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Controlled Waters

Detailed Quantitative Risk Assessment For former British Airways and Vodafone Plots

Former British Airways and Vodafone Plots, North Hyde Gardens, Hayes, UB3 4QQ

A REPORT PREPARED

FOR AND ON BEHALF OF ARK DATA CENTRES LIMITED

C/O HURLEY PALMER FLATT

Issue Date:	11 November 2021
Revision NO:	C
Revision Date:	11 November 2021

ISSUING OFFICE:	Paragon, The Harlequin Building, 65 Southwark Street, London, SE1 0HR Tel: 020 7125 0112
DATE:	11 November 2021
REFERENCE:	20.0023/CK/KJH
REPORT PREPARED BY:	Tim Cawood BSc(Hons) MSc MBA CEng CEnv MCIWEM ASoBRA SiLC
REPORT CHECKED BY:	Charlie Knox MSc CEnv
SIGNATURE:	
	For and on behalf of Paragon Building Consultancy Limited

H	*Critical or high risk issue for urgent management attention*
M/H	*Moderate to high risk issue considered as a significant management item*
M	*Medium risk issue for ongoing management or action*
L/M	*Low to medium risk issue that may require management or action*
L	*Low risk item or for information only*

CONTENTS

CONTROLLED WATERS DQRA

CLIENT NAME:	Ark Data Centres Limited c/o Hurley Palmer Flatt
PROPERTY ADDRESS:	Former British Airways and Vodafone Plots North Hyde Gardens, Hayes
INSPECTION DATE:	Various

1.0 INTRODUCTION

1.1 General

1.1.1 In January 2020, Paragon was commissioned by Ark Data Centres Limited c/o Hurley Palmer Flatt (hereafter referred to as HPF) to undertake a Phase 2 Ground Investigation for the Bulls Bridge site in Hayes. The site location is shown on Figure 1.

1.1.2 The report was issued in March 2020 and identified risks to Controlled Waters which required further assessment. In order to further assess those risks, HPF commissioned Paragon to undertake this Detailed Quantitative Risk Assessment (DQRA) for Controlled Waters. It should be noted that this report relates solely to the assessment of risks to Controlled Waters and not to Human Health. The latter are covered by separate reports, discussed in section 3.

1.2 Part IIA Regulatory Regime

1.2.1 The Environmental Protection Act 1990: Part IIA Contaminated Land (EPA), defines pollution of the water environment in terms of the direct or indirect introduction into the water environment of substances which may give rise to harm to human health (i.e. through abstraction for drinking water) or the quality of aquatic ecosystems or terrestrial ecosystems directly depending of aquatic ecosystems, result in damage to material property of impair or interfere with amenities and other legitimate uses of Controlled Waters.

1.2.2 The principal Controlled Waters receptor is considered to be the River Crane (as an ecological receptor) which forms a discharge zone for shallow groundwater passing through the site. Due to the history of industrial land use in the surrounding area it is not envisaged that groundwater beneath the site will be used as a future drinking water resource.

1.2.3 The purpose of this report is to assess if significant pollution or the significant possibility of significant pollution of controlled waters is occurring as a result of historic groundwater contamination on the Bulls Bridge site, via shallow groundwater (pathway) to the River Crane (principal receptor) (i.e. identify potential pollutant linkages with respect to the River Crane).

1.2.4 Detailed Quantitative Risk Assessment has been undertaken to derive groundwater remedial targets, to be protective of Controlled Waters, for those contaminants with potential pollution linkages identified in the Phase 2 Ground Investigations.

1.3 Report Structure

1.3.1 This report is presented in a format with a strong focus on the DQRA and methodology. Therefore, the report has the following outline structure:

- Section 1 – *Introduction*: This section introduces the report.
- Section 2 – *Outline Risk Assessment Methodology*: This section provides an outline of the risk assessment methodology developed for the appropriate understanding of risks to controlled waters at the site.
- Section 3 – *Environmental Setting*: The environmental setting is established in this section of the report. This is a key section as it provides the necessary information to understand the water environment in relation to the site, and in particular understanding the updated Conceptual Site Model provided in the following section.
- Section 4 – *Updated Conceptual Site Model*: This section provides the updated conceptual site model to clearly establish the pollutant linkages (source-pathway-receptor) considered as part of the DQRA.
- Sections 5 – *Tier 3/4 Risk Assessment*: This section introduces the Tier 3 assessment undertaken; the sensitivity analyses, findings and how these were obtained are discussed.
- Section 6 – *Conclusions and Recommendations*: This section provides conclusions and recommendations for the report.

2.0 RISK ASSESSMENT METHODOLOGY

2.1 Outline Risk Assessment Methodology

2.1.1 The Controlled Waters DQRA has been undertaken on a tiered basis for the Bulls Bridge site. The initial assessment and findings are detailed within the Phase 2 Ground Investigation Reports. These considered water and soil leachate results against generic, conservative, Tier 1 screening values to allow the robust risk assessment of potential contaminated land issues at the site.

2.1.2 In accordance with the UK tiered approach to risk assessment, those determinands identified as exceeding the River Crane (Ecological Receptor) Tier 1 assessment criteria were identified as potential Contaminants of Concern (CoC). The Tier 1 assessment criteria applied and screening sheets are provided in Appendix A.

2.1.3 The Detailed Quantitative Risk Assessment and derivation of remedial targets (or site specific assessment criteria (SSACs)) was undertaken using the Environment Agency's Remedial Targets Methodology (RTM) (2006).

2.1.4 RTM Level 1 contaminant source locations were identified on a contaminant by contaminant basis using the identified Tier 1 contaminants of concern (i.e. those contaminants found to be in concentrations exceeding the Tier 1 screening criteria). The most conservatively located source location for each CoC was used to input the relevant spatial descriptor parameters into the RTM spreadsheets (e.g. saturated aquifer thickness, distance to compliance point).

2.1.5 An RTM Level 3 assessment was undertaken, which incorporates potential contaminant dilution and attenuation effects within the shallow aquifer, but does not include potential dilution of the shallow groundwater on discharge to the River Crane. The initial Level 3 assessment used conservative degradation rates.

2.1.6 The soil and leachate chemical testing data set was then screened against the derived RTM Level 3 Remedial Targets.

2.1.7 For those contaminants that demonstrated significant numbers of concentrations above the derived RTM Level 3 values, a further Level 4 RTM assessment was undertaken where appropriate. This took into consideration the potential dilution of shallow groundwater on discharge to the River Crane.

2.1.8 Exceedances of the derived Level 3/4 values were then subject to sensitivity analysis in order to assess the level of conservatism incorporated in the initial RTM models. The Level 3 and Level 4 RTM spreadsheets are provided in Appendix E.

3.0 ENVIRONMENTAL SETTING

3.1 Introduction

3.1.1 The following sub-sections identify the water environment setting for the site; these are provided to assist the understanding of an appropriate Conceptual Site model in consideration of the site and its surrounding environmental setting.

3.2 Previous Investigations

3.2.1 Four previous investigations have been carried out at the site. These are:

- Jomas Associates. May 2018. Geo-environmental & Geotechnical Assessment Ground Investigation Report for North Hyde Gardens, Hayes, UB3 4QR. Ref P1470J1364/SL.
- Paragon BC. December 2020. Phase 1 Preliminary Risk Assessment. Ref 19.0633/CB/NW. Rev D, November 2021.
- Paragon BC. August 2019. Phase 2 Ground Investigation Report. Ref 19.0633/CB/NW.
- Paragon BC. December 2020. Phase 2 Ground Investigation Report. Ref 20.0023/CB/NW Rev D, November 2021.

3.2.2 Approximately 53no exploratory locations have been drilled/excavated across the site in recent investigations (see Figure 2 - Composite Exploratory Hole Plan). These include:

- 10no in-situ CBR;
- 3no Cable percussive boreholes;
- 8no Sonic boreholes;
- 7no Hand dug trial pits;
- 10no Machine excavated trial pits; and
- 15no Window sample boreholes.

The general succession of strata encountered across these exploratory locations is summarised in Table 1.

3.2.3 ***Table 1. Summary of Ground Conditions***

Depth From (min/max) (m)	Depth To (min/max) (m)	Soil Type	Description
0.0	0.05 / 0.1	Concrete / Tarmcadam	Concrete / Tarmacadam hardstanding.
0.05 / 0.1	1.5 / 5.8	Made Ground	Variable Made Ground comprising soft to firm, dark brown, gravelly clay. Gravel is brick, suspected slag, clinker, timber fragments, concrete and mixed lithologies.
1.5 / 5.8	5.7 / 10.2	Gravel	Yellowish orange brown slightly clayey sandy GRAVEL. Gravel is sub-rounded to well-rounded fine to coarse mixed lithologies. (LYNCH HILL GRAVEL MEMBER)
5.7 / 10.2	Not Proven	Clay	Firm to stiff silty CLAY. (LONDON CLAY)

3.3 River Crane – River Basin Management Plan

3.3.1 The River Crane is located within the Thames River Basin District. The most recent River Basin Management Plan (Environment Agency, 2015) contains limited information in relation to the River Crane catchment and references the Crane Valley Partnership as a source of further information.

3.3.2 The River Crane is a heavily modified river which flows almost entirely through urban areas. It originates in Harrow and flows south then east to join the River Thames in Isleworth.

3.3.3 The Environment Agency Catchment Data Explorer (https://environment.data.gov.uk/catchment-planning/OperationalCatchment/3112/Summary) contains monitoring data from four points within the Crane catchment. These are all assessed as having good chemical status and poor to good ecological status. The river quality objective for the catchment is to achieve good ecological status across all four monitoring points.

3.3.4 Approximately 500m upstream of the site, a tributary of the River Crane, the Yeading Brook, flows adjacent to the former Southall Gasworks. This is a likely source of background contamination in the River Crane.

3.4 River Crane – Discharge Zone

3.4.1 The River Crane is considered to be the primary controlled waters receptor for the Bulls Bridge site. Based on site investigation data for the site, it is considered that the groundwater flowing beneath the site will discharge into the River Crane and not pass beyond it. This is on the basis that shallow groundwater levels monitored in boreholes in the vicinity of the River Crane are at a similar level to the river and are constrained from downward flow by the London Clay.

3.4.2 Almost the entire site is located within 250m of the River Crane. It is therefore considered appropriate that the River Crane is adopted as the primary controlled waters receptor, and that drinking water resource considerations are not appropriate (i.e. shallow groundwater should be considered as a potential pathway to the River Crane, rather than a receptor). In addition, it appears from the available data that the contamination present has already entered groundwater underlying the site.

3.5 Dilution

3.5.1 In order to assess the diluting capacity of the River Crane (receiving surface watercourse and receptor), with respect to the chemistry of the shallow groundwater (pathway), a hydrologically defined dilution factor was calculated.

3.5.2 The dilution factor calculated solely on a hydrology basis, utilising calculated values of the groundwater flux through the shallow aquifer and low flow conditions (Q95) in the River Crane (1978-2018), was 43.5. The corresponding dilution factor calculated using more typical flow conditions in the River Crane (Q50) was 115. The details of these calculations are reported in Section 5.5.1.

3.5.3 A dilution factor of 40 was applied by Paragon within the Level 4 RTM assessment (by increasing the target concentration by a factor of 40).

3.6 Groundwater / Surface Water Conditions

3.6.1 The recent site investigations undertaken at the site have included monitoring of groundwater levels in a total of 14no boreholes. The recorded groundwater levels are shown in Table 2.

3.6.2 BH07 is the closest borehole to the River Crane, approximately 20m to the north west. Groundwater levels recorded in BH07 ranged between 4.01-4.20mbgl (26.76-26.57mAOD). In comparison, the base of the River Crane channel adjacent to the site is around 25.00mAOD based on Environment Agency LiDAR data.

3.6.3 Figure 3 shows a generalised cross-section through the site in the direction of groundwater flow. This is based on a 3d ground model constructed from all available site investigation data. The groundwater under the site is perched on the London Clay and the majority of groundwater flow appears to be through the Lynch Hill Gravel Member to the River Crane. It also appears likely that the base of the River Crane's channel intersects, or is close to intersecting, the top of the London Clay.

3.6.4

Table 2. Groundwater Levels

Borehole Name	Response Zone mbgl / [mAOD]	Monitoring Date								
		25/6/19	**27/6/19**	**3/7/19**	**22/1/20**	**29/1/20**	**12/2/20**	**19/2/20**	**4/6/20**	**18/6/20**
BH1 - J	1.00 – 5.00	3.67 [27.10]		3.72 [27.05]	3.62 [27.15]	3.64 [27.13]	3.66 [27.11]	3.59 [27.18]	3.70 [27.07]	3.66 [27.11]
BH2 - J	1.00 – 5.00	2.20 [28.57]								
BH3 - J	1.00 – 5.00			1.82 [28.95]	1.70 [29.07]	1.69 [29.08]	1.74 [29.03]	1.70 [29.07]		
WS2 - J	1.00 – 3.00	2.03 [28.74]		2.20 [28.57]			1.85 [28.92]	1.75 [29.02]		
WS7 - J	1.00 – 4.60						1.95 [28.82]	1.88 [28.89]		
WS3	1.00 – 2.00		Dry	1.67 [29.10]						
WS4	0.50 – 2.50			1.80 [28.97]						
WS5	1.00 – 4.00		Dry	2.86 [27.91]						
WS6	1.50 – 5.00		Dry	3.86 [26.91]						
WS7	1.00 – 5.00			3.25 [27.52]	3.08 [27.69]	3.06 [27.71]	3.20 [27.57]	3.18 [27.59]	3.26 [27.51]	3.18 [27.59]
WS8	1.00 – 5.00			4.90 [27.87]						
BH02	4.50 – 6.30					1.83 [28.94]	1.96 [28.81]	1.82 [28.95]	2.00 [28.77]	
BH07	4.00 – 6.00					4.01 [26.76]	4.20 [26.57]	4.16 [26.61]		
BH08 (Shallow)	4.50 – 6.00					3.37 [27.40]	3.12 [27.65]	3.08 [27.69]	3.37 [27.40]	3.34 [27.43]
BH08 (Deep)	9.00 – 10.00					9.32 [21.45]	6.80 [23.97]	6.05 [24.72]		

3.6.5 The following contaminants were identified in the previous Paragon investigations as exceeding the Tier 1 (EQS) screening levels in leachate and/or groundwater:

- Copper;
- Lead;
- Nickel;
- Zinc;
- Ammonia;
- Phenols;
- Naphthalene;
- Anthracene;
- Fluoranthene; and
- Xylenes.

3.6.6 In addition, the banded hydrocarbons testing (TPHCWG) indicated the presence of aromatic hydrocarbons. However, the three PAHs already listed as contaminants of potential concern (CoPC) are recommended as indicator compounds for the controlled waters risk assessment of petroleum hydrocarbons in CL:AIRE (2017). Therefore, no Tier 3 analysis will be undertaken for TPHCWG bands.

3.6.7 Trimethylbenzenes were also identified in the initial groundwater monitoring. As no published EQS exists for these and they are broadly similar to Xylenes (CL:AIRE, 2017), which are being taken forward to Tier 3, trimethylbenzenes are not assessed separately.

3.6.8 In order to confirm these findings and improve the dataset, further groundwater monitoring visits were undertaken on 4th June 2020 and 18th June 2020. This work was undertaken using low flow methods with monitoring of in-situ groundwater parameters using a flow-through cell. The field records for this are included as Appendix B and the laboratory results as Appendix C.

3.6.9 The additional monitoring visits confirmed the list of contaminants which exceeded the Tier 1 (EQS) screening levels. These are considered further in a Tier 3 assessment in Section 5.

3.7 Surface Water (River Crane Upstream Conditions)

3.7.1 Two surface water samples were obtained from the River Crane upstream of the site during the additional groundwater monitoring visits on 4th and 18th June 2020. Assessment of surface water contaminant concentrations at Tier 1 has indicated that the below contaminants are elevated on occasion with respect to Tier 1 published criteria in surface waters upstream of the site:

- Copper;
- Lead;
- Zinc; and
- Ammonia.

3.8 Surface Water (River Crane Downstream Conditions)

3.8.1 Assessment of surface water contaminant concentrations at Tier 1 has indicated that the below determinands are elevated with respect to Tier 1 published criteria in surface waters downstream of the site:

- Copper;
- Zinc and
- Ammonia.

3.8.2 Following the Tier 1 review of the surface water chemical testing, there appears to be a slight downward trend in the average contaminant concentrations in the River Crane from the upstream to the downstream sampling locations. This may suggest that the site is having no tangible effect on the River Crane.

3.9 Site-specific Groundwater Characterisation

3.9.1 The Environment Agency designate the superficial deposits underlying the site, the Lynch Hill Gravel Member, as a Principal Aquifer. The bedrock underlying the site, the London Clay, is designated as a Unproductive. The site is not within a Source Protection Zone.

3.9.2 Groundwater beneath the site is present within the Made Ground and the Lynch Hill Gravel Member. These two bodies are in continuity with one another. The groundwater flow within the superficial deposits discharges into the River Crane.

3.10 Metal Bioavailability Assessment

3.10.1 Exceedances of the Tier 1 (EQS) values were identified for Copper, Lead, Nickel and Zinc in groundwater at a number of locations across the site. The EQS values for these contaminants are based on the bioavailable fraction in the environment. The Metal Bioavailability Assessment Tool (M-BAT) produced by the Water Framework Directive UK Technical Advisory Group (WFD-UKTAG) has been used to produce site-specific $EQS_{bioavailable}$ values (Appendix D). The values derived were:

- Copper 21.34ug/l
- Lead 7.63ug/l
- Nickel 9.71ug/l
- Zinc 32.71ug/l

3.10.2 Of all the groundwater results available, only two results exceeded the $EQS_{bioavailable}$ values. These were:

- WS7 (04/6/20)Lead 52ug/l
- WS7 (18/6/20)Zinc 59ug/l

3.10.3 In both cases the mean concentrations across three monitoring visits fell below the $EQS_{bioavailable}$. No further assessment is considered necessary.

4.0 UPDATED CONCEPTUAL SITE MODEL

4.1 Introduction

4.1.1 A Conceptual Site Model (CSM) for the site was constructed within the Paragon Phase 2 investigation reports. This has been updated below, considering only the water environment.

4.1.2 UK legislation and guidance on assessing potentially contaminated land recommends use of a risk assessment process based on a review of source/pathway/receptor relationships for various environmental media. The level of remediation required will be dependent upon the current and/or proposed future use of the land, commonly referred to as a 'suitable for use' approach.

4.1.3 In order for a site to require remediation, a significant pollutant linkage must be identified between the source and a sensitive receptor via an appropriate environmental pathway. The degree of significance of a pollutant linkage depends on a number of factors including the hazardous nature of the source, the type of pathway (such as direct or indirect contact with contaminants) and the sensitivity of the receptor.

A key component of the overall risk assessment process is the development of a CSM, which identifies:

- potential sources of contamination;
- potential pathways along which identified contaminants could migrate, and;
- potential receptors, which may become exposed.

4.1.4 Development of a CSM allows a detailed understanding of the surface and subsurface environment at the site, potential pollutant linkages and the likely behaviour of any contaminants within that regime.

4.1.5 An updated CSM has been developed for the Bulls Bridge site based upon data from the Paragon Phase 2 investigation reports and the additional groundwater and surface water monitoring recently undertaken.

4.1.6 A summary of the updated CSM is provided in this section. A geological cross-section representing the CSM is included as Figure 3.

4.2 Conceptual Site Model

Potential Contaminant Sources

4.2.1 The following tables list contaminants identified as exceeding the Tier 1 screening criteria, and therefore considered as potential CoC's. The Tier 1 screening spreadsheets are provided in Appendix A.

Table 3. Contaminants of Concern Following Tier 1 Assessment (Leachate)

Leachate	Location			
	TP204 0.6m	TP208 2.0m	BH07 5.80-6.00m	BH08 5.50-6.00
Naphthalene			✓	✓
Anthracene			✓	✓
Fluoranthene		✓	✓	✓
Xylenes (Acenaphthylene)				✓

4.2.2 *Table 4: Contaminants of Concern Following Tier 1 Assessment (Groundwater)*

Groundwater	Location				
	WS7	BH02	BH01 J	BH07	BH08
Ammonia	✓	✓	✓		✓
Phenol			✓		✓
Naphthalene	✓	✓			✓
Anthracene		✓		✓	✓
Fluoranthene		✓		✓	✓
Xylenes (Acenaphthylene)					✓

Potential Pathways

4.2.3 The only potentially significant pathway identified is groundwater flow in the shallow aquifer (Lynch Hill Gravel Member).

Potential Receptors

4.2.4 As previously described in Section 3.4, the River Crane is considered to be the primary controlled waters receptor. It should be noted that the further assessment undertaken as part of this report has concluded that the canal to the immediate south west of the site is not a potential receptor. This is because it sits at a higher elevation than groundwater on site.

4.2.5 Groundwater itself is not considered to be a receptor because it appears the contamination has already entered groundwater and no significant ongoing source has been identified.

CSM Summary

4.2.6 Table 5 summarises the updated CSM. It should be noted that this updated CSM represents the state / level of risk assessment prior to undertaking the DQRA modelling.

Table 5. Updated Conceptual Site Model

Receptor	Potential sources	Pathways	Probability	Consequences	Risk and Justification
River Crane	*Leachate:* Naphthalene *Groundwater:* Ammonia Phenol Naphthalene Anthracene Fluoranthene Xylenes (Acenaphthylene)	Migration in shallow groundwater underlying the site	Likely to Highly Likely	Medium	**Moderate to High risk:** The majority of the site is located within 250m of the River Crane and shallow groundwater at the site appears to be in continuity with the river. The River Crane is already impacted upstream but further derogation should be avoided if possible.

5.0 TIER 3/4 RISK ASSESSMENT

5.1 General

5.1.1 The Tier 3 Risk Assessment has been undertaken on a contaminant specific basis, using the Tier 1 soil and soil leachate sources shown in Figure 3.

5.1.2 The methodology applied in the case of each assessment approach, modelled parameter information and the results are discussed in the following sections. Copies of all Remedial Targets Methodology (RTM) spreadsheets are provided in Appendix D.

5.1.3 It should be noted that this section relates solely to the assessment of risks to controlled waters.

5.2 Parameter Justification

Infiltration

5.2.1 The average rainfall at the site, based on the Meteorological Office Rainfall Annual Average rainfall at Heathrow 1981-200, is between 601.7mm/yr. The site is largely covered by impermeable hardstanding. The proposed development will have similar levels of hardstanding. Therefore, the effective rainfall has been conservatively estimated at half the annual rainfall.

Permeability of the Shallow Aquifer

5.2.2 Assessment of the permeability properties of the shallow aquifer (Lynch Hill Gravel Member) present on site was undertaken by in-situ slug testing at BH08 and BH1 J. The testing was conducted using a downhole datalogger and only the rising head results were used in the calculations. The data and calculation sheets for these are included as Appendix E. The results are summarised in Table 6.

Table 6. Results of in-situ variable head testing

Location	K (m/s)	K (m/d)	Response Zone	Strata
BH08	1.90E-06	1.64E-01	4.50 – 6.00m	4.50 – 6.00m: Lynch Hill Gravel Member
BH01 J #1	9.30E-06	8.04E-01	1.00 – 6.00m	1.00 – 5.00m: Made Ground 5.00 – 6.00m: Lynch Hill Gravel Member
BH01 J #2	4.10E-06	3.54E-01		
BH01 J #3	2.50E-06	2.16E-01		
BH01 J Mean	5.30E-06	4.58E-01		

5.2.3 The results indicate a range of K values from 1.90E-06m/s to 9.30E-06m/s. This is in the expected range for a silty sand. Based on the available PSDs for the Lynch Hill Gravel Member on site, this appears appropriate. It should be noted that only the test undertaken in BH08 was undertaken in a well screened purely in the Lynch Hill Gravel Member. The well screen in BH01 J crosses the Made Ground and the Lynch Hill Gravel Member. However, the field descriptions of these in this borehole are both of a very clayey gravel and so would be expected to display similar permeability.

Hydraulic Gradient

5.2.4 Hydraulic gradients were calculated using two monitoring rounds selected on the basis they included the most boreholes in a single round. One is representative of summer conditions (3/7/19) and the other winter conditions (12/2/20). The calculated gradients were 0.0136 and 0.0131, respectively.

Degradation of Contaminants

5.2.5 The groundwater monitoring undertaken at the site included field measurement of water quality parameters and geochemical indicators of degradation. These results have been assessed in line with Environment Agency (2000) guidance on monitoring of natural attenuation of contaminants in groundwater.

5.2.6 The groundwater monitoring also included dipping the wells on site with an oil/water interface probe to check for the presence of Non Aqueous Phase Liquids (NAPL), also known as free product. No NAPL was identified in the monitoring work.

5.2.7 Dissolved oxygen levels were generally quite low in groundwater, averaging around 0.35mg/l.

5.2.8 Redox varied between the two monitoring rounds, showing slightly reducing conditions on 4/6/20 and slightly oxidising conditions on 18/6/20. Laboratory analysis undertaken on groundwater samples obtained on 29/1/20 indicated slightly oxidising conditions.

5.2.9 Dissolved carbon dioxide is often indicative of aerobic degradation taking place, with the carbon dioxide being produced by the degrading processes. The levels of dissolved CO_2 were highest in the boreholes with the most elevated concentrations of readily degradable organic contaminants, BH08 and WS7. This combined with the reduced dissolved O_2 levels in these boreholes supports the hypothesis that aerobic degradation is taking place.

5.2.10 Sulphate concentrations were generally lower in BH08 and WS7 than less impacted boreholes. This may indicate that some sulphate reduction is taking place.

5.2.11 Degradation of organic contaminants was modelled within Level 3 of the RTM models, applied to the dissolved phase only. The degradation rates applied were the highest published values for anaerobic degradation. Although there is clear evidence of aerobic degradation, the initial use of the slowest anaerobic rates was chosen as a conservative approach to the modelling. A summary of the organic parameters applied are provided in Appendix G.

5.2.12 Degradation of Ammonia (NH_3) takes place by oxidation to Nitrite (NO_2) and then to Nitrate (NO_3). The recent monitoring undertaken included analysis for NH_3, NO_2 and NO_3. This indicates that in general, NH_3 concentrations reduced between the two monitoring visits. At the same time, the concentrations of NO_2 increased significantly. While this only represents a small amount of data, coupled with the reduced dissolved oxygen levels in groundwater, it does appear to give some indication that the NH_3 in groundwater at the site is biodegrading. On this basis, degradation was applied in the Level 3 modelling at the slowest published rate.

Retardation

5.2.13 Site specific Koc values were calculated for Anthracene, Fluoranthene and Naphthalene using the equation:

(soil concentration / leachate concentration) / fraction of organic carbon

The calculations are included as Appendix H.

5.3 Level 3 Assessment Methodology

5.3.1 Tier 1 exceedances were plotted on a site plan for each contaminant, and the most conservatively located sources were modelled using RTM. The modelled source locations are shown in Figure 4.

5.3.2 The Environment Agency's Remedial Targets Methodology (2006) spreadsheets were used to derive Tier 3 remedial targets. It should be noted potential unsaturated zone contaminant attenuation (via retardation or biodegradation) have been incorporated within this assessment, in order to provide suitably conservative site-specific screening criteria.

5.4 RTM Parameter Inputs

5.4.1 The following sections detail the parameters used within the RTM spreadsheets.

Partition Coefficients

5.4.2 Where applicable, Koc and Kd values were obtained from the literature sources as detailed in Appendix G. Site specific Koc values were calculated for Anthracene, Acenaphthylene and Naphthalene (Appendix H).

Source Area and Dimensions

5.4.3 All potential source areas were initially based on a 25m circle centred on each respective borehole. Subsequent sensitivity analysis indicated that increasing the source area had a negligible effect on the derived remedial targets.

Saturated Aquifer Thickness

5.4.4 The thickness of the saturated aquifer was based on the actual thickness recorded at each borehole source area.

Mixing Thickness

5.4.5 The mixing zone thickness was generally entered as 'Calculated' in the RTM spreadsheets, which estimated the mixing zone thickness as the entire thickness of the saturated aquifer specified.

Distance to Receptor

5.4.6 The distance to the receptor (River Crane) was the distance in meters from the respective borehole locations to the River Crane.

Level 3 Assessment

5.4.7 The Level 3 Remedial Targets derived from the RTM spreadsheets for each CoC was applied to a site-wide Level 3 screen of soil and leachate data. This resulted in possible exceedances of the initial Level 3 Remedial Targets at the following locations: BH02, BH03 and BH07.

5.4.8 New RTM models were created for these locations principally in order to account for the difference in distance to the receptor.

5.4.9 The RTM spreadsheets and the Level 3 results are provided in Appendices F and I, respectively.

5.4.10 Following Level 3 RTM assessment (without dilution applied), four determinands were not taken forward for further assessment. This was on the basis of passes of the soil and groundwater remedial targets.

- Phenol;
- Naphthalene;
- Fluoranthene; and
- Xylenes (Acenaphthylene).

5.4.11 It should be noted that some of these exceed their respective remedial targets for leachate. Less weight has been attributed to the leachate results on the basis that they tend to over predict the amount of leachate that would actually be produced in the field.

5.4.12 The contaminants above that have not been identified on site above the Level 3 RTM remedial targets (or the Level 1 screening values) require no further assessment as they are considered not to constitute a significant risk to controlled waters. This assessment corroborates the pollutant linkage assessment undertaken in Section 4.2.4.

5.4.13 The contaminants which were found in concentrations above the Level 3 RTM remedial targets have been taken forward to a Level 4 assessment, which incorporates dilution of the shallow groundwater on discharge to the River Crane.

5.5 Dilution Applied Assessment – Level 4

5.5.1 Those contaminants of concern that have been identified at higher concentrations than the Level 3 RTM remedial targets have been further assessed by incorporating a dilution factor representing the dilution of the shallow groundwater on discharge to the River Crane.

5.5.2 This section details the dilution calculations that have been undertaken, the dilution factor applied and the results of the Level 4 assessment.

Dilution

5.5.3 In order to assess the dilution of the shallow groundwater upon discharge to the River Crane, the low flow conditions in the River Crane and the flux of groundwater in the shallow aquifer on site were assessed.

River Crane Q95 (Low Flow Conditions)

5.5.4 The average daily flow conditions, as measured at the Cranford Park Gauging Station (NGR: TQ103778) 1978-2018 were used to assess flow in the River Crane (Appendix J). The Q_{95} flow (the flow value relative to which 95% of all recorded flow conditions are greater) was $0.087m^3/s$.

Shallow Aquifer Flux

5.5.5 The groundwater flux across the site, within the shallow aquifer, was calculated according to the following equation:

Q = Aik

Where:

A = Cross-sectional area (m^2)

i = hydraulic gradient (dimensionless)

k = hydraulic conductivity (m/s)

5.5.6 The average flux was calculated as 2.03E-05m^3/s (applying the site average hydraulic conductivity (1.90E-06m/s) and hydraulic gradient (0.0136)). When compared to the low flow (Q95) conditions in the River Crane (0.087m^3/s), this gives a dilution factor of 43.5. For comparison, the dilution factor calculated by applying mid-flow conditions in the River Crane (Q50 = 0.233m^3/s) was 115, which is considered to be more representative of the typical River Crane flow conditions.

Level 4 RTM Assessment

5.5.7 In order to derive Level 4 RTM remedial targets, the target concentration term of the RTM spreadsheet (the relevant EQS value) has been multiplied by the dilution factor (43.5). In accordance with guidance on Level 4 assessment in the RTM main report, the EQS has also been divided by 10 in order to maintain a level of conservatism. Overall, this results in the EQS being multiplied by 4.35. The Level 4 RTM spreadsheets are provided in Appendix F. The results and screening are provided in Appendix I.

5.5.8 Only Anthracene was assessed at Level 4. This is on the basis that no Anthracene (or any other organic contaminants) were detected in surface water sampling of the River Crane.

5.5.9 Conversely, Ammonia was present in all river water samples at levels in excess of the EQS, though a small reduction in average Ammonia concentrations from upstream to downstream was observed. Due to the presence of Ammonia in the River Crane, it was not considered appropriate to undertake a Level 4 assessment for Ammonia.

5.6 Sensitivity Analysis

5.6.1 Due to the significant effects even small changes to some parameters in the RTM model can have on the derived remedial targets, sensitivity analysis was undertaken in order to assess the suitability of the input parameters used. As is usually the case with RTM models, effective porosity, hydraulic gradient, hydraulic conductivity and degradation half-life were found to be the most sensitive parameters.

The sensitivity analysis is included as Appendix K.

5.7 Summary of Controlled Waters Level 3/4 Remedial Targets and Contaminants of Concern

5.7.1 The following table details the Level 3 and Level 4 (diluted) Remedial Targets derived for both soils and groundwater, using RTM spreadsheets. Level 3 and 4 RTM assessment was only undertaken on those contaminants that were encountered in elevated concentrations with respect to the Tier 1 screening criteria.

Table 7. Summary of Level 3 and Level 4 Remedial Targets (Dilution Factor = 4.5)

Contaminant	Location	RTM Assessment Level	Derived Remedial Target		Exceedances Identified?
			Soil (mg/kg)	Groundwater (ug/l)	
Ammonia	WS7	L3	-	270	Yes
Ammonia	BH01 J	L3	-	28.6	Yes
Phenol	BH08	L3	>1E+99	7.17E+29	No
Naphthalene	BH08	L3	87.1	16310	No
Anthracene	BH08	L 3	24.3	3.81	Yes
Anthracene	BH02	L3	60300	21.8	No
Anthracene	BH07	L3	11.5	0.607	Yes
Fluoranthene	BH08	L3	100.6	4.32	No
Fluoranthene	BH03	L3	57200	1.86E+06	No
Xylenes (Acenaphthylene)	BH08	L3	484000	1.45E+07	No
Anthracene	BH08	L4	106	16.6	No
Anthracene	BH07	L4	50.2	2.64	No

5.7.2 The results of the Level 3 and Level 4 RTM modelling indicates that Ammonia is the only contaminant of concern identified on the Bulls Bridge Industrial Estate site. It is present in a number of locations (particularly WS7 and BH01 J) at maximum concentrations which exceed the derived remedial targets by around 60 to 300 times. However, the modelling was undertaken using a degradation rate at the slowest end of the range of values in published literature as a conservative measure. As demonstrated in the sensitivity analysis in Appendix K, a degradation rate chosen from the faster end of the scale would bring the model close to passing.

5.7.3 Modelling Anthracene at Level 3 resulted in two modest exceedances. Modelling at Level 4 produced no exceedances. The use of Level 4 assessment is considered appropriate in the case of Anthracene as the exceedances at Level 3 were marginal and it was not detected during monitoring of the receiving water, upstream or downstream. It should also be noted that there is strong evidence for degradation of organic contaminants taking place on the site. Therefore, there is likely to be a declining source which will attenuate in time.

6.0 CONCLUSIONS & RECOMMENDATION

6.1 Conclusions

6.1.1 Several phases of intrusive site investigation have been undertaken at the Bulls Bridge site in Hayes. These have allowed a robust characterisation of the ground conditions at the site. These investigations identified contamination in site soils and groundwater which would potentially pose a risk to controlled waters in the site's vicinity.

6.1.2 The site is underlain by a variable thickness of Made Ground up to a maximum thickness of 5.8m (average 3.4m) and typically comprising gravelly clay.

6.1.3 Superficial geology at the site is sandy gravel (occasionally clayey) of the Lynch Hill Gravel Member. This is designated as a Principal Aquifer, though is only around 1.8m thick on average at the site location.

6.1.4 Bedrock at the site comprises London Clay, proven to at least 35m below the site. This acts as an aquitard and prevents downward migration of groundwater.

6.1.5 The River Crane forms the eastern boundary of the site and is in hydraulic continuity with the groundwater on site. The site investigation information on the site indicates that the majority of contamination on site has already entered groundwater and the principal receptor for the contamination is the River Crane.

6.1.6 Monitoring of surface water in the River Crane has indicated that it is generally free of contamination, with the exception of Ammonia. This was found to be present upstream and downstream of the site, with the concentrations dropping slightly from upstream to downstream. This may indicate that the site is not having a tangible effect on the river.

6.1.7 Groundwater monitoring at the site has indicated that degradation of contamination is taking place, with several lines of evidence supporting this.

6.1.8 Detailed Quantitative Risk Assessment (DQRA) undertaken using the Remedial Targets Methodology has shown that the site does not pose any significant risks to controlled waters (River Crane).

6.1.9 Following the site investigations and DQRA undertaken to date it is considered unlikely that the contamination identified in site soils or groundwater would warrant remediation. Also, due to the presence of high levels of Ammonia already in the River Crane, it is unlikely that any remediation carried out on the Bulls Bridge would result in a measurable benefit to the River Crane.

6.2 Recommendation

6.2.1 Although the site has been extensively investigated there remains the possibility that unexpected contamination may be encountered during redevelopment of the site. It would be prudent to have a plan in place for actions to be taken in the event that unexpected contamination is discovered. There is a separate remediation strategy for the site, which includes a watching brief and discovery strategy.

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8.0 EXTENT OF SURVEY AND LIMITATIONS

This report is for your sole use, and consequently no responsibility whatsoever is undertaken or accepted to any third party for the whole or any part of its contents. Paragon accept no responsibility or liability for the consequences of this document being used for any purpose or project other than for which it was commissioned or a third party with whom an agreement has not been executed. Should any third party which to use or rely upon the contents of the report, written approval must be sought from Paragon, a charge may be levied against such approval.

The report has been designed to address potential source, pathway and receptor pollutant linkages associated with the proposed development, by means of intrusive investigation. The content and findings of the report are based on data obtained by employing site assessment methods and techniques, considered appropriate to the site as far as can be interpreted from desk-based materials and a visual walkover of the site. Such techniques and methods are subject to limitations and constraints set out in the report. The findings and opinions are relevant at the time of writing, and should not be relied upon at a substantially later date as site conditions can changes. For example, seasonal groundwater levels, natural degradation of contaminants etc.

No liability can be accepted for the conditions that have not been revealed by the exploratory hole locations, or those which occur between each location. Whilst every effort will be made to interpolate the conditions between exploratory locations, such information is only indicative and liability cannot be accepted for its accuracy. By their nature, exploratory holes provide a relatively small and localised snapshot of the ground conditions relative to the size of the site.

Specific comment is made regarding the site's status under Part 2A of the Environmental Protection Act (EPA) 1990, which provides a statutory definition of Contaminated Land and as revised under The Contaminated Land (England) (Amendment) Regulations 2012. Unless specifically stated as relating to this definition, references to 'contamination' and 'contaminants' relate in general terms to the presence of potentially hazardous substances in, on or under the site.

The opinions given within this report have been dictated by the finite data on which they are based and are relevant only to the purpose for which the report was commissioned. If additional information or data becomes available which may affect the opinions expressed in this report, Paragon reserves the right to review such information and, if warranted, to modify the opinions accordingly. Paragon reserves the right to charge additional fees for; un-anticipated second opinion reviewing of previous reports.

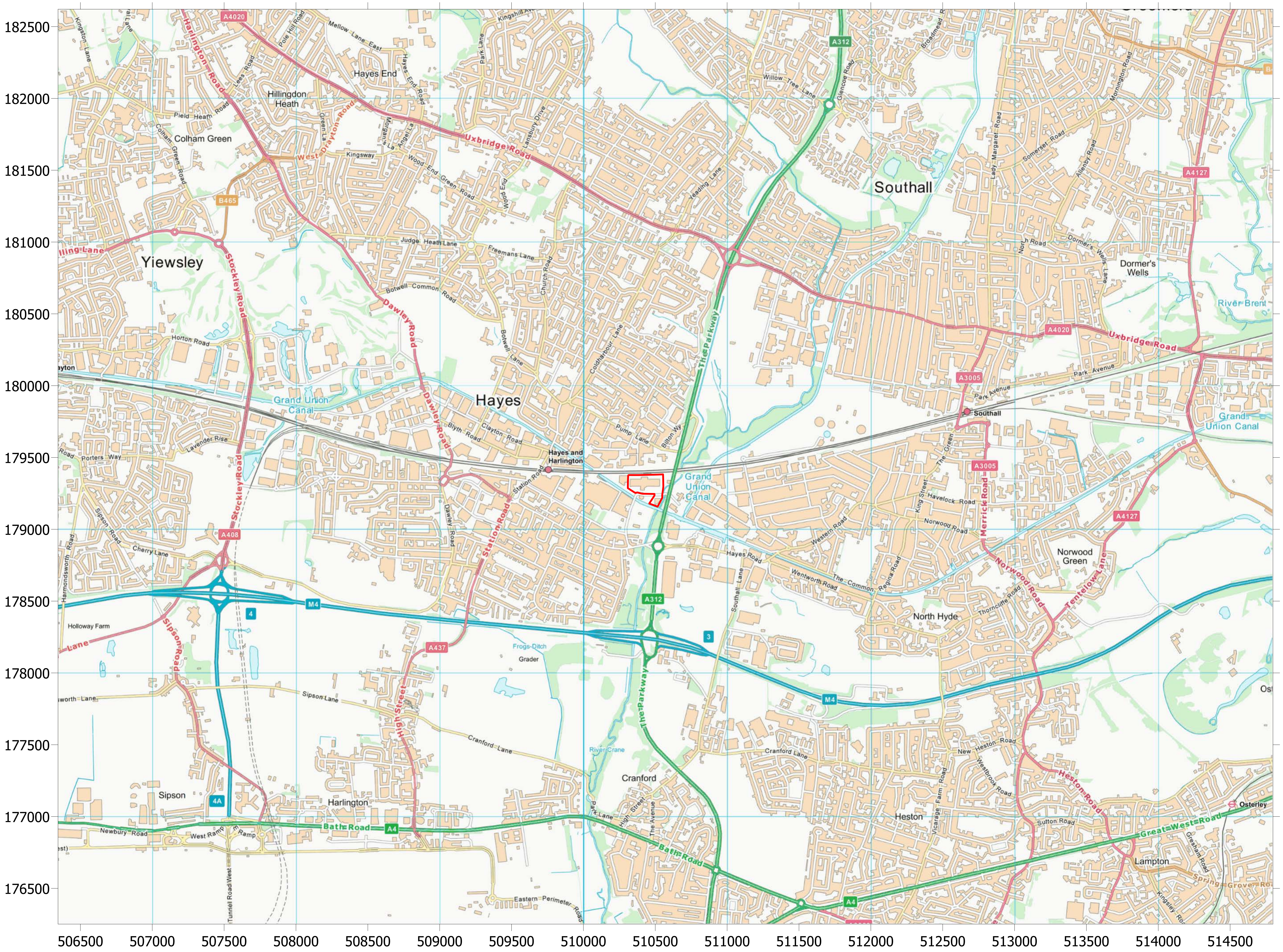
Paragon has prepared this report with reasonable skill, care and diligence. The recommendations contained in this report represent our professional opinions. These opinions were arrived at in accordance with currently accepted industry practices at this time. The work undertaken to provide the basis of this report comprised a study of available documented information from a variety of sources. We cannot provide guarantees or warranties for the accuracy of third-party data, which is reviewed in good faith and assumed to be representative and accurate.

It should be noted that any risks identified in this report are perceived risks based on the information reviewed. No liability can be accepted for the effects of any future changes to such guidelines and legislation. In the event that guidance / legislation changes it may be necessary for Paragon to update or modify reports. The risk assessment is completed in line with the relevant land use agreed for the site and the time of completing the works. Changes to site conditions or land use may require a reassessment.

FIGURES

20.0023 22

Notes



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Rev	Description	By	Date
A			

Status

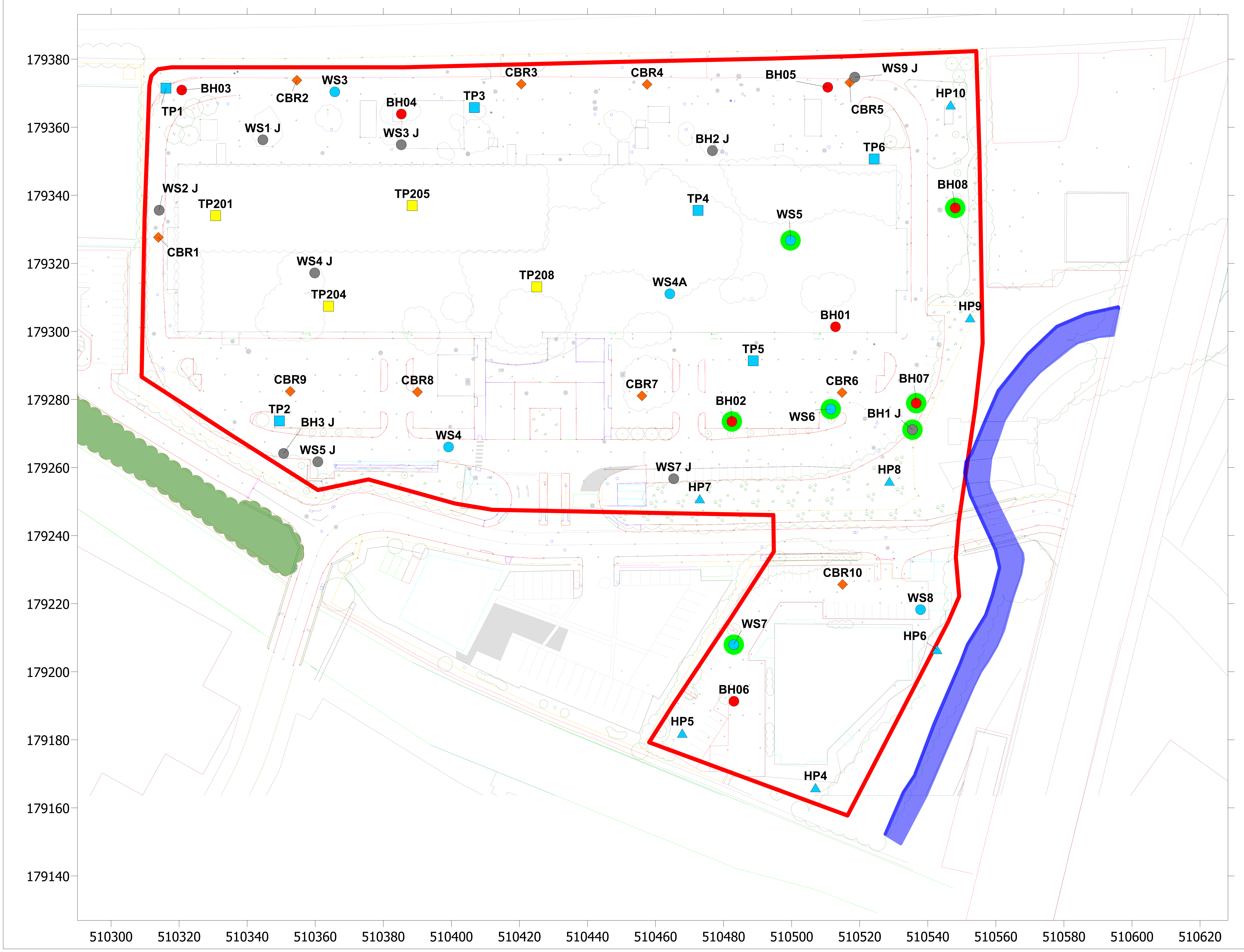
Client
Hurley Palmer Flatt

Site
Bulls Bridge, Hayes

Title
Site Location Plan

Scale at A3	Date	Drawn	Checked
1:25,000	07/05/20	TC	CK

Project No	Drawing No	Rev
20.0023	Figure 1	



Notes

- CBR Paragon 2020
- Borehole Paragon 2020
- Hand Pit Paragon 2019
- Borehole Paragon 2019
- Trial Pit Paragon 2019
- Trial Pit Paragon 2019
- Jomas Boreholes 2018
- Groundwater Sampled

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A			
Rev	Description	By	Date

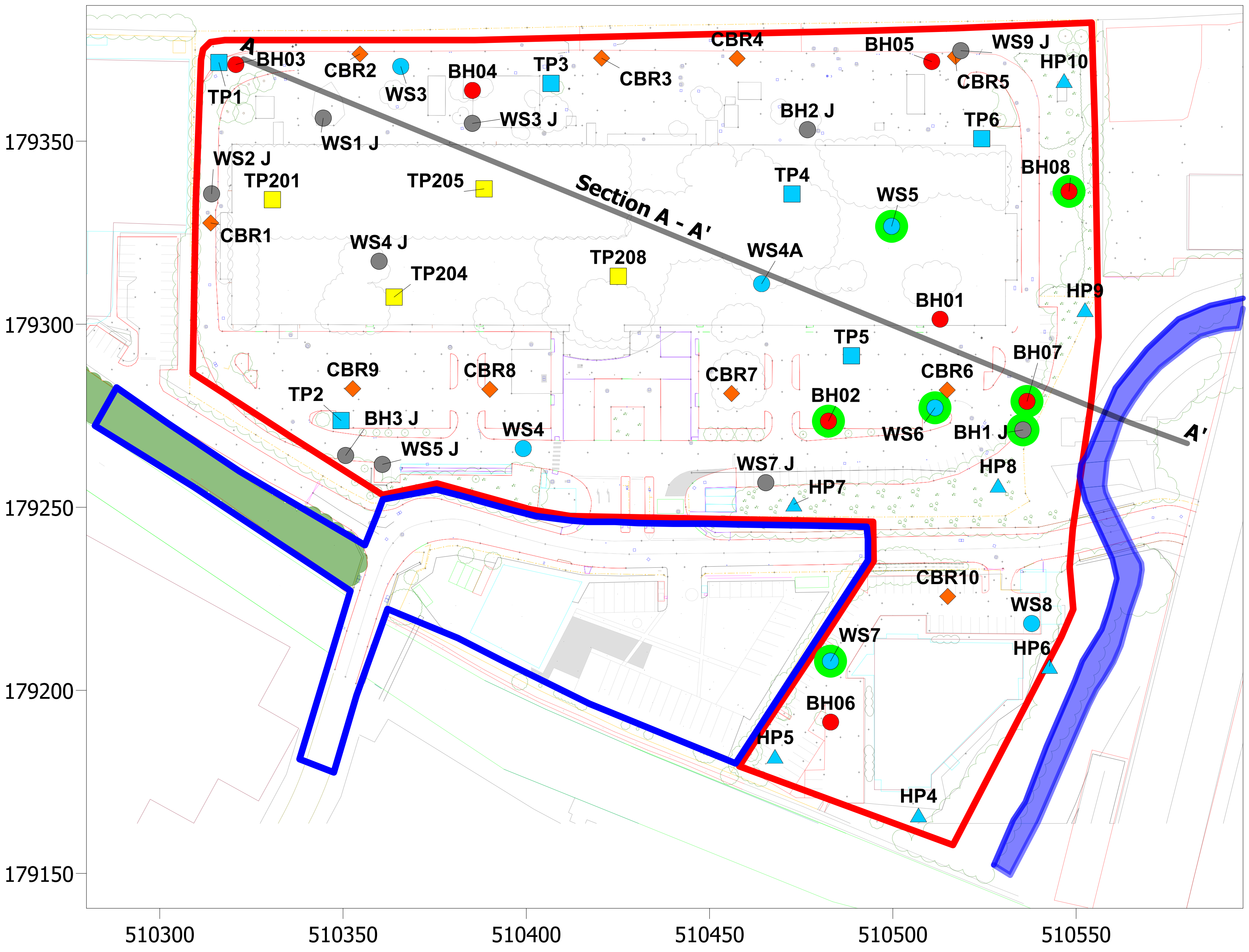
Status

Client
Hurley Palmer Flatt

Site
Bulls Bridge, Hayes

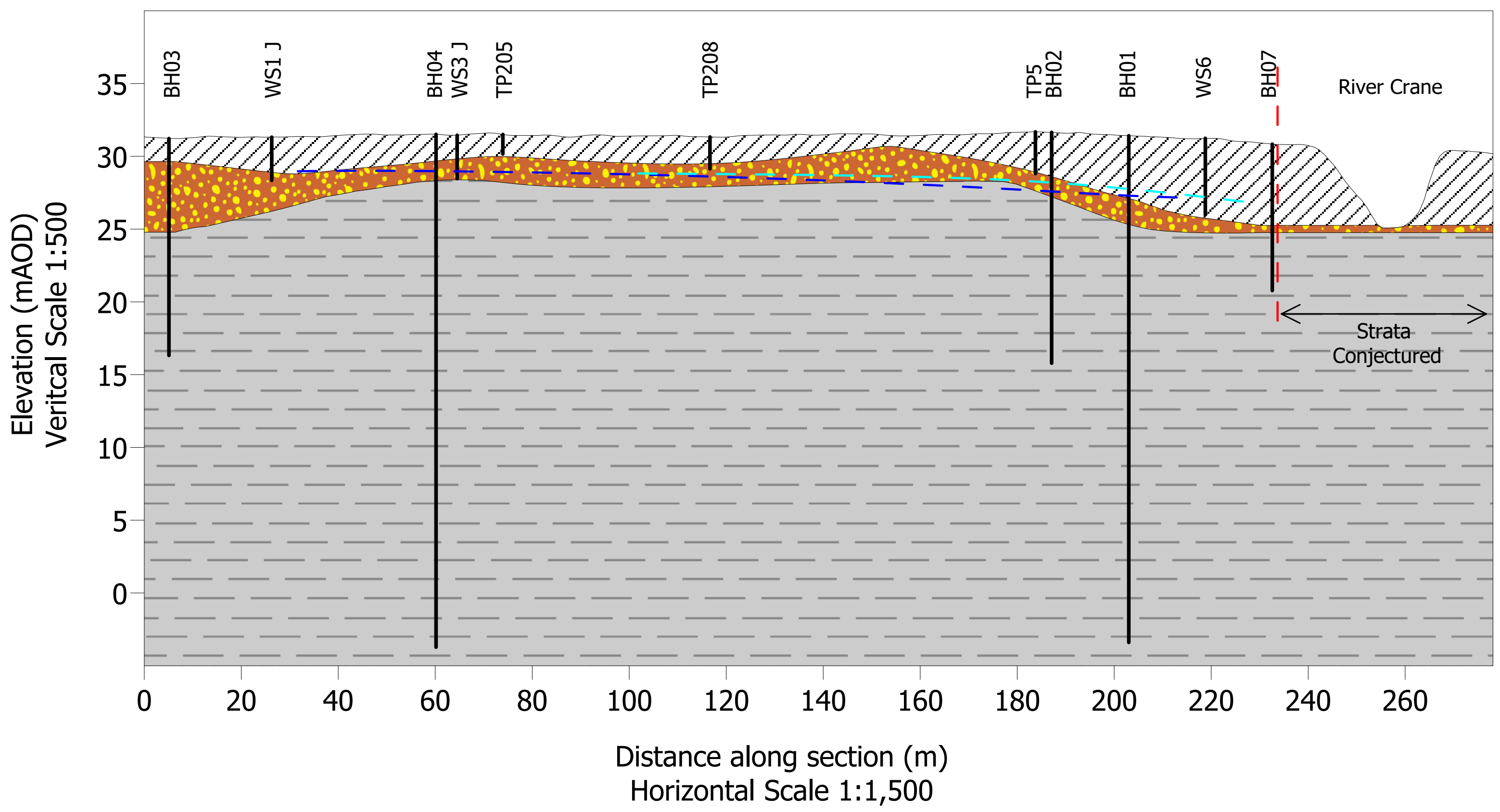
Title
Composite Exploratory Hole Plan

Scale at A3	Date	Drawn	Checked
1:1,000	07/05/20	TC	CK
Project No	Drawing No		Rev
20.0023	Figure 2		



Notes

- CBR Paragon 2020
- Borehole Paragon 2020
- Hand Pit Paragon 2019
- Borehole Paragon 2019
- Trial Pit Paragon 2019
- Trial Pit Paragon 2019
- Jomas Boreholes 2018
- Groundwater Sampled



- Made Ground
- Lynch Hill Gravel Member
- London Clay
- Groundwater Contours July 2019
- Groundwater Contours February 2020

Ground levels derived from Environment Agency 1m LiDAR DTM 2017. Licensed under the Open Government Licence v2.0

A			
Rev	Description	By	Date

Status

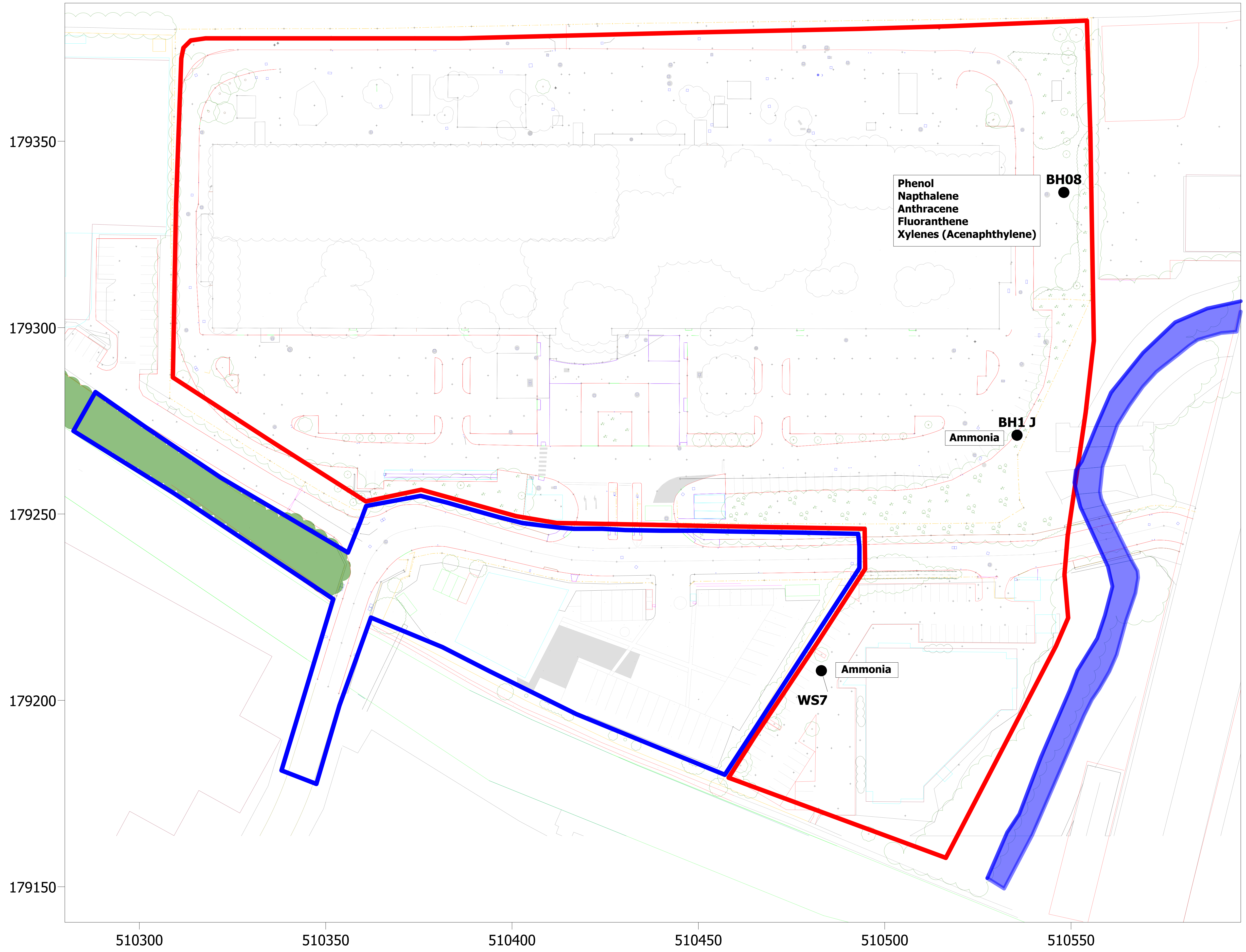
paragon

Client
Hurley Palmer Flatt

Site
Bulls Bridge, Hayes

Title
Geological Cross-Section

Scale at A3	Date	Drawn	Checked
1:1,500	07/05/20	TC	CK
Project No	Drawing No		Rev
20.0023	Figure 3		



Notes

Rev	Description	By	Date
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Status

Client: Hurley Palmer Flatt

Site: Bulls Bridge, Hayes

Title: Modelled Source Locations

Scale at A3	Date	Drawn	Checked
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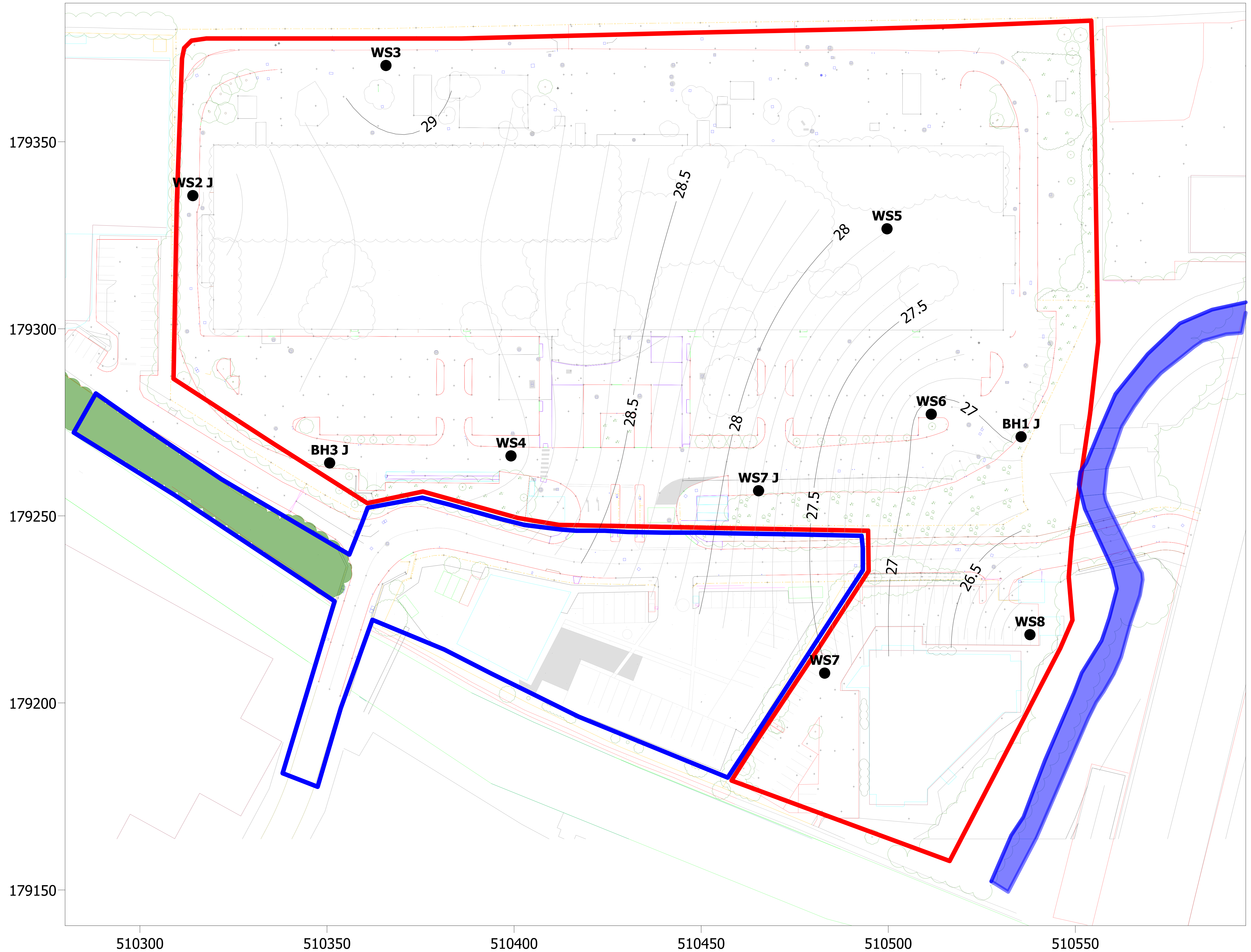
Project No	Drawing No	Rev	
20.0023	Figure 4		



Notes

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Rev	Description	By	Date

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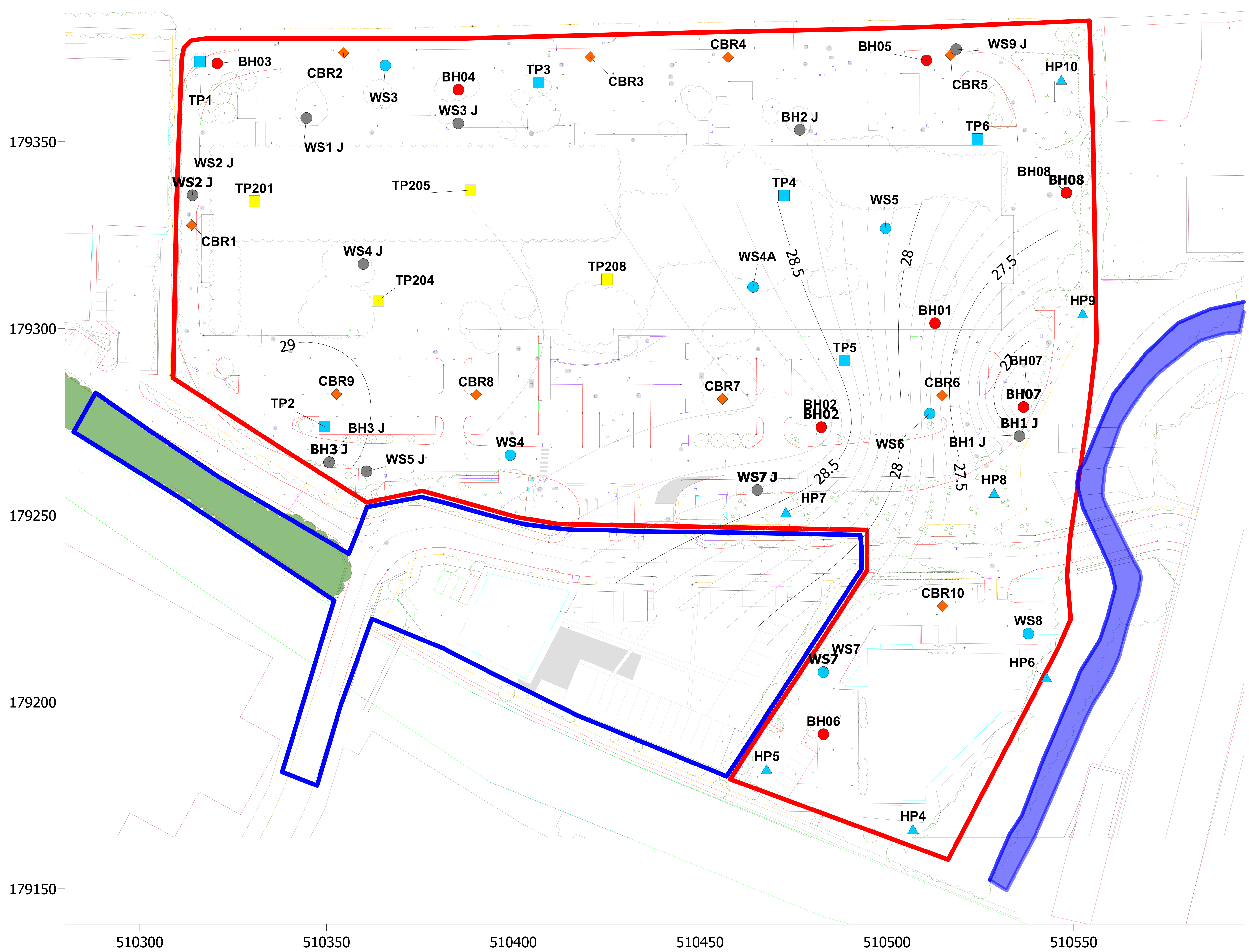
Client
Hurley Palmer Flatt

Site
Bulls Bridge, Hayes

Title
Groundwater Contours 3/07/19 (mAOD)

Scale at A3	Date	Drawn	Checked
1:1,000	03/07/20	TC	CK

Project No	Drawing No	Rev
20.0023	Figure 5	



Notes

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Status

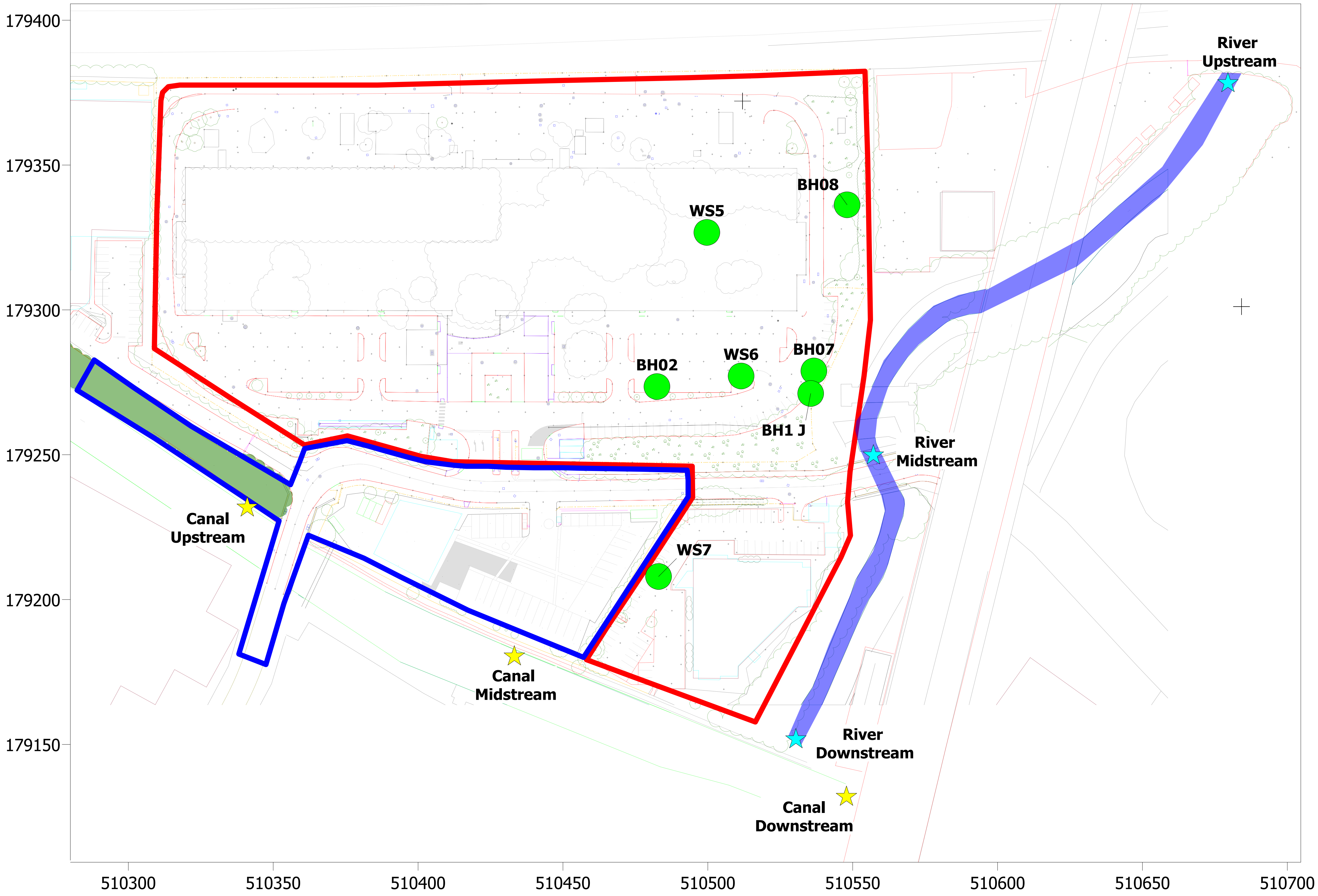
Client
Hurley Palmer Flatt

Site
Bulls Bridge, Hayes

Title
Groundwater Contours 12/2/20 (mAOD)

Scale at A3	Date	Drawn	Checked
1:1,000	03/07/20	TC	CK

Project No	Drawing No	Rev
20.0023	Figure 6	



Notes

Rev	Description	By	Date
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Status

Client: Hurley Palmer Flatt

Site: Bulls Bridge, Hayes

Title: Water Monitoring Points

Scale at A3	Date	Drawn	Checked
1:1,500	07/05/20	TC	CK

Project No	Drawing No	Rev
20.0023	Figure 7	

APPENDIX A: TIER 1 SCREENING SHEETS

Leachate Analysis
Bulls Bridge, Hayes

Determinand	Unit	LOD	TP / BH No	TP204	TP208	BH07	BH08
			Depth (m)	0.6	2	5.80-6.00	5.50-6.00
			Date Sampled	24/07/2019	24/07/2019	24/01/2020	24/01/2020
			Report No:	19-51430	19-51431	20-83394	20-83394
			Sample No	1275534	1275535	1424098	1424099
Determinand	**Unit**	**LOD**	**Freshwater EQS**				
pH	pH Units	N/A	6.0-9.0	10.1	7.8	7.7	7.3
Electrical Conductivity	µS/cm	10		400	290	99	39
Free Cyanide	µg/l	10	1	< 10	< 10	< 10	< 10
Sulphate as SO_4	mg/l	0.1		147	114	12.3	3.8
Nitrate as N	mg/l	0.01		1.55	0.84	0.02	0.08
Hardness - Total	mgCaCO3/l	1		219	137	38.4	14.3
Calcium (dissolved)	mg/l	0.012		87	48	11	3.8
Magnesium (dissolved)	mg/l	0.005		0.32	3.9	2.8	1.2
Arsenic (dissolved)	µg/l	1.1	50	6.5	3.7	< 1.1	< 1.1
Barium (dissolved)	µg/l	0.05		22	49	17	8.6
Beryllium (dissolved)	µg/l	0.2	15	< 0.2	< 0.2	< 0.2	< 0.2
Boron (dissolved)	µg/l	10		27	130	45	20
Cadmium (dissolved)	µg/l	0.08	0.08	< 0.08	< 0.08	< 0.08	< 0.08
Chromium (dissolved)	µg/l	0.4	4.7	18	2.5	0.8	2.1
Copper (dissolved)	µg/l	0.7	1	14	8.7	3.3	2.8
Lead (dissolved)	µg/l	1	4	3.8	14	< 1.0	< 1.0
Mercury (dissolved)	µg/l	0.5	0.07	< 0.5	1	< 0.5	< 0.5
Nickel (dissolved)	µg/l	0.3	4	0.5	1.8	< 0.3	1
Selenium (dissolved)	µg/l	4		< 4.0	< 4.0	< 4.0	< 4.0
Vanadium (dissolved)	µg/l	1.7		40	10	2.4	7.1
Zinc (dissolved)	µg/l	0.4	10.9	3.4	10	7.3	9.4
Naphthalene	µg/l	0.01	2	< 0.01	0.61	250	4700
Acenaphthylene	µg/l	0.01		0.02	0.66	4.7	9
Acenaphthene	µg/l	0.01		< 0.01	7.5	81	170
Fluorene	µg/l	0.01		< 0.01	1.6	52	64
Phenanthrene	µg/l	0.01		< 0.01	< 0.01	41	41
Anthracene	µg/l	0.01	0.1	0.01	< 0.01	3	5.8
Fluoranthene	µg/l	0.01	0.1	0.03	0.75	2.1	4.8
Pyrene	µg/l	0.01		0.02	0.5	1.3	4.1
Benzo(a)anthracene	µg/l	0.01		0.02	< 0.01	< 0.01	< 0.01
Chrysene	µg/l	0.01		0.01	< 0.01	< 0.01	< 0.01
Benzo(b)fluoranthene	µg/l	0.01		0.01	< 0.01	< 0.01	< 0.01
Benzo(k)fluoranthene	µg/l	0.01		0.01	< 0.01	< 0.01	< 0.01
Benzo(a)pyrene	µg/l	0.01	0.02	0.01	< 0.01	< 0.01	< 0.01
Indeno(1,2,3-cd)pyrene	µg/l	0.01		0.01	< 0.01	< 0.01	< 0.01
Dibenz(a,h)anthracene	µg/l	0.01		< 0.01	< 0.01	< 0.01	< 0.01
Benzo(ghi)perylene	µg/l	0.01		0.01	< 0.01	< 0.01	< 0.01
Total EPA-16 PAHs	µg/l	0.2	LOD	< 0.2	12	430	5000
Benzene	µg/l	1	10	< 1.0	< 1.0	< 1.0	< 1.0
Toluene	µg/l	1	74	< 1.0	< 1.0	< 1.0	1.7
Ethylbenzene	µg/l	1		< 1.0	< 1.0	< 1.0	16
p & m-xylene	µg/l	1		< 1.0	< 1.0	< 1.0	29
o-xylene	µg/l	1		< 1.0	< 1.0	< 1.0	18
MTBE (Methyl Tertiary Butyl Ether)	µg/l	10		< 10	< 10	< 10	< 10
TPH-CWG - Aliphatic >C5 - C6	µg/l	1		< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aliphatic >C6 - C8	µg/l	1		< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aliphatic >C8 - C10	µg/l	1		< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aliphatic >C10 - C12	µg/l	10		< 10	< 10	< 10	< 10
TPH-CWG - Aliphatic >C12 - C16	µg/l	10		< 10	< 10	< 10	< 10
TPH-CWG - Aliphatic >C16 - C21	µg/l	10		< 10	< 10	< 10	< 10
TPH-CWG - Aliphatic >C21 - C35	µg/l	10		< 10	< 10	< 10	< 10
TPH-CWG - Aliphatic >C35 - C44	µg/l	10		< 10	< 10	< 10	< 10
TPH-CWG - Aliphatic (C5 - C35)	µg/l	10		< 10	< 10	< 10	< 10
TPH-CWG - Aliphatic (C5 - C44)	µg/l	10		< 10	< 10	< 10	< 10
TPH-CWG - Aromatic >C5 - C7	µg/l	1		< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aromatic >C7 - C8	µg/l	1		< 1.0	< 1.0	< 1.0	1.7
TPH-CWG - Aromatic >C8 - C10	µg/l	1		< 1.0	< 1.0	< 1.0	88
TPH-CWG - Aromatic >C10 - C12	µg/l	10		< 10	< 10	370	5600
TPH-CWG - Aromatic >C12 - C16	µg/l	10		< 10	< 10	600	2000
TPH-CWG - Aromatic >C16 - C21	µg/l	10		< 10	120	100	1000
TPH-CWG - Aromatic >C21 - C35	µg/l	10		< 10	58	< 10	< 10
TPH-CWG - Aromatic >C35 - C44	µg/l	10		< 10	< 10	< 10	< 10
TPH-CWG - Aromatic (C5 - C35)	µg/l	10		< 10	180	1100	8700
TPH-CWG - Aromatic (C5 - C44)	µg/l	10		< 10	180	1100	8700
Total TPH (C5-C35)	µg/l	10	10	< 10	180	1100	8700

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Soil Analysis Bulls Bridge, Hayes

			TP / BH No	WS1	WS2	WS3	WS4	WS5	WS5	WS6A	WS7	WS8	WS9	WS10	TP4	TP6
			Depth (m)	0.75	0.5	0.75	0.8	0.5	3.5	0.8	2.5	0.3	2	0.5	0.8	1
			Date Sampled	27/06/2019	27/06/2019	25/06/2019	27/06/2019	25/06/2019	25/06/2019	25/06/2019	26/06/2019	27/06/2019	26/06/2019	26/06/2019	25/06/2019	25/06/2019
			Report No:	19-09356	19-09356	19-09356	19-09356	19-09356	19-09356	19-09356	19-09356	19-09356	19-09356	19-09356	19-09356	19-09356
			Sample No	418781	418782	418783	418784	418785	418786	418787	418788	418789	418790	418791	418792	418793
Determinand	**Unit**	**LOD**	**GAC**													
Asbestos Screen (S)	N/a	N/a	Detection	Not Detected	Not Detected	Detected	Not Detected	Not Detected	Not Detected	Detected	Not Detected	Detected	Not Detected	Not Detected	Not Detected	Detected
Sample Matrix (S)	Material Type	N/A	Detection			Bundle of Chrysotile fibres				Bundle of Chrysotile fibres		Bundle of Chrysotile fibres				Bundle of Chrysotile fibres
Asbestos Type (S)	PLM Result	N/A	Detection			Chrysotile				Chrysotile		Chrysotile				Chrysotile
Quantification	%	<0.001	Detection			0.004				0.004		0.002				0.005
pH	pH Units	N/A	N/A	7.5	7.5	8	8.4	9.9	7.1	9.1	7.5	10.4	9.2	8.3	7.8	8.1
Total Cyanide	mg/kg	< 2	LOD	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
W/S Sulphate as SO4 (2:1)	mg/l	< 10	N/A	153	152	148	200	585	198	224	605	601	246	55	191	55
W/S Sulphate as SO4 (2:1)	g/l	< 0.01	N/A	0.15	0.15	0.15	0.2	0.58	0.2	0.22	0.6	0.6	0.25	0.05	0.19	0.05
Organic Matter	%	< 0.1	N/A	5.7	3.2	3.6	3.3	2.7	1.5	1.7	3.1	2.2	2.4	6.7	4.4	1.2
Arsenic (As)	mg/kg	< 2	640	32	20	19	34	12	7	15	22	14	12	6	317	13
Cadmium (Cd)	mg/kg	< 0.2	410	0.2	0.4	0.2	0.2	< 0.2	< 0.2	< 0.2	0.4	< 0.2	< 0.2	< 0.2	5.8	0.3
Chromium (Cr)	mg/kg	< 2	8600	16	26	23	89	24	17	26	32	22	143	13	18	11
Chromium (hexavalent)	mg/kg	< 2	49	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Copper (Cu)	mg/kg	< 4	68000	105	87	76	113	24	12	35	62	46	76	13	75	31
Lead (Pb)	mg/kg	< 3	2330	28	146	381	67	58	25	102	307	843	77	27	52	60
Mercury (Hg)	mg/kg	< 1	1100	< 1	< 1	1.1	< 1	< 1	< 1	< 1	1.7	< 1	< 1	< 1	< 1	< 1
Nickel (Ni)	mg/kg	< 3	980	41	24	22	56	13	8	25	22	16	19	11	32	11
Selenium (Se)	mg/kg	< 3	12000	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3
Zinc (Zn)	mg/kg	< 3	730000	54	210	211	116	146	34	114	285	124	86	32	48	73
Total Phenols (monohydric)	mg/kg	< 2	N/A	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Naphthalene	mg/kg	< 0.1	460	< 0.1	0.41	0.85	< 0.1	< 0.1	0.13	4.65	0.81	0.35	0.57	< 0.1	0.12	1.82
Acenaphthylene	mg/kg	< 0.1	97000	< 0.1	0.25	< 0.1	< 0.1	< 0.1	< 0.1	0.2	0.15	< 0.1	0.33	< 0.1	< 0.1	0.18
Acenaphthene	mg/kg	< 0.1	97000	< 0.1	< 0.1	0.13	< 0.1	< 0.1	0.17	9.79	1.73	0.16	0.12	< 0.1	< 0.1	0.57
Fluorene	mg/kg	< 0.1	68000	< 0.1	0.14	0.18	< 0.1	< 0.1	< 0.1	8.6	2.1	0.16	1.22	< 0.1	< 0.1	0.41
Phenanthrene	mg/kg	< 0.1	22000	0.23	0.85	1.22	0.33	0.74	0.33	33.7	11.3	1.56	14.2	< 0.1	0.33	3.77
Anthracene	mg/kg	< 0.1	540000	0.15	0.48	0.31	< 0.1	0.2	< 0.1	7.27	6.42	0.32	4.22	< 0.1	< 0.1	2.23
Fluoranthene	mg/kg	< 0.1	23000	0.25	2.35	1.96	0.32	0.73	0.46	20.6	22.1	2.84	23.8	< 0.1	0.2	8.03
Pyrene	mg/kg	< 0.1	22000	0.24	2.22	1.7	0.28	0.54	0.35	15	15.4	2.54	17.5	0.13	0.16	6.05
Benzo(a)anthracene	mg/kg	< 0.1	N/A	< 0.1	1.66	0.76	0.41	0.22	0.18	3.05	7.68	1.34	7.92	< 0.1	< 0.1	2.53
Chrysene	mg/kg	< 0.1	N/A	< 0.1	1.47	1.04	0.56	0.29	0.29	2.94	6.35	1.42	7.78	< 0.1	0.17	2.98
Benzo(b)fluoranthene	mg/kg	< 0.1	N/A	0.37	1.94	1.13	1.27	0.3	0.32	2.45	6.17	1.71	7.83	< 0.1	0.12	2.95
Benzo(k)fluoranthene	mg/kg	< 0.1	N/A	< 0.1	0.58	0.32	0.31	< 0.1	< 0.1	0.74	2.08	0.53	2.54	< 0.1	< 0.1	0.89
Benzo(a)pyrene	mg/kg	< 0.1	76	< 0.1	1.28	0.63	0.33	0.16	0.17	1.55	4.42	1.23	4.81	< 0.1	< 0.1	1.49
Indeno(1,2,3-cd)pyrene	mg/kg	< 0.1	N/A	< 0.1	1.09	0.43	0.37	0.11	0.13	0.73	1.79	0.8	2.31	< 0.1	< 0.1	0.94
Dibenz(a,h)anthracene	mg/kg	< 0.1	N/A	< 0.1	0.11	< 0.1	< 0.1	< 0.1	< 0.1	0.15	0.44	0.14	0.69	< 0.1	< 0.1	0.2
Benzo(ghi)perylene	mg/kg	< 0.1	N/A	< 0.1	0.81	0.35	0.3	0.12	< 0.1	0.6	1.29	0.67	1.85	< 0.1	< 0.1	0.72
Total EPA-16 PAHs	mg/kg	< 1.6	N/A	< 1.6	15.6	11	4.5	3.4	2.5	112	90.3	15.8	97.6	< 1.6	< 1.6	35.8
Aliphatic >C5 - C6	mg/kg	< 0.01	5900	< 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
Aliphatic >C6 - C8	mg/kg	< 0.05	17000	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Aliphatic >C8 - C10	mg/kg	< 2	4800	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Aliphatic >C10 - C12	mg/kg	< 2	23000	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Aliphatic >C12 - C16	mg/kg	< 3	82000 (24)	< 3	< 3	< 3	< 3	4	< 3	10	< 3	5	< 3	25	< 3	< 3
Aliphatic >C16 - C21	mg/kg	< 3	1700000	< 3	< 3	< 3	< 3	23	< 3	8	< 3	8	< 3	126	< 3	3
Aliphatic >C21 - C34	mg/kg	< 10	1700000	< 10	< 10	< 10	< 10	285	< 10	< 10	< 10	23	< 10	754	< 10	21
Aliphatic (C5 - C34)	mg/kg	< 21	N/A	< 21	< 21	< 21	< 21	312	< 21	< 21	< 21	36	< 21	905	< 21	25
Aromatic >C5 - C7	mg/kg	< 0.01	46000	< 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
Aromatic >C7 - C8	mg/kg	< 0.05	110000	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Aromatic >C8 - C10	mg/kg	< 2	8100	< 2	< 2	< 2	< 2	< 2	< 2	6	< 2	< 2	< 2	< 2	< 2	< 2
Aromatic >C10 - C12	mg/kg	< 2	28000	< 2	< 2	< 2	< 2	< 2	< 2	11	3	< 2	< 2	< 2	< 2	3
Aromatic >C12 - C16	mg/kg	< 2	37000 (169)	< 2	3	4	< 2	< 2	< 2	96	22	6	14	6	< 2	11
Aromatic >C16 - C21	mg/kg	< 3	28000	4	10	14	< 3	9	< 3	193	125	20	116	151	< 3	47
Aromatic >C21 - C35	mg/kg	< 10	28000	25	36	22	< 10	79	< 10	164	240	75	270	1584	< 10	112
Aromatic (C5 - C35)	mg/kg	< 21	N/A	29	49	40	< 21	88	< 21	470	391	102	400	1741	< 21	174
Total >C5 - C35	mg/kg	< 42	N/A	< 42	49	< 42	< 42	400	< 42	488	391	138	400	2646	< 42	198
Petroleum Range Organics (C6 - C10)	mg/kg	0.1														
TPH C10 - C40	mg/kg	10														
TPH2 (C6 - C10)	mg/kg	0.1														
TPH C6 - C40	mg/kg	10														
TPH (C10 - C25)	mg/kg	10														
TPH (C25 - C40)	mg/kg	10														
Benzene	ug/kg	< 2	98	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	12	< 2	< 2	< 2
Toluene	ug/kg	< 5	110000	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	13	< 5	< 5	< 5
Ethylbenzene	ug/kg	< 2	13000	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
p & m-xylene	ug/kg	< 2	14000	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
o-xylene	ug/kg	< 2	15000	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
MTBE	ug/kg	< 5	N/A	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5

TP / BH No	WS202	WS202	WS203	WS203	TP201	TP205	TP208	BH03	BH02	BH07	BH07	BH08	BH08
Depth (m)	0.60-0.90	2.10-2.40	0.40-0.70	3	0.3	0.5	0.4	3.8	1.5	2.55-3.00	5.80-6.00	2.50-3.00	5.50-6.00
Date Sampled	24/07/2019	24/07/2019	24/07/2019	24/07/2019	24/07/2019	24/07/2019	24/07/2019	29/01/2020	29/01/2020	24/01/2020	24/01/2020	24/01/2020	24/01/2020
Report No:	19-51430	19-51431	19-51432	19-51433	19-51434	19-51435	19-51436	20-83728	20-83728	20-82909	20-82909	20-82909	20-82909
Sample No	1275527	1275528	1275529	1275530	1275531	1275532	1275533	1425656	1425657	1421299	1421300	1421301	1421302
Determinand													
Asbestos Screen (S)			Detected		Detected			Not Detected	Detected		Not Detected		Not Detected
Sample Matrix (S)			Chrysotile- Loose Fibres		Chrysotile- Loose Fibres				Chrysotile Loose Fibrous Debris				
Asbestos Type (S)									Chrysotile				
Quantification									0.019				
pH	9.7	8.3	9.3	9	11.4	10.4	10.8	7.2	7.3	7.7	8.1	8.8	7.9
Total Cyanide	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
W/S Sulphate as SO4 (2:1)	446	204	367	294	1440	734	326	509	698	195	27.5	955	29
W/S Sulphate as SO4 (2:1)	0.45	0.2	0.37	0.29	1.4	0.73	0.33	0.51	0.7	0.19	0.028	0.96	0.029
Organic Matter	2.7	0.6	4.3	1.5	4.4	1.5	0.8	2.5	5.8	3.4	0.5	2.1	0.4
Arsenic (As)	9.1	12	14	26	9.4	14	12	22	18	18	13	15	8.4
Cadmium (Cd)	0.3	< 0.2	0.7	< 0.2	< 0.2	< 0.2	0.9	< 0.2	0.4	0.3	< 0.2	0.9	< 0.2
Chromium (Cr)	24	30	52	40	23	21	24	30	42	42	27	47	23
Chromium (hexavalent)	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2
Copper (Cu)	71	18	160	68	31	37	43	14	360	200	12	100	8.7
Lead (Pb)	63	23	190	210	47	74	120	11	230	350	14	180	4.7
Mercury (Hg)	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	2.2	< 0.3	< 0.3	< 0.3
Nickel (Ni)	24	23	34	44	14	23	15	33	41	37	26	34	21
Selenium (Se)	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Zinc (Zn)	170	46	190	120	58	86	110	40	270	72	43	70	26
Total Phenols (monohydric)								< 1.0	< 1.0	230	38	390	58
Naphthalene	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	3.9	1.6	0.92	65	1.3	79
Acenaphthylene	< 0.05	< 0.05	0.33	< 0.05	0.8	< 0.05	< 0.05	3.4	1.1	< 0.05	3	< 0.05	< 0.05
Acenaphthene	0.24	< 0.05	1	< 0.05	1.6	< 0.05	< 0.05	100	79	1.5	72	0.5	42
Fluorene	0.23	< 0.05	1.1	< 0.05	1.4	< 0.05	< 0.05	270	62	1.1	73	0.45	37
Phenanthrene	2.2	< 0.05	3.6	0.73	13	1.4	0.64	32	70	3.8	200	1.8	100
Anthracene	0.77	< 0.05	2.2	0.25	3.3	0.56	0.4	76	83	1.4	25	0.47	18
Fluoranthene	5.7	< 0.05	5.2	1.5	23	4	1.8	380	95	7.2	93	2.4	37
Pyrene	5.1	< 0.05	4.8	1.3	19	4.9	1.6	230	64	6.1	63	2	24
Benzo(a)anthracene	3.4	< 0.05	2.6	0.67	12	2.7	1.1	61	14	3	19	1.4	5.9
Chrysene	2.5	< 0.05	1.9	0.54	8.1	1.9	0.89	44	9.9	2.1	11	0.98	3.4
Benzo(b)fluoranthene	2.9	< 0.05	2.5	0.61	11	2.1	1	20	8.4	2	4.5	1	1.6
Benzo(k)fluoranthene	1.8	< 0.05	1.4	0.32	5.2	1.5	0.6	8.1	2.1	1.3	3.6	0.79	1.1
Benzo(a)pyrene	3.1	< 0.05	2.1	0.48	11	2.1	0.98	11	4.1	1.9	3	1	1.2
Indeno(1,2,3-cd)pyrene	1.8	< 0.05	1.1	0.31	5.5	1.1	0.57	2.2	1.5	0.65	0.85	0.42	< 0.05
Dibenz(a,h)anthracene	0.47	< 0.05	0.39	< 0.05	1.6	0.33	0.21	0.95	0.43	0.26	< 0.05	< 0.05	< 0.05
Benzo(ghi)perylene	2.4	< 0.05	1.5	0.35	7	1.5	0.86	2.1	1.7	0.91	0.54	0.55	< 0.05
Total EPA-16 PAHs	32.5	< 0.80	31.5	7.06	123	23.9	10.6	1250	499	34.1	641	15.1	354
Aliphatic >C5 - C6	< 0.001							< 0.001	< 0.001	< 0.001	< 0.001		< 0.001
Aliphatic >C6 - C8	< 0.001							< 0.001	< 0.001	< 0.001	< 0.001		< 0.001
Aliphatic >C8 - C10	< 0.001							< 0.001	< 0.001	< 0.001	< 0.001		< 0.001
Aliphatic >C10 - C12	< 1.0							8.7	13	7.6	9.5		9.2
Aliphatic >C12 - C16	< 2.0							41	250	120	39		30
Aliphatic >C16 - C21	< 8.0							27	340	1500	27		32
Aliphatic >C21 - C34	43							< 8.0	260	520	17		23
Aliphatic (C5 - C34)										-	94		95
Aromatic >C5 - C7	< 0.001							< 0.001	< 0.001	< 0.001	< 0.001		< 0.001
Aromatic >C7 - C8	< 0.001							< 0.001	< 0.001	< 0.001	< 0.001		< 0.001
Aromatic >C8 - C10	< 0.001							< 0.001	< 0.001	< 0.001	< 0.001		< 0.001
Aromatic >C10 - C12	< 1.0							22	10	1.7	70		110
Aromatic >C12 - C16	< 2.0							930	200	78	300		380
Aromatic >C16 - C21	17							1900	490	560	390		410
Aromatic >C21 - C35								480	210	370	140		44
Aromatic (C5 - C35)								3300	900	-	900		940
Total >C5 - C35	< 10	49	1100	160	950	110		3377	1770	3100	994		1035
Petroleum Range Organics (C6 - C10)										< 0.1		< 0.1	
TPH C10 - C40										2800		98	
TPH2 (C6 - C10)										< 0.1		< 0.1	
TPH C6 - C40										2800		98	
TPH (C10 - C25)										2600		82	
TPH (C25 - C40)										550		< 10	
Benzene	< 1.0							< 1.0	< 1.0	< 1.0	< 1.0		< 1.0
Toluene	< 1.0							< 1.0	< 1.0	< 1.0	< 1.0		< 1.0
Ethylbenzene	< 1.0							< 1.0	< 1.0	< 1.0	< 1.0		< 1.0
p & m-xylene	< 1.0							< 1.0	< 1.0	< 1.0	< 1.0		< 1.0
o-xylene	< 1.0							< 1.0	< 1.0	< 1.0	< 1.0		< 1.0
MTBE	< 1.0							< 1.0	< 1.0	< 1.0	< 1.0		< 1.0

building & project consultants

paragon

Soil Analysis Bulls Bridge, Hayes

			TP / BH No	WS1	WS2	WS3	WS4	WS5	WS5	WS6A	WS7	WS8	WS9	WS10	TP4	TP6	WS202	WS202	WS203	WS203	TP201	TP205	TP208	BH03	BH02	BH07	BH07	BH08	BH08
			Depth (m)	0.75	0.5	0.75	0.8	0.5	3.5	0.8	2.5	0.3	2	0.5	0.8	1	0.60-0.90	2.10-2.40	0.40-0.70	3	0.3	0.5	0.4	3	1.5	2.55-3.00	5.80-6.00	2.50-3.00	5.50-6.00
			Date Sampled	27/06/2019	27/06/2019	25/06/2019	27/06/2019	25/06/2019	25/06/2019	25/06/2019	26/06/2019	27/06/2019	26/06/2019	26/06/2019	25/06/2019	25/06/2019	24/07/2019	24/07/2019	24/07/2019	24/07/2019	24/07/2019	24/07/2019	24/07/2019	29/01/2020	29/01/2020	24/01/2020	24/01/2020	24/01/2020	24/01/2020
			Report No:	19-09356	19-09356	19-09356	19-09356	19-09356	19-09356	19-09356	19-09356	19-09356	19-09356	19-09356	19-09356	19-09356	19-51430	19-51431	19-51432	19-51433	19-51434	19-51435	19-51436	20-83728	20-83728	20-82909	20-82909	20-82909	20-82909
			Sample No	418781	418782	418783	418784	418785	418786	418787	418788	418789	418790	418791	418792	418793	1275527	1275528	1275529	1275530	1275531	1275532	1275533	1425656	1425657	1421299	1421300	1421301	1421302
Determinand	**Unit**	**LOD**	**GAC**																										
Dichlorodifluoromethane	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
Vinyl Chloride	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
Chloromethane	ug/kg	< 10	LOD				< 10	< 10							< 10	< 10													
Chloroethane	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
Bromomethane	ug/kg	< 10	LOD				< 10	< 10							< 10	< 10													
Trichlorofluoromethane	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
1,1-Dichloroethene	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
MTBE	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
trans-1,2-Dichloroethene	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
1,1-Dichloroethane	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
cis-1,2-Dichloroethene	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
2,2-Dichloropropane	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
Chloroform	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
Bromochloromethane	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
1,1,1-Trichloroethane	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
1,1-Dichloropropene	ug/kg	< 10	LOD				< 10	< 10							< 10	< 10													
Carbon Tetrachloride	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
1,2-Dichloroethane	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
Benzene	ug/kg	< 2	LOD				< 2	< 2							< 2	< 2													
1,2-Dichloropropane	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
Trichloroethene	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
Bromodichloromethane	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
Dibromomethane	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
TAME	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
cis-1,3-Dichloropropene	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
Toluene	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
trans-1,3-Dichloropropene	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
1,1,2-Trichloroethane	ug/kg	< 10	LOD				< 10	< 10							< 10	< 10													
1,3-Dichloropropane	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
Tetrachloroethene	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
Dibromochloromethane	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
1,2-Dibromoethane	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
Chlorobenzene	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
1,1,1,2-Tetrachloroethane	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
Ethyl Benzene	ug/kg	< 2	LOD				< 2	< 2							< 2	< 2													
m,p-Xylene	ug/kg	< 2	LOD				< 2	< 2							< 2	< 2													
o-Xylene	ug/kg	< 2	LOD				< 2	< 2							< 2	< 2													
Styrene	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
Bromoform	ug/kg	< 10	LOD				< 10	< 10							< 10	< 10													
Isopropylbenzene	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
1,1,2,2-Tetrachloroethane	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
1,2,3-Trichloropropane	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
n-Propylbenzene	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
Bromobenzene	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
2-Chlorotoluene	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
1,3,5-Trimethylbenzene	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
4-Chlorotoluene	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
tert-Butylbenzene	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
1,2,4-Trimethylbenzene	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
sec-Butylbenzene	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
p-Isopropyltoluene	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
1,3-Dichlorobenzene	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
1,4-Dichlorobenzene	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
n-Butylbenzene	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
1,2-Dichlorobenzene	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
1,2-Dibromo-3-chloropropane	ug/kg	< 10	LOD				< 10	< 10							< 10	< 10													
Hexachlorobutadiene	ug/kg	< 5	LOD				< 5	< 5							< 5	< 5													
Chloromethane	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
Chloroethane	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
Bromomethane	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
Vinyl Chloride	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
Trichlorofluoromethane	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
1,1-Dichloroethene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
1,1,2-Trichloro 1,2,2-Trifluoroethane	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
Cis-1,2-dichloroethene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
MTBE (Methyl Tertiary Butyl Ether)	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
1,1-Dichloroethane	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
2,2-Dichloropropane	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
Trichloromethane	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
1,1,1-Trichloroethane	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
1,2-Dichloroethane	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
1,1-Dichloropropene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
Trans-1,2-dichloroethene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
Benzene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
Tetrachloromethane	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
1,2-Dichloropropane	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
Trichloroethene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
Dibromomethane	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
Bromodichloromethane	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
Cis-1,3-dichloropropene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
Trans-1,3-dichloropropene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
Toluene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
1,1,2-Trichloroethane	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
1,3-Dichloropropane	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
Dibromochloromethane	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
Tetrachloroethene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
1,2-Dibromoethane	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
Chlorobenzene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
1,1,1,2-Tetrachloroethane	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
Ethylbenzene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
p & m-Xylene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
Styrene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
Tribromomethane	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
o-Xylene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
1,1,2,2-Tetrachloroethane	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
Isopropylbenzene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
Bromobenzene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
n-Propylbenzene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
2-Chlorotoluene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
4-Chlorotoluene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
1,3,5-Trimethylbenzene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
tert-Butylbenzene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
1,2,4-Trimethylbenzene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
sec-Butylbenzene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
1,3-Dichlorobenzene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
p-Isopropyltoluene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
1,2-Dichlorobenzene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
1,4-Dichlorobenzene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
Butylbenzene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
1,2-Dibromo-3-chloropropane	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
1,2,4-Trichlorobenzene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
Hexachlorobutadiene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0
1,2,3-Trichlorobenzene	µg/kg	1	LOD																					< 1.0	< 1.0		< 1.0		< 1.0

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Water Analysis
Bulls Bridge, Hayes

			TP / BH No	Canal Up Stream	Canal Mid Stream	Canal Down Stream	River Up stream	River Mid stream	River Down stream	River Up Stream	River Mid Stream	River Down Stream
			Depth (m)	04/06/2020	04/06/2020	04/06/2020	04/06/2020	04/06/2020	04/06/2020	18/06/2020	18/06/2020	18/06/2020
			Date Sampled	None Supplied	None Supplied	None Supplied	None Supplied	None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
			Lab Report No:	20-12662	20-12662	20-12662	20-12662	20-12662	20-12662	20-14987	20-14987	20-14987
			Lab Sample No	1526060	1526061	1526062	1526057	1526058	1526059	1538548	1538549	1538550
Determinand	**Unit**	**LOD**	**GAC Freshwater EQS (ug/l)**									
pH	pH Units	N/a	6.0-9.0	8.3	8.3	8.3	7.9	7.8	7.8	8.2	8	7.9
Ammonia as NH_3	µg/l	15	15	360	180	200	390	400	430	560	770	440
Dissolved Organic Carbon (DOC)	mg/l	0.1		5.49	5.44	5.47	6.7	6.98	6.36	8.38	9.17	7.05
Arsenic (dissolved)	ug/l	< 5	50	0.98	1.13	0.58	2.11	1.71	2.11	1.23	1.96	1.4
Cadmium (dissolved)	ug/l	< 0.4	0.08	< 0.02	< 0.02	0.05	< 0.02	0.05	< 0.02	< 0.02	0.02	0.02
Calcium (dissolved)	mg/l	0.012		110	110	100	120	120	120	46	38	36
Chromium (dissolved)	ug/l	< 5	4.7	0.7	< 0.2	0.6	< 0.2	0.3	< 0.2	< 0.2	< 0.2	< 0.2
Copper (dissolved)	ug/l	< 5	1	5.2	4.1	5	2.9	2.2	2.8	5.1	7.6	5
Lead (dissolved)	ug/l	< 5	1.2	0.6	0.5	0.7	1.1	2.5	0.7	1.3	1.1	1.1
Mercury (dissolved)	ug/l	< 0.05	0.07	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Nickel (dissolved)	ug/l	< 5	4	1.8	1.8	1.8	2	2.4	2	1.4	1.7	1.3
Selenium (dissolved)	ug/l	< 5		1.1	1.2	1.1	1.3	1.3	1.3	0.7	0.7	< 0.6
Zinc (dissolved)	ug/l	< 2	10.9	4.4	6.9	5.4	5.7	9.5	7.3	16	29	12
Total Phenols (monohydric)	ug/l	< 10	7.7	< 3.5	< 3.5	< 3.5	< 3.5	< 3.5	< 3.5	< 3.5	< 3.5	< 3.5
Naphthalene	ug/l	< 0.01	2	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Acenaphthylene	ug/l	< 0.01		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Acenaphthene	ug/l	< 0.01		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Fluorene	ug/l	< 0.01		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Phenanthrene	ug/l	< 0.01		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Anthracene	ug/l	< 0.01	0.1	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Fluoranthene	ug/l	< 0.01	0.1	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Pyrene	ug/l	< 0.01		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(a)anthracene	ug/l	< 0.01		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Chrysene	ug/l	< 0.01		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(b)fluoranthene	ug/l	< 0.01		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(k)fluoranthene	ug/l	< 0.01		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(a)pyrene	ug/l	< 0.01	0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Indeno(1,2,3-cd)pyrene	ug/l	< 0.01		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Dibenz(a,h)anthracene	ug/l	< 0.01		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(ghi)perylene	ug/l	< 0.008		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Total EPA-16 PAHs	ug/l	< 0.01		< 0.16	< 0.16	< 0.16	< 0.16	< 0.16	< 0.16	< 0.16	< 0.16	< 0.16
Aliphatic >C5 - C6	ug/l	< 10		< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aliphatic >C6 - C8	ug/l	< 10		< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aliphatic >C8 - C10	ug/l	< 10		< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aliphatic >C10 - C12	ug/l	< 10		< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aliphatic >C12 - C16	ug/l	< 10		< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aliphatic >C16 - C21	ug/l	< 10		< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aliphatic >C21 - C34	ug/l	< 10		< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aliphatic (C5 - C34)	ug/l	< 70		< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aromatic >C5 - C7	ug/l	< 10		< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aromatic >C7 - C8	ug/l	< 10		< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aromatic >C8 - C10	ug/l	< 10		< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aromatic >C10 - C12	ug/l	< 10		< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aromatic >C12 - C16	ug/l	< 10		< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aromatic >C16 - C21	ug/l	< 10		< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aromatic >C21 - C35	ug/l	< 10		< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aromatic (C5 - C35)	ug/l	< 70		< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Total >C5 - C35	ug/l	< 140	10	<140	<140	<140	<140	<140	<140	<140	<140	<140
Benzene	ug/l	< 1	10	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Toluene	ug/l	< 5	74	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethylbenzene	ug/l	< 5	300	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p & m-xylene	ug/l	< 10	30	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-xylene	ug/l	< 5	30	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
MTBE	ug/l	< 10		< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0

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Water Analysis
Bulls Bridge, Hayes

			TP / BH No	**WS5**	**WS6**	**WS7**	**BH02**	**BH07**	**BH08**	**BH01 (J)**	**BH08**	**BH02**	**WS7**	**BH01(J)**	**BH08**	**WS7**
			Depth (m)	2.88	3.86	3.25	2.8	4.85	4.8	3.70-5.93	3.37-6.00	2.00-5.62	3.26-5.00	3.66-5.91	3.34-5.99	3.18-4.99
			Date Sampled	03/07/2019	03/07/2019	03/07/2019	29/01/2020	29/01/2020	29/01/2020	04/06/2020	04/06/2020	04/06/2020	04/06/2020	18/06/2020	18/06/2020	18/06/2020
			Lab Report No:	19-09550	19-09550	19-09550	20-83728	20-83728	20-83728	20-12662	20-12662	20-12662	20-12662	20-14987	20-14987	20-14987
			Lab Sample No	419616	419617	419618	1425653	1425654	1425655	1526053	1526054	1526055	1526056	1538545	1538546	1538547
Determinand	**Unit**	**LOD**	**GAC Freshwater EQS (ug/l)**													
pH	pH Units	N/a	6.0-9.0	7.1	7.4	6.6	7.5	7.5	7.3	7.2	6.9	7.1	7.2	8.2	7.1	7.2
Electrical Conductivity	uS/cm	< 5		1850	4840	2350	1600	1500	1300							
Total Cyanide	ug/l	< 5		< 5	7	7										
Free Cyanide	µg/l	<10	1				< 10	< 10	< 10							
Sulphate as SO4	mg/l	< 1		114	270	10	157	169	33.4	103	3.81	95.4	24.7	71.2	2.93	48.9
Total Sulphur	µg/l	15								34000	1300	32000	8200	24000	980	16000
Sulphide	µg/l	5								< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Ammonia as NH_3	µg/l	15	15							8900	2100	1600	17000	4200	1900	17000
Dissolved Organic Carbon (DOC)	mg/l	0.1								5.85	28.4	32.1	30.6	7.4	8.12	32.3
Nitrate as N	mg/l	0.01					1.14	0.67	1.57	6.11	0.34	0.3	0.28	1.45	0.27	0.18
Nitrate as NO_3	mg/l	0.05								27	1.52	1.32	1.22	6.42	1.18	0.78
Nitrite as N	µg/l	1								87	11	7.8	8.4	130	31	17
Nitrite as NO_2	µg/l	5								290	37	26	28	430	100	55
Chemical Oxygen Demand (Total)	mg/l	2					100	55	91	14	180	150	140	31	120	120
BOD (Biochemical Oxygen Demand)	mg/l	1					18	6.1	31	7.7	19	8	8.6	4.1	8.1	3.1
Carbonate	mgCaCO3/l	10								210	390	330	840	260	720	1400
Dissolved Carbon Dioxide	mg/l	1								30	96	58	100	3.7	110	200
Methane	mg/L	0.1								< 0.1	0.2	4.5	8.2	< 0.1	0.2	6.4
Total Organic Carbon (TOC)	mg/l	< 0.1		8.5	16.9	1.5										
Hardness - Total	mgCaCO3/l	< 1		1010	880	1330	626	618	813							
Redox Potential	mV	-800					65.7	71.2	84.7							
Iron (dissolved)	mg/l	0.004								0.3	2.8	0.39	2.6	0.13	0.18	0.75
Fe^{2+}	mg/l	0.2								< 0.20	0.32	< 0.20	< 0.20	< 0.20	< 0.20	0.23
Fe^{3+}	mg/l	0.2								0.3	2.43	0.29	2.52	< 0.20	< 0.20	0.51
Mn (II)	mg/l	0.02								0.14	4.32	7.34	1.84	0.06	0.26	0.49
Mn (IV)	mg/l	0.02								< 0.02	0.22	0.03	1.1	0.02	4.37	2.09
Arsenic (dissolved)	ug/l	< 5	50	21	< 5	12	1.95	1.39	2.96	1.35	7.71	3.16	8.84	1.79	7.63	1.79
Barium (dissolved)	ug/l	< 5		140	120	268	110	130	97							
Beryllium (dissolved)	ug/l	< 3	15	< 3	< 3	< 3	< 0.1	< 0.1	< 0.1							
Boron (dissolved)	ug/l	< 5		510	575	1300	420	370	220							
Cadmium (dissolved)	ug/l	< 0.4	0.08	< 0.4	< 0.4	< 0.4	0.03	< 0.02	< 0.02	0.22	< 0.02	< 0.02	0.06	0.09	< 0.02	< 0.02
Calcium (dissolved)	mg/l	0.012					170	160	210	120	170	240	170	86	150	320
Chromium (dissolved)	ug/l	< 5	4.7	< 5	< 5	< 5	0.5	0.3	0.3	0.2	1.8	1.3	0.5	< 0.2	0.3	< 0.2
Copper (dissolved)	ug/l	< 5	1	< 5	< 5	< 5	1.6	2	0.6	5.9	2	1.5	2.7	4.3	2.2	0.6
Lead (dissolved)	ug/l	< 5	1.2	< 5	< 5	< 5	0.4	0.7	0.3	0.8	3.7	5.3	52	1	0.9	< 0.2
Magnesium (dissolved)	mg/l	0.005					48	55	68							
Mercury (dissolved)	ug/l	< 0.05	0.07	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Nickel (dissolved)	ug/l	< 5	4	< 5	< 5	5	4.7	3.3	7.3	2.2	7.3	3.4	0.9	1.8	6.4	1
Selenium (dissolved)	ug/l	< 5		< 5	< 5	< 5	33	2.1	4.2	1.2	2.3	4.5	7.5	0.9	2.1	6.6
Vanadium (dissolved)	ug/l	< 5		< 5	< 5	< 5	0.5	0.3	< 0.2							
Zinc (dissolved)	ug/l	< 2	10.9	7	4	7	2.4	9.3	8.8	26	7.2	3.7	32	30	6.2	59
Total Phenols (monohydric)	ug/l	< 10	7.7	< 10	< 10	< 10	280	< 10	190	< 3.5	< 3.5	< 3.5	< 3.5	< 3.5	790	< 3.5
Naphthalene	ug/l	< 0.01	2	< 0.01	< 0.01	0.06	0.27	0.1	585	< 0.01	2480	65.8	1.93	1.86	5260	37.1
Acenaphthylene	ug/l	< 0.01		< 0.01	< 0.01	< 0.01	0.29	0.29	0.87	< 0.01	5.98	5.31	< 0.01	< 0.01	14.1	< 0.01
Acenaphthene	ug/l	< 0.01		0.03	< 0.01	0.11	6.01	11.2	13.7	< 0.01	105	110	< 0.01	< 0.01	234	1.43
Fluorene	ug/l	< 0.01		< 0.01	< 0.01	0.03	2.59	2.76	5.13	< 0.01	39.4	45.8	< 0.01	< 0.01	101	0.39
Phenanthrene	ug/l	< 0.01		< 0.01	< 0.01	0.04	2.22	< 0.01	5.04	< 0.01	19.4	14.8	< 0.01	< 0.01	56.5	< 0.01
Anthracene	ug/l	< 0.01	0.1	< 0.01	0.03	0.02	0.55	0.4	0.79	< 0.01	5.07	2.69	< 0.01	< 0.01	15.9	< 0.01
Fluoranthene	ug/l	< 0.01	0.1	< 0.01	0.03	0.03	0.5	0.9	0.75	< 0.01	1.26	2.06	< 0.01	< 0.01	3.09	< 0.01
Pyrene	ug/l	< 0.01		< 0.01	0.02	0.03	0.3	0.51	0.57	< 0.01	0.64	1.09	< 0.01	< 0.01	1.72	< 0.01
Benzo(a)anthracene	ug/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	< 0.01
Chrysene	ug/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	< 0.01
Benzo(b)fluoranthene	ug/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	< 0.01
Benzo(k)fluoranthene	ug/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	< 0.01
Benzo(a)pyrene	ug/l	< 0.01	0.02	< 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
Indeno(1,2,3-cd)pyrene	ug/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	< 0.01
Dibenz(a,h)anthracene	ug/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	< 0.01
Benzo(ghi)perylene	ug/l	< 0.008		< 0.008	< 0.008	< 0.008	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Total EPA-16 PAHs	ug/l	< 0.01		0.03	0.08	0.32	12.7	16.1	612	< 0.16	2660	248	1.93	1.86	5680	39
Aliphatic >C5 - C6	ug/l	< 10		< 10	< 10	< 10	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aliphatic >C6 - C8	ug/l	< 10		< 10	< 10	< 10	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aliphatic >C8 - C10	ug/l	< 10		< 10	< 10	< 10	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aliphatic >C10 - C12	ug/l	< 10		< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aliphatic >C12 - C16	ug/l	< 10		< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aliphatic >C16 - C21	ug/l	< 10		< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aliphatic >C21 - C34	ug/l	< 10		< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aliphatic (C5 - C34)	ug/l	< 70		< 70	< 70	< 70	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aromatic >C5 - C7	ug/l	< 10		< 10	< 10	< 10	3.5	< 1.0	2.9	< 1.0	< 1.0	7.1	< 1.0	< 1.0	3.5	< 1.0
Aromatic >C7 - C8	ug/l	< 10		< 10	< 10	< 10	< 1.0	< 1.0	6.9	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	10	< 1.0
Aromatic >C8 - C10	ug/l	< 10		< 10	< 10	< 10	6.8	< 1.0	390	< 1.0	370	32	< 1.0	< 1.0	610	< 1.0
Aromatic >C10 - C12	ug/l	< 10		< 10	< 10	< 10	< 10	70	1500	< 10	2800	610	< 10	< 10	9600	38
Aromatic >C12 - C16	ug/l	< 10		< 10	< 10	< 10	820	150	1000	< 10	4600	1700	< 10	< 10	6000	< 10
Aromatic >C16 - C21	ug/l	< 10		< 10	< 10	< 10	400	70	500	< 10	4600	1100	< 10	< 10	1500	< 10
Aromatic >C21 - C35	ug/l	< 10		< 10	< 10	< 10	< 10	< 10	< 10	< 10	210	91	< 10	< 10	300	< 10
Aromatic (C5 - C35)	ug/l	< 70		< 70	< 70	< 70	1200	290	3400	< 10	13000	3500	< 10	< 10	18000	38
Total >C5 - C35	ug/l	< 140	10	< 140	< 140	< 140	1200	290	3400	<140	13000	3500	<140	<140	18000	38
Benzene	ug/l	< 1	10	< 1	< 1	< 1	3.5	< 1.0	2.9	< 1.0	< 1.0	7.1	< 1.0	< 1.0	3.5	< 1.0
Toluene	ug/l	< 5	74	< 5	< 5	< 5	< 1.0	< 1.0	6.9	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	10.4	< 1.0
Ethylbenzene	ug/l	< 5	300	< 5	< 5	< 5	2	< 1.0	81.1	< 1.0	72.7	6.6	< 1.0	< 1.0	122	< 1.0
p & m-xylene	ug/l	< 10	30	< 10	< 10	< 10	< 1.0	< 1.0	170	< 1.0	141	5.8	< 1.0	< 1.0	243	< 1.0
o-xylene	ug/l	< 5	30	< 5	< 5	< 5	3	< 1.0	76.7	< 1.0	76	11.1	< 1.0	< 1.0	117	< 1.0
MTBE	ug/l	< 10		< 10	< 10	< 10	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0

building & project consultants

paragon

Determinand	Unit	LOD	TP / BH No	WS5	WS6	WS7	BH02	BH07	BH08
			Depth (m)	2.88	3.86	3.25	2.8	4.85	4.8
			Date Sampled	03/07/2019	03/07/2019	03/07/2019	29/01/2020	29/01/2020	29/01/2020
			Lab Report No:	19-09550	19-09550	19-09550	20-83728	20-83728	20-83728
			Lab Sample No	419616	419617	419618	1425653	1425654	1425655
Determinand	Unit	LOD	GAC (LOD)						
Chloromethane	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
Chloroethane	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
Bromomethane	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
Vinyl Chloride	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
Trichlorofluoromethane	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
1,1-Dichloroethene	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
1,1,2-Trichloro-1,2,2-trifluoroethane	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
Cis-1,2-dichloroethene	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
MTBE (Methyl Tertiary Butyl Ether)	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
1,1-Dichloroethane	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
2,2-Dichloropropane	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
Trichloromethane	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
1,1,1-Trichloroethane	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
1,2-Dichloroethane	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
1,1-Dichloropropene	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
Trans-1,2-dichloroethene	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
Benzene	µg/l	1	LOD				3.5	< 1.0	2.9
Tetrachloromethane	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
1,2-Dichloropropane	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
Trichloroethene	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
Dibromomethane	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
Bromodichloromethane	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
Cis-1,3-dichloropropene	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
Trans-1,3-dichloropropene	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
Toluene	µg/l	1	LOD				< 1.0	< 1.0	6.9
1,1,2-Trichloroethane	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
1,3-Dichloropropane	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
Dibromochloromethane	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
Tetrachloroethene	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
1,2-Dibromoethane	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
Chlorobenzene	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
1,1,1,2-Tetrachloroethane	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
Ethylbenzene	µg/l	1	LOD				2	< 1.0	81.1
p & m-Xylene	µg/l	1	LOD				< 1.0	< 1.0	170
Styrene	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
Tribromomethane	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
o-Xylene	µg/l	1	LOD				3	< 1.0	76.7
1,1,2,2-Tetrachloroethane	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
Isopropylbenzene	µg/l	1	LOD				< 1.0	< 1.0	4.4
Bromobenzene	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
n-Propylbenzene	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
2-Chlorotoluene	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
4-Chlorotoluene	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
1,3,5-Trimethylbenzene	µg/l	1	LOD				< 1.0	< 1.0	19.1
tert-Butylbenzene	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
1,2,4-Trimethylbenzene	µg/l	1	LOD				1.8	< 1.0	41.9
sec-Butylbenzene	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
1,3-Dichlorobenzene	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
p-Isopropyltoluene	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
1,2-Dichlorobenzene	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
1,4-Dichlorobenzene	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
Butylbenzene	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
1,2-Dibromo-3-chloropropane	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
1,2,4-Trichlorobenzene	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
Hexachlorobutadiene	µg/l	1	LOD				< 1.0	< 1.0	< 1.0
1,2,3-Trichlorobenzene	µg/l	1	LOD				< 1.0	< 1.0	< 1.0

APPENDIX B: MONITORING FIELD RECORDS

Low Flow Sampling Sheet

CLIENT Paragon
DATE 04.06.20
WEATHER Overcast

SITE Hayes Bulls Bridge Ind. Est
TIME On: 07:10 Off: 15:35
MONITORING PERSONNEL Jake T

Monitoring Location	Time	DTL m	DTB m	Casing Height m	EC us/cm	Temp C	DO %	DO mg/l	ORP mV	pH	Purge Volume L	Odour description	Sediment description	Oil/grease visible	Colour description	Turbidity description	Comments
BH01(J)	08:45:16	3.70			908.3091	13.32171	43.8729	4.528773	120.5913	7.276639		None	None	No	Light Brown	Low	
	08:48:16	3.70			889.2727	13.30765	10.16974	1.050162	39.37398	7.089705		None	None	No	Light Brown	Low	
	08:51:16	3.70			939.157	13.35273	6.017889	0.6207076	7.404434	7.02459		None	None	No	Light Brown	Low	
	08:54:16	3.70			944.0995	13.38056	5.222782	0.5383563	-7.274994	6.97686		None	None	No	Light Brown	Low	
	08:57:16	3.70			969.2421	13.4516	5.488389	0.5647981	-14.81618	6.927		None	None	No	Light Brown	Low	
	09:00:16	3.70			1003.908	13.49151	6.302979	0.6479817	-17.73204	6.888855		None	None	No	Light Brown	Low	
	09:03:16	3.70			1008.447	13.49724	6.094414	0.6264505	-19.24123	6.884244		None	None	No	Light Brown	Low	
	09:06:16	3.70	5.93	0	1016.028	13.54125	5.858695	0.6016207	-20.04231	6.870462	3	None	None	No	Light Brown	Low	
BH08	09:49:07	3.37			1570.18	14.65	40.99	4.10	-194.70	6.84268		Organic	None	Yes - Slight Sheen	Light Brown	Low	
	09:52:07	3.53			1636.88	13.49	7.02	0.72	-196.82	6.82929		Organic	None	Yes - Slight Sheen	Light Brown	Low	
	09:55:07	3.66			1645.49	13.33	6.03	0.62	-204.12	6.82462		Organic	None	Yes - Slight Sheen	Light Brown	Low	
	09:58:07	3.71			1644.33	13.26	7.56	0.78	-214.89	6.80882		Organic	None	Yes - Slight Sheen	Light Brown	Low	
	10:01:07	3.77			1637.48	13.22	5.75	0.59	-223.40	6.8023		Organic	None	Yes - Slight Sheen	Light Brown	Low	
	10:04:07	3.78			1637.36	13.23	5.07	0.52	-228.75	6.81237		Organic	None	Yes - Slight Sheen	Light Brown	Low	
	10:07:07	3.78			1646.29	13.27	3.89	0.40	-232.37	6.82116		Organic	None	Yes - Slight Sheen	Light Brown	Low	
	10:10:07	3.78	6	0	1641.17	13.25	4.06	0.42	-232.49	6.82438	3	Organic	None	Yes - Slight Sheen	Light Brown	Low	
BH02	10:55:37	2.00			2103.81	16.06	25.21	2.44	-209.65	6.93264		None	None	No	Light Brown	Low	Destroyed lid and missing gas valve.
	10:58:37	2.01			2055.49	14.72	6.89	0.69	-231.71	6.90769		None	None	No	Light Brown	Low	GA readings taken without bung
	11:01:37	2.01			2182.12	14.51	7.77	0.78	-235.26	6.83391		None	None	No	Light Brown	Low	
	11:04:37	2.01			2119.22	14.27	5.51	0.55	-235.76	6.76397		None	None	No	Light Brown	Low	
	11:07:37	2.02			2111.75	14.25	6.47	0.65	-239.95	6.72842		None	None	No	Light Brown	Low	
	11:10:37	2.02			2068.02	14.29	4.11	0.41	-242.28	6.73112		None	None	No	Light Brown	Low	
	11:13:37	2.02			2073.99	14.26	4.12	0.42	-245.78	6.73529		None	None	No	Light Brown	Low	
	11:16:37	2.02	5.62	0	2049.19	14.22	3.76	0.38	-247.36	6.74797	4	None	None	No	Light Brown	Low	
WS7	12:00:01	3.26			2690.68	15.97	38.54	3.73	-232.29	6.85954		None	None	No	Light Grey	None	2x vials
	12:03:01	3.62			2711.66	14.75	5.45	0.54	-254.50	6.8579		None	None	No	Light Grey	None	1 x full 300ml glass, 0.5x full 300ml glass
	12:06:01	3.74			2816.28	14.67	3.78	0.38	-258.67	6.82591		None	None	No	Light Grey	None	
	12:09:01	3.97			2730.46	14.67	4.37	0.44	-260.30	6.8186		None	None	No	Light Grey	None	
	12:12:01	4.09			2855.36	14.67	4.66	0.46	-265.58	6.80858		None	None	No	Light Grey	None	
	12:15:01	4.28			2787.58	14.68	4.03	0.40	-267.24	6.82491		None	None	No	Light Grey	None	
	12:18:01	4.37			2839.31	15.27	1.95	0.19	-275.88	6.86757		None	None	No	Light Grey	None	
	12:21:01	4.48	5.00	0	2890.42	15.32	3.42	0.34	-274.69	6.84863	3	None	None	No	Light Grey	None	
River Crane DS	14:11:10	-	-	-	1003.46	14.65	75.45	7.56	3.25	7.67514	-	None	None	No	Clear	None	
River Crane MS	13:15:21	-	-	-	1004.29	15.5630	72.3100	7.1063	-80.3438	7.6349	-	None	None	No	Clear	None	
River Crane US	13:29:49	-	-	-	997.78	15.54	93.61	9.20	-23.39	7.7347	-	None	None	No	Clear	None	
Grand Union Canal DS	14:24:57	-	-	-	847.64	18.14	110.15	10.26	19.82	110.152	-	None	None	No	Clear	None	
Grand Union Canal MS	14:35:51	-	-	-	848.05	18.52	115.13	10.64	16.64	8.16928	-	None	None	No	Clear	None	
Grand Union Canal US	14:50:31	-	-	-	847.0647	18.1939	116.6977	10.8761	25.8673	8.2158	-	None	None	No	Clear	None	

Low Flow Sampling Sheet

CLIENT Paragon
DATE 18.06.20
WEATHER Overcast. Heavy rainfall

SITE Hayes Bulls Bridge Ind. Est
TIME On: 08:10 Off: 15:00
MONITORING PERSONNEL Jake T

Monitoring Location	Time	DTL m	DTB m	Casing Height m	EC us/cm	Temp C	DO %	DO mg/l	ORP mV	pH	Purge Volume L	Odour description	Sediment description	Oil/grease visible	Colour description	Turbidity description	Comments
BH01(J)	09:41:50	3.66			927.6765	15.1094	39.3718	3.9497	200.8280	7.3513		None	None	No	Clear	Low	
	09:44:50	3.67			880.6565	14.6320	4.4128	0.4473	207.6492	6.7181		None	None	No	Clear	Low	
	09:47:50	3.67			866.2248	14.5474	3.0114	0.3059	211.4854	6.5708		None	None	No	Clear	Low	
	09:50:50	3.67			793.8553	14.6643	2.6442	0.2679	211.7834	6.5355		None	None	No	Clear	Low	
	09:53:50	3.67			804.0623	14.7248	2.5237	0.2554	210.3600	6.5493		None	None	No	Clear	Low	
	09:56:50	3.67			684.4159	14.7447	2.6804	0.2712	208.2047	6.5956		None	None	No	Clear	Low	
	09:59:50	3.67			776.8582	14.7326	2.8517	0.2886	208.1046	6.5955		None	None	No	Clear	Low	
	10:02:50	3.67			836.4188	14.7227	2.8362	0.2870	207.5920	6.6048		None	None	No	Clear	Low	
	10:05:50	3.67	5.91	0	760.7771	14.7488	2.7043	0.2736	204.7548	6.6360	4	None	None	No	Clear	Low	
BH08	10:30:35	3.34			1836.4560	14.9261	39.0134	3.9177	189.4388	6.8023		Slight Hydrocarbon/Organic	None	No	Light Grey	Low	
	10:33:35	3.55			1905.3240	13.9254	4.0493	0.4155	183.6023	6.6257		Slight Hydrocarbon/Organic	None	No	Light Grey	Low	
	10:36:35	3.6			1890.4750	13.7819	2.9177	0.3001	180.0618	6.5054		Slight Hydrocarbon/Organic	None	No	Light Grey	Low	
	10:39:35	3.64			1872.0330	13.6121	3.0696	0.3171	174.4613	6.4622		Slight Hydrocarbon/Organic	None	No	Light Grey	Low	
	10:42:35	3.65			1818.8790	13.6075	2.4063	0.2487	167.4494	6.4702		Slight Hydrocarbon/Organic	None	No	Light Grey	Low	
	10:45:35	3.66			1755.9080	13.5671	2.2680	0.2347	161.8633	6.4525		Slight Hydrocarbon/Organic	None	No	Light Grey	Low	
	10:48:35	3.67			1685.9470	13.5430	2.3189	0.2401	156.1222	6.4583		Slight Hydrocarbon/Organic	None	No	Light Grey	Low	
	10:51:35	3.65			1728.1900	13.5728	1.8336	0.1897	147.8181	6.5187		Slight Hydrocarbon/Organic	None	No	Light Grey	Low	
	10:54:54	3.65			1725.0640	13.6519	2.0754	0.2144	142.3297	6.5150		Slight Hydrocarbon/Organic	None	Yes - Slight Sheen	Light Grey	Low	
	10:57:54	3.65			1716.9930	13.6605	2.0303	0.2097	136.9343	6.5288		Slight Hydrocarbon/Organic	None	Yes - Slight Sheen	Light Grey	Low	
	11:00:54	3.65	5.99	0	1650.2340	13.6297	1.9236	0.1989	130.5923	6.5823	5	Slight Hydrocarbon/Organic	None	Yes - Slight Sheen	Light Grey	Low	
WS7	11:38:58	3.18			3046.6310	15.8857	57.7319	5.6569	157.2046	6.6427		Slight Hydrocarbon/Organic	None	No	Light Grey	Low	Low flow stopped at 15 minutes due rapid drawdown to ensure full suite of samples obtained
	11:41:58	3.45			1852.2330	15.0318	3.4499	0.3456	143.2333	6.8182		Slight Hydrocarbon/Organic	None	No	Light Grey	Low	
	11:44:58	3.61			3009.1960	14.9812	2.4781	0.2476	138.1144	6.7977		Slight Hydrocarbon/Organic	None	No	Light Grey	Low	
	11:47:58	3.74			2110.1920	15.0308	2.2705	0.2273	132.7643	6.7833		Slight Hydrocarbon/Organic	None	No	Light Grey	Low	
	11:50:58	3.88			1778.3570	15.0027	2.1126	0.2118	128.3440	6.7665		Slight Hydrocarbon/Organic	None	Yes - Sheen	Light Grey	Low	
	11:53:58	4	4.99	0	935.3191	14.9759	2.0171	0.2029	123.3611	6.7709	3	Slight Hydrocarbon/Organic	None	Yes - Sheen	Light Grey	Low	
River Crane DS	14:08:54	-	-	-	400.9422	16.5305	54.9579	5.3265	125.7035	7.7100	-	None	Fine brown - High. Plant material	No	Light Brown/Grey	High	Sediment load and turbidity attributable to high rainfall
River Crane MS	13:04:38	-	-	-	493.10	16.4488	54.9777	5.3316	100.1485	8.2885	-	None	Fine brown - High	No	Light Brown/Grey	High	Sediment load and turbidity attributable to high rainfall
River Crane US	13:24:18	-	-	-	529.73	16.52	53.01	5.13	109.80	7.793316	-	None	Fine brown - High	No	Light Brown/Grey	High	Sediment load and turbidity attributable to high rainfall
Grand Union Canal DS	13:48:11	-	-	-	939.50	18.50	102.57	9.52	120.53	7.934254	-	None	None	No	Clear	None	
Grand Union Canal MS	14:27:36	-	-	-	925.80	18.70	106.87	9.88	123.55	7.957411	-	None	None	No	Clear	None	
Grand Union Canal US	14:42:06	-	-	-	888.0435	18.5610	104.3449	9.6781	106.5479	7.9899	-	None	None	No	Clear	None	

APPENDIX C: LABORATORY ANALYSIS

Charlie Knox
Paragon New Homes Ltd
7 Swallow Place
London
W1B 2AG

e: charlieknox@paragonbc.co.uk

i2 Analytical Ltd.
7 Woodshots Meadow,
Croxley Green
Business Park,
Watford,
Herts,
WD18 8YS

t: 01923 225404
f: 01923 237404
e: reception@i2analytical.com

Analytical Report Number : 20-12662

Project / Site name:	Hayes Balls Bridge Ind Est	**Samples received on:**	05/06/2020
Your job number:		**Sample instructed/ Analysis started on:**	05/06/2020
Your order number:		**Analysis completed by:**	17/06/2020
Report Issue Number:	1	**Report issued on:**	17/06/2020
Samples Analysed:	10 water samples		

Signed: A. Czerwińska

Agnieszka Czerwińska

Technical Reviewer (Reporting Team)
For & on behalf of i2 Analytical Ltd.

Standard Geotechnical, Asbestos and Chemical Testing Laboratory located at: ul. Pionierów 39, 41 -711 Ruda Śląska, Poland.

Accredited tests are defined within the report, opinions and interpretations expressed herein are outside the scope of accreditation.

Standard sample disposal times, unless otherwise agreed with the laboratory, are :

soils	- 4 weeks from reporting
leachates	- 2 weeks from reporting
waters	- 2 weeks from reporting
asbestos	- 6 months from reporting

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Any assessments of compliance with specifications are based on actual analytical results with no contribution from uncertainty of measurement. Application of uncertainty of measurement would provide a range within which the true result lies. An estimate of measurement uncertainty can be provided on request.

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The results included within the report relate only to the sample(s) submitted for testing.

Analytical Report Number: 20-12662

Project / Site name: Hayes Balls Bridge Ind Est

Lab Sample Number				1526053	1526054	1526055	1526056	1526057
Sample Reference				BH01 (J)	BH08	BH02	WS7	River Up stream
Sample Number				None Supplied	Shallow	None Supplied	None Supplied	None Supplied
Depth (m)				3.70-5.93	3.37-6.00	2.00-5.62	3.26-5.00	None Supplied
Date Sampled				04/06/2020	04/06/2020	04/06/2020	04/06/2020	04/06/2020
Time Taken				0906	1010	1120	1230	1330
Analytical Parameter (Water Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
General Inorganics								
pH	pH Units	N/A	ISO 17025	7.2	6.9	7.1	7.2	7.9
Sulphate as SO_4	mg/l	0.045	ISO 17025	103	3.81	95.4	24.7	-
Total Sulphur	µg/l	15	NONE	34000	1300	32000	8200	-
Sulphide	µg/l	5	NONE	< 5.0	< 5.0	< 5.0	< 5.0	-
Ammonia as NH_3	µg/l	15	ISO 17025	8900	2100	1600	17000	390
Dissolved Organic Carbon (DOC)	mg/l	0.1	NONE	5.85	28.4	32.1	30.6	6.70
Nitrate as N	mg/l	0.01	ISO 17025	6.11	0.34	0.30	0.28	-
Nitrate as NO_3	mg/l	0.05	ISO 17025	27.0	1.52	1.32	1.22	-
Nitrite as N	µg/l	1	ISO 17025	87	11	7.8	8.4	-
Nitrite as NO_2	µg/l	5	ISO 17025	290	37	26	28	-
Chemical Oxygen Demand (Total)	mg/l	2	ISO 17025	14	180	150	140	-
BOD (Biochemical Oxygen Demand) (Total) - PL	mg/l	1	ISO 17025	7.7	19	8.0	8.6	-
Carbonate	mgCaCO3/l	10	NONE	210	390	330	840	-
Dissolved Carbon Dioxide	mg/l	1	NONE	30	96	58	100	-
Phenols by HPLC								
Catechol	µg/l	0.5	NONE	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Resorcinol	µg/l	0.5	NONE	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Ethylphenol & Dimethylphenol	µg/l	0.5	NONE	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Cresols	µg/l	0.5	NONE	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Naphthols	µg/l	0.5	NONE	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Isopropylphenol	µg/l	0.5	NONE	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Phenol	µg/l	0.5	NONE	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Trimethylphenol	µg/l	0.5	NONE	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Total Phenols								
Total Phenols (HPLC)	µg/l	3.5	NONE	< 3.5	< 3.5	< 3.5	< 3.5	< 3.5
Speciated PAHs								
Naphthalene	µg/l	0.01	ISO 17025	< 0.01	2480	65.8	1.93	< 0.01
Acenaphthylene	µg/l	0.01	ISO 17025	< 0.01	5.98	5.31	< 0.01	< 0.01
Acenaphthene	µg/l	0.01	ISO 17025	< 0.01	105	110	< 0.01	< 0.01
Fluorene	µg/l	0.01	ISO 17025	< 0.01	39.4	45.8	< 0.01	< 0.01
Phenanthrene	µg/l	0.01	ISO 17025	< 0.01	19.4	14.8	< 0.01	< 0.01
Anthracene	µg/l	0.01	ISO 17025	< 0.01	5.07	2.69	< 0.01	< 0.01
Fluoranthene	µg/l	0.01	ISO 17025	< 0.01	1.26	2.06	< 0.01	< 0.01
Pyrene	µg/l	0.01	ISO 17025	< 0.01	0.64	1.09	< 0.01	< 0.01
Benzo(a)anthracene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Chrysene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(b)fluoranthene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(k)fluoranthene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(a)pyrene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Indeno(1,2,3-cd)pyrene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Dibenz(a,h)anthracene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(ghi)perylene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Total PAH								
Total EPA-16 PAHs	µg/l	0.16	ISO 17025	< 0.16	2660	248	1.93	< 0.16

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Analytical Report Number: 20-12662

Project / Site name: Hayes Balls Bridge Ind Est

Lab Sample Number				1526053	1526054	1526055	1526056	1526057
Sample Reference				BH01 (J)	BH08	BH02	WS7	River Up stream
Sample Number				None Supplied	Shallow	None Supplied	None Supplied	None Supplied
Depth (m)				3.70-5.93	3.37-6.00	2.00-5.62	3.26-5.00	None Supplied
Date Sampled				04/06/2020	04/06/2020	04/06/2020	04/06/2020	04/06/2020
Time Taken				0906	1010	1120	1230	1330
Analytical Parameter (Water Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Heavy Metals / Metalloids								
Mn (II)	mg/l	0.02	NONE	0.14	4.32	7.34	1.84	-
Mn (IV)	mg/l	0.02	NONE	< 0.02	0.22	0.03	1.10	-
Arsenic (dissolved)	µg/l	0.15	ISO 17025	1.35	7.71	3.16	8.84	2.11
Cadmium (dissolved)	µg/l	0.02	ISO 17025	0.22	< 0.02	< 0.02	0.06	< 0.02
Calcium (dissolved)	mg/l	0.012	ISO 17025	120	170	240	170	120
Chromium (dissolved)	µg/l	0.2	ISO 17025	0.2	1.8	1.3	0.5	< 0.2
Copper (dissolved)	µg/l	0.5	ISO 17025	5.9	2.0	1.5	2.7	2.9
Iron (dissolved)	mg/l	0.004	ISO 17025	0.30	2.8	0.39	2.6	-
Fe^{2+}	mg/l	0.2	NONE	< 0.20	0.32	< 0.20	< 0.20	-
Fe^{3+}	mg/l	0.2	NONE	0.30	2.43	0.29	2.52	-
Lead (dissolved)	µg/l	0.2	ISO 17025	0.8	3.7	5.3	52	1.1
Mercury (dissolved)	µg/l	0.05	ISO 17025	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Nickel (dissolved)	µg/l	0.5	ISO 17025	2.2	7.3	3.4	0.9	2.0
Selenium (dissolved)	µg/l	0.6	ISO 17025	1.2	2.3	4.5	7.5	1.3
Zinc (dissolved)	µg/l	0.5	ISO 17025	26	7.2	3.7	32	5.7
Monoaromatics & Oxygenates								
Benzene	µg/l	1	ISO 17025	< 1.0	< 1.0	7.1	< 1.0	< 1.0
Toluene	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethylbenzene	µg/l	1	ISO 17025	< 1.0	72.7	6.6	< 1.0	< 1.0
p & m-xylene	µg/l	1	ISO 17025	< 1.0	141	5.8	< 1.0	< 1.0
o-xylene	µg/l	1	ISO 17025	< 1.0	76.0	11.1	< 1.0	< 1.0
MTBE (Methyl Tertiary Butyl Ether)	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Petroleum Hydrocarbons								
TPH-CWG - Aliphatic >C5 - C6	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aliphatic >C6 - C8	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aliphatic >C8 - C10	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aliphatic >C10 - C12	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aliphatic >C12 - C16	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aliphatic >C16 - C21	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aliphatic >C21 - C35	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aliphatic (C5 - C35)	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aromatic >C5 - C7	µg/l	1	ISO 17025	< 1.0	< 1.0	7.1	< 1.0	< 1.0
TPH-CWG - Aromatic >C7 - C8	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aromatic >C8 - C10	µg/l	1	ISO 17025	< 1.0	370	32	< 1.0	< 1.0
TPH-CWG - Aromatic >C10 - C12	µg/l	10	NONE	< 10	2800	610	< 10	< 10
TPH-CWG - Aromatic >C12 - C16	µg/l	10	NONE	< 10	4600	1700	< 10	< 10
TPH-CWG - Aromatic >C16 - C21	µg/l	10	NONE	< 10	4600	1100	< 10	< 10
TPH-CWG - Aromatic >C21 - C35	µg/l	10	NONE	< 10	210	91	< 10	< 10
TPH-CWG - Aromatic (C5 - C35)	µg/l	10	NONE	< 10	13000	3500	< 10	< 10
Environmental Forensics								
Gases								
Methane	mg/L	0.1	NONE	< 0.1	0.2	4.5	8.2	-

U/S = Unsuitable Sample   I/S = Insufficient Sample

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The results included within the report relate only to the sample(s) submitted for testing.

Analytical Report Number: 20-12662

Project / Site name: Hayes Balls Bridge Ind Est

Lab Sample Number				1526058	1526059	1526060	1526061	1526062
Sample Reference				River Mid stream	River Down stream	Canal Up Stream	Canal Mid Stream	Canal Down Stream
Sample Number				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Depth (m)				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Date Sampled				04/06/2020	04/06/2020	04/06/2020	04/06/2020	04/06/2020
Time Taken				1300	1400	1500	1445	1430
Analytical Parameter (Water Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					

General Inorganics

pH	pH Units	N/A	ISO 17025	7.8	7.8	8.3	8.3	8.3
Sulphate as SO_4	mg/l	0.045	ISO 17025	-	-	-	-	-
Total Sulphur	µg/l	15	NONE	-	-	-	-	-
Sulphide	µg/l	5	NONE	-	-	-	-	-
Ammonia as NH_3	µg/l	15	ISO 17025	400	430	360	180	200
Dissolved Organic Carbon (DOC)	mg/l	0.1	NONE	6.98	6.36	5.49	5.44	5.47
Nitrate as N	mg/l	0.01	ISO 17025	-	-	-	-	-
Nitrate as NO_3	mg/l	0.05	ISO 17025	-	-	-	-	-
Nitrite as N	µg/l	1	ISO 17025	-	-	-	-	-
Nitrite as NO_2	µg/l	5	ISO 17025	-	-	-	-	-
Chemical Oxygen Demand (Total)	mg/l	2	ISO 17025	-	-	-	-	-
BOD (Biochemical Oxygen Demand) (Total) - PL	mg/l	1	ISO 17025	-	-	-	-	-
Carbonate	mgCaCO3/l	10	NONE	-	-	-	-	-
Dissolved Carbon Dioxide	mg/l	1	NONE	-	-	-	-	-

Phenols by HPLC

Catechol	µg/l	0.5	NONE	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Resorcinol	µg/l	0.5	NONE	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Ethylphenol & Dimethylphenol	µg/l	0.5	NONE	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Cresols	µg/l	0.5	NONE	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Naphthols	µg/l	0.5	NONE	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Isopropylphenol	µg/l	0.5	NONE	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Phenol	µg/l	0.5	NONE	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Trimethylphenol	µg/l	0.5	NONE	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Total Phenols

Total Phenols (HPLC)	µg/l	3.5	NONE	< 3.5	< 3.5	< 3.5	< 3.5	< 3.5

Speciated PAHs

Naphthalene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Acenaphthylene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Acenaphthene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Fluorene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Phenanthrene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Anthracene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Fluoranthene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Pyrene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(a)anthracene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Chrysene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(b)fluoranthene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(k)fluoranthene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(a)pyrene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Indeno(1,2,3-cd)pyrene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Dibenz(a,h)anthracene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(ghi)perylene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

Total PAH

Total EPA-16 PAHs	µg/l	0.16	ISO 17025	< 0.16	< 0.16	< 0.16	< 0.16	< 0.16

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The results included within the report relate only to the sample(s) submitted for testing.

UKAS TESTING 4041

Analytical Environmental Science

Analytical Report Number: 20-12662

Project / Site name: Hayes Balls Bridge Ind Est

Lab Sample Number				1526058	1526059	1526060	1526061	1526062
Sample Reference				River Mid stream	River Down stream	Canal Up Stream	Canal Mid Stream	Canal Down Stream
Sample Number				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Depth (m)				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Date Sampled				04/06/2020	04/06/2020	04/06/2020	04/06/2020	04/06/2020
Time Taken				1300	1400	1500	1445	1430
Analytical Parameter (Water Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Heavy Metals / Metalloids								
Mn (II)	mg/l	0.02	NONE	-	-	-	-	-
Mn (IV)	mg/l	0.02	NONE	-	-	-	-	-
Arsenic (dissolved)	µg/l	0.15	ISO 17025	1.71	2.11	0.98	1.13	0.58
Cadmium (dissolved)	µg/l	0.02	ISO 17025	0.05	< 0.02	< 0.02	< 0.02	0.05
Calcium (dissolved)	mg/l	0.012	ISO 17025	120	120	110	110	100
Chromium (dissolved)	µg/l	0.2	ISO 17025	0.3	< 0.2	0.7	< 0.2	0.6
Copper (dissolved)	µg/l	0.5	ISO 17025	2.2	2.8	5.2	4.1	5.0
Iron (dissolved)	mg/l	0.004	ISO 17025	-	-	-	-	-
Fe^{2+}	mg/l	0.2	NONE	-	-	-	-	-
Fe^{3+}	mg/l	0.2	NONE	-	-	-	-	-
Lead (dissolved)	µg/l	0.2	ISO 17025	2.5	0.7	0.6	0.5	0.7
Mercury (dissolved)	µg/l	0.05	ISO 17025	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Nickel (dissolved)	µg/l	0.5	ISO 17025	2.4	2.0	1.8	1.8	1.8
Selenium (dissolved)	µg/l	0.6	ISO 17025	1.3	1.3	1.1	1.2	1.1
Zinc (dissolved)	µg/l	0.5	ISO 17025	9.5	7.3	4.4	6.9	5.4
Monoaromatics & Oxygenates								
Benzene	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Toluene	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethylbenzene	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p & m-xylene	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-xylene	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
MTBE (Methyl Tertiary Butyl Ether)	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Petroleum Hydrocarbons								
TPH-CWG - Aliphatic >C5 - C6	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aliphatic >C6 - C8	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aliphatic >C8 - C10	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aliphatic >C10 - C12	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aliphatic >C12 - C16	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aliphatic >C16 - C21	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aliphatic >C21 - C35	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aliphatic (C5 - C35)	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aromatic >C5 - C7	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aromatic >C7 - C8	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aromatic >C8 - C10	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aromatic >C10 - C12	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aromatic >C12 - C16	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aromatic >C16 - C21	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aromatic >C21 - C35	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aromatic (C5 - C35)	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
Environmental Forensics								
Gases								
Methane	mg/L	0.1	NONE	-	-	-	-	-

U/S = Unsuitable Sample   I/S = Insufficient Sample

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Analytical Report Number : 20-12662

Project / Site name: Hayes Balls Bridge Ind Est

Water matrix abbreviations: Surface Water (SW) Potable Water (PW) Ground Water (GW) Process Water (PrW)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
Alkalinity in Water (by titration)	Determination of Alkalinity by titration (colorimetry).	In house method based on MEWAM & USEPA Method 310.2.	L025-PL	W	NONE
Ammonia as NH3 in water	Determination of Ammonium/Ammonia/ Ammoniacal Nitrogen by the colorimetric salicylate/nitroprusside method. Accredited matrices SW, GW, PW.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton	L082-PL	W	ISO 17025
Biological oxygen demand (total) of water	Determination of biochemical oxygen demand in water (5 days). Accredited matrices: SW, PW, GW.	In-house method based on standard method 5210B.	L086-PL	W	ISO 17025
BTEX and MTBE in water (Monoaromatics)	Determination of BTEX and MTBE in water by headspace GC-MS. Accredited matrices: SW PW GW	In-house method based on USEPA8260	L073B-PL	W	ISO 17025
Chemical Oxygen Demand in Water (Total)	Determination of total COD in water by reflux oxidation with acidified K2Cr2O7 followed by colorimetry. Accredited matrices: SW, PW, GW.	HACH DR/890 Colorimeter Procedures Manual (48470-22) (Ref 0170.2)	L065-PL	W	ISO 17025
Dissolved Carbon Dioxide in water	Determination of dissolved carbon dioxide in water by colorimetry and calculation.	In house method - based on Alkalinity	L025-PL	W	NONE
Dissolved Organic Carbon in water	Determination of dissolved inorganic carbon in water by TOC/DOC NDIR Analyser.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton	L037-PL	W	NONE
Gases C1-C4	Determination of volatile hydrocarbons by Refinery Gas Analyzer	In-house methods		W	NONE
Iron (II) and Iron (III) in water	Determination of Iron II and Iron III in water by coloration with phenanthroline and calculation.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton	L079-PL	W	NONE
Manganese II and IV in Water	Analysis of manganese compounds by periodate oxidation method.	In house method and calculation based on standard methods for the examination of water and waste water.	L090-PL	W	NONE
Metals in water by ICP-MS (dissolved)	Determination of metals in water by acidification followed by ICP-MS. Accredited Matrices: SW, GW, PW except B=SW,GW, Hg=SW,PW, Al=SW,PW.	In-house method based on USEPA Method 6020 & 200.8 "for the determination of trace elements in water by ICP-MS.	L012-PL	W	ISO 17025
Metals in water by ICP-OES (dissolved)	Determination of metals in water by acidification followed by ICP-OES. Accredited Matrices SW, GW, PW, PrW.(Al, Cu,Fe,Zn).	In-house method based on MEWAM 2006 Methods for the Determination of Metals in Soil.	L039-PL	W	ISO 17025
Nitrate as N in water	Determination of nitrate by reaction with sodium salicylate and colorimetry. Accredited matrices SW, GW, PW.	In-house method based on Examination of Water and Wastewatern & Polish Standard Method PN-82/C-04579.08,	L078-PL	W	ISO 17025
Nitrate in water	Determination of nitrate by reaction with sodium salicylate and colorimetry. Accredited matrices SW, GW, PW	In-house method based on Examination of Water and Wastewatern & Polish Standard Method PN-82/C-04579.08,	L078-PL	W	ISO 17025
Nitrite as N in water	Determination of nitrite in water by addition of sulphanilamide and NED followed by discrete analyser (colorimetry). Accredited matrices SW, GW, PW.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton	L082-PL	W	ISO 17025
Nitrite in water	Determination of nitrite in water by addition of sulphanilamide and NED followed by discrete analyser (colorimetry).Accredited matrices SW, GW, PW.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton	L082-PL	W	ISO 17025
pH at 20oC in water (automated)	Determination of pH in water by electrometric measurement. Accredited matrices: SW PW GW	In house method.	L099-PL	W	ISO 17025

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Analytical Report Number : 20-12662

Project / Site name: Hayes Balls Bridge Ind Est

Water matrix abbreviations: Surface Water (SW) Potable Water (PW) Ground Water (GW) Process Water (PrW)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
Phenols, speciated, in water, by HPLC	Determination of speciated phenols by HPLC.	In house method based on Blue Book Method.	L030-PL	W	NONE
Speciated EPA-16 PAHs in water	Determination of PAH compounds in water by extraction in dichloromethane followed by GC-MS with the use of surrogate and internal standards. Accredited matrices: SW PW GW	In-house method based on USEPA 8270	L102B-PL	W	ISO 17025
Sulphate in water	Determination of sulphate in water by acidification followed by ICP-OES. Accredited matrices: SW PW GW, PrW.	In-house method based on MEWAM 2006 Methods for the Determination of Metals in Soil.	L039-PL	W	ISO 17025
Sulphide in water	Determination of sulphide in water by ion selective electrode.	In-house method	L029-PL	W	NONE
Total Sulphur in water	Determination of total sulphur in water by acidification followed by ICP-OES.	In-house method based on MEWAM 1986 Methods for the Determination of Metals in Soil""	L039-PL	W	NONE
TPHCWG (Waters)	Determination of dichloromethane extractable hydrocarbons in water by GC-MS, speciation by interpretation.	In-house method	L070-PL	W	NONE

For method numbers ending in 'UK' analysis have been carried out in our laboratory in the United Kingdom.
For method numbers ending in 'PL' analysis have been carried out in our laboratory in Poland.
Soil analytical results are expressed on a dry weight basis. Where analysis is carried out on as-received the results obtained are multiplied by a moisture correction factor that is determined gravimetrically using the moisture content which is carried out at a maximum of 30oC.

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Sample ID	Other_ID	Sample Type	Job	Sample Number	Sample Deviation Code	test_name	test_ref	Test Deviation code
BH01 (J)		W	20-12662	1526053	c	Ammonia as NH3 in water	L082-PL	c
BH01 (J)		W	20-12662	1526053	c	Ammoniacal Nitrogen as N in water	L082-PL	c
BH01 (J)		W	20-12662	1526053	c	Biological oxygen demand (total) of water	L086-PL	c
BH01 (J)		W	20-12662	1526053	c	Iron (II) and Iron (III) in water	L079-PL	c
BH01 (J)		W	20-12662	1526053	c	Manganese II and IV in Water	L090-PL	c
BH01 (J)		W	20-12662	1526053	c	pH at 20oC in water (automated)	L099-PL	c
BH02		W	20-12662	1526055	c	Ammonia as NH3 in water	L082-PL	c
BH02		W	20-12662	1526055	c	Ammoniacal Nitrogen as N in water	L082-PL	c
BH02		W	20-12662	1526055	c	Biological oxygen demand (total) of water	L086-PL	c
BH02		W	20-12662	1526055	c	Iron (II) and Iron (III) in water	L079-PL	c
BH02		W	20-12662	1526055	c	Manganese II and IV in Water	L090-PL	c
BH02		W	20-12662	1526055	c	pH at 20oC in water (automated)	L099-PL	c
BH08	Shallow	W	20-12662	1526054	c	Ammonia as NH3 in water	L082-PL	c
BH08	Shallow	W	20-12662	1526054	c	Ammoniacal Nitrogen as N in water	L082-PL	c
BH08	Shallow	W	20-12662	1526054	c	Biological oxygen demand (total) of water	L086-PL	c
BH08	Shallow	W	20-12662	1526054	c	Iron (II) and Iron (III) in water	L079-PL	c
BH08	Shallow	W	20-12662	1526054	c	Manganese II and IV in Water	L090-PL	c
BH08	Shallow	W	20-12662	1526054	c	pH at 20oC in water (automated)	L099-PL	c
Canal Down Stream		W	20-12662	1526062	c	Ammonia as NH3 in water	L082-PL	c
Canal Down Stream		W	20-12662	1526062	c	Ammoniacal Nitrogen as N in water	L082-PL	c
Canal Down Stream		W	20-12662	1526062	c	pH at 20oC in water (automated)	L099-PL	c
Canal Mid Stream		W	20-12662	1526061	c	Ammonia as NH3 in water	L082-PL	c
Canal Mid Stream		W	20-12662	1526061	c	Ammoniacal Nitrogen as N in water	L082-PL	c
Canal Mid Stream		W	20-12662	1526061	c	pH at 20oC in water (automated)	L099-PL	c
Canal Up Stream		W	20-12662	1526060	c	Ammonia as NH3 in water	L082-PL	c
Canal Up Stream		W	20-12662	1526060	c	Ammoniacal Nitrogen as N in water	L082-PL	c
Canal Up Stream		W	20-12662	1526060	c	pH at 20oC in water (automated)	L099-PL	c
River Down stream		W	20-12662	1526059	c	Ammonia as NH3 in water	L082-PL	c
River Down stream		W	20-12662	1526059	c	Ammoniacal Nitrogen as N in water	L082-PL	c
River Down stream		W	20-12662	1526059	c	pH at 20oC in water (automated)	L099-PL	c
River Mid stream		W	20-12662	1526058	c	Ammonia as NH3 in water	L082-PL	c
River Mid stream		W	20-12662	1526058	c	Ammoniacal Nitrogen as N in water	L082-PL	c
River Mid stream		W	20-12662	1526058	c	pH at 20oC in water (automated)	L099-PL	c
River Up stream		W	20-12662	1526057	c	Ammonia as NH3 in water	L082-PL	c
River Up stream		W	20-12662	1526057	c	Ammoniacal Nitrogen as N in water	L082-PL	c
River Up stream		W	20-12662	1526057	c	pH at 20oC in water (automated)	L099-PL	c
WS7		W	20-12662	1526056	c	Ammonia as NH3 in water	L082-PL	c
WS7		W	20-12662	1526056	c	Ammoniacal Nitrogen as N in water	L082-PL	c
WS7		W	20-12662	1526056	c	Biological oxygen demand (total) of water	L086-PL	c
WS7		W	20-12662	1526056	c	Iron (II) and Iron (III) in water	L079-PL	c
WS7		W	20-12662	1526056	c	Manganese II and IV in Water	L090-PL	c
WS7		W	20-12662	1526056	c	pH at 20oC in water (automated)	L099-PL	c

Key: a - No sampling date b - Incorrect container
c - Holding time d - Headspace e - Temperature

Charlie Knox
Paragon New Homes Ltd
7 Swallow Place
London
W1B 2AG

i2 Analytical Ltd.
7 Woodshots Meadow,
Croxley Green
Business Park,
Watford,
Herts,
WD18 8YS

t: 01923 225404
f: 01923 237404

e: charlieknox@paragonbc.co.uk
e: reception@i2analytical.com

Analytical Report Number : 20-14987

Project / Site name:	Hayes Balls Bridge Ind Est	**Samples received on:**	19/06/2020
Your job number:	200023	**Sample instructed/ Analysis started on:**	19/06/2020
Your order number:		**Analysis completed by:**	01/07/2020
Report Issue Number:	1	**Report issued on:**	01/07/2020
Samples Analysed:	6 water samples		

Signed: Karolina Marek

Karolina Marek
PL Head of Reporting Team

For & on behalf of i2 Analytical Ltd.

Standard Geotechnical, Asbestos and Chemical Testing Laboratory located at: ul. Pionierów 39, 41 -711 Ruda Śląska, Poland.

Accredited tests are defined within the report, opinions and interpretations expressed herein are outside the scope of accreditation.

Standard sample disposal times, unless otherwise agreed with the laboratory, are :

soils	- 4 weeks from reporting
leachates	- 2 weeks from reporting
waters	- 2 weeks from reporting
asbestos	- 6 months from reporting

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Any assessments of compliance with specifications are based on actual analytical results with no contribution from uncertainty of measurement. Application of uncertainty of measurement would provide a range within which the true result lies. An estimate of measurement uncertainty can be provided on request.

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UKAS TESTING 4041

i2 Analytical Environmental Science

Analytical Report Number: 20-14987

Project / Site name: Hayes Balls Bridge Ind Est

Lab Sample Number				1538545	1538546	1538547	1538548	1538549
Sample Reference				BH01(J)	BH08	WS7	River Up Stream	River Mid Stream
Sample Number				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Depth (m)				3.66-5.91	3.34-5.99	3.18-4.99	None Supplied	None Supplied
Date Sampled				18/06/2020	18/06/2020	18/06/2020	18/06/2020	18/06/2020
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Water Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
General Inorganics								
pH	pH Units	N/A	ISO 17025	8.2	7.1	7.2	8.2	8.0
Sulphate as SO_4	mg/l	0.045	ISO 17025	71.2	2.93	48.9	-	-
Total Sulphur	µg/l	15	NONE	24000	980	16000	-	-
Sulphide	µg/l	5	NONE	< 5.0	< 5.0	< 5.0	-	-
Ammonia as NH_3	µg/l	15	ISO 17025	4200	1900	17000	560	770
Dissolved Organic Carbon (DOC)	mg/l	0.1	NONE	7.40	8.12	32.3	8.38	9.17
Nitrate as N	mg/l	0.01	ISO 17025	1.45	0.27	0.18	-	-
Nitrate as NO_3	mg/l	0.05	ISO 17025	6.42	1.18	0.78	-	-
Nitrite as N	µg/l	1	ISO 17025	130	31	17	-	-
Nitrite as NO_2	µg/l	5	ISO 17025	430	100	55	-	-
Chemical Oxygen Demand (Total)	mg/l	2	ISO 17025	31	120	120	-	-
BOD (Biochemical Oxygen Demand) (Total) - PL	mg/l	1	ISO 17025	4.1	8.1	3.1	-	-
Carbonate	mgCaCO3/l	10	NONE	260	720	1400	-	-
Dissolved Carbon Dioxide	mg/l	1	NONE	3.7	110	200	-	-
Phenols by HPLC								
Catechol	µg/l	0.5	NONE	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Resorcinol	µg/l	0.5	NONE	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Ethylphenol & Dimethylphenol	µg/l	0.5	NONE	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Cresols	µg/l	0.5	NONE	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Naphthols	µg/l	0.5	NONE	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Isopropylphenol	µg/l	0.5	NONE	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Phenol	µg/l	0.5	NONE	< 0.5	790	< 0.5	< 0.5	< 0.5
Trimethylphenol	µg/l	0.5	NONE	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Total Phenols								
Total Phenols (HPLC)	µg/l	3.5	NONE	< 3.5	790	< 3.5	< 3.5	< 3.5
Speciated PAHs								
Naphthalene	µg/l	0.01	ISO 17025	1.86	5260	37.1	< 0.01	< 0.01
Acenaphthylene	µg/l	0.01	ISO 17025	< 0.01	14.1	< 0.01	< 0.01	< 0.01
Acenaphthene	µg/l	0.01	ISO 17025	< 0.01	234	1.43	< 0.01	< 0.01
Fluorene	µg/l	0.01	ISO 17025	< 0.01	101	0.39	< 0.01	< 0.01
Phenanthrene	µg/l	0.01	ISO 17025	< 0.01	56.5	< 0.01	< 0.01	< 0.01
Anthracene	µg/l	0.01	ISO 17025	< 0.01	15.9	< 0.01	< 0.01	< 0.01
Fluoranthene	µg/l	0.01	ISO 17025	< 0.01	3.09	< 0.01	< 0.01	< 0.01
Pyrene	µg/l	0.01	ISO 17025	< 0.01	1.72	< 0.01	< 0.01	< 0.01
Benzo(a)anthracene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Chrysene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(b)fluoranthene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(k)fluoranthene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(a)pyrene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Indeno(1,2,3-cd)pyrene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Dibenz(a,h)anthracene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(ghi)perylene	µg/l	0.01	ISO 17025	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Total PAH								
Total EPA-16 PAHs	µg/l	0.16	ISO 17025	1.86	5680	39.0	< 0.16	< 0.16

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Analytical Report Number: 20-14987

Project / Site name: Hayes Balls Bridge Ind Est

Lab Sample Number				1538545	1538546	1538547	1538548	1538549
Sample Reference				BH01(J)	BH08	WS7	River Up Stream	River Mid Stream
Sample Number				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Depth (m)				3.66-5.91	3.34-5.99	3.18-4.99	None Supplied	None Supplied
Date Sampled				18/06/2020	18/06/2020	18/06/2020	18/06/2020	18/06/2020
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Water Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Heavy Metals / Metalloids								
Mn (II)	mg/l	0.02	NONE	0.06	0.26	0.49	-	-
Mn (IV)	mg/l	0.02	NONE	0.02	4.37	2.09	-	-
Zinc (dissolved)	µg/l	0.4	ISO 17025	-	-	59	-	29
Arsenic (dissolved)	µg/l	0.15	ISO 17025	1.79	7.63	1.79	1.23	1.96
Cadmium (dissolved)	µg/l	0.02	ISO 17025	0.09	< 0.02	< 0.02	< 0.02	0.02
Calcium (dissolved)	mg/l	0.012	ISO 17025	86	150	320	46	38
Chromium (dissolved)	µg/l	0.2	ISO 17025	< 0.2	0.3	< 0.2	< 0.2	< 0.2
Copper (dissolved)	µg/l	0.5	ISO 17025	4.3	2.2	0.6	5.1	7.6
Iron (dissolved)	mg/l	0.004	ISO 17025	0.13	0.18	0.75	-	-
Fe^{2+}	mg/l	0.2	NONE	< 0.20	< 0.20	0.23	-	-
Fe^{3+}	mg/l	0.2	NONE	< 0.20	< 0.20	0.51	-	-
Lead (dissolved)	µg/l	0.2	ISO 17025	1.0	0.9	< 0.2	1.3	1.1
Mercury (dissolved)	µg/l	0.05	ISO 17025	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Nickel (dissolved)	µg/l	0.5	ISO 17025	1.8	6.4	1.0	1.4	1.7
Selenium (dissolved)	µg/l	0.6	ISO 17025	0.9	2.1	6.6	0.7	0.7
Zinc (dissolved)	µg/l	0.5	ISO 17025	30	6.2	-	16	-
Monoaromatics & Oxygenates								
Benzene	µg/l	1	ISO 17025	< 1.0	3.5	< 1.0	< 1.0	< 1.0
Toluene	µg/l	1	ISO 17025	< 1.0	10.4	< 1.0	< 1.0	< 1.0
Ethylbenzene	µg/l	1	ISO 17025	< 1.0	122	< 1.0	< 1.0	< 1.0
p & m-xylene	µg/l	1	ISO 17025	< 1.0	243	< 1.0	< 1.0	< 1.0
o-xylene	µg/l	1	ISO 17025	< 1.0	117	< 1.0	< 1.0	< 1.0
MTBE (Methyl Tertiary Butyl Ether)	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Petroleum Hydrocarbons								
TPH-CWG - Aliphatic >C5 - C6	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aliphatic >C6 - C8	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aliphatic >C8 - C10	µg/l	1	ISO 17025	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aliphatic >C10 - C12	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aliphatic >C12 - C16	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aliphatic >C16 - C21	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aliphatic >C21 - C35	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aliphatic (C5 - C35)	µg/l	10	NONE	< 10	< 10	< 10	< 10	< 10
TPH-CWG - Aromatic >C5 - C7	µg/l	1	ISO 17025	< 1.0	3.5	< 1.0	< 1.0	< 1.0
TPH-CWG - Aromatic >C7 - C8	µg/l	1	ISO 17025	< 1.0	10	< 1.0	< 1.0	< 1.0
TPH-CWG - Aromatic >C8 - C10	µg/l	1	ISO 17025	< 1.0	610	< 1.0	< 1.0	< 1.0
TPH-CWG - Aromatic >C10 - C12	µg/l	10	NONE	< 10	9600	38	< 10	< 10
TPH-CWG - Aromatic >C12 - C16	µg/l	10	NONE	< 10	6000	< 10	< 10	< 10
TPH-CWG - Aromatic >C16 - C21	µg/l	10	NONE	< 10	1500	< 10	< 10	< 10
TPH-CWG - Aromatic >C21 - C35	µg/l	10	NONE	< 10	300	< 10	< 10	< 10
TPH-CWG - Aromatic (C5 - C35)	µg/l	10	NONE	< 10	18000	38	< 10	< 10
Environmental Forensics								
Gases								
Methane	mg/L	0.1	NONE	< 0.1	0.2	6.4	-	-

U/S = Unsuitable Sample   I/S = Insufficient Sample

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Analytical Report Number: 20-14987

Project / Site name: Hayes Balls Bridge Ind Est

Lab Sample Number				1538550				
Sample Reference				River Down Stream				
Sample Number				None Supplied				
Depth (m)				None Supplied				
Date Sampled				18/06/2020				
Time Taken				None Supplied				
Analytical Parameter (Water Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
General Inorganics								
pH	pH Units	N/A	ISO 17025	7.9				
Sulphate as SO_4	mg/l	0.045	ISO 17025	-				
Total Sulphur	µg/l	15	NONE	-				
Sulphide	µg/l	5	NONE	-				
Ammonia as NH_3	µg/l	15	ISO 17025	440				
Dissolved Organic Carbon (DOC)	mg/l	0.1	NONE	7.05				
Nitrate as N	mg/l	0.01	ISO 17025	-				
Nitrate as NO_3	mg/l	0.05	ISO 17025	-				
Nitrite as N	µg/l	1	ISO 17025	-				
Nitrite as NO_2	µg/l	5	ISO 17025	-				
Chemical Oxygen Demand (Total)	mg/l	2	ISO 17025	-				
BOD (Biochemical Oxygen Demand) (Total) - PL	mg/l	1	ISO 17025	-				
Carbonate	mgCaCO3/l	10	NONE	-				
Dissolved Carbon Dioxide	mg/l	1	NONE	-				
Phenols by HPLC								
Catechol	µg/l	0.5	NONE	< 0.5				
Resorcinol	µg/l	0.5	NONE	< 0.5				
Ethylphenol & Dimethylphenol	µg/l	0.5	NONE	< 0.5				
Cresols	µg/l	0.5	NONE	< 0.5				
Naphthols	µg/l	0.5	NONE	< 0.5				
Isopropylphenol	µg/l	0.5	NONE	< 0.5				
Phenol	µg/l	0.5	NONE	< 0.5				
Trimethylphenol	µg/l	0.5	NONE	< 0.5				
Total Phenols								
Total Phenols (HPLC)	µg/l	3.5	NONE	< 3.5				
Speciated PAHs								
Naphthalene	µg/l	0.01	ISO 17025	< 0.01				
Acenaphthylene	µg/l	0.01	ISO 17025	< 0.01				
Acenaphthene	µg/l	0.01	ISO 17025	< 0.01				
Fluorene	µg/l	0.01	ISO 17025	< 0.01				
Phenanthrene	µg/l	0.01	ISO 17025	< 0.01				
Anthracene	µg/l	0.01	ISO 17025	< 0.01				
Fluoranthene	µg/l	0.01	ISO 17025	< 0.01				
Pyrene	µg/l	0.01	ISO 17025	< 0.01				
Benzo(a)anthracene	µg/l	0.01	ISO 17025	< 0.01				
Chrysene	µg/l	0.01	ISO 17025	< 0.01				
Benzo(b)fluoranthene	µg/l	0.01	ISO 17025	< 0.01				
Benzo(k)fluoranthene	µg/l	0.01	ISO 17025	< 0.01				
Benzo(a)pyrene	µg/l	0.01	ISO 17025	< 0.01				
Indeno(1,2,3-cd)pyrene	µg/l	0.01	ISO 17025	< 0.01				
Dibenz(a,h)anthracene	µg/l	0.01	ISO 17025	< 0.01				
Benzo(ghi)perylene	µg/l	0.01	ISO 17025	< 0.01				
Total PAH								
Total EPA-16 PAHs	µg/l	0.16	ISO 17025	< 0.16				

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Analytical Report Number: 20-14987

Project / Site name: Hayes Balls Bridge Ind Est

Lab Sample Number				1538550				
Sample Reference				River Down Stream				
Sample Number				None Supplied				
Depth (m)				None Supplied				
Date Sampled				18/06/2020				
Time Taken				None Supplied				
Analytical Parameter (Water Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Heavy Metals / Metalloids								
Mn (II)	mg/l	0.02	NONE	-				
Mn (IV)	mg/l	0.02	NONE	-				
Zinc (dissolved)	µg/l	0.4	ISO 17025	-				
Arsenic (dissolved)	µg/l	0.15	ISO 17025	1.40				
Cadmium (dissolved)	µg/l	0.02	ISO 17025	0.02				
Calcium (dissolved)	mg/l	0.012	ISO 17025	36				
Chromium (dissolved)	µg/l	0.2	ISO 17025	< 0.2				
Copper (dissolved)	µg/l	0.5	ISO 17025	5.0				
Iron (dissolved)	mg/l	0.004	ISO 17025	-				
Fe^{2+}	mg/l	0.2	NONE	-				
Fe^{3+}	mg/l	0.2	NONE	-				
Lead (dissolved)	µg/l	0.2	ISO 17025	1.1				
Mercury (dissolved)	µg/l	0.05	ISO 17025	< 0.05				
Nickel (dissolved)	µg/l	0.5	ISO 17025	1.3				
Selenium (dissolved)	µg/l	0.6	ISO 17025	< 0.6				
Zinc (dissolved)	µg/l	0.5	ISO 17025	12				
Monoaromatics & Oxygenates								
Benzene	µg/l	1	ISO 17025	< 1.0				
Toluene	µg/l	1	ISO 17025	< 1.0				
Ethylbenzene	µg/l	1	ISO 17025	< 1.0				
p & m-xylene	µg/l	1	ISO 17025	< 1.0				
o-xylene	µg/l	1	ISO 17025	< 1.0				
MTBE (Methyl Tertiary Butyl Ether)	µg/l	1	ISO 17025	< 1.0				
Petroleum Hydrocarbons								
TPH-CWG - Aliphatic >C5 - C6	µg/l	1	ISO 17025	< 1.0				
TPH-CWG - Aliphatic >C6 - C8	µg/l	1	ISO 17025	< 1.0				
TPH-CWG - Aliphatic >C8 - C10	µg/l	1	ISO 17025	< 1.0				
TPH-CWG - Aliphatic >C10 - C12	µg/l	10	NONE	< 10				
TPH-CWG - Aliphatic >C12 - C16	µg/l	10	NONE	< 10				
TPH-CWG - Aliphatic >C16 - C21	µg/l	10	NONE	< 10				
TPH-CWG - Aliphatic >C21 - C35	µg/l	10	NONE	< 10				
TPH-CWG - Aliphatic (C5 - C35)	µg/l	10	NONE	< 10				
TPH-CWG - Aromatic >C5 - C7	µg/l	1	ISO 17025	< 1.0				
TPH-CWG - Aromatic >C7 - C8	µg/l	1	ISO 17025	< 1.0				
TPH-CWG - Aromatic >C8 - C10	µg/l	1	ISO 17025	< 1.0				
TPH-CWG - Aromatic >C10 - C12	µg/l	10	NONE	< 10				
TPH-CWG - Aromatic >C12 - C16	µg/l	10	NONE	< 10				
TPH-CWG - Aromatic >C16 - C21	µg/l	10	NONE	< 10				
TPH-CWG - Aromatic >C21 - C35	µg/l	10	NONE	< 10				
TPH-CWG - Aromatic (C5 - C35)	µg/l	10	NONE	< 10				
Environmental Forensics								
Gases								
Methane	mg/L	0.1	NONE	-				

U/S = Unsuitable Sample   I/S = Insufficient Sample

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Analytical Report Number : 20-14987

Project / Site name: Hayes Balls Bridge Ind Est

Water matrix abbreviations: Surface Water (SW) Potable Water (PW) Ground Water (GW) Process Water (PrW)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
Alkalinity in Water (by titration)	Determination of Alkalinity by titration (colorimetry).	In house method based on MEWAM & USEPA Method 310.2.	L025-PL	W	NONE
Ammonia as NH3 in water	Determination of Ammonium/Ammonia/ Ammoniacal Nitrogen by the colorimetric salicylate/nitroprusside method. Accredited matrices SW, GW, PW.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton	L082-PL	W	ISO 17025
Biological oxygen demand (total) of water	Determination of biochemical oxygen demand in water (5 days). Accredited matrices: SW, PW, GW.	In-house method based on standard method 5210B.	L086-PL	W	ISO 17025
BTEX and MTBE in water (Monoaromatics)	Determination of BTEX and MTBE in water by headspace GC-MS. Accredited matrices: SW PW GW	In-house method based on USEPA8260	L073B-PL	W	ISO 17025
Chemical Oxygen Demand in Water (Total)	Determination of total COD in water by reflux oxidation with acidified K2Cr2O7 followed by colorimetry. Accredited matrices: SW, PW, GW.	HACH DR/890 Colorimeter Procedures Manual (48470-22) (Ref 0170.2)	L065-PL	W	ISO 17025
Dissolved Carbon Dioxide in water	Determination of dissolved carbon dioxide in water by colorimetry and calculation.	In house method - based on Alkalinity	L025-PL	W	NONE
Dissolved Organic Carbon in water	Determination of dissolved inorganic carbon in water by TOC/DOC NDIR Analyser.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton	L037-PL	W	NONE
Gases C1-C4	Determination of volatile hydrocarbons by Refinery Gas Analyzer	In-house methods		W	NONE
Iron (II) and Iron (III) in water	Determination of Iron II and Iron III in water by coloration with phenanthroline and calculation.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton	L079-PL	W	NONE
Manganese II and IV in Water	Analysis of manganese compounds by periodate oxidation method.	In house method and calculation based on standard methods for the examination of water and waste water.	L090-PL	W	NONE
Metals in water by ICP-MS (dissolved)	Determination of metals in water by acidification followed by ICP-MS. Accredited Matrices: SW, GW, PW except B=SW,GW, Hg=SW,PW, Al=SW,PW.	In-house method based on USEPA Method 6020 & 200.8 "for the determination of trace elements in water by ICP-MS.	L012-PL	W	ISO 17025
Metals in water by ICP-OES (dissolved)	Determination of metals in water by acidification followed by ICP-OES. Accredited Matrices SW, GW, PW, PrW.(Al, Cu,Fe,Zn).	In-house method based on MEWAM 2006 Methods for the Determination of Metals in Soil.	L039-PL	W	ISO 17025
Nitrate as N in water	Determination of nitrate by reaction with sodium salicylate and colorimetry. Accredited matrices SW, GW, PW.	In-house method based on Examination of Water and Wastewatern & Polish Standard Method PN-82/C-04579.08,	L078-PL	W	ISO 17025
Nitrate in water	Determination of nitrate by reaction with sodium salicylate and colorimetry. Accredited matrices SW, GW, PW	In-house method based on Examination of Water and Wastewatern & Polish Standard Method PN-82/C-04579.08,	L078-PL	W	ISO 17025
Nitrite as N in water	Determination of nitrite in water by addition of sulphanilamide and NED followed by discrete analyser (colorimetry). Accredited matrices SW, GW, PW.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton	L082-PL	W	ISO 17025
Nitrite in water	Determination of nitrite in water by addition of sulphanilamide and NED followed by discrete analyser (colorimetry).Accredited matrices SW, GW, PW.	In-house method based on Examination of Water and Wastewater 20th Edition: Clesceri, Greenberg & Eaton	L082-PL	W	ISO 17025
pH at 20oC in water (automated)	Determination of pH in water by electrometric measurement. Accredited matrices: SW PW GW	In house method.	L099-PL	W	ISO 17025

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Analytical Report Number : 20-14987

Project / Site name: Hayes Balls Bridge Ind Est

Water matrix abbreviations: Surface Water (SW) Potable Water (PW) Ground Water (GW) Process Water (PrW)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
Phenols, speciated, in water, by HPLC	Determination of speciated phenols by HPLC.	In house method based on Blue Book Method.	L030-PL	W	NONE
Speciated EPA-16 PAHs in water	Determination of PAH compounds in water by extraction in dichloromethane followed by GC-MS with the use of surrogate and internal standards. Accredited matrices: SW PW GW	In-house method based on USEPA 8270	L102B-PL	W	ISO 17025
Sulphate in water	Determination of sulphate in water by acidification followed by ICP-OES. Accredited matrices: SW PW GW, PrW.	In-house method based on MEWAM 2006 Methods for the Determination of Metals in Soil.	L039-PL	W	ISO 17025
Sulphide in water	Determination of sulphide in water by ion selective electrode.	In-house method	L029-PL	W	NONE
Total Sulphur in water	Determination of total sulphur in water by acidification followed by ICP-OES.	In-house method based on MEWAM 1986 Methods for the Determination of Metals in Soil""	L039-PL	W	NONE
TPHCWG (Waters)	Determination of dichloromethane extractable hydrocarbons in water by GC-MS, speciation by interpretation.	In-house method	L070-PL	W	NONE

For method numbers ending in 'UK' analysis have been carried out in our laboratory in the United Kingdom.
For method numbers ending in 'PL' analysis have been carried out in our laboratory in Poland.
Soil analytical results are expressed on a dry weight basis. Where analysis is carried out on as-received the results obtained are multiplied by a moisture correction factor that is determined gravimetrically using the moisture content which is carried out at a maximum of 30oC.

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APPENDIX D: M-BAT CALCULATIONS

Metal Bioavailability Assessment Tool (M-BAT)

Back

Calculate

Clear Data

INPUT DATA										
ID	Location	Waterbody	Date	Measured Cu Concentration (dissolved) (µg l^{-1})	Measured Zn Concentration (dissolved) (µg l^{-1})	Measured Mn Concentration (dissolved) (µg l^{-1})	Measured Ni Concentration (dissolved) (µg l^{-1})	pH	DOC	Ca
1	River Down Stream	R Crane	04/06/2020	2.8	7.3		2	7.8	6.36	120
2	River Mid Stream	R Crane	04/06/2020	2.2	9.5		2.4	7.8	6.98	120
3	River Up Stream	R Crane	04/06/2020	2.9	5.7		2	7.9	6.7	120
4	River Down Stream	R Crane	18/06/2020	5	12		1.3	7.9	7.05	36
5	River Mid Stream	R Crane	18/06/2020	7.6	29		1.7	8	9.17	38
6	River Up Stream	R Crane	18/06/2020	5.1	16		1.4	8.2	8.38	46

	RESULTS (Copper)				RESULTS (Zinc)				RESULTS (Mn)				RESULTS (Ni)			
ID	Site-specific PNEC Dissolved Copper (µg l^{-1})	BioF	Bioavailable Copper Concentration (µg l^{-1})	Risk Characterisation Ratio	Site-specific PNEC Dissolved Zinc (µg l^{-1})	BioF	Bioavailable Zinc Concentration (µg l^{-1})	Risk Characterisation Ratio	Site-specific PNEC Dissolved Manganese (µg l^{-1})	BioF	Bioavailable Manganese Concentration (µg l^{-1})	Risk Characterisation Ratio	Site-specific PNEC Dissolved Nickel (µg l^{-1})	BioF	Bioavailable Nickel Concentration (µg l^{-1})	Risk Characterisation Ratio
1	24.89	0.04	0.11	0.11	32.71	0.33	2.43	0.22	323.36	0.38			14.63	0.27	0.55	0.14
2	27.50	0.04	0.08	0.08	34.65	0.31	2.99	0.27	323.36	0.38			15.47	0.26	0.62	0.16
3	24.23	0.04	0.12	0.12	34.50	0.32	1.80	0.17	266.45	0.46			13.93	0.29	0.57	0.14
4	25.46	0.04	0.20	0.20	35.97	0.30	3.64	0.33	144.53	0.85			11.31	0.35	0.46	0.11
5	29.54	0.03	0.26	0.26	45.42	0.24	6.96	0.64	123.00	1.00			12.34	0.32	0.55	0.14
6	21.34	0.05	0.24	0.24	41.98	0.26	4.15	0.38	123.00	1.00			9.61	0.42	0.58	0.15

Pb Screening Tool 1.0

Back

Calculate

Clear Data

INPUT DATA						RESULTS (Pb)			
ID	Location	Waterbody	Date	Measured Pb Concentration (dissolved) (µg l^{-1})	DOC	Site Specific PNEC Dissolved Pb (µg l^{-1})	BioF	Available Pb (µg l^{-1})	Risk Characterisation Ratio
1	Upstream	R Crane	04/06/2020	1.10	6.70	8.04	0.15	0.16	0.14
2	Midstream	R Crane	04/06/2020	52.00	6.98	8.38	0.14	7.45	6.21
3	Downstream	R Crane	04/06/2020	0.70	6.36	7.63	0.16	0.11	0.09
4	Upstream	R Crane	18/06/2020	1.30	8.38	10.06	0.12	0.16	0.13
5	Midstream	R Crane	18/06/2020	1.10	9.17	11.00	0.11	0.12	0.10
6	Downstream	R Crane	18/06/2020	1.10	7.05	8.46	0.14	0.16	0.13

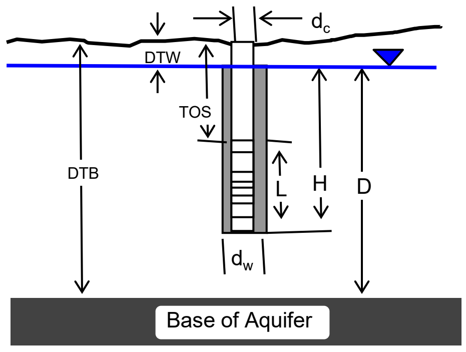
APPENDIX E: IN-SITU PERMEABILITY CALCULATIONS

WELL ID: BH1 J

Local ID: Bulls Bridge
Date: 02/06/2020
Time: 10:56

INPUT

Construction:	
Casing dia. (d_c)	0.05 Meter
Annulus dia. (d_w)	0.15 Meter
Screen Length (L)	4.93 Meter
Depths to:	
water level (DTW)	3.72 Meter
top of screen (TOS)	1 Meter
Base of Aquifer (DTB)	6 Meter
Annular Fill:	
across screen -- Gravel	
above screen -- Bentonite	
Aquifer Material -- Fine Sand	



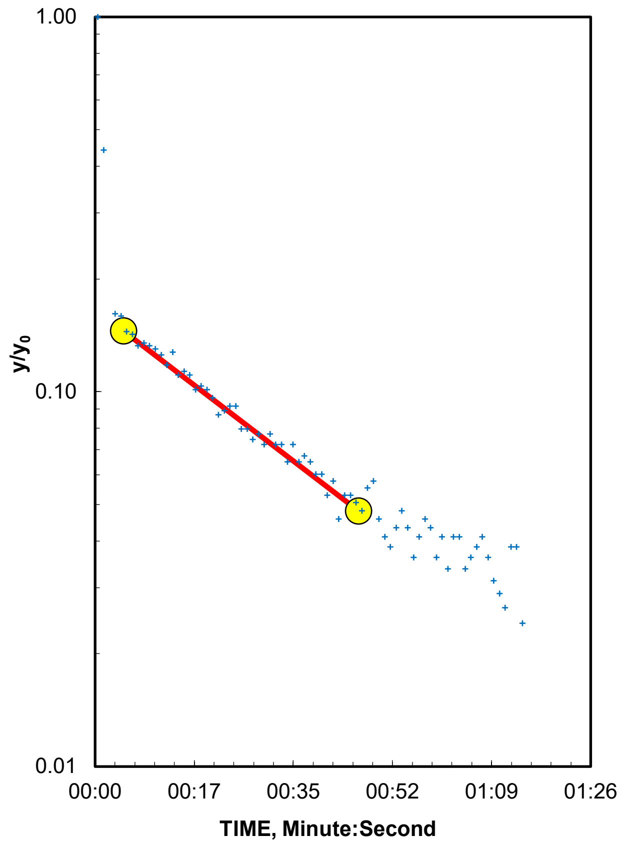
COMPUTED

L_{wetted}	2.21 Meter
D =	2.28 Meter
H =	2.21 Meter
L/r_w =	29.47
$y_{0\text{-DISPLACEMENT}}$ =	0.42 Meter
$y_{0\text{-SLUG}}$ =	0.47 Meter
From look-up table using L/r_w	
Partial penetrate A =	2.494
B =	0.411
ln(Re/rw) =	2.446
Re =	2.84 Meter
Slope =	0.01171 $\log_{10}$/sec
$t_{90\%}$ recovery =	85 sec

Input is consistent.

K =	9.3E-06 Meter/Second
	9.30E-06

Adjust slope of line to estimate K



K= 0.0000093 is less than likely minimum of 0.0000106 for Fine Sand

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

Reduced Data

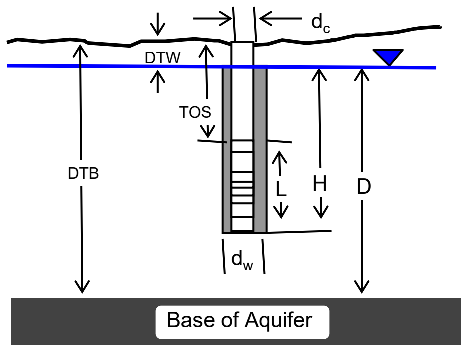
Entry	Time, Hr:Min:Sec	Water Level
1	0:00:00.0	3.31
2	0:00:01.0	3.54
3	0:00:03.0	3.65
4	0:00:04.0	3.65
5	0:00:05.0	3.66
6	0:00:06.0	3.66
7	0:00:07.0	3.67
8	0:00:08.0	3.66
9	0:00:09.0	3.67
10	0:00:10.0	3.67
11	0:00:11.0	3.67
12	0:00:12.0	3.67
13	0:00:13.0	3.67
14	0:00:14.0	3.67
15	0:00:15.0	3.67
16	0:00:16.0	3.67
17	0:00:17.0	3.68
18	0:00:18.0	3.68
19	0:00:19.0	3.68
20	0:00:20.0	3.68
21	0:00:21.0	3.68
22	0:00:22.0	3.68
23	0:00:23.0	3.68
24	0:00:24.0	3.68
25	0:00:25.0	3.69
26	0:00:26.0	3.69
27	0:00:27.0	3.69
28	0:00:28.0	3.69
29	0:00:29.0	3.69
30	0:00:30.0	3.69
31	0:00:31.0	3.69
32	0:00:32.0	3.69
33	0:00:33.0	3.69
34	0:00:34.0	3.69
35	0:00:35.0	3.69
36	0:00:36.0	3.69
37	0:00:37.0	3.69
38	0:00:38.0	3.70
39	0:00:39.0	3.70
40	0:00:40.0	3.70
41	0:00:41.0	3.70
42	0:00:42.0	3.70
43	0:00:43.0	3.70
44	0:00:44.0	3.70
45	0:00:45.0	3.70

WELL ID: BH1 J

Local ID: Bulls Bridge
Date: 02/06/2020
Time: 10:56

INPUT

Construction:	
Casing dia. (d_c)	0.05 Meter
Annulus dia. (d_w)	0.15 Meter
Screen Length (L)	4.93 Meter
Depths to:	
water level (DTW)	3.72 Meter
top of screen (TOS)	1 Meter
Base of Aquifer (DTB)	6 Meter
Annular Fill:	
across screen -- Gravel	
above screen -- Bentonite	
Aquifer Material -- Fine Sand	



COMPUTED

L_{wetted}	2.21 Meter
D =	2.28 Meter
H =	2.21 Meter
L/r_w =	29.47
$y_{0\text{-DISPLACEMENT}}$ =	0.77 Meter
$y_{0\text{-SLUG}}$ =	0.78 Meter

From look-up table using L/r_w

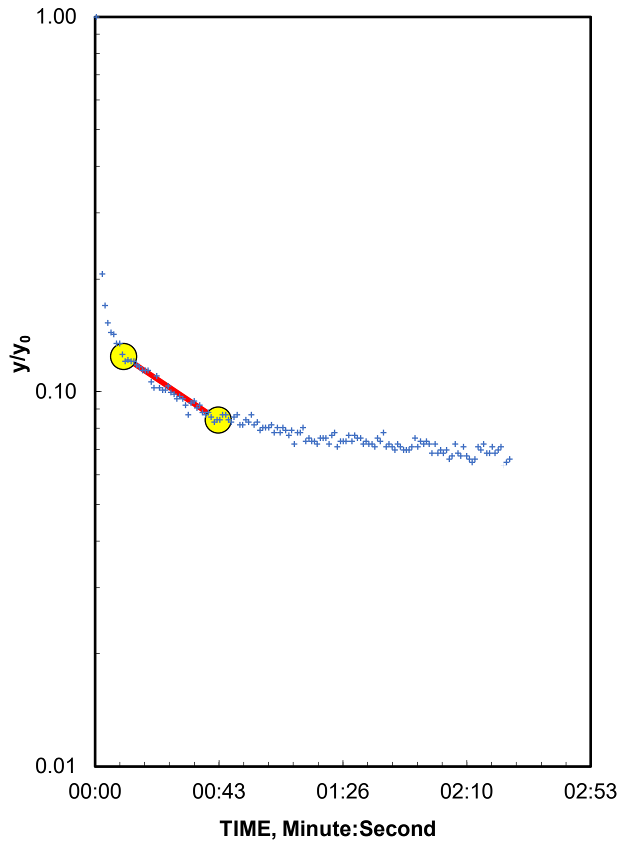
Partial penetrate A =	2.494
B =	0.411
ln(Re/rw) =	2.446
Re =	2.84 Meter
Slope =	0.005126 $\log_{10}$/sec
$t_{90\%}$ recovery =	195 sec

Input is consistent.

K = 4.1E-06 Meter/Second

4.10E-06

Adjust slope of line to estimate K



K= 0.0000041 is less than likely minimum of 0.0000106 for Fine Sand

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

Reduced Data

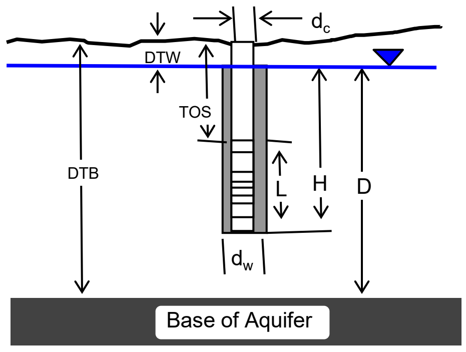
Entry	Time, Hr:Min:Sec	Water Level
1	0:00:00.0	2.95
2	0:00:04.0	3.60
3	0:00:07.0	3.62
4	0:00:10.0	3.63
5	0:00:13.0	3.63
6	0:00:16.0	3.63
7	0:00:19.0	3.64
8	0:00:22.0	3.64
9	0:00:25.0	3.64
10	0:00:28.0	3.65
11	0:00:31.0	3.65
12	0:00:34.0	3.65
13	0:00:37.0	3.65
14	0:00:40.0	3.65
15	0:00:43.0	3.66
16	0:00:46.0	3.66
17	0:00:49.0	3.65
18	0:00:52.0	3.66
19	0:00:55.0	3.66
20	0:00:58.0	3.66
21	0:01:01.0	3.66
22	0:01:04.0	3.66
23	0:01:07.0	3.66
24	0:01:10.0	3.66
25	0:01:13.0	3.66
26	0:01:16.0	3.66
27	0:01:19.0	3.66
28	0:01:22.0	3.66
29	0:01:25.0	3.66
30	0:01:28.0	3.66
31	0:01:31.0	3.66
32	0:01:34.0	3.66
33	0:01:37.0	3.67
34	0:01:40.0	3.66
35	0:01:43.0	3.67
36	0:01:46.0	3.67
37	0:01:49.0	3.67
38	0:01:52.0	3.67
39	0:01:55.0	3.66
40	0:01:58.0	3.66
41	0:02:01.0	3.67
42	0:02:04.0	3.67
43	0:02:07.0	3.67
44	0:02:10.0	3.67
45	0:02:13.0	3.67

WELL ID: BH1 J

Local ID: Bulls Bridge
Date: 02/06/2020
Time: 10:56

INPUT

Construction:	
Casing dia. (d_c)	0.05 Meter
Annulus dia. (d_w)	0.15 Meter
Screen Length (L)	4.93 Meter
Depths to:	
water level (DTW)	3.72 Meter
top of screen (TOS)	1 Meter
Base of Aquifer (DTB)	6 Meter
Annular Fill:	
across screen -- Gravel	
above screen -- Bentonite	
Aquifer Material -- Fine Sand	



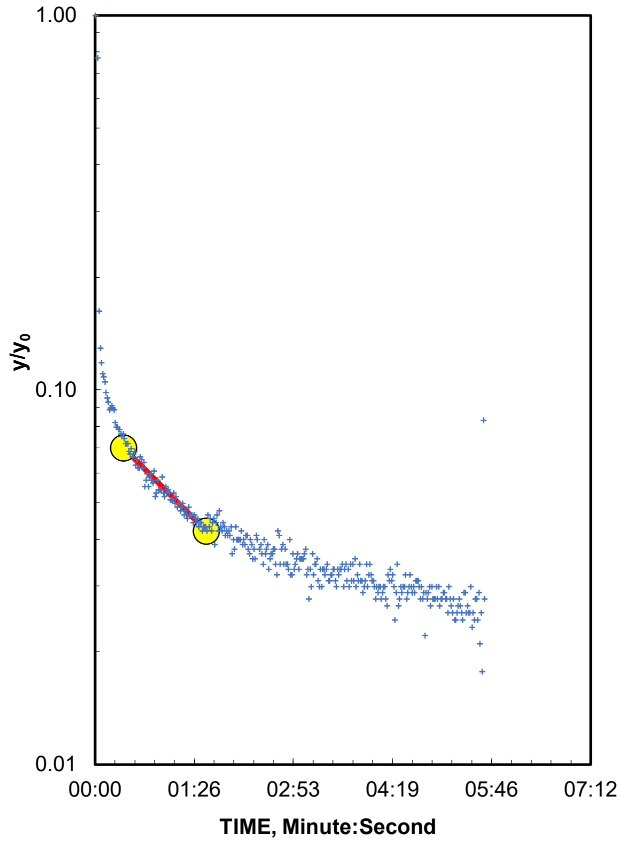
COMPUTED

L_{wetted}	2.21 Meter
D =	2.28 Meter
H =	2.21 Meter
L/r_w =	29.47
$y_{0\text{-DISPLACEMENT}}$ =	0.90 Meter
$y_{0\text{-SLUG}}$ =	0.78 Meter
From look-up table using L/r_w	
Partial penetrate A =	2.494
B =	0.411
ln(Re/rw) =	2.446
Re =	2.84 Meter
Slope =	0.003081 $\log_{10}$/sec
$t_{90\%}$ recovery =	325 sec

Input is consistent.

K =	2.5E-06 Meter/Second
	2.50E-06

Adjust slope of line to estimate K



K= 0.0000025 is less than likely minimum of 0.0000106 for Fine Sand

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:00.0	2.82
2	0:00:08.0	3.63
3	0:00:15.0	3.64
4	0:00:22.0	3.65
5	0:00:29.0	3.66
6	0:00:36.0	3.66
7	0:00:43.0	3.67
8	0:00:50.0	3.67
9	0:00:57.0	3.67
10	0:01:04.0	3.67
11	0:01:11.0	3.68
12	0:01:18.0	3.68
13	0:01:25.0	3.68
14	0:01:32.0	3.68
15	0:01:39.0	3.68
16	0:01:46.0	3.68
17	0:01:53.0	3.68
18	0:02:00.0	3.68
19	0:02:07.0	3.68
20	0:02:14.0	3.69
21	0:02:21.0	3.68
22	0:02:28.0	3.69
23	0:02:35.0	3.69
24	0:02:42.0	3.69
25	0:02:49.0	3.68
26	0:02:56.0	3.69
27	0:03:03.0	3.69
28	0:03:10.0	3.69
29	0:03:17.0	3.69
30	0:03:24.0	3.69
31	0:03:31.0	3.69
32	0:03:38.0	3.69
33	0:03:45.0	3.69
34	0:03:52.0	3.69
35	0:03:59.0	3.69
36	0:04:06.0	3.69
37	0:04:13.0	3.70
38	0:04:20.0	3.69
39	0:04:27.0	3.69
40	0:04:34.0	3.69
41	0:04:41.0	3.69
42	0:04:48.0	3.69
43	0:04:55.0	3.70
44	0:05:02.0	3.70
45	0:05:09.0	3.70

WELL ID: BH08 Rising Head

Local ID: Bulls Bridge
Date: 02/06/2020
Time: 12:56

INPUT

Construction:

Casing dia. (d_c) 0.05 Meter
Annulus dia. (d_w) 0.15 Meter
Screen Length (L) 1.5 Meter

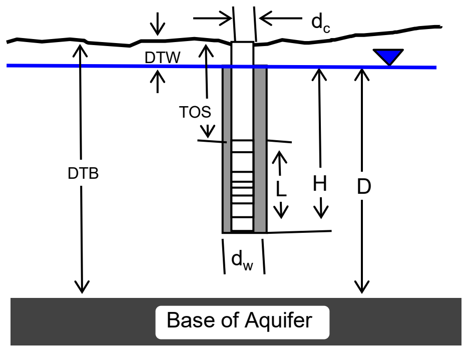
Depths to:

water level (DTW) 3.43 Meter
top of screen (TOS) 4.5 Meter
Base of Aquifer (DTB) 6.2 Meter

Annular Fill:

across screen -- Gravel
above screen -- Bentonite

Aquifer Material -- Fine Sand



COMPUTED

L_{wetted} 1.5 Meter
D = 2.77 Meter
H = 2.57 Meter
L/r_w = 20.00
$y_{0\text{-DISPLACEMENT}}$ = 1.24 Meter
$y_{0\text{-SLUG}}$ = 1.30 Meter

From look-up table using L/r_w

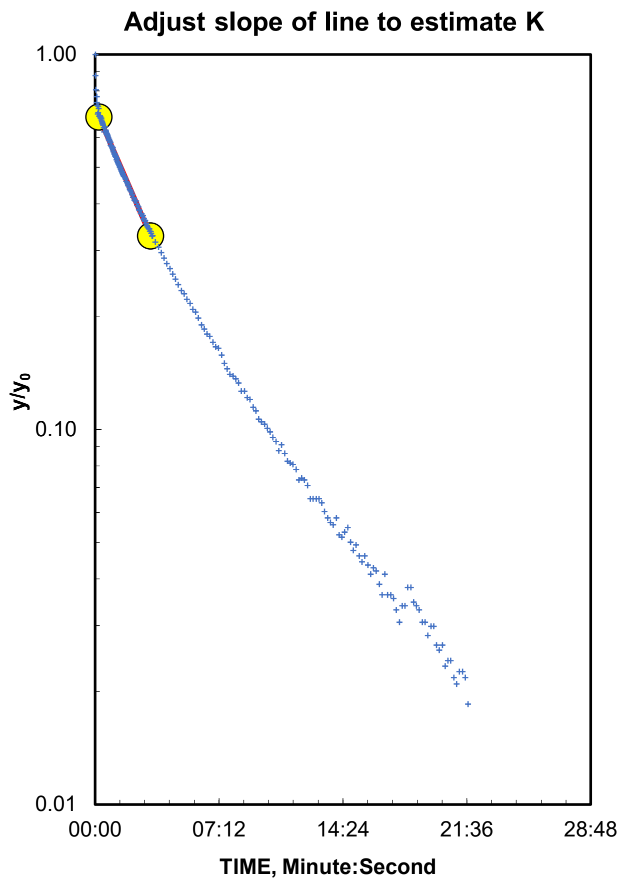
Partial penetrate A = 2.202
B = 0.345

ln(Re/rw) = 2.282
Re = 2.41 Meter

Slope = 0.001759 $\log_{10}$/sec
$t_{90\%}$ recovery = 568 sec

Input is consistent.

K = 1.9E-06 Meter/Second
1.90E-06



K= 0.0000019 is less than likely minimum of 0.0000106 for Fine Sand

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	0:00:00.0	2.19
2	0:00:07.0	2.52
3	0:00:14.0	2.58
4	0:00:19.0	2.59
5	0:00:24.0	2.61
6	0:00:30.0	2.64
7	0:00:38.0	2.66
8	0:00:43.0	2.68
9	0:00:48.0	2.69
10	0:00:53.0	2.71
11	0:00:58.0	2.73
12	0:01:03.0	2.75
13	0:01:08.0	2.76
14	0:01:13.0	2.77
15	0:01:18.0	2.79
16	0:01:23.0	2.80
17	0:01:28.0	2.81
18	0:01:33.0	2.82
19	0:01:38.0	2.84
20	0:01:46.0	2.85
21	0:01:56.0	2.88
22	0:02:06.0	2.90
23	0:02:16.0	2.92
24	0:02:26.0	2.94
25	0:02:36.0	2.95
26	0:02:46.0	2.97
27	0:02:55.0	2.98
28	0:03:05.0	3.00
29	0:03:15.0	3.02
30	0:03:40.0	3.05
31	0:04:30.0	3.11
32	0:05:20.0	3.15
33	0:06:10.0	3.19
34	0:07:00.0	3.22
35	0:07:50.0	3.26
36	0:08:40.0	3.27
37	0:09:30.0	3.30
38	0:10:20.0	3.31
39	0:11:10.0	3.33
40	0:12:00.0	3.34
41	0:12:50.0	3.35
42	0:13:40.0	3.36
43	0:14:30.0	3.36
44	0:15:20.0	3.37
45	0:16:10.0	3.38

APPENDIX F: LEVEL 3 AND 4 RTM WORKSHEETS

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

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

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

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

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

Details to be completed for each assessment

Site Name:	**Bulls Bridge**			
Site Address:	**North Hyde Gardens, Hayes, UB3 4QQ**			
Completed by:	**T Cawood**			
Date:	**08-Jul-20**		**Version:**	**1**
Contaminant	**Acenaphthylene**			
Target Concentration (C_T)	**0.0058**	**mg/l**	**Origin of C_T:**	**EQS**

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

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

Remedial Targets Worksheet , Release 3.2

Environment Agency

Level 1 - Soil

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

Calculate for non-polar organic chemicals

Contaminant		**Acenaphthylene**		
Target concentration	C_T	**0.0058**	**mg/l**	
Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	2.00E-01	fraction	Calculated
Air filled soil porosity	θa	8.10E-02	fraction	Calculated
Bulk density of soil zone material	ρ	2.00E+00	g/cm^3	Calculated
Henry's Law constant	H	3.40E-03	dimensionless	*EA SR7*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	1.74E-02	fraction	Site soil mean
Organic carbon partition coefficient	Koc	6.76E+03	l/kg	*Mackay, Shiu and Ma, 2000*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**1.17E+02**	**l/kg**	*Calculated value*

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

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

Level 1 Remedial Target

Level 1 Remedial Target	**6.81E-01**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.0058	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08-Jul-20
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**Acenaphthylene**		from Level 1	This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).
Target concentration	C_T	**0.0058**	**mg/l**	from Level 1	

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

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	8.25E-04	m/d	**Mean daily rainfall at Heathrow 1981-2010 / 2**	
Area of contaminant source	A	0.00E+00	m^2		Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	2.50E+01	m		
Saturated aquifer thickness	da	3.50E+00	m		
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.64E-01	m/d		
Hydraulic gradient of water table	i	1.36E-02	fraction		
Width of contaminant source perpendicular to groundwater flow	w	2.50E+01	m		Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	3.50E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**1.38E+00**		
Level 2 Remedial Target		**8.00E-03**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentrati**
		or		
		9.39E-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:	Bulls Bridge
Completed by:	T Cawood
Date:	08-Jul-20
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters	Variable	Value	Unit	Source
Contaminant		Acenaphthylene		from Level 1
Target Concentration	C_T	0.0058	mg/l	from Level 1
Dilution Factor	DF	1.38E+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
Enter source concentration		**Soil leachate concentration as mg/l**		
Enter soil leachate concentration		0.009	mg/l	
Half life for degradation of contaminant in water	$t_{1/2}$	1.20E+02	days	
Calculated decay rate	λ	5.78E-03	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	2.50E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	3.50E+00	m	from Level 2
Bulk density of aquifer materials	ρ	2.00E+00	g/cm^3	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	4.95E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.64E-01	m/d	from Level 2
Distance to compliance point	x	4.60E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	4.44E+01	l/kg	*see options*
Longitudinal dispersivity	ax	4.600	m	*see options*
Transverse dispersivity	az	0.460	m	*see options*
Vertical dispersivity	ay	0.046	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.71E-02	m/d
Retardation factor	Rf	2.97E+02	fraction
Decay rate used	λ	1.94E-05	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	4.95E-02	fraction
Rate of contaminant flow due to retardation	u	9.11E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	1.94E-03	fraction
Attenuation factor (C_O/C_{ED})	**AF**	**5.16E+02**	**fraction**
Soil leachate concentration	Co	9.00E-03	

Remedial Targets

Level 3 Remedial Target		**4.12E+00**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		4.84E+02	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**46**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**1.94E-03**	**fraction**	Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	6.57E-03	fraction
Organic carbon partition coefficient	Koc	6.76E+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	4.44E+01	l/kg

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

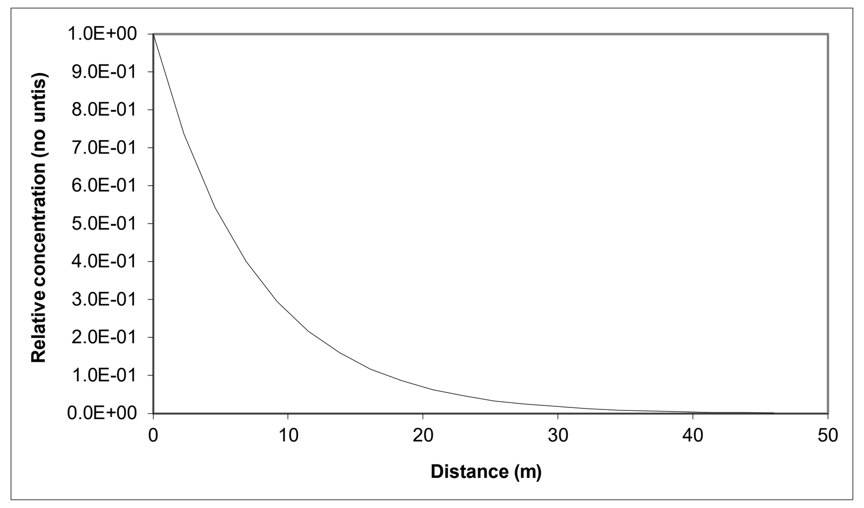
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	4.60E+00	2.83E+00	m
Transverse dispersivity	**az**	0.00E+00	4.60E-01	2.83E-01	m
Vertical dispersivity	**ay**	0.00E+00	4.60E-02	2.83E-02	m

Note values of dispersivity must be > 0

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

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



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

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

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

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

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	########
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	6.53E-03
2.3	7.37E-01	4.81E-03
4.6	5.44E-01	3.55E-03
6.9	4.01E-01	2.62E-03
9.2	2.95E-01	1.93E-03
11.5	2.18E-01	1.42E-03
13.8	1.60E-01	1.05E-03
16.1	1.18E-01	7.69E-04
18.4	8.65E-02	5.64E-04
20.7	6.34E-02	4.14E-04
23.0	4.64E-02	3.03E-04
25.3	3.39E-02	2.21E-04
27.6	2.47E-02	1.62E-04
29.9	1.80E-02	1.18E-04
32.2	1.31E-02	8.58E-05
34.5	9.56E-03	6.24E-05
36.8	6.96E-03	4.54E-05
39.1	5.06E-03	3.30E-05
41.4	3.68E-03	2.40E-05
43.7	2.67E-03	1.74E-05
46.0	1.94E-03	1.27E-05

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Environment Agency

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		Acenaphthylene		from Level 1
Target Concentration	C_T	5.80E-03	mg/l	from Level 1

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

Ogata Banks — Equations in HRA publication

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

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

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

	Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	1.41E-02	mg/l	*Max concentration at BH08*
Half life for degradation of contaminant in water	$t_{1/2}$	1.20E+02	days	*Howard et al, 1991*
Calculated decay rate	λ	5.78E-03	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	2.50E+01	m	*Estimate based on site data*
Plume thickness at source	Sy	3.25E+00	m	*Estimate based on site data*
Saturated aquifer thickness	da	3.50E+00	m	*Sturated thickness at BH08*
Bulk density of aquifer materials	ρ	1.60E+00	g/cm^3	*Estimate based on site data*
Effective porosity of aquifer	n	3.00E-01	fraction	*Estimate based on site data*
Hydraulic gradient	i	1.36E-02	fraction	*Calculatated from site data*
Hydraulic conductivity of aquifer	K	1.64E-01	m/d	*Calculated from variable head testing*
Distance to compliance point	x	4.60E+01	m	*Distance to River Crane*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	4.44E+01	l/kg	*see options*
Longitudinal dispersivity	ax	4.60E+00	m	*see options*
Transverse dispersivity	az	4.60E-01	m	*see options*
Vertical dispersivity	ay	4.60E-02	m	*see options*

Calculated Parameters

	Variable	Value	Unit
Groundwater flow velocity	v	7.43E-03	m/d
Retardation factor	Rf	2.38E+02	fraction
Decay rate used	λ	2.43E-05	d^{-1}
Rate of contaminant flow due to retardation	u	3.13E-05	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	5.64E-09	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**2.50E+06**	

Remedial Targets

Remedial Target	**1.45E+04**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	**46**	**m**	
Concentration of contaminant at compliance point C_{ED}/C_0	**5.64E-09**	**mg/l**	Ogata Banks
after	**1.0E+100**	**days**	

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	6.57E-03	fraction
Organic carbon partition coefficient	Koc	6.76E+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	4.44E+01	l/kg

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

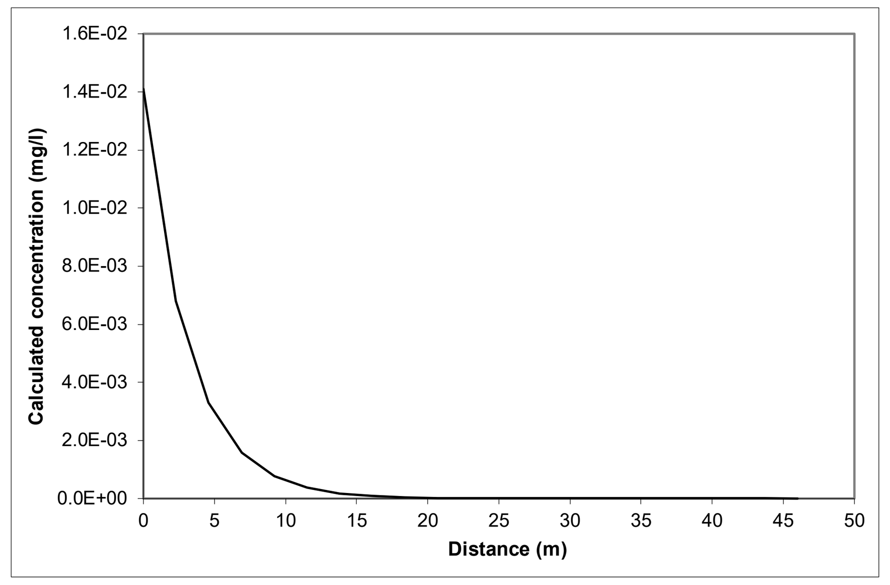
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	0.00E+00	4.60E+00	2.83E+00	m
Transverse dispersivity	**az**	0.00E+00	4.60E-01	2.83E-01	m
Vertical dispersivity	**ay**	0.00E+00	4.60E-02	2.83E-02	

Note values of dispersivity must be > 0

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

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



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

Note

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

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

The measured groundwater concentration should be compared
with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

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

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	########
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Concentration**
	mg/l
0	**1.4E-02**
2.3	**6.81E-03**
4.6	**3.29E-03**
6.9	**1.59E-03**
9.2	**7.67E-04**
11.5	**3.70E-04**
13.8	**1.78E-04**
16.1	**8.57E-05**
18.4	**4.11E-05**
20.7	**1.97E-05**
23.0	**9.43E-06**
25.3	**4.51E-06**
27.6	**2.15E-06**
29.9	**1.02E-06**
32.2	**4.88E-07**
34.5	**2.32E-07**
36.8	**1.10E-07**
39.1	**5.25E-08**
41.4	**2.50E-08**
43.7	**1.19E-08**
46.0	**5.64E-09**

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

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

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

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

Details to be completed for each assessment				
Site Name:	**Bulls Bridge**			
Site Address:	**North Hyde Gardens, Hayes, UB3 4QQ**			
Completed by:	**T Cawood**			
Date:	**08-Jul-20**		**Version:**	**1**
Contaminant	**Ammonia**			
Target Concentration (C_T)	**0.015**	**mg/l**	**Origin of C_T:**	**EQS**

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

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

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		Ammonia		from Level 1
Target Concentration	C_T	1.50E-02	mg/l	from Level 1

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

Ogata Banks — Equations in HRA publication

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

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

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

	Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	8.90E+00	mg/l	*Max concentration at BH01 J*
Half life for degradation of contaminant in water	$t_{1/2}$	2.19E+03	days	*NGWCLC report NC/02/49*
Calculated decay rate	λ	3.17E-04	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	3.00E+02	m	*Estimate based on site data*
Plume thickness at source	Sy	2.00E+00	m	*Estimate based on site data*
Saturated aquifer thickness	da	2.25E+00	m	*Sturated thickness at WS7*
Bulk density of aquifer materials	ρ	2.00E+00	g/cm^3	*Estimate based on site data*
Effective porosity of aquifer	n	3.00E-01	fraction	*Estimate based on site data*
Hydraulic gradient	i	2.72E-02	fraction	*Calculated from site data*
Hydraulic conductivity of aquifer	K	1.64E-01	m/d	*Calculated from variable head testing*
Distance to compliance point	x	1.60E+01	m	*Distance to River Crane*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	9.00E-01	l/kg	*see options*
Longitudinal dispersivity	ax	1.60E+00	m	*see options*
Transverse dispersivity	az	1.60E-01	m	*see options*
Vertical dispersivity	ay	1.60E-02	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	1.49E-02	m/d
Retardation factor	Rf	7.00E+00	fraction
Decay rate used	λ	4.52E-05	d^{-1}
Rate of contaminant flow due to retardation	u	2.12E-03	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	6.37E+00	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**1.40E+00**	

Remedial Targets

Remedial Target	**2.10E-02**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	**16**	**m**	
Concentration of contaminant at compliance point C_{ED}/C_0	**6.37E+00**	**mg/l**	Ogata Banks
after	**1.0E+100**	**days**	

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

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

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	9.00E-01	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	9.00E-01	l/kg

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

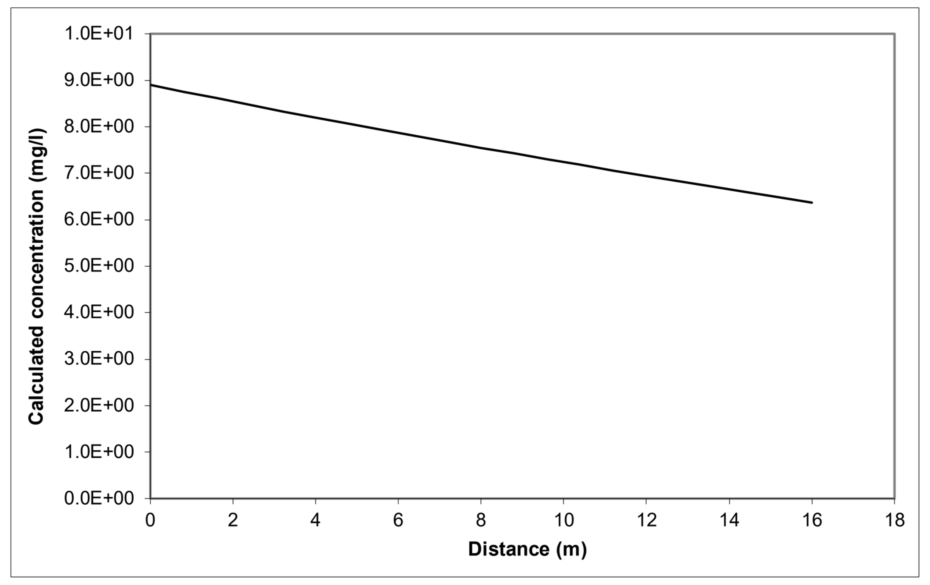
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	0.00E+00	1.60E+00	1.30E+00	m
Transverse dispersivity	**az**	0.00E+00	1.60E-01	1.30E-01	m
Vertical dispersivity	**ay**	0.00E+00	1.60E-02	1.30E-02	

Note values of dispersivity must be > 0

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

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



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

Note

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

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

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

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

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

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08/07/2020
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	8.9E+00
0.8	8.75E+00
1.6	8.61E+00
2.4	8.47E+00
3.2	8.33E+00
4.0	8.20E+00
4.8	8.06E+00
5.6	7.93E+00
6.4	7.80E+00
7.2	7.67E+00
8.0	7.55E+00
8.8	7.42E+00
9.6	7.30E+00
10.4	7.18E+00
11.2	7.06E+00
12.0	6.94E+00
12.8	6.82E+00
13.6	6.71E+00
14.4	6.59E+00
15.2	6.48E+00
16.0	6.37E+00

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

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

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

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

Details to be completed for each assessment

Site Name:	**Bulls Bridge**			
Site Address:	**North Hyde Gardens, Hayes, UB3 4QQ**			
Completed by:	**T Cawood**			
Date:	**08-Jul-20**		**Version:**	**2**
Contaminant	**Ammonia**			
Target Concentration (C_T)	**0.06**	**mg/l**	**Origin of C_T:**	**EQS x 0.1 + Dilution Factor of 40**

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

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

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		Ammonia		from Level 1
Target Concentration	C_T	6.00E-02	mg/l	from Level 1

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

Ogata Banks — Equations in HRA publication

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

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

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

	Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	1.70E+01	mg/l	*Max concentration at WS7*
Half life for degradation of contaminant in water	$t_{1/2}$	2.19E+03	days	*NGWCLC report NC/02/49*
Calculated decay rate	λ	3.17E-04	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.75E+02	m	*Estimate based on site data*
Plume thickness at source	Sy	2.00E+00	m	*Estimate based on site data*
Saturated aquifer thickness	da	2.25E+00	m	*Sturated thickness at WS7*
Bulk density of aquifer materials	ρ	2.00E+00	g/cm^3	*Estimate based on site data*
Effective porosity of aquifer	n	3.00E-01	fraction	*Estimate based on site data*
Hydraulic gradient	i	1.36E-02	fraction	*Calculated from site data*
Hydraulic conductivity of aquifer	K	1.64E-01	m/d	*Calculated from variable head testing*
Distance to compliance point	x	6.40E+01	m	*Distance to River Crane*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	*1.57E+01*
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	9.00E-01	l/kg	*see options*
Longitudinal dispersivity	ax	6.40E+00	m	*see options*
Transverse dispersivity	az	6.40E-01	m	*see options*
Vertical dispersivity	ay	6.40E-02	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	7.43E-03	m/d
Retardation factor	Rf	7.00E+00	fraction
Decay rate used	λ	4.52E-05	d^{-1}
Rate of contaminant flow due to retardation	u	1.06E-03	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	9.44E-01	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**1.80E+01**	

Remedial Targets

Remedial Target	**1.08E+00**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	**64**	**m**	
Concentration of contaminant at compliance point C_{ED}/C_0	**9.44E-01**	**mg/l**	Ogata Banks
after	**1.0E+100**	**days**	

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

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

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	9.00E-01	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	9.00E-01	l/kg

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

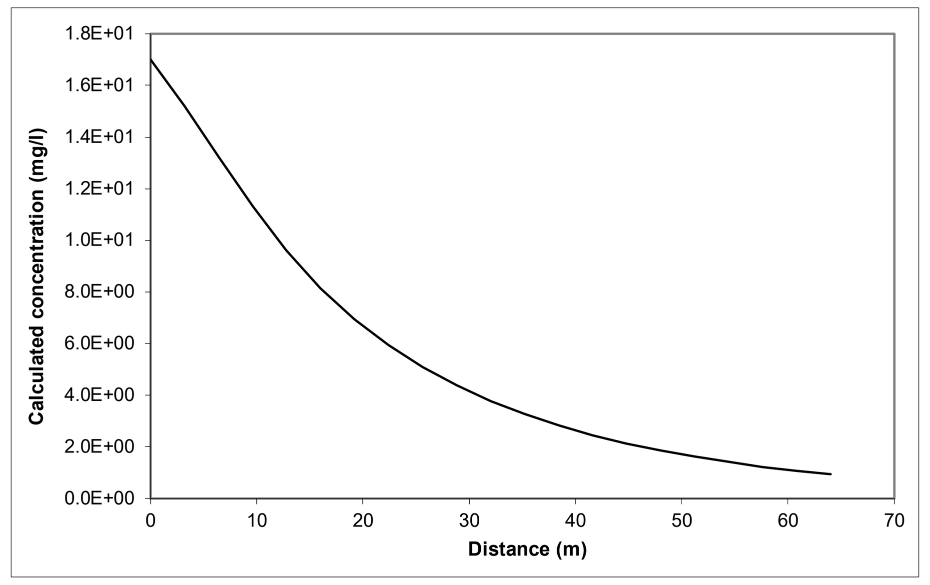
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	0.00E+00	6.40E+00	3.46E+00	m
Transverse dispersivity	**az**	0.00E+00	6.40E-01	3.46E-01	m
Vertical dispersivity	**ay**	0.00E+00	6.40E-02	3.46E-02	

Note values of dispersivity must be > 0

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

Environment Agency



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

Note

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

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

The measured groundwater concentration should be compared
with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

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

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08/07/2020
Version:	2

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	1.7E+01
3.2	1.52E+01
6.4	1.32E+01
9.6	1.13E+01
12.8	9.60E+00
16.0	8.16E+00
19.2	6.95E+00
22.4	5.94E+00
25.6	5.10E+00
28.8	4.38E+00
32.0	3.78E+00
35.2	3.26E+00
38.4	2.83E+00
41.6	2.45E+00
44.8	2.13E+00
48.0	1.85E+00
51.2	1.62E+00
54.4	1.41E+00
57.6	1.23E+00
60.8	1.08E+00
64.0	9.44E-01

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

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

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

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

Details to be completed for each assessment

Site Name:	**Bulls Bridge**			
Site Address:	**North Hyde Gardens, Hayes, UB3 4QQ**			
Completed by:	**T Cawood**			
Date:	**08-Jul-20**		**Version:**	**1**
Contaminant	**Ammonia**			
Target Concentration (C_T)	**0.015**	**mg/l**	**Origin of C_T:**	**EQS**

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

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

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		Ammonia		from Level 1
Target Concentration	C_T	1.50E-02	mg/l	from Level 1

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

Ogata Banks — **Equations in HRA publication**

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

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

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

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	8.90E+00	mg/l	*Max concentration at WS7*
Half life for degradation of contaminant in water	$t_{1/2}$	2.19E+03	days	*NGWCLC report NC/02/49*
Calculated decay rate	λ	3.17E-04	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.75E+02	m	*Estimate based on site data*
Plume thickness at source	Sy	2.00E+00	m	*Estimate based on site data*
Saturated aquifer thickness	da	2.25E+00	m	*Sturated thickness at WS7*
Bulk density of aquifer materials	ρ	2.00E+00	g/cm^3	*Estimate based on site data*
Effective porosity of aquifer	n	3.00E-01	fraction	*Estimate based on site data*
Hydraulic gradient	i	1.36E-02	fraction	*Calculatated from site data*
Hydraulic conductivity of aquifer	K	1.64E-01	m/d	*Calculated from variable head testing*
Distance to compliance point	x	1.60E+01	m	*Distance to River Crane*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	*3.11E+02*
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	9.00E-01	l/kg	*see options*
Longitudinal dispersivity	ax	1.60E+00	m	*see options*
Transverse dispersivity	az	1.60E-01	m	*see options*
Vertical dispersivity	ay	1.60E-02	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	7.43E-03	m/d
Retardation factor	Rf	7.00E+00	fraction
Decay rate used	λ	4.52E-05	d^{-1}
Rate of contaminant flow due to retardation	u	1.06E-03	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	4.67E+00	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**1.91E+00**	

Remedial Targets

Remedial Target	**2.86E-02**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	**16**	**m**	
Concentration of contaminant at compliance point C_{ED}/C_0	**4.67E+00**	**mg/l**	Ogata Banks
after	**1.0E+100**	**days**	

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

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

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	9.00E-01	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	9.00E-01	l/kg

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

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

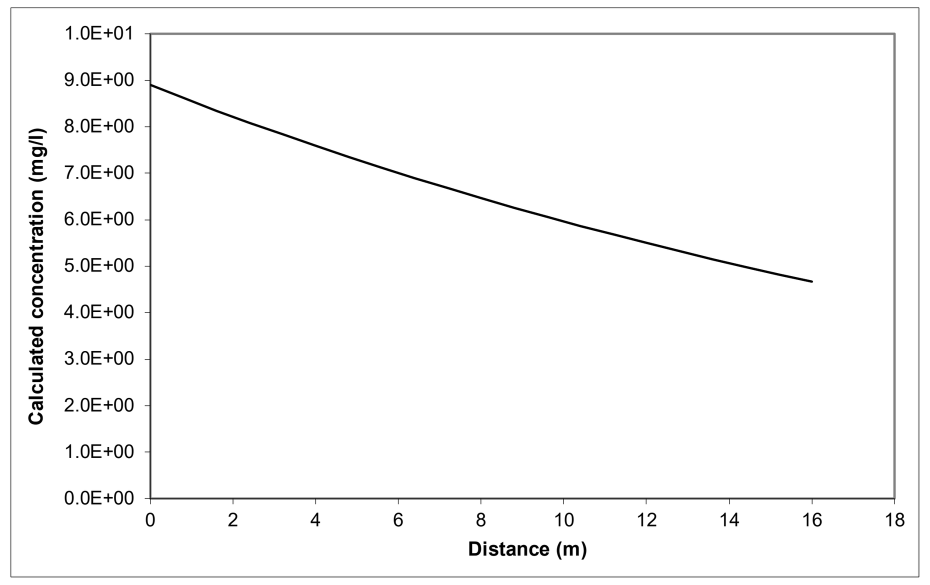
		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	0.00E+00	1.60E+00	1.30E+00	m
Transverse dispersivity	**az**	0.00E+00	1.60E-01	1.30E-01	m
Vertical dispersivity	**ay**	0.00E+00	1.60E-02	1.30E-02	

Note values of dispersivity must be > 0

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

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

Environment Agency



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

Note

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

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

The measured groundwater concentration should be compared

with the Level 3 remedial target to determine the need for further action.

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

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

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08/07/2020
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Concentration**
	mg/l
0	**8.9E+00**
0.8	**8.62E+00**
1.6	**8.35E+00**
2.4	**8.09E+00**
3.2	**7.83E+00**
4.0	**7.58E+00**
4.8	**7.34E+00**
5.6	**7.11E+00**
6.4	**6.89E+00**
7.2	**6.67E+00**
8.0	**6.46E+00**
8.8	**6.26E+00**
9.6	**6.06E+00**
10.4	**5.87E+00**
11.2	**5.68E+00**
12.0	**5.50E+00**
12.8	**5.32E+00**
13.6	**5.15E+00**
14.4	**4.99E+00**
15.2	**4.82E+00**
16.0	**4.67E+00**

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

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

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

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

Details to be completed for each assessment				
Site Name:	**Bulls Bridge**			
Site Address:	**North Hyde Gardens, Hayes, UB3 4QQ**			
Completed by:	**T Cawood**			
Date:	**08-Jul-20**		**Version:**	**1**
Contaminant	**Anthracene**			
Target Concentration (C_T)	**0.0001**	**mg/l**	**Origin of C_T:**	**EQS**

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

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

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

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

Calculate for non-polar organic chemicals

Contaminant		**Anthracene**		
Target concentration	C_T	**0.0001**	**mg/l**	
Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	2.00E-01	fraction	Calculated
Air filled soil porosity	θa	8.10E-02	fraction	Calculated
Bulk density of soil zone material	ρ	2.00E+00	g/cm^3	Calculated
Henry's Law constant	H	1.60E-03	dimensionless	*EA SR7*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	1.74E-02	fraction	Site soil mean
Organic carbon partition coefficient	Koc	2.77E+06	l/kg	*Site Specific Koc*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**4.81E+04**	**l/kg**	*Calculated value*

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

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

Level 1 Remedial Target

Level 1 Remedial Target	**4.81E+00**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.0001	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08-Jul-20
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**Anthracene**		from Level 1
Target concentration	C_T	**0.0001**	**mg/l**	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 contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	8.25E-04	m/d	**Mean daily rainfall at Heathrow 1981-2010 / 2**	
Area of contaminant source	A	0.00E+00	m^2		Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	2.50E+01	m		
Saturated aquifer thickness	da	3.50E+00	m		
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.64E-01	m/d		
Hydraulic gradient of water table	i	1.36E-02	fraction		
Width of contaminant source perpendicular to groundwater flow	w	2.50E+01	m		Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	3.50E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**1.38E+00**		
Level 2 Remedial Target		**1.38E-04**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentrati**
		or		
		6.64E+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)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08-Jul-20
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters

Input Parameters	Variable	Value	Unit	Source
Contaminant		Anthracene		from Level 1
Target Concentration	C_T	0.0001	mg/l	from Level 1
Dilution Factor	DF	1.38E+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
Enter source concentration		**Soil leachate concentration as mg/l**		
Enter soil leachate concentration		0.0058	mg/l	
Half life for degradation of contaminant in water	$t_{1/2}$	9.20E+02	days	*Howard et al, 1991*
Calculated decay rate	λ	7.54E-04	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	2.50E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	3.50E+00	m	from Level 2
Bulk density of aquifer materials	ρ	2.00E+00	g/cm^3	*Estimate based on site data*
Effective porosity of aquifer	n	3.00E-01	fraction	*Estimate based on site data*
Hydraulic gradient	i	4.95E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.64E-01	m/d	from Level 2
Distance to compliance point	x	7.00E+01	m	*Distance to River Crane*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.82E+04	l/kg	*see options*
Longitudinal dispersivity	ax	7.000	m	*see options*
Transverse dispersivity	az	0.700	m	*see options*
Vertical dispersivity	ay	0.070	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.71E-02	m/d
Retardation factor	Rf	1.22E+05	fraction
Decay rate used	λ	6.20E-09	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	4.95E-02	fraction
Rate of contaminant flow due to retardation	u	2.23E-07	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	1.10E-01	fraction
Attenuation factor (C_O/C_{ED})	**AF**	**9.09E+00**	**fraction**
Soil leachate concentration	Co	5.80E-03	

Remedial Targets

Level 3 Remedial Target		**1.25E-03**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		6.03E+01	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**70**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**1.10E-01**	**fraction**	Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	6.57E-03	fraction
Organic carbon partition coefficient	Koc	2.77E+06	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	1.82E+04	l/kg

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

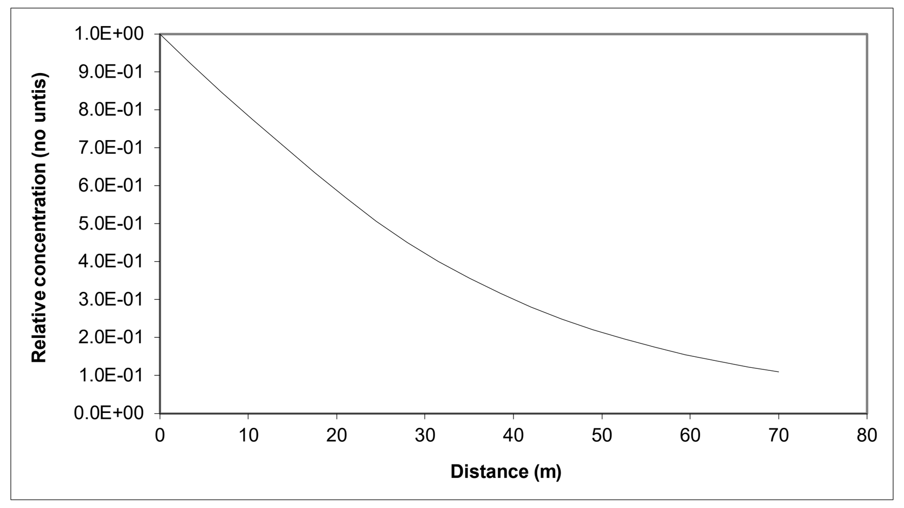
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	7.00E+00	3.64E+00	m
Transverse dispersivity	**az**	0.00E+00	7.00E-01	3.64E-01	m
Vertical dispersivity	**ay**	0.00E+00	7.00E-02	3.64E-02	m

Note values of dispersivity must be > 0

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

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



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

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

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

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

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08/07/2020
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	4.21E-03
3.5	9.20E-01	3.87E-03
7.0	8.46E-01	3.56E-03
10.5	7.75E-01	3.26E-03
14.0	7.04E-01	2.96E-03
17.5	6.35E-01	2.67E-03
21.0	5.69E-01	2.39E-03
24.5	5.08E-01	2.14E-03
28.0	4.52E-01	1.90E-03
31.5	4.01E-01	1.69E-03
35.0	3.56E-01	1.50E-03
38.5	3.16E-01	1.33E-03
42.0	2.80E-01	1.18E-03
45.5	2.49E-01	1.05E-03
49.0	2.21E-01	9.30E-04
52.5	1.96E-01	8.26E-04
56.0	1.75E-01	7.35E-04
59.5	1.55E-01	6.54E-04
63.0	1.38E-01	5.82E-04
66.5	1.23E-01	5.19E-04
70.0	1.10E-01	4.63E-04

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Environment Agency

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		Anthracene		from Level 1
Target Concentration	C_T	1.00E-04	mg/l	from Level 1

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

Ogata Banks — Equations in HRA publication

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

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

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

	Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	1.59E-02	mg/l	*Max concentration at BH08*
Half life for degradation of contaminant in water	$t_{1/2}$	9.20E+02	days	*Howard et al, 1991*
Calculated decay rate	λ	7.54E-04	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	2.50E+01	m	*Estimate based on site data*
Plume thickness at source	Sy	3.25E+00	m	*Estimate based on site data*
Saturated aquifer thickness	da	3.50E+00	m	*Sturated thickness at BH08*
Bulk density of aquifer materials	ρ	2.00E+00	g/cm^3	*Estimate based on site data*
Effective porosity of aquifer	n	3.00E-01	fraction	*Estimate based on site data*
Hydraulic gradient	i	1.36E-02	fraction	*Calculated from site data*
Hydraulic conductivity of aquifer	K	1.64E-01	m/d	*Calculated from variable head testing*
Distance to compliance point	x	7.00E+01	m	*Distance to River Crane*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.82E+04	l/kg	*see options*
Longitudinal dispersivity	ax	7.00E+00	m	*see options*
Transverse dispersivity	az	7.00E-01	m	*see options*
Vertical dispersivity	ay	7.00E-02	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	7.43E-03	m/d
Retardation factor	Rf	1.22E+05	fraction
Decay rate used	λ	6.20E-09	d^{-1}
Rate of contaminant flow due to retardation	u	6.12E-08	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	7.31E-05	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**2.18E+02**	

Remedial Targets

Remedial Target	**2.18E-02**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	**70**	**m**	
Concentration of contaminant at compliance point C_{ED}/C_0	**7.31E-05**	**mg/l**	Ogata Banks
after	**1.0E+100**	**days**	

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	6.57E-03	fraction
Organic carbon partition coefficient	Koc	2.77E+06	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	1.82E+04	l/kg

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

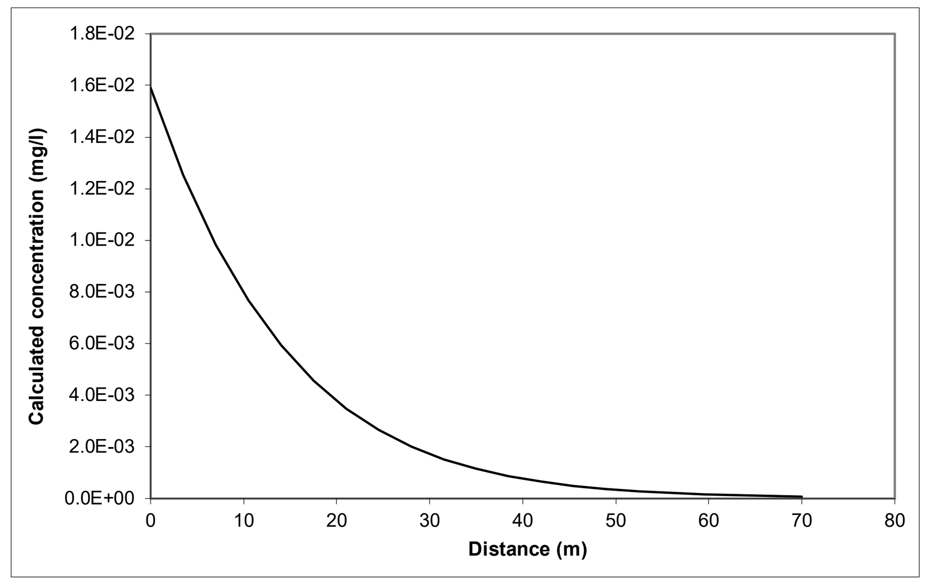
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	0.00E+00	7.00E+00	3.64E+00	m
Transverse dispersivity	**az**	0.00E+00	7.00E-01	3.64E-01	m
Vertical dispersivity	**ay**	0.00E+00	7.00E-02	3.64E-02	

Note values of dispersivity must be > 0

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

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



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

Note

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

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

The measured groundwater concentration should be compared

with the Level 3 remedial target to determine the need for further action.

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

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

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08/07/2020
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Concentration**
	mg/l
0	**1.6E-02**
3.5	**1.25E-02**
7.0	**9.83E-03**
10.5	**7.68E-03**
14.0	**5.94E-03**
17.5	**4.56E-03**
21.0	**3.48E-03**
24.5	**2.64E-03**
28.0	**2.00E-03**
31.5	**1.52E-03**
35.0	**1.15E-03**
38.5	**8.69E-04**
42.0	**6.58E-04**
45.5	**4.99E-04**
49.0	**3.78E-04**
52.5	**2.87E-04**
56.0	**2.18E-04**
59.5	**1.66E-04**
63.0	**1.26E-04**
66.5	**9.59E-05**
70.0	**7.31E-05**

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

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

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

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

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

Details to be completed for each assessment

Site Name:	**Bulls Bridge**			
Site Address:	**North Hyde Gardens, Hayes, UB3 4QQ**			
Completed by:	**T Cawood**			
Date:	**08-Jul-20**		**Version:**	**1**
Contaminant	**Anthracene**			
Target Concentration (C_T)	**0.000435**	**mg/l**	**Origin of C_T:**	**EQS x 0.1 + Dilution Factor of 43.5**

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

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

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Environment Agency

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

Calculate for non-polar organic chemicals

Contaminant		**Anthracene**		
Target concentration	C_T	**0.000435**	**mg/l**	
Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	2.00E-01	fraction	Calculated
Air filled soil porosity	θa	8.10E-02	fraction	Calculated
Bulk density of soil zone material	ρ	2.00E+00	g/cm^3	Calculated
Henry's Law constant	H	1.60E-03	dimensionless	*EA SR7*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	1.74E-02	fraction	Site soil mean
Organic carbon partition coefficient	Koc	2.77E+06	l/kg	*Site Specific Koc*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**4.81E+04**	**l/kg**	*Calculated value*

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

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

Level 1 Remedial Target

Level 1 Remedial Target	**2.09E+01**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.000435	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08-Jul-20
Version:	1

Remedial Targets Worksheet , Release 3.2

Environment Agency

Level 2 - Soil

Contaminant		Anthracene		from Level 1	This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).
Target concentration	C_T	**0.000435**	**mg/l**	from Level 1	

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

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	8.25E-04	m/d	**Mean daily rainfall at Heathrow 1981-2010 / 2**	
Area of contaminant source	A	0.00E+00	m^2		Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	2.50E+01	m		
Saturated aquifer thickness	da	3.50E+00	m		
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.64E-01	m/d		
Hydraulic gradient of water table	i	1.36E-02	fraction		
Width of contaminant source perpendicular to groundwater flow	w	2.50E+01	m		Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	3.50E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**1.38E+00**		
Level 2 Remedial Target		**6.00E-04**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentrati**
		or		
		2.89E+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:	Bulls Bridge
Completed by:	T Cawood
Date:	08-Jul-20
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Input Parameters

Input Parameters	Variable	Value	Unit	Source
Contaminant		Anthracene		from Level 1
Target Concentration	C_T	0.000435	mg/l	from Level 1
Dilution Factor	DF	1.38E+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
Enter source concentration		**Soil leachate concentration as mg/l**		
Enter soil leachate concentration		**0.0058**	mg/l	
Half life for degradation of contaminant in water	$t_{1/2}$	9.20E+02	days	*Howard et al, 1991*
Calculated decay rate	λ	7.54E-04	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	2.50E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	3.50E+00	m	from Level 2
Bulk density of aquifer materials	ρ	2.00E+00	g/cm^3	*Estimate based on site data*
Effective porosity of aquifer	n	3.00E-01	fraction	*Estimate based on site data*
Hydraulic gradient	i	4.95E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.64E-01	m/d	from Level 2
Distance to compliance point	x	2.10E+01	m	*Distance to River Crane*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.82E+04	l/kg	*see options*
Longitudinal dispersivity	ax	2.100	m	*see options*
Transverse dispersivity	az	0.210	m	*see options*
Vertical dispersivity	ay	0.021	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Calculated Parameters	Variable	Value	Unit
Groundwater flow velocity	v	2.71E-02	m/d
Retardation factor	Rf	1.22E+05	fraction
Decay rate used	λ	6.20E-09	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	4.95E-02	fraction
Rate of contaminant flow due to retardation	u	2.23E-07	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	5.75E-01	fraction
Attenuation factor (C_O/C_{ED})	**AF**	**1.74E+00**	**fraction**
Soil leachate concentration	Co	5.80E-03	

Remedial Targets

Level 3 Remedial Target		**1.04E-03**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		5.02E+01	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**21**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**5.75E-01**	**fraction**	Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	6.57E-03	fraction
Organic carbon partition coefficient	Koc	2.77E+06	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	1.82E+04	l/kg

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

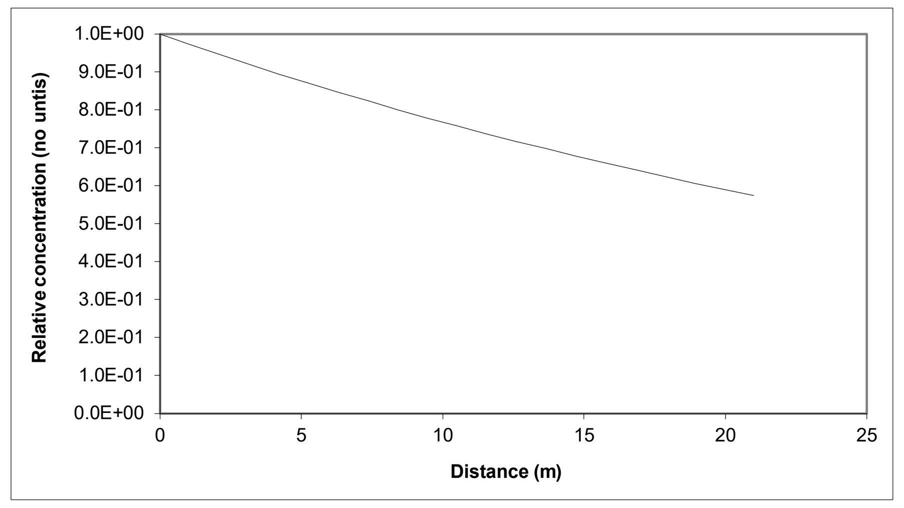
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	2.10E+00	1.63E+00	m
Transverse dispersivity	**az**	0.00E+00	2.10E-01	1.63E-01	m
Vertical dispersivity	**ay**	0.00E+00	2.10E-02	1.63E-02	m

Note values of dispersivity must be > 0

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

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



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

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

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

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

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08/07/2020
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	4.21E-03
1.1	9.73E-01	4.09E-03
2.1	9.46E-01	3.98E-03
3.2	9.20E-01	3.87E-03
4.2	8.95E-01	3.77E-03
5.3	8.71E-01	3.66E-03
6.3	8.47E-01	3.56E-03
7.4	8.24E-01	3.47E-03
8.4	8.01E-01	3.37E-03
9.5	7.79E-01	3.28E-03
10.5	7.58E-01	3.19E-03
11.6	7.37E-01	3.10E-03
12.6	7.17E-01	3.02E-03
13.7	6.98E-01	2.94E-03
14.7	6.79E-01	2.86E-03
15.8	6.60E-01	2.78E-03
16.8	6.42E-01	2.70E-03
17.9	6.25E-01	2.63E-03
18.9	6.07E-01	2.56E-03
20.0	5.91E-01	2.49E-03
21.0	5.75E-01	2.42E-03

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Environment Agency

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		Anthracene		from Level 1
Target Concentration	C_T	4.35E-04	mg/l	from Level 1

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

Ogata Banks — Equations in HRA publication

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

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

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

	Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	1.59E-02	mg/l	*Max concentration at BH08*
Half life for degradation of contaminant in water	$t_{1/2}$	9.20E+02	days	*Howard et al, 1991*
Calculated decay rate	λ	7.54E-04	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	2.50E+01	m	*Estimate based on site data*
Plume thickness at source	Sy	3.25E+00	m	*Estimate based on site data*
Saturated aquifer thickness	da	3.50E+00	m	*Sturated thickness at BH08*
Bulk density of aquifer materials	ρ	2.00E+00	g/cm^3	*Estimate based on site data*
Effective porosity of aquifer	n	3.00E-01	fraction	*Estimate based on site data*
Hydraulic gradient	i	1.36E-02	fraction	*Calculatated from site data*
Hydraulic conductivity of aquifer	K	1.64E-01	m/d	*Calculated from variable head testing*
Distance to compliance point	x	2.10E+01	m	*Distance to River Crane*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.82E+04	l/kg	*see options*
Longitudinal dispersivity	ax	2.10E+00	m	*see options*
Transverse dispersivity	az	2.10E-01	m	*see options*
Vertical dispersivity	ay	2.10E-02	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	7.43E-03	m/d
Retardation factor	Rf	1.22E+05	fraction
Decay rate used	λ	6.20E-09	d^{-1}
Rate of contaminant flow due to retardation	u	6.12E-08	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	2.62E-03	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**6.07E+00**	

Remedial Targets

Remedial Target	**2.64E-03**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	**21**	**m**	
Concentration of contaminant at compliance point C_{ED}/C_0	**2.62E-03**	**mg/l**	Ogata Banks
after	**1.0E+100**	**days**	

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	6.57E-03	fraction
Organic carbon partition coefficient	Koc	2.77E+06	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	1.82E+04	l/kg

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

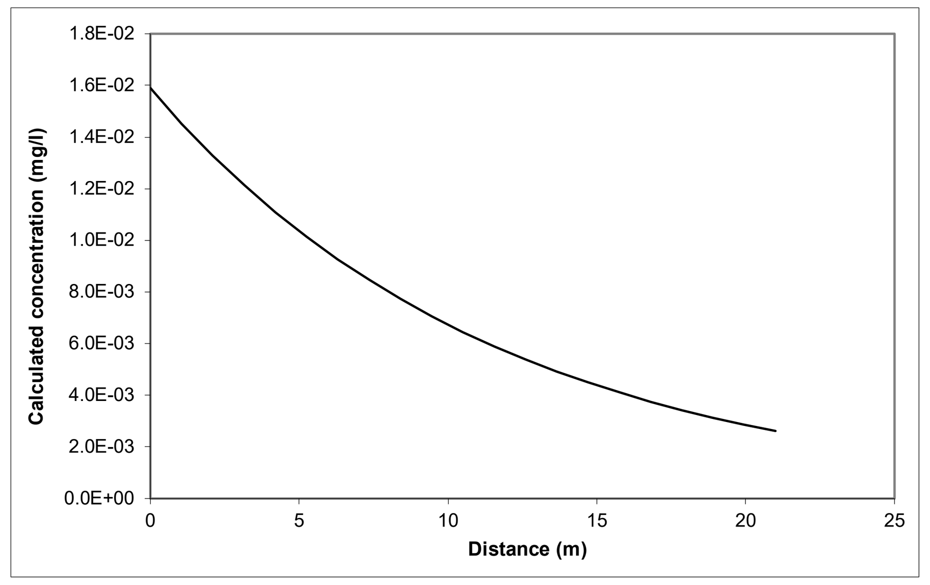
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	0.00E+00	2.10E+00	1.63E+00	m
Transverse dispersivity	**az**	0.00E+00	2.10E-01	1.63E-01	m
Vertical dispersivity	**ay**	0.00E+00	2.10E-02	1.63E-02	

Note values of dispersivity must be > 0

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

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



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

Note

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

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

The measured groundwater concentration should be compared

with the Level 3 remedial target to determine the need for further action.

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

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

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08/07/2020
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	1.6E-02
1.1	1.45E-02
2.1	1.33E-02
3.2	1.21E-02
4.2	1.11E-02
5.3	1.01E-02
6.3	9.26E-03
7.4	8.46E-03
8.4	7.73E-03
9.5	7.06E-03
10.5	6.45E-03
11.6	5.90E-03
12.6	5.39E-03
13.7	4.92E-03
14.7	4.50E-03
15.8	4.11E-03
16.8	3.76E-03
17.9	3.43E-03
18.9	3.14E-03
20.0	2.87E-03
21.0	2.62E-03

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

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

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

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

Details to be completed for each assessment				
Site Name:	**Bulls Bridge**			
Site Address:	**North Hyde Gardens, Hayes, UB3 4QQ**			
Completed by:	**T Cawood**			
Date:	**08-Jul-20**		**Version:**	**1**
Contaminant	**Anthracene**			
Target Concentration (C_T)	**0.0001**	**mg/l**	**Origin of C_T:**	**EQS**

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

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

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

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

Calculate for non-polar organic chemicals

Contaminant		**Anthracene**		
Target concentration	C_T	**0.0001**	**mg/l**	
Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	2.00E-01	fraction	Calculated
Air filled soil porosity	θa	8.10E-02	fraction	Calculated
Bulk density of soil zone material	ρ	2.00E+00	g/cm^3	Calculated
Henry's Law constant	H	1.60E-03	dimensionless	*EA SR7*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	1.74E-02	fraction	Site soil mean
Organic carbon partition coefficient	Koc	2.77E+06	l/kg	*Site Specific Koc*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**4.81E+04**	**l/kg**	*Calculated value*

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

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

Level 1 Remedial Target

Level 1 Remedial Target	**4.81E+00**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.0001	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08-Jul-20
Version:	1

Remedial Targets Worksheet , Release 3.2

Environment Agency

Level 2 - Soil

Contaminant		**Anthracene**		from Level 1	This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).
Target concentration	C_T	**0.0001**	**mg/l**	from Level 1	

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

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	8.25E-04	m/d	**Mean daily rainfall at Heathrow 1981-2010 / 2**	
Area of contaminant source	A	0.00E+00	m^2		Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	2.50E+01	m		
Saturated aquifer thickness	da	3.50E+00	m		
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.64E-01	m/d		
Hydraulic gradient of water table	i	1.36E-02	fraction		
Width of contaminant source perpendicular to groundwater flow	w	2.50E+01	m		Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	3.50E+00	m		

Calculated Parameters

Dilution Factor	DF	**1.38E+00**		
Level 2 Remedial Target		**1.38E-04**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentrati**
		or		
		6.64E+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)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08-Jul-20
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Input Parameters

	Variable	Value	Unit	Source
Contaminant		Anthracene		from Level 1
Target Concentration	C_T	0.0001	mg/l	from Level 1
Dilution Factor	DF	1.38E+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
Enter source concentration	Soil leachate concentration as mg/l			
Enter soil leachate concentration		**0.0058**	mg/l	
Half life for degradation of contaminant in water	$t_{1/2}$	9.20E+02	days	*Howard et al, 1991*
Calculated decay rate	λ	7.54E-04	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	2.50E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	3.50E+00	m	from Level 2
Bulk density of aquifer materials	ρ	2.00E+00	g/cm^3	*Estimate based on site data*
Effective porosity of aquifer	n	3.00E-01	fraction	*Estimate based on site data*
Hydraulic gradient	i	4.95E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.64E-01	m/d	from Level 2
Distance to compliance point	x	2.10E+01	m	*Distance to River Crane*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.82E+04	l/kg	*see options*
Longitudinal dispersivity	ax	2.100	m	*see options*
Transverse dispersivity	az	0.210	m	*see options*
Vertical dispersivity	ay	0.021	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters

	Variable	Value	Unit
Groundwater flow velocity	v	2.71E-02	m/d
Retardation factor	Rf	1.22E+05	fraction
Decay rate used	λ	6.20E-09	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	4.95E-02	fraction
Rate of contaminant flow due to retardation	u	2.23E-07	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	5.75E-01	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**1.74E+00**	**fraction**
Soil leachate concentration	Co	5.80E-03	

Remedial Targets

		Value	Unit	
Level 3 Remedial Target		**2.40E-04**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		1.15E+01	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**21**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**5.75E-01**	**fraction**	Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	6.57E-03	fraction
Organic carbon partition coefficient	Koc	2.77E+06	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	1.82E+04	l/kg

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

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

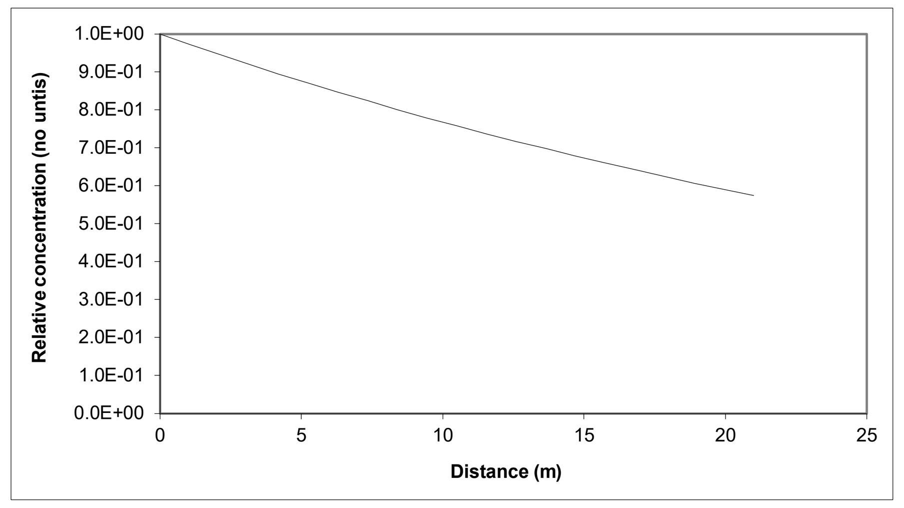
		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	2.10E+00	1.63E+00	m
Transverse dispersivity	**az**	0.00E+00	2.10E-01	1.63E-01	m
Vertical dispersivity	**ay**	0.00E+00	2.10E-02	1.63E-02	m

Note values of dispersivity must be > 0

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

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

Environment Agency



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

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

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

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

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08/07/2020
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Relative concentration (No units)**	**Concentration mg/l**
0	**1.0E+00**	**4.21E-03**
1.1	**9.73E-01**	**4.09E-03**
2.1	**9.46E-01**	**3.98E-03**
3.2	**9.20E-01**	**3.87E-03**
4.2	**8.95E-01**	**3.77E-03**
5.3	**8.71E-01**	**3.66E-03**
6.3	**8.47E-01**	**3.56E-03**
7.4	**8.24E-01**	**3.47E-03**
8.4	**8.01E-01**	**3.37E-03**
9.5	**7.79E-01**	**3.28E-03**
10.5	**7.58E-01**	**3.19E-03**
11.6	**7.37E-01**	**3.10E-03**
12.6	**7.17E-01**	**3.02E-03**
13.7	**6.98E-01**	**2.94E-03**
14.7	**6.79E-01**	**2.86E-03**
15.8	**6.60E-01**	**2.78E-03**
16.8	**6.42E-01**	**2.70E-03**
17.9	**6.25E-01**	**2.63E-03**
18.9	**6.07E-01**	**2.56E-03**
20.0	**5.91E-01**	**2.49E-03**
21.0	**5.75E-01**	**2.42E-03**

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		Anthracene		from Level 1
Target Concentration	C_T	1.00E-04	mg/l	from Level 1

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

Ogata Banks — Equations in HRA publication

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

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

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

	Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	1.59E-02	mg/l	*Max concentration at BH08*
Half life for degradation of contaminant in water	$t_{1/2}$	9.20E+02	days	*Howard et al, 1991*
Calculated decay rate	λ	7.54E-04	days^{-1}	
Width of plume in aquifer at source (perpendicular to flow)	Sz	2.50E+01	m	*Estimate based on site data*
Plume thickness at source	Sy	3.25E+00	m	*Estimate based on site data*
Saturated aquifer thickness	da	3.50E+00	m	*Sturated thickness at BH08*
Bulk density of aquifer materials	ρ	2.00E+00	g/cm^3	*Estimate based on site data*
Effective porosity of aquifer	n	3.00E-01	fraction	*Estimate based on site data*
Hydraulic gradient	i	1.36E-02	fraction	*Calculatated from site data*
Hydraulic conductivity of aquifer	K	1.64E-01	m/d	*Calculated from variable head testing*
Distance to compliance point	x	2.10E+01	m	*Distance to River Crane*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.82E+04	l/kg	*see options*
Longitudinal dispersivity	ax	2.10E+00	m	*see options*
Transverse dispersivity	az	2.10E-01	m	*see options*
Vertical dispersivity	ay	2.10E-02	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	7.43E-03	m/d
Retardation factor	Rf	1.22E+05	fraction
Decay rate used	λ	6.20E-09	d^{-1}
Rate of contaminant flow due to retardation	u	6.12E-08	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	2.62E-03	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**6.07E+00**	

Remedial Targets

Remedial Target	**6.07E-04**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	**21**	**m**	
Concentration of contaminant at compliance point C_{ED}/C_0	**2.62E-03**	**mg/l**	Ogata Banks
after	**1.0E+100**	**days**	

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	6.57E-03	fraction
Organic carbon partition coefficient	Koc	2.77E+06	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	1.82E+04	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	2.10E+00	1.63E+00	m
Transverse dispersivity	**az**	0.00E+00	2.10E-01	1.63E-01	m
Vertical dispersivity	**ay**	0.00E+00	2.10E-02	1.63E-02	

Note values of dispersivity must be > 0

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

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

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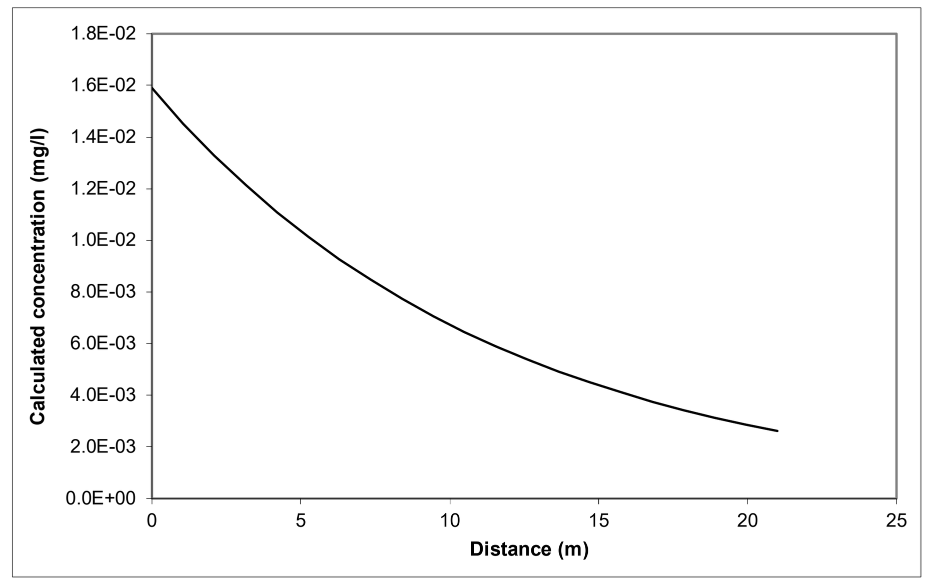

Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

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

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

The measured groundwater concentration should be compared

with the Level 3 remedial target to determine the need for further action.

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

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

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08/07/2020
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Concentration**
	mg/l
0	**1.6E-02**
1.1	**1.45E-02**
2.1	**1.33E-02**
3.2	**1.21E-02**
4.2	**1.11E-02**
5.3	**1.01E-02**
6.3	**9.26E-03**
7.4	**8.46E-03**
8.4	**7.73E-03**
9.5	**7.06E-03**
10.5	**6.45E-03**
11.6	**5.90E-03**
12.6	**5.39E-03**
13.7	**4.92E-03**
14.7	**4.50E-03**
15.8	**4.11E-03**
16.8	**3.76E-03**
17.9	**3.43E-03**
18.9	**3.14E-03**
20.0	**2.87E-03**
21.0	**2.62E-03**

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

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

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

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

Details to be completed for each assessment

Site Name:	**Bulls Bridge**			
Site Address:	**North Hyde Gardens, Hayes, UB3 4QQ**			
Completed by:	**T Cawood**			
Date:	**08-Jul-20**		**Version:**	**2**
Contaminant	**Anthracene**			
Target Concentration (C_T)	**0.000435**	**mg/l**	**Origin of C_T:**	**EQS x 0.1 + Dilution Factor of 43.5**

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

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

Remedial Targets Worksheet , Release 3.2

Environment Agency

Level 1 - Soil

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

Calculate for non-polar organic chemicals

Contaminant		**Anthracene**		
Target concentration	C_T	**0.000435**	**mg/l**	
Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	2.00E-01	fraction	Calculated
Air filled soil porosity	θa	8.10E-02	fraction	Calculated
Bulk density of soil zone material	ρ	2.00E+00	g/cm^3	Calculated
Henry's Law constant	H	1.60E-03	dimensionless	*EA SR7*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	1.74E-02	fraction	Site soil mean
Organic carbon partition coefficient	Koc	2.77E+06	l/kg	*Site Specific Koc*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**4.81E+04**	**l/kg**	*Calculated value*

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

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

Level 1 Remedial Target

Level 1 Remedial Target	**2.09E+01**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.000435	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08-Jul-20
Version:	2

Remedial Targets Worksheet , Release 3.2

Environment Agency

Level 2 - Soil

Contaminant		Anthracene		from Level 1	This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).
Target concentration	C_T	**0.000435**	**mg/l**	from Level 1	

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

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	8.25E-04	m/d	**Mean daily rainfall at Heathrow 1981-2010 / 2**	
Area of contaminant source	A	0.00E+00	m^2		Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	2.50E+01	m		
Saturated aquifer thickness	da	3.50E+00	m		
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.64E-01	m/d		
Hydraulic gradient of water table	i	1.36E-02	fraction		
Width of contaminant source perpendicular to groundwater flow	w	2.50E+01	m		Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	3.50E+00	m		

Calculated Parameters

Dilution Factor	DF	**1.38E+00**		
Level 2 Remedial Target		**6.00E-04**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentrati**
		or		
		2.89E+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:	Bulls Bridge
Completed by:	T Cawood
Date:	08-Jul-20
Version:	2

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Input Parameters	Variable	Value	Unit	Source
Contaminant		Anthracene		from Level 1
Target Concentration	C_T	0.000435	mg/l	from Level 1
Dilution Factor	DF	1.38E+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
Enter source concentration		**Soil leachate concentration as mg/l**		
Enter soil leachate concentration		**0.0058**	mg/l	
Half life for degradation of contaminant in water	$t_{1/2}$	9.20E+02	days	*Howard et al, 1991*
Calculated decay rate	λ	7.54E-04	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	2.50E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	3.50E+00	m	from Level 2
Bulk density of aquifer materials	ρ	2.00E+00	g/cm^3	*Estimate based on site data*
Effective porosity of aquifer	n	3.00E-01	fraction	*Estimate based on site data*
Hydraulic gradient	i	4.95E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.64E-01	m/d	from Level 2
Distance to compliance point	x	4.60E+01	m	*Distance to River Crane*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.82E+04	l/kg	*see options*
Longitudinal dispersivity	ax	4.600	m	*see options*
Transverse dispersivity	az	0.460	m	*see options*
Vertical dispersivity	ay	0.046	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.71E-02	m/d
Retardation factor	Rf	1.22E+05	fraction
Decay rate used	λ	6.20E-09	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	4.95E-02	fraction
Rate of contaminant flow due to retardation	u	2.23E-07	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	2.73E-01	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**3.66E+00**	**fraction**
Soil leachate concentration	Co	5.80E-03	

Remedial Targets

Level 3 Remedial Target		**2.20E-03**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		1.06E+02	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**46**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**2.73E-01**	**fraction**	Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	6.57E-03	fraction
Organic carbon partition coefficient	Koc	2.77E+06	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	1.82E+04	l/kg

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

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

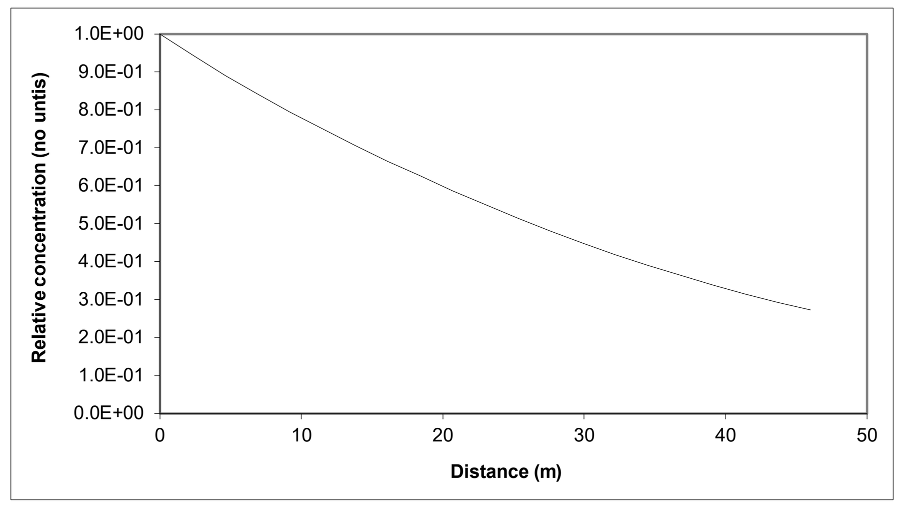
		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	4.60E+00	2.83E+00	m
Transverse dispersivity	**az**	0.00E+00	4.60E-01	2.83E-01	m
Vertical dispersivity	**ay**	0.00E+00	4.60E-02	2.83E-02	m

Note values of dispersivity must be > 0

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

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

Environment Agency



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

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

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

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

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08/07/2020
Version:	2

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	4.21E-03
2.3	9.44E-01	3.97E-03
4.6	8.92E-01	3.75E-03
6.9	8.42E-01	3.54E-03
9.2	7.95E-01	3.34E-03
11.5	7.50E-01	3.16E-03
13.8	7.07E-01	2.97E-03
16.1	6.66E-01	2.80E-03
18.4	6.26E-01	2.63E-03
20.7	5.87E-01	2.47E-03
23.0	5.50E-01	2.32E-03
25.3	5.15E-01	2.17E-03
27.6	4.82E-01	2.03E-03
29.9	4.50E-01	1.89E-03
32.2	4.20E-01	1.77E-03
34.5	3.91E-01	1.65E-03
36.8	3.64E-01	1.53E-03
39.1	3.39E-01	1.43E-03
41.4	3.16E-01	1.33E-03
43.7	2.94E-01	1.24E-03
46.0	2.73E-01	1.15E-03

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Environment Agency

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		Anthracene		from Level 1
Target Concentration	C_T	4.35E-04	mg/l	from Level 1

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

Ogata Banks — Equations in HRA publication

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

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

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

	Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	1.59E-02	mg/l	*Max concentration at BH08*
Half life for degradation of contaminant in water	$t_{1/2}$	9.20E+02	days	*Howard et al, 1991*
Calculated decay rate	λ	7.54E-04	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	2.50E+01	m	*Estimate based on site data*
Plume thickness at source	Sy	3.25E+00	m	*Estimate based on site data*
Saturated aquifer thickness	da	3.50E+00	m	*Sturated thickness at BH08*
Bulk density of aquifer materials	ρ	2.00E+00	g/cm^3	*Estimate based on site data*
Effective porosity of aquifer	n	3.00E-01	fraction	*Estimate based on site data*
Hydraulic gradient	i	1.36E-02	fraction	*Calculatated from site data*
Hydraulic conductivity of aquifer	K	1.64E-01	m/d	*Calculated from variable head testing*
Distance to compliance point	x	4.60E+01	m	*Distance to River Crane*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.82E+04	l/kg	*see options*
Longitudinal dispersivity	ax	4.60E+00	m	*see options*
Transverse dispersivity	az	4.60E-01	m	*see options*
Vertical dispersivity	ay	4.60E-02	m	*see options*

Calculated Parameters

	Variable	Value	Unit
Groundwater flow velocity	v	7.43E-03	m/d
Retardation factor	Rf	1.22E+05	fraction
Decay rate used	λ	6.20E-09	d^{-1}
Rate of contaminant flow due to retardation	u	6.12E-08	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	4.17E-04	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**3.81E+01**	

Remedial Targets

Remedial Target	**1.66E-02**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	**46**	**m**	
Concentration of contaminant at compliance point C_{ED}/C_0	**4.17E-04**	**mg/l**	Ogata Banks
after	**1.0E+100**	**days**	

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	6.57E-03	fraction
Organic carbon partition coefficient	Koc	2.77E+06	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	1.82E+04	l/kg

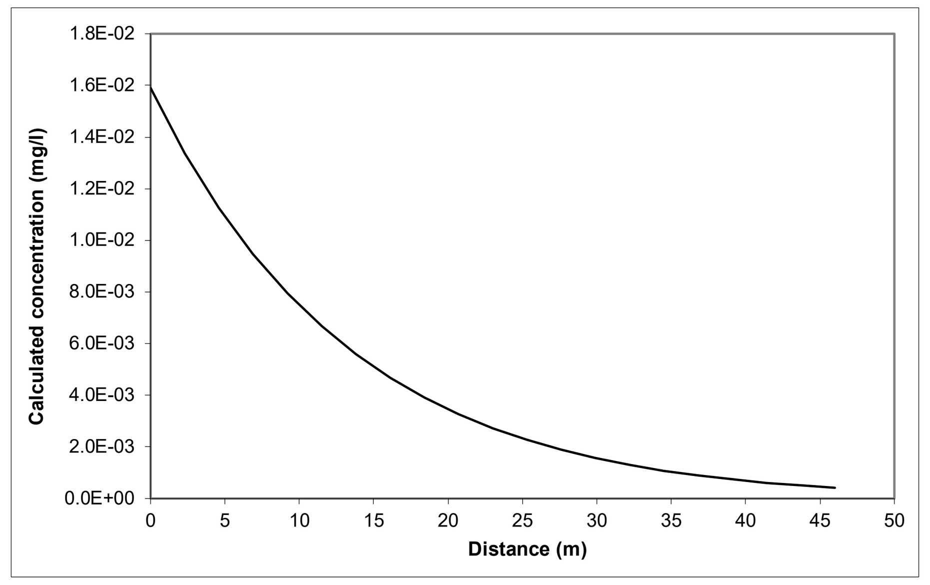
Define dispersivity (click brown cell and use pull down list)

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

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	0.00E+00	4.60E+00	2.83E+00	m
Transverse dispersivity	**az**	0.00E+00	4.60E-01	2.83E-01	m
Vertical dispersivity	**ay**	0.00E+00	4.60E-02	2.83E-02	

Note values of dispersivity must be > 0

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



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

Note

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

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

The measured groundwater concentration should be compared
with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

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

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08/07/2020
Version:	2

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	1.6E-02
2.3	1.34E-02
4.6	1.12E-02
6.9	9.46E-03
9.2	7.95E-03
11.5	6.68E-03
13.8	5.60E-03
16.1	4.69E-03
18.4	3.92E-03
20.7	3.27E-03
23.0	2.72E-03
25.3	2.27E-03
27.6	1.88E-03
29.9	1.56E-03
32.2	1.30E-03
34.5	1.07E-03
36.8	8.90E-04
39.1	7.36E-04
41.4	6.09E-04
43.7	5.04E-04
46.0	4.17E-04

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

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

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

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

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

Details to be completed for each assessment

Site Name:	**Bulls Bridge**			
Site Address:	**North Hyde Gardens, Hayes, UB3 4QQ**			
Completed by:	**T Cawood**			
Date:	**08-Jul-20**		**Version:**	**1**
Contaminant	**Anthracene**			
Target Concentration (C_T)	**0.0001**	**mg/l**	**Origin of C_T:**	**EQS**

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

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

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

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

Calculate for non-polar organic chemicals

Contaminant		**Anthracene**		
Target concentration	C_T	**0.0001**	**mg/l**	
Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	2.00E-01	fraction	Calculated
Air filled soil porosity	θa	8.10E-02	fraction	Calculated
Bulk density of soil zone material	ρ	2.00E+00	g/cm^3	Calculated
Henry's Law constant	H	1.60E-03	dimensionless	*EA SR7*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	1.74E-02	fraction	Site soil mean
Organic carbon partition coefficient	Koc	2.77E+06	l/kg	*Site Specific Koc*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**4.81E+04**	**l/kg**	*Calculated value*

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

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

Level 1 Remedial Target

Level 1 Remedial Target	**4.81E+00**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.0001	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08-Jul-20
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		Anthracene		from Level 1
Target concentration	C_T	**0.0001**	**mg/l**	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 contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	8.25E-04	m/d	**Mean daily rainfall at Heathrow 1981-2010 / 2**	
Area of contaminant source	A	0.00E+00	m^2		Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	2.50E+01	m		
Saturated aquifer thickness	da	3.50E+00	m		
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.64E-01	m/d		
Hydraulic gradient of water table	i	1.36E-02	fraction		
Width of contaminant source perpendicular to groundwater flow	w	2.50E+01	m		Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	3.50E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**1.38E+00**		
Level 2 Remedial Target		**1.38E-04**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentrati**
		or		
		6.64E+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)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08-Jul-20
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Input Parameters	Variable	Value	Unit	Source
Contaminant		Anthracene		from Level 1
Target Concentration	C_T	0.0001	mg/l	from Level 1
Dilution Factor	DF	1.38E+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
Enter source concentration		**Soil leachate concentration as mg/l**		
Enter soil leachate concentration		**0.0058**	mg/l	
Half life for degradation of contaminant in water	$t_{1/2}$	9.20E+02	days	*Howard et al, 1991*
Calculated decay rate	λ	7.54E-04	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	2.50E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	3.50E+00	m	from Level 2
Bulk density of aquifer materials	ρ	2.00E+00	g/cm^3	*Estimate based on site data*
Effective porosity of aquifer	n	3.00E-01	fraction	*Estimate based on site data*
Hydraulic gradient	i	4.95E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.64E-01	m/d	from Level 2
Distance to compliance point	x	4.60E+01	m	*Distance to River Crane*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.82E+04	l/kg	*see options*
Longitudinal dispersivity	ax	4.600	m	*see options*
Transverse dispersivity	az	0.460	m	*see options*
Vertical dispersivity	ay	0.046	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.71E-02	m/d
Retardation factor	Rf	1.22E+05	fraction
Decay rate used	λ	6.20E-09	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	4.95E-02	fraction
Rate of contaminant flow due to retardation	u	2.23E-07	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	2.73E-01	fraction
Attenuation factor (C_O/C_{ED})	**AF**	**3.66E+00**	**fraction**
Soil leachate concentration	Co	5.80E-03	

Remedial Targets

Level 3 Remedial Target		**5.05E-04**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		2.43E+01	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**46**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	**C_{ED}/C_0**	**2.73E-01**	**fraction**	Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	6.57E-03	fraction
Organic carbon partition coefficient	Koc	2.77E+06	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	1.82E+04	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	4.60E+00	2.83E+00	m
Transverse dispersivity	**az**	0.00E+00	4.60E-01	2.83E-01	m
Vertical dispersivity	**ay**	0.00E+00	4.60E-02	2.83E-02	m

Note values of dispersivity must be > 0

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

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

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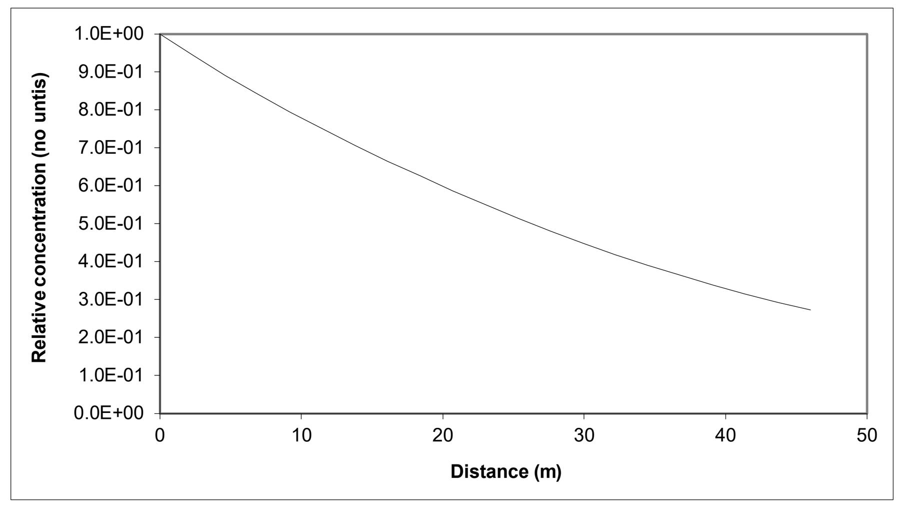

Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is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

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

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

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

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08/07/2020
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	4.21E-03
2.3	9.44E-01	3.97E-03
4.6	8.92E-01	3.75E-03
6.9	8.42E-01	3.54E-03
9.2	7.95E-01	3.34E-03
11.5	7.50E-01	3.16E-03
13.8	7.07E-01	2.97E-03
16.1	6.66E-01	2.80E-03
18.4	6.26E-01	2.63E-03
20.7	5.87E-01	2.47E-03
23.0	5.50E-01	2.32E-03
25.3	5.15E-01	2.17E-03
27.6	4.82E-01	2.03E-03
29.9	4.50E-01	1.89E-03
32.2	4.20E-01	1.77E-03
34.5	3.91E-01	1.65E-03
36.8	3.64E-01	1.53E-03
39.1	3.39E-01	1.43E-03
41.4	3.16E-01	1.33E-03
43.7	2.94E-01	1.24E-03
46.0	2.73E-01	1.15E-03

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

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

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

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

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

Details to be completed for each assessment

Site Name:	**Bulls Bridge**			
Site Address:	**North Hyde Gardens, Hayes, UB3 4QQ**			
Completed by:	**T Cawood**			
Date:	**08-Jul-20**		**Version:**	**1**
Contaminant	**Fluoranthene**			
Target Concentration (C_T)	**0.0001**	**mg/l**	**Origin of C_T:**	**EQS**

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

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

Environment Agency

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

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

Calculate for non-polar organic chemicals

Contaminant		**Fluoranthene**		
Target concentration	C_T	**0.0001**	**mg/l**	
Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	2.00E-01	fraction	Calculated
Air filled soil porosity	θa	8.10E-02	fraction	Calculated
Bulk density of soil zone material	ρ	2.00E+00	g/cm^3	Calculated
Henry's Law constant	H	4.20E-04	dimensionless	*EA SR7*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	1.74E-02	fraction	Site soil mean
Organic carbon partition coefficient	Koc	1.10E+07	l/kg	*Site Specific Koc*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**1.90E+05**	**l/kg**	*Calculated value*

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

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

Level 1 Remedial Target

Level 1 Remedial Target	**1.90E+01**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.0001	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08-Jul-20
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**Fluoranthene**		from Level 1	This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).
Target concentration	C_T	**0.0001**	**mg/l**	from Level 1	

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

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	8.25E-04	m/d	**Mean daily rainfall at Heathrow 1981-2010 / 2**	
Area of contaminant source	A	0.00E+00	m^2		Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	2.50E+01	m		
Saturated aquifer thickness	da	3.50E+00	m		
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.64E-01	m/d		
Hydraulic gradient of water table	i	1.36E-02	fraction		
Width of contaminant source perpendicular to groundwater flow	w	2.50E+01	m		Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	3.50E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**1.38E+00**		
Level 2 Remedial Target		**1.38E-04**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentrati**
		or		
		2.62E+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:	Bulls Bridge
Completed by:	T Cawood
Date:	08-Jul-20
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters

Input Parameters	Variable	Value	Unit	Source
Contaminant		Fluoranthene		from Level 1
Target Concentration	C_T	0.0001	mg/l	from Level 1
Dilution Factor	DF	1.38E+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
Enter source concentration		Soil leachate concentration as mg/l		
Enter soil leachate concentration		0.0048	mg/l	
Half life for degradation of contaminant in water	$t_{1/2}$	8.80E+02	days	
Calculated decay rate	λ	7.88E-04	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	2.50E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	3.50E+00	m	from Level 2
Bulk density of aquifer materials	ρ	2.00E+00	g/cm^3	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	4.95E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.64E-01	m/d	from Level 2
Distance to compliance point	x	2.55E+02	m	
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.82E+04	l/kg	*see options*
Longitudinal dispersivity	ax	25.500	m	*see options*
Transverse dispersivity	az	2.550	m	*see options*
Vertical dispersivity	ay	0.255	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Calculated Parameters	Variable	Value	Unit
Groundwater flow velocity	v	2.71E-02	m/d
Retardation factor	Rf	1.22E+05	fraction
Decay rate used	λ	6.48E-09	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	4.95E-02	fraction
Rate of contaminant flow due to retardation	u	2.23E-07	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	4.58E-04	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**2.18E+03**	**fraction**
Soil leachate concentration	Co	4.80E-03	

Remedial Targets

Level 3 Remedial Target		**3.01E-01**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		5.72E+04	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**255**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**4.58E-04**	**fraction**	Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	6.57E-03	fraction
Organic carbon partition coefficient	Koc	2.77E+06	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	1.82E+04	l/kg

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

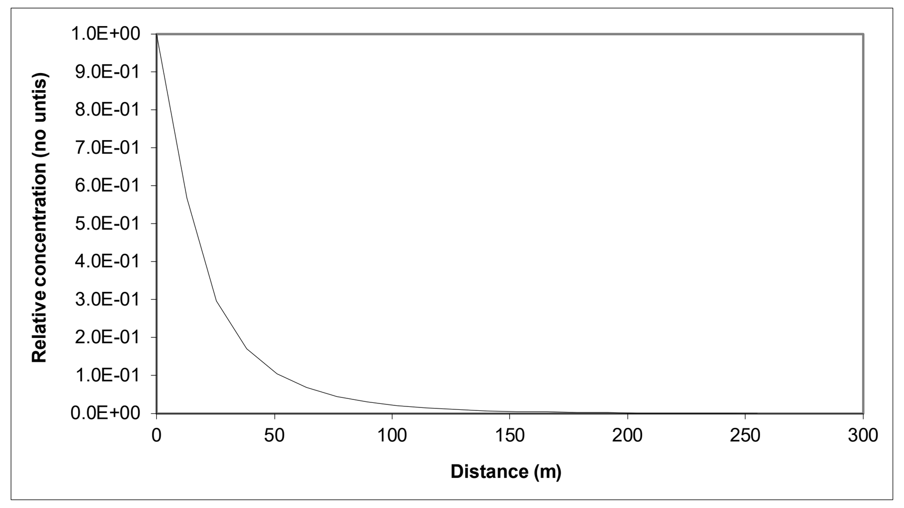
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	2.55E+01	6.91E+00	m
Transverse dispersivity	**az**	0.00E+00	2.55E+00	6.91E-01	m
Vertical dispersivity	**ay**	0.00E+00	2.55E-01	6.91E-02	m

Note values of dispersivity must be > 0

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

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



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

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

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

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

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08/07/2020
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	3.48E-03
12.8	5.69E-01	1.98E-03
25.5	2.96E-01	1.03E-03
38.3	1.71E-01	5.95E-04
51.0	1.06E-01	3.68E-04
63.8	6.82E-02	2.38E-04
76.5	4.54E-02	1.58E-04
89.3	3.09E-02	1.07E-04
102.0	2.13E-02	7.43E-05
114.8	1.49E-02	5.20E-05
127.5	1.06E-02	3.68E-05
140.3	7.55E-03	2.63E-05
153.0	5.43E-03	1.89E-05
165.8	3.93E-03	1.37E-05
178.5	2.86E-03	9.94E-06
191.3	2.09E-03	7.27E-06
204.0	1.53E-03	5.33E-06
216.8	1.13E-03	3.93E-06
229.5	8.33E-04	2.90E-06
242.3	6.17E-04	2.15E-06
255.0	4.58E-04	1.60E-06

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		**Fluoranthene**		from Level 1
Target Concentration	C_T	**1.00E-04**	mg/l	from Level 1

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

Ogata Banks — **Equations in HRA publication**

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

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

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

	Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	3.09E-03	mg/l	*Max concentration at BH08*
Half life for degradation of contaminant in water	$t_{1/2}$	8.80E+02	days	*Howard et al, 1991*
Calculated decay rate	λ	7.88E-04	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	2.00E+00	m	*Estimate based on site data*
Plume thickness at source	Sy	3.25E+00	m	*Estimate based on site data*
Saturated aquifer thickness	da	3.50E+00	m	*Sturated thickness at BH08*
Bulk density of aquifer materials	ρ	1.60E+00	g/cm^3	*Estimate based on site data*
Effective porosity of aquifer	n	3.00E-01	fraction	*Estimate based on site data*
Hydraulic gradient	i	1.36E-02	fraction	*Calculatated from site data*
Hydraulic conductivity of aquifer	K	1.64E-01	m/d	*Calculated from variable head testing*
Distance to compliance point	x	2.55E+02	m	*Distance to River Crane*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.82E+04	l/kg	*see options*
Longitudinal dispersivity	ax	2.55E+01	m	*see options*
Transverse dispersivity	az	2.55E+00	m	*see options*
Vertical dispersivity	ay	5.10E-02	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	7.43E-03	m/d
Retardation factor	Rf	9.72E+04	fraction
Decay rate used	λ	8.11E-09	d^{-1}
Rate of contaminant flow due to retardation	u	7.65E-08	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	1.66E-10	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**1.86E+07**	

Remedial Targets

Remedial Target	**1.86E+03**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	**255**	**m**	
Concentration of contaminant at compliance point C_{ED}/C_0	**1.66E-10**	**mg/l**	Ogata Banks
after	**1.0E+100**	**days**	

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	6.57E-03	fraction
Organic carbon partition coefficient	Koc	2.77E+06	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	1.82E+04	l/kg

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

User defined values for dispersivity

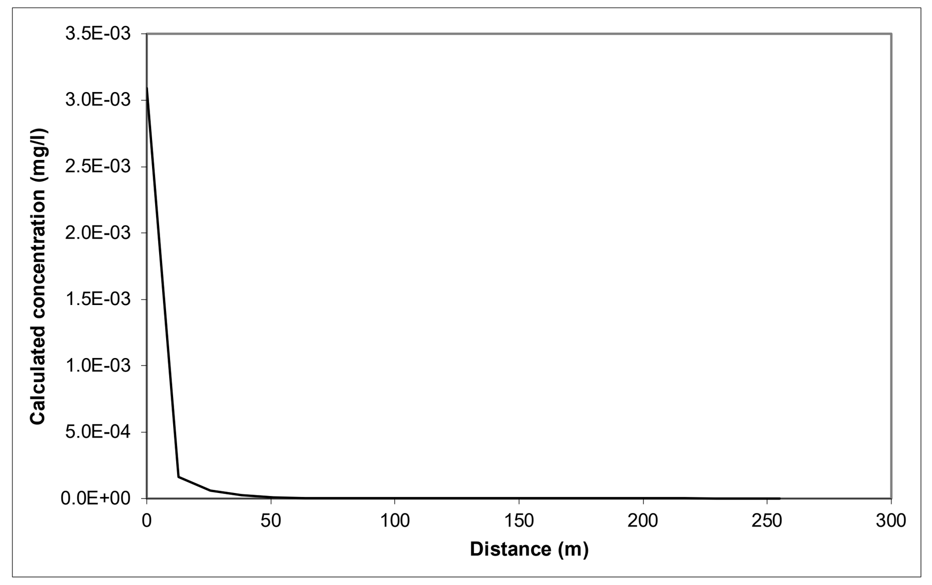
		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	2.55E+01	2.55E+01	6.91E+00	m
Transverse dispersivity	**az**	2.55E+00	2.55E+00	6.91E-01	m
Vertical dispersivity	**ay**	5.10E-02	2.55E-01	6.91E-02	

Note values of dispersivity must be > 0

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

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

Environment Agency



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

Note

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

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

The measured groundwater concentration should be compared
with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

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

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08/07/2020
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Concentration**
	mg/l
0	**3.1E-03**
12.8	**1.65E-04**
25.5	**6.10E-05**
38.3	**2.55E-05**
51.0	**1.13E-05**
63.8	**5.18E-06**
76.5	**2.44E-06**
89.3	**1.17E-06**
102.0	**5.67E-07**
114.8	**2.79E-07**
127.5	**1.38E-07**
140.3	**6.91E-08**
153.0	**3.48E-08**
165.8	**1.76E-08**
178.5	**8.95E-09**
191.3	**4.57E-09**
204.0	**2.34E-09**
216.8	**1.20E-09**
229.5	**6.21E-10**
242.3	**3.21E-10**
255.0	**1.66E-10**

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

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

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

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

Details to be completed for each assessment

Site Name:	**Bulls Bridge**			
Site Address:	**North Hyde Gardens, Hayes, UB3 4QQ**			
Completed by:	**T Cawood**			
Date:	**08-Jul-20**		**Version:**	**1**
Contaminant	**Fluoranthene**			
Target Concentration (C_T)	**0.0001**	**mg/l**	**Origin of C_T:**	**EQS**

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

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

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

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

Calculate for non-polar organic chemicals

Contaminant		**Fluoranthene**	
Target concentration	C_T	**0.0001**	**mg/l**

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	2.00E-01	fraction	Calculated
Air filled soil porosity	θa	8.10E-02	fraction	Calculated
Bulk density of soil zone material	ρ	2.00E+00	g/cm^3	Calculated
Henry's Law constant	H	4.20E-04	dimensionless	*EA SR7*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	1.74E-02	fraction	Site soil mean
Organic carbon partition coefficient	Koc	1.10E+07	l/kg	*Site Specific Koc*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**1.90E+05**	**l/kg**	*Calculated value*

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

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

Level 1 Remedial Target

Level 1 Remedial Target	**1.90E+01**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.0001	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08-Jul-20
Version:	1

Remedial Targets Worksheet , Release 3.2

Environment Agency

Level 2 - Soil

Contaminant		**Fluoranthene**		from Level 1	
Target concentration	C_T	**0.0001**	**mg/l**	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 contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	8.25E-04	m/d	**Mean daily rainfall at Heathrow 1981-2010 / 2**	
Area of contaminant source	A	0.00E+00	m^2		Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	2.50E+01	m		
Saturated aquifer thickness	da	3.50E+00	m		
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.64E-01	m/d		
Hydraulic gradient of water table	i	1.36E-02	fraction		
Width of contaminant source perpendicular to groundwater flow	w	2.50E+01	m		Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	3.50E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**1.38E+00**		
Level 2 Remedial Target		**1.38E-04**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentrati**
		or		
		2.62E+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:	Bulls Bridge
Completed by:	T Cawood
Date:	08-Jul-20
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Input Parameters	Variable	Value	Unit	Source
Contaminant		Fluoranthene		from Level 1
Target Concentration	C_T	0.0001	mg/l	from Level 1
Dilution Factor	DF	1.38E+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
Enter source concentration		**Soil leachate concentration as mg/l**		
Enter soil leachate concentration		**0.0048**	mg/l	
Half life for degradation of contaminant in water	$t_{1/2}$	8.80E+02	days	
Calculated decay rate	λ	7.88E-04	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	2.50E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	3.50E+00	m	from Level 2
Bulk density of aquifer materials	ρ	2.00E+00	g/cm^3	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	4.95E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.64E-01	m/d	from Level 2
Distance to compliance point	x	4.60E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.82E+04	l/kg	*see options*
Longitudinal dispersivity	ax	4.600	m	*see options*
Transverse dispersivity	az	0.460	m	*see options*
Vertical dispersivity	ay	0.046	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.71E-02	m/d
Retardation factor	Rf	1.22E+05	fraction
Decay rate used	λ	6.48E-09	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	4.95E-02	fraction
Rate of contaminant flow due to retardation	u	2.23E-07	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	2.61E-01	fraction
Attenuation factor (C_O/C_{ED})	**AF**	**3.84E+00**	**fraction**
Soil leachate concentration	Co	4.80E-03	

Remedial Targets

Level 3 Remedial Target		**5.29E-04**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		1.01E+02	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**46**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	**C_{ED}/C_0**	**2.61E-01**	**fraction**	Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	6.57E-03	fraction
Organic carbon partition coefficient	Koc	2.77E+06	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	1.82E+04	l/kg

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

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

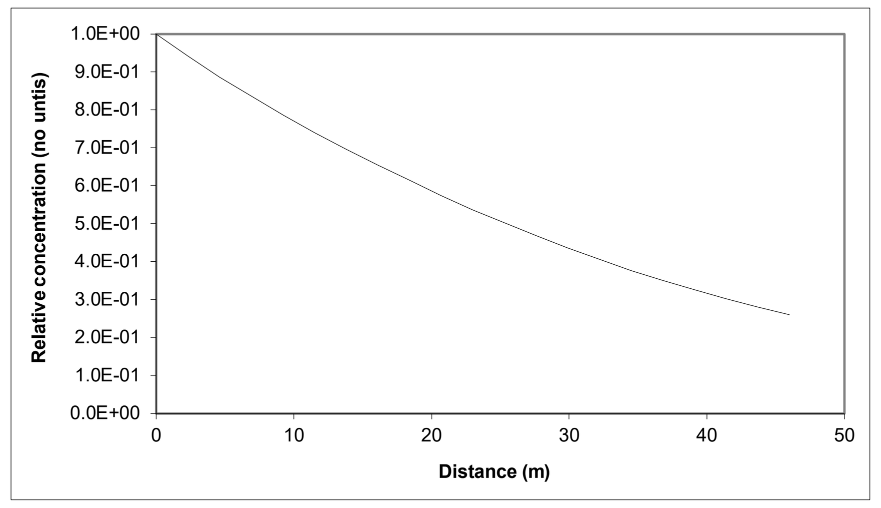
		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	4.60E+00	2.83E+00	m
Transverse dispersivity	**az**	0.00E+00	4.60E-01	2.83E-01	m
Vertical dispersivity	**ay**	0.00E+00	4.60E-02	2.83E-02	m

Note values of dispersivity must be > 0

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

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

Environment Agency



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

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

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

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

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08/07/2020
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	3.48E-03
2.3	9.42E-01	3.28E-03
4.6	8.87E-01	3.09E-03
6.9	8.36E-01	2.91E-03
9.2	7.87E-01	2.74E-03
11.5	7.41E-01	2.58E-03
13.8	6.97E-01	2.43E-03
16.1	6.55E-01	2.28E-03
18.4	6.14E-01	2.14E-03
20.7	5.75E-01	2.00E-03
23.0	5.38E-01	1.87E-03
25.3	5.02E-01	1.75E-03
27.6	4.68E-01	1.63E-03
29.9	4.36E-01	1.52E-03
32.2	4.06E-01	1.41E-03
34.5	3.77E-01	1.31E-03
36.8	3.51E-01	1.22E-03
39.1	3.26E-01	1.13E-03
41.4	3.03E-01	1.05E-03
43.7	2.81E-01	9.78E-04
46.0	2.61E-01	9.07E-04

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Environment Agency

Input Parameters (using pull down menu)

Input Parameters	Variable	Value	Unit	Source
Contaminant		Fluoranthene		from Level 1
Target Concentration	C_T	1.00E-04	mg/l	from Level 1

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

Ogata Banks — Equations in HRA publication

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

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

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

Parameter	Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	3.09E-03	mg/l	*Max concentration at BH08*
Half life for degradation of contaminant in water	$t_{1/2}$	8.80E+02	days	*Howard et al, 1991*
Calculated decay rate	λ	7.88E-04	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	2.50E+01	m	*Estimate based on site data*
Plume thickness at source	Sy	3.25E+00	m	*Estimate based on site data*
Saturated aquifer thickness	da	3.50E+00	m	*Sturated thickness at BH08*
Bulk density of aquifer materials	ρ	1.60E+00	g/cm^3	*Estimate based on site data*
Effective porosity of aquifer	n	3.00E-01	fraction	*Estimate based on site data*
Hydraulic gradient	i	1.36E-02	fraction	*Calculatated from site data*
Hydraulic conductivity of aquifer	K	1.64E-01	m/d	*Calculated from variable head testing*
Distance to compliance point	x	4.60E+01	m	*Distance to River Crane*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.82E+04	l/kg	*see options*
Longitudinal dispersivity	ax	4.60E+00	m	*see options*
Transverse dispersivity	az	4.60E-01	m	*see options*
Vertical dispersivity	ay	4.60E-02	m	*see options*

Calculated Parameters

Calculated Parameters	Variable	Value	Unit
Groundwater flow velocity	v	7.43E-03	m/d
Retardation factor	Rf	9.72E+04	fraction
Decay rate used	λ	8.11E-09	d^{-1}
Rate of contaminant flow due to retardation	u	7.65E-08	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	7.15E-05	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**4.32E+01**	

Remedial Targets

Remedial Target	**4.32E-03**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	**46**	**m**	
Concentration of contaminant at compliance point C_{ED}/C_0	**7.15E-05**	**mg/l**	Ogata Banks
after	**1.0E+100**	**days**	

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	6.57E-03	fraction
Organic carbon partition coefficient	Koc	2.77E+06	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	1.82E+04	l/kg

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

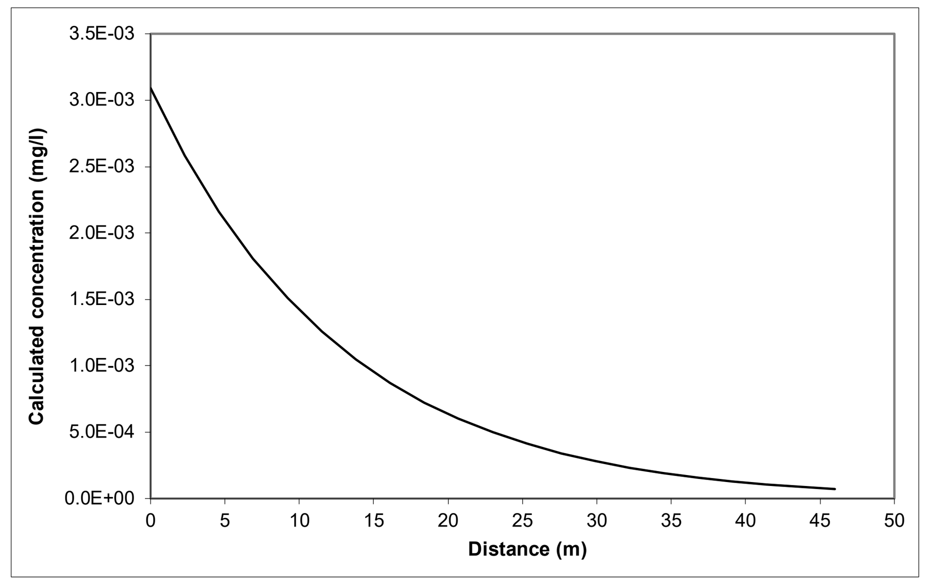
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	0.00E+00	4.60E+00	2.83E+00	m
Transverse dispersivity	**az**	0.00E+00	4.60E-01	2.83E-01	m
Vertical dispersivity	**ay**	0.00E+00	4.60E-02	2.83E-02	

Note values of dispersivity must be > 0

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

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



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

Note

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

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

The measured groundwater concentration should be compared
with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

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

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08/07/2020
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Concentration**
	mg/l
0	**3.1E-03**
2.3	**2.58E-03**
4.6	**2.16E-03**
6.9	**1.80E-03**
9.2	**1.51E-03**
11.5	**1.26E-03**
13.8	**1.05E-03**
16.1	**8.72E-04**
18.4	**7.25E-04**
20.7	**6.01E-04**
23.0	**4.97E-04**
25.3	**4.11E-04**
27.6	**3.40E-04**
29.9	**2.80E-04**
32.2	**2.31E-04**
34.5	**1.90E-04**
36.8	**1.56E-04**
39.1	**1.29E-04**
41.4	**1.06E-04**
43.7	**8.70E-05**
46.0	**7.15E-05**

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

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

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

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

Details to be completed for each assessment

Site Name:	**Bulls Bridge**			
Site Address:	**North Hyde Gardens, Hayes, UB3 4QQ**			
Completed by:	**T Cawood**			
Date:	**08-Jul-20**		**Version:**	**1**
Contaminant	**Naphthalene**			
Target Concentration (C_T)	**0.002**	**mg/l**	**Origin of C_T:**	**EQS**

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

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

Environment Agency

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

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

Calculate for non-polar organic chemicals

Contaminant		**Naphthalene**	
Target concentration	C_T	**0.002**	**mg/l**

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	2.00E-01	fraction	Calculated
Air filled soil porosity	θa	8.10E-02	fraction	Calculated
Bulk density of soil zone material	ρ	2.00E+00	g/cm^3	Calculated
Henry's Law constant	H	1.74E-02	dimensionless	*EA SR7*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	1.74E-02	fraction	Site soil mean
Organic carbon partition coefficient	Koc	5.21E+04	l/kg	*Site Specific Koc*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**9.03E+02**	**l/kg**	*Calculated value*

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

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

Level 1 Remedial Target

Level 1 Remedial Target	**1.81E+00**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.002	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08-Jul-20
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**Naphthalene**		from Level 1
Target concentration	C_T	**0.002**	**mg/l**	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 contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	8.25E-04	m/d	**Mean daily rainfall at Heathrow 1981-2010 / 2**	
Area of contaminant source	A		m^2		Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	2.50E+01	m		
Saturated aquifer thickness	da	3.50E+00	m		
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.64E-01	m/d		
Hydraulic gradient of water table	i	1.36E-02	fraction		
Width of contaminant source perpendicular to groundwater flow	w	2.50E+01	m		Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	3.50E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**1.38E+00**		
Level 2 Remedial Target		**2.76E-03**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentrati**
		or		
		2.49E+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)	Cc	6.89E-04	mg/l	
Calculated concentration within receptor (dilution only)		5.00E-04	mg/l	0

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08-Jul-20
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	1.38E+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
Enter source concentration		Soil leachate concentration as mg/l		
Enter soil leachate concentration		4.7	mg/l	
Half life for degradation of contaminant in water	$t_{1/2}$	2.58E+02	days	*Howard et al, 1991*
Calculated decay rate	λ	2.69E-03	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	2.50E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	3.50E+00	m	from Level 2
Bulk density of aquifer materials	ρ	2.00E+00	g/cm^3	*Esitmate based on site data*
Effective porosity of aquifer	n	3.00E-01	fraction	*Esitmate based on site data*
Hydraulic gradient	i	4.95E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.64E-01	m/d	from Level 2
Distance to compliance point	x	4.60E+01	m	*Distance to River Crane*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	3.42E+02	l/kg	*see options*
Longitudinal dispersivity	ax	4.600	m	*see options*
Transverse dispersivity	az	0.460	m	*see options*
Vertical dispersivity	ay	0.046	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.71E-02	m/d
Retardation factor	Rf	2.28E+03	fraction
Decay rate used	λ	1.18E-06	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	4.95E-02	fraction
Rate of contaminant flow due to retardation	u	1.19E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	2.86E-02	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**3.50E+01**	**fraction**
Soil leachate concentration	Co	4.70E+00	

Remedial Targets

Level 3 Remedial Target		**9.64E-02**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		8.71E+01	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**46**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**2.86E-02**	**fraction**	Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	6.57E-03	fraction
Organic carbon partition coefficient	Koc	5.21E+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	3.42E+02	l/kg

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

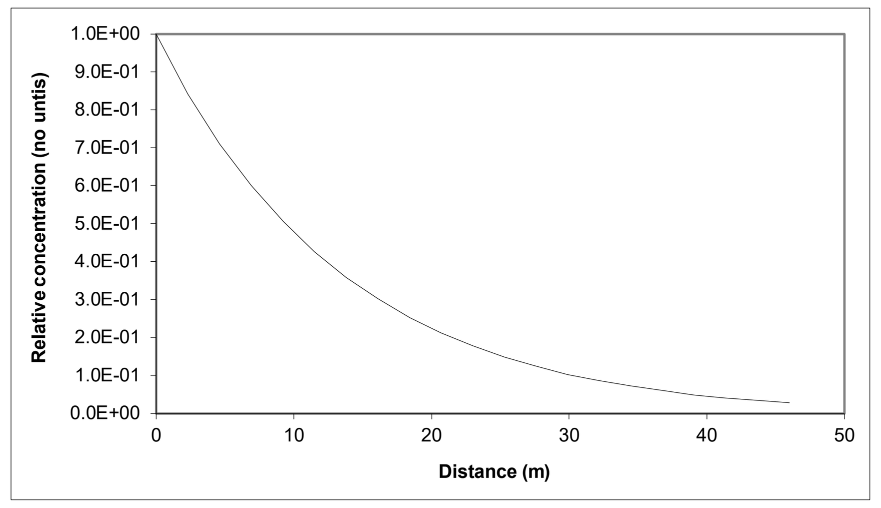
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	4.60E+00	2.83E+00	m
Transverse dispersivity	**az**	0.00E+00	4.60E-01	2.83E-01	m
Vertical dispersivity	**ay**	0.00E+00	4.60E-02	2.83E-02	m

Note values of dispersivity must be > 0

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

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



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

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

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

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

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08/07/2020
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	3.41E+00
2.3	8.43E-01	2.88E+00
4.6	7.11E-01	2.43E+00
6.9	6.00E-01	2.05E+00
9.2	5.06E-01	1.73E+00
11.5	4.27E-01	1.45E+00
13.8	3.59E-01	1.22E+00
16.1	3.02E-01	1.03E+00
18.4	2.54E-01	8.65E-01
20.7	2.13E-01	7.25E-01
23.0	1.78E-01	6.07E-01
25.3	1.49E-01	5.08E-01
27.6	1.24E-01	4.24E-01
29.9	1.04E-01	3.54E-01
32.2	8.65E-02	2.95E-01
34.5	7.20E-02	2.45E-01
36.8	5.99E-02	2.04E-01
39.1	4.98E-02	1.70E-01
41.4	4.14E-02	1.41E-01
43.7	3.44E-02	1.17E-01
46.0	2.86E-02	9.75E-02

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		Naphthalene		from Level 1
Target Concentration	C_T	2.00E-03	mg/l	from Level 1

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

Ogata Banks — Equations in HRA publication

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

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

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

	Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	5.62E+00	mg/l	*Max concentration at BH08*
Half life for degradation of contaminant in water	$t_{1/2}$	2.58E+02	days	*Howard et al, 1991*
Calculated decay rate	λ	2.69E-03	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	2.50E+01	m	*Estimate based on site data*
Plume thickness at source	Sy	3.25E+00	m	*Estimate based on site data*
Saturated aquifer thickness	da	3.50E+00	m	*Sturated thickness at BH08*
Bulk density of aquifer materials	ρ	2.00E+00	g/cm^3	*Estimate based on site data*
Effective porosity of aquifer	n	3.00E-01	fraction	*Estimate based on site data*
Hydraulic gradient	i	1.36E-02	fraction	*Calculatated from site data*
Hydraulic conductivity of aquifer	K	1.64E-01	m/d	*Calculated from variable head testing*
Distance to compliance point	x	4.60E+01	m	*Distance to River Crane*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	3.42E+02	l/kg	*see options*
Longitudinal dispersivity	ax	4.60E+00	m	*see options*
Transverse dispersivity	az	4.60E-01	m	*see options*
Vertical dispersivity	ay	4.60E-02	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	7.43E-03	m/d
Retardation factor	Rf	2.28E+03	fraction
Decay rate used	λ	1.18E-06	d^{-1}
Rate of contaminant flow due to retardation	u	3.26E-06	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	6.89E-04	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**8.15E+03**	

Remedial Targets

Remedial Target	**1.63E+01**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	**46**	**m**	
Concentration of contaminant at compliance point C_{ED}/C_0	**6.89E-04**	**mg/l**	Ogata Banks
after	**1.0E+100**	**days**	

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	6.57E-03	fraction
Organic carbon partition coefficient	Koc	5.21E+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	3.42E+02	l/kg

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

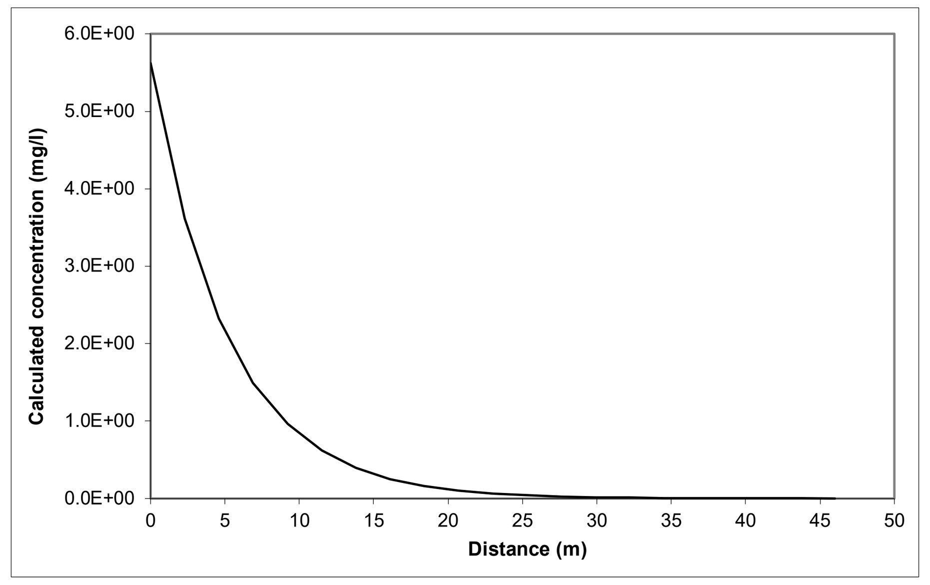
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	0.00E+00	4.60E+00	2.83E+00	m
Transverse dispersivity	**az**	0.00E+00	4.60E-01	2.83E-01	m
Vertical dispersivity	**ay**	0.00E+00	4.60E-02	2.83E-02	

Note values of dispersivity must be > 0

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

Environment Agency



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

Note

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

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

The measured groundwater concentration should be compared

with the Level 3 remedial target to determine the need for further action.

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

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

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08/07/2020
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Concentration**
	mg/l
0	**5.6E+00**
2.3	**3.61E+00**
4.6	**2.32E+00**
6.9	**1.49E+00**
9.2	**9.61E-01**
11.5	**6.17E-01**
13.8	**3.96E-01**
16.1	**2.53E-01**
18.4	**1.62E-01**
20.7	**1.03E-01**
23.0	**6.58E-02**
25.3	**4.19E-02**
27.6	**2.66E-02**
29.9	**1.69E-02**
32.2	**1.07E-02**
34.5	**6.79E-03**
36.8	**4.30E-03**
39.1	**2.72E-03**
41.4	**1.72E-03**
43.7	**1.09E-03**
46.0	**6.89E-04**

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

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

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

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

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

Details to be completed for each assessment

Site Name:	**Bulls Bridge**			
Site Address:	**North Hyde Gardens, Hayes, UB3 4QQ**			
Completed by:	**T Cawood**			
Date:	**08-Jul-20**		**Version:**	**1**
Contaminant	**Phenol**			
Target Concentration (C_T)	**0.0077**	**mg/l**	**Origin of C_T:**	**EQS**

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

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

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Environment Agency

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

Calculate for non-polar organic chemicals

Contaminant		**Phenol**		
Target concentration	C_T	**0.0077**	**mg/l**	
Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	2.00E-01	fraction	Calculated
Air filled soil porosity	θa	8.10E-02	fraction	Calculated
Bulk density of soil zone material	ρ	2.00E+00	g/cm^3	Calculated
Henry's Law constant	H	2.62E-05	dimensionless	
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	1.74E-02	fraction	Site soil mean
Organic carbon partition coefficient	Koc	2.88E+03	l/kg	*Mackay, Shui and Ma, 2000*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**5.00E+01**	**l/kg**	*Calculated value*

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

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

Level 1 Remedial Target

Level 1 Remedial Target	**3.86E-01**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.0077	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08-Jul-20
Version:	1

Remedial Targets Worksheet , Release 3.2

Environment Agency

Level 2 - Soil

Contaminant		Phenol		from Level 1
Target concentration	C_T	**0.0077**	**mg/l**	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 contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	8.25E-04	m/d	**Mean daily rainfall at Heathrow 1981-2010 / 2**	
Area of contaminant source	A	0.00E+00	m^2		Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	2.50E+01	m		
Saturated aquifer thickness	da	3.50E+00	m		
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.64E-01	m/d		
Hydraulic gradient of water table	i	1.36E-02	fraction		
Width of contaminant source perpendicular to groundwater flow	w	2.50E+01	m		Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	3.50E+00	m		

Calculated Parameters

Dilution Factor	DF	**1.38E+00**		
Level 2 Remedial Target		**1.06E-02**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentrati**
		or		
		5.32E-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:	Bulls Bridge
Completed by:	T Cawood
Date:	08-Jul-20
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	1.38E+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
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		390	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	7.00E+00	days	
Calculated decay rate	λ	9.90E-02	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	2.50E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	3.50E+00	m	from Level 2
Bulk density of aquifer materials	ρ	2.00E+00	g/cm^3	
Effective porosity of aquifer	n	3.00E-01	fraction	
Hydraulic gradient	i	4.95E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.64E-01	m/d	from Level 2
Distance to compliance point	x	4.60E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.89E+01	l/kg	*see options*
Longitudinal dispersivity	ax	4.600	m	*see options*
Transverse dispersivity	az	0.460	m	*see options*
Vertical dispersivity	ay	0.046	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.71E-02	m/d
Retardation factor	Rf	1.27E+02	fraction
Decay rate used	λ	7.78E-04	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	4.95E-02	fraction
Rate of contaminant flow due to retardation	u	2.13E-04	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	1.45E-16	fraction
Attenuation factor (C_O/C_{ED})	**AF**	**6.88E+15**	**fraction**
Calculated soil leachate concentration	Co	7.78E+00	mg/l

Remedial Targets

Level 3 Remedial Target		**7.30E+13**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		3.66E+15	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**46**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**1.45E-16**	**fraction**	Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	6.57E-03	fraction
Organic carbon partition coefficient	Koc	2.88E+03	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.89E+01	l/kg

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

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

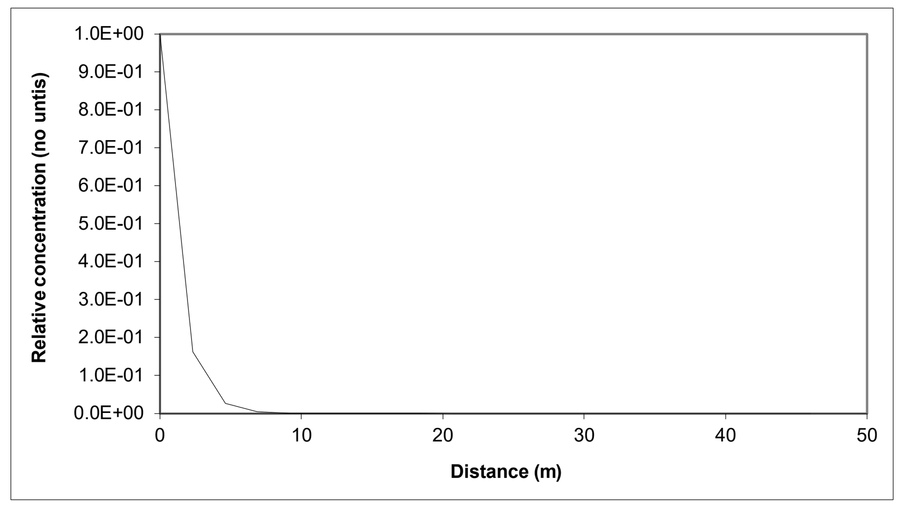
		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	4.60E+00	2.83E+00	m
Transverse dispersivity	**az**	0.00E+00	4.60E-01	2.83E-01	m
Vertical dispersivity	**ay**	0.00E+00	4.60E-02	2.83E-02	m

Note values of dispersivity must be > 0

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

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

Environment Agency



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

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

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

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

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08/07/2020
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	5.64E+00
2.3	1.63E-01	9.18E-01
4.6	2.65E-02	1.49E-01
6.9	4.31E-03	2.43E-02
9.2	7.00E-04	3.95E-03
11.5	1.14E-04	6.43E-04
13.8	1.85E-05	1.04E-04
16.1	3.00E-06	1.69E-05
18.4	4.86E-07	2.74E-06
20.7	7.86E-08	4.44E-07
23.0	1.27E-08	7.16E-08
25.3	2.05E-09	1.16E-08
27.6	3.30E-10	1.86E-09
29.9	5.31E-11	2.99E-10
32.2	8.53E-12	4.81E-11
34.5	1.37E-12	7.73E-12
36.8	2.20E-13	1.24E-12
39.1	3.53E-14	1.99E-13
41.4	5.66E-15	3.19E-14
43.7	9.07E-16	5.12E-15
46.0	1.45E-16	8.20E-16

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		Phenol		from Level 1
Target Concentration	C_T	7.70E-03	mg/l	from Level 1

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

Ogata Banks — Equations in HRA publication

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

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

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

	Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	7.90E-01	mg/l	*Max concentration at BH08*
Half life for degradation of contaminant in water	$t_{1/2}$	7.00E+00	days	*Howard et al, 1991*
Calculated decay rate	λ	9.90E-02	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	2.50E+01	m	*Estimate based on site data*
Plume thickness at source	Sy	3.25E+00	m	*Estimate based on site data*
Saturated aquifer thickness	da	3.50E+00	m	*Sturated thickness at BH08*
Bulk density of aquifer materials	ρ	1.60E+00	g/cm^3	*Estimate based on site data*
Effective porosity of aquifer	n	3.00E-01	fraction	*Estimate based on site data*
Hydraulic gradient	i	1.36E-02	fraction	*Calculated from site data*
Hydraulic conductivity of aquifer	K	1.64E-01	m/d	*Calculated from variable head testing*
Distance to compliance point	x	4.60E+01	m	*Distance to River Crane*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.89E+01	l/kg	*see options*
Longitudinal dispersivity	ax	4.60E+00	m	*see options*
Transverse dispersivity	az	4.60E-01	m	*see options*
Vertical dispersivity	ay	4.60E-02	m	*see options*

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	6.57E-03	fraction
Organic carbon partition coefficient	Koc	2.88E+03	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.89E+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	4.60E+00	2.83E+00	m
Transverse dispersivity	**az**	0.00E+00	4.60E-01	2.83E-01	m
Vertical dispersivity	**ay**	0.00E+00	4.60E-02	2.83E-02	

Note values of dispersivity must be > 0

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

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

Calculated Parameters

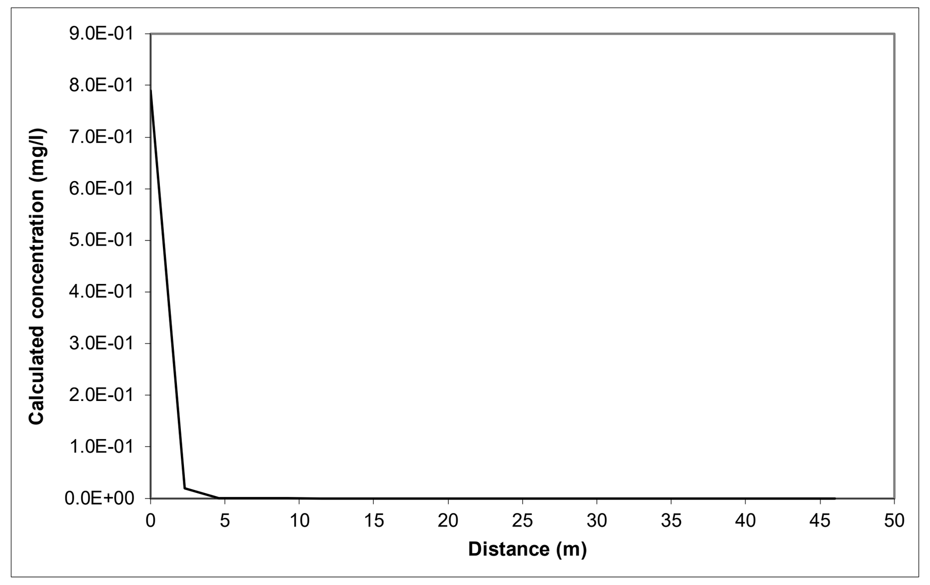
	Variable	Value	Unit
Groundwater flow velocity	v	7.43E-03	m/d
Retardation factor	Rf	1.02E+02	fraction
Decay rate used	λ	9.70E-04	d^{-1}
Rate of contaminant flow due to retardation	u	7.28E-05	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	8.48E-33	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**9.31E+31**	

Remedial Targets

Remedial Target	**7.17E+29**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	**46**	**m**	
Concentration of contaminant at compliance point C_{ED}/C_0	**8.48E-33**	**mg/l**	Ogata Banks
after	**1.0E+100**	**days**	

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

Environment Agency



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

Note

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

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

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

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

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

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	**Concentration**
	mg/l
0	**7.9E-01**
2.3	**2.01E-02**
4.6	**5.11E-04**
6.9	**1.30E-05**
9.2	**3.30E-07**
11.5	**8.39E-09**
13.8	**2.13E-10**
16.1	**5.39E-12**
18.4	**1.36E-13**
20.7	**3.44E-15**
23.0	**8.66E-17**
25.3	**2.18E-18**
27.6	**5.47E-20**
29.9	**1.37E-21**
32.2	**3.45E-23**
34.5	**8.64E-25**
36.8	**2.16E-26**
39.1	**5.42E-28**
41.4	**1.36E-29**
43.7	**3.39E-31**
46.0	**8.48E-33**

Site being assessed:	Bulls Bridge
Completed by:	T Cawood
Date:	08/07/2020
Version:	1

APPENDIX G: RTM INPUT PARAMETERS

Site Specific Parameters - Bulls Bridge, Hayes

Level 1 - Soil

Water filled soil porosity	fraction	0.2	Calculated from site specific moisture content
Air filled soil porosity	fraction	0.081	Calculated from site specific moisture content
Bulk density of soil zone material	g/cm^3	2	Estimate based on site data
Fraction of organic carbon (in soil)	fraction	0.01735	Calculated from lab data

Level 2 - Soil

Infiltration	m/d	0.000825	Mean daily rainfall at Heathrow 1981-2010 / 2
Hydraulic Conductivity of aquifer in which dilution occurs	m/d	0.164	Variable head testing undertaken on site
Hydraulic gradient of water table	fraction	0.0136	Calculated from groundwater contours

Level 3 - Soil / Groundwater

Bulk density of aquifer materials	g/cm3	2	Estimate based on site data
Effective porosity of aquifer	fraction	0.3	Estimate based on site data
Hydraulic Conductivity of aquifer in which dilution occurs	m/d	0.164	Variable head testing undertaken on site
Hydraulic gradient of water table	fraction	0.0136	Calculated from groundwater contours
Fraction of organic carbon in aquifer	fraction	0.00657	Calculated from lab data

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Contaminant Specific Parameters - Bulls Bridge, Hayes

Contaminant	Koc	Kd	Reference	Henry's Law Constant	Reference	Half Life (days)	Reference
Anthracene	2774475	-	Site Specific	0.0016	Environment Agency, 2008	919.8	Howard et al, 1991
Acenaphthylene	6761	-	Mackay et al, 2000	0.0034	Environment Agency, 2008	120	Howard et al, 1991
Fluoranthene	10958025	-	Site Specific	0.00042	Environment Agency, 2008	879.65	Howard et al, 1991
Naphthalene	52073	-	Site Specific	0.0174	Environment Agency, 2008	258	Howard et al, 1991
Phenol	2884	-	Mackay et al, 2000	0.0000262	Environment Agency, 2008	7	Howard et al, 1991
Ammonia	-	0.9	EA /SNIFFER, 2007	-		2190	EA /SNIFFER, 2007

Environment Agency (2008), Compilation of data for priority organic pollutants for derivation of Soil Guideline Values. Science report: SC050021/SR7.
Howard, P. H. et al, (1991). Handbook of Environmental Degradation Rates. CRC Press.
Mackay, D., Shiu, W-Y and Ma, K-C. (2000). Physical-Chemical Properties and Environmental Fate Handbook. Chapman & Hall / CRCnetBASE.
Environment Agency / SNIFFER (2007). Proposed EQS for Water Framework Directive Annex VIII substances: ammonia (un-ionised). Science Report: SC040038/SR2.

APPENDIX H : SITE SPECIFIC KOC CALCULATIONS

Koc Calculations - Bulls Bridge, Hayes

	BH08	BH08	Kd	Koc	BH07	BH07	Kd	Koc	Mean Koc
	5.50-6.00	5.50-6.00			5.80-6.00	5.80-6.00			
	ug/l	ug/kg			ug/l	ug/kg			
Naphthalene	4700	79000	17	7245	250	65000	260	89655	52073
Anthracene	5.8	18000	3103	1337693	3	25000	8333	2873563	2774475
Fluoranthene	4.8	37000	7708	3322557	2.1	93000	44286	15270936	10958025
Soil Organic Matter (%)		0.4				0.5			
FOC (SOM x 0.0058)		0.00232				0.00290			

APPENDIX I: RTM RESULTS AND SCREENING

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Level 3 RTM Results and Screening - Bulls Bridge, Hayes

Contaminant	Location	RTM Assessment Level	Derived Remedial Target			Max Lab Value at Location		
			Groundwater (ug/l)	Leachate (ug/l)	Soil (mg/kg)	Groundwater (ug/l)	Leachate (ug/l)	Soil (mg/kg)
Ammonia	WS7	L3	270			17000		
Ammonia	BH01 J	L3	28.6			8900		
Phenol	BH08	L3	7.17E+29	EE	EE	790	-	390
Naphthalene	BH08	L3	16310	96.4	87.1	5620	4700	79
Anthracene	BH08	L3	3.81	0.505	24.3	15.9	5.8	18
Anthracene	BH02	L3	21.8	1.25	60300	2.69	-	83
Anthracene	BH07	L3	0.607	0.24	11.5	0.4	2.1	25
Fluoranthene	BH08	L3	4.32	0.529	100.6	3.09	4.8	37
Fluoranthene	BH03	L3	1.86E+06	301	57200			380
Xylenes (Acenaphthylene)	BH08	L3	1.45E+07	4120	484000	14.1	9.0	0.05
Anthracene	BH08	L4	16.6	2.2	106	15.9	5.8	18
Anthracene	BH07	L4	2.64	1.04	50.2	0.4	2.1	25

(green)	Remedial Target Not Exceeded
(amber)	Remedial Target Exceeded
EE	Remedial Target Extremely High

APPENDIX J: RIVER CRANE GAUGING DATA

39057 - Crane at Cranford Park

Station info | Daily flow data | Live data | Peak flow data | Catchment info | Photo gallery

Data Series: Gauged Daily Flow

Period of Record:	1978 - 2018
Percent Complete:	>99 %
Base Flow Index:	0.33
Mean Flow:	0.507 m^3/s
95% Exceedance (Q95):	0.087 m^3/s
70% Exceedance (Q70):	0.162 m^3/s
50% Exceedance (Q50):	0.233 m^3/s
10% Exceedance (Q10):	1.1 m^3/s
5% Exceedance (Q5):	1.83 m^3/s

Download Data

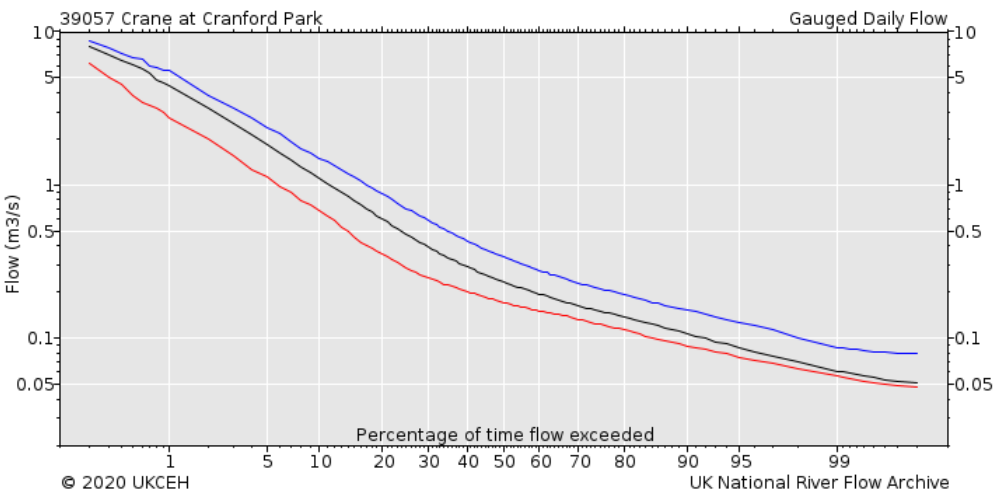
Gauged daily flow (GDF) data is available for download for this station.

Download flow data

Catchment daily rainfall (CDR) data is available for download for this station from 1961 or the start of the flow record (whichever is earliest) to 2017.

Download catchment daily rainfall data

Graph Type: Flow Duration Curve



Key: Black line - annual; blue line - December to March; red line - June to September.
Underlying data supplied by the Environment Agency

:: Data Completeness

	1970s	1980s	1990s	2000s	2010s	2020s
GDF						

@UK_NRFA

- RT @UK_CEH: Latest UK Hydrological Summary published: #river flows in the west likely to be normal to above normal in July; flo… https://t.co/hvPLupgiDK — *10 hours 23 min* ago
- #ICYMI: Last week the @UK_CEH team published a blog post considering the dramatic hydrological change over the spri… https://t.co/8elOaDfvqE — *3 weeks 9 hours* ago
- RT @DrEdHenderson: At Langwathby on the River Eden in #Cumbria there is a ‘temporary’ bridge installed after a #flood in March 1968 to… https://t.co/Bv4gtxn81r — *3 weeks 5 days* ago

Environment Agency

SEPA
Scottish Environment Protection Agency

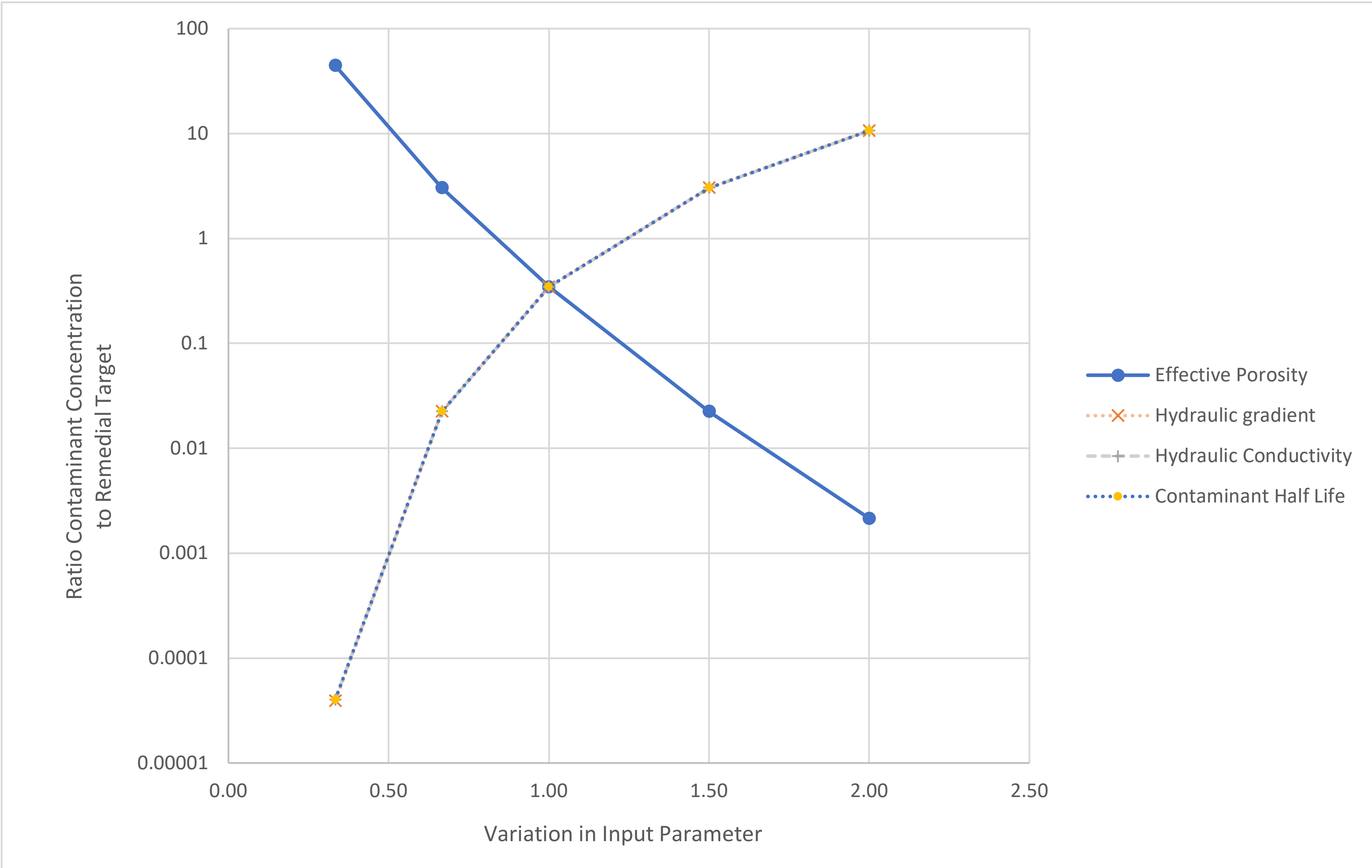
Cyfoeth Naturiol Cymru
Natural Resources Wales

APPENDIX K: SENSITIVITY ANALYSIS

Naphthalene BH08 Sensitivity Analysis

			Sensitive?
Initial contaminant concentration in groundwater at plume core	5.62	mg/l	
Half life for degradation of contaminant in water	258	days	
Calculated decay rate	0.002687	days-1	
Width of plume in aquifer at source (perpendicular to flow)	25	m	No
Plume thickness at source	3.25	m	No
Saturated aquifer thickness	3.5	m	No
Bulk density of aquifer materials	2	g/cm3	No
Effective porosity of aquifer	0.3	fraction	Yes
Hydraulic gradient	0.0136	fraction	Yes
Hydraulic conductivity of aquifer	0.164	m/d	Yes
Distance to compliance point	46	m	
Fraction of organic carbon in aquifer	0.00657	fraction	
Organic carbon partition coefficient	52073	l/kg	
Remedial Target	16.30	mg/l	

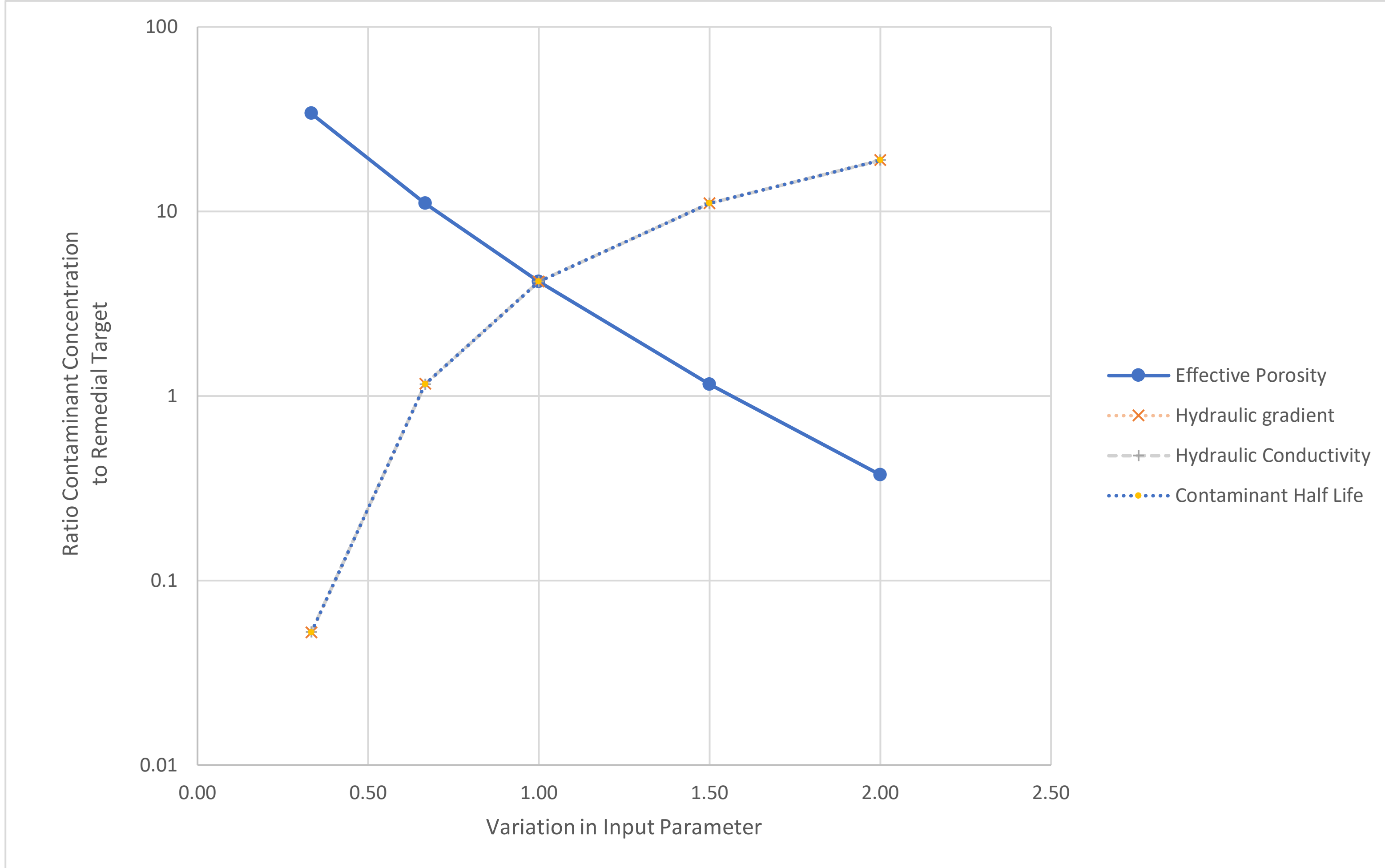
				Remedial Target	Ratio
Effective porosity of aquifer	0.1	fraction	0.33	0.13	44.53545058
	0.2	fraction	0.67	1.85	3.032015789
	0.3	fraction	1.00	16.3	0.344785276
	0.45	fraction	1.50	251	0.022370498
	0.6	fraction	2.00	2617	0.002147847
Hydraulic gradient	0.00453	fraction	0.33	144270.8	3.89545E-05
	0.00907	fraction	0.67	250.5	0.022432472
	0.01360	fraction	1.00	16.3	0.344785276
	0.02040	fraction	1.50	1.9	3.032015789
	0.02720	fraction	2.00	0.5	10.65033884
Hydraulic conductivity of aquifer	0.054667	m/d	0.33	139701.3	4.02287E-05
	0.109333	m/d	0.67	251.2	0.022369984
	0.164	m/d	1.00	16.3	0.344785276
	0.246	m/d	1.50	1.85	3.032015789
	0.328	m/d	2.00	0.528	10.65033884
Half life for degradation of contaminant in water	86	days	0.33	139710.59	4.0226E-05
	172	days	0.67	251.22	0.022370498
	258	days	1.00	16.30	0.344785276
	387	days	1.50	1.85	3.032015789
	516	days	2.00	0.53	10.65033884



Anthracene BH08 Sensitivity Analysis

			Sensitive?
Initial contaminant concentration in groundwater at plume core	0.0159	mg/l	
Half life for degradation of contaminant in water	919.8	days	
Calculated decay rate	0.000754	days-1	
Width of plume in aquifer at source (perpendicular to flow)	25	m	No
Plume thickness at source	3.25	m	No
Saturated aquifer thickness	3.5	m	No
Bulk density of aquifer materials	2	g/cm3	No
Effective porosity of aquifer	0.3	fraction	Yes
Hydraulic gradient	0.0136	fraction	Yes
Hydraulic conductivity of aquifer	0.164	m/d	Yes
Distance to compliance point	46	m	
Fraction of organic carbon in aquifer	0.00657	fraction	
Organic carbon partition coefficient	2774475	l/kg	
Remedial Target	0.00381	mg/l	

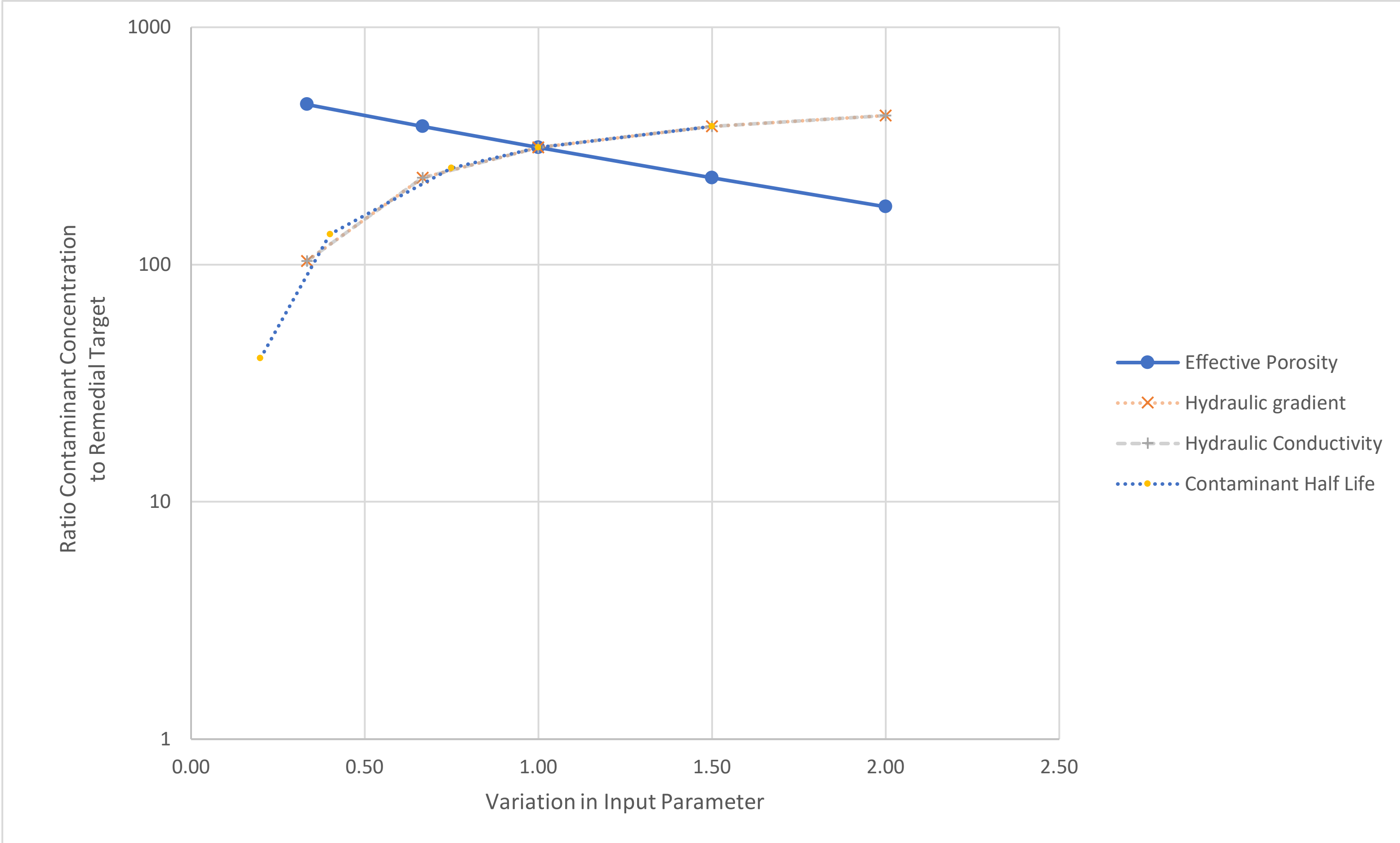
				Remedial Target	Ratio
Effective porosity of aquifer	0.1	fraction	0.33	0.000469	33.92567
	0.2	fraction	0.67	0.001439	11.05047
	0.3	fraction	1.00	0.003810	4.173228
	0.45	fraction	1.50	0.013717	1.159135
	0.6	fraction	2.00	0.042495	0.374164
Hydraulic gradient	0.00453	fraction	0.33	0.304766	0.052171
	0.00907	fraction	0.67	0.013699	1.160665
	0.01360	fraction	1.00	0.003810	4.173228
	0.02040	fraction	1.50	0.001439	11.05047
	0.02720	fraction	2.00	0.000840	18.92831
Hydraulic conductivity of aquifer	0.0547	m/d	0.33	0.302541	0.052555
	0.1093	m/d	0.67	0.013732	1.157867
	0.1640	m/d	1.00	0.003810	4.173228
	0.2460	m/d	1.50	0.001439	11.05047
	0.3280	m/d	2.00	0.000840	18.92831
Half life for degradation of contaminant in water	306.6	days	0.33	0.303547	0.052381
	613.2	days	0.67	0.013717	1.159135
	919.8	days	1.00	0.003810	4.173228
	1379.7	days	1.50	0.001439	11.05047
	1839.6	days	2.00	0.000840	18.92831



Ammonia BH01 J Sensitivity Analysis

			Sensitive?
Initial contaminant concentration in groundwater at plume core	8.9	mg/l	
Half life for degradation of contaminant in water	2190	days	
Calculated decay rate	0.000317	days-1	
Width of plume in aquifer at source (perpendicular to flow)	300	m	No
Plume thickness at source	2	m	No
Saturated aquifer thickness	2.25	m	No
Bulk density of aquifer materials	2	g/cm3	No
Effective porosity of aquifer	0.3	fraction	Yes
Hydraulic gradient	0.0136	fraction	Yes
Hydraulic conductivity of aquifer	0.164	m/d	Yes
Distance to compliance point	16	m	
Soil water partition coefficient	2774475	l/kg	
Remedial Target	0.02860	mg/l	

				Remedial Target	Ratio
Effective porosity of aquifer	0.1	fraction	0.33	0.018829	472.6858
	0.2	fraction	0.67	0.023299	381.9836
	0.3	fraction	1.00	0.02860	311.1784
	0.45	fraction	1.50	0.038386	231.8555
	0.6	fraction	2.00	0.050807	175.1738
Hydraulic gradient	0.00453	fraction	0.33	0.086050	103.4283
	0.00907	fraction	0.67	0.038374	231.9289
	0.01360	fraction	1.00	0.02860	311.1784
	0.02040	fraction	1.50	0.023299	381.9836
	0.02720	fraction	2.00	0.020967	424.4692
Hydraulic conductivity of aquifer	0.0547	m/d	0.33	0.086050	103.4283
	0.1093	m/d	0.67	0.038374	231.9289
	0.1640	m/d	1.00	0.028601	311.1784
	0.2460	m/d	1.50	0.023299	381.9836
	0.3280	m/d	2.00	0.020967	424.4692
Half life for degradation of contaminant in water	438	days	0.20	0.221011	40.26955
	876	days	0.40	0.066437	133.9617
	1642.5	days	0.75	0.034857	255.3283
	2190	days	1.00	0.028601	311.1784
	3285	days	1.50	0.023299	381.9836



APPENDIX L: QUALITATIVE RISK ASSESSMENT METHODOLOGY

QRA METHODOLOGY

RISK ASSESSMENT METHODOLOGY

The Qualitative Risk Assessment presented in this report is based on the definitions outlined in CIRIA C552 (2001).

- highly likely: the event appears 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: it is probable that an event will occur or circumstances are such that the event is not inevitable, but possible in the short term and likely over the long term
- low likelihood: circumstances are possible under which an event could occur, but it is not certain even in the long term that an event would occur and it is less likely in the short term
- unlikely: circumstances are such that it is improbable the event would occur even in the long term.

The severity can be classified using a similar system also based on CIRIA C552. The terms and definitions relating to severity are:

- severe: short term (acute) risk to human health likely to result in 'significant harm' as defined by the Environment Protection Act 1990, Part IIA. Short-term risk of pollution of sensitive water resources. Catastrophic damage to buildings or property. Short-term risk to an ecosystem or organism forming part of that ecosystem (note definition of ecosystem in 'Draft Circular on Contaminated Land', DETR 2000).
- medium: chronic damage to human health ('significant harm' as defined in 'Draft Circular on Contaminated Land', DETR 2000), pollution of sensitive water resources, significant change in an ecosystem or organism forming part of that ecosystem.
- mild: pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services ('significant harm' as defined in 'Draft Circular on Contaminated Land', DETR 2000). Damage to sensitive buildings, structures or the environment
- minor: harm, not necessarily significant, but that could result in financial loss or expenditure to resolve. Non-permanent human health effects easily prevented by use of personal protective clothing. Easily repairable damage to buildings, structures and services.

Once the probability of an event occurring and its consequences have been classified, a risk category can be assigned according to the table below.

		Consequences			
		Severe	Medium	Mild	Minor
Probability	Highly likely	Very high	High	Moderate	Moderate/low
	Likely	High	Moderate	Moderate/low	Low
	Low likelihood	Moderate	Moderate/low	Low	Very low
	Unlikely	Moderate/low	Low	Very low	Very low

Definitions of these risk categories are as follows together with an assessment of the further work that may be required:

- Very high: there is a high probability that severe harm could occur or there is evidence that severe harm is currently happening. This risk, if realised, could result in substantial liability; urgent investigation and remediation are likely to be required.
- High: harm is likely to occur. Realisation of the risk is likely to present a substantial liability. Urgent investigation is required. Remedial works may be necessary in the short term and are likely over the long term.
- Moderate: it is possible that harm could arise, but it is unlikely that the harm would be severe and it is more likely that the harm would be relatively mild. Investigation is normally required to clarify the risk and determine the liability. Some remedial works may be required in the longer term.
- Low: it is possible that harm could occur, but it is likely that if realised this harm would at worst normally be mild.
- Very low: there is a low possibility that harm could occur and if realised the harm is unlikely to be severe.