Environmental Assessment (Southern Area) Broadwater Road Site, Welwyn Garden City, AL8 6UN, UK

On behalf of:
Wheat Quarter Limited

Project Reference:
016-1512

Revision:
REV 01

Date:
September 2018

Earth & Marine Environmental Consultants Limited
7th Floor, West One,
Forth Banks, Newcastle Upon Tyne,
NE1 3PA, UK

enquiry@eame.co.uk
www.eame.co.uk

United Kingdom | Romania | Iraq | Kurdistan Region of Iraq | Guyana

Earth & Marine Environmental Consultants Limited is a company registered in England and Wales.
Registered number: 7256990. Registered office: Fron Fawr Farm, Llanfairtalhaiarn, Abergele, Clwyd, Wales, LL22 8DJ, UK

Document Control Record				
Revision	**Date**	**Author(s)**	**Authorised by**	**Reason for Change**
00	23/03/18	MS/DW/TN	SPR	DRAFT
01	19/09/18	MS/DW/TN	SPR	Revised with SVS and Gas Assessment

COMMERCIAL-IN-CONFIDENCE

This document and all the information contained within it are proprietary to Earth and Marine Environmental Consultants Ltd (hereinafter called EAME) and are supplied in confidence. This document is not to be reproduced in whole or in part nor disclosed to any third party without the prior written permission of EAME. Nor shall it be used otherwise than for the purpose for which it has been supplied.

Contents

Figures

Tables

Photographs

Annexes

1 Introduction

1.1 Background

Earth & Marine Environmental Consultants Ltd ("EAME") was commissioned by Wheat Quarter Limited ("the Client") to undertake an environmental risk assessment in relation to a parcel of land located at Broadwater Road, Welwyn Garden City, AL8 6UN, UK ("the Site") (*Figure 1.1*). It is understood that the Client is planning to redevelop the site as a mixed development with residential properties (without gardens), office, retail, and leisure elements ("Proposed Development"). This report relates solely to the southern area of the development (*Figure 1-1*). A separate report will deal with the northern area, which has a different site history and contamination status to the southern site.

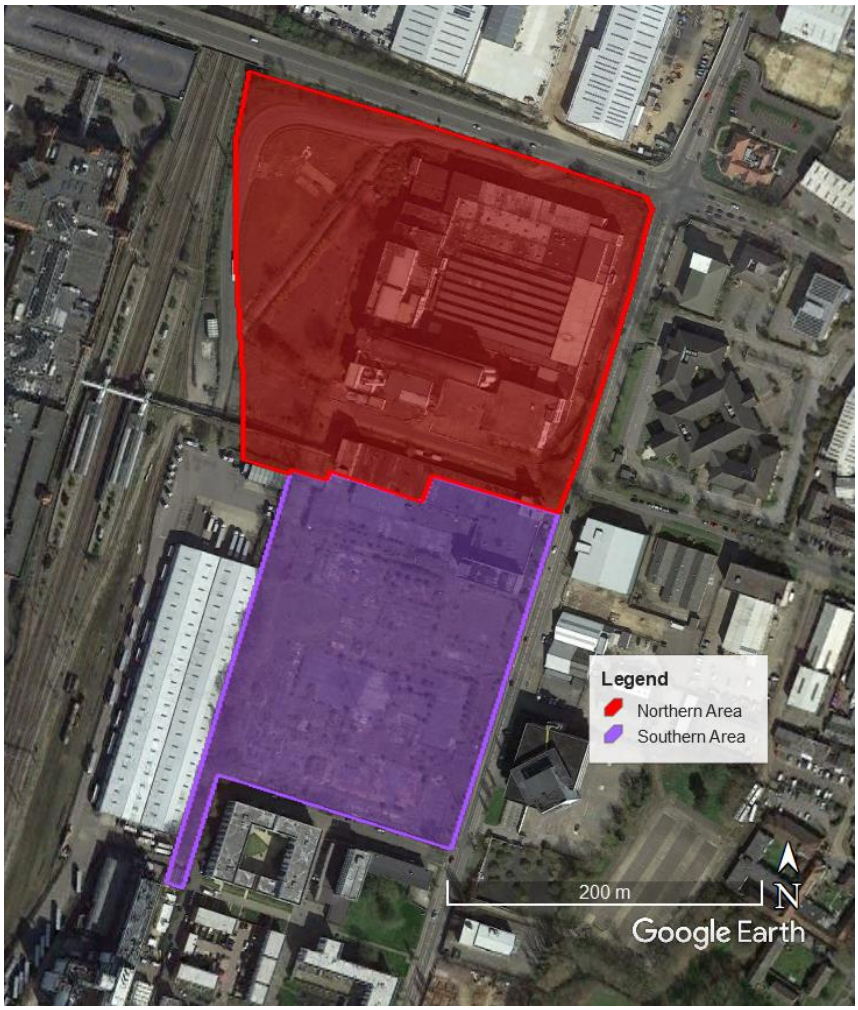


Figure 1-1: *Proposed Development Area*

Google Earth Imaging with the permission of Google – Licensed to Earth and Marine Environmental Consultants Ltd.

2 Phase I Environmental Assessment

2.1 Introduction

The site has been the subject of several Phase I Environmental Assessments since 1998, namely:

- Feb-1998 – Phase I Environmental Assessment (Ref. R2109) for Williams PLC by Dames and Moore (*Report not available*).
- July-2006 – Combined Phase I/II Environmental Assessment Cereal Partners (UK) Broadwater Road, Welwyn Garden City (Ref. 05-3046.01) for Cereal Partners (UK) by Delta-Simons (*Report available*).
- Jan-2015 – Phase I Environmental Assessment, Former Shredded Wheat Factory, Broadwater Road, Welwyn Garden City (Ref. 2342.17 V2) for Spen Hill Developments Ltd by Delta-Simons (*Report available*).

This Chapter outlines a summary of the current environmental conditions, where possible referring to previous Phase I Environmental Assessments (outlined above), as well as incorporating recent changes and updates associated with EAME's recent works at the site. Welwyn and Hatfield Borough Council has already formally accepted the Delta-Simons Phase I Environmental Assessment (Ref. 2342.17 V2) in relation to planning application reference N6/2015/0294/PP.

2.2 Site Location and Setting

The site is split into two distinct areas via a public road (Hydeway). As these are two distinct land parcels they are described separately and will be dealt with separately in terms of investigation and remedial activities. The broad distinction in contamination terms being that the northern site has had a relatively benign development history (food production), whereas the southern site has a known contaminative history

2.2.1 Northern Site

The northern site is approximately 5.3 ha and is accessed via Hydeway off Broadwater Road (A1000). The Site is located centrally within the town of Welwyn Garden City at National Grid Reference (NGR) TL 24199 12957 (51.801470, -0.20019472). The land is relatively flat and lies at an elevation of between 84 and 85 metres above ordnance datum (AOD). The site was 95% covered with buildings most of which (apart from those with Grade II listing) were demolished as part of the demolition site clearance activities.

The following current uses were identified surrounding the northern Site:

- **NORTH** – Bridge Road beyond which is a large-scale retail park.
- **EAST** – Broadwater Road (A1000) beyond which are commercial premises and offices.
- **SOUTH** – Hydeway beyond which is the southern Site.
- **WEST** – Railway lines (East Coast Mainline) associated with Welwyn Garden City station beyond which is the Howard Centre (2-storey mall with high-street fashion shops and department stores).

2.2.2 Southern Site

The southern site is approximately 3.6 ha in area and is also accessed via Hydeway off Broadwater Road (A1000) (*Figure 2-1*). The site is located centrally within the town of Welwyn Garden City at National Grid Reference (NGR) TL 24134 12739 (51.799529, -0.20121127). The site is relatively flat and lies at an elevation of between 84 and 85 metres above ordnance datum (AOD). As of September 2018, the site has been cleared of all above and below ground structures as part of the demolition site clearance activities.

The following current uses were identified surrounding the southern Site:

- **NORTH** – Hydeway beyond which is the northern Site.
- **EAST** – Broadwater Road (A1000) beyond which are commercial premises and offices.
- **SOUTH** – Disused Roche Products facility (buildings Grade II listed) and multiple residential blocks.
- **WEST** – P.W Gates Distribution Ltd warehouse (southern hub) beyond which are railway lines (East Coast Mainline) associated with Welwyn Garden City station and car parking.

The site is located within the jurisdiction of Hertfordshire County Council and Welwyn Hatfield Council (district council).

The remainder of this report will solely discuss the environmental aspects associated with the southern site.

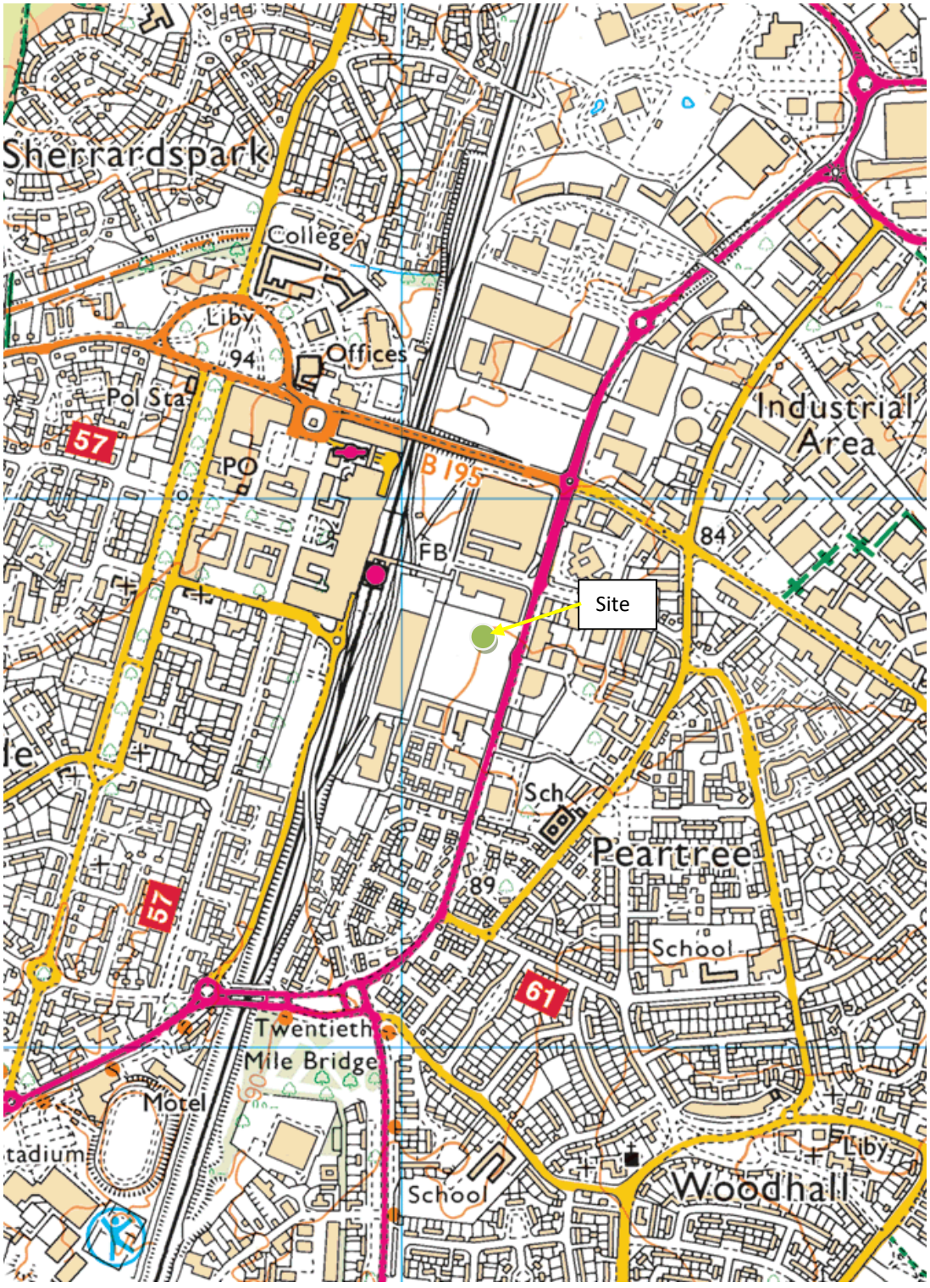


Figure 2-1: *Site Location*

Ordnance Survey 1: 25,000 scale map - with the permission of The Controller of Her Majesty's Stationery Office, Crown Copyright Earth and Marine Environmental Consultants Ltd, Licence No. 100050755

2.3 Southern Site History and Zoning

As part of the environmental assessment, historical maps, photographs and previous assessments were obtained and reviewed by EAME to determine the historical development of the site and identify potentially contaminative activities

The southern Site has been divided into three zones based on historic uses (*Figure 2-2*).

Figure 2-2: *Southern Site Zoning*

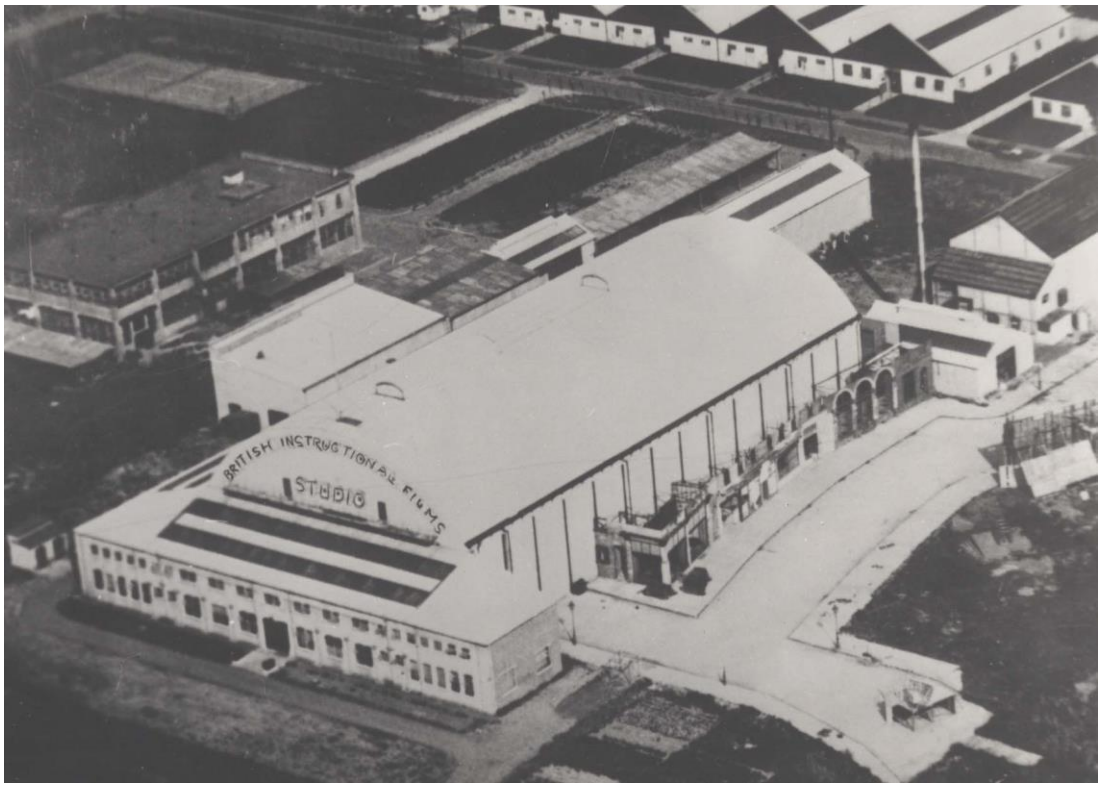
Google Earth Imaging with the permission of Google – Licensed to Earth and Marine Environmental Consultants Ltd.

The historical characteristics and potential environmental issues within each of the identified zones is outlined below.

2.4 Zone S01 – Polycell factory

2.4.1 Introduction

The Site was initially developed between 1925 and 1939, with the land immediately adjoining the site to the north and south developed between 1966 and 1976. The original use of the Site was as a film studio (*Photograph 2-1*) that opened in 1928.



Photograph 2-1*:British Instructional Films (BIF) (Broadwater Road Studio)*[1]

After this the site was taken over by Ardath Tobacco Company Ltd (1940s - 1960) and then by Polycell (1964). The Polycell Site ceased operation in late 1998.

A Dames and Moore Report (2000)[2] states that the Polycell facility produced a range of DIY products including Polyfilla and associated products, wallpaper adhesives and paint cleaning fluids. The primary operations carried out on site involved mixing of raw materials and packaging of products.

1 http://www.ourwelwyngardencity.org.uk/content/topics/the_workplace/film_studios/film_studios
2 Dames and Moore (2000). FINAL FACTUAL REPORT - POLYCELL PRODUCTS LIMITED, WELWYN GARDEN CITY FOR WILLIAMS PLC, Ref: R2779/38842-019-401/WH, 14 July 2000

There were two principal areas of production; the Polyfilla powder and paste area and the liquids area.

The Polyfilla and paste area was used primarily to produce dry products and some liquid pastes and was located at the western corner of the site. Associated with this area was a wastewater tank for receiving the washing water from the paste lines. The warehouse was adjacent to the powders and paste building and was used for storage of all products produced on the Site.

The liquids area, located at the northern end of the Site, was used to produce paint strippers and brush cleansers (*Figure 2-3)*.

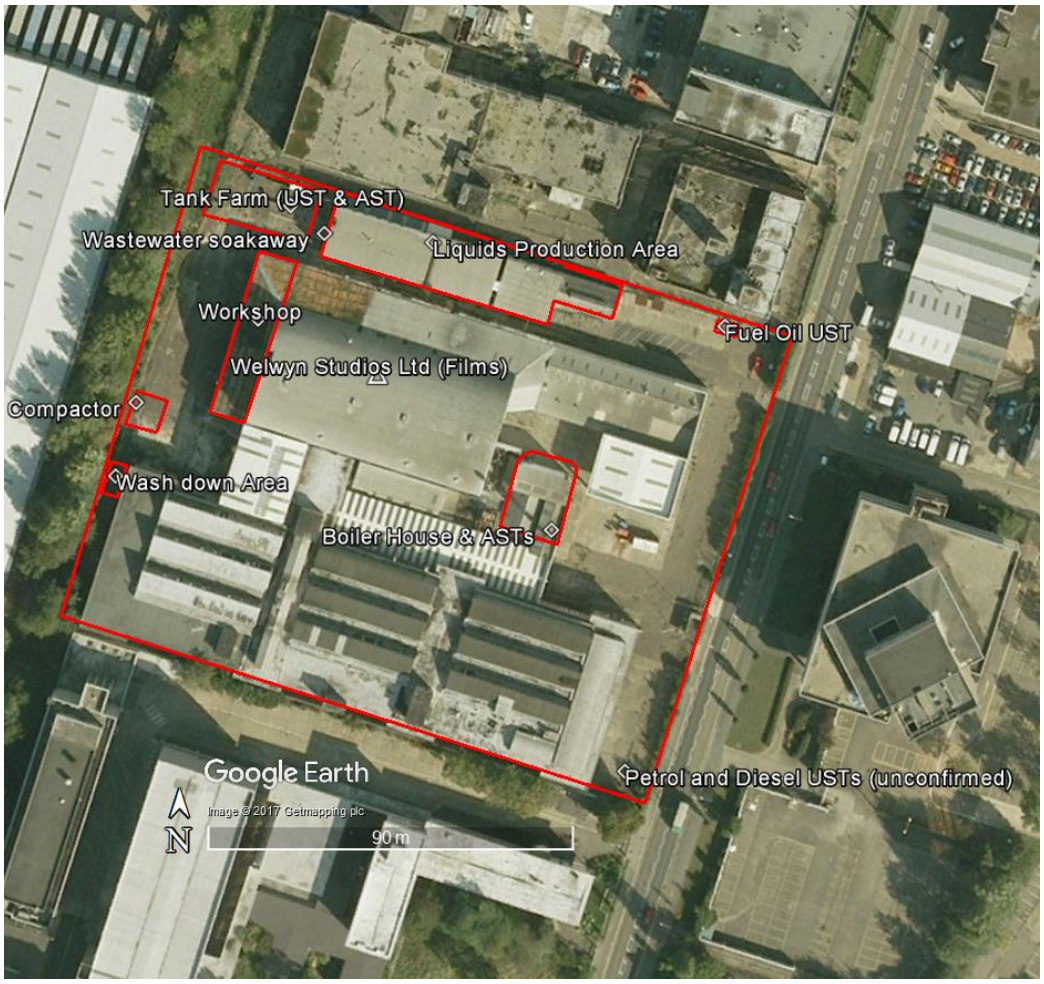


Figure 2-3: *Key potential contamination sources – Polycell Factory (2006)*

Google Earth Imaging with the permission of Google – Licensed to Earth and Marine Environmental Consultants Ltd.

Associated with the liquids area was a solvent tank farm (*Figure 2-4*) comprising 13 (six in use when the site was operational, seven redundant) underground storage tanks (USTs) and one above ground storage tank (AST).

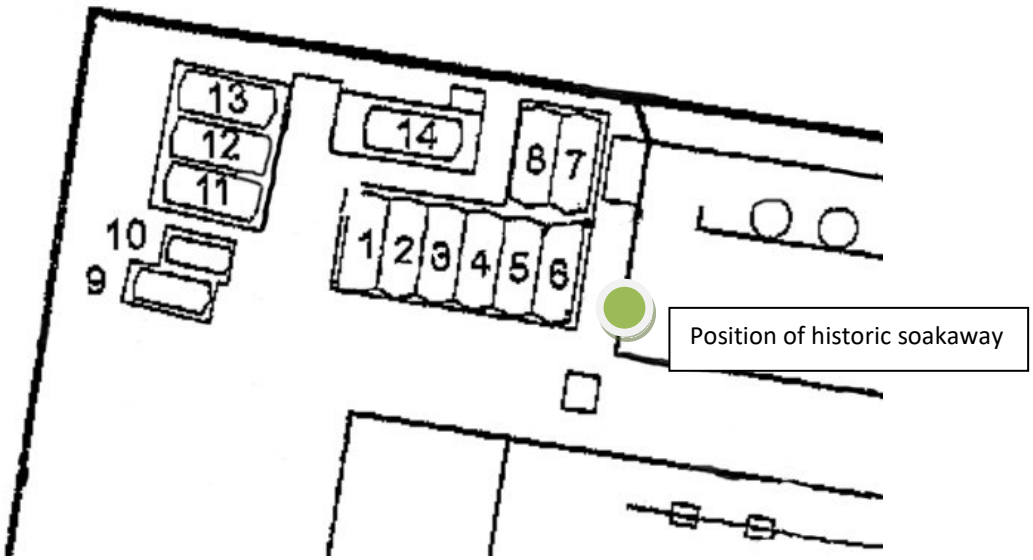


Figure 2-4: *Layout of Polycell tank farm and historic soakaway*[3]

Naphtha, white spirit and methanol were stored in the six 4,000-gallon USTs (tanks 7 & 8, 5 & 6, and 3 & 4 respectively) and methylene chloride was stored in a 6,250-gallon AST (tank 14). The seven redundant tanks have volumes ranging from 1,500 to 6,000 gallons and were used to store white spirit, derv, IPA, oxtail, naphtha, turps and methanol.

Other areas of interest noted by Delta-Simons are outlined in *Table 2-1*.

Table 2-1: *Polycell Factory – Areas of interest*

Item	Delta Simons Observations	EAME Observations
Heavy fuel oil boiler and ASTs	A boiler room located in the centre of the site with three heavy fuel oil ASTs in the adjacent room.	Confirmed (51.798973°, -0.200918°) No staining or hydrocarbon odours noted around the area of the previous activity.

3 Modified from URS Presentation (October 2000), Polycell products Ltd, Welwyn Garden City, Findings of Site Investigations and Risk Assessment, Welwyn Hatfield Council Offices, 12th October 2000.

Item	Delta Simons Observations	EAME Observations
Diesel and Petrol USTs	In the eastern corner of the site, it is reported that two USTs were used historically for diesel and petrol. These tanks were cleaned, decommissioned and in-filled with concrete in the late 1970s.	Unconfirmed. John F Hunt (demolition contractor) did not uncover any USTs in the eastern corner of the factory during the demolition and site clearance process.
Wastewater soakaway	The site formerly held a waste management licence to dispose of industrial effluent from wastewater treatment to a soakaway located near to the tank farm (*Figure 2-4*).	Confirmed (51.799629°, -0.201730°) Approximate location only
Fuel Oil USTs	In 2013 Delta-Simons[4] reported two fuel oil USTs located near to the northern edge of the Site. The USTs are described in *Section 2.4.2*.	Confirmed (51.799437°, -0.200312°)
Firing range	In the 2015 Delta-Simons[4] reported evidence of basements under part of the southern Site, which may have been used as a rifle range. During the remediation works Delta-Simons identified the presence of deep flooded ducts close to the southern boundary of the Site which contained lagged pipework with asbestos warning labels. The firing range is described in *Section2.4.3*.	Confirmed (51.798894°, -0.202270°)

2.4.2 Fuel Oil USTs

During the slab removal John F Hunts uncovered two USTs in June 2018. It was reported that the two tanks were each approximately 1,000 gallons. The USTs were found to have been cleaned in place and sand filled. John F Hunts reported a slight diesel odour from within the tanks as they were removed from Site (*Photograph 2-2*). No perched groundwater or

4 Delta-Simons (2015). Phase I Environmental Assessment, Former Shredded Wheat Factory, Broadwater, Road, Welwyn Garden City for Spen Hill Developments Ltd, Delta-Simons Project No. 2342.17 V2

evidence of hydrocarbon impacted soils was noted upon removal of the USTs (*Photograph 2-3*).

Photograph 2-2: *USTs removed from southern site*

Photograph 2-3: *Base of pit where USTs were removed from*

2.4.3 Firing Range

In 2015 Delta-Simons reported evidence of basements under part of the southern Site, which may have been used as a rifle range (*Figure 2-5*). In addition, Delta-Simons identified the presence of surface water flooded ducts close to the southern boundary of the Site which contained lagged pipework with asbestos warning labels.

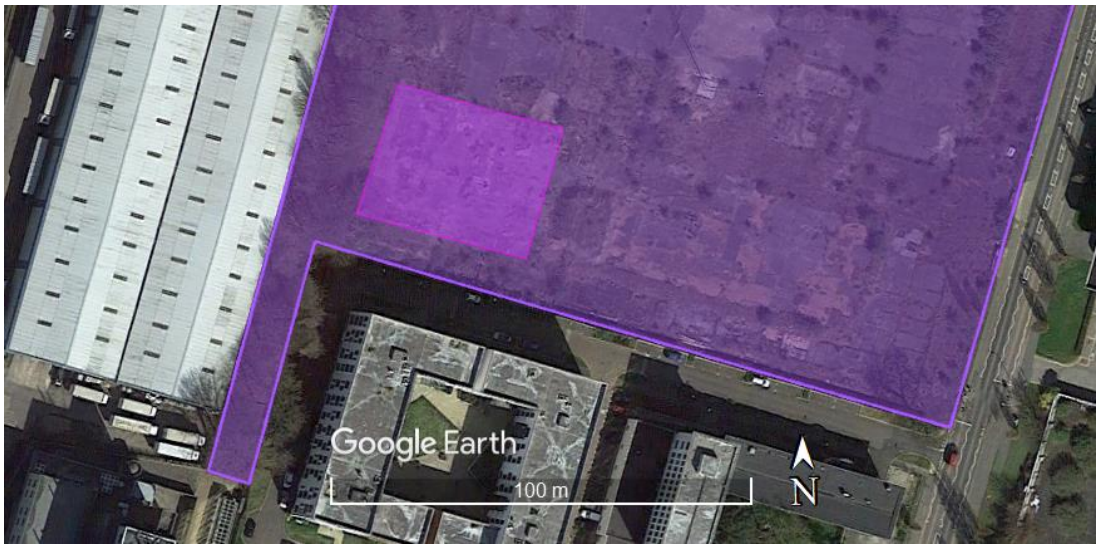


Figure 2-5: *Location of below ground historic firing range*

During the slab removal process John F Hunts surveyed the extent of the firing range before demolition works were undertaken. The area was found to be an extensive 1.5-2.0 metre-deep 2,000 m^2 basement (*Photograph 2-5*) with an attached historic firing range (*Photograph 2-4*).

Photograph 2-4: *Demolition of the firing range tunnels*

Photograph 2-5: *Demolition of the firing range tunnels and basement*

The sediment and water within the basement and associated ducts were sampled by John F Hunts for off-site treatment and disposal. The results of this work, including the asbestos survey and strip of the ducts, are provided under a separate cover.

2.5 Zone S02 – Suchard Chocolate Factory

The historical maps for the area have been reviewed to assess historical land use of the Suchard Chocolate Factory Site. From 1878 until 1923, the Site is undeveloped agricultural land. By 1938, the Site is occupied by an electric heater manufacturer and a single railway track which travels north towards the centre of the Site. By 1960, the Site is labelled as a 'unspecified factory', and the railway track is no longer present. By 1968, the Site is labelled as a confectionary factory.

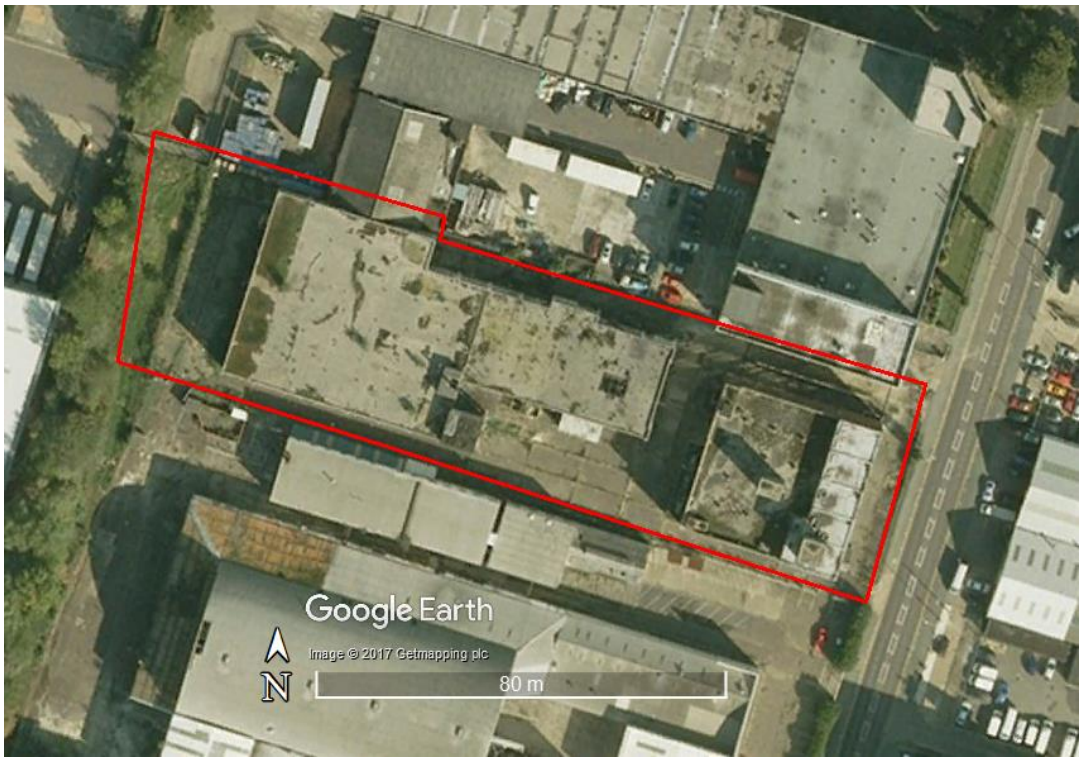


Figure 2-6: *Footprint of previous Suchard Chocolate Factory (2006)*

Google Earth Imaging with the permission of Google – Licensed to Earth and Marine Environmental Consultants Ltd.

The Site was operated by Suchard as a regional distribution unit and offices until closure in the mid-1970s. No specific sources of contamination have been identified associated with the use of the Site by Suchard's.

2.5.1 Cement-based Asbestos Containing Materials

An area (approximately 15 metres x 12 metres) of broken cement-based asbestos containing materials (ACMs), Asbestos Insulating Board (AIB) and fibrous lagging was located by John F Hunts during the removal of the slab (51.799862°, -0.200896°). John F Hunts initially

removed approximately 20 bags of material before the area was quarantined (*i.e.* fenced and signed) (*Photograph 2-6* and *Photograph 2-7*).

Photograph 2-6: *Area of ACM find*

Photograph 2-7: *Quarantine area with visible cement-based ACMs*

The resulting remediation and verification of this area is described within the stand-alone John F Hunt Report (provided under a separate cover).

2.6 Zone S03 – Cereal Partners Facility (South of Hydeway)

The historical maps for the area have been reviewed to assess historical land use of the Cereal Partners Facility (South of Hydeway). From 1878 until 1923, the Site is undeveloped agricultural land. By 1938, part of the Site is used for electric heater manufacturing by Unity Heating (Young, Osmond & Young Ltd.) (central southern area), while a tennis court occupies the north-eastern corner. By 1960, works occupy the southern area of the Site while a factory occupies the northern part of the Site. By 1968, the works in the southern part of the Site are labelled as plastics engineering works, and the factory in the northern part of the Site is labelled as a biscuit factory. In addition, a tank is noted to be associated with the biscuit factory (southern side of building facing the yard area) (1968 map).

Figure 2-7: *Key potential contamination sources – Cereal Partners South Site (2006)*

Google Earth Imaging with the permission of Google – Licensed to Earth and Marine Environmental Consultants Ltd.

A Delta-Simons Report (2006)[5] reports that the Site to the south of Hydeway was noted to be occupied by two large buildings. Of these, one was being utilised as a warehouse for the storage of food process raw materials and packaging products (Cromac Building), the other was being used as a food research and development laboratory for the development of new products (CPW R&D). A maintenance warehouse and associated storage yard was also noted, as was a portacabin, which housed hygiene services. To the west of the portacabin was an area of hardstanding, which was being utilised as car parking.

In terms of contamination potential and environmental risks it is the former polycell area (Zone S01) that is of most interest and the focus of the substantive assessment works set out in this report.

5 Delta-Simons (2006). Combined Phase I/II Environmental Assessment, Cereal Partners (U.K), Broadwater Road, Welwyn Garden City for Cereal Partners (U.K.), DELTA-SIMONS PROJECT NO. 05-3046.01

3 Environmental Setting

3.1 Introduction

Desk-based research of the local geology, hydrogeology, hydrology and ecology was carried out to establish the potential for migration of contamination onto or away from the site, and to assess the surface water and groundwater sensitivity of the surrounding area. Information was obtained from several sources, namely:

- inspection of the British Geological Survey (BGS) information *i.e.* Geology of Britain Viewer, Lexicon of Named Rock Units and borehole logs for the area[6];
- examination of the Environment Agency's (EA's) on-line aquifer classification[7];
- examination of EA's flood map for planning[8];
- a review of MAGIC geographic information about the natural environment from across UK government[9]; and
- a review of online web-based information searches.

The significance of the environmental Site setting is provided below.

3.2 Geology

The relevant British Geological Survey (BGS) 1:50,000 map of the area (Sheet 239, Hertford, drift, 1:50,000, 1996) (*Figure 3-1*) and the BGS Geology of Britain Viewer, outline that the site is directly underlain by:

- **Superficial deposits** – The northern part of the site is underlain by Kesgrave Catchment Subgroup (Sand and Gravel) and the southern area by Boulder Clay (Lowestoft Formation – Diamicton).
- **Bedrock deposits** – The entire site is underlain by Lewes Nodular Chalk Formation and Seaford Chalk Formation (undifferentiated).

[6] http://www.bgs.ac.uk/
[7] http://maps.Environment-agency.gov.uk/
[8] https://flood-map-for-planning.service.gov.uk/
[9] http://www.natureonthemap.naturalengland.org.uk/

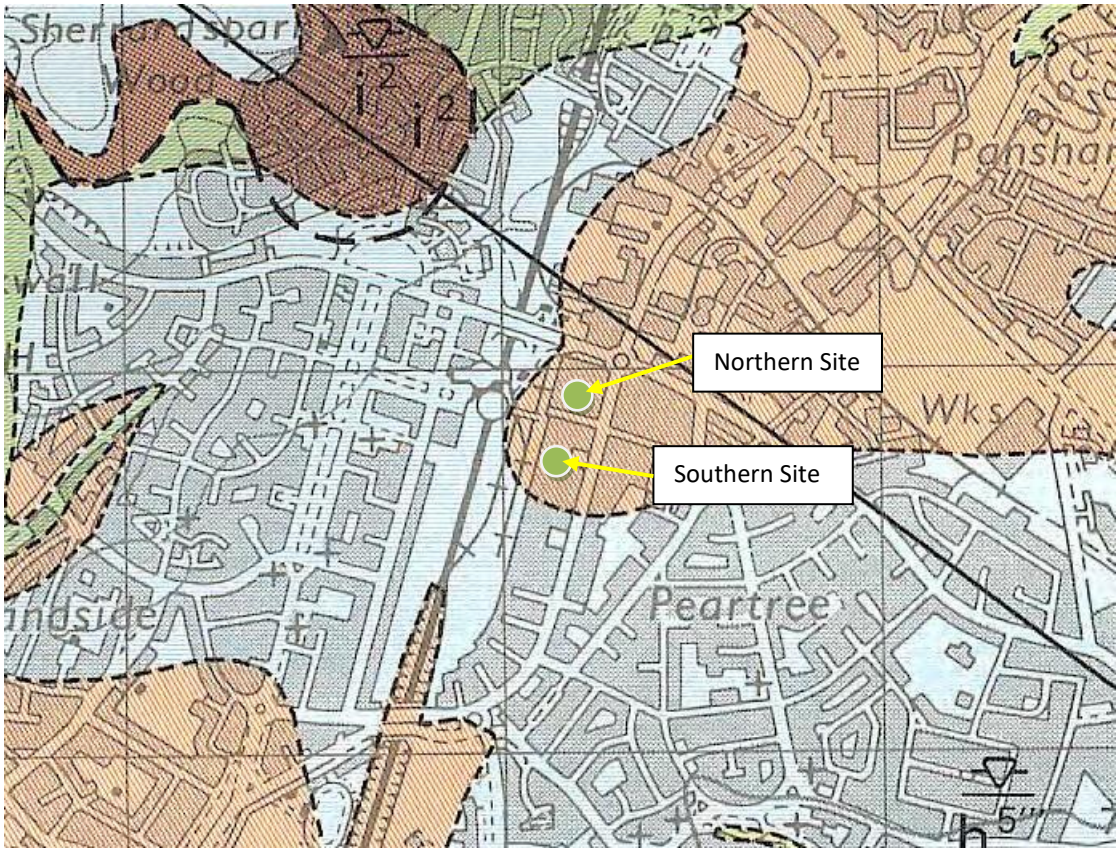


Figure 3-1: *Site Geology*

British Geological Survey (http://www.largeimages.bgs.ac.uk/iip/mapsportal.html?id=1001732)

Two BGS boreholes are recorded adjacent to the site:

- BGS ID: 533333: BGS Reference: TL21SW22/A (British National Grid (27700): 524000,212480) Depth 91.44 metres – Roche Products water abstraction borehole (off-site).
- BGS ID: 18726905: BGS Reference: TL21SW211 (British National Grid (27700): 524090,212710) Depth 30 metres – WR38 record related to the remedial activities (2008).

3.3 Hydrogeology

The aquifer classification system was last updated on 1st April 2010 which provided new aquifer designations to replace the old system of aquifer classifications, such as Major, Minor and Non-Aquifer. This revised system is in line with the EA's Groundwater Protection Policy (GP3) and the Water Framework Directive (WFD) and is based on British Geological Survey mapping. From a review of the EA on-line maps the site is located on the following:

- **Superficial deposits** – The northern part of the Site is underlain by Kesgrave Catchment Subgroup (Sand and Gravel) and classified by the EA as a Secondary A Aquifer. These are defined as permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers. The southern area (Boulder Clay of the Lowestoft Formation – Diamicton) is classified by the EA as a Secondary (Undifferentiated) Aquifer. This has been assigned in cases where it has not been possible to attribute either category A or B to a rock type. In most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type.

- **Bedrock deposits** – The entire Site is underlain by Lewes Nodular Chalk Formation and Seaford Chalk Formation (undifferentiated). This is defined by the EA as a Principal Aquifer. These are layers of rock or drift deposits that have high intergranular and/or fracture permeability. They may support water supply and/or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as major aquifer.

The EA have defined Groundwater Source Protection Zones (SPZs) for 2000 groundwater sources such as wells, boreholes and springs used for public drinking water supply. These zones are designated to protect the location from the risk of contamination from any activities that might cause pollution in the area, *i.e.* the closer the activity, the greater the risk. The maps show three main zones; an inner, an outer and the total catchment with a fourth zone of special interest, which the EA occasionally apply, to a groundwater source. The EA website indicates that the entirety of the Site is within the Total Catchment Zone 3 (*Figure 3-2*).

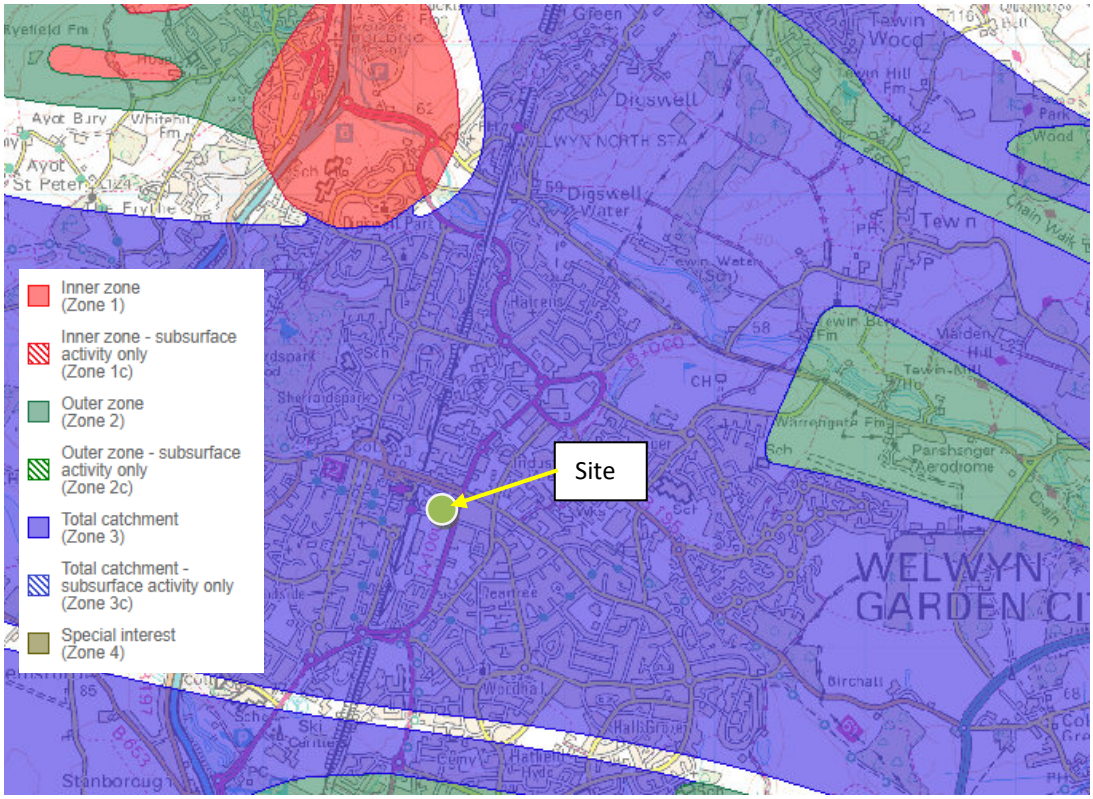


Figure 3-2: *Source Protection Zones*

http://maps.environment-agency.gov.uk/

3.4 Hydrology

The nearest surface watercourse to the Site is the River Mimram (1.75 km north) and the River Lee (1.76 km south southwest) (*Figure 3-3*).

There are no on-site water features.

3.4.1 Flood Risk

According to the EA flood mapping the Site is not located in a Flood Zone (Zone I, II, III) and is not at risk of flooding from rivers.

Parts of the Site are predicted to be at risk of surface water flooding (*Figure 3-4*).

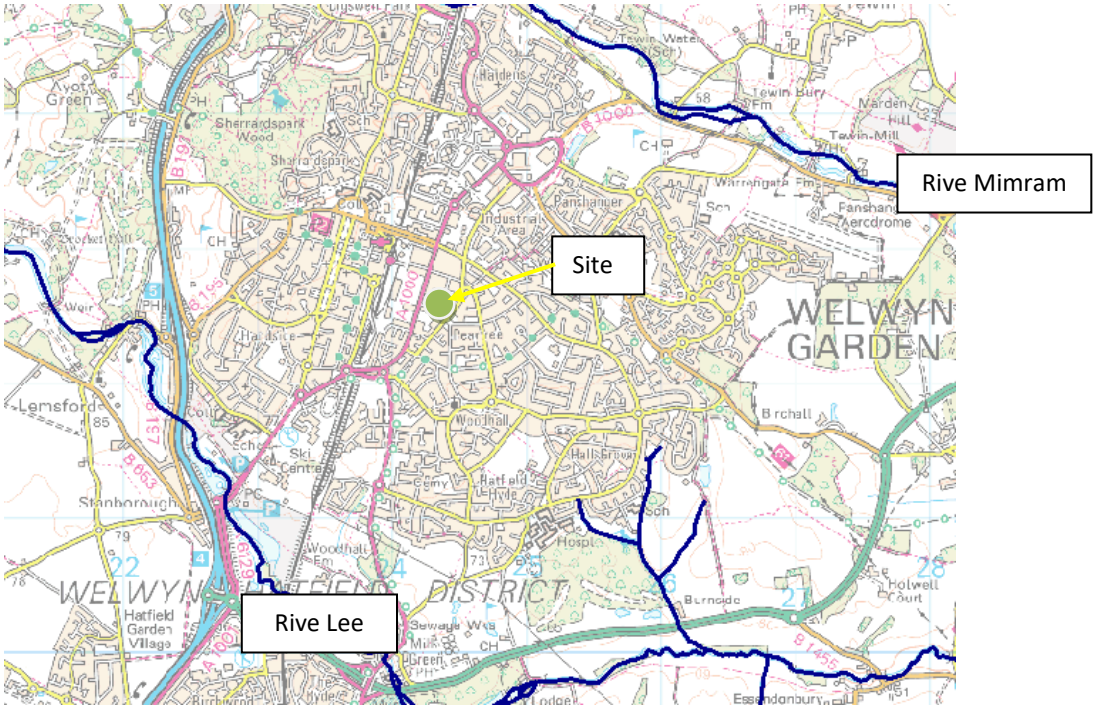


Figure 3-3: *Main Rivers*

http://maps.environment-agency.gov.uk/

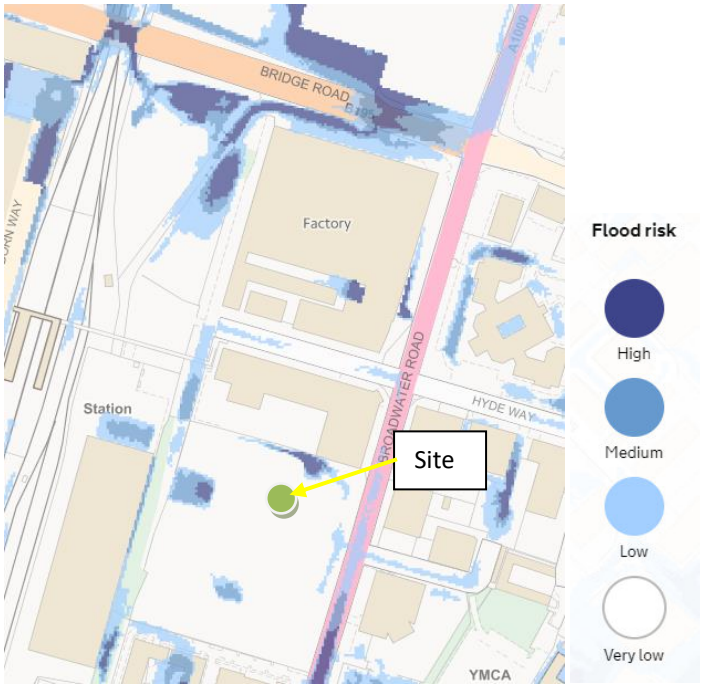


Figure 3-4: *Flood risk from surface water*

https://flood-warning-information.service.gov.uk/

3.5 Sensitive Land Uses

3.5.1 Ecological Receptors

The MAGIC website which is managed by the Department for Environment, Food and Rural Affairs (Defra), was queried to locate Sites of Special Scientific Interest (SSSI), Special Protection Areas (SPAs), Special Areas of Conservation (SACs), Ramsar Sites, National Nature Reserves (NNR), Areas of Outstanding Natural Beauty (AONB), National Parks and Local Nature Reserves (LNR) within 1-km of the Site. The closest designated site is the Sherrard Spark Wood SSSI, located c.940 metres to northwest of the Site (*Figure 3-5*).

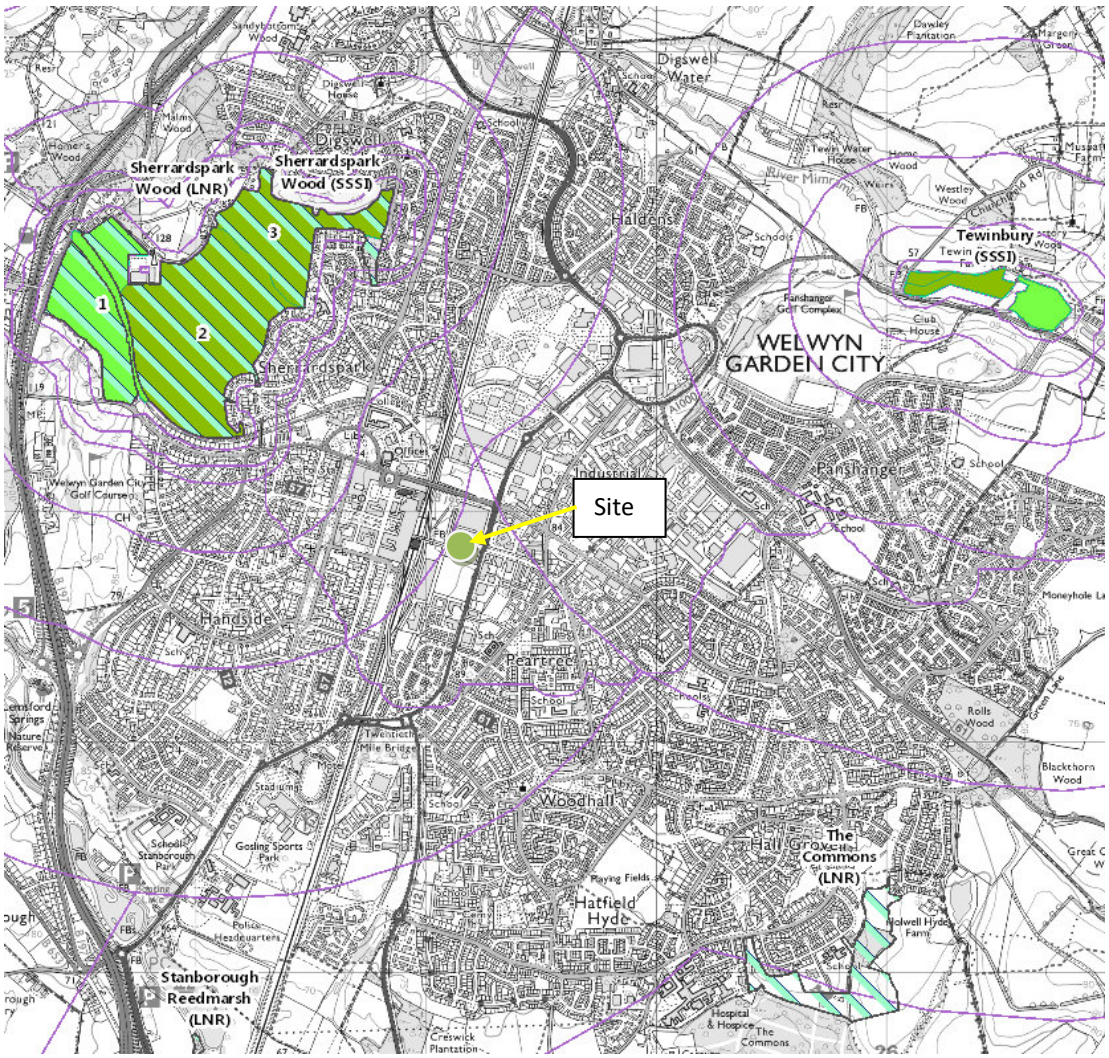


Figure 3-5: *Environmental landscape and ecological designations*

https://flood-warning-information.service.gov.uk/

3.5.2 Protected Buildings

Both the MAGIC and Historic England websites were queried to locate Scheduled Monuments, World Heritage Sites and Listed Buildings within 1-km of the Site. There is one listing associated with the northern Site:

- The Nabisco Shredded Wheat Factory, Reference1101084, Grade II, Legacy UID158251.

In addition, there is a single listed property immediately adjacent to the southern boundary:

- Office Block (Buildings 1 to 4) To Roche Products Factory, Reference1348142, Grade II, Legacy UID158234.

3.5.3 Residential Receptors

The closest residential properties (apartment block) are located approximately 15 metres from the southern Site boundary.

3.6 Significance of the Environmental Setting

The significance of the environmental setting is considered by EAME to be as follows:

- **Groundwater [HIGH SENSITIVITY]** – The Site is partially located on a Secondary A Aquifer and a Secondary (Undifferentiated) Aquifer (superficial deposits) and underlain by a Principal Aquifer (bedrock). The site is in the Total Catchment (Zone 3) of an SPZ.
- **Surface Water [LOW SENSITIVITY]** – The nearest surface watercourse to the Site is the River Mimram (1.75 km north) and the River Lee (1.76 km south southwest).
- **Flood Risk [LOW SENSITIVITY]** – The site is not located in area at risk of flooding due to Rivers. Parts of the Site are predicted to be at risk of surface water flooding.
- **Ecological Sensitive Areas [LOW SENSITIVITY]** – The closest designated site is the Sherrard Spark Wood SSSI, located c.940 metres to northwest of the Site.
- **Protected Buildings and Structures [MODERATE SENSITIVITY]** – There is one listing associated with the Site *i.e.* The Nabisco Shredded Wheat Factory, Reference1101084, Grade II, and one property immediately adjacent to the southern boundary *i.e.* Office Block (Buildings 1 to 4) To Roche Products Factory, Reference1348142, Grade II.
- **Residential Areas [HIGH SENSITIVITY]** – With respect to residential properties the site is in a highly sensitive area (*i.e.* residential receptors are currently located adjacent to the southern boundary).

4 Site Investigation and Assessment History

4.1 Introduction

The Site has been subject to various and substantial phases of environmental assessment and remediation as outlined in *Table 4-1*.

Table 4-1: *Historic Environmental Assessments and Reports*

Report Date	Report	Client	Contractor	Report Status
Feb-1998	(a) Phase I Environmental Assessment (Ref. R2109)	Williams PLC	Dames and Moore	Not available
Mar-1999	(b) Phase II Site Investigation (Ref. R2335)	Williams PLC	Dames and Moore	Not available
Jul-2000	(c) Final Factual Report Polycell Products Limited Welwyn Garden City (Ref. R2779/38842-019 401/WH)	Williams PLC	Dames and Moore	Partially available
Aug-2000	(d) Final Interpretative Report Risk Assessment Polycell Products Limited Welwyn Garden City (Ref. R3060/38842-024-401/WH/RJD)	Williams PLC	Dames and Moore	Partially available
Oct-2003	(e) Environmental Assessment Broadwater Road Welwyn Garden City (Ref. 2342-03)	Chinacorp PLC	Delta-Simons	Available
Nov-2004	(f) Phase II Environmental Assessment Cereal Partners Site Broadwater Road Welwyn Garden City (Ref. 2342-05)	Chinacorp PLC	Delta-Simons	Available
Dec-2005	(g) Quantitative Risk Assessment, Broadwater Road, Welwyn Garden City (Ref. 2342.06)	Tesco Stores Ltd	Delta-Simons	Available
July-2006	(h) Combined Phase I/II Environmental Assessment Cereal Partners (UK) Broadwater Road, Welwyn Garden City (Ref. 05-3046.01)	Cereal Partners (UK)	Delta-Simons	Partially available

Report Date	Report	Client	Contractor	Report Status
Dec-2006	(i) Groundwater Monitoring 2006-Broadwater Road, Welwyn-Garden-City (Ref. ELM/AJF/ES/2342-07/051206/BroadwaterRd.letrep)	Chinacorp PLC	Delta-Simons	Available
Feb-2007	(j) Executive Summary Supplementary Site Investigation Cereal Partners (UK), Broadwater Road, Welwyn Garden City (Ref. 05-3046.02)	Cereal Partners (UK)	Delta-Simons	Available
Mar-2007	(k) Technical Specification for Remediation Tender Former Polycell & Confectionary Factories Broadwater Road Welwyn Garden City (Ref. 2342-08)	Tesco Stores Ltd	Delta-Simons	Available
Dec-2008	(l) Remediation Summary Report Tank Excavation and Groundwater Monitoring Broadwater Road, Welwyn Garden City (Ref. 2342-10)	Tesco Stores Ltd	Delta-Simons	Available
May-2009	(m) Remediation Summary Report Tank Excavation and Groundwater Monitoring Broadwater Road, Welwyn Garden City (Ref. 2342-10)	Tesco Stores Ltd	Delta-Simons	Available
Feb-2010	(o) Broadwater Road, Interim Remediation Summary Report (Ref. E0711)	Delta-Simons	Bilfinger Berger Environmental Ltd	Available
Feb-2011	(p) Remediation Summary Report Ongoing Groundwater Monitoring Broadwater Road, Welwyn Garden City (Ref. 2342-10)	Tesco Stores Ltd	Delta-Simons	Available
Sep-2011	(q) Remediation Summary Report & Ongoing Groundwater Monitoring Broadwater Road, Welwyn Garden City (Ref. 2342-10)	Tesco Stores Ltd	Delta-Simons	Available
Jun-2012	(r) Remediation and Groundwater Monitoring Report Broadwater Road, Welwyn Garden City (Ref. 2342-10)	Tesco Stores Ltd	Delta-Simons	Available

Report Date	Report	Client	Contractor	Report Status
May-2013	(s) Groundwater Monitoring Update Report Broadwater Road, Welwyn Garden City (Ref. 2342-10)	Tesco Stores Ltd	Delta-Simons	Available
Nov-2013	(t) Groundwater Monitoring Update Report – November 2013, Broadwater Road, Welwyn Garden City (Ref. 2342-10)	Tesco Stores Ltd	Delta-Simons	Partially Available
Dec-2013	(u) Phase I Geotechnical Desk Study Assessment Broadwater Road, Welwyn Garden City (Ref. 2342.17)	Spen Hill Developments Ltd	Delta-Simons	Available
Oct-2014	(v) Desktop Foundation Assessment Broadwater Road West, Welwyn Garden City (Ref. 2342.18_D)	Spen Hill Developments Ltd	Delta-Simons	Available
Jan-2015	(w) Phase I Environmental Assessment, Former Shredded Wheat Factory, Broadwater Road, Welwyn Garden City (Ref. 2342.17 V2)	Spen Hill Developments Ltd	Delta-Simons	Available
Jan-2015	(x) Factual and Interpretative Geotechnical Report Former Shredded Wheat Factory, Broadwater Road, Welwyn Garden City, AL7 3AX (Ref. 2342.18_G V2)	Spen Hill Developments Ltd	Delta-Simons	Available
Mar-2016	(y) Final Post-Remediation Groundwater Monitoring Report Broadwater Road, Welwyn Garden City	Tesco Stores Ltd	Delta-Simons	Available

4.2 Summary of Previous Works

At the time of the Site acquisition by Tesco Stores Ltd they were informed that the Site was contaminated, and the nature and extent of the contamination was confirmed by subsequent Site investigations undertaken by Delta-Simons. Delta-Simons undertook several phases of intrusive site investigation and long-term groundwater monitoring at the Site between 2003-2016. A long-term strategy was agreed (in conjunction with the Welwyn Hatfield Council and the Environment Agency) to undertake a voluntary groundwater remediation scheme to reduce the associated environmental risks.

Delta-Simons investigations at the Site identified localised soil contamination and significant widespread groundwater contamination at depth within the Principal Chalk Aquifer. The source of the contamination was determined to be leakage from the USTs located in the north-west corner of the former Polycell factory (Zone S01).

The key contaminants identified in the groundwater at the Site comprise 'White Spirit' characterised by a mix of light end aliphatic hydrocarbons, dichloromethane, trimethylbenzene, naphthalene, ethylbenzene and xylenes. Non-aqueous phase liquid (NAPL) free product was identified on the surface of the groundwater at a depth of approximately 22 m within the Chalk within selected boreholes.

Elevated concentrations of total petroleum hydrocarbons (TPH) and volatile organic compounds (VOC) were identified within shallow Made Ground around the periphery of the tank farm. The contamination is considered to have been caused by leakages from the pipework associated with the tank farm, or from the USTs themselves, or a combination of both.

Elevated concentrations of TPH, semi-volatile organic compounds (SVOC) and VOC at depth within the Chalk, in the direction of the identified groundwater flow (primarily towards the southeast), were associated with the free product on the surface of the groundwater.

Groundwater monitoring undertaken prior to the remediation works identified that the dissolved contamination was reaching the boundaries of the Site and investigations on the adjacent CPUK land (to the north of the Site) identified deep groundwater contamination in several boreholes, which has been identified as originating from the tank farm.

4.3 Remediation Summary

Given the scale and extent of the groundwater contamination at the Site a remediation strategy and monitoring programme was devised following a Detailed quantitative risk assessment (DQRA) completed by Delta-Simons in December 2005. The main objective of the remediation strategy was to remove the principal source of contamination, therefore,

preventing the continued contamination of groundwater from the source area. The source was considered to comprise the tank farm and surrounding impacted shallow soils, and free product on the groundwater at depth beneath the tank farm. The secondary objective of the remediation programme was to remediate the dissolved phase groundwater contamination to the derived remedial targets, to minimise impact to the wider groundwater environment.

The remediation scheme comprised a combination of techniques to remove the source of the contamination and address the dissolved phase contamination plume across the wider Site. These included:

- **Stage 1** – Tank pull and soil excavation – completed September/October 2008;
- **Stage 2** – Soil excavation validation – completed October 2008;
- **Stage 3** – On-site ex-situ biopile remediation – completed July 2009;
- **Stage 4** – Pump and Treat groundwater remediation/Free product recovery – completed January 2011;
- **Stage 5** – Soil vapour extraction – completed January 2011;
- **Stage 6** – Oxygen Releasing Compound (ORC) injection – completed early 2011; and
- **Stage 7** – Long-term groundwater monitoring/Monitored Natural Attenuation (MNA) – October 2008 to September 2015.

In September 2015 Delta-Simons concluded that the source removal and ex-situ soil remediation was successful in removing the bulk of the soil contamination source and treating the contaminated soils. The active groundwater remediation phase was successful in removing free product from the groundwater: free product has not been recorded on the groundwater table since March 2010. In addition, the soil vapour extraction system removed approximately 70 tonnes of volatile compounds from the soils beneath the former tank farm. The results of the long-term groundwater monitoring programme indicate that the groundwater remediation scheme has been effective in significantly reducing the dissolved phase hydrocarbon and VOC contamination within the source zone and the dissolved phase plume.

It should be noted, that contamination levels within the groundwater beneath the former tank farm remain elevated in some instances. Although, overall, the identified concentrations are below the Delta-Simons derived remedial target values, there are occasional exceedances of the very low target values for n-Propylbenzene. However, as noted in Delta-Simons DQRA Report and additional modelling undertaken at the request of the Environment Agency, the remedial target value for n-Propylbenzene is (considered)

overly conservative, due to the use of a default half-life value of 9 x 10^{99}, and this does not consider biodegradation. In hindsight, therefore, it is considered to be an unrealistic remedial target in the case of this parameter.

The results show that concentrations of contaminants within the monitoring wells down hydraulic gradient of the source area are exhibiting an overall declining trend, whereas monitoring wells to the south of the main plume (which are less impacted), exhibit variable, but generally reduced concentrations.

Delta-Simons work at the Site was completed in September 2015 with the final report issued in March 2016.

No further investigation, monitoring or remediation has been undertaken at the site until the recent round of works by EAME, discussed in the remainder of this report.

5 Assessment Strategy

5.1 Scope of Works

Based on the previous Site investigations and remedial works the following staged approach was outlined within the site investigation scheme submitted to Welwyn Hatfield Borough Council (WHBC) on 29th September 2017 in relation to N6/2015/0294/PP – Planning Condition No. 1 *i.e. "A site investigation scheme, based on the submitted phase 1 Environmental Assessment (Delta-Simons ref 2342.17 V2) to provide information for a detailed assessment of the risk to all receptors that may be affected, including those off site"* (*Figure 5-1*).

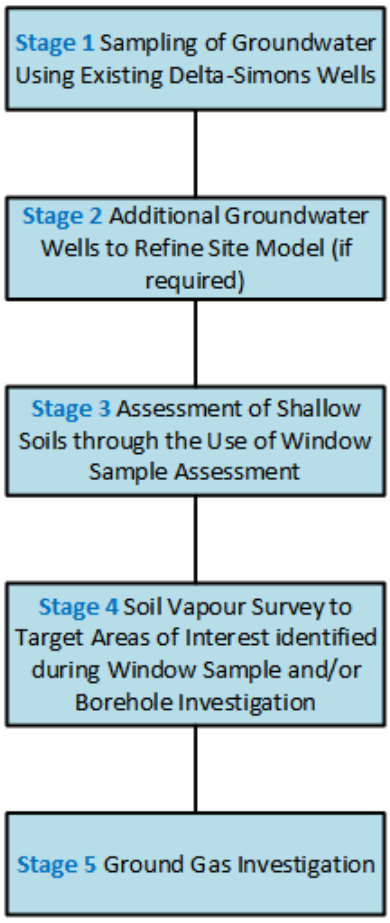


Figure 5-1: *Agreed Site Investigation Scheme with WHBC*

Formal acceptance of the site investigation scheme was received from Mr. Tim Croot (WHBC Environmental Health Department) on 07/11/17.

6 Stage 1 – Groundwater Assessment (Existing Wells)

6.1 Introduction

Due to the intervening two years since Delta-Simons last conducted groundwater monitoring at the Site vegetation growth has been extensive across the southern Site (*Photograph 6-1*).

Photograph 6-1: *Vegetation growth across the southern Site*

The Site was visited by EAME on 19th – 20th September 2017 during which the existing boreholes (last monitored by Delta-Simons in September 2015) were GPS located (approximately), photographed, dipped to verify accessibility and cleared of surrounding vegetation. All groundwater wells were clearly marked using road cones and/or 50 cm sections of (yellow) gas-pipe fixed to the ground using Postcrete. The location of all wells was formerly recorded and communicated to the demolition contractors (John F Hunt), who will be performing contract works on the site as part of the development proposals.

In total 29 boreholes were located of which 4 were dry (BH413-BHD, BH301, R1, BH209).

The Site was visited again by EAME between the 26th – 28th September 2017 during which time the available groundwater wells were purged and sampled. Of the 25 boreholes previously identified two (BHE-BH37, BH306) could not be successfully purged or sampled due to ground movements leading to pipework damage and one (BH201) was abandoned due to its proximity to other available wells. The remaining 22 wells were successfully purged and sampled as outlined within *Figure 6-1* and *Table 6-1.*

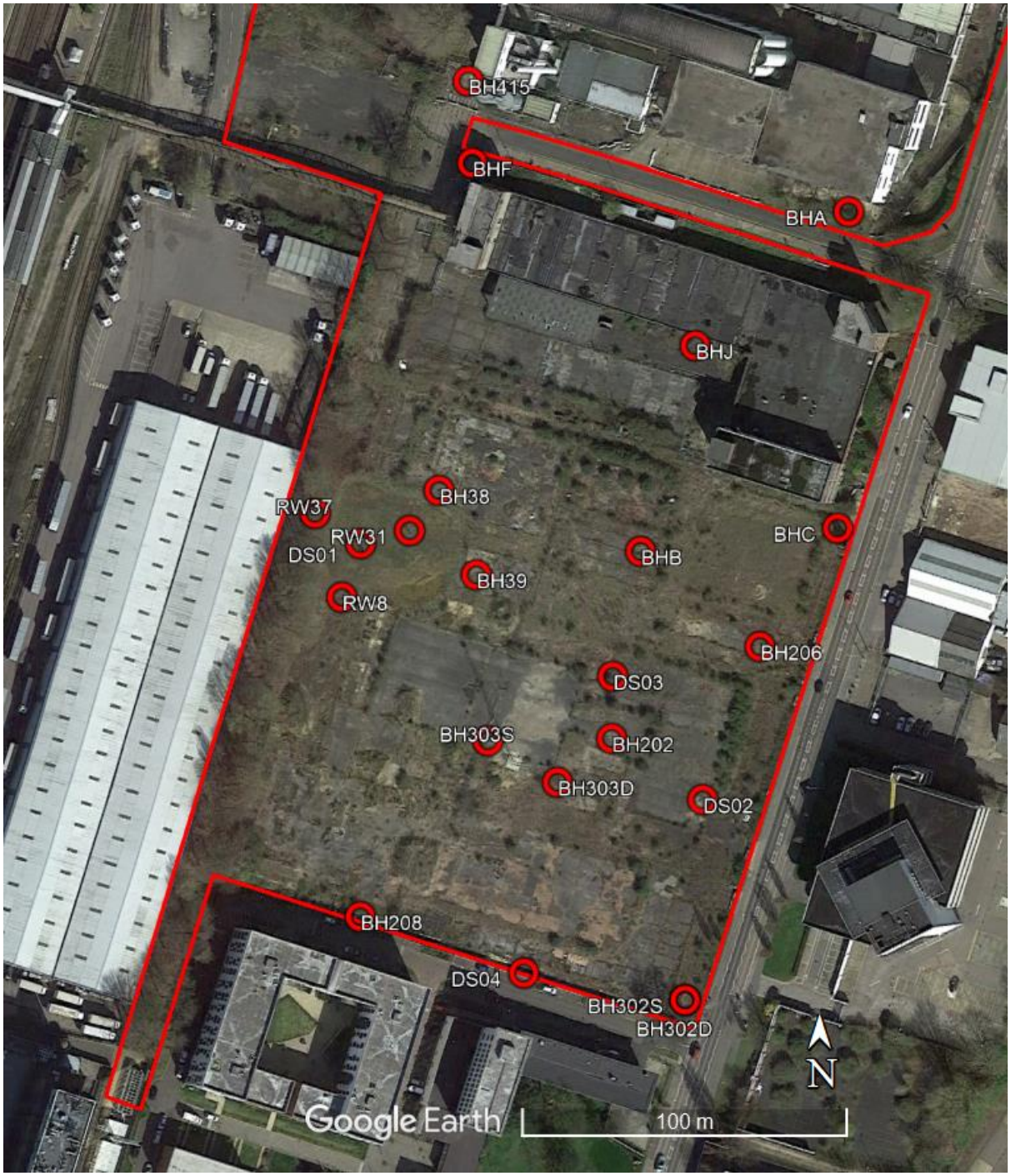


Figure 6-1: *Groundwater wells monitored during September 2017*

Google Earth Imaging with the permission of Google – Licensed to Earth and Marine Environmental Consultants Ltd.

Table 6-1: *Existing Boreholes – Location Details*

Ref.	Easting	Northing	Elevation	Notes
BH202	524117.411	212692.711	85.358 m AOD	Delta-Simons
BH206	524097.731	212771.202	85.874 m AOD	Delta-Simons
BH208	524110.028	212752.166	85.637 m AOD	Delta-Simons
BH302d	524101.834	212899.8	85.423 m AOD	Delta-Simons
BH302s	524219.398	212863.343	85.467 m AOD	Delta-Simons
BH303d	524160.612	212755.483	85.213 m AOD	Delta-Simons
BH303s	524219.236	212763.498	85.167 m AOD	Delta-Simons
BH38	524109.449	212870.773	85.5 m AOD	Delta-Simons
BH39	524175.789	212818.878	85.371 m AOD	Delta-Simons
BH415	524076.388	212752.482	85.461 m AOD	Delta-Simons
BHA	524180.394	212675.938	84.971 m AOD	Delta-Simons
BHB	524148.514	212722.676	85.224 m AOD	Delta-Simons
BHC	524133.064	212624.575	84.664 m AOD	Delta-Simons
BHF	524090.893	212758.136	85.363 m AOD	Delta-Simons
BHJ	524062.478	212759.24	85.767 m AOD	Delta-Simons
DS01	524057.225	212731.302	85.453 m AOD	Delta-Simons
DS02	524117.411	212692.711	85.358 m AOD	Delta-Simons
DS03	524097.731	212771.202	85.874 m AOD	Delta-Simons
DS04	524110.028	212752.166	85.637 m AOD	Delta-Simons
RW31	524101.834	212899.8	85.423 m AOD	Delta-Simons
RW37	524219.398	212863.343	85.467 m AOD	Delta-Simons
RW8	524160.612	212755.483	85.213 m AOD	Delta-Simons

6.2 Sample Acquisition and On-Site Analysis

6.2.1 Purging of Wells

The on-site wells had not been purged or sampled since the last round of Delta-Simons monitoring in September 2015. In addition, most wells on-site were found without gas taps or protective caps (apparently removed by Delta-Simons). Due to these poor conditions, all available groundwater wells were purged using Waterra Standard High-Density Polyethylene (HDPE) tubing (16 mm) and a Waterra PP1 Power-pack (*Photograph 6-2*). Pipework was dedicated to each borehole and not re-used.

Photograph 6-2: *Groundwater well purging through use of HDPE tubing and Power-pack*

All wells were dipped prior to purging, using a Geotech Interface Meter to determine current well volume and to determine if any free-phase liquid was present. All wells were then purged using the three-standard well volume methodology (where achievable)[10,11]. Two wells could not be purged using this method (BH208 and BH202) due to the inability to extend the HDPE tubing down the well. This was most likely due to ground movements and the formation of a lip between well screen sections. These two wells were purged using dedicated 39 mm (1,000 ml) bio-bailers.

All wells were left for a minimum of 24 hours between purging and sampling.

10 Environment Agency (2003). Guidance on monitoring of landfill leachate, groundwater and surface water. 283pp.
11 ASTM (2012). ASTM D6542 2012. Standard guide for purging methods for wells used for groundwater quality investigations

6.2.2 Groundwater Sampling

Prior to sampling all wells were again dipped using a Geotech Interface Meter to determine resting groundwater level and to verify whether free product was present.

Groundwater samples were then obtained from all wells (except BH208 and BH202) using a Geotech Geocontrol Pro low-flow sampler combined with a Geotech stainless steel bladder pump (*Photograph 6-3*). The use of low flow sampling was 'recommended' by the Environment Agency (EA) who visited the Site on 20th September 2017. Dedicated polyethylene (PE) 42 mm bladders and low-density polyethylene (LDPE) tubing were used with each well.

Photograph 6-3: *Groundwater sampling using low-flow bladder pump*

All samples were collected in new glassware (*i.e.* 2 x 40 ml amber vials followed by 2 x 300 ml amber bottles) provided by i2 Analytical Ltd. After the sample collection the groundwater from the wells was examined visually and any unusual odours were noted. A separate sample (approximately 125-ml) was collected within a 250-ml jar and lidded (with a small sealable hole) for headspace testing.

6.2.3 Headspace Testing

All groundwater samples were tested by dynamic headspace analysis, for the presence of volatile organic compounds (VOCs) using a Photoionization Detector (PID). Dynamic

headspace analysis refers to the manual agitation (warming) of a sample to facilitate the volatilisation of organic compounds present in the water into the headspace above which is then analysed using the PID. The PID screens for a wide range of volatile organic compounds including hydrocarbon compounds and certain chlorinated solvents but does not indicate a specific compound. The measurements obtained by the instrument in parts per million by volume (ppmv) provide a semi-quantitative indication of the concentration of hydrocarbon vapours that are.

The PID used during the assessment, and associated calibration status, is outlined in *Table 6-2*.

Table 6-2: *PID Details*

Criteria	Description
Instrument	PhoCheck Tiger
Supplied by	Shawcity Limited
Lamp	10.6 eV krypton PID
Serial No.	T-105329
Calibration Method	CM03
Ambient Conditions	20°C ± 2°C and 50% (± 20%) Relative Humidity
Results	Isobutylene (Lot No. 270123), Ref value 100 ppm, indicated value 100 ppm
Calibration Date	09/05/2017
Certificate No.	60913

6.2.4 Sample Integrity

All samples were placed in containers appropriate to the type of analysis being undertaken and stored in cool boxes maintained at a low temperature (using ice packs), to avoid the loss of volatile compounds. Dispatch to the accredited laboratory took place as soon as possible following the completion of the investigation.

Samples were then collected, placed immediately into containers appropriate to the type of analysis being undertaken and stored in cool boxes (with ice packs) maintained at a low temperature, to avoid the loss of volatile compounds.

All sampling was undertaken using EAME in-house field procedures (available on request) and relevant guidance, such as BS ISO 5667-11:2009, BS 6068-6.11:2009 Water quality Sampling. Guidance on sampling of groundwaters.

All collected samples were submitted to i2 Analytical Ltd a UKAS (ISO 17025) accredited laboratory for chemical analysis. Discussions were held with the laboratory prior to the commencement of any works to determine the quantity of sample required and the containers to be used.

All samples were given a unique reference number, dated and the information recorded on an appropriate Chain of Custody (CoC) form for dispatch with the samples to the appropriate laboratory.

6.2.5 Groundwater Observations and Headspace Test Results

Visual and/or olfactory evidence of groundwater contamination was noted during the works. These combined with the associated headspace results are outlined in *Table 6-3*.

Table 6-3: *Groundwater Observations and Headspace Test Results (ppmv)*

Borehole	Appearance	Odour	PID (ppmv)
BHA	No sheen	Slight VOC odour	19
BH415	No sheen	No odour detected	0.075
BHF (or BHE)	No sheen	No odour detected	0.024
BHJ	No sheen	VOC odour	183
RW38 (or BH38)	No sheen	VOC odour	50.51
RW39 (or BH39)	Slight sheen	Strong VOC odour	432.5
RW31	No sheen	No odour detected	7
DS01 (or BH31)	No sheen	VOC odour	38.29
RW37 (or BH36)	No sheen	Strong VOC odour	124.5
RW8	Slight sheen	Strong VOC odour	900
DS03	No sheen	Strong VOC odour	85.22
BHB	No sheen	Slight VOC odour	1.62
BH206 (or BH101)	No sheen	No odour detected	0.336

Borehole	Appearance	Odour	PID (ppmv)
BHC	No sheen	No odour detected	0.057
DS02	No sheen	Slight VOC odour	17.9
BH303d	No sheen	Slight VOC odour	26.25
BH303s	No sheen	Slight VOC odour	46.78
BH208	No sheen	Slight VOC odour	0.384
DS04	No sheen	Slight VOC odour	0.049
BH302(s)	No sheen	VOC odour	101.2
BH302(d)	No sheen	No odour detected	0.105
BH202	No sheen	VOC odour	23.01

Notes:

Maximum – RW8 – 900 ppmv

Average (22 readings) – 93.5 ppmv

No free product was detected during the monitoring of the wells.

6.3 Groundwater Chemical Data

6.3.1 Groundwater Analytical Strategy

The analytical strategy was designed by EAME to provide an assessment of the presence of a common range of potential contaminants likely to be associated with the previous uses of the Site and to ensure alignment and comparison with the earlier work conducted by Delta-Simons. The analytical suites are outlined in *Table 6-4*.

Table 6-4: *Analytical Strategy*

Analytical Suite	Groundwater Samples
EAME Suite B Arsenic (dissolved), Cadmium (dissolved), Chromium (dissolved), Cr (VI), Lead (dissolved), Mercury (dissolved), Selenium (dissolved), Copper (dissolved), Nickel (dissolved), Zinc (dissolved), Vanadium (dissolved), Beryllium (dissolved), Water Soluble Boron, Total Cyanide, Monohydric Phenols, pH Value, Total Petroleum Hydrocarbon TPH - CWG (C5-35) Aliphatic/Aromatic Split (with CWG banding - Aliphatic C5-6,>6-8,>8-10,>10-12,>12-16,>16-21,>21-35) (Aromatic - >C6-7,>7-8,>8-10,>C10-12,>12-16,>16-21,>21-35), Speciated Polycyclic Aromatic Hydrocarbon (PAHs) (USEPA-16), Sulphate (water soluble), benzene, toluene, ethylbenzene, and xylenes (BTEX) and Methyl tert-butyl ether (MTBE)	**22 samples** BH202, BH206, BH208, BH302d, BH302s, BH303d, BH303s, BH415, BHA, BHB, BHC, BHF, BHJ, DS01, DS02, DS03, DS04, RW31, RW37, RW38, RW39 and RW8
Volatile Organic Compounds (VOCs) + Tentatively Identified Compounds (TICs) Standard i2 Analytical Ltd VOC suite was amended to include Dichloromethane (DCM) in-line with previous works conducted by Delta-Simons.	
Semi Volatile Organic Compounds (SVOCs) + TICs Standard range of PAHs, Phenols that form the standard i2 Analytical Ltd SVOC suite.	
Polychlorinated Biphenyls (PCBs) 7 Congeners + Total PCBs	**9 samples** BH206, BH302d, BH302s, BH415, BHA, BHC, DS02, DS03 and RW38.

6.3.2 Groundwater Analysis

Twenty-two groundwater sample were recovered (*i.e.* BH202, BH206, BH208, BH302d, BH302s, BH303d, BH303s, BH415, BHA, BHB, BHC, BHF, BHJ, DS01, DS02, DS03, DS04, RW31, RW37, RW38, RW39 and RW8) and were scheduled for laboratory analysis. The first stage of assessment was to screen out those compounds that were not recorded above the laboratory analytical method detection limits (MDLs). These are listed below and have not been considered further:

- Total Cyanide (MDL 10 µg/l);
- TPH-CWG - Aliphatic >C5 - C6 (MDL 1 µg/l);
- TPH-CWG - Aliphatic >C10 - C12 (MDL 10 µg/l);
- TPH-CWG - Aliphatic >C12 - C16 (MDL 10 µg/l);
- TPH-CWG - Aliphatic >C16 - C21 (MDL 10 µg/l);
- TPH-CWG - Aliphatic >C21 - C35 (MDL 10 µg/l);
- TPH-CWG - Aromatic >C16 - C21 (MDL 10 µg/l);
- TPH-CWG - Aromatic >C21 - C35 (MDL 10 µg/l);
- Speciated PAHs (Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Indeno(1,2,3-cd)pyrene, Dibenz(a,h)anthracene and Benzo(ghi)perylene) (Individual PAH MDL 0.01 µg/l);
- Beryllium (MDL 0.1 µg/l);
- Cadmium (MDL 0.02 µg/l);
- Chromium (hexavalent) (MDL 5 µg/l);
- Mercury (MDL 0.05 µg/l);
- MTBE (Methyl Tertiary Butyl Ether) (MDL 1 µg/l);
- Specific VOCs as listed within analytical report 17-62108 (MDL 1 µg/l);
- Specific SVOCs as listed within analytical report 17-62108 (MDL variable);

- PCBs (PCB Congener 28, PCB Congener 52, PCB Congener 101, PCB Congener 118, PCB Congener 138, PCB Congener 153 and PCB Congener 180) (MDL 0.02 µg/l); and
- PCB (total) (MDL 0.14 µg/l).

6.3.3 Tier 1 Screening – Generic Quantitative Risk Assessment

The remaining determinands, present in the samples above their respective laboratory MDLs, have been reported and compared with stated Tier 1 screening values as outlined within *Table 6-5*. The following Generic Quantitative Risk Assessment screening values have been used within the assessment process:

(E) Environmental Guideline Values

*E1 – AA-EQS (micrograms per litre) *The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015*. An annual average concentration EQS (AA), defined as the highest concentration to which an aquatic ecosystem may be exposed without any likely adverse effects.

*E2 – MAC-EQS (micrograms per litre) *The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015*. A maximum allowable concentration EQS (MAC), defined as the highest transient concentration that would be expected to cause adverse effects. The MAC is designed to protect against short-term episodic pollution events, while the AA is designed to protect against long-term continuous pollution.

*E3 – N J Ayscough, W Young and P Whitehouse (2002). Proposed Environmental Quality Standards for Ethylbenzene in Water, R&D Technical Report P2-115/TR4, WRc-NSF Ltd, Environment Agency 2002.

(H) Human Health Guideline Values

*H1 – Drinking Water Standards (*The Water Supply (Water Quality) Regulations 2016*)

*H2 – Drinking Water Standards (*The Water Supply (Water Quality) Regulations 1989*)

*H3 – WHO Guidelines for Drinking Water Quality. Fourth Edition (2011)

*H4 – WHO (2008). Petroleum Products in Drinking-water, Background document for development of WHO Guidelines for Drinking-water Quality, WHO/SDE/WSH/05.08/123

These initial groundwater results are discussed in combination with the additional groundwater results described in *Section 7* within the Detailed Quantitative Risk Assessment (DQRA) outlined in *Section 11*.

Table 6-5: *Tier 1 Groundwater Risk Assessment (n = 22)*

Parameter	Range	Environmental			Human Health		
		Guideline	Exceedences		Guideline	Exceedences	
General Inorganics							
pH	6.2 to 7.2	6 – 9*[E2]	0	-	6.5 – 9.5*[H1]	2	RW39 (6.2) BH303d (6.4)
Sulphate as SO_4 (mg/l)	1.37 – 314	400*[E1]	0	-	250*[H1]	1	BH208 (314 mg/l)
Heavy Metals / Metalloids							
Arsenic (dissolved) (µg/l)	0.24 – 12.50	50*[E1]	0	-	10*[H1]	1	BH302s (12.5 µg/l)
Boron (dissolved) (µg/l)	19 - 690	2000*[E1]	0	-	1000*[H1]	0	-
Chromium (dissolved) (µg/l)	<MDL – 0.7	4.7*[E1]	0	-	50*[H1]	0	-

Parameter	Range	Environmental			Human Health		
		Guideline	Exceedences		Guideline	Exceedences	
Copper (dissolved) (µg/l)	<MDL – 6.8	1.0[*E1]	12	BH303d (1.1 µg/l) BH208 (1.3 µg/l) DS03 (1.7 µg/l) BHF (1.7 µg/l) BH206 (1.9 µg/l) BH302d (2.0 µg/l) BH415 (2.0 µg/l) DS04 (2.3 µg/l) RW31 (2.5 µg/l) BHC (3.3 µg/l) BHJ (4.1 µg/l) RW8(6.8 µg/l)	2000[*H1]	0	-
Lead (dissolved) (µg/l)	<MDL – 0.8	1.2[*E1]	0	-	10[*H1]	0	-

Parameter	Range	Environmental			Human Health		
		Guideline	Exceedences		Guideline	Exceedences	
Nickel (dissolved) (µg/l)	1.0 – 78	4.0[*E1]	9	RW8 (4.6 µg/l) BH208 (4.7 µg/l) DS01 (5.2 µg/l) DS04 (6.3 µg/l) BHC (6.9 µg/l) RW37 (7.8 µg/l) BHB (8.1 µg/l) BH206 (11.0 µg/l) RW39 (78.0 µg/l)	20[*H1]	1	RW39 (78 µg/l)
Selenium (dissolved) (µg/l)	<MDL – 0.8	NA	-	-	10[*H1]	0	-
Vanadium (dissolved) by ICP-MS (µg/l)	<MDL – 0.9	20 – 60[*E1]	0	-	NA	-	-

Parameter	Range	Environmental			Human Health		
		Guideline	Exceedences		Guideline	Exceedences	
Zinc (dissolved) (µg/l)	1.4 - 65	10.9[*E1]	8	BH302d (11 µg/l) BHA (13 µg/l) BHF (15 µg/l) BHC (16 µg/l) DS03 (17 µg/l) BH206 (19 µg/l) BH415 (22 µg/l) BHJ (65 µg/l)	5,000[*H2]	0	-
Petroleum Hydrocarbons							
TPH-CWG - Aliphatic >C6 - C8 (µg/l)	<MDL – 10.0	NA	-	-	15,000[*H4]	0	-
TPH-CWG - Aliphatic >C8 - C10 (µg/l)	<MDL – 11,000	NA	-	-	300[*H4]	1	RW37 (11,000 µg/l)
TPH-CWG - Aliphatic (C5 - C35)	<MDL – 11,000	NA	-	-	NA	-	-
TPH-CWG - Aromatic >C5 - C7 (µg/l)	<MDL – 3.2	10[*E1(Benzene)]	0	-	1[*H4(Benzene)]	2	RW39 (3.1 µg/l) DS01 (3.2 µg/l)

Parameter	Range	Environmental			Human Health		
		Guideline	Exceedences		Guideline	Exceedences	
TPH-CWG - Aromatic >C7 - C8 (µg/l)	<MDL – 89	74*E1(Toluene)	1	RW39 (89 µg/l)	700*H4(Toluene)	0	-
TPH-CWG - Aromatic >C8 - C10 (µg/l)	<MDL – 610,000	20*E3(ethylbenzene)	12	DS02 (140 µg/l) BH202 (300 µg/l) BHJ (520 µg/l) BH302s (930 µg/l) BH303s (1,800 µg/l) BH303d (2,000 µg/l) RW38 (2,300 µg/l) DS03 (7,500 µg/l) RW8 (19,000 µg/l) DS01 (20,000 µg/l) RW39 (42,000 µg/l) RW37 (610,000 µg/l)	300*H4(ethylbenzene)	10	BHJ (520 µg/l) BH302s (930 µg/l) BH303s (1,800 µg/l) BH303d (2,000 µg/l) RW38 (2,300 µg/l) DS03 (7,500 µg/l) RW8 (19,000 µg/l) DS01 (20,000 µg/l) RW39 (42,000 µg/l) RW37 (610,000 µg/l)

Parameter	Range	Environmental			Human Health		
		Guideline	Exceedences		Guideline	Exceedences	
TPH-CWG - Aromatic >C10 - C12 (µg/l)	<MDL – 12,000	NA	-	-	90[*H4]	15	BHB (190 µg/l) RW31 (880 µg/l) BH202 (970 µg/l) BHA (1,400 µg/l) RW38 (1,700 µg/l) BH303d (2,600 µg/l) DS02 (3,000 µg/l) BHJ (4,300 µg/l) BH302s (4,600 µg/l) BH303s (6,300 µg/l) DS01 (6,400 µg/l) DS03 (8,400 µg/l) RW8 (8,600 µg/l) RW37 (8,800 µg/l) RW39 (12,000 µg/l)

Parameter	Range	Environmental			Human Health		
		Guideline	Exceedences		Guideline	Exceedences	
TPH-CWG - Aromatic >C12 - C16 (µg/l)	<MDL – 370	NA	-	-	90[*H4]	6	BH303s (93 µg/l) BH302s (140 µg/l) DS03 (170 µg/l) RW31 (180 µg/l) RW39 (330 µg/l) DS02 (370 µg/l)
TPH-CWG - Aromatic (C5 - C35) (µg/l)	<MDL – 620,000	NA	-	-	NA	-	-
Volatile Organic Compounds (VOCs)							
1,1-Dichloroethene (µg/l)	<MDL – 4.6	NA	-	-	NA	-	-
Cis-1,2-dichloroethene (µg/l)	<MDL – 51.3	NA	-	-	NA	-	-
Trichloromethane (µg/l)	<MDL – 10.3	2.5[*E1]	1	BH208 (10.3 µg/l)	NA	-	-
Benzene (µg/l)	<MDL – 3.2	10[*E1]	0	-	1[*H1]	2	RW39 (3.1 µg/l) DS01 (3.2(µg/l)

Parameter	Range	Environmental			Human Health		
		Guideline	Exceedences		Guideline	Exceedences	
Trichloroethene (TCE) (µg/l)	<MDL – 13.4	NA	-	-	20*H3	0	-
Toluene (µg/l)	<MDL – 88.9	74*E1	1	RW39 (88.9 µg/l)	700*H3	0	-
Tetrachloroethene (PCE or PERC) (µg/l)	<MDL – 7.4	NA	-	-	40*H3	0	-
Ethylbenzene (µg/l)	<MDL - 370	NA	-	-	300*H3	1	RW39 (370 µg/l)
p & m-Xylene (µg/l)	<MDL – 7,060	30*E1	6	BH303d (49.2 µg/l) DS03 (158 µg/l) RW8 (346 µg/l) DS01 (656 µg/l) RW39 (2,240 µg/l) RW37 (7,060 µg/l)	500*H3	3	DS01 (656 µg/l) RW39 (2,240 µg/l) RW37 (7,060 µg/l)
o-Xylene (µg/l)	<MDL – 5,420	30*E1	5	DS03 (66.4 µg/l) RW8 (70.6 µg/l) DS01 (381 µg/l) RW39 (2,400 µg/l) RW37 (5,420 µg/l)	500*H3	2	RW39 (2,400 µg/l) RW37 (5,420 µg/l)

Parameter	Range	Environmental			Human Health		
		Guideline	Exceedences		Guideline	Exceedences	
Isopropylbenzene (µg/l)	<MDL – 3,280	NA	-	-	NA	-	-
n-Propylbenzene (µg/l)	<MDL – 14,300	NA	-	-	NA	-	-
1,3,5-Trimethylbenzene (µg/l)	<MDL – 79,600	NA	-	-	NA	-	-
1,2,4-Trimethylbenzene (µg/l)	<MDL – 151,000	NA	-	-	NA	-	-
sec-Butylbenzene (µg/l)	<MDL - 353	NA	-	-	NA	-	-
p-Isopropyltoluene (µg/l)	<MDL – 9,660	NA	-	-	NA	-	-
Butylbenzene (µg/l)	<MDL - 343	NA	-	-	NA	-	-
Dichloromethane (µg/l)	<MDL – 15,000	20[*E1]	4	RW31 (310 µg/l) RW37 (1,800 µg/l) DS01 (10,000 µg/l) RW39 (15,000 µg/l)	20[*H3]	4	RW31 (310 µg/l) RW37 (1,800 µg/l) DS01 (10,000 µg/l) RW39 (15,000 µg/l)
Semi-volatile Organic Compounds (SVOCs)							
2-Methylnaphthalene	<MDL - 4	NA	-	-	NA	-	-

Parameter	Range	Environmental			Human Health		
		Guideline	Exceedences		Guideline	Exceedences	
Naphthalene (µg/l)	<MDL - 130	2[*E1]	14	BHA (2.2 µg/l) RW31 (2.9 µg/l) BH202 (4.6 µg/l) BH302s (7.7 µg/l) DS02 (9.3 µg/l) BH303d (14.0 µg/l) RW38 (19.0 µg/l) DS03 (24.0 µg/l) BH303s (24.0 µg/l) DS01 (27.0 µg/l) BHJ (29.0 µg/l) RW8 51.0 µg/l) RW39 (61.0 µg/l) RW37 (130.0 µg/l)	NA	-	-

Parameter	Range	Environmental		Human Health	
		Guideline	Exceedences	Guideline	Exceedences
Notes: All results expressed in µg/l except for pH (unitless) and where indicated <MDL = Less than Method Detection Limit ND = Not recorded above limit of detection NA= Not available - = Not relevant					

7 Stage 2 – Soil and Groundwater Assessment (New Boreholes)

7.1 Introduction

To improve our knowledge of the current on-site conditions and to validate the previous ground investigations the drilling of six additional deep boreholes was proposed. The location of the new boreholes is presented in *Table 7-1* and *Figure 7-1.*

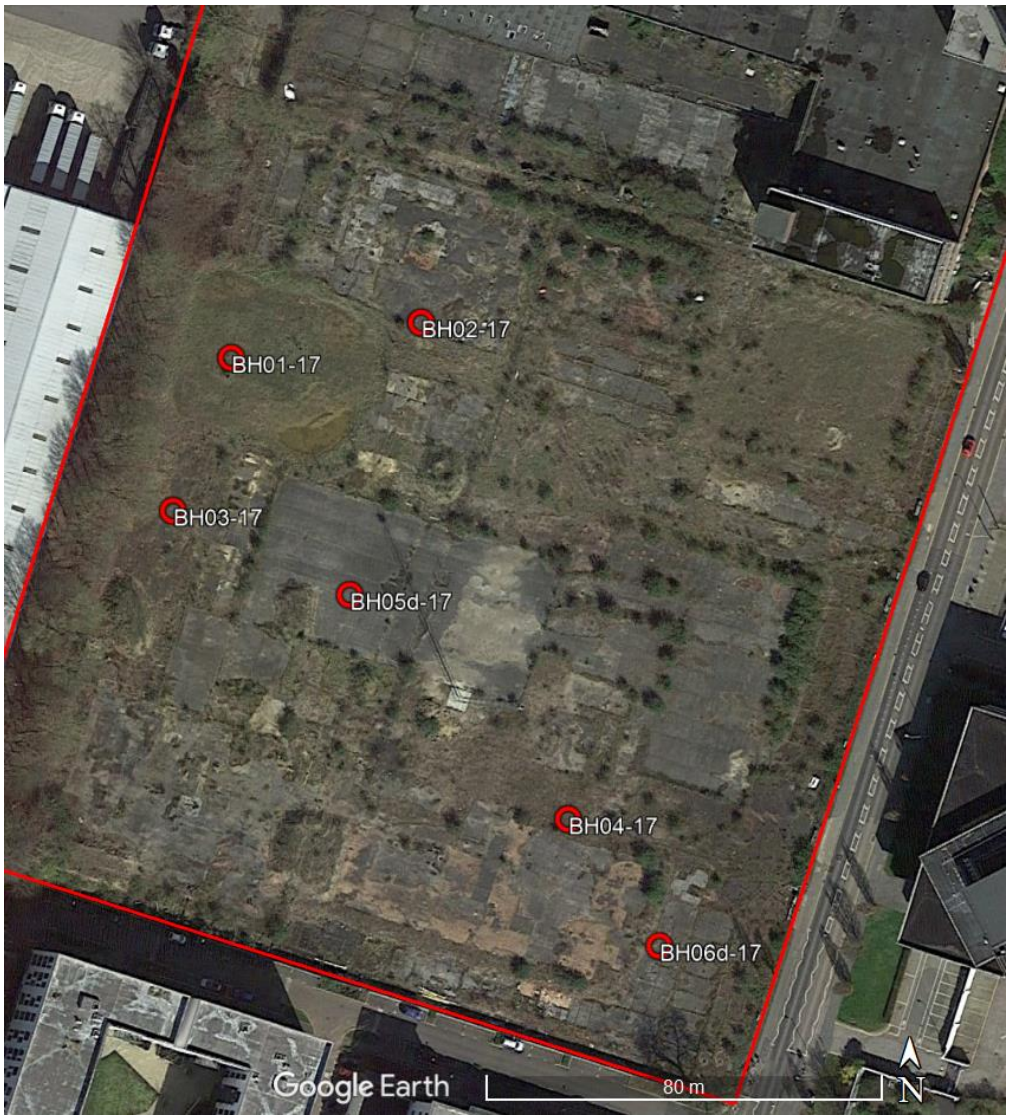


Figure 7-1: *New boreholes drilled December 2017 – January 2018*

Google Earth Imaging with the permission of Google – Licensed to Earth and Marine Environmental Consultants Ltd.

Table 7-1: *New Boreholes – Location Details*

Ref.	Easting	Northing	Elevation	Notes
BH01-17	524078.136	212758.289	84.893 m AOD	Shallow well (c. 28 m bgl) to intersect top of Chalk aquifer.
BH02-17	524116.588	212766.212	85.467 m AOD	Shallow well (c. 28.5 m bgl) to intersect top of Chalk aquifer.
BH03-17	524067.244	212727.505	85.192 m AOD	Shallow well (c. 28 m bgl) to intersect top of Chalk aquifer.
BH04-17	524148.003	212667.001	85.281 m AOD	Shallow well (c. 28 m bgl) to intersect top of Chalk aquifer.
BH05d-17	524103.558	212711.406	85.316 m AOD	Deeper well (c. 38 m bgl) into the potential dissolved phase plume (previously identified by Delta-Simons).
BH06d-17	524167.876	212642.478	84.981 m AOD	Deeper well (c. 40 m bgl) into the potential dissolved phase plume (previously identified by Delta-Simons).

7.2 Assessment Strategy

The scope of the investigation works is summarised below:

- a non-intrusive utility search for the presence of Site services was carried out by obtaining service utility plans and the undertaking of a survey of the Site by an EAME approved service tracing specialist (RP Drilling Ltd);
- the drilling of six (6) shell and auger boreholes to a maximum depth of 41 metres below ground level (bgl) by an EAME approved sub-contractor (Geotron UK Ltd.);
- the installation of 50mm diameter monitoring wells at six (6) locations to facilitate groundwater monitoring;
- positioning of all intrusive locations using a standalone Leica Global Positioning System (GPS)/ Global Navigation Satellite System (GNSS);

- the logging, sampling and on-site screening of soil samples for Volatile Organic Compounds (VOCs) at regular intervals (every ½ metre) throughout the soil profile using a Photo Ionisation Detector (PID); and

- submission of selected soil samples to a UKAS and MCERTS accredited independent laboratory (i2 Analytical Ltd) for the analysis of a range of contaminants, which are likely to be associated with the former/current activities and ground conditions on the Site.

7.2.1 Health and Safety

A detailed project specific Health and Safety Plan (HSP) was prepared in advance of the commencement of the investigatory works. The project specific HSP was approved by the Project Director and was provided to all on-site EAME employees. For the avoidance of doubt, EAME staff as a minimum adhere to relevant legislation and best practice, including the Health and Safety Executive Guidance Note HS(G) 47 "Avoiding Danger from Underground Services", and other relevant regulatory and legal requirements *e.g. Health & Safety at Work Act 1974 etc.*

7.2.2 Drilling

All drilling and borehole installation were undertaken by Geotron UK Limited. Geotron UK Ltd. was founded in 2002 by the collaboration of a UK based team with an environmental consultancy background and Geotron International B.V., an established Dutch drilling contractor operating internationally on environmental and geotechnical drilling programmes since 1989.

The rig used was a Dando 2500 shell and auger rig. Full rig certification and driller CVs are held on-file. The well installations were made using <1mm slotted well screen, 1-2mm washed and graded filter gravel and high-quality bentonite sealing materials. All materials were supplied by Geotron UK Limited.

Drilling commenced on 11th December 2017, but drilling was not completed until 16th January 2018 as there were two rig breakdowns (4 working days lost) and the Christmas period (8 working days lost) during the drilling campaign.

7.2.3 Sample Integrity

All collected soil and groundwater samples were submitted to an MCERTS and UKAS (ISO 17025) accredited laboratory (i2 Analytical) for chemical analysis. Discussions were held with the laboratory prior to the commencement of any works to determine the quantity of sample required and the containers to be used.

All samples obtained were placed in the appropriate container for the analysis to be carried out and were immediately put into a temperature regulated cool box with frozen cool packs. All samples were given a unique reference number, dated and the information recorded on an appropriate Chain of Custody (CoC) form for dispatch with the samples to the appropriate laboratory.

7.3 Borehole PID Profiles

Soil samples every ½ metre (where recovered) were tested by dynamic headspace analysis, for the presence of volatile organic compounds (VOCs) using a Photoionization Detector (PID). Dynamic headspace analysis refers to the manual agitation (warming) of a sample to facilitate the volatilisation of organic compounds present in the water into the headspace above which is then analysed using the PID. The PID screens for a wide range of volatile organic compounds including hydrocarbon compounds and certain chlorinated solvents but does not indicate a specific compound. The measurements obtained by the instrument in parts per million by volume (ppmv) provide a semi-quantitative indication of the concentration of hydrocarbon vapours that are.

The profiles generated through this process are outlined in *Figure 7-2* to *Figure 7-7* below. The PID profiles are summarised within the individual borehole logs (*Annex C*) and within *Annex C - Figure C1*.

7.3.1 BH01-17 (Located within the historic tank farm/remediation area)

Remedial works have been undertaken by Delta-Simons around the Polycell tank farm to remove 13 underground tanks. The impacted soils were removed (to a depth of approximately 3.5 metres below ground level) and bioremediated on-site then replaced within the excavation. A pump and treat groundwater remediation system was installed to inject oxygen and remove free product followed by an on-going period of Monitored Natural Attenuation (MNA) of the dissolved phase contamination (last monitored in late 2015).

The PID profile versus sample depth is outlined in *Figure 7-2*. It is important to note that where continuous ½ metre samples could not be obtained interpolation of the data has not been presented (*i.e.* the data points have not been joined).

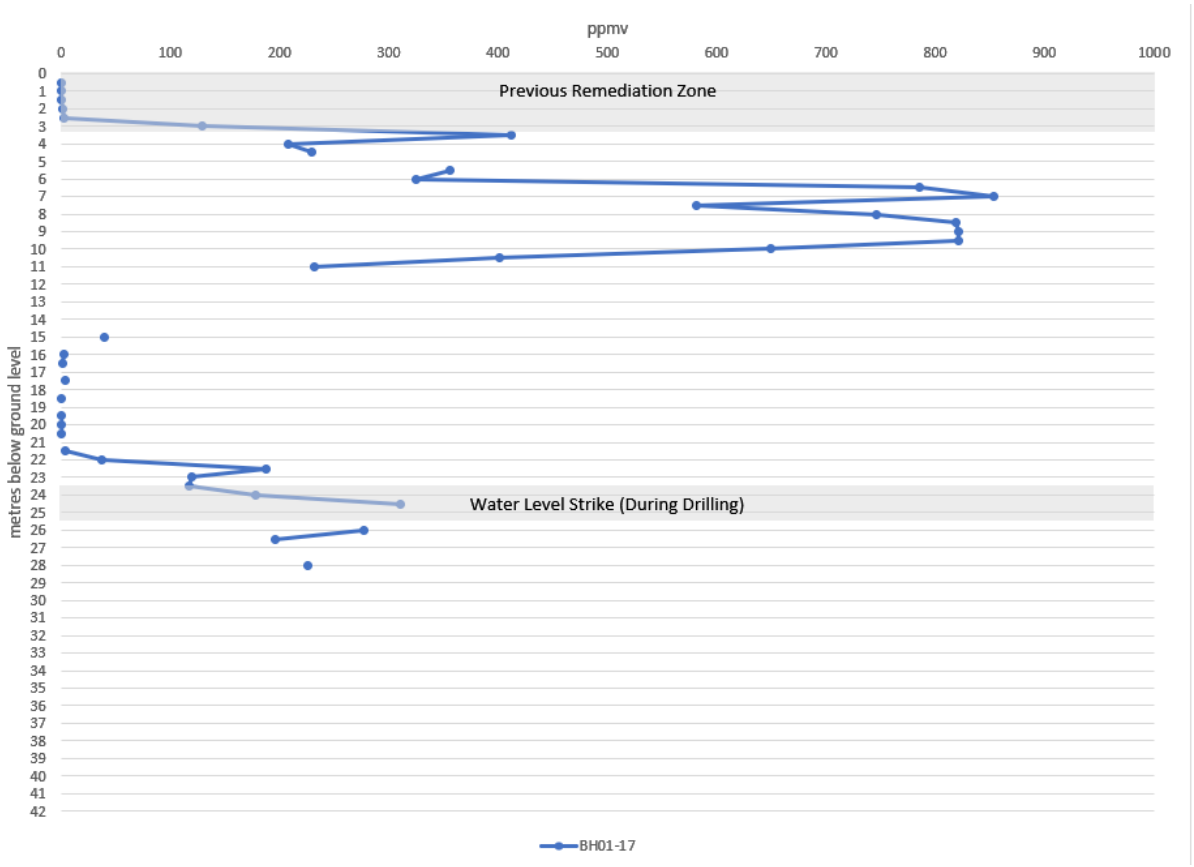


Figure 7-2: *PID profile associated with BH01-17 (0.5 m to 28 m bgl)*

The observation from this well is that the previous remedial works have successfully reduced soil vapour levels within the zone 0 – 3.5 m bgl. Between 3.5 – 11 m bgl the soil vapour levels are highly elevated associated with sand and gravel horizons, but these are significantly reduced between 15 – 21.5 m bgl. The next peak is associated with the water strike at 23.5 m bgl.

7.3.2 BH02-17 (40 m east of BH01-17, 10 m from edge of remediation area)

The historical maps for the area have been reviewed to assess historical land use of the Suchard Chocolate Factory Site. From 1878 until 1923, the Site is undeveloped agricultural land. By 1938, the Site is occupied by an electric heater manufacturer and a single railway track which travels north towards the centre of the Site. By 1960, the Site is labelled as a 'unspecified factory', and the railway track is no longer present. By 1968, the Site is labelled as a confectionary factory.

The PID profile versus sample depth is outlined in *Figure 7-3*. It is important to note that where continuous ½ metre samples could not be obtained interpolation of the data has not been presented (*i.e.* the data points have not been joined).

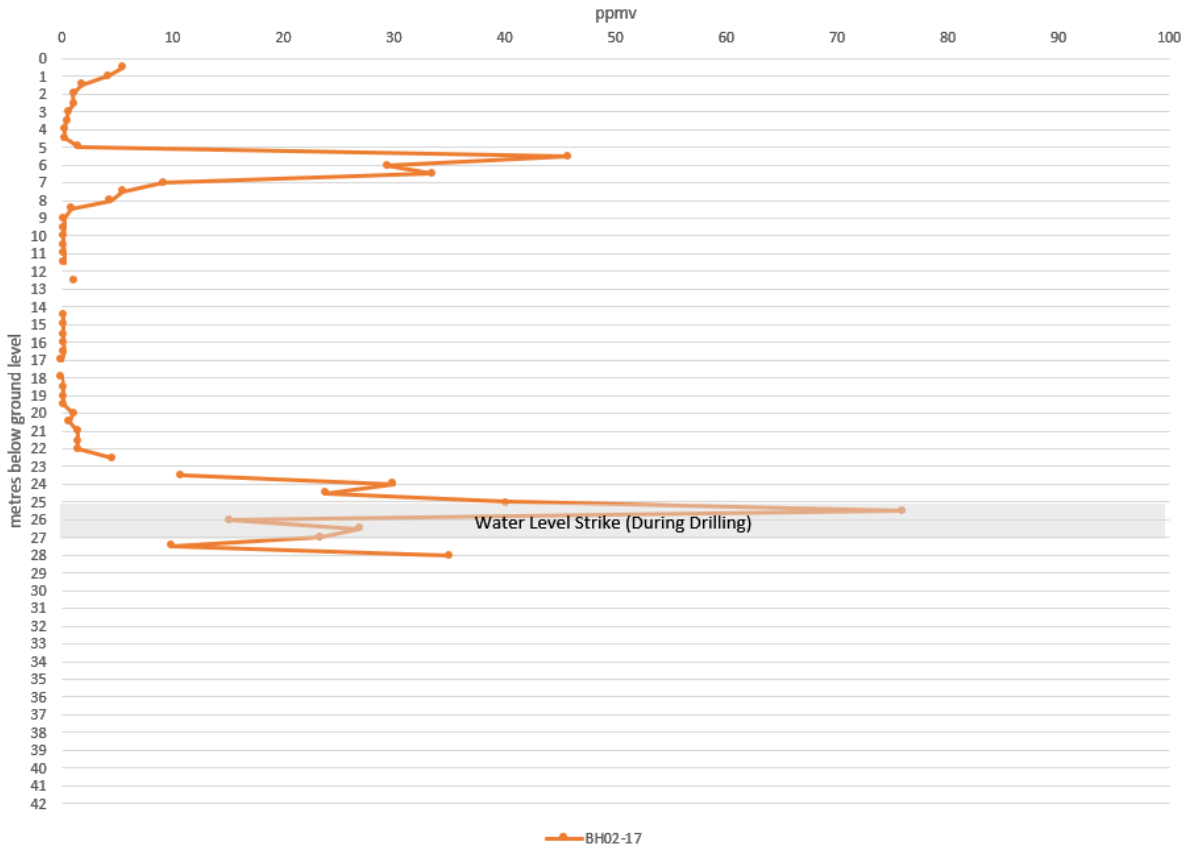


Figure 7-3: *PID profile associated with BH02-17 (0.5 m to 28.5 m bgl)*

The observation from this well is that the soil vapour between 0 – 4.5 m bgl is generally low. Between 4.5 – 8 m bgl the soil vapour levels are elevated associated with clayey horizons, but these are significantly reduced between 8.5 – 22.5 m bgl. The next peak is associated with the water strike at 25 m bgl.

7.3.3 BH03-17 (35 m south southwest of BH01-17, 18 m from the edge of remediation area)

The borehole is located within the historic Polycell facility near to a workshop at the western end of the historic British Instructional Films (BIF) Broadwater Road Studio building.

The PID profile versus sample depth is outlined in *Figure 7-4*. It is important to note that where continuous ½ metre samples could not be obtained interpolation of the data has not been presented (*i.e.* the data points have not been joined).

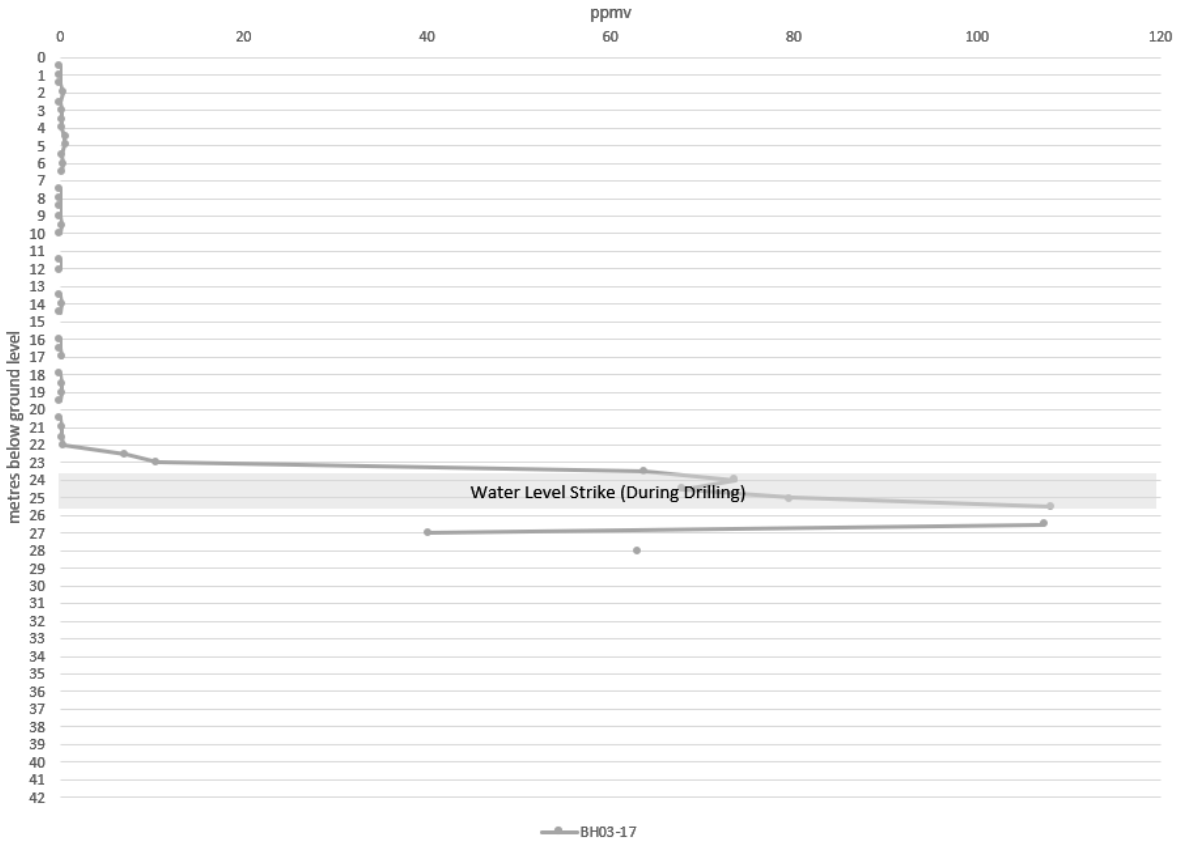


Figure 7-4: *PID profile associated with BH03-17 (0.5 m to 28 m bgl)*

The observation from this well is that the soil vapour between 0 – 22 m bgl are generally low. The main peak is associated with the water strike at 23.5 m bgl.

7.3.4 BH04-17 (115 m southeast of BH01-17, 90 m from edge of the remediation area)

The borehole is located within the historic Polycell facility near to a location of the historic boiler house.

The PID profile versus sample depth is outlined in *Figure 7-5*. It is important to note that where continuous ½ metre samples could not be obtained interpolation of the data has not been presented (*i.e.* the data points have not been joined).

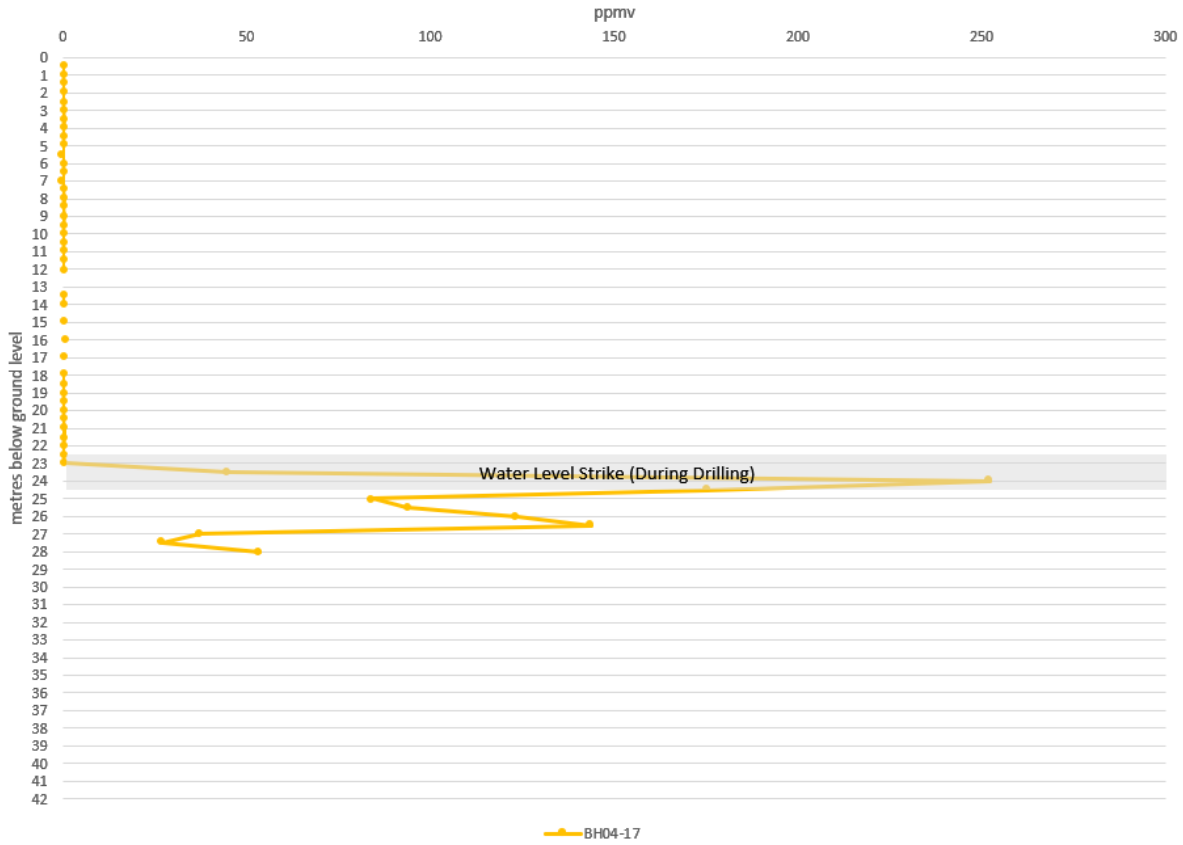


Figure 7-5: *PID profile associated with BH01-17 (0.5 m to 28 m bgl)*

The observation from this well is that the soil vapour levels between 0 – 22 m bgl are generally low. The main peak is associated with the water strike at 22.5 m bgl.

7.3.5 BH05-17d (153 m south southeast of BH01-17, 30 m from edge of the remediation area)

The borehole is located within the historic Polycell facility.

The PID profile versus sample depth is outlined in *Figure 7-6*. It is important to note that where continuous ½ metre samples could not be obtained interpolation of the data has not been presented (*i.e.* the data points have not been joined).

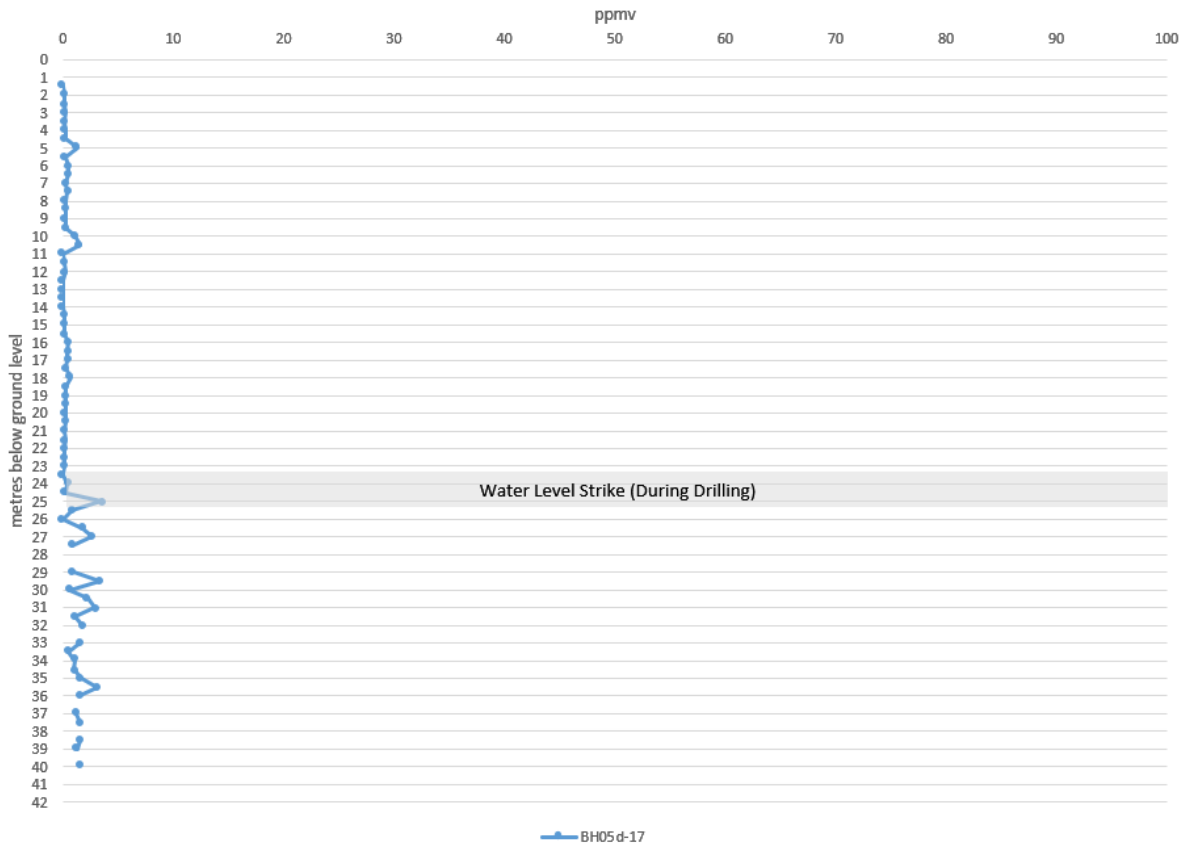


Figure 7-6: *PID profile associated with BH05d-17 (0.5 m to 38 m bgl)*

The observation from this well is that the soil vapour levels between 0 – 23 m bgl are generally low. A slight peak is associated with the water strike at 23.5 m bgl. The lower overall levels observed in this well (30 m from the remediation area) and the higher levels observed within BH04-17 (90 m from the remediation area could not be explained through direct observation.

7.3.6 BH06-17d (145 m southeast of BH01-17, 120 metres from edge of the remediation area)

The borehole is located within the historic Polycell facility.

The PID profile versus sample depth is outlined in *Figure 7-7*. It is important to note that where continuous ½ metre samples could not be obtained interpolation of the data has not been presented (*i.e.* the data points have not been joined).

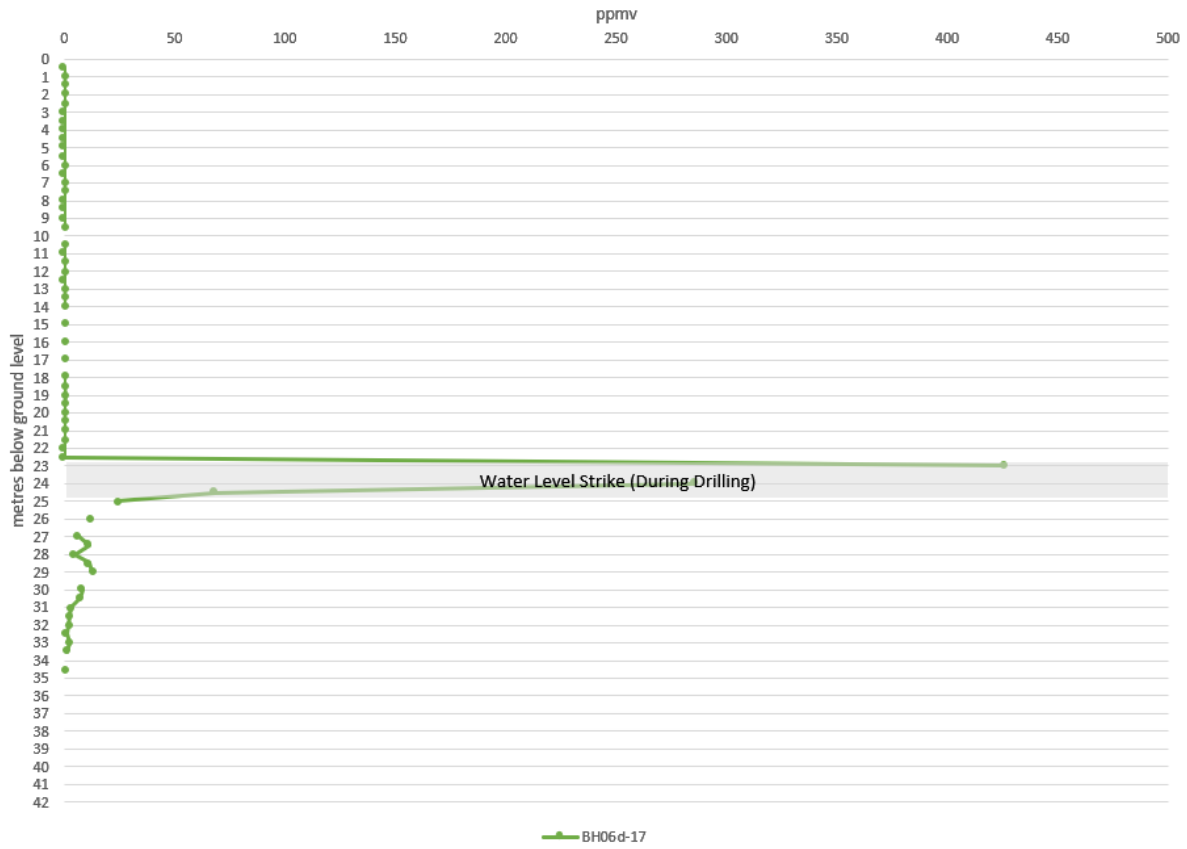


Figure 7-7: *PID profile associated with BH06d-17 (0.5 m to 40 m bgl)*

The observation from this well is that the soil vapour levels between 0 – 23 m bgl are generally low. A notable peak is associated with the water strike at 23 m bgl.

The borehole logs from the installed wells are provided in *Annex C.*

8 Stage 3 – Shallow Soils Assessment (Windowless Samples)

8.1 Introduction

The planning permission (N6/2015/0294/PP) and associated conditions state:

1) A site investigation scheme, based on the submitted phase 1 Environmental Assessment (Delta-Simons ref 2342.17 V2) to provide information for a detailed assessment of the risk to all receptors that may be affected, including those off site.

The previously referred to Delta-Simons report outlines previous work but did not include a detailed scope of works beyond the paragraph *'Prior to the redevelopment of the Site, additional Site-wide investigation of the shallow soils, including ground gas and soil vapour monitoring is likely to be required to confirm, through standard planning conditions, that the Site is suitable for the proposed mixed use including residential, retail, office, hotel, gym and community hub'*.

As a result, EAME developed a detailed scope of works (Ref. 016-1512 Plutus Estates Welwyn Garden City - Planning Condition1 LETTER REV00 – 29/09/17) which was submitted to Welwyn Hatfield Borough Council for approval. The scheme of or works was approved by Mr. Tim Croot (Welwyn Hatfield Borough Council, Environmental Health Department) on 7th November 2017.

8.2 Scope of Works

A targeted intrusive investigation at the Site was undertaken to better understand the ground conditions and to assess the nature and extent of any contamination. The breakdown of the strategy to investigate and assess conditions can be summarised as follows:

- a non-intrusive utility search for the presence of Site services was carried out by obtaining service utility plans and the undertaking of a survey of the Site by an EAME approved service tracing specialist (RP Drilling Ltd);
- the drilling of twenty-four (24) windowless sample locations to a maximum depth of 5.0 metres below ground level (bgl) by an EAME approved sub-contractor (RP Drilling Ltd) between 28th November 2017 and 1st December 2017;
- the installation of 50mm diameter monitoring wells at fifteen (15) locations to facilitate gas and groundwater monitoring;

- positioning of all intrusive locations using a standalone Leica Global Positioning System (GPS)/ Global Navigation Satellite System (GNSS);
- the logging, sampling and on-site screening of soil samples for Volatile Organic Compounds (VOCs) at regular intervals throughout the soil profile using a Photo Ionisation Detector (PID); and
- submission of selected soil samples and groundwater samples to a UKAS and MCERTS accredited independent laboratory (i2 Analytical Ltd) for the analysis of a range of contaminants, which are likely to be associated with the former/current activities and ground conditions on the Site.

The location of the agreed windowless sample locations is outlined in *Figure 8.1* with the co-ordinates presented in *Table 8-1*.

The area outlined yellow in *Figure 8-1* could not be targeted due to the presence of an extensive 1.5-2.0 metre-deep 2,000 m^2 basement (historic firing range). The sediment and water within this void have been sampled by John F Hunts for off-site treatment and disposal. The results of this work are provided under a separate cover.

Figure 8-1: *Windowless Sample Locations (WS01-17 to WS24-17)*

Google Earth Imaging with the permission of Google – Licensed to Earth and Marine Environmental Consultants Ltd.

Table 8-1: *Windowless Sample Locations (2017)*

Ref.	Easting	Northing	Elevation	Notes
WS01-17	524171.133	212621.869	84.762 m AOD	-
WS02-17	524121.283	212652.644	85.304 m AOD	-
WS03-17	524082.03	212645.412	85.325 m AOD	Hole drilled but it caught the edge of the firing range. At that point the extent of the basement had not been determined. The WS was abandoned.
WS04-17	524190.648	212673.212	84.787 m AOD	-
WS05-17	524143.299	212649.645	85.299 m AOD	-
WS06-17	524112.357	212670.435	85.021 m AOD	-
WS07-17	524060.991	212712.828	85.234 m AOD	-
WS08-17	524179.242	212709.673	85.198 m AOD	-
WS09-17	524154.992	212681.31	85.194 m AOD	Refusal due to secondary underlying slab. Unable to penetrate. The WS was abandoned.
WS10-17	524099.306	212683.425	85.175 m AOD	-
WS11-17	524206.769	212716.914	84.758 m AOD	-
WS12-17	524159.396	212729.56	85.079 m AOD	-
WS13-17	524131.605	212718.968	85.323 m AOD	-
WS14-17	524118.686	212743.99	85.215 m AOD	Refusal due to secondary underlying slab. Unable to penetrate. The WS was abandoned.
WS15-17	524097.616	212754.983	84.829 m AOD	-
WS16-17	524104.558	212773.723	85.484 m AOD	-
WS17-17	524136.882	212752.92	85.356 m AOD	-
WS18-17	524079.577	212782.801	85.68 m AOD	-
WS19-17	524146.062	212775.543	85.455 m AOD	-
WS20-17	524162.04	212820.504	85.363 m AOD	-
WS21-17	524093.336	212821.609	85.540 m AOD	-

Ref.	Easting	Northing	Elevation	Notes
WS22-17	524125.158	212817.694	85.545 m AOD	-
WS23-17	524166.576	212799.649	85.662 m AOD	-
WS24-17	524185.705	212814.664	85.172 m AOD	-

As three refusals were encountered (WS0-3-17, WS09-17, WS14-17) additional soil samples were obtained from the remaining locations to increase sample numbers.

8.2.1 Health and Safety

A detailed project specific Health and Safety Plan (HSP) was prepared in advance of the commencement of the investigatory works. The project specific HSP was approved by the Project Director and was provided to all on-site EAME employees. For the avoidance of doubt, EAME staff as a minimum adhere to relevant legislation and best practice, including the Health and Safety Executive Guidance Note HS(G) 47 "Avoiding Danger from Underground Services", and other relevant regulatory and legal requirements *e.g. Health & Safety at Work Act 1974 etc.*

8.2.2 Drilling

All drilling and windowless sample installations were undertaken by RP Drilling Ltd using a small tracked rig. Since 2008 RP Drilling Ltd has supplied windowless sampling services to both the geotechnical and environmental industries. Lead drillers hold NVQs and all operatives possess CSCS cards.

The well installations were made using <1mm slotted well screen, 1-2mm washed and graded filter gravel and high-quality bentonite sealing materials. All materials were supplied by RP Drilling Limited. Drilling commenced on 28th November 2017 and was completed on 1st December 2017.

8.2.3 PID Field Data (Headspace Testing)

All soil samples were tested by dynamic headspace analysis, for the presence of volatile organic compounds (VOCs) using a Photoionization Detector (PID). Dynamic headspace analysis refers to the manual agitation (warming) of a sample to facilitate the volatilisation of organic compounds present in the water into the headspace above which is then analysed using the PID. The PID screens for a wide range of volatile organic compounds including hydrocarbon compounds and certain chlorinated solvents but does not indicate a specific compound. The measurements obtained by the instrument in parts per million by volume

(ppmv) provide a semi-quantitative indication of the concentration of hydrocarbon vapours that are.

The unit used was a PhoCheck Tiger supplied by Shawcity Limited. The results of the headspace testing are outlined in *Table 8-2*.

Table 8-2: *Windowless Sample PID Results (2017)*

WS Ref.	Visual and Olfactory Observations	Sample Depth (m)	PID Reading (ppmv)	Laboratory analysis	Installed
WS01-17	None	0.4 m	0.036	Yes	Yes
	None	2.2 – 2.4m	0.047	Yes	
WS02-17	None	0.3 – 0.4 m	0.077	Yes	Yes
	None	0.8 – 0.9 m	0.031	Yes	
	None	2.3 – 2.4 m	0.007	-	
	None	3.5 – 3.6 m	0.003	-	
WS03-17	WS Abandoned	WS Abandoned	WS Abandoned	WS Abandoned	No
WS04-17	None	0.45 – 0.55 m	0.295	Yes	No
	None	2.0 – 2.1 m	0.198	-	
	None	3.6 – 3.7 m	0.303	Yes	
WS05-17	None	0.9 – 1.0 m	0.200	Yes	No
	None	3.5 – 3.6 m	0.053	Yes	
WS06-17	None	0.6 – 0.7 m	0.593	-	No
	None	1.7 – 1.8 m	0.874	Yes	
	None	2.1 – 2.2 m	0.906	Yes	
WS07-17	None	0.2 – 0.3 m	0.066	Yes	Yes
	None	0.8 – 1.0 m	0.077	-	
	None	2.8 – 2.9 m	0.022	-	
	None	3.8 – 4.0 m	0.050	Yes	

WS Ref.	Visual and Olfactory Observations	Sample Depth (m)	PID Reading (ppmv)	Laboratory analysis	Installed
WS08-17	None	0.4 – 0.5 m	0.222	Yes	Yes
	None	1.3 – 1.4 m	0.073	Yes	
	None	3.6 – 3.7 m	1.245	-	
WS09-17	WS Abandoned	WS Abandoned	WS Abandoned	WS Abandoned	No
WS10-17	None	0.6 – 0.7 m	0.074	Yes	Yes
	None	0.9 – 1.0 m	0.087	Yes	
WS11-17	None	0.4 – 0.6 m	0.709	Yes	Yes
	None	1.0 – 1.2 m	0.333	-	
	None	3.9 – 4.0m	1.444	Yes	
WS12-17	None	0.5 – 0.6 m	1.108	Yes	Yes
	None	2.8 – 2.9 m	0.442	-	
	None	3.8 – 3.9 m	1.289	Yes	
WS13-17	None	0.7 – 0.8 m	0.033	Yes	Yes
	None	1.0 – 1.1 m	0.035	Yes	
	None	1.5 m	0.52	-	
	None	2.6 m	0.033	-	
WS14-17	WS Abandoned	WS Abandoned	WS Abandoned	WS Abandoned	No
WS15-17	None	0.5 – 0.6 m	1.754	Yes	Yes
	None	2.5 – 2.6 m	1.200	Yes	
	Strong solvent odours	3.6 – 3.7 m	104.22	Yes	
	Strong solvent odours	4.7 – 4.8m	123.8	Yes	
WS16-17	None	1.5 – 1.6 m	0.836	Yes	No
	None	2.6 – 2.7 m	0.382	-	
	None	3.5 – 3.6 m	1.033	Yes	

WS Ref.	Visual and Olfactory Observations	Sample Depth (m)	PID Reading (ppmv)	Laboratory analysis	Installed
WS17-17	None	1.1 – 1.2 m	1.287	Yes	No
	None	2.6 – 2.7 m	1.883	Yes	
	None	3.4 – 3.5 m	0.785	-	
WS18-17	None	0.6 – 0.7 m	0.135	Yes	Yes
	None	0.85 – 0.90 m	1.112	Yes	
	None	3.9 – 4.0m	0.477	-	
WS19-17	None	0.4 – 0.5 m	1.409	Yes	Yes
	None	1.4 – 1.5 m	1.150	Yes	
WS20-17	None	0.5 – 0.6 m	0.875	Yes	Yes
	None	1.7 – 1.8 m	0.485	-	
	None	2.6 – 2.7 m	0.928	Yes	
WS21-17	None	0.4 – 0.5 m	0.340	-	Yes
	None	0.8 – 0.9 m	1.180	Yes	
	None	1.5 – 1.6 m	1.570	Yes	
WS22-17	None	0.50 – 0.60 m	1.709	Yes	Yes
	None	2.0 – 2.10 m	0.952	-	
	None	3.9 – 4.0 m	1.671	Yes	
WS23-17	None	0.45 – 0.55 m	1.266	Yes	Yes
	None	1.7 – 1.8 m	1.522	Yes	
	None	2.30 – 2.40 m	0.246	-	
WS24-17	None	0.3 – 0.4 m	0.961	Yes	No
	None	0.8 – 0.9 m	0.389	-	
	None	1.9 – 2.0 m	1.300	Yes	

Notes:

All installed Windowless Sample locations identified above (15 in total) were dipped on the 23/01/18 and 24/01/18. No sampleable water was encountered in any of the locations.

The spread of the PID readings versus depth is outlined in *Figure 8-2*. The two outliers are associated with WS15-17 which is located within the area of the historic tank farm/remediation area. The two elevated levels were detected immediately below the 3.5 metres of remediated soil that was replaced into the tank farm excavation.

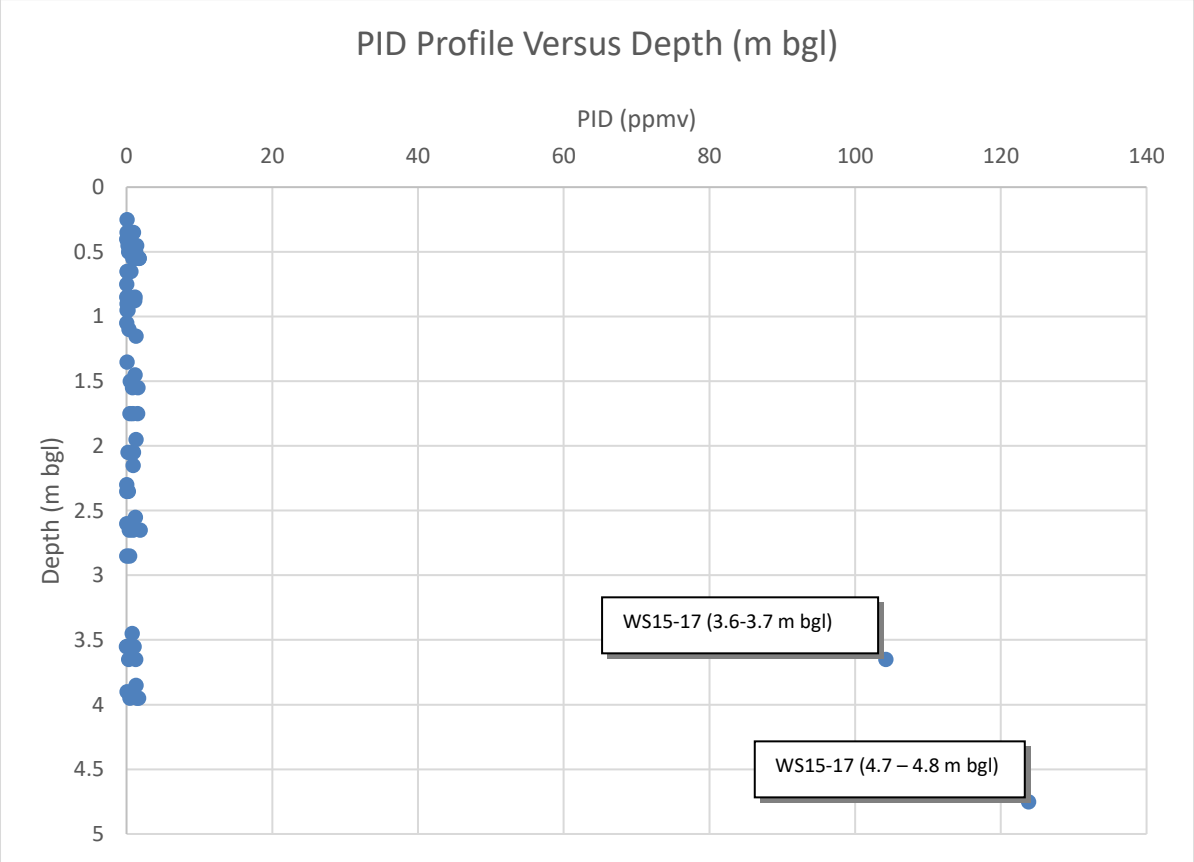


Figure 8-2: *PID Profile using sample mid-points (WS01-17 to WS24-17)*

8.2.4 Sample Integrity

All collected soil samples were submitted to an MCERTS (Soils) and UKAS (ISO 17025) accredited laboratory (i2 Analytical) for chemical analysis. Discussions were held with the laboratory prior to the commencement of any works to determine the quantity of sample required and the containers to be used.

All samples obtained were placed in the appropriate container for the analysis to be carried out and were immediately put into a temperature regulated cool box with frozen cool packs. All samples were given a unique reference number, dated and the information recorded on an appropriate Chain of Custody (CoC) form for dispatch with the samples to the appropriate laboratory.

8.3 Soil Analytical Strategy

The analytical strategy was designed by EAME to provide an assessment of the presence of a common range of potential contaminants likely to be associated with the previous uses of the Site. The analytical suites are outlined in *Table 8-3*.

In addition to the Windowless Sample data seven additional soil samples were obtained from the boreholes that were installed in 2017/2018 (as outlined within *Section 7*). The samples within the range 0.0 – 5.5 m bgl have been included within the shallow soil assessment process to expand the provided dataset.

Table 8-3: *Windowless Sample (2017) Analytical Strategy*

Analytical Suite	Soil Samples
EAME Suite B Arsenic, Cadmium, Chromium, Cr (VI), Lead, Mercury, Selenium, Copper, Nickel, Zinc, Vanadium, Beryllium, Water Soluble Boron, Total Cyanide, Monohydric Phenols, pH Value, Total Petroleum Hydrocarbon TPH - CWG (C5-35) Aliphatic/Aromatic Split (with CWG banding - Aliphatic C5-6,>6-8,>8-10,>10-12,>12-16,>16-21,>21-35) (Aromatic - >C6-7,>7-8,>8-10,>C10-12,>12-16,>16-21,>21-35), Speciated Polycyclic Aromatic Hydrocarbon (PAHs) (USEPA-16), Sulphate (water soluble), benzene, toluene, ethylbenzene, and xylenes (BTEX) and Methyl tert-butyl ether (MTBE)	**51 samples (44 WS and 7 BH)** WS01-17 (0.4 m), WS01-17 (2.2-2.4m) WS02-17 (0.4m), WS02-17 (0.8-0.9m) WS04-17 (0.45m), WS04-17 (3.6-3.7m) WS05-17 (0.9-1.0m), WS05-17 (3.5-3.6m) WS06-17 (1.7-1.8m), WS06-17 (2.1-2.2m) WS07-17 (0.2-0.3m), WS07-17 (3.8-4.0m) WS08-17 (0.4-0.5m), WS08-17 (1.3-1.4m) WS10-17 (0.6-0.7m), WS10-17 (0.9-1.0m) WS11-17 (0.4-0.6m), WS11-17 (3.9-4.0m) WS12-17 (0.5-0.6m), WS12-17 (3.8-3.9m) WS13-17 (0.7-0.8m), WS13-17 (1.0-1.1m) WS15-17 (0.5-0.6m), WS15-17 (2.5-2.6m),
Volatile Organic Compounds (VOCs) Standard i2 Analytical Ltd VOC suite was amended to include Dichloromethane (DCM) in-line with previous works conducted by Delta-Simons.	

Analytical Suite	Soil Samples
Semi Volatile Organic Compounds (SVOCs) Standard range of PAHs, Phenols that form the standard i2 Analytical Ltd SVOC suite.	WS15-17 (3.0-3.7m), WS15-17 (4.7-4.8m) WS16-17 (0.85-0.9m), WS16-17 (1.5-1.6m) WS17-17 (1.1-1.2m), WS17-17 (2.6-2.7m) WS18-17 (0.6-0.7m), WS18-17 (0.85-0.9m) WS19-17 (0.4-0.5m), WS19-17 (1.4-1.5m) WS20-17 (0.5-0.6m), WS20-17 (2.6-2.7m) WS21-17 (0.8-0.9m), WS21-17 (1.5-1.6m) WS22-17 (0.5-0.6m), WS22-17 (3.9-4.0m) WS23-17 (0.45-0.55m), WS23-17 (1.7-1.8m) WS24-17 (0.3-0.4m), WS24-17 (1.9-2.0m), BH02-17 (0.5m), BH02-17 (5.5m) BH03-17 (5.5m), BH05d-17 (2.5m) BH04-17 (3.5m), BH06d-17 (1.0m) **Firing Range (FR1 and FR2)**
Polychlorinated Biphenyls (PCBs) 7 Congeners + Total PCBs	**10 Samples (5 WS and 5 BH)** WS05-17 (0.9-1.0m), WS08-17 (0.4-0.5m), WS19-17 (0.4-0.5m), WS23-17 (0.45-0.55m), WS24-17 (0.3-0.4m), BH02-17 (0.5m), BH03-17 (5.5m), BH05d-17 (2.5m), BH04-17 (3.5m), BH06d-17 (1.0m) **Firing Range (FR1 and FR2)**
Asbestos	**12 samples** WS01-17 (0.4 m), WS02-17 (0.8-0.9m), WS04-17 (0.45m), WS07-17 (0.2-0.3m), WS13-17 (0.7-0.8m), WS15-17 (0.5-0.6m), WS15-17 (2.5-2.6m), WS18-17 (0.6-0.7m), WS20-17 (0.5-0.6m), WS21-17 (0.8-0.9m), WS22-17 (0.5-0.6m), WS23-17 (0.45-0.55m) **Firing Range (FR1 and FR2)**

8.3.1 Soil Chemical Data

Fifty-one (#51) soil samples were recovered (0.0 – 5.5 m bgl) and were scheduled for laboratory analysis (*Table 8-3*). The first stage of initial assessment was to screen out those compounds that were not recorded above the laboratory analytical method detection limits (MDLs). These are provided below and have not been considered further:

- Asbestos in soil;
- Total Cyanide (MDL 1 mg/kg);
- Total Phenols (MDL 1 mg/kg);
- Selected Polyaromatic Hydrocarbons (PAHs) (*i.e.* Acenaphthylene, Acenaphthene, Fluorene and Dibenz(a,h)anthracene – Individual MDL 0.05 mg/kg);
- Chromium (hexavalent) (MDL 4 mg/kg);
- Monoaromatics (*i.e.* Benzene, Toluene, Ethylbenzene, p & m-xylene, o-xylene, MTBE (Methyl Tertiary Butyl Ether - Individual MDL 1 µg/kg)
- TPH-CWG - Aliphatic >C5 - C6 (MDL 0.001 mg/kg);
- TPH-CWG - Aliphatic >C6 – C8 (MDL 0.001 mg/kg);
- TPH-CWG - Aliphatic >C8 – C10 (MDL 0.001 mg/kg);
- TPH-CWG - Aromatic >C5 – C7 (MDL 0.001 mg/kg);
- TPH-CWG - Aromatic >C7 – C8 (MDL 0.001 mg/kg);
- All VOCs (MDL 1 µg/kg) except for Isopropylbenzene, n-Propylbenzene, 1,3,5-Trimethylbenzene, 1,2,4-Trimethylbenzene, sec-Butylbenzene, p-Isopropyltoluene, dichloromethane (MDL 100 µg/kg);
- All SVOCs (MDL variable) except for Naphthalene, 2-Methylnaphthalene, Dibenzofuran, Phenanthrene, Anthracene, Anthraquinone, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Indeno(1,2,3-cd)pyrene, Benzo(ghi)perylene;
- PCBs (PCB Congener 28, PCB Congener 52, PCB Congener 101, PCB Congener 118, PCB Congener 138, PCB Congener 153 and PCB Congener 180) (Individual MDL 0.001 mg/kg); and
- PCB (total) (MDL 0.007 mg/kg).

8.3.2 Assessment Criteria

Assessment of contaminated soils in the UK follows a risk-based approach and is structured in a tiered manner. As well as having a systematic approach to collecting the data it is also

necessary to adopt recognised techniques and standards in assessing them and particularly regarding environmental risk assessment.

The information gathered during the site investigation was utilised to develop a conceptual site model based on the risk assessment principles of source, pathway and receptor.

The soil analytical results have been compared against an appropriate set of assessment criteria:

- Soil Guideline Values (SGVs) for the 11 compounds published in 2009 by the Environment Agency (EA);
- Suitable 4 Use Levels (S4UL) for 89 substances published by the Chartered Institute of Environmental Health (CIEH) and the Land Quality Management Group (LQM) in 2015[12]. S4UL replaces the 2nd edition of the LQM/CIEH generic assessment criteria published in 2009. The LQM/CIEH S4ULs are intended to provide a complete and updated replacement for the LQM/CIEH General Assessment Criteria (GAC)[13];
- Defra. Category 4 Screening Levels (C4SLs) for Lead; and
- Contaminated Land: Applications in Real Environments (2010). Soil Generic Assessment Criteria (GAC) for Human Health Risk Assessment, C:LAIRE, ISBN 978-1-905046-20-1, January 2010.

The SGV values for soil assessment were developed in accordance with current UK legislation and Environment Agency policy using the Contaminated Land Exposure Assessment (CLEA) risk assessment model (CLEA Version 1.06). The S4UL values are based on health criteria values, updated to reflect changes since 2009. They are derived for the standard CLEA land uses and the two public open space scenarios outlined in document SP1010[14] (CL:AIRE, 2014). The S4ULs are also compliant with EA document SR2[15] and the long-standing principle of 'suitable for use' whilst also reflecting changes to exposure parameters outlined in document in SP1010 (CL:AIRE, 2014).

12 Nathanail, C.P.; McCaffrey,C.; Gillett, A.G.; Ogden, R.C. & Nathanail, J.F. (2015), LQM/CIEH Suitable 4 Use Levels, Land Quality Press, Nottingham, ISBN: 978-0-9931084-0-2

13 Copyright Land Quality Management Limited reproduced with permission; Publication Number S4UL3241

14 Contaminated Land: Applications in Real Environments (CL:AIRE) (2014), SP1010 – Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination, Final Project Report (Revision 2)

15 Environment Agency (2009), Human health toxicological assessment of contaminants in soil, Science Report – Final SC050021/SR2

The S4UL values are intended to be 'trigger values' that mark the concentration of a substance in soil at or below which human exposure can be considered to represent a 'tolerable' or 'minimal' level of risk such that the land is suitable for its use.

Neither of these guidelines referred to have any legal status in the UK, they merely provide a useful screening guide to help identify where more site-specific risk assessment may be required *i.e.* exceedence of a guideline value should trigger further consideration and not be presumed to imply remediation is needed. Where known contamination exists above guideline values and this presents a significant risk to potential receptors then more sophisticated site-specific Quantitative Risk Assessment (QRA) can be undertaken to better define the risks and identify appropriate remediation target values for the substances of concern.

8.3.3 Site End use

Six land use categories are outlined within the S4UL guidance:

- residential with home-grown produce;
- residential without home-grown produce;
- allotment;
- commercial;
- public open spaces (residential); and
- public open spaces (park).

The proposed development is residential but there are no individual gardens. All green spaces are shared *i.e.* The weave (a central public area of green space), Podium level residential gardens (recreational space for residents located above ground floor parking), Sensory garden (a publicly accessible space with individual and combined sensory opportunities), Roof gardens (roof level gardens) and a Green edge infrastructure (utilising existing trees and vegetation). These will be managed spaces where the residents will not have the ability to use the land as they wish to, for example, grow things.

As a result, public open spaces (residential) has been selected as the appropriate land use.

8.3.4 Soil Organic Matter

Ten samples were submitted for organic matter analysis. The results range from 0.1% to 1.5 %. The Tier 1 LQM/CIEH screening value is therefore based on S4UL Public Open Spaces

(Residential) (SOM 1%) has been used in the assessment except for heavy metals/metalloids where no SOM is stated.

The Tier 1 screening values used are:

*1 LQM/CIEH (Public Open Spaces (Residential) S4ULs, based on 1% Soil Organic Matter)

*2 LQM/CIEH (Public Open Spaces (Residential) S4ULs, no Soil Organic Matter stated)

*3 Category 4 Screening Levels (C4SLs), Public Open Spaces 1 (Grassed area adjacent to residential housing)

*4 C:LAIRE GAC for 1% SOM residential without homegrown produce (January 2010)

The Tier 1 soils assessment is outlined within *Table 8-4.*

Table 8-4: *Tier 1 Soil Assessment – South Site*

Contaminant	No. Samples Tested	No. Samples > MDL	Concentration Range (mg/kg)	Location and Max. Concentration	Screening Value (mg/kg)	No. of Exceedences of Screening Criteria
General Inorganics						
pH	51	51	6.3 – 12.2	N/A	NG	-
Sulphate (water soluble) as SO_4 (g/l), (2:1 Leachate Equivalent)	51	51	0.0075 – 0.82	WS15-17 (2.5-2.6m)	NG	-
Speciated PAHs						
Naphthalene	51	1	<MDL – 0.53	WS18-17 (0.6-0.7m) 0.53 mg/kg	4900[*1]	0
Phenanthrene	51	6	<MDL – 1.6	BH02-17 (0.5m) 1.6 mg/kg	3100[*1]	0
Anthracene	51	2	<MDL – 0.4	WS18-17 (0.6-0.7m) 0.4 mg/kg	74000[*1]	0
Fluoranthene	51	9	<MDL – 2.8	WS18-17 (0.6-0.7m) 2.8 mg/kg	3100[*1]	0
Pyrene	51	9	<MDL – 2.3	WS18-17 (0.6-0.7m) 2.3 mg/kg	7400[*1]	0

Contaminant	No. Samples Tested	No. Samples > MDL	Concentration Range (mg/kg)	Location and Max. Concentration	Screening Value (mg/kg)	No. of Exceedences of Screening Criteria
Benzo(a)anthracene	51	9	<MDL – 1.1	WS18-17 (0.6-0.7m) 1.1 mg/kg	29[*1]	0
Chrysene	51	9	<MDL – 1.5	WS18-17 (0.6-0.7m) 1.5 mg/kg	57[*1]	0
Benzo(b)fluoranthene	51	9	<MDL – 1.7	WS18-17 (0.6-0.7m) 1.7 mg/kg	7.1[*1]	0
Benzo(k)fluoranthene	51	6	<MDL – 0.92	WS18-17 (0.6-0.7m) 0.92 mg/kg	190[*1]	0
Benzo(a)pyrene	51	9	<MDL – 1.3	WS18-17 (0.6-0.7m) 1.3 mg/kg	5.7[*1]	0
Indeno(1,2,3-cd)pyrene	51	4	<MDL – 0.67	WS18-17 (0.6-0.7m) 0.67 mg/kg	82[*1]	0
Benzo(ghi)perylene	51	4	<MDL – 0.81	WS18-17 (0.6-0.7m) 0.81 mg/kg	640[*1]	0
Total PAH						
Speciated Total EPA-16 PAHs	51	9	<MDL – 15.5	WS18-17 (0.6-0.7m) 15.5 mg/kg	NG	-
Heavy Metals / Metalloids						

Contaminant	No. Samples Tested	No. Samples > MDL	Concentration Range (mg/kg)	Location and Max. Concentration	Screening Value (mg/kg)	No. of Exceedences of Screening Criteria
Arsenic	51	51	5.7 - 140	WS17-17 (1.1-12m) 140 mg/kg	79[*2]	**3** WS16-17 (1.5-1.6m) – 85 mg/kg WS17-17 (1.1-1.2m) – 140 mg/kg WS23-17 (1.7-1.8m) – 110 mg/kg
Beryllium	51	51	0.31 – 3.7	WS23-17 (1.7-1.8m) 3.7 mg/kg	2.2[*2]	4 WS07-17 (0.2-0.3m) – 2.7 mg/kg WS16-17 (1.5-1.6m) – 2.3 mg/kg WS17-17 (1.1-1.2m) – 2.2 mg/kg WS23-17 (1.7-1.8m) – 3.7 mg/kg
Boron	51	49	<MDL – 5	WS05-17 (0.9-1.0m) 5 mg/kg	21000[*2]	0
Cadmium	51	4	<MDL – 0.9	WS18-17 (0.6-0.7m) 0.9 mg/kg	120[*2]	0
Chromium	51	51	12 - 44	WS08-17 (1.3-1.4m) 44 mg/kg	1500[*2]	0
Copper	51	51	4.6 – 230	WS18-17 (0.6-0.7m) 230 mg/kg	12000[*2]	0
Lead	51	51	3.9 - 320	WS18-17 (0.6-0.7m) 320 mg/kg	630[*3]	0

Contaminant	No. Samples Tested	No. Samples > MDL	Concentration Range (mg/kg)	Location and Max. Concentration	Screening Value (mg/kg)	No. of Exceedences of Screening Criteria
Mercury	51	3	<MDL – 0.8	WS23-17 (0.45-0.55m) 0.8 mg/kg	16[*2]	0
Nickel	51	51	11 – 110	WS17-17 (1.1-1.2m) 110 mg/kg	230[*2]	0
Selenium	51	1	<MDL – 1.1	BH6d-17 (1.0m) 1.1 mg/kg	1100[*2]	0
Vanadium	51	51	18 – 74	WS07-17 (0.2-0.3m) 74 mg/kg	2000[*2]	0
Zinc	51	51	27 – 510	WS05-17 (3.5-3.6m) 510 mg/kg	81000[*2]	0
Petroleum Hydrocarbons						
TPH-CWG – Aliphatic >EC10 - EC12	51	5	<MDL – 6	WS02-17 (0.4m) 6 mg/kg	13000[*1]	0
TPH-CWG – Aliphatic >EC12 – EC16	51	6	<MDL - 92	WS02-17 (0.4m) 92 mg/kg	13000[*1]	0
TPH-CWG – Aliphatic >EC16 – EC21	51	5	<MDL - 250	WS02-17 (0.4m) 250 mg/kg	250000[*1]	0

Contaminant	No. Samples Tested	No. Samples > MDL	Concentration Range (mg/kg)	Location and Max. Concentration	Screening Value (mg/kg)	No. of Exceedences of Screening Criteria
TPH-CWG – Aliphatic >EC21 – EC35	51	8	<MDL - 410	WS02-17 (0.4m) 410 mg/kg	250000[*1]	0
TPH-CWG - Aliphatic (EC5 - EC35)	51	9	<MDL - 760	WS02-17 (0.4m) 760 mg/kg	NG	-
TPH-CWG – Aromatic >EC8 - EC10	51	1	<MDL – 2.6	WS15-17 (4.7-4.8m) 2.6 mg/kg	5000[*1]	0
TPH-CWG – Aromatic >EC10 - EC12	51	4	<MDL – 6.4	WS02-17 (0.4m) 6.4 mg/kg	5000[*1]	0
TPH-CWG – Aromatic >EC12 – EC16	51	6	<MDL – 82	WS02-17 (0.4m) 82 mg/kg	5100[*1]	0
TPH-CWG – Aromatic >EC16 – EC21	51	4	<MDL – 220	WS02-17 (0.4m) 220 mg/kg	3800[*1]	0
TPH-CWG – Aromatic >EC21 – EC35	51	8	<MDL – 380	WS02-17 (0.4m) 380 mg/kg	3800[*1]	0
TPH-CWG - Aromatic (EC5 - EC35)	51	9	<MDL – 680	WS02-17 (0.4m) 680 mg/kg	NG	-
Volatile Organic Compounds (VOCs)						

Contaminant	No. Samples Tested	No. Samples > MDL	Concentration Range (mg/kg)	Location and Max. Concentration	Screening Value (mg/kg)	No. of Exceedences of Screening Criteria
Isopropylbenzene	51	1	<MDL – 22 µg/kg	WS15-17 (3.0-3.7m) 22 µg/kg	12000[*4]	0
n-Propylbenzene	51	1	<MDL – 120 µg/kg	WS15-17 (3.0-3.7m) 120 µg/kg	NG	-
1,3,5-Trimethylbenzene	51	1	<MDL – 200 µg/kg	WS15-17 (3.0-3.7m) 200 µg/kg	NG	-
1,2,4-Trimethylbenzene	51	1	<MDL – 1800 µg/kg	WS15-17 (3.0-3.7m) 1800 µg/kg	410[*4]	1 WS15-17 (3.0-3.7m) – 1800 µg/kg
sec-Butylbenzene	51	1	<MDL – 35 µg/kg	WS15-17 (3.0-3.7m) 35 µg/kg	NG	-
p-Isopropyltoluene	51	1	<MDL – 300 µg/kg	WS15-17 (3.0-3.7m) 300 µg/kg	NG	-
Semi-volatile Organic Compounds (SVOCs)						
2-Methylnaphthalene	51	2	<MDL – 0.6	WS15-17 (3-3.7m) 0.6 mg/kg	NG	-
Dibenzofuran	51	2	<MDL – 0.5	WS15-17 (3-3.7m) 0.5 mg/kg	NG	-

Contaminant	No. Samples Tested	No. Samples > MDL	Concentration Range (mg/kg)	Location and Max. Concentration	Screening Value (mg/kg)	No. of Exceedences of Screening Criteria
Anthraquinone	51	1	<MDL – 0.3	WS18-17 (0.6-0.7m) 0.3 mg/kg	NG	-
'LQM/CIEH Copyright Land Quality Management Limited reproduced with permission; Publication Number S4UL3241'						

Notes:

Units are mg/kg except where indicated otherwise

NG = No Guideline available

<MDL = Below the Method Detection Limit

The exceedences of the stated screening values are:

Arsenic – Concentration range of 5.7 – 140 mg/kg with 3 samples more than the 79 mg/kg LQM/CIEH Public Open Spaces (Residential) S4ULs, no Soil Organic Matter stated) screening value.

Beryllium – Concentration of 0.31 – 3.7 mg/kg with 4 samples more than the 2.2 mg/kg LQM/CIEH Public Open Spaces (Residential) S4ULs, no Soil Organic Matter stated) screening value.

1,2,4-Trimethylbenzene – One sample above detection limit (1800 µg/kg) and above the 410 µg/kg C:LAIRE GAC for 1% SOM residential without homegrown produce screening value. It is important to note that the sample was obtained from within the historic remediation zone immediately below the area subject to remediation (*i.e.* WS15 (3.0-3.7m).

8.3.5 Background Heavy Metals and Metalloids

According to the BGS Contaminant Distribution in Soil Atlas the Welwyn Garden City area has higher than average 'normal background concentrations' of Arsenic (*Figure 8-3*).

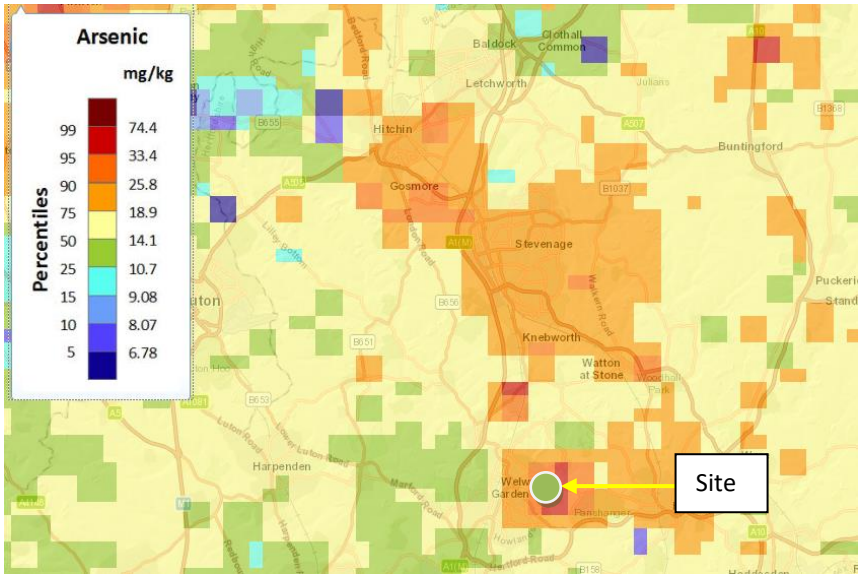


Figure 8-3: *BGS Arsenic in Soil (normal background concentrations)*[16]

No background data is currently available for Beryllium as the BGS has not identified this as a current contaminant of concern. It seems reasonable to conclude, however, that the elevated metals are a natural rather than anthropogenic phenomenon on this site. Nonetheless, we have considered their significance below.

8.4 Statistical Analysis of Soil Exceedences

To assess the significance of the screening value exceedences the recommended statistical techniques outlined within CL:AIRE guidance has been utilised[17]. The assessments have been undertaken using the 'Planning Scenario' approach.

8.4.1 Arsenic

The data was reviewed and found to meet the data quality criteria outlined within CL:AIRE Guidance on Comparing Soil Contamination Data with a Critical Concentration (May 2008).

The planning scenario is appropriate; therefore, the key question is:

16 http://mapapps2.bgs.ac.uk/bccs/home.html

17 CL:AIRE (2008). Guidance on Comparing Soil Contamination Data with a Critical Concentration, May 2008, The Chartered Institute of Environmental Health, CL:AIRE, ISBN10 1-904306-79-9, ISBN13 978-1-904306-79-5.

- Is there sufficient evidence that the true mean concentration of Arsenic (μ) is less than the critical concentration (Cc)?

The Null Hypotheses (H0) is that the true mean is equal to, or greater than, the critical concentration. The Alternative Hypothesis(H1) is that the true mean concentration is less than the critical concentration.

No non-detects were reported within the dataset.

Outlier Test

A Grubb's outlier tests was performed (n = 51 and α = 0.05). The 140 mg/kg and 100 mg/kg values are considered outliers at a confidence level of 95%. These data points have been excluded from further assessment.

Probability Plot

A probability plot for the data was produced as the data does not align along the 45-degree line it can be concluded that the dataset is not normally distributed.

Shapiro-Wilk Normality Test

The results are outlined in *Table 8-5*.

Table 8-5: *Shapiro-Wilk Normality Test (Arsenic)*

Sample Size (n)	49
Mean	30.79
Standard Deviation (SD)	19.71
Calculated W	0.894
Significance Level	0.05
Shapiro-Wilk Critical Level	0.947
Result	W < critical value at significance level of 0.05, therefore data set is not normally distributed. Use Non-Parametric Procedure.
Screening value	79 mg/kg LQM/CIEH Public Open Spaces (Residential) S4ULs, no Soil Organic Matter stated) (Mean < screening value)
Test	One-sided Chebychev Theorem can be applied

Non-Parametric Test

The results of the non-parametric test are outlined in *Table 8-6*.

Table 8-6: *Non-Parametric Test (Arsenic)*

Upper Tolerance Limit for data	88.9
Mean	30.8
Standard Deviation	19.71
No. of data observations (n)	49
$k_{0.05}$	4.36
Square Root (n)	7.00
$UCL_{0.95}$	43.06
k0	-3.272
Critical Concentration (Cc)	79 mg/kg
Is Mean < Cc?	Yes

K_{crit} = K0.05 therefore K_{crit}	4.36
Is k0 < k_{crit}?	Yes
	H0 is rejected
k_0	-17.122
minus k_0 therefore k_1	17.122
therefore alpha	0.01
p_1	0.99
Estimate against H0 being true	99%
Is p_1>95%	TRUE

The conclusion is that there is a very high degree of confidence H0 is rejected *i.e.* the true mean concentration is less than the critical concentration.

8.4.2 Beryllium

The data was reviewed and found to meet the data quality criteria outlined within CL:AIRE Guidance on Comparing Soil Contamination Data with a Critical Concentration (May 2008).

The planning scenario is appropriate; therefore, the key question is:

- Is there sufficient evidence that the true mean concentration of Beryllium (μ) is less than the critical concentration (Cc)?

The Null Hypotheses (H0) is that the true mean is equal to, or greater than, the critical concentration. The Alternative Hypothesis(H1) is that the true mean concentration is less than the critical concentration.

No non-detects were reported within the dataset.

Outlier Test

A Grubb's outlier tests was performed (n = 51 and α = 0.05). The 2.7 mg/kg and 3.7 mg/kg values are considered outliers at a confidence level of 95%. These data points have been excluded from further assessment.

Probability Plot

A probability plot for the data was produced as the data does not align along the 45-degree line it can be concluded that the dataset is not normally distributed.

Shapiro-Wilk Normality Test

The results are outlined in *Table 8-7*.

Table 8-7: *Shapiro-Wilk Normality Test (Beryllium)*

Sample Size (n)	49
Mean	1.10
Standard Deviation (SD)	0.42
Calculated W	0.901
Significance Level	0.05

Shapiro-Wilk Critical Level	0.947
Result	W < critical value at significance level of 0.05, therefore data set is not normally distributed. Use Non-Parametric Procedure.
Screening value	2.2 mg/kg LQM/CIEH Public Open Spaces (Residential) S4ULs, no Soil Organic Matter stated) (Mean < screening value)
Test	One-sided Chebychev Theorem can be applied

Non-Parametric Test

The results of the non-parametric test are outlined in *Table 8-8*.

Table 8-8: *Non-Parametric Test (Beryllium)*

Table 8.8:	
Upper Tolerance Limit for data	2.3
Mean	1.10
Standard Deviation	0.4
No. of data observations (n)	49
$k_{0.05}$	4.36
Square Root (n)	7.00
$UCL_{0.95}$	1.37
k0	-18.236
Critical Concentration (Cc)	2.2 mg/kg
Is Mean < Cc?	Yes

K_{crit} = K0.05 therefore K_{crit}	4.36
Is k0 < k_{crit}?	Yes
	H0 is rejected