



Quakers Yard Gasworks: Geo-environmental detailed quantitative risk assessment

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Quakers Yard Gasworks: Geo-environmental detailed quantitative risk assessment

Client

Englobe Regeneration UK Ltd
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Drawings

P23545_R1_D01 Site Location

P23545_R1_D02 Location of historic Site areas



P23545_R1_D03 Exploratory locations

P23545_R1_D04 Conceptual Site model

P23545_R1_D05 Source Areas Plan

P23545_R1_D06 Borehole locations

Appendices

Appendix A: Report conditions

Appendix B: Historical exploratory hole logs

Appendix C: Chemical laboratory analysis summary

Appendix D: P20 spreadsheets

Appendix E: CIRIA 552 Risk matrix



Executive summary

Report context	This report has collated the available historical and contemporary data on soil and groundwater chemistry beneath the Site. This data has then been used to inform an assessment of potential risks posed to human health and the wider environment (as represented by controlled waters) by the soil and groundwater conditions that are present on the Site as a legacy of its former use as a gasworks
Report scope	This report has been compiled in order to: 1) Review the historical and newly collected soil and groundwater data; 2) Assess the data to provide an assessment of risk, including using Detailed Quantitative Risk Assessment (DQRA) techniques, 3) Inform the remediation strategy (being compiled by Englobe) This work is being undertaken in order that the Site can be rendered to pose an acceptably low risk to both human health and the wider environment such that it is a). suitable for use as a public open space (park) and b). demonstrated to not pose a statutory risk, including not falling under the definition of contaminated land under Part 2A of the Environmental Protection Act 1990.
Data review	Statistical analysis of soil data and Site observations of visual and olfactory contamination leads to the conclusion that two areas of the Site are potential sources of contamination that should be assessed separately from the rest of the Site. These are source area A which comprises Gasholders No.1 and No.2 and source area B which comprises former gas process work areas across the centre of the Site. The remainder of the Site, source area C, also contains asbestos that is of potential concern with respect to human health.
Conceptual site model	<u>Environmental receptors</u> The Bargoed Taff River which borders the Site likely receives water from groundwater flow as well as the spring which runs across the north of the Site, making it a critical receptor with respect to controlled waters and environment. Groundwater within the Made Ground, superficial deposits and bedrock is likely in hydraulic connectivity meaning it is possible that contamination is migrating into the wider aquifer. <u>Human health (on Site):</u> Current and future Site users have been assessed as potential sensitive receptors associated with GAC exceedances and asbestos in soils. <u>Off Site:</u> Nearby residential properties to the north-west (Treharris), south-west and south (Quaker's Yard) are assessed as being at very low risk of dust and



Source Area A	vapour phase within the shallow unsaturated zone, due to groundwater flow being in the opposite direction and the presence of both a horizontal and vertical separation between the Site and residential properties.
	The results of the DQRA indicates that this area (>5m from river) has concentrations of free cyanide, total cyanide, ammoniacal nitrogen NH ₄ , anthracene, fluoranthene, naphthalene, benzene, aromatic EC5-EC7 and aromatic EC10-EC12 in soils that pose a potentially unacceptable risk to the wider environment.
	Statistical analysis suggests PAHs, TPHs, cyanides, lead, mercury, selected SVOCs/VOCs and asbestos in soils may pose an unacceptable risk to public open space (park) users.
Source Area B	The results of the DQRA indicates that this area (>5m from river) has concentrations of free cyanide, total cyanide, ammoniacal nitrogen NH ₄ , anthracene, fluoranthene, naphthalene, benzene and aromatic EC10-EC12 in soils that pose a potentially unacceptable risk to the wider environment.
	Statistical analysis suggests benzo(b)fluoranthene, benzo(a)pyrene, dibenzo(ah)anthracene, complex cyanide and asbestos in soils may pose an unacceptable risk to public open space (park) users.
Source Area C	The results of the DQRA indicates that this area (>5m from river) has concentrations of free cyanide, total cyanide and fluoranthene in soils that pose a potentially unacceptable risk to the wider environment.
	Asbestos in soils may pose an unacceptable risk to public open space (park) users.
Conclusions	Remediation is required to address the following:
	• To manage the risks posed to current/ future Site users (in a public open space scenario) by shallow Site soils; • To reduce contaminant concentrations in soils in source areas A and B to acceptably low concentrations as to not pose significant risk to the Bargoed Taff river. RTVs have been calculated herein to inform that process; • To isolate the spring and its drainage channel from the Site soils, and; • To create an engineered riverbank of materials in accordance with RTVs derived herein.



1 Introduction

1.1 Instruction

Yellow Sub Geo Ltd (Yellow Sub) was instructed by Englobe Regeneration UK Ltd (Englobe; the Client) to provide a technical geo-environmental risk-based report for the former gasworks at Quakers Yard, Treharris (the Site). This work is to be used by the Client to underpin their proposed Remediation Implementation Plan (RIP) and is to form part of the technical documentation to be submitted in support of a planning application to undertake said remediation works.

Instruction to proceed in accordance to our proposal (Ref: P23545_P1) was received via email from the Client dated 7th February 2023.

1.2 Brief

The Client has been appointed by Wales & West Utilities (WWU) to undertake remediation works on the Site with the objective of returning the Site to a public open space with a cycle path. Once remediated, the current expectation is that the Site may be transferred to the Local Authority. Remediation will include the removal/ treatment of identified accessible “gross” contamination.

“Gross” contamination being defined as zones of continuous free phase (usually tar), which in the judgement of an experienced professional, has conceptual logic for being continuous at a scale which makes it a source that is identified on the Conceptual Site Model (e.g. a pipe run, tank base, pocket or lenses of granular material) and a soil type that has the visual appearance of spent oxide (both colour and/ or texture).

The ground conditions beneath Site have been previously subject to two Site investigations by Advisian in 2015 and 2016, as well as groundwater and surface water monitoring between 2017 and 2022. The brief provided to Yellow Sub was to collate from these reports the available factual geo-environmental information pertaining to the Site and use these data, together with new data collected by the Client, to create a risk-based assessment of soil and groundwater conditions in order to underpin the Client’s remediation strategy and in order to satisfy planning requirements.

1.3 Scope

This current work builds upon the pre-existing factual reports by Advisian. In addition, the Client has collected additional soil, groundwater and surface water data, has undertaken a process of remediation options appraisal and has compiled a remediation strategy to address the brief provided to them by WWU, building on and drafted in tandem with this report.

This report provides a technical assessment of available soil, groundwater and vapour chemistry data with respect to potential risks to human health and the wider environment. It has been written in accordance with the UK Government’s Land Contamination Risk Management guidance (LCRM), focussing on the assessment of potential statutory risk under Part 2A of the Environmental Protection Act 1990 as enacted by the Environment Act 1995 (Part 2A). LCRM defines possible receptors under Part 2A to include human health, controlled waters, organisms



and ecosystems. This report uses the term “wider environment” to encapsulate those potential receptors not associated with human health.

This report defines a conceptual site model and a source-pathway-receptor pollutant linkage approach to determine the potential for unacceptable risk. It culminates in recommendations as to how the results of this assessment relate to the remediation options appraisal and strategy process.

In order to assess the potential risk to both human health and the wider environment, a generic quantitative risk assessment (GQRA) was first undertaken, comparing data on soils and groundwater gathered on the site with published “safe” values. This identified a number of contaminants of potential concern (CoPCs) which were then carried forward for more detailed assessment, including a detailed quantitative risk assessment (DQRA) process. This is, in essence, a computer simulation of the movement of contaminants along pathways in the ground between a source (e.g. tank holder bases) and a receptor (e.g. the nearest watercourse). The modelling describes how much of the contamination present at the source is likely to reach the receptor (as some of it will decompose and become diluted enroute). This modelling is used in the first instance to quantify the potential risk to the critical receptor (statutory risk), and secondarily can be used to define the quality standards required to be achieved at the source through remediation (which in-turn enables data supported consideration of remedial options).

Following collation of the groundwater and soil chemistry data, key steps in the assessment process are:

- development of a conceptual site model (CSM), providing coherent representation of the ground and groundwater conditions beneath the Site;
- assess soil, groundwater and vapour conditions with respect to potential risk to human health;
- assess soil and groundwater conditions with respect to potential risk to the wider environment, and,
- detailed quantitative risk assessment (DQRA) to controlled waters.

1.4 Report conditions

This document relies on data collected by third parties, partly by the Client and partly as part of the previous works. In order to fulfil the brief for this report, data (in the form of plans, drawings, engineering logs, laboratory testing results) has been reproduced verbatim in the report in good faith of its accuracy and efficacy. Where considered salient, factual data from previous reports has been reproduced in the appendices to this report. Whilst a commentary is provided on the quality and validity of data, where considered prudent, Yellow Sub can accept no responsibility for any works undertaken by third parties.

This report is written strictly for the benefit of the Client and bound by the conditions presented in Appendix A.



2 Site Information

2.1 Site location

The Site is located off Mill Street, Quakers Yard, Treharris, CF46 5AG. National Grid Reference at the centre of Site is ST 09830 96669. The Site is roughly rectangular in shape, covering an area of approximately 0.55 hectares. Drawing P23545_R1_DO1 details the Site location.

2.2 Site description

The Site currently comprises a vacant and unsecured area of woodland with a public cycle path running through the northeast of the Site. The Site is gently sloping, with ground elevations ranging from 105m above Ordnance Datum (m aOD) in the north of the Site to 98m aOD in the south of the Site.

The south-eastern boundary of the Site forms the riverbank of the Bargoed Taff river. The riverbank itself is a mixture of derelict stone wall, areas of collapsed walling and earth banks. The Site lies on the outside of a bend in the river, with the higher energy, erosive section of the channel typically nearest to the Site. This has resulted in the erosion of the former stone walled riverbank in the decades since the Site was last occupied, leading to the broken walling and informal nature of the bank that is now present.

On the opposite side of the Site to the river, the north-western Site boundary is marked by the base of a steep, wooded slope. This wooded slope is retained by derelict stone walling in some places, but is largely an earth slope occupied by mature woodland. Four springs issue from the base of the steep slope on the Site's north-western boundary. The flow from these have been captured in a shallow unlined ditch and flow, within a shallow unlined channel, across the surface of the ground in the northeast of the Site, in a south westerly direction across the Site. The water then discharges over the bank of the river into the Bargoed Taff River.

Surrounding land use includes both public open space and residential, this is summarised in Table 2-1.

Table 2-1 Adjacent land use summary

Boundary	Land use
North-western	The area directly northwest of the Site is woodland. However, a housing estate lies north of this, with houses on Thornworld Place located from approximately 70m from the Site boundary. There is a significant elevation rise with the residential properties being some 20m higher than the Site.
North-eastern	The area northeast of the Site comprises woodland with a cycle path running through it.
South-eastern	The Bargoed Taff River marks the south-eastern boundary of the Site with Mill Street running parallel to the river on its opposite bank. The land on the far side of Mill Street is occupied by woodland opposite the north of the Site and occupied by barn/ stable buildings, sheds and animal enclosures



Boundary	Land use
	opposite the south of the Site. Towards the Sites south-western end, Mill Street diverges from the riverbank. The triangular piece of land that lies between the two is also occupied by a series of stables and animal enclosures. A small footbridge connects Mill Street to the Site.
South-western	The Site is bordered by woodland.

2.3 Site walkover

The Site was visited on 7th March 2023. It was viewed from the public cycle path and from the riverbank. The entire Site area was covered in woodland, much of which had been removed as part of recent vegetation removal works by an external contractor, unrelated to the Clients work. As a result, the majority of the site was covered with tree stumps and associated brash.

The Site elevation is some 2 metres or so above the riverbed level, and the Site slopes slightly both towards the river to the south-east, and also towards the downstream end to the south-west. The cycle path crosses the bridge over the Bargoed Taff river and enters the Site approximately one third of the way along its south-eastern boundary heading upstream. The path itself is covered in asphalt surfacing. Ground surface elsewhere is bare earth with vegetation.

The riverbank that forms the south-eastern Site boundary has exposed areas of riverbed/ pebble beach in places. Relic walls associated with the former use as a gasworks could be seen along the riverbank, particularly in the stretch to the north of the bridge. Some of these structures appear to be relics of a former river wall. Others may be associated with the gasholders. In some places, the river has eroded and removed the former river wall, with the course of the river now further north-west than is shown on most historical site plans.

Relic stone structures can also be seen to the north-west of the cycle path, in the area of former retort house and associated structures.

The ground rises rapidly from the Site's north-western boundary and a series of springs can be seen emanating from the ground in the north-eastern end of this boundary. The water flowing from these springs is captured in a single channel, which flows beneath the cycle path in a small piped culvert, before flowing over the ground surface in the area of Gasholder No. 1. It can be seen flowing into the river at the Site's south-eastern boundary, upstream of the bridge.

Visual evidence of contamination was noted during the walkover, comprising of a small ochreous and oily seep in the riverbed immediately upstream of the bridge, and of ashy made ground exposed in the riverbank in places. No olfactory evidence of contamination was encountered, possibly due to the prevailing high-pressure atmospheric conditions. Although, the Site walkover completed by Advisian in 2015 described the presence of a gasworks odour.

2.4 Current and future Site use

It is understood that the Client's brief is to remediate the Site as such that it is suitable to be returned to a public open space upon completion of the works. This public open space is to comprise reinstatement of the current cycle path, with land on either side of it being returned to



woodland. It is understood that Englobe's intended scope of works on the Site broadly comprises:

- Stabilisation of the contents of Gasholders No. 1 and 2;
- Turnover of the central portion of the Site, segregation and stabilisation of grossly impacted material, and placement of this within Gasholders No. 1 & 2. Replacement of non-impacted soils from whence excavated;
- Stabilisation of the riverbank using Site-won material and vegetation; and,
- Use of Site-won crushed aggregate and Site-won soils to provide a suitable cover where necessary.

We expect that, in addition to the above, it will be necessary to create a permanent lined channel within which the spring water can flow across the Site without interacting with the underlying soils.

2.5 History

Earliest Ordnance Survey (OS) mapping (1877) shows the Site to be vacant land surrounded by woodland. By 1900, the northern half of the Site had been developed into a gasworks comprising two below ground gasholders (Gasholders No.1 and No.2) and a number of unspecified buildings/ ancillary structures along the western Site boundary. Access to the newly developed Site was enabled via a new bridge over the Bargoed Taff River.

Gasholder No.3, an above ground gasholder with a capacity of 80,000ft³, was constructed in the southwest of the Site in circa 1919. Several other small buildings and ancillary structures were also added to the centre of the Site during this period.

The earliest available Site plan from Wales Gas Board, believed to be dated between the 1930s and 1940s, shows Gasholders No.1 and No.2 to be disused, with Gasholder No.1 being used as a tar well. The plan identifies a meter house and purifiers (towards the north of the Site between Gasholders No.1 and No.2) and an exhaustor house, disused retort house, Tully Gas Plant/ mess room and volumetric governor house (at the centre of the Site). By the early 1950's Gasholder No.1 was no longer shown on maps and by 1958, only Gasholder No.3, along with a collection of small buildings at the centre of the Site, remained. Gasholder No.3 was removed circa 1976, leaving 5 small buildings which have since been demolished.

A summary of the previous process areas is provided as annotations to the Site plan in Drawing P23545_R1_D02.

2.6 Geology

British Geological Survey (BGS) mapping (1:50,000 Sheet 249, 1997) details the geology beneath the Site as:

- Superficial: Alluvium (clay, silt, sand and gravel) and Till (diamicton); and,
- Bedrock: Hughes Member – Sandstone (Carboniferous) which is described by the BGS as green-grey lithic arenites with thin mudstone/siltstone and seat earth interbeds.

The geology is discussed in more detail in Section 3.2.



2.6.1 Coal Mining

A non-residential Coal Authority Mining Report was obtained by Advisian in June 2015 for the Site. Notably, the Site lies within the zone of influence of 4No, worked coal seams, all at significant depth (between 580m and 720m below ground level (mbgl)). These were last worked in 1989 and as such the Coal Authority expect any resultant ground movement to have now ceased.

2.7 Hydrology

The Bargoed Taff River flows along the south-eastern boundary of the Site, towards its confluence with the River Taff approximately 190m southwest of the Site. The Bargoed Taff River lies within the larger Berthlwyd Site of Importance for Nature Conservation (SINC).

Four springs issue from the base of the steep slope on the Site's north-western boundary. These then flow across the surface of the ground in the northeast of the Site, in a south westerly direction through the area of the former purifiers, retort house and Gasholder No.2. To facilitate the 2016 Site investigation, this spring was channelized and culverted, using pre-existing drainage, beneath the cycle path and over the former Gasholder No.1. This channel is unlined. The spring joins the Bargoed Taff directly south of the former Gasholder No.1. A steady but small flow of water could be seen flowing into the river here during the Site walkover and river gauging undertaken on 7th March 2023. The spring is shown on drawing P23545_R1_DO2.

The Environmental database report procured by Advisian does not identify any surface water or groundwater abstractions within the vicinity of the Site.

The river immediately upstream of the site is in a largely natural channel, with no known channel modifications/ weirs etc. A series of weirs are present on the river within the Taff Bargoed Country Park some 1.2km upstream of the Site. This is a static weir, and as such any affect it has on river flow will be consistent at each stage of river flow.

2.7.1 River flow

A flow gauging exercise was undertaken on 7th March 2023 in order to provide an indication of the volumetric flow on the Bargoed Taff. The gauging was undertaken on a transect along a line perpendicular to river flow, at a point approximately 20m downstream of the north-eastern Site boundary. This point was chosen as the presence of a stone wall on the Site's riverbank provided a good channel morphology from which to calculate geometry and therefore flow. The river channel was walked to observe potential inflows visible on either bank and none were observed between the point of the transect and the north-eastern Site boundary. The flow as measured was therefore considered representative of the flow entering the reach adjacent to the Site. Flow was seen to be entering the river from channel draining the springs (see above), with the point of confluence for this being approximately 30m downstream of the transect.

A spot flow measurement was taken every 0.1 m across the channel, using a Valeport BFM001 handheld flow meter. These flow readings were then used to calculate the volumetric flow for the river. As a result, the river flow between 14:50 and 15:50 on 7th March 2023 was determined to be 266 litres per second (l/s), or 0.266 cubic metres per second (m³/sec).



There is no gauging station on the Bargoed Taff. The nearest gauging station to the Site is on the River Taff at Fiddlers Elbow. This is downstream of the confluence of the Bargoed Taff, and upstream of the next significant tributary of the River Taff, the River Cynon. Flow data is available from the National River Flow Archives (NRFA) for a continuous monitoring period from 1973 to 2021. The relative catchment sizes of the River Taff at Fiddlers Elbow and of the Bargoed Taff at its confluence with the Taff have been used to provide an estimate for the river flow of the Bargoed Taff as follows:

The relative catchment sizes are 194.5 km² for the River Taff at Fiddlers Elbow¹ and 34.2 km² for the Bargoed Taff² which provides a ratio between the two of 0.18 (i.e. the Bargoed Taff catchment comprises 18% of the total catchment of the River Taff at Fiddlers Elbow). If it is assumed that rainfall and runoff occurs at a constant rate across the entire catchment, it can be assumed that the Bargoed Taff also contributes 18% of the flow to the River Taff at the same point. This crude relationship has been used to provide an indicative range of flows for the Bargoed Taff, by extrapolation from the NRFA data for the River Taff at Fiddlers Elbow, as summarised in the following table:

Table 2-2: Extrapolation of river flow data

	River Taff at Fiddlers Elbow*	Bargoed Taff at confluence with River Taff**	Catchment area ratio
Catchment size (km ²)	194.5	34.2	0.18
Q95 flow (m ³ /sec)	1.4	0.25	
Q50 flow (m ³ /sec)	3.49	0.6	
Q30 flow (m ³ /sec)	16.8	3.0	

* Area taken as defined by NRW for the river gauging station

** Area taken as defined by NRW in WFD catchment delineation

This places the flow as measured on 7th March 2023 as being approximately at the Q95 flow, which is generally taken as indicative of low-flow conditions. This is consistent with the preceding weather conditions, with a period of dry weather having been antecedent to the gauging.

¹ NRFA Station data for the River Taff at Fiddlers Elbow.

<https://nrfa.ceh.ac.uk/data/station/info/57007> accessed 20th March 2023.

² As defined by NRW Water Framework Directive River Waterbody Catchments boundaries.

https://datamap.gov.wales/layers/geonode:nrw_wfd_river_waterbody_catchments_c2 accessed 20th March 2023.



2.7.2 River chemistry

National Resources Wales (NRW) assessed the watercourse to be of moderate status overall and high quality with respect to ammonia, dissolved oxygen, pH and phosphorus.³

2.8 Hydrogeology

The bedrock beneath the Site (Hughes Member) and the superficial Alluvium deposits are each classified by NRW as Secondary A aquifers (permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers). The superficial Glacial Till is classed as unproductive strata.

The Secondary A Aquifer forms part of the larger South East Valleys Carboniferous Coal Measures under the Water Framework Directive, which was classified by NRW as being of poor status in 2021.

The Site does not lie within a groundwater source protection zone and there are no records relating to groundwater abstractions, however unlicensed private water supplies (generally <20m³) may exist.

It is not known whether the sequence of springs emanating from the base of the slope along the Site's north-western boundary are representative of the groundwater elevation within the sandstone bedrock in this location, or whether they are related to shallow groundwater bodies within the superficial deposits. The presence of flow during the Site walkover on 7th March, at a time when the Bargoed Taff was at near low-flow conditions, suggests a degree of groundwater storage that may be more attributable to a larger, bedrock aquifer. It is possible that the spring line relates to a change in permeability of the bedrock strata, with more permeable sandstone-dominated beds above, and less-permeable, mudstone beds beneath. This possible hydrogeological control is illustrated in Drawing P23545_R1_D04, but there is insufficient available information on the geology beneath the slope north of the Site to confirm whether this is indeed the case.

³ Water Watch Wales website, accessed May 2023.
<https://waterwatchwales.naturalresourceswales.gov.uk/en/>



3 Summary of previous works

3.1 Fieldwork and available data

Several phases of ground investigations have targeted the Site to date, two in 2015 and 2016 by Advisian, and most recently in 2022 by Englobe. Advisian also collected groundwater and surface water samples between March 2017 and March 2022. Data collected and work undertaken in each of these phases are summarised below. All exploratory positions associated with these works are presented in P23545_R1_DO3 and just boreholes are presented in P23545_R1_DO6. Exploratory logs are presented in Appendix B and chemical laboratory results are presented in Appendix C.

3.1.1 Advisian 2015

Site work was carried out between November and December 2015 and included the excavation of 27No. hand pits to a maximum depth of 1.3m bgl, 3No. rounds of outdoor vapour monitoring, 2No. rounds of surface water monitoring, a riverbank stability assessment and a geophysical survey of the Site. The full factual report (Document No. 305001-00009 51810-01) was provided to Yellow Sub. Soil, vapour and surface water samples underwent chemical analysis, these laboratory results, along with exploratory logs for the hand pits are provided as appendices.

3.1.2 Advisian 2016

Site work was carried out in July 2016 and included the excavation of 26No. trial pits to maximum depth of 4.1m bgl, drilling of 14No. boreholes to a maximum depth of 10m bgl and 4No. hand pits to a maximum depth of 1.15m bgl. 8No. boreholes were installed as monitoring wells within the superficial deposits, 3No. within the Made Ground and 1No. in the bedrock. MW16-07 and MW16-10A were not installed. Four rounds of groundwater and surface water monitoring were completed between July and September 2016, as well as in-situ permeability testing on two of these occasions. In addition, minor drainage works were undertaken, where a spring issuing across of the Site was channelised and diverted towards pre-existing drainage beneath the cycle path. The full factual report (Document No. 305001-00009 51810-02) was provided to Yellow Sub. Laboratory soil, groundwater and surface water results, exploratory logs, groundwater monitoring data and results of in-situ permeability testing were also provided.

3.1.3 Advisian 2017-2022

Between March 2017 and March 2022, over the course of 10No. visits, Advisian collected surface water and groundwater samples from the wells previously installed. The chemical laboratory results and records of groundwater elevation were provided to Yellow Sub.

3.1.4 Englobe 2022

The Client undertook an intrusive ground investigation in November 2022 comprising 4No. boreholes to a maximum depth of 13m bgl and 5No. trial pits to a maximum depth of 2.6m bgl. The four boreholes were installed as monitoring wells, all of which are screened against the



bedrock. Groundwater and surface water samples and groundwater monitoring data were collected in a return visit in November 2022. Further groundwater monitoring data was then collected during a January 2023 visit. Exploratory logs and the chemical laboratory results were provided to Yellow Sub.

3.2 Summary of ground conditions encountered by previous works

3.2.1 Made Ground

Made Ground was encountered in all exploratory positions across the Site to a maximum depth of 5.1m bgl in MW16-13 within the footprint of Gasholder No.2. Made Ground was typically deepest within former structures however the proven thickness across the entire Site ranges between 0.7m and 5.1m bgl. The Made Ground composition across Site is variable with descriptions ranging from a gravel to a silty, sandy, gravelly clay. Although it is most commonly recorded as a sandy gravel. The gravel typically comprised brick, concrete, clinker, sandstone and limestone with occasional asphalt, mudstone and coal. Occasional cobbles and boulders of concrete and sandstone were noted in some localities. Various anthropogenic inclusions were encountered including plastic (fragments, sheeting and pipes), metal (scraps, offcuts of pipes and wire mesh), wood fragments and glass (bottle and fragments). Various visual and olfactory signs of contamination were observed throughout the Made Ground as discussed in detail in Section 3.5.

Perched groundwater was encountered within the Made Ground in several exploratory positions from as shallow as 0.2m bgl (HP15-08).

3.2.2 Superficial deposits

Previous reports do not distinguish between the Alluvium and Glacial Till. Superficial deposits are encountered at depths of between 0.75m and 3.3m bgl. The proven thickness ranges from 5m (BH3 and BH4) to 9.5m (BH1A). Superficial deposits vary in composition across Site, with descriptions ranging from a sandy clay to boulders of sandstone and limestone, although they are most frequently described as a sandy gravel. Cobbles and boulders of sandstone and limestone are common and become increasingly so with depth. Some visual and olfactory signs of contamination were observed within the superficial deposits as discussed in detail in Section 3.5.

3.2.3 Bedrock

Bedrock has been previously encountered on Site in 6No. exploratory positions and is described as either as a greyish brown, heavily fractured, weathered, fine grained sandstone (MW16-12, MW16-06, BH3 and BH2) or a dark grey cohesive mudstone (BH1A, BH3, BH4). Rockhead is encountered at depths of between 3.7m and 11m bgl. In BH3, the boundary between the sandstone and mudstone is encountered at 9.5m bgl, making the sandstone 1.2m thick. This was not proven in any other exploratory positions. No visual or olfactory evidence of contamination was recorded within the bedrock.



3.2.4 Obstructions and buried infrastructure

Typically, former gasworks contain a significant amount of in-ground obstructions associated with the foundations of previous structures, and basements and underground aspects of the operational equipment. Gasholders, particularly older gasholders such as were present on this Site, were typically below-ground structures, extending several metres below ground level. Obstructions encountered in previous Site investigations are summarised in Table 3-1 below.

The concrete bases of Gasholders No. 2 and No. 3 have been proven to be at 4.9m to 5.1m bgl and 0.8m to 1.3m bgl respectively. The base of Gasholder No.1 has not been proven but is likely at 3.8m bgl, based on a refusal within MW16-09.

In addition to the gasholders, various structures were encountered, including those likely associated with the Tully gas plant/mess room, volumetric governor house, meter house, retort house and exhaustor house.

Table 3-1 Buried structures and obstructions from previous site investigations.

Exploratory position	Depth (m bgl)	Obstruction details	Likely associated structure
Centre of the Site			
HP15-01	0.95	Unidentified obstruction.	Tully Gas plant/ mess room
TP16-19	0.9-1.0	Brick wall and concrete.	Tully Gas plant/ mess room
HP15-02	0.35	Wire mesh obstruction	None.
HP15-03	1.1	Red brick structure in west of pit.	Unknown buildings 1958-1974
HP15-06	0.1	Concrete	Volumetric governor house
TP16-11	0.05-0.15	Concrete with red brick wall (basement) in southeast of the pit.	Volumetric governor house.
HP15-10	1.0	Firm layer of coal	Potential lid to Gasholder No.1
HP15-11	1.0	Unidentified obstruction	Potential lid to Gasholder No.1
MW16-09	3.8	Refusal.	Potential base of Gasholder No.1/ tar well.
TP16-08B	3.2	Unidentified obstruction.	Potential base of Gasholder No.1/ tar well.
HP15-16	0.75	Concrete. Frequent bricks from 0.4m bgl.	Meter house
TP16-07	1.0	Concrete and section of brick wall in north of the pit.	Meter house



Exploratory position	Depth (m bgl)	Obstruction details	Likely associated structure
MW16-01	0.6-0.9	Tarmac hard standing (0.6-0.7m) and solid black coal tar layer (0.7-0.9m)	Bitumen tar associated with former site level or possible solidified spill from tar tank
MW16-02	0.55-0.65 0.7	Concrete hard standing. Solid layer with coal tar odour	Bitumen tar associated with former site level or possible solidified spill from tar tank
TP5	1.3	Concrete slab.	Unknown
TP16-06	0.75	Bitumen tarmac	Former Site level
TP16-08	1.2-1.4	Bitumen tarmac.	Bitumen tar associated with former Site level.
TP16-09	0.8-1.4	Bitumen tarmac.	Bitumen tar associated with former Site level.
TP16-15	0.5 1.5	Metal joists. Concrete base.	Possible backfilled vehicle inspection pit associated with former garage.
TP16-16	0.4	Tarmac layer in south of the pit.	Former Site level.
TP16-17A	1.3	Red brick wall with concrete capping.	Former retort house.
TP16-17B	0.3	Concrete.	Former retort house
TP16-18	0.9	Brick wall in north and west of pit, and concrete at 0.9m bgl.	Former retort house/ unknown building.
TP16-20	0.9	Concrete wall (0.5m thick) with timber strut.	Exhauster house.
North of the Site			
MW16-05	3.8	Refusal.	Base of Gasholder No. 2.
MW16-13	4.9-5.1	Concrete.	Base of Gasholder No. 2.
HP15-19	1.2	Unidentified obstruction	
South of the Site			
HP15-23	0.55	Concrete.	Base of Gasholder No. 3
HP15-24	0.4	Northeast – southwest trending metal pipe of 150mm diameter	Base of Gasholder No. 3



Exploratory position	Depth (m bgl)	Obstruction details	Likely associated structure
	0.8	Concrete.	
TP16-01	1.0	Concrete.	Base of Gasholder No. 3.
TP16-02	0.8	Concrete in east of pit.	Base of Gasholder No. 3
TP16-03	1.1	Concrete in west of pit.	Base of Gasholder No. 3
TP16-04	0.85	Concrete.	Base of Gasholder No. 3.
MW16-10	0.92-1.3	Concrete base.	Base of Gasholder No. 3.
MW16-10A	0.92-1.3	Concrete base.	Base of Gasholder No. 3.
TP2	1.0	Concrete slab.	Base of Gasholder No. 3.
TP1	0.8	Concrete slab.	Unknown

3.3 Site specific hydrology

The Bargoed Taff River flows in a south-westerly direction along the Site boundary. The surface water level of the river was recorded in July and December 2015 and August 2016, with no measurements being made since. As the monitoring wells were not installed until 2016, only the August 2016 water level can be compared with groundwater levels. Surface water elevation in August 2016 ranged between 98.8m aOD upstream of the Site (at point A) and 97.29 m aOD downstream of the Site (at point C). Groundwater elevation (within boreholes screened against the superficial deposits) ranged between 98.564m aOD (MW16-04 in the north of the Site) and 97.24m aOD (MW16-11 in the south of the Site). This suggests the groundwater and stream are in connectivity given the similarity in water levels. As discussed in Section 3.4.4, comparison of the river water elevation with groundwater elevation in the nearest borehole in August 2016 suggests that, at this time, the river was a gaining reach (i.e. the river will have been receiving water from the aquifer).

Following the initial draft of this report, 6No. dataloggers were deployed between 22nd December 2023 and 10th January 2024, one within the river and five within boreholes across Site. The data collected is presented in Figure 3-1 alongside rainfall for the same period (data taken from the NRW Treharris rainfall gauge)⁴. The data logger within the river was placed in a stilling well that was attached to the former river gauging board, approximately 1 metre downstream of the cycle path bridge on the western side of the river. A barometer was also installed on Site and used to compensate results for atmospheric pressure variation. Recorded surface water (river) elevations varied between 98.339 and 99.198m aOD over the course of the monitoring period and groundwater elevations ranged between 98.034 and 100.018m aOD. A strong correlation is

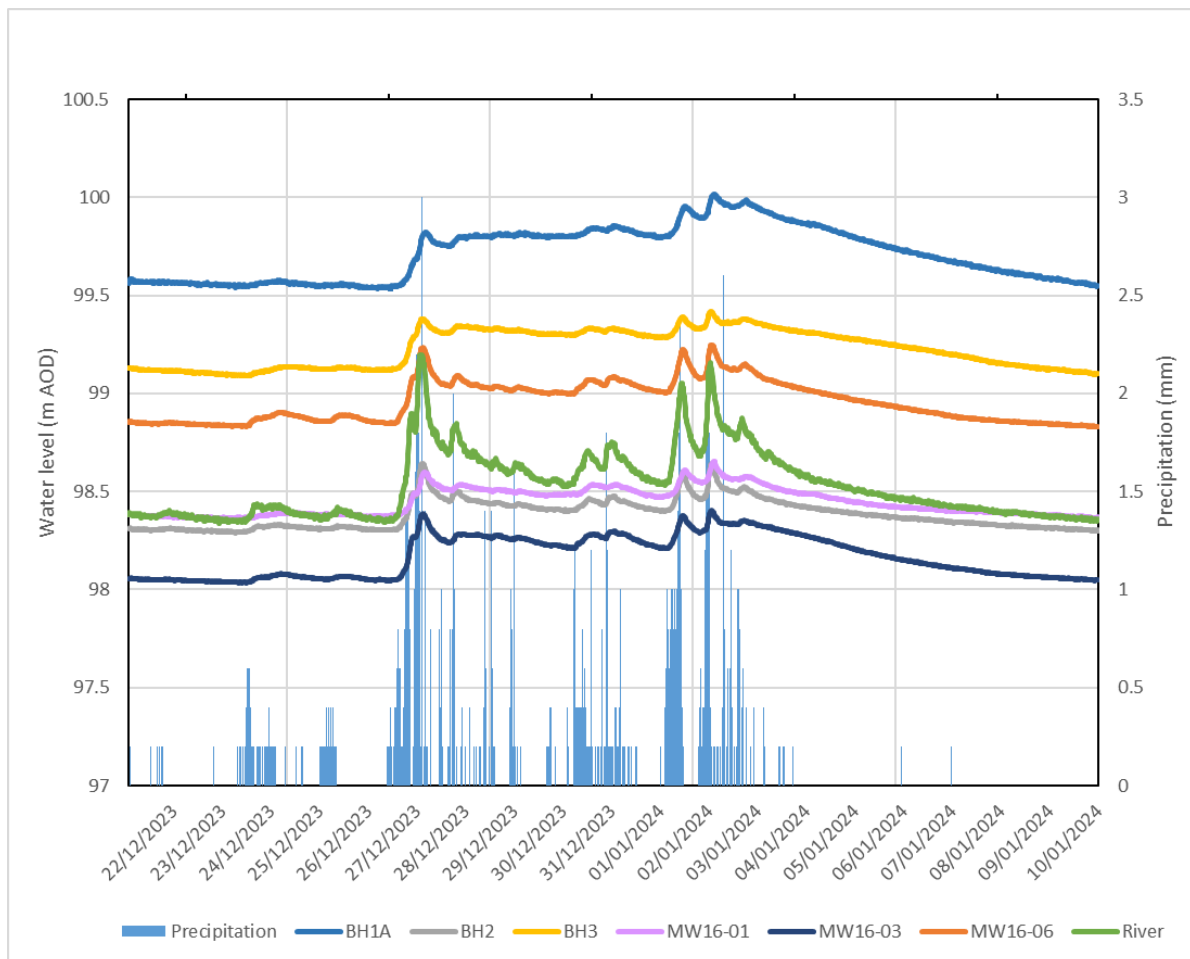
⁴ <https://rivers-and-seas.naturalresources.wales/?lang=en>



seen between groundwater elevations and surface water elevation in the river, indicating that both are strongly controlled by rainfall.

MW16-01 is positioned closest to the river monitoring point, and upstream (up-valley) from it. Comparison of the groundwater elevation in MW16-01 with the river water elevations therefore provides the best indication of the groundwater interaction with the river. During and in the days following rainfall events, the river level exceeds the groundwater level in MW16-01. During these periods, the head of water within the river will act against the potential for groundwater to flow into the river channel, and the river will likely become a losing reach. However, in the drier periods, the river level recedes to below the groundwater elevation in MW16-01, suggesting that the river becomes a gaining reach during periods of lower flow, and will likely accept groundwater inflow during such periods.

Figure 3-1 Groundwater and river level data (22nd December 2023 to 10th January 2024)





3.4 Site specific hydrogeology

The majority of installed boreholes have been screened against the Alluvium and Glacial Till, with MW16-12 and the four boreholes installed by the Client (BH1A, BH2, BH3 and BH4) screened against the sandstone bedrock. A total of 16No. groundwater monitoring rounds have been completed between 2016 and present. Only the most recent monitoring round in September 2023, and the datalogger data obtained in December 2023 and January 2024 record groundwater elevations for both the superficial and bedrock wells at the same time.

3.4.1 Groundwater elevations

The data from the most recent groundwater monitoring rounds undertaken in January 2023 and September 2023 are summarised in Table 3-2 below.

Table 3-2 Rest groundwater elevations

Exploratory Hole	Elevation m aOD	03/08/2016		05/01/2023		22/09/23		Strata Screened
		Depth to water table (m bgl)	Water elevation (m aOD)	Depth to water table (m bgl)	Water elevation (m aOD)	Depth to water table (m bgl)	Water elevation (m aOD)	
BH1A	103.04	-	-	2.83	100.21	3.69	99.35	Mudstone
BH2	100.402	-	-	1.76	98.642	2.23	98.172	Sandstone
BH3	100.519	-	-	0.94	99.579	1.56	98.959	Sandstone/ mudstone
BH4	99.572	-	-	0.54	99.032	1.42	98.152	Mudstone
MW16-01	100.52	2.256	98.144	-	-	2.09	98.31	Alluvium/ glacial till
MW16-02	99.95	1.888	97.972	-	-	1.62	98.24	Alluvium/ glacial till
MW16-03	98.94	1.281	97.549	-	-	0.85	97.98	Alluvium/ glacial till
MW16-04	103.06	3.8	99.25	-	-	3.81	99.24	Alluvium/ glacial till
MW16-05	101.87	2.154	99.606	-	-	Dry	Dry	Made Ground
MW16-06	101.72	2.938	98.762	-	-	2.87	98.83	Alluvium/ glacial till
MW16-08	101.05	2.204	98.746	-	-	1.89	99.06	Alluvium/ glacial till
MW16-09	101.02	2.332	98.578	-	-	2.36	98.55	Made Ground
MW16-10	98.81	1.368	97.372	-	-	1.03	97.71	Alluvium/ glacial till
MW16-11	98.74	1.39	97.24	-	-	1.08	97.55	Alluvium/ glacial till
MW16-12	99.64	1.668	97.922	-	-	-	-	Alluvium/Glacial Till/ Sandstone
MW16-13	102.06	13.343	98.717	-	-	3.18	98.88	Alluvium/Glacial Till/ Sandstone

These groundwater elevations have been contoured and the resulting plots provided as Figure 3-2 and Figure 3-3 below. Groundwater elevations collected by dataloggers on 27th December



2023 when water levels peaked, have also been contoured and the resulting plot provided as Figure 3-4 below.

Figure 3-2 Groundwater elevations (m aOD) on 5th January 2023 – bedrock wells only

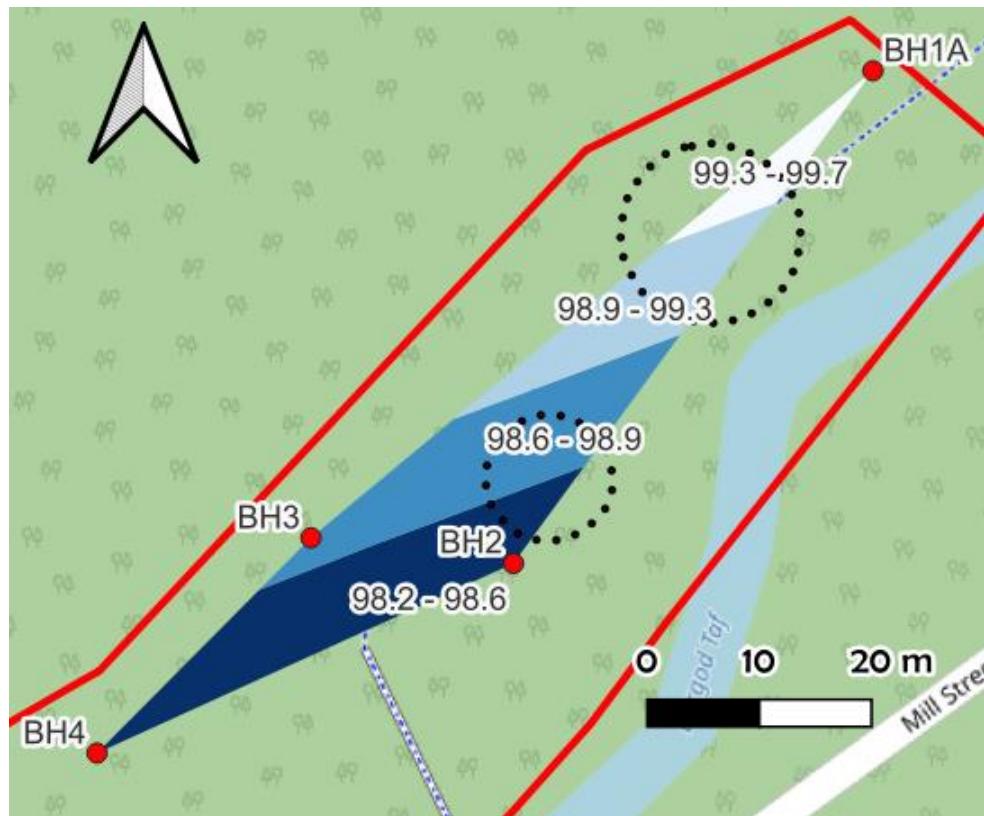




Figure 3-3 Groundwater elevations in bedrock and superficial deposits (m aOD) on 22nd September 2023

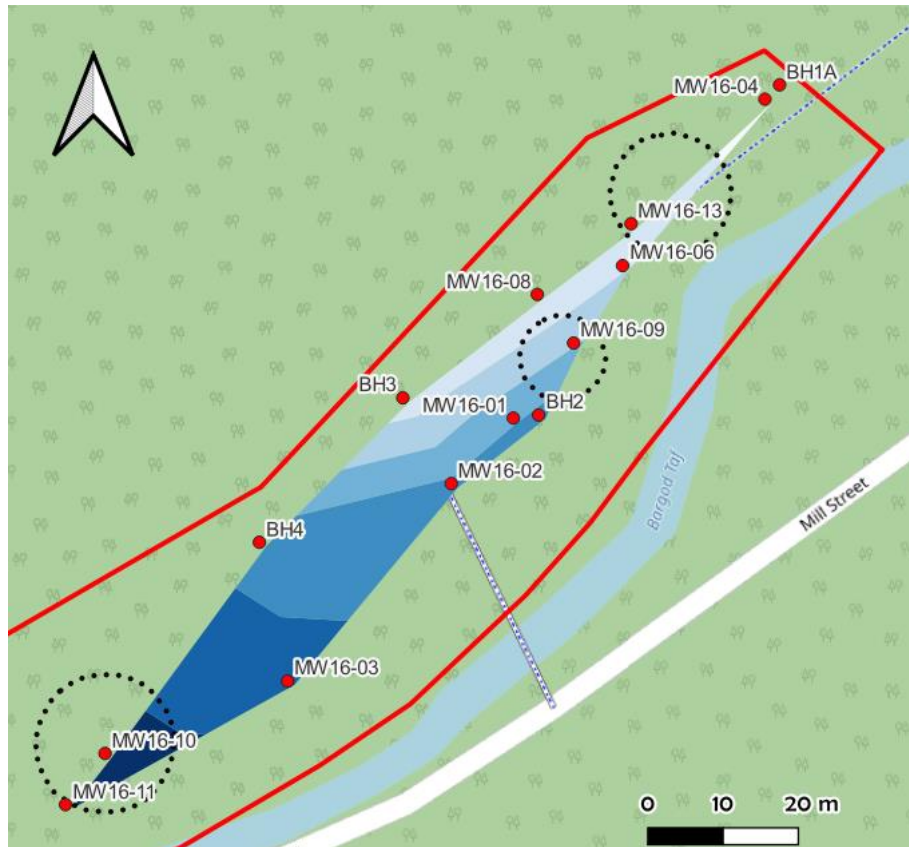
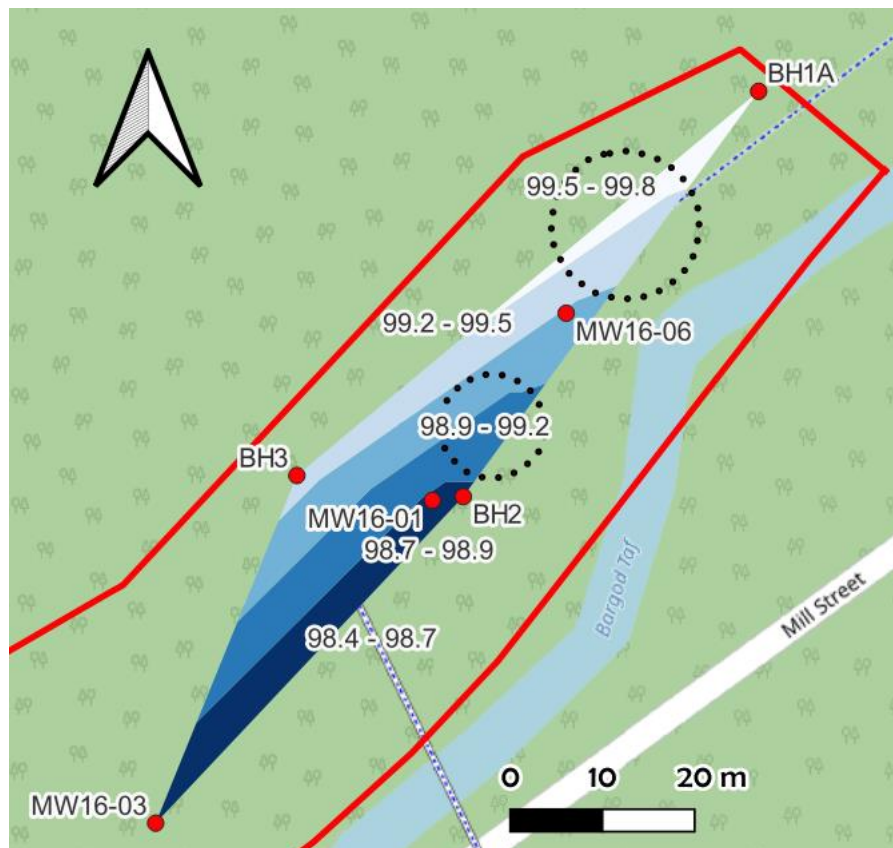




Figure 3-4 Groundwater elevations in bedrock and superficial deposits on 27th December 2023

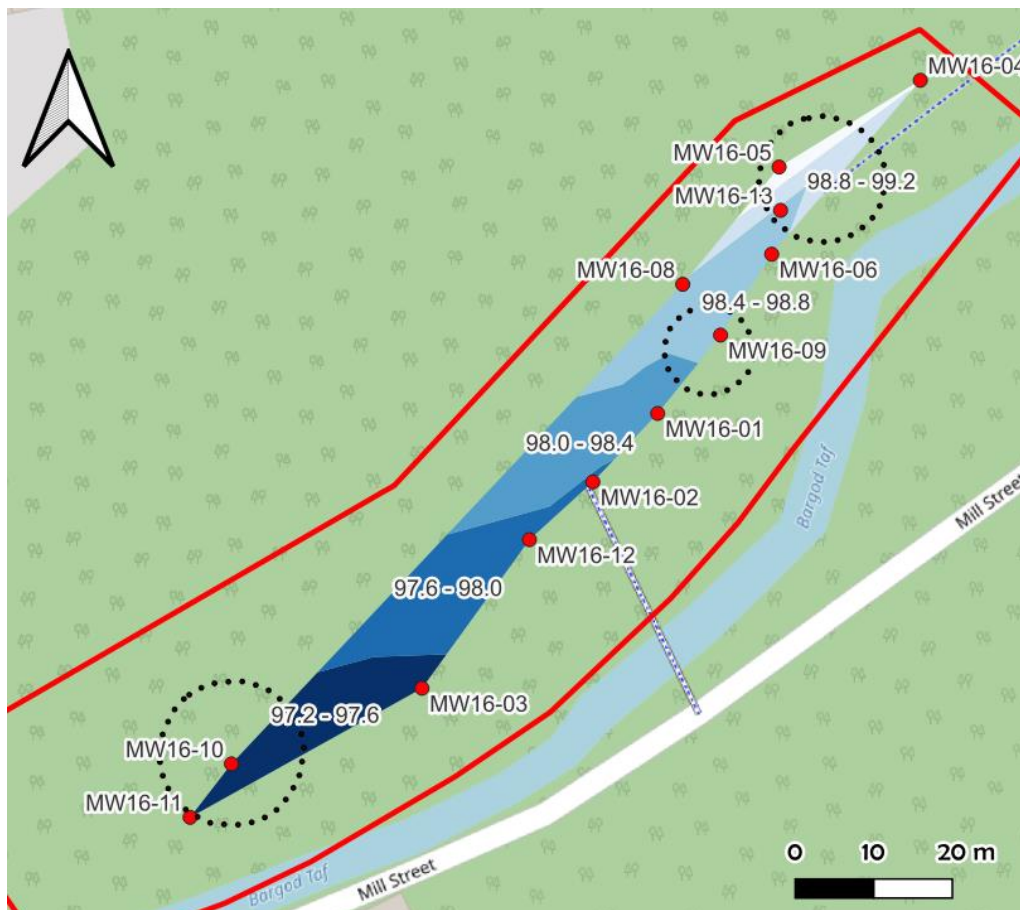


All three plots show general groundwater flow direction to be towards the south, towards the river both within the bedrock and within the superficial deposits. A south west component of flow is also seen towards the south of the Site, although this is most likely a function of the linear southwest to north east arrangement of the boreholes on Site rather than a true representation of groundwater flow direction on Site. Towards the centre of Site where there is a higher density of boreholes a southeasterly flow, towards the river, can be seen to dominate.

Earlier monitoring rounds were focussed on those wells installed within the superficial deposits. These have been reviewed, and a groundwater contour plot from 3rd August 2016 is presented as Figure 3-5 below. This round was selected as representative of these data, as the most boreholes were dipped on this occasion. The trend seen in Figure 3-5 is representative of all groundwater monitoring rounds undertaken 2016-2021, which generally show a south westerly groundwater flow direction within the superficial deposits, similar to that seen in September 2023 (Figure 3-3). As discussed above, it is likely the southwest to northeast linear arrangement of the boreholes is influencing the south westerly component of flow, rather than it being a true representation of groundwater flow direction on Site. On Site observations of contamination seeping into the river from the riverbank (during the Site walkover on 7th March 2023), suggests groundwater is flowing southeast, towards the river. This is shown in Figure 3-6 below.



Figure 3-5 Groundwater elevations (m aOD) on 3rd August 2016



There is consistency in the data across the superficial and bedrock aquifer in flow direction, strongly indicating that both aquifers are in direct connectivity. Recent data collected in December 2023 and presented in Figure 3-1 above depicts this well. There is a strong correlation between groundwater elevations in wells screened against the bedrock and superficial deposits, with fluctuations in water level mirrored across all the positions. Groundwater level is seen to fall in a south-westerly direction across the Site, with the highest levels recorded in BH1a at the north-east of the Site and the lowest within MW16-03, the only position downstream of the river datalogger monitoring point.

3.4.2 Groundwater within the Made Ground

3No. monitoring wells have been screened within the Made Ground (MW16-05, MW16-09 and MW16-13). Groundwater strikes have predominantly been within the Made Ground ranging from 0.2 to 3.3m bgl. Groundwater elevations recorded within MW16-05, MW16-09 and MW16-13 are in continuity with the remaining wells screened against the superficial deposits as shown in Figure 3-5. This suggests that groundwater within the Made Ground is in connectivity with the superficial deposits.



3.4.3 Summary

Variations in groundwater elevations within the bedrock, superficial deposits and Made Ground show a strong correlation suggesting the groundwater within these forms a single groundwater body. Only two monitoring rounds had been undertaken in which both the bedrock and superficial wells have been monitored at the same time (i.e. within the same visit), therefore data loggers were subsequently installed on Site in December 2023, providing sufficient data to confirm the groundwater bodies are in hydraulic connectivity. That said, there are springs flowing at the foot of the slope on the north-western Site boundary, whereas the groundwater elevations recorded beneath the Site are consistently below 1.2m bgl at their shallowest. Hence this would suggest some degree of vertical stratification to the bedrock aquifer.

3.4.4 Hydraulic head and flow direction

Observations made on 7th March 2023 suggest that contaminated groundwater may be seeping into the river, in at least one location (see Figure 3-6): An orange, ochreous seep with an oil sheen could be seen on the river edge immediately upstream of the pedestrian bridge. Empirical evidence therefore suggests that there is groundwater flow towards the river. This more south-easterly flow component has not necessarily been highlighted by the groundwater contouring exercise due to the linear geometry of the borehole array (itself a function of the Site's shape). Recent data logger installation in December 2023, shows river level to exceed groundwater level in MW16-01 for much of the monitoring period, only falling below groundwater level in drier periods. This suggests that whilst the groundwater flow is indeed towards the river, the groundwater does not feed into the river in wetter periods, when the head within the river channel will likely drive water into the aquifer (or at least inhibit groundwater discharge to the river).

As a result, it is considered prudent to assume a hydraulic gradient towards the river (i.e. towards the south-east), as can be demonstrated by comparing groundwater elevation with river elevation on the single monitoring round during which both were recorded. In August 2016, the change in elevation between the nearest groundwater well MW16-12 and the Bargoed Taff River was approximately 0.2m over a distance of 14m (giving a hydraulic gradient of 0.0159).

Since the first draft of this report was completed, additional data collection by Englobe has meant that the groundwater elevation and river elevation have now both been recorded more recently in September 2023. On this occasion, the change in elevation between MW16-03 and the Bargoed Taff was 0.13m over a distance of 7.5m giving a hydraulic gradient of 0.0173. Subsequent datalogger installation by Yellow Sub in December 2023 (data presented in Figure 3-1 above) enabled a hydraulic gradient of 0.0012 to be calculated. This is based upon the maximum recorded positive difference between MW16-01 groundwater elevations and river water level (0.03m, over a distance of 25m). In all other periods during datalogger deployment, the hydraulic head was smaller than this, and was anticipated to be near zero or even negative during periods of high river levels.

For comparison, the hydraulic head if calculated using the superficial aquifer data, in the south-westerly flow direction suggested by contouring of the groundwater data, is 0.0155 (an overall drop in head within the aquifer of 2.01m over a distance of 130m, between MW16-04 and MW16-11).



Figure 3-6 Orange coloured water seeping into the Bargoed Taff River (7th March 2023)



3.4.5 Hydraulic conductivity

Previous Site work by Advisian included a total of 24No. rising and falling head tests, completed between 18th August and 1st September 2016. Within the superficial deposits, a total of 18No. slug tests were undertaken in MW16-03, MW16-04 and MW16-11. Measured hydraulic conductivities ranged between 1.73 and 11.7m/day., with a geometric mean of 4.03m/day. The geometric mean is thought to be representative of the aquifer within the superficial deposits. An additional six tests were completed for MW16-12 within the sandstone bedrock giving a range of hydraulic gradients between 0.7 and 0.75m/day.

3.5 Visual and olfactory evidence of contamination

Visual and olfactory evidence of contamination encountered in previous Site investigations are summarised in Table 3-3. In addition to this, clinker, slag and ash were also recorded in a number of exploratory positions. It is evident that pockets of gross contamination are present across the Site although no columns of non-aqueous phase liquids (NAPL) were encountered.

Areas showing signs of pockets of contamination were primarily focussed in these three areas:



- In the vicinity of Gasholder No.1 (used as a tar well), including the area of visually impacted materials directly southwest of this former feature. It is from the area to the south-west of Gasholder No. 1 that the contaminated seep can be seen on the riverbank.
- Gasholder No.2 and the area south of this, comprising the former purifiers and meter house; and,
- In the west of the Site, in the area of the Tully gas plant/mess room, retort house and exhaustor house.

Impacts appear to be confined to the north and centre of the Site, the south of the Site and area surrounding Gasholder No.3 shows limited evidence of contamination.

Table 3-3 Summary of previously encountered visual and olfactory contamination

Location	Exploratory position	Contamination	Year logged
Gasholder No.1/ tar well and area to its south-west	TP16-08	1.2-1.4m bgl: Black staining and strong coal tar odour.	2016
	TP16-08B	1.2-1.4m bgl: Black staining and strong coal tar odour.	2016
		2.9m bgl: Very strong tar odour, frequent clinker (tar stained). LNAPL on surface of perched water.	
	TP16-09	0.8-1.4m bgl: Coal tar odour (associated with tarmac layer).	2016
	MW16-09	1.2-1.4m bgl: Coal tar odour.	2016
		2.6-3.4m bgl: Slight hydrocarbon odour.	
	HP15-10	1m bgl: Coal tar odour	2015
	TP16-21	0.5-1.4m bgl: Slight hydrocarbon odour.	2016
		2.0-3.3m bgl: Very strong petrol odour at base of pit.	
	MW16-01	0.7-0.9m bl: Solid black layer with coal tar odour.	2016
		0.9-1.9m bgl: Stained black with hydrocarbon odour.	
		1.9-3.5m bgl: Jet black sand and gravel. Gross tar contamination 3-3.5m bgl.	
	MW16-02	0.7-1.1m bgl: Solid black layer with coal tar odour.	2016
		1.1-1.5m bgl: Tar odour.	
	TP16-14	2.8-3.1m bgl: Black stained boulders.	2016
		0.6-1.4m bgl: Solidified coal tar with associated strong odour. Tar seeping at interface between layer 1.3-1.4m bgl.	
	TP16-14	1.7-2.25m bgl: Strong hydrocarbon odour and occasional white speckles (potential foul lime).	2016
		0.8-0.9m bgl: Ashy gravel with moderate hydrocarbon odour.	
	BH2	0.8-0.9m bgl: Ashy gravel with moderate hydrocarbon odour.	2022



Location	Exploratory position	Contamination	Year logged
Gasholder No. 2 and area south including purifiers and meter house	TP5	0.55–0.7m bgl: Mild phenolic odour. 0.75–1.3m bgl: Black cohesive gravelly bituminous deposit with a very strong phenolic odour. A lime deposit was noted at the southeast of the trail pit at 1.2m bgl.	2022
	HP15-18	1.0–1.3m bgl: Hydrocarbon odour	2015
	TP16-06A	1.1–1.6 bgl: Black tarmac with strong coal tar odour 1.6–2m bgl: Black staining and phenolic odour	2016
	TP16-06B	0.75–0.8m bgl: Black staining and phenolic coal tar odour 1.1–2m bgl: Black staining and phenolic coal tar odour	
	TP16-22	1.0–1.3m bgl: Very strong phenolic odour.	2016
	TP16-24	1.0–1.2m bgl: Very strong phenolic odour.	2016
	HP15-14	1.0–1.1m bgl Grey stained and minor phenolic/hydrocarbon odour	2015
	MW16-06	1.25–1.5m bgl: Black gravel of clinker and ash. 2.2–2.8m bgl: Grey/black staining with hydrocarbon odour.	2016
	TP16-17B	1.1–1.7m bgl: Phenolic odour.	2016
	TP16-19	0.8–.9m bgl: Hydrocarbon odour. 1.7–2.1m bgl: Very Strong phenolic odour.	2016
West of Site including Tully gas plant/mess room, retort house and exhaustor house.	HP15-01	0.8–0.95m bgl: Moderate hydrocarbon odour	2015
	TP16-15	1.4–1.5m bgl: Strong hydrocarbon odour and sheen on bricks	
	TP16-16	0.25–0.3m bgl: Layer of black ash with clinker	2016
	HP15-09	0.2–0.5m bgl: Hydrocarbon odour and grey sheen 0.4–0.5m bgl	2015
	TP16-20	1.1m bgl: Perched water with tar globules. Very strong hydrocarbon odour.	2016

The presence of non-aqueous phase liquids is limited to a record of LNAPL on the water surface in a single trial pit 16–08B in the area of Gasholder 1) and occasional tar globules or tar seeps. Monitoring undertaken with an interface probe did not detect the presence of a NAPL column in



any of the monitoring wells on any of the monitoring rounds. Whilst visual and olfactory impact to soils was noted consistently, particularly in the north of the Site, no evidence of a gross NAPL phase source was encountered.



4 Source-pathway-receptor linkages

Based on the above data review, a preliminary assessment of potential source-pathway-receptor linkages has been undertaken, as detailed below.

4.1.1 Potential sources

Historical data and data collected by the Client has reported the presence of visual and olfactorily impacted soils and groundwater beneath the Site. This is recorded primarily within the shallow Made Ground and associated with historical structures (e.g. gasholder 1), but also within the underlying superficial strata. Limited to no impact has been noted in the deeper bedrock strata, although only 6No. exploratory positions have encountered the bedrock. There is therefore a potential source term present beneath the Site that requires more detailed consideration and assessment.

4.1.2 Potential pathways

The Site is predominantly soft standing and will be returned to public open space following remediation, therefore there is potential for humans to make direct contact with soils beneath the Site, and potential for dust and vapour pathways to human exposure to exist.

Groundwater has been recorded beneath the Site, in connectivity with the adjacent Bargoed Taff River. In addition, a stream runs across the Site, across Gasholder No.1, where it then joins the Bargoed Taff River. The presence of soft standing provides the potential for infiltration of rainwater and leaching of contaminants.

The river is actively eroding the made ground soils exposed in the river bank upstream of the cycle path bridge, in the area of Gasholders 1 & 2. This represents a direct pathway for contribution of contamination to the river.

Potential pathways for migration of contamination from Site towards environmental receptors (including controlled waters) therefore exists.

4.1.3 Potential receptors

Human receptors at present comprise the users of the cycle path and open space around it, and also to Englobe and other contractors working on the Site. In the future, once the Site is returned to public open space, human receptors will be present in the context of a public open space scenario identical to that currently in place.

The residential properties to the north-west, south and south-west of the Site also represent potential off Site receptors, should a pathway exist for the migration of vapours from the contamination beneath the Site towards these properties. This pathway is considered limited, particularly to properties to the north-west, which are elevated above the Site by some 20m or more.

The Secondary A Aquifers beneath Site and Bargoed Taff River adjacent to the Site also represent sensitive environmental receptors. The River Taff also lies approximately 190m south



west of the Site. The Bargoed Taff River, as both the closest and most sensitive receptor, has been used as representative of the “wider environment” as discussed in Section 1.3.

4.1.4 Summary

The initial desk based data review and Site walkover indicates that there is potential for viable source-pathway-receptor linkages to be present between the soils/ groundwater beneath the Site and sensitive receptors. The assessment has therefore been progressed to undertaking a generic quantitative risk assessment in Section 5 below.

Table 4-1 Summary of preliminary source-pathway-receptor linkage

Sources	Pathways	Receptors
Visual and olfactorily impacted soils and groundwater beneath the Site Contents of former tar wells and Gasholders	Direct (dermal/ ingestion) exposure, inhalation of dust and vapours.	Current and future users of the Site (users of the cycle path and informal recreation). Residents of nearby residential properties
	Leaching into dissolved phase	Bargoed Taff River
	Lateral migration/ dispersion in dissolved phase in shallow aquifer towards Bargoed Taff.	
	Dissolved contaminant migration within spring flow towards Bargoed Taff.	
	Erosion of made ground, washing soils and associated contamination directly into the river channel.	
	Vertical migration and the lateral migration in the dissolved phase in deeper aquifer.	River Taff Secondary (A) Aquifer



5 Generic quantitative risk assessment

5.1 Introduction and rationale

The following potential risks require consideration:

1. The risk that soils pose an unacceptable risk to human health of current or future Site users in a public open space scenario;
2. The risk that dissolved-phase concentrations or NAPL in the saturated zone pose a risk to human health, either on-Site in a public open space scenario, or off-Site following off-Site migration under a residential scenario;
3. The risk that soils/ dissolved phase/ NAPL on-Site poses an unacceptable risk to the Bargoed Taff River as representative of the wider environment (including the direct erosion of soils by the river); and,
4. The risk that soils/ dissolved phase/ NAPL on-Site poses an unacceptable risk to the Secondary A Aquifers.

Each of these are discussed in turn below.

5.2 Data sources used

The following table details the reports and data which has been used to inform this assessment.

Table 5-1 Summary of data sources for soil and groundwater chemistry data

Date	Publisher	Report summary	Soils data?	Groundwater data?	Soil vapour data?
2022	Englobe	Factual records	Yes	Yes	No
2017-2022	Advisian	Laboratory results	No	Yes	No
2016	Advisian	Factual SI	Yes	Yes	No
2015	Advisian	Factual SI	Yes	Yes	Yes

5.3 Human health risk associated with shallow soils

5.3.1 Data processing methodology

The data sources employed to inform an assessment of potential risk to human health from soils on Site are listed in Table 5-1. The data from each epoch of investigation has been combined to compile a single soils dataset for the Site. The resultant dataset is presented in a summary table in Appendix C. This includes contaminants typical of gasworks, including BTEX, cyanides, PAHs, phenols, TPH and asbestos. The reader is referred back to the original reports for full details on the sampling and testing methodologies employed. The following section presents an assessment of the data with respect to potential risks to human health.



5.3.2 Data screening methodology

In order to determine the potential risk posed to human health by soils, a number of organisations have published screening criteria, or Generic Acceptance Criteria (GACs) representative of low risk in a range of land-use scenarios. In order to determine risk posed to future Site users the public open space (parks) land use scenario has been chosen for comparison with the soil analysis results. This is considered a conservative approach, as the woodland and cycle path present on the Site represent a lower exposure risk than a formal park, as it lacks (for example) amenities such as seated areas, play areas etc and therefore, an individual would spend less time at the site than would be the case in a formal park.

In order of priority, the following sources have been used to provide GACs:

- Category 4 screening levels (Defra, 2014⁵)
- Suitable for use levels (S4ULs) (LQM/ CIEH, 2015)⁶
- Regional screening limits (RSLs), (USEPA, May 2021)⁷. RSLs have been used for cyanide and various VOCs in the absence of UK sources. There are no reports of cyanide being a carcinogen. Therefore, under guidance set out in EA (2009), the use of USEPA values can be considered appropriate (as the derivation of Reference Doses (RfDs) and Reference Concentrations (RfCs) by USEPA largely follows the same principles as those used in the UK to derive tolerable daily intakes (TDIs)).

A number of these GACs require information on the soil organic matter in order to determine the correct value for use as representative of the Site. The soils on Site have been within a woodland environment in recent decades, following the colonisation of the Site in the period since the gasworks was last operational. The soils are also recorded to contain clinker and ash in parts. A relatively high organic matter content can therefore be anticipated.

Previous works have analysed for organic carbon content of soils as part of their work. In order to determine a representative value for the soils, those samples which were visibly or olfactorily impacted by organic contamination (tars/ oils/ odours etc.) were removed from the dataset and statistics calculated from the remaining data. SOM ranged from 0.2% to 44.45%, with a mean average of 7.67% and a 95% LCL of 6.15%. A soil organic matter (SOM) of 6% has therefore been assumed for the purposes of screening.

The initial process of assessment comprises the direct comparison of soil results with GACs. Additional assessment can be progressed should contaminants be found to exceed the GACs following initial screening. The results of this screening exercise are provided in Appendix C.

⁵ CL:AIRE/ Defra 2014. SP1010 – Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination. Defra.

⁶ Nathanail et al. 2015. The LQM/CIEH S4ULs for Human Health Risk Assessment. Land Quality Press, Nottingham.

⁷ USEPA 2021. Regional Screening Level (RSL) Summary Table (TR=IE-O6, HQ=1). May 2021



The screening exercise assessed the received laboratory test results against these published criteria, with the purpose of identifying potential constituents of concern (CoC), that is; a contaminant recorded to exceed the published criteria.

5.3.3 Human health screening assessment

Comparison of the results with the GACs reveals some exceedances, where soil concentrations are in excess of the GACs. These are detailed in the following table:

Table 5-2 Statistical exceedances of human health GACs in soil (for TPH exceedances, see Table 5-4)

Contaminant	Number of samples	GAC (mg/kg)	GAC source	Min (mg/kg)	Max (mg/kg)	Mean (mg/kg)	95% UCL	Number of exceedances (location) (Some locations exceeded in samples at more than one depth)
Aromatic C16-21	50	7800	LQM	<7	30985	2687.6	4205.5	4 (MW16-01, RB16-02, TP16-08, TP16-09)
Aromatic C21-35	50	7900	LQM	16	32170	3758	5506.9	7 (HP15-09, MW16-01, RB16-02, TP16-08, TP16-09, TP16-20)
Benzo(a)anthracene	148	62	LQM	<0.06	3078.6 5	121.1	186.1	31 (BH2, BH4, HP15-09, HP15-10, HP15-11, HP15-15, HP15-17, HP15-18, MW16-01, MW16-06, MW16-07, MW16-13, RB16-02, TP16-06, TP16-06A, TP16-08, TP16-08B, TP16-09, TP16-11, TP16-14, TP16-15, TP16-20, TP16-21, TP16-22, TP16-24, TP5)
Benzo(a)pyrene	148	13	LQM	<0.04	2090.4 1	85.3	128.1	54 (BH1A, BH2, BH4, HP15-03, HP15-09, HP15-10, HP15-11, HP15-13, HP15-14, HP15-15, HP15-17, HP15-18, HP15-19, MW16-01, MW16-02, MW16-05, MW16-06, MW16-07, MW16-10, MW16-11, MW16-13, RB16-01, RB16-02, RB16-04, SP16-03, TP16-01, TP16-04, TP16-05, TP16-06A, TP16-07, TP16-08, TP16-08B, TP16-09, TP16-11, TP16-12, TP16-14, TP16-15, TP16-20, TP16-21, TP16-22, TP16-24, TP3, TP5)
Benzo(b)fluoranthene	148	16	LQM	<0.05	2564.7 5	121.8	182.6	56 (BH1A, BH2, BH4, HP15-03, HP15-05, HP15-09, HP15-10, HP15-11, HP15-13, HP15-14, HP15-15, HP15-17, HP15-18, HP15-19, MW16-01, MW16-02, MW16-05, MW16-06, MW16-07, MW16-10, MW16-11, MW16-13, RB16-01, RB16-02, RB16-04, SP16-03, TP16-01, TP16-04, TP16-05, TP16-06A, TP16-07, TP16-08, TP16-08B, TP16-09, TP16-11, TP16-12, TP16-14, TP16-15, TP16-16, TP16-20, TP16-21, TP16-22, TP16-24, TP2, TP3, TP5)
Benzo(k)fluoranthene	148	440	LQM	<0.02	997.4	47.7	71.4	5 (HP15-11, MW16-01, RB16-02, TP16-08, TP16-08B)



Contaminant	Number of samples	GAC (mg/kg)	GAC source	Min (mg/kg)	Max (mg/kg)	Mean (mg/kg)	95% UCL	Number of exceedances (location) (Some locations exceeded in samples at more than one depth)
Chrysene	148	120	LQM	<0.02	3536.45	128.5	201.7	18 (BH2, BH4, HP15-09, HP15-10, HP15-11, HP15-18, MW16-01, MW16-07, MW16-13, RB16-02, TP16-08, TP16-08B, TP16-09, TP16-15, TP16-20, TP16-21)
Complex cyanide	148	78	USEPA	<0.5	25499	466.1	848.7	25 (HP15-09, HP15-10, HP15-14, HP15-17, HP15-18, MW16-05, MW16-06, MW16-08, MW16-09, MW16-13, RB16-01, RB16-02, TP16-06, TP16-08, TP16-09, TP16-22, TP16-24)
Dibenzo(ah)anthracene	148	1.4	LQM	<0.04	454.42	17.4	26.3	70 (BH1A, BH2, BH4, HP15-01, HP15-03, HP15-05, HP15-09, HP15-10, HP15-11, HP15-13, HP15-14, HP15-15, HP15-16, HP15-17, HP15-18, HP15-19, HP15-20, HP15-23, MW16-01, MW16-02, MW16-05, MW16-06, MW16-07, MW16-08, MW16-10, MW16-11, MW16-13, RB16-01, RB16-02, RB16-04, SP16-03, TP16-01, TP16-02, TP16-04, TP16-05, TP16-06A, TP16-07, TP16-08, TP16-08B, TP16-09, TP16-10, TP16-12, TP16-11, TP16-14, TP16-15, TP16-16, TP16-17B, TP16-18, TP16-19, TP16-20, TP16-21, TP16-22, TP16-24, TP2, TP3, TP4, TP5)
Fluoranthene	148	6400	LQM	<0.03	47660.4	557.7	1197.1	1 (RB16-02)
Free cyanide	148	23	USEPA	<0.5	330	6.2	12	6 (BH2, HP15-18, RB16-02, MW16-13, TP5)
Indeno(123cd)pyrene	148	180	LQM	<0.04	1242.65	56.9	84.7	10 (BH2, HP15-09, HP15-10, HP15-11, MW16-01, RB16-02, TP16-08, TP16-08B, TP16-09, TP16-15)
Lead	148	580	C4SL	<5	1435	99	124.8	4 (HP15-09, MW16-06, RB16-01, TP16-08)
Mercury	148	30	LQM	<0.1	50.9	0.7	1.4	1 (TP16-08)
Naphthalene	148	3000	LQM	<0.04	23107.15	377.9	759.4	4 (MW16-01, TP16-08, TP16-08B, TP16-09)
Phenanthrene	148	6300	LQM	<0.03	38478.53	546.2	1084.4	4 (MW16-01, RB16-02, TP16-08, TP16-08B)
1,2,3-Trichloropropane	27	0.0051	USEPA	<0.002	0.02	0.0045	0.0057	1 (MW16-01)
1,2,4-Trimethylbenzene	27	300	USEPA	<0.005	338.85	16.89	41.73	1 (MW16-01)
1,2-Dibromo-3-chloropropane	27	0.0053	USEPA	<0.04	0.02	0.0046	0.0057	1 (MW16-01)
2-Methylnaphthalene	24	240	USEPA	<0.01	1323.87	119.28	258.68	3 (MW16-01, TP16-08, TP16-09)
Dibenzofuran	24	1000	USEPA	<0.01	1059.67	115.82	224	1 (TP16-08)



5.3.3.1 PAHs

For the most part, PAH exceedances were limited to the Made Ground, with the exception of BH1A, HP15-21, MW16-01 and MW16-08 where failures were recorded within the superficial deposits. Samples with failures were taken between ground level and 4.8m bgl. Due to the quantity of exceedances further statistical screening was carried out to identify outlying data points.

5.3.3.2 Heavy Metals: Lead and Mercury

The following table provides context for the recorded lead and mercury exceedances.

Table 5-3 Context exceedances of lead and mercury

Locality	Depth of sample (m)	Lead (mg/kg)	Mercury (mg/kg)	GAC	Location context	Log summary
RB16-01	0	612		580	Riverbank adjacent to Gasholder No.1	No log provided. However, it is noted visual contamination was present.
HP15-09	0.5	1435		580	Exhauster House	Made Ground: Grey-silver, sandy and clayey gravel of limestone, slate and coal. Moderate hydrocarbon odour.
TP16-08	0.5	594		580	Gasholder No.1	Made Ground; Black-brown sandy gravel of sandstone and red brick.
MW16-06	2.5	739		580	Meter house	Made Ground: Grey stained black, sandy gravel. Hydrocarbon odour.
TP16-08	1.3		50.9	30	Gasholder No.1	Made Ground: Firm black layer with coal tar odour.

5.3.3.3 Cyanide

Free Cyanide exceedances are limited to the Made Ground, as are the majority of the complex cyanide failures, with the exception of samples taken at 3m bgl in MW16-06 and MW16-08 within the superficial deposits. Due to the quantity of exceedances further statistical screening was carried out to identify outlying data points.

5.3.3.4 VOCs and SVOCs

Exceedances of the GACs for 1,2,3-Trichloropropane, 1,2,4-Trimethylbenzene, 1,2-Dibromo-3-chloropropane and 2-Methylnaphthalene were recorded within a sample at 2.8m bgl in MW16-01. Samples taken from 1.3m bgl in TP16-08 and 1.0m bgl in TP16-09 also showed failures for 2-Methylnaphthalene. A single exceedance of dibenzofuran was also recorded in TP16-08. All three of these samples are associated with significant visual and olfactory evidence of contamination, with TP16-08 located within Gasholder No.1 and TP16-09 and MW16-01 lying southwest of Gasholder No.1.



5.3.3.5 TPHs

TPH exceedances are limited to two discrete areas, the exhauster house and Gasholder No.1 (including the area to its south-west). The exceedances and their context have been summarised in Table 5-4 below.

Table 5-4 Context exceedances of TPHs (mg/kg)

Locality	Depth of sample (m)	Aromatic C16-21	GAC	Aromatic C21-35	GAC	Location context	Log summary
HP15-09	0.35	3867	7800	8813	7900	Exhauster House	Made Ground: brown-black, sandy and clayey gravel of limestone, slate and coal. Slight hydrocarbon odour. PID reading 0.3 ppm
HP15-09	0.5	3508	7800	11095	7900	Exhauster House	Made Ground: Grey-silver, sandy and clayey gravel of limestone, slate and coal. Moderate hydrocarbon odour.
MW16-01	2.8	19164	7800	19826	7900	Downgradient of Gasholder No.1	Black sand and gravel. Tar stained. Gross tar contamination. PID reading 116 ppm
RB16-02	0	14249	7600	23376	7800	Riverbank adjacent to Gasholder No.1	No log provided. However, it is noted visual contamination was present.
TP16-08	1.3	30985	7600	32170	7800	Gasholder No.1	Made Ground: Firm black layer with coal tar odour. PID reading 0 ppm
TP16-09	1	10934	7600	12125	7800	Adjacent to Gasholder No.1	Made Ground: 'Tarmac' layer. Very strong coal tar odour when broken up. Stiff, brown stained black clay. Strong hydrocarbon odour. PID reading 165 ppm
TP16-20	1	7479	7600	9436	7800	Exhauster House	Made Ground: Black, slightly sandy, clayey gravel of brick, concrete and slag. At 1.1m bgl, ingress of perched water. Very strong hydrocarbon odour and tar globules on surface water. PID reading 14.1 ppm



5.3.4 Statistical Human Health screening assessment

5.3.4.1 Methodology

Two methods of statistical analysis were used to assess the soils dataset. Firstly, a statistical method was used to identify the potential for outliers to exist within the sample population for each of the contaminants. This test helps to identify areas of the Site that may not be representative of the whole, and so should be treated differently to the wider Made Ground (i.e. may represent areas of more notable contamination). This was undertaken following the guidance laid out in CL:AIRE/ CIEH 2008⁸. Whilst this 2008 guidance has since been superseded by CL:AIRE 2020, the latter requires that an outlier test be undertaken, and signposts to the same outlier test method as is set out in the 2008 document, hence referring back to this document for this purpose. A critical concentration has been identified using the Outlier Test (Grubb's Test). The critical concentration is the concentration above which a value may be considered an outlier. In the context of contaminated land, this may indicate an area with anomalously high contamination, representative of a history or previous process that has contributed higher degree of contamination than is seen elsewhere on the Site.

Secondly, a mean value test was undertaken in order to define the 95% Upper Confidence Limit (UCL) of each sample population for those contaminants identified as a potential contaminant of concern (CoC) in Table 5-2. This enables the assessment of the dataset as representative of the entire Site. The use of a Mean Value Test is considered suitable on this Site, outside of the Gasholders and outside of areas identified as outliers, as there are limited other historical process areas identified that might otherwise require subdivision of the dataset into smaller sub-sets (in other words, once the area of former structures are removed from the dataset, the Site largely comprises general Made Ground). In order to justify use of the mean value test, CL:AIRE 2020 require that a series of tests be passed, as detailed in the following table:

Table 5-5 Mean value test justification for soils (outside of gasholders)

Test	Comment
There must be a CSM that identifies which zones you are sampling and why	The area surrounding Gasholder No.1 and Gasholder No.2, as depicted as AREA A in drawing P23545_R1_DO5, has been excluded from the dataset as the soils in this area are notably impacted by previous gasworks processes. The areas of outliers have been excluded in accordance with Table 5-6. There are several other gaswork process areas across the remainder of the Site including purifiers, exhauster house, retort house, Tully gas plant and volumetric governor house. These were included in the initial mean value test as summarised in Table 5-8. These were then excluded from the dataset as

⁸ CL:AIRE/ CIEH 2008. Guidance on Comparing Soil Contamination Data with a Critical Concentration.



Test	Comment
	indicative of a further source area (AREA B in drawing P23545_R1_DO5), and the mean value test re-run for the remaining data (AREA C in drawing P23545_R1_DO5).
The sampling strategy must use simple or stratified random sampling to measure the zone(s) identified in the CSM	Sampling strategies are not detailed in the historical reports. The distribution of soil sampling across three epochs of investigation provides a simple random pattern when taken as an entire dataset.
Samples should not be composite samples	No details are provided by previous works as to sampling technique. It is assumed that composite sampling was not undertaken, as this would be outside of WWU core specification.
A quality check has been made between the analysis and field data to identify any anomalies and you have established a method for dealing with non-detects	A quality check has been undertaken on the data as part of the process of compiling it into a single digital dataset. Non-detects have been assumed to be at the laboratory limit of detection.

A 95% confidence interval has been used in the assessment. In a Part 2A scenario, CL:AIRE 2020 suggest that a lower, 80% confidence interval may be sufficient, given that the evidence level required is a "balance of probabilities". Further comment is provided on this following Table 5-8 below.

5.3.4.2 Results

The results of the Outlier Test in the form of critical concentrations and samples identified as exceeding these are summarised in Table 5-6 below.

Table 5-6 Outlier Test for soils (mg/kg)

Contaminant	Outlier if greater than (mg/kg)	Locations with outliers
Aromatic C16-21	18,837	MW16-01, TP16-08
Aromatic C21-35	22,365	RB16-02, TP16-08,
Benzo(a)anthracene	1,589.2	MW16-01, RB16-02, TP16-08B,
Benzo(a)pyrene	1,050.9	MW16-01, RB16-02, TP16-08, TP16-08B
Benzo(b)fluoranthene	1,494.5	MW16-01, RB16-02, TP16-08, TP16-08B



Contaminant	Outlier if greater than (mg/kg)	Locations with outliers
Benzo(k)fluoranthene	583	MW16-01, RB16-02, TP16-08, TP16-08B
Chrysene	1,780.7	RB16-02, TP16-08, TP16-08B
Complex cyanide	9,102.7	RB16-02
Dibenzo(ah)anthracene	218.2	RB16-02, TP16-08, TP16-08B
Fluoranthene	14,990.7	RB16-02
Free cyanide	137.3	BH2, TP5
Indeno(123cd)pyrene	684.8	HP15-11, MW16-01, TP16-08, TP16-08B, RB16-02
Lead	681.3	HP15-09, MW16-06
Mercury	16	TP16-08
Naphthalene	8,990.9	MW16-01, TP16-08B
Phenanthrene	12,694.9	RB16-02
1,2,3-Trichloropropane	0.013	MW16-01
1,2,4-Trimethylbenzene	193.5	MW16-01
1,2-Dibromo-3-chloropropane	0.013	MW16-01
2-Methylnaphthalene	1,032.9	TP16-08, TP16-09
Dibenzofuran	825.1	TP16-08

Following the statistical screening assessment, 10No. exploratory holes were identified as potential outliers:

- BH2, HP15-09, HP15-11 MW16-01, MW16-06, RB16-02, TP16-08, TP16-08B, TP16-09 and TP5

Of these MW16-01, RB16-02 and TP16-08 appear as outliers for the greatest number of contaminants (11No. each), TP16-08B also appears for 8No. contaminants. These positions are all located in the vicinity of Gasholder No. 1, TP16-08 and TP16-08B spans across the former base, RB16-02 is taken from the riverbank directly east of the gasholder and MW16-01 lies 5m southwest. HP15-11 which is an outlier for indeno(123cd)pyrene is also located on the footprint of Gasholder No.1 and BH2, TP5 and TP16-09, which are all outliers for one contaminant, lie directly southwest of Gasholder No.1. This suggests a localised area of contamination around Gasholder No.1 which is significantly different to the surrounding Site.



The remaining outliers, HP15-09 and MW16-06 are located in the area of the former exhauster house and meter house respectively. These may represent additional areas of elevated contamination.

Each of the outliers was associated with visual and olfactory signs of contamination which are summarised in Table 5-7 below. Highly elevated PID readings were also recorded for MW16-01, TP16-09 and TP5.

Table 5-7 Visual and olfactory signs of contamination of outliers

Exploratory position	Visual and olfactory signs of contamination	Sample depths (m bgl)
BH2	0.8-0.9m bgl: Ashy gravel with moderate hydrocarbon odour.	0.7
HP15-09	0.2-0.5m bgl: Hydrocarbon odour and grey sheen 0.4-0.5m bgl. PID reading: 0.3ppm	0.5
HP15-11	0-1m bgl: Clinker	0.95
MW16-01	1.9-3.5m bgl: Jet black sand and gravel. Gross tar contamination 3-3.5m bgl. PID reading 116ppm	2.8
MW16-06	2.2-2.8m bgl: Grey/black staining with hydrocarbon odour. PID reading: Oppm	2.5
RB16-02	No available logs. Although it is noted riverbank samples were taken in areas of visual contamination in the largely inaccessible riverbank.	0
TP16-08	1.2-1.4m bgl: Black staining and strong coal tar odour. PID reading: Oppm	1.3
TP16-08B	2.9m bgl: Very strong tar odour, frequent clinker (tar stained). LNAPL on surface of perched water. PID reading Oppm	3.2
TP16-09	0.8-1.4m bgl: Coal tar odour (associated with tarmac layer). PID reading: 165ppm	1.0
TP5	0.55-0.7m bgl: Mild phenolic odour. 0.75-1.3m bgl: Black cohesive gravelly bituminous deposit with a very strong phenolic odour. PID reading: 148ppm	0.8

The presence of these outliers indicates that these areas of the Site should be viewed as separate from (i.e. not representative of) the rest of the soils on Site. The correlation of outliers with observations of gross contamination confirms that this area should be considered separately from the wider Made Ground on Site.

Data associated with the area within and around Gasholders No. 1 & 2 has therefore been removed from the dataset. Similarly, the data associated with the area around the former exhauster and meter houses has also been removed from the main dataset. The Mean Value Test



was then run on the remaining data. The results of the Mean Value Test are presented in Table 5-8 below, with bold red text indicating exceedance of the GAC.

Table 5-8 Mean Value Test results for soils in mg/kg (excluding AREA A (Gasholders No. 1 and 2) and excluding outliers)

Contaminant	GAC	Count	Min	Max	Mean	95% UCL
Benzo(a)anthracene	62	94	0.06	776.6	29.8	49.2
Chrysene	120	94	0.02	745.2	29.4	48.2
Benzo(a)pyrene	13	94	0.04	491.4	23.4	36.4
Indeno(123cd)pyrene	180	94	0.04	264	14.7	21.9
Dibenzo(ah)anthracene	1.4	94	0.04	83.2	4.3	6.5
Benzo(b)fluoranthene	16	94	0.05	723.7	32.7	51.3
Aromatic EC21-C36	7900	23	51	9436	1337.3	2331
Complex cyanide	78	94	0.5	4120.1	105.2	214.9
1,2,3- Trichlorobenzene	63	14	0.007	85.8	6.1	17.7

Three PAHs (benzo(b)fluoranthene, benzo(a)pyrene and dibenzo(a,h)anthracene) as well as complex cyanide remain as potential CoCs. For each of these, consideration of an 80% UCL (to reflect the Part 2A requirement for “balance of probability”) does not materially alter the UCL value, being 36mg/kg, 26mg/kg, 4.8mg/kg and 107mg/kg respectively (i.e. all four have a UCL in excess of the critical concentration at both 95% and 80% confidence).

TP16-15 recorded the highest PAH concentrations, TP16-20 contained the highest Aromatic EC21-35 concentration and the highest complex cyanide was seen in HP15-14. These positions are associated with various historical structures which, for the most part, are located towards the central portion of the Site. TP16-15 is located under the Tully gas plant/ mess room, TP16-20 the exhaustor house and HP15-14 the purifiers.

The combination of the distribution of soil exceedances and the visual & olfactory observations of contamination therefore suggests that the Site can be further subdivided into three areas:

- AREA A: In and around Gasholders No.1 & 2;
- AREA B: The area associated with former gasworks processes across the centre and north of the Site, but outside of the Gasholder No.1 & 2 area; and,
- AREA C: The southern area of the Site and area north of Gasholder No.2, which was neither subject to significant gasworks processes nor has significant visual or olfactory evidence of gasworks contamination.

These three areas are depicted on drawing P23545_R1_DO5).

The data for AREA A had already been split from the main dataset prior to running the Mean Value Test, as had data associated with outliers in AREA B. Due to the differences seen in contaminative content and historical processes, the decision was taken to further subdivide the



dataset, splitting it between AREA B and AREA C. In order to assess the risk posed to human health from soils in AREA C, the Mean Value Test has been repeated using the data from exploratory positions that lie within this area only. The results are presented in Table 5-9 below, as above, bold red text indicates an exceedance of the GAC.

Table 5-9 Mean Value Test results for soils in Area C in mg/kg

Contaminant	GAC	Count	Min	Max	Mean	95% UCL	80% UCL
Benzo(a)pyrene	13	40	0.04	52.1	7.4	10.9	4.4
Dibenzo(ah)anthracene	1.4	40	0.04	11.5	1.6	2.3	1.6
Benzo(b)fluoranthene	16	40	0.05	75.3	10.2	15.3	10.3

Statistical review

An assessment of the distribution of results around the sample mean and median were assessed for each of the contaminant datasets. Due to the presence of a large number of non-detects and a clustering of results near to the laboratory limit of detection, most datasets were adjudged to have a long-tail distribution. This distribution type requires a large dataset, proportional to the number of extreme values. Guidance in Appendix B of CL:AIRE 2020 was used to assess the required size of dataset on this basis. In each case, the dataset size for the smallest of the Mean Value test datasets (that for Area C, 40 samples) exceeded the required dataset size (with the largest required dataset being 29 samples, for benzo(a)pyrene) and hence the statistical analysis undertaken is considered valid in this regard.

As can be seen from Table 5-10, viewing the sample population as a whole within Area C places both benzo(a)pyrene and benzo(b)fluoranthene below the GAC. Whilst the mean, 95% UCL and 80% UCL remain above the GAC for dibenzo(ah)anthracene, the mean and 80% UCL are both very marginal exceedances.

5.3.5 Asbestos Containing Materials (ACM)

The results from samples analysed for the presence of asbestos in soils are summarised in Table 5-10 below.

Table 5-10 Summary of laboratory test results for asbestos in soils

No. Samples	53
No. Samples containing asbestos (location)	11 (HP15-O1, HP15-O8, MW16-O2, MW16-O3, MW16-O8, MW16-11, SP16-O1, TP16-O2, TP16-O8, TP16-12, TP16-21)
No. samples containing crocidolite (location)	0



No samples containing chrysotile (location)	8 (MW16-03, MW16-08, MW16-11, SP16-01, TP16-02, TP16-08, TP16-12, TP16-21)
No samples containing amosite (location)	4 (HP15-01, HP15-08, MW16-02, TP16-08)
Mean quantified asbestos (%)	0.00464
Max quantified asbestos (%)	0.032
Min quantified asbestos (%)	<0.001

From 2015 to present, 53No. samples have been analysed of which 11No. contained asbestos fibres in soil. Positions where asbestos fibres have been detected are distributed across Site as summarised below:

- **Area A** – HP15-08, TP16-08,
- **Area B** – HP15-01, MW16-02, MW16-08, TP16-12, TP16-21,
- **Area C** – MW16-03, MW16-11, SP16-01, TP16-02

There was no recorded visual evidence of ACMs in any of the exploratory positions.

5.3.6 Human health summary (soil)

Potential constituents of concern		
<i>Shallow soils posing potential risks to current and future Site users (human health):</i>		
AREA A	AREA B	AREA C
Aromatic C16-21	Benzo(b)fluoranthene	Dibenzo(ah)anthracene
Aromatic C21-35	Benzo(a)pyrene	Asbestos in soil
Benzo(a)anthracene	Dibenzo(ah)anthracene	
Benzo(a)pyrene	Complex cyanide	
Benzo(b)fluoranthene	Asbestos in soil	
Benzo(k)fluoranthene		
Chrysene		
Complex cyanide		
Dibenzo(ah)anthracene		
Fluoranthene		
Free cyanide		
Indeno(123cd)pyrene		
Lead		
Mercury		
Naphthalene		
Phenanthrene		
1,2,3-Trichloropropane		
1,2,4-Trimethylbenzene		
1,2-Dibromo-3-chloropropane		



2-Methylnaphthalene
Dibenzofuran
Asbestos in soil

5.4 Human health risks associated with dissolved phase contamination

Since 2016, 15No, rounds of groundwater sampling have been undertaken at the Site, the most recent completed by the Client on 6th December 2022. The samples were analysed for a range of contaminants typical of a gasworks and in accordance with similar suites of contaminants employed during the previous works. A summary table of the groundwater analysis results is provided in Appendix C. This includes results for contaminants typical on gasworks, including BTEX, cyanides, PAHs, phenols and TPH.

In order to assess the potential risk to human health from soil-derived vapours the results of the recent monitoring by the Client, plus the 2016 to 2021 groundwater data has been screened against published Society of Brownfield Risk Assessment's (SoBRA) GAC_{gwwap}. The SoBRA GAC_{gwwap} have been developed using the EA Contaminated Land Exposure Assessment model (CLEA) v1.07. The method is described by SoBRA as follows:

"As part of the process of calculating soil phase concentrations, the software calculates the vapour phase concentrations (termed the "soil vapour concentration" within the model) and the pore water dissolved concentration (termed the "soil solution concentration") at the soil GAC. Fundamentally, for a given soil GAC derived to be protective of health, calculation of the soil vapour phase concentration at which exposure to the critical receptor from both indoor and outdoor air is deemed to present a tolerable risk, also results in the calculation of a soil solution concentration that would give rise to this vapour concentration.

The methodology used within this assessment essentially identifies the soil solution concentration calculated within the soil GAC model, and with a series of unit conversions, reports this as the groundwater vapour GAC concentration."

The modelling process assumes a depth to groundwater of 0.65m. The depth to groundwater beneath the Site has been recorded as greater than 1m bgl in all wells on all monitoring occasions with a single exception (EN-BH4-22 in January 2023). For the vast majority of the Site, the depth to groundwater is therefore significantly deeper than the assumed depth within the GAC model.

In order to assess the potential risk to human health from soil-derived vapours, two potential exposure scenarios have been considered:

1. Exposure to a human on Site for a public open space use. In this scenario, the compiled groundwater chemistry data have all been screened against published Society of Brownfield Risk Assessment (SoBRA) GAC's for a commercial setting sourced from 'Development of Generic Assessment Criteria for Assessing Vapour Risks to Human Health from Volatile Contaminants' (GAC_{gwwap}). This is a conservative approach, as the current and future use of the Site is public open space, which does not include indoor vapour exposure (which is one of the exposure pathways considered under the commercial scenario); and,



2. Migration of dissolved-phase contamination off-Site and beneath nearby residential properties. If migration as far as, and beneath nearby properties were to occur, such dissolved phase may then pose a vapour risk. To assess this scenario, the groundwater chemistry data from Site has been screened against published Society of Brownfield Risk Assessment (SoBRA) GAC's for a residential setting.

The findings of these screening exercises are summarised in Table 5-11 below:

Table 5-11 Exceedances of human health GACs in Groundwater

Contaminant	No. of samples	GAC commercial (mg/l)	GAC residential (mg/l)	Min (mg/l)	Max (mg/l)	Average (mg/l)	Number of exceedances (location)
Naphthalene	181	23	0.22	0.00001	12	0.9	30 (BH3, MW16-01, MW16-02, MW16-12) – residential only
Benzene	181	20	0.21	0.001	2.2	0.1	22 (MW16-01, MW16-02, MW16-12) – residential only
Aliphatic EC8-C10	176	57000	57	0.005	835	43	21 (MW16-01, MW16-02, MW16-12) – residential only
Aliphatic EC10-C12	176	3600	37	0.005	84	3.7	1 (MW16-02) – residential only
Aromatic EC8-C10	176	190000	1900	0.01	2512	119	7 (MW16-01) – residential only
Aromatic EC10-12	176	660000	37	0.005	28413	887	30 (BH2, BH3, MW16-01, MW16-02, MW16-08, MW16-12)

In light of the above, the comparison of groundwater chemistry with GAC_{gwvap} indicates that the groundwater beneath the Site poses an acceptably low risk to human health across the Site under its proposed continued use as public open space.

When a residential setting is considered, naphthalene, benzene and some TPH fractions are assessed as exceeding the GAC.

The SoBRA exposure model assesses risk from a contaminant groundwater source that sits directly below the residential property at a depth of 0.65m. That is not the case here. Residential properties to the north-west are up hydraulic gradient, approximately 70m away, with approximately 20m vertical separation (as the properties sit on an elevated position in comparison with the Site). The single residential property to the south-west is also about 70m away. The nearest properties to the south (on the opposite bank of the Bargoed Taff) are at least 70m away, and the presence of the river provides a barrier to shallow groundwater flow (as the river received groundwater from the Site).



The residential properties to the north of the Site (up hydraulic gradient) and the residential properties to the south of the site (separated by the river) are discounted as potential receptors on the basis of a lack of meaningful pathway.

Whilst a theoretical pathway might exist to the single property towards the south-west of the Site, the length of the pathway is such that the exceedances listed in Table 5-11 are not considered to be of concern. This is discussed further in Section 6.3.1 below.

5.5 Risks to human health from soil vapour phase

Outdoor vapour monitoring has been undertaken on Site on 3No. occasions, between November and December 2015. Samples were collected in the vicinity of Gasholder No.1 and from a point north of the Site, to provide background sampling conditions. Samples were analysed by a laboratory for Naphthalene, BTEX, Phenols, Cresol and various VOCs.

The calculated air concentrations from the vapour sampling and analysis have been compared against UK Workplace Exposure Limits and against Reference Concentrations for inhalation (RfC_{inhal}), where available. Use of RfC_{inhal} is defined by the USEPA (which is also adopted in the UK and elsewhere) as “an estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime”. The RfC_{inhal} listed in Table 5-12 below have been taken from UK literature. Directly comparing the site data with the RfC_{inhal} is a very conservative approach, as it does not take into account the exposure scenario, but rather compares the test result directly with theoretical safe inhalation concentrations at the point of inhalation. Numerous factors acting upon the pathway and the exposure duration and frequency will reduce the risks significantly. Notwithstanding this, all the detections above laboratory LOD are summarised in Table 5-12 below, and no exceedances of either workplace exposure limits or RfC_{inhal} were recorded.

Table 5-12 Summary of outdoor vapour monitoring results

Contaminant	No. of samples	Workplace exposure limit (mg/m ³)	Reference concentration (mg/m ³) ¹	Max (mg/m ³)	Number of exceedances
Toluene	18	191	5	4.86	0
Acetone	18	1,210	–	1.33	0
Propan-2-ol	18	999	4,900 ²	0.45	0
Hexane	18	72	0.7	0.8	0
Tertiary butanol	18	–	5 ³	0.37	0
Undecane	18	–	–	0.38	0

¹ As summarised in Nathanail et al 2015, unless stated otherwise.

² Based on LEL, as defined by NIOSH: <https://www.cdc.gov/niosh/idlh/67630.html>

³ EPA 2021: Toxicological Review of tert-Butyl Alcohol (tert-Butanol) [CASRN 75-65-0] https://iris.epa.gov/static/pdfs/1036_summary.pdf



As a result, it can be concluded that the site data indicates a lack of significant vapour risk on site. Any risk posed to off-site residential receptors will be reduced still further, due to the multiple mitigating factors at play given that soils are free to vent to air.

5.6 Risks to the wider environment

5.6.1 Groundwater screening

Drawing P23545_R1_DO3 details the location of groundwater monitoring wells installed on the Site and provides a synopsis of the historical process areas and features.

Soil leachate data exists for the Site. However, given the historic nature of the contamination on the site (decades), the soils and groundwater are considered to be in equilibrium. There is a good groundwater dataset collected over a period of 8 years, and hence it is considered more appropriate to focus on groundwater and soils data, rather than lab soil leachate tests, which are reflective of lab process, rather than reflective of site conditions.

The groundwater beneath the Site lies within the superficial deposits Secondary A Aquifer, which is considered to be in connectivity with the underlying Hughes Member Secondary A Aquifer and with the overlying Made Ground. Site data suggests that the aquifer is in connectivity with the Bargoed Taff River adjacent to the Site. Groundwater on Site has therefore been assessed to be within a single aquifer.

In order to be protective of the Bargoed Taff River, the results of analysis of the groundwater samples obtained from 2015 to 2022 have been screened against GACs which have been drawn from published Environmental Quality Standards (EQS) Annual Average concentrations. Soil leachate analysis results have not been reviewed separately, as given the historic nature of the contamination on Site, the soils and groundwater are considered to be in equilibrium. Hence it is considered more appropriate to focus on groundwater and soils data, rather than laboratory soil leachate tests, which are reflective on lab processes rather than on Site conditions.

It should be noted that these standards are for use in protecting and regulating water quality in rivers, as such, their direct comparison with groundwater is inherently very conservative, and does not take account of natural attenuation that occurs within aquifer systems. This initial screen of data is therefore undertaken to identify potential Constituents of Concern (CoCs), each of which can then be considered in more detail in subsequent sections of this report. In some cases, the GAC used is lower than the laboratory LOD (i.e. the EQS is more stringent than can be measured using current standard contaminated land assessment laboratory techniques). In these instances, only genuine exceedances have been listed in the following table (i.e. where detectable concentrations exceed the GAC).

TPH analyses are speciated according to the Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG) approach (TPHCWG 1997). There are no UK published GACs for TPHCWG speciated fractions for controlled waters.



Where available, indicator compounds, have been used to provide a GAC for each speciated fraction, as per the recommended petroleum hydrocarbon indicators in CL:AIRE (2017).⁹ This has enabled the definition of a specific indicator EQS for all aromatic fractions. Unfortunately, the lack of published EQS for the indicator compounds for aliphatic fractions necessitates the use of a proxy EQS. Therefore, 10ug/l has been chosen as a GAC by Yellow Sub as a suitably conservative value for each individual speciated aliphatic fraction, based on professional judgement.

In accordance with the guidance accompanying current EQS values, benzo(a)pyrene (BaP) has been used as a proxy to represent potential risk associated with five PAH species (benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene and indeno(123cd)pyrene in addition to BaP).

Table 5-13 details the CoCs identified as a result of this process.

Table 5-13 Exceedances of EQS in groundwater (all ug/l)

Contaminant	Max	95% UCL	EQS	No. Samples	Exceedances (location)
Dissolved Chromium III	68	7.7	4.7	165	12 (MW16-03, MW16-05, MW16-06, MW16-09, MW16-10, MW16-11, MW16-13)
Copper	17	7.1	1	165	4 (BH4, MW16-05, MW16-09, MW16-13)
Lead	32	5.4	1.2	165	1 (MW16-13)
Nickel	27	3	4	165	15 (BH4, MW16-02, MW16-03, MW16-06, MW16-10, MW16-11, MW16-13)
Vanadium	49.1	2.8	20	165	2 (MW16-13)
Zinc	234	11.7	10.9	165	12 (MW16-02, MW16-03, MW16-09, MW16-13)
Naphthalene	12032	1438.2	2	165	55 (BH1A, BH2, BH3, MW16-01, MW16-02, MW16-05, MW16-06, MW16-08, MW16-09, MW16-12, MW16-13)
Anthracene	9.9	1.6	0.1	165	76 (BH3, MW16-01, MW16-02, MW16-03, MW16-05, MW16-06, MW16-08, MW16-09, MW16-12)
Fluoranthene	18	2.3	0.0063	165	125 (All installed wells)
Benzo(a)pyrene	3.4	0.29	0.00017	165	62 (BH1A, BH2, BH3, BH4, MW16-01, MW16-02, MW16-03, MW16-05, MW16-06, MW16-08, MW16-09, MW16-11, MW16-12, MW16-13)
Benzene	2202	203.4	10	165	48 (BH3, MW16-01, MW16-02, MW16-06, MW16-08, MW16-10, MW16-12, MW16-13)
Toluene	1287	120.7	74	165	15 (MW16-01, MW16-12)
m/p-xylene	1895	203.6	30	165	35 (BH3, MW16-01, MW16-02, MW16-12)
o-xylene	677	84.1	30	165	32 (BH3, MW16-01, MW16-02, MW16-12)

⁹ Recommended petroleum hydrocarbon CoPC indicator (CL:AIRE, 2017) Petroleum Hydrocarbons in Groundwater: Guidance on assessing petroleum hydrocarbons using existing hydrogeological risk assessment methodologies.



Contaminant	Max	95% UCL	EQS	No. Samples	Exceedances (location)
Phenol	1910	83.4	7.7	165	17 (MW16-01, MW16-02, MW16-12)
Sulphate as SO4	1061200	68,344.7	400000	165	2 (MW16-13)
Free cyanide	70	15.7	1	165	57 (MW16-01, MW16-02, MW16-05, MW16-06, MW16-08, MW16-09, MW16-12, MW16-13)
Total cyanide	3430	235.5	1	165	132 (BH2, BH3, MW16-01, MW16-02, MW16-03, MW16-05, MW16-06, MW16-08, MW16-09, MW16-10, MW16-11, MW16-12, MW16-13)
Ammoniacal Nitrogen as N	56,900	10,653.6	600	165	77 (BH2, BH3, MW16-01, MW16-02, MW16-03, MW16-08, MW16-10, MW16-11, MW16-12, MW16-13)
Aliphatic C6-8	793	74.8	10	164	43 (MW16-01, MW16-02, MW16-06, MW16-10, MW16-12)
Aliphatic C8-10	835	103	10	164	45 (MW16-01, MW16-02, MW16-03, MW16-06, MW16-10, MW16-12, MW16-13)
Aliphatic C10-12	100	7.7	10	164	2 (MW16-02)
Aliphatic C12-16	650	26	10	164	8 (BH2, MW16-02, MW16-05, MW16-06)
Aliphatic C16-21	460	23.5	10	164	7 (BH2, MW16-02, MW16-05, MW16-06)
Aliphatic C21-35	67	11.4	10	164	2 (BH2, MW16-02)
Aromatic C5-7	2202	199.7	10	164	47 (BH3, MW16-01, MW16-02, MW16-06, MW16-08, MW16-10, MW16-12, MW16-13)
Aromatic C7-8	1287	118.6	74	164	14 (MW16-01, MW16-12)
Aromatic C8-10	2960	317.1	30	164	47 (BH3, MW16-01, MW16-02, MW16-10, MW16-12)
Aromatic C10-12	28,413	2121.4	2	164	49 (BH1A, BH2, BH3, MW16-01, MW16-02, MW16-05, MW16-06, MW16-08, MW16-12, MW16-13)
Aromatic C12-16	2120	244.5	10	164	48 (BH2, BH3, MW16-01, MW16-02, MW16-05, MW16-06, MW16-08, MW16-12, MW16-13)
Aromatic C16-21	1310	119.1	0.1	164	51 (BH2, BH3, MW16-01, MW16-02, MW16-05, MW16-06, MW16-08, MW16-12, MW16-13)
Aromatic C21-35	370	25.6	0.00017	164	6 (BH3, MW16-01, MW16-05, MW16-06)

The sandstone bedrock aquifer beneath the Site is designated as a Secondary (A) Aquifer. Groundwater flow direction is south-easterly from the Site towards the River Taff, which is situated approximately 190 m away on the far side of Quaker's Yard village. It is anticipated to discharge into the Taff. Given the urban nature and small extent of aquifer downstream from the Site, it is considered unlikely that this aquifer will provide a significant groundwater resource in the small area of land beneath the village of Quakers Yard.

Notwithstanding this, the groundwater chemistry data has been compared with Drinking Water Standards protective of the aquifer as a potential groundwater resource. The results are summarised below:



Table 5-14 Exceedances of DWS in groundwater (all ug/l)

Contaminant	Max	95% UCL	DWS	No. Samples	Exceedances (location)
Dissolved Arsenic	10.2	3.2	10	165	1 (MW16-13)
Dissolved Chromium III	68	7.7	50	165	1 (MW16-13))
Lead	32	5.4	10	165	1 (MW16-13)
Nickel	27	3	20	165	1 (MW16-13)
Benzo(a)pyrene	3.4	0.29	0.01	165	57 (MW16-01, MW16-02, MW16-03, MW16-05, MW16-06, MW16-08, MW16-09, MW16-11, MW16-12, MW16-13)
Indeno(1,2,3,cd)pyrene	2.2	0.19	0.1	165	14 (MW16-01, MW16-02, MW16-03, MW16-05, MW16-06, MW16-09, MW16-12)
Benzo(ghi)perylene	2.2	0.17	0.1	165	10 (MW16-01, MW16-02, MW16-05, MW16-06, MW16-09, MW16-12)
Benzo(b)fluoranthene	4.7	0.3	0.1	165	21 (MW16-01, MW16-02, MW16-03, MW16-05, MW16-06, MW16-08, MW16-09, MW16-12, MW16-13)
Benzo(k)fluoranthene	2	0.17	0.1	165	14 (MW16-01, MW16-02, MW16-03, MW16-05, MW16-06, MW16-09, MW16-12)
Benzene	2202	203.4	1	165	55 (BH3, MW16-01, MW16-02, MW16-06, MW16-08, MW16-10, MW16-12, MW16-13)
Sulphate as SO4	1061200	68,344.7	250000	165	7 (MW16-08, MW16-13)
Free cyanide	70	15.7	50	165	3 (MW16-06, MW16-08, MW16-13)
Total cyanide	3430	235.5	50	165	84 (BH2, BH3, MW16-01, MW16-02, MW16-05, MW16-06, MW16-08, MW16-09, MW16-12, MW16-13)
Ammoniacal Nitrogen as NH4	73280	10,653.6	500	165	83 (BH2, BH3, MW16-01, MW16-02, MW16-03, MW16-06, MW16-08, MW16-09, MW16-10, MW16-12, MW16-13)

As shown in the tables above, groundwater failures have been consistently seen in PAHs, hydrocarbons and heavy metals for the majority of monitoring wells. Three of the wells (MW16-05, MW16-09 and MW16-13) are screened within the shallow Made Ground and five (BH1a, BH2, BH3, BH4 and MW16-12) within the bedrock, the remainder are screened within the superficial deposits.

5.6.1.1 PAHs

Where EQS screening values are considered, there are widespread PAH exceedances across the Site, with a minimum of one PAH exceedance being recorded within each well over the entire monitoring period. Where results are compared with DWS, which are in all cases higher than their EQS counterparts, exceedances are still prevalent with the 95% UCL exceeding the DWS value in all instances. Generally, exceedances are located towards the north and centre of the Site, with few detections above the LOD recorded in the south of the Site within MW16-10 and MW16-11. The highest PAH exceedances are typically recorded within MW16-01, MW16-12, MW16-06 and MW16-05, suggesting a hotspot of elevated contamination across the north and centre of the



Site encompassing Gasholders No.1 and No.2, and historical process areas (including the volumetric governor house where MW16-12 lies). This aligns with AREA A and AREA B as shown in Drawing P23545_R1_DO5. Naphthalene, anthracene, fluoranthene and benzo(a)pyrene were carried forwards as Contaminants of Potential Concern (CoPC) for Area A and B. Only fluoranthene and benzo(a)pyrene were taken forwards as CoPCs for Area C, on the basis that the 95% UCL for results here fell below the EQS values for anthracene and naphthalene.

5.6.1.2 Heavy metals

Heavy metal exceedances were recorded for chromium, copper, lead, nickel, vanadium and zinc where EQS values are considered. There is no clear spatial or temporal trend in these exceedances. For each of these the maximum recorded concentration was recorded within MW16-13 (Gasholder No.2) between 2019 and 2020. Although, this is not replicated in subsequent MW16-13 samples from 2021 to 2022, with no heavy metal exceedances being recorded.

Lead was recorded as an exceedance in a single sample of the 180No. analysed. Copper was recorded as an exceedance in 4No. of the 179No. analysed. Vanadium was recorded as an exceedance in 2No. of the 180No. samples analysed. All three metals were recorded their largest concentration in MW16-13 (Gasholder No.2) in September 2019 and September 2022. With the exception of a single, smaller exceedance of copper in September 2016, these three metals were all below the laboratory LOD on the other 13No. occasions this well was sampled. Gasholder No.2 is the location of maximum concentrations and exceedances in other, organic contaminants.

Where DWS values are considered a single exceedance of Chromium III, nickel, lead and arsenic is recorded, all within MW16-13. Arsenic being the only one of these where the DWS value is lower than its EQS counterpart. The arsenic exceedance is marginal and isolated, and as such has not been carried forward as a CoPC.

The isolated and inconsistent nature of exceedances for these three metals is such that they are not taken forward as CoPC. Notwithstanding this, they will be subject to betterment following the remediation required in and around Gasholder No.2 to address risks associated with mobile hydrocarbon and PAH contaminants.

Whilst nickel and zinc were recorded as exceedances in 13No. and 12No. samples of the 179No. analysed respectively, the 95% UCL of the results falls below the EQS. These two metals have also therefore not been taken forward as CoPCs.

Chromium III is the only metal to be carried forward as a CoPC and this relates to areas A and C

5.6.1.3 Cyanide

As an initial screening exercise, total cyanide has been compared with GAC for free cyanide. This is in the absence of speciated analysis of the composition of the total cyanide, and in the absence of total cyanide screening values. The use of the free cyanide GAC for total cyanide is conservative, as cyanide is much less mobile in its complex form.

However, free cyanide has also been analysed for during each groundwater monitoring visit. Free cyanide is a measurement of disassociated cyanide ions and of easily disassociated hydrogen cyanide – the two more toxic forms of cyanide. Where EQS values are considered, free cyanide exceedances are widespread, with detection above the LOD recorded in MW16-01, MW16-02,



MW16-05, MW16-06, MW16-08, MW16-09, MW16-12 and MW16-13. Where DWS values are considered only 3 exceedances of free cyanide are recorded of the 165 sampled, notwithstanding this both have been carried forward as CoPC in areas A and B. In area C, only total cyanide has been carried forward as a CoPC as there are no recorded exceedances of free cyanide within area C.

5.6.1.4 TPH fractions

The highest concentrations of light aliphatic TPH fractions (C6-8 and C8-10) are consistently recorded in MW16-01 followed by MW16-02 and MW16-12. MW16-01 lies close to Gasholder No.1 with MW16-02 and MW16-12 also in the vicinity. Additional isolated exceedances are also recorded within MW16-03, MW16-06, MW16-10 and MW16-13. Heavier aliphatic TPH fractions show fewer exceedances and less of an obvious spatial pattern, although multiple exceedances are recorded within MW16-02. This aligns with the fact that heavier fractions ($>C_{10}$ to C_{35}) have very limited mobility in water, as evidenced by their extremely high organic-water partition coefficient (K_{oc}) 25,000 to 630,000,000 l/kg (hence they are much less likely to have mobilised from their initial point of release into the soils/ groundwater).

The highest exceedances for the lower fraction aromatic TPH are also consistently seen in MW16-01 with multiple exceedances also recorded within the downgradient wells MW16-02 and MW16-12. Similarly, of the exceedances noted for aromatic TPH ($>EC_5$ to EC_{35}), the upper fractions are similarly immobile ($>C_{16}$ to C_{35} , 16,000 to 130,000 l/kg). Although exceedances for Aromatic C16-21 are as widespread as the lighter fractions, with once again the highest exceedances being recorded in MW16-01.

The lack of mobility for the heavier-end fractions considerably restricts their potential to pose significant risks to off-Site receptors, due to their affinity for the sorbed phase. In line with the guidance set out in CL:AIRE (2017), fractions with low or very low mobility (aliphatic fraction C8 to C35 and aromatic fractions C16-35) have not been taken forward as CoPCs. This is with the exception of individual PAH compounds within the aromatic C16 to C35 range, which are taken forward as CoPCs, due to their specific toxicity.

Aromatic C5 to C16 and aliphatic C6 to C10 are taken forward as CoPCs in Area A and Area B. In Area C, aliphatic C6-8 and aromatic EC7-8, EC8-10 and EC16-16 were not carried forward as the 95% UCL of samples fell below the respective GAC.

5.6.1.5 BTEX

As with TPHs, the highest concentrations of BTEX are consistently recorded in MW16-01 followed by MW16-02, BH3 and MW16-12. Where EQS values are considered, of the 12 Toluene exceedances recorded, 11 are within MW16-01. Isolated exceedances are also recorded within MW16-06, MW16-08, MW16-10 and MW16-13 for benzene.

Of the BTEX compounds, a DWS value exists only for benzene, as this falls below the LOD any detections above LOD are recorded as exceedances. In Areas A and B, exceedances are widespread however in Area C, only one detection above LOD is recorded within MW16-10, on one occasion in 2017. Subsequent monitoring of MW16-10 has not recorded any detections of benzene above LOD, therefore it is not carried forwards within Area C.



Benzene, toluene and xylenes are all carried forward as CoPCs within Area A. In Area B, toluene was not carried forward as there was only a single exceedance recorded and the 95% UCL of results was below the EQS value. None were carried forward within Area C, due to reasons discussed above for benzene, and because all other BTEX had a 95% UCL below the annual average EQS value.

5.6.1.6 Others

Where EQS values are considered, two exceedances were recorded for Sulphate as SO_4 , both within MW16-13, the first in September 2019 and the second in September 2020. This was not replicated in subsequent visits. Where DWS values are considered, 7 exceedances are recorded, 6 within MW16-13 and 1 within MW16-08. The 95% UCL falls below both the EQS and the DWS screening values. As such Sulphate as SO_4 has not been taken forward as a CoPC.

The EQS value for phenol, falls below the LOD therefore all detections above LOD are recorded as exceedances. There are 17 detections above LOD for phenol, 14 of which are within MW16-01. Phenol has been carried forward as a CoPC within Areas A and B.

Where EQS values are considered, Ammoniacal Nitrogen as N exceedances are widespread, with 81 of 180 samples recording failures. Highest values are consistently recorded within MW16-02. Similarly, comparison with DWS values shows 83 exceedances of Ammoniacal Nitrogen as NH_4 . Ammoniacal Nitrogen as N has been carried forward as a CoPC for Areas A, B and C.

5.6.1.7 Contaminants of Potential Concern (CoPC)

As with the soils the groundwater results have been divided into three datasets, Source Area A (comprising Gasholder No.1 and No.2), Source Area B (comprising other historical process areas) and Source Area C (the remainder of the Site). Table 5-15, Table 5-16 and Table 5-17 summarise the CoPC which will be carried forward to the DQRA assessment for each area.

Table 5-15 Contaminants of Potential Concern (CoPC) within Source Area A

CoPC	Number of samples	EQS	Maximum (ug/l)	95% UCL (ug/l)	Number of exceedances
Naphthalene	71	2	12030	2760	29
Anthracene	71	0.1	9.9	2.8	39
Fluoranthene	71	0.0063	17	4.3	70
Benzo(a)pyrene	71	0.00017	3.4	0.5	35
Benzene	71	10	2200	360.9	16
Toluene	71	74	1290	250.8	14
m/p-Xylene	71	30	1900	418.1	14
o-Xylene	71	30	680	155.4	14
Aliphatic >C6-C8	70	10	790	134.9	14



CoPC	Number of samples	EQS	Maximum (ug/l)	95% UCL (ug/l)	Number of exceedances
Aliphatic >C8-C10	70	10	840	179.3	15
Aromatic >C5-EC7	70	10	2200	352.2	10
Aromatic >EC7-EC8	70	74	1290	243.9	8
Aromatic >EC8-EC10	70	30	2960	622	8
Aromatic >EC10-EC12	70	2	28410	4130.7	18
Aromatic >EC12-EC16	70	10	2120	398.8	20
Phenol	70	7.7	1910	177.6	14
Free Cyanide	71	1	60	20	43
Total Cyanide	71	1	3430	442.2	70
Ammoniacal Nitrogen as N	71	600	39810	7170	31
Total Dissolved Chromium III	70	4.7	68	9.8	8

Table 5-16 Contaminants of potential concern (CoPC) in groundwater within Source Area B

CoPC	Number of samples	EQS	Maximum (ug/l)	95%UCL (ug/l)	Number of exceedances
Naphthalene	44	2	12030	1336.8	24
Anthracene	44	0.1	9.3	1.7	32
Fluoranthene	44	0.0063	11	2.1	38
Benzo(a)pyrene	44	0.00017	3.2	0.4	22
Benzene	44	10	1490	221.7	30
m/p-Xylene	44	30	1380	123.1	20
Aliphatic >C6-C8	44	10	560	71.3	27
Aliphatic >C8-C10	44	10	470	105.5	27
Aromatic >C5-EC7	44	10	1490	222.1	30
Aromatic >EC7-EC8	44	74	990	74.5	1
Aromatic >EC8-EC10	44	30	2230	249.1	28
Aromatic >EC10-EC12	44	2	8750	1796.7	29
Aromatic >EC12-EC16	44	10	1100	325.8	27
Phenol	44	7.7	60	14.3	3



CoPC	Number of samples	EQS	Maximum (ug/l)	95%UCL (ug/l)	Number of exceedances
Free Cyanide	44	1	70	17.2	16
Total Cyanide	44	1	660	195.2	43
Ammoniacal Nitrogen as N	44	600	56,900	27.2	42

Table 5-17 Contaminants of potential concern (CoPC) in groundwater within Source Area C

CoPC	Number of samples	EQS	Maximum (ug/l)	95%UCL (ug/l)	Number of exceedances
Fluoranthene	50	0.0063	22	0.15	21
Benzo(a)pyrene	50	0.00017	0.2	0.03	4
Aliphatic >C6-C8	50	10	30	9.8	1
Aliphatic >C8-C10	50	10	100	14	1
Aromatic <EC5-EC7	50	10	120	14.9	1
Aromatic <EC8-EC10	50	30	130	15.7	1
Aromatic >EC10-EC12	50	2	30	6.5	1
Total Cyanide	50	1	50	14.5	15
Ammoniacal Nitrogen as N	50	600	51,290	3,873.8	8
Total Dissolved Chromium III	50	4.7	12	6.5	4

Average concentrations for all of the TPH species apart from aromatic C10-12 are below the EQS and attributed to isolated exceedances in wells for which all other data are below the EQS. These are therefore not considered to be CoPCs for Area C.

The exceedance of the average value for dissolved chromium is largely attributable to the fact that the LoD for this species (6 ug/l) is greater than the EQS. The total dissolved chromium analysis of the same samples has an LoD of 1.5 ug/l, and the average value is 2.2 ug/l. As such, chromium is not considered to be a CoPCs for Area B.



Free cyanide has not been detected above the LoD in any of the 50 samples taken. The total cyanide results are therefore not considered significant in Area C, as all are attributable to stable, non-mobile complexes.

Ammoniacal nitrogen as N and benzo(a)pyrene exceedances are limited in both geographical extent (MW16-03 and MW16-10) and do not recur temporally. Benzo(a)pyrene exceedances above the LoD are in less than 10% of samples, and ammoniacal nitrogen and N exceedances are in less than 20% of samples. Whilst these contaminants and fluoranthene remain as CoPCs for this area, the much reduced area and reduced prevalence of exceedances in this area suggests that the critical source area for contamination does not extend into this area.

5.6.2 Water chemistry within surface waters

The Bargoed Taff River and the spring water that crosses the Site have been subject to 16No. rounds of water sampling between 2015 and 2022, with samples being analysed for a broad range of contaminants. For the majority of visits, the same five sampling points have been used, which are as follows:

- A: Upstream of the Site, approximately 5m northeast of the Site boundary;
- B: At the bridge, downstream of Gasholder No.1 and downstream of the outfall from the channel draining the springs;
- C: Downstream of the Site: approximately 10m southwest of the Site boundary;
- D: Upstream of the site at the spring, at the northern Site boundary; and,
- E: The spring water channel before its confluence with the Bargoed Taff River.

In the most recent monitoring round in November 2022, only an upstream and downstream point were sampled, SW1 and SW2 respectively, which are in the same location as sample points A and C respectively. Drawing P23545_R1_D03 details the locations of the sampling points. Results have been collated and screened against the EQS in an identical way to the groundwater data, exceedances above the laboratory limit of detection (LOD) are summarised in Table 5-18 below.

As discussed below, there are far more frequent exceedances at Point D (upstream of the spring) than there are for Point A (upstream of the Site), suggesting the Site soils are impacting the waters here. Point D samples are taken from water ponding at the Site surface, hence there is potential for mixing with or dispersal of contamination from Site soils with the spring water as it upwells through the Made Ground soils beneath the sampling point.

*Table 5-18 Exceedances of EQS in surface water (all ug/l)**

Contaminant	Min	Max	Mean	EQS	Exceedances (upstream)	Exceedances (downstream)
Copper	3.1	7	6.9	7	1 (SW1)	1 (SW2)
Zinc	<3	11	3.5	10.9	1 (D)	0
Anthracene	<0.005	0.86	0.027	0.1	1 (D)	2 (E)
Fluoranthene	<0.005	4.7	0.1	0.0063	5 (A (x3), D (x2))	13 (B (x4), C (x2), E (x7))
Benzo(a)pyrene	<0.005	2.2	0.056	0.00017	2 (D)	11 (B (x3), C, E(x7))



Contaminant	Min	Max	Mean	EQS	Exceedances (upstream)	Exceedances (downstream)
Total cyanide	<10	60	10.8	1	1 (D)	2 (B, E)
Ammoniacal Nitrogen as N	<30	2830	138	600	1 (A)	3 (B, C, E)
Dissolved Chromium III	6	7	6	4.7	0	1 (E)
Aromatic C16-21	<10	20	10	10	0	1 (E)

* Upstream samples comprise Sample A & SW1 (Bargoed Taff River) and Sample D (spring upstream of site)

Downstream samples comprise Samples B, C & SW2 (Bargoed Taff River) and Sample E (discharge of springwater into Bargoed Taff River)

When considering the potential contaminant impact on upstream waters, it is important to consider that the upstream spring sample (Sample D) has been taken from a ditch that is in contact with site soils. It is therefore possible (likely) that this does not represent a true upstream sample, and that the impact seen in it (for anthracene, fluoranthene, benzo(a)pyrene and cyanide) is likely attributable to the Site.

It is also important to note that the river water chemistry downstream of the Site is likely being impacted via three separate pollutant linkages; by migration into the river of dissolved phase groundwater, by leaching into the small stream that flows across the Site surface and by the direct erosion of site soils by the river.

5.6.2.1 Heavy metals

Two copper exceedances were recorded in November 2022, however similar values are recorded both upstream and downstream of the Site. A single zinc exceedance was recorded at Point D, in September 2016. These are considered to be representative of natural variation and are not considered further.

A single exceedance is recorded for Chromium III at Point E in March 2019. All other samples were below the LOD.

5.6.2.2 PAHs

PAH failures were recorded for anthracene, fluoranthene and benzo(a)pyrene. Exceedances for benzo(a)pyrene and anthracene are limited to within the spring waters, or downstream of its confluence with the river. Downstream samples only show exceedances for fluoranthene in September 2019 and March 2022 and for benzo(a)pyrene in March 2022.

Fluoranthene exceedances are also focussed on the spring, its drainage channel and the river downstream of its confluence. However, on 3No. occasions fluoranthene also exceeded the EQS in the upstream sample, suggesting an influence from other factors besides the Site.

The majority of failures are recorded at Point E, where the spring joins the Bargoed Taff River after flowing through the former Gasholder No.1. On five of the seven occasions where PAH exceedances were recorded, failures were not recorded at any of the other monitoring points. During the two monitoring rounds in August 2016, exceedances were also recorded at Points A, B



and D. There is a clear pattern of contaminants joining the river at Point E via the spring, becoming more dispersed by Points B and C.

5.6.2.3 Inorganics

Total cyanide is recorded as exceeding three times, all on isolated occasions and at different locations. The exceedances are in the spring (Point D), in the drainage channel at its confluence with the river (Point E) and in the river immediately downstream of this point (Point B).

Ammoniacal nitrogen records four failures, which are all in March 2020. Concentrations increase from 0.67 mg/l upstream of the Site to 3.65 mg/l downstream of the Site with intermediate values recorded at Points B and E.

5.6.2.4 TPH

Aromatic C16-21 records a single exceedance in August 2016 at Point E. No detections are recorded at any of the monitoring points downstream.

BTEX contaminants have also been analysed but have never exceeded the EQS.

5.7 CoPCs with respect to controlled waters

Following the screening of data against GACs, the following CoPCs in groundwater have been identified as requiring further consideration.

Table 5-19 CoPCs identified in groundwater after comparison of data with GACs

Contaminant	CoPC in groundwater in AREA A	CoPC in groundwater in AREA B	CoPC in groundwater in AREAC	Recorded as present as exceedances of EQS in Bargoed Taff (Sample location)
Naphthalene	✓	✓	x	No
Anthracene	✓	✓	x	Yes (D, E)
Fluoranthene	✓	✓	✓	Yes (A, B, C, D, E)
Benzo(a)pyrene	✓	✓	✓	Yes (B, C, D, E)
Benzene	✓	✓	x	No
m/p-Xylene	✓	✓	x	No
O-Xylene	✓	X	x	No
Toluene	✓	X	x	No
Aliphatic >C6-C8	✓	✓	x	No
Aliphatic >C8-C10	✓	✓	x	No
Aromatic >EC5-EC7	x	✓	x	No
Aromatic >EC7-EC8	✓	✓	x	No
Aromatic >EC8-EC10	✓	✓	x	No



Contaminant	CoPC in groundwater in AREA A	CoPC in groundwater in AREA B	CoPC in groundwater in AREAC	Recorded as present as exceedances of EQS in Bargoed Taff (Sample location)
Aromatic >EC10-EC12	✓	✓	x	No
Aromatic >EC12-EC16	✓	✓	x	No
Phenol	✓	✓	x	No
Free Cyanide	✓	✓	x	No
Total Cyanide	✓	X	x	Yes (B, E)
Ammoniacal Nitrogen as NH4	✓	✓	✓	Yes (B ,C, E)
Total Dissolved Chromium III	✓	X	x	Yes (E)

In addition to the above CoPCs in the dissolved phase, the river is actively eroding soils, contributing contamination to the river directly. This is extremely difficult to quantify, but requires further consideration as a potentially significant pollutant pathway.



6 Conceptual Site Model

On the basis of the observations and testing of soils and groundwater beneath the Site, a conceptual site model (CSM) of the subsurface has been compiled. Best practice in the assessment of contaminated land (for example; LCRM, EA 2017, EA 2016, CL:AIRE 2017, BS EN ISO 21365) requires that a conceptual model should represent the characteristics of a site, include consideration of contaminant sources, a receptor that is sensitive to such contamination and a pathway linking the two (i.e. a source-pathway-receptor linkage).

The purpose of this report is to assess potential interaction between the ground and groundwater conditions beneath the Site with either human health or the wider environment. The latter comprises controlled waters (groundwater within aquifers and local surface watercourses) and the ecosystems they support.

The following section discusses the various aspects of the ground and groundwater conditions beneath the Site. It then develops potential “source-pathway-receptor” pollutant linkages that describe the mechanism by which the recorded soil and groundwater chemistry may impact receptors. This in turn then provides the foundation for the DQRA process described in Section 7. A pictorial representation of the conceptual model is provided in Drawing P23545_R1_D04.

6.1 Potential sources of contamination

6.1.1 AREA A: Gasholders No.1 and No.2

During statistical soil analysis exploratory positions BH2, HP15-11, MW16-01, MW16-06, RB16-02, TP16-08, TP16-08B and TP16-09 were identified as outliers all of which lie in the area of Gasholder No.1 and No.2. The following contaminants were identified as potential constituents of concern within soil:

- PAHs: Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(ah)anthracene, fluoranthene, indeno(123cd)pyrene, naphthalene and phenanthrene;
- TPH fractions: Aromatic >EC16-21 and >EC21-35;
- Free and Complex Cyanide;
- Heavy metals: lead and mercury;
- SVOCs and VOCs: 1,2,3 – Trichloropropane, 1,2,4 – Trimethylbenzene, 1,2- Dibro,o-3- chlopropane and 2-Methylnaphthalene.

The screening of groundwater results against EQS values identified 19No. potential contaminants of concern:

- PAHs: Naphthalene, Anthracene, Fluoranthene and Benzo(a)pyrene;
- BTEX: Benzene, Toluene, m/p-Xylene and o-Xylene;
- TPH fractions: Aliphatic >C6-C8, C6-C10 and Aromatic >C5-EC7 >EC7-EC8, >EC8-EC10, >EC10-EC12 and >EC12-EC16;
- Phenol;
- Free Cyanide and Total Cyanide;
- Ammoniacal Nitrogen as N; and



- Total Dissolved Chromium III.

Asbestos in soils also represent a potential source of contamination within this area.

An LNAPL sheen was identified in a single trial pit in Gasholder 1, with no other evidence of a discrete NAPL body seen on site. Hence there is not considered to be a discrete NAPL source on site. Notwithstanding this, the presence of globules and sheens has been assessed as representative of some localised soil saturation, as represented by the soil chemistry.

6.1.2 AREA B: Gasworks process areas (including tully gasworks, purifiers and exhaustor house)

During statistical soil analysis HP15-O9 and TP5 were both identified as outliers for lead and free cyanide respectively. HP15-O9 lies on the footprint of the former exhaustor house and TP5 downgradient of Gasholder No.1. A review of soils data excluding Gasholder No.1 and No.2 indicated that soils in this area have concentrations of benzo(b)fluoranthene, benzo(a)pyrene, dibenzo(ah)anthracene and complex cyanide above the GAC.

Asbestos in soils also represent a potential source of contamination within this area.

The screening of groundwater results against EQS values identified 16No. potential contaminants of concern:

- PAHs: Naphthalene, Anthracene, Fluoranthene and Benzo(a)pyrene;
- BTEX: Benzene and m/p-Xylene;
- TPH fractions: Aliphatic >C6-C8, >EC8-EC10 and Aromatic >C5-EC7, >EC8-EC10, >EC10-EC12 and >EC12-EC16;
- Phenol;
- Free Cyanide and Total Cyanide; and,
- Ammoniacal Nitrogen as N.

6.1.3 AREA C: Southern area of site

A review of the soils data indicates that soils across AREA C Site has concentrations of dibenzo(ah)anthracene above the GAC. However, the exceedance seen is very marginal (80% UCL of 1.6 mg/kg compared with a GAC of 1.4 mg/kg). Asbestos in soils also represent a potential source of contamination within this area.

The screening of groundwater results against EQS values identified 6No. potential contaminants of concern:

- PAHs: Fluoranthene and Benzo(a)pyrene; and,
- Ammoniacal Nitrogen as N.

The extent and prevalence of these contaminants are considered insufficient for this area to be considered as part of the source term area for controlled waters DQRA modelling. Hence the source term has been assumed to be the extent of Areas A and B combined.



6.2 Potential receptors

6.2.1 Human health

6.2.1.1 *Current and future Site users (public open space park scenario)*

The Site is currently used a public open space, with a cycle path crossing the Site and informal, wooded area open to the public on either side. Once remediation is completed the Site will be returned to the same use. Any change from this future use scenario will require a reassessment of potential risks with respect to human health.

6.2.1.2 *Nearby residential properties*

There are residential properties within 70m of the Site, to the north-west, south-west and south of the Site. Those to the north-west are separated from the Site by an elevation difference of approximately 20m, due to the steep slope that extends up from the Site boundary. Those to the south are separated from the Site by the river. These have been discounted as receptors (see Section 5.4). The single house to the south-west (also approximately 70m away) remains a potential receptor. However, the distance to the receptors, the geological and hydrogeological setting and the fact that the shallow ground is free to vent to atmosphere are considered sufficient to reduce any risk that may be posed to very low.

6.2.2 Wider environment

6.2.2.1 *Bargoed Taff River and River Taff*

The Bargoed Taff River runs along the southeast of the Site joining the River Taff approximately 190m southwest of the Site. This lies within the Berthlwyd Site of Importance for Nature Conservation (SINC) and represents a sensitive receptor. Groundwater on Site flows towards the river providing a potential pathway for contaminants.

6.2.2.2 *Spring*

The water emanating from a series of springs along the north-western Site boundary are captured by a drainage channel and conveyed across the Site surface, across the footprint of Gasholder No.1 before flowing into the Bargoed Taff.

6.2.2.3 *Secondary A Aquifers (Alluvium and Hughes Member)*

Groundwater beneath Site is within the Made Ground, superficial deposits and bedrock. The groundwater elevation data suggests that these are all in hydraulic continuity with each other. The Site does not lie within a groundwater source protection zone and there are no records relating to groundwater abstractions.

The shallow groundwater within this aquifer is assumed to be in hydraulic continuity with the Bargoed Taff. Deeper portions of the aquifer may continue to flow southwards beneath the Bargoed Taff river channel. The aquifer is considered likely to drain to the River Taff, some 250m away.

The aquifer is not considered to have a significant resource potential, due to the limited areal extent between the Site and the River Taff, and the urban nature of the intervening land. Hence



the aquifer is not considered to be of note from a resource potential, but is of note with respect to it being a pathway towards both rivers.

6.3 Potential pathways

6.3.1 Human health

The following pathways are present on Site with respect to the direct potential exposure of human health to contaminants beneath the Site under a public open space (park) scenario:

- Dermal contact;
- Ingestion; and,
- Inhalation of dust, vapours and asbestos fibres (outdoor only).

There are several mechanisms by which vapours may impact on human health: Firstly, volatilisation and upwards migration of soil-phase/ NAPL and dissolved-phase contamination provides the most direct potential vapour pathway. Secondly, dissolved-phase or NAPL contamination may migrate laterally due to groundwater or NAPL head, and hence cause the potential for the volatilisation and upwards migration of vapour from the corresponding groundwater plume, which might extend beneath and beyond the boundaries of the Site.

Comparison of groundwater data with GACs protective of human health via vapours indicated no exceedances of the commercial GAC for groundwater samples on Site.

The movement of groundwater is likely southeast towards the Bargoed Taff River. Contaminant movement, if it is occurring, is considered to mirror this direction. The river itself is considered to be a boundary to contaminant migration in the shallow aquifer (i.e. groundwater flow is towards, and into the river).

Movement of groundwater is in the opposite direction to the residential properties that lie north-west of the Site. Migration of mobile contamination towards these properties is therefore considered very unlikely. The combination of the horizontal and vertical separation between the Site and the residential properties also renders the likelihood that vapour migration between the Site and the properties is very low.

6.3.2 Wider environment

6.3.2.1 Springs and the associated drainage channel

The spring and associated drainage channel are impacted by gasworks contaminants, indicating a direct pathway (via leaching and partition of contaminants) between the site soils, groundwaters and this watercourse. The springs currently emanate directly onto made ground soils and then flow across made ground soils in the drainage channel that crosses the area of Gasholder No.1.

Surface water chemistry data show an impact to the drainage channel water as it enters the river. It also shows some impact at the sampling point of the spring itself, at site surface.

Given the direct interaction of this water with the site soils, and given the impact to the river water chemistry that is seen from it, the remediation works will need to include an engineering



solution to isolate the spring and drainage channel from the Site soils (for example, in a capture trench and channel that is lined with low permeability clay).

The conceptual model discussed below and assessed by DQRA assumes that this isolation of the spring and channel waters will be implemented. Hence groundwater modelling has focussed on flow towards the river.

6.3.2.2 Direct erosion of site soils by Bargoed Taff River

The river channel is actively migrating westwards into the Site, eroding soil from the site in the vicinity of Gasholder 1 and Gasholder 2. This is directly impacting the river water quality, but is extremely difficult to quantify.

6.3.2.3 Bargoed Taff River

Both the groundwater and the spring across the north of the Site feed into the Bargoed Taff River representing a clear pathway between the Site and river. Elevated concentrations of gaswork contaminants (PAH, TPH, cyanide, ammoniacal nitrogen as N) have been recorded within the river. The available data suggests a link between the two direct mechanisms (the inflow of contaminated water to the river from the spring drainage channel and/ or the erosion of soils near Gasholders 1 & 2) and impact on river water quality, as impact is typically noted downstream of the area of the confluence, which is between Gasholders 1 & 2. In some cases the impact is seen to decrease with downstream distance from the confluence. Conversely, some contaminants are noted as elevated upstream of the site on some occasions (e.g. ammoniacal nitrogen as N).

It is considered likely that the spring drainage channel and the direct erosion are currently the primary mechanisms by which gasworks contaminants originating from site soils and groundwater are entering the river. However, the potential for contaminated groundwater also impacting the river cannot be ruled out. Indeed, the small, contaminated seep seen in the riverbank upstream of the bridge confirms this does occur.

6.3.2.4 Bedrock aquifer

Recent sampling of the aquifer in monitoring wells screened within the bedrock aquifer confirms the presence of gasworks contaminants at this depth. Given the generally southerly direction of groundwater flow, it is feasible that this contamination is migrating beneath the river and into the wider aquifer.

There is not considered to be sufficient resource potential within the aquifer downgradient of the Site (i.e. beneath the village of Quaker's Yard) to be considered a sensitive receptor in this respect. This is due to the lack of recorded abstractions, the limited aerial extent before the aquifer is assumed to discharge to the Taff and the urban setting.

The aquifer is considered to be of importance with respect to the discharge of baseflow to the River Taff downgradient from the site.

6.3.3 Source-Pathway-Receptor linkage summary

The following table provides a summary of the source-pathway-receptor linkages considered to be present associated with the Site. Each has been assessed in light of the results of the generic



quantitative risk assessment set out in Section 5 and a commentary provided on whether each remains of potential concern.

Each linkage considered to remain of potential concern has been carried forward to detailed quantitative risk assessment and/ or carried forward for addressing through remediation, as set out in Sections 7 and 8.

Table 6-1 Source-pathway-receptor linkages of potential concern following GQRA

Sources	Pathways	Receptors	Potentially linkage of concern following GQRA?
AREA A: Contents of former Gasholders 1 & 2 and surrounding soils	Direct (dermal/ ingestion) exposure, inhalation of dust and vapours.	Current and future users of the Site (users of the cycle path and informal recreation).	Yes
		Residents of nearby residential properties	No
	Leaching into dissolved phase		
	Lateral migration/ dispersion in dissolved phase in shallow aquifer towards Bargoed Taff.		
	Dissolved contaminant migration within spring flow towards Bargoed Taff	Bargoed Taff River	Yes
	Direct erosion of site soils by the river		
		River Taff	Yes
	Vertical migration and the lateral migration in the dissolved phase in deeper aquifer.	Secondary (A) Aquifer as a source of baseflow to River Taff	Yes
		Secondary (A) Aquifer as groundwater resource	No



AREA B: Visual and olfactorily impacted soils and groundwater in northern and central area of site, including potential former tar tank	Direct (dermal/ ingestion) exposure, inhalation of dust and vapours.	Current and future users of the Site (users of the cycle path and informal recreation).	Yes
		Residents of nearby residential properties	No
	Leaching into dissolved phase		
	Lateral migration/ dispersion in dissolved phase in shallow aquifer towards Bargoed Taff.		
		Bargoed Taff River	Yes
	Dissolved contaminant migration within spring flow towards Bargoed Taff		
	Direct erosion of site soils by the river		
		River Taff	Yes
	Vertical migration and the lateral migration in the dissolved phase in deeper aquifer.	Secondary (A) Aquifer as a source of baseflow to River Taff	Yes
		Secondary (A) Aquifer as groundwater resource	No
AREA C: Soils and groundwater in southern area of site.	Direct (dermal/ ingestion) exposure, inhalation of dust and vapours.	Current and future users of the Site (users of the cycle path and informal recreation).	Yes
		Residents of nearby residential properties	No
	Leaching into dissolved phase	Bargoed Taff River	No



	<i>Lateral migration/ dispersion in dissolved phase in shallow aquifer towards Bargoed Taff.</i>		
	<i>Dissolved contaminant migration within spring flow towards Bargoed Taff</i>		
		<i>River Taff</i>	No
	<i>Vertical migration and the lateral migration in the dissolved phase in deeper aquifer.</i>	<i>Secondary (A) Aquifer as a source of baseflow to River Taff</i>	No
		<i>Secondary (A) Aquifer as groundwater resource</i>	No



7 Land Quality Assessment: DQRA

7.1 DQRA Modelling for controlled waters (wider environment)

7.1.1 Introduction and rationale

A process of computer modelling of the behaviour of dissolved phase contamination has been undertaken using the Environment Agency P20 Worksheets Version 3.2 (EA 2013). The models have been run assuming a steady-state (i.e. the source does not decline over time). The model calculation sheets are provided in Appendix D.

The critical environmental receptor is that of the Bargoed Taff. The model has therefore been constructed to represent the potential contaminant linkage between the Site and the Bargoed Taff River. A sensitivity analysis is then undertaken to increase pathway length, in order to assess the secondary risk to the wider aquifer, in its role in providing baseflow to the River Taff.

7.1.1.1 Hydrogeological parameters

Previous Site work by Advisian included a total of 24 rising and falling head tests, completed across 18th August and 1st September 2016. Within the superficial deposits, a total of 18 slug tests were undertaken for MW16-03, MW16-04 and MW16-11. Measured hydraulic conductivities ranged between 1.73 and 11.7m/day, with a geometric mean of 4.03m/day. An additional six tests were completed for MW16-12 within the sandstone bedrock giving a range of hydraulic gradients between 0.7 and 0.75m/day.

Table 7-1 Hydrogeological parameters

Parameter	Comment	Chosen value
Infiltration (m/d)	Mean annual rainfall for nearest Met Office climate station (Tredegar, 12 miles away) is 1715.85 mm (Met Office 2019) = 4.7 mm/d. Current surfacing is predominantly soft standing beneath woodland. This will continue in the future. Assume 50% infiltration within broadleaved woodland, as median value in ICE (2022) in soft standing areas only due to loss of 50% to evapotranspiration = $4.7 \times 0.5 = 2.35$ mm/d or 0.00235 m/d.	0.00235
Saturated aquifer thickness (m)	Average thickness of superficial deposits as recorded in Advisian and Englobe logs	5.2
Hydraulic gradient (fraction)	Difference between water level of the river and MW16-12 on the 3 rd /4 th August 2016, over a 14m distance 97.922-97.7	0.0159
Hydraulic conductivity of aquifer (m/day)	Slug test results for the superficial deposits ranged between 1.73 and 11.7m/day with a geometric mean of 4.03m/day	4.03



7.1.1.2 Source areas

Two conjectured source areas have been plotted as set out in Drawing P25345_R1_D04, the first comprising AREA A (Gasholders No.1 and No.2 and the surrounding area) and the second (AREA B) also encompassing the former gas processing areas at the centre of Site. These areas have been defined using both the GQRA assessment results and also the visual and olfactory evidence of contamination (see Table 3-3). For the purposes of initial assessment, the combination of the two source areas has been used to represent the source term on Site, with the same area being used to define both the unsaturated zone source term and the dissolved phase source term, as aquifer and soils impact were noted to be largely coincident.

Ammoniacal nitrogen, benzo(a)pyrene and fluoranthene have also been identified as exceeding the GQRA EQS screening values in groundwater in Area C. There was no corresponding visual or olfactory evidence of contamination, and the concentrations recorded in Area C were not considered sufficient to drive its inclusion as part of the source area.

7.1.1.3 NAPL

There are no records of a column of NAPL recorded by any previous works. Observations of visual and olfactory contamination include descriptions of small discrete pockets of tar within the soil matrix, and of smearing on the soil matrix. This is consistent with a lack of NAPL source, but the presence of globules and sheens indicative of a made ground soil source that is near to soil saturation limit in places. This is associated with largely immobile hydrocarbons, as is to be expected of gasworks contamination.

As such, there is not considered to be a mobile NAPL source on Site. DQRA modelling has therefore focussed on the mobility of dissolved-phase contamination, assuming a steady-state source to represent the presence of residual NAPL contamination.

7.1.1.4 Biodegradation

Due to the constrained nature of the Site, and the short pathway lengths between the Site and the river, there is insufficient evidence to provide a primary indication of biodegradation within the aquifer (i.e. the groundwater monitoring points do not provide sufficient spread to delineate plume behaviour).

Secondary evidence

During the purging of groundwater, in-line measurement of physio-chemical aquifer parameters was undertaken by the Client in order to be able to characterise the conditions within the aquifer with respect to potential for aerobic or anaerobic biodegradation. Table 7-2 summarises the data collected for BH1a, BH2, BH3 and BH4, all of which are screened against the bedrock. Data collected by Advisian from the superficial deposits aquifer across four monitoring rounds in August and September 2016, has also been reviewed and is summarised in Table 7-3. Dissolved oxygen concentrations are approximately 0.5 mg/l or above in the majority of wells. 0.5 mg/l is the limit identified by EA (2000) as the boundary above which aerobic conditions prevail. Notably lower dissolved oxygen is recorded with BH4, although as this is screened against the deeper bedrock, anaerobic conditions are expected. Contrastingly, Oxidation-Reduction Potential (ORP) is for the most part negative indicating an anaerobic environment across the



majority of Site, MW16-10 and MW16-11 are the only two boreholes where average ORP suggests an aerobic environment. MW16-10 and MW16-11 lie towards the south of the Site and are the only boreholes outside of source areas A and B. This suggests that physio-chemical aquifer parameters are being impacted by contamination, with a more reducing environment seen in areas more impacted by contamination. Therefore, with remediation it is expected that the aquifer will become aerobic and biodegradation can be assumed in the long term. Once remediation has removed the source term, it is considered likely that biodegradation on Site will occur in all phases. However, for the purpose of the DQRA model and conservatism, biodegradation has been assumed to occur in dissolved phase only.

Table 7-2 Stabilised physio-chemical parameters within the bedrock

Borehole	Dissolved oxygen (%)	Dissolved oxygen (mg/l)	Conductivity (uS/cm)	pH	REDOX Potential (mV)
BH1a	4.3	0.47	412.7	6.68	-47.2
BH2	8.3	0.9	476	7.03	-134.8
BH3	4.3	0.47	477	7.15	-109
BH4	0.6	0.07	398.4	6.59	-19.7

Table 7-3 Stabilised physio-chemical parameters within the superficial deposits

Borehole	Dissolved Oxygen mg/l			Oxidation-Reduction Potential mV		
	Min	Max	Stabilised Average	Min	Max	Stabilised Average
MW16-01	0.28	1.47	0.53	-132.3	-47	-105.05
MW16-02	0.21	7.71	0.32	-164.9	-69.9	-122.94
MW16-03	0.31	1.98	0.57	-16.5	39.6	-0.70625
MW16-05	0.43	3.43	0.82	-105.8	116.3	-9.83
MW16-06	0.33	3.59	0.73	-73	-7.6	-33.41
MW16-08	0.24	2.29	0.39	-100.5	32.4	-61.61
MW16-09	0.35	2.00	0.50	-93.8	-14	-48.22
MW16-10	0.28	6.82	0.42	-12.7	52.4	12.26
MW16-11	0.36	3.73	0.49	-71.2	74.7	18.61
MW16-12	0.30	3.32	0.46	-515.5	32.5	-63.78



7.1.2 Modelling approach

Three models have been run in order to provide a modelling process that is as representative of reality as can be achieved within the constraints of the modelling process. These are defined as follows:

7.1.2.1 *Engineered riverbank (within 5m of the river edge)*

The river has eroded into the soils on site during the preceding decades. As a result, the original river wall is now no longer present in places, and the site soils are directly exposed to the river. As part of the remediation process, a stabilised soil slope is proposed, reinforced with a combination of site-won wood material and imported rocks. In order to form this engineered soil slope, a process of overdig and engineered placement of the soils is required adjacent to the riverbank. These soils will then effectively be in direct contact with the river water, thus there is a zero pathway for contaminant attenuation between these soils and the river. A pathway length of zero (0 m) has been assumed for this scenario, in order to provide Remedial Target Values (RTVs) for soils that are protective of the river.

7.1.2.2 *Site soils (>5 m from the river edge)*

In order to create a series of RTVs for use in the zone of the Site that is greater than 5 m from the river edge, a second iteration of the P20 model has been run, with a pathway length of 5 m. This has been used to derive RTVs that are protective of the river relevant to site soils >5 m from the river edge.

7.1.2.3 *Site groundwater (whole site)*

Groundwater management will be required in order to facilitate the remediation of site soils. This provides the opportunity to treat the groundwater as it is pumped, thus providing betterment to the chemistry of groundwater on the Site. It is not considered practical to attempt to define a different RTV for groundwater with distance from the river as has been done with soils, due to the dynamic nature of groundwater. Hence a single RTV has been defined, assuming a nominal 1 m long pathway between site groundwater and the river. A 1 m pathway is in effect the shortest practicable pathway that can be modelled using the P20 approach.

7.1.2.4 *Level 4 dilution*

Section 6.3.2 provides a discussion on the interaction of the spring, groundwater and river under the current, unremediated scenario. The available data suggests that the inflow of spring water provides the primary mechanism by which the river is currently being impacted by gasworks contamination. This spring is to be captured within an engineered ditch and conveyed to the river in an engineered channel lined with low permeability material, thus separating the influent spring water from the site soils. Once this has been undertaken, the impact on river water quality will be limited to that which may occur via the groundwater.

RTM guidance (EA 2006) sets out the ability to consider dilution within the receiving water body (compliance point), termed Level 4 Dilution. The guidance stipulates that the consideration of Level 4 Dilution represents a special case that can only be taken into account where a number of



conditions are met. These are set out in Table 7-4, together with discussion on the Site's status with respect to each:

Table 7-4 Considerations for use of Level 4 Dilution in the model

Dilution in the receptor can only be taken into account where;	Site context
The impact of groundwater contamination on the aquifer between the source and the receptor has been assessed.	The Site soils form the river bank, and hence there is no aquifer between the source and the receptor.
The impact does not prevent current or future use of the aquifer.	The DQRA assessment is also considering the potential impact on the wider aquifer (beyond the river, assuming groundwater flow beneath it) through consideration of 50m sentinel compliance point (Section 7.1.6.1), hence addressing this point. As discussed in the above row of this table, there is no aquifer between the source and the receptor.
The predicted impact on the receptor does not result in any measurable deterioration in water quality	EQS values have been used to derive the RTVs protective of the Bargoed Taf. EQS values are being exceeded in the river at present. Hence remediation of the site to the derived RTVs will deliver betterment to this scenario.
The predicted impact on the receptor does not result in exceedance of environmental standards	EQS values have been used to derive the RTVs protective of the Bargoed Taf. Adoption of these values as validation criteria during remediation will address this point.
The predicted impact on the receptor does not result in failure to achieve objectives	Both the Bargoed Taf and the River Taff downstream of their confluence are currently assessed as of High quality for chemistry. The WFD objective for these waters will therefore be to ensure no deterioration of this status. Measurement of water chemistry downstream of the Bargoed Taf suggests that the site is currently impacting river water quality for several contaminants typical of gasworks (e.g. benzo(a)pyrene, fluoranthene – see Table 5-18). The rivers downstream of here are maintaining a High chemical status despite this. Hence consideration of Level 4 Dilution in this model, the results of which will be used to improve soil and groundwater chemistry at



Dilution in the receptor can only be taken into account where;	Site context
	the site, can therefore be assumed to only deliver betterment to this scenario.
The dilution factor should be calculated for low flow	Q95 flow has been used in the model
The assessment should consider the total contaminant loading on the stream	Upstream surface water sampling in the river indicates a lack of exceedance of gasworks contaminants. 16 samples have been taken over a 7 year period and there is only a single exceedance of EQS for ammoniacal nitrogen and 3 exceedances for fluoranthene (see Table 5-18). With the exception of fluoranthene and ammoniacal nitrogen, all of the gasworks contaminants (PAHs, BTEX, TPH, cyanide, ammoniacal nitrogen, phenols) have all results below laboratory detection limit. The 3 fluoranthene exceedances are the only detectable instances of this pollutant (the LoD exceeds the EQS). 5 of the 16 results for ammoniacal nitrogen are at LoD. A single detectable concentration exceeds EQS, all others are below the EQS, many are an order of magnitude below the EQS.
The assessment should consider if there is any evidence of an impact on surface water that could be attributed to the Site	This has been investigated and considered and the results provided in Table 5-18.
The assessment should consider whether any impact would be detectable	Any impact, if detectable, would be an improvement on current conditions. Current conditions (in the Bargoed Taf and in downstream River Taff) are already assessed as High for chemistry.
The assessment should consider upstream surface water quality	This has been investigated and considered – see Table 5-18 and text above.
The assessment should consider impact on surface water quality of other contaminant sources.	This has been investigated and considered – see Table 5-18 and text above. RTM recommends that EQSx10% be used as a basis for setting target concentrations in order to provide conservatism where other contaminant sources may be impacting the



Dilution in the receptor can only be taken into account where;	Site context
	river. With the exception of fluoranthene and ammoniacal nitrogen, upstream water sampling indicates no such detectable impact across 7 years of monitoring. Such additional conservatism is therefore not considered necessary, and the EQS has been used. Sensitivity analysis for fluoranthene and ammoniacal nitrogen is then undertaken to assess the impact on RTV of adopting EQSx10% for these contaminants only.
The significance of attenuation of contaminants in river sediments and the variability in the type of sediments present.	It is acknowledged that the hyporheic zone may deliver some attenuation of contaminants at the groundwater/ surface water interface, as set out in the RTM guidance. This has not been taken account of in the model due to the uncertainties associated with the heterogeneity of this zone, and the lack of data available for it. This likely adds further conservatism into the model used.

In order to best represent the scenario at play on the Site, the models constructed for the three scenarios above have included the dilution effect that is seen as groundwater seeps enter the river. The flow of the river at Q95 has been taken as indicative of the low-flow conditions (the time at which least dilution will be occurring). This has been interpolated as 0.25 m³/sec. In order to estimate the influent flow of groundwater, the following has been assumed:

Table 7-5 Parameters for calculation of groundwater flow

Parameter	Value	Unit
Q=kAi		
k= Hydraulic conductivity	4.03	m/d
k= Hydraulic conductivity	4.66E-05	m/s
i= hydraulic gradient of water table	0.0159	m/m
width of source zone	80	m
Assumed height of water table above river level at riverbank	0.1	m
A= column cross section*	8	m ²
Q=volumetric rate of groundwater flow	5.93E-06	m ³ /sec
Q=volumetric rate of groundwater flow	5.93E-03	l/s



Volumetric flow of river (Q95)	0.255	l/s
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Ratio of flows river/ gw	43
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*in order to provide an assumed cross sectional area for volumetric flow, it is assumed that the lower 0.1m of the riverbank is saturated.

The Level 4 dilution assessment assumes that the river intercepts the entirety of the dissolved plume within the shallowest section of the aquifer (i.e. the entire plume width where groundwater elevations are higher than the river). This is a conservative assumption.

The results of the Level 3 P20 modelling process have been adjusted using the ratio of flows between river and groundwater in order to provide the RTVs.

7.1.3 Input parameters

The following table sets out the input parameters used for the P20 modelling, and the rationale for choice of each.

Table 7-6 DQRA input parameters for CoPCs

Constituent of concern	Indicator compound	Organic partition coefficient K_{oc} (l/kg)	Soil/ water distribution coefficient K_d (l/kg)	Half – life (days)	Henry's law constant (dimensionless)	Max in gw (ug/l)	Max in soil (mg/kg)	EQS (ug/l)
Free cyanide	n/a	–	9.9 ⁽⁶⁾	15–365 ⁽⁶⁾	0 ⁽¹³⁾	70	330	1
Total cyanide	n/a	–	9.9 ⁽⁶⁾	15–365 ⁽⁶⁾	0 ⁽¹³⁾	3430	25529.9	1
Ammoniacal nitrogen NH ₄	n/a	–	0.4 ⁽²⁾	365 – 2,190 ⁽⁴⁾	5.66x10 ⁻⁹ ⁽⁷⁾	73280	128.5	600
Chromium III	n/a	–	4,800 ⁽³⁾	–	0	68	201.7	4.7
Phenol	n/a	83 ⁽¹⁾	–	6.5 – 7 ⁽⁵⁾	8.35x10 ⁻⁶ ⁽³⁾	1910	22	7.7
Anthracene	n/a	5,623 ⁽¹⁾	–	100–920 ⁽⁵⁾	1.98x10 ⁻³ ⁽³⁾	9.9	5379.8	0.1
Fluoranthene	n/a	18,197 ⁽¹⁾	–	280–880 ⁽⁵⁾	3.87x10 ⁻⁴ ⁽³⁾	17.8	47660.4	0.0063
Benzo(a)pyrene	n/a	128,825 ⁽¹⁾	–	114 – 1,060 ⁽⁵⁾	1.86x10 ⁻⁵ ⁽³⁾	3.4	2090.4	0.00017
Naphthalene	n/a	645 ⁽¹⁾	–	1–258 ⁽⁵⁾	1.72x10 ⁻² ⁽³⁾	12032	23107.2	2
Benzene	n/a	68 ⁽¹⁾	–	10 – 720 ⁽⁵⁾	0.116 ⁽³⁾	2202	89.4	10
Toluene	n/a	204 ⁽¹⁾	–	7 – 28 ⁽⁵⁾	0.115 ⁽³⁾	1287	207	74
o-xylene	n/a	426 ⁽¹⁾	–	14 – 360 ⁽⁵⁾	0.092 ⁽³⁾	677	90.2	30
m/p-xylene	n/a	489 ⁽¹⁾	–	14 – 360 ⁽⁵⁾	0.112 ⁽³⁾ ⁽⁸⁾	1895	236.8	30
Aliphatic >EC6–EC8	n-heptane	790 ⁽¹¹⁾	–	4–24 ⁽¹¹⁾	80.3 ⁽¹²⁾	793	36.6	10
Aliphatic >EC8–EC10	n-octane n-nonane	32,000 ⁽¹²⁾	–	5 – 15 ⁽¹²⁾	143 ⁽¹²⁾	835	123	10
Aromatic >EC5–EC7	Benzene	68 ⁽¹⁰⁾	–	10 – 720 ⁽⁵⁾	0.116 ⁽³⁾	2202	76.3	10
Aromatic >EC7–EC8	toluene	204 ⁽¹⁾	–	7 – 28 ⁽⁵⁾	0.115 ⁽³⁾	1287	172.8	74
Aromatic >EC8–EC10	xylene	489 ⁽¹⁾	–	14–360 ⁽⁵⁾	0.112 ⁽³⁾	2960	302.8	30



Constituent of concern	Indicator compound	Organic partition coefficient K_{oc} (l/kg)	Soil/ water distribution coefficient K_d (l/kg)	Half – life (days)	Henry/s law constant (dimensionless)	Max in gw (ug/l)	Max in soil (mg/kg)	EQS (ug/l)
Aromatic >EC10–EC12	naphthalene	645 ⁽¹⁾	–	1–258 ⁽⁵⁾	1.72×10^{-2} ⁽³⁾	28413	8381.3	2
Aromatic >EC12–EC16	acenaphthene	5,000 ⁽¹⁾	–	25–204 ⁽⁵⁾	7.6×10^{-3} ⁽³⁾	2120	8908	10

1. EA (2008) Compilation of Data for Priority Organic Pollutants for Derivation of Soil Guideline Values (SR7) as summarised in Nathanail et al (2015)⁽³⁾.
2. EA NC/02/49 (2003). Review of ammonium attenuation in soil and groundwater. Conservative (lowest) value for sand & gravel with clay
3. Nathanail et al., 2009. The LQM/ CIEH Generic Assessment Criteria for Human Health Risk Assessment (2nd Ed). Land Quality Press, Nottingham
4. EA NC/02/49 (2003). Range for sands and gravels
5. Howard (1991) Handbook of Environmental Degradation Rates. (Groundwater half-life, high end of range provided)
6. The value adopted for cyanide degradation has been derived to provide a suitably conservative modelling parameter considered to be representative of the microbial degradation conditions that would prevail at a gasworks site. This takes into account the potential inhibitory effect on degradation that is considered likely due to multiple contaminants present. The principal reference sources used are a) Chemistry and Treatment of Cyanidation Wastes. Adrian Smith and Terry Mudder. Mining Journal Books Limited, London, p293, b) Proposed EQS for WFD Annex VIII Substances: Cyanide (free) [for consultation]. Environment Agency [2012]) and c) The Fate of Cyanide in Groundwater at Gasworks sites in South Eastern Australia. Meehan. September 2000, PhD University of Melbourne.
7. Lagos, LE, Katsenovich, Y & Emerson, HP 2014. Ammonia Chemistry and Methods of Analysis. US Department of Energy, Office of Environmental Management.
8. Parameter values taken from references for m-xylene.
9. Cyanide conservatively modelled using fate and transport for free cyanide.
10. Recommended petroleum hydrocarbon CoPC indicator (CL:AIRE, 2017) Petroleum Hydrocarbons in Groundwater: Guidance on assessing petroleum hydrocarbons using existing hydrogeological risk assessment methodologies.
11. PubChem 2020 (<https://pubchem.ncbi.nlm.nih.gov/compound/heptane#section=Environmental-Fate-Exposure-Summary>)
12. PubChem 2020 <https://pubchem.ncbi.nlm.nih.gov/compound/Octane#section=Environmental-Fate-Exposure-Summary>
13. CLEA v1.06

Table 7–7 DQRA input parameters (physical parameters)

Parameter	Comment	Chosen value
Infiltration (m/d)	Mean annual rainfall for nearest Met Office climate station (Tredegar, 12 miles away) is 1715.85 mm (Met Office 2019) = 4.7 mm/d. Current surfacing is predominantly soft standing. Assume 50% infiltration in soft standing areas only due to loss of 50% to evapotranspiration = $4.7 \times 0.5 = 2.35$ mm/d or 0.00235 m/d.	0.00235
Area of contaminant source (m ²)	Estimated extent of groundwater and soil impact in AREA A plus AREA B as shown on drawing P23545_R1_D05	1,970m ²



Parameter	Comment	Chosen value
Width of plume (m)	Width of conjectured source area (Area A and Area B) as drawn on drawing P23545_R1_D05	80
Plume thickness (m)	Average thickness of superficial deposits as recorded in Advisian and Englobe logs, allowing model room for vertical dispersion	5
Length of source in direction of groundwater flow (m)	Length of conjectured source area (Area A and Area B) as drawn on drawing P23545_R1_D05	30
Saturated aquifer thickness (m)	Average thickness of superficial deposits as recorded in Advisian and Englobe logs	5.2
Dispersivity (%)	Model defaults	10%,1%,0.1%
Bulk density of aquifer material (g/cm ³)	Assumed value, has little impact on RTV	2
Water filled porosity of aquifer (fraction)	Assumed value, has little impact on RTV	0.3
Air filled porosity of aquifer (fraction)	Assumed value, has little impact on RTV	0.1
Effective porosity (fraction)	Assumed value as 100% of water filled porosity	0.3
Background concentration in groundwater beneath the site (all contaminants) (mg/l)	Groundwater upgradient originates beneath a combination of woodland, and residential area. Background concentration is assumed to be minimal.	1 x 10 ⁻¹⁰
Hydraulic gradient (fraction)	Difference between water level of the river and MW16-12 on the 3 rd /4 th August 2016, over a 14m distance 97.922-97.7	0.0159
Hydraulic conductivity of aquifer (m/day)	Slug test results for the superficial deposits ranged between 1.73 and 11.7m/day with a geometric mean of 4.03m day	4.03
Distance to compliance point (m)	Thickness of engineered riverbank	5
	Distance to river from soils within engineered riverbank	0
	Distance to river for groundwater migration in finished design	1
Time since pollutant entered groundwater (days)	Steady state	1x10 ¹⁰⁰
Fraction of organic carbon (aquifer)	Average of 28No. values for the superficial deposits, samples where there was significant visual and olfactory evidence of contamination were discounted. Therefore the data is considered suitably representative of aquifer conditions outside of gross impact.	0.011
Fraction of organic carbon (soils)	As discussed in Section 5.3.2, representative SOM for soils has been taken as 6.15%. This equates to an FOC of 0.0357	0.0357



7.1.4 Results

Table 7-8 **Error! Reference source not found.** summarises the results of the DQRA modelling process.

Table 7-8 P20 DQRA modelling results

Contaminant	SOILS	SOILS	GROUNDWATER	Max concentration in (mg/kg)	Max concentration in (mg/l)
	For use within the riverbank reconstruction Level 2 RTV after dilution (mg/kg)	For zone >5m from river Level 3 after dilution (mg/kg)	For use site-wide Nominal 1m pathway. Level 3 RTV after dilution (mg/l)		
Free cyanide	2.067	2.21	0.0438	330	0.07
Total cyanide	2.067	2.21	0.0438	25,529.9	3.43
Ammoniacal Nitrogen as NH4	67.908	68.77	25.87	128.5	73.28
Chromium III	4641.790	4641.79	0.20	201.7	0.068
Phenol	4.943	25.27	0.52	22	1.91
Anthracene	4.135	4.24	0.0043	5379.8	0.0099
Fluoranthene	0.842	0.86	0.0003	47,660.4	0.0178
Benzo(a)pyrene	0.161	0.16	0.0000	2,090.4	0.0034
Naphthalene	9.541	10.53	0.0881	23,107.2	12.032
Benzene	5.329	5.50	0.434	89.4	2.202
Toluene	113.036	224.78	3.817	207	1.287
O-Xylene	94.985	101.43	1.311	90.2	0.677
M/P-xylene	108.738	116.47	1.311	236.8	1.895
Aliphatic EC6-EC8	66.618	155.16	0.5372	36.6	0.793
Aliphatic EC8-EC10	2363.875	7478.44	0.589	123	0.835
Aromatic EC5-EC7 (Benzene)	5.329	5.50	0.434	76.3	2.202
Aromatic EC7-EC8 (Toluene)	113.036	224.78	3.817	172.8	1.287
Aromatic EC8-EC10 (Xylenes)	108.738	116.47	1.311	302.8	2.96
Aromatic EC10-EC12 (naphthalene)	9.541	10.53	0.0881	8381.3	28.413
Aromatic EC12-EC16	367.475	410.45	0.443	8908	2.12

*Bold red text denotes an exceedance of the Level 2 RTV for soils or an exceedance of the groundwater RTV



7.1.5 Model limitations, uncertainties, and assumptions

7.1.5.1 Model conservatism

Where the model input parameters rely on literature values, conservative assumptions are made when selecting these parameters, as detailed in Sections 7.1.1 and 7.1.3. In order to assess conservatism within the model, a series of sensitivity analyses has been undertaken, detailed in the following section.

7.1.5.2 Data age

The model relies on Site data which in some instances is up to 7 years old. Whilst ideally, more recent data would be used, due to the lack of changes in Site conditions in the last 7 years, this data is still considered valid and representative of the Site. This is evidenced by the comparison of historical and current data where available, which has consistently confirmed the lack of significant change in soil chemistry, groundwater chemistry or groundwater behaviour since 2016.

7.1.5.3 Migration of River

The modelling process uses a series of pathway lengths relating to the distance to the river. The river actively erodes the Site boundary, and as such the river bank is migrating north-westwards onto Site. As a result, available base maps and aerial imagery show slightly differing positions of the river. In calculating Site specific parameters, the most recent available mapping has been used, in order to be as accurate as possible in representing the Site.

7.1.5.4 Distribution of data

The recent Englobe Site investigation was unable to target Gasholder No.1 given concerns regarding river bank stability and disturbance of the gasholder walls, given its proximity to the river. Machine access was also a concern. As such, historic, predominantly shallow data has formed the basis for assessment of Gasholder No.1.

7.1.6 Sensitivity analysis

7.1.6.1 Pathway length

The baseline modelling process has focussed on the risk to the river, due to the immediate proximity of the site to it. In order to determine the potential risk posed by the Site to the wider aquifer, a sensitivity analysis has been undertaken in order to determine the effect on RTV of assuming a pathway length of 50m. This distance has been chosen as representative of a sentinel compliance point within the aquifer. This assessment has focussed on the role that the aquifer is anticipated to play in providing base flow to the River Taff, and hence EQS values have been used as the target concentration at the point of compliance. This is because the small area of aquifer between the Site and the Taff is beneath an urban area, and considered to be of insufficient resource value with respect to potential drinking water.

This sensitivity analysis has been undertaken on the Level 3 results of the P20 modelling (i.e. there is no consideration of Level 4 dilution in this sensitivity analysis). The resultant RTVs are summarised in the following table:



Table 7-9 RTVS with 50m pathway length

Contaminant	Soil Level 3 Remedial target with 50m pathway length (mg/kg)	Groundwater Level 3 Remedial target with 50m pathway length (mg/l)	Max concentration in (mg/kg)	Max concentration in (mg/l)
Free cyanide	0.0968	0.00226	330	0.07
Total cyanide	0.0968	0.00226	25529.9	3.43
Ammoniacal Nitrogen as NH ₄	1.86	0.698	128.5	73.28
Chromium III	115	0.0048	201.7	0.068
Phenol	1940	633	22	1.91
Anthracene	0.131	0.00014	5379.8	0.0099
Fluoranthene	0.026	8.49x10 ⁻⁶	47660.4	0.0178
Benzo(a)pyrene	0.00494	2.28x10 ⁻⁷	2090.4	0.0034
Naphthalene	0.587	0.00638	23107.2	12.032
Benzene	0.185	0.0157	89.4	2.202
Toluene	384	26.4	207	1.287
O-Xylene	4.48	0.0687	90.2	0.677
M/P-xylene	5.14	0.0687	236.8	1.895
Aliphatic EC6-EC8	547	9.88	36.6	0.793
Aliphatic EC8-EC10	94500	60.6	123	0.835
Aromatic EC5-EC7 (Benzene)	0.185	0.0157	76.3	2.202
Aromatic EC7-EC8 (Toluene)	384	26.4	172.8	1.287
Aromatic EC8-EC10 (Xylenes)	5.14	0.0687	302.8	2.96
Aromatic EC10-EC12 (naphthalene)	0.587	0.00638	8381.3	28.413
Aromatic EC12-EC16	25.2	0.0361	8908	2.12

*Bold red text denotes an exceedance of the Level 3 RTV for soils or an exceedance of the groundwater RTV

7.1.6.2 Biodegradation

Due to the proximity of the Site to the river and the Site's small and constrained nature, it has not been possible to install a sufficient array of monitoring wells to provide primary evidence of contaminant attenuation within the aquifer. For this reason and for the purpose of conservatism, the core model used biodegradation in dissolved phase only. Secondary evidence does indicate the prevalence of aerobic conditions outside of those areas impacted by contamination, thus being indicative that such conditions can be achieved in the remediated state. In such conditions, biodegradation in the sorbed phase is considered likely, hence the 5 m pathway



model has been re-run with biodegradation in all phases for the Level 3 RTVs. The level 2 RTV is not impacted by this change. The results are summarised in the following table:

Table 7-10 RTVs with biodegradation in all phases

Contaminant	Soil Level 3 RTV 5m pathway after dilution biodegradation in all phases (mg/kg)	Groundwater Level 3 RTV 1m pathway after dilution, biodegradation in all phases (mg/l)	Groundwater Level 3 RTV 50m sentinel compliance, biodegradation in all phases (mg/l)	Max concentration in (mg/kg)	Max concentration in (mg/l)
Free cyanide	61.03	0.1212	2.84E+05	330	0.07
Total cyanide	61.03	0.1212	2.84E+05	25529.9	3.43
Ammoniacal N as NH4	70.49	26.05	0.961	128.5	73.28
Chromium III	4,641	0.2020	0.00482	201.7	0.068
Phenol	10,272	4.86	6.06E+13	22	1.91
Anthracene	2,389	0.0373	9.48E+09	5379.8	0.0099
Fluoranthene	15,601	0.0396	1.88E+19	47660.4	0.0178
Benzo(a)pyrene	7.82x10 ¹⁶	713	1.95E+61	2090.4	0.0034
Naphthalene	327	0.2579	1.21E+06	23107.2	12.032
Benzene	6.53	0.4513	0.0912	89.4	2.202
Toluene	114,755	34.68	3.60E+13	207	1.287
O-Xylene	610	2.19	7910	90.2	0.677
m/p-xylene	881	2.36	24100	236.8	1.895
Aliphatic EC6-EC8	9.50x10 ⁹	962	6.29E+31	36.6	0.793
Aliphatic EC8-EC10	4.22x10 ⁷⁶	2.70x10 ³⁵	7.94E+263	123	0.835
Aromatic EC5-EC7	6.53	0.4513	0.0912	76.3	2.202
Aromatic EC7-EC8	114,755	34.68	3.60E+13	172.8	1.287
Aromatic EC8-EC10	881	2.19	7910	302.8	2.96
Aromatic EC10-EC12	327.50	0.2579	1.21E+06	8381.3	28.413
Aromatic EC12-EC16	2.98x10 ⁹	250	1.84E+27	8908	2.12

*Bold red text denotes an exceedance of the Level 3 RTV for soils or an exceedance of the groundwater RTV

Where biodegradation in all phases is assumed, RTV values for all contaminants increase, in some cases significantly. Recorded benzo(a)pyrene, m/p-xylene, aromatic EC8-EC10 and aromatic EC12-EC16 no longer exceed the soil Level 3 RTV and free cyanide, anthracene, fluoranthene, benzo(a)pyrene, m/p-xylene and aromatic EC12-16 groundwater concentrations no longer exceed the groundwater RTV.

Many of the RTVs calculated assuming biodegradation in dissolved phase only (i.e. the model base-case) are too low to be achieved by current remediation technology. The RTVs taken forward for deployment in the Remediation Implementation Plan will therefore need to be carefully chosen to balance the modelled, theoretical environmental risk (with the inherent model



conservatism borne in mind) with what can feasibly be delivered given the best available current remediation techniques that can be meaningfully deployed on a constrained and difficult to access site such as this.

Secondary evidence does indicate the prevalence of aerobic conditions outside of those areas impacted by contamination, suggesting that biodegradation in all phases may dominate across Site following removal of the primary and secondary source terms on the Site during remediation.

7.1.6.3 Hydraulic Gradient

Following the completion of the first draft of this report, additional data was collected by Yellow Sub in December 2023. This most recent data has been used to calculate a hydraulic gradient of 0.0012 (based upon the maximum recorded exceedance of river level within MMW16-01, 0.03m, over a distance of 25m). This is an order of magnitude smaller than the hydraulic gradient used in the model (0.0159, based on data collected in August 2016). The 5m pathway model has been re-run using a hydraulic gradient of 0.0012, to provide an indication of the impact the new data may have on the calculated RTVs. The results are summarised in the following table:

Table 7-11 RTVs: hydraulic gradient sensitivity analysis

Contaminant	BASE CASE		SENSITIVITY ANALYSIS		Max concentration in (mg/kg)	Max concentration in (mg/l)
	Soil Level 3 RTV 5m pathway after dilution (mg/kg) Hydraulic gradient = 0.0159	Groundwater Level 3 RTV 1m pathway after dilution (mg/kg) Hydraulic gradient = 0.0159	Soil Level 3 RTV 5m pathway after dilution (mg/kg) Hydraulic gradient = 0.0012	Groundwater Level 3 RTV 1m pathway after dilution (mg/kg) Hydraulic gradient = 0.0012		
Free cyanide	2.21	0.0438	0.78	0.054	330	0.07
Total cyanide	2.21	0.0438	0.78	0.054	25,529.9	3.43
Ammoniacal Nitrogen as NH4	68.77	25.87	20.11	26.65	128.5	73.28
Chromium III	4641.79	0.20	1315.17	0.202	201.7	0.068
Phenol	25.27	0.52	318.05	27.46	22	1.91
Anthracene	4.24	0.0043	1.31	0.0047	5379.8	0.0099
Fluoranthene	0.86	0.0003	0.24	0.00029	47,660.4	0.0178
Benzo(a)pyrene	0.16	0.00001	0.05	0.0000079	2,090.4	0.0034
Naphthalene	10.53	0.0881	4.11	0.12	23,107.2	12.032
Benzene	5.50	0.434	1.75	0.48	89.4	2.202
Toluene	224.78	3.817	419.05	24.50	207	1.287
O-Xylene	101.43	1.311	36.06	1.62	90.2	0.677
M/P-xylene	116.47	1.311	41.35	1.62	236.8	1.895



Contaminant	BASE CASE		SENSITIVITY ANALYSIS		Max concentration in (mg/kg)	Max concentration in (mg/l)
	Soil Level 3 RTV 5m pathway after dilution (mg/kg) Hydraulic gradient = 0.0159	Groundwater Level 3 RTV 1m pathway after dilution (mg/kg) Hydraulic gradient = 0.0159	Soil Level 3 RTV 5m pathway after dilution (mg/kg) Hydraulic gradient = 0.0012	Groundwater Level 3 RTV 1m pathway after dilution (mg/kg) Hydraulic gradient = 0.0012		
Aliphatic EC6-EC8	155.16	0.5372	413.03	5.07	36.6	0.793
Aliphatic EC8-EC10	7478.44	0.589	37693.06	11.05	123	0.835
Aromatic EC5-EC7 (Benzene)	5.50	0.434	1.75	0.48	76.3	2.202
Aromatic EC7-EC8 (Toluene)	224.78	3.817	419.05	24.50	172.8	1.287
Aromatic EC8-EC10 (Xylenes)	116.47	1.311	41.35	1.62	302.8	2.96
Aromatic EC10-EC12 (naphthalene)	10.53	0.0881	4.11	0.12	8381.3	28.413
Aromatic EC12-EC16	410.45	0.443	166.76	0.62	8908	2.12

*Bold red text denotes an exceedance of the Level 3 RTV for soils or an exceedance of the groundwater RTV

As can be seen, in some instances, the revised RTV is smaller (due to the decreased influence of dilution of soil leachate within the aquifer), for other contaminants it is larger (due to the increased residence time in the aquifer, enabling increased degradation). Changes are generally within an order of magnitude, however more significant changes are seen within some contaminant RTVs. For instance the benzo(a)pyrene RTV, changes from 0.16mg/kg where hydraulic gradient is 0.0159 to 0.0004mg/kg where hydraulic gradient is 0.0012.

Hydraulic gradient will be a dynamic aspect of the Site related to rainfall and to river level and as such will vary throughout the year. The original hydraulic gradient of 0.0159 is based upon measurements collected within the dryer summer month of August, whereas the hydraulic gradient of 0.0012 is based upon data collected during the wetter winter month of December. The range of gradients presented above likely provide an indication of the degree to which this natural variation will impact the resultant RTVs. As discussed in Section 3.4.4, during large parts of wetter periods the river is not thought to receive water from the groundwater (when river levels are raised above that of groundwater).

When viewing the model as a whole, the critical risk to the river is considered to occur in periods of low flow, as has been represented in the model by the use of Q95 river flow in the dilution element of the model. The hydraulic gradient used in the model (0.0159) is representative of these low-flow conditions, recorded as it was during August 2016 when river levels were around the Q95 levels. In periods of higher river flow, when smaller hydraulic gradient may occur, the



river flows will be significantly greater, hence counteracting any reduction in RTV value that the decreased hydraulic gradient may cause. Indeed, in times of substantial flow, river elevations lie above those of the groundwater, effectively preventing groundwater baseflow into the river altogether.

The chosen hydraulic gradient (0.0159) is also very similar to that calculated for the more south-westerly component of aquifer flow (0.0155), and hence is considered suitably representative of wider aquifer conditions.

7.1.6.4 Hydraulic conductivity

The value used for hydraulic conductivity was the geometric mean (4.03m/day) of slug test results for the superficial deposits. Results ranged between 1.73 and 11.7m/day, therefore the 5m pathway model has been re-run using these two values for hydraulic conductivity, to provide an indication of the impact the new data may have on the calculated RTVs. The results are summarised in the following table:

Table 7-12 RTVs: Hydraulic conductivity sensitivity analysis

Contaminant	BASE CASE: Hydraulic gradient = 0.0159		Hydraulic conductivity = 1.73m/day		Hydraulic conductivity = 11.7m/day		Max concentration in (mg/kg)	Max concentration in (mg/l)
	Soil Level 3 RTV 5m pathway after dilution (mg/kg)	Groundwater Level 3 RTV 1m pathway after dilution (mg/kg)	Soil Level 3 RTV 5m pathway after dilution (mg/kg)	Groundwater Level 3 RTV 1m pathway after dilution (mg/kg)	Soil Level 3 RTV 5m pathway after dilution (mg/kg)	Groundwater Level 3 RTV 1m pathway after dilution (mg/kg)		
Free cyanide	2.21	0.0438	1.49	0.045	0.46	0.043	330	0.07
Total cyanide	2.21	0.0438	1.49	0.045	0.46	0.043	25,529.9	3.43
Ammoniacal Nitrogen as NH4	68.77	25.87	43.84	25.960	147.42	25.831	128.5	73.28
Chromium III	4641.79	0.20	29355.03	0.202	10014.23	0.202	201.7	0.068
Phenol	25.27	0.52	57.16	0.915	21.45	0.389	22	1.91
Anthracene	4.24	0.0043	2.75	0.004	9.03	0.004	5379.8	0.0099
Fluoranthene	0.86	0.0003	0.55	0.00027	1.84	0.00027	47,660.4	0.0178
Benzo(a)pyrene	0.16	0.00001	0.11	7.39x10 ⁻⁶	0.35	7.31x10 ⁻⁶	2,090.4	0.0034
Naphthalene	10.53	0.0881	7.31	0.091	21.40	0.087	23,107.2	12.032
Benzene	5.50	0.434	3.60	0.438	11.65	0.430	89.4	2.202
Toluene	224.78	3.817	258.31	4.814	324.07	3.387	207	1.287
O-Xylene	101.43	1.311	68.77	1.341	210.60	1.298	90.2	0.677
M/P-xylene	116.47	1.311	78.65	1.341	241.12	1.298	236.8	1.895
Aliphatic EC6-EC8	155.16	0.5372	201.14	0.718	203.72	0.464	36.6	0.793



Contaminant	BASE CASE: Hydraulic gradient = 0.0159		Hydraulic conductivity = 1.73m/day		Hydraulic conductivity = 11.7m/day		Max concentration in (mg/kg)	Max concentration in (mg/l)
	Soil Level 3 RTV 5m pathway after dilution (mg/kg)	Groundwater Level 3 RTV 1m pathway after dilution (mg/kg)	Soil Level 3 RTV 5m pathway after dilution (mg/kg)	Groundwater Level 3 RTV 1m pathway after dilution (mg/kg)	Soil Level 3 RTV 5m pathway after dilution (mg/kg)	Groundwater Level 3 RTV 1m pathway after dilution (mg/kg)		
Aliphatic EC8-EC10	7478.44	0.589	12120.23	0.872	8252.07	0.481	123	0.835
Aromatic EC5-EC7 (Benzene)	5.50	0.434	3.60	0.438	11.65	0.430	76.3	2.202
Aromatic EC7-EC8 (Toluene)	224.78	3.817	258.31	4.814	324.07	3.387	172.8	1.287
Aromatic EC8-EC10 (Xylenes)	116.47	1.311	78.65	1.341	241.12	1.298	302.8	2.96
Aromatic EC10-EC12 (naphthalene)	10.53	0.0881	7.31	0.091	21.40	0.087	8381.3	28.413
Aromatic EC12-EC16	410.45	0.443	288.82	0.460	829.51	0.434	8908	2.12

*Bold red text denotes an exceedance of the Level 3 RTV for soils or an exceedance of the groundwater RTV

As can be seen, in some instances, the revised RTV is smaller, for other contaminants it is larger (dependent upon whether dilution within the aquifer or retardation/ degradation are the dominant factors). Differences between RTVs based on a hydraulic conductivity of 1.73m/day and 11.7m/day, are all within one order of magnitude. Local variations in hydraulic conductivity will exist across the Site with changes in strata, therefore the values presented above represent the degree to which this natural variation will impact the calculated RTVs. The geometric mean of 4.03m/day which was used in the base model is thought to be an appropriate representation of the aquifer conditions.

7.1.6.5 Level 4 Dilution

As discussed in Section 7.1.2.4, the only contaminants for which there is detectable evidence of other potential contaminant sources having impact on the Bargoed Taf river is fluoranthene and ammoniacal nitrogen. For all other contaminants, there is considered sufficient certainty (16 samples analysed over 7 years) that there is no other detectable impact on the river for gasworks contaminants (PAHs, TPH, cyanide, phenol). Some uncertainty exists for fluoranthene and ammoniacal nitrogen. RTM methodology recommends the use of EQSx10% to provide conservatism where there is uncertainty in this regard. A sensitivity analysis has therefore been run for these two contaminants, using EQSx10% as the basis for calculating RTVs. The results are summarised below:



Table 7-13 RTVs: Level 4 Dilution target concentration sensitivity analysis

Contaminant	BASE CASE		SENSITIVITY ANALYSIS		Max concentration in (mg/kg)	Max concentration in (mg/l)
	Soil Level 3 RTV 5m pathway after dilution (mg/kg) Target concentration = EQS	Groundwater Level 3 RTV 1m pathway after dilution (mg/kg) Target concentration = EQS	Soil Level 3 RTV 5m pathway after dilution (mg/kg) Target concentration = EQSx10%	Groundwater Level 3 RTV 1m pathway after dilution (mg/kg) Target concentration = EQSx10%		
Ammoniacal Nitrogen as NH ₄	68.77	25.87	6.887	2.59	128.5	73.28
Fluoranthene	0.86	0.0003	0.086	0.00003	47,660.4	0.0178

7.2 DQRA Summary

In light of the sensitivity analysis results, it is considered that, in the main, the chosen model parameters in the base-case model are suitably protective of the environmental receptors.

However, it is clear that careful thought will need to be used in determining the chosen RTVs, given that those associated with the base-case are likely to be unachievable. The choice of RTVs therefore needs to balance the need to remain as protective of the environmental receptors as can be achieved, whilst recognising the following factors;

- Outside of the groundwater modelling process, there is a clear and current risk of direct impact to the river due to the ongoing erosion of the site soils by the river. To date, this has not compromised the integrity of the gasholder structures, but some direct impact to the river can be seen at times of low flow, as evidenced by the oily seep at the base of the river bank. Intervention is therefore required with a degree of urgency, in order to remedy this situation.
- The Site is extremely constrained with respect to access, with the only point of access being along the narrow dog-legging cycle path from Treharris to the north. This severely restricts the type of plant that can access the Site. Holistic sustainability is therefore a key consideration when determining the degree to which the Site should be remediated.
- The remediation criteria that can be achieved on the Site will be limited by the technical limitations of currently available remediation techniques which cannot achieve some of the RTVs calculated in the base case.
- The proposed remediation works that this assessment underpins are being undertaken by WWU on a voluntary basis, in accordance with their environmental and sustainability commitments.
- The works as proposed involve the excavation of the vast majority of the Site. The entirety of Areas A and B will be excavated in order to remediate the primary and secondary source terms therein. A large proportion of Area C will also be excavated in order to win suitably clean material to form the new engineered river bank.



- It is accepted that the evidence for biodegradation occurring in the aquifer is limited. However, some evidence to suggest aerobic aquifer conditions does exist, and it is our opinion that it is reasonable to assume biodegradation can and will occur in the aquifer following remediation of the primary and secondary source terms.

Against this backdrop, it is considered reasonable to adopt final RTVs derived from the sensitivity analysis with biodegradation occurring in both the dissolved and sorbed phases. These are represented in Table 7-14 below.

On this basis, some contaminants can be disregarded as potential CoCs with respect to the potential risks to the wider environment. Hence, they need not be considered further in this report. This is due to the fact that the calculated RTV values are greater than the maximum recorded concentrations on Site. For the wider Site soils (>5m from the river edge), free cyanide, total cyanide, ammoniacal Nitrogen NH₄, anthracene, fluoranthene, naphthalene, benzene, aromatic EC5-EC7 and aromatic EC10-EC12 remain as potential CoCs. For soils less than 5m from the riverbank, remaining potential CoCs include: Free cyanide, total cyanide, ammoniacal nitrogen NH₄, phenol, anthracene, fluoranthene, benzo(a)pyrene, naphthalene, benzene, toluene, m/p-Xylene, aromatic EC5-EC7, aromatic EC7-EC8, aromatic EC8-EC10, aromatic EC10-EC12 and aromatic EC12-EC16.

Table 7-14 Final RTVs

Contaminant	SOILS For use within the riverbank reconstruction	SOILS For zone >5m from river	GROUNDWATER For use site- wide	Max concentration in (mg/kg)	Max concentration in (mg/l)
	Level 2 RTV after dilution (mg/kg)	Level 3 after dilution (mg/kg)	Nominal 1m pathway. Level 3 RTV after dilution (mg/l)		
Free cyanide	2.067	61.03	0.1212	330	0.07
Total cyanide	2.067	61.03	0.1212	25529.9	3.43
Ammoniacal Nitrogen NH ₄ [#]	6.7908	7.049	2.60456	128.5	73.28
Dissolved Chromium III	4641.790	4641.79	0.2020	201.7	0.068
Phenol	4.943	10272.11	4.8567	22	1.91
Anthracene	4.135	2389.66	0.0373	5379.8	0.0099
Fluoranthene [#]	0.0842	1560.157	0.00396	47660.4	0.0178
Benzo(a)pyrene	0.161	7.82E+16	713.4604	2090.4	0.0034
Naphthalene	9.541	327.50	0.2579	23107.2	12.032
Benzene	5.329	6.53	0.4513	89.4	2.202
Toluene	113.036	114755.37	34.6845	207	1.287
O-Xylene	94.985	610.31	2.1920	90.2	0.677



Contaminant	SOILS	SOILS	GROUNDWATER	Max concentration in (mg/kg)	Max concentration in (mg/l)
	For use within the riverbank reconstruction	For zone >5m from river	For use site-wide		
	Level 2 RTV after dilution (mg/kg)	Level 3 after dilution (mg/kg)	Nominal 1m pathway. Level 3 RTV after dilution (mg/l)		
m/p-xylene	108.738	881.08	2.3553	236.8	1.895
Aliphatic EC6-EC8	66.618	9.50E+09	962.7417	36.6	0.793
Aliphatic EC8-EC10	2363.875	4.22E+76	2.70E+35	123	0.835
Aromatic EC5-EC7	5.329	6.53	0.4513	76.3	2.202
Aromatic EC7-EC8	113.036	114755.37	34.6845	172.8	1.287
Aromatic EC8-EC10	108.738	881.08	2.1920	302.8	2.96
Aromatic EC10-EC12	9.541	327.50	0.2579	8381.3	28.413
Aromatic EC12-EC16	367.475	2.98E+09	250.1409	8908	2.12

*Bold red text denotes that the RTV is exceeded by the maximum concentrations recorded on site

Ammoniacal nitrogen and fluoranthene RTVs are multiplied by 10% to take account of uncertainty that other sources may impact the Bargoed Taf river (see Sections 7.1.2.4 and 7.1.6.5).

7.2.1 Solubility limits

The results of the groundwater RTV derivation have been compared with solubility limits for each of the PAH and TPH fractions modelled. The results are provided in Table 7-15 below.

Table 7-15 Hydrocarbon groundwater RTVs compared with solubility limits

Contaminant	Groundwater RTV (mg/l) 1m pathway	Solubility limit (mg/l)	Max concentration in groundwater (mg/l)
Phenol	4.8567	82800	1.91
Anthracene	0.0373	0.056	0.0099
Fluoranthene	0.00396	0.23	0.0178
Benzo(a)pyrene	713.4604	0.0038	0.0034
Naphthalene	0.2579	24.5	12.032
Benzene	0.4513	1,780	2.202
Toluene	34.6845	526	1.287



O-Xylene	2.1920	198	0.677
M/P-xylene	2.3553	64.6	1.895
Aliphatic EC6-EC8	962.7417	5.4	0.793
Aliphatic EC8-EC10	2.70E+35	0.43	0.835
Aromatic EC5-EC7 (Benzene)	0.4513	1780	2.202
Aromatic EC7-EC8 (Toluene)	34.6845	520	1.287
Aromatic EC8-EC10 (Xylenes)	2.1920	64.6	2.96
Aromatic EC10-EC12 (naphthalene)	0.2579	24.5	28.413
Aromatic EC12-EC16	250.1409	5.75	2.12

*Bold red text denotes that the value exceeds the solubility limit

For benzo(a)pyrene, aliphatic EC6-EC8, aliphatic EC8-EC10 and aromatic EC12-EC16, the calculated RTV exceeds the solubility limit, indicating that, theoretically, free phase could be present whilst still not posing a significant risk to the modelled receptor.

Notwithstanding this, in all but two cases (aliphatic EC8-EC10 and aromatic EC10-EC12), the maximum recorded groundwater concentration on Site is below the solubility limit. This confirms the observations from fieldwork in that mobile NAPL is not present beneath the Site.

7.2.2 Distribution of contaminants in excess of RTVs

The tables in Appendix B provide a screen of the Site data using the RTVs for the engineered riverbank (0m pathway length) and for general site soils (>5m from river edge). The distribution of exceedances of RTVs are summarised in Table 7-16 and Table 7-17.

Exceedances in site soils for use within the engineered riverbank (within 5m of the river edge)

Table 7-16 Distribution of exceedances of RTVs (for use within the river bank up to 5m from river's edge)

Contaminant	Soil Level 2 RTV after dilution (mg/kg)	Max concentration in (mg/kg)	No. exceedances Source Area A	No. exceedances Source Area B	No. exceedances Source Area C
Free cyanide	2.067	330	19	12	None
Total cyanide	2.067	25529.9	34	28	12
Ammoniacal Nitrogen NH4	6.7908	128.5	8	14	None
Phenol	4.943	22	2	1	None
Anthracene	4.135	5379.8	23	22	9
Fluoranthene	0.0842	47660.4	45	58	34



Contaminant	Soil Level 2 RTV after dilution (mg/kg)	Max concentration in (mg/kg)	No. exceedances Source Area A	No. exceedances Source Area B	No. exceedances Source Area C
Benzo(a)pyrene	0.161	2090.4	44	49	31
Naphthalene	9.541	23107.2	12	11	None.
Benzene	5.329	89.4	2	None	None.
Toluene	113.036	207.1	1	None.	None.
O-Xylene	94.985	236.8	None	None.	None.
M/P-Xylene	108.738	90.2	2	None.	None.
Aromatic EC5- EC7	5.329	76.3	2	None.	None.
Aromatic EC7- EC8	113.036	172.8	1	None.	None.
Aromatic EC8- EC10	108.738	302.8	1	None.	None.
Aromatic EC10- EC12 (naphthalene)	9.541	8381.3	12	12	1
Aromatic EC12- EC16	367.475	8908	10	7	1

Exploratory positions within 5m of the river edge are currently limited to RB16-O1, RB16-O2, RB16-O3 and RB16-O4 for which RTV exceedances for anthracene, fluoranthene, naphthalene, benzo(a)pyrene, aromatic EC10-EC12, aromatic EC12-EC16, free cyanide and total cyanide are recorded. With continued erosion of the Site soils by the river however soils associated with source Area A, which showed widespread RTV failures, will soon come within 5m of the river edge. As part of the remediation process, an engineered riverbank will be created to create a barrier between these soils and the river. Soils used to create this riverbank will have to meet the Soil Level 2 RTV after dilution (Column 2 of Table 7-14 Final RTVs). At present, failures are recorded Site wide as seen in Table 7-16. Soils from source area C consistently show the least failures, with many of the exceedances being marginal. However, total cyanide, fluoranthene, anthracene and benzo(a)pyrene failures are seen within area C.

Review of the data indicates that the soil samples exceeding this RTV in Area C are all within the upper 2 m of the soil profile, and most are within the upper 1m. Soils analysed from depths in excess of 2 mbgl have no exceedances of this RTV. Soils present at depths in excess of 2m are therefore considered potentially suitable for excavation and re-use along the riverbank, within 5m of the river's edge.

Site soils (>5m of the river edge)



Table 7-17 Distribution of exceedances of RTVs (for use in areas >5m from river bank)

Contaminant	Soil Level 3 RTV after dilution (mg/kg)	Max concentration in (mg/kg)	No. exceedances Source Area A	No. exceedances Source Area B	No. exceedances Source Area C
Free cyanide	61.03	330	1	1	None
Total cyanide	61.03	25529.9	17	12	None
Ammoniacal Nitrogen NH4	7.049	128.5	8	14	None
Anthracene	2389.66	5379.8	2	None	None
Fluoranthene	1560.157	47660.4	7	2	None
Naphthalene	327.50	23107.2	5	2	None
Benzene	6.53	89.4	2	1	None
Aromatic EC5- EC7	6.53	76.3	2	None	None
Aromatic EC10- EC12	327.50	8381.3	4	1	None

As can be seen in the table above, soils in Area C all fall below the RTV for retention of soils outside of the zone within 5m of the river (i.e. no remediation is required in Area C in order for soils present to be retained, provided they are in excess of 5m from the river's edge).

Remediation of soils will be required in Areas A and B in order to render soils suitable for retention without posing potential unacceptable risk to the river.

Groundwater

Table 7-18 Distribution of exceedances for groundwater RTVs

Contaminant	Groundwater Level 3 RTV after dilution (mg/l)	Max concentration in (mg/l)	No. exceedances Source Area A	No. exceedances Source Area B	No. exceedances Source Area C
Total cyanide	0.1212	3.43	43	13	None
Ammoniacal Nitrogen as NH4	2.60456	73.28	16	31	2
Naphthalene	0.2579	12.032	14	15	None
Fluoranthene	0.00396	0.0178	25	4	None
Benzene	0.4513	2.202	14	2	None
Aromatic EC5- EC7 (Benzene)	0.4513	2.202	13	2	None
Aromatic EC8- EC10 (Xylenes)	2.1920	2.96	7	1	None



Aromatic EC10- EC12 (naphthalene)	0.2579	28.413	12	18	None
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There are only two exceedances of the ammoniacal Nitrogen as NH₄ RTV within Area C, with no other exceedances of groundwater RTVs recorded within Area C. However both Areas A and B show failures within groundwater for total cyanide, ammoniacal Nitrogen as NH₄, naphthalene, benzene and aromatic EC5-EC7, EC8-EC10 and EC10-EC12.



8 Land quality assessment

8.1 Revised conceptual site model

The postulated conceptual model for the Site is described in Sections 6.1, 6.2 and 6.3. In light of the DQRA assessment set out in the preceding Section 7, potential source-pathway-receptor linkages can be refined further as discussed below.

8.1.1 Source Area A: Gasholder No.1 and No.2

8.1.1.1 *Linkage to current and future Site users*

This area remains of concern with respect to the presence of soil contaminants that may pose an unacceptable risk to the human health of current and future Site users under a public open spaces (parks) scenario. This is because contaminants have been identified that exceed GACs for human health. Statistical assessment of the soils data has indicated that the soils in this area can be considered as outliers from the wider Site, with BH2, HP15-11, MW16-01, MW16-06, RB16-02, TP16-08, TP16-08B and TP16-09 all identified as outliers. This tallies with the presence of a greater density of visually and olfactorily impacted soils in the Made Ground in this area.

The recorded presence of asbestos in soils in this area poses a potentially unacceptable risk to current and future Site users, as the area does not benefit from concrete or asphalt cover at present.

8.1.1.2 *Linkage to adjacent residential properties*

Groundwater flow is considered to be southeast, towards the Bargoed Taff River and in the opposite direction to the residential properties that lie northwest of the Site. The river represents a separation between shallow groundwater and residential properties to the south (over 70m away). The distance to properties in all directions, plus the other mitigating factors associated with the pathways to them, leads to the conclusion that the migration of mobile contaminants towards these properties is considered highly unlikely.

Given the woodland nature of the site, the potential for fugitive wind-blown dust is considered negligible.

8.1.1.3 *Linkage to controlled waters and wider environment*

Both the groundwater and spring, which flows across Source Area A, feed into the Bargoed Taff River providing a clear pathway between Site and river.

The waters flowing from the spring should be captured within an impermeably lined channel in order to separate them from site soils. This will sever any linkage between the emergent spring water and soil contamination on site. At present, no such lining is present and hence the spring water leaches contaminants as it flows over the site soils, impacting the chemistry of the Bargoed Taff.

The direct erosion of Site soils provides a direct mechanism impacting on river water quality. The river bank should be excavated and replaced with a clean, engineered structure to prevent further erosion of the bank.



DQRA modelling of the movement of contaminants in groundwater indicates that free cyanide, total cyanide, ammoniacal nitrogen NH₄, anthracene, fluoranthene, naphthalene, benzene, aromatic EC5-EC7 and aromatic EC10-EC12 in the soils within source area A exceed RTVs calculated to protect controlled waters and the wider environment (assuming a 5m pathway length).

DQRA modelling also indicates ammoniacal nitrogen NH₄, chromium III, benzene and aromatic EC5-EC7 in soils within the source area exceed RTVs calculated to be protective of the aquifer (assuming a 50m sentinel compliance point).

8.1.2 Source Area B: Gaswork process areas (including tully gasworks, purifiers and exhaust house)

8.1.2.1 Linkage to current and future Site users

Comparison of GACs with soil data from this area has indicated the presence of benzo(b)fluoranthene, benzo(a)pyrene, dibenzo(ah)anthracene and complex cyanide in soil that may pose an unacceptable risk to human health of current and future Site users under a public open space (parks) scenario.

The recorded presence of asbestos in soils in this area poses a potentially unacceptable risk to current and future Site users, as the area does not benefit from concrete or asphalt cover at present.

8.1.2.2 Linkage to adjacent residential properties

Groundwater flow is considered to be southeast, towards the Bargoed Taff River and in the opposite direction to the residential properties that lie northwest of the Site. The river represents a separation between shallow groundwater and residential properties to the south (over 70m away). The distance to properties in all directions, plus the other mitigating factors associated with the pathways to them, leads to the conclusion that the migration of mobile contaminants towards these properties is considered highly unlikely.

Given the woodland nature of the site, the potential for fugitive wind-blown dust is considered negligible.

8.1.2.3 Linkage to controlled waters and wider environment

Both the groundwater and spring, which flows across Source Area B, feed into the Bargoed Taff River providing a clear pathway between Site and river.

As discussed for Area A, the spring water needs to be isolated in an impermeably lined channel. At present, it leaches site soils as it flows across them, impacting the Bargoed Taff.

Again, as discussed for Area A the direct erosion of Site soils provides a direct mechanism impacting on river water quality. The river bank should be excavated and replaced with a clean, engineered structure to prevent further erosion of the bank.

DQRA modelling of contaminant movement in groundwater indicates that free cyanide, total cyanide, ammoniacal nitrogen NH₄, anthracene, fluoranthene, naphthalene, benzene and aromatic



EC10-EC12 in the soils within source area B exceed RTVs calculated to protect controlled waters and the wider environment (assuming a 5m pathway length).

8.1.3 Area C: Wider Site

8.1.3.1 Linkage to current and future Site users

Comparison of soils data with GACs indicates concentrations of dibenzo(ah)anthracene in soils that marginally exceed the human health GAC protective of current and future Site users under a public open space (parks) scenario. Given the marginal exceedance and given that the area is to be returned to woodland (rather than playing field, for example), it is considered unlikely that this exceedance is significant.

The recorded presence of asbestos in soils in this area poses a potentially unacceptable risk to current and future Site users.

8.1.3.2 Linkage to adjacent residential properties

Groundwater flow is considered to be southeast, towards the Bargoed Taff River and in the opposite direction to the residential properties that lie northwest of the Site. The river represents a separation between shallow groundwater and residential properties to the south (over 70m away). The distance to properties in all directions, plus the other mitigating factors associated with the pathways to them, leads to the conclusion that the migration of mobile contaminants towards these properties is considered highly unlikely.

Given the woodland nature of the site, the potential for fugitive wind-blown dust is considered negligible.

8.1.3.3 Linkage to controlled waters and wider environment

Groundwater flow towards the Bargoed Taff River provides a clear pathway between source area C and the river. DQRA modelling indicates that there are no exceedances of the RTV in the soils of this area (assuming a 5m pathway length). However, soils in this area have been assessed to exceed RTVs if present within 5m of the river's edge.

Due to the altered direction of flow in the river, the on-site riverbank in Area C lies on the inside of the river bend, and so is an area of deposition for the river, rather than erosion. The same direct mechanism (erosion of site soils) for contributing contamination to the river does not therefore exist here as is the case in Areas A & B.

8.2 Risk assessment

The sources described in Section 6.1 have been combined with the pathways and receptors described in Sections 6.2 and 6.3 in Table 8-1 to provide a summary of the potential contaminant linkages associated with the Site. For each linkage, an assessment of the risks posed is provided. These risks have been defined using the risk assessment methodology described in CIRIA C552 (2001). As such, risk is considered to be a function of both the probability (likelihood) of contamination occurring at the study site and also the potential severity (consequence) of the environmental impacts associated with any such contamination. The classification system used to define contaminant probability, consequence and risk is described in Appendix E.



Table 8-1 Pollutant linkage assessment

Sources	Pathways	Receptors	Consequence	Probability	Risk	Risk Management
Source Area A: Gasholder No.1 and No.2 Soils and groundwater	Direct human contact exposure pathways (Dermal, ingestion, inhalation of dust, generation of ground gases and vapours)	Future construction workers	Medium	High likelihood	High	Risk to future construction works can be adequately managed to low by standard precautions and health and safety procedures commensurate with working on brownfield sites.
		Current Site users	Medium	Likely	Moderate	Risk requires management to manage risks associated with GAC exceedances and asbestos in soil. Remediation planned to address this risk.
		Future Site users	Medium	Likely	Moderate	
	Lateral migration and upwards vapour migration, inhalation	Nearby residential properties	Mild	Unlikely	Very low	None required. A viable pathway is considered very unlikely.
	Leakage, leaching and/ or water mobile constituents passing through permeable sub-surface soils and/ or shallow preferential pathways	Bargoed Taff River	Medium	High likelihood	High	DQRA indicates action required to manage free cyanide, total cyanide, ammoniacal nitrogen NH ₄ , anthracene, fluoranthene, naphthalene, benzene and aromatic EC10-EC12 concentrations in soil in this area. It is recommended that the spring and its drainage channel is isolated from site soils, removing this direct pathway to the river. As contaminated riverbank soils are currently in direct contact with the river, the construction of a engineered riverbank of suitably verified material is recommended to increase the pathway length and prevent erosion. Area-wide remediation of soils is required.
		Secondary A Aquifer	Medium	Low likelihood	Moderate/low	DQRA indicates action required to manage free cyanide, total cyanide, ammoniacal nitrogen NH ₄ , chromium III, fluoranthene, benzene and aromatic EC5-EC7 concentrations in soil in this area.



Sources	Pathways	Receptors	Consequence	Probability	Risk	Risk Management
Source Area B: Gasworks process areas (including tully gasworks, purifiers and exhauster house)	Direct human contact exposure pathways (Dermal, ingestion, inhalation of dust, generation of ground gases and vapours)	Future construction workers	Medium	High likelihood	High	Risk to future construction works can be adequately managed to low by standard precautions and health and safety procedures commensurate with working on brownfield sites.
		Current Site users	Medium	Likely	Moderate	Risk requires management to manage risks associated with GAC exceedances and asbestos in soil. Remediation planned to meet calculated RTVs.
		Future Site users	Medium	Likely	Moderate	
	Lateral migration and upwards vapour migration, inhalation	Adjacent residential properties	Mild	Unlikely	Very low	None required. A viable pathway is considered very unlikely.
	Leakage, leaching and/ or water mobile constituents passing through permeable sub-surface soils and/ or shallow preferential pathways	Bargoed Taff River	Medium	High likelihood	High	DQRA indicates action required to manage free cyanide, total cyanide, ammoniacal nitrogen NH ₄ , anthracene, fluoranthene, naphthalene, benzene, aromatic EC5-EC7 and aromatic EC10-EC12 concentrations in soil in this area. It is recommended that the spring and its drainage channel is isolated from site soils, removing this direct pathway to the river. As contaminated riverbank soils are currently in direct contact with the river, the construction of a engineered riverbank of suitable material is recommended to increase the pathway length and prevent erosion. Area-wide remediation of soils is required.
Soils and groundwater		Secondary A Aquifer	Medium	Low likelihood	Moderate/low	DQRA indicates action required to manage free cyanide, total cyanide, ammoniacal nitrogen NH ₄ , chromium III, fluoranthene, benzene and aromatic EC5-EC7 concentrations in soil in this area.



Sources	Pathways	Receptors	Consequence	Probability	Risk	Risk Management
Source Area C: Southern and norther area of Site Soils and groundwater	Direct human contact exposure pathways (Dermal, ingestion, inhalation of dust, generation of ground gases and vapours)	Future construction workers	Mild	High likelihood	Moderate	Risk to future construction works can be adequately managed to low by standard precautions and health and safety procedures commensurate with working on brownfield sites.
		Current Site users	Mild	Likely	Moderate/low	Risk requires management to manage risks associated with asbestos in soil. Marginal exceedance of dibenzo(ah)anthracene is not considered of sufficient significance to drive a requirement for remediation.
		Future Site users	Mild	Likely	Moderate/low	
	Lateral migration and upwards vapour migration, inhalation	Adjacent residential properties	Mild	Unlikely	Very low	None required. A viable pathway is considered very unlikely.
	Leakage, leaching and/ or water mobile constituents passing through permeable sub-surface soils and/ or shallow preferential pathways	Bargoed Taff River	Medium	Likely	Moderate	DQRA indicates action required to address risks posed to the river within 5m of the river's edge to manage free cyanide, total cyanide and fluoranthene concentrations in soil in this area. Outside of this zone, no remedial action is required.
		Secondary A Aquifer	Medium	Low likelihood	Moderate/low	DQRA indicates action required to manage free cyanide, total cyanide, ammoniacal nitrogen NH ₄ , chromium III, fluoranthene, benzene and aromatic EC5-EC7 concentrations in soil in this area.



9 Conclusions and next steps

This report provides a summary of the work undertaken to compile and assess fieldwork data collected by various previous works on the Quakers Yard former gasworks site, Treharris. Upon completion of the assessment process, the following conclusions and recommendations have been drawn.

These recommendations are focussed on reducing the risk posed by the Site to human health and the wider environment. Their aim is to reduce these risks such that they pose an acceptably low risk to both human health and the wider environment, that, on the balance of probabilities, it can be demonstrated that the Site does not fall under the definition of contaminated land under Part 2A of the Environmental Protection Act 1990 and does not pose a statutory risk.

9.1 Risks to human health of current and future Site users

9.1.1 Source Area A

This assessment has concluded that the following may be present in shallow soils at concentrations that may pose an unacceptable risk to human health under a public open spaces (parks) scenario: asbestos, aromatic C16–21, aromatic C21–35, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, complex cyanide, dibenzo(ah)anthracene, fluoranthene, free cyanide, indeno(123cd)pyrene, lead, mercury, naphthalene, phenanthrene, 1,2,3-trichloropropane, 1,2,4-trimethylbenzene, 1,2-dibromo-3-chloropropane, 2-methylnaphthalene and dibenzofuran.

On this basis the risk to human health is assessed to be MODERATE. Remediation to meet the calculated RTV values and/ or values protective of human health in a public open space (parks) setting (whichever is the smaller) will be required to render this area suitable as a public open space.

The risk to construction workers is assessed as HIGH, and will require mitigation during the proposed remediation works through use of a suitable Safe System of Work.

9.1.2 Source Area B

This assessment has concluded that the following may be present in shallow soils at concentrations that may pose an unacceptable risk to human health under a public open spaces (parks) scenario: benzo(a)pyrene, benzo(b)fluoranthene, complex cyanide, dibenzo(ah)anthracene and asbestos.

On this basis the risk to human health is assessed to be MODERATE. Remediation to meet the calculated RTV values and/ or values protective of human health in a public open space (parks) setting (whichever is the smaller) will be required to render this area suitable as a public open space.

The risk to construction workers is assessed as HIGH, and will require mitigation during the proposed remediation works through use of a suitable Safe System of Work.



9.1.3 Source Area C

This assessment has concluded that the risks associated with a marginal exceedance of dibenzo(ah)anthracene in soils in this area is not sufficiently of significance to warrant a need for remedial action. Asbestos in soils do require addressing to mitigate risks to human health of current and future site users.

On this basis the risk to human health is assessed to be MODERATE to LOW. The risk associated with asbestos can be mitigated by undertaking a pick of asbestos materials, in accordance with standard such remediation on brownfield sites.

9.2 Risks to the wider environment

9.2.1 Source Area A and source Area B

The risk to the wider environment, namely the Bargoed Taff River, is assessed as being HIGH. Both the groundwater and spring, which flows across Source Area A, feed into the Bargoed Taff River providing a clear pathway between Site and river. DQRA modelling of contaminant movement in groundwater indicates that free cyanide, total cyanide, ammoniacal nitrogen NH₄, anthracene, fluoranthene, naphthalene, benzene, aromatic EC5-EC7 and aromatic EC10-EC12 in the soils within source area A exceed RTVs calculated to protect controlled waters and the wider environment (assuming a 5m pathway length). Within source area B, soils exceed calculated RTVs for free cyanide, total cyanide, ammoniacal nitrogen as NH₄, naphthalene, benzene and aromatic EC10-EC12.

Groundwater within Source Area A and B, exceeds calculated RTVs for total cyanide, ammoniacal nitrogen as NH₄, naphthalene, benzene, aromatic EC5-EC7, EC8-EC10 and EC10-EC12.

DQRA modelling also indicates free cyanide, total cyanide, ammoniacal nitrogen NH₄, chromium III, fluoranthene, benzene and aromatic EC5-EC7 in soils within the source area exceed RTVs calculated to be protective of the aquifer (assuming a 50m sentinel compliance point).

It is recommended that the spring and its drainage channel is isolated from site soils, removing this direct pathway to the river.

As contaminated riverbank soils are currently in direct contact with the river, the construction of an engineered riverbank of suitable material is recommended to increase the pathway length and prevent erosion.

Area-wide remediation of soils is required. Some remediation of groundwater is also required.

9.2.2 Source Area C

The soils in this area were assessed as falling below the RTV where soils are in excess of 5m from the river's edge. Some remediation of site soils will be required within 5m of the river.

Laboratory analysis results for soils sampled at depths beneath 2 mbgl in this area suggest that these soils may be suitable for excavation and re-use in the zone within 5 m of the river's edge, and thus could form an on-site source of chemically suitable soils to this end.



Groundwater within this area falls below the RTVs calculated to protect controlled waters and the wider environment, with the exception of ammoniacal Nitrogen as NH_4 .

9.3 Risks to off Site residential properties

The risk to nearby residential properties is assessed to be VERY LOW; this is on the basis that;

- groundwater flow is considered to be southeast, towards the Bargoed Taff River and in the opposite direction to the residential properties of Treharris that lie northwest of the Site.
- The shallow groundwater on Site is separated from the residential properties of Quakers Yard by the Bargoed Taff River, into which the groundwater flows.
- The pathway lengths to all properties is at least 70m, which is considered sufficiently long to ameliorate any risks that may be posed.



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Drawings

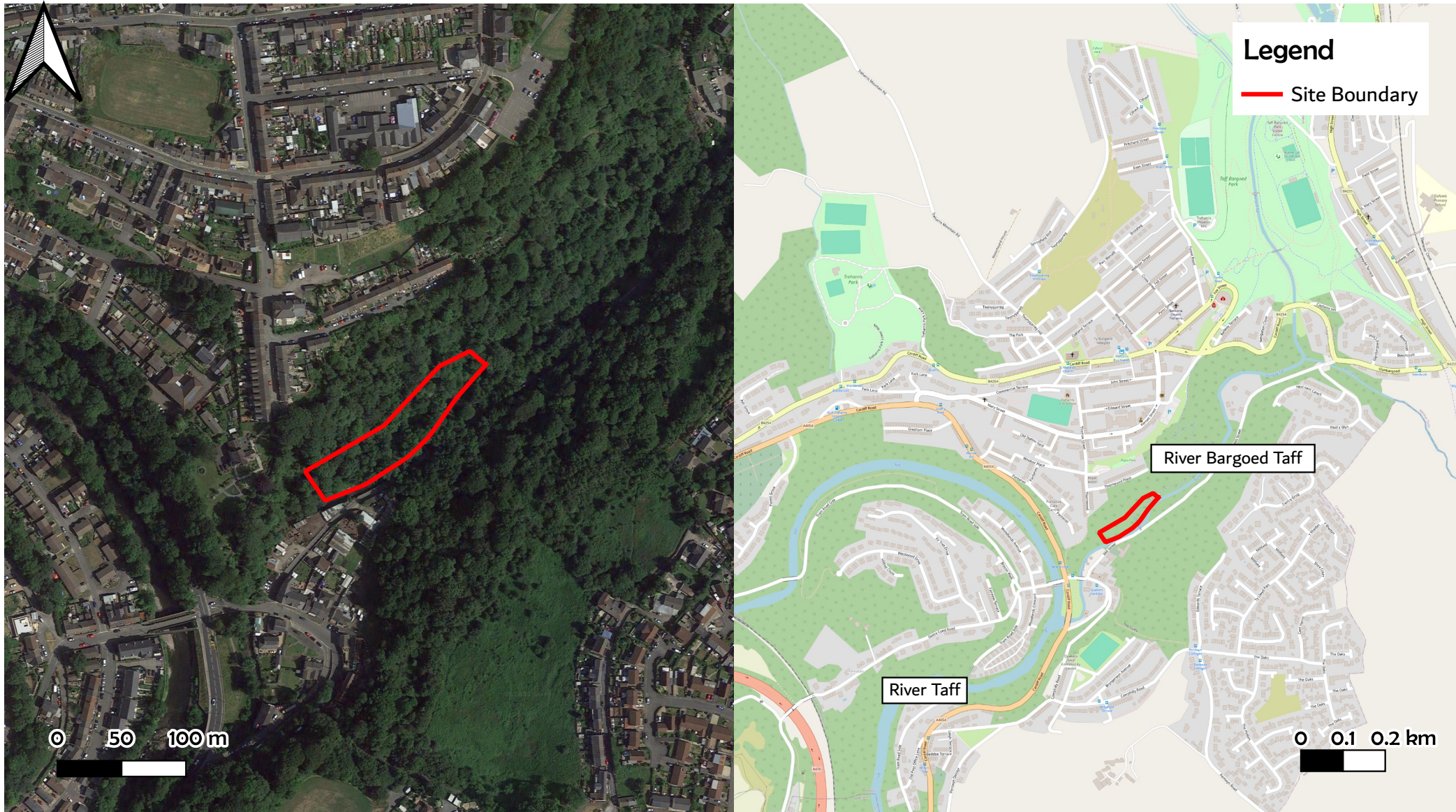


Figure Title

Site location, Quakers Yard

Client

Englobe Regeneration UK

Drawing Number

P23545_R1_DO1

Project Number

P23545

Date

06/04/2023

Scale

NTS

Drawn

RLW

Site Location

Quakers Yard, Treharris

Original

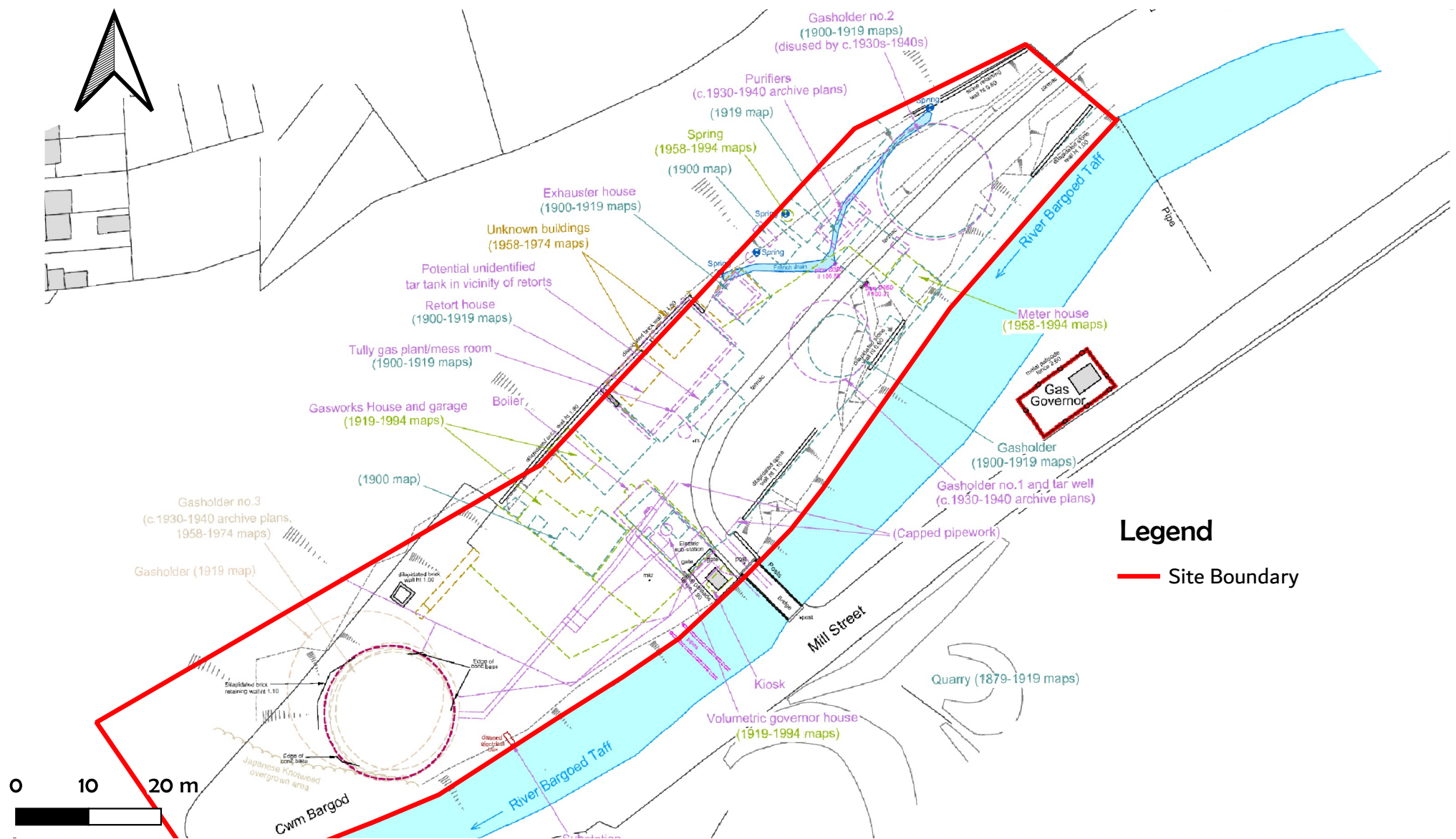
A4

Checked

JEM



YELLOWSUB
GEO



Legend

— Site Boundary

Figure Title

Location of historic Site areas, Quakers Yard

Client

Englobe Regeneration UK

Drawing Number

P23545_R1_D02

Project Number

P23545

Date

26/09/2023

Scale

1:1,200

Drawn

RLW

Site Location

Quakers Yard, Treharris

Original

A4

Checked

JEM



YELOWSUB
GEO

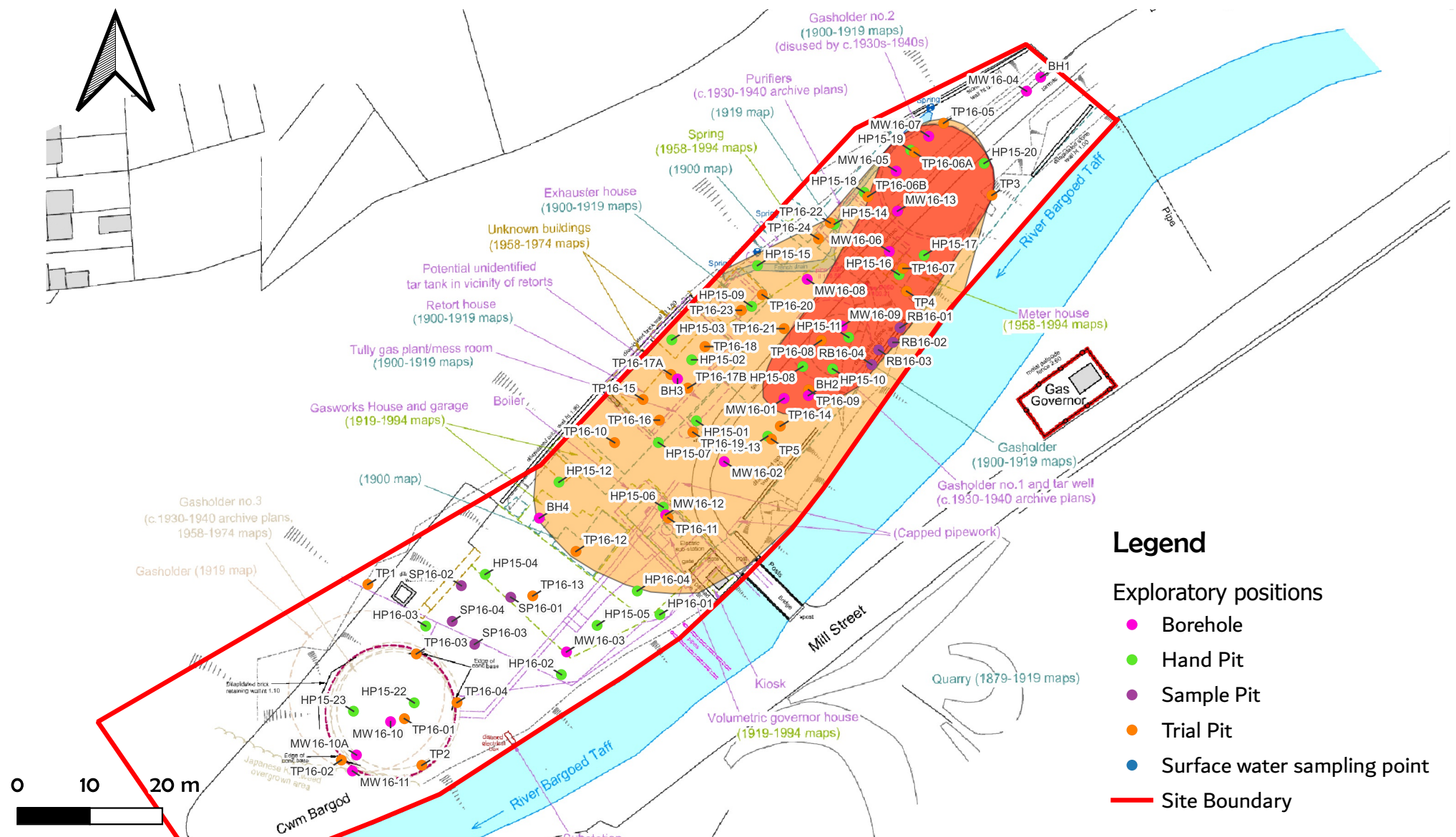


Figure Title

Exploratory Positions, Quakers Yard

Client

Englobe Regeneration UK

Drawing Number

P23545_R1_D03

Project Number

P23545

Date

26/09/2023

Scale

1:1,200

Drawn

RLW

Site Location

Quakers Yard, Treharris

Original

A4

Checked

JEM



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- 1 Potential linkage to current and future site users in public open space (parks) scenario, direct contact and inhalation.
- 2 Potential linkage for dissolved phase contamination, leached by spring water, flowing across site in unlined channel and flowing into river.
- 3 Downwards migration of contamination from shallow unsaturated zone (made ground) to aquifer and lateral flow into river.
- 4 Some limited downwards migration of dissolved phase into deeper aquifer, with potential to flow beneath river into wider aquifer.
- 5 Potential for off-site migration of dissolved phase and then upwards vapours phase migration considered very limited



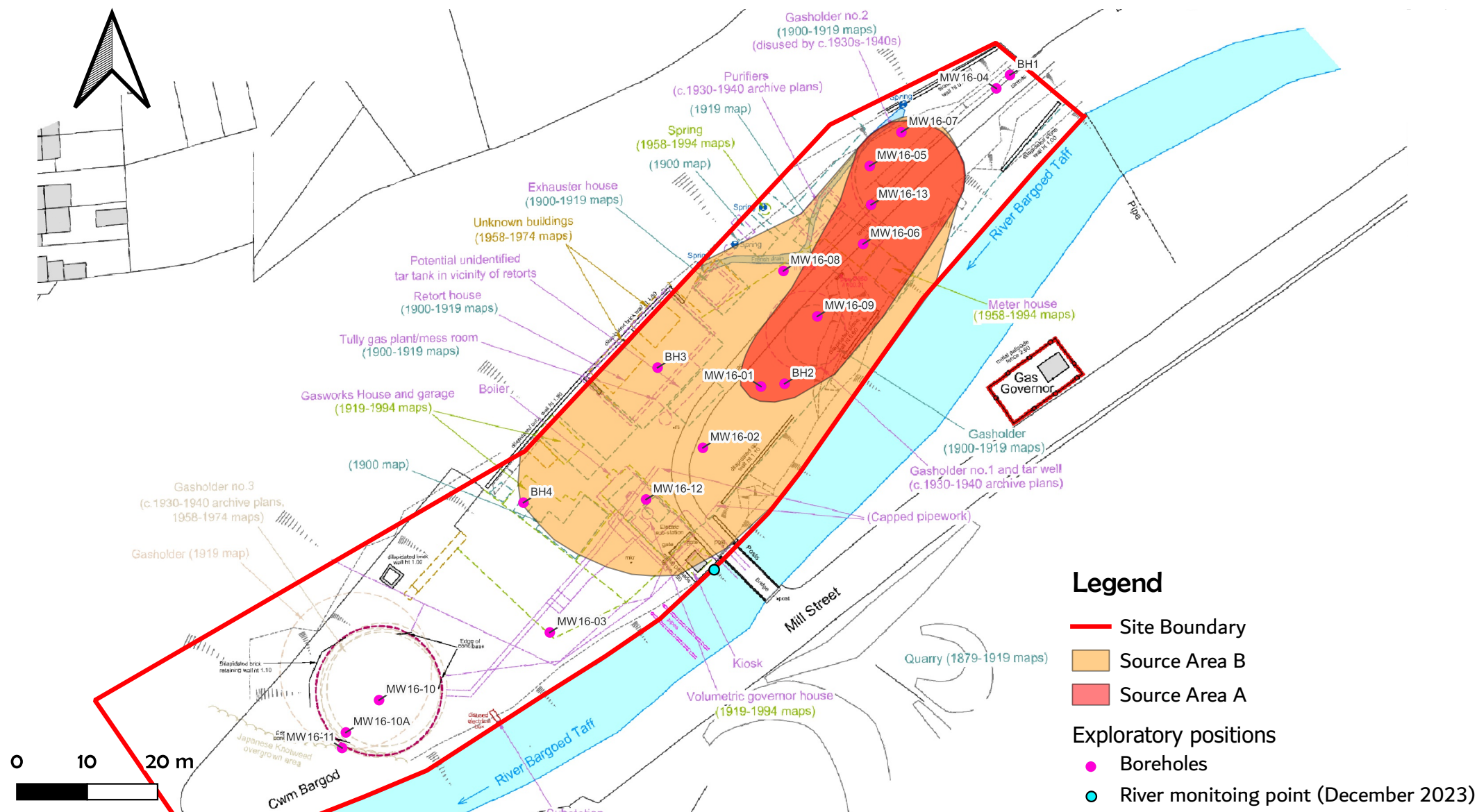


Figure Title
Borehole Positions, Quakers Yard

Client

Englobe Regeneration UK

Drawing Number
P23545_R1_D06

Project Number
P23545

Date
18/01/2024

Scale
1:1,200

Drawn
RLW

Site Location
Quakers Yard, Treharris

Original
A4

Checked
JEM



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Appendices



Appendix A: Report Conditions



Report Conditions

This report has been prepared by Yellow Sub Geo Ltd. (Yellow Sub Geo) in its professional capacity as soil and groundwater specialists, with reasonable skill, care and diligence within the agreed scope and terms of contract and taking account of the manpower and resources devoted to it by agreement with its client, and is provided by Yellow Sub Geo solely for the internal use of its client.

The advice and opinions in this report should be read and relied on only in the context of the report as a whole, taking account of the terms of reference agreed with the client. The findings are based on the information made available to Yellow Sub Geo at the date of the report (and will have been assumed to be correct) and on current UK standards, codes, technology and practices as at that time. They do not purport to include any manner of legal advice or opinion. New information or changes in conditions and regulatory requirements may occur in future, which will change the conclusions presented here.

Where necessary and appropriate, the report represents and relies on published information from third party, publicly and commercially available sources which is used in good faith of its accuracy and efficacy. Yellow Sub Geo cannot accept responsibility for the work of others.

Site investigation results necessarily rely on tests and observations within exploratory holes only. The inherent variation in ground conditions mean that the results may not be representative of ground conditions between exploratory holes. Yellow Sub Geo take no responsibility for variation in ground conditions between exploratory positions.

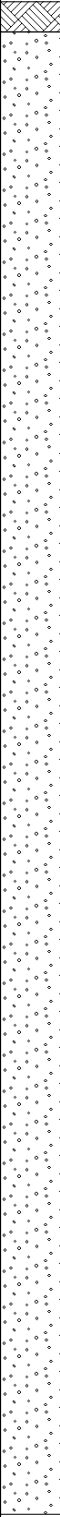
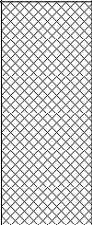
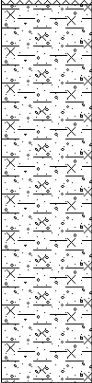
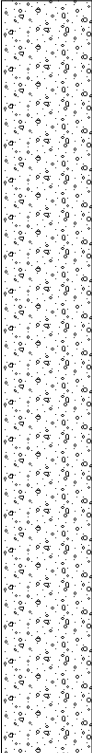
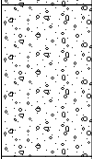
This report is confidential to the client. The client may submit the report to regulatory bodies, where appropriate. Should the client wish to release this report to any other third party for that party's reliance, Yellow Sub Geo may, by prior written agreement, agree to such release, provided that it is acknowledged that Yellow Sub Geo accepts no responsibility of any nature to any third party to whom this report or any part thereof is made known. Yellow Sub Geo accepts no responsibility for any loss or damage incurred as a result, and the third party does not acquire any rights whatsoever, contractual or otherwise, against Yellow Sub Geo except as expressly agreed with Yellow Sub Geo in writing. Yellow Sub Geo reserves the right to withhold and/ or negotiate the transference of reliance on this report, subject to legal and commercial review.



Appendix B: Historical exploratory logs

Percussion Drilling Log

Project Name: Quaker's Yard		Client: WWU		Date: 15/11/2022	
Location: Mill Street, Treharris		Contractor: Englobe			
Project No. : C1871		Crew Name:		Drilling Equipment:	
Borehole Number BH1A	Hole Type BH	Level	Logged By MS	Scale 1:50	Page Number Sheet 1 of 2

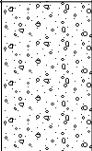
Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		0.30	Solid/Asb		1.50			Brownish greyish clayey silty sandy GRAVEL with cobbles and frequent rootlets to 0.3 m. Sand is fine to coarse; gravel is fine to coarse angular to sub-angular of sandstone and concrete. Cobbles are sub-angular to sub-rounded of sandstone and concrete.	1
		1.50	Solid/Asb					Soft to firm greyish brownish silty sandy gravelly CLAY. Sand is fine to coarse; gravel is fine to coarse sub-angular to rounded of sandstone.	2
									3
					4.00			Greyish sandy GRAVEL with cobbles and boulders. Sand is medium to coarse; insufficient recovery to determine angularity of cobbles and boulders.	4
									5
									6
									7
									8
									9
					9.00			Greyish sandy GRAVEL with cobbles. Sand is medium to coarse; insufficient recovery to determine angularity of cobbles.	10

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks

Percussion Drilling Log

Project Name: Quaker's Yard		Client: WWU		Date: 15/11/2022	
Location: Mill Street, Treharris		Contractor: Englobe			
Project No. : C1871		Crew Name:		Drilling Equipment:	
Borehole Number BH1A	Hole Type BH	Level	Logged By MS	Scale 1:50	Page Number Sheet 2 of 2

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
					11.00			Greyish sandy GRAVEL with cobbles. Sand is medium to coarse; insufficient recovery to determine angularity of cobbles.	11
								Dark grey cohesive MUDSTONE rock head.	12
					13.00			End of Borehole at 13.000m	13
									14
									15
									16
									17
									18
									19
									20

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks

Percussion Drilling Log

Project Name: Quaker's Yard		Client: WWU		Date: 03/11/2022	
Location: Mill Street, Treharris		Contractor: Englobe			
Project No. : C1871		Crew Name:		Drilling Equipment:	
Borehole Number BH2	Hole Type BH	Level	Logged By MS	Scale 1:50	Page Number Sheet 1 of 1

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
					0.10			Vegetation cover over.	
		0.70	Solid/Asb		0.80			Brownish greyish clayey silty sandy GRAVEL with frequent rootlets to 0.3 m bgl. Sand is fine to coarse; gravel is fine to coarse angular to sub-angular of sandstone and concrete.	1
		1.30	Solid/Asb		0.90			Greyish blackish ashy GRAVEL. Gravel is fine to coarse, angular with moderate hydrocarbon (phenolic) odour.	
					1.05			Brownish greyish clayey silty sandy GRAVEL. Sand is fine to coarse; gravel is fine to coarse angular to sub-angular of sandstone and concrete.	
					1.10			Greyish blackish ashy GRAVEL. Gravel is fine to coarse, angular with moderate hydrocarbon (phenolic) odour.	2
					1.25			Brownish greyish clayey silty sandy GRAVEL. Sand is fine to coarse; gravel is fine to coarse angular to sub-angular of sandstone and concrete.	
					2.15			Soft brownish greyish silty sandy slightly ashy gravelly CLAY. Sand is fine to coarse; gravel is fine to coarse angular to sub-angular of partially combusted and non-combusted coal ash, clinker, sandstone and concrete.	3
					3.00			Black silty sandy ashy gravelly CLAY. Sand is fine to coarse; gravel is fine to coarse angular to sub-angular of partially combusted and non-combusted coal ash, sandstone and concrete. Boulder obstruction encountered at 3.0 m bgl; drillers instructed to core.	4
					4.50			Grey sandy GRAVEL with cobbles and boulders. Sand is fine to coarse; gravel is fine to coarse sub-angular to rounded of sandstone; cobbles are fine to coarse sub-rounded to rounded of sandstone; boulders are of sandstone - insufficient recovery to determine angularity.	5
								Grey silty sandy GRAVEL with cobbles. Sand is fine to coarse; gravel is fine to coarse sub-angular to rounded of sandstone; cobbles are fine to coarse sub-rounded to rounded of sandstone.	6
					8.00			Grey silty sandy GRAVEL with cobbles. Sand is fine to medium; gravel is fine to coarse sub-angular to rounded of sandstone; cobbles are fine to coarse sub-rounded to rounded of sandstone.	8
					8.40			Greyish brownish SANDSTONE rock head. Sandstone is coarse grained, heavily weathered with regular and consistent fracturing and oxidation staining throughout column.	9
					10.00			End of Borehole at 10.000m	10

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks

Percussion Drilling Log

Project Name: Quaker's Yard		Client: WWU		Date: 08/11/2022	
Location: Mill Street, Treharris		Contractor: Englobe			
Project No. : C1871		Crew Name:		Drilling Equipment:	
Borehole Number BH3	Hole Type BH	Level	Logged By MS	Scale 1:50	Page Number Sheet 1 of 2

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
					0.10			Vegetation cover over.	
					0.60			Soft dark brown silty sandy ashy gravelly CLAY with cobbles and boulders. Sand is fine to coarse; gravel is fine to coarse angular of partially combusted coal, sandstone and concrete; cobbles are angular to rounded of sandstone, concrete and red brick; boulders are angular to sub-angular of sandstone, concrete and asphalt.	1
					1.40			Soft to firm brownish greyish silty sandy ashy gravelly CLAY with cobbles and boulders. Sand is fine to coarse; gravel is fine to coarse angular of partially combusted coal, sandstone, concrete and red brick; cobbles are angular to rounded of sandstone, concrete and red brick; boulders are angular to sub-angular of sandstone, concrete and asphalt.	2
					1.55				
					1.80				
								Concrete slab.	
								Medium to coarse COBBLES with gravel. Gravel is medium to coarse angular to sub-angular of sandstone, red brick, yellow brick and concrete. Cobbles are fine to coarse of sandstone, red brick, yellow brick and concrete.	3
					3.30			Soft brownish greyish silty sandy gravelly CLAY. Sand is fine to coarse; gravel is fine to coarse angular to sub-angular of sandstone and concrete. Grey sandy GRAVEL with cobbles and boulders. Sand is fine to coarse; gravel is fine to coarse sub-angular to rounded of sandstone; cobbles are fine to coarse sub-rounded to rounded of sandstone; boulders are of sandstone - insufficient recovery to determine angularity.	4
					4.80			Grey silty sandy GRAVEL with cobbles. Sand is fine to coarse; gravel is fine to coarse sub-angular to rounded of sandstone; cobbles are fine to coarse sub-rounded to rounded of sandstone.	5
									6
									7
									8
					8.30			Greyish brownish SANDSTONE rock head. Sandstone is coarse grained, heavily weathered with regular and consistent fracturing and oxidation staining throughout column.	9
					9.50			Dark grey cohesive MUDSTONE rock head.	10

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks

Percussion Drilling Log

Project Name: Quaker's Yard			Client: WWU			Date: 08/11/2022		
Location: Mill Street, Treharris			Contractor: Englobe					
Project No. : C1871			Crew Name:			Drilling Equipment:		
Borehole Number BH3		Hole Type BH		Level		Logged By MS		Page Number Sheet 2 of 2

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
					10.50			Dark grey cohesive MUDSTONE rock head.	11
								End of Borehole at 10.500m	
									12
									13
									14
									15
									16
									17
									18
									19
									20

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks

Percussion Drilling Log

Project Name: Quaker's Yard		Client: WWU		Date: 08/11/2022	
Location: Mill Street, Treharris		Contractor: Englobe			
Project No. : C1871		Crew Name:		Drilling Equipment:	
Borehole Number BH4	Hole Type BH	Level	Logged By MS	Scale 1:50	Page Number Sheet 1 of 2

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
					0.10			Vegetation cover over.	
					0.70			Soft brownish greyish silty sandy gravelly CLAY with cobbles and boulders. Sand is fine to coarse; gravel is fine to coarse angular to sub-rounded of sandstone, concrete and red brick; boulders are angular to sub-rounded of sandstone.	1
		0.85	Solid/Asb					Soft light brownish silty sandy gravelly CLAY with cobbles and boulders. Sand is fine to coarse; gravel is fine to coarse angular to sub-rounded of sandstone, concrete and occasional red brick; boulders are sub-angular to sub-rounded of sandstone.	2
		1.50	Solid/Asb						
					3.00			Grey sandy GRAVEL with cobbles and boulders. Sand is fine to coarse; gravel is fine to coarse sub-angular to rounded of sandstone; cobbles are fine to coarse sub-rounded to rounded of sandstone; boulders are of sandstone - insufficient recovery to determine angularity.	3
									4
									5
									6
									7
					8.00			Dark grey cohesive MUDSTONE rock head.	8
									9
					10.00				10

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks

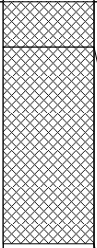
Percussion Drilling Log

Project Name: Quaker's Yard			Client: WWU			Date: 08/11/2022		
Location: Mill Street, Treharris			Contractor: Englobe					
Project No. : C1871			Crew Name:			Drilling Equipment:		
Borehole Number BH4		Hole Type BH		Level		Logged By MS		Page Number Sheet 2 of 2

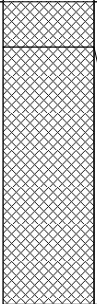
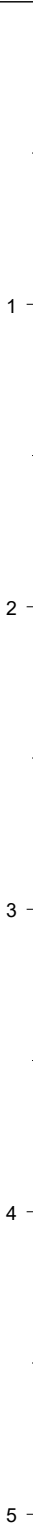
Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
								End of Borehole at 10.500m	11
									12
									13
									14
									15
									16
									17
									18
									19
									20

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks

		Trial Pit Log							
Project Name: Quaker's Yard				Client: WWU			Date: 04/11/2022		
Location: Mill Street, Treharris				Contractor: Englobe					
Project No. : C1871				Crew Name: CD (Englobe)			Equipment: 8T 360 Excavator		
Location Number TP1		Location Type TP		Level		Logged By MS		Scale 1:25	Page Number Sheet 1 of 1
Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		0.30	ES		0.15			MADE GROUND comprising soft dark brownish greyish silty sandy gravelly CLAY with frequent rootlets. Sand is fine to coarse; gravel is fine to coarse angular to sub-angular of sandstone and concrete.	1
					0.80 0.80			MADE GROUND comprising dark brown clayey silty sandy GRAVEL with frequent cobbles and occasional boulders. Sand is fine to coarse; gravel is fine to coarse angular to sub- angular of sandstone and concrete; cobbles are fine to coarse angular to sub- angular of sandstone, concrete, red brick and cementitious paving slab. Boulders are angular to sub-angular of sandstone, concrete and cementitious paving slab. Perched water ingress at 0.8 m bgl	
								MADE GROUND comprising flat horizontal concrete slab.	
								End of Trial Pit at 0.800m	
Dimensions		Pit Stability		Shoring Used		Trench Support and Comment		Pumping Data	
Pit Length	Pit Width	Pit Stability	Shoring Used	Remarks		Date	Rate	Remarks	
3.00	0.70	Unstable	None	Perched water at 0.80m bgl.					
Remarks									
Low cohesion material subject to collapse									

		Trial Pit Log							
Project Name: Quaker's Yard				Client: WWU				Date: 04/11/2022	
Location: Mill Street, Treharris				Contractor: Englobe					
Project No. : C1871				Crew Name: CD (Englobe)				Equipment: 8T 360 Excavator	
Location Number TP2		Location Type TP		Level		Logged By MS		Scale 1:25	Page Number Sheet 1 of 1

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
					0.15			MADE GROUND comprising soft dark brownish greyish silty sandy gravelly CLAY with frequent rootlets. Sand is fine to coarse; gravel is fine to coarse angular to sub-angular of sandstone and concrete. MADE GROUND comprising dark brown clayey silty sandy GRAVEL with frequent cobbles and occasional boulders. Sand is fine to coarse; gravel is fine to coarse angular to sub- angular of sandstone and concrete; cobbles are fine to coarse angular to sub- angular of sandstone, concrete, red and yellow brick. Boulders are angular to sub-angular of sandstone and concrete. Perched water ingress at 0.9 m bgl	
		0.60	ES		1.00				
					1.00				
							MADE GROUND comprising flat horizontal concrete slab. End of Trial Pit at 1.000m		

Dimensions		Trench Support and Comment			Pumping Data		
Pit Length 3.00	Pit Width 0.70	Pit Stability Unstable	Shoring Used None	Remarks Perched water at 0.90m bgl.	Date	Rate	Remarks

Remarks Low cohesion material subject to collapse							

Project Name: Quaker's Yard		Client: WWU		Date: 08/11/2022	
Location: Mill Street, Treharris		Contractor: Englobe			
Project No. : C1871		Crew Name: CD (Englobe)		Equipment: 8T 360 Excavator	
Location Number TP3	Location Type TP	Level	Logged By MS	Scale 1:25	Page Number Sheet 1 of 1

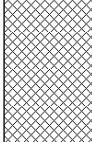
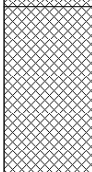
Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		0.70	ES					MADE GROUND comprising soft dark brownish-greyish friable silty sandy gravelly CLAY with cobbles and occasional boulders. Sand is fine to coarse; gravel is fine to coarse sub-angular to rounded of mixed lithologies; cobbles are angular to rounded of sandstone, concrete and occasional red brick; boulders are sub-angular to rounded of sandstone. Frequent tree roots and rootlets extend throughout the trial pit; infrequent inclusions of polythene and polyethelene debris, and one 32 mm redundant yellow MDPE pipe extending upwards and diagonally 1 m from base of trial pit.	1
		1.60	ES						
					2.00			End of Trial Pit at 2.000m	2
									3
									4
									5

Dimensions		Trench Support and Comment			Pumping Data		
Pit Length	Pit Width	Pit Stability	Shoring Used	Remarks	Date	Rate	Remarks
2.50	0.90	Unstable	None				

Remarks Low cohesion material subject to collapse							
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		Trial Pit Log							
Project Name: Quaker's Yard				Client: WWU				Date: 08/11/2022	
Location: Mill Street, Treharris				Contractor: Englobe					
Project No. : C1871				Crew Name: CD (Englobe)				Equipment: 8T 360 Excavator	
Location Number TP4		Location Type TP		Level		Logged By MS		Scale 1:25	Page Number Sheet 1 of 1
Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		2.60	ES		2.60			MADE GROUND comprising soft brown friable silty sandy gravelly CLAY with cobbles and occasional boulders. Sand is fine to coarse; gravel is fine to coarse sub-angular to rounded of mixed lithologies; cobbles are angular to sub-rounded of sandstone, concrete and frequent red brick; boulders are angular to sub-angular of sandstone and demolished red brick structure. Occasional rootlets extend from surface to 1.2 m within pit.	1
								End of Trial Pit at 2.600m	2
									3
									4
									5
Dimensions		Trench Support and Comment				Pumping Data			
Pit Length 2.00	Pit Width 0.90	Pit Stability Unstable	Shoring Used None	Remarks			Date	Rate	Remarks
Remarks Uncohesive material subject to collapse									

Project Name: Quaker's Yard		Client: WWU		Date: 09/11/2022	
Location: Mill Street, Treharris		Contractor: Englobe			
Project No. : C1871		Crew Name: CD (Englobe)		Equipment: 8T 360 Excavator	
Location Number TP5	Location Type TP	Level	Logged By MS	Scale 1:25	Page Number Sheet 1 of 1

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		1.30	ES		0.26			MADE GROUND comprising soft light greyish silty sandy gravelly CLAY. Sand is fine to coarse, gravel is fine to coarse angular to sub-angular of mixed lithologies; occasional fine rootlets throughout surface layer.	
					0.75			MADE GROUND comprising yellowish-brownish silty sandy gravelly CLAY with cobbles. Sand is fine to coarse; gravel is fine to coarse angular to sub-angular of mixed lithologies; cobbles are angular to sub-angular of sandstone and occasional chalk or solidified lime. Clay colour change to grey-dark grey 0.55 to 0.7 m bgl with accompanying mild phenolic odour.	
					1.30			MADE GROUND comprising firm black cohesive gravelly bituminous deposit with accompanying very strong phenolic / hydrocarbon odour. Gravel is fine to coarse angular to sub-angular of mixed lithologies bound into a bituminous aggregate. Material extended to 1.3 mbgl, terminating above a likely concrete horizontal slab. Lime deposit observed to SE end of trench, appearing at 1.2 m bgl; deposit was not chased to base. Chemical analysis sample obtained at 0.8 m bgl; 4 x stabilisation bench trial samples obtained 0.8 to 1.3 m bgl; PID headspace test: maximum 148 ppm. Water ingress into excavation at 1.2 m bgl.	1
					1.30			MADE GROUND comprising flat horizontal concrete slab.	2
End of Trial Pit at 1.300m									
									3
									4
									5

Dimensions		Trench Support and Comment			Pumping Data		
Pit Length	Pit Width	Pit Stability	Shoring Used	Remarks	Date	Rate	Remarks
3.50	1.00	Stable	None	Perched water at 1.20m bgl.			

Remarks							
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Advisian

WorleyParsons Group

HAND DUG PIT LOG

Exploratory
Hole No.
HP15-01

Sheet 1 of 1

Advisian, Bull Wharf, Redcliff Street, BS1 6QR, Telephone: 0117 925 1304, E-mail: info@advisian.com

Project Name: Quakers Yard WWU	Project No: 51810-01	Co-ords: E 309834 N 196678 Level: 100.21 m AOD	Date 02/12/2015
Location: Quakers Yard	Dimensions: m Depth 0.95 m E Orientation: ° degrees from North		Scale 1 : 8.02
Client: WWU			Logged By A SMITH
			Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
0.1		HP15-01-1 (ES)	0.40	PID 0 ppm		MADE GROUND: Vegetation over: Brown, slightly clayey, gravelly sand. Gravel is sub-rounded to sub-angular, fine to coarse mudstone, sandstone and limestone with rare slag/clinker. Rare fragment of red brick. Some minor rare white particles from 0.25 - 0.45. Rare cobbles.			
0.2									
0.3					(0.60)				
0.4									
0.5		HP15-01-2 (ES)	0.90	PID 0 ppm					
0.6					0.60	MADE GROUND: Dense, grey-brown, sandy gravel. Gravel is sub-angular to sub-rounded, fine to coarse limestone and mudstone with rare clinker.	99.61		
0.7					(0.20)				
0.8					0.80	MADE GROUND: Soft, grey-brown, sandy, gravelly clay. Sand is medium to fine grained. Gravel is sub-angular to sub-rounded, fine to coarse sandstone and limestone (reworked natural). Moderate hydrocarbon odour. Obstruction at 0.95 m bgl.	99.41		
0.9	1				(0.15)				
0.95					0.95	Hand dug pit terminated at 0.95m	99.26		
1.0									1
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination: Moderate hydrocarbon odour at 0.8 - 0.95 m bgl. Clinker.

General Notes: Perched water at 0.9 m bgl.



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HAND DUG PIT LOG

Exploratory
Hole No.
HP15-02

Sheet 1 of 1

Advisian, Bull Wharf, Redcliff Street, BS1 6QR, Telephone: 0117 925 1304, E-mail: info@advisian.com

Project Name: Quakers Yard WWU		Project No: 51810-01	Co-ords: E 309833 N 196686 Level: 101.12 m AOD	Date 02/12/2015
Location: Quakers Yard			Dimensions: m Depth 0.35 m E	Scale 1 : 8.02
Client: WWU			Orientation: ° degrees from North	Logged By A SMITH Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
0.1		HP15-02-1 (ES)	0.20	PID 0 ppm	(0.35)	MADE GROUND: Dark brown, sandy gravel. Gravel is sub-angular to sub-rounded, fine to coarse limestone and sandstone. Frequent boulders of sandstone. Wire mesh obstruction at 0.35 m bgl.	100.77		
0.2									
0.3					0.35	Hand dug pit terminated at 0.35m			
0.4									
0.5									
0.6									
0.7									
0.8									
0.9									
1.0									
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination: No visual or olfactory signs of contamination.



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HAND DUG PIT LOG

Exploratory
Hole No.
HP15-03

Sheet 1 of 1

Advisian, Bull Wharf, Redcliff Street, BS1 6QR, Telephone: 0117 925 1304, E-mail: info@advisian.com

Project Name: Quakers Yard WWU		Project No: 51810-01	Co-ords: E 309831 N 196689 Level: 101.65 m AOD	Date 02/12/2015
Location: Quakers Yard			Dimensions: m Depth 1.10 m E Orientation: ° degrees from North	Scale 1 : 8.02
Client: WWU			Logged By A SMITH	Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
0.1		HP15-03-1 (ES)	0.30	PID 0 ppm	(0.70)	MADE GROUND: Grey-brown, sandy, gravelly clay. Gravel is sub-angular to sub-rounded, fine to coarse sandstone and limestone. Rare coal and clinker. Rare red brick. Occasional cobble.			
0.2									
0.3									
0.4									
0.5		HP15-03-2 (ES)	1.00	PID 0 ppm	(0.40)	MADE GROUND: Brown, mottled black, sandy gravel. Gravel is sub-angular to angular, fine to medium clinker, red brick and sandstone. Red brick obstruction at 1.1 m bgl.	100.95		
0.6									
0.7									
0.8									
0.9						Hand dug pit terminated at 1.10m	100.55		
1.0									
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination: Clinker.

Surface and Subsurface Structures: Brick in West of pit from circa 0.3 - 1.1 m bgl.

HAND DUG PIT LOG: QUAKERS YARD LOGS.GPJ GINT STD AGS 3 - 1.GDT 20/1/16



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HAND DUG PIT LOG

Exploratory
Hole No.
HP15-04

Sheet 1 of 1

Advisian, Bull Wharf, Redcliff Street, BS1 6QR, Telephone: 0117 925 1304, E-mail: info@advisian.com

Project Name: Quakers Yard WWU		Project No: 51810-01	Co-ords: E 309804 N 196657 Level: 100.07 m AOD	Date 02/12/2015
Location: Quakers Yard			Dimensions: m Depth 0.25 m E	Scale 1 : 8.02
Client: WWU			Orientation: ° degrees from North	Logged By A SMITH Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
		Name (Type)	Depth (m)	Result					
0.1		HP15-04-1 (ES)	0.20	PID 0 ppm	(0.10)	MADE GROUND: Decomposing matter over: Dark brown-black, gravelly, silty sand. Gravel of angular to sub-rounded, fine to coarse flint, brick and coal.	99.97		
					0.10	MADE GROUND: Light brown to black, soft to firm, gravelly, sandy clay. Gravel of flint and layered coal.			
0.2					(0.15)				
					0.25	Hand dug pit terminated at 0.25m	99.82		
0.3									
0.4									
0.5									
0.6									
0.7									
0.8									
0.9									
1.0									
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination: No visual or olfactory signs of contamination.

**Advisian**

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HAND DUG PIT LOG

Exploratory
Hole No.
HP15-05

Sheet 1 of 1

Advisian, Bull Wharf, Redcliff Street, BS1 6QR, Telephone: 0117 925 1304, E-mail: info@advisian.com

Project Name: Quakers Yard WWU	Project No: 51810-01	Co-ords: E 309820 N 196650 Level: 98.90 m AOD	Date 02/12/2015
Location: Quakers Yard	Dimensions: m Depth 0.15 m E Orientation: ° degrees from North		Scale 1 : 8.02
Client: WWU			Logged By A SMITH Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
0.1		HP15-05-1 (ES)	0.10	PID 0 ppm	(0.15)	MADE GROUND: Decomposing matter over: Dark brown-black, soft to firm, gravelly, silty clay. Gravel of angular to rounded, fine to coarse clinker, coal and flint.	98.75		
0.2					0.15	Hand dug pit terminated at 0.15m			
0.3									
0.4									
0.5									
0.6									
0.7									
0.8									
0.9									
1.0									
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination: Clinker.



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HAND DUG PIT LOG

Exploratory
Hole No.
HP15-06

Sheet 1 of 1

Advisian, Bull Wharf, Redcliff Street, BS1 6QR, Telephone: 0117 925 1304, E-mail: info@advisian.com

Project Name: Quakers Yard WWU		Project No: 51810-01	Co-ords: E 309829 N 196666 Level: 99.54 m AOD	Date 02/12/2015
Location: Quakers Yard		Dimensions: m Depth 0.10 m E		Scale 1 : 8.02
Client: WWU		Orientation: ° degrees from North		Logged By A SMITH
				Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
		Name (Type)	Depth (m)	Result					
0.1		HP15-06-1 (ES)	0.05	PID 0 ppm	(0.10) 0.10	MADE GROUND: Decomposing organic matter over: Loose, dark brown to black, slightly sandy, silty gravel. Gravel of angular to rounded, fine to coarse coal. Concrete at 0.1 m bgl. Hand dug pit terminated at 0.10m	99.44		
0.2									
0.3									
0.4									
0.5									
0.6									
0.7									
0.8									
0.9									
1.0									
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination: No visual or olfactory signs of contamination.

Surface and Subsurface Structures: Concrete at 0.1 m bgl.

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WorleyParsons Group

HAND DUG PIT LOG

Exploratory
Hole No.
HP15-07

Sheet 1 of 1

Advisian, Bull Wharf, Redcliff Street, BS1 6QR, Telephone: 0117 925 1304, E-mail: info@advisian.com

Project Name: Quakers Yard WWU		Project No: 51810-01	Co-ords: E 309828 N 196675 Level: 100.06 m AOD	Date 02/12/2015
Location: Quakers Yard			Dimensions: m Depth 0.20 m E	Scale 1 : 8.02
Client: WWU			Orientation: ° degrees from North	Logged By A SMITH Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
		Name (Type)	Depth (m)	Result					
0.1		HP15-07-1 (ES)	0.15	PID 0 ppm	(0.20)	MADE GROUND: Decomposing organic matter over: Soft to firm, grey-dark brown, slightly sandy, gravelly, clayey silt. Cobbles until 0.1 m bgl. Gravel of angular to sub-rounded, fine to coarse flint, clinker and brick.	99.86		
0.2					0.20	Hand dug pit terminated at 0.20m			
0.3									
0.4									
0.5									
0.6									
0.7									
0.8									
0.9									
1.0									1
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination: Clinker.



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HAND DUG PIT LOG

Exploratory
Hole No.
HP15-08

Sheet 1 of 1

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Project Name: Quakers Yard WWU		Project No: 51810-01	Co-ords: E 309849 N 196685 Level: 100.60 m AOD	Date 02/12/2015
Location: Quakers Yard			Dimensions: m Depth 0.20 m E	Scale 1 : 8.02
Client: WWU			Orientation: ° degrees from North	Logged By A SMITH Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
		Name (Type)	Depth (m)	Result					
0.1		HP15-08-1 (ES)	0.10	PID 0 ppm	0.05	MADE GROUND: Vegetation and rootlets over:	100.55		
					(0.15)	MADE GROUND: Brown-black, slightly clayey, sandy gravel. Gravel is sub-angular to sub-rounded, fine to coarse limestone, sandstone, red brick and clinker. Rare boulder.			
0.2					0.20	Hand dug pit terminated at 0.20m	100.40		
0.3									
0.4									
0.5									
0.6									
0.7									
0.8									
0.9									
1.0									1
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination: Clinker.

General Notes: Perched water at 0.2 m bgl.

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HAND DUG PIT LOG

Exploratory
Hole No.
HP15-09

Sheet 1 of 1

Advisian, Bull Wharf, Redcliff Street, BS1 6QR, Telephone: 0117 925 1304, E-mail: info@advisian.com

Project Name: Quakers Yard WWU	Project No: 51810-01	Co-ords: E 309842 N 196693 Level: 100.61 m AOD	Date 02/12/2015
Location: Quakers Yard	Dimensions: m Depth 0.50 m E Orientation: ° degrees from North		Scale 1 : 8.02
Client: WWU			Logged By A SMITH
			Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
		Name (Type)	Depth (m)	Result					
0.1					(0.15)	MADE GROUND: Brown topsoil with rootlets.			
0.2					0.15	MADE GROUND: Brown-black, sandy and clayey gravel. Gravel is angular to sub-rounded, fine to coarse limestone and slate, some coal fragments. Slight hydrocarbon odour.	100.46		
0.3	1 ↓				(0.20)				
0.4		HP15-09-1 (ES)	0.35	PID 0.3 ppm	0.35	MADE GROUND: Concrete boulder.	100.26		
0.5		HP15-09-2 (ES)	0.50	PID 0.4 ppm	0.40	MADE GROUND: Grey-silver, sandy and clayey gravel. Gravel is angular to sub-rounded, fine to coarse limestone and slate, some coal fragments. Moderate hydrocarbon odour.	100.21		
0.6					(0.10)				
0.7					0.50	Hand dug pit terminated at 0.50m	100.11		
0.8									
0.9									
1.0									
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:**Summary of Visual and Olfactory Contamination:** 0.2 - 0.5 m bgl hydrocarbon odour. Grey sheen from 0.4 - 0.5 m bgl.**General Notes:** Perched water at 0.3 m bgl - end due to water.



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HAND DUG PIT LOG

Exploratory
Hole No.
HP15-10

Sheet 1 of 1

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Project Name: Quakers Yard WWU		Project No: 51810-01	Co-ords: E 309853 N 196685 Level: 100.62 m AOD	Date 02/12/2015
Location: Quakers Yard			Dimensions: m Depth 1.00 m E	Scale 1 : 8.02
Client: WWU			Orientation: ° degrees from North	Logged By A SMITH Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
		Name (Type)	Depth (m)	Result					
0.1					0.05	MADE GROUND: Vegetation over:	100.57		
0.2						MADE GROUND: Brown-black, slightly clayey, sandy gravel. Gravel is sub-angular to sub-rounded, fine to coarse limestone and sandstone with occasional brick, coal and clinker. Frquent boulders. Obstruction at 1.0 m bgl on firm layer comprising coal. Coal tar odour.			
0.3		HP15-10-1 (ES)	0.25	PID 0 ppm					
0.4									
0.5					(0.95)				
0.6									
0.7									
0.8									
0.9									
1.0		HP15-10-2 (ES)	1.00	PID 0.6 ppm	1.00	Hand dug pit terminated at 1.00m	99.62		1
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination: Coal tar odour at 1.0 m bgl. Clinker.



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HAND DUG PIT LOG

Exploratory
Hole No.
HP15-11

Sheet 1 of 1

Advisian, Bull Wharf, Redcliff Street, BS1 6QR, Telephone: 0117 925 1304, E-mail: info@advisian.com

Project Name: Quakers Yard WWU		Project No: 51810-01	Co-ords: E 309855 N 196689 Level: 100.69 m AOD	Date 02/12/2015
Location: Quakers Yard			Dimensions: m Depth 1.00 m E	Scale 1 : 8.02
Client: WWU			Orientation: ° degrees from North	Logged By A SMITH Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
0.1		HP15-11-1 (ES)	0.20	PID 0 ppm	(1.00)	MADE GROUND: Brown, slightly clayey, sandy gravel. Gravel is sub-angular to sub-rounded, fine to coarse sandstone and limestone, coal and clinker. Frequent rootlets. Obstruction at 1.0 m bgl.			
0.2									
0.3									
0.4									
0.5		HP15-11-2 (ES)	0.95	PID 0 ppm	1.00	Hand dug pit terminated at 1.00m	99.69		1
0.6									
0.7									
0.8									
0.9									
1.0									
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination: Clinker.

Surface and Subsurface Structures: Obstruction at 1.0 m bgl.

HAND DUG PIT LOG: QUAKERS YARD LOGS.GPJ GINT STD AGS 3 - 1.GDT 20/1/16



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HAND DUG PIT LOG

Exploratory
Hole No.
HP15-12

Sheet 1 of 1

Advisian, Bull Wharf, Redcliff Street, BS1 6QR, Telephone: 0117 925 1304, E-mail: info@advisian.com

Project Name: Quakers Yard WWU		Project No: 51810-01	Co-ords: E 309815 N 196670 Level: 100.11 m AOD	Date 02/12/2015
Location: Quakers Yard			Dimensions: m Depth 0.30 m E	Scale 1 : 8.02
Client: WWU			Orientation: ° degrees from North	Logged By A SMITH Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
0.1		HP15-12-1 (ES)	0.25	PID 0 ppm	(0.30)	MADE GROUND: Cobbles and organic matter over: Soft, dark brown-black, very gravelly, silty clay. Gravel of sub-angular to rounded, fine to coarse flint, coal, clinker and brick. Frequent cobbles up to 150 mm.	99.81		
0.2					0.30	Hand dug pit terminated at 0.30m			
0.3									
0.4									
0.5									
0.6									
0.7									
0.8									
0.9									
1.0									
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination: Clinker.

HAND DUG PIT LOG: QUAKERS YARD LOGS.GPJ GINT STD AGS 3 - 1.GDT 20/1/16



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HAND DUG PIT LOG

Exploratory
Hole No.
HP15-13

Sheet 1 of 1

Advisian, Bull Wharf, Redcliff Street, BS1 6QR, Telephone: 0117 925 1304, E-mail: info@advisian.com

Project Name: Quakers Yard WWU		Project No: 51810-01	Co-ords: E 309844 N 196675 Level: 99.91 m AOD	Date 02/12/2015
Location: Quakers Yard		Dimensions: m Depth 0.15 m E		Scale 1 : 8.02
Client: WWU		Orientation: ° degrees from North		Logged By A SMITH Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
		Name (Type)	Depth (m)	Result					
0.1		HP15-13-1 (ES)	0.10	PID 0 ppm	(0.15)	MADE GROUND: Moss and decomposing organic matter over: Soft dark brown-black, slightly sandy, gravelly, clayey silt. Gravel of sub-angular to sub-rounded, fine to coarse flint and coal. Very frequent rootlets.	99.76		
0.2					0.15	Hand dug pit terminated at 0.15m			
0.3									
0.4									
0.5									
0.6									
0.7									
0.8									
0.9									
1.0									
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination: No visual or olfactory signs of contamination.



Advisian

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HAND DUG PIT LOG

Exploratory
Hole No.
HP15-14

Sheet 1 of 1

Advisian, Bull Wharf, Redcliff Street, BS1 6QR, Telephone: 0117 925 1304, E-mail: info@advisian.com

Project Name: Quakers Yard WWU		Project No: 51810-01	Co-ords: E 309853 N 196704 Level: 101.31 m AOD	Date 02/12/2015
Location: Quakers Yard			Dimensions: m Depth 1.10 m E Orientation: ° degrees from North	Scale 1 : 8.02
Client: WWU			Logged By A SMITH	Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
0.1		HP15-14-1 (ES)	0.20	PID 0 ppm	(0.10)	MADE GROUND: Grass and topsoil over:	101.21		
0.2					0.10	MADE GROUND: Grey-brown, sandy gravel. Gravel is sub-angular to sub-rounded, fine to coarse sandstone and mudstone with rare clinker.			
0.3									
0.4									
0.5									
0.6									
0.7									
0.8									
0.9									
1.0					1.00	MADE GROUND: Grey stained, black peat / sandy clay. Minor phenolic/hydrocarbon odour.	100.31		1
1.1		HP15-14-2 (ES) HP15-14-3 (ES)	1.10	PID 0.2 ppm	1.10	Hand dug pit terminated at 1.10m	100.21		
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination: Phenolic/hydrocarbon odour at 1.0 m bgl. Clinker.

General Notes: Perched water from 1.0 m bgl.

**Advisian**

WorleyParsons Group

HAND DUG PIT LOG

Exploratory
Hole No.
HP15-15

Sheet 1 of 1

Advisian, Bull Wharf, Redcliff Street, BS1 6QR, Telephone: 0117 925 1304, E-mail: info@advisian.com

Project Name: Quakers Yard WWU		Project No: 51810-01	Co-ords: E 309843 N 196699 Level: 101.18 m AOD	Date 03/12/2015
Location: Quakers Yard			Dimensions: m Depth 0.15 m E	Scale 1 : 8.02
Client: WWU			Orientation: ° degrees from North	Logged By A SMITH
				Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
0.1		HP15-15-1 (ES)	0.10	PID 0 ppm	(0.15)	MADE GROUND: Decomposing organic matter over: Soft, dark brown , gravelly, clayey silt. Gravel of sub-angular to sub-rounded, fine to coarse flint, clinker and coal. Occasional cobble. Frquent rootlets.	101.03		
0.2					0.15	Hand dug pit terminated at 0.15m			
0.3									
0.4									
0.5									
0.6									
0.7									
0.8									
0.9									
1.0									
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination: No visual or olfactory signs of contamination.

**Advisian**

WorleyParsons Group

HAND DUG PIT LOG

Exploratory
Hole No.
HP15-16

Sheet 1 of 1

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Project Name: Quakers Yard WWU		Project No: 51810-01	Co-ords: E 309862 N 196697 Level: 101.11 m AOD	Date 03/12/2015
Location: Quakers Yard			Dimensions: m Depth 0.75 m E	Scale 1 : 8.02
Client: WWU			Orientation: ° degrees from North	Logged By A SMITH Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
0.1		HP15-16-1 (ES)	0.70	PID 0 ppm	0.05	MADE GROUND: Grass and moss over:	101.06		
					(0.10)	MADE GROUND: Tarmac in poor condition.			
0.2					0.15	MADE GROUND: Grey-black, sandy gravel. Gravel is sub-angular to sub-rounded, fine to coarse sandstone, mudstone and clinker. Occasional bricks and tarmac. Concrete hardstanding at 0.75 m blg.	100.96		
0.3									
0.4					(0.60)				
0.7					0.75	Hand dug pit terminated at 0.75m	100.36		
0.8									
0.9									
1.0									
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:**Summary of Visual and Olfactory Contamination:** Clinker.**Surface and Subsurface Structures:** Brick structure/frequent bricks at 0.4 m bgl. Concrete at 0.75 m bgl.

HAND DUG PIT LOG: QUAKERS YARD LOGS.GPJ GINT STD AGS 3 - 1.GDT 20/1/16



Advisian

WorleyParsons Group

HAND DUG PIT LOG

Exploratory
Hole No.
HP15-17

Sheet 1 of 1

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Project Name: Quakers Yard WWU		Project No: 51810-01	Co-ords: E 309866 N 196700 Level: 101.31 m AOD	Date 03/12/2015
Location: Quakers Yard			Dimensions: m Depth 1.20 m E	Scale 1 : 8.02
Client: WWU			Orientation: ° degrees from North	Logged By A SMITH Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
		Name (Type)	Depth (m)	Result					
0.1						MADE GROUND: Moss and grass over: Grey-brown, sandy gravel. Gravel is angular to sub-rounded, fine to coarse mudstone and sandstone. Some coal and clinker.			
0.2									
0.3		HP15-17-1 (ES)	0.30	PID 0 ppm					
0.4									
0.5									
0.6					(1.20)				
0.7									
0.8									
0.9									
1.0									
1.1									
1.2		HP15-17-2 (ES)	1.20	PID 0 ppm	1.20	Hand dug pit terminated at 1.20m	100.11		
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination: Clinker.

HAND DUG PIT LOG: QUAKERS YARD LOGS.GPJ GINT STD AGS 3.1.GDT 20/1/16

**Advisian**

WorleyParsons Group

HAND DUG PIT LOG

Exploratory
Hole No.
HP15-18

Sheet 1 of 1

Advisian, Bull Wharf, Redcliff Street, BS1 6QR, Telephone: 0117 925 1304, E-mail: info@advisian.com

Project Name: Quakers Yard WWU	Project No: 51810-01	Co-ords: E 309857 N 196709 Level: 101.54 m AOD	Date 03/12/2015
Location: Quakers Yard	Dimensions: m Depth 1.30 m E		Scale 1 : 8.02
Client: WWU	Orientation: ° degrees from North		Logged By A SMITH
			Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend (m)
		Name (Type)	Depth (m)	Result				
0.1						MADE GROUND: Brown, sandy gravel. Gravel is sub-angular to sub-rounded mudstone, sandstone and clinker.		
0.2								
0.3								
0.4		HP15-18-1 (ES)	0.40	PID 0 ppm				
0.5					(1.00)			
0.6								
0.7								
0.8								
0.9								
1.0					1.00	MADE GROUND: Grey-black, slightly gravelly, sandy clay. Fragment of metal. Hydrocarbon odour.	100.54	1
1.1					(0.30)			
1.2								
1.3		HP15-18-2 (ES) HP15-18-3 (ES)	1.30	PID 0.2 ppm	1.30	Hand dug pit terminated at 1.30m	100.24	
1.4								
1.5								

SHORING: N/A

STABILITY: OK

REMARKS:**Summary of Visual and Olfactory Contamination:** Hydrocarbon odour at 1.0 - 1.3 m bgl. Clinker.**General Notes:** Perched water at 1.3 m bgl.

HAND DUG PIT LOG: QUAKERS YARD LOGS.GPJ GINT STD AGS 3 - 1.GDT 20/1/16



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HAND DUG PIT LOG

Exploratory
Hole No.
HP15-19

Sheet 1 of 1

Advisian, Bull Wharf, Redcliff Street, BS1 6QR, Telephone: 0117 925 1304, E-mail: info@advisian.com

Project Name: Quakers Yard WWU		Project No: 51810-01	Co-ords: E 309864 N 196714 Level: 102.13 m AOD	Date 03/12/2015
Location: Quakers Yard			Dimensions: m Depth 1.20 m E	Scale 1 : 8.02
Client: WWU			Orientation: ° degrees from North	Logged By A SMITH Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
		Name (Type)	Depth (m)	Result					
0.1						MADE GROUND: Brown, sandy gravel. Gravel is sub-angular to sub-rounded, fine to coarse sandstone and mudstone. Rare fragments of coal and clinker. Occasional boulders. Obstruction at 1.2 m bgl.			
0.2									
0.3		HP15-19-1 (ES)	0.30	PID 0 ppm					
0.4									
0.5									
0.6					(1.20)				
0.7									
0.8									
0.9									
1.0									1
1.1									
1.2		HP15-19-2 (ES)	1.20	PID 0 ppm	1.20	Hand dug pit terminated at 1.20m	100.93		
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination: Clinker.

HAND DUG PIT LOG - QUAKERS YARD LOGS.GPJ GINT STD AGS 3 - 1.GDT 20/1/16

**Advisian**

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HAND DUG PIT LOG

Exploratory
Hole No.
HP15-20

Sheet 1 of 1

Advisian, Bull Wharf, Redcliff Street, BS1 6QR, Telephone: 0117 925 1304, E-mail: info@advisian.com

Project Name: Quakers Yard WWU		Project No: 51810-01	Co-ords: E 309874 N 196712 Level: 102.64 m AOD	Date 03/12/2015
Location: Quakers Yard			Dimensions: m Depth 0.75 m E	Scale 1 : 8.02
Client: WWU			Orientation: ° degrees from North	Logged By A SMITH Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
0.1		HP15-20-1 (ES)	0.20	PID 0 ppm	(0.40)	MADE GROUND: Moss and vegetation over: Loose, dark brown-black, slightly sandy, silty gravel. Gravel of angular to sub-rounded, fine to coarse flint and clinker. Frequent cobbles. Rare boulder.	102.24		
0.2									
0.3									
0.4		HP15-20-2 (ES)	0.75	PID 0 ppm	0.40	MADE GROUND: Loose, dark brown-black, slightly sandy, silty gravel. Gravel of angular to sub-rounded, fine to coarse brick, flint, coal and clinker. Frequent cobbles. Rare boulder.	101.89		
0.5					(0.35)				
0.6									
0.7									
0.8					0.75	Hand dug pit terminated at 0.75m			
0.9									
1.0									
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination: Clinker.

HAND DUG PIT LOG - QUAKERS YARD LOGS.GPJ GINT STD AGS 3 - 1.GDT 20/1/16

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WorleyParsons Group

HAND DUG PIT LOG

Exploratory
Hole No.
HP15-21

Sheet 1 of 1

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Project Name: Quakers Yard WWU		Project No: 51810-01	Co-ords: E N Level: m AOD	Date 03/12/2015
Location: Quakers Yard			Dimensions: m Depth 1.30 m E	Scale 1 : 8.02
Client: WWU			Orientation: ° degrees from North	Logged By A SMITH Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
		Name (Type)	Depth (m)	Result					
0.1						MADE GROUND: Decomposing organic matter over: Soft, slightly gravelly, slightly sandy, silty clay. Gravel of sub-angular to sub-rounded, fine to coarse coal and flint.			
0.2					(0.40)				
0.3									
0.4		HP15-21-1 (ES)	0.40	PID 0 ppm	0.40	Soft to firm, grey mottled orange and brown, slightly sandy CLAY. Sand is fine.			
0.5									
0.6									
0.7					(0.60)				
0.8									
0.9									
1.0					1.00	Soft to firm, grey mottled orange and brown, clayey SAND. Sand is fine to coarse.			1
1.1					(0.30)				
1.2									
1.3		HP15-21-2 (ES)	1.30	PID 0 ppm	1.30	Hand dug pit terminated at 1.30m			
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination: No visual or olfactory signs of contamination.

HAND DUG PIT LOG - QUAKERS YARD LOGS.GPJ GINT STD AGS 3 - 1.GDT 20/1/16



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HAND DUG PIT LOG

Exploratory
Hole No.
HP15-22

Sheet 1 of 1

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Project Name: Quakers Yard WWU		Project No: 51810-01	Co-ords: E 309794 N 196640 Level: 98.62 m AOD	Date 03/12/2015
Location: Quakers Yard			Dimensions: m Depth 0.80 m E	Scale 1 : 8.02
Client: WWU			Orientation: ° degrees from North	Logged By A SMITH Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
0.1		HP15-22-1 (ES)	0.15	PID 0 ppm	(0.50)	MADE GROUND: Decomposing organic matter over: Loose, dark grey-black, speckled white, sandy gravel. Gravel of angular to sub-rounded, fine to coarse mudstone, coal and concrete. Occasional rootlet. Occasional boulder.	98.12		
0.2									
0.3									
0.4									
0.5		HP15-22-2 (ES)	0.80	PID 0 ppm	0.80	MADE GROUND: Loose, dark grey-black, speckled white, sandy gravel with slight clay content. Gravel of angular to sub-rounded, fine to coarse mudstone, coal and concrete. Occasional rootlet. Occasional boulder.	98.12		
0.6									
0.7									
0.8									
0.8		HP15-22-2 (ES)	0.80	PID 0 ppm	0.80	MADE GROUND: Obstruction - likely base water perched on top.	97.87		
0.9									
1.0									
1.1									
1.2		HP15-22-2 (ES)	0.80	PID 0 ppm	0.80	Hand dug pit terminated at 0.80m	97.82		
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination: No visual or olfactory signs of contamination.



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WorleyParsons Group

HAND DUG PIT LOG

Exploratory
Hole No.
HP15-23

Sheet 1 of 1

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Project Name: Quakers Yard WWU		Project No: 51810-01	Co-ords: E 309786 N 196639 Level: 98.79 m AOD	Date 03/12/2015
Location: Quakers Yard			Dimensions: m Depth 0.55 m E	Scale 1 : 8.02
Client: WWU			Orientation: ° degrees from North	Logged By A SMITH Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
0.1		HP15-23-1 (ES)	0.20	PID 0 ppm	(0.40)	MADE GROUND: Decomposing organic matter over: Loose, dark brown, slightly sandy, silty gravel. Gravel of angular to sub-rounded, fine to coarse flint, coal and clinker. Occasional cobble. Occasional white particle.			
0.2									
0.3									
0.4		HP15-23-2 (ES)	0.55	PID 0 ppm	0.40	MADE GROUND: Loose, dark brown, slightly sandy, slightly clayey, silty gravel. Gravel of angular to sub-rounded, fine to coarse flint, coal, brick and clinker. Occasional cobble. Occasional white particle. Infrequent boulder. Concrete obstruction at 0.55 m bgl - probably base.	98.39		
0.5					(0.15)				
0.6					0.55	Hand dug pit terminated at 0.55m	98.24		
0.7									
0.8									
0.9									
1.0									
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination: Clinker.

Surface and Subsurface Structures: Concrete obstruction at 0.55 m bgl.



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HAND DUG PIT LOG

Exploratory
Hole No.
HP15-24

Sheet 1 of 1

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Project Name: Quakers Yard WWU		Project No: 51810-01	Co-ords: E N Level: m AOD	Date 04/12/2015
Location: Quakers Yard			Dimensions: m Depth 0.80 m E	Scale 1 : 8.02
Client: WWU			Orientation: ° degrees from North	Logged By A SMITH Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
		Name (Type)	Depth (m)	Result					
0.1						MADE GROUND: Boulders at surface.			
0.2					(0.40)				
0.3									
0.4					0.40	MADE GROUND: Metal pipe in North of pit (appears curved).			
0.5					0.45	MADE GROUND: Brown, sandy gravel. Gravel is sub-angular to sub-rounded, fine to coarse sandstone, mudstone. Frequent boulders. Obstruction at 0.8 m bgl.			
0.6	1 ▽				(0.35)				
0.7									
0.8					0.80	Hand dug pit terminated at 0.80m			
0.9									
1.0									1
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination: No visual or olfactory signs of contamination.

General Notes: Boulders on surface - removed by hand. Perched water at 0.6 m bgl.

Surface and Subsurface Structures: Metal pipe at 0.4 m bgl trending North East to South West approximately 150 mm diameter. Unknown obstruction at 0.8 m bgl.

HAND DUG PIT LOG: QUAKERS YARD LOGS.GPJ GINT STD AGS 3 - 1.GDT 20/1/16



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HAND DUG PIT LOG

Exploratory
Hole No.
HP15-25

Sheet 1 of 1

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Project Name: Quakers Yard WWU		Project No: 51810-01	Co-ords: E N Level: m AOD	Date 04/12/2015
Location: Quakers Yard			Dimensions: m Depth 0.80 m E	Scale 1 : 8.02
Client: WWU			Orientation: ° degrees from North	Logged By A SMITH Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
		Name (Type)	Depth (m)	Result					
0.1						MADE GROUND: Brambles and leaf litter over: Dark brown, sandy gravel. Gravel is angular to sub-rounded, fine to coarse sanstone, rare clinker/coal.			
0.2									
0.3					(0.60)				
0.4									
0.5									
0.6					0.60	Orange-brown, sightly clayey, slightly gravelly SAND.			
0.7					(0.20)				
0.8					0.80	Hand dug pit terminated at 0.80m			
0.9									
1.0									1
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination: Clinker.

General Notes: Perched water at 0.7 m bgl.

HAND DUG PIT LOG: QUAKERS YARD LOGS.GPJ GINT STD AGS 3 - 1.GDT 20/1/16



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HAND DUG PIT LOG

Exploratory
Hole No.
HP15-26

Sheet 1 of 1

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Project Name: Quakers Yard WWU		Project No: 51810-01	Co-ords: E N Level: m AOD	Date 04/12/2015
Location: Quakers Yard		Dimensions: m Depth 0.80 m E		Scale 1 : 8.02
Client: WWU		Orientation: ° degrees from North		Logged By A SMITH Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
		Name (Type)	Depth (m)	Result					
0.1						MADE GROUND: Brambles and leaf litter over: Dark brown, sandy gravel. Gravel is angular to sub-rounded, fine to coarse sanstone, rare clinker/coal.			
0.2									
0.3					(0.60)				
0.4									
0.5									
0.6					0.60	Orange-brown, sightly clayey, slightly gravelly SAND.			
0.7					(0.20)				
0.8					0.80	Hand dug pit terminated at 0.80m			
0.9									
1.0									1
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination: Clinker.

General Notes: Perched water at 0.7 m bgl.

HAND DUG PIT LOG: QUAKERS YARD LOGS.GPJ GINT STD AGS 3 - 1.GDT 20/1/16



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WorleyParsons Group

HAND DUG PIT LOG

Exploratory
Hole No.
HP15-27A

Sheet 1 of 1

Advisian, Bull Wharf, Redcliff Street, BS1 6QR, Telephone: 0117 925 1304, E-mail: info@advisian.com

Project Name: Quakers Yard WWU		Project No: 51810-01	Co-ords: E N Level: m AOD	Date 04/12/2015
Location: Quakers Yard		Dimensions: m Depth 0.40 m E		Scale 1 : 8.02
Client: WWU		Orientation: ° degrees from North		Logged By A SMITH Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
0.1					(0.30)	MADE GROUND: Decaying organic matter and brambles over: Brown-grey, sandy gravel. Gravel is sub-angular to sub-rounded, fine to coarse sandstone and mudstone with rare coal/clinker and red brick.			
0.2									
0.3					0.30	MADE GROUND: Metal pipe.			
0.4	1 ▽				(0.10) 0.40	Hand dug pit terminated at 0.40m			
0.5									
0.6									
0.7									
0.8									
0.9									
1.0									1
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination: Clinker.

General Notes: Perched water at 0.4 m bgl.

Surface and Subsurface Structures: At 0.3 m bgl black cast iron (metal) pipe trending approximately North to South. Diameter approximately 20 mm.

HAND DUG PIT LOG: QUAKERS YARD LOGS.GPJ GINT STD AGS 3 - 1.GDT 20/1/16



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HAND DUG PIT LOG

Exploratory
Hole No.
HP15-27B

Sheet 1 of 1

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Project Name: Quakers Yard WWU		Project No: 51810-01	Co-ords: E N Level: m AOD	Date 04/12/2015
Location: Quakers Yard		Dimensions: m Depth 0.40 m E		Scale 1 : 8.02
Client: WWU		Orientation: ° degrees from North		Logged By A SMITH Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
0.1		Name (Type)	Depth (m)	Result	(0.30)	MADE GROUND: Decaying organic matter and brambles over: Brown-grey, sandy gravel. Gravel is sub-angular to sub-rounded, fine to coarse sandstone and mudstone with rare coal/clinker and red brick.			
0.2					0.30	MADE GROUND: Metal pipe.			
0.3					(0.10)				
0.4					0.40	Hand dug pit terminated at 0.40m			
0.5									
0.6									
0.7									
0.8									
0.9									
1.0									
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination: Clinker.

General Notes: Perched water at 0.4 m bgl.

Surface and Subsurface Structures: At 0.3 m bgl black cast iron (metal) pipe trending approximately North to South. Diameter approximately 20 mm.



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HAND DUG PIT LOG

Exploratory
Hole No.
HP15-27C

Sheet 1 of 1

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Project Name: Quakers Yard WWU		Project No: 51810-01	Co-ords: E N Level: m AOD	Date 04/12/2015
Location: Quakers Yard		Dimensions: m Depth 0.40 m E		Scale 1 : 8.02
Client: WWU		Orientation: ° degrees from North		Logged By A SMITH Checked By NB

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
		Name (Type)	Depth (m)	Result					
0.1					(0.30)	MADE GROUND: Decaying organic matter and brambles over: Brown-grey, sandy gravel. Gravel is sub-angular to sub-rounded, fine to coarse sandstone and mudstone with rare coal/clinker and red brick.			
0.2									
0.3					0.30	MADE GROUND: Metal pipe.			
0.4	1 ▽				(0.10)				
0.4					0.40	Hand dug pit terminated at 0.40m			
0.5									
0.6									
0.7									
0.8									
0.9									
1.0									1
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination: Clinker.

General Notes: Perched water at 0.4 m bgl.

Surface and Subsurface Structures: At 0.3 m bgl black cast iron (metal) pipe trending approximately North to South. Diameter approximately 20 mm.



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WorleyParsons Group

BOREHOLE LOG

Exploratory Hole No.

MW16-01

Sheet 1 of 1

Advisian, Bull Wharf, Redcliff Street, BS1 6QR, Telephone: 0117 925 1304, E-mail: infoEurope@advisian.com

Project Name: Quakers Yard Wales & West Utilities		Project No: 51810-02	Co-ords: E 309846 N 196681	Hole Type
Location: Quakers Yard			Level: 100.40 m AOD	
Client: Wales & West Utilities			Dates: 01/07/2016 to: 14/07/2016	Scale 1 : 68.75
			Contractor: CCGI	Logged By AS Checked By TP

(m)	Samples & In Situ Testing				Water Levels	Legend	Depth (m bgl)	Elevation (m AOD)	Description	Install	(m)
	Depth (m bgl)	Type	Test Result	PID (ppmv)							
0.40	MW16-01-1		PID (ppmv) 0.0				0.10	100.30	MADE GROUND: Vegetation over:		0.20
							0.60	99.80	MADE GROUND: Dark brown-black, sandy gravel. Sand is medium grained. Gravel is sub-angular to angular sandstone and limestone. Occasional red brick. Occasional boulder of sandstone.		
							0.70	99.70	MADE GROUND: Tarmac hardstanding.		
							0.90	99.50	MADE GROUND: Solid layer of black bitumen type material with coal tar odour.		
							(1.00)		MADE GROUND: Brown stained black-grey, slightly clayey sand. Hydrocarbon odour.		
							1.90	98.50	Black SAND AND GRAVEL. Tar stained. Gross tar contamination from 3.0 - 3.5 m bgl.		2.00
							(1.60)				2.10
2.80	MW16-01-2		PID (ppmv) 116				3.50	96.90	Borehole completed at 3.50m		3.10

REMARKS:

Obstruction at 0.7 m bgl. Solid layer with coal tar odour (cored through).
Obstruction (boulder) at 3.5 m bgl. Collapse to 3.1 m bgl. Could not advance casing through.
From 0.9 - 1.9 m bgl black staining and hydrocarbon odour.
From 1.9 - 3.5 m bgl jet black staining with gross tar contamination.

Groundwater:

Date	Strike Depth (m)	Casing Depth (m)	Depth After Observation (m)
21/07/16	2.87		2.28

Hole and Install Details:

Drilling Method: Dynamic sampling and coring
Borehole Diameter: 128 mm
Screen Material: HDPE
Screen Diameter: 50 mm
Screen Slot Size: 0.75 mm
Sand Particle Size: 1 - 2 mm

Key:

m bgl: Metres below ground level
m AOD: Metres above ordnance datum
 Water Strike Level
 Water Rest Level



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BOREHOLE LOG

Exploratory Hole No.

MW16-02

Sheet 1 of 1

Advisian, Bull Wharf, Redcliff Street, BS1 6QR, Telephone: 0117 925 1304, E-mail: infoEurope@advisian.com

Project Name: Quakers Yard Wales & West Utilities	Project No: 51810-02	Co-ords: E 309837 N 196672	Hole Type
Location: Quakers Yard		Level: 99.86 m AOD	Scale 1 : 68.75
Client: Wales & West Utilities		Dates: 01/07/2016 to: 19/07/2016	Logged By AS
		Contractor: CCGI	Checked By TP

Samples & In Situ Testing				Water Levels	Legend	Depth (m bgl)	Elevation (m AOD)	Description	Install	(m)
Depth (m bgl)	Type	Test Result	PID (ppmv)							
0.30	MW16-02-1		PID (ppm) 0.0			0.05	99.81	MADE GROUND: Vegetation cover over:		0.20
						0.55	99.31	MADE GROUND: Brown, sandy gravel. Sand is medium to coarse grained. Gravel is sub-angular to sub-rounded, fine to coarse sandstone and limestone. Frequent boulders of sandstone. From 0.6 m bgl sulphurous odour.		
1.20	MW16-02-2		PID (ppm) 4.3			0.65	99.21			
						0.70	99.16	MADE GROUND: Concrete.		
						1.10	98.76			
						1.50	98.36	MADE GROUND: Black-brown, sandy gravel. Gravel is sub-angular to sub-rounded, fine to coarse sandstone and limestone.		
						(1.30)		Solid black layer with coal tar odour (clinker).		2.00
								Grey-black, slightly clayey SAND. Tar odour. Sand is medium.		2.10
								Grey-brown SAND. Sand is medium.		
2.60	MW16-02-3		PID (ppm) 0.6			2.80	97.06	Black stained, rounded BOULDERS of sandstone.		
						3.10	96.76	Borehole completed at 3.10m		3.10

REMARKS:

Concrete at 0.55 m bgl.
Obstruction at 0.7 m bgl with coal tar odour.
Refusal at 3.1 m bgl (suspected boulders).
Did not core through due to contamination above.
1.10 - 1.50 m bgl tar odour.
2.8 - 3.1 m bgl black stained boulders.

Groundwater:

Date	Strike Depth (m)	Casing Depth (m)	Depth After Observation (m)
19/07/16	1.55		1.93

Hole and Install Details:

Drilling Method: Dynamic sampling and coring
Borehole Diameter: 128 mm
Screen Material: HDPE
Screen Diameter: 50 mm
Screen Slot Size: 0.75 mm
Sand Particle Size: 1 - 2 mm

Key:

m bgl: Metres below ground level
m AOD: Metres above ordnance datum
 Water Strike Level
 Water Rest Level



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BOREHOLE LOG

Exploratory Hole No.

MW16-03

Sheet 1 of 1

Advisian, Bull Wharf, Redcliff Street, BS1 6QR, Telephone: 0117 925 1304, E-mail: infoEurope@advisian.com

Project Name: Quakers Yard Wales & West Utilities		Project No: 51810-02	Co-ords: E 309815 N 196646	Hole Type
Location: Quakers Yard			Level: 98.83 m AOD	
Client: Wales & West Utilities			Dates: 01/07/2016 to: 14/07/2016	Scale 1 : 68.75
			Contractor: CCGI	Logged By AS Checked By TP

Samples & In Situ Testing				Water Levels	Legend	Depth (m bgl)	Elevation (m AOD)	Description	Install	(m)
Depth (m bgl)	Type	Test Result	PID (ppmv)							
0.40	MW16-03-1		PID (ppmv) 0.0			0.05	98.78	MADE GROUND: Vegetation cover over:		0.20
						(1.15)		MADE GROUND: Brown, very sandy gravel. Gravel is rounded to sub-angular, fine to coarse sandstone and limestone.		
1.70	MW16-03-2		PID (ppmv) 4.1			1.20	97.63	Orange-brown, slightly gravelly SAND. Sand is fine to medium grained.		
						1.50	97.33	Grey sandstone boulder.		
						1.65	97.18	Orange-brown stained grey, sandy GRAVEL. Moderate hydrocarbon odour. Gravel of angular to sub-angular, fine to coarse sandstone.		
						2.05	96.78	Grey-off white SAND AND GRAVEL. No obvious odour. Gravel is angular to sub-angular, fine to coarse sandstone. Sand is coarse grained.		
						(0.95)		[Coring approximately 40% recovery] BOULDERS of sandstone and limestone.		2.90
4.00	MW16-03-3		PID (ppmv) 0.0			3.00	95.83			3.00
						(2.50)				4.50
						5.50	93.33	Borehole completed at 5.50m		

REMARKS:

Hand dug to 1.5 m bgl.
Coring from 3.0 m bgl.
Collapse to 5.0 m bgl.
Moderate hydrocarbon odour 1.65 - 2.05 m bgl.

Groundwater:

Date	Strike Depth (m)	Casing Depth (m)	Depth After Observation (m)
01/07/16	1.20		
21/07/16	1.32		
14/07/16	1.50		

Hole and Install Details:

Drilling Method: Dynamic sampling and coring
Borehole Diameter: 128 mm
Screen Material: HDPE
Screen Diameter: 50 mm
Screen Slot Size: 0.75 mm
Sand Particle Size: 1 - 2 mm

Key:

m bgl: Metres below ground level
m AOD: Metres above ordnance datum
 Water Strike Level
 Water Rest Level



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BOREHOLE LOG

Exploratory Hole No.

MW16-04

Sheet 1 of 1

Advisian, Bull Wharf, Redcliff Street, BS1 6QR, Telephone: 0117 925 1304, E-mail: infoEurope@advisian.com

Project Name: Quakers Yard Wales & West Utilities		Project No: 51810-02	Co-ords: E 309880 N 196722	Hole Type
Location: Quakers Yard			Level: 103.05 m AOD	
Client: Wales & West Utilities			Dates: 11/07/2016 to 11/07/2016	Scale 1 : 68.75
			Contractor: CCGI	Logged By AS Checked By TP

(m)	Samples & In Situ Testing				Water Levels	Legend	Depth (m bgl)	Elevation (m AOD)	Description	Install	(m)
	Depth (m bgl)	Type	Test Result	PID (ppmv)							
	0.50	MW16-04-1		PID (ppm) 0.0			0.05	103.00	MADE GROUND: Grass over:		0.20
							(1.15)		MADE GROUND: Brown, sandy gravel. Gravel is sub-rounded to sub-angular, fine to coarse sandstone. Frequent cobbles.		
1							1.20	101.85	MADE GROUND: Grey-black ash layer with minor hydrocarbon odour.		
	1.70	MW16-04-2		PID (ppm) 0.0	1		1.60	101.45	Brown, slightly clayey SAND. Sand is medium to coarse grained.		
2							2.00	101.05	Soft, orange-brown, sandy CLAY. Sand is fine grained.		
							(0.60)				
							2.60	100.45	Grey, slightly gravelly SAND. Sand is fine to medium grained. Gravel of angular to sub-angular, fine to coarse sandstone.		2.40
3							(1.40)				2.50
	3.50	MW16-04-3 MW16-04-4		PID (ppm) 0.0	2		4.00	99.05	Borehole completed at 4.00m		4.00
4											
5											
6											
7											
8											
9											
10											
11											

REMARKS:

1.2 - 1.6 m bgl minor hydrocarbon odour.

Groundwater:

Date	Strike Depth (m)	Casing Depth (m)	Depth After Observation (m)
11/07/16	1.70		
21/07/16	3.84		

Hole and Install Details:

Drilling Method: Dynamic sampling and coring
Borehole Diameter: 128 mm
Screen Material: HDPE
Screen Diameter: 50 mm
Screen Slot Size: 0.75 mm
Sand Particle Size: 1 - 2 mm

Key:

m bgl: Metres below ground level
m AOD: Metres above ordnance datum
↓ Water Strike Level
↓ Water Rest Level



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BOREHOLE LOG

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Exploratory Hole No.

MW16-05

Sheet 1 of 1

Project Name: Quakers Yard Wales & West Utilities	Project No: 51810-02	Co-ords: E 309862 N 196712	Hole Type
Location: Quakers Yard	Level: 101.76 m AOD	Dates: 11/07/2016 to 11/07/2016	Scale 1 : 68.75
Client: Wales & West Utilities	Contractor: CCGI	Logged By AS	Checked By TP

Samples & In Situ Testing				Water Levels	Legend	Depth (m bgl)	Elevation (m AOD)	Description	Install	(m)
Depth (m bgl)	Type	Test Result	PID (ppmv)							
0.15						0.15	101.61	MADE GROUND: Brown, sandy topsoil with frequent rootlets.		0.20
(0.60)						0.75	101.01	MADE GROUND: Orange-brown, sandy gravel (Type 1). Scraps of metal and tarmac from 0.4 m bgl. Occasional whole brick. Frequent off-cuts of metal pipe.		
0.80						0.80	100.96	MADE GROUND: Tarmac.		
1.10						1.10	100.66	MADE GROUND: Orange-pink, slightly gravelly sand.		
						1.60	100.16	MADE GROUND: Black 'tarmac' with strong coal tar odour.		
						1.80	99.96	MADE GROUND: Grey stained black, sandy gravel. Gravel is subangular, fine to coarse sandstone. Slight phenolic odour.		
						(0.95)		MADE GROUND: Black stained, slightly clayey, gravelly sand. Strong phenolic odour. Sand is fine to medium. Gravel of angular to sub-angular, fine to coarse sandstone.		2.20
2.80	MW16-05-1		PID (ppm) 0.0			2.75	99.01	MADE GROUND: Grey stained black, sandy gravel with frequent fragments of wood. Hydrocarbon odour. Sand is fine to medium. Gravel of angular to sub-angular, fine to coarse sandstone.		2.30
						(0.85)				
3.70	MW16-05-2		PID (ppm) 0.1			3.60	98.16	MADE GROUND: Black, sandy gravel with strong tar odour. Refusal at 3.8 m bgl (on suspected base). Sand is fine to medium. Gravel of angular to sub-angular, fine to coarse sandstone.		3.80
						3.80	97.96	Borehole completed at 3.80m		

REMARKS:

Water strike not determined - casing used.
 1.10 - 1.60 m bgl strong coal tar odour.
 1.6 - 1.8 m bgl slight phenolic odour.
 1.80 - 2.75 m bgl strong phenolic odour.
 2.75 - 3.6 m bgl black staining with hydrocarbon odour.
 3.6 - 3.8 m bgl black staining with strong tar odour.
 Terminated at 3.8 m bgl on suspected base.

Groundwater:

Date	Strike Depth (m)	Casing Depth (m)	Depth After Observation (m)
21/07/16	3.22		

Hole and Install Details:

Drilling Method: Dynamic sampling and coring
 Borehole Diameter: 128 mm
 Screen Material: HDPE
 Screen Diameter: 50 mm
 Screen Slot Size: 0.75 mm
 Sand Particle Size: 1 - 2 mm

Key:

m bgl: Metres below ground level
 m AOD: Metres above ordnance datum
 Water Strike Level
 Water Rest Level



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BOREHOLE LOG

Exploratory Hole No.

MW16-06

Sheet 1 of 1

Advisian, Bull Wharf, Redcliff Street, BS1 6QR, Telephone: 0117 925 1304, E-mail: infoEurope@advisian.com

Project Name: Quakers Yard Wales & West Utilities		Project No: 51810-02	Co-ords: E 309861 N 196701	Hole Type
Location: Quakers Yard			Level: 101.70 m AOD	
Client: Wales & West Utilities			Dates: 12/07/2016 to: 12/07/2016	Scale 1 : 68.75
			Contractor: CCGI	Logged By AS Checked By TP

Samples & In Situ Testing				Water Levels	Legend	Depth (m bgl)	Elevation (m AOD)	Description	Install	(m)
Depth (m bgl)	Type	Test Result	PID (ppmv)							
						(1.10)		MADE GROUND: Grey-brown, sandy gravel. Gravel is sub-rounded to sub-angular, fine to coarse sandstone, limestone, concrete and red brick fragments. Frequent cobbles.		0.20
1						1.10	100.60	MADE GROUND: Red brick foundations.		
						1.25	100.45	MADE GROUND: Black gravel of clinker and ash.		
						1.50	100.20	MADE GROUND: Brown-grey, sandy gravel. Gravel is sub-angular to sub-rounded, fine to coarse clinker.		
						1.60	100.10	MADE GROUND: Red brick.		
						1.80	99.90	MADE GROUND: Yellow brick.		
						2.20	99.50	MADE GROUND: Grey stained black, sandy gravel. Hydrocarbon odour. Gravel of angular to sub-angular, fine to coarse sandstone.		
2.50	MW16-06-1		PID (ppm) 0.0			2.60	99.10	Weak, grey stained orange, laminated MUDSTONE. Moderate hydrocarbon odour.		2.70
						2.80	98.90	Grey-brown, slightly sandy GRAVEL. Gravel is angular to sub-angular, fine to coarse sandstone. Occasional boulders.		2.80
3.00	MW16-06-2		PID (ppm) 0.0			(0.90)		Grey, medium grained SANDSTONE.		3.50
						3.70	98.00			
						(0.70)				
						4.40	97.30	Borehole completed at 4.40m		4.40

REMARKS:

Hand dug to 1.1 m bgl.
1.25 - 1.50 m bgl clinker and ash.
2.20 - 2.60 m bgl grey/black staining with hydrocarbon odour.
2.60 - 2.80 m bgl grey/black staining with moderate hydrocarbon odour.
Cored through boulders from 3.2 m bgl.
Collapse to 3.5 m bgl.
Bentonite used 3.5 to 4.4 m bgl

Groundwater:

Date	Strike Depth (m)	Casing Depth (m)	Depth After Observation (m)
21/07/16	3.02		
12/07/16	3.10		

Hole and Install Details:

Drilling Method: Dynamic sampling and coring
Borehole Diameter: 128 mm
Screen Material: HDPE
Screen Diameter: 50 mm
Screen Slot Size: 0.75 mm
Sand Particle Size: 1 - 2 mm

Key:

m bgl: Metres below ground level
m AOD: Metres above ordnance datum
 Water Strike Level
 Water Rest Level

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WorleyParsons Group

BOREHOLE LOG

Exploratory Hole
No.**MW16-07**

Sheet 1 of 1

Advisian, Bull Wharf, Redcliff Street, BS1 6QR, Telephone: 0117 925 1304, E-mail: infoEurope@advisian.com

Project Name: Quakers Yard Wales & West Utilities		Project No: 51810-02	Co-ords: E 309866 N 196716	Hole Type
Location: Quakers Yard			Level: m AOD	
Client: Wales & West Utilities			Dates: 12/07/2016 to 12/07/2016	Scale 1 : 68.75
			Contractor: CCGI	Logged By AS
				Checked By TP

(m)	Samples & In Situ Testing				Water Levels	Legend	Depth (m bgl)	Elevation (m AOD)	Description	Install	(m)
	Depth (m bgl)	Type	Test Result	PID (ppmv)							
1							0.50		MADE GROUND: Vegetation and moss over: Brown sandy gravel. Gravel is sub-angular to sub-rounded, fine to coarse sandstone, concrete, tarmac and red brick. Fragments of plastic sheeting. Rootlets.		
							(1.00)		MADE GROUND: Orange-brown, sandy gravel. Gravel is subangular, fine to medium sandstone, limestone, concrete, with occasional patches of tarmac waste. Whole red bricks at 1.4 m bgl (loose).		
							1.50		MADE GROUND: Yellow brick fragments and red brick fragments.		
2							2.00		MADE GROUND: Brown, sandy gravel. Gravel is rounded to sub-angular, fine to coarse sandstone. Frequent cobbles from 2.6 m bgl. No visual or olfactory signs of contamination (NVOSC).		
	2.20	MW16-07-1		PID (ppm) 0.0			(1.70)				
	3.50	MW16-07-2		PID (ppm) 0.0			3.70		Borehole completed at 3.70m		
4											
5											
6											
7											
8											
9											
10											
11											

REMARKS:Refusal at 2.5 m bgl.
Cored to 3.7 m bgl.
No install - backfilled.**Groundwater:**

Date Strike Depth (m) Casing Depth (m) Depth After Observation (m)

Hole and Install Details:Drilling Method: Dynamic sampling and coring
Borehole Diameter: 128 mm
Screen Material: HDPE
Screen Diameter: 50 mm
Screen Slot Size: 0.75 mm
Sand Particle Size: 1 - 2 mm**Key:**m bgl: Metres below ground level
m AOD: Metres above ordnance datum
↓ Water Strike Level
↓ Water Rest Level



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BOREHOLE LOG

Exploratory Hole No.

MW16-08

Sheet 1 of 1

Advisian, Bull Wharf, Redcliff Street, BS1 6QR, Telephone: 0117 925 1304, E-mail: infoEurope@advisian.com

Project Name: Quakers Yard Wales & West Utilities		Project No: 51810-02	Co-ords: E 309849 N 196697	Hole Type
Location: Quakers Yard			Level: 100.95 m AOD	
Client: Wales & West Utilities			Dates: 13/07/2016 to 13/07/2016	Scale 1 : 68.75
			Contractor: CCGI	Logged By AS Checked By TP

(m)	Samples & In Situ Testing				Water Levels	Legend	Depth (m bgl)	Elevation (m AOD)	Description	Install	(m)
	Depth (m bgl)	Type	Test Result	PID (ppmv)							
0.40	MW16-08-1		PID (ppm) 0.3				0.10	100.85	MADE GROUND: Black topsoil type material with slight hydrocarbon odour.		0.20
1.80	MW16-08-2		PID (ppm) 1.8				1.70	99.25	MADE GROUND: Brown, sandy gravel. Gravel is sub-rounded to sub-angular, fine to coarse sandstone, limestone. Frequent rounded boulders of sandstone.		
3.00	MW16-08-3		PID (ppm) 0.0				2.10	98.85	MADE GROUND: Black, medium grained, slightly gravelly sand with strong hydrocarbon odour.		2.10
	MW16-08-4						(1.10)		Orange-brown, sandy GRAVEL. Slight hydrocarbon odour. Gravel of angular to sub-angular, fine to coarse sandstone. Sand is fine to medium.		2.20
							3.20	97.75	Borehole completed at 3.20m		3.20

REMARKS:

Hand dug to 1.5 m bgl.
0.0 - 0.1 m bgl slight hydrocarbon odour.
1.7 - 2.1 m bgl black staining and strong hydrocarbon odour.
2.1 - 3.2 m bgl slight hydrocarbon odour.

Groundwater:

Date	Strike Depth (m)	Casing Depth (m)	Depth After Observation (m)
21/07/16	2.31		

Hole and Install Details:

Drilling Method: Dynamic sampling and coring
Borehole Diameter: 128 mm
Screen Material: HDPE
Screen Diameter: 50 mm
Screen Slot Size: 0.75 mm
Sand Particle Size: 1 - 2 mm

Key:

m bgl: Metres below ground level
m AOD: Metres above ordnance datum
 Water Strike Level
 Water Rest Level



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BOREHOLE LOG

Exploratory Hole No.

MW16-09

Sheet 1 of 1

Advisian, Bull Wharf, Redcliff Street, BS1 6QR, Telephone: 0117 925 1304, E-mail: infoEurope@advisian.com

Project Name: Quakers Yard Wales & West Utilities		Project No: 51810-02	Co-ords: E 309854 N 196690	Hole Type
Location: Quakers Yard			Level: 100.91 m AOD	
Client: Wales & West Utilities			Dates: 13/07/2016 to 13/07/2016	Scale 1 : 68.75
			Contractor: CCGI	
				Logged By AS
				Checked By TP

Samples & In Situ Testing					Water Levels	Legend	Depth (m bgl)	Elevation (m AOD)	Description	Install	(m)
Depth (m bgl)	Type	Test Result	PID (ppmv)								
0.10							0.10	100.81	MADE GROUND: Vegetation cover, rootlets and topsoil type material over:		0.20
(1.10)							(1.10)		MADE GROUND: Brown-black, sandy gravel. Gravel is sub-rounded to sub-angular, fine to coarse sandstone, limestone, concrete and red brick.		
1.20							1.20	99.71			
1.40							1.40	99.51	MADE GROUND: Firm layer, black with coal tar odour.		
(0.90)							(0.90)		MADE GROUND: Black-brown, sandy gravel. Gravel is sub-angular to sub-rounded, fine to coarse sandstone and red brick. Occasionally gravel appears 'rusty brown'.		
2.30							2.30	98.61	MADE GROUND: Crushed red brick with fragments of clinker.		2.10
2.60							2.60	98.31			2.20
2.80							2.80	98.11	MADE GROUND: Grey stained black, sandy clay with slight hydrocarbon odour. Sand is fine to medium.		
(0.60)							(0.60)		MADE GROUND: Saturated grey, slightly clayey sand and gravel with slight hydrocarbon odour. Sand is fine to medium. Gravel of angular to sub-angular, fine to coarse sandstone.		3.20
3.40							3.40	97.51			
3.80							3.80	97.11	Grey, sandy gravel. Gravel is sub-rounded to sub-angular, fine to coarse sandstone and limestone.		3.80
									Borehole completed at 3.80m		

REMARKS:

Refusal at 3.8 m bgl.
Collapse to 3.2 m bgl.
1.2 - 1.4 m bgl coal tar odour.
2.6 - 3.4 m bgl slight hydrocarbon odour.
(Potential base.)

Groundwater:

Date	Strike Depth (m)	Casing Depth (m)	Depth After Observation (m)
21/07/16	2.35		2.36

Hole and Install Details:

Drilling Method: Dynamic sampling and coring
Borehole Diameter: 128 mm
Screen Material: HDPE
Screen Diameter: 50 mm
Screen Slot Size: 0.75 mm
Sand Particle Size: 1 - 2 mm

Key:

m bgl: Metres below ground level
m AOD: Metres above ordnance datum
 Water Strike Level
 Water Rest Level

**Advisian**

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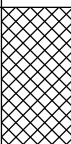
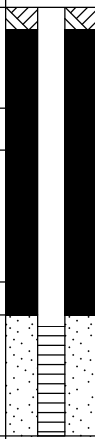
BOREHOLE LOG

Exploratory Hole
No.**MW16-10**

Sheet 1 of 1

Advisian, Bull Wharf, Redcliff Street, BS1 6QR, Telephone: 0117 925 1304, E-mail: infoEurope@advisian.com

Project Name: Quakers Yard Wales & West Utilities		Project No: 51810-02	Co-ords: E 309791 N 196637	Hole Type
Location: Quakers Yard			Level: 98.74 m AOD	
Client: Wales & West Utilities			Dates: 18/07/2016 to 18/07/2016	Scale 1 : 68.75
			Contractor: CCGI	Logged By AS
				Checked By TP

(m)	Samples & In Situ Testing				Water Levels	Legend	Depth (m bgl)	Elevation (m AOD)	Description	Install	(m)
	Depth (m bgl)	Type	Test Result	PID (ppmv)							
	0.50	MW16-10-1		PID (ppm) 0.4			(0.92)		MADE GROUND: Topsoil type material over: Brown sandy gravel. Gravel is sub-rounded to sub-angular, fine to coarse sandstone, limestone and red brick. Frequent demolition boulders. Piece of yellow PE scrap pipe.		0.20
-1							0.92	97.82	MADE GROUND: Flat concrete.		
	1.70	MW16-10-2		PID (ppm) 21.0			1.30	97.44	Grey-brown, sandy GRAVEL. Gravel is sub-angular, fine to coarse sandstone. Sand is medium grained. Slight hydrocarbon odour.		
-2							(1.20)				
	2.70	MW16-10-3 MW16-10-4		PID (ppm) 0.0		2.50	96.24	Orange-brown, slightly sandy GRAVEL. Sand is fine to medium grained. Gravel is sub-rounded to sub-angular, fine to coarse sandstone. Slight hydrocarbon odour ('sweet' petrol odour).		2.80	
-3						2.80	95.94				Brown COBBLES of sandstone and limestone. Sandstone cobbles appear fine to medium grained. NVOSC.
							(1.10)				
-4							3.90	94.84	Borehole completed at 3.90m		3.90
-5											
-6											
-7											
-8											
-9											
-10											
-11											

REMARKS:

Holder base (concrete) at 0.92 m bgl.
Cored through base.
1.3 - 2.5 m bgl slight hydrocarbon odour.
2.5 - 2.8 m bgl slight hydrocarbon odour ("sweet petrol odour").

Groundwater:

Date	Strike Depth (m)	Casing Depth (m)	Depth After Observation (m)
21/07/16	1.40		

Hole and Install Details:

Drilling Method: Dynamic sampling and coring
Borehole Diameter: 128 mm
Screen Material: HDPE
Screen Diameter: 50 mm
Screen Slot Size: 0.75 mm
Sand Particle Size: 1 - 2 mm

Key:

m bgl: Metres below ground level
m AOD: Metres above ordnance datum
 Water Strike Level
 Water Rest Level



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BOREHOLE LOG

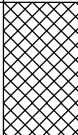
Exploratory Hole No.

MW16-10A

Sheet 1 of 1

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Project Name: Quakers Yard Wales & West Utilities		Project No: 51810-02	Co-ords: E 309786 N 196633	Hole Type
Location: Quakers Yard		Level: m AOD		Scale 1 : 68.75
Client: Wales & West Utilities		Dates: 18/07/2016 to 18/07/2016		
		Contractor: CCGI		Logged By AS
				Checked By TP

(m)	Samples & In Situ Testing				Water Levels	Legend	Depth (m bgl)	Elevation (m AOD)	Description	Install	(m)
	Depth (m bgl)	Type	Test Result	PID (ppmv)							
1							(0.92) 0.92 1.22		MADE GROUND: Topsoil type material over: Brown sandy gravel. Gravel is sub-rounded to sub-angular, fine to coarse sandstone, limestone and red brick. Frequent domolition boulders. Piece of yellow PE scrap pipe. MADE GROUND: Flat concrete. Borehole completed at 1.22m		1.22
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											

REMARKS:

Cored concrete.
Backfilled with bentonite.

Groundwater:

Date	Strike Depth (m)	Casing Depth (m)	Depth After Observation (m)
------	------------------	------------------	-----------------------------

Hole and Install Details:

Drilling Method: Dynamic sampling and coring
Borehole Diameter: 128 mm
Screen Material: HDPE
Screen Diameter: 50 mm
Screen Slot Size: 0.75 mm
Sand Particle Size: 1 - 2 mm

Key:

m bgl: Metres below ground level
m AOD: Metres above ordanace datum
 Water Strike Level
 Water Rest Level



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BOREHOLE LOG

Exploratory Hole No.

MW16-11

Sheet 1 of 1

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Project Name: Quakers Yard Wales & West Utilities		Project No: 51810-02	Co-ords: E 309785 N 196630	Hole Type
Location: Quakers Yard			Level: 98.63 m AOD	
Client: Wales & West Utilities			Dates: 18/07/2016 to: 18/07/2016	Scale 1 : 68.75
			Contractor: CCGI	Logged By AS
				Checked By TP

(m)	Samples & In Situ Testing				Water Levels	Legend	Depth (m bgl)	Elevation (m AOD)	Description	Install	(m)
	Depth (m bgl)	Type	Test Result	PID (ppmv)							
0.50	MW16-11-1		PID (ppm) 0.0				(1.20)		MADE GROUND: Topsoil type material with rootlets over: Brown, sandy gravel with frequent boulders. Gravel is sub-rounded to sub-angular, fine to coarse, concrete and sandstone. Rare red brick fragments.		0.20
1.20							1.20	97.43	Orange-brown, slightly gravelly SAND. Sand is fine to medium. Gravel of angular to sub-angular, fine to coarse sandstone.		
1.60							1.60	97.03	Orange-brown, sandy GRAVEL. Sand is medium grained. Gravel is sub-rounded to sub-angular, fine to coarse sandstone. Occasional cobbles. Hydrocarbon odour from 2.2 m bgl.		
2.40	MW16-11-2		PID (ppm) 21.6				2.50	96.13	Grey-brown COBBLES of medium grained sandstone. Slight hydrocarbon odour.		2.50
3.50	MW16-11-3		PID (ppm) 0.0				(1.10)				2.60
3.60							3.60	95.03	Borehole completed at 3.60m		3.60

REMARKS:

Hand dug to 1.3 m bgl.
2.2 - 3.6 m bgl hydrocarbon 'petrol' odour on water strike.
Cored cobbles from 2.5 m bgl.

Groundwater:

Date	Strike Depth (m)	Casing Depth (m)	Depth After Observation (m)
21/07/16	1.54		1.50

Hole and Install Details:

Drilling Method: Dynamic sampling and coring
Borehole Diameter: 128 mm
Screen Material: HDPE
Screen Diameter: 50 mm
Screen Slot Size: 0.75 mm
Sand Particle Size: 1 - 2 mm

Key:

m bgl: Metres below ground level
m AOD: Metres above ordnance datum
 Water Strike Level
 Water Rest Level



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BOREHOLE LOG

Exploratory Hole No.

MW16-12

Sheet 1 of 1

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Project Name: Quakers Yard Wales & West Utilities	Project No: 51810-02	Co-ords: E 309829 N 196665	Hole Type
Location: Quakers Yard		Level: 99.59 m AOD	Scale 1 : 68.75
Client: Wales & West Utilities		Dates: 19/07/2016 to: 19/07/2016	Logged By AS
		Contractor: CCGI	Checked By TP

Samples & In Situ Testing					Water Levels	Legend	Depth (m bgl)	Elevation (m AOD)	Description	Install	(m)
Depth (m bgl)	Type	Test Result	PID (ppmv)								
0.05							0.05	99.54	MADE GROUND: Vegetation cover over:		
0.15							0.15	99.44	MADE GROUND: Concrete hardstanding.		
(0.65)									MADE GROUND: Brown, sandy gravel. Gravel is sub-angular to sub-rounded, fine to coarse limestone, sandstone. Frequent demolition rubble (concrete and whole bricks).		
0.80							0.80	98.79	Orange-brown, slightly gravelly SAND. Sand is fine to medium. Gravel of angular to sub-angular, fine to coarse sandstone.		
(1.00)											
1.80							1.80	97.79	Firm, brown, slightly gravelly, sandy CLAY. Sand is fine to medium grained. Moderate phenolic/hydrocarbon odour.		
2.30							2.30	97.29	Grey stained black, sandy GRAVEL. Gravel is angular to sub-angular, fine to coarse sandstone. Sand is medium to coarse grained. Slight phenolic/hydrocarbon odour. Frequent cobbles.		
(0.70)											
3.00	MW16-12-1		PID (ppm) 1.6				3.00	96.59	Grey, occasionally orange-brown sandstone COBBLES [poor recovery approximately 40%.]		
7.25	MW16-12-2 MW16-12-3		PID (ppm) 0.0								
(5.50)											
8.50							8.50	91.09	Grey weathered brown, fine grained SANDSTONE. More competent from 8.7 m bgl. Sandstone is heavily fractured.		
(1.50)											
10.00							10.00	89.59	Borehole completed at 10.00m		

REMARKS:

Drilled in former trial pit.
Geotechnical tests conducted (SPTs).
1.8 - 2.3 m bgl moderate phenolic/hydrocarbon odour.
2.3 - 3.0 m bgl slight phenolic/hydrocarbon odour.
Cored from 3.0 m bgl in cobbles. Bedrock at 8.5 m bgl.

Groundwater:

Date Strike Depth (m) Casing Depth (m) Depth After Observation (m)

Hole and Install Details:

Drilling Method: Dynamic sampling and coring
Borehole Diameter: 128 mm
Screen Material: HDPE
Screen Diameter: 50 mm
Screen Slot Size: 0.75 mm
Sand Particle Size: 1 - 2 mm

Key:

m bgl: Metres below ground level
m AOD: Metres above ordnance datum
↓ Water Strike Level
↓ Water Rest Level



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BOREHOLE LOG

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Exploratory Hole No.

MW16-13

Sheet 1 of 1

Project Name: **Quakers Yard Wales & West Utilities**

Project No:
51810-02

Co-ords: E 309862 N 196706

Hole Type

Location: **Quakers Yard**

Level: 102.06 m AOD

Scale
1 : 68.75

Client: **Wales & West Utilities**

Dates: 21/07/2016 to: 21/07/2016

Contractor: CCGI

Logged By
CV

Checked By
TP

Samples & In Situ Testing					Water Levels	Legend	Depth (m bgl)	Elevation (m AOD)	Description	Install	(m)
Depth (m bgl)	Type	Test Result	PID (ppmv)								
0.50	MW16-13-1		PID (ppm) 1.6				0.50	101.56	MADE GROUND: Brown, sandy gravel. Sand is fine to coarse. Gravel is angular to sub-rounded, fine to coarse sandstone and limestone. MADE GROUND: Cobbles and gravel of angular to sub-angular, fine to coarse sandstone and limestone. Rare fragments of coal.		0.20
1							(1.60)				
2							2.10	99.96	MADE GROUND: Brown, sandy gravel. Sand is fine to coarse. gravel is angular to sub-angular, fine to coarse sandstone, limestone and concrete.		
2.80	MW16-13-2		PID (ppm) 1.7				2.50	99.56	MADE GROUND: Orange stained (appears 'rusty') sandy gravel. Sand is fine to coarse. Gravel is angular to sub-rounded, fine to coarse concrete, sandstone and limestone. Minor clinker.		2.80
3							(1.30)				2.90
4							3.80	98.26	MADE GROUND: Black, slightly clayey, sandy gravel. Sand is fine. Gravel is sub-angular to sub-rounded, fine to coarse concrete, sandstone and limestone.		
4							(1.10)				4.40
4.80	MW16-13-3		PID (ppm) 1.4				4.90	97.16	MADE GROUND: Concrete (in-situ).		
5							5.10	96.96	Grey COBBLES of sandstone with evidence of historic tar staining.		
5							5.50	96.56	Borehole completed at 5.50m		5.50
6											
7											
8											
9											
10											
11											

REMARKS:

Backfilled with bentonite seal to 4.5 m bgl.
4.9 - 5.1 m bgl concrete encountered - likely base of former gasholder tank.
5.1 - 5.5 m bgl historic tar staining on sandstone cobbles.

Groundwater:

Date Strike Depth (m) Casing Depth (m) Depth After Observation (m)

Hole and Install Details:

Drilling Method: Dynamic sampling and coring
Borehole Diameter: 128 mm
Screen Material: HDPE
Screen Diameter: 50 mm
Screen Slot Size: 0.75 mm
Sand Particle Size: 1 - 2 mm

Key:

m bgl: Metres below ground level
m AOD: Metres above ordnance datum
↓ Water Strike Level
↓ Water Rest Level



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TRIAL PIT LOG

Pit No
TP16-01
Sheet 1 of 1

Project Name: Quakers Yard Wales & West
Utilities

Project No:
51810-02

Co-ords: E 309793 N 196637
Level: 98.62mAOD

Date
04/07/2016

Location: Quakers Yard

Dimensions: m

Depth

1.00m

Orientation:
° from North

Scale

1 : 47.62

Logged

By

AS

Checked

By

TP

Client: Wales & West Utilities

Photo



Photo Description:

(m)	Water Levels	Samples		PID Result (ppmv)	Legend	Depth (m) (thickness)	Elevation (mAOD)	Description
		Type	Depth (m)					
0.5		TP16-01-1	0.30	PID (ppm) 0.0		0.05 (0.95)	98.57	MADE GROUND: Vegetation cover over: MADE GROUND: Brown, sandy gravel. Gravel is sub-rounded to sub-angular, fine to coarse sandstone, limestone and concrete. Frequent concrete boulders from 0.2 m bgl (0.07 m thick). Yellow piece of plastic. Whole red brick. Concrete hardstanding at 1.0 m bgl.
1.0		TP16-01-2	0.95	PID (ppm) 0.0		1.00	97.62	Trial pit completed at 1.00m
1.5								
2.0								
2.5								
3.0								
3.5								
4.0								
4.5								
5.0								

GENERAL REMARKS:

Summary of Visual and Olfactory Contamination
N/A

BURIED STRUCTURES:

Concrete hardstanding at 1.0 m bgl.

SHORING: N/A

STABILITY: OK



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TRIAL PIT LOG

Pit No
TP16-02
Sheet 1 of 1

Project Name: Quakers Yard Wales & West
Utilities

Project No:
51810-02

Co-ords: E 309784 N 196632
Level: 98.60mAOD

Date
04/07/2016

Location: Quakers Yard

Dimensions: m

Depth
0.90m

Orientation:
° from North

Scale
1 : 47.62

Logged	Checked
By AS	By TP

Client: Wales & West Utilities

Photo



Photo Description:

(m)	Water Levels	Samples		PID Result (ppmv)	Legend	Depth (m) (thickness)	Elevation (mAOD)	Description
		Type	Depth (m)					
0.5		TP16-02-1	0.50	PID (ppm)	[Cross-hatched pattern]	0.05	98.55	MADE GROUND: Vegetation over: MADE GROUND: Brown, sandy gravel with frequent demolition rubble (gravel of concrete, red brick, fragment of metal). Sand is fine to coarse.
		TP' 16-02-2	0.75	0.0		(0.75)		
1.0				PID (ppm)		0.80	97.80	MADE GROUND: Orange-brown, slightly gravelly sand. Sand is fine to medium. Gravel of angular to sub-angular, fine to coarse sandstone. [In east of pit: concrete hardstanding.] Trial pit completed at 0.90m
				0.0		0.90	97.70	
1.5								
2.0								
2.5								
3.0								
3.5								
4.0								
4.5								
5.0								

GENERAL REMARKS:

Summary of Visual and Olfactory Contamination
N/A

BURIED STRUCTURES:

Concrete hardstanding in east of pit at 0.8 m bgl.

SHORING: N/A

STABILITY: OK



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TRIAL PIT LOG

Pit No
TP16-03
Sheet 1 of 1

Project Name: Quakers Yard Wales & West
Utilities

Project No:
51810-02

Co-ords: E 309795 N 196646
Level: 98.78mAOD

Date
04/07/2016

Location: Quakers Yard

Dimensions: m

Depth
1.20m

Orientation:
° from North

Scale

1 : 47.62

Logged By AS

Checked By TP

Client: Wales & West Utilities

Photo



Photo Description:

(m)	Water Levels	Samples Type	Depth (m)	PID Result (ppmv)	Legend	Depth (m) (thickness)	Elevation (mAOD)	Description
0.5		TP16-03-1	0.20	PID (ppm) 0.0		0.05 0.15 (1.05)	98.73 98.63	MADE GROUND: Vegetation cover over: MADE GROUND: Brown, sandy gravel. Gravel is sub-angular to sub-rounded, fine to coarse sandstone, red brick and concrete. Frequent demolition rubble from 0.3 m bgl. MADE GROUND: Brown-grey, slightly clayey sand. Sand is fine to coarse. Concrete hardstanding (in west of pit).
1.0		TP16-03-2	1.20	PID (ppm) 0.0		1.20	97.58	Trial pit completed at 1.20m
1.5								
2.0								
2.5								
3.0								
3.5								
4.0								
4.5								
5.0								

GENERAL REMARKS:

Summary of Visual and Olfactory Contamination

None.

General Notes

Deeper soil sample taken outside of concrete.

BURIED STRUCTURES:

Concrete hardstanding at 1.1 m bgl west of pit.

SHORING: N/A

STABILITY: OK



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TRIAL PIT LOG

Pit No

TP16-04

Sheet 1 of 1

Project Name: Quakers Yard Wales & West
Utilities

Project No:
51810-02

Co-ords: E 309800 N 196640
Level: 98.58mAOD

Date
04/07/2016

Location: Quakers Yard

Dimensions: m

Depth

0.90m

Orientation:
° from North

Scale

1 : 47.62

Logged

By

AS

Checked

By

TP

Client: Wales & West Utilities

Photo



Photo Description:

(m)	Water Levels	Samples		PID Result (ppmv)	Legend	Depth (m) (thickness)	Elevation (mAOD)	Description
		Type	Depth (m)					
0.5		TP16-04-1	0.70	PID (ppm) 0.0		0.05	98.53	MADE GROUND: Vegetation cover over:
						(0.80)		MADE GROUND: Brown, sandy gravel. Gravel is sub-rounded to sub-angular, fine to coarse sandstone, concrete and red brick.
1.0						0.85	97.73	MADE GROUND: Concrete hardstanding across north of pit.
						0.90	97.68	Trial pit completed at 0.90m
1.5								
2.0								
2.5								
3.0								
3.5								
4.0								
4.5								
5.0								

GENERAL REMARKS:

Summary of Visual and Olfactory Contamination
N/A

BURIED STRUCTURES:

Concrete hardstanding at 0.85 m bgl.
Some broken metal pipework at 0.2 and 0.6 m bgl.

SHORING: N/A

STABILITY: OK



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TRIAL PIT LOG

Pit No
TP16-05
Sheet 1 of 1

Project Name: Quakers Yard Wales & West
Utilities

Project No:
51810-02

Co-ords: E 309869 N 196718
Level: 102.18mAOD

Date
05/07/2016

Location: Quakers Yard

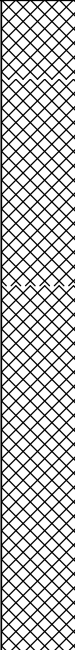
Dimensions: m
Depth 4.10m
Orientation: ° from North

Scale
1 : 47.62
Logged By AS
Checked By TP

Client: Wales & West Utilities



Photo Description:

(m)	Water Levels	Samples		PID Result (ppmv)	Legend	Depth (m) (thickness)	Elevation (mAOD)	Description	
Type	Depth (m)								
0.5		TP16-05-1	0.40	PID (ppm) 0.0		(0.50)	101.68	MADE GROUND: Vegetation and moss over: Brown, sandy gravel. Gravel is sub-angular to sub-rounded, fine to coarse sandstone, concrete, tarmac and red brick. Fragments of plastic sheeting. Rare rootlets noted.	
1.0						0.50			MADE GROUND: Orange-brown, sandy gravel. Gravel is sub-angular, fine to medium sandstone, limestone and concrete. Occasional patch of tarmac waste. Whole red bricks at 1.4 m bgl (loose).
1.5						(1.30)			
2.0		TP16-05-2	1.90	PID (ppm) 0.0		1.80	100.38	MADE GROUND: Orange-brown sandy gravel. Gravel is rounded to sub-rounded, fine to coarse sandstone.	
2.5									
3.0					(2.30)				
3.5									
4.0		TP16-05-3	4.10	PID (ppm) 0.0		4.10	98.08	Trial pit completed at 4.10m	
4.5									
5.0									

GENERAL REMARKS:

Summary of Visual and Olfactory Contamination
N/A
General Notes
N/A

BURIED STRUCTURES:

None.

SHORING: N/A

STABILITY: OK



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TRIAL PIT LOG

Pit No
TP16-06A
Sheet 1 of 1

Project Name: Quakers Yard Wales & West
Utilities

Project No:
51810-02

Co-ords: E 309864 N 196714
Level: 102.14mAOD

Date
05/07/2016

Location: Quakers Yard

Dimensions: m

Depth
3.80m

Orientation:
° from North

Scale
1 : 47.62

Logged	Checked
By AS	By TP

Client: Wales & West Utilities



Photo Description:

(m)	Water Levels	Samples		PID Result (ppmv)	Legend	Depth (m) (thickness)	Elevation (mAOD)	Description
		Type	Depth (m)					
0.15		TP16-06-1	0.50	PID (ppm) 0.0		0.15	101.99	MADE GROUND: Brown, sandy topsoil type material with frequent rootlets.
0.5						(0.60)		MADE GROUND: Orange-brown, sandy gravel (Type 1). Scraps of metal and tarmac from 0.4 m bgl. Occasional whole brick. Frequent off-cuts of metal pipe.
0.75						0.75	101.39	MADE GROUND: Tarmac.
0.80						0.80	101.34	
1.0		TP16-06-2	1.70	PID (ppm) 0.0		1.10	101.04	MADE GROUND: Orange-pink, slightly gravelly sand. Sand is fine to medium. Gravel of angular to sub-angular, fine to coarse sandstone.
1.5						(0.50)		MADE GROUND: Black 'tarmac' with strong coal tar odour.
1.60						1.60	100.54	MADE GROUND: Grey stained black, sandy gravel. Gravel is subangular, fine to coarse sandstone. Slight phenolic odour.
1.80						1.80	100.34	
2.0		TP16-06-3	3.80	PID (ppm) 0.9		(2.00)		MADE GROUND: Black stained, slightly clayey, gravelly sand. Strong phenolic odour. Sand is fine to medium. Gravel of angular to sub-angular, fine coarse sandstone. Frequent boulder at 3.0 - 3.6 m bgl. End of pit at 3.8 m bgl - pit collapsed.
2.5								
3.0						3.80	98.34	Trial pit completed at 3.80m
3.5								
4.0								
4.5								
5.0								

GENERAL REMARKS:

Summary of Visual and Olfactory Contamination
1.6 to 2.0 m bgl black staining and phenolic odour.

General Notes

Moved pit east to attempt to locate wall.

BURIED STRUCTURES:

Distinct 'tarmac' which has phenolic coal tar odour. 0.75 - 1.6 m bgl.

SHORING: N/A

STABILITY: OK



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TRIAL PIT LOG

Pit No
TP16-06B
Sheet 1 of 1

Project Name: Quakers Yard Wales & West
Utilities

Project No:
51810-02

Co-ords: E 309858 N 196708
Level: 101.55mAOD

Date
05/07/2016

Location: Quakers Yard

Dimensions: m

Depth
3.80m

Orientation:
° from North

Scale
1 : 47.62

Logged	Checked
By AS	By TP

Client: Wales & West Utilities



Photo

Photo Description:

(m)	Water Levels	Samples		PID Result (ppmv)	Legend	Depth (m) (thickness)	Elevation (mAOD)	Description
		Type	Depth (m)					
0.15						0.15	101.40	MADE GROUND: Brown, sandy topsoil type material with frequent rootlets.
0.5						(0.60)		MADE GROUND: Orange-brown, sandy gravel (Type 1). Scraps of metal and tarmac from 0.4 m bgl. Occasional whole brick. Frequent off-cuts of metal pipe.
0.75						0.75	100.80	MADE GROUND: Tarmac.
0.80						0.80	100.75	MADE GROUND: Orange-pink, slightly gravelly sand. Sand is fine to medium.
1.0						1.10	100.45	MADE GROUND: Black 'tarmac' with strong coal tar odour.
1.5						(0.50)		
1.60						1.60	99.95	MADE GROUND: Grey stained black, sandy gravel. Gravel is subangular, fine to coarse sandstone. Slight phenolic odour.
1.80						1.80	99.75	MADE GROUND: Black stained, slightly clayey, gravelly sand. Strong phenolic odour. Sand is fine to medium. Gravel of angular to sub-angular, fine to coarse sandstone. Frequent boulder at 3.0 - 3.6 m bgl. End of pit at 3.8 m bgl - pit collapsed.
2.0								
2.5								
3.0						(2.00)		
3.5								
3.80						3.80	97.75	Trial pit completed at 3.80m
4.0								
4.5								
5.0								

GENERAL REMARKS:

Summary of Visual and Olfactory Contamination
1.6 to 2.0 m bgl black staining and phenolic odour.

General Notes

Moved pit east to attempt to locate wall.

BURIED STRUCTURES:

Distinct 'tarmac' which has pheno

SHORING: N/A

STABILITY: OK

TRIAL PIT LOG

Pit No
TP16-07
Sheet 1 of 1

Project Name: Quakers Yard Wales & West Utilities

Project No:
51810-02

Co-ords: E 309863 N 196698
Level: 100.99mAOD

Date
06/07/2016

Location: Quakers Yard

Dimensions: m

Scale

1 : 47.62

Client: Wales & West Utilities

Depth
1.00m

Orientation:
° from North

Logged	Checked
By	By
AS	TP



Photo Description:

GENERAL REMARKS:

Summary of Visual and Olfactory Contamination
N/A

BURIED STRUCTURES:

1.0 m bgl concrete floor in north of pit. Concrete wall and two rows of bricks above.

SHORING: N/A

STABILITY: OK



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TRIAL PIT LOG

Pit No
TP16-08
Sheet 1 of 1

Project Name: Quakers Yard Wales & West
Utilities

Project No:
51810-02

Co-ords: E 309851 N 196688
Level: 100.88mAOD

Date
06/07/2016

Location: Quakers Yard

Dimensions: m
Depth 2.90m
Orientation: ° from North

Scale
1 : 47.62
Logged By AS
Checked By TP

Client: Wales & West Utilities



Photo Description:

(m)	Water Levels	Samples		PID Result (ppmv)	Legend	Depth (m) (thickness)	Elevation (mAOD)	Description
		TP16-08-1	0.50	PID (ppm) 0.0		0.10	100.78	MADE GROUND: Vegetation cover, rootlets and topsoil type material over:
0.5						(1.10)	MADE GROUND: Brown-black, sandy gravel. Gravel is sub-rounded to sub-angular, fine to coarse sandstone, limestone, concrete and red brick.	
1.0		TP16-08-2	1.30	PID (ppm) 0.0		1.20	99.68	MADE GROUND: Firm layer, black with coal tar odour.
1.5						1.40	99.48	MADE GROUND: Black-brown, sandy gravel. Gravel is sub-angular to sub-rounded, fine to coarse sandstone and red brick. Occasionally gravel appears 'rusty brown'. End at 2.9 m bgl due to water ingress (extension pit).
2.0						(1.50)		
2.5								
3.0						2.90	97.98	Trial pit completed at 2.90m
3.5								
4.0								
4.5								
5.0								

GENERAL REMARKS:

Summary of Visual and Olfactory Contamination
Some black staining, no odour until 'tarmac' layer 1.2 to 1.4 m bgl.
Tarmac layer very firm and pliable. Strong coal tar odour.

BURIED STRUCTURES:

Tarmac hard standing at 1.2 m bgl - 1.4 m bgl (coal tar tarmac).

SHORING: N/A

STABILITY: OK



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TRIAL PIT LOG

Pit No
TP16-08B
Sheet 1 of 1

Project Name: Quakers Yard Wales & West
Utilities

Project No:
51810-02

Co-ords: E 309851 N 196688
Level: 100.88mAOD

Date
19/07/2016

Location: Quakers Yard

Dimensions: m

Depth
3.20m

±

Orientation:
° from North

Scale
1 : 47.62

Logged	Checked
By DG	By TP

Client: Wales & West Utilities

Photo

(m)	Water Levels	Samples		PID Result (ppmv)	Legend	Depth (m) (thickness)	Elevation (mAOD)	Description
Type	Depth (m)							
						0.10	100.78	MADE GROUND: Vegetation cover, rootlets and topsoil type material over:
						(1.10)		MADE GROUND: Brown-black, sandy gravel. Gravel is sub-rounded to sub-angular, fine to coarse sandstone, limestone, concrete and red brick.
						1.20	99.68	
						1.40	99.48	MADE GROUND: Firm layer, black with coal tar odour.
						(1.50)		MADE GROUND: Black-brown, sandy gravel. Gravel is sub-angular to sub-rounded, fine to coarse sandstone and red brick. Occasionally gravel appears 'rusty brown'.
						2.90	97.98	
						3.20	97.68	MADE GROUND: At 3.0 m bgl tar stained clinker. End at 3.2 due to water ingress.
								Trial pit completed at 3.20m

Photo Description:

GENERAL REMARKS:

Summary of Visual and Olfactory Contamination

Very strong tar odour at 2.9 m bgl. LNAPL on surface of perched water. Tar stained clinker.

BURIED STRUCTURES:

JCB driver reported potential firm structure at 3.2 m bgl.

SHORING: N/A

STABILITY: OK



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TRIAL PIT LOG

Pit No
TP16-09
Sheet 1 of 1

Project Name: Quakers Yard Wales & West
Utilities

Project No:
51810-02

Co-ords: E 309849 N 196682
Level: 100.51mAOD

Date
06/07/2016

Location: Quakers Yard

Dimensions: m

Depth
2.20m

Orientation:
° from North

Scale
1 : 47.62

Logged	Checked
By AS	By TP

Client: Wales & West Utilities

Photo



Photo Description:

(m)	Water Levels	Samples		PID Result (ppmv)	Legend	Depth (m) (thickness)	Elevation (mAOD)	Description
		Type	Depth (m)					
0.5						(0.80)		MADE GROUND: Vegetation cover over: Brown, sandy gravel. Gravel is sub-rounded to sub-angular, fine to coarse limestone and sandstone. Occasional red brick, concrete, rags, glass bottle. Large (750 mm) slab of concrete.
1.0		TP16-09-1	1.00	PID (ppm) 165		(0.60)	99.71	MADE GROUND: 'Tarmac' layer. Very strong coal tar odour when broken up. Stiff, brown stained black clay. Strong hydrocarbon odour.
1.5						(0.80)	99.11	MADE GROUND: Orange-brown, slightly clayey sand. Occasional coal fragment. No significant odour. Sand is fine to medium.
2.0		TP16-09-2	2.15	PID (ppm) 0.0		2.20	98.31	Trial pit completed at 2.20m
2.5								
3.0								
3.5								
4.0								
4.5								
5.0								

GENERAL REMARKS:

Summary of Visual and Olfactory Contamination
Coal tar odour from 0.8 m bgl associated with 'tarmac' layer.

BURIED STRUCTURES:

'Tarmac' layer at 0.8 to 1.4 m bgl with coal tar odour.
Metal pipe running north to south at 0.9 m bgl.

SHORING: N/A

STABILITY: OK



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TRIAL PIT LOG

Pit No
TP16-10
Sheet 1 of 1

Project Name: Quakers Yard Wales & West
Utilities

Project No:
51810-02

Co-ords: E 309822 N 196675
Level: 100.23mAOD

Date
06/07/2016

Location: Quakers Yard

Dimensions: m
Depth 1.90m
Orientation: ° from North

Scale
1 : 47.62
Logged By AS
Checked By TP

Client: Wales & West Utilities

Photo



Photo Description:

(m)	Water Levels	Samples		PID Result (ppmv)	Legend	Depth (m) (thickness)	Elevation (mAOD)	Description
0.5		TP16-10-1	0.60	PID (ppm) 0.0		(1.00)		MADE GROUND: Brown topsoil type material with frequent organic matter over: (Loose) brown, sandy gravel. Gravel is sub-rounded to sub-angular, fine to coarse sandstone, limestone, concrete and red brick.
1.0						1.00	99.23	MADE GROUND: Compact cobbles and boulders of angular concrete and brick (demolition rubble). MADE GROUND: Soft, orange-brown, sandy clay with red brick pieces. [Cast iron black pipe running diagonally across pit.] Brown, slightly gravelly SAND. Sand is fine to medium. Gravel of angular to sub-angular, fine to coarse sandstone.
1.10						1.10	99.13	
1.20						1.20	99.03	
1.5		TP16-10-2	1.80	PID (ppm) 0.0		(0.70)		
2.0						1.90	98.33	Trial pit completed at 1.90m
2.5								
3.0								
3.5								
4.0								
4.5								
5.0								

GENERAL REMARKS:

General Notes
Moved trial pit south away from pipe.

BURIED STRUCTURES:

Black cast iron pipe at 1.1 m bgl.

SHORING: N/A

STABILITY: OK



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TRIAL PIT LOG

Pit No
TP16-11
Sheet 1 of 1

Project Name: Quakers Yard Wales & West
Utilities

Project No:
51810-02

Co-ords: E 309830 N 196664
Level: 99.62mAOD

Date
07/07/2016

Location: Quakers Yard

Dimensions: m

Depth
2.10m

Orientation:
° from North

Scale
1 : 47.62

Logged	Checked
By AS	By TP

Client: Wales & West Utilities

Photo



Photo Description:

(m)	Water Levels	Samples		PID Result (ppmv)	Legend	Depth (m) (thickness)	Elevation (mAOD)	Description
		Type	Depth (m)					
0.5		TP16-11-1	0.40	PID (ppm) 0.0		0.05 0.15 (0.65)	99.57 99.47	MADE GROUND: Vegetation cover over: MADE GROUND: Concrete hardstanding. MADE GROUND: Brown, sandy gravel. Gravel is sub-angular to sub-rounded, fine to coarse limestone and sandstone. Frequent demolition rubble (concrete and whole bricks).
1.0						0.80	98.82	Orange-brown, slightly gravelly SAND.
1.5		TP16-11-2	1.60	PID (ppm) 0.0		(1.00)		
2.0		TP16-11-3	2.00	PID (ppm) 5.1		1.80 2.10	97.82 97.52	Brown, slightly gravelly, sandy CLAY. Sand is fine to medium grained. Moderate phenolic/hydrocarbon odour. Trial pit completed at 2.10m
2.5								
3.0								
3.5								
4.0								
4.5								
5.0								

GENERAL REMARKS:

Summary of Visual and Olfactory Contamination

1.8 - 2.1 m bgl moderate phenolic /hydrocarbon odour on soil beneath water table.

BURIED STRUCTURES:

Red brick built wall in south east corner of trial pit wall to 0.9 m bgl depth.

SHORING: N/A

STABILITY: OK



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TRIAL PIT LOG

Pit No
TP16-12
Sheet 1 of 1

Project Name: Quakers Yard Wales & West
Utilities

Project No:
51810-02

Co-ords: E 309817 N 196660
Level: 99.46mAOD

Date
07/07/2016

Location: Quakers Yard

Dimensions: m

Depth
2.10m

E

Orientation:
° from North

Scale
1 : 47.62

Logged	Checked
By AS	By TP

Client: Wales & West Utilities

Photo



Photo Description:

(m)	Water Levels	Samples		PID Result (ppmv)	Legend	Depth (m) (thickness)	Elevation (mAOD)	Description
		Type	Depth (m)					
0.5		TP16-12-1	0.60	PID (ppm) 0.0		(0.75)	98.71	MADE GROUND: Vegetation cover over: Brown, sandy gravel. Gravel is sub-angular to sub-rounded, fine to coarse sandstone, limestone, concrete, occasional pockets of brown sand. Small coal fragments.
1.0						0.75		Orange-brown, slightly clayey SAND. Sand is fine to medium. NVOSC.
1.5						(0.65)		
2.0		TP16-12-2 TP16-12-3	2.10	PID (ppm) 1.3		1.40	98.06	Orange-brown, slightly gravelly SAND. Sand is fine to medium.
2.5						(0.60)		
3.0						2.00		Orange-brown, occasionally grey SANDY GRAVEL. Sand is medium to coarse grained. Gravel is rounded to sub-angular sandstone. NVOSC.
3.5						2.10	97.36	Trial pit completed at 2.10m
4.0								
4.5								
5.0								

GENERAL REMARKS:

Summary of Visual and Olfactory Contamination
None.

BURIED STRUCTURES:

None.

SHORING: N/A

STABILITY: OK



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TRIAL PIT LOG

Pit No
TP16-13
Sheet 1 of 1

Project Name: Quakers Yard Wales & West
Utilities

Project No:
51810-02

Co-ords: E 309811 N 196654
Level: 99.35mAOD

Date
07/07/2016

Location: Quakers Yard

Dimensions: m
Depth 1.80m
Orientation: ° from North

Scale
1 : 47.62
Logged By AS
Checked By TP

Client: Wales & West Utilities

Photo



Photo Description:

(m)	Water Levels	Samples Type	Depth (m)	PID Result (ppmv)	Legend	Depth (m) (thickness)	Elevation (mAOD)	Description
0.5		TP16-13-1	0.40	PID (ppm) 0.0		0.20 (0.50)	99.15	MADE GROUND: Vegetation over loose boulders of sandstone.
1.0						0.70 (0.70)	98.65	MADE GROUND: Brown, sandy gravel with boulders of sandstone. Occasional metal pipe cut-offs.
1.5	1							Orange-brown, occasionally grey, slightly clayey SAND. Sand is fine to medium grained. NVOSC.
2.0		TP16-13-2 TP16-13-3	1.75	PID (ppm) 0.0		1.40 (0.40)	97.95	Orange-brown SAND AND GRAVEL. Gravel is rounded to sub-rounded, fine to coarse sandstone. Sand is fine to medium. NVOSC.
2.5						1.80	97.55	Trial pit completed at 1.80m
3.0								
3.5								
4.0								
4.5								
5.0								

GENERAL REMARKS:

Summary of Visual and Olfactory Contamination
NVOSC.

BURIED STRUCTURES:

N/A

SHORING: N/A

STABILITY: OK



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TRIAL PIT LOG

Pit No
TP16-14
Sheet 1 of 1

Project Name: Quakers Yard Wales & West
Utilities

Project No:
51810-02

Co-ords: E 309845 N 196677
Level: 100.08mAOD

Date
07/07/2016

Location: Quakers Yard

Dimensions: m

Depth
2.25m
Orientation:
° from North

Scale
1 : 47.62

Logged By AS
Checked By TP

Client: Wales & West Utilities

Photo	(m)	Water Levels	Samples Type	Depth (m)	PID Result (ppmv)	Legend	Depth (m) (thickness)	Elevation (mAOD)	Description
	0.5						(0.60)		MADE GROUND: Vegetation over brown, sandy gravel. Sand is fine to medium. Gravel of angular to sub-angular, fine to coarse sandstone.
	0.60							99.48	MADE GROUND: 'Tarmac' hardstanding (solidified tar). Strong coal tar/hydrocarbon odour when broken up.
	1.0						(0.80)		
	1.5		TP16-14-1	1.45	PID (ppm) 13.2		1.40	98.68	MADE GROUND: Soft to firm, grey-black, sandy clay. Strong hydrocarbon odour. Occasional white speckles (potential foul lime?).
	2.0						1.70	98.38	Grey stained black, slightly clayey SAND. Strong hydrocarbon odour. Sand is fine to medium.
	2.20		TP16-14-2	2.20	PID (ppm) 33		(0.55)		
	2.25						2.25	97.83	Trial pit completed at 2.25m
	2.5								
	3.0								
	3.5								
	4.0								
	4.5								
	5.0								

GENERAL REMARKS:

Summary of Visual and Olfactory Contamination

0.6 m bgl solidified coal tar with associated strong odour. Tar seeping in at interface between layer 1.3 - 1.4 m bgl.

General Notes

Solidified tar ('tarmac') 0.6 m bgl. Had to use breaker.

BURIED STRUCTURES:

SHORING: N/A

STABILITY: OK



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TRIAL PIT LOG

Pit No
TP16-15
Sheet 1 of 1

Project Name: Quakers Yard Wales & West
Utilities

Project No:
51810-02

Co-ords: E 309826 N 196681
Level: 100.23mAOD

Date
11/07/2016

Location: Quakers Yard

Dimensions: m

Depth
1.60m

Orientation:
° from North

Scale
1 : 47.62

Logged	Checked
By DG	By TP

Client: Wales & West Utilities

Photo



Photo Description:

(m)	Water Levels	Samples		PID Result (ppmv)	Legend	Depth (m) (thickness)	Elevation (mAOD)	Description
		Type	Depth (m)					
0.5						0.05	100.18	MADE GROUND: Vegetation cover over: MADE GROUND: (Medium dense) red-brown demolition rubble, rare, sandy gravel. Frequent fire bricks.
1.0						(1.35)		
1.5	1	TP16-15-1	1.40	PID (ppm) 19.4		1.40	98.83	MADE GROUND: (Loose) red-black, sandy gravel. Gravel of sub-angular, fine to coarse red brick and concrete, ash and coal. Strong hydrocarbon odour and sheen on brick. Occasional pockets of gravelly clay near concrete base. MADE GROUND: Concrete base of potential inspection pit. Slight ingress of perched water on top of base (sheen noted). Pit terminated at 1.6 m bgl due to unstable sides. Trial pit completed at 1.60m
2.0						1.50	98.73	
2.5						1.60	98.63	
3.0								
3.5								
4.0								
4.5								
5.0								

GENERAL REMARKS:

Summary of Visual and Olfactory Contamination
Strong hydrocarbon odour and sheen at 1.4 m bgl.
General Notes
Stock pile removed from surface to ground level.

BURIED STRUCTURES:

Two metal supporting joists on each side of pit. Brick wall at south side.

SHORING: N/A

STABILITY: OK



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TRIAL PIT LOG

Pit No
TP16-16
Sheet 1 of 1

Project Name: Quakers Yard Wales & West
Utilities

Project No:
51810-02

Co-ords: E 309829 N 196678
Level: 100.31mAOD

Date
11/07/2016

Location: Quakers Yard

Dimensions: m

Depth
2.00m

±

Orientation:
° from North

Scale
1 : 47.62

Logged	Checked
By DG	By TP

Client: Wales & West Utilities

Photo



Photo Description:

(m)	Water Levels	Samples		PID Result (ppmv)	Legend	Depth (m) (thickness)	Elevation (mAOD)	Description
		Type	Depth (m)					
0.5		TP16-16-1	0.25	PID (ppm) 0.0		0.25 0.30	100.06 100.01	MADE GROUND: Vegetation over: (Loose) brown-black, slightly sandy, clayey gravel. Gravel is angular to sub-angular, fine to coarse, brick, concrete, coal and clinker. MADE GROUND: Layer of black ash with clinker. MADE GROUND: (Loose) yellow-orange, slightly clayey sand with occasional brick.
1.0						(1.50)		
1.5								
2.0		TP16-16-2	1.90	PID (ppm) 0.0		1.80 2.00	98.51 98.31	(Loose) green, clayey SAND. Sand is fine. NVOSC. Trial pit completed at 2.00m
2.5								
3.0								
3.5								
4.0								
4.5								
5.0								

GENERAL REMARKS:

Summary of Visual and Olfactory Contamination
Layer of ash/clinker at 0.25 m bgl.

BURIED STRUCTURES:

Wall in middle of pit. Tarmac layer at 0.4 m bgl in south of pit.

SHORING: N/A

STABILITY: OK



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TRIAL PIT LOG

Pit No
TP16-17A
Sheet 1 of 1

Project Name: Quakers Yard Wales & West
Utilities

Project No:
51810-02

Co-ords: E 309830 N 196684
Level: 100.32mAOD

Date
11/07/2016

Location: Quakers Yard

Dimensions: m

Depth
1.30m

Orientation:
° from North

Scale
1 : 47.62

Logged	Checked
By DG	By TP

Client: Wales & West Utilities

Photo

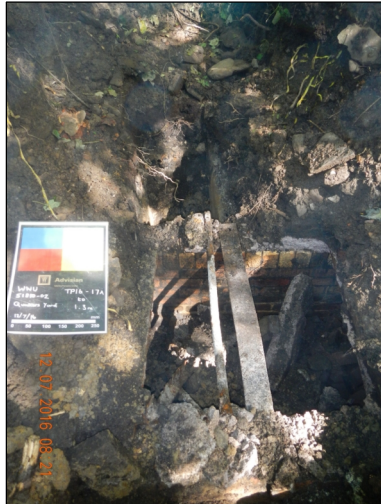


Photo Description:

(m)	Water Levels	Samples		PID Result (ppmv)	Legend	Depth (m) (thickness)	Elevation (mAOD)	Description
		Type	Depth (m)					
0.5		TP16-017A-1	1.10	PID (ppm) 0.0		0.25	100.07	MADE GROUND: Vegetation over: (Loose) brown, slightly sandy, clayey gravel. Gravel is fine to coarse, angular brick, coal and concrete.
1.0						(1.05)		MADE GROUND: Layer of black ash. (Loose) yellow-orange, slightly gravelly, clayey sand. Gravel of brick. (NVOSC.) Frequent cobbles of limestone.
1.5						1.30	99.02	End of pit at 1.3 m bgl. In south of pit, two red brick walls with concrete top. Hollow between with demolition rubble.
2.0								Trial pit completed at 1.30m
2.5								
3.0								
3.5								
4.0								
4.5								
5.0								

GENERAL REMARKS:

Summary of Visual and Olfactory Contamination
NVOSC.

BURIED STRUCTURES:

Two brick walls. With hollow chamber full of demolition rubble.

SHORING: N/A

STABILITY: OK



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TRIAL PIT LOG

Pit No
TP16-17B
Sheet 1 of 1

Project Name: Quakers Yard Wales & West
Utilities

Project No:
51810-02

Co-ords: E 309833 N 196682
Level: 100.43mAOD

Date
11/07/2016

Location: Quakers Yard

Dimensions: m
Depth 1.70m
Orientation: ° from North

Scale
1 : 47.62
Logged By DG Checked By TP

Client: Wales & West Utilities

Photo



Photo Description:

(m)	Water Levels	Samples Type	Depth (m)	PID Result (ppmv)	Legend	Depth (m) (thickness)	Elevation (mAOD)	Description
0.5		TP16-17B-1	0.20	PID (ppm) 0.0		(1.10)		MADE GROUND: Vegetation over: (Loose) brown, slightly sandy, clayey gravel. Gravel is fine to medium, sub-angular to angular brick, coal and concrete. Frequent pieces of metal, glass and plastic. Frequent cobbles of brick and concrete.
1.0						1.10 (0.60)	99.33	MADE GROUND: (Soft) yellow-green, sandy clay. Sand is medium coarse. Strong phenolic odour and staining.
1.5		TP16-17B-2	1.60	PID (ppm) 43.4		1.70	98.73	Trial pit completed at 1.70m
2.0								
2.5								
3.0								
3.5								
4.0								
4.5								
5.0								

GENERAL REMARKS:

Summary of Visual and Olfactory Contamination
Phenolic odour at 1.1 - 1.7 m bgl.

BURIED STRUCTURES:

Concrete at north of pit at 0.3 m bgl. Cut metal structure/pipe north of pit (diameter 0.9 m) depth 300 mm.

SHORING: N/A

STABILITY: OK



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TRIAL PIT LOG

Pit No
TP16-18
Sheet 1 of 1

Project Name: Quakers Yard Wales & West
Utilities

Project No:
51810-02

Co-ords: E 309835 N 196688
Level: 100.34mAOD

Date
12/07/2016

Location: Quakers Yard

Dimensions: m

Depth
1.80m

±

Orientation:
° from North

Scale
1 : 47.62

Logged	Checked
By DG	By TP

Client: Wales & West Utilities



Photo Description:

(m)	Water Levels	Samples		PID Result (ppmv)	Legend	Depth (m) (thickness)	Elevation (mAOD)	Description
		Type	Depth (m)					
0.5		TP16-18-1	0.60	PID (ppm) 0.0		(0.40) 0.40	99.94	MADE GROUND: Vegetation over: (Loose) brown, slightly sandy, clayey gravel. Gravel is fine to coarse, sub-angular to angular brick, limestone, concrete and clinker. Frequent brick, roots, metal and wood. MADE GROUND: Demolition rubble (whole/part brick). Gravel, cobbles and boulders of sandstone. End of pit at 1.8 m bgl - concrete base layer.
1.0						(1.40)		
1.5								
2.0		TP16-18-2	1.80	PID (ppm) 0.0		1.80	98.54	Trial pit completed at 1.80m
2.5								
3.0								
3.5								
4.0								
4.5								
5.0								

GENERAL REMARKS:

Summary of Visual and Olfactory Contamination
NVOSC.
General Notes
Spoil on sides of pit.

BURIED STRUCTURES:

Redundant cut yellow pipe. Brick wall on north and west of pit. Layer of concrete at 0.9 m bgl.

SHORING: N/A

STABILITY: OK



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TRIAL PIT LOG

Pit No
TP16-19
Sheet 1 of 1

Project Name: Quakers Yard Wales & West
Utilities

Project No:
51810-02

Co-ords: E 309833 N 196676
Level: 100.26mAOD

Date
12/07/2016

Location: Quakers Yard

Dimensions: m
Depth 2.10m
Orientation: ° from North

Scale
1 : 47.62

Client: Wales & West Utilities

Logged By
Checked By
DG TP

Photo



Photo Description:

(m)	Water Levels	Samples Type	Depth (m)	PID Result (ppmv)	Legend	Depth (m) (thickness)	Elevation (mAOD)	Description
0.5								
1.0		TP16-19-1	0.80	PID (ppmv) 0.0		(1.20)		MADE GROUND: Vegetation over: (Loose) brown, slightly sandy, clayey gravel. Gravel is fine to coarse, sub-angular to rounded brick, coal, ash, clinker, concrete, limestone and chert. Occasional piece of clinker and plastic noted. At 0.8 m bgl slight hydrocarbon odour with layer of ash material. At 0.9 m bgl layer of concrete (0.2 m thick in places). At 1.0 m bgl concrete walls running north to south of pit.
1.5						1.20	99.06	
2.0		TP16-19-2	2.10	PID (ppmv) 38.3		(0.50)		MADE GROUND: (Loose) black, slightly sandy, clayey gravel. Gravel is fine to coarse, sub-angular to rounded brick, coal, ash, clinker, concrete, limestone and chert. Occasional piece of clinker and plastic noted.
2.5						1.70	98.56	
3.0						(0.40)		MADE GROUND: (Soft) yellow-green, sandy clay. Sand is medium to coarse. Occasional cobbles of concrete. Very strong phenolic odour increasing with depth.
3.5						2.10	98.16	
4.0								Trial pit completed at 2.10m
4.5								
5.0								

GENERAL REMARKS:

Summary of Visual and Olfactory Contamination

Hydrocarbon odour at 0.8 m bgl. Very strong phenolic odour at 1.7 m bgl.

General Notes

Ingress of water at 1.3 m bgl.

BURIED STRUCTURES:

Wall at 1.0 m bgl broken out. Concrete layer at 0.9 m bgl (0.2 m thick). White pipe at 2.1 m bgl (possibly concrete pipe).

SHORING: N/A

STABILITY: OK



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TRIAL PIT LOG

Pit No
TP16-20
Sheet 1 of 1

Project Name: Quakers Yard Wales & West
Utilities

Project No:
51810-02

Co-ords: E 309843 N 196695
Level: 100.85mAOD

Date
12/07/2016

Location: Quakers Yard

Dimensions: m

Depth
1.10m

±

Orientation:
° from North

Scale
1 : 47.62

Logged	Checked
By DG	By TP

Client: Wales & West Utilities

Photo



Photo Description:

(m)	Water Levels	Samples		PID Result (ppmv)	Legend	Depth (m) (thickness)	Elevation (mAOD)	Description
0.5	1 ▽	TP16-20-1	0.50	PID (ppm) 0.0		(0.90)		MADE GROUND: Vegetation over: (Loose) brown, slightly sandy, clayey gravel. Gravel is medium to coarse, sub-angular to angular brick, concrete and slag. Frequent cobbles of limestone in north of pit. At 0.9 m bgl limestone and concrete wall (0.5 m thick).
1.0		TP16-20-2	1.00	PID (ppm) 14.1		0.90 1.10	99.95 99.75	MADE GROUND: (Loose) black slightly sandy, clayey gravel. Gravel is medium to coarse, sub-angular to angular brick, concrete and slag. End of pit at 1.1 m bgl - ingress of perched water. Very strong hydrocarbon odour and tar globules on surface water level same north and south of wall. Trial pit completed at 1.10m
1.5								
2.0								
2.5								
3.0								
3.5								
4.0								
4.5								
5.0								

GENERAL REMARKS:

Summary of Visual and Olfactory Contamination
Perched water with tar globules. Very strong hydrocarbon odour.

BURIED STRUCTURES:

Concrete wall with timber strut at 0.9 m bgl. 500 mm thick.

SHORING: N/A

STABILITY: OK



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TRIAL PIT LOG

Pit No
TP16-21
Sheet 1 of 1

Project Name: Quakers Yard Wales & West
Utilities

Project No:
51810-02

Co-ords: E 309846 N 196690
Level: 100.67mAOD

Date
13/07/2016

Location: Quakers Yard

Dimensions: m

Depth
3.30m

±

Orientation:
° from North

Scale
1 : 47.62

Logged	Checked
By DG	By TP

Client: Wales & West Utilities

Photo



Photo Description:

(m)	Water Levels	Samples		PID Result (ppmv)	Legend	Depth (m) (thickness)	Elevation (mAOD)	Description
0.5		TP16-21-1	0.40	PID (ppm) 0.0		(1.40)		MADE GROUND: Vegetation over: (Loose) brown, sandy gravel. Gravel is medium to coarse, sub-angular to angular brick, concrete, slag, coke and ash. Frequent cobbles of brick and concrete, roots and rootlets. At 0.7 m bgl tarmacadam layer.
1.0								
1.5		TP16-21-2	1.40	PID (ppm) 8.0		1.40	99.27	MADE GROUND: Service encountered at 1.4 m bgl. Pit terminated as very strong signal with CAT in power mode. (Slight hydrocarbon odour at 0.5 to 1.4 m bgl.)
2.0						(1.80)		
2.5								
3.0	1					3.20	97.47	
3.5		TP16-21-3	3.30	PID (ppm) 172		3.30	97.37	Pit extended. Black stained boulders of sandstone. End at 3.3 m bgl due to water ingress. Trial pit completed at 3.30m
4.0								
4.5								
5.0								

GENERAL REMARKS:

Summary of Visual and Olfactory Contamination

Slight hydrocarbon odour at 0.5 - 1.4 m bgl. From 2.0 very strong petrol odour at base of pit.

General Notes

Strong signal in 'Power' on CAT. Unknown service at 1.4 m bgl. Pit extended to depth in alternative location.

BURIED STRUCTURES:

Service at 1.4 m bgl.

SHORING: N/A

STABILITY: OK



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TRIAL PIT LOG

Pit No
TP16-22
Sheet 1 of 1

Project Name: Quakers Yard Wales & West
Utilities

Project No:
51810-02

Co-ords: E 309853 N 196705
Level: 101.19mAOD

Date
13/07/2016

Location: Quakers Yard

Dimensions: m

Depth
1.30m

±

Orientation:
° from North

Scale

1 : 47.62

Logged	Checked
By DG	By TP

Client: Wales & West Utilities

Photo



Photo Description:

(m)	Water Levels	Samples		PID Result (ppmv)	Legend	Depth (m) (thickness)	Elevation (mAOD)	Description
0.5						(1.00)		MADE GROUND: Vegetation cover over: (Loose) light brown, slightly sandy, clayey gravel. Gravel is coarse, sub-angular to rounded brick, concrete, ash, slag and chert. Frequent brick and concrete, metal and wood (damp).
1.0	1	TP16-22-1	0.80	PID (ppm) 0.0		1.00	100.19	MADE GROUND: Soft, sandy, gravelly clay. Gravel is coarse, sub-angular brick, concrete and slag. Occasional white plastic. Frequent hair-like material, wood and cut metal pipe. Very strong phenolic odour. End of pit at 1.3 m bgl due to water ingress. Trial pit completed at 1.30m
1.5		TP16-22-2	1.20	PID (ppm) 3.0		1.30	99.89	
2.0								
2.5								
3.0								
3.5								
4.0								
4.5								
5.0								

GENERAL REMARKS:

Summary of Visual and Olfactory Contamination
Very strong phenolic odour at 1.0 m bgl.

General Notes
Black perched water at 1.2 m bgl.

BURIED STRUCTURES:

SHORING: N/A

STABILITY: OK



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TRIAL PIT LOG

Pit No
TP16-23
Sheet 1 of 1

Project Name: Quakers Yard Wales & West
Utilities

Project No:
51810-02

Co-ords: E 309840 N 196693
Level: 100.78mAOD

Date
13/07/2016

Location: Quakers Yard

Dimensions: m

Depth
1.10m

±

Orientation:
° from North

Scale
1 : 47.62

Logged	Checked
By DG	By TP

Client: Wales & West Utilities

Photo



Photo Description:

(m)	Water Levels	Samples		PID Result (ppmv)	Legend	Depth (m) (thickness)	Elevation (mAOD)	Description
		Type	Depth (m)					
0.5						(0.90)		MADE GROUND: Vegetation over: (Loose) brown, slightly sandy, clayey gravel. Gravel is medium to coarse, sub-angular to angular brick, concrete and slag. Frequent cobbles of limestone in north of pit. At 0.9 m bgl limestone and concrete wall (0.5 m thick). MADE GROUND: (Loose) black slightly sandy, clayey gravel. Gravel is medium to coarse, sub-angular to angular brick, concrete and slag. End of pit at 1.1 m bgl - ingress of perched water. Very strong hydrocarbon odour and tar globules on surface water level same north and south of wall. Trial pit completed at 1.10m
1.0						0.90	99.88	
1.5						1.10	99.68	
2.0								
2.5								
3.0								
3.5								
4.0								
4.5								
5.0								

GENERAL REMARKS:

Summary of Visual and Olfactory Contamination

1.1 m bgl perched water with tar globules on surface with very strong hydrocarbons odour.

BURIED STRUCTURES:

SHORING: N/A

STABILITY: OK



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TRIAL PIT LOG

Pit No
TP16-24
Sheet 1 of 1

Project Name: Quakers Yard Wales & West
Utilities

Project No:
51810-02

Co-ords: E 309851 N 196702
Level: 100.73mAOD

Date
19/07/2016

Location: Quakers Yard

Dimensions: m

Depth
1.20m

±

Orientation:
° from North

Scale
1 : 47.62

Logged	Checked
By DG	By TP

Client: Wales & West Utilities

Photo



Photo Description:

(m)	Water Levels	Samples		PID Result (ppmv)	Legend	Depth (m) (thickness)	Elevation (mAOD)	Description
		Type	Depth (m)					
0.5		TP16-24-1	0.20	PID (ppm) 0.0		(1.00)		MADE GROUND: Vegetation cover over: (Loose) light brown, slightly sandy, clayey gravel. Gravel is coarse, sub-angular to rounded brick, concrete, ash, slag and chert. Frequent brick and concrete metal wood (damp).
1.0		TP16-24-2	1.00	PID (ppm) 0.9		1.00 1.20	99.73 99.53	MADE GROUND: Soft, sandy, gravelly clay. Gravel is coarse, sub-angular brick, concrete and slag. Occasional white plastic. Frequent hair like material, wood and cut metal pipe. Very strong phenolic odour. End of pit at 1.3 m bgl due to water ingress. Trial pit completed at 1.20m
1.5								
2.0								
2.5								
3.0								
3.5								
4.0								
4.5								
5.0								

GENERAL REMARKS:

Summary of Visual and Olfactory Contamination
1.0 - 1.2 m bgl very strong phenolic odour.

BURIED STRUCTURES:

SHORING: N/A

STABILITY: OK



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HAND DUG PIT LOG

Exploratory Hole No.

HP16-01

Sheet 1 of 1

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Project Name: Quakers Yard Wales & West Utilities		Project No: 51810-02	Co-ords: E 309828 N 196651 Level: 99.26 m AOD	Date: 30/06/2016
Location: Quakers Yard			Dimensions: m	Scale: 1 : 8.02
Client: Wales & West Utilities			Depth: 1.10 m	Orientation: ° from North

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
		Type	Depth (m)	Result					
0.1					0.05	MADE GROUND: Grass and leaf litter over:	99.21		
0.2						MADE GROUND: Brown, sandy gravel. Sand is medium grained. Gravel is rounded to sub-angular, fine to coarse sandstone and limestone. Rare fragment of china. Frequent rootlets. Occasional boulder. Black metal pipe at 1.1 m bgl.			
0.3									
0.4									
0.5									
0.6					(1.05)				
0.7									
0.8									
0.9									
1.0									
1.1					1.10	Hand dug pit terminated at 1.10m	98.16		
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination

None.

General Notes

No soil samples. Hand pit to locate gas main only.

Surface and Subsurface Structures

1.1 m bgl - black metal pipe bending east to west.

HAND DUG PIT LOG - PORTRAIT - QUAKERS YARD SECOND VERSION GPJ GINT STD AGS 3 - 1.GDT - 29/11/16



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HAND DUG PIT LOG

Exploratory Hole No.

HP16-02

Sheet 1 of 1

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Project Name: Quakers Yard Wales & West Utilities		Project No: 51810-02	Co-ords: E 309814 N 196643 Level: 98.76 m AOD	Date: 30/06/2016
Location: Quakers Yard			Dimensions: Depth 1.15 m E Orientation: ° from North	Scale: 1 : 8.02
Client: Wales & West Utilities			Logged By: AS	Checked By: TP

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
		Type	Depth (m)	Result					
0.1						MADE GROUND: Grass and leaf litter over:			
0.2									
0.3									
0.4									
0.5					(0.90)				
0.6									
0.7									
0.8									
0.9					0.90	MADE GROUND: Brown, slightly clayey sandy gravel. Gravel is rounded to sub-angular, fine to coarse sandstone and limestone. Black metal pipe at 1.15 m bgl.	97.86		
1.0					(0.25)				1
1.1									
1.2					1.15	Hand dug pit terminated at 1.15m	97.61		
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination

None.

General Notes

To locate gas main only.

Surface andSubsurface Structures

Black metal pipe heading east to west at 1.15 m bgl. 8 diameter.

HAND DUG PIT LOG - PORTRAIT - QUAKERS YARD SECOND VERSION GPJ - GINT STD AGS 3 - 1.GDT - 29/11/16

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HAND DUG PIT LOG

Exploratory Hole No.

HP16-03

Sheet 1 of 1

Advisian, Bull Wharf, Redcliff Street, BS1 6QR, Telephone: 0117 925 1304, E-mail: infoEurope@advisian.com

Project Name: Quakers Yard Wales & West Utilities		Project No: 51810-02	Co-ords: E 309796 N 196650 Level: 99.01 m AOD	Date 30/06/2016
Location: Quakers Yard		Dimensions: m Depth 0.55 m E		Scale 1 : 8.02
Client: Wales & West Utilities		Orientation: ° from North		Logged By AS Checked By TP

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
		Type	Depth (m)	Result					
0.1					(0.10)	MADE GROUND: Decomposed organic material over:	98.91		
0.2					0.10	MADE GROUND: Brown, slightly clayey, slightly gravelly sand. Sand is medium to coarse grained. Gravel of angular to sub-angular, fine to coarse sandstone. Black metal pipe at 0.55 m bgl.			
0.3					(0.45)				
0.4									
0.5					0.55	Hand dug pit terminated at 0.55m	98.46		
0.6									
0.7									
0.8									
0.9									
1.0									
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination

None.

Surface and Subsurface Structures

Black metal pipe at 0.55 m bgl. 20 cm diameter heading north.



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HAND DUG PIT LOG

Exploratory Hole No.

HP16-04

Sheet 1 of 1

Advisian, Bull Wharf, Redcliff Street, BS1 6QR, Telephone: 0117 925 1304, E-mail: infoEurope@advisian.com

Project Name: Quakers Yard Wales & West Utilities		Project No: 51810-02	Co-ords: E 309825 N 196654 Level: 99.33 m AOD	Date: 01/07/2016
Location: Quakers Yard			Dimensions: m Depth 0.90 m E Orientation: ° from North	Scale: 1 : 8.02
Client: Wales & West Utilities			Logged By: AS	Checked By: TP

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
		Type	Depth (m)	Result					
0.1						MADE GROUND: Vegetation cover over: Brown, sandy gravel. Sand is medium grained. Gravel is sub-rounded to sub-angular, fine to coarse sandstone, limestone and red brick. Occasional boulder of sandstone. Yellow (metal?) pipe at 0.9 m bgl.			
0.2									
0.3									
0.4									
0.5					(0.90)				
0.6									
0.7									
0.8									
0.9					0.90		98.43		
1.0						Hand dug pit terminated at 0.90m			1
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination

None.

Surface and Subsurface Structures

Yellow metal (?) pipe at 0.9 m bgl trending north to south.

HAND DUG PIT LOG - PORTRAIT - QUAKERS YARD SECOND VERSION GPJ GINT STD AGS 3 - 1.GDT - 29/11/16



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HAND DUG PIT LOG

Exploratory Hole
No.

SP16-01

Sheet 1 of 1

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Project Name: Quakers Yard Wales & West Utilities		Project No: 51810-02	Co-ords: E 309808 N 196654 Level: 99.81 m AOD	Date: 21/07/2016
Location: Quakers Yard			Dimensions: m Depth 0.05 m E	Scale 1 : 8.02
Client: Wales & West Utilities			Orientation: ° from North	Logged By CV Checked By TP

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
		Type	Depth (m)	Result					
		SP16-01-1	0.00	PID (ppm) 0.0 ppm	0.05	MADE GROUND: Brown, sandy gravel. Sand is medium grained. Gravel is sub-angular to rounded, fine to coarse sandstone and limestone. Frequent rootlets noted. Hand dug pit terminated at 0.05m	99.76		
0.1									
0.2									
0.3									
0.4									
0.5									
0.6									
0.7									
0.8									
0.9									
1.0									
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination

None.

Surface and Subsurface Structures

None.



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HAND DUG PIT LOG

Exploratory Hole
No.

SP16-02

Sheet 1 of 1

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Project Name: Quakers Yard Wales & West Utilities		Project No: 51810-02	Co-ords: E 309801 N 196656 Level: 100.09 m AOD	Date: 21/07/2016
Location: Quakers Yard			Dimensions: m Depth 0.05 m E	Scale: 1 : 8.02
Client: Wales & West Utilities			Orientation: ° from North	Logged By: CV Checked By: TP

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
		Type	Depth (m)	Result					
0.1		SP16-02-1	0.00	PID (ppm) 0.0 ppm	0.05	MADE GROUND: Moss and twig litter over: Brown, sandy gravel. Sand is fine. Gravel is angular to sub-rounded, fine to coarse sandstone, limestone, rare concrete and rare clinker. Rare fragments of glass and ceramic. Rare rootlets noted. Hand dug pit terminated at 0.05m	100.04		
0.2									
0.3									
0.4									
0.5									
0.6									
0.7									
0.8									
0.9									
1.0									
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination
Clinker.
Surface and Subsurface Structures
None.



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HAND DUG PIT LOG

Exploratory Hole
No.

SP16-03

Sheet 1 of 1

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Project Name: Quakers Yard Wales & West Utilities		Project No: 51810-02	Co-ords: E 309803 N 196648 Level: 99.28 m AOD	Date: 21/07/2016
Location: Quakers Yard			Dimensions: m Depth 0.05 m E	Scale 1 : 8.02
Client: Wales & West Utilities			Orientation: ° from North	Logged By CV Checked By TP

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
		Type	Depth (m)	Result					
		SP16-03-1	0.00	PID (ppm) 0.0 ppm	0.05	MADE GROUND: Brown, sandy gravel. Sand is fine. Gravel is sub-angular to rounded, fine to coarse sandstone, limestone, frequent clinker and rare glass. Rare roots and rootlets noted. Hand dug pit terminated at 0.05m	99.23		
0.1									
0.2									
0.3									
0.4									
0.5									
0.6									
0.7									
0.8									
0.9									
1.0									
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination
Clinker.
Surface andSubsurface Structures
None.



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HAND DUG PIT LOG

Exploratory Hole
No.

SP16-04

Sheet 1 of 1

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Project Name: Quakers Yard Wales & West Utilities		Project No: 51810-02	Co-ords: E 309800 N 196651 Level: 99.45 m AOD	Date: 21/07/2016
Location: Quakers Yard			Dimensions: m Depth 0.05 m E	Scale: 1 : 8.02
Client: Wales & West Utilities			Orientation: ° from North	Logged By: CV Checked By: TP

(m)	Water Levels	Samples & In Situ Testing			Depth (m)	Description	Elevation (mAOD)	Legend	(m)
		Type	Depth (m)	Result					
		SP16-04-1	0.00	PID (ppm) 0.0 ppm	0.05	MADE GROUND: Moss and twig litter over: Brown, sandy gravel. Sand is fine. Gravel is sub-angular to rounded, fine to coarse sandstone and limestone. Rare rootlets noted. Hand dug pit terminated at 0.05m	99.40		
0.1									
0.2									
0.3									
0.4									
0.5									
0.6									
0.7									
0.8									
0.9									
1.0									
1.1									
1.2									
1.3									
1.4									
1.5									

SHORING: N/A

STABILITY: OK

REMARKS:

Summary of Visual and Olfactory Contamination

None.

Surface and Subsurface Structures

None.



Appendix C: Chemical laboratory analysis summary

Key	Sample ID	BH2	BH2	BH4	BH4	ENB5A-22	ENB5A-22	HP15-01-1	HP15-01-2	HP15-02-1	HP15-03-1	HP15-03-2	HP15-04	HP15-05	HP15-06	HP15-07	HP15-08-1	HP15-09-1	HP15-09-2	HP15-10-1	HP15-10-2	HP15-11-1	HP15-11-2	HP15-12	HP15-13	HP15-14-1	HP15-14-2	HP15-14-3	HP15-15	HP15-16-1	HP15-17-1	HP15-17-2								
Depth	1.30	0.70	0.30	0.85	0.7	1.5	0.4	0.9	0.3	0.3	1.0	0.2	0.1	0.05	0.15	0.1	0.35	0.50	0.25	1.0	0.2	0.95	0.25	0.1	0.2	1.1	1.1	0.1	0.1	0.7	0.3	1.2								
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil								
Sample Date	07/10/2022	07/10/2022	07/10/2022	07/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022									
Sample Received Date	07/10/2022	07/10/2022	07/10/2022	07/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022	09/10/2022									
J E Sample No																																								
Historical Structures																																								
Test	Method	Units	SOI 1%	SOI 2.5%	SOI 6%	LOD	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG								
Arsenic	TM30PM15	mg/kg	170	170	170	<1	0.5	7.6	34	9.8	17	10	9.9	6.3	13.6	18.7	142	143	178	101	181	117	186	498	379	28.9	31.6	42	4.9	27	12	3.8	8.5	30	26.7	13	3	8.9	29	29
Barium	TM30PM15	mg/kg	22000	22000	22000	<1	0.5	7.6	34	9.8	17	10	9.9	6.3	13.6	18.7	142	143	178	101	181	117	186	498	379	28.9	31.6	42	4.9	27	12	3.8	8.5	30	26.7	13	3	8.9	29	29
Beryllium	TM30PM15	mg/kg	63	63	63	<0.5	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4	
Bismuth	TM30PM15	mg/kg	532	532	532	<1	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4	0.2	0.4	
Chromium	TM30PM15	mg/kg	220	220	220	<0.5	20	18	11	12	16	16	15	42.5	36.7	42.7	28.4	34.3	34.2	30.8	69.1	21.2	47.6	41.7	39.1	46.6	45.7	32.4	31.5	106.6	29.7	95.2	57.9	41.9	32.5	34.4	36.4	36.4		
Copper	TM30PM15	mg/kg	4400	4400	4400	<1	33	49	25	40	16	12	21	112	102	102	11	34	41	32	8	44	66	57	87	86	36	46	42	26	8	33	43	10	8	14	62	62		
Lead	TM30PM15	mg/kg	580	580	580	<1	80	160	54	63	40	36	48	63	81	41	122	132	34	37	25	303	155	113	204	57	103	131	48	119	30	84	95	29	35	35	277	277		
Mercury	TM30PM15	mg/kg	30	30	30	<0.1	0.3	2.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3			
Nickel	TM30PM15	mg/kg	800	800	800	<1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
Selenium	TM30PM15	mg/kg	1800	1800	1800	<1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
Vanadium	TM30PM15	mg/kg	5000	5000	5000	<1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
Water Soluble Boron	TM74PM32	mg/kg	46000	46000	46000	<0.1	0.8	0.5	0.7	0.7	0.5	0.3	0.2	1	0.4	0.4	0.8	0.3	0.5	0.6	1.4	1	0.5	0.3	1	0.6	0.5	0.3	1.1	0.8	0.5	0.1	0.3	0.4	0.3	0.4	0.1	0.1		
Zinc	TM30PM15	mg/kg	17000	17000	17000	<1	0.8	1.30	91	100	75	75	75	53	0.7	111	179	385	73	124	113	73	84	66	219	657	114	214	238	107	163	152	172	100	117	161	64	53	69	41
PAH MS	TM30PM15	mg/kg	1200	1900	3000	<0.04	0.77	130	1.5	9.1	1.3	2.3	0.4	2.51	0.11	0.54	0.4	0.18	4.52	0.38	0.24	0.37	256.97	272.85	0.72	892.71	0.51	80.73	0.3	1.1	0.54	3.04	0.42	0.92	0.52	1.01	3.43	3.43		
Acenaphthylene	TM30PM15	mg/kg	29000	30000	30000	<0.05	0.68	43	1.1	12	5.6	7.1	0.5	0.5	0.05	7.96	0.63	0.05	1.01	0.15	0.1	0.19	15.16	101.29	0.15	62.07	0.07	28.96	0.05	0.12	0.1	0.1	0.15	2.69	1.99	0.60	1.79			
Fluorene	TM30PM15	mg/kg	20000	20000	20000	<0.04	0.86	310	1.9	8.2	5.1	7.4	0.4	0.52	0.04	7.25	0.71	0.04	6.31	0.77	0.13	0.33	128.11	678.49	0.35	670.09	0.24	218.61	0.1	1.58	0.4	1.46	0.23	5.06	2.04	0.79	3.47			
Phenanthrene	TM30PM15	mg/kg	6200	6200	6200	<0.03	7.2	1300	12	600	26	34	1.5	38.2	0.12	26.24	4.67	0.18	20.38	4.59	1.31	3.37	483.39	2657.17	4.79	2528.36	3.17	1505.37	0.85	20.47	3.63	5.73	1.41	56.01	12.9	4.96	41.31			
Pyrene	TM30PM15	mg/kg	30000	30000	30000	<0.04	2.8	630	3.9	220	7.8	11	0.78	3.17	0.04	10.47	2.67	0.06	7.03	1.26	1.24	1.05	877.33	137	696.64	0.45	5.67	1.2	8.96	0.88	178.69	28.49	4.03	2.27	19.46	19.46				
Fluoranthene	TM30PM15	mg/kg	6300	6300	6400	<0.03	16	1400	19	970	48	69	2.61	15.2	0.21	54.46	10.56	0.39	16.59	4.37	1.52	7.63	452.51	2281.72	11.34	2135.56	8.71	2944.69	3.17	33.66	8.19	61.26	4	109.99	20.99	14.15	90.23			
Benz[a]anthracene	TM30PM15	mg/kg	15000	15000	15000	<0.03	11	1100	14	450	32	49	1.81	13.17	0.17	33.05	7.06	0.12	14.86	4.98	1.74	1.25	32	579	1505.86	1.76	22.46	1.59	18.73	2.97	15.39	13.13	10.71	65.61	65.61					
Benz[b]fluoranthene	TM30PM15	mg/kg	49	56	62	<0.06	7.6	110	11	380	30	45	1.75	9.03	0.17	32.31	5.94	0.29	12.24	2.06	3.22	4.36	199.77	833.08	5.75	893.41	4.6	1246.24	1.34	17.45	8.28	43.27	2.97	7.69	10.86	96	96.93			
Benz[k]fluoranthene	TM30PM15	mg/kg	93	110	120	<0.03	6.9	110	11	490	25	37	1.49	9.28	0.16	34.39	1.96	0.36	14.96	3.36	4.36	4.36	199.77	833.08	5.75	893.41	4.6	1246.24	1.34	17.45	8.28	43.27	2.97	7.69	10.86	96	96.93			
Benz[a]pyrene	TM30PM15	mg/kg	11	12	13	<0.04	6.2	120	13	490	25	37	1.49	9.28	0.16	34.39	1.96	0.36	14.96	3.36	4.36	4.36	199.77	833.08	5.75	893.41	4.6	1246.24	1.34	17.45	8.28	43.27	2.97	7.69	10.86	96	96.93			
Benz[b]fluoranthene	TM30PM15	mg/kg	11	12	13	<0.04	6.2	120	13	490	25	37	1.49	9.28	0.16	34.39	1.96	0.36	14.96	3.36	4.36	4.36	199.77	833.08	5.75	893.41	4.6	1246.24	1.34	17.45	8.28	43.27	2.97	7.69	10.86	96	96.93			
Indeno[1,2,3-cd]pyrene	TM30PM15	mg/kg	150	170	180	<0.04	3.8	260	5.5	140	13	21	1.17	8.43	0.12	14.44	3.83	0.23	9.22	1.13	2.76	2.71	114.77	456.07	4.3	410.12	3.17	11.56	4.23	40.56	5.94	51.39	7.17	7.86	14.62	14.62				
Dibenz[a,h]anthracene	TM30PM15	mg/kg	1.1	1.3	1.4	<0.04	1.2	96	1.7	42	4.5	6.8	0.5	2.69	0.04	8.17	1.28	0.05	4.93	0.38	0.64	0.7	38.63	121.34	1.21	130.08	0.95	181.62	0.32	3.29	1.06	13.32	1.33	14.17	2.71	2.32	17.14			
Benzofluoranthene	TM30PM15	mg/kg	1400	1500	1600	<0.04	4	250	5.2	140	13	22	0.4	5.65	0.08	11.92	3.27	0.15	5.68	0.89	2.2	2.06	33.5	33.5	3.09	77.8	2.25	55.22	0.86	4.31	3.1	17.4	3.63	6.17	39.32	39.32				
Coronene	TM30PM15	mg/kg	1.1	1.3	1.4	<0.04	1.2	96	1.7	42	4.5	6.8	0.5	2.69	0.04	8.17	1.28	0.05	4.93	0.38	0.64	0.7	38.63	121.34	1.21	130.08	0.95	181.62	0.32	3.29	1.06	13.32	1.33	14.17	2.71	2.32	17.14			
PAH 16 Total	TM30PM15	mg/kg	1200	1900	3000	<0.04	0.77	130	1.5	9.1	1.3	2.3	0.4	2.51	0.11	0.54	0.4	0.18	4.52	0.38	0.24	0.37	256.97	272.85	0.72	892.71	0.51	80.73	0.3	1.1	0.54	3.04	0.42	0.92	0.52	1.01	3.43			
PAH 17 Total	TM30PM15	mg/kg	1200	1900	3000	<0.04	0.77	130	1.5	9.1	1.3	2.3	0.4	2.51	0.11	0.54	0.4	0.18	4.52	0.38	0.24	0.37	256.97	272.85	0.72	892.71	0.51	80.73	0.3	1.1	0.54	3.04	0.42	0.92	0.52	1.01	3.43			
Benzofluoranthene	TM30PM15	mg/kg	12	15	16	<0.05	7.8	110	11	380	30	45																												

[illegible]

[illegible]

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[illegible]

[illegible]

Key	
<LOD	
No POS Value, Commercial used instead	
Screening Value exceeded	
Outlier	Outlier

Sample ID	TP16-15-1	TP16-16-1	TP16-16-2	TP16-17A-1	TP16-17B-1	TP16-17B-2	TP16-18-1	TP16-18-2	TP16-19-1	TP16-19-2	TP16-20-1	TP16-20-2	TP16-21-1	TP16-21-2	TP16-22-1	TP16-22-2	TP16-24-1	TP16-24-2	TP1	TP2	TP3	TP3	TP4	TP5	WA-018-KEY
Depth	1.0	0.25	1.90	1.10	0.20	1.60	0.60	1.80	0.80	2.10	0.50	1.00	0.40	1.40	3.3	0.80	1.20	0.2	1.0	0.3	0.3	0.6	1.6	2.4	0.8
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Sampled Date	11/07/2016	11/07/2016	11/07/2016	11/07/2016	11/07/2016	11/07/2016	11/07/2016	11/07/2016	11/07/2016	11/07/2016	11/07/2016	11/07/2016	11/07/2016	11/07/2016	11/07/2016	11/07/2016	11/07/2016	11/07/2016	07/11/22	07/11/22	08/11/2022	08/11/2022	08/11/2022	09/07/2016	07/07/2016
Sample Received Date	11/07/2016	11/07/2016	11/07/2016	11/07/2016	11/07/2016	11/07/2016	11/07/2016	11/07/2016	11/07/2016	11/07/2016	11/07/2016	11/07/2016	11/07/2016	11/07/2016	11/07/2016	11/07/2016	11/07/2016	11/07/2016	07/11/22	07/11/22	08/11/2022	08/11/2022	08/11/2022	09/07/2016	07/07/2016
J E Sample No	22-23	24-25	26-27	28-29	30-31	32-33	34-35	36-37	41-42	43-44	45-46	47-48	1-2	3-4	24-25	5-6	7-8	27-28	29-30						43-45
Historical Structures		Tully gas plant mess room	Tully gas plant mess room	Tully gas plant mess room	Potential unidentified tar tank in vicinity	Potential unidentified tar tank in vicinity	Potential unidentified tar tank in vicinity	Potential unidentified tar tank in vicinity	Potential unidentified tar tank in vicinity	Tully gas plant mess room	Tully gas plant mess room	Exhauster house	Exhauster house	Adjacent to Gas holder No.1	Adjacent to Gas holder No.1	Adjacent to Gas holder No.1	Purifiers	Purifiers	Purifiers						Number of exceedance
Test	Method	Units	SOM 3%	SOM 2.5%	SOM 6%	LOD	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	Count
trans-1,2-Dichloroethene	TM15PM10	mg/kg	46	46	46	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	27
1,1-Dichloroethene	TM15PM10	mg/kg	3.6	3.6	3.6	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	27
cis-1,2-Dichloroethene	TM15PM10	mg/kg	0.003	0.003	0.003	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	27
2,2-Dichloroethene	TM15PM10	mg/kg	2.5	2.5	2.5	<0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	27
Bromochloroethane	TM15PM10	mg/kg	150	150	150	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	27
Chloroform	TM15PM10	mg/kg	0.32	0.32	0.32	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	27
1,1,1-Trichloroethane	TM15PM10	mg/kg	8100	8100	8100	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	27
1,1-Dichloropropane	TM15PM10	mg/kg	-	-	-	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	27
1,2-Dichloropropane	TM15PM10	mg/kg	0.65	0.65	0.65	<0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	27
1,2-Dichloroethane	TM15PM10	mg/kg	0.46	0.46	0.46	<0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	27
Benzene	TM15PM10	mg/kg	50	100	100	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	27
Trichloroethene (TCE)	TM15PM10	mg/kg	-	-	-	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	27
1,2-Dichloropropane	TM15PM10	mg/kg	2.5	2.5	2.5	<0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	27
Dibromochloroethane	TM15PM10	mg/kg	24	24	24	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	27
Bromodichloroethane	TM15PM10	mg/kg	0.29	0.29	0.29	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	27
cis-1,3-Dichloropropene	TM15PM10	mg/kg	1.8	1.8	1.8	<0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	27
Toluene	TM15PM10	mg/kg	87000	87000	87000	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	27
trans-1,3-Dichloropropene	TM15PM10	mg/kg	-	-	-	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	27
1,1,2-Trichloroethane	TM15PM10	mg/kg	1.2	1.2	1.2	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	27
Tetrachloroethene (PCE)	TM15PM10	mg/kg	-	-	-	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	27
1,3-Dichlorobenzene	TM15PM10	mg/kg	1600	1600	1600	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	27
Dibromochloroethane	TM15PM10	mg/kg	8.3	8.3	8.3	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	27
1,2-Dichlorobenzene	TM15PM10	mg/kg	0.036	0.036	0.036	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	27
Chlorobenzene	TM15PM10	mg/kg	280	280	280	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	27
1,1,1,2-Tetrachloroethane	TM15PM10	mg/kg	2	2	2	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	27
Ethylbenzene	TM15PM10	mg/kg	17000	17000	17000	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	27
p,m-Xylene	TM15PM10	mg/kg	17000	17000	17000	<0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	27
o-Xylene	TM15PM10	mg/kg	17000	17000	17000	<0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	27
Styrene	TM15PM10	mg/kg	600	600	600	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	27
Bromoforn	TM15PM10	mg/kg	19	19	19	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	27
Isopropylbenzene	TM15PM10	mg/kg	-	-	-	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	27
1,2,2,2-Tetrachloroethane	TM15PM10	mg/kg	0.05	0.05	0.05	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	27
Bromobenzene	TM15PM10	mg/kg	290	290	290	<0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	27
1,2,3-Trichloropropane	TM15PM10	mg/kg	0.0051	0.0051	0.0051	<0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	27
Propylbenzene	TM15PM10	mg/kg	0.004	0.004	0.004	<0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	27
2-Chlorotoluene	TM15PM10	mg/kg	1600	1600	1600	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	27
1,2,5-Trimethylbenzene	TM15PM10	mg/kg	270	270	270	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	27
4-Chlorotoluene	TM15PM10	mg/kg	1600	1600	1600	<0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	27
tert-Butylbenzene	TM15PM10	mg/kg	7800	7800	7800	<0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	27
1,2,4-Trimethylbenzene	TM15PM10	mg/kg	300	300																					

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Element Materials Technolo

Report: EMT Job No: Client: Client ref: Location: Contact	Liqui 2314701 Worley 3050101 WWU (C Mike Eli	Sample ID Depth Sample Type Sample Date Received Date EMT Sample No Batch Number	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-03	MW16-03	MW16-03	MW16-03	MW16-03	MW16-03	MW16-03
			N/A																			
			MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-03	MW16-03	MW16-03	MW16-03	MW16-03
			MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-03	MW16-03	MW16-03	MW16-03	MW16-03
			MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-02	MW16-03	MW16-03	MW16-03	MW16-03	MW16-03
Test																						
Method Units																						
LOD																						
Dissolved Arsenic																						
Dissolved Barium																						
Dissolved Beryllium																						
Dissolved Boron																						
Dissolved Cadmium																						
Total Dissolved Chromium																						
Dissolved Copper																						
Dissolved Lead																						
Dissolved Mercury																						
Dissolved Nickel																						
Dissolved Selenium																						
Dissolved Vanadium																						
Dissolved Zinc																						
PAH MS																						
Naphthalene																						
Acenaphthylene																						
Acenaphthene																						
Fluorene																						
Phenanthrene																						
Anthracene																						
Fluoranthene																						
Pyrene																						
Benzo(a)anthracene																						
Chrysene																						
Benzo(k)fluoranthene																						
Benzo(a)pyrene																						
Indeno(1,2,3cd)pyrene																						
Dibenzo(ah)anthracene																						
Benzo(ghi)perylene																						
PAH 16 Total																						
Benzo(k)fluoranthene																						
Benzo(a)fluoranthene																						
PAH Surrogate % Recovery																						
MTBE																						
Benzene																						
Toluene																						
Ethylbenzene																						
m,p-Xylene																						
o-Xylene																						
Xylenes (sum of isomers)																						
TPH CWG																						
Aliphatics																						
>C5-C6																						
Aliphatic EC8-EC8																						
Aliphatic EC8-EC10																						
C10-C12																						
C12-C16																						
>C16-C21																						
>C21-C35																						
Total aliphatics C5-35																						
Aromatics																						
Aromatic EC5-EC7 (Benzene)																						
Aromatic EC7-EC8 (Toluene)																						
Aromatic EC8-EC10 (Xylenes)																						
Aromatic EC10-EC12 (naphthalene)																						
Aromatic EC12-EC16																						
EC16-EC21																						
EC21-EC35																						
Total aromatics C5-35																						
Total aliphatics and aromatics (C5-35)																						
Phenol																						
Sulphate as SO4																						
Free Cyanide																						
Total Cyanide																						
Complex Cyanide																						
Ammoniacal Nitrogen as N																						
Ammoniacal Nitrogen as NH4																						
Hexavalent Chromium																						
Chromium III																						
Thiocyanate																						
pH																						
Total Organic Carbon																						

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Element Materials Technolo

Report:		Liqui	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
EMT Job No:		Sample ID	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
Client:		Sample Date	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
Client ref:		Sample Date	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
Location:		Sample Date	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
Contact:		Sample Date	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08
		Batch Number	Depth	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-06	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08	MW16-08		

		Sample ID	MW16-08	MW16-08	MW16-08	MW16-08	MW16-09	MW16-09	MW16-09	MW16-09	MW16-09	MW16-09	MW16-09	MW16-09	MW16-09	MW16-09	MW16-09	MW16-09	MW16-09	MW16-10	MW16-10			
Report:	Liqui	Depth																						
Client Job No:	2317-4701	Sample Type	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water			
EMT Location:	30500	Received Date	17/09/2018	01/09/2016	11/09/2017	26/03/2019	21/09/2021	16/03/2022	19/03/2020	21/03/2020	17/03/2021	26/03/2019	11/09/2017	17/09/2018	04/09/2020	11/09/2017	13/09/2018	07/09/2016	04/08/2016	01/09/2016	18/08/2016	27/09/2019	13/03/2018	26/09/2019
Contact:	WWU (Mike Eli)	Batch Number	55-64	65-72	57-64	19-27	25-32	25-32	10-18	9-16	10-18	49-56	49-56	57-64	49-56	57-64	43-48	65-72	73-80	57-63	28-36	15/03/2018	28/09/2019	
Test	Method Units	LOD					Gasholder 2	Gasholder 4	Gasholder 1		Gasholder 1	Gasholder 1	Gasholder 1	Gasholder 1	Gasholder 1	Gasholder 1	Gasholder 2			Gasholder 1	Gasholder 3	Gasholder 3		
Dissolved Arsenic	TMSDPH42 mg/l	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.008	0.0085	0.0071	0.0042	0.0025	0.0025	0.0029	
Dissolved Barium	TMSDPH42 mg/l	0.003	0.0047	0.042	0.064	0.033	0.078	0.067	0.062	0.064	0.06	0.062	0.09	0.08	0.075	0.056	0.094	0.07	0.095	0.073	0.103	0.076	0.076	
Dissolved Beryllium	TMSDPH42 mg/l	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	
Dissolved Boron	TMSDPH42 mg/l	0.012	0.047	0.046	0.045	0.03	0.024	0.019	0.029	0.03	0.036	0.046	0.053	0.047	0.061	0.029	0.073	0.056	0.056	0.041	0.047	0.018	0.055	
Dissolved Cadmium	TMSDPH42 mg/l	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	
Total Dissolved Chromium	TMSDPH42 mg/l	0.0015	0.0015	0.0015	0.0018	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0042	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	
Dissolved Copper	TMSDPH42 mg/l	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.009	0.007	0.007	0.007	
Dissolved Lead	TMSDPH42 mg/l	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	
Dissolved Mercury	TMSDPH42 mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	
Dissolved Nickel	TMSDPH42 mg/l	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.007	0.003	
Dissolved Selenium	TMSDPH42 mg/l	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	
Dissolved Vanadium	TMSDPH42 mg/l	0.0015	0.0023	0.0015																				

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		Sample ID		MW16-10	MW16-10	MW16-10	MW16-10	MW16-10	MW16-10	MW16-10	MW16-10	MW16-10	MW16-10	MW16-10	MW16-10A	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11
Report:		Liquid	Depth			N/A														N/A				
EMT Job No:	2314701	Sample	Sample Date	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water
Client:	Worley	Sample Type	Sample Date	03/09/2020	20/09/2021	15/03/2022	17/09/2018	25/03/2019	18/03/2020	16/03/2021	03/08/2016	18/08/2016	01/09/2016	11/09/2017	07/09/2017	Liquid	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water
Client ref:	30501	Received Date	Sample Date	05/09/2020	22/09/2021	17/03/2022	19/09/2018	26/03/2019	20/03/2020	18/03/2021	05/08/2016	20/08/2016	03/09/2016	13/09/2017	09/09/2016	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water
Location:	WUU (	EMT Sample No	Batch Number	25-32	1-8	1-8	9-16	10-18	12-20	9-16	1-8	1-7	9-16	9-16	49-54	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water
Contact	Mike Eli	Batch Number	Batch Number	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
				Gasholder 3	Gasholder 3	Gasholder 3	Gasholder 3	Gasholder 3	Gasholder 3	Gasholder 3	Gasholder 3					Gasholder 3	Gasholder 3		Adjacent to ga	Adjacent to ga	Adjacent to ga	Adjacent to ga	Adjacent to ga	Adjacent to ga
Test		Method	Units	LOD																				
Dissolved Arsenic		TMSDFP64	mg/l	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0027	0.0025	0.0025	0.0025	0.0025	0.0025
Dissolved Barium		TMSDFP64	mg/l	0.003	0.086	0.083	0.061	0.07	0.081	0.097	0.082	0.061	0.081	0.097	0.074	0.091	0.316	0.082	0.056	0.073	0.057	0.072	0.058	0.071
Dissolved Beryllium		TMSDFP64	mg/l	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Dissolved Boron		TMSDFP64	mg/l	0.012	0.038	0.03	0.016	0.036	0.024	0.02	0.025	0.012	0.013	0.012	0.038	0.031	0.027	0.012	0.029	0.042	0.042	0.027	0.031	0.034
Dissolved Cadmium		TMSDFP64	mg/l	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Dissolved Chromium		TMSDFP64	mg/l	0.0015	0.0015	0.0015	0.0036	0.0064	0.0015	0.0015	0.0027	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0075	0.0015	0.0015	0.0019	0.0019
Dissolved Copper		TMSDFP64	mg/l	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
Dissolved Lead		TMSDFP64	mg/l	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Dissolved Mercury		TMSDFP64	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Dissolved Nickel		TMSDFP64	mg/l	0.002	0.002	0.002	0.002	0.002	0.003	0.002	0.003	0.002	0.002	0.002	0.006	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.005
Dissolved Selenium		TMSDFP64	mg/l	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Dissolved Vanadium		TMSDFP64	mg/l	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0016	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015
Dissolved Zinc		TMSDFP64	mg/l	0.003	0.003	0.003	0.003	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.005	0.003	0.004	0.003	0.003	0.003	0.003	0.008
PAH MS																								
Naphthalene		TMSDFP62	mg/l	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Acenaphthylene		TMSDFP62	mg/l	0.000013	0.000013	0.000013	0.000005	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000086	0.000013	0.000013	0.000013	0.000013	0.000013	0.000005	0.000013
Acenaphthene		TMSDFP62	mg/l	0.000013	0.000013	0.000013	0.000005	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000005	0.000013	0.000013
Phenanthrene		TMSDFP62	mg/l	0.000011	0.000011	0.000011	0.000005	0.000011	0.000022	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000051	0.000011	0.000011	0.000011	0.000011	0.000005	0.000011	0.000011
Anthracene		TMSDFP62	mg/l	0.000013	0.000013	0.000013	0.000005	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000073	0.000013	0.000013	0.000013	0.000013	0.000005	0.000013	0.000013
Fluoranthene		TMSDFP62	mg/l	0.000012	0.000012	0.000012	0.000005	0.000012	0.000012	0.000014	0.000012	0.000012	0.000012	0.000012	0.000012	0.000012	0.000017	0.000012	0.000012	0.000019	0.000012	0.000012	0.000008	0.000012
Pyrene		TMSDFP62	mg/l	0.000013	0.000013	0.000013	0.000006	0.000013	0.000014	0.000013	0.000015	0.000013	0.000013	0.000013	0.000013	0.000013	0.000021	0.000013	0.000013	0.000022	0.000013	0.000013	0.000007	0.000013
Benzo(a)anthracene		TMSDFP62	mg/l	0.000015	0.000015	0.000015	0.000005	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015	0.000005	0.000015	0.000035
Chrysene		TMSDFP62	mg/l	0.000011	0.000011	0.000011	0.000005	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000005	0.000011	0.000043
Benzo(k)fluoranthene		TMSDFP62	mg/l	0.000018	0.000018	0.000018	0.000008	0.000018	0.000018	0.000018	0.000018	0.000018	0.000018	0.000018	0.000018	0.000018	0.000018	0.000018	0.000018	0.000018	0.000018	0.000009	0.000018	0.000072
Dibenz(a,h)pyrene		TMSDFP62	mg/l	0.000016	0.000016	0.000016	0.000008	0.000016	0.000016	0.000016	0.000016	0.000016	0.000016	0.000016	0.000016	0.000016	0.000016	0.000016	0.000016	0.000016	0.000016	0.000008	0.000016	0.000041
Indeno(1,2,3-cd)pyrene		TMSDFP62	mg/l	0.000011	0.000011	0.000011	0.000005	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000005	0.000011	0.000026
Benzo(a)anthracene		TMSDFP62	mg/l	0.00001	0.00001	0.00001	0.000005	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.000005	0.00001	0.00001
Benzo(g,h)perylene		TMSDFP62	mg/l	0.000011	0.000011	0.000011	0.000005	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000011	0.000005	0.000011	0.000024
PAH 16 Total		TMSDFP62	mg/l	0.000195	0.000195	0.000195	0.000173	0.000195	0.000195	0.000195	0.000195	0.000195	0.000195	0.000195	0.000195	0.000225	0.000195	0.00022812	0.000195	0.000195	0.000195	0.000173	0.000195	0.000413
Benzo(b)fluoranthene		TMSDFP62	mg/l	0.00001	0.00001	0.00001	0.000005	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.000005	0.00001	0.00005
Benzo(k)fluoranthene		TMSDFP62	mg/l	0.00001	0.00001	0.00001	0.000005	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.000005	0.00001	0.00002
PAH Surrogate % Recovery		TMSDFP62	%	0	84	85	91	72	73	85	92	85	70	77	80	70	85	73	81	76	84	87	88	76
MTBE		TMSDFP62	mg/l	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Benzene		TMSDFP62	mg/l	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.12	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Toluene		TMSDFP62	mg/l	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Ethylbenzene		TMSDFP62	mg/l	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.036	0.005	0.005	0.005	0.005	0.005	0.005	0.005
m,p-Xylene		TMSDFP62	mg/l	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.032	0.005	0.005	0.005	0.005	0.005	0.005	0.005
o-Xylene		TMSDFP62	mg/l	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.06	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Xylenes (sum of isomers)		TMSDFP62	mg/l	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.09	0.01	0.01	0.01	0.01	0.01	0.01	0.01
TPH CWG																								
Aliphatics																								
>C5-C6																								

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Report:	Liquid	Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
EMT Job No:	Sample Type	Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
Client ref:	Received Date	Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
Location:	EMT Sample No	Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
Contact:	Batch Number	Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
23121701	Sample	Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
30500	Sample	Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
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Mike El	Batch Number	Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
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		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
		Sample ID	Depth	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-11	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12	MW16-12
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Report:		Liqui	Sample ID	MW16-12	MW16-12	MW16-12	MW16-12A	MW16-13	MW16-13	MW16-13	MW16-13	MW16-13	MW16-13	MW16-13	MW16-13	MW16-13	MW16-13	MW16-13	MW16-13	MW16-13			
EMT Job No:		Sample	Depth	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Liquid	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water			
Client:		Sample Date	Sample Type	18/08/2016	17/09/2018	11/09/2017	03/08/2016	19/08/2016	20/08/2016	22/09/2021	03/08/2016	01/09/2016	16/03/2022	07/09/2016	26/03/2019	11/09/2017	11/09/2017	18/09/2018	14/03/2018	17/03/2021			
Client ref:		Received Date	Received Date	20/08/2016	19/09/2018	13/09/2017	05/08/2016	20/08/2016	20/08/2016	22/09/2021	05/08/2016	03/09/2016	18/03/2022	09/09/2016	27/03/2019	13/09/2017	13/09/2017	19/09/2018	15/03/2018	18/03/2021			
Location:		EMT Sample No	EMT Sample No	22-28	25-32	25-32	89-96	43-49	25-32	49-56	57-64	49-56	67-72	37-45	73-81	73-81	73-80	89-96	25-32	27-35			
Contact:		Batch Number	Batch Number	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
		Mike Eli	Mike Eli	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
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Report:	Liqui	Depth
EMT Job No:	21J14701	Sample Type
Client:	Worley	Sampled Date
Client ref:	305001	Sample Received Date
Location:	WWU C	EMT Sample No
Contact	Mike Eli	Batch Number

Test	Method	Units	LOD	No. Exceedances	Count	Min	Max	Average	Standard Deviation	95% Confidence	95% UCL	Degrees of freedom	Tn	Level of significance	Tcrit	Outlier if >
Dissolved Arsenic	TM03P04	mg/l	0.0025	0	165	0.00024	0.0102	0.002991333	0.001392538	0.000212478	0.003203811	164	5.176639403	0.05	3.698724265	0.008141947
Dissolved Barium	TM03P04	mg/l	0.003	0	161	0.02	0.368	0.087850932	0.075523779	0.011665916	0.099516848	160	3.709415413	1.05	3.684723553	0.366135177
Dissolved Beryllium	TM03P04	mg/l	0.0005	0	161	0.0005	0.00054	0.000545963	0.000431089	6.65889E-05	0.000612552	160	11.25994194	2.05	3.684723553	0.002134407
Dissolved Boron	TM03P04	mg/l	0.012	0	161	0.012	0.111	0.040508696	0.019599592	0.00308315	0.043691846	160	3.52662697	3.05	3.684723553	0.1141556
Dissolved Cadmium	TM03P04	mg/l	0.0005	161	165	0.00002	0.0005	0.000488485	7.30679E-05	1.11489E-05	0.000499634	164	0.15759524	4.05	3.698724265	0.000758143
Total Dissolved Chromium	TM03P04	mg/l	0.0015	17	165	0.0002	0.0677	0.002737576	0.006284732	0.000958943	0.003696519	164	10.33654586	5.05	3.698724265	0.025893068
Dissolved Copper	TM03P04	mg/l	0.007	162	165	0.0005	0.017	0.006953333	0.001240993	0.000189354	0.007142688	164	8.095664793	6.05	3.698724265	0.011543426
Dissolved Lead	TM03P04	mg/l	0.005	161	165	0.0002	0.032	0.005047273	0.002230357	0.000340315	0.005387587	164	12.0848992	7.05	3.698724265	0.013296748
Dissolved Mercury	TM03P04	mg/l	0.001	161	165	0.00005	0.001	0.00097697	0.000146111	2.2294E-05	0.000999264	164	0.157622081	8.05	3.698724265	0.001517394
Dissolved Nickel	TM03P04	mg/l	0.002	15	165	0.0007	0.027	0.002651155	0.002567999	0.000391833	0.003043348	164	9.48150087	9.05	3.698724265	0.012149835
Dissolved Selenium	TM03P04	mg/l	0.003	0	165	0.0006	0.004	0.002948485	0.000374426	5.7131E-05	0.00309616	164	2.808340592	10.05	3.698724265	0.004333363
Dissolved Vanadium	TM03P04	mg/l	0.0015	2	161	0.0015	0.0491	0.00213919	0.004347281	0.000671511	0.00280443	160	10.80378244	11.05	3.684723553	0.018151449
Dissolved Zinc	TM03P04	mg/l	0.003	11	165	0.002	0.234	0.00803697	0.02369678	0.003615725	0.011652695	164	9.535600816	12.05	3.698724265	0.095648823
PAH MS				0	0	0	0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	-1	#DIV/0!	13.05	#N/A	#N/A
Naphthalene	TM03P03	mg/l	0.0001	54	165	0.00001	12.0321	1.004166727	2.844342529	0.433998286	1.438165013	164	3.877146708	15.05	3.698724265	11.52460546
Acenaphthylene	TM03P03	mg/l	0.000013	0	165	0.000005	0.118839	0.010327691	0.027282605	0.004182861	0.014490552	164	3.977307435	16.05	3.698724265	0.111238525
Acenaphthene	TM03P03	mg/l	0.000013	0	165	0.000005	0.205212	0.020352176	0.043138849	0.00581949	0.026934125	164	4.285427158	17.05	3.698724265	0.17990496
Fluorene	TM03P03	mg/l	0.000014	0	165	0.000005	0.108054	0.010821527	0.02324702	0.0035471	0.014368627	164	4.182577867	18.05	3.698724265	0.09805845
Phenanthrene	TM03P03	mg/l	0.000011	0	165	0.000005	0.10997	0.009937103	0.023846176	0.003638521	0.013575624	164	4.194924006	19.05	3.698724265	0.098137534
Anthracene	TM03P03	mg/l	0.000013	74	165	0.000005	0.009916	0.001224885	0.002303463	0.000351469	0.001576354	164	3.773065374	20.05	3.698724265	0.009744758
Fluoranthene	TM03P03	mg/l	0.000012	163	165	0.000005	0.017835	0.001831248	0.003293395	0.000502516	0.002333764	164	4.859348159	21.05	3.698724265	0.014012607
Pyrene	TM03P03	mg/l	0.000013	0	165	0.000005	0.011406	0.001020067	0.001898665	0.000289704	0.001309771	164	5.470123847	22.05	3.698724265	0.008042705
Benzo(a)anthracene	TM03P03	mg/l	0.000015	165	165	0.000005	0.005315	0.000246991	0.000252124	0.000389205	0.000389205	164	6.142027306	23.05	3.698724265	0.00309861
Chrysene	TM03P03	mg/l	0.000011	0	165	0.000005	0.004181	0.000216618	0.00063758	9.72838E-05	0.000313902	164	6.217859598	24.05	3.698724265	0.00257485
Benzo(k)fluoranthene	TM03P03	mg/l	0.000018	0	161	0.000008	0.006537	0.000314851	0.001023176	0.000158047	0.000472898	160	6.08120802	25.05	3.684723553	0.004084973
Benzo(a)pyrene	TM03P03	mg/l	0.000016	165	165	0.000005	0.003409	0.000189927	0.000632547	9.65159E-05	0.000286443	164	5.089063213	26.05	3.698724265	0.002529545
Indeno(1,2,3cd)pyrene	TM03P03	mg/l	0.000011	165	165	0.000005	0.0022	0.000124309	0.000420373	6.41418E-05	0.000188451	164	4.937732266	27.05	3.698724265	0.001679154
Dibenzo(ah)anthracene	TM03P03	mg/l	0.00001	0	165	0.000005	0.002	7.87818E-05	0.00029607	4.51753E-05	0.000123957	164	6.489064756	28.05	3.698724265	0.001173864
Benzo(ghi)perylene	TM03P03	mg/l	0.000011	165	165	0.000005	0.0022	0.000111733	0.000377351	5.75774E-05	0.000169311	164	5.534011685	29.05	3.698724265	0.001507452
PAH 16 Total	TM03P03	mg/l	0.000195	0	163	0.00016	12.500334	1.061215564	2.972906195	0.456389343	1.517604907	162	3.847789901	30.05	3.691767122	12.03649291
Benzo(b)fluoranthene	TM03P03	mg/l	0.000011	165	165	0.000008	0.004711	0.000318903	0.000268333	0.000160696	0.00304126	164	4.076265112	38.05	3.698724265	0.002769876
Benzo(e)fluoranthene	TM03P03	mg/l	0.00001	165	165	0.000008	0.002	0.000112897	0.00037945	5.78976E-05	0.000170795	164	4.973257767	32.05	3.698724265	0.001516378
PAH Surrogate % Recovery	TM03P03	%	0	0	161	60	116	81.60248447	8.255455191	1.275193756	82.87767823	160	4.166640692	33.05	3.684723553	112.0215547
MTBE	TM03P02	mg/l	0.005	0	0	0	0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	-1	#DIV/0!	34.05	#N/A	#N/A
Benzene	TM03P02	mg/l	0.005	47	165	0.001	2.202	0.145945455	0.37631686	0.057419551	0.203365006	164	5.463625912	36.05	3.698724265	1.537837754
Toluene	TM03P02	mg/l	0.005	15	165	0.001	1.287	0.082375798	0.251387359	0.038357435	0.120733192	164	4.791904602	37.05	3.698724265	1.012188282
Ethylbenzene	TM03P02	mg/l	0.005	165	165	0.001	0.391	0.039449091	0.08624374	0.011315272	0.052608863	164	4.076265112	38.05	3.698724265	0.358439552
m,p-Xylene	TM03P02	mg/l	0.005	35	165	0.001	1.899	0.140969697	0.410781782	0.062675261	0.203644958	164	4.77018866	39.05	3.698724265	1.660264267
o-Xylene	TM03P02	mg/l	0.005	32	165	0.001	0.677	0.061187879	0.150152875	0.022910775	0.084098653	164	4.101234296	40.05	3.698724265	0.616561961
Xylenes (sum of isomers)	TM03P02	mg/l	0.01	41	164	0.001	2.57	0.201786585	0.56129847	0.085905313	0.287691899	163	4.219169551	41.05	3.695256364	2.27592833
TPH CWG				0	0	0	0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	-1	#DIV/0!	42.05	#N/A	#N/A
Aliphatics				0	0	0	0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	-1	#DIV/0!	43.05	#N/A	#N/A
>C5-C6	TM03P02	ug/l	10	0	0	0	0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	-1	#DIV/0!	44.05	#N/A	#N/A
Aliphatic EC6-EC8	TM03P02	ug/l	10	42	164	1	8.353858537	5.254861509	0.386423677	8.740082214	163	0.652052185	45.05	3.695256364	17.6826691	
Aliphatic EC8-EC10	TM03P02	ug/l	10	44	164	1	793	54.28585537	133.7910076	20.4763758	74.76296117	163	5.521398095	46.05	3.695256364	548.6786577
>C10-C12	TM03P02	ug/l	5	2	164	5	835	76.3902439	173.2963946	26.52257551	102.9128194	163	4.377527632	47.05	3.695256364	716.764849
>C12-C16	TM03P02	ug/l	10	8	164	10	100	6.182262829	9.607070629	1.470337895	7.653264725	163	9.765419324	48.05	3.695256364	41.68351571
>C16-C21	TM03P02	ug/l	10	7	164	10	650	17.82317073	53.67085051	8.214188115	26.03735885	163	11.7787472	49.05	3.695256364	216.1507226
>C21-C35	TM03P02	ug/l	10	2	164	10	460	17.0304878	42.33309029	6.47897255	23.50846035	163	10.46390682	50.05	3.695256364	173.4621091
Total aliphatics C5-35	TM03P02	ug/l	10	0	164	8	67	10.50146341	5.40529779	0.827267175	11.41873059	163	10.43578703	51.05	3.695256364	30.56542447
Aromatics				0	1	0	1440	141.4146341	318.1061508	48.68534295	190.0999771	163	4.082239097	52.05	3.695256364	1316.898412
Aromatic EC5-EC7 (Benzene)	TM03P02	ug/l	10	46	164	1	2202	143.0243902	370.4945599	56.70325664	199.7276469	163	5.557370695	54.05	3.695256364	1512.09677
Aromatic EC7-EC8 (Toluene)	TM03P02	ug/l	10	14	164	1	1287	81.06707317	245.2646189	37.53713047	118.6042036	163	4.916864618	55.05	3.695256364	987.3827172
Aromatic EC8-EC10 (Xylenes)	TM03P02	ug/l	10	42	164	1	2960	222.2317073	619.7928411	94.85772892	317.0894362	163	4.417231228	56.05	3.695256364	2512.525148
Aromatic EC10-EC12 (naphthalene)	TM03P02	ug/l	5	164	164	5	28413	1419.676829	4584.780949	701.690675	2121.367504	163	5.887579929	57.05	3.695256364	18361.65476
Aromatic EC12-EC16	TM03P02	ug/l	10	47	164	10	2120	180.9268293	415.6977907	63.62149694	244.5483262	163	4.664622267	58.05	3.695256364	1717.036736
>EC16-EC21	TM03P02	ug/l	10	164	164	10	1310	88.13414634	202.4451905	30.9837251	119.1178714	163	6.035539053	59.05	3.695256364	836.221025
>EC21-EC35	TM03P02	ug/l	10	164	164	10	370	17.98780488	49.51200739	7.577687679	25.56549256	163	7.109632869	60.05	3.695256364	200.9473653
Total aliphatics C5-35	TM03P02	ug/l	10	0	164	10	35217	1974.640244	5967.278322	913.276862	2887.917106	163	5.570774223	61.05	3.695256364	24025.26311
Total aromatics and aromatics(C5-35)	TM03P02	ug/l	10	0	161	0	36220	2096.031056	6262.90152	967.410384	3063.44142	160	5.448587821	62.05	3.684723553	25173.0918
Phenol	TM0															

Report: Job No: Client: Client ref: Location: Contact	Liquid Sample ID Sample Type Sample Received Date Batch Number EMT Sample No Sent Job No	Sample ID																											
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Report:	Liquid	Sample ID	Depth																													
	MT Job No:	SW19 - C	SW19 - E	SW19 - D	SW19 - A	SW19-B	SW19-C	SW19-E	SW19-D	SW19-A	SW19-B	SW19-C	SW19-E	SW19-D	SW19-A	SW19-B	SW19-C	SW19-E	SW19-D	SW19-A	SW19-B	SW19-C	SW19-E	SW19-D	SW19-A	SW19-B	SW19-C	SW19-E	SW19-D	SW19-A		
	Client ref:	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water	Surface Water		
	Location:	Worley Pans	Worley Pans	Worley Pans	Worley Pans	Worley Pans	Worley Pans	Worley Pans	Worley Pans	Worley Pans	Worley Pans	Worley Pans	Worley Pans	Worley Pans	Worley Pans	Worley Pans	Worley Pans	Worley Pans	Worley Pans	Worley Pans	Worley Pans	Worley Pans	Worley Pans	Worley Pans	Worley Pans	Worley Pans	Worley Pans	Worley Pans	Worley Pans	Worley Pans		
	Contact:	SS0501-000	SS0501-000	SS0501-000	SS0501-000	SS0501-000	SS0501-000	SS0501-000	SS0501-000	SS0501-000	SS0501-000	SS0501-000	SS0501-000	SS0501-000	SS0501-000	SS0501-000	SS0501-000	SS0501-000	SS0501-000	SS0501-000	SS0501-000	SS0501-000	SS0501-000	SS0501-000	SS0501-000	SS0501-000	SS0501-000	SS0501-000	SS0501-000	SS0501-000	SS0501-000	
	EMT Sample No	Batch Number	Received Date	Sample Type	Sample Depth	Sample Received Date	Sample Type	Sample Depth	Sample Received Date	Sample Type	Sample Depth	Sample Received Date	Sample Type	Sample Depth	Sample Received Date	Sample Type	Sample Depth	Sample Received Date	Sample Type	Sample Depth	Sample Received Date	Sample Type	Sample Depth	Sample Received Date	Sample Type	Sample Depth	Sample Received Date	Sample Type	Sample Depth	Sample Received Date	Sample Type	Sample Depth
EQM Job No	Units	SoBRA	EQA	LOD	Units	SoBRA	EQA	LOD	Units	SoBRA	EQA	LOD	Units	SoBRA	EQA	LOD	Units	SoBRA	EQA	LOD	Units	SoBRA	EQA	LOD	Units	SoBRA	EQA	LOD	Units	SoBRA	EQA	LOD
Dissolved Arsenic *	TM30/PM14	mg/l	None	0.05	0.0025	0.0025	0.0025	0.0026	0.0029	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	
Dissolved Barium *	TM30/PM14	mg/l	None	None	0.003	0.028	0.028	0.038	0.029	0.025	0.025	0.024	0.039	0.027	0.026	0.026	0.025	0.03	0.026	0.029	0.03	0.038	0.031	0.024	0.026	0.044	0.031	0.025	0.044	0.031	0.025	
Dissolved Beryllium	TM30/PM14	mg/l	None	None	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	
Dissolved Cadmium *	TM30/PM14	mg/l	None	0.00015	0.0005	0.0023	0.025	0.031	0.031	0.026	0.023	0.024	0.031	0.027	0.024	0.014	0.022	0.033	0.024	0.014	0.024	0.019	0.038	0.019	0.025	0.022	0.031	0.034	0.022	0.031	0.034	
Total Dissolved Chromium *	TM30/PM14	mg/l	None	0.0034	0.0015	0.0065	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	
Dissolved Copper *	TM30/PM14	mg/l	None	0.001	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	
Dissolved Lead *	TM30/PM14	mg/l	None	0.0012	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	
Dissolved Mercury *	TM30/PM14	mg/l	0.095	0.00007	0.001	0.001	0.0																									

[illegible]



Appendix D: P20 spreadsheets

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Aliphatic >EC6-EC8
0.01

mg/l
from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

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 contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

2.35E-03
1.97E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

3.00E+01
5.20E+00
4.03E+00
1.59E-02
8.00E+01
1.00E-10

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
4.17E+00

m
m

Calculated Parameters

Dilution Factor

DF

4.79E+00

Level 2 Remedial Target

4.79E-02

mg/l

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

or

1.55E+00

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)

C_c

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Quakers Yard
Completed by: Rebekah Wain
Date: 13-Mar-23
Version: 1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Aliphatic >EC6-EC8		from Level 1
Target Concentration	C _T	0.01	mg/l	from Level 1
Dilution Factor	DF	4.79E+00		from Level 2

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

Ogata Banks	Equations in HRA publication
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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 pollutants in all phases (e.g. field derived value, ...)

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration			
Enter soil concentration	36.6	mg/kg	
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	v	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	az	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Groundwater flow velocity	v	2.70E-01	m/d
Retardation factor	Rf	5.89E+01	fraction
Decay rate used	λ	4.95E-02	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	2.01E-02	fraction
Rate of contaminant flow due to retardation	u	4.55E-03	m/d
Ratio of Compliance Point to Source Concentration	C ₀ /C _T	1.40E-30	fraction
Attenuation factor (C ₀ /C _T)	AF	7.16E+29	fraction
Calculated soil leachate concentration	Co	1.13E+00	mg/l

Remedial Targets

Level 3 Remedial Target	3.43E+28	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or	1.11E+30	This assumes Level 1 Remedial Target is based on Target Concentration.
Distance to compliance point	50	m	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₀ /C _T	1.40E-30	fraction

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

Enter if specify partition coefficient (option)	Kd	l/kg
Soil water partition coefficient		
Enter for non-polar organic chemicals (option)		
Fraction of organic carbon in aquifer	foc	1.10E-02 fraction
Organic carbon partition coefficient	Koc	7.90E+02 l/kg
Enter 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	8.69E+00 l/kg

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

Dispersivities 10% 1% 0.1% of pathway length

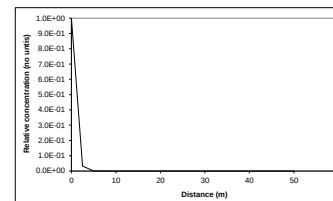
Enter value	Calc value	Xu & Eckstein
Longitudinal dispersivity	ax	5.00E+00 5.00E+00 2.98E+00 m
Transverse dispersivity	az	0.00E+00 5.00E-01 2.98E-01 m
Vertical dispersivity	ay	0.00E+00 5.00E-02 2.98E-02 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀x)^{0.414}, 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 described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration 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.

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks	Relative concentration	Concentration
From calculation sheet	(No units)	mg/l
Distance		
0	1.0E+00	2.36E-01
2.5	3.23E-02	7.62E-03
5.0	1.04E-03	2.46E-04
7.5	3.36E-05	7.93E-06
10.0	1.08E-06	2.56E-07
12.5	3.49E-08	8.25E-09
15.0	1.13E-09	2.66E-10
17.5	3.63E-11	8.58E-12
20.0	1.17E-12	2.76E-13
22.5	3.76E-14	8.89E-15
25.0	1.21E-15	2.86E-16
27.5	3.89E-17	9.19E-18
30.0	1.25E-18	2.95E-19
32.5	4.01E-20	9.48E-21
35.0	1.29E-21	3.04E-22
37.5	4.13E-23	9.76E-24
40.0	1.32E-24	3.13E-25
42.5	4.25E-26	1.00E-26
45.0	1.36E-27	3.22E-28
47.5	4.36E-29	1.03E-29
50.0	1.40E-30	3.39E-31

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:	Quakers Yard
Completed by:	Rebekah Wain
Date:	#####
Version:	1

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note



Input Parameters (using pull down menu)

Contaminant	Aliphatic >EC6-EC8	from Level 1
Target Concentration	1.00E-02	from Level 1
C _r	mg/l	

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

Domenico - Steady state	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 pollutants in all phases (e.g. field derived value)

Initial contaminant concentration in groundwater at plume core	C ₀	7.93E-01	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	1.40E+01	days	
Calculated decay rate	λ	4.95E-02	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	8.00E+01	m	
Plume thickness at source	Sy	5.00E+00	m	
Saturated aquifer thickness	da	5.20E+00	m	
Bulk density of aquifer materials	ρ	2.00E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	1.59E-02	fraction	
Hydraulic conductivity of aquifer	K	4.03E+00	m/d	
Distance to compliance point	x	1.00E+00	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+100	days	time variant options only
Parameters values determined from options				
Partition coefficient	Kd	8.69E+00	l/kg	see options
Longitudinal dispersivity	ax	1.00E-01	m	see options
Transverse dispersivity	az	1.00E-02	m	see options
Vertical dispersivity	ay	1.00E-03	m	see options

Calculated Parameters

Groundwater flow velocity	V	2.14E-01	m/d
Retardation factor	Rf	5.89E+01	fraction
Decay rate used	λ	4.95E-02	d ⁻¹
Rate of contaminant flow due to retardation	u	3.62E-03	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{ed}	3.55E-04	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	2.24E+03	

Remedial Targets

Remedial Target	2.24E+01	mg/l	For comparison with measured groundwater concentration.
Domenico - Steady state			
Distance to compliance point	1	m	
Concentration of contaminant at compliance point	C _{ed} /C _r	3.55E-04	mg/l Domenico - Steady state

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)

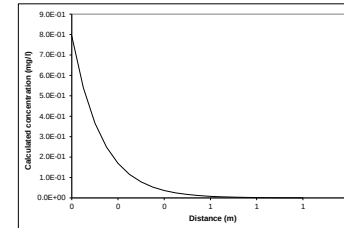
Calculate for non-polar organic chemicals

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	1.10E-02 fraction
Organic carbon partition coefficient	Koc	7.90E+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	8.69E+00 l/kg

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

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

Longitudinal dispersivity	ax	Enter value	Calc value Xu & Eckstein	m
Transverse dispersivity	az	0.00E+00	1.00E-01	0.00E+00 m
Vertical dispersivity	ay	0.00E+00	1.00E-02	0.00E+00 m
		0.00E+00	1.00E-03	0.00E+00 m
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+1.5} ; 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 described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed: Quakers Yard
Completed by: Rebekah Wain
Date: 01/04/2023
Version: 1

Calculated concentrations for distance-concentration graph

Domenico - Steady state

From calculation sheet

Distance Concentration

0	7.9E-01
0.1	5.39E-01
0.1	3.67E-01
0.2	2.49E-01
0.2	1.70E-01
0.3	1.15E-01
0.3	7.84E-02
0.4	5.33E-02
0.4	3.63E-02
0.5	2.47E-02
0.5	1.68E-02
0.6	1.14E-02
0.6	7.75E-03
0.7	5.27E-03
0.7	3.59E-03
0.8	2.44E-03
0.8	1.66E-03
0.9	1.13E-03
0.9	7.67E-04
1.0	5.21E-04
1.0	3.55E-04

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Aliphatic >EC8-EC10
0.01 mg/l

from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

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 contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

2.35E-03
1.97E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

3.00E+01
5.20E+00
4.03E+00
1.59E-02
8.00E+01
1.00E-10

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
4.17E+00

m
m

Calculated Parameters

Dilution Factor

DF

4.79E+00

Level 2 Remedial Target

4.79E-02

mg/l

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

or

5.50E+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

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Quakers Yard
Completed by: Rebekah Wain
Date: 13-Mar-23
Version: 1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Aliphatic >ECB-EC10		from Level 1
Target Concentration	C _T	0.01	mg/l	from Level 1
Dilution Factor	DF	4.79E+00		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 pollutants in all phases (e.g. field derived value,)

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	123	mg/kg	
Enter soil concentration			
Half life for degradation of contaminant in water	1.00E+01	days	
Calculated decay rate	6.93E-02	days ⁻¹	calculated
Width of plume in aquifer at source	8.00E+01	m	from Level 2
Plume thickness in aquifer at source	4.17E+00	m	from Level 2
Bulk density of aquifer materials	2.00E+00	g/cm ³	
Effective porosity of aquifer	3.00E-01	fraction	
Hydraulic gradient	2.01E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	4.03E+00	m/d	from Level 2
Distance to compliance point	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction		m	
Distance (depth) to compliance point perpendicular to flow direction		m	
Time since pollutant entered groundwater	1.00E+100	days	time variant options only
Parameters values determined from options			
Partition coefficient	3.52E+02	l/kg	see options
Longitudinal dispersivity	5.000	m	see options
Transverse dispersivity	0.500	m	see options
Vertical dispersivity	0.050	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	2.70E-01	m/d
Retardation factor	2.35E+03	fraction
Decay rate used	6.93E-02	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	2.01E-02	fraction
Rate of contaminant flow due to retardation	1.15E-04	m/d
Ratio of Compliance Point to Source Concentration	5.29E+237	fraction
Attenuation factor (C _p /C ₀)	1.89E+236	fraction
Calculated soil leachate concentration	1.07E-01	mg/l

Remedial Targets

Level 3 Remedial Target	9.05E+234	mg/l	For comparison with measured pore water concentration.
Ogata Banks	1.04E+238	mg/kg	This assumes Level 1 Remedial Target is based on Target Concentration.
Distance to compliance point	50	m	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C _p /C ₀	5.29E+237	fraction

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

Enter if specify partition coefficient (option)	K _d		l/kg
Soil water partition coefficient			
Enter for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	f _{oc}	1.10E-02	fraction
Organic carbon partition coefficient	K _{oc}	3.20E+04	l/kg
Enter for ionic organic chemicals (option)			
Sorption coefficient for related species	K _{d,ion}		l/kg
Sorption coefficient for ionised species	K _{d,ion}		l/kg
pH value	pH		
Acid dissociation constant	pK _a		
Fraction of organic carbon in aquifer	f _{oc}		fraction
Soil water partition coefficient	K _d	3.52E+02	l/kg

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

Dispersivities 10% 1% 0.1% of pathway length

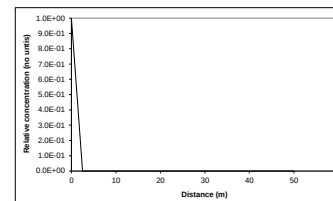
	Enter value	Calc value	Xu & Eckstein
Longitudinal dispersivity	ax	5.00E+00	5.98E+00 m
Transverse dispersivity	az	5.00E-01	2.98E-01 m
Vertical dispersivity	ay	5.00E-02	3.00E-02 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}K)^{0.414}$, $az = ax/10$, $ay = ax/100$ 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 described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration 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.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration (No units)	Concentration
0	1.0E+00	2.23E-02
2.5	1.54E-12	3.44E-14
5.0	2.37E-24	5.30E-26
7.5	3.65E-36	8.17E-38
10.0	5.63E-48	1.26E-49
12.5	8.66E-60	1.94E-61
15.0	1.33E-71	2.98E-73
17.5	2.05E-83	4.59E-85
20.0	3.16E-95	7.05E-97
22.5	4.85E-107	1.08E-108
25.0	7.45E-119	1.66E-120
27.5	1.14E-130	2.55E-132
30.0	1.75E-142	3.92E-144
32.5	2.69E-154	6.00E-156
35.0	4.12E-166	9.20E-168
37.5	6.30E-178	1.41E-179
40.0	9.65E-190	2.16E-191
42.5	1.48E-201	3.30E-203
45.0	2.26E-213	5.05E-215
47.5	3.46E-225	7.73E-227
50.0	5.29E-237	1.18E-238

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:	Quakers Yard
Completed by:	Rebekah Wain
Date:	#####
Version:	1

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Aliphatic >EC8-EC10	from Level 1
Target Concentration	1.00E-02	mg/l from Level 1

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

Domenico - Steady state	Equations in HRA publication
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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 pollutants in all phases (e.g. field derived value)

Initial contaminant concentration in groundwater at plume core	C ₀	8.35E-01	mg/l	Source of parameter value
Half life for degradation of contaminant in water	t _{1/2}	1.00E+01	days	
Calculated decay rate	λ	6.93E-02	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	8.00E+01	m	
Plume thickness at source	Sy	5.00E+00	m	
Saturated aquifer thickness	da	5.20E+00	m	
Bulk density of aquifer materials	ρ	2.00E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	1.59E-02	fraction	
Hydraulic conductivity of aquifer	K	4.03E+00	m/d	
Distance to compliance point	x	1.00E+00	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+100	days	time variant options only

Parameters values determined from options				
Partition coefficient	Kd	3.52E+02	l/kg	see options
Longitudinal dispersivity	ax	1.00E-01	m	see options
Transverse dispersivity	az	1.00E-02	m	see options
Vertical dispersivity	ay	1.00E-03	m	see options

Calculated Parameters

Groundwater flow velocity	V	2.14E-01	m/d
Retardation factor	Rf	2.35E+03	fraction
Decay rate used	λ	6.93E-02	d ⁻¹
Rate of contaminant flow due to retardation	u	9.10E-05	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{ed}	1.33E-36	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	6.29E+35	

Remedial Targets

Remedial Target	6.29E+33	mg/l	For comparison with measured groundwater concentration.
Domenico - Steady state			
Distance to compliance point	1	m	
Concentration of contaminant at compliance point	C _{ed} /C ₀	1.33E-36	mg/l Domenico - Steady state

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)

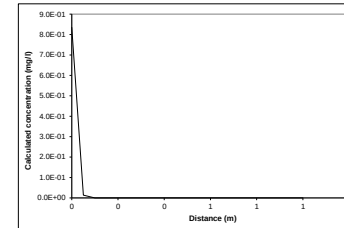
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)	Kd		l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)	foc	1.10E-02	fraction
Fraction of organic carbon in aquifer			
Organic carbon partition coefficient	Koc	3.20E+04	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	3.52E+02	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	m
Longitudinal dispersivity	ax	0.00E+00	1.00E-01	0.00E+00
Transverse dispersivity	az	0.00E+00	1.00E-02	0.00E+00
Vertical dispersivity	ay	0.00E+00	1.00E-03	0.00E+00
Note values of dispersivity must be > 0				
For calculated value, assumes $\alpha_x = 0.1 \cdot x$, $\alpha_y = 0.01 \cdot x$, $\alpha_z = 0.001 \cdot x$				
$Xu \& Eckstein$ (1995) report $\alpha_x = 0.83(\log_{10}x)^{2+1.5}$; $\alpha_z = \alpha_{10}$, $\alpha_y = \alpha_{10}/100$ 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 described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed: Quakers Yard
Completed by: Rebekah Wain
Date: 01/04/2023
Version: 1

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Ammoniacal nitrogen NH4

0.6

mg/l

from Level 1

from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

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 contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf

2.35E-03

m/d

A

1.97E+03

m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L

3.00E+01

m

da

5.20E+00

m

K

4.03E+00

m/d

i

1.59E-02

fraction

w

8.00E+01

m

Cu

1.00E-10

mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz

Calculate

m

Mz

4.17E+00

m

Calculated Parameters

Dilution Factor

DF

4.79E+00

Level 2 Remedial Target

2.87E+00

mg/l

or

1.58E+00

mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

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

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Quakers Yard
Completed by: Rebekah Wain
Date: 13-Mar-23
Version: 1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Aromatic >EC12-EC16		from Level 1
Target Concentration	C _T	0.01	mg/l	from Level 1
Dilution Factor	DF	4.79E+00		from Level 2

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

Ogata Banks	Equations in HRA publication
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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 pollutants in all phases (e.g. field derived value, ...)

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	8908	mg/kg	
Enter soil concentration	1.15E+02	mg/kg	
Half life for degradation of contaminant in water	t _{1/2}	days	
Calculated decay rate	λ	days ⁻¹	calculated
Width of plume in aquifer at source	Sz	m	from Level 2
Plume thickness in aquifer at source	Sy	m	from Level 2
Bulk density of aquifer materials	ρ	g/cm ³	
Effective porosity of aquifer	n	fraction	
Hydraulic gradient	i	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	m/d	from Level 2
Distance to compliance point	x	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	v	m	
Time since pollutant entered groundwater	t	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	l/kg	see options
Longitudinal dispersivity	ax	m	see options
Transverse dispersivity	az	m	see options
Vertical dispersivity	ay	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	2.70E-01 m/d
Retardation factor	Rf	3.68E+02
Decay rate used	λ	6.05E-03 days ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	2.01E-02
Rate of contaminant flow due to retardation	u	7.34E-04 m/d
Ratio of Compliance Point to Source Concentration	C ₀ /C _i	1.50E-26
Attenuation factor (C ₀ /C _i)	AF	6.66E+25
Calculated soil leachate concentration	Co	4.99E+01 mg/l

Remedial Targets

Level 3 Remedial Target	3.19E+24	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or	5.69E+26	This assumes Level 1 Remedial Target is based on Target Concentration.
Distance to compliance point	50	m	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₀ /C _i	1.50E-26	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)	Kd	l/kg
Soil water partition coefficient		
Entry for non-polar organic chemicals (option)		
Fraction of organic carbon in aquifer	foc	1.10E-02 fraction
Organic carbon partition coefficient	Koc	5.00E+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	5.50E+01 l/kg

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

Dispersivities 10% 1% 0.1% of pathway length

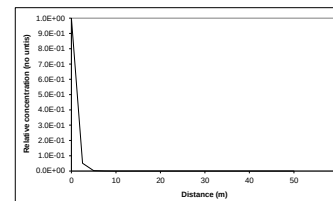
	Enter value	Calc value	Xu & Eckstein
Longitudinal dispersivity	ax	5.00E+00	5.98E+00 m
Transverse dispersivity	az	5.00E-01	2.98E-01 m
Vertical dispersivity	ay	5.00E-02	3.00E-02 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}K)^{+0.44}$, $az = ax/10$, $ay = ax/100$ 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 described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration 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.

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks	Relative concentration	Concentration
Distance	(No units)	mg/l
0	1.0E+00	1.04E+01
2.5	5.13E-02	5.34E-01
5.0	2.63E-03	2.74E-02
7.5	1.35E-04	1.41E-03
10.0	6.93E-06	7.22E-05
12.5	3.56E-07	3.70E-06
15.0	1.82E-08	1.90E-07
17.5	9.35E-10	9.74E-09
20.0	4.79E-11	4.99E-10
22.5	2.45E-12	2.56E-11
25.0	1.25E-13	1.31E-12
27.5	6.42E-15	6.68E-14
30.0	3.28E-16	3.42E-15
32.5	1.67E-17	1.74E-16
35.0	8.55E-19	8.90E-18
37.5	4.36E-20	4.54E-19
40.0	2.22E-21	2.32E-20
42.5	1.13E-22	1.18E-21
45.0	5.78E-24	6.02E-23
47.5	2.95E-25	3.07E-24
50.0	1.50E-26	1.56E-25

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:	Quakers Yard
Completed by:	Rebekah Wain
Date:	#####
Version:	1

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Aromatic >EC12-EC16	from Level 1
Target Concentration	1.00E-02	from Level 1
C _r		

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

Domenico - Steady state	Equations in HRA publication
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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 pollutants in all phases (e.g. field derived value)

Initial contaminant concentration in groundwater at plume core	C ₀	2.12E+00	mg/l	Source of parameter value
Half life for degradation of contaminant in water	t _{1/2}	1.15E+02	days	
Width of plume in aquifer at source (perpendicular to flow)	λ	6.05E-03	days ²	
Plume thickness at source	Sz	8.00E+01	m	
Saturated aquifer thickness	da	5.20E+00	m	
Bulk density of aquifer materials	ρ	2.00E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	1.59E-02	fraction	
Hydraulic conductivity of aquifer	K	4.03E+00	m/d	
Distance (lateral) to compliance point perpendicular to flow	x	1.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+100	days	time variant options only

Parameters values determined from options

Partition coefficient	Kd	5.50E+01	l/kg	see options
Longitudinal dispersivity	ax	1.00E-01	m	see options
Transverse dispersivity	az	1.00E-02	m	see options
Vertical dispersivity	ay	1.00E-03	m	see options

Calculated Parameters

Groundwater flow velocity	V	2.14E-01	m/d
Retardation factor	Rf	3.68E+02	fraction
Decay rate used	λ	6.05E-03	d ⁻¹
Rate of contaminant flow due to retardation	u	5.81E-04	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{eq}	3.64E-03	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	5.82E+02	

Remedial Targets

Remedial Target	5.82E+00	mg/l	For comparison with measured groundwater concentration.
Domenico - Steady state			
Distance to compliance point	1	m	
Concentration of contaminant at compliance point	C _{eq} /C _r	3.64E-03	mg/l Domenico - Steady state

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)	Kd		l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)	foc	1.10E-02	fraction
Fraction of organic carbon in aquifer			
Organic carbon partition coefficient	Koc	5.00E+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	5.50E+01	l/kg

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

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

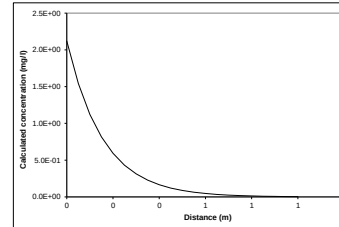
		Enter value	Calc value Xu & Eckstein	m
Longitudinal dispersivity	ax	0.00E+00	1.00E-01	0.00E+00
Transverse dispersivity	az	0.00E+00	1.00E-02	0.00E+00
Vertical dispersivity	ay	0.00E+00	1.00E-03	0.00E+00

Note values of dispersivity must be > 0

For calculated value, assumes $\alpha_x = 0.1 \times x$, $\alpha_y = 0.01 \times y$, $\alpha_z = 0.001 \times z$

Xu & Eckstein (1995) report $\alpha_x = 0.83(\log_{10} x)^{2.41}$; $\alpha_y = ax/10$, $\alpha_z = az/100$ are assumed

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(log₁₀x)^{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 described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed: Quakers Yard
Completed by: Rebekah Wain
Date: 01/04/2023
Version: 1

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Benzene
0.01 mg/l

from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

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 contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

2.35E-03
1.97E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

3.00E+01
5.20E+00
4.03E+00
1.59E-02
8.00E+01
1.00E-10

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
4.17E+00

m
m

Calculated Parameters

Dilution Factor

DF

4.79E+00

Level 2 Remedial Target

4.79E-02
or
1.24E-01

mg/l
mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

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)

C_c

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Quakers Yard
Completed by: Rebekah Wain
Date: 13-Mar-23
Version: 1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Benzene		from Level 1
Target Concentration	C _T	0.01	mg/l	from Level 1
Dilution Factor	DF	4.79E+00		from Level 2

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

Ogata Banks	Equations in HRA publication
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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 pollutants in all phases (e.g. field derived value, ...)

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	89.4	mg/kg	
Enter soil concentration	3.65E+02	mg/kg	
Half life for degradation of contaminant in water	1.90E-03	days	
Calculated decay rate	1.90E-03	days ⁻¹	calculated
Width of plume in aquifer at source	8.00E+01	m	from Level 2
Plume thickness in aquifer at source	4.17E+00	m	from Level 2
Bulk density of aquifer materials	2.00E+00	g/cm ³	
Effective porosity of aquifer	3.00E-01	fraction	
Hydraulic gradient	2.01E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	4.03E+00	m/d	from Level 2
Distance to compliance point	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction		m	
Distance (depth) to compliance point perpendicular to flow direction		m	
Time since pollutant entered groundwater	1.00E+100	days	time variant options only
Parameters values determined from options			
Partition coefficient	7.48E-01	l/kg	see options
Longitudinal dispersivity	5.000	m	see options
Transverse dispersivity	0.500	m	see options
Vertical dispersivity	0.050	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	2.70E-01	m/d
Retardation factor	5.99E+00	fraction
Decay rate used	1.90E-03	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	2.01E-02	fraction
Rate of contaminant flow due to retardation	4.51E-02	m/d
Ratio of Compliance Point to Source Concentration	1.57E-01	fraction
Attenuation factor (C _p /C _s)	6.36E+00	fraction
Calculated soil leachate concentration	3.46E+01	mg/l

Remedial Targets

Level 3 Remedial Target	3.05E-01	mg/l	For comparison with measured pore water concentration.
Ogata Banks	7.87E-01	mg/kg	This assumes Level 1 Remedial Target is based on Target Concentration.
Distance to compliance point	50	m	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C _p /C _s	1.57E-01	fraction

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

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer

Organic carbon partition coefficient

Entry for ionic organic chemicals (option)

Sorption coefficient for related species

Sorption coefficient for ionised species

pH value

Acid dissociation constant

Fraction of organic carbon in aquifer

Soil water partition coefficient

K_dK_{oc}K_{oc,n}K_{oc,i}

pH

pKa

foc

K_d

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant				
Target Concentration	C _r	Benzene	1.00E-02	mg/l
				from Level 1
				from Level 1

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

Domenico - Steady state 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 pollutants in all phases (e.g. field derived value)

Initial contaminant concentration in groundwater at plume core	C ₀	2.20E+00	mg/l	Source of parameter value
Half life for degradation of contaminant in water	t _{1/2}	3.65E+02	days	
Calculated decay rate	λ	1.90E-03	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	8.00E+01	m	
Plume thickness at source	Sy	5.00E+00	m	
Saturated aquifer thickness	da	5.20E+00	m	
Bulk density of aquifer materials	ρ	2.00E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	1.59E-02	fraction	
Hydraulic conductivity of aquifer	K	4.03E+00	m/d	
Distance to compliance point	x	1.00E+00	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+100	days	time variant options only
Parameters values determined from options				
Partition coefficient	Kd	7.48E-01	l/kg	see options
Longitudinal dispersivity	ax	1.00E-01	m	see options
Transverse dispersivity	az	1.00E-02	m	see options
Vertical dispersivity	ay	1.00E-03	m	see options

Calculated Parameters

Groundwater flow velocity	V	2.14E-01	m/d
Retardation factor	Rf	5.99E+00	fraction
Decay rate used	λ	1.90E-03	d ⁻¹
Rate of contaminant flow due to retardation	u	3.57E-02	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{eq}	2.09E+00	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	1.05E+00	

Remedial Targets

Remedial Target	1.05E-02	mg/l	For comparison with measured groundwater concentration.
Domenico - Steady state			
Distance to compliance point	1	m	
Concentration of contaminant at compliance point	C _{eq} /C _r	2.09E+00	mg/l Domenico - Steady state

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)

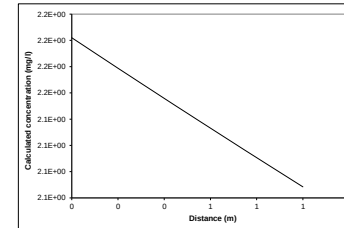
Calculate for non-polar organic chemicals

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	1.10E-02	fraction
Organic carbon partition coefficient	Koc	6.80E+01	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	7.48E-01	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	n
Longitudinal dispersivity	ax	0.00E+00	1.00E-01	0.00E+00
Transverse dispersivity	az	0.00E+00	1.00E-02	0.00E+00
Vertical dispersivity	ay	0.00E+00	1.00E-03	0.00E+00
Note values of dispersivity must be > 0				
For calculated value, assumes $ax = 0.1 \cdot x$, $az = 0.01 \cdot x$, $ay = 0.001 \cdot x$				
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 described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed:	Quakers Yard
Completed by:	Rebekah Wain
Date:	01/04/2023
Version:	1

Calculated concentrations for distance-concentration graph

Domenico - Steady state

From calculation sheet

Distance	Concentration
	mg/l
0	2.2E+00
0.1	2.20E+00
0.2	2.19E+00
0.3	2.18E+00
0.4	2.17E+00
0.5	2.16E+00
0.6	2.15E+00
0.7	2.14E+00
0.8	2.13E+00
0.9	2.12E+00
1.0	2.11E+00
1.0	2.09E+00
1.0	2.08E+00

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Dissolved Chromium III
0.0047 mg/l

from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

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 contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

2.35E-03
1.97E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

3.00E+01
5.20E+00
4.03E+00
1.59E-02
8.00E+01
1.00E-10

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
4.17E+00

m
m

Calculated Parameters

Dilution Factor

DF

4.79E+00

Level 2 Remedial Target

2.25E-02

mg/l

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

or

1.08E+02

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

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Quakers Yard
Completed by: Rebekah Wain
Date: 13-Mar-23
Version: 1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Dissolved Chromium III		from Level 1
Target Concentration	C _T	0.0047	mg/l	from Level 1
Dilution Factor	DF	4.79E+00		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 pollutants in all phases (e.g. field derived value, ...)

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	201.7	mg/kg	
Enter soil concentration	1.00E+100	days	
Half life for degradation of contaminant in water	6.93E-101	days ⁻¹	calculated
Calculated decay rate	8.00E+01	m	from Level 2
Width of plume in aquifer at source	4.17E+00	m	from Level 2
Plume thickness in aquifer at source	2.00E+00	g/cm ³	
Bulk density of aquifer materials	3.00E-01	fraction	
Effective porosity of aquifer	2.01E-02	fraction	from Level 2 (adjusted)
Hydraulic gradient	4.03E+00	m/d	from Level 2
Hydraulic conductivity of saturated aquifer	5.00E+00	m	
Distance to compliance point	5.00E+00	m	
Distance (lateral) to compliance point perpendicular to flow direction		m	
Distance (depth) to compliance point perpendicular to flow direction		m	
Time since pollutant entered groundwater	1.00E+100	days	time variant options only
Parameters values determined from options			
Partition coefficient	4.80E+03	l/kg	see options
Longitudinal dispersivity	0.500	m	see options
Transverse dispersivity	0.050	m	see options
Vertical dispersivity	0.005	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	2.70E-01	m/d
Retardation factor	3.20E+04	fraction
Decay rate used	6.93E-101	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	2.01E-02	fraction
Rate of contaminant flow due to retardation	8.44E-06	m/d
Ratio of Compliance Point to Source Concentration	1.00E+00	fraction
Attenuation factor (C _p /C ₀)	1.00E+00	fraction
Calculated soil leachate concentration	4.20E-02	mg/l

Remedial Targets

Level 3 Remedial Target	2.25E-02	mg/l	For comparison with measured pore water concentration.
Ogata Banks	1.08E+02	mg/kg	This assumes Level 1 Remedial Target is based on Target Concentration.
Distance to compliance point	5	m	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C _p /C ₀	1.00E+00	fraction

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)
User specified value for partition coefficient

Entry if specify partition coefficient (option)	Kd	4.80E+03	l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)	foc		fraction
Fraction of organic carbon in aquifer			
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)	K _{oc,n}		l/kg
Sorption coefficient for related 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	4.80E+03	l/kg

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

Dispersivities 10% 1% 0.1% of pathway length

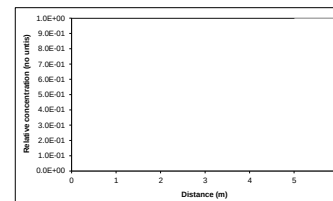
	Enter value	Calc value	Xu & Eckstein
Longitudinal dispersivity	ax	5.00E-01	3.50E-01
Transverse dispersivity	az	5.00E-02	3.50E-02
Vertical dispersivity	ay	5.00E-03	3.50E-03

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀X)^{-0.414}, 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 described by an electron limited degradation such as oxidation by O₂, NO₃⁻, SO₄²⁻ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration 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.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	8.78E-03
0.3	1.00E+00	8.78E-03
0.5	1.00E+00	8.78E-03
0.8	1.00E+00	8.78E-03
1.0	1.00E+00	8.78E-03
1.3	1.00E+00	8.78E-03
1.5	1.00E+00	8.78E-03
1.8	1.00E+00	8.78E-03
2.0	1.00E+00	8.78E-03
2.3	1.00E+00	8.78E-03
2.5	1.00E+00	8.78E-03
2.8	1.00E+00	8.78E-03
3.0	1.00E+00	8.78E-03
3.3	1.00E+00	8.78E-03
3.5	1.00E+00	8.78E-03
3.8	1.00E+00	8.78E-03
4.0	1.00E+00	8.78E-03
4.3	1.00E+00	8.78E-03
4.5	1.00E+00	8.78E-03
4.8	1.00E+00	8.78E-03
5.0	1.00E+00	8.78E-03

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:	Quakers Yard
Completed by:	Rebekah Wain
Date:	00000000
Version:	1

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Dissolved Chromium III	from Level 1
Target Concentration	4.70E-03	mg/l from Level 1

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

Domenico - Steady state 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 pollutants in all phases (e.g. field derived value)

Initial contaminant concentration in groundwater at plume core	C ₀	6.80E-02	mg/l	Source of parameter value
Half life for degradation of contaminant in water	t _{1/2}	1.00E+100	days	
Width of plume in aquifer at source (perpendicular to flow)	λ	6.93E-101	days ²	
Plume thickness at source	Sz	8.00E+01	m	
Saturated aquifer thickness	da	5.20E+00	m	
Bulk density of aquifer materials	ρ	2.00E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	1.59E-02	fraction	
Hydraulic conductivity of aquifer	K	4.03E+00	m/d	
Distance (lateral) to compliance point	X	1.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	Y		m	
Time since pollutant entered groundwater	t	1.00E+100	days	time variant options only
Parameters values determined from options				
Partition coefficient	Kd	4.80E+03	l/kg	see options
Longitudinal dispersivity	ax	1.00E-01	m	see options
Transverse dispersivity	az	1.00E-02	m	see options
Vertical dispersivity	ay	1.00E-03	m	see options

Calculated Parameters

Groundwater flow velocity	V	2.14E-01	m/d
Retardation factor	Rf	3.20E+04	fraction
Decay rate used	λ	6.93E-101	d ⁻¹
Rate of contaminant flow due to retardation	u	6.67E-06	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{eq}	6.80E-02	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	1.00E+00	

Remedial Targets

Remedial Target	4.70E-03	mg/l	For comparison with measured groundwater concentration.
Domenico - Steady state			
Distance to compliance point	1	m	
Concentration of contaminant at compliance point	C _{eq} /C ₀	6.80E-02	mg/l Domenico - Steady state

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)

User specified value for partition coefficient

Entry if specify partition coefficient (option)	Kd	4.80E+03	l/kg
Entry for non-polar organic chemicals (option)	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)	K _{oc,n}		l/kg
Sorption coefficient for related 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	4.80E+03	l/kg

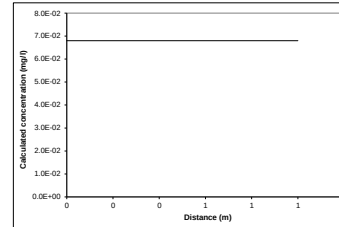
Define dispersivity (click brown cell and use pull down list)

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

		Enter value	Calc value Xu & Eckstein	n
Longitudinal dispersivity	ax	0.00E+00	1.00E-01	0.00E+00
Transverse dispersivity	az	0.00E+00	1.00E-02	0.00E+00
Vertical dispersivity	ay	0.00E+00	1.00E-03	0.00E+00

Note values of dispersivity must be > 0

For calculated value, assumes $ax = 0.1 \cdot x$, $az = 0.01 \cdot x$, $ay = 0.001 \cdot x$
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 described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed:	Quakers Yard
Completed by:	Rebekah Wain
Date:	#####
Version:	1



Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Benzo(a)pyrene
0.00000017 mg/l

from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

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 contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

2.35E-03
1.97E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

3.00E+01
5.20E+00
4.03E+00
1.59E-02
8.00E+01
1.00E-10

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
4.17E+00

m
m

Calculated Parameters

Dilution Factor

DF

4.78E+00

Level 2 Remedial Target

8.13E-07
or
3.74E-03

mg/l
mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

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)

C_c

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Quakers Yard
Completed by: Rebekah Wain
Date: 13-Mar-23
Version: 1

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Benzo(a)pyrene	from Level 1
Target Concentration	1.70E-07	from Level 1
C _r	mg/l	

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

Domenico - Steady state 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 pollutants in all phases (e.g. field derived value)

Initial contaminant concentration in groundwater at plume core	C ₀	3.40E-03	mg/l	Source of parameter value
Half life for degradation of contaminant in water	t _{1/2}	5.87E+02	days	
Calculated decay rate	λ	1.18E-03	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	8.00E+01	m	
Plume thickness at source	Sy	5.00E+00	m	
Saturated aquifer thickness	da	5.20E+00	m	
Bulk density of aquifer materials	ρ	2.00E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	1.59E-02	fraction	
Hydraulic conductivity of aquifer	K	4.03E+00	m/d	
Distance to compliance point	X	1.00E+00	m	
Distance (lateral) to compliance point perpendicular to flow direction	Y		m	
Distance (depth) to compliance point perpendicular to flow direction	Z		m	
Time since pollutant entered groundwater	t	1.00E+100	days	time variant options only
Parameters values determined from options				
Partition coefficient	Kd	1.42E+03	l/kg	see options
Longitudinal dispersivity	ax	1.00E-01	m	see options
Transverse dispersivity	az	1.00E-02	m	see options
Vertical dispersivity	ay	1.00E-03	m	see options

Calculated Parameters

Groundwater flow velocity	V	2.14E-01	m/d
Retardation factor	Rf	9.45E+03	fraction
Decay rate used	λ	1.18E-03	d ⁻¹
Rate of contaminant flow due to retardation	u	2.28E-05	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{ed}	3.49E-11	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	9.75E+07	

Remedial Targets

Remedial Target	1.66E+01	mg/l	For comparison with measured groundwater concentration.
Domenico - Steady state			
Distance to compliance point	1	m	
Concentration of contaminant at compliance point	C _{ed} /C _r	3.49E-11	mg/l Domenico - Steady state

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

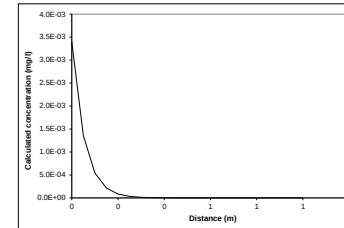
Entry if specify partition coefficient (option)

Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	1.10E-02	fraction
Organic carbon partition coefficient	Koc	1.29E+05	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	1.42E+03	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	m
Longitudinal dispersivity	ax	0.00E+00	1.00E-01	0.00E+00
Transverse dispersivity	az	0.00E+00	1.00E-02	0.00E+00
Vertical dispersivity	ay	0.00E+00	1.00E-03	0.00E+00
Note values of dispersivity must be > 0				
For calculated value, assumes $ax = 0.1 \cdot x$, $az = 0.01 \cdot x$, $ay = 0.001 \cdot x$				
Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2+1.5}$; $az = ax/10$, $ay = ax/100$ 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 described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed:	Quakers Yard
Completed by:	Rebekah Wain
Date:	01/04/2023
Version:	1

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Fluoranthene
0.0000063 mg/l

from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

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 contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

2.35E-03
1.97E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

3.00E+01
5.20E+00
4.03E+00
1.59E-02
8.00E+01
1.00E-10

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
4.17E+00

m
m

Calculated Parameters

Dilution Factor

DF

4.79E+00

Level 2 Remedial Target

3.02E-05 mg/l
or
1.96E-02 mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

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

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Quakers Yard
Completed by: Rebekah Wain
Date: 13-Mar-23
Version: 1

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Fluoranthene	from Level 1
Target Concentration	6.30E-06	mg/l from Level 1

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

Domenico - Steady state	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 pollutants in all phases (e.g. field derived value)

Initial contaminant concentration in groundwater at plume core	C ₀	1.78E-02	mg/l	Source of parameter value
Half life for degradation of contaminant in water	t _{1/2}	5.80E+02	days	
Calculated decay rate	λ	1.20E-03	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	8.00E+01	m	
Plume thickness at source	Sy	5.00E+00	m	
Saturated aquifer thickness	da	5.20E+00	m	
Bulk density of aquifer materials	ρ	2.00E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	1.59E-02	fraction	
Hydraulic conductivity of aquifer	K	4.03E+00	m/d	
Distance to compliance point	X	1.00E+00	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+100	days	time variant options only
Parameters values determined from options				
Partition coefficient	Kd	2.00E+02	l/kg	see options
Longitudinal dispersivity	ax	1.00E-01	m	see options
Transverse dispersivity	az	1.00E-02	m	see options
Vertical dispersivity	ay	1.00E-03	m	see options

Calculated Parameters

Groundwater flow velocity	V	2.14E-01	m/d
Retardation factor	Rf	1.34E+03	fraction
Decay rate used	λ	1.20E-03	d ⁻¹
Rate of contaminant flow due to retardation	u	1.60E-04	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{eq}	1.22E-04	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	1.46E+02	

Remedial Targets

Remedial Target	9.22E-04	mg/l	For comparison with measured groundwater concentration.
Domenico - Steady state			
Distance to compliance point	1	m	
Concentration of contaminant at compliance point	C _{eq} /C ₀	1.22E-04	mg/l Domenico - Steady state

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)

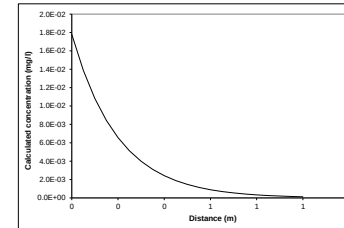
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)	Kd		l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)	foc	1.10E-02	fraction
Fraction of organic carbon in aquifer		1.82E+04	l/kg
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)	K _{oc,n}		l/kg
Sorption coefficient for related species	K _{oc,i}		l/kg
Sorption coefficient for ionised species	pH		
pH value	pKa		fraction
acid dissociation constant	foc		
Fraction of organic carbon in aquifer			
Soil water partition coefficient	Kd	2.00E+02	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	m
Longitudinal dispersivity	ax	0.00E+00	1.00E-01	0.00E+00
Transverse dispersivity	az	0.00E+00	1.00E-02	0.00E+00
Vertical dispersivity	ay	0.00E+00	1.00E-03	0.00E+00
Note values of dispersivity must be > 0				
For calculated value, assumes $\alpha_x = 0.1 \cdot x$, $\alpha_y = 0.01 \cdot x$, $\alpha_z = 0.001 \cdot x$				
$Xu \& Eckstein$ (1995) report $\alpha_x = 0.83(\log_{10}x)^{2.414}$; $\alpha_z = \alpha_{10}$, $\alpha_y = \alpha_{10}/10$ 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 described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed: Quakers Yard
Completed by: Rebekah Wain
Date: 21/04/2023
Version: 1

Calculated concentrations for distance-concentration graph

Domenico - Steady state

From calculation sheet

Distance Concentration

	mg/l
0	1.8E-02
0.1	1.39E-02
0.2	1.08E-02
0.3	8.43E-03
0.4	6.57E-03
0.5	5.12E-03
0.6	3.99E-03
0.7	3.11E-03
0.8	2.42E-03
0.9	1.89E-03
1.0	1.47E-03
1.1	1.15E-03
1.2	8.94E-04
1.3	6.96E-04
1.4	5.43E-04
1.5	4.23E-04
1.6	3.20E-04
1.7	2.57E-04
1.8	2.00E-04
1.9	1.56E-04
2.0	1.22E-04

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Free cyanide
0.001 mg/l

from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

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 contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

2.35E-03
1.97E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

3.00E+01
5.20E+00
4.03E+00
1.59E-02
8.00E+01
1.00E-10

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
4.17E+00

m
m

Calculated Parameters

Dilution Factor

DF

4.79E+00

Level 2 Remedial Target

4.79E-03
or
4.81E-02

mg/l
mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

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

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Quakers Yard
Completed by: Rebekah Wain
Date: 13-Mar-23
Version: 1

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Free cyanide	from Level 1
Target Concentration	1.00E-03	from Level 1
C _r		

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

Domenico - Steady state 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 pollutants in all phases (e.g. field derived value)

Initial contaminant concentration in groundwater at plume core	C ₀	7.00E-02	mg/l	Source of parameter value
Half life for degradation of contaminant in water	t _{1/2}	1.90E+02	days	
Calculated decay rate	λ	3.65E-03	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	8.00E+01	m	
Plume thickness at source	Sy	5.00E+00	m	
Saturated aquifer thickness	da	5.20E+00	m	
Bulk density of aquifer materials	ρ	2.00E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	1.59E-02	fraction	
Hydraulic conductivity of aquifer	K	4.03E+00	m/d	
Distance to compliance point	x	1.00E+00	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+100	days	time variant options only
Parameters values determined from options				
Partition coefficient	Kd	9.90E+00	l/kg	see options
Longitudinal dispersivity	ax	1.00E-01	m	see options
Transverse dispersivity	az	1.00E-02	m	see options
Vertical dispersivity	ay	1.00E-03	m	see options

Calculated Parameters

Groundwater flow velocity	V	2.14E-01	m/d
Retardation factor	Rf	6.70E+01	fraction
Decay rate used	λ	3.65E-03	d ⁻¹
Rate of contaminant flow due to retardation	u	3.19E-03	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{ed}	2.48E-02	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	2.82E+00	

Remedial Targets

Remedial Target	2.82E-03	mg/l	For comparison with measured groundwater concentration.
Domenico - Steady state			
Distance to compliance point	1	m	
Concentration of contaminant at compliance point	C _{ed} /C _r	2.48E-02	mg/l Domenico - Steady state

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)

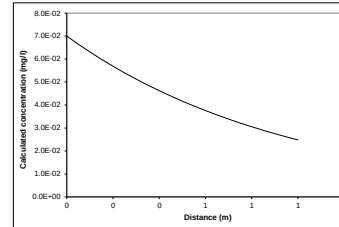
User specified value for partition coefficient

Entry if specify partition coefficient (option)	Kd	9.90E+00	l/kg
Entry for non-polar organic chemicals (option)	foc		fraction
Fraction of organic carbon in aquifer	Koc		l/kg
Organic carbon partition coefficient	K _{oc,n}		l/kg
Entry for ionic organic chemicals (option)	K _{oc,i}		l/kg
Sorption coefficient for related species	pH		
pH value	pKa		fraction
acid dissociation constant	foc		fraction
Fraction of organic carbon in aquifer	Kd	9.90E+00	l/kg
Soil water partition coefficient			

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

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

		Enter value	Calc value Xu & Eckstein	n
Longitudinal dispersivity	ax	0.00E+00	1.00E-01	0.00E+00
Transverse dispersivity	az	0.00E+00	1.00E-02	0.00E+00
Vertical dispersivity	ay	0.00E+00	1.00E-03	0.00E+00
Note values of dispersivity must be > 0				
For calculated value, assumes $ax = 0.1 \cdot x$, $az = 0.01 \cdot x$, $ay = 0.001 \cdot x$				
Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2+1.5}$; $az = ax/10$, $ay = ax/100$ 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 described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed:	Quakers Yard
Completed by:	Rebekah Wain
Date:	20/04/2023
Version:	1

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

m/p-Xylene
0.03 mg/l

from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

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 contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

2.35E-03
1.97E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

3.00E+01
5.20E+00
4.03E+00
1.59E-02
8.00E+01
1.00E-10

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
4.17E+00

m
m

Calculated Parameters

Dilution Factor

DF

4.79E+00

Level 2 Remedial Target

1.44E-01

mg/l

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

or

2.53E+00

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)

C_c

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Quakers Yard
Completed by: Rebekah Wain
Date: 13-Mar-23
Version: 1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		m/p-Xylene		from Level 1
Target Concentration	C _T	0.03	mg/l	from Level 1
Dilution Factor	DF	4.79E+00		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
Soil concentration as mg/kg			
Enter source concentration	236.8	mg/kg	
Enter soil concentration	1.87E+02	mg/kg	
Half life for degradation of contaminant in water	3.71E-03	days	
Calculated decay rate	8.00E+01	days ⁻¹	calculated
Width of plume in aquifer at source	4.17E+00	m	from Level 2
Plume thickness in aquifer at source	2.00E+00	m	from Level 2
Bulk density of aquifer materials	3.00E-01	g/cm ³	
Effective porosity of aquifer	2.01E-02	fraction	from Level 2 (adjusted)
Hydraulic gradient	4.03E+00	m/d	from Level 2
Hydraulic conductivity of saturated aquifer	5.00E+00	m/d	
Distance to compliance point		m	
Distance (lateral) to compliance point perpendicular to flow direction		m	
Distance (depth) to compliance point perpendicular to flow direction		m	
Time since pollutant entered groundwater	1.00E+100	days	time variant options only
Parameters values determined from options			
Partition coefficient	5.38E+00	l/kg	see options
Longitudinal dispersivity	0.500	m	see options
Transverse dispersivity	0.050	m	see options
Vertical dispersivity	0.005	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	2.70E-01	m/d
Retardation factor	3.69E+01	fraction
Decay rate used	1.01E-04	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	2.01E-02	fraction
Rate of contaminant flow due to retardation	7.32E-03	m/d
Ratio of Compliance Point to Source Concentration	9.34E-01	fraction
Attenuation factor (C _p /C ₀)	1.07E+00	fraction
Calculated soil leachate concentration	1.34E+01	mg/l

Remedial Targets

Level 3 Remedial Target	1.54E-01	mg/l	For comparison with measured pore water concentration.
Ogata Banks	2.71E+00	mg/kg	This assumes Level 1 Remedial Target is based on Target Concentration.
Distance to compliance point	5	m	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C _p /C ₀	9.34E-01	fraction

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

Enter if specify partition coefficient (option)	K _d		l/kg
Soil water partition coefficient			
Enter for non-polar organic chemicals (option)	f _{oc}	1.10E-02	fraction
Fraction of organic carbon in aquifer	K _{oc}	4.89E+02	l/kg
Organic carbon partition coefficient			
Enter for ionic organic chemicals (option)	K _{oc,n}		l/kg
Sorption coefficient for related species	K _{oc,i}		l/kg
Sorption coefficient for ionised species	pH		
Acid dissociation constant	pK _a		
Fraction of organic carbon in aquifer	f _{oc}		fraction
Soil water partition coefficient	K _d	5.38E+00	l/kg

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

Dispersivities 10% 1% 0.1% of pathway length

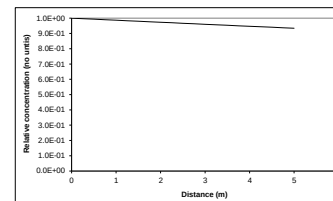
	Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	ax	5.00E-01	3.50E-01	m
Transverse dispersivity	az	5.00E-02	3.50E-02	m
Vertical dispersivity	ay	5.00E-03	3.00E-03	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}K)^{+0.14}$, $az = ax/10$, $ay = ax/100$ 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 described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration 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.

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks	Relative concentration	Concentration
From calculation sheet	(No units)	mg/l
Distance		
0	1.0E+00	2.81E+00
0.3	9.97E-01	2.80E+00
0.5	9.93E-01	2.79E+00
0.8	9.90E-01	2.78E+00
1.0	9.86E-01	2.77E+00
1.3	9.83E-01	2.76E+00
1.5	9.80E-01	2.75E+00
1.8	9.76E-01	2.74E+00
2.0	9.73E-01	2.73E+00
2.3	9.70E-01	2.72E+00
2.5	9.66E-01	2.72E+00
2.8	9.63E-01	2.71E+00
3.0	9.60E-01	2.70E+00
3.3	9.57E-01	2.69E+00
3.5	9.53E-01	2.68E+00
3.8	9.50E-01	2.67E+00
4.0	9.47E-01	2.66E+00
4.3	9.44E-01	2.65E+00
4.5	9.40E-01	2.64E+00
4.8	9.37E-01	2.63E+00
5.0	9.34E-01	2.62E+00

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:	Quakers Yard
Completed by:	Rebekah Wain
Date:	#####
Version:	1

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Variable	Value	Unit	Source
Target Concentration	C _r	m/p-Xylene 3.00E-02	mg/l	from Level 1

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

Domenico - Steady state 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 pollutants in all phases (e.g. field derived value)

Initial contaminant concentration in groundwater at plume core	C ₀	1.90E+00	mg/l	Source of parameter value
Half life for degradation of contaminant in water	t _{1/2}	1.87E+02	days	
Calculated decay rate	λ	3.71E-03	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	3.00E+01	m	
Plume thickness at source	Sy	5.00E+00	m	
Saturated aquifer thickness	da	5.20E+00	m	
Bulk density of aquifer materials	ρ	2.00E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	1.59E-02	fraction	
Hydraulic conductivity of aquifer	K	4.03E+00	m/d	
Distance to compliance point	X	1.00E+00	m	
Distance (lateral) to compliance point perpendicular to flow direction	Y		m	
Distance (depth) to compliance point perpendicular to flow direction	Z		m	
Time since pollutant entered groundwater	t	1.00E+100	days	time variant options only
Parameters values determined from options				
Partition coefficient	Kd	5.38E+00	l/kg	see options
Longitudinal dispersivity	ax	1.00E-01	m	see options
Transverse dispersivity	az	1.00E-02	m	see options
Vertical dispersivity	ay	1.00E-03	m	see options

Calculated Parameters

Groundwater flow velocity	V	2.14E-01	m/d
Retardation factor	Rf	3.69E+01	fraction
Decay rate used	λ	3.71E-03	d ⁻¹
Rate of contaminant flow due to retardation	U	5.79E-03	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{eq}	1.04E+00	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	1.83E+00	

Remedial Targets

Remedial Target	5.48E-02	mg/l	For comparison with measured groundwater concentration.
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Domenico - Steady state

Distance to compliance point	1	m
Concentration of contaminant at compliance point	C _{eq} /C _r	1.04E+00 mg/l Domenico - Steady state

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)

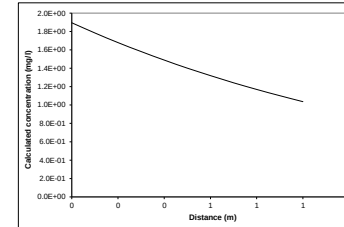
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)	Kd		l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	1.10E-02	fraction
Organic carbon partition coefficient	Koc	4.89E+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	5.38E+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	n
Longitudinal dispersivity	ax	0.00E+00	1.00E-01	0.00E+00
Transverse dispersivity	az	0.00E+00	1.00E-02	0.00E+00
Vertical dispersivity	ay	0.00E+00	1.00E-03	0.00E+00
Note values of dispersivity must be > 0				
For calculated value, assumes $ax = 0.1 \cdot x$, $az = 0.01 \cdot x$, $ay = 0.001 \cdot x$				
Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2+1.5}$; $az = ax/10$, $ay = ax/100$ 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 described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed:	Quakers Yard
Completed by:	Rebekah Wain
Date:	01/04/2023
Version:	1

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Naphthalene
0.002 mg/l

from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

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 contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

2.35E-03
1.97E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

3.00E+01
5.20E+00
4.03E+00
1.59E-02
8.00E+01
1.00E-10

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
4.17E+00

m
m

Calculated Parameters

Dilution Factor

DF

4.79E+00

Level 2 Remedial Target

9.57E-03
or
2.22E-01

mg/l
mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

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

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Quakers Yard
Completed by: Rebekah Wain
Date: 13-Mar-23
Version: 1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Naphthalene		from Level 1
Target Concentration	C _T	0.002	mg/l	from Level 1
Dilution Factor	DF	4.79E+00		from Level 2

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

Ogata Banks	Equations in HRA publication
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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 pollutants in all phases (e.g. field derived value,)

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	23107.2	mg/kg	
Enter soil concentration	1.30E+02	mg/kg	
Half life for degradation of contaminant in water	1.30E+02	days	
Calculated decay rate	5.35E-03	days ⁻¹	calculated
Width of plume in aquifer at source	8.00E+01	m	from Level 2
Plume thickness in aquifer at source	4.17E+00	m	from Level 2
Bulk density of aquifer materials	2.00E+00	g/cm ³	
Effective porosity of aquifer	3.00E-01	fraction	
Hydraulic gradient	2.01E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	4.03E+00	m/d	from Level 2
Distance to compliance point	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction		m	
Distance (depth) to compliance point perpendicular to flow direction		m	
Time since pollutant entered groundwater	1.00E+100	days	time variant options only
Parameters values determined from options			
Partition coefficient	7.10E+00	l/kg	see options
Longitudinal dispersivity	5.000	m	see options
Transverse dispersivity	0.500	m	see options
Vertical dispersivity	0.050	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	2.70E-01	m/d
Retardation factor	4.83E+01	fraction
Decay rate used	5.35E-03	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	2.01E-02	fraction
Rate of contaminant flow due to retardation	5.59E-03	m/d
Ratio of Compliance Point to Source Concentration	2.49E-08	fraction
Attenuation factor (C _p /C _s)	4.02E+07	fraction
Calculated soil leachate concentration	9.97E+02	mg/l

Remedial Targets

Level 3 Remedial Target	3.85E+05	mg/l	For comparison with measured pore water concentration.
Ogata Banks	8.92E+06	mg/kg	This assumes Level 1 Remedial Target is based on Target Concentration.
Distance to compliance point	50	m	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C _p /C _s	2.49E-08	fraction

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

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer

Organic carbon partition coefficient

Entry for ionic organic chemicals (option)

Sorption coefficient for related species

Sorption coefficient for ionised species

pH value

Acid dissociation constant

Fraction of organic carbon in aquifer

Soil water partition coefficient

K_{oc}K_{oc,n}K_{oc,i}

pH

pKa

foc

K_d

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Naphthalene	from Level 1
Target Concentration	2.00E-03	from Level 1
C _r	mg/l	

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

Domenico - Steady state	Equations in HRA publication
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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 pollutants in all phases (e.g. field derived value)

Initial contaminant concentration in groundwater at plume core	C ₀	1.20E+01	mg/l	Source of parameter value
Half life for degradation of contaminant in water	t _{1/2}	1.29E+02	days	
Calculated decay rate	λ	5.39E-03	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	8.00E+01	m	
Plume thickness at source	Sy	5.00E+00	m	
Saturated aquifer thickness	da	5.20E+00	m	
Bulk density of aquifer materials	ρ	2.00E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	1.59E-02	fraction	
Hydraulic conductivity of aquifer	K	4.03E+00	m/d	
Distance to compliance point	X	1.00E+00	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+100	days	time variant options only

Parameters values determined from options				
Partition coefficient	Kd	7.10E+00	l/kg	see options
Longitudinal dispersivity	ax	1.00E-01	m	see options
Transverse dispersivity	az	1.00E-02	m	see options
Vertical dispersivity	ay	1.00E-03	m	see options

Calculated Parameters

Groundwater flow velocity	V	2.14E-01	m/d
Retardation factor	Rf	4.93E+01	fraction
Decay rate used	λ	5.39E-03	d ⁻¹
Rate of contaminant flow due to retardation	U	4.42E-03	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{eq}	4.01E+00	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	3.00E+00	

Remedial Targets

Remedial Target	6.00E-03	mg/l	For comparison with measured groundwater concentration.
Domenico - Steady state			
Distance to compliance point	1	m	
Concentration of contaminant at compliance point	C _{eq} /C _r	4.01E+00	mg/l Domenico - Steady state

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)

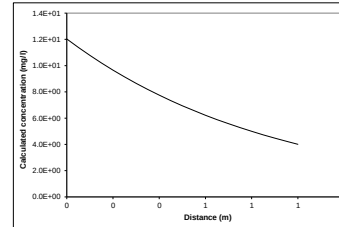
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)	Kd		l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	1.10E-02	fraction
Organic carbon partition coefficient	Koc	6.45E+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	7.10E+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	m
Longitudinal dispersivity	ax	0.00E+00	1.00E-01	0.00E+00
Transverse dispersivity	az	0.00E+00	1.00E-02	0.00E+00
Vertical dispersivity	ay	0.00E+00	1.00E-03	0.00E+00
Note values of dispersivity must be > 0				
For calculated value, assumes $\alpha_x = 0.1 \cdot x$, $\alpha_z = 0.01 \cdot x$, $\alpha_y = 0.001 \cdot x$				
$Xu \& Eckstein$ (1995) report $\alpha_x = 0.83(\log_{10}x)^{2.414}$; $\alpha_z = \alpha_{x10}$, $\alpha_y = \alpha_{x100}$ 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 described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed:	Quakers Yard
Completed by:	Rebekah Wain
Date:	01/04/2023
Version:	1



Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

O-Xylene
0.03 mg/l

from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

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 contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

2.35E-03
1.97E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

3.00E+01
5.20E+00
4.03E+00
1.59E-02
8.00E+01
1.00E-10

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
4.17E+00

m
m

Calculated Parameters

Dilution Factor

DF

4.79E+00

Level 2 Remedial Target

1.44E-01
or
2.21E+00

mg/l
mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

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)

C_c

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Quakers Yard
Completed by: Rebekah Wain
Date: 13-Mar-23
Version: 1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		O-Xylene		from Level 1
Target Concentration	C _T	0.03	mg/l	from Level 1
Dilution Factor	DF	4.79E+00		from Level 2

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

Ogata Banks	Equations in HRA publication
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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
Soil concentration as mg/kg			
Enter source concentration	90.2	mg/kg	
Enter soil concentration	1.87E+02	mg/kg	
Half life for degradation of contaminant in water	3.71E-03	days	
Calculated decay rate	8.00E+01	days ⁻¹	calculated
Width of plume in aquifer at source	4.17E+00	m	from Level 2
Plume thickness in aquifer at source	2.00E+00	m	
Bulk density of aquifer materials	3.00E-01	g/cm ³	
Effective porosity of aquifer	2.01E-02	fraction	from Level 2 (adjusted)
Hydraulic gradient	4.03E+00	m/d	from Level 2
Hydraulic conductivity of saturated aquifer	5.00E+00	m/d	
Distance to compliance point		m	
Distance (lateral) to compliance point perpendicular to flow direction		m	
Distance (depth) to compliance point perpendicular to flow direction		m	
Time since pollutant entered groundwater	1.00E+100	days	time variant options only
Parameters values determined from options			
Partition coefficient	4.89E+00	l/kg	see options
Longitudinal dispersivity	0.500	m	see options
Transverse dispersivity	0.050	m	see options
Vertical dispersivity	0.005	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	2.70E-01	m/d
Retardation factor	3.22E+01	fraction
Decay rate used	1.15E-04	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	2.01E-02	fraction
Rate of contaminant flow due to retardation	8.37E-03	m/d
Ratio of Compliance Point to Source Concentration	9.34E-01	fraction
Attenuation factor (C ₀ /C ₁₀)	1.07E+00	fraction
Calculated soil leachate concentration	5.87E+00	mg/l

Remedial Targets

Level 3 Remedial Target	1.54E-01	mg/l	For comparison with measured pore water concentration.
Ogata Banks	2.36E+00	mg/kg	This assumes Level 1 Remedial Target is based on Target Concentration.
Distance to compliance point	5	m	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₀ /C ₁	9.34E-01	fraction

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

Enter if specify partition coefficient (option)	K _d		l/kg
Soil water partition coefficient			
Enter for non-polar organic chemicals (option)	Fraction of organic carbon in aquifer	f _{oc}	1.10E-02
Organic carbon partition coefficient		K _{oc}	4.26E+02
Enter for ionic organic chemicals (option)	Sorption coefficient for related species	K _{oc,n}	
Sorption coefficient for ionised species		K _{oc,i}	
pH value		pH	
Acid dissociation constant		pK _a	
Fraction of organic carbon in aquifer		f _{oc}	
Soil water partition coefficient	K _d	4.69E+00	l/kg

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

Dispersivities 10% 1% 0.1% of pathway length

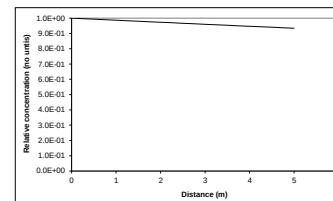
	Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	ax	5.00E-01	3.50E-01	m
Transverse dispersivity	az	5.00E-02	3.50E-02	m
Vertical dispersivity	ay	5.00E-03	3.00E-03	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}K)^{+0.44}$, $az = ax/10$, $ay = ax/100$ 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 described by an electron limited degradation such as oxidation by O₂, NO₃⁻, SO₄²⁻ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration 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.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	1.23E+00
0.3	9.97E-01	1.22E+00
0.5	9.93E-01	1.22E+00
0.8	9.90E-01	1.21E+00
1.0	9.86E-01	1.21E+00
1.3	9.83E-01	1.21E+00
1.5	9.80E-01	1.20E+00
1.8	9.76E-01	1.20E+00
2.0	9.73E-01	1.19E+00
2.3	9.70E-01	1.19E+00
2.5	9.66E-01	1.19E+00
2.8	9.63E-01	1.18E+00
3.0	9.60E-01	1.18E+00
3.3	9.57E-01	1.17E+00
3.5	9.53E-01	1.17E+00
3.8	9.50E-01	1.17E+00
4.0	9.47E-01	1.16E+00
4.3	9.44E-01	1.16E+00
4.5	9.40E-01	1.15E+00
4.8	9.37E-01	1.15E+00
5.0	9.34E-01	1.15E+00

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:	Quakers Yard
Completed by:	Rebekah Wain
Date:	000000
Version:	1

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	O-Xylene	from Level 1
Target Concentration	3.00E-02	from Level 1
C _r	mg/l	

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

Domenico - Steady state	Equations in HRA publication
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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 pollutants in all phases (e.g. field derived value)

Initial contaminant concentration in groundwater at plume core	C ₀	6.77E-01	mg/l	Source of parameter value
Half life for degradation of contaminant in water	t _{1/2}	1.87E+02	days	
Width of plume in aquifer at source (perpendicular to flow)	λ	3.71E-03	days	
Plume thickness at source	Sz	8.00E+01	m	
Saturated aquifer thickness	da	5.20E+00	m	
Bulk density of aquifer materials	ρ	2.00E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	1.59E-02	fraction	
Hydraulic conductivity of aquifer	K	4.03E+00	m/d	
Distance (lateral) to compliance point perpendicular to flow direction	X	1.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	Y		m	
Time since pollutant entered groundwater	t	1.00E+100	days	time variant options only
Parameters values determined from options				
Partition coefficient	Kd	4.69E+00	l/kg	see options
Longitudinal dispersivity	ax	1.00E-01	m	see options
Transverse dispersivity	az	1.00E-02	m	see options
Vertical dispersivity	ay	1.00E-03	m	see options

Calculated Parameters

Groundwater flow velocity	V	2.14E-01	m/d
Retardation factor	Rf	3.22E+01	fraction
Decay rate used	λ	3.71E-03	d ⁻¹
Rate of contaminant flow due to retardation	U	6.63E-03	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{ed}	3.98E-01	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	1.70E+00	

Remedial Targets

Remedial Target	5.10E-02	mg/l	For comparison with measured groundwater concentration.
Domenico - Steady state			
Distance to compliance point	1	m	
Concentration of contaminant at compliance point	C _{ed} /C _r	3.98E-01	mg/l Domenico - Steady state

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)

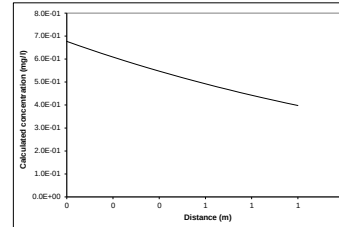
Calculate for non-polar organic chemicals

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	1.10E-02 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	4.69E+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	m
Longitudinal dispersivity	ax	0.00E+00	1.00E-01	0.00E+00
Transverse dispersivity	az	0.00E+00	1.00E-02	0.00E+00
Vertical dispersivity	ay	0.00E+00	1.00E-03	0.00E+00
Note values of dispersivity must be > 0				
For calculated value, assumes $\alpha_x = 0.1 \cdot x$, $\alpha_z = 0.01 \cdot x$, $\alpha_y = 0.001 \cdot x$				
$Xu \& Eckstein$ (1995) report $\alpha_x = 0.83(\log_{10}x)^{2+1.5}$; $\alpha_z = \alpha_{x10}$, $\alpha_y = \alpha_{x100}$ 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 described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed:	Quakers Yard
Completed by:	Rebekah Wain
Date:	01/04/2023
Version:	1



Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Phenol
0.0077 mg/l

from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

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 contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

2.35E-03
1.97E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

3.00E+01
5.20E+00
4.03E+00
1.59E-02
8.00E+01
1.00E-10

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
4.17E+00

m
m

Calculated Parameters

Dilution Factor

DF

4.79E+00

Level 2 Remedial Target

3.69E-02

mg/l

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

or

1.15E-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

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Quakers Yard
Completed by: Rebekah Wain
Date: 13-Mar-23
Version: 1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Phenol		from Level 1
Target Concentration	C _T	0.0077	mg/l	from Level 1
Dilution Factor	DF	4.79E+00		from Level 2

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

Ogata Banks	Equations in HRA publication
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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 pollutants in all phases (e.g. field derived value,)

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	22	mg/kg	
Enter soil concentration	6.75E+00	mg/kg	
Half life for degradation of contaminant in water	1.03E-01	days	
Calculated decay rate	1.03E-01	days ⁻¹	calculated
Width of plume in aquifer at source	8.00E+01	m	from Level 2
Plume thickness in aquifer at source	4.17E+00	m	from Level 2
Bulk density of aquifer materials	2.00E+00	g/cm ³	
Effective porosity of aquifer	3.00E-01	fraction	
Hydraulic gradient	2.01E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	4.03E+00	m/d	from Level 2
Distance to compliance point	5.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction		m	
Distance (depth) to compliance point perpendicular to flow direction		m	
Time since pollutant entered groundwater	1.00E+100	days	time variant options only
Parameters values determined from options			
Partition coefficient	9.13E-01	l/kg	see options
Longitudinal dispersivity	5.000	m	see options
Transverse dispersivity	0.500	m	see options
Vertical dispersivity	0.050	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	2.70E-01	m/d
Retardation factor	7.09E+00	fraction
Decay rate used	1.03E-01	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	2.01E-02	fraction
Rate of contaminant flow due to retardation	3.81E-02	m/d
Ratio of Compliance Point to Source Concentration	1.13E-14	fraction
Attenuation factor (C ₀ /C ₁₀)	8.85E+13	fraction
Calculated soil leachate concentration	7.07E+00	mg/l

Remedial Targets

Level 3 Remedial Target	3.26E+12	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or	1.02E+13	This assumes Level 1 Remedial Target is based on Target Concentration.
Distance to compliance point	50	m	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₀ /C ₁	1.13E-14	fraction

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

Enter if specify partition coefficient (option)	K _d		l/kg
Soil water partition coefficient			
Enter for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	f _{oc}	1.10E-02	fraction
Organic carbon partition coefficient	K _{oc}	8.30E+01	l/kg
Enter 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	pK _a		
Fraction of organic carbon in aquifer	f _{oc}		fraction
Soil water partition coefficient	K _d	9.13E-01	l/kg

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

Dispersivities 10% 1% 0.1% of pathway length

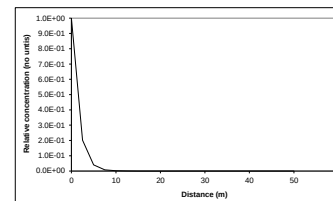
	Enter value	Calc value	Xu & Eckstein
Longitudinal dispersivity	ax	5.00E+00	5.00E+00 m
Transverse dispersivity	az	5.00E-01	2.98E-01 m
Vertical dispersivity	ay	5.00E-02	3.00E-02 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀X)^{-0.414}, 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 described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration 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.

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks	Relative concentration	Concentration
From calculation sheet	(No units)	mg/l
Distance		
0	1.0E+00	1.48E+00
2.5	2.01E-01	2.97E-01
5.0	4.06E-02	5.99E-02
7.5	8.17E-03	1.21E-02
10.0	1.65E-03	2.43E-03
12.5	3.31E-04	4.89E-04
15.0	6.67E-05	9.84E-05
17.5	1.34E-05	1.98E-05
20.0	2.70E-06	3.98E-06
22.5	5.42E-07	8.00E-07
25.0	1.09E-07	1.61E-07
27.5	2.18E-08	3.22E-08
30.0	4.39E-09	6.47E-09
32.5	8.78E-10	1.30E-09
35.0	1.76E-10	2.60E-10
37.5	3.52E-11	5.20E-11
40.0	7.05E-12	1.04E-11
42.5	1.41E-12	2.08E-12
45.0	2.82E-13	4.17E-13
47.5	5.65E-14	8.34E-14
50.0	1.13E-14	1.67E-14

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:	Quakers Yard
Completed by:	Rebekah Wain
Date:	#####
Version:	1

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Phenol	from Level 1
Target Concentration	7.70E-03	from Level 1
C _r	mg/l	

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

Domenico - Steady state 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 pollutants in all phases (e.g. field derived value)

Initial contaminant concentration in groundwater at plume core	C ₀	1.91E+00	mg/l	Source of parameter value
Half life for degradation of contaminant in water	t _{1/2}	6.75E+00	days	
Width of plume in aquifer at source (perpendicular to flow)	λ	1.03E-01	days ²	
Plume thickness at source	Sz	8.00E+01	m	
Saturated aquifer thickness	da	5.20E+00	m	
Bulk density of aquifer materials	ρ	2.00E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	1.59E-02	fraction	
Hydraulic conductivity of aquifer	K	4.03E+00	m/d	
Distance (lateral) to compliance point perpendicular to flow direction	X	1.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	Y		m	
Time since pollutant entered groundwater	t	1.00E+100	days	time variant options only
Parameters values determined from options				
Partition coefficient	Kd	9.13E-01	l/kg	see options
Longitudinal dispersivity	ax	1.00E-01	m	see options
Transverse dispersivity	az	1.00E-02	m	see options
Vertical dispersivity	ay	1.00E-03	m	see options

Calculated Parameters

Groundwater flow velocity	V	2.14E-01	m/d
Retardation factor	Rf	7.09E+00	fraction
Decay rate used	λ	1.03E-01	d ⁻¹
Rate of contaminant flow due to retardation	u	3.01E-02	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{eq}	1.30E-01	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	1.47E+01	

Remedial Targets

Remedial Target	1.13E-01	mg/l	For comparison with measured groundwater concentration.
Domenico - Steady state			
Distance to compliance point	1	m	
Concentration of contaminant at compliance point	C _{eq} /C _r	1.30E-01	mg/l Domenico - Steady state

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)

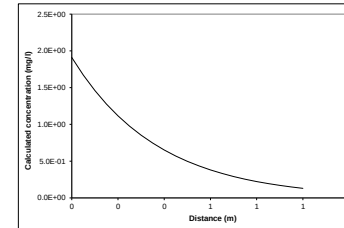
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)	Kd		l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)	foc	1.10E-02	fraction
Fraction of organic carbon in aquifer			
Organic carbon partition coefficient	Koc	8.30E+01	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	9.13E-01	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	m
Longitudinal dispersivity	ax	0.00E+00	1.00E-01	0.00E+00
Transverse dispersivity	az	0.00E+00	1.00E-02	0.00E+00
Vertical dispersivity	ay	0.00E+00	1.00E-03	0.00E+00
Note values of dispersivity must be > 0				
For calculated value, assumes $\alpha_x = 0.1 \cdot x$, $\alpha_y = 0.01 \cdot x$, $\alpha_z = 0.001 \cdot x$				
$Xu \& Eckstein$ (1995) report $\alpha_x = 0.83(\log_{10}x)^{2+1.4}$; $\alpha_z = \alpha_{10}$, $\alpha_y = \alpha_{10}/100$ 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 described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed:	Quakers Yard
Completed by:	Rebekah Wain
Date:	01/04/2023
Version:	1

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Toluene
0.074 mg/l

from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

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 contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

2.35E-03
1.97E+03

m/d
m²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

3.00E+01
5.20E+00
4.03E+00
1.59E-02
8.00E+01
1.00E-10

m
m
m/d
fraction
m
mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate
4.17E+00

m
m

Calculated Parameters

Dilution Factor

DF

4.79E+00

Level 2 Remedial Target

3.54E-01
or
2.63E+00

mg/l
mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

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

0.00E+00

mg/l

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed: Quakers Yard
Completed by: Rebekah Wain
Date: 13-Mar-23
Version: 1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Toluene		from Level 1
Target Concentration	C _T	0.074	mg/l	from Level 1
Dilution Factor	DF	4.79E+00		from Level 2

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

Ogata Banks	Equations in HRA publication
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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 pollutants in all phases (e.g. field derived value, ...)

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration	207	mg/kg	
Enter soil concentration	1.75E+01	mg/kg	
Half life for degradation of contaminant in water	1.75E+01	days	
Calculated decay rate	3.96E-02	days ⁻¹	calculated
Width of plume in aquifer at source	8.00E+01	m	from Level 2
Plume thickness in aquifer at source	4.17E+00	m	from Level 2
Bulk density of aquifer materials	2.00E+00	g/cm ³	
Effective porosity of aquifer	3.00E-01	fraction	
Hydraulic gradient	2.01E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	4.03E+00	m/d	from Level 2
Distance to compliance point	5.00E+00	m	
Distance (lateral) to compliance point perpendicular to flow direction		m	
Distance (depth) to compliance point perpendicular to flow direction		m	
Time since pollutant entered groundwater	1.00E+100	days	time variant options only
Parameters values determined from options			
Partition coefficient	K _d	2.24E+00	l/kg
Longitudinal dispersivity	ax	0.500	m
Transverse dispersivity	az	0.050	m
Vertical dispersivity	ay	0.005	m

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	2.70E-01	m/d
Retardation factor	1.60E+01	fraction
Decay rate used	3.96E-02	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	2.01E-02	fraction
Rate of contaminant flow due to retardation	1.69E-02	m/d
Ratio of Compliance Point to Source Concentration	C ₀ /C _i	fraction
Attenuation factor (C ₀ /C _i)	AF	1.01E+03
Calculated soil leachate concentration	Co	2.78E+01

Remedial Targets

Level 3 Remedial Target	3.58E+02	mg/l	For comparison with measured pore water concentration.
Ogata Banks	2.67E+03	mg/kg	This assumes Level 1 Remedial Target is based on Target Concentration.
Distance to compliance point	5	m	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₀ /C _i	9.89E-04	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)	K _d		l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)	foc	1.10E-02	fraction
Fraction of organic carbon in aquifer	Koc	2.04E+02	l/kg
Organic carbon partition coefficient			
Entry for ionic organic chemicals (option)	K _{oc,n}		l/kg
Sorption coefficient for related species	K _{oc,i}		l/kg
Sorption coefficient for ionised species	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	K _d	2.24E+00	l/kg

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

Dispersivities 10% 1% 0.1% of pathway length

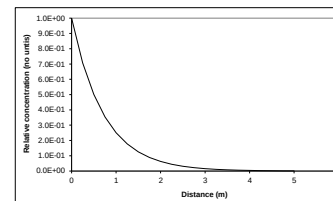
	Enter value	Calc value	Xu & Eckstein
Longitudinal dispersivity	ax	0.00E+00	5.00E-01
Transverse dispersivity	az	0.00E+00	5.00E-02
Vertical dispersivity	ay	0.00E+00	5.00E-03

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀V)^{-0.414}, 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 described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentration 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.

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	5.81E+00
0.3	7.08E-01	4.11E+00
0.5	5.01E-01	2.91E+00
0.8	3.54E-01	2.06E+00
1.0	2.51E-01	1.46E+00
1.3	1.77E-01	1.03E+00
1.5	1.25E-01	7.29E-01
1.8	8.88E-02	5.16E-01
2.0	6.28E-02	3.65E-01
2.3	4.44E-02	2.58E-01
2.5	3.14E-02	1.83E-01
2.8	2.22E-02	1.29E-01
3.0	1.57E-02	9.15E-02
3.3	1.11E-02	6.47E-02
3.5	7.88E-03	4.58E-02
3.8	5.58E-03	3.24E-02
4.0	3.94E-03	2.29E-02
4.3	2.79E-03	1.62E-02
4.5	1.97E-03	1.15E-02
4.8	1.40E-03	8.12E-03
5.0	9.89E-04	5.79E-03

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:	Quakers Yard
Completed by:	Rebekah Wain
Date:	00000000
Version:	1

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Toluene	from Level 1
Target Concentration	7.40E-02	from Level 1
C _r	mg/l	

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

Domenico - Steady state 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 pollutants in all phases (e.g. field derived value)

Initial contaminant concentration in groundwater at plume core	C ₀	1.29E+00	mg/l	Source of parameter value
Half life for degradation of contaminant in water	t _{1/2}	1.75E+01	days	
Calculated decay rate	λ	3.96E-02	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	8.00E+01	m	
Plume thickness at source	Sy	5.00E+00	m	
Saturated aquifer thickness	da	5.20E+00	m	
Bulk density of aquifer materials	ρ	2.00E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	1.59E-02	fraction	
Hydraulic conductivity of aquifer	K	4.03E+00	m/d	
Distance to compliance point	x	1.00E+00	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+100	days	time variant options only
Parameters values determined from options				
Partition coefficient	Kd	2.24E+00	l/kg	see options
Longitudinal dispersivity	ax	1.00E-01	m	see options
Transverse dispersivity	az	1.00E-02	m	see options
Vertical dispersivity	ay	1.00E-03	m	see options

Calculated Parameters

Groundwater flow velocity	V	2.14E-01	m/d
Retardation factor	Rf	1.60E+01	fraction
Decay rate used	λ	3.96E-02	d ⁻¹
Rate of contaminant flow due to retardation	u	1.34E-02	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{ed}	1.18E-01	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	1.09E+01	

Remedial Targets

Remedial Target	8.07E-01	mg/l	For comparison with measured groundwater concentration.
Domenico - Steady state			
Distance to compliance point	1	m	
Concentration of contaminant at compliance point	C _{ed} /C _r	1.18E-01	mg/l Domenico - Steady state

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)

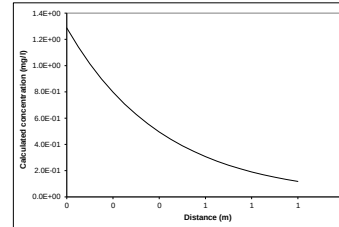
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)	Kd	l/kg
Soil water partition coefficient		
Entry for non-polar organic chemicals (option)		
Fraction of organic carbon in aquifer	foc	1.10E-02 fraction
Organic carbon partition coefficient	Koc	2.04E+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	2.24E+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	m
Longitudinal dispersivity	ax	0.00E+00	1.00E-01	0.00E+00
Transverse dispersivity	az	0.00E+00	1.00E-02	0.00E+00
Vertical dispersivity	ay	0.00E+00	1.00E-03	0.00E+00
Note values of dispersivity must be > 0				
For calculated value, assumes $\alpha_x = 0.1 \cdot x$, $\alpha_y = 0.01 \cdot x$, $\alpha_z = 0.001 \cdot x$				
$Xu \& Eckstein$ (1995) report $\alpha_x = 0.83(\log_{10}x)^{2.414}$; $\alpha_z = \alpha_{10}$, $\alpha_y = \alpha_{10}/100$ 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 described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed:	Quakers Yard
Completed by:	Rebekah Wain
Date:	01/04/2023
Version:	1

Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant
Target concentration

C_T

Total cyanide	
0.001	mg/l

from Level 1
from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

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 contamination' (Environment Agency 2006)

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Infiltration
Area of contaminant source

Inf
A

2.35E-03	m/d
1.97E+03	m ²

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow
Saturated aquifer thickness
Hydraulic Conductivity of aquifer in which dilution occurs
Hydraulic gradient of water table
Width of contaminant source perpendicular to groundwater flow
Background concentration of contaminant in groundwater beneath site

L
da
K
i
w
Cu

3.00E+01	m
5.20E+00	m
4.03E+00	m/d
1.59E-02	fraction
8.00E+01	m
1.00E-10	mg/l

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Enter mixing zone thickness
Calculated mixing zone thickness

Mz
Mz

Calculate	
	m
4.17E+00	m

Calculated Parameters

Dilution Factor

DF

4.79E+00

Level 2 Remedial Target

4.79E-03
or
4.81E-02

mg/l
mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration

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)

C_c

0.00E+00

mg/l

--

Calculated concentration within receptor (dilution only)

0.00E+00

mg/l

0

Site being assessed:	Quakers Yard
Completed by:	Rebekah Wain
Date:	13-Mar-23
Version:	1

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Total cyanide	from Level 1
Target Concentration	C _r 1.00E-03	mg/l from Level 1

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

Domenico - Steady state 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 pollutants in all phases (e.g. field derived value)

Initial contaminant concentration in groundwater at plume core	C ₀	3.43E+00	mg/l	Source of parameter value
Half life for degradation of contaminant in water	t _{1/2}	1.90E+02	days	
Calculated decay rate	λ	3.65E-03	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	3.00E+01	m	
Plume thickness at source	Sy	5.00E+00	m	
Saturated aquifer thickness	da	5.20E+00	m	
Bulk density of aquifer materials	ρ	2.00E+00	g/cm ³	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	1.59E-02	fraction	
Hydraulic conductivity of aquifer	K	4.03E+00	m/d	
Distance to compliance point	X	1.00E+00	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+100	days	time variant options only
Parameters values determined from options				
Partition coefficient	Kd	9.90E+00	l/kg	see options
Longitudinal dispersivity	ax	1.00E-01	m	see options
Transverse dispersivity	az	1.00E-02	m	see options
Vertical dispersivity	ay	1.00E-03	m	see options

Calculated Parameters

Groundwater flow velocity	V	2.14E-01	m/d
Retardation factor	Rf	6.70E+01	fraction
Decay rate used	λ	3.65E-03	d ⁻¹
Rate of contaminant flow due to retardation	u	3.19E-03	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{eq}	1.22E+00	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	2.82E+00	

Remedial Targets

Remedial Target	2.82E-03	mg/l	For comparison with measured groundwater concentration.
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Domenico - Steady state

Distance to compliance point	1	m
Concentration of contaminant at compliance point	C _{eq} /C _r	1.22E+00 mg/l Domenico - Steady state

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)

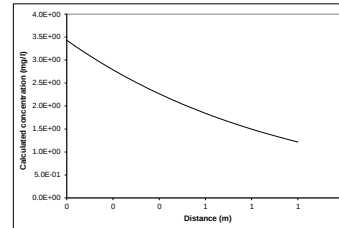
User specified value for partition coefficient

Entry if specify partition coefficient (option)	Kd	9.90E+00	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		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	9.90E+00	l/kg

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

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

Longitudinal dispersivity	ax	Enter value	Calc value Xu & Eckstein	m
Transverse dispersivity	az	0.00E+00	1.00E-01	0.00E+00 m
Vertical dispersivity	ay	0.00E+00	1.00E-02	0.00E+00 m
		0.00E+00	1.00E-03	0.00E+00 m
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+1.5} ; 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 described by an electron limited degradation such as oxidation by O₂, NO₃, SO₄ etc than an alternative solution should be used

Site being assessed:	Quakers Yard
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Date:	01/04/2023
Version:	1



Appendix E: CIRIA 552 Risk Matrix

Risk classification methodology

The method of risk evaluation adopted in this document is consistent with CIRIA C552 (2001). Hence, risk is considered to be a function of both the probability (likelihood) of contamination occurring at the study site and also the potential severity (consequence) of the environmental impacts associated with this contamination.

The classification system used to define contaminant probability, consequence and risk is described in the following tables.

Table A: Classification of probability

Classification	Definition
High Likelihood	There is a contaminant linkage and an event that appears either very likely in the short term and almost inevitable over the long term, or there is evidence at the receptor of harm or pollution.
Likely	There is a contaminant linkage and all the elements are present and in the right place, which means that it is probably that an event will occur. Circumstances are such that an event is not inevitable, but possible in the short term, and likely over the long term.
Low Likelihood	There is a contaminant linkage and circumstances are possible under which an event could occur. However, it is by no means certain that even over a longer period such event would take place, and is less likely in the shorter term.
Unlikely	There is contaminant linkage but circumstances are such that it is improbable that an event would occur even in the long term.

Table B: Classification of consequence

Classification	Receptor	Definition	Examples
Severe	Humans	Short-term (acute) risk to human health likely to result in "significant harm" as defined in the CTL Statutory Guidance	High concentrations of cyanide on the surface of an informal recreation area
	Controlled waters	Short-term risk of pollution (note: Water Resources Act contains no scope for considering significance of pollution) of sensitive water resource	Major spillage of contaminants from site into controlled water
	Property	Catastrophic damage to buildings/property	Explosion, causing building collapse (can also equate to an acute human health risk if buildings are occupied)
	Ecology	A short-term risk to a particular ecosystem, or organism forming part of such eco-system	Potentially long term derogation of a designated site or protected species
Medium	Humans	Chronic damage to human health ("significant harm" as defined in the CTL Statutory Guidance)	Concentrations of a contaminant from a residential site exceed the site-specific assessment criteria
	Controlled waters	Pollution of sensitive water resources (note: Water Resources Act contains no scope for considering significance of pollution)	Leaching of contaminants from a site to a principal or secondary aquifer
	Property	Significant damage to crops, buildings, structures and services	Damage to building rendering it unsafe to occupy (e.g. foundation damage resulting in instability).
	Ecology	A significant change in a particular ecosystem	Death of a species within a designated nature reserve

Classification	Receptor	Definition	Examples
Mild	Humans	Contamination present although unlikely to constitute a significant chronic health risk	Concentrations of a contaminant from a public access site moderately exceed the generic assessment criteria
	Controlled waters	Pollution of non-water resources	Pollution of non-classified groundwater
	Property	Damage to sensitive buildings/structures/services	Aggressive ground conditions leading to potential for long term degradation of buried concrete
	Ecology	Damage to the environment	Localised damage to aquatic habitat causing temporary relocation of certain species
Minor	Humans	Non-permanent health effects to human health (easily prevented by means such as personal protective clothing etc.)	The presence of contaminants at such concentrations that protective equipment is required during site works.
	Controlled waters	Potential minor release of contamination to local water features	Short term or low volume release of potentially polluting material to a secondary surface water course of low existing quality
	Property	Easily reparable effects of damage to buildings, structures and services. Harm which may result in a financial loss, or expenditure to resolve.	The loss of plants in a landscaping scheme. Discolouration of concrete
	Ecology	Short term, localised damage may occur; consequences are spatially and temporally limited	Short term or localised disruption to in situ flora or fauna; no lasting effects

Table C: Risk classification (comparison of consequence and probability)

Probability (likelihood)		Consequence (severity)			
		<i>Severe</i>	<i>Medium</i>	<i>Mild</i>	<i>Minor</i>
	<i>High likelihood</i>	Very high risk	High risk	Moderate risk	Low risk
	<i>Likely</i>	High risk	Moderate risk	Moderate/low risk	Low risk
	<i>Low likelihood</i>	Moderate risk	Moderate/low risk	Low risk	Very low risk
	<i>Unlikely</i>	Moderate/low risk	Low risk	Very low risk	Very low risk