTIGATION

FIGURE 3
CROSS SECTION A-A''

SCALE	PROJECT No.
1:1000 H, 1:50 V	JL30529
CONTENT	DRAWN
RPL	AJR
CHECKED	DATE
RPL	AUGUST 2012



File name: AJR9843.dwg
Plot date: Oct 11, 2012 - 9:28am
Ref: \\Enviros\Design\PROJECTS\JL30529\Figures\



KEY:

- SKME Percussion Boreholes
- Delta Simons Boreholes
- SKME Trial Pits
- Groundwater Contour mAOD
- Groundwater Level mAOD
- Boreholes screened in the London Clay - excluded from groundwater contours

NOTE:
Groundwater levels taken from Round 2, 9/8/12, within boreholes screened within gravels.
Groundwater depths mAOD reported to Ordnance Survey Grid

HPHA LTD

PHASE 2
SITE INVESTIGATION

FIGURE 4
GROUNDWATER LEVELS AND
CONTOURS FROM BOREHOLES
SCREENED WITHIN THE LYNCH
HILL GRAVELS

SCALE	1:1250 @ A3	PROJECT No.	JL30529
CONTENT	RLP	DRAWN	AJR
CHECKED	RLP	DATE	AUGUST 2012



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