Next Generation Engineering Consultancy Services

Detailed Quantitative Risk Assessment for Greenheys Business Centre, Pencroft Way, Manchester Science Park, M15 6JJ

Project No: NX534



Client

Next Generation Engineering Consultancy Services

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EXECUTIVE SUMMARY

Site Location	Greenheys Business Centre, Pencroft Way, Manchester, M15 6JJ.
Grid Reference	384283E, 396283N.
Site Area	0.56ha
Risk to future site users (Health)	There is no anticipated risk to future site users from contamination identified at the site
Risk to controlled waters (groundwater and surface water)	Remedial target concentrations have been developed for localised hydrocarbon contamination identified in soil and groundwater. No soil targets are exceeded by site concentrations. Groundwater targets are exceeded for TPH aromatic fractions C_{10} to C_{12} and C_{12} to C_{16}. However predicted concentrations down hydraulic gradient have not been realised and this suggests plume migration may be more restricted than modelled data initially suggests.
Risk from piling activities	CFA piles do generally result in good seals in low permeable layers where the clay thickness is equal to or greater than two pile diameters. Individual pile diameters at Greenheys are likely to be between. 450 to 600mm, giving a required cohesive layer thickness of 900 to 1,200mm or more. Exploratory logs indicate a minimum thickness of Glacial Till of approximately 3.5m. Sufficient clay should be present to ensure a seal and prevent seepage along the pile.
Risk from construction activities	Piling method statement should consider appropriate and necessary PPE to reduce exposure to ground contamination and include a toolbox talk to ensure drilling contractors are aware of ground conditions before any works commence. Residual **organic vapours** in made ground, drift deposits and shallow groundwater could present a risk to the integrity of standard damp proof membranes even after remediation. Hydrocarbon resistant membranes should be considered.
Further action	Assessment of the likely source area should be undertaken during made ground turn over and a remedial strategy should be developed for removing /treating source material and localised impacted soils. Active groundwater remediation is not recommended. However, some localised dewatering in areas of high impact or where services intersect the shallow groundwater may be required. Further action includes:. 1) develop construction environment management plan 2) develop a piling method statement 3) develop a remediation strategy 4) develop a material management plan

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1.0 INTRODUCTION

1.1 Instruction

NX Consulting Limited have been commissioned by Bruntwood SciTech (The Client) to complete a detailed risk assessment to support the development of a remediation strategy for land off Greenheys Business Centre, Pencroft Way, Manchester, M15 6JJ.

The development includes the construction of a 7-storey building comprising commercial floorspace across 6 occupiable floors, plus plant level above; with associated cycle parking, hard and soft landscaping, access and other associated works.

1.3 Objectives & Scope of Work

The objective of this report is to assess the risks associated with contamination identified and to:

- determine whether viable migration pathways are present
- consider migration pathways introduced via the proposed development
- undertake numerical modelling of viable pathways to derive remediation targets for soils and, where appropriate groundwater
- consider uncertainties in the available site data
- provide a summary of action needed to support the production of a remediation strategy

This risk assessment is based on data collected over several phases of investigation. A brief summary of ground conditions has been presented. Further detail is included in NX Consulting Phase 1 & Supplementary Phase 2 Geoenvironmental Report for Land off Greenheys Business Centre, Manchester, ref NX534 rev 2, dated August 2023.

This risk assessment and the Supplementary Phase 2 Geoenvironmental Report should be read in conjunction with each other.

1.3 Report Layout

- Section 2 of this report provides a brief summary of environmental setting, history, ground conditions and contamination, as recorded in the Supplementary Phase 2 Geoenvironmental Report.

- Section 3 discussed the hydrological and hydrogeological setting at the site and wider area.

- Section 4 summarises the conceptual site model and identifies the contaminant linkages to be considered further within the detailed risk assessment

- Section 5 provides details on the risk model, inputs and assumptions, along with results and sensitivity analysis

- Section 6 considers construction activity risks including piling risk assessment, dewatering and residual vapour risks

- Section 7 provides a summary of the report findings and includes actions to be considered in the remediation strategy.

1.4 Limitations

The accuracy of the data supplied by third parties should be considered in the context of any known site conditions for which NX Consulting Limited cannot be held liable.

The comments made in this report are based on the data available at the time of its completion. Any unusual or conflicting evidence discovered during any future site works must be presented to NX Consulting as soon as possible so that any implications may be considered.

This report is provided for the benefit only of the party to whom it is addressed. NX Consulting does not extend responsibility to any third party for the whole or any part of the contents. Nx Consulting owes no duty of care in relation to this report to any third party. The investigation and reportage has been undertaken with all reasonable skill, care and due diligence. NX Consulting disclaims any responsibility to the client or others in respect of any matter(s) outside this agreed scope of the above works.

In addition to the above it should be noted that when investigating or developing land, sub-surface conditions might vary both spatially and over time. This risk assessment has been based on available public register data and NX Consulting ground investigation data, making reasonable assumptions of likely source areas and movement based on observed effects, the absence of certain ground, contamination or groundwater conditions at the individual locations is not a guarantee that these conditions do not exist elsewhere on the site. Additional information, changes in legislation or revised practices may necessitate re-interpretation of part or all of this report.

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2.0 BACKGROUND

This section summarises pertinent information about the site location, environmental setting, history and ground conditions included in NX Consulting Phase 1 & Supplementary Phase 2 Geoenvironmental Report ref NX534 rev 2, dated August 2023.

2.1 Site Location & Setting

Site Location	Greenheys Business Centre, Pencroft Way, Manchester, M15 6JJ.
Grid Reference	384283E, 396283N.
Site Area	≈0.56 hectares
Site Description	Greenheys House is a turn of the century brick and glass clad warehouse building which was converted into offices with various additions, alterations and extensions over the last 20years. The site is bordered to the north by areas of car parking and cleared ground. A takeaway restaurant – located within a terraced property – and the McDougall Centre can also be found to the north. Car parking is located to the east of the main entrance in the east of the building. The building is bound to the west by Greenheys Lane with residential properties beyond, and to the south by New Base Building.
History	**On-Site** Historical mapping indicates the land has been developed since at least 1848. Identified potentially contaminative past usages include a garage, a warehouse and a depot. Greenheys Business Centre is likely to have been built on the site between 1990 and 1994. **Off-Site** Numerous potentially contaminative land usage was identified in close proximity to the site including: yards, mills, works, garages, car-parks, electrical substations, warehouses, breweries. Surrounding land also includes residential properties, school, science park, churches and The Victorian University of Manchester. A historical tank was identified in the Groundsure report 165m SW of the site on 1985 mapping, and 212m NE of the site on 1977 mapping. The content and structure of the tanks (above or below ground) was not recorded.
Offsite sources (Diesel Storage)	There are nearby locations within Manchester Science Park of diesel storage. The locations and details are present below: **Williams House** 1. Telecity have a 6000l tank to service their data centre back up generator **Kilburn House** 2. Telecity have a 7000l tank to service their data centre back up generator **Telecity**

	3. Size tbc tank to service their data centre back up generator **Skelton House** 4. Qiagen have a 7000l tank to service their data centre back up generator 5. Icon have a 1000l tank to service their data centre back up generator All tanks are above ground.

2.1 Ground conditions

The BGS 1:50,000 geological map sheet 85 indicates the site is directly underlain by Glacial Till, overlain in areas by Glaciofluvial sand and gravel. Glacial Till is underlain by the Chester Pebble Beds Formation (sandstone).

During the intrusive investigation made ground was identified across the site, to a maximum depth of 1.5m, more typically 0.75m. Made Ground comprised gravelly sands with some soft to firm dark brown sandy, gravelly clay and included fragments of concrete, metal, timber and brick.

Obstructions, including brick walls and demolition arisings were noted and are likely to be associated with former building services and foundations.

Glaciofluvial sand and gravel was identified directly below made ground to depths of approx. 2.5m. Glacial Till (firm clay with gravel) was recorded from approx. 2.5m to 5m.

A layer of red/brown sand & gravel was identified between 6 and 11mbgl. This could be further glacial deposits or a possible band of weathered sandstone.

Competent sandstone bedrock was recorded at 11mbgl.

Groundwater monitoring wells were levelled and dipped on the 25th August 2023 to support this risk assessment. The results are summarised in table 1 below.

Table 1 – summary of groundwater level and dip data

Borehole ID	Depth to water (mbgl)	Depth to water (mAOD)	Depth to base of well (mbgl)
WS04	1.51	32.65	1.98
WS05B	1.80	30.57	4.56
WS08	1.50	31.79	2.55
WS09	1.75	31.88	2.51
WS10	1.81	29.56	4.65
WS11	1.94	31.38	3.11
WS14	1.97	32.37	2.07
WS16	1.98	32.81	2.08
WS17A	1.96	31.64	3.11
WS18A	2.11	31.72	2.99
WS19	2.00	32.32	2.49
WS20	2.13	30.98	3.65
WS22	2.01	32.34	2.43
RBH01	1.61	30.46	4.06
RBH02	1.60	29.91	4.67

All level data and installation details for monitoring wells are recorded on the corresponding exploratory log included in Appendix B of this report.

2.2 Limitations of ground investigation

Access to the site has been restricted and a phased investigation has been undertaken as more access is granted. However, this still means that the main building area has only been investigated by window sampler. These small diameter exploratory holes are useful in areas with limited access, or where there is a need to protect the integrity of the surface covering (concrete pads and areas of trafficking) but only provide a visual inspection of a small percentage of the ground. This can make interpretation of the extent and source of contamination difficult. Installation of small diameter boreholes to exact depths with changes of geological sequencing can also be problematic.

Below ground obstructions and services have also limited the extent of intrusive investigation.

2.3 Contamination

Visual and olfactory evidence of hydrocarbon contamination was recorded during the preliminary and supplementary site investigation works within a number of exploratory locations (WS08, 10, 17, 18 & 20 and TP05). No visible free phase contamination was identified.

Laboratory analysis indicates the higher concentrations of hydrocarbon are found in drift groundwater. Concentrations recorded in made ground and drift soils were unlikely to be sufficient to be the source of the groundwater contamination and are considered to be more likely a result of smearing from fluctuations in groundwater levels.

Furthermore, contamination was only identified at depths of approx. 2mbgl (32mAOD), suggesting a migrating plume of contamination from a source area not yet identified.

Olfactory observations during fieldwork and review of the distribution of aliphatic and aromatic fractions indicates a possible diesel source, with higher concentrations of aliphatic and aromatic C_{12} to C_{21} and some, low level, naphthalene, toluene and xylene. The presence of these organic compounds could suggest a relatively new spillage, as these are often absent in heavily weathered diesel. However, no methylnaphthalene was recorded, a further chemical of concern associated with diesel spillages.

There was no indication of benzene or MTBE, and either an absence or significantly lower concentrations of lighter carbon fractions (C_8 to C_{10}) which are usually associated with petrol.

There were also lower concentrations of heavier carbon fractions (C_{21} to C_{40}) which usually indicate a hydraulic or lubricating oil.

Semi volatile and volatile organic analysis identified very low concentrations of tetrachloroethane, dinitrotoluene, nitroaniline, dinitrobenzene, diphenylamine and di-n-butyl phthalate within the source area. These compounds could be associated with diesel additives and fuel dyes but could also be unrelated.

The source area is identified on Drawing RA01 included in Appendix A.

Diesel storage has been identified beyond the site boundary, within the Science Park. However, to date, there is no evidence of widespread contamination or hydrocarbon contamination in exploratory locations to the north or east of the likely source area.

Longer carbon chains (aliphatic C_{10} to C_{35}, and aromatic C_{16} to C_{35}) are not generally considered to be very mobile in groundwater. Since these fractions have been identified in the source area and in the suspected plume, it could suggest a more local source, possibly associated with the former use as a garage, warehouse or depot.

Given the limitations with the intrusive investigation, the presence of a below ground tank or sump within the development boundary cannot be discounted.

A summary of the soil and groundwater impact is included in table 2 below.

Table 2a – summary of contamination in source area (total TPH)

Borehole ID	Concentration in soil (mg/kg)	Depth of sample (m)	Concentration in water (mg/l)	Depth of sample (m)
WS08	3400	1.8	350	1.7
WS09	N/S	N/A	0.075	1.8
WS17a			160	2.0
WS18a			38	2.0
WS20	1400	2.1	4.4	2.15
WS10	N/S	N/A	<0.001	2.0
TP05	110	2.0	N/S	N/A

Table 2b– summary of contamination in source area (Naphthalene)

Borehole ID	Concentration in soil (mg/kg)	Depth of sample (m)	Concentration in water (mg/l)	Depth of sample (m)
WS08	1.7	1.8	0.01	1.7
WS09	N/S	N/A	0.086	1.8
WS17a			<0.005	2.0
WS18a			<0.005	2.0
WS20			0.0014	2.15
WS10			N/S	N/A
TP05	<0.1	2.0		

Table 2c – summary of contamination in source area (Toluene)

Borehole ID	Concentration in soil (mg/kg)	Depth of sample (m)	Concentration in water (mg/l)	Depth of sample (m)
WS08	<0.001	1.8	<0.001	1.7
WS09	N/S	N/A	<0.001	1.8
WS17a			0.003	2.0
WS18a			<0.001	2.0
WS20	<0.001	2.1	<0.001	2.15
WS10	N/S	N/A		N/A

Table 2d – summary of contamination in source area (Xylene sum of m, p & o)

Borehole ID	Concentration in soil (mg/kg)	Depth of sample (m)	Concentration in water (mg/l)	Depth of sample (m)
WS08	<0.001	1.8	0.001	1.7
WS09	N/S	N/A	<0.001	1.8
WS17a			0.005	2.0
WS18a			<0.001	2.0
WS20	<0.001	2.1	<0.001	2.15
WS10	N/S	N/A	N/S	N/A

The contamination shows a general decrease in concentration from WS08 to WS20. Concentrations of hydrocarbon were not detected in groundwater from WS10, although hydrocarbon odour was noted in soils at approx. 2m on the exploratory log.

3 HYDROLOGICAL AND HYDROGEOLOGICAL SETTING

3.1 Hydrology

A culverted watercourse, Cornbrook, is situated approx. 5m west, adjacent to Greenhays Lane. This is identified as a 'Hidden River' on the Manchester waterways digital map[1]

Cornbrook culvert starts to the east of the site, near Openshaw. It follows a 5.5km route to the west, through vaulted brick channels (max. 3m high) and newer reinforced concrete channels (1 to 2m in height), finally flowing below Bridgewater canal and discharging to the Manchester Ship Canal. The culvert is understood to be part of a series of channels, originally built in the early 1800's to take overflow from the ship canal.

The exact depth and composition of the culvert as it passes to the east of the site is unknown, although photographs of the internal of the culvert are available[2]. Photographs show some discharge pipes and evidence of groundwater seepage though staining and mineralisation of the culvert walls. Photographs also show evidence of a concrete floor, suggesting it is fully enclosed.

The exact depth of the culvert is unknown. Assuming the culvert is a minimum of 1m below current ground levels, which is reasonable as it passes below highways, and, based on evidence in photographs, it has a maximum internal height of approximately 3m, the base of the culvert should lie within the Glacial Till clay. However, if the thickness of clay decreases to the west, the culvert could provide a link between the Glaciofluvial sand and gravel and the Chester Pebble Beds Formation.

Given the minimal volume of water recorded in the Fluvial sands and gravels (see section 3.2 below), it is unlikely there would be sufficient head of water to force groundwater into the culvert at this point. It is more likely shallow groundwater would track along the external annulus of the culvert.

3.2 Hydrogeology

Shallow drift groundwater

The drift deposits across Manchester are complex and generally comprise glacial deposits of variable nature overlain by river terrace deposits, alluvium and peat. It is considered that the drift sequencing in this area could represent as many as five different glaciations. The different phases of glaciation within the area has resulted in large beds of sand and gravel in Glacial Till and sandy gravelly beds created by glacial meltwaters (Glaciofluvial deposits).

The Glacial Till deposits are classified by the Environment Agency as a secondary undifferentiated aquifer. This typically describes a highly variable strata. Bands of granular material could contain groundwater but are unlikely to contain sufficient groundwater to support an abstraction.

[1] https://hidden-manchester.org.uk/#/waterways/corn-brook
[2] https://substormflow.com/drain/cornbrook/

The Glaciofluvial deposits are ony mapped beyond the north and west boundary, but were found during the intrusive investigation to extend across the site. Glaciofluvial deposits are classified as a secondary A aquifer. A secondary A aquifer comprises permeable layers that can support local water supplies and may form an important source of base flow to rivers.

Shallow groundwater was recorded in the Glaciofluvial sand and gravel with a resting water level of approx. 32 to 32.5mAOD. The Glaciofluvial deposits were not saturated and based on site data groundwater appears to be flowing with drift topography to the southwest.

Groundwater dip data from across the site (summarised in Table 1 below) initially suggests a further band of groundwater within the Glacial Till. However once groundwater level data was plotted on the geological cross sections, it was apparent that the lower band of groundwater was more likely Glaciofluvial groundwater which had drained into the lower section of the monitoring well standpipe.

A falling head test was undertaken on two locations, WS04 & WS11, to determine the permeability of the Glaciofluvial deposits. A falling head test was undertaken in preference to a rising head test due to the limited volume of groundwater in the drift deposits and the increased accuracy provided across the length of the response zone in highly variable strata.

The permeability recorded in WS11 was $1x10^{-4}$m/s, which is consistent with a gravelly sand.

The permeability test for WS04 did not return a measurable value as water dissipated faster than could be measured. Review of the installation depths indicates WS04 is installed on a Glacial Till rise. The response zone remains saturated from the base (29.6mAOD) to top 0.5m above the Glacial Till at 33.12mAOD (1.5mbgl). The water added during the permeability test drained rapidly along the falling topography.

The cross-section lines and cross sections are presented together in Drawing RA02 in Appendix A of this report. The two cross sections (fig 1 and 2) are reproduced below for ease of reference.

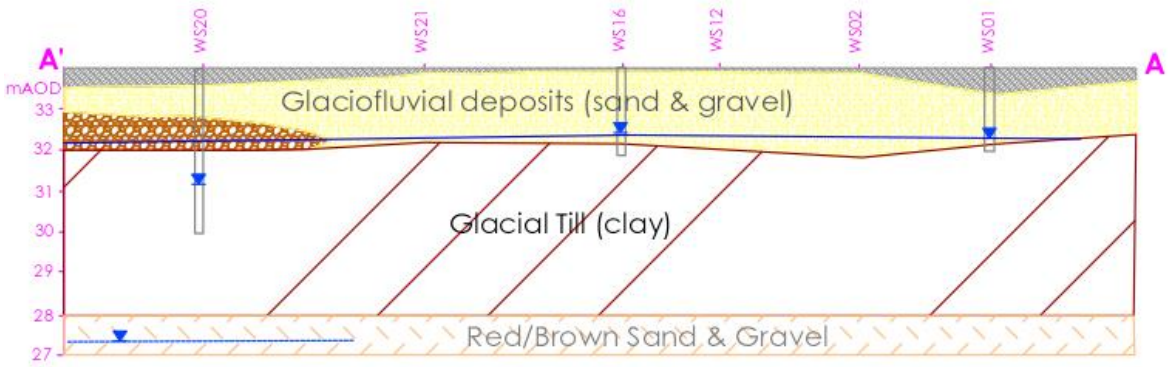


Fig 1 – cross section east to west shows a relatively consistent level of the base of the Glaciofluvial deposits.

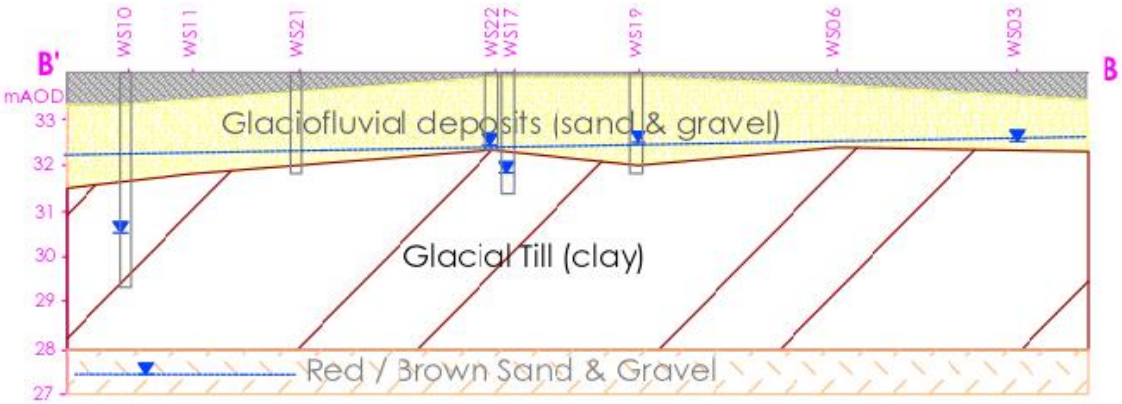


Fig 2 – cross section northeast to southwest shows a dip in the Glaciofluvial deposits, which corresponds to the suspected plume migration.

Deep bedrock groundwater

Groundwater flow in the Sandstone is complicated on a regional level due to multiple faulting. The dominant directional trend for faults in the Manchester area are towards the north west-south east. Faulting in the area is thought to have a considerable impact on the hydrogeology, and faulting is believed to have altered the dip of the Sherwood Sandstone, causing some hydraulic connectivity between the Sherwood Sandstone and the Collyhurst Sandstone[3].

The BGS records indicate a borehole was advanced in centre of the former McDougal Building carpark to the north of site to 237m depth in 1999. The findings are summarised below:

- 0 to 0.5m – made ground.
- 0.5 to 5.0m - clay and sand.
- 6.0 to 8.0m - Grey/brown sandy Clay with gravel and cobbles.
- 8.0 to 9.0m - Gravel of variable lithology
- 9.0 to 11.0m+ - fine to medium grained red SANDSTONE.

Groundwater was observed at 12mbgl during drilling, rising to 7.7mbgl.

Data from the Environment Agency hydrology data explorer indicates groundwater in the Sandstone lies at approx. 27.8mAOD in the north at High School (monitoring station ID SJ89_214) and 27.59mAOD in the south at Hough End (monitoring station ID SJ89_229).

Intrusive investigation data from rotary holes advanced on the site confirmed red/brown sand & gravel below the Glacial Till. Groundwater strikes were not recorded in the Sandstone during fieldwork, however it is not unusual for groundwater strikes in Sandstone to be masked during rotary drilling. The red/brown sand & gravel were recorded between 28 to 23mAOD, competent bedrock was recorded at approx. 23mAOD (11mbgl).

Groundwater levels indicate the Sandstone is saturated and in hydraulic continuity with the overlying red/brown sand & gravel, with a resting water level of approx. 27.6mAOD below the site. The resting groundwater level is shown on Fig 1 & 2.

[3] BGS Baseline Report Series: 8. The Permo-Tirassic Sandstones of Manchester and East Cheshire, ref NC/99/74/8, dated 2017

Based on data from the groundwater monitoring locations above, groundwater in the Sandstone block is likely to be flowing with dip of the bedrock, to the west, at a very shallow gradient of approximately 0.000047 (based on the difference in groundwater head and distance between High School and Hough End).

The site is located in groundwater source protection zone 3 (total abstraction catchment) associated with the brewery abstraction, approx. 500m to the southwest. Given the limited distance between the site and the abstraction at Royal Mossgate Brewery it is highly likely that locally the deeper bedrock groundwater will be influenced by the cone of depression around this abstraction, drawing the local groundwater flow towards the southwest. Given the saturated nature of the Sandstone it is unlikely the gradient will be significantly altered.

The deep Sandstone groundwater is hydraulically separated from the shallow drift groundwater on site by the Glacial Till. It is uncertain if this separation is maintained to the west as the Glaciofluvial deposits become more prominent and the culvert intersects the drift.

4 CONTAMINANTS OF (POTENTIAL) CONCERN & CONTAMINANT LINKAGES

Potential diesel contamination has been identified in shallow groundwater in one area on site. Concentrations recorded in soils are unlikely to be sufficient to have resulted in concentrations observed in shallow groundwater. It is considered likely that a source, possibly a below ground tank or sump, could be present. The most likely location of the source, based on recorded chemical data, is within the area marked on Drawing RA02, included in Appendix A of this report.

It is understood that all concrete hardstanding will be broken out and a full turnover of made ground undertaken. Obstructions will, where possible, be chased out to support future foundations. Where chasing out to full depth is not possible, the location of obstructions will be surveyed and mapped.

During turnover the area around the hydrocarbon contamination will be fully inspected and any potential sources removed. The contaminant linkages identified below have been assessed based on the assumption that there will be no ongoing release of contamination within the site boundary following turn over.

The site will be developed with a commercial end use. The depth and nature of the contamination means it is unlikely to present a health risk to future site users, although potential risk to build material should be considered and are discussed more in section 6. Risks to health are not considered further in this risk assessment.

4.1 Contaminants of concern

The contaminants of concern identified at the site are most likely associated with diesel, given historic land uses. Laboratory certificates report possible diesel contamination as concentrations of Total Petroleum Hydrocarbons (TPH). TPH comprises a mixture of hydrocarbons and cannot be assessed as a single "total" value.

The UK support the assumptions and recommendations made by the Total Petroleum Hydrocarbons Criteria Working Group (TPHCWG) and their work identifying key hydrocarbons in each aliphatic and aromatic banding.

The TPHCWG have broken down "TPH" into fourteen representative constituent fractions or "EC Bandings". EC Bandings are based around Equivalent Carbon numbers and the TPHCWG have derived a series of physiochemical and toxicological parameters for each EC banding or fraction, which best describe the characteristics observed within that banding. The methodology for the derivation of these banding-specific properties is outlined in the TPHCWG series volumes 1-4.

The approach set out for assessing petroleum hydrocarbons in groundwater and identifying contaminants of potential concern (CL:AIRE 2017 publication[4]) has been adopted, the CL:AIRE publication also advocates use of the TPHCWG EC bandings.

The contaminants of concern considered in this risk assessment are:

- Aromatic TPH fraction C_{10} - C_{12}
- Aromatic TPH fraction C_{12} - C_{16}
- Naphthalene
- Toluene
- Xylene (sum of all isomers)

Other hydrocarbon fractions have been identified within the source area, however these are known to have a low to very low mobility in the environment. Whilst these may be present in soil and locally in groundwater, there is considerable evidence that these aliphatic and longer chain aromatic hydrocarbons are unlikely to migrate in dissolved phase or present a longer-term groundwater risk.

4.2 Contaminant linkages

The contaminant linkages detailed in the table below have been considered further in this detailed risk assessment. Only contaminant linkages that have a viable migration pathway, or the presence of a migration pathway can be reasonably assumed based on currently available site data, have been included.

[4] Petroleum Hydrocarbons in Groundwater: Guidance on assessing petroleum hydrocarbons using existing hydrogeological risk assessment methodologies, published by CL:AIRE dated 2017

Table 3 – Contaminant Linkages

Source	Pathways	Receptor	Comments
Hydrocarbon impact around WS08, 17a, 18a & 20	Horizontal migration in shallow groundwater	Glaciofluvial Sand secondary A aquifer	**Yes** - There is evidence of plume migration in shallow groundwater.
	Vertical migration to Sandstone via pathways created from the culvert (off site)	Chester Pebble Beds Formation principal aquifer	**Uncertain** – insufficient data to discount (see discussion in section 5 below)
	Horizontal migration in shallow groundwater	Cornbrook surface water	**No** - It is considered highly unlikely that a plausible pathway exists to Cornbrook surface water. Internal pictures show the culvert to be in a good state of repair and there is insufficient head of groundwater in the Glaciofluvial deposits to create a driving head of water into the culvert.

5 APPROACH TO MODELLING RISK

5.1 Selection of numerical model

The presence of a contaminant linkage to the Chester Pebble Beds is unclear. BGS borehole logs to the west and southwest all indicate the presence of Glacial Till. However, these records are of variable quality and the descriptions are also highly variable. Whilst all exploratory logs note the presence of clay, this is described as sandy and gravelly, with occasional cobbles.

The third-party data is not sufficiently reliant to adequately discount the external annulus of the culvert as a plausible migration pathway for the shallow groundwater to drain into the Chester Pebble Beds. Since the red/brown sand & gravel, which directly underly the Glacial Till, are not fully saturated, and the groundwater is not exhibiting confined properties, there is no upward head gradient to inhibit migration.

The initial approach to numerically modelling the scenario was to develop the conceptual site model in ConSim. ConSim allows the physical properties of a confining layer and an unsaturated zone to be included in the site assessment. This tool makes ConSim a powerful numerical model for complicated geological sequencing, where retardation in the unsaturated zone is a critical consideration.

However, during development of the model input parameters, the degree of uncertainty in the ground conditions offsite meant a high level of conservatism had to be assumed and generic reference values adopted for aquifer properties.

Assuming worst-case pathways and using generic reference values rather than site specific data reduces the realism of the assessed risk via the ConSim modelled migration pathway. This will always result in an over calculation of risk and by default over remediation. This is clearly not sustainable and is not the objective of detailed risk assessment.

However, it is clear that migration towards the culvert is directly linked to migration within the Secondary A aquifer, which is a viable water receptor. Therefore, this risk assessment focuses on reducing migration in the secondary A aquifer. This will, by default, also minimise the risk to the principal aquifer.

Since dissolved phase hydrocarbon contamination has already been detected in the Secondary A aquifer, the approach set out in the Environment Agency's R&D document – Hydrogeological Risk Assessment for Land Contamination will be adopted. This methodology is consistent with current UK legislation and guidance for assessing impacts on controlled waters.

The hydrogeological risk assessment methodology allows a three-tiered approach to aid quantification of risks to surface waters and\or groundwaters from contaminated sites. These tiers comprise:

- Tier 1 considers the contaminant concentration in pore water, most commonly via leaching tests. Tier 1 ignores the effects from dilution, dispersion and attenuation.
- Tier 2 considers dilution by the receiving groundwater or surface water, and whether this is sufficient to reduce contaminant concentrations to acceptable levels.
- Tiers 3 & 4 consider natural attenuation including dispersion, retardation and degradation and whether these are sufficient to reduce contaminant concentrations to acceptable levels.

At each tier a remedial target is derived, but this is likely to be less onerous at the next tier as additional factors (such as dilution and attenuation) are taken into account. With successive tiers, data requirements and sophistication of the analysis increase, and confidence in the predicted impact also increases. Consequently, the source-pathway-receptor relationship is better defined, and remedial requirements are likely to be less onerous, from tier 3 output.

Assessment in relation to contaminated groundwater commences at Tier 2 as the contaminants have already moved through the soil zone.

5.2 Model Limitations

The methodology relies on values determined for pore water quality. Chemical partitioning between soil and water is difficult to predict and laboratory results can vary significantly. Remedial targets derived for soils based on partitioning can be highly conservative. Soil targets should include a sense check based on effective solubility of key risk drivers.

The model assumes that the source of contamination is directly above the saturated zone. The model cannot consider the retardation, degradation or protection that may be provided within the unsaturated zone. This is not an issue within the site conceptual model, since dissolved phase contamination has already been detected in the saturated zone.

The methodology calculations include assumptions on aquifer characteristics i.e. aquifer is intergranular, homogeneous and isotropic, steady state groundwater flow exists and adsorption is linear, instantaneous and reversible. In practice few of these assumptions will be accurate. Sensitivity analysis should always be undertaken considering a range of site derived values wherever possible.

The framework does not provide recommendations for appropriate target concentrations or compliance distances. Careful consideration is needed to ensure the scenario is representative of the conceptual site model and can be justified as following best practice for groundwater risk assessments, as set out in Environment Agency publications[5].

5.3 Model input parameters

It has been assumed that the source area is in direct contact with the unsaturated Glaciofluvial sands, and the aquifer exists in the saturated section of the Glaciofluvial sands. Glacial deposits can be highly heterogenous due to the mechanisms of deposit and as such selecting a single representative value can be problematic.

The values adopted in the risk assessment are based on site-measured data wherever possible including hydraulic gradient, hydraulic conductivity and anticipated source dimensions. All site-specific data is presented in NX Consulting Phase 2 report or, in the case of permeability test data, included as Appendix C to this report. Where a range of values could be reasonably assumed, the effect of the range has been discussed in the sensitivity assessment.

Details of the input parameters adopted in the main assessment are summarised in the table below.

Table 4 – model input parameters

Parameter	Value	Data source and justification
Tier 1		
Contaminant of potential concern (COPC)	Aromatic TPH fraction C_{10} - C_{12} Aromatic TPH fraction C_{12} - C_{16} Naphthalene Toluene Xylene (sum of all isomers)	Key risk drivers from source area
Target concentrations (mg/l)	Aromatic fraction C_{10} - C_{12} – 0.09 Aromatic fraction C_{12} - C_{16} – 0.09 Naphthalene – 0.14 Toluene – 0.7 Xylene (sum of all isomers) – 0.5	No UK DWS for CoPC Target concentrations are based on WHO guide values for drinking water.
Water/air porosity (fraction)	0.14/0.14 total porosity (P) of 0.28 P = (1-(BD/PD)) x 100	Based on the assumed bulk density (BD) of 1.9 and particle density (PD) of 2.65 for a glacial sand and average site measured moisture content of sand in the unsaturated zone (14%).
Bulk density (g/cm3)	1.9	Value for a medium river sand from BS8002
Henrys Law constant	See risk spreadsheets	TPHCWG Documents Vol 3
Soil water partition co-efficient	Calculated in the model using site measured organic carbon and organic carbon partition coefficient	TPHCWG Documents Vol 3
Fraction organic carbon	0.007	Average of site measured value in unsaturated sands
Organic carbon partition co-efficient (l/kg)	See risk spreadsheets	TPHCWG Documents Vol 3

[5] Groundwater Protection: Principles and Practice (GP3), Environment Agency, 2013 and https://www.gov.uk/guidance/groundwater-risk-assessment-for-your-environmental-permit#identify-compliance-points

Parameter	Value	Data source and justification
pH	7.5	Average of site measured value in unsaturated sands
Tier 2		
Infiltration rate (m/day)	104mm/yr $2.8x10^{-4}$ m/day	10% of annual average for Manchester taken from the Met office data set. 10% assumed due to high percentage of hardstanding in development and across surrounding area.
Area of source (m2)	11.25	Assuming a 20,000lt tank with dimensions 4.5m x 2.5m x 2.5m
Length of source area in direction of groundwater flow (m)	4.5m	Max length of assumed tank
Saturated aquifer thickness (m)	0.5	Maximum saturated zone measured on site
Hydraulic conductivity (m/day)	$1x10^{-4}$m/s 8.6m/day	Site measured value (WS11) Academic recorded mean for Glacial sands is approx. 2.5m/day The range can be between 0.1 – 40m/day
Hydraulic gradient (m/day)	0.004	Site value. Based on level data from WS04 and WS22, located approx. 72.5m apart in the direction of groundwater flow.
Width of source perpendicular to groundwater flow	2.5m	Assumed width of fuel tank
Background concentration of CoPC in groundwater	N/A	No background concentrations assumed. The water quality of the principal aquifer is recorded as poor. No data is available for the Secondary A aquifer. Diesel is a hazardous substance and as such any background impact should not be taken into account in the modelling. Consideration of background concentrations is not the same as managing a possible offsite source (where no source can be identified on site, contamination is most likely to have arisen from an offsite source)
Mixing zone depth (m)	0.5m	Full depth of the saturated Glaciofluvial sands
Tier 3 soils and groundwater		
Groundwater concentration (mg/L)	See tables 2a to 2d in section 2 of this report for a summary	Site measured values
Half life for degradation	N/A	No evidence of degradation available
Width of plume in aquifer (m)	20	Based on evidence from SI
Plume thickness in aquifer (m)	0.5	Assumed to be the full thickness of the saturated zone
Bulk density of aquifer material (g/cm3)	1.9	Value for a medium river sand from BS8002
Effective porosity of aquifer	0.33 Range reported in a Glaciofluvial sand can vary from 0.004 to 0.4, depending on how well sorted the	Value for a medium sand from McWorter & Sunada 1993

Parameter	Value	Data source and justification
	sands are and the degree of silt present.	
Hydraulic gradient and conductivity for aquifer	As set in Tier 2 assessment	
Distance to compliance point	50m	Distance from anticipated source area to the site boundary in the direction of groundwater flow.
Longitudinal dispersivity in relation to compliance point	Based on Xu & Eckstein equation assuming transverse and vertical dispersivity is 0.01 and 0.001 time the longitudinal dispersivity	Xu & Eckstein equation assumed due to small aquifer thickness and mixing zone.
Lateral dispersivity in relation to longitudinal dispersivity		
Time since pollution entered groundwater	-	Model default assumed

5.4 Model output – critical concentrations

The table below summarises the output from the hydrological assessment, based on the soil and groundwater concentrations observed and assuming a compliance distance of 50m (source area to the site boundary).

Table 5 – remedial targets

Determinant	Max soil concentration	Remedial target	Max water concentration	Remedial target
	(mg/kg)		(mg/L)	
TPH Aromatic C10 – C12	31	566	4.5	0.42
TPH Aromatic C12- C16	440	1123	49	0.42
Naphthalene	1.7	750	0.01	0.66
Toluene	<0.01	550	0.003	3.2
Xylenes	0.2	900	0.12	3.25

The assessment has been based on the Ogata Banks model, assuming degradation occurs only in the dissolved phase with one-way vertical dispersion. These assumptions are default within the supporting guidance unless site specific data can justify adopting an alternative model.

As can be seen from the table above, all soil concentrations are well below the calculated remedial target. This supports the initial assessment that another source, as yet unidentified, is likely to be present on site, or to the northeast of the site boundary.

Dissolved phase indicator compounds naphthalene, toluene and xylene concentrations are all well below the calculated remedial target. However, concentrations of TPH aromatic C_{10} – C_{12} and Aromatic C_{12} – C_{16} exceed the remedial target.

5.5 Sensitivity analysis and review of uncertainties

Most parameters used within the numerical risk assessment are likely to have some natural variability, a single value is highly unlikely to accurately represent all ground conditions. The effect this variability can have on the output of the risk assessment should be considered. This is usually undertaken by considering firstly the accuracy of the conceptual site model and assumed migration pathways (discussed in section 5.1); secondly by applying a variability (usually 20%) to a selection of key parameters and considering the impact the variation has on the remedial targets.

Within this conceptual site model some parameters have a high degree of confidence such as the saturated aquifer thickness, mixing zone and groundwater gradient. These are all site measured and show consistency across the site.

Other parameters are likely to exhibit the greatest natural variability such as hydraulic conductivity and effective porosity. The distance to the compliance point will also influence remedial targets.

Variations to the following three parameters will be applied to TPH Aromatic C_{10}-C_{12} groundwater assessment.

- Hydraulic conductivity typical range of Glacial sand (0.22m/day to 43.2m/day)
- Effective porosity considering the possible documented range of 0.004 to 0.4
- Compliance distance at
  - 500m (brewery abstraction BH),
  - 250m boundary of the brewry site and
  - 100m (likely intersect with Cornbrook culvert in the direction of groundwater movement)

Table 6a - Hydraulic conductivity

	Parameter		
	0.22m/day	8.6m/day	43.2m/day
Target	0.42	0.42	0.42

Variation to the hydraulic conductivity does not change the groundwater remedial target concentration. Hydraulic conductivity is used to calculate the dilution factor and attenuation factor. Increasing the value does increase the degree of dilution but decreases the attenuation resulting no overall change to the target.

Table 6b – Effective porosity

	Parameter		
	0.004	0.33	0.4
Target	0.42	0.42	0.42

Variation in the effective porosity is linked to the groundwater flow velocity, retardation factor and decay rate. However, where no degradation rate is applied the effective porosity has little influence on the remedial target.

Table 6c – Compliance distance

	Parameter			
	50m	100m	250m	500m
Target	0.42	0.95	3.22	8.31

Unsurprisingly the longer the distance to the compliance point the higher the remedial target. This is due to the increased degree of dilution, dispersion and attenuation. However, even with a travel distance of 500m the dissolved concentration of TPH aromatic fractions C_{10} to C_{12} and C_{12} to C_{16} are at, or above, the remedial target.

Uncertainties

The calculated critical concentration (remedial target) for groundwater assumes a continuous discharge from a point source. Due to time and project constraints, it is not possible to undertake further ground investigation to reduce this uncertainty before the demolition of the building and grubbing up of hardstanding is completed.

Whilst there is reasonable confidence in the assumed receptor characteristics, the output from the numerical modelling must also be considered against actual site data.

Considering only the data from TPH aromatic fractions C_{10} to C_{12} and C_{12} to C_{16}, groundwater sampled from WS18, located 13m down hydraulic gradient of the hydrocarbon source, returned a groundwater value of 0.3 and 5.4mg/l respectively; the model predicted this should be around 1.97 and 2.14mg/l. Samples obtained from WS20, approximately 25m from the source area returned concentrations of 0.038 and 0.6mg/l in contrast to the predicted concentrations of 1.42 and 1.54mg/l.

Groundwater samples taken for WS10, the monitoring well at the point the plume is predicted to leave the site, indicated all hydrocarbon contamination were below the laboratory limit of detection (<0.0001mg/l). The model predicted a concentration of 1.04mg/l after 100 days. Migration in the secondary A aquifer is clearly more restricted than indicated by modelled data.

The uncertainty regarding a possible on-site source of hydrocarbon should be considered in the remediation strategy. If it can be confidently confirmed that upgradient groundwater is not impacted and the source has been removed, or no longer exists; or the source is upgradient and off site, active remediation of groundwater is unlikely to be required.

6 PILING AND CONSTRUCTION RISKS

A remediation strategy is being prepared for the site and this focuses on source removal where contamination is encountered during made ground turnover. The remediation approach will be supported by the findings of this risk assessment, which assumes there is hydraulic separation between the secondary A aquifer and the underlying principal aquifer. To support the remediation proposal, all piling on site must be undertaken following a methodology to retain the low permeable layer provided by the Glacial Till deposits and prevent the creation of migration pathways.

6.1 Piling method

It is understood that ground conditions support the use of continuous flight auger (CFA) to install the concrete piles.

CFA is a cast in-situ method of piling suited to environmentally sensitive sites where soft natural strata and/or water-bearing strata would usually require deep casings to be used.

A hollow stem auger is advanced into the ground at a constant penetration rate to the desired pile depth. The auger is then extracted, at the same time concrete is pumped down the hollow inside of the auger, continuously filling the resultant void space.

Pressure and volume of the pumped concrete is controlled by instrumentation in the piling rig to ensure positive pressure is maintained as the concrete is pumped into the ground,

this prevents the drilled hole from collapsing as the auger is withdrawn. Maintaining a positive pressure also prevents wash out of concrete in aquifers with high transmissivity, although some localised dispersion is likely. The borehole is completely filled with concrete to surface. Steel reinforcement can then be inserted as required.

Some soils are bought to surface as the auger is retracted.

6.2 Risk evaluation

Studies into piling approaches[6] indicate CFA has the least ground disturbance and draw down when drilling through low permeable confining layers.

The degree of displacement depends on the speed of rotation relative to the speed of penetration. Theoretically, according to the study, it should be possible to adjust the rotation speeds so that the volume of soil removed is equal to the volume of concrete placed. If this is achieved, displacements of the surrounding ground should be negligible. There have also been instances of severe ground loss due to over-rotation and the risk is larger in soil deposits containing sand layers below the water table (the geological setting at the Greenheys site).

Research also suggested there was a negligible change in hydraulic gradient after piling, suggesting CFA piles do generally result in good seals in low permeable layers where the clay thickness is equal to or greater than two pile diameters. Individual pile diameters at Geenhays will be between 450 to 600mm, giving a required cohesive layer thickness of 900 to 1200mm or more.

Exploratory logs indicate a minimum thickness of Glacial Till of approximately 3.5m. Sufficient clay should be present to ensure a seal and prevent seepage along the pile.

Good workmanship and operation of the CFA rig is essential as is the requirement for a method statement that considers the specific ground conditions and details how drilling will be undertaken to minimise displacement and ensure good seals.

Consideration should also be given to the use of casing through made ground and Glaciofluvial sands in the area of hydrocarbon impact, to prevent migration of mobile contamination during the drilling process.

The table below summarises key risk drivers when considering piling activities and the possible creation of contaminant linkages.

[6] Piling in layered ground: risks to groundwater and archaeology, Science Report SC020074/SR, published by Environment Agency, dated 2006

Table 7 - piling risk drivers

Pollution risk	Likelihood	Mitigation
Creation of preferential pathways, through a low permeability layer	Moderate	The use of CFA piles should reduce this risk, providing the piling approach is well designed. Piling method statement must consider possible migration pathways and develop an approach to mitigate
Creation of preferential pathways, through a low permeability surface layer, to allow upward migration of landfill gas, soil gas, or contaminant vapours to the surface	Low	Organic contamination is above the cohesive layer, piling will not increase the potential for vapour migration to surface. Mine workings have not been identified on site and mines gas is not anticipated.
Direct contact of site workers and others with contaminated soil arisings	Low	Minimal arisings likely during CFA piling. Providing appropriate health and safety training, planning and monitoring are in place for the works the risks are anticipated to be low. Piling contractors must be made aware of the potential issues associated with potentially contaminated material and this should be included in their piling method statement. Potential exposure can be mitigated with suitable PPE and contaminated arisings will be disposed of offsite as waste.
Direct contact of the piles or engineered structures with contaminated soil or leachate causing degradation of pile materials	Low	Contamination is restricted to an area of Glaciofluvial sand in the southwest area of the site. Contamination should not be in contact with deeper pile material. Whilst it is unlikely shallow contamination would cause degradation of the pile material, the effect should be considered in the piling method statement and the use of chemical resistant concrete should be considered. However this would depend on the degree of remediation undertaken prior to piling.
The movement of solid contaminants down into an aquifer during pile driving	Low	Research indicates CFA drilling displace material horizontally with minimal downward heave. Some material may be brought to surface as the auger is retracted.
Contamination of groundwater by concrete, cement paste, or grout	Low	The viscosity and set time of the concrete mix, as well as the bleed potential, will need to be precise to provide confidence the pile has been suitable created. This is particularly important in granular strata with a high groundwater flow. Consideration of this should be detailed in the method statement.

6.3 Piling method statement

The selected piling contractors should produce a method statement detailing the approach to ensure continued protection of the low permeable Glacial Till, having full regard to this risk assessment and potential risk drivers summarised in the table above.
The method statement should include maximum drill rates to minimise the degree of draw down and displacement and to provide confidence the final concrete pile has achieved a good seal.

The method statement should include the approach to cleaning the drill rig between locations and how contaminated arisings will be managed.

It is considered unlikely that contaminated water will be brought to the surface during piling. However, for completeness the method statement should also include a section on managing contaminated waters as a precaution.

Piling using CFA causes minimal displacement of ground and does not create significant volumes of arisings or result in dust. However, the piling method statement should consider appropriate and necessary PPE to reduce exposure to ground contamination and a toolbox talk to ensure drilling contractors are aware of ground conditions before any works commence.

The drillers method statement should be reviewed and approved by the Principal Contractor prior to any works commencing on site.

6.4 Other construction risks

A **construction environment method plan** (CEMP) should be developed, prior to commencement of any works on site. This CEMP should include details of:

- likely contamination
- approach to mitigate pathways and exposure
- information to be included in the site induction and toolbox talks for site works
- details of appropriate PPE and personal hygiene when working with potential contamination.

A plan showing the area of identified contamination should be included in the site office.

Redundant drains and infrastructure are likely to be present associated with the former warehouse, depot and garage, this could also include below ground tanks and sumps.

All redundant drainage and associated infrastructure such as interceptors may include residual contaminated sludge and waters. These must not be released to ground.
All drains exiting the site will be identified, as far as possible, and capped.

All sludges and contaminated waters contained in drains encountered during earthworks will be carefully removed from the drains and infrastructure, transferred into containers for removal off-site subject to chemical sampling, waste classification and duty of care requirements.

Chemical sampling to allocate a waste code should consider the likely waste material derived from site activities and will likely include heavy metals, speciated TPH & PAH.
Since all made ground will be excavated, with a full depth turn over it is likely that most gullies, drains and below ground structures will be identified and decontaminated prior to the construction phase.

New services and infrastructure should be kept as shallow as possible to avoid the need for dewatering.

An approach to mitigate contaminant migration into service trenches where these pass through any residual areas of organic contamination, should be included in the CEMP. All areas of residual contamination should be identified, and the location surveyed during earthworks.

Where residual contamination remains, consideration should be given to lining service trenches as they pass through the impacted area. The purpose of the mitigation is to limit the degree of contamination around the service to reduce risks to individuals during any future maintenance.

Low level organic concentrations (particularly PAHs) can present a risk of impregnation of potable water pipes at concentrations that may not be considered a risk within the overall redevelopment setting. It is recommended that a barrier pipe, such as Protecta-Line (or similar) be adopted.

Dewatering of excavations is unlikely to exceed the volumes or conditions of the groundwater activity exclusion within Section 5 of the groundwater abstraction and impoundment legislation as detailed below, therefore a groundwater abstraction permit would not be required. If the conditions set out below can not be met further assessment must be completed.

The restriction on abstraction does not apply to an abstraction or series of abstractions of water carried out in the course of building or engineering works for the purpose of dewatering from a sump or excavation if

a) the abstraction or series of abstractions are temporary and in any event carried out over a period of less than six consecutive months beginning with commencement of the first abstraction,

b) each abstraction does not cause or is not likely to cause damage to a conservation site or specific features in such a site,

c) each abstraction does not cause or is not likely to cause damage to protected species, and

d) either—

(i)the water abstracted is immediately discharged to a soakaway, or

(ii)the volume of water abstracted is less than 100 cubic metres of water per day and there is no intervening use of that water before discharge (but see paragraph (2))

e) The abstraction is not undertaken within 500 metres of a conservation site or within 250 metres of a spring, well or borehole

Any water entering excavations will be pumped to holding containers, visually assessed for the presence of contamination and treated by separation for removal of sediment, and if required, separation of free phase contamination. The disposal point for groundwater is likely to be to foul sewer under consent, but this should be confirmed before works commence on site.

Abstracted water must not be discharged back to ground or directly to a surface water drain without the appropriate environmental permit from the Environment Agency.

A **Materials Management Plan** (MMP) will be required to support the potential retention and re-use of made ground arisings to demonstrate these have a clear and intended

purpose and are therefore not a waste. The MMP will include details of stockpile areas, the volume of material for reuse and where this will be sourced.

Site preparatory works associated with this project are likely to involve the re-use of both natural and made ground soils on site.

The MMP will document how all of the materials to be excavated during the proposed site preparatory and remediation earthworks are to be dealt with. A updated version of the MMP may also be required to set out reuse of material excavated during the construction phase, once initial earthworks have been completed.

The MMP must be in place before any material is excavated, the qualified person declaration must be in place before any material is reused.

All material included in the material management plan must be tracked in a clear and transparent manner and a final verification report produced.

Hazardous ground gas is not considered to present a risk at the site, post construction. Even without remediation the hydrocarbon contamination is not considered likely to present a vapour risk to future site users within a commercial setting, both due to the relatively low volatility and the depth to contamination.

However, residual organic vapours in made ground, drift deposits and shallow groundwater could present a risk to the integrity of standard damp proof membranes even after remediation. It is recommended that the DMP supplier be contacted regarding the concentration on site. A hydrocarbon resistant membrane should be considered.

7 SUMMARY

NX Consulting Limited have been commissioned by Bruntwood SciTech (The Client) to complete a detailed risk assessment to support the development of a remediation strategy for land off Greenheys Business Centre, Pencroft Way, Manchester, M15 6JJ.

Greenheys House is a turn of the century brick and glass clad warehouse building which was converted into offices with various additions, alterations and extensions over the last 20years.

Historical mapping indicates the site has been developed since at least 1848. Identified past usages include a garage, a warehouse and a depot. Greenheys Business Centre is likely to have been built on the site between 1990 and 1994.

Off-Site numerous potentially contaminative land usage were identified including: yards, mills, works, garages, car-parks, electrical substations, warehouses and breweries.

Visual and olfactory evidence of hydrocarbon contamination was recorded during the preliminary and supplementary site investigation works within a number of exploratory locations (WS08, 10, 17, 18 & 20 and TP05). No visible free phase contamination was identified.

Laboratory analysis indicates the higher concentrations of hydrocarbon are found in drift groundwater (Secondary A aquifer).

A detailed quantitative risk assessment has been undertaken, adopting the Environment Agency methodology to hydrogeological risk assessment.

The table below summarises the output from the hydrological assessment, based on the soil and groundwater concentrations observed and assuming a compliance distance of 50m (source area to the site boundary).

Table 5– remedial targets

Determinant	Max soil concentration	Remedial target	Max water concentration	Remedial target
	(mg/kg)		(mg/L)	
TPH Aromatic C10 – C12	31	566	4.5	0.42
TPH Aromatic C12- C16	440	1123	49	0.42
Naphthalene	1.7	750	0.01	0.66
Toluene	<0.01	550	0.003	3.2
Xylenes	0.2	900	0.12	3.25

NB table reproduced from section 4

As can be seen from the table above, all soil concentrations are well below the calculated remedial target.

Dissolved phase indicator compounds naphthalene, toluene and xylene concentrations are all well below the calculated remedial target. However, concentrations of TPH aromatic C10 – C12 and Aromatic C12 – C16 exceed the remedial target.

Groundwater samples taken for WS10, the monitoring well at the point the plume is predicted to leave the site, indicated all hydrocarbon contamination was below the laboratory limit of detection (<0.0001mg/l). This is contrary to the model predicted concentration of 1.04mg/l. Migration in the secondary A aquifer is clearly more restricted than indicated by modelled data.

It is recommended that the remediation strategy includes an approach to undertake and validate the following actions:

- confirm if a primary source is present on site
- remove any primary sources
- chase out significant contamination in made ground and Glaciofluvial sand in source area
- validate excavations and material for reuse based on soil targets in table 5.

Active remediation of groundwater is not deemed necessary, since site monitoring has confirmed the plume is retained on site. Potential risks to offsite receptors should therefore be mitigated following removal of any primary source and reduction in the volume of contamination in made ground and Glaciofluvial sand.

This risk assessment has been developed with the assumption the primary source of contamination remains on site. However, an offsite source to the northeast cannot be discounted at this stage. If during site preparatory works evidence of an offsite source

becomes apparent, it is recommended that a notice is sent to surrounding landowners to check assets for damage / leakage.

A further possibility is that the area of contamination could have arisen from a discrete historic spillage and the area of impact is localised; soil concentrations have simply degraded over time, resulting in higher concentrations recorded in groundwater. Degradation of hydrocarbons in the environment is a complex process and can be highly variable depending on the degree of organic carbon, redox potential, bacterial action.

The remediation strategy should include detailed recommendations for recording site observations and a set frequency of soil validation testing, clear transparent records will be required to allow final verification of the site given the uncertainty over the source term.

APPENDICES

Appendix A – Drawings

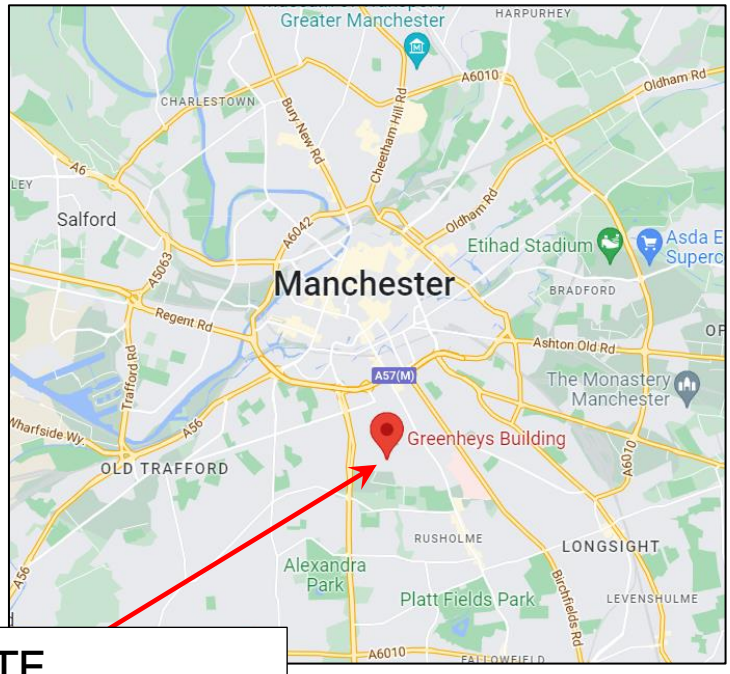
Appendix B – Exploratory hole logs

Appendix C – Permeability test data

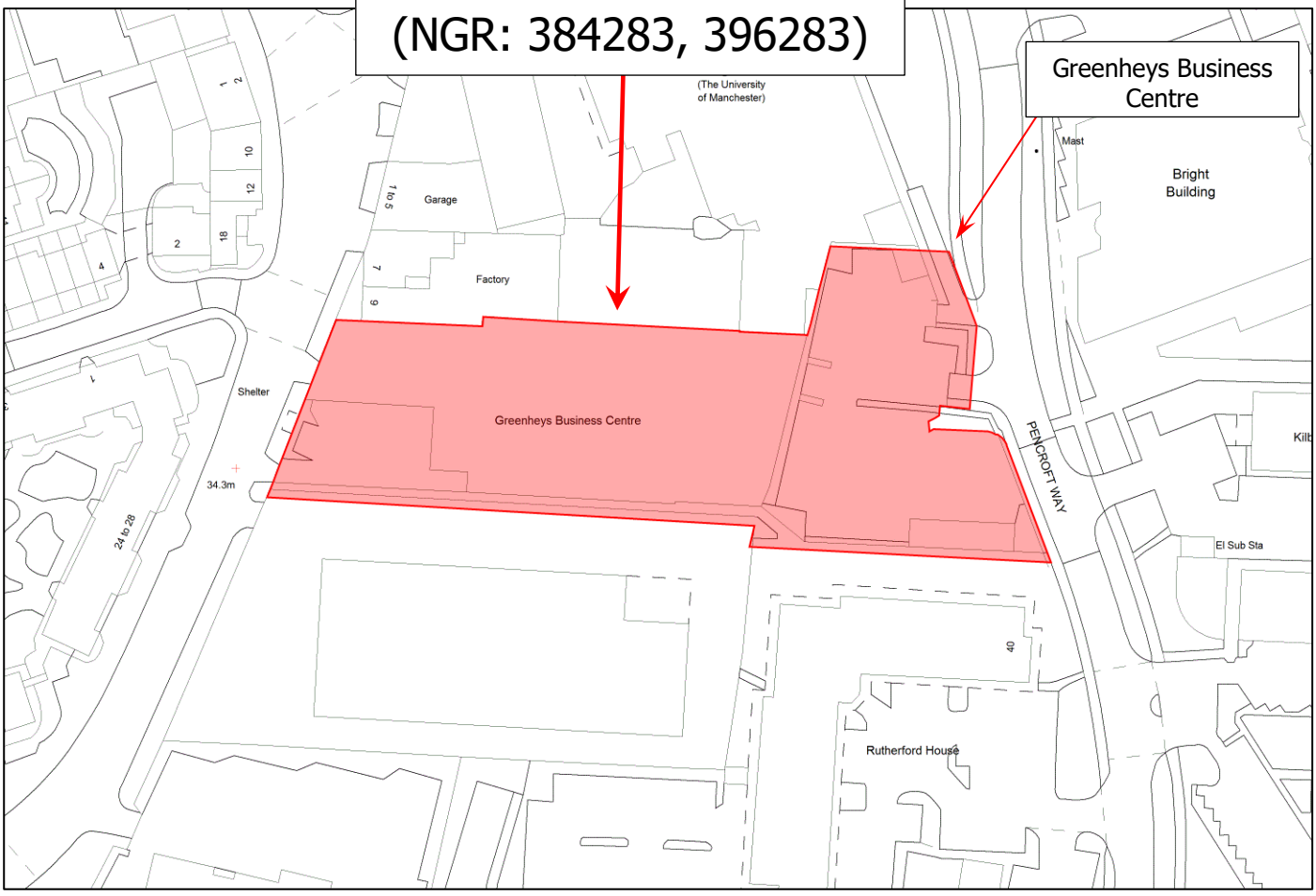
Appendix D – Risk assessment sheets

Appendix A – Drawings





SITE
(NGR: 384283, 396283)

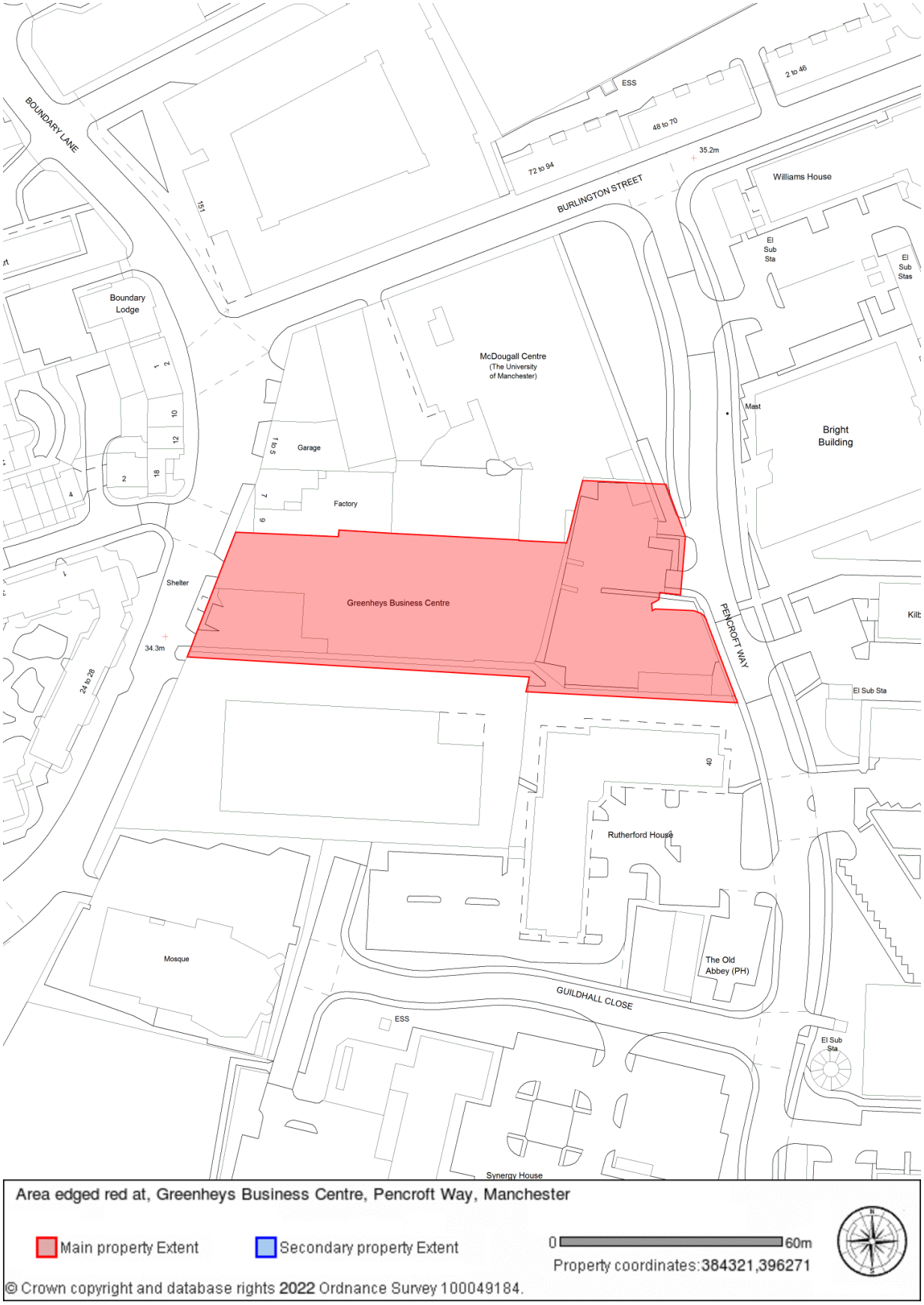


nxconsulting
Next Generation Engineering Consultancy Services
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E-mail: admin@nxconsulting.org.uk
Web: www.nxconsulting.org.uk

Ref: NX534 Figure 1

Project:
GREENHEYS BUSINESS CENTRE, PENCROFT WAY, MANCHESTER, M15 6JJ

Title:
Site Location Plan



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Ref: NX534 Figure 2

Project:

GREENHEYS BUSINESS CENTRE, PENCROFT WAY, MANCHESTER, M15 6JJ

Title:

Site Boundary Plan

BURLINGTON STREET

GREENHEYS LANE

BRONTE STREET

PENCROFT WAY

Proposed site boundary

Greenheys Redevelopment Building

BASE Building

GENERAL NOTES

Do not scale this drawing.

Contractor to check all dimensions and report all errors and omissions to the Engineer.

Details shown on this drawing are schematic only and are subject to detailed design by architect

Rev	Detail	By	Auth	Date

Revisions

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Client

Bruntwood SciTech

Project

Greenheys Redevelopment
Manchester Science Park

Drawing Title

Proposed Site Layout

Drawing Status

scheme

Drawing No.

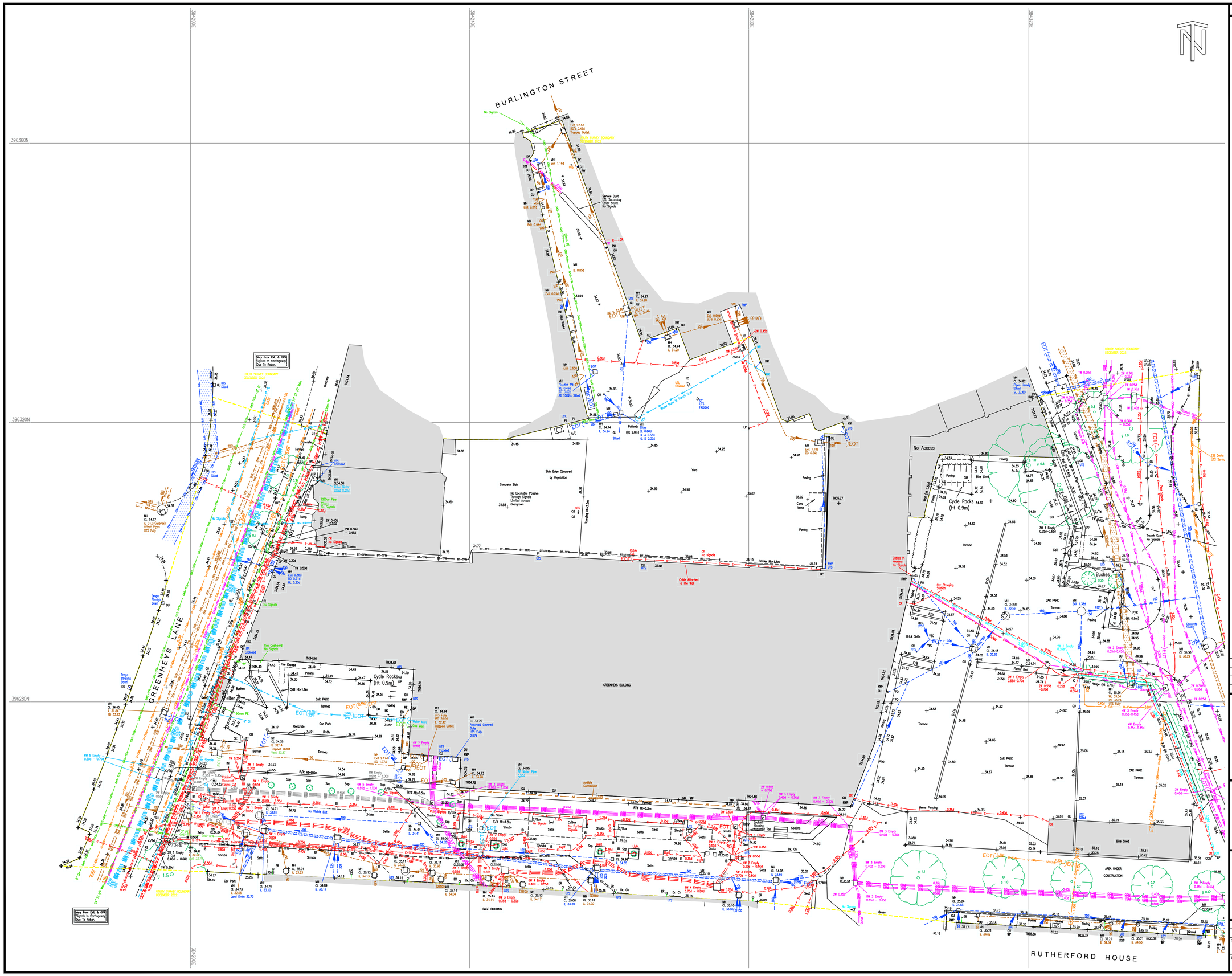
GRE-DWC-XX-DR-C-200

Scale	Sheet Size	Revision
1:250	A1	P01

Date	Drawn	Checked	Auth
Jan'23			

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DWG INFO: Z:_DW LLP\DW LLP JOBS\DW2025 BIOBANK MSP\ FRA AND DRAINAGE STRATEGY\GRE-DWC-XX-DR-C-200



NOTES

KEY

Grid & Datum - Local Plane Grid related to OS National Grid & Datum By GNSS RTK Observations

STANDARD ABBREVIATIONS

STREET FURNITURE

A/C - AIR CONDITIONING
AE - AERIAL
AL - ALARM
AV - AIR VALVE
BA - BUOYANCY AID
BB - BELISHA BEACON
BD - BUILDING DIVIDE
BH - BOREHOLE
BL - BASEMENT LIGHT
BO - BOLLARD
BP - BOUNDARY POST
BR - BOULDER
BU - BUS STOP
CA - CABLE
CB - CONTROL BOX
CC - CLOSE CIRCUIT TV
CIB - CIGARETTE BIN
Col - COLUMN
CT - CLOSE CIRCUIT TV POLE
DP - DOWN PIPE
DR - DRAIN
Dr.Ch - DRAINAGE CHANNEL
DU - DUCT
E - ELECTRIC
EP - ELECTRICITY POLE
ER - EARTH ROD
FA - FENDOR ANCHOR
F/B - FLOWER BED
FH - FIRE HYDRANT
FL - FLOODLIGHT
FS - FLAG STAFF
GA - GAS
GM - GAS METER
G - GIRTH
GP - GATE POST
GU - GULLY
GV - GAS VALVE
Hyd - HYDRANT
IC - INSPECTION COVER
IT - TRAFFIC COVER
JB - JUNCTION BOX
KO - KERB OFFLET
LA - LADDER
LB - LITTER BIN
LC - LIGHTING COLUMN
LI - LIGHT
LP - LAMP POST
MBO - MOORING BOLLARD
MA - MAST
MH - MANHOLE
MO - MONUMENT
MP - MILE POST
MR - MOORING RING
MW - MONITORING WELL
NP - NAME PLATE
OH - OVERHEAD
OSBM - ORDNANCE SURVEY BENCH MARK
PA - PLAY APPARATUS
PB - POLICE BOX
PH - PUBLIC HOUSE
PI - PIPE
PL - PLANT
PM - PARKING METER
PN - PLANTER
PO - POST
PP - PETROL POL PUMP
RH - RIDGE HEIGHT
RS - ROAD SIGN
RTW - RETAINING WALL
RWP - RAINWATER PIPE
SM - STANCHION
SC - SPEED CAMERA
SD - SATELITTE DISH
S/F - SAFETY FENCE
SG - SIGNAL
SI - SIGN
SMP - SERVICE MARKER POST
SS - SECURITY SENSOR
ST - STOP TAP
SU - STUMP
SV - STOP VALVE
SW - SWITCHGEAR
TA - TANK
TA - TAP
TBM - TEMPORARY BENCH MARK
TCB - TELEPHONE CALL BOX
TE - TELEPHONE
TM - TICKET MACHINE
TS - TRAFFIC SIGNAL
TP - TELEGRAPH POLE
UTL - UNABLE TO LIFT
VDP - VEHICLE DETECTOR PAD
VP - VENT PIPE
WB - WHISTLE BLOW
WM - WATER METER
WO - WASH OUT
WP - WASTE PIPE

FENCE TYPES

B/W - BARBED WIRE
C/B - CLOSE BOARDED
C/I - CORRUGATED IRON
C/P - CONCRETE PANEL
HRN - HANDRAIL
I/R - IRON RAILING
PAL - PALISADE
P/C - POST & CHAIN
P/P - POST & PANEL
P/R - POST & RAIL
PSB - PEDESTRIAN SAFETY BARRIER
P/W - POST & WIRE
W/M - WIRE MESH

LEVELS

BL43.45 - BED LEVEL
EV43.45 - EAVE LEVEL
IL43.45 - INVERT LEVEL
43.45 - SPOT LEVEL
RF43.45 - ROOF LEVEL
RL43.45 - RIDGE LEVEL
SB43.45 - SOFT BED LEVEL
SL43.45 - SOFFIT LEVEL
TH43.45 - THRESHOLD LEVEL
WL43.45 - WATER LEVEL

SYMBOLS

HEDGE
GATE
BUILDING
TREE CANOPY
CONTROL STATION
TACTILE PAVING
TREE

UNDERGROUND SERVICE KEY

Foul/Combined water drain
Foul/Combined drain 300Ø and above
Surface water drain
Surface water drain 300Ø and above
End of trace
Electric cables
HV cables
Gas
Water
Telephone
Catv
CCTV
Comms
Fibre Optics
Pipe
Vents
Fuel
Offsets
Vapour Recovery
Gauge Lines
Unidentified GPR
Unidentified EML
Taken From Records
Assumed Routes
Empty Ducts
Earth Rod
Rising Main
Overhead
Heating Pipes
Traffic Signals

Where chamber extents are significantly greater than the cover size, their approximate extents are shown thus;

ABBREVIATION KEY

AR assumed route
BB base bend
BD backdrop
CC cable chase
CL cable level
CR cable riser
DP down pipe
EOT end of trace
EP electricity pole
FH fire hydrant
G gully
GV gas valve
HOR head of run
HL high level
IC inspection chamber
IL invert level
MH manhole
PR pipe riser
RE rodding eye
RWP rainwater pipe
SV stop valve
SVP soil vent pipe
TE trapped exit
TFR taken from records
TP telegraph pole
UTF unable to find
UTL unable to lift
UTS unable to survey
UTT unable to trace
WC water closet
WL water level
WM water meter
WO wash out valve

UTILITY SURVEY NOTES

ELECTROMAGNETIC AND/OR GROUND PENETRATING RADAR TECHNIQUES HAVE BEEN USED TO LOCATE AND MAP UNDERGROUND UTILITIES AND FEATURES ON THIS DRAWING. N D OLIVER & CO LTD HAVE MADE EVERY ENDEAVOUR TO MAKE SURE THAT THE INFORMATION CONTAINED WITHIN THIS DRAWING IS ACCURATE AND OF THE HIGHEST QUALITY. HOWEVER, THE RESULTS FROM THESE TYPES OF SURVEYS ARE NOT INFALLIBLE AND SHOULD THE LOCATION OR DEPTH OF SERVICES/FEATURES BE OF PARTICULAR IMPORTANCE TO A PROJECT, THEN IT IS STRONGLY ADVISED THAT TRIAL EXCAVATIONS SHOULD BE UNDERTAKEN TO CONFIRM SURVEY RESULTS.

N D OLIVER & CO LTD HAVE USED ALL RECORD DRAWINGS THAT WERE AVAILABLE TO US BY THE CLIENT OR BY THE RELEVANT UTILITY COMPANIES AT THE TIME OF SURVEY. WHERE THESE RECORDS ARE INCOMPLETE OR OF INSUFFICIENT PAPER SIZED, MATERIAL IS NOT GUARANTEED. SERVICES LOCATED FROM RECORD DRAWINGS WILL BE SHOWN AND ANNOTATED AS TAKEN FROM RECORDS (TFR). HISTORIC RECORD INFORMATION IS OFTEN INCOMPLETE/INACCURATE AND CANNOT BE RELIED UPON.

A SINGLE LINE INDICATING A UTILITY MAY INDICATE THE PRESENCE OF MULTIPLE SERVICES WITHIN CLOSE PROXIMITY TO EACH OTHER. WHERE A SINGLE LINE TYPE IS SHOWN WE RECOMMEND HAND DIGGING WITHIN 0.5m, TO EXPOSE HIDDEN SERVICES.

WHERE QUOTED, DEPTH INFORMATION OF UNDERGROUND SERVICES/FEATURES IS STATED, DEPTHS ARE GENERALLY WITHIN +/- 10% ACCURATE, BUT CANNOT BE GUARANTEED. ANY DEPTHS SHOWN ARE USUALLY TO THE TOP OF THE SERVICE/FEATURE, UNLESS STATED OTHERWISE. GRAVITY SEWERS AND DRAINS ARE USUALLY TO INVERT (BASE OF DRAINAGE CHANNEL) UNLESS OTHERWISE STATED.

AT N D OLIVER & CO LTD WE USE SKILLED STAFF AND MODERN CALIBRATED EQUIPMENT TO PERFORM OUR SURVEYS. HOWEVER, THE COMPLETENESS OF ANY UNDERGROUND SURVEY CANNOT BE 100% GUARANTEED AND WE CANNOT BE HELD RESPONSIBLE FOR ANY INACCURACIES BEYOND THOSE THAT COULD BE REASONABLY EXPECTED BY A COMPETENT COMPANY.

CONTRACTORS UTILISING OUR DRAWINGS FOR INTRUSIVE WORK SHOULD TAKE ALL REASONABLE MEASURES TO WORK SAFELY IN ACCORDANCE WITH HSG47 GUIDELINES 'AVOIDING DANGER FROM UNDERGROUND SERVICES'.

Rev	Date	Drawn	Description	Ch'k'd	App'd

N D OLIVER & CO
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Client
BDP
11 DUCIE STREET
PICCADILLY BASIN
MANCHESTER
M1 2JB

Title
GREENHEYS BUILDING
MANCHESTER SCIENCE PARK
M15 6JJ

TOPOGRAPHICAL SURVEY
SHEET 1 OF 2

Surveyed	PK	Drawn	PK	Drawn Date: 16/12/2022
Checked	AM	Approved	NDO	
Scale 1:250 @ A1		Project 9872		Status ORIG
		CAD File \\NDO-SBS\Projects\9872\DRAWING\9872_005.DWG		
Drawing No 9872 / 005 / 1				Rev 0

GENERAL NOTES

Do not scale this drawing.

Contractor to check all dimensions and report all errors and omissions to the Engineer.

WS09i 34.39
TP04 34.84
WS07 34.91
TP05 34.47
WS08i 34.35
WS06 34.99
WS17 34.76
WS17Ai 34.76
WS18Ai 34.72
WS19i 34.81
WS20i 34.63
WS16i 34.89
WS22i 34.78
WS15 34.81
WS12A 34.88
WS12 34.87
TP06 SA02 34.24
WS21i 34.56
WS10i 34.22
WS011i RBH03 34.49
WS13A 34.81
WS14i 34.80
WS13 34.80
WS03 34.57
RBH02i 34.59
TP03 34.60
WS04i 34.63
WS02 34.49
RBH01i 34.52
WS01 34.81
TP01 SA01 35.10
TP02 34.90
WS05BI 35.13
WS05A 35.21
WS05 35.17

Rev	Detail	By	Auth	Date

Revisions

nx consulting
Office: 0161 904 0187
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Client: GREENHEYS BIOHUB

Project: GREENHEYS BIOHUB,MSP, PENCROFT WAY, MANCHESTER, M15 6JJ

Drawing Title: EXPLORATORY HOLE LOCATION PLAN

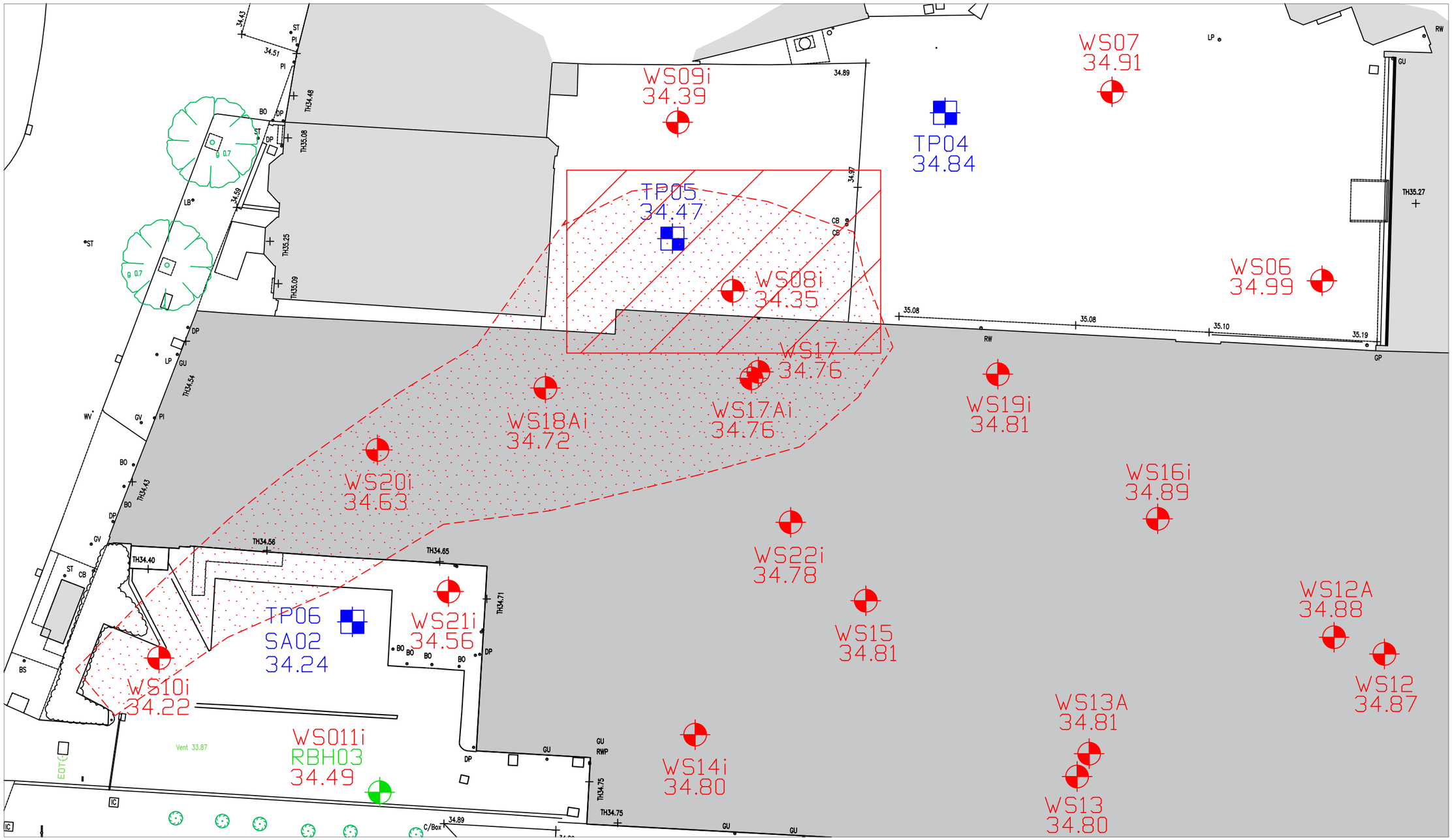
Drawing Status:

Project No.	Discipline	Drawing No.
NX534	E	1 of 1

Scale	Sheet Size	Revision
NTS	A1	A

Date	Drawn	Checked	Auth
22/8/2023	AC	MN	MN

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Key

- Possible area of source
- Groundwater plume

Rev	Detail	By	Chk	Date

Revisions

Client: Bruntwood SciTech

Project: Greenheys Business Centre, Manchester

Drawing Status

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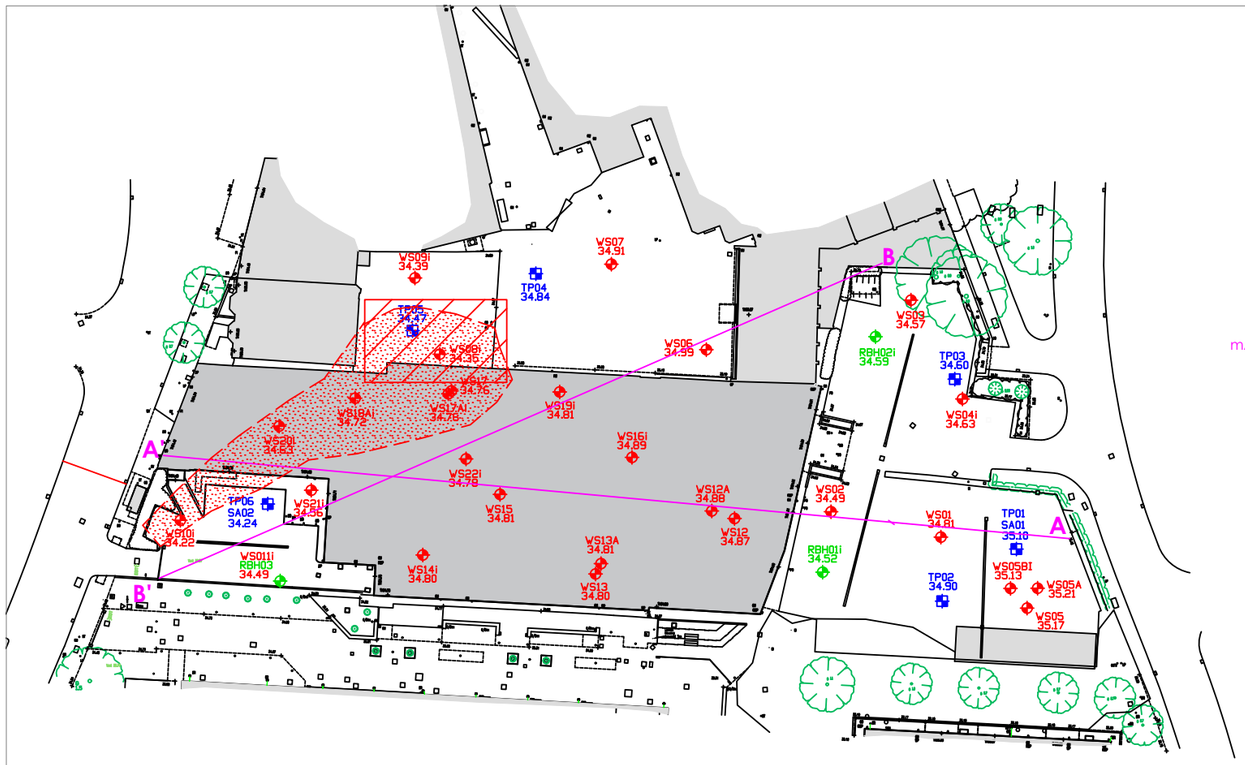
Drawing Title: Geological cross sections with groundwater

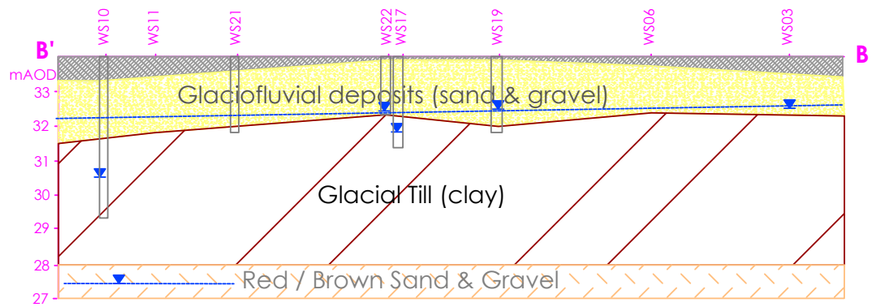
Project No.	Discipline	Drawing No.
NX534	E	RA01

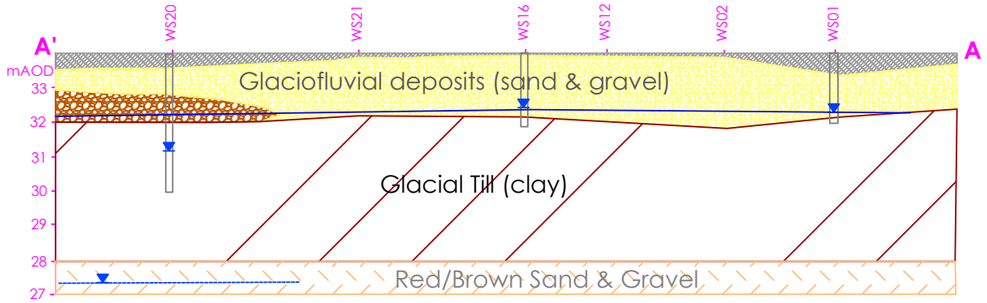
Scale	Sheet Size	Revision
	A3	

Date	Drawn	Checked	Auth
04.09.23	LH		

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Rev	Detail	By	Chk	Date

Revisions

Drawing Status

Client: Bruntwood SciTech

Project: Greenheys Business Centre, Manchester

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Drawing Title: Geological cross sections with groundwater

Project No.	Discipline	Drawing No.
NX534	E	RA02

Scale	Sheet Size	Revision
As shown on x-section	A3	

Date	Drawn	Checked	Auth
04.09.23	LH		

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Appendix B – Exploratory hole logs

NX Consulting

Dynamic Sampler Borehole Log

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				RBH01
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	12-04-23	34.52	E 384,303.6 N 396,271.1	
Contractor				Sheet
Taylor Drilling Services				1 of 2

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.32		0.20	MADE GROUND: Compact black/dark grey ashy sandy gravel. Gravel is fine to coarse, angular to subrounded of tarmacadam.		
0.30	ES			34.17		0.35			
0.50-1.00	B					(0.65)	MADE GROUND: Uncompact brown fine to coarse gravelly sand. Gravel is fine to coarse, angular to subrounded of limestone, sandstone and other mixed lithology.		
0.50	ES			33.52		1.00			
1.10	ES					(0.70)	Firm brown slightly silty slightly sandy CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone, sandstone and other mixed lithology. Very rare gravel of coal and organic material.		
1.20	SPT	14		32.82		1.70			
2.00-3.00	B						Loose to medium dense light brown fine to coarse slightly clayey slightly gravelly SAND with rare pockets of sandy CLAY. Gravel is fine to coarse, angular to subrounded of mudstone, sandstone and other mixed lithology.		
3.00	SPT	27				(4.30)	Firm brown CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone, sandstone and other mixed lithology.		
				28.52		6.00			
6.00	SPT	50/219mm					Red/brown SAND AND GRAVEL (Drillers Description). 6.00 ...SPT refusal, borehole continued as open holed.		
7.50	SPT	50/93mm				(5.00)			
9.00	SPT	50/35mm							
10.50	SPT	50/35mm					10.50 ...becoming reddish brown in colour.		
				23.52		11.00			

Borehole continued as a Cored Drillhole

Boring Progress and Water Observations						Chiselling			Water Added	
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To

GENERAL REMARKS

No visual or olfactory evidence of hydrocarbon or solvent contamination.
Groundwater not observed during drilling.
Frequent drilling induced fractures due to poor cementation.

All dimensions in metres Scale 1:68.75	Client Bruntwood SciTech	Method/ Plant Used BERETTA	Logged By MT

AGS3 UK BH NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 13/9/23

NX Consulting **ROTARY CORE BOREHOLE LOG**

Project				DRILLHOLE No
Greenheys Business Centre, Manchester Science Park				**RBH01**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	12-04-23	34.52	E 384,303.6 N 396,271.1	
Contractor				Sheet
Taylor Drilling Services				2 of 2

RUN DETAILS					STRATA				
Depth / Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick-ness)	DESCRIPTION Discontinuities	Detail	Main	Geology	Instrument/ Backfill
11.00			23.52		11.00	11.00 - 20.00 ...borehole continued as a Cored Drillhole.		Weak to medium strong reddish brown fine to coarse grained SANDSTONE with rare mineral inclusions and intraclasts. Subhorizontal bedding fractures, thinly spaced, planar, smooth to slightly rough.		
12.00	65 (50) 0	0								
13.00	70 (65) 0	0								
14.00	95 (90) 16	0								
15.00	25 (20) 0	0								
16.00	95 (90) 29.4	1			(9.00)					
17.00	100 (98) 71	1								
18.00	0 (0) 0	0				17.00 - 18.00 ...no recovery.				
19.00	100 (95) 48	1								
20.00	100 (98) 47.5	1	14.52		20.00					
								...borehole ended at 20.00mbgl.		

Drilling Progress and Water Observations						
Date	Time	Depth	Casing	Core Dia mm	Water Strike	Water Standing

Rotary Flush			
From	To	Type	Returns

GENERAL REMARKS

No visual or olfactory evidence of hydrocarbon or solvent contamination. Groundwater not observed during drilling. Frequent drilling induced fractures due to poor cementation.

All dimensions in metres Scale 1:68.75	Client Bruntwood SciTech	Method/ Plant Used BERETTA	Logged By MT

AGS UK DH.1 NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

DYNAMIC SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				RBH02
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	14-04-23	34.59	E 384,311.3 N 396,305.2	
Contractor				Sheet
Taylor Drilling Services				1 of 2

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.44		0.15	MADE GROUND: Compact black/dark grey ashy sandy gravel. Gravel is fine to coarse, angular to subrounded of tarmacadam.		
0.20	ES			34.34		0.25			
0.30	ES			33.84		0.75	MADE GROUND: Soft to firm dark brown/grey clay with rare gravel. Gravel is fine to coarse, angular to subrounded of brick, ash, clinker and other mixed lithology.		
0.70-1.00	B								
0.80	ES					(0.75)			
1.20	SPT	14		33.09		1.50	MADE GROUND: Uncompact dark brown fine to coarse slightly ashy slightly silty clayey sand with rare gravel. Gravel is fine to coarse, angular to subrounded of sandstone, mudstone, limestone, brick and other mixed lithology.		
2.00-3.00	B						Loose to medium dense light brown fine to coarse slightly clayey slightly gravelly SAND with rare pockets of sandy CLAY. Gravel is fine to coarse, angular to subrounded of mudstone, sandstone and other mixed lithology.		
3.00	SPT	28					Firm brown CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone, sandstone and other mixed lithology.		
						(4.50)			
							4.00 ...becoming very stiff.		
4.50	SPT	29							
							5.20 - 5.50 ...pocket of firm brown clay.		
							5.50 ...becoming very stiff to hard.		
				28.59		6.00			
6.00	SPT	50/245mm					Red/brown SAND AND GRAVEL (Drillers Description).		
							6.00 ...SPT refusal, borehole continued as open holed.		
6.50-7.00	B								
7.50	SPT	50/111mm				(5.00)			
9.00	SPT	50/95mm							
10.50	SPT	50/86mm							
				23.59		11.00			

Borehole continued as a Cored Drillhole

Boring Progress and Water Observations						Chiselling			Water Added	
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To

GENERAL REMARKS

No visual or olfactory evidence of hydrocarbon or solvent contamination.
Groundwater not observed during drilling.
Frequent drilling induced fractures due to poor cementation.

All dimensions in metres Scale 1:68.75	Client Bruntwood SciTech	Method/ Plant Used BERETTA	Logged By MT

AGS3 UK BH NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 13/9/23

NX Consulting **ROTARY CORE BOREHOLE LOG**

Project				DRILLHOLE No
Greenheys Business Centre, Manchester Science Park				**RBH02**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	14-04-23	34.59	E 384,311.3 N 396,305.2	
Contractor				Sheet
Taylor Drilling Services				2 of 2

RUN DETAILS						STRATA			
Depth / Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick-ness)	DESCRIPTION			Geology	Instrument/ Backfill
						Discontinuities	Detail	Main		
11.00	50 (35) 0	0	23.59		11.00	11.00 - 12.20 ...poor recovery due to poorly cemented rock. 11.00 - 20.00 ...borehole continued as a Cored Drillhole.		Weak to medium strong light brown fine to coarse grained SANDSTONE with rare mineral inclusions and intraclasts. Subhorizontal bedding fractures, thinly spaced, planar, smooth to slightly rough.		
12.00										
13.00	90 (80) 11	0								
14.00	95 (90) 0	0								
15.00	0 (0) 0	0				14.00 - 16.00 ...no recovery.				
16.00	0 (0) 0	0			(9.00)					
17.00	()	0								
18.00	80 (50) 12	0				17.00 ...becoming reddish brown.				
19.00	95 (85) 15	0								
20.00	99 (95) 87	0	14.59		20.00					
								...borehole ended at 20.00mbgl.		

Drilling Progress and Water Observations						
Date	Time	Depth	Casing	Core Dia mm	Water Strike	Water Standing

Rotary Flush			
From	To	Type	Returns

GENERAL REMARKS

No visual or olfactory evidence of hydrocarbon or solvent contamination.
Groundwater not observed during drilling.
Frequent drilling induced fractures due to poor cementation.

All dimensions in metres Scale 1:68.75	Client Bruntwood SciTech	Method/ Plant Used BERETTA	Logged By MT

AGS UK DH.1 NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

DYNAMIC SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				RBH03
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	18-04-23	34.49	E 384,224.9 N 396,269.8	
Contractor				Sheet
Taylor Drilling Services				1 of 2

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.34		0.15	MADE GROUND: Compact black ashy fine to coarse slightly sandy angular gravel of tarmacadam.		
				34.09		0.40	MADE GROUND: Compact black/grey ashy sandy gravel. Gravel is fine to coarse, angular to subrounded of limestone and other mixed lithology.		
				33.99		0.50	MADE GROUND: Soft to firm brown slightly ashy reworked clay with rare gravel. Gravel is fine to coarse, angular to subrounded of brick, ash, limestone and other mixed lithology.		
						(2.10)	Loose to medium dense light brown fine to coarse SAND with rare gravel. Gravel is fine to coarse, angular to subrounded of sandstone, mudstone and other mixed lithology.		
				31.89		2.60	Stiff to very stiff dark brown CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone and other mixed lithology.		
						(4.40)			
				27.49		7.00	Red/brown SAND AND GRAVEL (Drillers Description).		
7.50	SPT	42							
9.00	SPT	50/86mm				(4.00)			
10.50	SPT	50/35mm							
				23.49		11.00	Borehole continued as a Cored Drillhole		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	
											No visual or olfactory evidence of hydrocarbon or solvent contamination. Groundwater not observed during drilling. Frequent drilling induced fractures due to poor cementation.

All dimensions in metres Scale 1:68.75	Client Bruntwood SciTech	Method/ Plant Used BERETTA	Logged By MT

AGS3 UK BH NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 13/9/23

NX Consulting **ROTARY CORE BOREHOLE LOG**

Project				DRILLHOLE No
Greenheys Business Centre, Manchester Science Park				**RBH03**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	18-04-23	34.49	E 384,224.9 N 396,269.8	
Contractor				Sheet 2 of 2
Taylor Drilling Services				

RUN DETAILS						STRATA				
Depth / Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick-ness)	DESCRIPTION			Geology	Instrument/ Backfill
						Discontinuities	Detail	Main		
11.00	75 (20) 0	0	23.49		11.00	11.00 - 12.00 ...poor recovery. 11.00 - 20.00 ...borehole continued as a Cored Drillhole.		Weak to medium strong light brown fine to coarse grained SANDSTONE with rare mineral inclusions and intraclasts. Subhorizontal bedding fractures, thinly spaced, planar, smooth to slightly rough.		
12.00										
13.00	85 (82) 10	0								
14.00	80 (80) 11	0								
15.00	33 (20) 12	0				14.00 - 15.00 ...poor recovery.				
16.00	75 (72) 35	0			(9.00)					
17.00	85 (80) 60	1								
18.00	0 (0) 0	0				17.00 - 18.00 ...no recovery.				
19.00	90 (90) 11	0								
20.00	95 (95) 80	0	14.49		20.00					
								...borehole ended at 20.00mbgl.		

Drilling Progress and Water Observations						
Date	Time	Depth	Casing	Core Dia mm	Water Strike	Water Standing

Rotary Flush			
From	To	Type	Returns

GENERAL REMARKS

No visual or olfactory evidence of hydrocarbon or solvent contamination. Groundwater not observed during drilling. Frequent drilling induced fractures due to poor cementation.

All dimensions in metres Scale 1:68.75	Client Bruntwood SciTech	Method/ Plant Used BERETTA	Logged By MT

AGS UK DH.1 NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				**WS01**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	12-04-23	34.81	E 384,320.8 N 396,276.2	
Contractor				Sheet
Taylor Drilling Services				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.66		0.15	MADE GROUND: Compact black ashy fine to coarse slightly sandy angular gravel of tarmacadam.		
						(1.05)	MADE GROUND: Compact grey ashy sandy gravel. Gravel is fine to coarse, angular to subrounded of limestone and other mixed lithology.		
1.00	SPT	25		33.61		1.20			
1.30	ES			33.31		(0.30) 1.50	MADE GROUND: Medium dense brown slightly ashy slightly clayey sandy gravel. Gravel is fine to coarse, angular to subrounded of brick, ash, limestone, concrete and other mixed lithology.		
1.60	ES		▼1				Medium dense light brown fine to coarse very gravelly SAND with rare gravel. Gravel is fine to coarse, angular to subrounded of sandstone, mudstone and other mixed lithology.		
2.00	SPT D	7				(0.90)			
				32.41		2.40			
2.50	ES						Firm to stiff dark brown CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone and other mixed lithology.		
3.00	SPT D	19							
						(2.60)			
4.00	SPT D	15							
				29.81		5.00			
5.00	SPT D	20					...borehole ended at 5.0mbgl.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	No visual or olfactory evidence of hydrocarbon or solvent contamination. Groundwater observed at 1.7mbgl.

All dimensions in metres Scale 1:31.875	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				**WS02**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	12-04-23	34.49	E 384,304.8 N 396,279.8	
Contractor				Sheet
Taylor Drilling Services				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.34		0.15	MADE GROUND: Compact black ashy fine to coarse slightly sandy angular gravel of tarmacadam.		
				34.09		(0.25) 0.40	MADE GROUND: Compact black/grey ashy sandy gravel. Gravel is fine to coarse, angular to subrounded of limestone and other mixed lithology.		
0.40	ES			33.99		0.50	MADE GROUND: Soft to firm brown slightly ashy reworked clay with rare gravel. Gravel is fine to coarse, angular to subrounded of brick, ash, limestone, mudstone and other mixed lithology.		
0.60	ES						Loose to medium dense light brown fine to coarse SAND with rare gravel and pockets of sandy clay. Gravel is fine to coarse, angular to subrounded of sandstone, mudstone and other mixed lithology.		
1.00	SPT	18					1.10 ...rare cobbles of sandstone and mudstone present.		
			1			(2.00)	1.30 ...becoming medium brown.		
2.00	S D ES	5					1.90 ...becoming dark brown slightly silty, with increased gravel content.		
				31.99		2.50			
							Firm to stiff dark brown CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone and other mixed lithology.		
3.00	SPT D	18							
						(2.50)			
4.00	SPT D	22					4.00 ...becoming very stiff.		
				29.49		5.00			
5.00	SPT D	28					...borehole ended at 5.0mbgl.		

Boring Progress and Water Observations						Chiselling			Water Added	
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To

GENERAL REMARKS

No visual or olfactory evidence of hydrocarbon or solvent contamination. Groundwater observed at 1.5mbgl.

All dimensions in metres Scale 1:31.875	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				**WS03**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	12-04-23	34.57	E 384,316.4 N 396,310.5	
Contractor				Sheet
Taylor Drilling Services				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.42		0.15	MADE GROUND: Compact black ashy fine to coarse slightly sandy angular gravel of tarmacadam.		
				34.17		(0.25) 0.40	MADE GROUND: Compact grey/black ashy sandy gravel. Gravel is fine to coarse, angular to subrounded of limestone and other mixed lithology.		
0.50	ES					(0.50)	MADE GROUND: Uncompact brown/black fine to coarse ashy slightly clayey gravelly sand. Gravel is fine to coarse, angular to subrounded of brick, ash, sandstone, concrete, limestone, mudstone and other mixed lithology.		
				33.67		0.90			
1.00	S D ES	18		33.37		(0.30) 1.20	Loose to medium dense light brown fine to coarse SAND with rare gravel. Gravel is fine to coarse, angular to subrounded of sandstone and other mixed lithology.		
1.30	ES					(0.90)	Loose to medium dense brown slightly clayey gravelly SAND with rare gravel. Gravel is fine to coarse, angular to subrounded of sandstone, mudstone and other mixed lithology.		
2.00	SPT D	6		32.47		2.10			
3.00	SPT D	22				(2.90)	Firm to stiff dark brown CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone and other mixed lithology.		
							3.70 ...becoming very stiff.		
4.00	SPT D	18							
				29.57		5.00			
5.00	SPT D	23					...borehole ended at 5.0mbgl.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	No visual or olfactory evidence of hydrocarbon or solvent contamination. Groundwater observed at 1.9mbgl.

All dimensions in metres Scale 1:31.875	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				WS04
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	13-04-23	34.63	E 384,323.9 N 396,296.2	
Contractor				Sheet
Taylor Drilling Services				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.48		0.15	MADE GROUND: Compact black ashy fine to coarse slightly sandy angular gravel of tarmacadam.		
						(0.50)	MADE GROUND: Compact black/grey ashy sandy gravel. Gravel is fine to coarse, angular to subrounded of limestone and other mixed lithology.		
				33.98		0.65	MADE GROUND: Compact red/orange/brown fine to coarse sandy gravel. Gravel is fine to coarse, angular to subrounded of brick.		
						(0.45)			
1.00-2.00	B			33.53		1.10			
1.00	SPT D	6					Loose dense brown fine to coarse very clayey gravelly SAND. Gravel is fine to coarse, angular to subrounded of sandstone, mudstone and other mixed lithology. Rare cobbles of sandstone.		
1.20	ES								
1.50	ES		1			(0.90)			
				32.63		2.00			
2.00	SPT D	14					Firm to stiff dark brown CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone and other mixed lithology.		
2.10	ES						2.00 - 2.30 ...slightly sandy.		
3.00	SPT D	13					3.00 ...becoming stiff to very stiff.		
3.30	SV	125				(3.00)			
4.00	SPT D	21							
				29.63		5.00			
5.00	SPT	23					...borehole ended at 5.0mbgl.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	
											No visual or olfactory evidence of hydrocarbon or solvent contamination. Groundwater observed at 1.7mbgl.

All dimensions in metres Scale 1:40.625	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				**WS05**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	13-04-23	35.17	E 384,333.3 N 396,265.9	
Contractor				Sheet
Taylor Drilling Services				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				35.02		(0.15) 0.15	MADE GROUND: Compact black ashy fine to coarse slightly sandy angular gravel of tarmacadam.		
				34.82		(0.20) 0.35	MADE GROUND: Compact black/grey ashy sandy gravel. Gravel is fine to coarse, angular to subrounded of limestone and other mixed lithology.		
				34.72		(0.10) 0.45	MADE GROUND: Compact ashy gravelly sand. Gravel is fine to coarse, angular to subrounded of tarmac, concrete, ash and other mixed lithology.		
							...borehole ended at 0.45mbgl due to a solid obstruction and redrilled as WS05A.		

Boring Progress and Water Observations					
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt

Chiselling			Water Added	
From	To	Hours	From	To

GENERAL REMARKS

No visual or olfactory evidence of hydrocarbon or solvent contamination. No groundwater observed during drilling.

All dimensions in metres Scale 1:4.375	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				**WS05A**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	13-04-23	35.21	E 384,334.8 N 396,268.8	
Contractor				Sheet
Taylor Drilling Services				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
						(0.15)	MADE GROUND: Compact black ashy fine to coarse slightly sandy angular gravel of tarmacadam.		
				35.06		0.15			
						(0.50)	MADE GROUND: Compact black/grey ashy sandy gravel. Gravel is fine to coarse, angular to subrounded of limestone and other mixed lithology. 0.60 ...100mm diameter plastic pipe present in western face of hand pit, trending NW-SE.		
				34.56		0.65			
						(0.10)	MADE GROUND: Soft to firm brown slightly ashy reworked clay with rare gravel. Gravel is fine to coarse, angular to subrounded of brick, ash, limestone, mudstone and other mixed lithology.		
				34.46		0.75			
							...borehole ended at 0.75mbgl due to a solid obstruction and redrilled as WS0BA.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	No visual or olfactory evidence of hydrocarbon or solvent contamination. Water observed at 650mmbgl during hand pit excavation.

All dimensions in metres Scale 1:6.25	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				**WS05B**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	14-04-23	35.13	E 384,330.9 N 396,268.7	
Contractor				Sheet
Taylor Drilling Services				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.98		0.15	MADE GROUND: Compact black ashy fine to coarse slightly sandy angular gravel of tarmacadam.		
				34.73		(0.25) 0.40	MADE GROUND: Compact black/grey ashy sandy gravel. Gravel is fine to coarse, angular to subrounded of limestone and other mixed lithology.		
				34.33		(0.40) 0.80	MADE GROUND: Soft to firm brown slightly ashy reworked clay with rare gravel. Gravel is fine to coarse, angular to subrounded of brick, ash, limestone, mudstone and other mixed lithology.		
1.00	SPT D	4		34.03		(0.30) 1.10	MADE GROUND: Uncompact black ashy very sandy gravel. Gravel is fine to coarse, angular to subrounded of concrete, tarmacadam, ash and other mixed lithology.		
1.10	ES						Loose to medium dense light brown fine to coarse SAND with rare gravel. Gravel is fine to coarse, angular to subrounded of sandstone, mudstone and other mixed lithology.		
			1			(1.40)	1.70 - 2.50 ...increased gravel content.		
1.90	ES								
2.00	SPT D	5							
2.10-2.50	B			32.63		2.50			
							Firm to stiff dark brown CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone and other mixed lithology.		
3.00	SPT D	14					3.10 ...becoming very stiff.		
						(2.50)			
4.00	SPT D	20							
				30.13		5.00			
5.00	SPT D	26					...borehole ended at 5.0mbgl		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	
											No visual or olfactory evidence of hydrocarbon or solvent contamination. Groundwater observed at 1.8mbgl.

All dimensions in metres Scale 1:31.875	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				**WS06**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	19-06-23	34.99	E 384,286.8 N 396,303.3	
Contractor				Sheet
Taylor Drilling Services				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.89		0.10	MADE GROUND: Compact black ashy fine to coarse slightly sandy angular gravel of tarmacadam.		
				34.79		0.20			
0.30	ES					(0.50)	MADE GROUND: Compact black/dark grey ashy sandy gravel. Gravel is fine to coarse, angular to subrounded of limestone and other mixed lithology.		
				34.29		0.70	MADE GROUND: Uncompact black fine to coarse ashy gravelly sand. Gravel is fine to coarse, angular to subrounded of ash, clinker, brick, limestone and other mixed lithology.		
0.80	ES					(0.40)	MADE GROUND: Dark brown soft to firm slightly silty slightly sandy clay with rare gravel (reworked clay). Gravel is fine to coarse, angular to subrounded of brick, concrete, limestone sandstone, mudstone and other mixed lithology.		
1.00	SPT	12		33.89		1.10			
1.20	ES		1				Loose to medium dense light brown fine to coarse SAND.		
						(1.40)	1.70 ...increased gravel content.		
2.00	SPT D	9					2.20 ...becoming clayey.		
				32.49		2.50			
2.60	ES						Firm brown CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone, sandstone and other mixed lithology.		
2.70	SV	82							
3.00	SPT D	19					3.00 ...becoming firm to stiff.		
							3.20 - 3.30 ...sandstone cobble (90mm diameter).		
						(2.50)			
4.00	SPT D	15							
							4.50 ...becoming firm.		
4.70	SV	70							
				29.99		5.00			
5.00	SPT D	19					...borehole ended at 5.0mbgl.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	No visual or olfactory evidence of hydrocarbon or solvent contamination. Groundwater observed at 1.5mbgl.

All dimensions in metres Scale 1:31.875	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				**WS07**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	19-06-23	34.91	E 384,273.0 N 396,315.7	
Contractor				Sheet
Taylor Drilling Services				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.81		0.10	MADE GROUND: Compact black ashy fine to coarse slightly sandy angular gravel of tarmacadam.		
				34.71		0.20	MADE GROUND: Compact black/dark grey ashy sandy gravel. Gravel is fine to coarse, angular to subrounded of limestone and other mixed lithology.		
				34.41		(0.30) 0.50	MADE GROUND: Uncompact black fine to coarse ashy gravelly sand. Gravel is fine to coarse, angular to subrounded of ash, clinker, brick, limestone and other mixed lithology. Rare cobbles of concrete.		
0.60	ES					(0.60)	MADE GROUND: Dark brown soft to firm slightly silty slightly sandy clay with rare gravel (reworked clay). Gravel is fine to coarse, angular to subrounded of brick, concrete, limestone sandstone, mudstone and other mixed lithology.		
1.00	SPT	4		33.81		1.10	Loose to medium dense light brown fine to coarse SAND.		
1.20	ES					(1.40)	2.00 ...increased gravel content.		
2.00	SPT	11	▼1	32.41		2.50	Firm brown CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone, sandstone and other mixed lithology.		
2.70	SV	82					3.00 ...becoming stiff to very stiff.		
3.00	SPT D	16							
3.70	SV	130				(2.50)			
4.00	SPT D	15							
4.70	SV	105		29.91		5.00			
5.00	SPT D	17					...borehole ended at 5.0mbgl.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	No visual or olfactory evidence of hydrocarbon or solvent contamination. Groundwater observed at 2.1mbgl.

All dimensions in metres Scale 1:31.875	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				**WS08**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	19-06-23	34.35	E 384,248.1 N 396,302.7	
Contractor				Sheet
Taylor Drilling Services				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.25		0.10	MADE GROUND: Compact concrete recovered as a core.		
				34.22		0.13	MADE GROUND: Screed.		
						(0.77)	MADE GROUND: Dark brown soft to firm slightly silty slightly sandy clay with rare gravel (reworked clay). Gravel is fine to coarse, angular to subrounded of brick, concrete, limestone sandstone, mudstone and other mixed lithology.		
				33.45		0.90			
1.00	SPT	8				(0.80)	Loose to medium dense light brown fine to coarse SAND.		
1.50	ES		▼1	32.65		1.70			
1.80	ES					(0.40)	Loose to medium dense dark grey brown fine to coarse slightly silty slightly clayey SAND with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone, sandstone, and other mixed lithology.		
2.00	SPT D	10		32.25		2.10	1.70 - 2.10 ...becoming dark grey with increased gravel content and a faint to moderate hydrocarbon odour.		
2.30	ES					(2.90)	Firm brown CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone, sandstone, coal and other mixed lithology.		
2.70	SV	75							
3.00	SPT D	21							
3.70	SV	82							
4.00	SPT D	21							
4.70	SV	72							
				29.35		5.00			
5.00	SPT D	16					...borehole ended at 5.0mbgl.		

Boring Progress and Water Observations					
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt

Chiselling			Water Added	
From	To	Hours	From	To

GENERAL REMARKS

Olfactory evidence of hydrocarbon or solvent contamination between 1.7mbgl to 2.1mbgl. Groundwater observed at 1.7mbgl.

All dimensions in metres Scale 1:31.875	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				**WS09**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	19-06-23	34.39	E 384,244.5 N 396,313.7	
Contractor				Sheet
Taylor Drilling Services				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.29		0.10	MADE GROUND: Compact concrete recovered as a core.		
				34.14		0.25	MADE GROUND: Sandstone boulder recovered as a core (cobble sett).		
0.50	ES					(0.75)	Uncompact light brown fine to coarse clayey SAND.		
				33.39		1.00			
1.00	SPT	10					Loose to medium dense medium brown fine to coarse clayey SAND.		
1.50	ES		▼1			(1.10)			
2.00	SPT	13		32.29		2.10			
							Firm brown CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone and other mixed lithology.		
2.70	SV	130							
3.00	SPT D	18							
						(2.90)	3.50 ...becoming stiff.		
3.70	SV	118							
4.00	SPT D	15							
4.70	SV	120							
				29.39		5.00			
5.00	SPT D	24					...borehole ended at 5.0mbgl.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	No visual or olfactory evidence of hydrocarbon or solvent contamination. Groundwater observed at 1.7mbgl.

All dimensions in metres Scale 1:31.875	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				**WS10**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	13-04-23	34.22	E 384,210.5 N 396,278.6	
Contractor				Sheet
Taylor Drilling Services				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.07		0.15	MADE GROUND: Compact black ashy fine to coarse slightly sandy angular gravel of tarmacadam.		
				34.02		0.20			
0.25	ES					(0.45)	MADE GROUND: Uncompact light brown fine to coarse slightly silty sandy gravel. Gravel is fine to coarse, angular to subrounded of sandstone and other mixed lithology.		
				33.57		0.65	MADE GROUND: Soft to firm black/grey/brown ashy slightly silty very sandy very gravelly clay. Gravel is fine to coarse, angular to subrounded of brick, concrete, sandstone, clinker, ash, limestone, mudstone and other mixed lithology. Rare cobbles of brick.		
0.70	ES						0.20 - 0.65 ...faint hydrocarbon odour observed.		
1.00-2.00	B						Loose to medium dense light brown fine to coarse SAND with rare gravel and pockets of sandy clay. Gravel is fine to coarse, angular to subrounded of sandstone, mudstone and other mixed lithology. Very rare angular gravel of coal.		
1.00	SPT	4							
1.10	ES								
			▼1			(1.85)	1.00 ...becoming very clayey.		
2.00	SPT	11							
				31.72		2.50			
							Firm to stiff dark brown CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone, sandstone and other mixed lithology. Very rare angular gravel of coal.		
2.80	SV	130					2.80 ...becoming very stiff.		
3.00	SPT D	20							
						(2.50)			
3.80	SV	125							
4.00	SPT D	19							
				29.22		5.00			
5.00	SPT D	24					...borehole ended at 5.0mbgl.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	Olfactory evidence of hydrocarbon or solvent contamination between 0.20m and 0.65mbgl. Groundwater observed at 1.7mbgl.

All dimensions in metres Scale 1:31.875	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				**WS11**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	13-04-23	34.49	E 384,224.9 N 396,269.8	
Contractor				Sheet
Taylor Drilling Services				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.34		0.15	MADE GROUND: Compact black ashy fine to coarse slightly sandy angular gravel of tarmacadam.		
				34.09		(0.25) 0.40	MADE GROUND: Compact black/grey ashy sandy gravel. Gravel is fine to coarse, angular to subrounded of limestone and other mixed lithology.		
0.40-0.70	B			33.99		0.50	MADE GROUND: Soft to firm brown slightly ashy reworked clay with rare gravel. Gravel is fine to coarse, angular to subrounded of brick, ash, limestone and other mixed lithology.		
0.50	ES						Loose to medium dense light brown fine to coarse SAND with rare gravel. Gravel is fine to coarse, angular to subrounded of sandstone, mudstone and other mixed lithology.		
0.80	ES								
1.00	SPT	6					1.40 ...becoming gravelly.		
1.50	ES					(2.10)			
2.00	SPT	10	▼						
				31.89		2.60	Stiff to very stiff dark brown CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone and other mixed lithology.		
2.80	SV	130					2.60 - 3.20 ...rare pockets of sandy clay.		
3.00	SPT D	9					3.50 ...becoming stiff.		
						(2.40)			
4.00	SPT D	16					4.00 - 5.00 ...becoming firm to stiff.		
4.50	SV	68							
				29.49		5.00			
5.00	SPT D	26					...borehole continued with dyanmic probing.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	
											No visual or olfactory evidence of hydrocarbon or solvent contamination. Groundwater observed at 2.0mbgl.

All dimensions in metres Scale 1:31.875	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				**WS12**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	16-04-23	34.87	E 384,290.8 N 396,278.9	
Contractor				Sheet
Taylor Drilling Services				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.86		0.01	MADE GROUND: Laminate floor covering.		
							MADE GROUND: Reinforced concrete.		
							0.05 ...1cm diameter metal rebar present.		
						(0.24)			
				34.62		0.25			
							MADE GROUND: Compact dark brown fine to coarse ashy silty sandy gravel. Gravel is fine to coarse, angular to subrounded of brick, sandstone, concrete, ash, clinker, limestone and other mixed lithology. Rare cobbles of brick.		
							0.25 - 0.70 ...relic insitu brick walls present in west and eastern faces of hand pit, orientated N-S.		
							0.40 ...cobble with rebar present.		
						(0.45)			
				34.17		0.70			
							...borehole ended at 0.7mbgl due to a solid obstruction.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	
											No visual or olfactory evidence of hydrocarbon or solvent contamination. No groundwater observed.

All dimensions in metres Scale 1:5.625	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				**WS12A**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	16-04-23	34.88	E 384,287.5 N 396,280.0	
Contractor				Sheet
Taylor Drilling Services				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.87		0.01	MADE GROUND: Laminate floor covering.		
						(0.24)	MADE GROUND: Reinforced concrete. 0.05 ...1cm diameter metal rebar present.		
				34.63		0.25			
						(0.45)	MADE GROUND: Compact dark brown/red fine to coarse ashy silty sandy gravel. Gravel is fine to coarse, angular to subrounded of brick, ash, clinker, limestone and other mixed lithology. Frequent cobbles of brick. 0.25 - 0.70 ...relic insitu brick walls present in west and eastern faces of hand pit, orientated N-S.		
				34.18		0.70			
							...borehole ended at 0.7mbgl due to a solid obstruction.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	No visual or olfactory evidence of hydrocarbon or solvent contamination. No groundwater observed.

All dimensions in metres Scale 1:5.625	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				**WS13**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	16-04-23	34.80	E 384,270.7 N 396,270.8	
Contractor				Sheet
Taylor Drilling Services				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.79		0.01	MADE GROUND: Laminate floor covering.		
				34.75		(0.04) 0.05	MADE GROUND: Concrete.		
						(0.20)	MADE GROUND: Compact light grey gravel. Gravel is fine to coarse, angular to subrounded of brick, concrete and other mixed lithology.		
				34.55		0.25			
						(0.35)	MADE GROUND: Compact brown/grey fine to coarse ashy silty sandy gravel. Gravel is fine to coarse, angular to subrounded of brick, sandstone, concrete, ash, limestone and other mixed lithology.		
				34.20		0.60			
							...borehole ended at 0.6mbgl due to a solid obstruction.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	No visual or olfactory evidence of hydrocarbon or solvent contamination. No groundwater observed.

All dimensions in metres Scale 1:5	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				WS13A
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	16-04-23	34.81	E 384,271.5 N 396,272.3	
Contractor				Sheet
Taylor Drilling Services				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.80		0.01	MADE GROUND: Laminate floor covering.		
						(0.04)	MADE GROUND: Concrete.		
				34.76		0.05			
							MADE GROUND: Relic insitu brick wall, recovered as a core.		
						(0.45)			
				34.31		0.50			
							...borehole ended at 0.5mbgl due to a solid obstruction.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	No visual or olfactory evidence of hydrocarbon or solvent contamination. No groundwater observed.

All dimensions in metres Scale 1:4.375	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				**WS14**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	16-04-23	34.80	E 384,245.6 N 396,273.6	
Contractor				Sheet
Taylor Drilling Services				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.79		0.01	MADE GROUND: Laminate floor covering.		
				34.75		0.05	0.00 - 0.20 ...core depth.		
				34.60		0.20	MADE GROUND: Screed over red grey brown cement bound fine to coarse angular gravel (Weakly concrete gravel bound floor slab).		
0.30-0.70 0.30	B ES					(0.50)	MADE GROUND: Compact fine to coarse ashy sandy gravel. Gravel is fine to coarse, angular to subrounded of brick, sandstone, concrete, ash, limestone and other mixed lithology.		
				34.10		0.70	MADE GROUND: Uncompact black/brown slightly ashy slightly clayey slightly silty sand with gravel. Gravel is fine to coarse, angular to subrounded of brick, sandstone, ash, clinker, limestone and other mixed lithology.		
						(0.25)	MADE GROUND: Soft to firm black/dark brown slightly ashy slightly sandy clay.		
				33.85		0.95			
1.00	ES						Loose to medium dense light brown fine to coarse SAND with rare gravel. Gravel is fine to coarse, angular to subrounded of sandstone and other mixed lithology.		
							1.50 ...becoming dark brown with increased gravel content.		
						(1.55)			
				32.30		2.50			
2.60	ES						Firm to stiff brown CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone, sandstone and other mixed lithology.		
						(0.50)			
				31.80		3.00			
3.00	D						...borehole ended at 3.0mbgl.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	No visual or olfactory evidence of hydrocarbon or solvent contamination. Groundwater observed at 1.9mbgl.

All dimensions in metres Scale 1:21.875	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				WS15
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	16-04-23	34.81	E 384,256.8 N 396,282.4	
Contractor				Sheet
Taylor Drilling Services				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.80		0.01	MADE GROUND: Laminate floor covering.		
						(0.24)	MADE GROUND: Concrete over red grey brown cement bound fine to coarse angular gravel (Weakly concrete gravel bound floor slab).		
				34.56		0.25			
0.30	ES					(0.50)	MADE GROUND: Uncompact dark brown ashy sand with rare gravel. Gravel is fine to coarse, angular to subrounded of brick, sandstone, ash, clinker, limestone and other mixed lithology. Rare cobble setts present.		
				34.06		0.75			
0.75-0.90	B						MADE GROUND: Soft black/dark brown slightly ashy slightly sandy clay.		
0.80	ES			33.91		0.90			
1.00	ES					(1.60)	Loose to medium dense light brown fine to coarse SAND with rare gravel. Gravel is fine to coarse, angular to subrounded of sandstone and other mixed lithology. 1.60 ...becoming dark brown with increased gravel content.		
				32.31		2.50			
2.60-3.00	B					(0.50)	Firm to stiff brown CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone, sandstone and other mixed lithology.		
				31.81		3.00			
3.00	D						...borehole ended at 3.0mbgl.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	
											No visual or olfactory evidence of hydrocarbon or solvent contamination. Groundwater observed at 1.9mbgl.

All dimensions in metres Scale 1:21.875	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				WS16
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	15-04-23	34.89	E 384,276.0 N 396,287.7	
Contractor				Sheet
Taylor Drilling Services				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.88		0.01	MADE GROUND: Laminate floor covering. 0.00 - 0.30 ...core depth.		
						(0.29)	MADE GROUND: Concrete over red grey brown cement bound fine to coarse angular gravel (Weakly concrete gravel bound floor slab).		
				34.59		0.30			
0.30	ES					(0.45)	MADE GROUND: Uncompact black/grey/red/brown ashy slightly clayey gravelly cobblery sand. Gravel is fine to coarse, angular to subrounded of brick, sandstone, ash, limestone and other mixed lithology. Rare full intact bricks and cobble setts. 0.40 - 0.70 ...3no. cobble setts present (250mm x 200mm x 150mm).		
				34.14		0.75			
0.80	ES			33.99		0.90	MADE GROUND: Soft to firm black/dark brown slightly ashy slightly sandy clay.		
1.00-2.00	B						Loose to medium dense light brown fine to coarse SAND with rare gravel. Gravel is fine to coarse, angular to subrounded of sandstone, mudstone and other mixed lithology.		
1.00	ES						1.20 ...becoming slightly clayey.		
1.70	ES		▼			(1.80)	1.70 ...becoming dark brown with increased gravel content.		
				32.19		2.70			
2.70	D					(0.30)	Firm to stiff brown CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone and other mixed lithology.		
				31.89		3.00			
							...borehole ended at 3.0mbgl.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	
											No visual or olfactory evidence of hydrocarbon or solvent contamination. Groundwater observed at 1.7mbgl.

All dimensions in metres Scale 1:21.875	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP. MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				**WS17**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	15-04-23	34.76	E 384,249.8 N 396,297.4	
Contractor				Sheet
Taylor Drilling Services				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.46		(0.30) 0.30	MADE GROUND: Screed over red grey brown cement bound fine to coarse angular gravel (Weakly concrete gravel bound floor slab). 0.00 - 0.30 ...core depth.		
0.30	ES			34.16		(0.30) 0.60	MADE GROUND: Uncompact black/grey/red/brown ashy slightly clayey gravelly sand. Gravel is fine to coarse, angular to subrounded of brick, sandstone, ash, limestone and other mixed lithology. Rare cobble setts.		
0.70	ES			34.01		0.75	MADE GROUND: Soft black/dark brown slightly ashy slightly sandy clay.		
0.80	ES					(1.65)	Loose to medium dense light brown fine to coarse SAND with rare gravel. Gravel is fine to coarse, angular to subrounded of sandstone, mudstone and other mixed lithology. 1.20 ...becoming slightly clayey. 1.50 - 2.50 ...poor stability and partial collapse.		
1.90	ES		1				1.90 - 2.50 ...becoming dark grey with hydrocarbon odour.		
				32.36		2.40			
2.50-3.00	B					(1.00)	Firm to stiff brown CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone and other mixed lithology.		
2.50	ES								
3.00	B								
				31.36		3.40			
							...borehole ended at 3.4mbgl.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	
											Olfactory evidence of hydrocarbon or solvent contamination between 1.9mbgl to 2.5mbgl. Groundwater observed at 2.0mbgl.

All dimensions in metres Scale 1:21.875	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP. MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				WS17a
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	22-06-23	34.76	E 384,249.3 N 396,296.9	
Contractor				Sheet
Taylor Drilling Services				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.46		(0.30) 0.30	MADE GROUND: Screed over red grey brown cement bound fine to coarse angular gravel (Weakly concrete gravel bound floor slab).		
				34.26		(0.20) 0.50	MADE GROUND: Uncompact black/grey/red/brown ashy slightly clayey gravelly sand. Gravel is fine to coarse, angular to subrounded of brick, sandstone, ash, limestone and other mixed lithology. Rare cobble setts.		
				33.46		(0.80) 1.30	MADE GROUND: Uncompact ashy clayey gravelly SAND. Gravel is fine to coarse, angular to subrounded of brick, concrete, sandstone, ash, clinker, limestone and other mixed lithology. Rare cobbbles of brick.		
1.80	ES		▼1	32.26		(1.20) 2.50	Loose to medium dense light brown fine to coarse SAND with rare gravel. Gravel is fine to coarse, angular to subrounded of sandstone, mudstone and other mixed lithology. 1.50 - 2.50 ...poor stability and partial collapse. 1.90 - 2.50 ...becoming dark grey with increased gravel content and hydrocarbon odour observed.		
2.20	ES								
2.90	ES			30.76		(1.50) 4.00	Firm to stiff brown CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone and other mixed lithology.		
3.20	ES								
							...borehole ended at 4.0mbgl.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	
											Olfactory evidence of hydrocarbon or solvent contamination between 1.9mbgl to 2.8mbgl. Groundwater observed at 2.0mbgl.

All dimensions in metres Scale 1:25.625	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				**WS18**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	15-04-23	34.72	E 384,235.8 N 396,296.3	
Contractor				Sheet
Taylor Drilling Services				1 of 2

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.47		(0.25) 0.25	MADE GROUND: Screed over red grey brown cement bound fine to coarse angular gravel (Weakly concrete gravel bound floor slab). 0.00 - 0.25 ...core depth.		
				34.22		(0.25) 0.50	MADE GROUND: Uncompact black/grey/red/brown ashy slightly clayey sand with rare gravel. Gravel is fine to coarse, angular to subrounded of brick, sandstone, ash, limestone and other mixed lithology. Rare cobble setts.		
				33.97		(0.25) 0.75	MADE GROUND: Soft to firm black/dark brown slightly ashy slightly sandy clay.		
0.80	ES					(1.55)	Loose to medium dense light brown fine to coarse SAND with rare gravel. Gravel is fine to coarse, angular to subrounded of sandstone, mudstone and other mixed lithology.		
2.10	ES						2.00 - 2.50 ...becoming dark grey with hydrocarbon odour.		
				32.42		2.30			
				31.72		(0.70) 3.00	Firm to stiff brown CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone and other mixed lithology.		
							...borehole ended at 3.0mbgl.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	Olfactory evidence of hydrocarbon or solvent contamination between 2.0mbgl to 2.5mbgl. No groundwater observed during drilling.

All dimensions in metres Scale 1:19.375	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP. MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				WS18
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	15-04-23	34.72	E 384,235.8 N 396,296.3	
Contractor				Sheet
Taylor Drilling Services				2 of 2

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
							...becoming very stiff.		

Boring Progress and Water Observations						Chiselling			Water Added	
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To

GENERAL REMARKS

Olfactory evidence of hydrocarbon or solvent contamination between 2.0mbgl to 2.5mbgl.
No groundwater observed during drilling.

All dimensions in metres Scale 1:19.375	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				**WS18a**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	22-06-23	34.72	E 384,235.8 N 396,296.3	
Contractor				Sheet
Taylor Drilling Services				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.47		(0.25) 0.25	MADE GROUND: Screed over red grey brown cement bound fine to coarse angular gravel (Weakly concrete gravel bound floor slab). 0.00 - 3.00 ...WS18 borehole redrilled as WS18.		
				34.22		(0.25) 0.50	MADE GROUND: Uncompact black/grey/red/brown ashy slightly clayey sand with rare gravel. Gravel is fine to coarse, angular to subrounded of brick, sandstone, ash, limestone and other mixed lithology. Rare cobble setts.		
				33.97		(0.25) 0.75	MADE GROUND: Soft to firm black/dark brown slightly ashy slightly sandy clay.		
				32.42		(1.55) 2.30	Loose to medium dense light brown fine to coarse SAND with rare gravel. Gravel is fine to coarse, angular to subrounded of sandstone, mudstone and other mixed lithology. 2.00 - 2.50 ...hydrocarbon odour observed within redrilled strata.		
				30.72		(1.70) 4.00	Firm to stiff brown CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone and other mixed lithology.		
							...borehole ended at 4.0mbgl.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	Olfactory evidence of hydrocarbon or solvent contamination between 2.0mbgl to 2.5mbgl. No groundwater observed.

All dimensions in metres Scale 1:25.625	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				**WS19**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	20-06-23	34.82	E 384,265.5 N 396,297.2	
Contractor				Sheet
Taylor Drilling Services				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.81		0.01	MADE GROUND: Laminate floor covering.		
				34.62		(0.19) 0.20	MADE GROUND: Concrete over red grey brown cement bound fine to coarse angular gravel (Weakly concrete gravel bound floor slab).		
				34.52		0.30	MADE GROUND: Sandstone boulder recovered as a core (cobble sett).		
0.35	ES			34.32		(0.20) 0.50	MADE GROUND: Soft brown slightly sandy silty gravelly clay. Gravel is fine to coarse, angular to subrounded of brick, concrete, limestone and other mixed lithology.		
				34.02		(0.30) 0.80	MADE GROUND: Dark brown soft to firm slightly silty slightly sandy clay with rare gravel (reworked clay). Gravel is fine to coarse, angular to subrounded of brick, concrete, limestone sandstone, mudstone and other mixed lithology.		
1.00	SPT	7					Loose to medium dense light brown fine to coarse SAND with rare gravel. Gravel is fine to coarse, angular to subrounded of sandstone, mudstone and other mixed lithology.		
							1.50 ...becoming darker in colour with increased gravel content.		
2.00	SPT	8				(1.70)			
2.40	ES			32.32		2.50			
						(0.50)	Firm to stiff brown CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone and other mixed lithology.		
3.00	SPT	16		31.82		3.00	...borehole ended at 3.0mbgl.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	No visual or olfactory evidence of hydrocarbon or solvent contamination. No groundwater observed.

All dimensions in metres Scale 1:19.375	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				**WS20**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	22-06-23	34.63	E 384,224.8 N 396,292.2	
Contractor				Sheet
Taylor Drilling Services				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.57		0.06	MADE GROUND: Compact concrete.		
						(0.52)	MADE GROUND: Concrete over red grey brown cement bound fine to coarse angular gravel (Weakly concrete gravel bound floor slab). 0.10 - 0.25 ...metal girder present.		
				34.05		0.58			
						(0.37)	MADE GROUND: Soft to firm black/dark brown slightly ashy slightly sandy clay.		
				33.68		0.95			
1.00	SPT	12				(0.85)	Loose to medium dense light brown fine to coarse SAND with rare gravel. Gravel is fine to coarse, angular to subrounded of sandstone, mudstone and other mixed lithology.		
				32.83		1.80			
1.90	ES						Loose to medium dense brown fine to coarse SAND AND GRAVEL. Gravel is fine to coarse, sub angular to rounded of mudstone, sandstone and other mixed lithology.		
2.00	SPT	15				(0.60)	2.00 - 2.40 ...becoming dark grey with moderate hydrocarbon odour. Fainter odour than WS17, WS17a, WS18 & WS18.		
2.10	ES								
2.25	PID	9.5ppm		32.23		2.40			
							Firm to stiff brown CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone and other mixed lithology.		
2.60	ES								
3.00	SPT D	19				(1.60)			
				30.63		4.00			
4.00	SPT D	19					...borehole ended at 4.0mbgl.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	Olfactory evidence of hydrocarbon or solvent contamination between 2.0mbgl to 2.5mbgl. No groundwater observed.

All dimensions in metres Scale 1:25.625	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				WS21
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	20-06-23	34.56	E 384,229.4 N 396,283.0	
Contractor				Sheet
Taylor Drilling Services				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.46		0.10	MADE GROUND: Concrete paving slab.		
				34.06		(0.40) 0.50	MADE GROUND: Compact black/dark grey ashy sandy gravel. Gravel is fine to coarse, angular to subrounded of limestone and other mixed lithology.		
				33.66		(0.40) 0.90	MADE GROUND: Uncompact dark brown slightly silty sandy clayey gravel. Gravel is fine to coarse, angular to subrounded of brick, concrete, limestone sandstone, mudstone and other mixed lithology.		
1.80	ES		▼1	32.16		(1.50) 2.40	Loose to medium dense light brown fine to coarse SAND.		
				29.56		(2.60) 5.00	Firm brown CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone, sandstone and other mixed lithology.		
							...borehole ended at 5.0mbgl.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	No visual or olfactory evidence of hydrocarbon or solvent contamination. Groundwater observed at 1.8mbgl.

All dimensions in metres Scale 1:31.875	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

WINDOW SAMPLER BOREHOLE LOG

Project				BOREHOLE No
Greenheys Business Centre, Manchester Science Park				WS22
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	20-06-23	34.78	E 384,251.9 N 396,287.5	
Contractor				Sheet
Taylor Drilling Services				1 of 1

SAMPLES & TESTS			Water	STRATA				Geology	Instrument/ Backfill
Depth	Type No	Test Result		Reduced Level	Legend	Depth (Thick-ness)	DESCRIPTION		
				34.77		0.01	MADE GROUND: Laminate floor covering.		
				34.53		(0.24) 0.25	MADE GROUND: Concrete over red grey brown cement bound fine to coarse angular gravel (Weakly concrete gravel bound floor slab).		
				34.08		(0.45) 0.70	MADE GROUND: Uncompact black/brown ashy slightly silty gravelly sand. Gravel is fine to coarse, angular to subrounded of brick, concrete, ash, clinker, sandstone, limestone, mudstone and other mixed lithology. Rare cobbles of brick including full intact bricks.		
				33.98		0.80	MADE GROUND: Soft to firm black/dark brown slightly ashy slightly sandy clay.		
1.00	SPT D	12				(1.70)	Loose to medium dense light brown fine to coarse SAND with rare gravel. Gravel is fine to coarse, angular to subrounded of sandstone, mudstone and other mixed lithology.		
2.00	S D ES	12							
				32.28		2.50			
				31.78		(0.50) 3.00	Firm to stiff brown CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone and other mixed lithology.		
3.00	SPT D	19					...borehole ended at 3.0mbgl.		

Boring Progress and Water Observations						Chiselling			Water Added		GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia. mm	Water Dpt	From	To	Hours	From	To	No visual or olfactory evidence of hydrocarbon or solvent contamination. No groundwater observed.

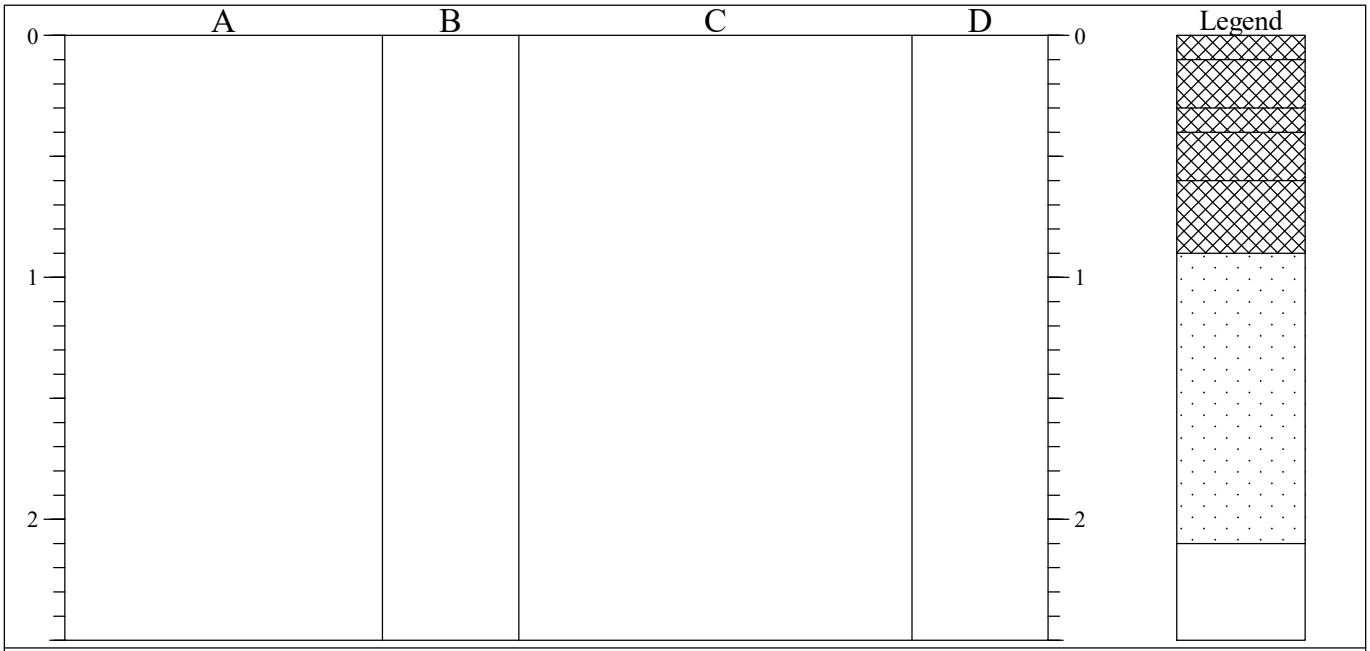
All dimensions in metres Scale 1:19.375	Client Bruntwood SciTech	Method/ Plant Used Tracked Archway Dart	Logged By MT

AGS3 UK WS NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

TRIAL PIT LOG

Project				TRIAL PIT No
Greenheys Business Centre, Manchester Science Park				**TP01**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	20-06-23	35.10	E 384,331.7 N 396,274.4	
Contractor				Sheet
Taylor Drilling Services				1 of 1

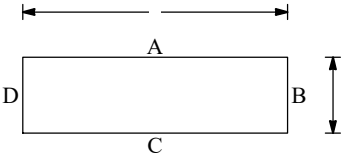


STRATA

SAMPLES & TESTS

Depth	No	DESCRIPTION	Depth	No	Remarks/Tests
0.00-0.10		MADE GROUND: Compact black ashy fine to coarse slightly sandy angular gravel of tarmacadam.			
0.10-0.30		MADE GROUND: Compact black/dark grey ashy sandy gravel. Gravel is fine to coarse, angular to subrounded of limestone and other mixed lithology.			
0.30-0.40		MADE GROUND: Uncompact light brown/grey fine to coarse sand with rare gravel of sandstone, mudstone and other mixed lithology.			
0.40-0.60		MADE GROUND: Compact light brown ashy sandy gravel. Gravel is fine to coarse, angular to subrounded of limestone and other mixed lithology.			
0.60-0.90		MADE GROUND: Uncompact brown/grey ashy gravelly sand with rare pockets of clay. Gravel is fine to coarse, angular to subrounded of brick, ash, clinker, limestone, concrete, sandstone and other mixed lithology. Rare cobbles of bricks.			
0.90-2.10		Loose to medium dense light brown fine to coarse SAND. 0.90 - 1.10 ...rare cobble setts within base of Made Ground. 1.80 ...becoming dark brown with increased gravel content.			
2.10		...trial pit ended at 2.1mbgl.			

Shoring/Support:
Stability: Poor





GENERAL REMARKS

No visual or olfactory evidence of hydrocarbon or solvent contamination.
No groundwater observed.

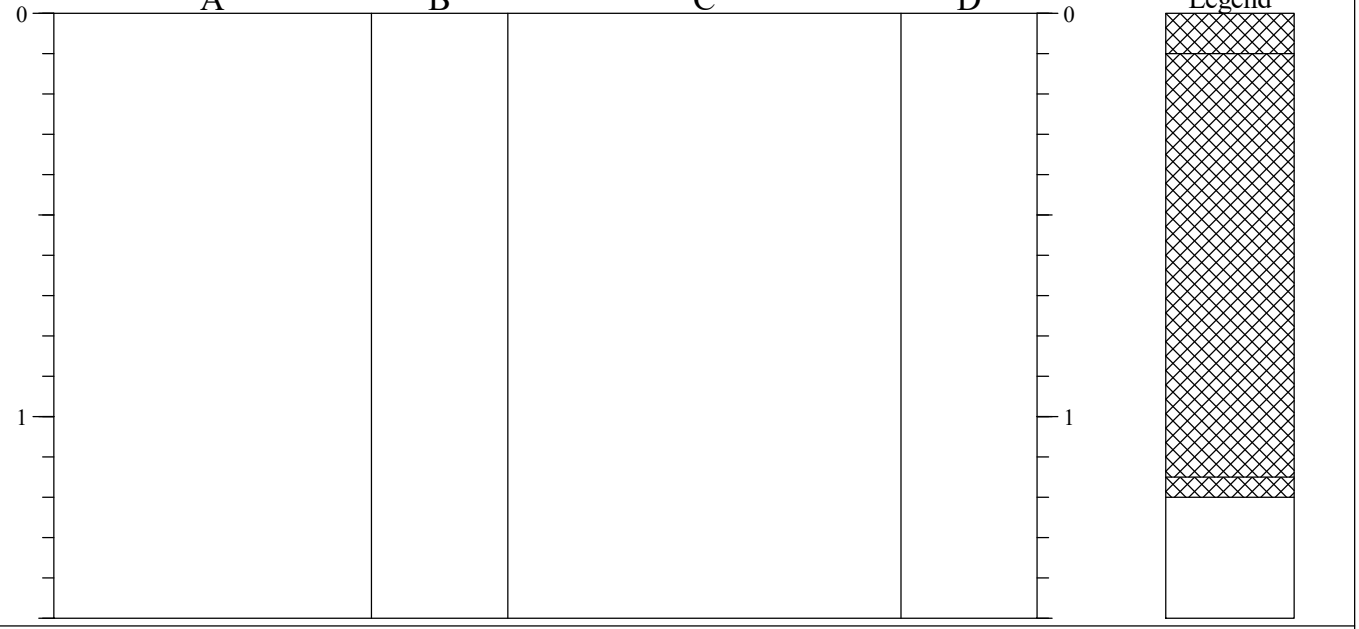
All dimensions in metres Scale 1:31.25	Client Bruntwood SciTech	Method/ Plant Used JCB	Logged By MT

AGS3 UK TP NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

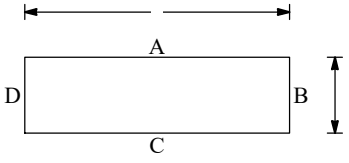
TRIAL PIT LOG

Project				TRIAL PIT No
Greenheys Business Centre, Manchester Science Park				**TP02**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	20-06-23	34.90	E 384,321.0 N 396,266.9	
Contractor				Sheet
Taylor Drilling Services				1 of 1



STRATA			SAMPLES & TESTS		
Depth	No	DESCRIPTION	Depth	No	Remarks/Tests
0.00-0.10		MADE GROUND: Compact black ashy fine to coarse slightly sandy angular gravel of tarmacadam.			
0.10-1.15		MADE GROUND: Compact grey ashy sandy cobbley gravel. Gravel is fine to coarse, angular to subrounded of limestone and other mixed lithology (subbase material). Rare cobbles of brick including full intact bricks.			
1.15-1.20		MADE GROUND: Uncompact brown fine to coarse ashy clayey sand with rare gravel. Gravel is fine to coarse, angular to subrounded of brick, sandstone, mudstone and other mixed lithology. Very rare gravel of glass.			
1.20		...trial pit ended at 1.2mbgl due to poor stability and partial collapse.			

Shoring/Support:
Stability: Poor





GENERAL REMARKS

No visual or olfactory evidence of hydrocarbon or solvent contamination.
No groundwater observed.

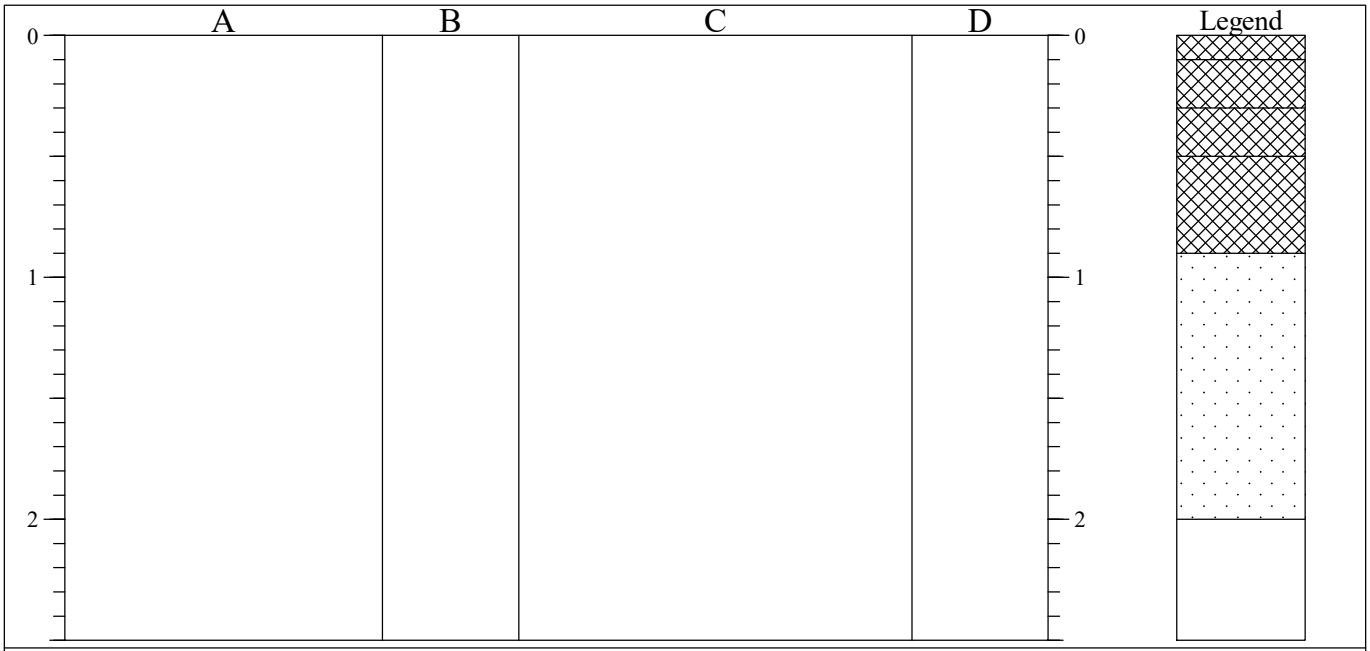
All dimensions in metres Scale 1:18.75	Client Bruntwood SciTech	Method/ Plant Used JCB	Logged By MT

AGS3 UK TP NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

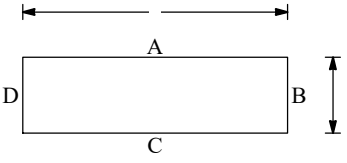
TRIAL PIT LOG

Project				TRIAL PIT No
Greenheys Business Centre, Manchester Science Park				**TP03**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	21-06-23	34.60	E 384,322.8 N 396,299.1	
Contractor				Sheet
Taylor Drilling Services				1 of 1



STRATA			SAMPLES & TESTS		
Depth	No	DESCRIPTION	Depth	No	Remarks/Tests
0.00-0.10		MADE GROUND: Compact black ashy fine to coarse slightly sandy angular gravel of tarmacadam.			
0.10-0.30		MADE GROUND: Compact black/dark grey ashy sandy gravel. Gravel is fine to coarse, angular to subrounded of limestone and other mixed lithology.			
0.30-0.50		MADE GROUND: Compact black/dark grey ashy sandy cobbley gravel. Gravel is fine to coarse, angular to subrounded of limestone and other mixed lithology. Rare cobbles of brick including full intact bricks.			
0.50-0.90		MADE GROUND: Uncompact brown fine to coarse ashy slightly clayey gravelly sand. Gravel is fine to coarse, angular to subrounded of brick, ash, concrete, clinker, limestone and other mixed lithology.			
0.90-2.00		Loose to medium dense light brown fine to coarse SAND.			
		1.70 ...becoming darker in colour with increased gravel content.			
2.00		...trial pit ended at 2.0mbgl.			

Shoring/Support:
Stability: Poor





GENERAL REMARKS

No visual or olfactory evidence of hydrocarbon or solvent contamination.
No groundwater observed.

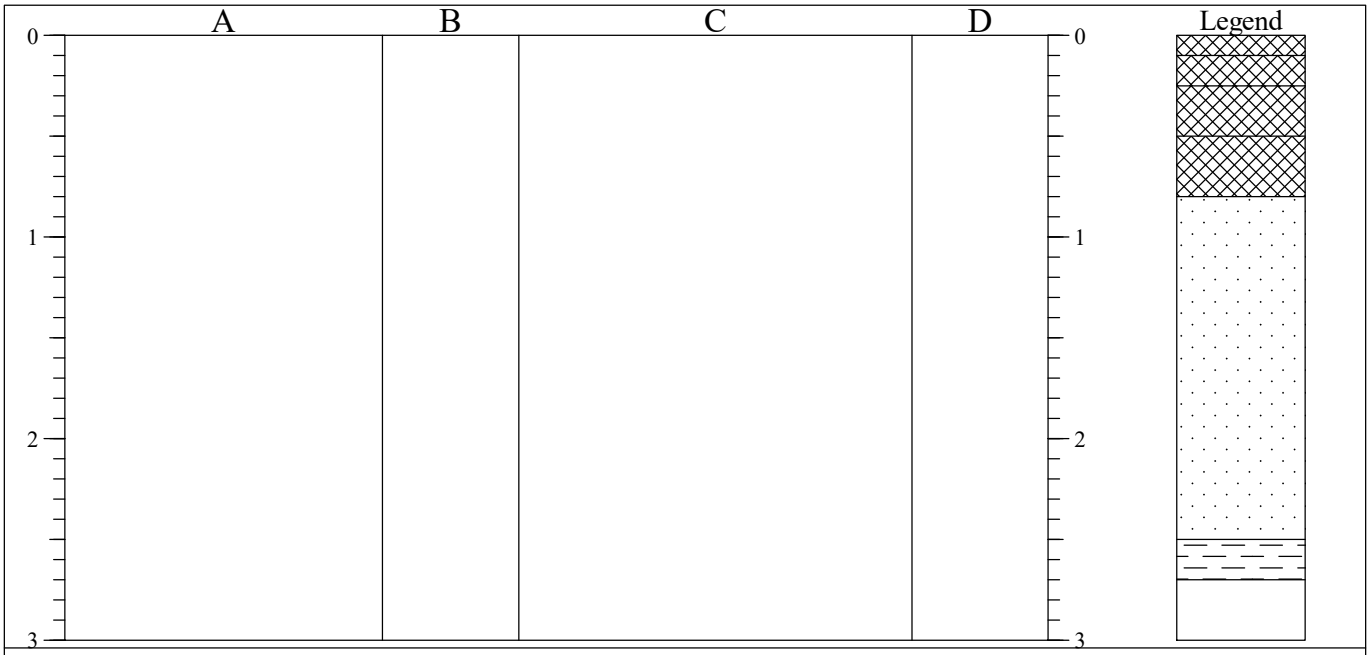
All dimensions in metres Scale 1:31.25	Client Bruntwood SciTech	Method/ Plant Used JCB	Logged By MT

AGS3 UK TP NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

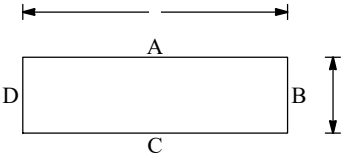
TRIAL PIT LOG

Project				TRIAL PIT No
Greenheys Business Centre, Manchester Science Park				**TP04**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	20-06-23	34.84	E 384,262.0 N 396,314.4	
Contractor				Sheet
Taylor Drilling Services				1 of 1



STRATA			SAMPLES & TESTS		
Depth	No	DESCRIPTION	Depth	No	Remarks/Tests
0.00-0.10		MADE GROUND: Compact black ashy fine to coarse slightly sandy angular gravel of tarmacadam.			
0.10-0.25					
0.25-0.50		MADE GROUND: Compact black ashy sandy gravel. Gravel is fine to coarse, angular to subrounded of tarmacadam, concrete, limestone and other mixed lithology.			
0.50-0.80		MADE GROUND: Uncompact black fine to coarse ashy gravelly sand. Gravel is fine to coarse, angular to subrounded of ash, brick, limestone, concrete, tarmacadam and other mixed lithology. Rare cobbles of brick including full intact bricks.			
0.80-2.50		MADE GROUND: Dark brown soft to firm slightly silty slightly sandy clay with rare gravel (reworked clay). Gravel is fine to coarse, angular to subrounded of brick, concrete, limestone sandstone, mudstone and other mixed lithology.			
		Loose to medium dense light brown fine to coarse SAND.			
		1.70 ...becoming darker in colour with increased gravel content.			
2.50-2.70		Firm to stiff brown CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone, coal and other mixed lithology.			
2.70		...trial pit ended at 2.7mbgl.			

Shoring/Support:
Stability: Poor





GENERAL REMARKS

No visual or olfactory evidence of hydrocarbon or solvent contamination. Slight to moderate groundwater ingress observed at 2.3mbgl.

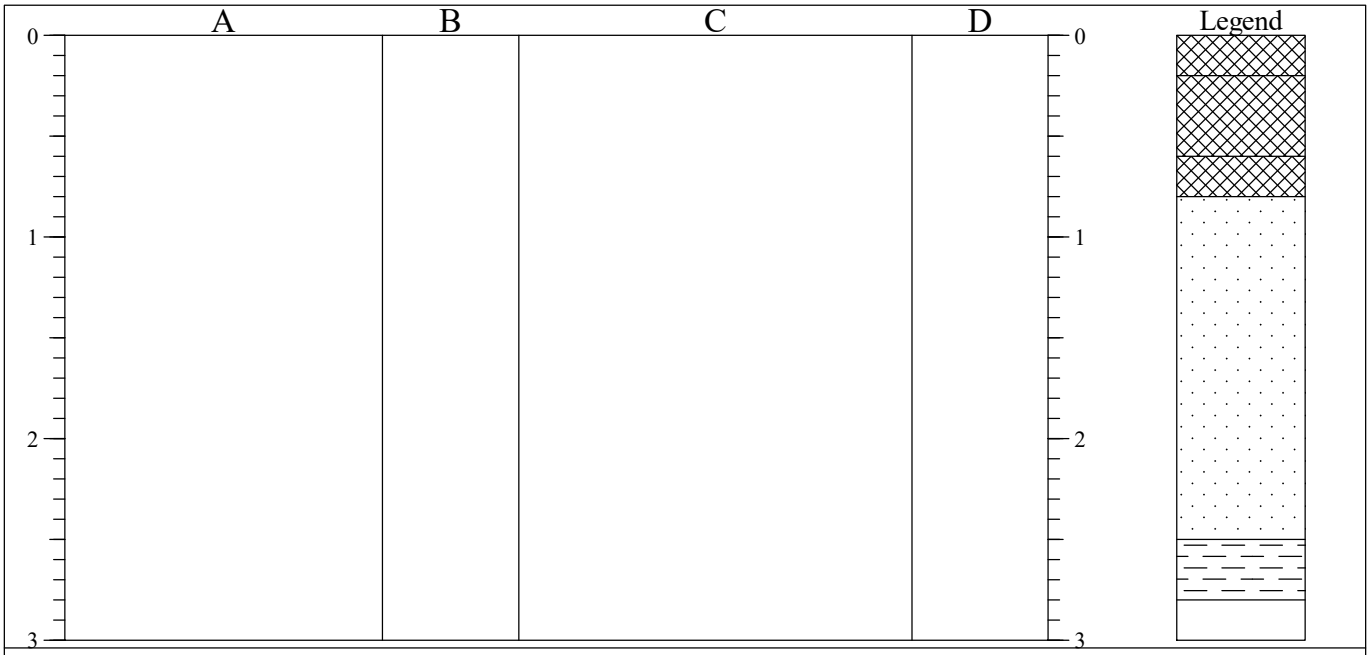
All dimensions in metres Scale 1:37.5	Client Bruntwood SciTech	Method/ Plant Used JCB	Logged By MT

AGS3 UK TP NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

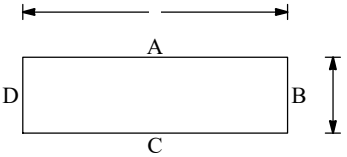
TRIAL PIT LOG

Project				TRIAL PIT No
Greenheys Business Centre, Manchester Science Park				**TP05**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	21-06-23	34.47	E 384,244.1 N 396,306.1	
Contractor				Sheet
Taylor Drilling Services				1 of 1



STRATA			SAMPLES & TESTS		
Depth	No	DESCRIPTION	Depth	No	Remarks/Tests
0.00-0.20		MADE GROUND: (Moss over) Compact light grey cement bound gravel (former concrete slab).			
0.20-0.60		MADE GROUND: Compact light grey ashy sandy gravel. Gravel is fine to coarse, angular to subrounded of concrete, brick, limestone sandstone, ash, clinker and other mixed lithology.			
0.60-0.80		MADE GROUND: Dark brown soft to firm slightly silty slightly sandy clay with rare gravel (reworked clay). Gravel is fine to coarse, angular to subrounded of brick, concrete, limestone sandstone, mudstone and other mixed lithology.			
0.80-2.50		Loose to medium dense light brown fine to coarse SAND.	1.60	ES	
		1.90 - 2.50 ...becoming dark grey with moderate hydrocarbon odour.	1.90	PID	9.6ppm
			2.00	ES	
			2.30	PID	17.6ppm
2.50-2.80		Firm to stiff brown CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone, coal and other mixed lithology.			
		2.60 ...iridescent appearance on the surface of the water within base of trial pit.	2.70	ES	
2.80		...trial pit ended at 2.8mbgl.	2.71	PID	0.7ppm

Shoring/Support:
Stability: Poor





GENERAL REMARKS

Olfactory and visual evidence of hydrocarbon or solvent contamination between 1.9mbgl to 2.5mbgl.
Slight to moderate groundwater ingress observed at 2.2mbgl.

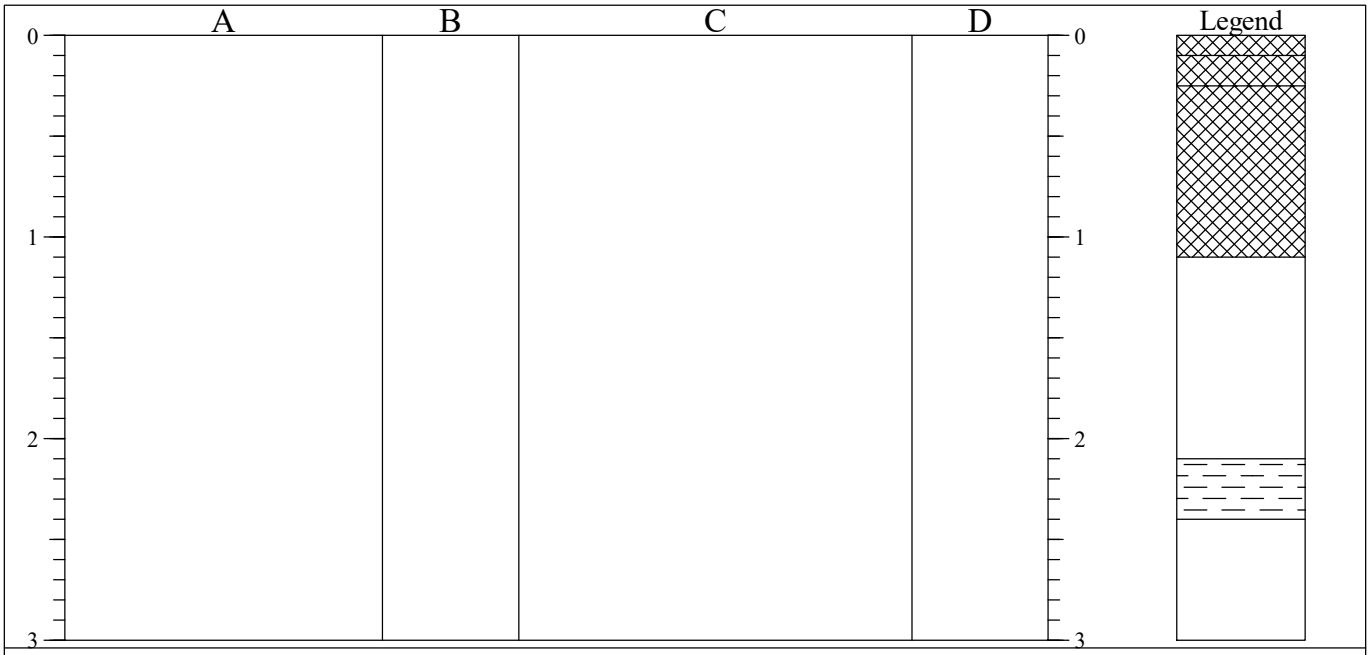
All dimensions in metres Scale 1:37.5	Client Bruntwood SciTech	Method/ Plant Used JCB	Logged By MT

AGS3 UK TP NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

NX Consulting

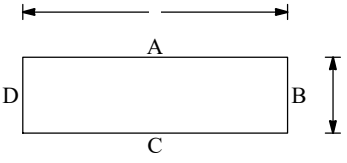
TRIAL PIT LOG

Project				TRIAL PIT No
Greenheys Business Centre, Manchester Science Park				**TP06**
Job No	Date	Ground Level (m)	Co-Ordinates ()	
NX534	20-06-23	34.24	E 384,223.1 N 396,281.0	
Contractor				Sheet
Taylor Drilling Services				1 of 1



STRATA			SAMPLES & TESTS		
Depth	No	DESCRIPTION	Depth	No	Remarks/Tests
0.00-0.10		MADE GROUND: Compact black ashy fine to coarse slightly sandy angular gravel of tarmacadam.			
0.10-0.25					
0.25-1.10		MADE GROUND: Compact black/dark grey ashy sandy gravel. Gravel is fine to coarse, angular to subrounded of limestone and other mixed lithology.			
		MADE GROUND: Uncompact brown/grey ashy gravelly sand. Gravel is fine to coarse, angular to subrounded of brick, ash, clinker, limestone, concrete, sandstone and other mixed lithology. Frequent cobbles of bricks including full intact bricks. 0.25 - 0.70 ...relic insitu brick wall present in northern face of pit.			
1.10-2.10		Loose to medium dense light brown fine to coarse SAND.			
			1.50	B	
		1.75 ...becoming darker in colour with increased gravel content.			
2.10-2.40		Firm brown CLAY with rare gravel. Gravel is fine to coarse, angular to subrounded of mudstone, sandstone and other mixed lithology.			
2.40		...trial pit ended at 2.4mbgl.			

Shoring/Support:
Stability: Poor





GENERAL REMARKS

No visual or olfactory evidence of hydrocarbon or solvent contamination.
No groundwater observed.

All dimensions in metres Scale 1:37.5	Client Bruntwood SciTech	Method/ Plant Used JCB	Logged By MT

AGS3 UK TP NX534 GREENHEYS MSP, MANCHESTER.GPJ AGS 3_1.GDT 25/8/23

Appendix C – Permeability test data

Next Generation Engineering Consultancy Services

DRILLING REPORT								Borehole Number:			**WS04**
ENGINEER:- Matt Tomkinson											
CLIENT:	**Bruntwood Scitech**		**Site:**	**Greenheys**							
Date:	**25.08.2023**		**FALLING HEAD PERMEABILITY TEST**					Job No.			**NX534**
Time:	**11-45**							GL AOD:			

384323.901,396296.193,34.632			(m)							
Depth of borehole during test	a	:	2.04							
Depth to equilidrium watertable	b	:	1.51		**PERMEABILITY (BRE Digest 365 method)**					
Height of casing above ground	c	:	0.00							
Depth of casing below ground	d	:	0.00		Vp =	0.0025	m3/m			
Depth of from top of casing to water level	e	:			Vp 50 =	Vp x e50	m3			
Diameter of standpipe	D2	:	0.050		Vp 50 =	#VALUE!				
Diameter of borehole	D1	:	0.087		As =	0.273	m2/m			
					As 50=	As x e50	m2			
					As 50=	#VALUE!				

**Borehole filled with water twice prior to testing.*

Elapsed Time, t (Mins)	Depth to water, e (m)	Head of water, H (m)
0.00	0.89	
0.50	1.51	

e1 =	N/A					t1 =	N/A		
e2 =	N/A					t2 =	N/A		
e50	N/A			t50 =	N/A	min			

f = Vp 50 /(60 x t50 x As 50)

f = N/A

Next Generation Engineering Consultancy Services

DRILLING REPORT								Borehole Number:			**WS11**
ENGINEER:- Matt Tomkinson											
CLIENT:	**Bruntwood Scitech**		**Site:**	**Greenheys**							
Date:	**25.08.2023**		**FALLING HEAD PERMEABILITY TEST**					Job No.			**NX534**
Time:	**10-45**							GL AOD:			

384224.935,396269.789,34.493				(m)							
Depth of borehole during test		a	:	3.33							
Depth to equilidrium watertable		b	:	1.81		**PERMEABILITY (BRE Digest 365 method)**					
Height of casing above ground		c	:	0.00							
Depth of casing below ground		d	:	0.00		Vp =	0.0025	m3/m			
Depth of from top of casing to water level		e	:			Vp 50 =	Vp x e50	m3			
Diameter of standpipe		D2	:	0.050		Vp 50 =	0.000825				
Diameter of borehole		D1	:	0.087		As =	0.273	m2/m			
						As 50=	As x e50	m2			
						As 50=	0.09009				

**Borehole filled with water twice prior to testing.*

Elapsed Time, t (Mins)	Depth to water, e (m)	Head of water, H (m)										
0.00	0.00											
0.50	**1.02**		**t1 & e1**									
1.00	1.12											
2.00	1.35		**t2 & e2**									
3.00	1.47											
4.00	1.56											
5.00	1.60					e1 =	1.02				t1 =	0.50
10.00	1.67					e2 =	1.35				t2 =	2.00
15.00	1.74											
20.00	1.76					e50	0.33	t50 =		1.50	min	
30.00	1.80											
35.00	1.81					**f = Vp 50 /(60 x t50 x As 50)**						

f = 1.02E-04

Appendix D – Risk assessment sheets

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	**Greenhays Business Centre**			
Site Address:	**Greenhays Road, Manchester**			
Completed by:	**Liz Hart**			
Date:	**07 09 23**		**Version:**	**1**
Contaminant	**Naphthalene**			
Target Concentration (C_T)	**0.14**	**mg/l**	**Origin of C_T:**	**WHO Drinking water standard**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant		**Naphthalene**		
Target concentration	**C_T**	**0.14**	**mg/l**	

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	1.40E-01	fraction	
Air filled soil porosity	θa	1.40E-01	fraction	
Bulk density of soil zone material	ρ	1.90E+00	g/cm^3	
Henry's Law constant	H	1.74E-02	dimensionless	
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	7.00E-03	fraction	
Organic carbon partition coefficient	Koc	1.29E+03	l/kg	
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Soil water partition coefficient used in Level Assessment	**Kd**	**9.02E+00**	**l/kg**	*Calculated value*

Level 1 Remedial Target

Level 1 Remedial Target	**1.27E+00**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.14	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Greenhays Business Centre
Completed by:	Liz Hart
Date:	07 09 23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**Naphthalene**	from Level 1	This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).
Target concentration	**C_T**	**0.14** **mg/l**	from Level 1	

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	2.80E-04	m/d		
Area of contaminant source	A	1.13E+01	m^2		Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	4.50E+00	m		
Saturated aquifer thickness	da	5.00E-01	m		
Hydraulic Conductivity of aquifer in which dilution occurs	K	8.60E+00	m/d		
Hydraulic gradient of water table	i	4.00E-03	fraction		
Width of contaminant source perpendicular to groundwater flow	w	2.50E+00	m		Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Specify**			
Enter mixing zone thickness	Mz	5.00E-01	m		
Calculated mixing zone thickness	Mz		m		

Calculated Parameters

Dilution Factor	**DF**	**1.47E+01**		
Level 2 Remedial Target		**2.05E+00**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentra**
		or		
		1.86E+01	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	1.00E-02	mg/l	WS08 at 1.70m
Calculated concentration within receptor (dilution only)		6.83E-04	mg/l	0

Site being assessed:	Greenhays Business Centre
Completed by:	Liz Hart
Date:	07 09 23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters

	Variable	Value	Unit	Source
Contaminant		Naphthalene		from Level 1
Target Concentration	C_T	0.14	mg/l	from Level 1
Dilution Factor	DF	1.47E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		1.7	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	1.00E+100	days	
Calculated decay rate	λ	6.93E-101	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	2.50E+00	m	from Level 2
Plume thickness in aquifer at source	Sy	5.00E-01	m	from Level 2
Bulk density of aquifer materials	ρ	1.90E+00	g/cm^3	
Effective porosity of aquifer	n	3.30E-01	fraction	
Hydraulic gradient	i	4.29E-03	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	8.60E+00	m/d	from Level 2
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	9.02E+00	l/kg	*see options*
Longitudinal dispersivity	ax	5.000	m	*see options*
Transverse dispersivity	az	0.500	m	*see options*
Vertical dispersivity	ay	0.050	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.12E-01	m/d
Retardation factor	Rf	5.29E+01	fraction
Decay rate used	λ	1.31E-102	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	4.29E-03	fraction
Rate of contaminant flow due to retardation	u	2.11E-03	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	2.48E-02	fraction
Attenuation factor (C_T/C_{ETL})	**AF**	**4.03E+01**	**fraction**
Calculated soil leachate concentration	Co	1.87E-01	mg/l

Remedial Targets

Level 3 Remedial Target	**8.26E+01**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks	**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
	7.51E+02	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point	**50**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	**2.48E-02**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc	7.00E-03	fraction
Organic carbon partition coefficient	Koc	1.29E+03	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	9.02E+00	l/kg

Define dispersivity (click brown cell and use pull down list)

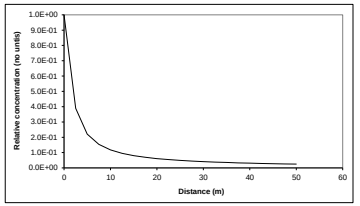
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	**az**	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	**ay**	0.00E+00	5.00E-02	2.98E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Greenhays Business Centre
Completed by:	Liz Hart
Date:	07 09 23
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	**1.0E+00**	**1.28E-02**
2.5	**3.90E-01**	**4.97E-03**
5.0	**2.21E-01**	**2.82E-03**
7.5	**1.54E-01**	**1.96E-03**
10.0	**1.18E-01**	**1.50E-03**
12.5	**9.54E-02**	**1.22E-03**
15.0	**8.02E-02**	**1.02E-03**
17.5	**6.92E-02**	**8.83E-04**
20.0	**6.08E-02**	**7.76E-04**
22.5	**5.43E-02**	**6.93E-04**
25.0	**4.90E-02**	**6.25E-04**
27.5	**4.46E-02**	**5.70E-04**
30.0	**4.10E-02**	**5.23E-04**
32.5	**3.79E-02**	**4.84E-04**
35.0	**3.53E-02**	**4.50E-04**
37.5	**3.30E-02**	**4.21E-04**
40.0	**3.09E-02**	**3.95E-04**
42.5	**2.91E-02**	**3.72E-04**
45.0	**2.75E-02**	**3.52E-04**
47.5	**2.61E-02**	**3.33E-04**
50.0	**2.48E-02**	**3.17E-04**

Remedial Targets Worksheet , Release 3.2

Calculation of contaminant concentration in groundwater from a soil source

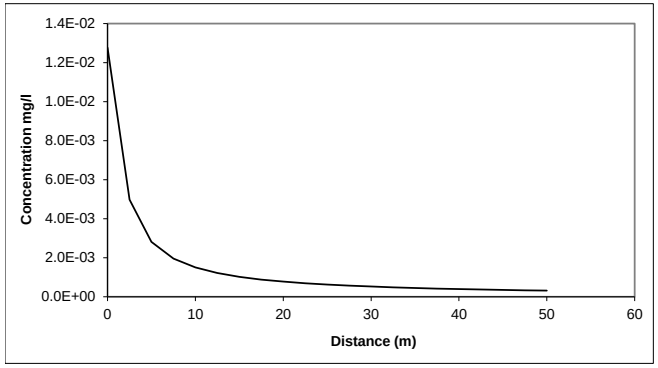
Only input required is Soil Contaminant Concentration

	Input Parameters			
	Soil contaminant concentration	C_0	1.70E+00	mg/kg
Level 1 Parameters				
	Water filled soil porosity	θ_w	1.40E-01	fraction
	Air filled soil porosity	θa	1.40E-01	fraction
	Bulk density	ρ	1.90E+00	g/cm^3
	Henry's Law constant	H	1.74E-02	dimensionless
	Soil water partition coefficient used in Level Assessment	Kd	9.02E+00	l/kg
	Factor (partitioning between soil and water)		9.09E+00	dimensionless
Level 2 Parameters	**Dilution Factor**	DF	1.47E+01	
Level 3 Parameters	**Attenuation factor (C_O/C_{ED})**	AF	4.03E+01	

Predicted concentrations at compliance point

Level 1	C	1.87E-01	mg/l	No dilution or attenuation
Level 2	C	1.28E-02	mg/l	Dilution taken into account
Level 3	C	3.17E-04	mg/l	Dilution and attenuation taken into account

Predicted concentrations between source and compliance point - Level 3



Distance m	Concentration mg/l
0.00	1.28E-02
2.50	4.97E-03
5.00	2.82E-03
7.50	1.96E-03
10.00	1.50E-03
12.50	1.22E-03
15.00	1.02E-03
17.50	8.83E-04
20.00	7.76E-04
22.50	6.93E-04
25.00	6.25E-04
27.50	5.70E-04
30.00	5.23E-04
32.50	4.84E-04
35.00	4.50E-04
37.50	4.21E-04
40.00	3.95E-04
42.50	3.72E-04
45.00	3.52E-04
47.50	3.33E-04
50.00	3.17E-04

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		Naphthalene		from Level 1
Target Concentration	C_T	1.40E-01	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

	Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	1.00E-02	mg/l	
Half life for degradation of contaminant in water	$t_{1/2}$	9.00E+99	days	
Calculated decay rate	λ	7.70E-101	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	2.00E+01	m	
Plume thickness at source	Sy	5.00E-01	m	
Saturated aquifer thickness	da	5.00E-01	m	
Bulk density of aquifer materials	ρ	1.90E+00	g/cm^3	
Effective porosity of aquifer	n	3.30E-01	fraction	
Hydraulic gradient	i	4.00E-03	fraction	
Hydraulic conductivity of aquifer	K	8.60E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	9.02E+00	l/kg	*see options*
Longitudinal dispersivity	ax	2.98E+00	m	*see options*
Transverse dispersivity	az	2.98E-01	m	*see options*
Vertical dispersivity	ay	2.98E-02	m	*see options*

Dispersed plume thickness exceeds aquifer thickness! Reduce vertical dispersivity

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.04E-01	m/d
Retardation factor	Rf	5.29E+01	fraction
Decay rate used	λ	1.46E-102	d^{-1}
Rate of contaminant flow due to retardation	u	1.97E-03	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	2.12E-03	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**4.71E+00**	

Remedial Targets

Remedial Target		**6.59E-01**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**50**	**m**	
Concentration of contaminant at compliance point	**C_{ED}/C_0**	**2.12E-03**	**mg/l**	Ogata Banks
after		**1.0E+100**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

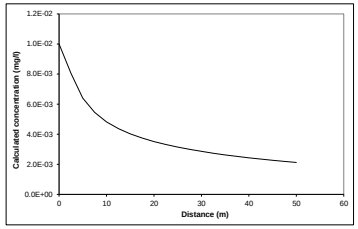
Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	7.00E-03	fraction
Organic carbon partition coefficient	Koc	1.29E+03	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	9.02E+00	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivity based on Xu & Eckstein (1995)

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	5.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	**az**	5.00E-01	5.00E-01	2.98E-01	m
Vertical dispersivity	**ay**	5.00E-04	5.00E-03	2.98E-02	

Note values of dispersivity must be > 0
For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x
Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	Greenhays Business Centre
Completed by:	Liz Hart
Date:	07 09 23
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	1.0E-02
2.5	8.05E-03
5.0	6.40E-03
7.5	5.45E-03
10.0	4.83E-03
12.5	4.37E-03
15.0	4.03E-03
17.5	3.75E-03
20.0	3.51E-03
22.5	3.32E-03
25.0	3.15E-03
27.5	3.00E-03
30.0	2.86E-03
32.5	2.74E-03
35.0	2.63E-03
37.5	2.53E-03
40.0	2.43E-03
42.5	2.35E-03
45.0	2.27E-03
47.5	2.19E-03
50.0	2.12E-03

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	**Greenhays Business Centre**			
Site Address:	**Greenhays Road, Manchester**			
Completed by:	**Liz Hart**			
Date:	**07 09 23**		**Version:**	**1**
Contaminant	**Toluene (C5-8)**			
Target Concentration (C_T)	**0.7**	**mg/l**	**Origin of C_T:**	**WHO Drinking water standard**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant		**Toluene (C5-8)**		
Target concentration	**C_T**	**0.7**	**mg/l**	

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	1.40E-01	fraction	
Air filled soil porosity	θa	1.40E-01	fraction	
Bulk density of soil zone material	ρ	1.90E+00	g/cm^3	
Henry's Law constant	H	2.21E-01	dimensionless	
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	7.00E-03	fraction	
Organic carbon partition coefficient	Koc	1.78E+02	l/kg	
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Soil water partition coefficient used in Level Assessment	**Kd**	**1.24E+00**	**l/kg**	*Calculated value*

Level 1 Remedial Target

Level 1 Remedial Target	**9.34E-01**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.7	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Greenhays Business Centre
Completed by:	Liz Hart
Date:	07 09 23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**Toluene (C5-8)**	from Level 1	This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).
Target concentration	**C_T**	**0.7** **mg/l**	from Level 1	

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	2.80E-04	m/d		
Area of contaminant source	A	1.13E+01	m^2		Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	4.50E+00	m		
Saturated aquifer thickness	da	5.00E-01	m		
Hydraulic Conductivity of aquifer in which dilution occurs	K	8.60E+00	m/d		
Hydraulic gradient of water table	i	4.00E-03	fraction		
Width of contaminant source perpendicular to groundwater flow	w	2.50E+00	m		Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Specify**			
Enter mixing zone thickness	Mz	5.00E-01	m		
Calculated mixing zone thickness	Mz		m		

Calculated Parameters

Dilution Factor	**DF**	**1.47E+01**		
Level 2 Remedial Target		**1.03E+01**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentra**
		or		
		1.37E+01	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	3.00E-03	mg/l	WS17a at 2.0m
Calculated concentration within receptor (dilution only)		2.05E-04	mg/l	0

Site being assessed:	Greenhays Business Centre
Completed by:	Liz Hart
Date:	07 09 23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters

	Variable	Value	Unit	Source
Contaminant		Toluene (C5-8)		from Level 1
Target Concentration	C_T	0.7	mg/l	from Level 1
Dilution Factor	DF	1.47E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		<0.01	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	1.00E+100	days	
Calculated decay rate	λ	6.93E-101	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	2.50E+00	m	from Level 2
Plume thickness in aquifer at source	Sy	5.00E-01	m	from Level 2
Bulk density of aquifer materials	ρ	1.90E+00	g/cm^3	
Effective porosity of aquifer	n	3.30E-01	fraction	
Hydraulic gradient	i	4.29E-03	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	8.60E+00	m/d	from Level 2
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.24E+00	l/kg	*see options*
Longitudinal dispersivity	ax	5.000	m	*see options*
Transverse dispersivity	az	0.500	m	*see options*
Vertical dispersivity	ay	0.050	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.12E-01	m/d
Retardation factor	Rf	8.17E+00	fraction
Decay rate used	λ	8.49E-102	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	4.29E-03	fraction
Rate of contaminant flow due to retardation	u	1.37E-02	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	2.48E-02	fraction
Attenuation factor (C_x/C_{efx})	**AF**	**4.03E+01**	**fraction**
Calculated soil leachate concentration	Co	#VALUE!	mg/l

Remedial Targets

Level 3 Remedial Target	**4.13E+02**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks	**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
	5.51E+02	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point	**50**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration C_{ED}/C_0	**2.48E-02**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc	7.00E-03	fraction
Organic carbon partition coefficient	Koc	1.78E+02	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.24E+00	l/kg

Define dispersivity (click brown cell and use pull down list)

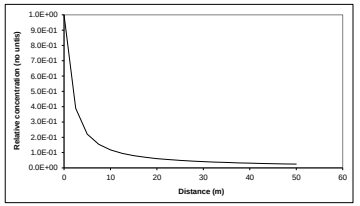
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	**az**	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	**ay**	0.00E+00	5.00E-02	2.98E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Greenhays Business Centre
Completed by:	Liz Hart
Date:	07 09 23
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	#VALUE!
2.5	3.90E-01	#VALUE!
5.0	2.21E-01	#VALUE!
7.5	1.54E-01	#VALUE!
10.0	1.18E-01	#VALUE!
12.5	9.54E-02	#VALUE!
15.0	8.02E-02	#VALUE!
17.5	6.92E-02	#VALUE!
20.0	6.08E-02	#VALUE!
22.5	5.43E-02	#VALUE!
25.0	4.90E-02	#VALUE!
27.5	4.46E-02	#VALUE!
30.0	4.10E-02	#VALUE!
32.5	3.79E-02	#VALUE!
35.0	3.53E-02	#VALUE!
37.5	3.30E-02	#VALUE!
40.0	3.09E-02	#VALUE!
42.5	2.91E-02	#VALUE!
45.0	2.75E-02	#VALUE!
47.5	2.61E-02	#VALUE!
50.0	2.48E-02	#VALUE!

Remedial Targets Worksheet , Release 3.2

Calculation of contaminant concentration in groundwater from a soil source

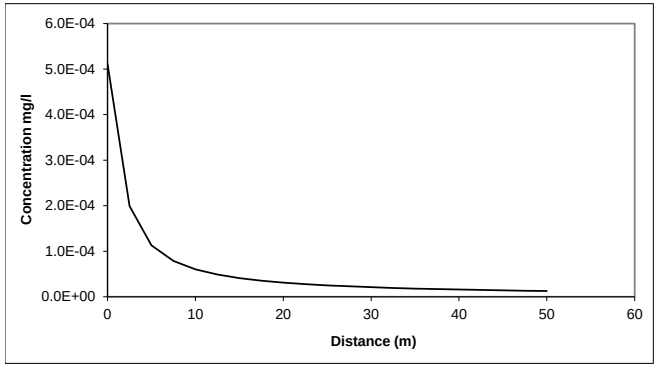
Only input required is Soil Contaminant Concentration

	Input Parameters			
	Soil contaminant concentration	C_0	1.00E-02	mg/kg
Level 1 Parameters				
	Water filled soil porosity	θ_w	1.40E-01	fraction
	Air filled soil porosity	θa	1.40E-01	fraction
	Bulk density	ρ	1.90E+00	g/cm^3
	Henry's Law constant	H	2.21E-01	dimensionless
	Soil water partition coefficient used in Level Assessment	Kd	1.24E+00	l/kg
	Factor (partitioning between soil and water)		1.33E+00	dimensionless
Level 2 Parameters	**Dilution Factor**	DF	1.47E+01	
Level 3 Parameters	**Attenuation factor (C_O/C_{ED})**	AF	4.03E+01	

Predicted concentrations at compliance point

Level 1	C	7.49E-03	mg/l	No dilution or attenuation
Level 2	C	5.11E-04	mg/l	Dilution taken into account
Level 3	C	1.27E-05	mg/l	Dilution and attenuation taken into account

Predicted concentrations between source and compliance point - Level 3



Distance m	Concentration mg/l
0.00	5.11E-04
2.50	1.99E-04
5.00	1.13E-04
7.50	7.85E-05
10.00	6.02E-05
12.50	4.88E-05
15.00	4.10E-05
17.50	3.54E-05
20.00	3.11E-05
22.50	2.78E-05
25.00	2.51E-05
27.50	2.28E-05
30.00	2.10E-05
32.50	1.94E-05
35.00	1.80E-05
37.50	1.69E-05
40.00	1.58E-05
42.50	1.49E-05
45.00	1.41E-05
47.50	1.34E-05
50.00	1.27E-05

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu) | Variable | Value | Unit | Source

Contaminant		Toluene (C5-8)		from Level 1
Target Concentration	C_T	7.00E-01	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	3.00E-03	mg/l	
Half life for degradation of contaminant in water	$t_{1/2}$	9.00E+99	days	
Calculated decay rate	λ	7.70E-101	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	2.00E+01	m	
Plume thickness at source	Sy	5.00E-01	m	
Saturated aquifer thickness	da	5.00E-01	m	
Bulk density of aquifer materials	ρ	1.90E+00	g/cm^3	
Effective porosity of aquifer	n	3.30E-01	fraction	
Hydraulic gradient	i	4.00E-03	fraction	
Hydraulic conductivity of aquifer	K	8.60E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.24E+00	l/kg	*see options*
Longitudinal dispersivity	ax	2.98E+00	m	*see options*
Transverse dispersivity	az	2.98E-01	m	*see options*
Vertical dispersivity	ay	2.98E-02	m	*see options*

Dispersed plume thickness exceeds aquifer thickness! Reduce vertical dispersivity

Calculated Parameters | Variable

Groundwater flow velocity	v	1.04E-01	m/d
Retardation factor	Rf	8.17E+00	fraction
Decay rate used	λ	9.43E-102	d^{-1}
Rate of contaminant flow due to retardation	u	1.28E-02	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	6.37E-04	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**4.71E+00**	

Remedial Targets

Remedial Target		**3.29E+00**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**50**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**6.37E-04**	**mg/l**	Ogata Banks
after		**1.0E+100**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

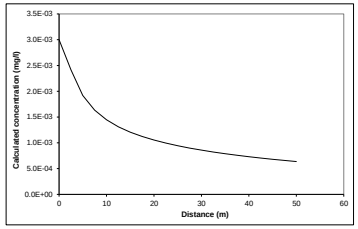
Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	7.00E-03	fraction
Organic carbon partition coefficient	Koc	1.78E+02	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.24E+00	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivity based on Xu & Eckstein (1995)

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	5.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	**az**	5.00E-01	5.00E-01	2.98E-01	m
Vertical dispersivity	**ay**	5.00E-04	5.00E-03	2.98E-02	

Note values of dispersivity must be > 0
For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x
Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	Greenhays Business Centre
Completed by:	Liz Hart
Date:	07 09 23
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	3.0E-03
2.5	2.41E-03
5.0	1.92E-03
7.5	1.64E-03
10.0	1.45E-03
12.5	1.31E-03
15.0	1.21E-03
17.5	1.12E-03
20.0	1.05E-03
22.5	9.95E-04
25.0	9.44E-04
27.5	8.99E-04
30.0	8.58E-04
32.5	8.22E-04
35.0	7.89E-04
37.5	7.58E-04
40.0	7.30E-04
42.5	7.05E-04
45.0	6.81E-04
47.5	6.58E-04
50.0	6.37E-04

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	**Greenhays Business Centre**			
Site Address:	**Greenhays Road, Manchester**			
Completed by:	**Liz Hart**			
Date:	**07 09 23**		**Version:**	**1**
Contaminant	**TPH Aromatic C10 -C12**			
Target Concentration (C_T)	**0.09**	**mg/l**	**Origin of C_T:**	**WHO Drinking water standard**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant		**TPH Aromatic C10 -C12**		
Target concentration	**C_T**	**0.09**	**mg/l**	
Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	1.40E-01	fraction	See table 4 of NX RA NX535, Sept '23
Air filled soil porosity	θa	1.40E-01	fraction	See table 4 of NX RA NX535, Sept '23
Bulk density of soil zone material	ρ	1.90E+00	g/cm^3	See table 4 of NX RA NX535, Sept '23
Henry's Law constant	H	4.90E-01	dimensionless	*See table 4 of NX RA NX535, Sept '23*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	7.00E-03	fraction	See table 4 of NX RA NX535, Sept '23
Organic carbon partition coefficient	Koc	2.51E+03	l/kg	*See table 4 of NX RA NX535, Sept '23*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**1.76E+01**	**l/kg**	*Calculated value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**1.59E+00**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.09	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Greenhays Business Centre
Completed by:	Liz Hart
Date:	07 09 23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**TPH Aromatic C10 -C12**	from Level 1	This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).
Target concentration	**C_T**	**0.09** **mg/l**	from Level 1	

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	2.80E-04	m/d	**See table 4 of NX RA NX535, Sept '23**	
Area of contaminant source	A	1.13E+01	m^2	**See table 4 of NX RA NX535, Sept '23**	Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	4.50E+00	m	**See table 4 of NX RA NX535, Sept '23**	
Saturated aquifer thickness	da	5.00E-01	m	**See table 4 of NX RA NX535, Sept '23**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	8.60E+00	m/d	**See table 4 of NX RA NX535, Sept '23**	
Hydraulic gradient of water table	i	4.00E-03	fraction	**See table 4 of NX RA NX535, Sept '23**	
Width of contaminant source perpendicular to groundwater flow	w	2.50E+00	m	**See table 4 of NX RA NX535, Sept '23**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l	**See table 4 of NX RA NX535, Sept '23**	
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Specify**			
Enter mixing zone thickness	Mz	5.00E-01	m		
Calculated mixing zone thickness	Mz		m		

Calculated Parameters

Dilution Factor	**DF**	**1.47E+01**		
Level 2 Remedial Target		**1.32E+00**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentra**
		or		
		2.33E+01	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	4.50E+00	mg/l	WS08 at 1.70m
Calculated concentration within receptor (dilution only)		3.07E-01	mg/l	0

Site being assessed:	Greenhays Business Centre
Completed by:	Liz Hart
Date:	07 09 23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Input Parameters	Variable	Value	Unit	Source
Contaminant		TPH Aromatic C10 -C12		from Level 1
Target Concentration	C_T	0.09	mg/l	from Level 1
Dilution Factor	DF	1.47E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		31	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	1.00E+100	days	*See table 4 of NX RA NX535, Sept '23*
Calculated decay rate	λ	6.93E-101	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	2.50E+00	m	from Level 2
Plume thickness in aquifer at source	Sy	5.00E-01	m	from Level 2
Bulk density of aquifer materials	ρ	1.90E+00	g/cm^3	*See table 4 of NX RA NX535, Sept '23*
Effective porosity of aquifer	n	3.30E-01	fraction	*See table 4 of NX RA NX535, Sept '23*
Hydraulic gradient	i	4.29E-03	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	8.60E+00	m/d	from Level 2
Distance to compliance point	x	5.00E+01	m	*See table 4 of NX RA NX535, Sept '23*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.76E+01	l/kg	*see options*
Longitudinal dispersivity	ax	2.984	m	*see options*
Transverse dispersivity	az	0.298	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	1.12E-01	m/d
Retardation factor	Rf	1.02E+02	fraction
Decay rate used	λ	6.78E-103	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	4.29E-03	fraction
Rate of contaminant flow due to retardation	u	1.09E-03	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	4.12E-02	fraction
Attenuation factor (C_T/C_{eff})	**AF**	**2.43E+01**	**fraction**
Calculated soil leachate concentration	Co	1.75E+00	mg/l

Remedial Targets

Level 3 Remedial Target	**3.20E+01**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks	**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
	5.66E+02	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point	**50**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration C_{ED}/C_0	**4.12E-02**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc	7.00E-03	fraction
Organic carbon partition coefficient	Koc	2.51E+03	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.76E+01	l/kg

Define dispersivity (click brown cell and use pull down list)

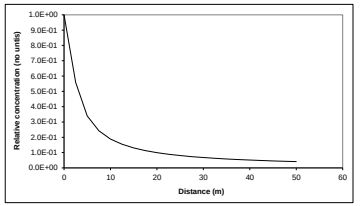
Dispersivity based on Xu & Eckstein (1995)

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	**az**	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	**ay**	0.00E+00	5.00E-02	2.98E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Greenhays Business Centre
Completed by:	Liz Hart
Date:	07 09 23
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	**1.0E+00**	**1.20E-01**
2.5	**5.58E-01**	**6.68E-02**
5.0	**3.40E-01**	**4.06E-02**
7.5	**2.43E-01**	**2.90E-02**
10.0	**1.89E-01**	**2.26E-02**
12.5	**1.54E-01**	**1.85E-02**
15.0	**1.30E-01**	**1.56E-02**
17.5	**1.13E-01**	**1.35E-02**
20.0	**9.97E-02**	**1.19E-02**
22.5	**8.92E-02**	**1.07E-02**
25.0	**8.06E-02**	**9.64E-03**
27.5	**7.36E-02**	**8.80E-03**
30.0	**6.77E-02**	**8.10E-03**
32.5	**6.27E-02**	**7.49E-03**
35.0	**5.83E-02**	**6.98E-03**
37.5	**5.46E-02**	**6.52E-03**
40.0	**5.12E-02**	**6.13E-03**
42.5	**4.83E-02**	**5.78E-03**
45.0	**4.57E-02**	**5.46E-03**
47.5	**4.33E-02**	**5.18E-03**
50.0	**4.12E-02**	**4.93E-03**

Remedial Targets Worksheet , Release 3.2

Calculation of contaminant concentration in groundwater from a soil source

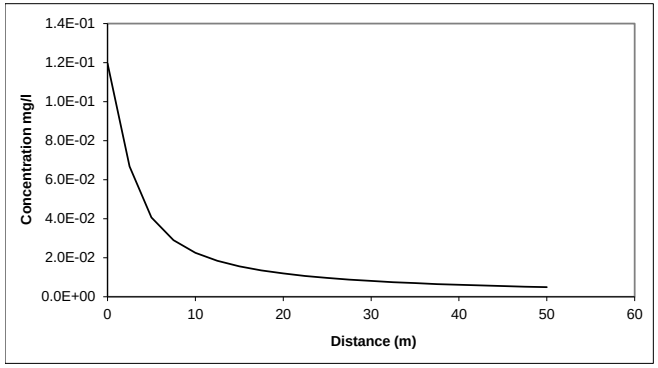
Only input required is Soil Contaminant Concentration

	Input Parameters			
	Soil contaminant concentration	C_0	3.10E+01	mg/kg
Level 1 Parameters				
	Water filled soil porosity	θ_w	1.40E-01	fraction
	Air filled soil porosity	θa	1.40E-01	fraction
	Bulk density	ρ	1.90E+00	g/cm^3
	Henry's Law constant	H	4.90E-01	dimensionless
	Soil water partition coefficient used in Level Assessment	Kd	1.76E+01	l/kg
	Factor (partitioning between soil and water)		1.77E+01	dimensionless
Level 2 Parameters	**Dilution Factor**	DF	1.47E+01	
Level 3 Parameters	**Attenuation factor (C_O/C_{ED})**	AF	2.43E+01	

Predicted concentrations at compliance point

Level 1	C	1.75E+00	mg/l	No dilution or attenuation
Level 2	C	1.20E-01	mg/l	Dilution taken into account
Level 3	C	4.93E-03	mg/l	Dilution and attenuation taken into account

Predicted concentrations between source and compliance point - Level 3



Distance m	Concentration mg/l
0.00	1.20E-01
2.50	6.68E-02
5.00	4.06E-02
7.50	2.90E-02
10.00	2.26E-02
12.50	1.85E-02
15.00	1.56E-02
17.50	1.35E-02
20.00	1.19E-02
22.50	1.07E-02
25.00	9.64E-03
27.50	8.80E-03
30.00	8.10E-03
32.50	7.49E-03
35.00	6.98E-03
37.50	6.52E-03
40.00	6.13E-03
42.50	5.78E-03
45.00	5.46E-03
47.50	5.18E-03
50.00	4.93E-03

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		TPH Aromatic C10 -C12		from Level 1
Target Concentration	C_T	9.00E-02	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	4.50E+00	mg/l	*See table 4 of NX RA NX535, Sept '23*
Half life for degradation of contaminant in water	$t_{1/2}$	9.00E+99	days	*See table 4 of NX RA NX535, Sept '23*
Calculated decay rate	λ	7.70E-101	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	2.00E+01	m	*See table 4 of NX RA NX535, Sept '23*
Plume thickness at source	Sy	5.00E-01	m	*See table 4 of NX RA NX535, Sept '23*
Saturated aquifer thickness	da	5.00E-01	m	*See table 4 of NX RA NX535, Sept '23*
Bulk density of aquifer materials	ρ	1.90E+00	g/cm^3	*See table 4 of NX RA NX535, Sept '23*
Effective porosity of aquifer	n	3.30E-01	fraction	*See table 4 of NX RA NX535, Sept '23*
Hydraulic gradient	i	4.00E-03	fraction	*See table 4 of NX RA NX535, Sept '23*
Hydraulic conductivity of aquifer	K	8.60E+00	m/d	*See table 4 of NX RA NX535, Sept '23*
Distance to compliance point	x	5.00E+01	m	*See table 4 of NX RA NX535, Sept '23*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	*See table 4 of NX RA NX535, Sept '23*
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	*See table 4 of NX RA NX535, Sept '23*
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.76E+01	l/kg	*see options*
Longitudinal dispersivity	ax	2.98E+00	m	*see options*
Transverse dispersivity	az	2.98E-01	m	*see options*
Vertical dispersivity	ay	2.98E-02	m	*see options*

Dispersed plume thickness exceeds aquifer thickness! Reduce vertical dispersivity

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.04E-01	m/d
Retardation factor	Rf	1.02E+02	fraction
Decay rate used	λ	7.53E-103	d^{-1}
Rate of contaminant flow due to retardation	u	1.02E-03	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	9.56E-01	mg/l
Attenuation factor (one way vertical dispersion, C0/CED)	**AF**	**4.71E+00**	

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	7.00E-03	fraction
Organic carbon partition coefficient	Koc	2.51E+03	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.76E+01	l/kg

Define dispersivity (click brown cell and use pull down list)

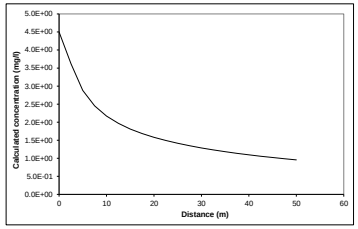
Dispersivity based on Xu & Eckstein (1995)

		Enter value	Calc value Xu & Eckstein		
Longitudinal dispersivity	**ax**	5.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	**az**	5.00E-01	5.00E-01	2.98E-01	m
Vertical dispersivity	**ay**	5.00E-04	5.00E-03	2.98E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	4.5E+00
2.5	3.62E+00
5.0	2.88E+00
7.5	2.45E+00
10.0	2.17E+00
12.5	1.97E+00
15.0	1.81E+00
17.5	1.69E+00
20.0	1.58E+00
22.5	1.49E+00
25.0	1.42E+00
27.5	1.35E+00
30.0	1.29E+00
32.5	1.23E+00
35.0	1.18E+00
37.5	1.14E+00
40.0	1.10E+00
42.5	1.06E+00
45.0	1.02E+00
47.5	9.87E-01
50.0	9.56E-01

Site being assessed:	Greenhays Business Centre
Completed by:	Liz Hart
Date:	07 09 23
Version:	1

Remedial Targets

Remedial Target		**4.24E-01**	**mg/l**
Ogata Banks			
Distance to compliance point		**50**	**m**
Concentration of contaminant at compliance point	C_{ED}/C_0	**9.56E-01**	**mg/l**
after		**1.0E+100**	**days**

For comparison with measured groundwater concentration.

Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	**Greenhays Business Centre**			
Site Address:	**Greenhays Road, Manchester**			
Completed by:	**Liz Hart**			
Date:	**07 09 23**		**Version:**	**1**
Contaminant	**TPH Aromatic C12-C16**			
Target Concentration (C_T)	**0.09**	**mg/l**	**Origin of C_T:**	**WHO Drinking water standard**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Environment Agency

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant		**TPH Aromatic C12-C16**		
Target concentration	**C_T**	**0.09**	**mg/l**	

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	1.40E-01	fraction	
Air filled soil porosity	θa	1.40E-01	fraction	
Bulk density of soil zone material	ρ	1.90E+00	g/cm^3	
Henry's Law constant	H	5.30E-02	dimensionless	
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	7.00E-03	fraction	
Organic carbon partition coefficient	Koc	5.01E+03	l/kg	
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	

Soil water partition coefficient used in Level Assessment	**Kd**	**3.51E+01**	**l/kg**	*Calculated value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**3.16E+00**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.09	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Greenhays Business Centre
Completed by:	Liz Hart
Date:	07 09 23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**TPH Aromatic C12-C16**	from Level 1	This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).
Target concentration	**C_T**	**0.09** **mg/l**	from Level 1	

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	2.80E-04	m/d		
Area of contaminant source	A	1.13E+01	m^2		Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	4.50E+00	m		
Saturated aquifer thickness	da	5.00E-01	m		
Hydraulic Conductivity of aquifer in which dilution occurs	K	8.60E+00	m/d		
Hydraulic gradient of water table	i	4.00E-03	fraction		
Width of contaminant source perpendicular to groundwater flow	w	2.50E+00	m		Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Specify**			
Enter mixing zone thickness	Mz	5.00E-01	m		
Calculated mixing zone thickness	Mz		m		

Calculated Parameters

Dilution Factor	**DF**	**1.47E+01**		
Level 2 Remedial Target		**1.32E+00**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentra**
		or		
		4.64E+01	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	4.90E+01	mg/l	WS08 at 1.70m
Calculated concentration within receptor (dilution only)		3.34E+00	mg/l	0

Site being assessed:	Greenhays Business Centre
Completed by:	Liz Hart
Date:	07 09 23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters

	Variable	Value	Unit	Source
Contaminant		TPH Aromatic C12-C16		from Level 1
Target Concentration	C_T	0.09	mg/l	from Level 1
Dilution Factor	DF	1.47E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		440	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	1.00E+100	days	
Calculated decay rate	λ	6.93E-101	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	2.50E+00	m	from Level 2
Plume thickness in aquifer at source	Sy	5.00E-01	m	from Level 2
Bulk density of aquifer materials	ρ	1.90E+00	g/cm^3	
Effective porosity of aquifer	n	3.30E-01	fraction	
Hydraulic gradient	i	4.29E-03	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	8.60E+00	m/d	from Level 2
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	3.51E+01	l/kg	*see options*
Longitudinal dispersivity	ax	2.984	m	*see options*
Transverse dispersivity	az	0.298	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.12E-01	m/d
Retardation factor	Rf	2.03E+02	fraction
Decay rate used	λ	3.41E-103	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	4.29E-03	fraction
Rate of contaminant flow due to retardation	u	5.51E-04	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	4.12E-02	fraction
Attenuation factor (C_T/C_{eff})	**AF**	**2.43E+01**	**fraction**
Calculated soil leachate concentration	Co	1.25E+01	mg/l

Remedial Targets

Level 3 Remedial Target	**3.20E+01**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks	**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
	1.12E+03	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point	**50**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration C_{ED}/C_0	**4.12E-02**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc	7.00E-03	fraction
Organic carbon partition coefficient	Koc	5.01E+03	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	3.51E+01	l/kg

Define dispersivity (click brown cell and use pull down list)

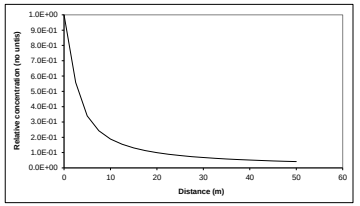
Dispersivity based on Xu & Eckstein (1995)

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	**az**	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	**ay**	0.00E+00	5.00E-02	2.98E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Greenhays Business Centre
Completed by:	Liz Hart
Date:	07 09 23
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	**1.0E+00**	**8.54E-01**
2.5	**5.58E-01**	**4.77E-01**
5.0	**3.40E-01**	**2.90E-01**
7.5	**2.43E-01**	**2.07E-01**
10.0	**1.89E-01**	**1.61E-01**
12.5	**1.54E-01**	**1.32E-01**
15.0	**1.30E-01**	**1.11E-01**
17.5	**1.13E-01**	**9.65E-02**
20.0	**9.97E-02**	**8.51E-02**
22.5	**8.92E-02**	**7.61E-02**
25.0	**8.06E-02**	**6.89E-02**
27.5	**7.36E-02**	**6.29E-02**
30.0	**6.77E-02**	**5.78E-02**
32.5	**6.27E-02**	**5.35E-02**
35.0	**5.83E-02**	**4.98E-02**
37.5	**5.46E-02**	**4.66E-02**
40.0	**5.12E-02**	**4.38E-02**
42.5	**4.83E-02**	**4.13E-02**
45.0	**4.57E-02**	**3.90E-02**
47.5	**4.33E-02**	**3.70E-02**
50.0	**4.12E-02**	**3.52E-02**

Remedial Targets Worksheet , Release 3.2

Calculation of contaminant concentration in groundwater from a soil source

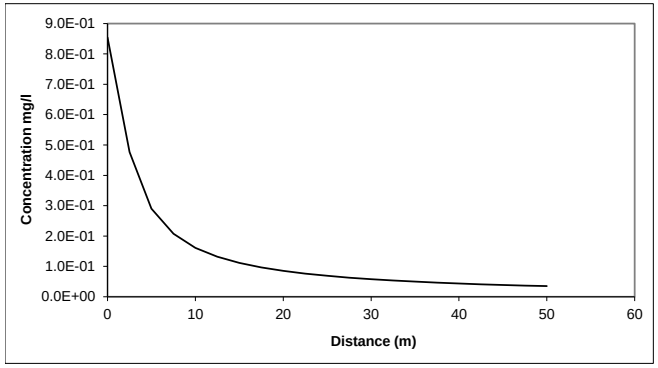
Only input required is Soil Contaminant Concentration

	Input Parameters			
	Soil contaminant concentration	C_0	4.40E+02	mg/kg
Level 1 Parameters				
	Water filled soil porosity	θ_w	1.40E-01	fraction
	Air filled soil porosity	θa	1.40E-01	fraction
	Bulk density	ρ	1.90E+00	g/cm^3
	Henry's Law constant	H	5.30E-02	dimensionless
	Soil water partition coefficient used in Level Assessment	Kd	3.51E+01	l/kg
	Factor (partitioning between soil and water)		3.52E+01	dimensionless
Level 2 Parameters	**Dilution Factor**	DF	1.47E+01	
Level 3 Parameters	**Attenuation factor (C_O/C_{ED})**	AF	2.43E+01	

Predicted concentrations at compliance point

Level 1	C	1.25E+01	mg/l	No dilution or attenuation
Level 2	C	8.54E-01	mg/l	Dilution taken into account
Level 3	C	3.52E-02	mg/l	Dilution and attenuation taken into account

Predicted concentrations between source and compliance point - Level 3



Distance m	Concentration mg/l
0.00	8.54E-01
2.50	4.77E-01
5.00	2.90E-01
7.50	2.07E-01
10.00	1.61E-01
12.50	1.32E-01
15.00	1.11E-01
17.50	9.65E-02
20.00	8.51E-02
22.50	7.61E-02
25.00	6.89E-02
27.50	6.29E-02
30.00	5.78E-02
32.50	5.35E-02
35.00	4.98E-02
37.50	4.66E-02
40.00	4.38E-02
42.50	4.13E-02
45.00	3.90E-02
47.50	3.70E-02
50.00	3.52E-02

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu) | Variable | Value | Unit | Source

Contaminant		TPH Aromatic C12-C16		from Level 1
Target Concentration	C_T	9.00E-02	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	4.90E+01	mg/l	
Half life for degradation of contaminant in water	$t_{1/2}$	9.00E+99	days	
Calculated decay rate	λ	7.70E-101	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	2.00E+01	m	
Plume thickness at source	Sy	5.00E-01	m	
Saturated aquifer thickness	da	5.00E-01	m	
Bulk density of aquifer materials	ρ	1.90E+00	g/cm^3	
Effective porosity of aquifer	n	3.30E-01	fraction	
Hydraulic gradient	i	4.00E-03	fraction	
Hydraulic conductivity of aquifer	K	8.60E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	3.51E+01	l/kg	*see options*
Longitudinal dispersivity	ax	2.98E+00	m	*see options*
Transverse dispersivity	az	2.98E-01	m	*see options*
Vertical dispersivity	ay	2.98E-02	m	*see options*

Dispersed plume thickness exceeds aquifer thickness! Reduce vertical dispersivity

Calculated Parameters | Variable

Groundwater flow velocity	v	1.04E-01	m/d
Retardation factor	Rf	2.03E+02	fraction
Decay rate used	λ	3.79E-103	d^{-1}
Rate of contaminant flow due to retardation	u	5.14E-04	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	1.04E+01	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**4.71E+00**	

Remedial Targets

Remedial Target		**4.24E-01**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**50**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**1.04E+01**	**mg/l**	Ogata Banks
after		**1.0E+100**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

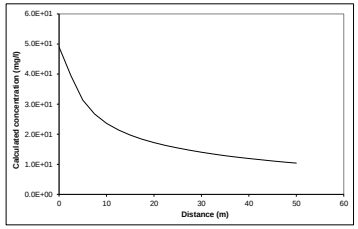
Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	7.00E-03	fraction
Organic carbon partition coefficient	Koc	5.01E+03	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	3.51E+01	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivity based on Xu & Eckstein (1995)

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	5.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	**az**	5.00E-01	5.00E-01	2.98E-01	m
Vertical dispersivity	**ay**	5.00E-04	5.00E-03	2.98E-02	

Note values of dispersivity must be > 0
For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x
Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	Greenhays Business Centre
Completed by:	Liz Hart
Date:	07 09 23
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	4.9E+01
2.5	3.94E+01
5.0	3.14E+01
7.5	2.67E+01
10.0	2.36E+01
12.5	2.14E+01
15.0	1.97E+01
17.5	1.84E+01
20.0	1.72E+01
22.5	1.63E+01
25.0	1.54E+01
27.5	1.47E+01
30.0	1.40E+01
32.5	1.34E+01
35.0	1.29E+01
37.5	1.24E+01
40.0	1.19E+01
42.5	1.15E+01
45.0	1.11E+01
47.5	1.08E+01
50.0	1.04E+01

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	**Greenhays Business Centre**			
Site Address:	**Greenhays Road, Manchester**			
Completed by:	**Liz Hart**			
Date:	**07 09 23**		**Version:**	**1**
Contaminant	**Xylenes (C8-10)**			
Target Concentration (C_T)	**0.5**	**mg/l**	**Origin of C_T:**	**WHO Drinking water standard**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant		**Xylenes (C8-10)**		
Target concentration	**C_T**	**0.5**	**mg/l**	

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	1.40E-01	fraction	
Air filled soil porosity	θa	1.40E-01	fraction	
Bulk density of soil zone material	ρ	1.90E+00	g/cm^3	
Henry's Law constant	H	2.16E-01	dimensionless	
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	7.00E-03	fraction	
Organic carbon partition coefficient	Koc	4.26E+02	l/kg	
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Soil water partition coefficient used in Level Assessment	**Kd**	**2.98E+00**	**l/kg**	*Calculated value*

Level 1 Remedial Target

Level 1 Remedial Target	**1.54E+00**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.5	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Greenhays Business Centre
Completed by:	Liz Hart
Date:	07 09 23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**Xylenes (C8-10)**	from Level 1	This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).
Target concentration	**C_T**	**0.5** **mg/l**	from Level 1	

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	2.80E-04	m/d		
Area of contaminant source	A	1.13E+01	m^2		Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	4.50E+00	m		
Saturated aquifer thickness	da	5.00E-01	m		
Hydraulic Conductivity of aquifer in which dilution occurs	K	8.60E+00	m/d		
Hydraulic gradient of water table	i	4.00E-03	fraction		
Width of contaminant source perpendicular to groundwater flow	w	2.50E+00	m		Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Specify**			
Enter mixing zone thickness	Mz	5.00E-01	m		
Calculated mixing zone thickness	Mz		m		

Calculated Parameters

Dilution Factor	**DF**	**1.47E+01**		
Level 2 Remedial Target		**7.33E+00**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentra**
		or		
		2.25E+01	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	1.20E-01	mg/l	WS17a at 2.0m
Calculated concentration within receptor (dilution only)		8.19E-03	mg/l	0

Site being assessed:	Greenhays Business Centre
Completed by:	Liz Hart
Date:	07 09 23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters

	Variable	Value	Unit	Source
Contaminant		Xylenes (C8-10)		from Level 1
Target Concentration	C_T	0.5	mg/l	from Level 1
Dilution Factor	DF	1.47E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		0.2	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	1.00E+100	days	
Calculated decay rate	λ	6.93E-101	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	2.50E+00	m	from Level 2
Plume thickness in aquifer at source	Sy	5.00E-01	m	from Level 2
Bulk density of aquifer materials	ρ	1.90E+00	g/cm^3	
Effective porosity of aquifer	n	3.30E-01	fraction	
Hydraulic gradient	i	4.29E-03	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	8.60E+00	m/d	from Level 2
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	2.98E+00	l/kg	*see options*
Longitudinal dispersivity	ax	5.000	m	*see options*
Transverse dispersivity	az	0.500	m	*see options*
Vertical dispersivity	ay	0.050	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.12E-01	m/d
Retardation factor	Rf	1.82E+01	fraction
Decay rate used	λ	3.81E-102	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	4.29E-03	fraction
Rate of contaminant flow due to retardation	u	6.16E-03	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	2.48E-02	fraction
Attenuation factor (C_T/C_{ETL})	**AF**	**4.03E+01**	**fraction**
Calculated soil leachate concentration	Co	6.51E-02	mg/l

Remedial Targets

Level 3 Remedial Target		**2.95E+02**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		9.06E+02	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**50**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**2.48E-02**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc	7.00E-03	fraction
Organic carbon partition coefficient	Koc	4.26E+02	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	2.98E+00	l/kg

Define dispersivity (click brown cell and use pull down list)

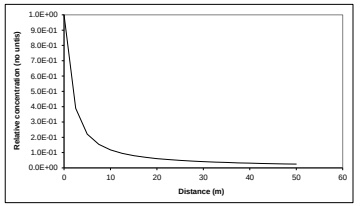
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	**az**	0.00E+00	5.00E-01	2.98E-01	m
Vertical dispersivity	**ay**	0.00E+00	5.00E-02	2.98E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Greenhays Business Centre
Completed by:	Liz Hart
Date:	07 09 23
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	4.44E-03
2.5	3.90E-01	1.73E-03
5.0	2.21E-01	9.80E-04
7.5	1.54E-01	6.82E-04
10.0	1.18E-01	5.23E-04
12.5	9.54E-02	4.24E-04
15.0	8.02E-02	3.56E-04
17.5	6.92E-02	3.08E-04
20.0	6.08E-02	2.70E-04
22.5	5.43E-02	2.41E-04
25.0	4.90E-02	2.18E-04
27.5	4.46E-02	1.98E-04
30.0	4.10E-02	1.82E-04
32.5	3.79E-02	1.69E-04
35.0	3.53E-02	1.57E-04
37.5	3.30E-02	1.46E-04
40.0	3.09E-02	1.37E-04
42.5	2.91E-02	1.30E-04
45.0	2.75E-02	1.22E-04
47.5	2.61E-02	1.16E-04
50.0	2.48E-02	1.10E-04

Remedial Targets Worksheet , Release 3.2

Calculation of contaminant concentration in groundwater from a soil source

Only input required is Soil Contaminant Concentration

Input Parameters			
Soil contaminant concentration	C_0	2.00E-01	mg/kg

Level 1 Parameters

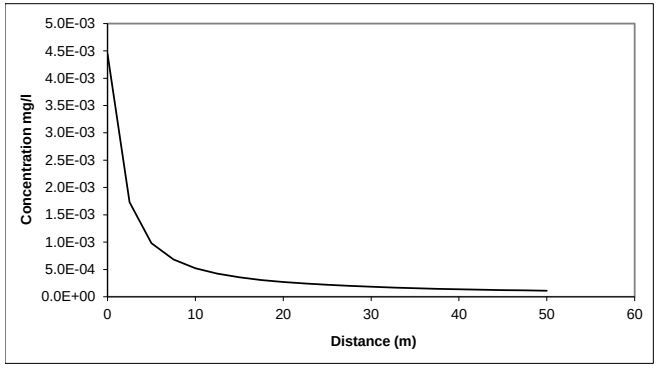
Water filled soil porosity	θ_w	1.40E-01	fraction
Air filled soil porosity	θa	1.40E-01	fraction
Bulk density	ρ	1.90E+00	g/cm^3
Henry's Law constant	H	2.16E-01	dimensionless
Soil water partition coefficient used in Level Assessment	Kd	2.98E+00	l/kg
Factor (partitioning between soil and water)		3.07E+00	dimensionless

Level 2 Parameters	**Dilution Factor**	DF	1.47E+01
Level 3 Parameters	**Attenuation factor (C_O/C_{ED})**	AF	4.03E+01

Predicted concentrations at compliance point

Level 1	C	6.51E-02	mg/l	No dilution or attenuation
Level 2	C	4.44E-03	mg/l	Dilution taken into account
Level 3	C	1.10E-04	mg/l	Dilution and attenuation taken into account

Predicted concentrations between source and compliance point - Level 3



Distance m	Concentration mg/l
0.00	4.44E-03
2.50	1.73E-03
5.00	9.80E-04
7.50	6.82E-04
10.00	5.23E-04
12.50	4.24E-04
15.00	3.56E-04
17.50	3.08E-04
20.00	2.70E-04
22.50	2.41E-04
25.00	2.18E-04
27.50	1.98E-04
30.00	1.82E-04
32.50	1.69E-04
35.00	1.57E-04
37.50	1.46E-04
40.00	1.37E-04
42.50	1.30E-04
45.00	1.22E-04
47.50	1.16E-04
50.00	1.10E-04

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		Xylenes (C8-10)		from Level 1
Target Concentration	C_T	5.00E-01	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	1.20E-01	mg/l	
Half life for degradation of contaminant in water	$t_{1/2}$	9.00E+99	days	
Calculated decay rate	λ	7.70E-101	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	2.00E+01	m	
Plume thickness at source	Sy	5.00E-01	m	
Saturated aquifer thickness	da	5.00E-01	m	
Bulk density of aquifer materials	ρ	1.90E+00	g/cm^3	
Effective porosity of aquifer	n	3.30E-01	fraction	
Hydraulic gradient	i	4.00E-03	fraction	
Hydraulic conductivity of aquifer	K	8.60E+00	m/d	
Distance to compliance point	x	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	2.98E+00	l/kg	*see options*
Longitudinal dispersivity	ax	2.98E+00	m	*see options*
Transverse dispersivity	az	2.98E-01	m	*see options*
Vertical dispersivity	ay	2.98E-02	m	*see options*

Dispersed plume thickness exceeds aquifer thickness! Reduce vertical dispersivity

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.04E-01	m/d
Retardation factor	Rf	1.82E+01	fraction
Decay rate used	λ	4.24E-102	d^{-1}
Rate of contaminant flow due to retardation	u	5.74E-03	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	2.55E-02	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**4.71E+00**	

Remedial Targets

Remedial Target		**2.35E+00**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**50**	**m**	
Concentration of contaminant at compliance point	**C_{ED}/C_0**	**2.55E-02**	**mg/l**	Ogata Banks
after		**1.0E+100**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

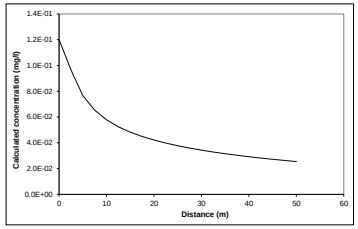
Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	7.00E-03	fraction
Organic carbon partition coefficient	Koc	4.26E+02	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	2.98E+00	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivity based on Xu & Eckstein (1995)

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	5.00E+00	5.00E+00	2.98E+00	m
Transverse dispersivity	**az**	5.00E-01	5.00E-01	2.98E-01	m
Vertical dispersivity	**ay**	5.00E-04	5.00E-03	2.98E-02	

Note values of dispersivity must be > 0
For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x
Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	Greenhays Business Centre
Completed by:	Liz Hart
Date:	07 09 23
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	1.2E-01
2.5	9.65E-02
5.0	7.68E-02
7.5	6.54E-02
10.0	5.79E-02
12.5	5.25E-02
15.0	4.83E-02
17.5	4.50E-02
20.0	4.22E-02
22.5	3.98E-02
25.0	3.78E-02
27.5	3.59E-02
30.0	3.43E-02
32.5	3.29E-02
35.0	3.15E-02
37.5	3.03E-02
40.0	2.92E-02
42.5	2.82E-02
45.0	2.72E-02
47.5	2.63E-02
50.0	2.55E-02