



EARTH ENVIRONMENTAL
& GEOTECHNICAL

GeoEnvironmental Site Investigation

Kingsley Road

Northenden

October 2022

On behalf of

Kingsley Developments Manchester Ltd



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**GEOENVIRONMENTAL SITE
INVESTIGATION & CONTROLLED
WATERS RISK ASSESSMENT**

KINGSLEY ROAD

NORTHENDEN

Report Ref: A3939/22

OCTOBER 2022

Prepared on Behalf of:

KINGSLEY DEVELOPMENTS MANCHESTER LTD

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GEOENVIRONMENTAL SITE INVESTIGATION REPORT

KINGSLEY ROAD, NORTHENDEN

Report Reference: A3939/22

Version B.0

Date: 21st October 2022

Prepared for: Kingsley Developments Manchester Ltd

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Definition of Version Code:

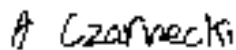
- D. Applied during initial drafting of the report before it has been reviewed.
- C. Applied after the report has been reviewed but before it has been approved by the Project Manager.
- B. Applied after the Project Manager has approved the report ready for issue to the client.
- A. Applied to reports after external/internal review.

The version number starts at "0" and is raised by "1" at each re-type.

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1.0 EXECUTIVE SUMMARY

Appointment	A site investigation has been commissioned to examine ground conditions for a proposed residential development (8no. units) at a former laundry located at 19 Kingsley Road, Northenden.
The Investigation	The investigation comprised 10no. windowless sample boreholes with associated sampling, in situ testing, and laboratory contamination testing.
The Site	The site is located in Northenden, Greater Manchester, approximately 0.5km south of Northenden Town Centre. The approximate National Grid Reference for the centre of the site is SJ 82903 89949 (X: 382903, Y: 389949). The site is underlain by Glaciofluvial Sheet Deposits underlain by the Tarporley Siltstone Formation.
Site History	Historically, the site was agricultural land until it was occupied by a steam laundry by 1910 with two smaller buildings in the southwestern corner of the site. From 1934 an additional two buildings are located in the south of the site, changing in size and shape through to 1981. From 1992, the buildings on site were unspecified. All laundrette infrastructure and industrial buildings have now been demolished and the site cleared of demolition materials.
Ground Conditions Encountered	The exploratory holes encountered Made Ground to a maximum depth of 1.80m bgl (WS104). Underlying the Made Ground were Superficial Deposits comprising sand to a maximum depth of 5.00m bgl and clay to a maximum depth of 5.50m bgl. Gravel was also encountered in boreholes WS107, WS108 and WS110 to a maximum depth of 6.00m bgl. Groundwater was encountered in borehole locations WS101 to WS103, WS106, WS109 and WS101 at depths of between 2.00m and 3.00m bgl.
Contamination Assessment	Chlorinated solvents have been identified in soils and groundwater which pose a risk to future end users and remediation is required Soil chemical exceedances - Cis 1,2 Dichloroethene, Tetrachloroethene (PCE) and Trichloroethene (TCE) Groundwater chemical exceedances - Cis 1,2 Dichloroethene, Tetrachloroethene (PCE) and Trichloroethene (TCE). Vinyl Chloride was identified in 1no. sample. Evidence of degradation is occurring on site due to the decrease in parent compound concentrations down gradient, and the presence of daughter products. Groundwater modelling demonstrates the risk to controlled waters are likely acceptable. However, further groundwater monitoring is recommended. Details of the remedial works and validation process are included within the Remediation Strategy.
<i>This sheet is intended to provide a summary only of the report. It does not provide a definitive engineering analysis for the purposes of costing or construction and is subject to the limitation of the agreed brief.</i>	

2.0 INTRODUCTION

2.1 Background

An additional Site Investigation has been commissioned by Kingsley Developments Manchester Ltd to further examine ground conditions for the proposed new residential development at a site off Kingsley Road, Northenden.

The additional Site Investigation was prompted by Manchester City Council after reviewing a previous Site Investigation Report by EEG Ltd, dated May 2021 and Remediation Strategy, dated May 2022. The key requests were identified as data gaps that required further assessment, i.e.:

- (i) *Further groundwater sampling to determine the impact to controlled waters both on site and off site.*
- (ii) *Establish groundwater flow to determine whether a plume of chlorinated solvents extend off-site.*

This report has been written to support the discharge of planning conditions 5 (contaminated land), attached to planning permission 125144/FO/2019.

2.2 Site History

Historically the site was used as a clothing launderette by Northern Laundry Services Ltd. An Environmental Permit (PPC/DC/RM/17/07), granted 12th February 2007, was held by Northenden Laundry Services Ltd for the dry cleaning of curtains and specialist fabrics.

The licence allowed for the use of a Fibromatic machine (installed in 1999) with Perchloroethylene (Tetrachloroethene) as the cleaning solvent.

There has been a steam laundry on the site for over 100 years. As the laundry element of business shrank, parts of the factory were let as industrial units.

Figure 1 shows a historical photograph of part of the former laundry.

Figure 1: Historical Photograph of Laundry



Planning permission was granted on the 5th of March 2021 by Manchester City Council for the erection of 8no dwelling houses comprising of 2no. two storey semi-detached and 6no. three storey terraced townhouses together with associated car parking, landscaping, and boundary treatment.

At the time of this investigation, all laundrette infrastructure and industrial buildings have been demolished and the site cleared of demolition materials.

2.3 Previous Investigations

The following reports have previously been prepared for the site by REC and Earth Environmental & Geotechnical Ltd and should be read in conjunction with this Site Investigation Report:

2.3.1 Resource and Environmental Consultants (REC) Ltd, Phase I GeoEnvironmental Assessment (106065p1r1), dated November 2018.

Historical archives show the site to have been first occupied by various parcels of agricultural land until pre-1910, thereafter a steam laundry building occupied most of the northern section of the site with two smaller buildings in the southwestern corner. From 1934 an additional two buildings are located in the south of the site, changing in size and shape through to 1981. From 1992, the buildings on site were unspecified.

Potential sources of contamination were identified as Made Ground from on and off-site development (including an infilled pond located off the site) and contaminants associated with the on-site laundry/dry cleaners including multiple solvents, polychlorinated biphenyls (PCBs) and total petroleum hydrocarbons (TPHs).

An Initial Conceptual Site Model was constructed and the risk to future land users was considered **MODERATE to LOW**. The risk to controlled waters was considered **LOW**.

An intrusive investigation was recommended to confirm the findings of the of the initial Conceptual Site Model and to access the anticipated depths of Made Ground.

2.3.2 Earth Environmental & Geotechnical Ltd, Geotechnical & Environmental Site Investigation (Reference: A3939/21B.0), dated May 2021.

An intrusive Site Investigation was conducted by EEG Ltd between 31st March and 1st April 2021 and comprised eight window sample boreholes. Standard Penetration Tests were conducted in-situ in accordance with BS EN ISO 22476-3. A photo ionisation detector (9.8eV lamp) was used to measure the concentration of volatile organic compounds in the soil headspace.

50mm monitoring standpipes were installed in all window sampling boreholes. A total of 4no. monitoring visits were conducted to measure ground gas concentrations and groundwater levels after the field work period.

The boreholes revealed a sequence of Made Ground at depths between ground level and 2.00m bgl comprising asphalt hardstanding, concrete and rebar, cobbles of brick, and sand with man-made inclusions of brick, plastic, clinker, timber, concrete, ash, and metal fixings.

Beneath the Made Ground were Glaciofluvial Deposits comprising a clayey gravelly SAND or gravelly SAND at depths between 0.30m and 6.00m bgl. Cohesive deposits comprising a sandy gravelly CLAY and gravelly CLAY were also encountered at depths between 1.60m and 5.00m bgl.

Groundwater was encountered at depths between 3.0m and 5.00m bgl during the site work. Subsequent monitoring encountered groundwater in the standpipes at depths between 1.43m and 2.10m bgl.

A range of geotechnical testing was conducted on soil samples retrieved from the site. It was concluded that shallow strip/pad foundations were suitable for the proposed development with localised deepened trench footings in areas of deep Made Ground.

Chemical analyses were conducted on fourteen soil samples retrieved from the exploratory holes. Testing included the CLEA soil suite, asbestos screen, Speciated Petroleum Hydrocarbons, Speciated Polycyclic Aromatic Hydrocarbons, Volatile Organic Compounds and Semi-Volatile Organic Compounds. Results were compared to a Residential End Use with Plant Uptake criteria.

The soil contaminant exceedances included:

- **Arsenic** in 1no. sample: WS08 (0.60m)
- **Lead** in 2no. samples: WS05 (1.20m) and WS08 (0.60m)
- **Tetrachloroethene (PCE)** in 3no. samples: WS04 (0.25m), WS06 (0.50m), and WS08 (0.60m)
- **Trichloroethene (TCE)** in 2no. samples: WS04 (0.25m) and WS08 (0.60m).

The report concluded that any soils removed from the site would need to be taken to a suitable landfill facility, soils were classified as Non-Hazardous waste.

Chemical analyses were conducted on five groundwater samples retrieved from exploratory holes WS01, WS04, WS05, WS06 and WS08. Testing included the CLEA water suite, Speciated Petroleum Hydrocarbons, Speciated Polycyclic Aromatic Hydrocarbons, Volatile Organic Compounds and Semi-Volatile Organic Compounds. Results were compared to DWQ and EQS guideline values.

The groundwater contaminant exceedances included:

- **Tetrachloroethene (PCE)** in 5no. samples: WS01, WS04, WS05, WS06, and WS08
- **Trichloroethene (TCE)** in 3no. samples: WS01, WS04, and WS06.

A risk to human health from volatile compounds in shallow groundwater in accordance with the SOBRA groundwater vapour GAC ($GAC_{gw vap}$) were found at WS01, WS04, WS05 and WS06.

Ground gas monitoring was conducted in the monitoring wells over a period of four weeks. The Carbon Dioxide GSV was calculated to be 0.0063 litres/hour, with the Methane GSV calculated as 0.00 litres/hour. These results suggested that the site can be given a "Gas Regime A, Negligible to Very Low risk".

The contamination assessment concluded that remedial measures will be required which could take the form of in-situ soil treatment or by the introduction of a vapour barrier in the foundations. Any remedial works would need to be described within a Remediation Strategy.

2.3.3 Earth Environmental & Geotechnical Ltd, Geotechnical & Environmental Site Investigation (Reference: A3939/21B.0), dated May 2021.

As part of the Remediation Strategy, a delineation exercise was carried out in the vicinity of the Tetrachloroethene (PCE) and Trichloroethene (TCE) hotspots encountered in the initial Site Investigation, to determine the extent of clean cover and vapour membrane placement.

The delineation sampling was conducted by EEG Ltd on 14th April 2022 and comprised 15no. hand dug pits. Sampling locations were positioned at 2.00m spacings outwards, where possible, from the contamination hotspots.

Chemical analyses were conducted on fifteen soil samples retrieved from the hand dug pits. Testing included the Volatile Organic Compounds and Semi-Volatile Organic Compounds. Results were compared to a Residential End Use with Plant Uptake criteria.

The soil contaminant exceedances included:

- **Tetrachloroethene (PCE)** in 2no. samples: Sample 10 (WS06 hotspot), Sample 14 (WS04 hotspot)
- **Trichloroethene (TCE)** in 4no. samples: Sample 12 (WS04 hotspot), Sample 13 (WS04 hotspot), Sample 14 (WS04 hotspot), and Sample 15 (WS04 hotspot)
- **Cis-1,2-Dichloroethene** in 2no samples: Sample 13 (WS04 hotspot), Sample 14 (WS04 hotspot).

The RMS strategy states that the rear garden plots of the southern semi-detached properties will need a clean cover capping system to break the pollutant linkage. The cover system will comprise a minimum of 600mm clean imported soil in rear gardens, reduced to 450mm in front gardens, and a geotextile membrane at the base of the clean cover. Clean cover may comprise a combination of subsoil and topsoil, with no less than 150mm topsoil.

To prevent the ingress of VOC vapours into the new buildings, the RMS states that vapour gas protection measures will need to be installed. Reference should be made to BS8485:2019 for details. However, as a minimum a pre-cast suspended segmental floor (i.e., beam and block) and a 0.40mm thick reinforced membrane which is impervious to VOC vapours and hydrocarbon immersions in accordance with CIRIA C748 should be installed.

2.4 Terms of Reference

Earth Environmental and Geotechnical Ltd (EEG) have been commissioned by the Client, to undertake a Site Investigation of the site in accordance with proposal A3939/21 dated 12th January 2021. The objectives of this investigation are as follows:

- *Provide factual information on the work undertaken including sampling location plan, borehole logs, monitoring and chemical testing.*
- *Tier 1 (semi-quantitative) risk assessment will be undertaken. This will compare the concentrations of soil, and groundwater contaminants identified against current and appropriate published guidelines, in relation to identified receptors, e.g., existing/ future end users and site neighbours.*
- *Assessment of risk to controlled waters from volatile organic and semi-volatile*

organic compounds. If necessary, a quantitative risk assessment would be performed by use of the Environment Agency Remedial Targets Worksheet V3.2.

2.5 Report Scope

This report presents full factual records of the site work carried out, the ground conditions encountered in the exploratory holes, the in situ and laboratory test results. All information collected has been used to provide an interpretation of the ground conditions, with recommendations on geotechnical design and potential ground contamination risks for the proposed development.

2.6 Limitations of the Study

The report is written in the context of an agreed scope of work and budget and should not be used in a different context. New information, improved practices or changes in legislation may require a reinterpretation of the report in whole or in part. EEG reserve the right to amend either conclusions or recommendations in light of any further information that may become available. The report is provided for the sole use by the client and is confidential to them.

Recommendations within this report are also based on exploratory records and examination of samples and, where applicable, laboratory tests. No liability can be accepted for conditions not revealed by the boreholes particularly at intervening locations. Whilst every effort is made to ensure accuracy of data supplied, all opinions expressed as to the spatial distribution of strata between sampling locations is for guidance only and no responsibility is accepted as to its accuracy.

3.0 SITE LOCATION & DESCRIPTION

The site is located in Northenden, Greater Manchester approximately 0.5km south of Northenden town centre. The approximate National Grid Reference for the centre of the site is SJ 82903 89949 (X: 382903, Y: 389949) with the closest postcode being M22 4NL.

The site is an irregular shaped parcel of land currently accessible via Kingsley Road to the northeast of the site. The site currently comprises foundations and part-built walls associated with the new residential development. The site is surfaced in bare ground, hardcore and areas of concrete. A small stockpile of soil is located in the southwest corner of the site. A site cabin is located in the southeast corner of the site.

The maximum dimensions of the proposed site are 70m north to south and 34m east to west. The site occupies an area of approximately 0.15 hectares with a generally flat and level topography.

The general surrounding area comprises predominantly of residential dwellings.

The site location is shown in the aerial photograph presented as Figure 2, below.

Figure 2: Aerial Photograph Showing Site Location



General site photographs are presented in Figure 3 overleaf.

Figure 3: General Site Photographs

View facing southeast showing the site cabin and skip



View facing southwest showing the new foundations and partially built walls



View facing northeast showing the hardcore and partially built buildings



View facing northwest showing the partially built buildings and rubble



3.1 Proposed Development

It is understood that the Client intends to build eight residential properties on site with associated soft landscaping and parking. Access will be provided via Kingsley Road and Beech Avenue.

The proposed development layout details are shown in Figure 4 below.

Figure 4: Proposed Development Plan



4.0 SITE INVESTIGATION

4.1 Exploratory Fieldwork

The fieldwork was carried out by EEG on Tuesday 9th August 2022 and comprised:

- Ten window sample boreholes (designated WS101 to WS110 inclusive) were each sunk to a maximum depth of 6.00m below existing ground level. Window sampler boring is carried out with a small, track-mounted rig, which uses a chain-driven trip hammer to drive sampling tubes or penetrometers into the ground. These tools are coupled to the anvil of the hammer by solid drill rods. Sampling tubes comprise “windowless samplers”, which are plain sampler tubes in which a continuous disturbed sample is recovered within a semi-rigid plastic liner. In order to reduce friction within the borehole, sampling tubes of progressively smaller diameter are used as the borehole depth increases. Sampler diameters generally range from between approximately 90mm to 50mm. Standard Penetration Tests (SPTs) were undertaken in the boreholes in accordance with BS EN ISO 22476-3. Groundwater observations were noted where possible. These observations relate to the time of the investigation only, and do not necessarily reflect seasonal fluctuations. Exploratory hole logs and sections are included in Appendix 1.
- 50mm diameter standpipes were installed in all window sample boreholes up to a maximum depth of 4.70m below ground level. Installation and backfill details are shown with the appropriate borehole log sheet. EEG carried out groundwater monitoring in standpipes after the fieldwork period on the 17th August and the 8th September 2022, the results of which are presented in Appendix 2.
- Soil Infiltration testing was conducted in three window sample boreholes (WS104, WS106 and WS107) after the fieldwork period to determine the soil permeability. The results of the tests are discussed in Section 5.5 and presented in Appendix 3.

Exploratory hole locations were selected on-site by an EEG engineer based on the proposed development layout and targeting areas of potential contamination to determine whether the chlorinated solvents extend off-site.

Each exploratory location was scanned using a Cable Avoidance Tool (CAT) in order to locate unrecorded underground services, and the exploratory locations were repositioned if necessary.

A power washer was used to decontaminate the drilling rods and sampling equipment between borehole locations.

A photo ionisation detector (9.8eV lamp) was used to measure the concentration of volatile organic compounds in the headspace of soil samples. Samples were placed in amber jars and the peak measurement recorded over the duration of 20 minutes. The measurements are shown on the borehole logs in Appendix 1.

Soil samples of approximately 250g were recovered in amber jars for volatile analysis. Groundwater samples were recovered in 60ml vials and 1L glass bottles for volatile analysis. All the samples were labelled and stored in cool boxes prior to being collected by courier at the end of the day for delivery to the DETS laboratory.

On completion, samples recovered from the site were taken to specialist laboratories for chemical testing. If collection was not possible the same day, then samples were stored in the sample storage fridge at the EEG offices below 4°C.

Samples were tracked using appropriate Chain of Custody forms provided by DETS.

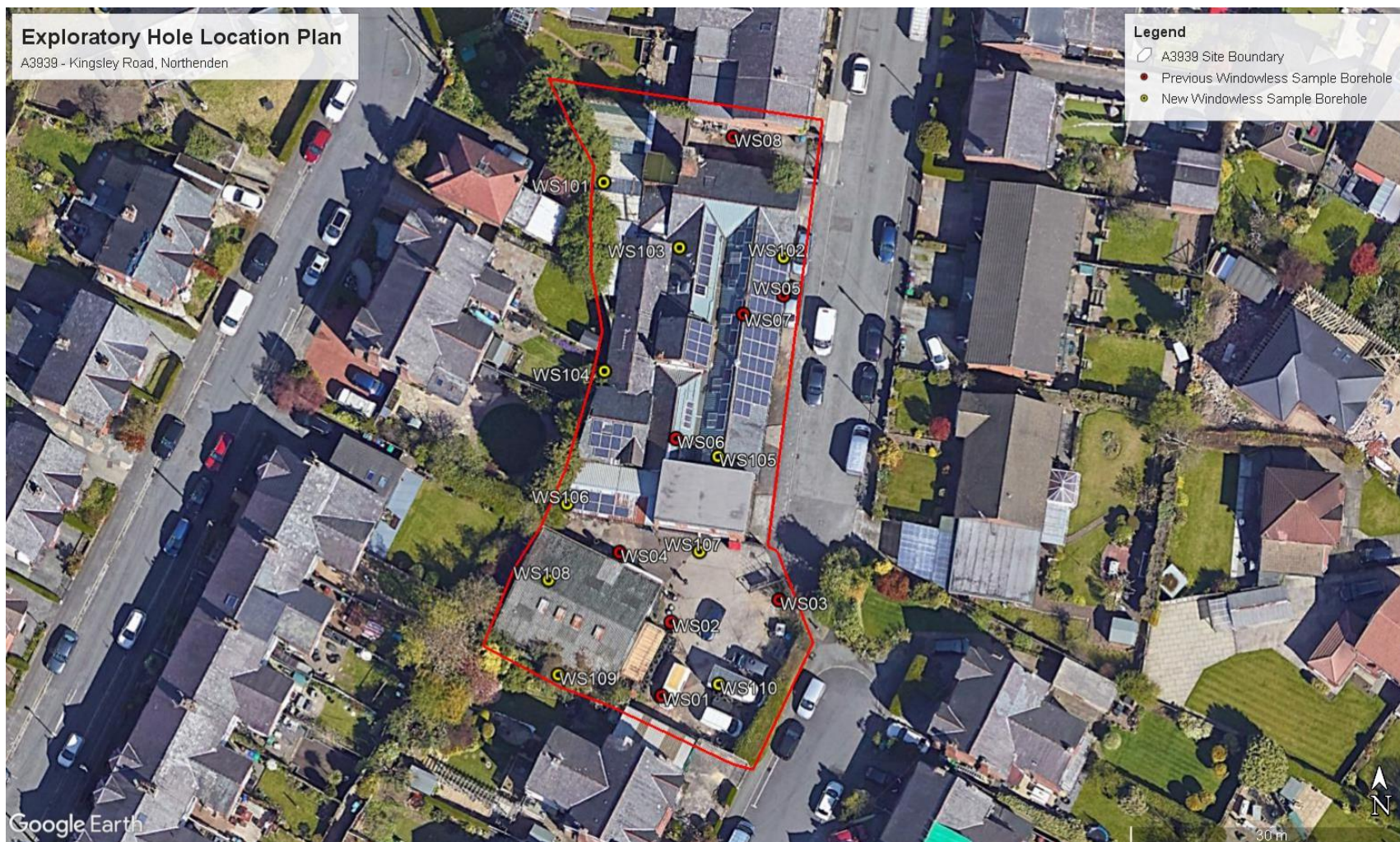
All site investigation work was supervised full time by a representative of EEG. The logging of soils and rocks has been carried out in accordance with BS5930^(2015+A1:2020) except where superseded by the soil and rock description methodology in BS EN14688-1⁽²⁰⁰²⁾, BS EN 14688-2⁽²⁰⁰⁴⁾ and BS EN 14689-1⁽²⁰⁰³⁾.

Groundwater collection was undertaken using a dedicated Waterra bailer. Water levels were monitored by use of an interface meter with a Heron interface meter used measure the thickness of any dense phase hydrocarbons.

All sampling locations were surveyed by use of a hand-held Trimble GeoXH GPS instrument that is capable of surveying to an accuracy of less than 10mm depending on satellite coverage, proximity to trees and building structures.

An Exploratory Hole Location Plan is presented as Figure 5, overleaf.

Figure 5: Exploratory Hole Location Plan



A summary of exploratory holes undertaken during the investigation are presented in Table 1 below.

Table 1: Summary of Exploratory Holes Undertaken

Hole	Type*	Depth (m)	Date Started	Date Finished	Easting (m)	Northing (m)	Backfill Details**
WS101	WS	4.700	04/08/2022	04/08/2022	382893.209	389969.028	SP
WS102	WS	3.600	04/08/2022	04/08/2022	382912.278	389961.426	SP
WS103	WS	3.300	04/08/2022	04/08/2022	382901.409	389962.267	SP
WS104	WS	4.000	04/08/2022	04/08/2022	382893.271	389949.280	SP
WS105	WS	4.000	04/08/2022	04/08/2022	382905.713	389940.219	SP
WS106	WS	3.000	04/08/2022	04/08/2022	382889.312	389935.752	SP
WS107	WS	4.000	04/08/2022	04/08/2022	382903.844	389930.722	SP
WS108	WS	4.000	04/08/2022	04/08/2022	382887.850	389927.101	SP
WS109	WS	3.600	04/08/2022	04/08/2022	382888.793	389917.822	SP
WS110	WS	6.000	04/08/2022	04/08/2022	382905.601	389916.571	SP
*WS = Window Sample Borehole **SP = Standpipe							

4.2 Laboratory Testing

4.2.1 Environmental Testing

The environmental chemistry of the ground was investigated by specialist chemical analysis of selected samples, scheduled by EEG, and carried out by DETS, a UKAS and MCERTS accredited laboratory.

Chemical analyses were carried out on twenty soil samples and were submitted for the following suite of determinants:

Volatile Organic Compounds (VOCs) and Semi-Volatile Organic Compounds (SVOCs).

Chemical analyses were carried out on five groundwater samples retrieved on the first monitoring visit, and a further nine retrieved on the second monitoring visit. The samples were submitted for the following suite of determinants:

Volatile Organic Compounds (VOCs) and Semi-Volatile Organic Compounds (SVOCs).

The results of the laboratory contamination tests are discussed in Section 6 and Section 7 and included in Appendix 4.

5.0 GROUND CONDITIONS ENCOUNTERED

5.1 Soil Profile Encountered

BGS digital mapping shows the site is underlain by superficial deposits of Glaciofluvial Sheet Deposits, comprising Devensian sand and gravel. The solid geology beneath the site is the Tarporley Siltstone Formation, comprising siltstone, mudstone, and sandstone. The sequence of strata encountered beneath the site was as follows:

- **Made Ground** – Variable Made Ground was encountered in all the exploratory holes (except WS104) to a maximum depth of 1.80m bgl, comprising:
 - Slightly clayey gravelly SAND containing brick and quartzite
 - Slightly clayey very gravelly SAND containing quartzite and cobbles of brick
 - Clayey slightly gravelly SAND containing brick, concrete, glass, and quartzite
 - Gravelly SAND containing quartzite and cobbles of brick
 - Sandy GRAVEL containing brick

- **Superficial Deposits** –

Sand was encountered in all the exploratory holes to a maximum depth of 5.00m bgl, comprising:

- Very gravelly SAND containing quartzite
- Gravelly SAND containing quartzite, siltstone, and sandstone
- Slightly clayey gravelly SAND containing quartzite
- Slightly gravelly SAND containing siltstone, sandstone, and quartzite
- Silty SAND

Gravel was encountered in exploratory hole locations WS107, WS108 and WS110 to a maximum depth of 6.00m bgl, comprising:

- Very clayey sandy GRAVEL containing sandstone, siltstone, and quartzite
- Clayey sandy GRAVEL containing sandstone, siltstone, and quartzite
- Slightly clayey slightly sandy GRAVEL containing siltstone, sandstone, and quartzite
- Sandy GRAVEL containing sandstone, siltstone, and quartzite

Clay was encountered in all the exploratory holes, to a maximum depth of 5.50m bgl, comprising:

- Slightly sandy slightly gravelly CLAY containing quartzite, siltstone, and sandstone
- Slightly sandy gravelly CLAY containing siltstone, sandstone, and quartzite.
- Sandy slightly gravelly CLAY containing siltstone, sandstone, and quartzite
- Sandy CLAY

The depths of the various materials encountered in the exploratory holes are summarised in Table 2 overleaf.

Table 2: Summary of Ground Conditions Encountered

Hole	Depth to Stratum (m bgl)					GROUNDWATER (m bgl)
	MADE GROUND		SUPERFICIAL DEPOSITS			
	SAND	GRAVEL	CLAY	SAND	GRAVEL	
WS101	GL - 1.50		1.80 - 4.70	1.50 - 1.80		3.00
WS102	GL - 1.30		1.60 - 2.90	1.30 - 1.60 2.90 - 3.60		2.00
WS103	GL - 0.40		0.40 - 1.40 1.50 - 3.30	1.40 - 1.50		2.00
WS104	GL - 1.60	1.60 - 1.80	2.10 - 3.00 3.40 - 4.00	1.80 - 2.10 3.00 - 3.40		-
WS105	GL - 1.20		1.20 - 1.50 2.00 - 4.00	1.50 - 2.00		-
WS106	GL - 0.50		2.30 - 3.00	0.50 - 2.30		2.00
WS107	GL - 0.60		2.40 - 3.00 3.50 - 4.00	0.60 - 1.80 3.00 - 3.50	1.80 - 2.40	-
WS108			2.00 - 3.50	GL - 2.00	3.50 - 3.80	-
WS109	GL - 0.40		2.50 - 3.00 3.20 - 3.60	0.40 - 2.50 3.00 - 3.20		2.10
WS110	GL - 1.20		1.90 - 3.70 4.00 - 4.80 5.00 - 5.50	1.20 - 1.90 3.70 - 4.00 4.80 - 5.00	5.50 - 6.00	2.50

5.2 Observable Indications of Contamination

Gravel of brick, concrete and rare glass fragments were encountered within the Made Ground; however, these are generally considered inert.

No olfactory indications of contamination were identified during the site investigation. However, the groundwater samples retrieved from the old monitoring well at location WS05 had a strong putrid odour.

5.3 Obstructions

No man-made obstructions were encountered in any of the exploratory hole locations aside from cobbles of red brick encountered in the Made Ground.

5.4 Groundwater

Groundwater was encountered in borehole locations WS101 to WS103, WS106, WS109 and WS101 at depths of between 2.00m and 3.00m bgl.

Subsequent monitoring in the standpipes on 2no. visits encountered groundwater in all borehole locations at depth between 1.04m (WS103) and 3.32m bgl (WS101).

5.5 Soil Infiltration Testing

Infiltration testing was carried out within 3no. of the installed windowless sample boreholes across the site in accordance with the methods described in BS5930 (Code of Practice for Site

Investigations). Each of the boreholes were filled rapidly with water and the water level monitored over an extended period.

Table 3 below summarises the results of the infiltration testing for each location tested.

Table 3: Summary of Soil Infiltration Testing

Location	No. of Tests	Geology in Response Zone	Average Soil Infiltration Rate	
			m/second	m/day
WS104	3	Clay	1.62E-06	1.40E-01
WS106	3	Sand	3.73E-05	3.22E+00
WS107	3	Sand & Gravel	2.40E-05	2.08E+00

The infiltration rate (m/d) was inputted into the Remedial Target Methodology Worksheet for Level 3 Groundwater. A geomean of 9.78E-01 metres/day was used for the hydraulic conductivity of the aquifer.

Full results are presented in Appendix 3.

6.0 SOIL CONTAMINATION RISK ASSESSMENT

6.1 Tier I Human Health Soil Risk Assessment – Future Site Users

The following section provides a Human Health Soil Assessment for future site users. Based on the proposed development type, the following section compares the results of contamination analyses to residential types of end development as specified by DEFRA/LQM/CIEH/ CL:AIRE. As part of the contamination assessment, the chemical results obtained by EEG have been screened against accepted compliance criteria, namely:

- DEFRA Category 4 Screening Levels ⁽²⁰²¹⁾ (C4SL), where available.
- Tier 1 Assessment Values - based on LQM/CIEH Suitable 4 Use Levels ⁽²⁰¹⁵⁾ (S4ULs).
- EIC/AGS/CL: AIRE Soil Generic Assessment Criteria for Human Health Risk Assessment ⁽²⁰¹⁰⁾.

The soil chemical testing results are summarised in Table 4, overleaf.

Potential contaminants of concern have been found in exceedance of long-term human health screening criteria for a Residential End Use (with plant uptake in gardens).

The soil contaminant exceedances include:

- **Cis 1,2 Dichloroethene** in 5no. samples: WS102 (1.60m), WS103 (1.50m), WS106 (0.50m), WS108 (0.70m), WS110 (0.80m).
- **Tetrachloroethene (PCE)** in 20no. samples: WS101 to WS110 (all sample depths)
- **Trichloroethene (TCE)** in 14no. samples: WS102, WS105, WS106, WS108 to WS110 (all sample depths), WS103 (1.50m) and WS107 (0.40m).

The maximum recorded PCE concentration was found in WS108 at 0.70m (9766mg/kg), the maximum recorded TCE concentration was found at WS108 at 0.70m (235mg/kg) and the maximum recorded Cis-DCE concentration was found at WS103 at 1.50 m (40mg/kg).

Plots showing the distribution of soil contaminants across the site are included in Figure 6, overleaf. The plots show the concentrations of PCE, TCE and Cis-DCE in the soils at 0-1m depth and 1-2m depth.

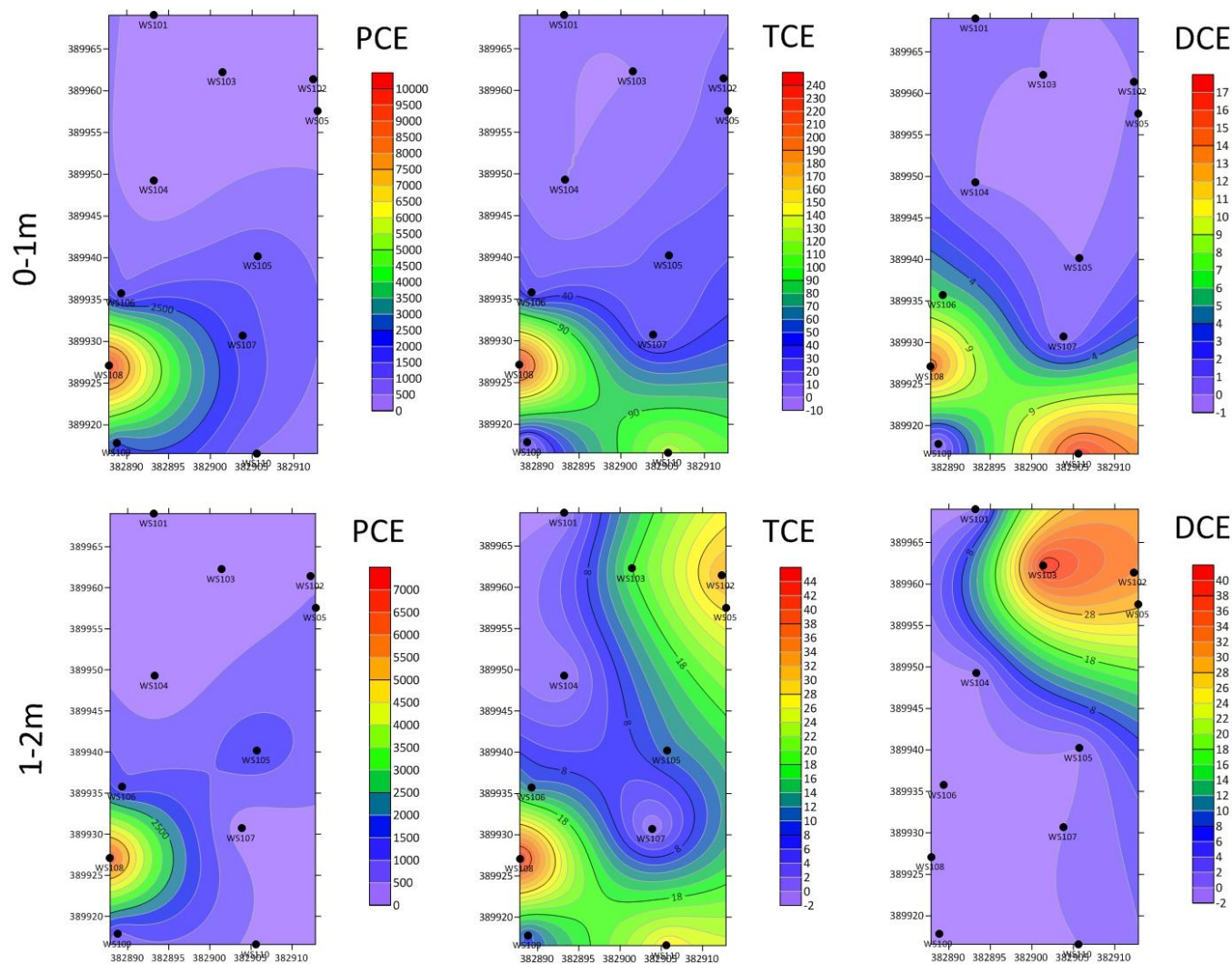
The concentration of volatile organic compounds in the headspace of soil samples was also measured using the photo ionisation detector (9.8eV lamp). The peak concentrations recorded ranged from 0.37ppm (WS110 at 4.50m) and >5000ppm (WS105 at 2.00m).

Due to the contamination encountered in the soils, a cover system is proposed within garden areas to break the pollutant linkage. The details of the remedial works are included within the Remediation Strategy.

Table 4: Soil Results Comparison with C4SL/S4UL Values

Parameter	C4SL/S4UL Levels Residential End Use (mg/kg)	WS101 1.20m	WS101 1.70m	WS102 0.70m	WS102 1.60m	WS103 0.50m	WS103 1.50m	WS104 0.50m	WS104 1.40m	WS105 0.60m	WS105 1.50m	No. of Exceedances
Phenols												
Phenol	280	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0
Volatile Organic Compounds												
Trans 1,2-Dichloroethene *	0.19	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	0
Cis 1,2 Dichloroethene *	0.11	< 5	< 5	< 5	32	< 5	40	< 5	< 5	< 5	< 5	2
Tetrachloroethene (PCE)	0.31	12	56	234	479	211	115	162	85	1357	1389	10
Trichloroethene (TCE)	0.0093	< 5	< 5	13	32	< 5	18	< 5	< 5	26	11	5
Vinyl Chloride	0.0064	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	0
Concentrations in red are above the assessment criteria based on Residential End Use with Plant Uptake (SOM content of 1%).												
*Based on The EIC/AGS/CL:AIRE Soil Generic Assessment Criteria for Human Health Risk Assessment												
Parameter	C4SL/S4UL Levels Residential End Use (mg/kg)	WS106 0.50m	WS106 1.20m	WS107 0.40m	WS107 1.20m	WS108 0.70m	WS108 1.80m	WS09 0.40m	WS09 1.40m	WS110 0.80m	WS110 1.60m	No. of Exceedances
Phenols												
Phenol	280	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0
Volatile Organic Compounds												
Trans 1,2-Dichloroethene *	0.19	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	0
Cis 1,2 Dichloroethene *	0.11	6	< 5	< 5	< 5	15	< 5	< 5	< 5	17	< 5	3
Tetrachloroethene (PCE)	0.31	1117	1131	1746	197	9766	6561	2457	845	949	401	10
Trichloroethene (TCE)	0.0093	25	11	20	< 5	235	44	10	9	127	28	9
Vinyl Chloride	0.0064	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	0
Concentrations in red are above the assessment criteria based on Residential End Use with Plant Uptake with 1% SOM												
*Based on The EIC/AGS/CL:AIRE Soil Generic Assessment Criteria for Human Health Risk Assessment (2010)												

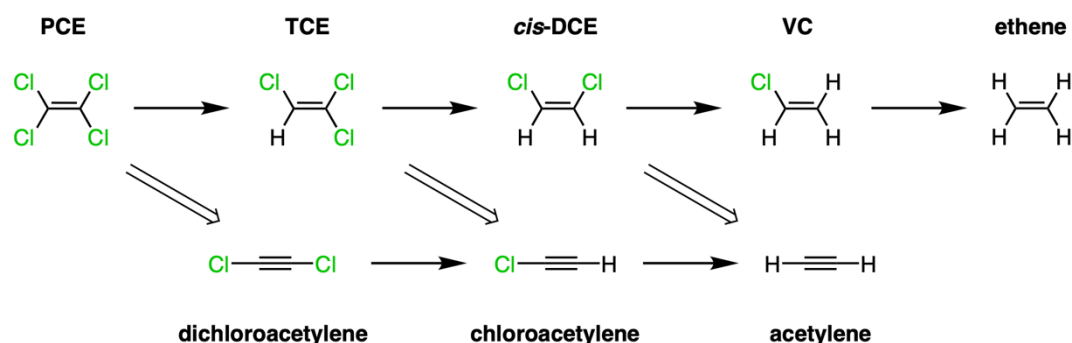
Figure 6: Soil Contamination Plans



Chlorinated solvents such as PCE and TCE are common contaminants of soil and groundwater at numerous sites of active and historical dry-cleaning facilities and industrial operations.

Chlorinated solvents are dense non-aqueous phase liquids (DNAPLs), and this character gives them a unique dispersal pattern and complex distribution that is controlled by local geological settings. As these substances are harmful and have been proved or are considered to be carcinogens, sites contaminated with these solvents often require remediation.

Complete biodegradation of PCE occurs in several ways, either by *Dehalococcoides mccartyi* alone or by a bacterial consortium where different bacteria carry out one or more steps of biodegradation.



The top pathway with single line arrows represent the reductive dechlorination (hydrogenolysis) pathway. The lower pathway with downward facing double line arrows represent the beta-elimination pathway.

Trichloroethylene (TCE) is a highly volatile solvent which has high mobility in water and is used in manufacturing to clean grease from machinery. In groundwater, TCE can undertake reductive dechlorination catalysed by anaerobic bacteria that yields vinyl chloride, a potent human carcinogen.

7.0 CONTROLLED WATER RISK ASSESSMENT

In the absence of specific UK guidelines regarding groundwater quality in the UK, chemical results obtained by EEG have been compared with the following statutory and non-statutory standards:

- Environmental Quality Standards (EQS); and
- UK Drinking Water standards ⁽²⁰⁰⁰⁾.

The existing Groundsure report indicates there is one active and two historical groundwater abstraction licences within 2km of the study site. The active license is located at Didsbury Golf Club, Northenden 1.1km northeast of site, used for spray irrigation. The two historical licenses are located 1.2km southeast and 1.9km southeast used for laundry use and spray irrigation.

The Groundsure report indicates there is one historical surface water abstraction license within 2km of the study site, located 1km north of site from the River Mersey for dust suppression and general/ process washing.

The site is not located within 500m of a groundwater Source Protection Zone and the nearest controlled water is Gatley Brook 1.1km to the southeast of the site.

The environmental setting of the site with respect to controlled waters is therefore one of a low risk due to an absence of controlled waters and local abstraction points.

One historical borehole (WS05) remained on site from the previous Site Investigation in 2021 which could be sampled for groundwater. The remainder were removed due to demolition and site clearance.

Shallow groundwater has been found in most of the monitoring wells, with depths ranging from 1.04m to 3.32m bgl.

No groundwater samples could be retrieved from WS101, WS104, WS105, WS106, WS107, and WS110 on the first monitoring visit (August) due to low volumes of water in the monitoring wells. Only 60ml of groundwater could be retrieved from WS109, therefore no semi-volatile organic carbon analysis was carried out on this sample which requires one litre of groundwater.

On the second monitoring visit (September) no groundwater samples could be retrieved from WS105 and WS110 due to damage to the monitoring wells. Only 60ml of groundwater could be retrieved from WS101, WS104, WS106 and WS107, therefore no semi-volatile organic carbon analysis was carried out on these samples which requires one litre of groundwater.

The concentration of potential contaminants of concern in the groundwater samples recovered from the monitoring wells have been compared to Environmental Quality Standards (EQS) and UK Drinking Water Standards.

The results from the groundwater samples retrieved in both August and September are summarised in Table 5 and Table 6 (overleaf).

Chlorinated solvents (including PCE & TCE) have been found in the shallow groundwater samples recovered from the monitoring wells.

The groundwater contaminant exceedances include:

- **Tetrachloroethene (PCE)** in 8no. sample locations: WS05, WS101, WS103, WS104, WS106 to WS109.
- **Trichloroethene (TCE)** in 3no. sample locations: WS106, WS108 and WS109
- **Cis 1,2 Dichloroethene (DCE)** in 8no. sample locations: WS05, WS101 to WS104, WS106, WS108 and WS109.
- **Vinyl chloride** in 1no. sample location: WS104.

The maximum recorded PCE concentration was found at WS109 (2304µg/litre) in August, the maximum recorded TCE concentration was found at WS109 (228µg/litre) in September and the maximum recorded Cis-DCE concentration was found at WS104 (872µg/litre) in September.

Plots showing the distribution of groundwater contaminants across the site are included in Figure 7, overleaf. The plots show the concentrations of PCE, TCE and Cis-DCE in the groundwater samples retrieved in August and September.

It should be noted that only Vinyl Chloride and Trichloroethene (TCE) are listed as **Hazardous Substances** according to JAGDAG, 2017.

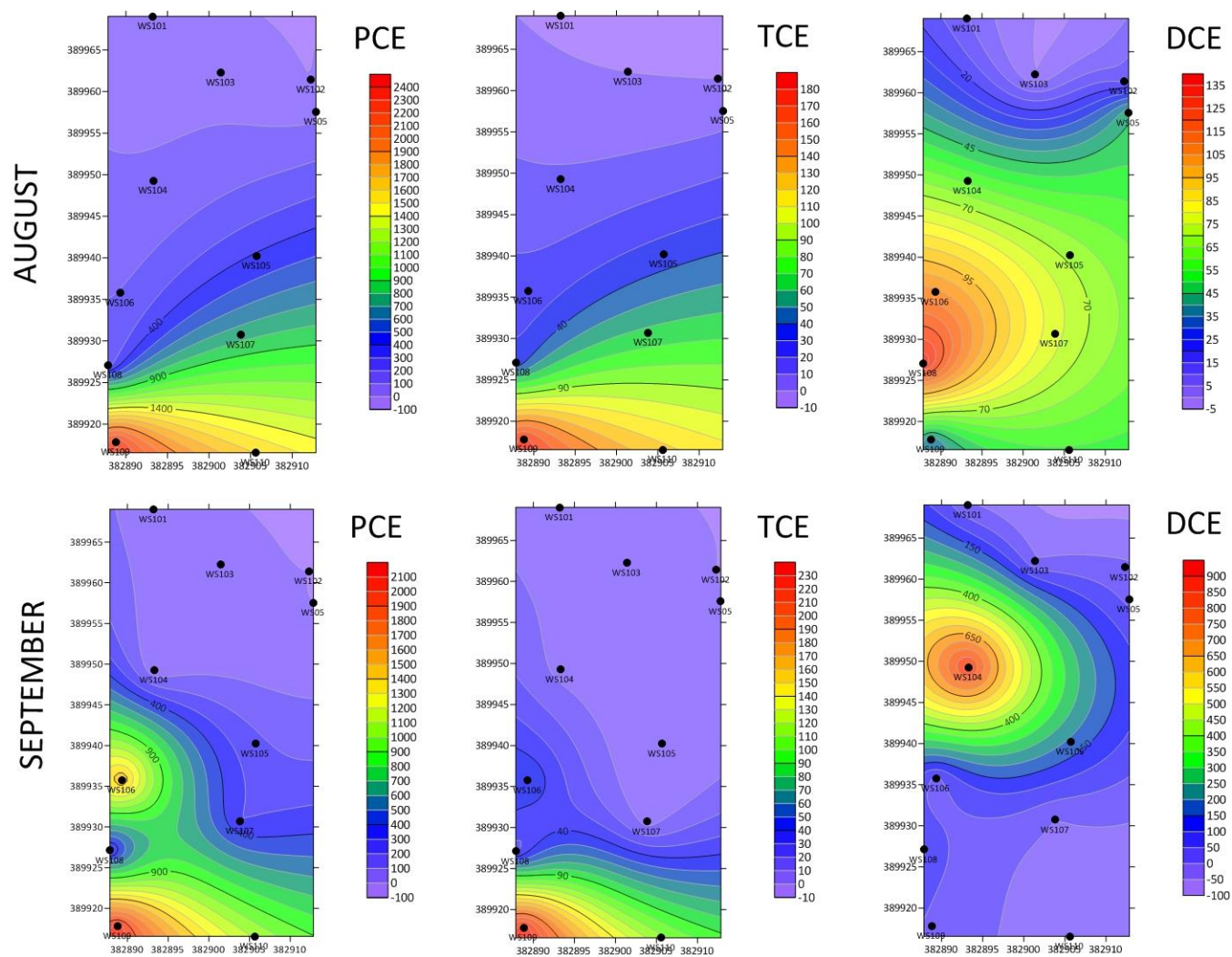
Table 5: Groundwater Results Comparisons with EQS/Drinking Water Quality Values (µg/l) August 2022

Determinand	EQS Value (1) µg/l	Drinking Water Quality (DWQ) Value (2) µg/l	WS05	WS102	WS103	WS108	WS109	No. of Exceedances
Phenols								
Phenol	46 ^(M)	500	< 0.1	< 0.1	< 0.1	< 0.1	-	-
Volatile Organic Compounds								
Trans 1,2-Dichloroethene	10	3	< 5	< 5	< 5	< 5	< 5	-
Cis 1,2 Dichloroethene	10	3	44	14	< 5	134	36	4 for (1 + 2)
Tetrachloroethene (PCE)	10	10*	74	< 5	77	255	2304	4 for (1 + 2)
Trichloroethene (TCE)	10	10*	6	< 5	< 5	33	174	2 for (1 + 2)
Vinyl Chloride	-	0.5	< 5	< 5	< 5	< 5	< 5	
All values in µg/l unless otherwise stated *Concentration is the sum of TCE and PCE. EQS Standards – (M) = Maximum Allowable Concentration Standard, (A) = Annual Average Standard. Values in red are elevated above the recommended guidance value								

Table 6: Groundwater Results Comparisons with EQS/Drinking Water Quality Values (µg/l) September 2022

Determinand	EQS Value (1) µg/l	Drinking Water Quality (DWQ) Value (2) µg/l	WS05	WS101	WS102	WS103	WS104	WS106	WS107	WS108	WS109	No. of Exceedances
Phenols												
Phenol	46 ^(M)	500	< 0.1	-	< 0.1	< 0.1	-	-	-	< 0.1	< 0.1	-
Volatile Organic Compounds												
Trans 1,2-Dichloroethene	10	3	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	-
Cis 1,2 Dichloroethene	10	3	37	6	12	6	872	36	< 5	79	44	6 for (1) 8 for (2)
Tetrachloroethene (PCE)	10	10*	< 5	38	< 5	46	34	1499	301	265	2058	7 for (1 + 2)
Trichloroethene (TCE)	10	10*	< 5	< 5	< 5	10	7	51	6	27	228	3 for (1 + 2)
Vinyl Chloride	-	0.5	< 5	< 5	< 5	< 5	46	< 5	< 5	< 5	< 5	1 for (2)
All values in µg/l unless otherwise stated *Concentration is the sum of TCE and PCE. EQS Standards – (M) = Maximum Allowable Concentration Standard, (A) = Annual Average Standard. Values in red are elevated above the recommended guidance value												

Figure 7: Groundwater Contamination Plans



7.1 Vapour Risk from Groundwater

The risk to human health for a residential end use scenario has been assessed by reference to Society of Brownfield Risk Assessment (SOBRA) Generic Assessment Criteria for Assessing Vapour Risks to Human Health from Volatile Contaminants in Groundwater, February 2017.

The SOBRA groundwater vapour GAC (GAC_{gwvap}) is intended as a conservative screening tool that assessors may choose to use to help assess the long-term (chronic) risks to human health from inhalation of vapours arising from groundwater. They are intended for comparison with measured groundwater concentrations and represent the estimated concentration in groundwater below which the long-term risks to human health from vapour migration and inhalation can be considered low/tolerable, i.e., unlikely to be of concern (for the land use scenarios considered). When used as part of a Generic Quantitative Risk Assessment (GQRA) (which includes consideration of uncertainties – see Defra and Environment Agency, 2004) comparison of the GAC_{gwvap} with measured concentrations in groundwater can be used to screen out contaminants as being unlikely to represent an unacceptable risk to humans living or working above the groundwater plume.

The GAC_{gwvap} have been developed in line with UK risk assessment guidance (e.g., Defra and Environment Agency, 2004; Environment Agency, 2009a) and are intended to be used for sites in the UK.

The GAC have been derived for two land use scenarios for which the vapour intrusion pathway is likely to require assessment: residential and commercial.

Generic assumptions have been made for each land use. These include assumptions about the depth to groundwater (default depth of 0.65m), soil type in the unsaturated zone (default of sand), building dimension (default small, terraced house) and foundation type, and receptor behaviour.

As described in CLEA SR3 report (Environment Agency, 2009a) the parameter values have been chosen to ensure that the GAC are precautionary for the vast majority of commercial and residential properties in the UK.

The maximum VOC concentrations encountered in locations WS05, WS102, WS103, WS108 and WS109 over the 2no. monitoring visits (August and September 2022) were included in the Vapor Risk Assessment Table, overleaf.

A risk to human health from volatile compounds in shallow groundwater have been found at 8no. of the 9no. samples analysed (WS05, WS101 to WS103, WS104, WS106 to WS109).

Solubility limits have not been exceeded at any location.

Table 7: Vapour Risk from Volatile Compounds (µg/l)

Determinand	SOBRA GAC	Aqueous Solubility µg/l	WS05	WS101	WS102	WS103	WS104	WS106	WS107	WS108	WS109	No. of GAC Exceedances
Cis 1,2 Dichloroethene	130	7,550,000	44	6	14	6	872	36	< 5	79	44	1
Tetrachloroethene (PCE)	34	225,000	74	38	< 5	46	34	1499	301	265	2058	7
Trichloroethene (TCE)	5.7	1,370,000	6	< 5	< 5	10	7	51	6	27	228	7
Vinyl Chloride	0.62	2,760,000	< 5	< 5	< 5	< 5	46	< 5	< 5	< 5	< 5	1

7.2 Groundwater Flow Modelling

The groundwater direction was modelled using Surfer® software. Contour maps were created using the Kriging Tool by inputting the groundwater depths observed in the monitoring wells over the two visits in August and September. Vector plots were created from the grid file to determine the groundwater flow direction.

However, due to the variable permeability of the Glaciofluvial Sheet Deposits, interpolation between different groundwater levels is impractical. Therefore, groundwater flow direction and gradient cannot be accurately determined from the groundwater contour plots.

The hydraulic gradient for the site was calculated to be approximately 0.0377 m/m, assuming a northwards groundwater flow between WS109 and WS101.

Figure 8 overleaf, shows the groundwater contour plots and flow direction.

7.3 Remedial Targets Worksheet (RTM)

The risks to controlled waters were assessed using the Environment Agency's Remedial Targets Methodology Hydrogeological Risk Assessment for Land Contamination (Environment Agency, 2006).

The worksheet allows remedial target concentrations for groundwater to be derived for selected contaminants. The methodology is a tiered approach, with a remedial target being derived at the end of each tier, which would provide sufficient protection to controlled water resources.

In the Level 3 Groundwater worksheet, the analytical solution was selected as Domenico – Steady State, the vertical dispersion was simulated in one direction, and the degradation of pollutants was simulated in all phases.

The model input parameters and sources of information are included in Table 8 and Table 9 overleaf. The Remedial Target Worksheets for Tetrachloroethene (PCE), Dichloroethene (DCE), Trichloroethene (TCE) and Vinyl Chloride are included in Appendix 5.

Table 8: Level 3 (Groundwater) Assessment – Inputs & Justification

Parameter	Units	Value	Source
Sz = Width of plume in aquifer at source (perpendicular to flow)	m	5.00E+00	Distance measured by the red contours on Surfer® contamination plots
Sy = Plume thickness at source	m	3.80E+00	Difference between surface of siltstone bedrock and observed groundwater level in the Glaciofluvial Sheet Deposits (superficial aquifer)
Da = Saturated aquifer thickness	m	3.80E+00	Assume the groundwater source thickness is equal to the whole thickness of the superficial aquifer.
r = Bulk density of aquifer materials	g/cm ³	1.60E+00	R&D Technical Report P2-228/TR Table 3.1
N = Effective porosity of aquifer	fraction	1.50E-01	Literature value
i = Hydraulic gradient	fraction	3.77E-02	Difference between groundwater level (m AOD) in monitoring wells WS109 and WS101 (September visit) divided by distance (m) between the two wells.
K = Hydraulic conductivity of aquifer	m/d	9.80E-01	Geomean of the infiltration rates calculated for the 3no. monitoring wells
X = Distance to compliance point	m	50 250	Environment Agency default compliance points: 50m for hazardous substances, 250m for non-hazardous substances
T = Time since pollutant entered groundwater	days	1.00E+100	The recommended value for time when calculating the remedial target is 9.9E+99.
Foc = Fraction of organic carbon in aquifer	fraction	1.70E-02	Geomean value calculated from the soil organic matter (SOM) concentrations identified in the previous report (<i>Reference: A3939/21B.0 Appendix 3</i>). FOC = SOM divided by 172

Table 9: Contaminant Specific Inputs

Parameter	Units	Contaminant	Value	Source
C _T = Target Concentration	mg/l	Tetrachloroethene (PCE)	1.00E-02	Drinking water quality value (DWQ)
		Dichloroethene (DCE)	1.00E-02	Drinking water quality value (DWQ)
		Trichloroethene (TCE)	1.00E-02	Drinking water quality value (DWQ)
		Vinyl Chloride	5.00E-04	Drinking water quality value (DWQ)
C ₀ = Initial contaminant concentration in groundwater at plume core	mg/l	Tetrachloroethene (PCE)	2.30E+00	Maximum PCE concentration observed in the groundwater chemical testing results
		Dichloroethene (DCE)	8.72E-01	Maximum <i>Cis</i> -DCE concentration observed in the groundwater chemical testing results
		Trichloroethene (TCE)	2.28E-01	Maximum TCE concentration observed in the groundwater chemical testing results
		Vinyl Chloride	4.60E-02	Maximum Vinyl Chloride concentration observed in the groundwater chemical testing results
t _{1/2} = Half-life for degradation of contaminant in water	days	Tetrachloroethene (PCE)	1.00E+03	R&D Technical Report P2-228/TR, slowest half-life observed in Table 4.12 (PCE)
		Dichloroethene (DCE)	3.00E+03	R&D Technical Report P2-228/TR, slowest half-life observed in Table 4.14 (DCE)
		Trichloroethene (TCE)	1.00E+03	R&D Technical Report P2-228/TR, slowest half-life observed in Table 4.13 (TCE)
		Vinyl Chloride	5.00E+02	R&D Technical Report P2-228/TR, slowest half-life observed in Table 4.15 (VC)
Koc = Organic carbon partition coefficient	l/kg	Tetrachloroethene (PCE)	2.69E+02	Environment Agency Science Report: SC050021/SR7, Log Koc values (cm ³ g ⁻¹) Table 3.49
		Dichloroethene (DCE)	4.90E+01	Koc value from R&D Technical Report P2-228/TR document Table 3.1
		Trichloroethene (TCE)	1.41E+02	Environment Agency Science Report: SC050021/SR7, converted Log Koc values (cm ³ g ⁻¹) Table 3.59
		Vinyl Chloride	1.66E+01	DCE value from R&D Technical Report P2-228/TR document table 3.12

7.3.1 Risk Evaluation

The RTM models for the chlorinated solvents indicate the contaminant with the highest risk to controlled waters is vinyl chloride, as the maximum concentration observed in WS104 exceeds the remedial target concentration by the greatest amount. However, vinyl chloride was not identified in the other monitoring wells on site.

The remaining chlorinated solvents (PCE, DCE and TCE) have remedial targets which are above the maximum concentration observed in the groundwater at source which indicates the levels are acceptable.

The remedial target concentrations are shown in Table 10, below.

Table 10: Summary of Remedial Targets

Determinand	Maximum concentration at source (ug/l)	Remedial Target (ug/l)	Concentration at compliance point (ug/l)
Tetrachloroethene (PCE)	2304	99146011	0.0002
Dichloroethene (DCE)	872	1236	7
Trichloroethene (TCE)	228	660	3
Vinyl Chloride	46	5	5

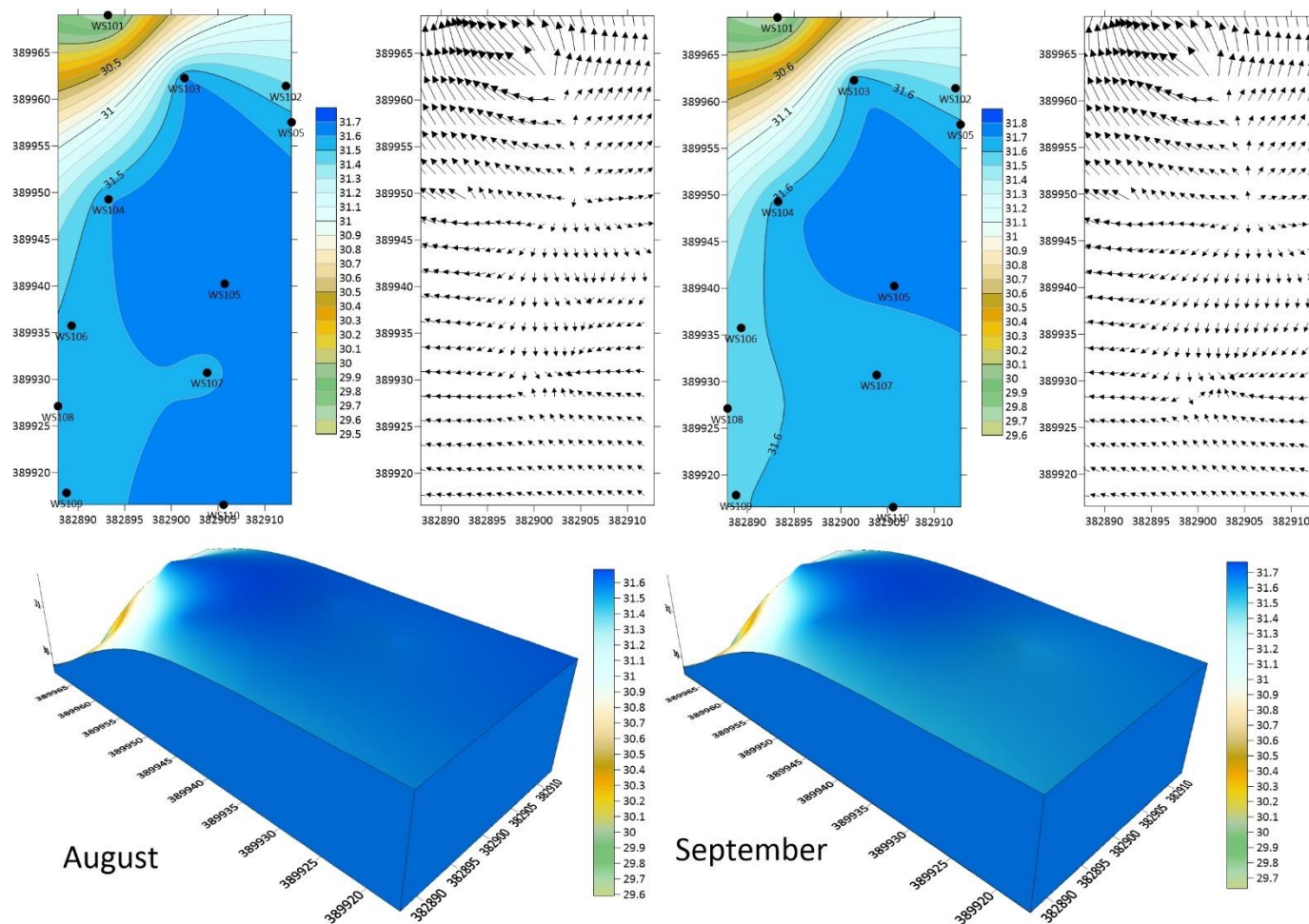
The distance between WS109 and WS101 is approximately 52m, this distance was inputted into the RTM worksheet to compare the simulated concentrations with the observed attenuation on site, assuming that the wells are directly down-gradient.

The concentration of PCE observed in WS109 in September was 2058ug/l and the concentration in WS101 in September was 38ug/l. The simulated concentration at the same distance was 38.9ug/l which is slightly higher.

Tentative Bulk Attenuation Rates (BAR) were calculated which take into account the attenuation occurring between wells i.e., sorption and dispersion, as well as degradation.

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Figure 8: Contour Plan Showing Groundwater Flow



7.4 Bulk Attenuation Rates

To assess site-specific attenuation, tentative Bulk Attenuation Rates (BAR) have been estimated. These were calculated by identifying pairs of wells along the observed flow path WS109-WS108-WS106-WS104-WS101 in which there was an observed decrease in concentrations. The number of half-lives required to achieve that observed reduction in concentration was calculated based on the COPC retarded flow rates simulated by RTM. This calculation makes the following assumptions:

- One well in each pair is directly down-hydraulic of the other.
- Both wells have response zones installed within strata in direct hydraulic connection.
- The plume is not expanding or shrinking and has not detached from the source.
- Degradation is an ongoing rather than historical process.
- Aquifer conditions to which they will be applied off-site are similar to those on site.

The estimated Bulk Attenuation Rates are shown in Table 11 below.

Table 11: Estimated Bulk Attenuation Rates (BAR)

COPC	Flow Path Pairs & Concentrations (ug/l)		Path Length (m)	Retarded Flow Rate (m/d)	Travel Time (days)	No Half lives Required* (No.)	Half life (days)	Tentative BAR (days)
PCE Sep	WS106	WS104	12	4.94E-03	2.43E+03	5.5	4.42E+02	500 days
PCE Aug	1499	34						
	no data	no data						
TCE Sep	WS109	WS106	17	9.25E-03	1.84E+03	2.2	8.35E+02	800 days
TCE Aug	228	51						
	174	no data						
	WS106	WS104	12	9.25E-03	1.30E+03	2.9	4.47E+02	400 days
TCE Sep	51	7						
DCE Sep	WS104	WS101	25	2.49E-02	1.00E+03	7.2	1.39E+02	100 days
	872	6						
DCE Aug	WS108	WS102						
	134	no data						
VC Sep	WS104	WS101	25	6.14E-02	4.07E+02	6	6.79E+01	100 days
	46	1						
Notes COPC - Chemical of Potential Concern *The number of half-lives required to achieve the observed attenuation between flow path pairs BAR - Bulk Attenuation Rate Half-lives were calculated by using Solver to adjust the half-life until observed attenuation was achieved								

7.5 Revised Conceptual Model

7.5.1 Contaminant Sources

Based on the current and historical uses of the site and its surroundings, and the findings of the investigation, it is concluded that the following contaminant sources should be considered:

- Historical Site Sources: Surface source of dry-cleaning fluid (PCE), the volume lost, and date(s) of loss are not known. The site was last known to have operated as a dry cleaners in the year 2009.
- Groundwater: A source of DNAPL has not been identified from the site investigation which is considered to have been to sufficient depth. The groundwater concentrations of PCE in WS108 are approximately 1% of the aqueous solubility limit for PCE (200 mg/l) which may indicate the presence of residual phase NAPL in saturated soils at that location.

An infinite source term is assumed for the model.

7.5.2 Contaminant Pathways

Contaminants can reach potential receptors through various routes. The following are considered to be applicable to this site:

- Ground Conditions: The aquifer is heterogenous, comprising predominantly clayey sand and sandy clays with apparently discontinuous horizons or lenses of more permeable sands and gravels. When considered at the scale of tens to hundreds of metres then the unit as a whole is likely to act as a low permeability system with transport by intergranular flow.
- Groundwater: Groundwater flow direction and gradient cannot be accurately determined from the groundwater contour plots due to the variable permeability making interpolation between different groundwater levels impractical. Local topography indicates that shallow groundwater is likely to flow approximately northwards towards the River Mersey or its tributaries. The topographic gradient of the area is relatively shallow (0.0124 m/m), indicating that groundwater gradients in superficial deposits are also unlikely to be steep. The hydraulic gradient measured on site is approximately 0.0377 m/m which is consistent with the low permeability geology but not the topographic gradient.
- Degradation: The chemical results show reducing concentrations of parent compounds down hydraulic gradient of the source (2304µg/l PCE in WS09, <5 µg/l PCE in WS02), together with the presence of daughter products (TCE, *Cis*-DCE, and vinyl chloride) showing that degradation is occurring or has occurred on site.

7.5.3 Contaminant Receptors

The following potential receptors are considered to be applicable to this site:

- Surface Water: In the absence of any nearby specific controlled waters receptors then the Environment Agency's default compliance points of 50m for hazardous substances and 250m for non-hazardous substances have been applied.
- Underlying Aquifer: Drinking Water Standards have been applied where available to be protective of the future resource quality of the aquifer, or EQS where a DWS not available.

8.0 CONCLUSIONS & RECOMMENDATIONS

8.1 Local Geology

The site investigation has proved a thin mantle of Made Ground underlain by variable sand and clay horizons. Gravel was also encountered in boreholes WS107, WS108 and WS110

8.2 Hydrology and Hydrogeology

The site is not located within 1kmetre of a surface water or a surface/groundwater abstraction borehole.

The sand and gravel that underlies the site is classified by the Environment Agency as a Secondary A aquifer.

8.3 Soil Infiltration Testing

Infiltration testing was carried out within 3no. of the installed windowless sample boreholes (WS104, WS106 and WS107).

A geomean result of 9.78E-01 m/d was used for the hydraulic conductivity of the aquifer in the Remedial Target Methodology.

8.4 Soil Contamination

Several exceedances in chlorinated solvents have been found in the soils when compared to a residential end use with plant uptake in gardens. The contaminant exceedances include Cis 1,2 Dichloroethene, Tetrachloroethene (PCE) and Trichloroethene (TCE).

Chlorinated solvents have been found in shallow soil and these pose an inhalation risk to future occupiers of residential properties. As a result, remedial measures will be required which will comprise a vapour barrier in the foundations.

A cover system will need to be placed within garden areas which would break pollutant linkages. Given the shallow water table and the presence of chlorinated solvents it would be prudent to install a capillary break layer as part of the cover system.

The details of the remedial works are included within the Remediation Strategy.

8.5 Groundwater Contamination

Several exceedances in chlorinated solvents have been found in the groundwater samples recovered from the monitoring wells when compared to the EQS and DWQ guideline values. The contaminant exceedances include Cis 1,2 Dichloroethene, Tetrachloroethene (PCE) and Trichloroethene (TCE). Vinyl Chloride was only found to exceed in the groundwater sample retrieved from borehole WS104.

Decreasing concentrations of parent compounds down hydraulic gradient of the source were observed, together with the presence of daughter products which show that degradation is occurring or has occurred on site.

The groundwater modelling demonstrates that the risks to controlled waters from chlorinated solvents are likely to be acceptable.

Given the environmental setting of the site and the absence of any nearby specific controlled waters (rivers, ponds, streams, canals), the risk is considered low.

However, further groundwater monitoring is recommended to determine representative concentrations of contaminants on site.

The chlorinated solvents pose an inhalation risk to future occupiers of residential properties as a result, remedial measures will be required which will comprise a vapour barrier in the foundations.

The details of the remedial works are included within the Remediation Strategy.

8.6 Risk to Buried (Water) Services

It is considered that, due to the presence of significant VOC contamination, non-standard materials will be required for new water pipes. Further advice should be sought from the local water company.

Previous guidance on buried water pipes was contained in Water Regulations Advisory Scheme (WRAS) Guidance Note No. 9-04-03⁽²⁰⁰²⁾, however this has been superseded by the UK Water Industry Research Report 'Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites' Ref 10/WM/03/21 (January 2011).

8.7 Site Personnel

As with all construction sites, personnel working on the site during the construction period should be encouraged to maintain a high standard of personal hygiene and on-site washing facilities should be available.

8.8 Other Matters

Due diligence is required during the construction period, and should any further evidence of contamination be found, appropriate investigation and / or action should be taken. The significance of any contamination not discovered by this investigation is outside the scope of this report.

APPENDIX 1

EXPLORATORY HOLE LOGS

APPENDIX 2

ENVIRONMENTAL MONITORING DATA

APPENDIX 3

INFILTRATION TESTING RESULTS

APPENDIX 4

CHEMICAL TESTING RESULTS

APPENDIX 5

REMEDIAL TARGET METHODOLOGY WORKSHEETS

APPENDIX 6

REPORT LIMITATIONS

REPORT LIMITATIONS

This contract was completed by Earth Environmental & Geotechnical Ltd on the basis of a defined programme and scope of works and terms and conditions agreed with the client. This report was compiled with all reasonable skill, and care, bearing in mind the project objectives, the agreed scope of works, the prevailing site conditions, the budget, and staff resources allocated to the project.

Other than that, expressly contained in the above paragraph, Earth Environmental & Geotechnical Ltd provides no other representation or warranty whether express or implied, is made in relation to the services. Unless otherwise agreed this report has been prepared exclusively for the use and reliance of the client in accordance with generally accepted consulting practices and for the intended purposes as stated in the agreement under which this work was completed. This report may not be relied upon, or transferred to, by any other party without the written agreement of a Director of Earth Environmental & Geotechnical Ltd.

If a third party relies on this report, it does so wholly at its own and sole risk and Earth Environmental & Geotechnical Ltd disclaims any liability to such parties.

It is Earth Environmental & Geotechnical Ltd understanding that this report is to be used for the purpose described in the introduction to the report. That purpose was an important factor in determining the scope and level of the services. Should the purpose for which the report is used, or the proposed use of the site change, this report will no longer be valid and any further use of, or reliance upon the report in those circumstances by the client without Earth Environmental & Geotechnical Ltd review and advice shall be at the client's sole and own risk.

The report was written in 2022 and should be read in light of any subsequent changes in legislation, statutory requirements, and industry best practices. Ground conditions can also change over time and further investigations, or assessment should be made if there is any significant delay in acting on the findings of this report. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. The information and conclusions contained in this report should not be relied upon in the future without the written advice of Earth Environmental & Geotechnical Ltd. In the absence of such written advice of Earth Environmental & Geotechnical Ltd, reliance on the report in the future shall be at the client's own and sole risk. Should Earth Environmental & Geotechnical Ltd be requested to review the report in the future, Earth Environmental & Geotechnical Ltd shall be entitled to additional payment at the then existing rate or such other terms as may be agreed between Earth Environmental & Geotechnical Ltd and the client.

The observations and conclusions described in this report are based solely upon the services that were provided pursuant to the agreement between the client and Earth Environmental & Geotechnical Ltd. Earth Environmental & Geotechnical Ltd has not performed any observations, investigations, studies or testing not specifically set out or mentioned within this report.

Earth Environmental & Geotechnical Ltd is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the services. For the avoidance of doubt, unless otherwise expressly referred to in the introduction to this report, Earth Environmental & Geotechnical Ltd did not seek to evaluate the presence on or off the site of electromagnetic fields, lead paint, radon gas or other radioactive materials.

The services are based upon Earth Environmental & Geotechnical Ltd observations of existing physical conditions at the site gained from a walkover survey of the site together with Earth Environmental & Geotechnical Ltd interpretation of information including documentation, obtained from third parties and from the client on the history and usage of the site. The findings and recommendations contained in this report are based in part upon information provided by third parties, and whilst Earth Environmental & Geotechnical Ltd have no reason to doubt the accuracy and that it has been provided in full from those it was requested from, the items relied on have not been verified.

No responsibility can be accepted for errors within third party items presented in this report. Further Earth Environmental & Geotechnical Ltd was not authorised and did not attempt to independently verify the accuracy or completeness of information, documentation or materials received from the client or third parties, including laboratories and information services, during the performance of the services. Earth Environmental & Geotechnical Ltd is not liable for any inaccurate information, misrepresentation of data or conclusions, the discovery of which inaccuracies required the doing of any act including the gathering of any information which was not reasonably available to Earth Environmental & Geotechnical Ltd and including the doing of any independent investigation of the information provided to Earth Environmental & Geotechnical Ltd save as otherwise provided in the terms of the contract between the client and Earth Environmental & Geotechnical Ltd.

Where field investigations have been carried out these have been restricted to a level of detail required to achieve the stated objectives of the work. Ground conditions can also be variable and as investigation excavations only allow examination of the ground at discrete locations. The potential exists for ground conditions to be encountered which are different to those considered in this report. The extent of the limited area depends on the soil and groundwater conditions, together with the position of any current structures and underground facilities and natural and other activities on site. In addition, chemical analysis was carried out for a limited number of parameters [as stipulated in the contract between the client and Earth Environmental & Geotechnical Ltd] based on an understanding of the available operational and historical information, and it should not be inferred that other chemical species are not present.

The groundwater conditions entered on the exploratory hole records are those observed at the time of investigation. The normal speed of investigation usually does not permit the recording of an equilibrium water level for any one water strike. Moreover, groundwater levels are subject to seasonal variation or changes in local drainage conditions and higher groundwater levels may occur at other times of the year than were recorded during this investigation.

Any site drawing(s) provided in this report is (are) not meant to be an accurate base plan but is (are) used to present the general relative locations of features on, and surrounding, the site.