



RoC Consulting

Plot NT02 Dantzic Street

Controlled Waters Risk Assessment

Project No. 11847 R01 (01)

RSK GENERAL NOTES

Project No.: 11847 R01 (01)

Title: Controlled Waters Risk Assessment, Plots NT02 Dantzic Street

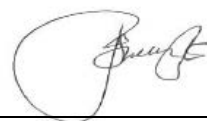
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Where field investigations have been carried out, these have been restricted to a level of detail required to achieve the stated objectives of the work.

This work has been undertaken in accordance with the quality management system of RSK Environment Ltd.

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ESK100 – Controlled waters conceptual site model

All other figures refer to those presented within Phase 2 site investigation report, completed by RoC Consulting in October 2023 (ref. 4328-ROC-ZZXX-RP-ES-P2-101 Rev02 updated following completion of supplementary site investigation (SI) works in December 2023) to which this report forms an appendix.

APPENDICES

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EXECUTIVE SUMMARY

Objective	RSK Geosciences have been instructed by RoC Consulting to complete a Detailed Quantitative Risk Assessment (DQRA) associated with the "Plot NT02" development parcel of the Plot NT02-04 residential led development henceforth known as "The site". Ground investigation works across the site have revealed an area of trichloroethene (TCE) contamination in soils and groundwater that have been deemed to pose a risk to controlled waters at the Generic Risk Assessment screening stage. The following DQRA has been completed to further assess the significance of this area of contamination in terms of risks posed to identified receptors and also support the development of a wider Phase 3a Remediation Strategy. The modelling assessment is being completed in tandem with a program of desk based and intrusive ground investigation works completed by RoC Consulting the findings of which are described in the below referenced documents. • RoC Consulting, Phase 1 Desktop Study, January 2023 (ref: 4328-ROC-ZZ-XX-RP-ES-PH1DTS) • RoC Consulting, Phase 2 Site Investigation Plot NT02, NT03 & NT04 dated December 2023 (ref: 4328-ROC-ZZ-XX-RP-ES-P2-101 Rev 02). It is recommended the above reports are reviewed in tandem with the current assessment contained within this report.
Site details	The site termed "Plot NT02" covers a roughly rectangular parcel of land within the wider Plot NT03 and 04 development master plan area. The site is bounded by Dantzic Street to the north beyond which lies a Travellers site and the River Irk (flowing roughly northeast to southwest) circa 21.00 m to the north of the site; an electrified railway line on a viaduct to the south with car repair garages; the wider Plot NT0X site to the east (comprising a former waste management operator); and the Victoria Riverside high rise apartment scheme to the west. Topographically a fall in site levels is noted across the site in a roughly south to north orientation toward the River Irk, with levels varying between 34.80 m above ordnance datum (AOD) and 31.20 mAOD across the Plot NT02 site. The site is to be developed for high rise residential led end uses comprising the construction of a 34-storey tower with associated public realm space, limited soft landscaping and hard standing. A planning application for this development has been lodged with the Local Authority (Manchester City Council, ref: 136814/FO/2023) for which this report and assessment has been collated to support with the associated discharge of pre-commencement conditions pertaining to ground contamination risks.
Previous works	A number of rounds of ground investigation have been completed across the Plot NT02-04 site, these include the aforementioned Phase 1 and 2 report collated by RoC Consulting in 2023 which capture the findings of previous works

	completed by LK Consult Ltd. The investigations have been completed to inform both design and planning requirements and are subdivided within the RoC Phase 2 report into plot specific ground conditions and risks. Controlled waters have been considered for the whole planning application boundary, noting the effects of soil borne contamination on one plot may manifest as ground water impacts on another. The design and layout of ground investigations was based on the findings of the Phase 1 desktop study and works previously completed by LK Consult Ltd. to characterise geological and geo-environmental conditions beneath the site, support the design of new building foundations/structures, inform waste disposal requirements and identify any contamination issues warranting remediation treatment.
SITE CONCEPTUALISATION	
Previous works	The recent RoC ground investigations were completed in several phases, undertaken between in September 2022 and December 2023 to establish ground conditions across the site and to further investigate TCE soil contamination beneath a warehouse in the south of Plot NT02 extending into the southwest of Plot NT03 and the associated dissolved phase chlorinated solvent groundwater plume in the underlying Chester Sandstone Formation (CHES). The findings of the ground investigations and monitoring have been used to form the basis for this DQRA assessment.
Ground conditions	Ground conditions generally comprise tarmac or concrete over made ground and a variable thickness of cohesive Till over the CHES (principal aquifer) and the Manchester Marl Formation (MM) (secondary aquifer). Groundwater was encountered within the underlying weathered bedrock and based on groundwater contours is anticipated to flow in a north-northeast direction in the CHES towards the River Irk.
Extent of soil contamination	A diffuse TCE soil plume is reported to cover the southern area of the Plot NT02 site extending into the southwestern area of Plot NT03 potentially covering the full width of the site within the footprint of an historic bolt works.
Extent of groundwater contamination	A dissolved phase plume of TCE was detected in the south underlying the soil source extending north-northeast and onto the adjacent Plot NT03. TCE daughter products were detected in groundwater in the north of the site.
Potentially complete contaminant linkages	The following pollution linkages have been identified as being of relevance to the DQRA process: - vertical migration of leachable contaminants from impacted soils present in the unsaturated zone to the underlying CHES - vertical and lateral migration of dissolved phase contaminants through the CHES aquifer to identified controlled water receptors including the wider CHES and MM aquifers.

	Due to the already poor surface water quality reported in the River Irk due to the long industrial past of the wider surrounding area and the distance from the identified TCE soil source to the river Irk, the river is considered to be of low sensitivity from the site. The most sensitive controlled water receptor is considered to be groundwater within the CHES (principal aquifer).
GENERIC QUANTITATIVE RISK ASSESSMENT	
GQRA conclusions	The RoC Phase 2 report concluded that TCE and carbon tetrachloride detected in soil and groundwater, and TCE and its daughter products (cis and trans 1,2, dichloroethene (DCE) and vinyl chloride (VC) and carbon tetrachloride require further assessment by DQRA.
DETAILED QUANTITATIVE RISK ASSESSMENT	
DQRA results	Modelling of the soil source in the south of the site indicates a marginal exceedance (in the same order of magnitude) of the target concentration for TCE at the 50.00 m compliance with concentrations falling below the drinking water standard (DWS) at a distance of 120 m. For the groundwater source the predicted concentrations of TCE, DCE and VC at the 50.00 m compliance point exceeded their respective target concentrations by an order of magnitude and carbon tetrachloride is predicted at a concentration exceeding its target concentration but is within the same order of magnitude. The predicted concentrations of TCE and DCE fall below the DWS at a distance of 200 m and VC at 110 m. Sensitivity analysis indicates that the model is particularly sensitive to hydraulic conductivity and hydraulic gradient. It is considered that there is now sufficient site-specific hydraulic conductivity and groundwater elevation data for the CHES available that the input parameters used in the model for these parameters are sufficiently robust. The model was also shown to be highly sensitive to degradation rates and calibration of the model has demonstrated that it is over predicting downgradient contaminant concentrations in the dissolved phase between one and two orders of magnitude. However, based on the available data set and that DCE and VC have been identified within the downgradient boreholes screened in the CHES, the calculation of site-specific degradation rates was not considered appropriate. Therefore, more conservative literature aerobic degradation rates were adopted in the model set up.
CONCLUSIONS AND RECOMMENDATIONS	
Conclusions	Modelling indicates that the TCE detected in unsaturated soils and the existing TCE dissolved phase plume, and its daughter products pose a potential risk to the wider principal aquifer. Screening of soil and groundwater data against the modelled remedial target values (RTV) indicates that remediation of soils and groundwater at the site is required. Whilst it is acknowledged that there is some degree of uncertainty in the current model, given the inherent conservatism associated with the modelling and the

	results of the sensitivity analysis and model calibration, it is considered that the proposed RTV are suitably protective of controlled waters receptors and will provide a significant degree of betterment at the site.
Recommendations	• Copies of this report, along with the RoC Consulting Phase 2 Site Investigation should be provided to the regulatory authorities to review and seek agreement on the proposed RTVs • Copies of this report, along with the wider RoC Consulting Phase 1 & 2 site investigations should be provided to remediation specialists to consider and advise comment.
Key assumptions and limitations	It is noted that the extents of the soil TCE source remain uncertain, however sensitivity analysis indicates that the model and therefore the calculated RTV have low sensitivity to changes in source size. It is also acknowledged that there is the potential for higher chlorinated solvent concentrations to be present in the dissolved phase beneath the site due to the sampling depth targeting the top 1.00 m to 2.00 m of the monitoring well response zone, whereas TCE may migrate towards the bottom of the water column due to its higher density than water when in free phase form. However, no free phase was detected during any of the monitoring rounds by the interface probe and the maximum measured TCE concentration recorded at the site of 0.572 mg/l is two orders of magnitude less than 1% of the solubility limit for TCE and as such, it is considered unlikely that a DNAPL source is present beneath the site. Therefore, it is considered highly unlikely that an increase in maximum dissolved phase concentrations would alter the conclusions drawn from the DQRA results, since exceedances of the DWS are already reported at the 50.00 m compliance point and the calculated RTVs are not reliant on input concentrations.
The information given in this summary is necessarily incomplete and is provided for initial briefing purposes only. The summary must not be used as a substitute for the full text of the report.	

1 INTRODUCTION

RSK Environment Limited (RSK) was commissioned by RoC Consulting (RoC), the Client, to prepare a controlled waters detailed quantitative risk assessment (DQRA) for the land at Plots NT02-04 Dantzic Street ('the site'). The site is proposed to be developed with a mixture of high and medium rise residential buildings to heights of between 20 and 35 stories with smaller buildings varying in heights of between 4 and 8 storeys. The development is also anticipated to include small areas of soft landscaping, and a new access road. The project was carried out to an agreed brief as set out in RSK's proposal (Ref. 11847 TL01 (00), dated June 2023).

This report is subject to the RSK service constraints given in **Appendix A**.

1.1 Background

The site is located at Manchester, at approximate National Grid reference E384690 N399470.

The site has historically been divided into three plots for planning purposes – Plot NT02 in the west, Plot NT03 in the centre and Plot NT04 in the east. Each of these has distinct land uses, as follows:

- Plot NT02 occupies the western portion of the site and comprises a light industrial building with several smaller buildings, associated access road and areas of hardstanding.
- Plot NT03 occupies the centre of the site. It is understood that a portion of the south of Plot NT03 is owned by Network Rail. The north of the plot is largely covered with hardstanding while the southern part and Network Rail land are occupied by two large earth mounds which likely overlap somewhat.
- Plot NT04 is comprised of semi vegetated disused land.

Historically the site was occupied by residential housing, a smithy, Victoria Screw & Bolt Works, Victoria Paint Works, printing works, a foundry, tripe works, and a warehouse.

Further details regarding the site are presented in **Section 2**.

There have been a number of geo-environmental site investigations previously undertaken at the site, including:

- Phase 2 site investigation report, completed by RoC Consulting in October 2022 (ref. 4328-ROC-ZZXX-RP-ES-P2-101 Rev02), updated following completion of supplementary site investigation (SI) works in December 2023
- RoC Consulting, January 2023. Technical Note on Plot NT03 Network Rail Mound (ref. 4328-ROCZZ-XX-TN-ES-TN2)
- RoC Consulting, January 2023. Phase 1 Desktop Study (ref: 4328-ROC-ZZ-XX-RP-ES-PH1DTS)
- LK, March 2020. Phase 2 Geo-Environmental Investigation, Risk Assessment and Remediation Strategy, at Plot NT02 only (ref: CL-602-LKC 20 1060-01)
- Allied Exploration & Geotechnics Ltd, March 2019. Northern Gateway Final Factual Report (Contract Number: NW1580)

- Hydrock, December 2015. Ground Conditions Desk Study (ref: R/151819/G001).

This controlled waters DQRA report has been completed in order to support the refinement of risks posed by trichloroethene (TCE) contaminants noted beneath the site to the southern and western extent and the associated chlorinated volatile organic compounds (VOC) groundwater plume. It is envisaged the outputs from this modelling assessment will be used to revise the refined conceptual site model postulated in the RoC Consulting Phase 2 site investigation report and support the design of remediation works moving forward. The overarching aim of all works will be to support planning condition discharge for the development and associated engagement with the regulatory authorities (namely Manchester City Council and the Environment Agency (EA)).

1.2 Objective and aims

The objective of this report was to evaluate risks to controlled waters receptors at Plot NT02. The aims of this report are to:

- carry out a controlled waters DQRA for the site in accordance with development of the site for high rise residential housing, using historical data and more recently obtained soil and groundwater data;
- derive site-specific targets for comparison to groundwater quality data;
- derive remedial targets to inform remediation of the site;
- provide initial recommendations for future work.

1.3 Scope

The scope of the investigation and layout of this report has been designed with consideration of Land Contamination Risk Management (LCRM) (EA, 2020) – which supersedes CLR11 Model Procedures for Land Contamination, and BS 10175: 2011 + A2 2017 (BSI, 2017) and guidance on groundwater protection issued by the EA (2017a) and includes:

- a review of previous reports;
- interpretation of recently acquired hydraulic conductivity field tests data;
- refinement of the hydrogeological assessment of the site;
- preparation of a controlled waters DQRA.

1.4 Existing reports

The following reports detailing previous works at the site were made available for review:

- Phase 2 site investigation report, completed by RoC Consulting in October 2022 (ref. 4328-ROC-ZZXX-RP-ES-P2-101 Rev02), updated following completion of supplementary SI works in December 2023
- RoC Consulting, January 2023. Phase 1 Desktop Study (ref: 4328-ROC-ZZ-XX-RP-ES-PH1DTS).

Pertinent information from these reports has been summarised in **Section 3**. For ease of reference hereafter, the above Phase 2 report will be referenced as “RoC Phase 2” report.

1.5 Limitations

The comments given in this report and the opinions expressed are primarily based on third party data and investigations, while RSK will undertake a critical review of the information provided we cannot be held liable for the quality of the data provided. There may be conditions pertaining to the site that have not been disclosed by the investigations and therefore could not be taken into account. In particular, it should be noted that there may be areas of made ground not detected due to the limited nature of the investigations or the thickness and quality of made ground across the site may be variable. In addition, groundwater levels and groundwater concentrations may vary from those reported due to seasonal, or other, effects.

2 SITE DETAILS

2.1 Site location

Site location details are presented in **Table 1**.

Table 1: Site location details

Site name	Plots NT02-04, Dantzic Street, Manchester
Full site address and postcode	M4 4NL
National Grid reference (centre of site)	E384690, N399470

2.2 Site description

The site covers an area of circa 2.30 hectares. It is currently occupied by the land uses detailed in **Section 1.1**. Topographically a fall in site levels is noted across the site in a roughly south to north orientation toward the River Irk, with levels varying between 34.80 m above ordnance datum (AOD) and 31.20 mAOD across the Plot NT02 site.

2.3 Development plans

The proposed layout of the site, at the time of preparing this report, is shown in RDB-MLA-2D-XX-DR-A-00110XXX in Appendix A of the RoC Phase 2 report.

It is understood that the site is to be developed with a mixture of high and medium rise residential buildings, with the former to heights of between 20 and 35 stories and the latter to heights of between 4 and 8 storeys. The development is also anticipated to include small areas of soft landscaping, and a new access road passing between NT02 and NT03 and continuing to the east along the southern site boundary.

No information on service routes or details of any changes planned in site levels have been provided. As such, for the purpose of this report it has been assumed that the current levels will remain unchanged. In addition, it is assumed a basement structure will not be constructed as part of the new development phases.

2.4 Surrounding land uses

The site is located in Manchester city centre, nearby Victoria Station, within a predominantly residential/car parking setting. Immediate surrounding land uses are described in Table 2 overleaf.

Table 2: Surrounding land uses

North	Dantzic Street to the north with an area occupied by caravans (Travellers site) and warehousing beyond, and the River Irk beyond.
East	The wider Plot NT0X site to the east (comprising a former waste management operator) and Dalton Street and residential housing.
South	Electrified railway line on a Network Rail viaduct and car repair garages.
West	Victoria Riverside high rise development.

2.5 Site history/operations

Based on the site's historical use a number of potentially contaminative activities/land uses were undertaken in the southern area of the site. These included the Victoria Screw and Bolt works from before 1891, the Victoria Paint Works from circa 1908, the Collyhurst Foundry from circa 1948, Asphalt Works and Tripe Works from circa 1958 and a Rubber Works from circa 1989.

More recently a waste management company known as Farlam Waste Management is known to have operated in the eastern portion of this plot, only having ceased operation within the past decade; anecdotal evidence from discussions on site with excavator operatives indicate the southern portion of the Plot NT02 was also used as a yard for construction plant.

The northern area of the site was occupied by terraced residential properties between the late 19th and mid-20th centuries before the entire area was turned over to commercial industrial/warehousing operations during the 1970's and 1980s.

The site is also surrounded by potential historic sources of contamination that may have impacted the site via migration of contaminated groundwater including a gasworks to the south, a rubber works to the west and gas holders to the north.

3 PREVIOUS REPORTS

A summary of pertinent information from previous investigations is included below in **Table 3**. Relevant information relating to the identified ground and groundwater conditions has not been included within the table below but has been incorporated into **Section 4**.

Table 3: Summary of previous investigation reports

Report 1	
Report details	LK, March 2020. Phase 2 Geo-Environmental Investigation, Risk Assessment and Remediation Strategy, at Plot NT02 only (ref: CL-602-LKC 20 1060-01) Summary based on review of report presented within the RoC 2023 GI report.
Site coverage	Whole site
Summary scope of works	The LK investigation comprises 7 window sample locations to a maximum depth of 4.45 m below ground level (bgl) and 2 rotary borehole locations to a maximum depth of 20.00 m bgl covering the whole of Plot NT02.
Does the client have reliance upon the report?	Yes
Key findings relevant for controlled waters	Results from chemical testing undertaken by LK Consult revealed the following issues in the Plot NT02 regarding contamination: - Elevated levels of heavy metals (lead) in soil at WS104, SP1 and SP2 (Likely associated with ash, clinker and coal noted within made ground deposits) - Elevated levels of polycyclic aromatic hydrocarbons (PAHs) - benzo(a)pyrene and naphthalene in soil at WS102, WS103, WS105, TP103, TP105 SP1 and WS205 (likely associated with ash, clinker and coal noted within made ground deposits) - Elevated levels of total petroleum hydrocarbons (TPH) – aliphatic >C12-C16, aromatic >C8-C10 and aromatic >C10-C12 in soil at WS205 (beneath the light industrial building and likely associated with the numerous historic industrial activities in this area of the site) - Elevated levels of VOCs/semi-volatile organic compounds (SVOCs) – benzene and TCE in made ground and superficial deposits at WS205, WS201, WS202 and WS204. Photo-ionisation detector (PID) readings in the southwest of the plot also indicate the presence of volatile

	contamination with readings between 4.3ppm and 207ppm (likely associated with the historic industrial activity in this area of the site) Elevated concentrations of contaminants in groundwater including vinyl chloride (VC) at RBH101 and TCE in RBH103. The report hypothesizes these may be linked to historic industrial activity on site or a result of historic industry across the wider area, such as the former gasworks.
Report 2	
Report details	Phase 2 site investigation report, completed by RoC Consulting in December 2023 (ref. 4328-ROC-ZZXX-RP-ES-P2-101 Rev02), updated following completion of supplementary SI works in June 2023.
Site coverage	The 2022 RoC site investigation covered the whole of NT02 whilst the 2023 supplementary focused primarily in the south of the site.
Summary scope of works	Several phases of site investigation were undertaken at the site in 2022 and 2023 including numerous trial pits, window sample boreholes and deeper rotary boreholes with monitoring wells installed in the made ground and the underlying Chester Sandstone formation and Manchester Marl formation. Full details of the SI scope can be found in Section 3 of the RoC Phase 2 report to which this DQRA is appended.
Does the client have reliance upon the report?	Yes
Key findings relevant for controlled waters	Numerous contaminants were detected in unsaturated soils at the site. Namely heavy metals/inorganics including arsenic and lead, TPH fractions, PAH and VOC/SVOC including TCE, hexachloroethane and low levels of numerous other chlorinated compounds. TCE was detected in soil at numerous locations across the south of Plot NT02 and in the southwest of Plot NT03 where historic industrial activities including the bolt works and foundry were located. Soil leachate results indicated the potential for the drinking water standards (DWS) to be exceeded in the underlying groundwater particularly at Plot NT02 where numerous exceedances were reported for metals/inorganics, PAH, TPH fractions and TCE. TCE exceedances of the DWS were reported in groundwater in the shallow sandstone in LK BH03, RBH203 and RBH501 located in the south of Plot NT02 and extending over the eastern site

boundary to RBH303 and RBH504 located in Plot NT03. Carbon tetrachloride was also reported to exceed the DWS in LK BH01, LK BH03, RBH203, RBH302, RBH501, RBH502 and RBH504 and chloroform exceedances were reported at RBH203.

TCE daughter compounds cis-1,2-dichloroethene, trans 1,2-dichloroethene (DCE), VC were reported to exceed the DWS in the shallow sandstone on the outskirts of the TCE groundwater plume and down hydraulic gradient to the north of NT02 and NT03. An exceedance of the DWS was also reported for DCE in the shallow Manchester Marl to the west of the TCE plume core at RBH502 P2.

Benzene exceedances were reported in groundwater in the sandstone and marl in the north of Plot NT02 and TPH fractions aliphatic and aromatic >C12-C16. Benzene was also reported to exceed the DWS in the southwest of the site. The profile of the TPH fractions indicates that these contaminants likely represent two distinct sources of TPH and benzene at the site and considering the absence of benzene detections in soils and leachate, the report concludes that both sources are most likely to have migrated onto site from off-site sources to the west and south.

It was noted that the metals, PAH compounds and TPH fractions detected in leachate testing and the other SVOC detected in soils testing were not reported at concentrations exceeding the generic assessment criteria (GAC) in groundwater likely due to degradation in the unsaturated zone and/or more preferential sorption to soils.

The report concluded that a potentially complete pollutant linkage for the migration of chlorinated VOC to the wider principal and secondary aquifers and recommended further assessment of potential risks to controlled waters via DQRA specifically for TCE, carbon tetrachloride, DCE and VC.

Since the majority of the benzene contamination is in the marl (secondary B aquifer) and not in the overlying principal sandstone aquifer and since it is most likely due to an off-site source, benzene was not considered a risk driving compound for the site and thus was not proposed for inclusion within the recommended DQRA.

4 SITE CONCEPTUALISATION

Information presented in this section has been mainly obtained from the previous RoC GIR updated report (December 2023) mentioned in **Section 1.4**.

4.1 Geology

The borehole records from the RoC Phase 2 report have been used to summarise the encountered geology and the results are given in **Table 4**. The historical investigations confirm the published geological records for the site area (British Geological Survey, Sheet 85). Geology is summarised for Plots NT03 and NT04 in addition to NT02 to provide information about the wider geological setting.

Table 4: Geology at the site

Geological unit	Description	Encountered thickness (m)
Made Ground	In Plot NT02 there is a surface covering of concrete and tarmac within and outside of buildings which is typically underlain by made ground of demolition fill type material. Typically, this is a gravelly sand or sandy gravel containing whole and half bricks and chunks of concrete; gravel of brick fragments, slate, clinker, and slag. Other anthropogenic inclusions included wire, metal, glass, plastic, metal pipes and beams, clay pipes, fabric, rubber, and timber.	0.3-3.2, average 1.40
	In Plot NT03 there is a surface covering of concrete and tarmac within and outside of buildings which is typically underlain by made ground of demolition fill type material, becoming a gravelly clay with depth	0.2-10.50, average 3.16
	The southern part of NT04 is surfaced with a concrete slab while the remainder comprises overgrown vegetation and weeds. Made ground was generally encountered as a gravelly sand or gravelly clay containing clinker, concrete, brick, slag, slate, coal, and ceramics.	0.6-9.00, average 1.83
Superficial deposits – River Terrace Deposits (RD) (<i>Plot NT03 only</i>)	Encountered in the south of Plot NT03 at RBH304, RBH401, RBH402 and RBH403 beneath made ground or Till, as medium sand or sand and gravel. It is also feasible these soils may extend further to the east into Plot NT04.	9.0-10.1, where proven, average 9.55
Superficial deposits – Till (Devensian)	Underneath Plot NT02, the Till is often thin and sometimes comprises granular soils. Most typically Devensian Till was encountered as brown sandy gravelly clay ranging in consistency from very soft to stiff but generally becoming stiff with depth. Till was not encountered in the west of the plot at RBH301, RBH302 and RBH505.	0.3-2.6, average 1.47
	Underneath Plot NT03, the Till was encountered as a firm to stiff slightly gravelly slightly sandy clay. Till was not encountered in the south of the plot at RBH401, RBH403 and RBH404.	0.4-4.5, average 1.47

Geological unit	Description	Encountered thickness (m)
	Underneath Plot NT04, the Till was typically encountered as a stiff brown or blueish grey clay, slightly gravelly in places. The Till is thickening progressively from West to East.	3.3-8.20, average 5.74
Bedrock – Chester Formation (Lower Triassic Sandstones)	Plot NT02 Bedrock of the Chester Formation (CHES) was encountered beneath Devensian Till deposits in all locations in NT02. The upper horizons of the Chester Formation were encountered to be significantly weathered and are effectively sand for up to the first 8.00 m. Deeper horizons of the bedrock also show weaknesses and may be affected by faulting (Section 2.2).	4.8 – 13.8, average 10.8
	Plot NT03 Bedrock of the Chester Formation was encountered beneath Devensian Till deposits in all locations in NT03 with the exception of RBH401 and RBH403 located in the southeast of the plot where mudstone was found to underly the River Terrace Deposits. The upper horizons of the Chester Formation are significantly weathered and are effectively sand for up to the first 6.00 m. Deeper horizons of the bedrock also show weaknesses and may be affected by faulting.	1.0 (RBH306) – 9.3, average 6.02
	Plot NT04 Bedrock of the Chester Formation was encountered in only one location at the western edge of NT04, RBH206. The upper horizons of the Chester Formation are significantly weathered. The Chester Formation is thinning progressively from West to East.	6.32 (RBH206, Plot NT04 west) but absent elsewhere
Bedrock – Manchester Marls Formation (Upper Permian mudstones)	Plot NT02 Reddish brown MUDSTONE recovered as clay when weathered, with interbedded SILTSTONE laminated layers and layers of weak reddish brown fine grained SANDSTONE, up to ~3.00 m thick.	Manchester Marls Formation (MM) was proven by drilling up to a depth of 25.00 m bgl.
	Plot NT03 Reddish brown MUDSTONE and fine to medium grained reddish brown SANDSTONE in layers up to 1.50 m thick.	
	Plot NT04 Reddish brown MUDSTONE and weak reddish brown fine grained SANDSTONE and siltstone thin layers < 1.00 m.	
Source: On-site exploratory hole records presented in ROC Phase 2 report.		

The historical exploratory hole locations are shown on Figures presented in Appendix A of the RoC Phase 2 report.

Cohesive Till is not uniformly present across Plot NT02 allowing direct leaching of contaminants from the made ground into the underlying weathered CHES.

4.2 Hydrology

A summary of the hydrology within the site area is presented in **Table 5**.

Table 5: Summary of hydrology in site area

Condition	Description
Surface watercourses/features	The nearest surface water feature is indicated 21.0 m to the north in the form of the River Irk. Water quality of this receptor indicates a General Quality Assessment (GQA) Grade of "E" (Poor) and a flow rate of less than 2.5 cumecs. The riverbed level is approximately at 26.30 mAOD and the surface water level at 26.90 mAOD in proximity of the site (as confirmed by RoC Consulting who have completed site level and earthworks appraisals). The river levels are comparable to the static groundwater elevations in the north of the site (around the time of the site levels survey in June 2023) at LK BH01 at 26.63 m AOD installed within the CHES and Manchester Marls indicating that there is likely some connectivity between groundwater in the north of the site and the River Irk.
Surface water abstractions	There are no active surface water abstractions at the site or within 500 m of the site boundary. The nearest active discharge consent is indicated 73.00 m to the northwest and held by United Utilities for the release of storm sewage overflow into the River Irk.
Site drainage	Surface drainage from the site appears to discharge into a local network to an outfall point into the existing adopted sewer network. Any areas of open ground or broken hard standing across the site (or damaged drainage runs) allow surface water to infiltrate into underlying soils and likely provide inputs into the underlying groundwater table, although quantification of these inputs is not possible at time. That being said, as the majority of the Plot NT02 site comprises either building or hardstand cover it is unlikely such flows provide a significant component to groundwater flows.
Preliminary flood risk assessment	The indicative floodplain map for the area, shows that the site lies within the designated floodplain of the River Irk, with a long-term flood risk classified as 'medium', according to latest info on gov.uk website. Medium risk means that this area has a chance of flooding of between 1% and 3.3% each year. This takes into account the effect of any flood defences in the area. These defences reduce but do not completely stop the chance of flooding as they can be overtopped or fail. A flood risk assessment (FRA) is outside the scope of this report.

4.3 Hydrogeology

Hydrogeology is summarised for Plots NT03 and NT04 in addition to NT02 to provide information about the wider hydrogeological setting in **Table 6** overleaf.

Table 6: Summary of hydrogeological setting

Condition	Description
Aquifer characteristics	The central-western part of the wider site (approximately Plots NT02 and 03 is underlain by a principal aquifer relating to the CHES. Generally, the CHES is shown to thin from west to east with the eastern part of the wider site (approximately Plot NT04) mostly directly underlain by a secondary aquifer relating to the MM. Given the variability in the bedrock geology encountered beneath the site groundwater movement (vertical and lateral) via fracture flow and pore flow may be active processes beneath the site. However, it is likely that the majority of the groundwater flow is occurring in the upper weathered portion of the CHES bedrock.
Depth to groundwater and flow	The groundwater level monitoring carried out in the period September 2022 to December 2023 generally indicates the following: Groundwater underlying Plot NT02 and the west of Plot NT03 was measured at depths of around 4.5 to 6.5m bgl. Groundwater in the CHES at Plot NT02 and NT03 is indicated on contours presented in Figures 4328-ROC-ZZ-XX-DR-ES-ES205 E to I in Appendix A of the RoC Phase 2 report to flow in a north-northeast direction towards the River Irk. Deeper groundwater in the underlying MM formation presented in Figures 4328-ROC-ZZ-XX-DR-ES-ES205 K shows a general groundwater flow at Plot NT02/03 to the west, consistent with the slope of the MM surface presented in Figure ZZ-XX-DR-ES-ES204 B in Appendix A of the RoC Phase 2 report. Charts plotting the average groundwater elevation (hydraulic head) for each borehole monitored across the four seasons are presented in Section 5.3 of the RoC Phase 2 report. They show little seasonal variation in relative groundwater elevations between the CHES and the MM. The similarity in groundwater elevation between the CHES and the MM, particularly in the north of Plot NT02/03 points to there likely being some connectivity between the two aquifers, however, the contaminant distribution of TCE and other chlorinated VOC in groundwater indicates limited vertical migration of contaminants from the CHES on site into the underlying MM.
Rising groundwater levels	Not applicable
Historical implications for hydrogeology	Not applicable
Licensed groundwater abstractions	The site is not located within close proximity to any sensitive groundwater abstraction points (e.g., for a potable water supply well). The nearest water abstraction point is indicated 533 m to the west relating to Joseph Hold Ltd. Water is abstracted from

Condition	Description
	groundwater for use in breweries/wine process water, it is not clear if the permit is still valid (ROC 2023 Phase 2 SI Report).
Source protection zones	The site does not lie within a currently designated groundwater Source Protection Zone (SPZ), (ROC 2023 Phase 2 SI Report).

4.3.1 Hydraulic conductivity

Rising and falling head tests were carried out in monitoring wells screened within the CHES across Plot NT02 and the west of Plot NT03. (RBH203 and RBH301 in April 2023; RBH203, RBH301, RBH302 and RBH303 in May 2023; and RBH503 and RBH505 in December 2023. The resulting tests were analysed using AquiferWin 32 and have been interpreted using the Bouwer-Rice slug test method of analysis in accordance with the CHES being an unconfined aquifer. The graphical analysis outputs are given in **Appendix B** and the results are summarised in **Table 7**.

Table 7: Summary of hydraulic conductivity test analysis at Plot NT02 for the CHES

Monitoring well location (lithology screened)	Response zone (m bgl)	Hydraulic conductivity (m/d) – Min. value	Hydraulic conductivity (m/d) – Max value	Hydraulic conductivity (m/d) – Geometric mean
RBH203 (Very weak reddish brown fine grained SANDSTONE)	10.00 – 15.00	8.00E-01	9.65E-01	8.78E-01
RBH301 (Reddish brown fine to medium grained SANDSTONE)	4.00 - 10.00	6.47E-01	7.22E-01	6.92E-01
RBH302 (Reddish brown fine to medium grained SANDSTONE)	4.00 – 12.00	1.41E+00	1.64E+00	1.52E+00
RBH303 (Reddish brown fine to medium grained SANDSTONE)	4.00 – 10.00	1.47E+00	1.47E+00	1.47E+00
RBH503 (Reddish brown SANDSTONE)	5.00 – 10.00	4.33E-01	4.33E-01	4.33E-01
RBH505 P1 (Reddish brown SANDSTONE)	4.50 – 11.80	4.56E-01	6.25E-01	5.33E-01

A value of 0.82m/day has been selected for modelling based on the geometric mean of the hydraulic conductivity geometric mean data for each location. Literature values for hydraulic conductivity within a sandstone are reported to be between 2.95E-05m/day and 5.18E-01m/day (reference CONSIM). The hydraulic conductivity values calculated from the NT02 site data are generally within the upper range of the reported literature values, with exception to BH302 and BH303 which have been measured at one order of magnitude higher.

The hydraulic conductivity values calculated in BH302 and BH303 appear to be within the range of literature values for a coarse sand between $7.78\text{E-}02\text{m/day}$ and $5.18\text{E+}02\text{m/day}$ (reference CONSIM) and could potentially indicate more weathering of the sandstone at these locations.

Based on the above, the calculated geometric mean from the site data (0.82m/day) is considered suitable for adoption within the DQRA model set up. The effect of hydraulic conductivity data on the model will also be considered within the sensitivity analysis, as detailed in **Section 5.9**.

4.3.2 Hydraulic gradient and infiltration

4.3.2.1 Hydraulic gradient

The groundwater elevations recorded during the monitoring have been used to calculate representative hydraulic gradients for the CHES aquifer beneath the site. The hydraulic gradients calculated ranged between 0.0030 and 0.0096 with an average of 0.0066. A summary of the hydraulic gradient calculations is presented in **Table 8**.

Table 8: Representative hydraulic gradients

Up gradient monitoring well location and elevation	Down gradient monitoring well locations and elevations	Groundwater elevation difference (m)	Distance between up and down gradient monitoring wells in direction of groundwater flow (m)	Calculated gradient (-)
16/06/2023 LKBH03 26.83 m	16/06/2023 LKBH01 26.63 m	LKBH03 & LKBH01 0.20 m	LKBH03 & LKBH01 67 m	0.0030
31/08/2023 LKBH03 27.10 m	31/08/2023 LKBH01 26.90 m	LKBH03 & LKBH01 0.20 m	LKBH03 & LKBH01 67 m	0.0030
13/11/2023 RBH203 27.20 m	13/11/2023 RBH503 26.865 m	RBH203 & RBH503 0.335 m	RBH203 & RBH503 40 m	0.0084
20/11/2023 RBH203 27.11 m	20/11/2023 RBH503 26.86 m	RBH203 & RBH503 0.25 m	RBH203 & RBH503 40 m	0.0063
01/12/2023 RBH203 27.07 m	01/12/2023 RBH503 26.83 m	RBH203 & RBH503 0.24 m	RBH203 & RBH503 40 m	0.0060
13/11/2023 RBH502 P1 27.59 m	13/11/2023 RBH505 P1 27.09 m	RBH502 P1 & RBH505 P1 0.50 m	RBH502 P1 & RBH505 P1 55 m	0.0091
20/11/2023 RBH502 P1 27.59 m	20/11/2023 RBH505 P1 27.06 m	RBH502 P1 & RBH505 P1 0.53 m	RBH502 P1 & RBH505 P1 55 m	0.0096
01/12/2023 RBH502 P1 27.41 m	01/12/2023 RBH505 P1 26.98 m	RBH502 P1 & RBH505 P1 0.43 m	RBH502 P1 & RBH505 P1 55 m	0.0078
Average hydraulic gradient				0.0066

4.3.2.2 Infiltration

An infiltration rate of 173 mm/year for the site is presented in Section 5.3.44 of the RoC Phase 2 report, based on data for the climate period 1991-2000, the annual rainfall at the Woodford station is estimated 864.40 mm/year. The UK average evapo-transpiration losses are typically 40%. Approximately 95% of the site is anticipated to be hardstanding and/or covered by buildings, thus increasing runoff; conservatively the overall infiltration (aquifer recharge) has been estimated to be approximately 20% of the total rainfall (~173 mm/year).

4.3.3 Aquifer conditions and biodegradation

Groundwater quality parameters were measured in-situ during the groundwater sampling. A summary of results is presented in **Table 9**.

Table 9: In-situ groundwater quality results

Monitoring well location	Dissolved oxygen (DO) (mg/l)	Indicative Aquifer Conditions (based on DO)	Redox (mV)	Indicative Aquifer Conditions (based on Redox)	Electrical Conductivity (µS/cm)
Date					
TCE plume core shallow sandstone/unconfined by marl					
RBH303 04/05/2023	2.78	Aerobic	408.9	Aerobic	692.5
RBH303 10/05/2023	2.73	Aerobic	419.4	Aerobic	731.9
RBH203 19/01/2023	1.94	Aerobic	253.5	Aerobic	1037
RBH203 04/05/2023	1.51	Aerobic	419.18	Aerobic	980.4
RBH203 10/05/2023	0.95	Mildly anaerobic	392.0	Aerobic	905.3
RBH203 27/09/2022	1.32	Aerobic	602.94	Aerobic	1109.9
RBH203 13/11/2023	0.40	Mildly anaerobic	149.38	Mildly anaerobic	1123.8
LKBH03 19/01/2023	4.97	Aerobic	226.6	Aerobic - Mildly anaerobic	808.8
LKBH03 04/05/2023	4.77	Aerobic	281.8	Aerobic	799.6
LKBH03 10/05/2023	4.86	Aerobic	397.6	Aerobic	838.1
RBH302 04/05/2023	4.29	Aerobic	439.9	Aerobic	862
RBH302 10/05/2023	4.34	Aerobic	385.4	Aerobic	891.71

Monitoring well location	Dissolved oxygen (DO) (mg/l)	Indicative Aquifer Conditions (based on DO)	Redox (mV)	Indicative Aquifer Conditions (based on Redox)	Electrical Conductivity (µS/cm)
RBH302 13/11/2023	6.01	Aerobic	149.4	Mildly anaerobic	905.5
LKBH01 27/09/2022	0.13	Mildly anaerobic	119.4	Mildly anaerobic	1620.8
LKBH01 19/01/2023	0.27	Mildly anaerobic	23.2	Mildly anaerobic	1060
RBH504 13/11/2023	0.94	Mildly anaerobic	120.15	Mildly anaerobic	1814.9
TCE plume fringes shallow sandstone					
RBH301 04/05/2023	0.21	Mildly anaerobic	35.5	Mildly anaerobic	1515
RBH301 10/05/2023	0.31	Mildly anaerobic	141.5	Mildly anaerobic	1582.4
RBH501 13/11/2023	1.02	Mildly anaerobic	371.8	Mildly anaerobic	755.5
RBH503 13/11/2023	0.31	Mildly anaerobic	-114.5	Moderately anaerobic	1403
RBH502 P1 13/11/2023	0.83	Mildly anaerobic	60.3	Mildly anaerobic	451.1
Outside TCE plume shallow sandstone					
RBH305 04/05/2023	2.56	Aerobic	375.1	Aerobic	1067
RBH305 11/05/2023	1.94	Aerobic	395.6	Aerobic	1245.3
RBH505 P1 13/11/2023	0.8	Mildly anaerobic	87.28	Mildly anaerobic	1582

Based upon in-situ field measurements of DO and REDOX potential measurements, aquifer conditions are considered to be generally aerobic within the TCE plume and mildly anaerobic to aerobic outside of the plume.

4.4 Potential controlled waters pollutant linkages

4.4.1 Sources

Chlorinated VOC

The main contaminants of concern identified at the site are TCE detected as a diffuse source within the unsaturated soils in the south of Plot NT02 extending into the southwest of Plot NT03 within the footprint of the historic bolt works as shown in Figure 4328-ROC-ZZ-XX-DR-ES-ES208, as well as TCE and its daughter products (DCE and VC) and carbon tetrachloride present as a dissolved phase plume predominantly within the underlying CHES.

TCE follows the anaerobic degradation sequence below:



The presence of TCE daughter compounds DCE and VC detected in the shallow sandstone at LK BH01, RBH301 and RBH503 in the north of the site as shown in Figure 4328-ROC-ZZ-XX-DR-ES-ES209A and VOC contour plots presented in **Appendix C** are consistent with the downgradient portion of the TCE plume undergoing some degree of anaerobic degradation and supports the proposed groundwater flow direction towards the north-northeast in this area of the site as shown on groundwater contours discussed in **Section 4.3**.

Since TCE is heavier than water and has a relatively low solubility limit, it can be present in groundwater as a dense non-aqueous phase liquid (DNAPL), however numerous rounds of groundwater monitoring with an interface probe have not encountered any measurable DNAPL thickness. Due to the more cohesive nature of the MM mudstone underlying the CHES, it is likely that any DNAPL present would accumulate on the surface of the MM. Surface contours for the MM presented on Figure 4328-ROC-ZZ-XX-DR-ES-ES204B in Appendix A of the RoC Phase 2 report show that the MM dips towards the west with the lowest point recorded at RBH502 located in the southwest of Plot NT02, approximately 20.00 m to the west of RBH203 where the maximum dissolved phase TCE was detected. No evidence of DNAPL was encountered at RBH502 P2 installed within the top of the MM formation with dissolved phase TCE concentrations recorded at 4 µg/l (November 2023), significantly below the maximum concentration of 572 µg/l recorded at RBH203 (October 2022).

As discussed in the RoC Phase 2 report, it is noted that TCE concentrations are variable between monitoring rounds, particularly at RBH203, LKBH03 and RBH303 where TCE concentrations were generally higher during the initial RoC monitoring rounds, (September/October 2022 for RBH203 and LKBH03 and May 2023 for RBH303) compared to subsequent rounds. Due to the likely age of the TCE source >60 years, it is considered unlikely that the observed changes in concentration represent an overall downward trend in concentrations due to the relatively short duration of monitoring undertaken (~1 year). As concluded in the RoC Phase 2 report the cause for observed changes are uncertain but may be due in part to the sampling depth, which is noted to have changed between monitoring rounds with higher TCE concentrations often but not always associated with a deeper sampling depth within the water column. Generally sampling was carried out within the top 1.00 m to 2.00 m of the monitoring well response zone whereas TCE may migrate towards the bottom of the water column due to its higher density than water when in free phase form (DNAPL). It is therefore feasible that higher TCE dissolved phase concentrations are present beneath the site, although it is noted that no DNAPL was detected during any of the monitoring rounds by the interface probe and the maximum measured TCE concentration recorded at the site of 0.572mg/l is two orders of magnitude less than 1% of the solubility limit for TCE (water solubility limit 1000mg/l, from Russell *et al.* 1992, 1% equals 10mg/l). As such, it is considered unlikely that a DNAPL source is present beneath the site. Uncertainty associated with the possibility of higher dissolved phase concentrations being present beneath the site has been taken into account within the DQRA and is discussed further in **Section 5.11**.

Benzene and petroleum hydrocarbons

Aliphatic and aromatic hydrocarbon bands >C12-C16 were detected in groundwater samples from RBH502 P1 (CHES) and P2 (top of the MM) located along the southwest boundary of the site, benzene was detected in this location in P2 only (top of the MM). TPH and benzene was also detected in the north of the Plot NT02 site at RBH505 P2 installed in the top of the MM, RBH301 installed in the CHES and LKBH01 installed across the CHES and into the top of the MM, however the profile of the TPH fractions detected in the north of the site differ from those at RBH502 indicating that these contaminants are likely to be from a different source. Historically, the northwest area of Plot NT02 has been the location of industrial buildings and labelled as containing tanks on maps dated late 1940's to early 1950's, associated with either the Collyhurst Foundry or the Rubber Works located immediately west/gas works to the south. It is possible that the source of the benzene in this area is located on-site, however, there are negligible concentrations of benzene reported within the unsaturated soils. As such, it is more plausible that the source is located off-site perhaps relating to the historic rubber works to the west which would be consistent with the groundwater flow direction in the sandstone aquifer to the north-northeast.

Given the flow direction of groundwater in the marl is from west to east, following the dip of the marl surface, the source of the benzene and TPH >C12-C16 at RBH502 P2 is less certain. Localised elevated TPH concentrations predominantly aromatic fractions >C10 – C35 were detected in soils at locations across the site, but no benzene has been detected, indicating the source is either located in an area of the site not sampled or is potentially migrating via groundwater from an off-site source.

It is noted that it is unusual that the lighter TPH fractions/benzene appear to be primarily within the deeper marl rather than the overlying sandstone which may indicate it is more likely to be due to an off-site source such as the historic rubber works to the west and/or the gas works to the south. This is supported by the distribution of the TCE groundwater plume which is from a known on-site source, and which has remained predominantly in the sandstone aquifer and has not significantly penetrated into the marl.

Groundwater chemical testing data from wells sealed into the MM across Plot NT04 (upgradient of plot NT02) do not indicate any levels of benzene and lighter TPH fractions (all of which were noted below limits of laboratory detection). Low levels (below GAC) of mid-range TPH aromatic fractions were noted in RBH306 approximately 100 m east of RBH502 on Plot NT03 within the MM, but no benzene was detected. This lack of evidence of contamination in the upgradient plots and the presence of thicker low permeability Till in Plot NT03 and Plot NT04 upgradient of RBH502, limiting vertical migration into the underlying aquifer, reduces the likelihood that the source of the benzene is located to the east of Plot NT02.

In addition to the above, the groundwater elevation within the MM suggests that in the west of the site the deeper MM groundwater table is recorded above the upper surface of the MM (resting within the CHES). There is the potential that fractured layers of mudstone permitting groundwater flow within the MM are being confined by less fractured/more competent shallower bands of mudstone in the upper reaches of this MM bedrock layer. As such, these more competent shallow mudstone layers are acting to confine the deeper groundwater within the MM, which in turn, would restrict the downward migration of any contamination from the sandstone above.

Information from Manchester City Council planning portal relating to the Gould Street gas works located beyond the railway line and Bromley Street to the south of Plot NT02 reports free phase tar was encountered at depth in the vicinity of the gas holders and tar tanks in the north of the site approximately 50.00 m to 80.00 m from Plot NT02. Since benzene is likely to form a component of gas works tar, this is considered to be the more likely source of the dissolved phase benzene and TPH detected at depth at BH502 P2 in the southwest of Plot NT02.

Since the highest concentrations of TPH and benzene are within the MM a secondary aquifer rather than the overlying CHES principal aquifer and the absence of a confirmed on-site source, TPH and benzene are not considered to be primary risk drivers for the site and as such were not taken forward to DQRA.

4.4.2 Controlled water pathways

The following have been identified as plausible potential pollutant pathways in relation to sensitive controlled waters:

- migration of leachable contaminants from impacted soils present in the unsaturated zone
- vertical and lateral migration of dissolved phase contaminants within the CHES and MM aquifers
- lateral migration of dissolved phase contaminants within the CHES and MM to the River Irk approximately 20.00 m to the north of the site.

4.4.3 Controlled water receptors

The nearest down gradient surface water receptor is the River Irk located approximately 20.00 m to the north of the site and is reported to be of low water quality (Grade E). Previously a gas works was located adjacent to the northern site boundary between the site and the River Irk. There are also numerous other potentially polluting current and historic industrial sites within the vicinity of this stretch of the River Irk including a dye works and additional gas works. Due to the already poor surface water quality reported in the River Irk due to the long industrial past of the wider surrounding area, the river is considered to be of low sensitivity from the site. It is also of note that the River Irk is located approximately 100 m from the TCE impacts identified in unsaturated soils in the south of Plot NT02 extending into the southwest of Plot NT03.

Based on the above, the most sensitive controlled water receptor is considered to be groundwater within the Chester Sandstone Formation (principal aquifer).

4.4.4 Potential linkages

The potentially complete controlled waters pollutant linkages identified in relation to the site are:

- vertical migration of leachable contaminants from impacted soils present in the unsaturated zone to the underlying CHES
- vertical and lateral migration of dissolved phase contaminants through the CHES aquifer to identified controlled water receptors including the wider CHES and MM aquifers.

A schematic controlled waters CSM is presented in relation to the chlorinated solvent impacts in **Figure ESK100** appended to this report.

5 QUANTITATIVE MODELLING

5.1 Assessment methodology and model parametrisation

The DQRA for controlled waters has been undertaken in line with the EA publication titled 'Remedial Targets Methodology: Hydrogeological Risk Assessment for Land Contamination' (RTM).

RTM considers two pathways, predominantly:

- leaching of COPC from impacted soil to groundwater beneath the site and the subsequent migration in groundwater to specified distances from the impacted soil
- migration of dissolved phase COPC in groundwater to specified distances from the groundwater source.

With respect to the leaching pathway, there are three levels of assessment termed Levels 1 to 3. Although more site-specific data is needed with each increase in level, the modelling results typically become less conservative as additional processes are considered. Level 1 uses partitioning equations to theoretically predict how much of a constituent could pass from the solid to liquid phase. This theoretical concentration is then compared to a screening value, termed the target concentration. Alternatively, the results of leachate test data and perched water can be compared directly to the target concentration. Level 2 considers the dilution of this liquid with groundwater flowing beneath a site and Level 3 predicts concentrations at specified distances when the processes of attenuation are considered.

With respect to the dissolved phase migration pathway, there are two levels of assessment termed Levels 2 and 3. Level 2 is the comparison of the groundwater data with the target concentration, which is undertaken as part of a Generic Quantitative Risk Assessment (GQRA). Level 3 predicts concentrations at specific distances when the processes of attenuation are considered in the same manner as the leaching pathway.

A Level 3 groundwater dissolved phase and soil leaching assessment has been undertaken and is documented in this report.

5.2 Model selection

The EA's RTM excel based spreadsheet tool software package was used to model the controlled water linkages. The RTM model is well established and considered by RSK to be appropriate for this site for the following reasons:

- the site conceptual model is consistent with the assumptions of the RTM model (including intergranular flow)
- the RTM model considers a single source area
- the RTM model allows the prediction of breakthrough concentrations as well as calculating suitably protective site-specific acceptance criteria (SSAC).

5.3 Sources

5.3.1 Modelled source area

TCE has been identified as the primary contaminant of concern at the site, detected as both a diffuse source within unsaturated soils in the south of the site and present with its daughter products (DCE and VC) and carbon tetrachloride present as a dissolved phase plume predominantly within the underlying CHES. In accordance with the identified potential sources of soil and groundwater contamination, RSK have selected the following as representative source areas for modelling purposes:

- soil source: TCE was detected in soils across the southern area of lot NT02 and in the southwest of Plot NT03 at RBH504 as shown on Figure 4328-ROC-ZZ-XX-DR-ES-ES208 in Appendix A of the RoC Phase 2 report. For modelling, the soil source has conservatively been set as the dimensions of the historic boltworks shown in the above referenced figure at 75 m wide by 25 m length.
- groundwater source: 75 m wide by 25 m length source area representing the plume core underlying the TCE soil source.

It is noted that DCE and VC were detected further downgradient than the TCE plume core at LKBH01, RBH301 and RBH503 in the north of the site, however, since it is considered that these contaminants originate from the TCE plume, for the purposes of the DQRA they are considered as a single groundwater source area alongside TCE.

DCE and VC were not detected in soils and therefore will be included within modelling of the groundwater source only.

5.4 Selection of compliance point

TCE, VC and carbon tetrachloride are designated as a hazardous substances with respect to groundwater receptors.

As per the EA's guidance (Land contamination ground compliance points: quantitative risk assessment' (EA, 2017b), entry of hazardous or non-hazardous substances into groundwater should be prevented to avoid pollution of groundwater and deterioration of the status of groundwater bodies, and to prevent sustained and upwards trends in concentrations of the substance in a groundwater body.

However, since COPC have already entered groundwater the EA guidance indicates that further entry should be minimised, and necessary and reasonable measures taken to limit the impact on the status of the groundwater body from future expansion of any plumes.

With reference to the EA guidance on 'Land contamination ground compliance points: quantitative risk assessment' (EA, 2017b), for hazardous substances where the substance has already entered groundwater, the default distance of 50.00 m from the boundary of the source can be selected as a compliance distance. For a strategically important aquifer, a case for extending the compliance point beyond the 50.00 m default distance may also be made based on consideration of:

- sensitivity of the environment

- impact of any pollution
- likely costs and benefits of preventing plume expansion, including sustainability of remedial actions.

In accordance with the current guidance and the site being underlain by a principal aquifer a compliance point of 50 m has been adopted.

5.5 Source and target concentrations

The site is underlain by a principal aquifer resting within the Chester Formation deposits. The nearest down gradient surface water receptor is the River Irk located approximately 20.00 m to the north of the site and is reported to be of low water quality (Grade E). The principal aquifer is considered to be the primary controlled waters receptor associated with the site and therefore drinking water standards (DWS) (where available) have been used as for target concentrations as presented in **Appendix C**.

Due to the likely age of the TCE source >60 years, contaminant concentrations in the aquifer are considered likely to be stable or decreasing. The maximum concentrations associated with the historic unsaturated soil data collected from the site and maximum dissolved phase COPC concentrations in groundwater have therefore been used to conservatively represent the source areas. The selected input concentrations and target concentrations for each contaminant are presented in **Table 10**.

Table 10: Summary of soil maximum unsaturated soil and groundwater concentrations used for DQRA

COPC	Concentrations		Target concentration (mg/l)
	Maximum concentration	Location and date	
Soil			
Trichloroethene (TCE)	1.13 mg/kg	WS308 1.00 m bgl 03/04/2023	0.01
Carbon tetrachloride	0.038 mg/kg	WS308 1.00 m bgl 03/04/2023	0.003
Groundwater			
Trichloroethene (TCE)	0.572 mg/l	RBH203 04/10/2022	0.01
Carbon tetrachloride	0.265 mg/l	RBH203 19/01/2023	0.003
Cis and trans-1,2-dichloroethene (DCE)	0.602 mg/l**	LK BH01 19/01/2023	0.05
Vinyl chloride (VC)	0.044 mg/l	RBH503 13/11/2023	0.0005
*Cis and trans 1,2-dichloroethene results combined in line with the DWS			

5.6 Selection/calculation of degradation rates

Although the presence of DCE and VC at downgradient boreholes in the north of the site indicate that some degree of anaerobic dichlorination of TCE is occurring within the groundwater plume, from the groundwater monitoring records discussed in **Section 4.3.3**, conditions within the plume core appear to be predominantly aerobic, resulting in slower biodegradation rates for chlorinated solvents when compared to anaerobic conditions. The possibility of calculating site specific degradation rates has been considered in the preparation of this DQRA, however, based on the available data set and that DCE and VC have been identified within the downgradient boreholes screened in the CHES, the calculation of site-specific degradation rates is not considered appropriate. Therefore, for initial modelling the more conservative literature aerobic degradation or in the case of chlorinated solvents the “high” rates for dissolved phase degradation have been adopted from the Handbook of Environmental Degradation Rate by Howard *et. al.* (1991). The effect of degradation rates on the model results will also be investigated further in sensitivity analysis in **Section 5.9**.

5.7 Model input parameters

Input parameters for the controlled waters DQRA along with justification for each input parameter are included within **Appendix E**. Site specific data (where available) has been used to populate the DQRA model. Where relevant site-specific data is not available, appropriate literature sourced data has been used. The model input parameters are also presented within **Appendix F**, along with the model input and output sheets.

5.8 Model results

The results of the controlled waters DQRA model run are summarised in **Table 11**.

Table 11: DQRA results summary

COPC	Target concentration (mg/l)	Predicted concentration (mg/l)	Estimated travel time to compliance point (yrs)
		50.00 m compliance point	
Soil leaching assessment			
Trichloroethene (TCE)	0.01	0.0255	37
Carbon tetrachloride	0.003	6.08E-05	59
Dissolved phase assessment			
Trichloroethene (TCE)	0.01	0.211	37
Carbon tetrachloride	0.003	5.33E-03	59
Cis and trans-1,2-dichloroethene	0.05	0.334	15

COPC	Target concentration (mg/l)	Predicted concentration (mg/l)	Estimated travel time to compliance point (yrs)
		50.00 m compliance point	
Vinyl chloride	0.0005	5.18E-03	10
Notes: Bold text indicates where the predicted breakthrough concentration at the 50 m compliance point is in excess of the target concentration			

Soil source

Modelling of the soil source in the south of the site indicates a marginal exceedance of the target concentration for TCE at the 50.00 m compliance point with concentrations of carbon tetrachloride predicted to be 2 orders of magnitude below the target concentration. The predicted concentrations of TCE fall below the defined target concentration for soil leaching at a distance of 120 m (0.0084 mg/l).

Groundwater source

For the groundwater source based on maximum recorded groundwater concentrations, the predicted concentrations of TCE, DCE and VC at the 50.00 m compliance point exceed their respective target concentrations by an order of magnitude. Carbon tetrachloride at the 50.00 m compliance point exceeds its respective target concentration but remains in the same order of magnitude as the target concentration.

The predicted concentrations of trichloroethene, and DCE fall below the defined target concentration for the groundwater source at a distance of 200 m with concentrations of 0.00842 mg/l for TCE and 0.0397 mg/l for DCE. VC falls below its target concentration at 110 m with a concentration of 4.83E-04 mg/l. Carbon tetrachloride falls below its target concentration at 60 m with a concentration of 2.62E-03 mg/l.

5.9 Sensitivity analysis

Sensitivity analysis has been undertaken on TCE in soil leaching and dissolved phase in order to qualify the validity of the DQRA assessment considering the inherent uncertainty related to some of the model input parameters.

The results of the sensitivity analysis are summarised in **Table 12** and **Table 13** (and presented in full in **Appendix G**). The assessment examines the model sensitivity to five key aquifer property parameters utilised in the groundwater assessment.

Table 12: Sensitivity analysis (soil leaching assessment) - TCE

Parameter	Value	Predicted concentration at 50.00 m compliance point (mg/l) – Soil Leaching assessment
Trichloroethene target concentration: 0.01 mg/l		
Hydraulic conductivity (m/day): Data range +/- 20%		

Parameter	Value	Predicted concentration at 50.00 m compliance point (mg/l) – Soil Leaching assessment
Trichloroethene target concentration: 0.01 mg/l		
Original	0.82	0.0255
+ 20%	0.984	0.0284
- 20%	0.656	0.0217
Maximum site-specific value recorded in the CHES (RBH303)	1.64	0.0355
Effective porosity (ad.): Data range +/- 20%		
Original	0.27	0.0255
+ 20%	0.324	0.0224
- 20 %	0.216	0.0290
Width of source (m): Data range +/- 20%		
Original	75	0.0255
+ 20%	90	0.0255
-20%	60	0.0255
Hydraulic gradient: Data range +/- 20%		
Original	0.0066	0.0255
+ 20%	0.00792	0.0255
-20%	0.00528	0.0248
Degradation rate: Data range aerobic/anaerobic		
Original - aerobic	1653 days Howard et al high half life	0.0255
anaerobic	321 days Howard et al low half life	0.00233
Notes: 1.23E-01 – Predicted concentration at the 50 m compliance point predicted to be in excess of the target concentration.		

Table 13: Sensitivity analysis (dissolved phase assessment) - TCE

Parameter	Value	Predicted concentration at 50.00 m compliance point (mg/l) – Dissolved phase assessment
Trichloroethene target concentration: 0.01 mg/l		
Hydraulic conductivity (m/day): Data range +/- 20%		

Parameter	Value	Predicted concentration at 50.00 m compliance point (mg/l) – Dissolved phase assessment
Trichloroethene target concentration: 0.01 mg/l		
Original	0.82	0.211
+ 20%	0.984	0.247
- 20%	0.656	0.168
Maximum site-specific value recorded in the CHES (RBH303)	1.64	0.341
Effective porosity (ad.): Data range +/- 20%		
Original	0.27	0.211
+ 20%	0.324	0.175
- 20%	0.216	0.255
Source width (m): Data range +/- 20%		
Original	75	0.211
+20%	90	0.211
-20%	60	0.211
Hydraulic gradient: Data range +/- 20%		
Original	0.0066	0.211
+20%	0.00792	0.247
-20%	0.00528	0.168
Degradation rate: Data range aerobic/anaerobic		
Original - aerobic	1653 days Howard et al high half life	0.211
anaerobic	321 days Howard et al low half life	0.00778
Notes: 1.23E-01 – Predicted concentration at the 50.00 m compliance point predicted to be in excess of the target concentration.		

5.9.1 Sensitivity analysis results

Hydraulic conductivity

Based on the results of the sensitivity analysis, it appears that both models are highly sensitive to hydraulic conductivity, with the highest sensitivity reported for the dissolved phase model.

For hydraulic conductivity in the soil leachate assessment, an increase in hydraulic conductivity by 20%, results in an 11% increase in predicted TCE concentration and a

decrease of hydraulic conductivity by 20% results in a 15% decrease in predicted TCE concentration.

For hydraulic conductivity in the dissolved phase assessment, an increase in hydraulic conductivity by 20%, results in an 17% increase in predicted TCE concentration and a decrease of hydraulic conductivity by 20% results in a 20% decrease in predicted TCE concentration.

As a further check, the maximum recorded site-specific hydraulic conductivity value was used in the model sensitivity to represent the effect of closer to worst case conditions. For the soil leachate assessment an increase in hydraulic conductivity to the maximum value resulted in a 25% increase in predicted concentration at 50.00 m. The dissolved phase assessment was more sensitive, resulting in an increase in predicted concentration of 38%. Overall, however, the predicted concentrations at the 50.00 m compliance point in the soil leachate and dissolved phase assessments remained in the same order of magnitude when adopting the maximum site-specific hydraulic conductivity values calculated from the CHES site-specific data.

Based on the contaminant distribution for TCE and chlorinated VOC in groundwater, the majority of the contaminant plume is present within the CHES formation, with significantly lower concentrations reported within the underlying MM and thus the hydraulic conductivity value used in the RTM assessment model has been derived from site-specific hydraulic conductivity data from six monitoring wells installed in the CHES in Plot NT02 and the west of Plot NT03. The test results showed a good degree of consistency between monitoring wells giving a range of 4.33E-01m/day to 1.64m/day. These values lie between reported CONSIM literature values for a solid sandstone of 2.95E-05m/day and 5.18E-01m/day and a coarse sand between 7.78E-02m/day and 5.18E+02m/day consistent with groundwater flow within a weathered sandstone.

Based on the above, the calculated hydraulic conductivity, based on the geometric mean of all the site collected data (0.82 m/day) is considered appropriate for use in the DQRA.

Effective porosity

The soil leaching model showed limited sensitivity to the effective porosity value with an increase in effective porosity of 20% resulting in a 12% decrease in predicted TCE concentration and a decrease in effective porosity of 20% resulting in a 14% increase in predicted TCE concentration.

The dissolved phase model showed a higher sensitivity to the effective porosity value with an increase in effective porosity of 20% resulting in a 17% decrease in predicted TCE concentration and a decrease in effective porosity of 20% resulting in a 21% increase in predicted TCE concentration.

The modelled parameter value for effective porosity was taken the mid-point of the geometric mean for literature value for sandstone and coarse sand consistent with the description of the shallow sandstone aquifer where peak TCE concentrations were detected, and the hydraulic conductivity values used within the model.

Source width

Source width was included in the sensitivity analysis due to the uncertainty around the extent of the soil source which was conservatively set in the model to the extents of the historic

boltworks, extending into the southwest of Plot NT03. However, the analysis shows that this is not a sensitive input parameter within the model, with no notable (<0.01%) changes in predicted TCE concentrations at the 50.00 m compliance point with changes in source width of +/- 20%.

Hydraulic gradient

The soil leaching model showed limited sensitivity to the hydraulic gradient value with an increase of 20% resulting in no notable increase (<0.01%) in predicted TCE concentration and a decrease in hydraulic gradient of 20% resulting in a 3% decrease in predicted TCE concentration.

The dissolved phase model showed a higher sensitivity to the hydraulic gradient value with an increase of 20% resulting in a 17% increase in predicted TCE concentration and a decrease in hydraulic gradient of 20% resulting in a 20% decrease in predicted TCE concentration.

The hydraulic gradient value used within the model was based on multiple sets of groundwater monitoring within the CHES from locations across Plot NT02 and the west of Plot NT03 between June and December 2023. Groundwater contours for the CHES presented in Figures 4328-ROC-ZZ-XX-DR-ES-ES205 E to I in Appendix A of the RoC Phase 2 report show a generally consistent flow direction and contour spacing towards the north-northeast. The hydraulic gradients calculated ranged between 0.0030 and 0.0096 with an average from the 8 No. representative gradient calculations of 0.0066. Since the hydraulic gradient value used in the model is based on site-specific data from a spread of locations across the target area of the site, with generally good consistency in contours between monitoring rounds, the value used is considered appropriate.

Degradation rates

Sensitivity analysis shows that both the soil leaching, and dissolved phase models are highly sensitive to biodegradation rates. Changing the degradation rate from the literature value for aerobic (1653 days) to anaerobic degradation (321 days) results in a decrease in predicted concentration at the 50.00 m compliance point by an order of magnitude for the soil leaching model and by two orders of magnitude for the dissolved phase model. In both cases, predicted concentrations are below the target concentration at a distance of 50.00 m.

In-situ groundwater quality parameters recorded during monitoring indicate that conditions within the TCE plume core are predominantly aerobic, with mildly anaerobic to aerobic conditions recorded outside and at the plume margins. However, the presence of DCE and VC recorded in groundwater in the north of the site, downgradient of the TCE plume core, indicates that some degree of anaerobic degradation may be occurring.

As already mentioned, based on the available data set and that DCE and VC have been identified within the downgradient boreholes screened in the CHES, the calculation of site-specific degradation rates has not been considered appropriate. Therefore, the adoption of more conservative literature aerobic degradation rates within the model is considered appropriate.

Conclusions

Sensitivity analysis has shown that the model is particularly sensitive to hydraulic conductivity and hydraulic gradient, since both values used in the model are based on site specific data

from motoring wells installed in the CHES at multiple locations spread across the plume area and close to the downgradient site boundary, the model parameters used are considered representative of conditions in the aquifer.

Degradation rates are also shown to have a significant impact on the modelled downgradient predicted contaminant concentrations and based on TCE concentrations recorded down gradient from the plume core in the north of the site, the aerobic value used in the model is likely to be overly conservative. This is assessed further by model calibration in **Section 5.9.3**.

The model is shown to have low sensitivity to the source dimensions, therefore whilst it is important to understand the full extent of the source area for remediation design, further delineation of the soil TCE source is unlikely to significantly affect predicted concentrations at the 50.00 m compliance point and/or modelled remedial target values.

5.9.2 Consideration of climate change effects

There is the potential for groundwater levels beneath the site to rise or fall to a greater extent than observed to date as a result of climate change. The rise or fall of groundwater levels in the future is not considered likely to have an effect on the controlled waters risk assessment based on the following:

- COPC have already leached from the unsaturated zone into the underlying aquifer, hence a Level 3 groundwater assessment has been conducted. None of the model input parameters associated with a Level 3 groundwater assessment are influenced by groundwater level changes.

In accordance with the above, no additional sensitivity analysis has been undertaken in relation to climate change effects.

5.9.3 Model calibration

In order to calibrate the model, the following has been undertaken:

- measured concentration of COPC in groundwater sampled from downgradient well RBH503 of <0.001mg/l on 13/11/2023 was compared to the model's predicted concentration, based on a compliance point distance of 40.00 m (approximate distance between RBH203 and RBH503) and an initial source concentration of 215mg/l (measured concentration in groundwater from RBH203 on 13/11/2023, considered to be representative of the dissolved phase source)
- measured concentration of COPC in groundwater sampled from downgradient well LKBH01 of 0.002mg/l on 19/01/2023 was compared to the model's predicted concentration, based on a compliance point distance of 48.00 m (approximate distance between LKBH01 and RBH203) and an initial source concentration of 0.418mg/l (measured concentration in groundwater from RBH203 on 19/01/2023, considered to be representative of the dissolved phase source).

The calibration modelling exercise is included in **Appendix H** and summarised in **Table 14** and **Table 15**.

Table 14: Predicted concentrations at RBH503

COPC	Concentration at RBH203 (mg/l)	Concentration at RBH503 (mg/l)	Predicted concentration at 40.00 m compliance point (distance from RBH203 to RBH503)	Travel time (years)
Trichloroethene (TCE)	0.2	<0.001	0.0901	29

Table 15: Predicted concentrations at LKBH01

COPC	Concentration at RBH203 (mg/l)	Concentration at LKBH01 (mg/l)	Predicted concentration at 48.00 m compliance point (distance from RBH203 to LKBH01)	Travel time (years)
Trichloroethene (TCE)	0.418	0.002	0.16	35

The modelled predicted concentrations at RBH503 and LKBH01 are one and two orders of magnitude higher respectively than the measured concentrations recorded in groundwater, indicating that the model may be over predicting downgradient concentrations, likely due to the observed degradation to DCE and VC.

As discussed in the sensitivity analysis, the model is highly sensitive to degradation rates, however, based on the available data set and that DCE and VC have been identified within the downgradient boreholes screened in the CHES, it has not been possible to calculate site-specific degradation rates. It may be possible to calculate site specific degradation rates in the future in the event that additional data is collected, however given the high degree of conservatism in the model, the results and resultant RTVs presented in **Section 5.10** from the current model set up are considered sufficiently protective of the principal aquifer to inform remediation of the chlorinated solvent impacts.

5.10 Remedial target values (RTV)

Whilst it is noted some uncertainties remain as discussed in **Section 5.11**, the following remedial target values (RTV) have been derived to inform remediation of the site. It should be noted that owing to the assumptions made in the modelling process, the values provided in **Table 16** are considered conservative and may be refined in the event that further data becomes available, however any changes to the RTVs would need to be agreed with the EA prior to use.

The remedial targets presented in **Table 16** have been compared to the soil and groundwater results in **Appendix I**. The selected soil and groundwater RTV are the Level 2 soil remedial targets and Level 3 groundwater targets respectively.

Table 16: Soil and groundwater RTV for controlled waters

COPC	Soil RTV (mg/kg)	Locations of soil RTV exceedances and max concentration (mg/kg)	Groundwater RTV (mg/l)	Locations of groundwater RTV exceedances and max concentration (mg/l)
Trichloroethene (TCE)	0.224	WS302 1.50 m bgl (0.602) WS304 0.50 m bgl (0.23) WS305 1.00 m bgl (0.427) WS308 0.6 & 1.00 m bgl (max 1.13)	0.0271	LKBH03 (max 0.250), RBH203 (max 0.572), RBH303 (max 0.277)
Carbon tetrachloride	0.116	NR	0.149	RBH203 (max 0.265), RBH302 (max 0.207)
Cis and trans-1,2-dichloroethene	NA	NA	0.0902	LKBH01 (max 0.602) RBH301 (0.102) RBH503 (0.100) RBH504 (0.151)
Vinyl chloride	NA	NA	0.00425	LKBH01 (max 0.016) RBH503 (0.044)
Notes: NR – no RTV exceedances recorded NA – DCE and VC not included in the leaching pathway model				

Screening of the soil and groundwater results against the proposed RTV results in exceedances for TCE in soil at WS302, WS304, WS305 and WS308 in the south of Plot NT02 and exceedances of TCE in three monitoring wells for groundwater at LKBH03, RBH203 and RBH303 located in the south of Plot NT02 and approximately 5.00 m beyond the eastern site boundary within Plot NT03. Groundwater exceedances were reported for carbon tetrachloride at RBH203 and RBH302 in the south of Plot NT02. DCE was reported to exceed the RTV at LKBH01 and RBH301 in the north of Plot NT02 and, RBH503 and RBH504 in the west of Plot NT03. VC exceedances were reported at LKBH01 in the north of Plot NT02 and RBH503 in the west of Plot NT03.

5.11 Uncertainties

Remaining uncertainties and data gaps in the refined conceptual site model have been identified in **Table 17** overleaf along with the key implications.

Table 17: Uncertainties and implications

Item	Details	Implications
Source(s) of TPH/benzene predominantly in groundwater in the MM in the southwest of the site	The source(s) of the dissolved phase benzene in the southwest/west of NT02 at RBH502 P2 is uncertain. The presence of the highest benzene concentrations in the shallow MM rather than the overlying CHES and the absence of benzene in unsaturated soils tested at the site possibly points to an off-site source as discussed in more detail in Section 4.4.1. Only one round of groundwater testing has been undertaken for 500 series monitoring wells including RBH502 P2 where the highest benzene and TPH concentration were recorded in the MM.	Whilst it is possible that a so far undetected source of benzene is present on site up gradient of BH502 the presence of benzene predominantly at depth in the MM rather than the overlying CHES indicates a lower risk to controlled waters. Should evidence of a potential source of benzene/TPH be identified in the remediation and ground works at the site (in accordance with a watching brief for unexpected contamination), potential controlled waters linkages relating to this source should be further assessed.
Lateral extents of the TCE soil plume	The TCE soil source has been shown to cover the southern portion of Plot NT02 up to its eastern site boundary and across into Plot NT03 at RBH504. To date limited soils testing for TCE has been undertaken in the southwest of Plot NT03 and thus the eastern extent of the soil source is uncertain.	For the purposes of the DQRA model the source area was assumed to cover the extent of the historic bolt works. The model is shown to have low sensitivity to the source dimensions, therefore whilst it is important to understand the full extent of the source area for remediation design, further delineation of the soil TCE source is unlikely to significantly affect modelled concentrations and/or modelled remedial target values.
Possible that higher dissolved phase chlorinated VOC concentrations are present in groundwater beneath the site	There is the potential for higher concentrations of chlorinated VOC to be present in the dissolved phase beneath the site due to the sampling depth targeting the top 1.00 m to 2.00 m of the monitoring well response zones. whereas TCE may migrate towards the bottom of the water column due to its higher density than water when in the free phase form (DNAPL). However, no DNAPL was detected during any of the monitoring rounds by the interface probe and the maximum measured TCE concentration recorded at the site of 0.572mg/l is two orders of magnitude less than 1% of the solubility limit for TCE and as such, it is considered unlikely that a DNAPL source is present beneath the site.	An increase in maximum dissolved phase VOC concentrations is considered highly unlikely to alter the conclusions drawn from the DQRA results, since exceedances of the DWS are already reported at the 50.00 m compliance point and the calculated RTVs are not reliant on input concentrations.

5.12 Discussion

- Modelling indicates that the TCE detected in unsaturated soils and the existing TCE dissolved phase plume, and its daughter products pose a potential risk to the wider principal aquifer primarily.
- Sensitivity analysis indicates that the model is particularly sensitive to hydraulic conductivity and hydraulic gradient. It is considered that there is now sufficient site-specific hydraulic conductivity and groundwater elevation data for the CHES formation available that the input parameters used in the model for these parameters are sufficiently robust. The model was also shown to be highly sensitive to degradation rates. The degradation rates used in the model are more conservative aerobic values. Sensitivity analysis conducted on degradation rates for TCE indicates that should anaerobic values be adopted within the model the predicted concentrations at the 50.00 m compliance point do not exceed the TCE target concentration. However, based on the available data set and that DCE and VC have been identified within the downgradient boreholes screened in the CHES, there is not considered to be sufficient evidence to allow the adoption of less conservative anaerobic degradation rates for the site or allow the calculation of site-specific degradation rates.
- Calibration of the model has demonstrated that it is over predicting downgradient contaminant concentrations in the dissolved phase between one and two orders of magnitude. It may be possible to calculate site specific degradation rates in the future in the event that additional data is collected. However, given the high degree of conservatism in the model, the results and resultant RTVs from the current model set up are considered sufficiently protective of the identified controlled waters receptors to inform remediation of the chlorinated solvent impacts and will provide a significant degree of betterment at the site.
- Due to the likely age of the TCE source >60 years, contaminant concentrations in the aquifer are considered likely to be stable or decreasing. Due to the current presence of a warehouse building over the core of the unsaturated soil TCE source in the south of Plot NT02, leaching of this contamination is currently likely to be minimal and therefore the concentrations of daughter products downgradient in the north of the site are likely due to the current dissolved phase TCE plume rather than due to ongoing leaching of TCE from impacted soils. Therefore, it is concluded that remediation should include for the cleanup of soils and groundwater in order to protect the surrounding principal aquifer.
- Currently there are no recorded groundwater abstractions within 500 m of the site and given the industrial history of the wider area surrounding the site, future drinking water abstraction in the area is unlikely.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

TCE has been detected as a diffuse source within unsaturated soils in the south of Plot NT02 and extending into the southwest of Plot NT03 and an underlying groundwater dissolved phase plume predominantly in the CHES formation. The results from the soil leaching and dissolved phase assessments indicate that predicted concentrations of TCE, DCE, VC and carbon tetrachloride at a theoretical compliance point 50.00 m downgradient of the site exceed their respective target concentrations. Therefore, a pollutant linkage is considered to exist between the VOC soil source and dissolved phase plume extending beneath Plot NT02 and controlled waters via leaching/vertical migration through the unsaturated zone and/or lateral migration through dissolved phase to the wider principal aquifer. In accordance with this remediation shall be required at the site. Subject to agreement of the targets derived with the EA, the RTVs presented in this report should be used to inform remedial works at the site.

Uncertainty remains on the full extents of the TCE soil source area, which may extend further east into Plot NT03, however sensitivity analysis showed no measurable change in predicted concentrations at the 50.00 m compliance point for a +/- 20% change in source width.

Although some uncertainty remains, given the inherent conservatism associated with the modelling and the results of the sensitivity analysis and model calibration, the conclusions drawn from this assessment are considered robust.

6.2 Recommendations

The following recommendations are made for remediation of the site to address the risks identified above:

- Copies of this report, along with the RoC Consulting Phase 2 Site Investigation should be provided to the regulatory authorities to review and seek agreement on the proposed RTVs
- Copies of this report, along with the wider RoC Consulting Phase 1 & 2 site investigations should be provided to remediation specialists to consider and advise comment.

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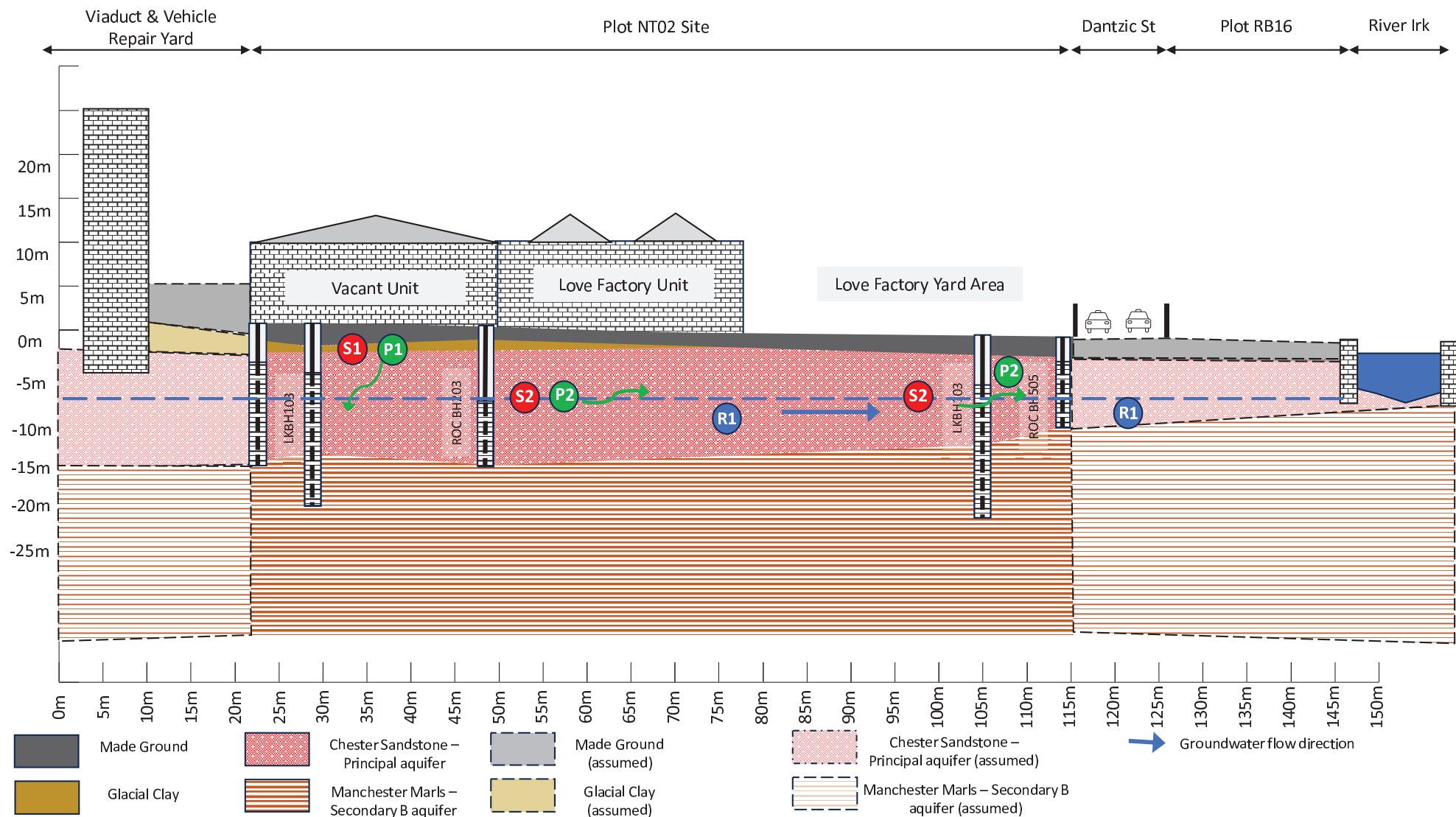
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FIGURES



Sources

- S1** Chlorinated VOC including TCE in unsaturated soils
- S2** Chlorinated VOC including TCE and daughter products (DCE, VC) in dissolved phase in the Chester Sandstone

Pathways

- P1** Leaching / remobilisation of contamination from unsaturated soils
- P2** Lateral migration of dissolved phase contamination within the Chester Sandstone (CHES)

Receptors

- R1** Groundwater within the Chester Sandstone – Principal aquifer

Complete / Potentially Complete Pollution Linkages

- On-site chlorinated VOC including TCE contamination in unsaturated soils from historic bolt works – Principal aquifer via leaching/remobilization of contamination
- On-site dissolved phase chlorinated VOC plume including TCE and daughter products (DCE, VC) – Wider principal and secondary aquifers via vertical and lateral migration of dissolved phase

JOB NO 11847
PROJECT TITLE Plot NT02 DQRA

SKETCH NO ESK100
SKETCH TITLE Conceptual Site Cross Section, Plot NT02

DRAWN BY : AS & LA 06/12/2023

APPENDIX A

SERVICE CONSTRAINTS

1. This report and the site investigation carried out in connection with the report (together the "Services") were compiled and carried out by RSK Environment Limited (RSK) for RoC Consulting Ltd (the "Client") in accordance with the terms of a contract [RSK Environment Standard Terms and Conditions] between RSK and the Client. The Services were performed by RSK with the reasonable skill and care ordinarily exercised by an environmental consultant at the time the Services were performed. Further, and in particular, the Services were performed by RSK taking into account the limits of the scope of works required by the client, the time scale involved and the resources, including financial and manpower resources, agreed between RSK and the Client.
2. Other than that, expressly contained in paragraph 1 above, RSK provides no other representation or warranty whether express or implied, in relation to the Services.
3. Unless otherwise agreed in writing, the Services were performed by RSK exclusively for the purposes of the Client. RSK is not aware of any interest of or reliance by any party other than the Client in or on the Services. Unless expressly provided in writing, RSK does not authorise, consent or condone any party other than the client relying upon the Services. Should this report or any part of this report, or otherwise details of the Services or any part of the Services be made known to any such party, and such party relies thereon that party does so wholly at its own and sole risk and RSK disclaims any liability to such parties. **Any such party would be well advised to seek independent advice from a competent environmental consultant and/or lawyer.**
4. It is RSK's understanding that this report is to be used for the purpose described in the introduction to the report. That purpose was a significant factor in determining the scope and level of the Services. Should the purpose for which the report is used, or the proposed use of the site change, this report may no longer be valid and any further use of or reliance upon the report in those circumstances by the client without RSK 's review and advice shall be at the client's sole and own risk. Should RSK be requested to review the report after the date of this report, RSK shall be entitled to additional payment at the then existing rates or such other terms as agreed between RSK and the client.
5. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. The information and conclusions contained in this report should not be relied upon in the future without the written advice of RSK. In the absence of such written advice of RSK, reliance on the report in the future shall be at the Client's own and sole risk. Should RSK be requested to review the report in the future, RSK shall be entitled to additional payment at the then existing rate or such other terms as may be agreed between RSK and the client.
6. The observations and conclusions described in this report are based solely upon the Services which were provided pursuant to the agreement between the Client and RSK. RSK has not performed any observations, investigations, studies or testing not specifically set out or required by the contract between the client and RSK. RSK is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the Services. For the avoidance of doubt, unless otherwise expressly referred to in the introduction to this report, RSK did not seek to evaluate the presence on or off the site of asbestos, invasive plants, electromagnetic fields, lead paint, heavy metals, radon gas or other radioactive or hazardous materials, unless specifically identified in the Services.
7. The Services are based upon RSK's observations of existing physical conditions at the Site gained from a visual inspection of the site together with RSK's interpretation of information, including documentation, obtained from third parties and from the Client on the history and usage of the site, unless specifically identified in the Services or accreditation system (such as UKAS ISO 17020:2012 clause 7.1.6):
 - a. The Services were based on information and/or analysis provided by independent testing and information services or laboratories upon which RSK was reasonably entitled to rely.

- b. The Services were limited by the accuracy of the information, including documentation, reviewed by RSK and the observations possible at the time of the visual inspection.
- c. The Services did not attempt to independently verify the accuracy or completeness of information, documentation or materials received from the client or third parties, including laboratories and information services, during the performance of the Services.

RSK is not liable for any inaccurate information or conclusions, the discovery of which inaccuracies required the doing of any act including the gathering of any information which was not reasonably available to RSK and including the doing of any independent investigation of the information provided to RSK save as otherwise provided in the terms of the contract between the Client and RSK.

- 8. The intrusive environmental site investigation aspects of the Services are a limited sampling of the site at pre-determined locations based on the known historic / operational configuration of the site. The conclusions given in this report are based on information gathered at the specific test locations and can only be extrapolated to an undefined limited area around those locations. The extent of the limited area depends on the properties of the materials adjacent and local conditions, together with the position of any current structures and underground utilities and facilities, and natural and other activities on site. In addition, chemical analysis was carried out for a limited number of parameters (as stipulated in the scope between the client and RSK, based on an understanding of the available operational and historical information) and it should not be inferred that other chemical species are not present.
- 9. Any site drawing(s) provided in this report is (are) not meant to be an accurate base plan but is (are) used to present the general relative locations of features on, and surrounding, the site. Features (intrusive and sample locations etc) annotated on site plans are not drawn to scale but are centred over the approximate location. Such features should not be used for setting out and should be considered indicative only.
- 10. The comments given in this report and the opinions expressed are based on the ground conditions encountered during the site work and on the results of tests made in the field and in the laboratory. However, there may be conditions pertaining to the site that have not been disclosed by the investigation and therefore could not be taken into account. In particular, it should be noted that there may be areas of made ground not detected due to the limited nature of the investigation or the thickness and quality of made ground across the site may be variable. In addition, groundwater levels and ground gas concentrations and flows, may vary from those reported due to seasonal, or other, effects and the limitations stated in the data should be recognised.
- 11. Asbestos is often observed to be present in soils in discrete areas. Whilst asbestos-containing materials may have been locally encountered during the fieldworks or supporting laboratory analysis, the history of brownfield and demolition sites indicates that asbestos fibres may be present more widely in soils and aggregates, which could be encountered during more extensive ground works.
- 12. Unless stated otherwise, only preliminary geotechnical recommendations are presented in this report and these should be verified in a Geotechnical Design Report, once proposed construction and structural design proposals are confirmed.



APPENDIX B

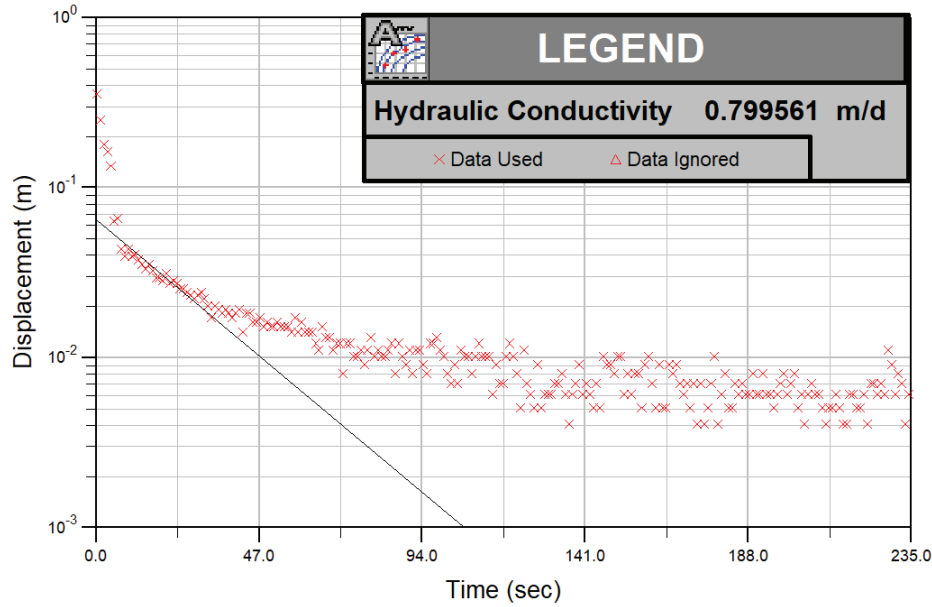
HYDRAULIC CONDUCTIVITY DATA

Plot NT02 - Permeability Testing Results

April 2023 data

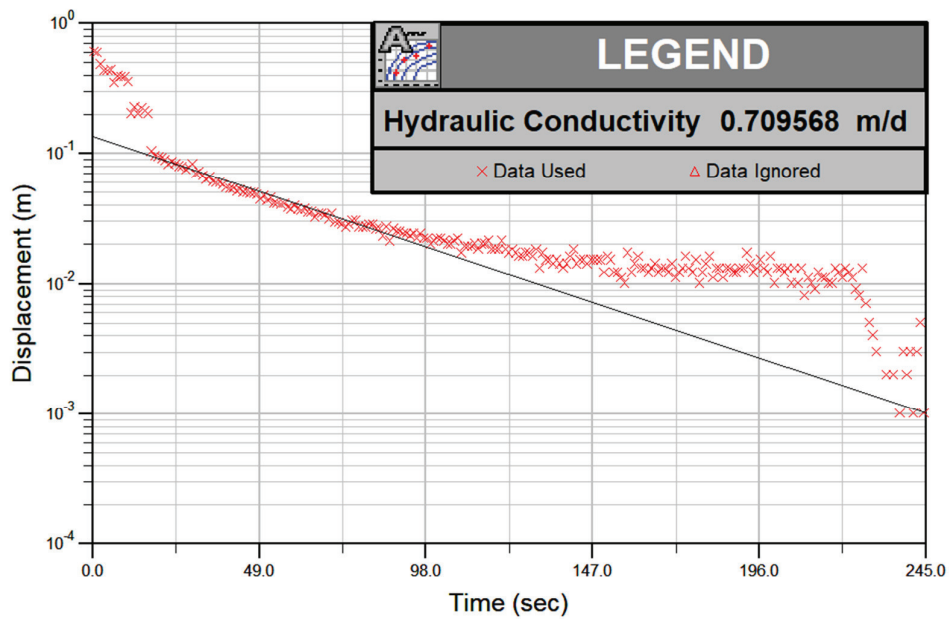
RBH203 Test 1 – Middle Response

Bouwer & Rice



RBH301 Test 2 – Middle Response

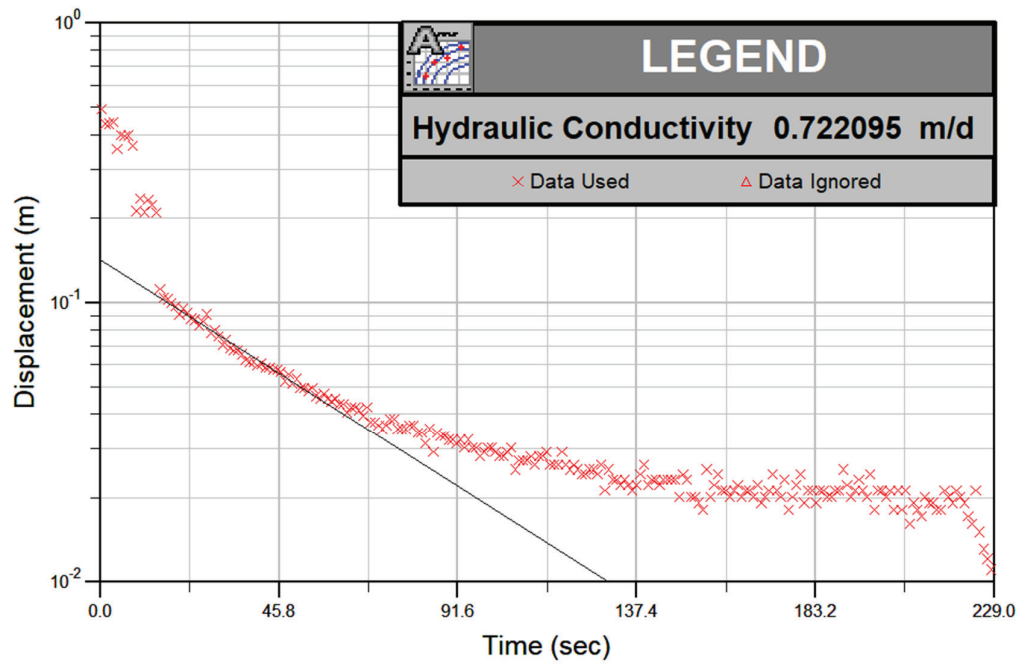
Bouwer & Rice



Plot NT02 - Permeability Testing Results

RBH301 Test 4 – Middle Response

Bouwer & Rice

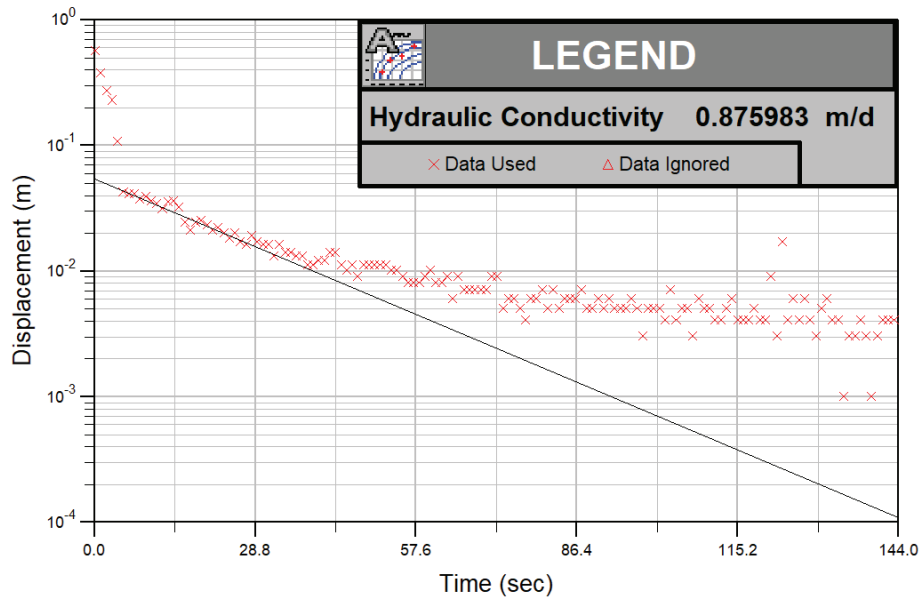


Plot NT02 - Permeability Testing Results

May 2023 data

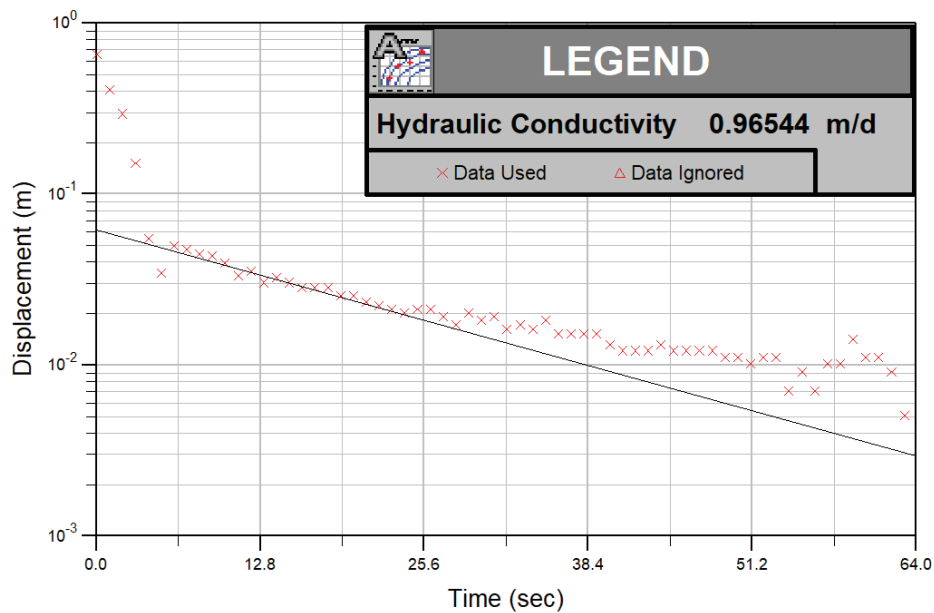
RBH203 – Test 1 – Middle Response

Bouwer & Rice



RBH203 – Test 3 – Middle Response

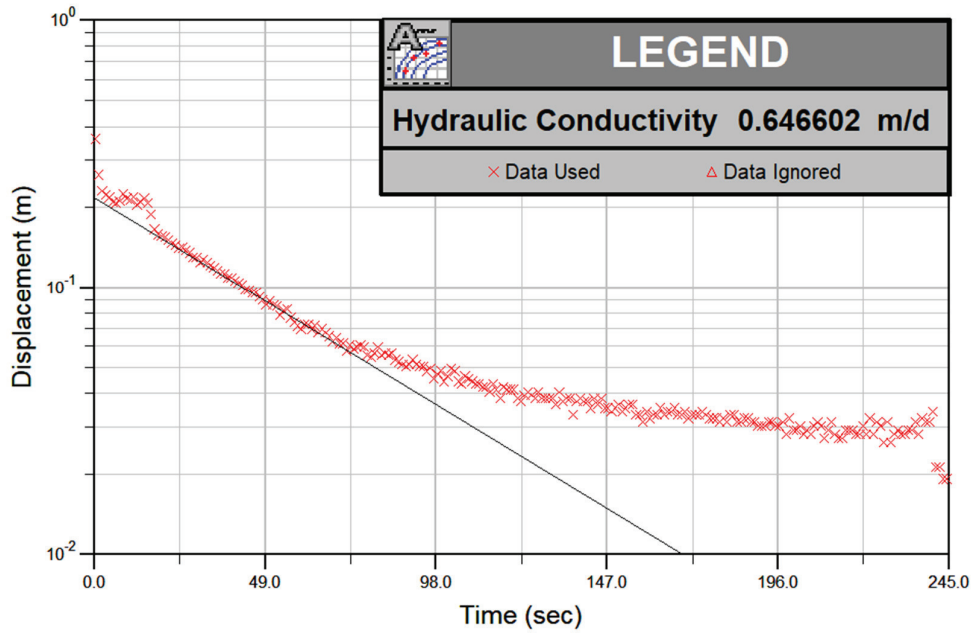
Bouwer & Rice



Plot NT02 - Permeability Testing Results

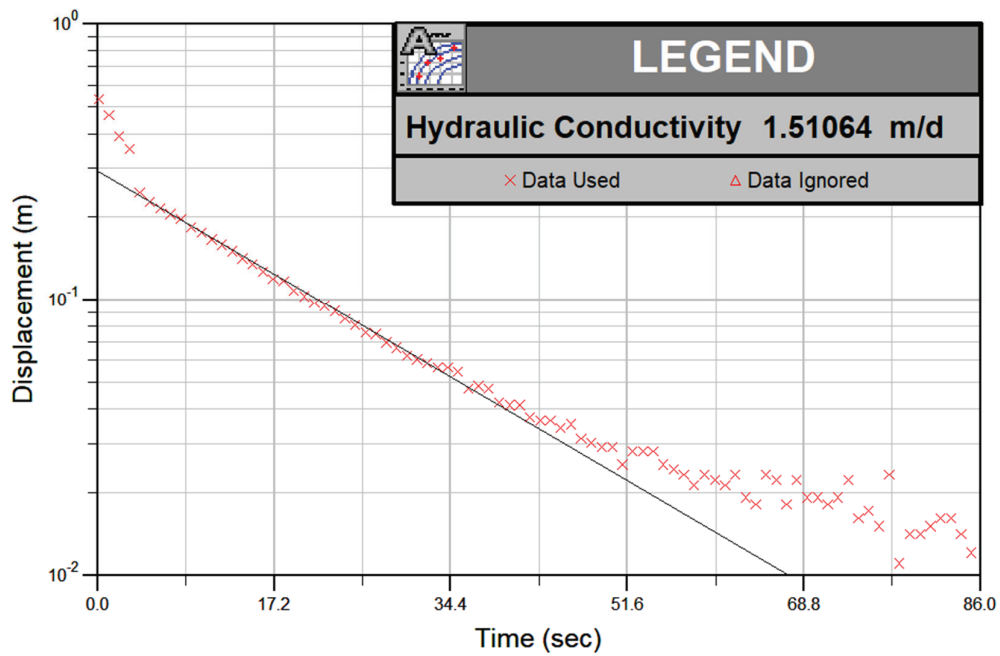
RBH301— Test 2 – Middle Response

Bouwer & Rice



RBH302 – Test 1 – Middle Response

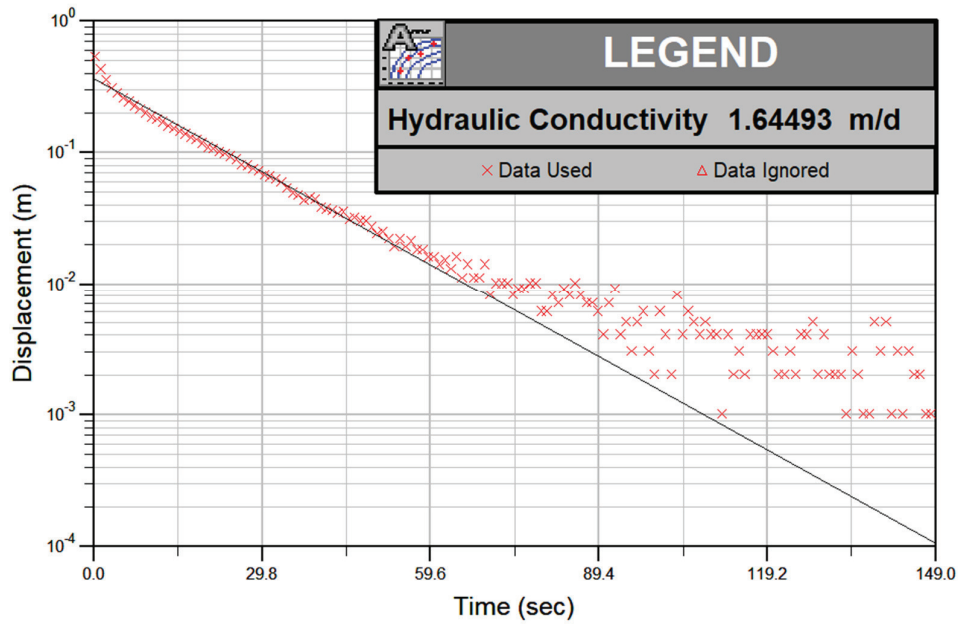
Bouwer & Rice



Plot NT02 - Permeability Testing Results

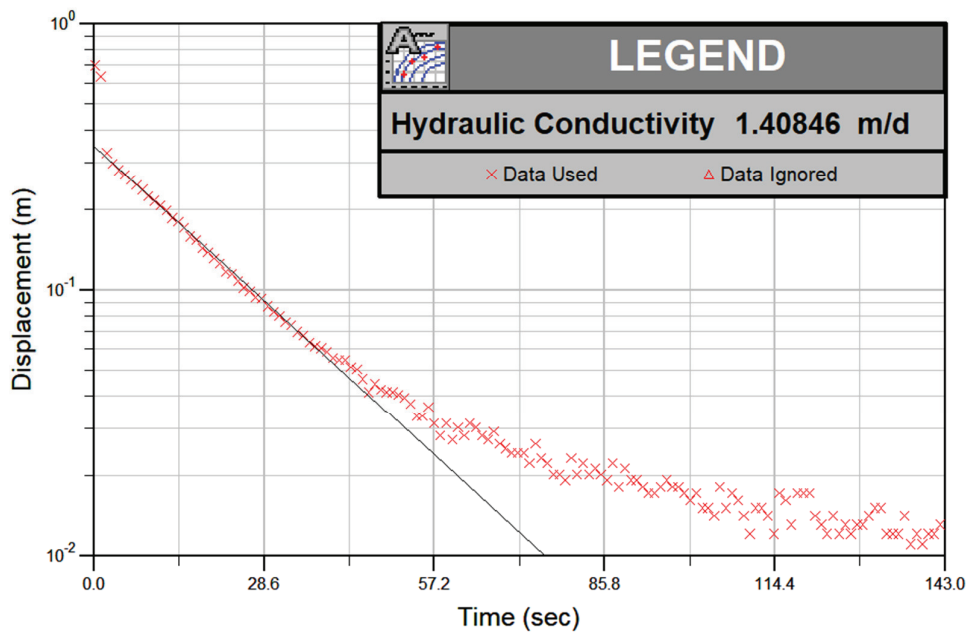
RBH302 – Test 2 – Middle Response

Bouwer & Rice



RBH302 – Test 3 – Middle Response

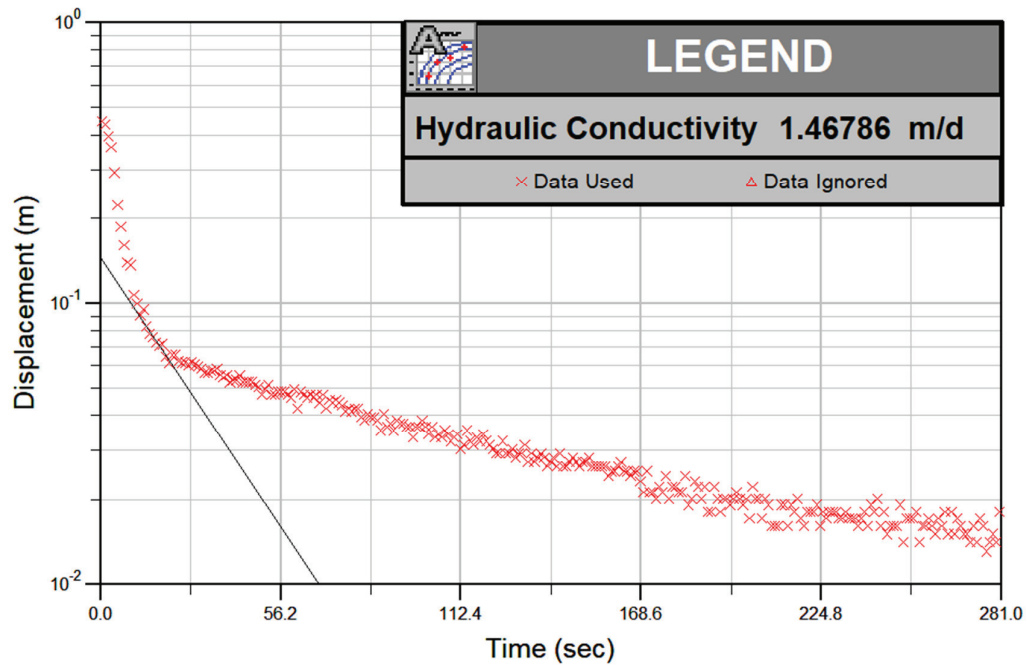
Bouwer & Rice



Plot NT02 - Permeability Testing Results

RBH303 – Test 2 – Middle Response

Bouwer & Rice

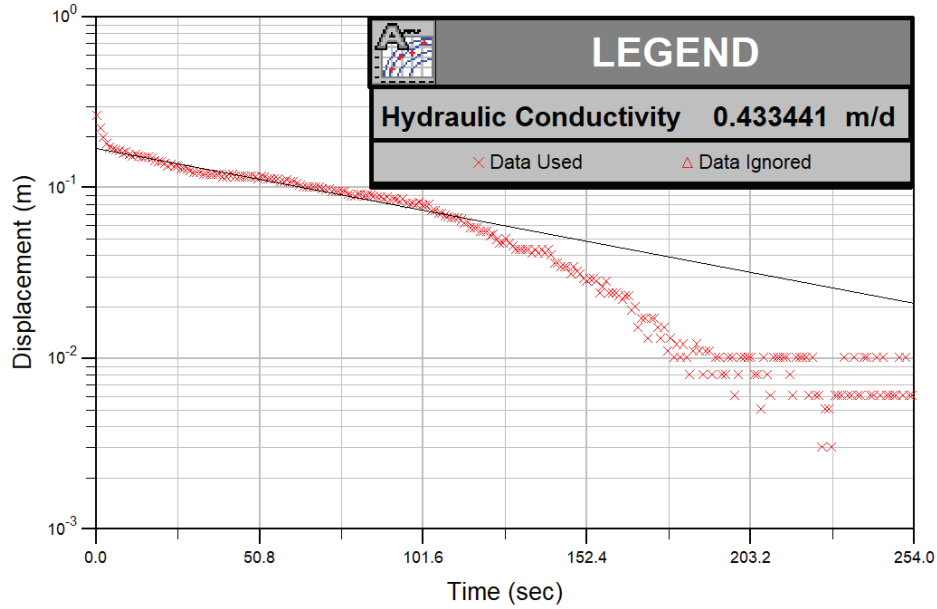


Plot NT02 - Permeability Testing Results

December 2023 data

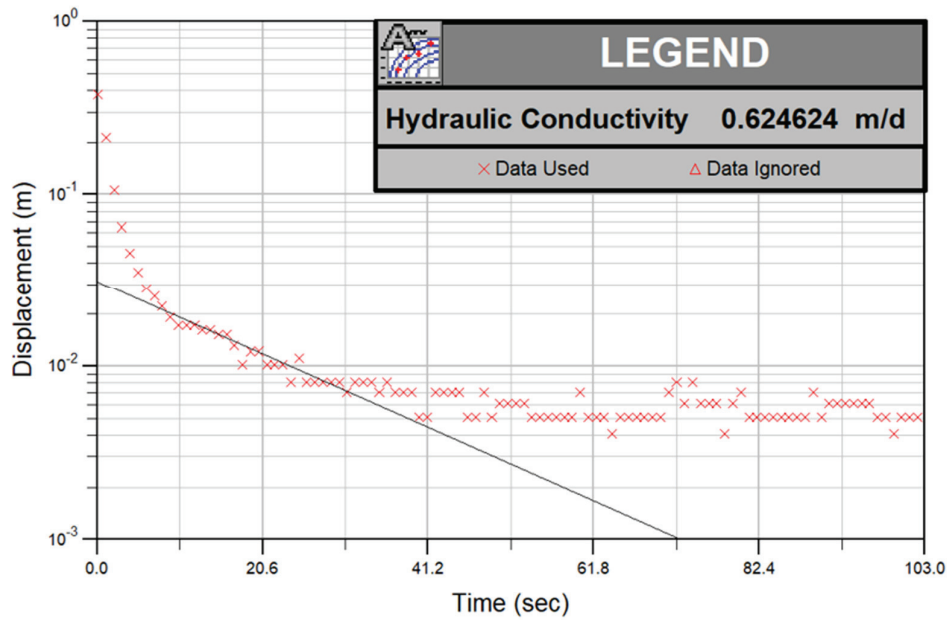
RBH503 – Test 1 – Middle Response

Bouwer & Rice



RBH505 – Test 2 – Middle Response

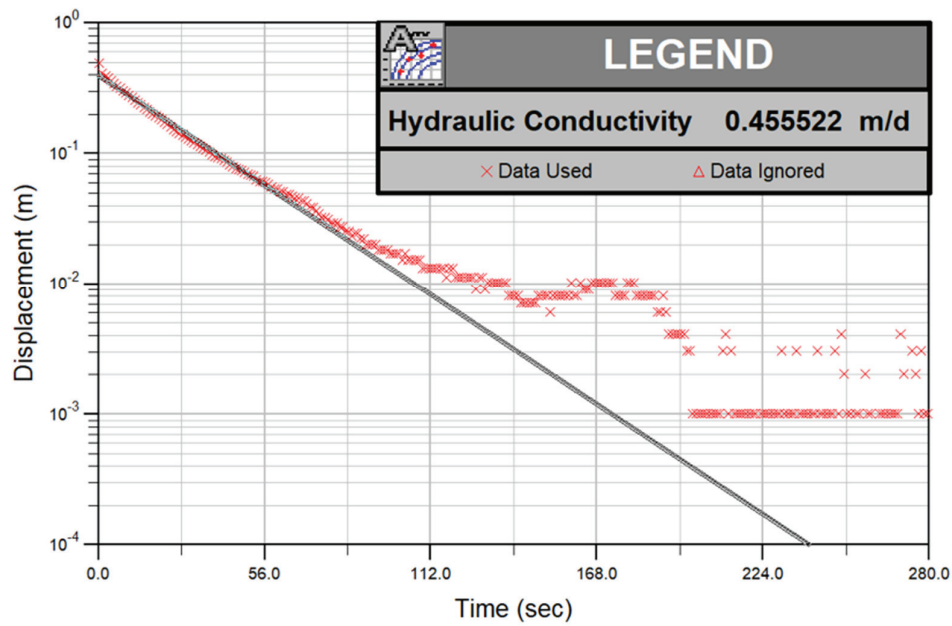
Bouwer & Rice



Plot NT02 - Permeability Testing Results

RBH505 – Test 3 – Middle Response

Bouwer & Rice

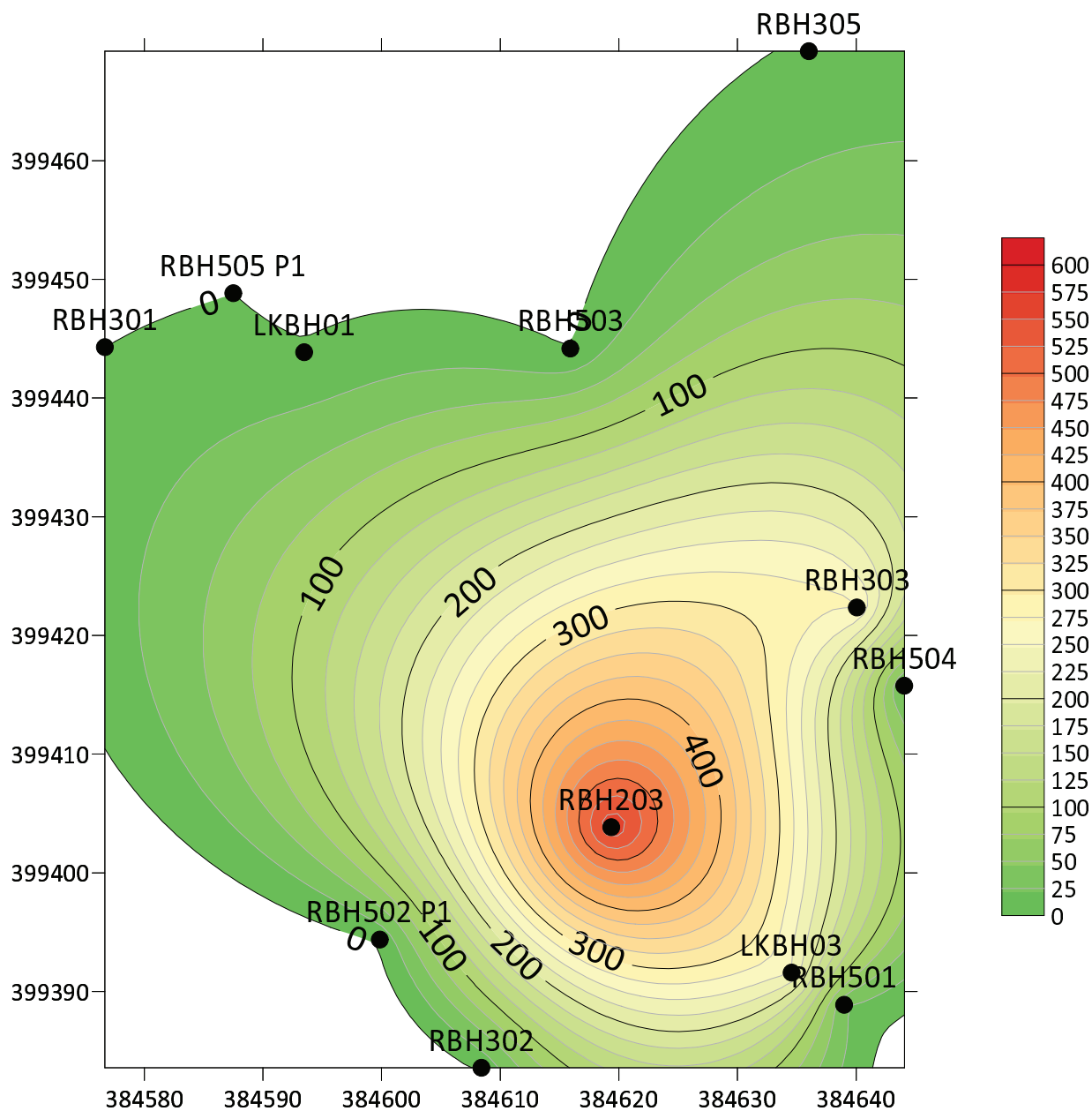




APPENDIX C

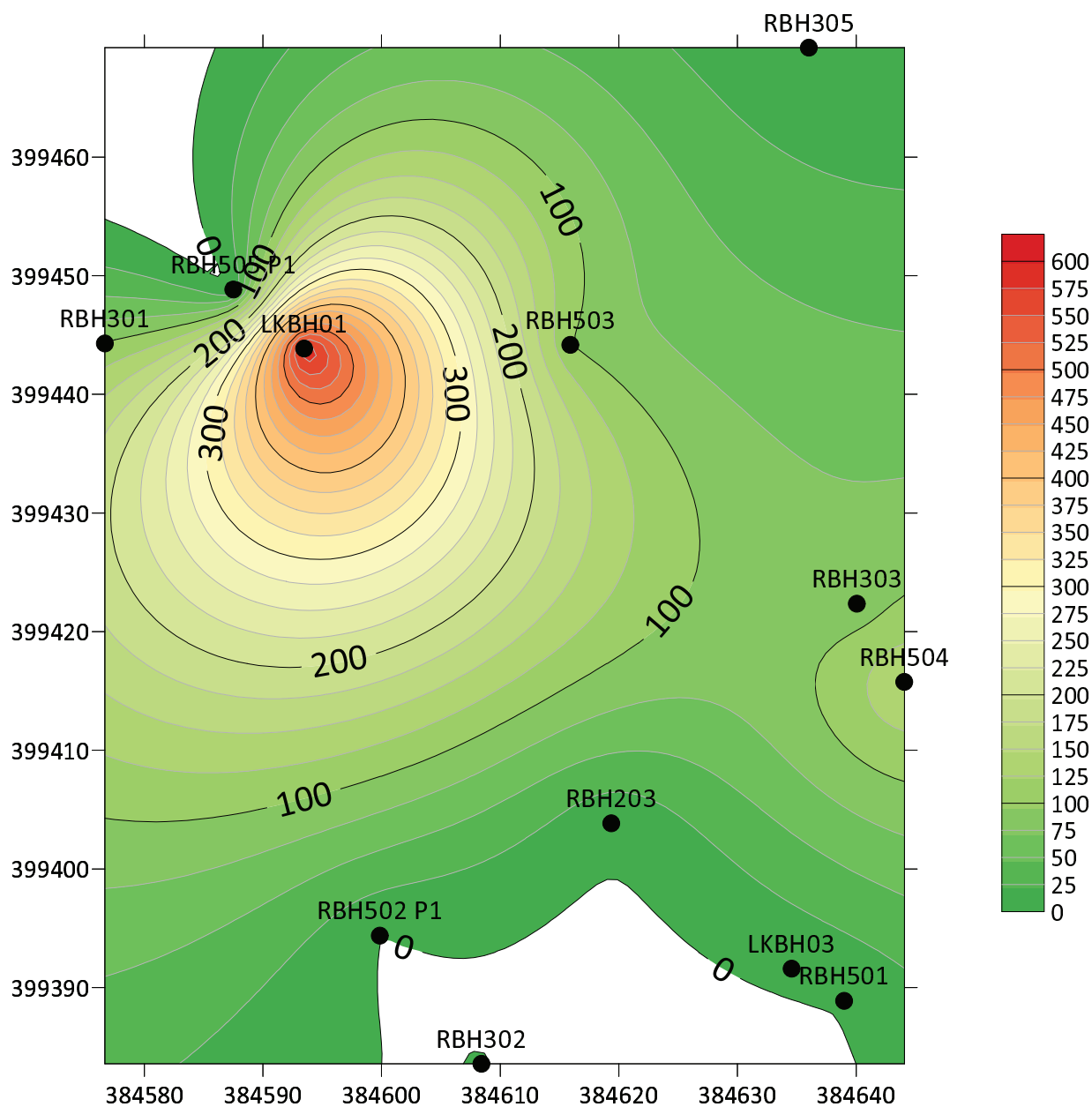
GROUNDWATER VOC SPATIAL DISTRIBUTION PLOTS

TCE Maximum Concentration in CHES

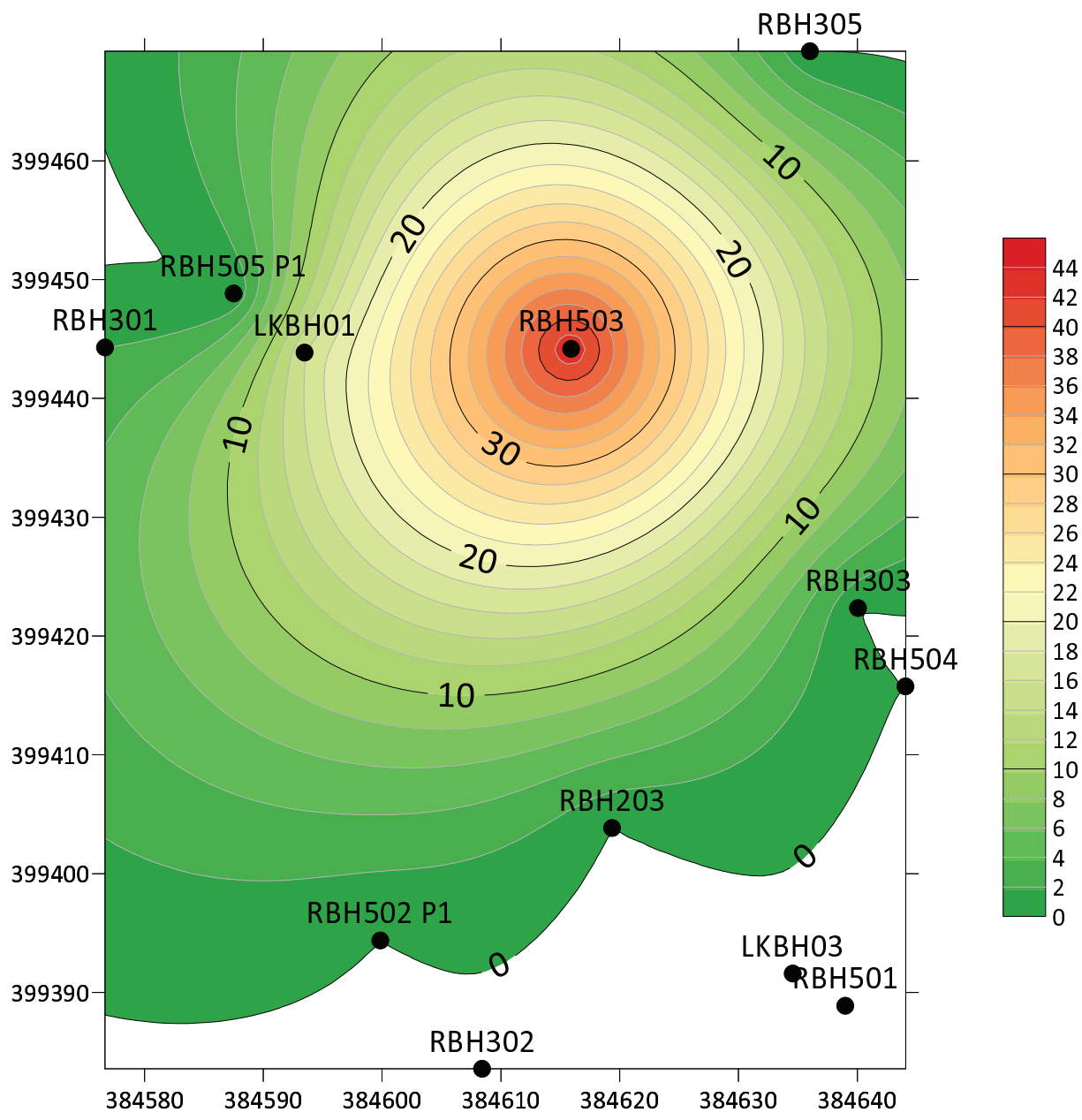


SUM - 1,2 Dichloroethene (cis and trans)

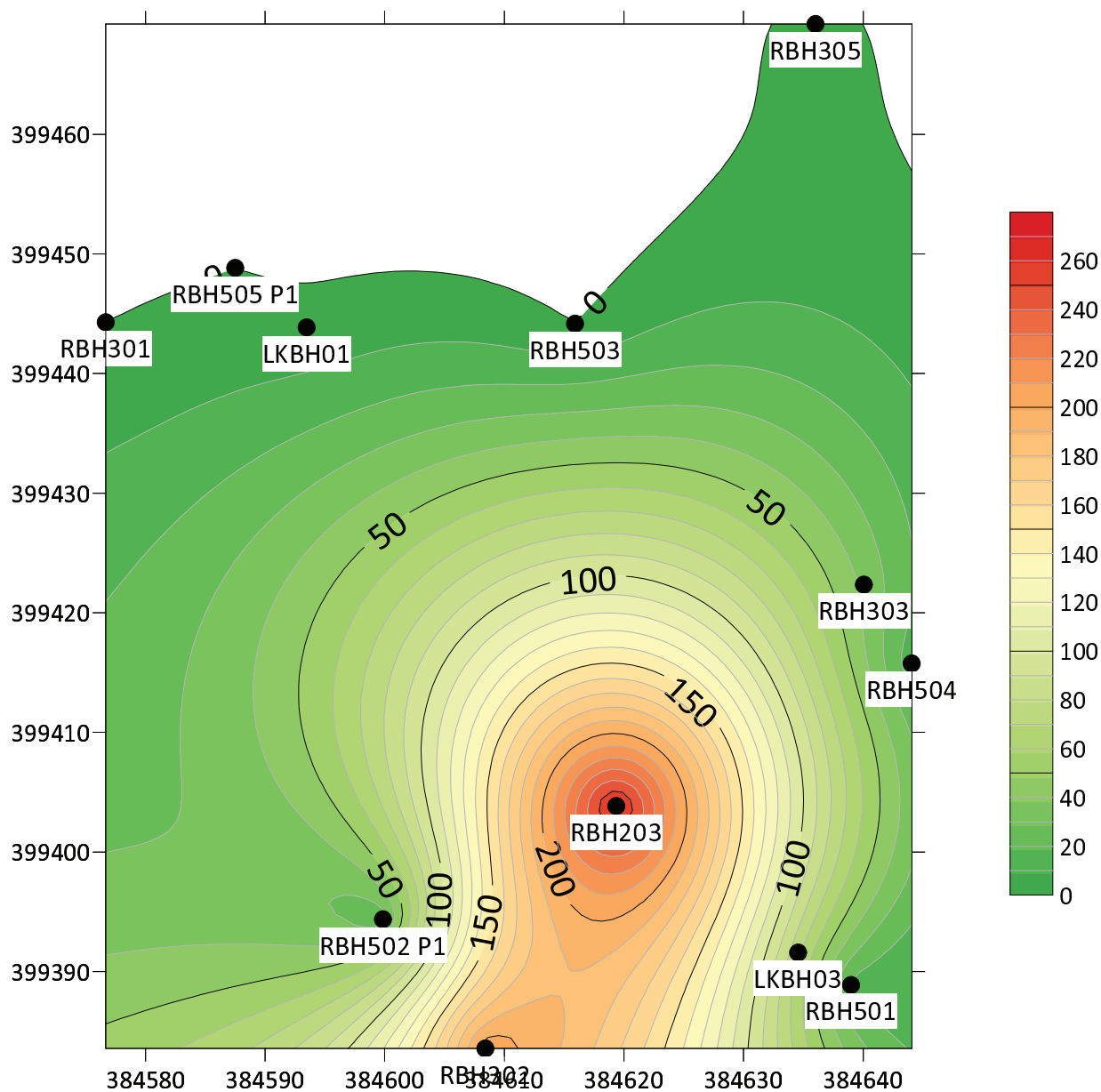
Maximum Concentrations in CHES



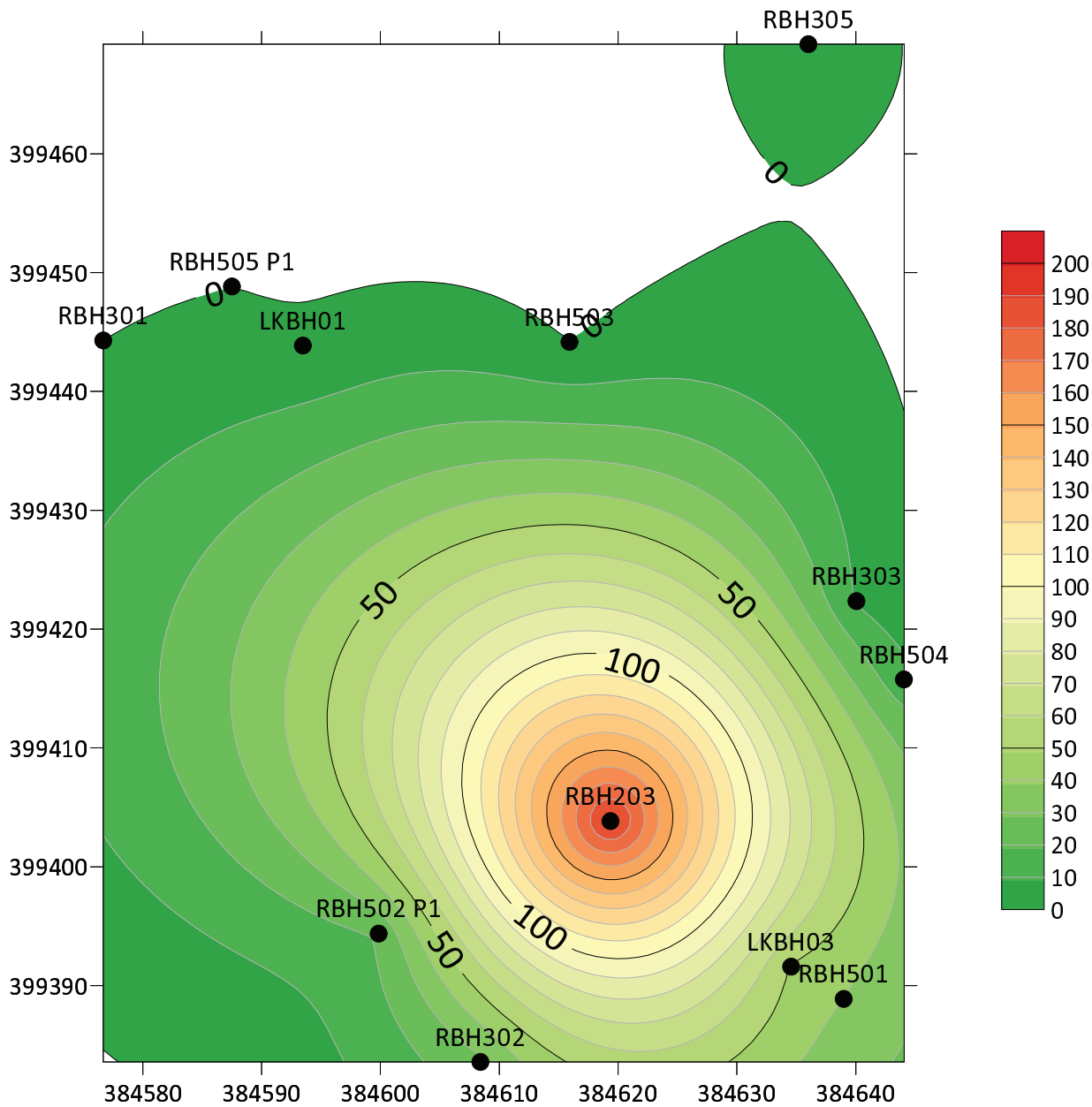
Vinyl Chloride Maximum Concentrations in CHES



Carbon Tetrachloride Maximum Concentrations in CHES



Chloroform Maximum Concentrations in CHES





APPENDIX D

CONTROLLED WATERS GENERIC ASSESSMENT CRITERIA

GENERIC ASSESSMENT CRITERIA FOR CONTROLLED WATERS

Protection of the water environment

The water environment in the United Kingdom is protected under a number of regulatory regimes. The relevant environmental regulator is consulted where there may be a risk that pollution of 'controlled waters' may occur or may have occurred in the past.

The term 'controlled waters' refers to coastal waters, inland freshwaters and groundwater. The EU Water Framework Directive (WFD) (2000/60/EC) is implemented via domestic regulations and guidance, covering aspects of groundwater and surface water protection as well as drinking water supply policy. Domestic legislation and guidance will vary across the United Kingdom. Therefore, the relevant legislation for England, Wales, Northern Ireland and Scotland should be reviewed, alongside guidance provided by the Environment Agency (EA), Natural Resource Wales (NRW), the Scottish Environmental Protection Agency (SEPA) or the Northern Ireland Environment Agency (NIEA), as appropriate.

The main objectives of the protection and remediation of groundwater under threat from land contamination are set out within "The Environment Agency's approach to groundwater protection", version 1.0 (March 2017)⁽¹⁾ and the associated guidance "Land contamination groundwater compliance points: quantitative risk assessments (March 2017)^(1a) that have replaced the previous guidance document "Groundwater Principles and Practice (GP3)". When assessing risks to groundwater, the following need to be considered:

- Where pollutants have not yet entered groundwater, all necessary and reasonable measures must be taken to:
 - **prevent** the input of **hazardous** substances into groundwater (see description of hazardous substances below)
 - **limit** the entry of other (non-hazardous) pollutants into groundwater to avoid pollution, deterioration in the status of groundwater bodies and to prevent sustained, upward trends in pollutant concentrations in groundwater.
- Where pollutants have already entered groundwater, the priority is to take all necessary and reasonable measures to:
 - **minimise** further entry of "contaminants" where there is a defined source
 - **limit the pollution** of groundwater or any effect on the status of the groundwater body from the future expansion of the 'plume', if necessary, by actively reducing its extent.

Within the context of groundwater risk assessments on sites affected by land contamination, "reasonable" means feasible without involving disproportionate costs. What costs are "disproportionate" depends on site-specific circumstances, which may include:

- Considerations of technical feasibility such as identified by the remedial options appraisal, this may be due to the distribution or nature of the contamination and the available remedial methods to treat the identified contamination;
- Sustainability considerations.

DEFINITIONS AND SUBSTANCE CLASSIFICATIONS

Risks to surface waters:

When assessing risks to surface waters, the following list of definitions should be understood:

Priority substances (PS) are harmful substances originally identified under the Water Framework Directive (WFD) 2000/60/EC as substances 'presenting a significant risk to or via the aquatic environment' at a European level. Member States are required to incorporate the identified **PS** into their country-wide monitoring programmes. There are currently 33 **PS** defined within the Priority Substances Directive (2013/39/EU; Annex 1), with a further 12 additional substances due to come into force from 22 December 2018. Directive 2013/39/EU has been transposed into domestic legislation for England and Wales by The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015.

Under the umbrella of **PS**, there is a sub-set of substances identified as being "hazardous", and these are referred to as **Priority hazardous substances (PHS)**. The list of **PHS** is defined at EU level within the Priority Substances Directive (2013/39/EU). The WFD defines hazardous substances as 'substances (or groups of substances) that are toxic, persistent and liable to bio-accumulate, and other substances or groups of substances that give rise to an equivalent level of concern.' There are currently **21 PHS** (previously 15 PHS, with a further 6 substances added in 22 December 2018).

There is also another group of substances defined at EU level and which are referred to as **other pollutants (OP)** in Directive 2013/39/EU. These are additional substances which although not **priority substances**, have EQS which are identical to those laid down in the legislation which applied prior to 13 January 2009 (Directive 2008/105/EU). The **OP** are listed along with the **priority substance (PS)** within the Priority Substances Directive (2013/39/EU), and their associated EQS are also listed therein. There are 6 **OP** defined within the Priority Substances Directive (2013/39/EU).

In addition to the EU level substances, there are also a group of pollutants defined at a Member State level, referred to as **Specific pollutants (SP)**. These substances are pollutants which are released in significant quantities into water bodies in each of the individual European Member States. Under the WFD, Member States are required to set their own EQS for these substances. An indicative list of **SP** is given in Annex VIII of the WFD. Many of the substances categorised as **SP** in the UK were formerly List 2 substances under the old Groundwater Directive (80/68/EEC). The **SP** are defined within Part 2 (Table 1) of The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015.

Risks to groundwater:

When assessing risks to groundwater, the following definitions should be understood:

Under the requirements of the Groundwater Daughter Directive (2006/118/EU), the UK has published a list of substances it considers to be **hazardous substances** with respect to groundwater. In their advisory capacity to the government, this list has been derived by the UK Joint Agencies Groundwater Directive Advisory Group (JAGDAG), of which the Environment Agency is a member. The latest JAGDAG list of **hazardous substances** was published in January 2019 and the Environment Agency will use the updated list of hazardous substances from this date for all new activities that may lead to the discharge of hazardous substances to groundwater. The list is extensive and can be found in full at:

<https://www.wfduk.org/stakeholders/jagdag>

Selecting the appropriate assessment criteria

When assessing the risks to controlled waters, various assessment criteria apply, depending on the nature of the assessment and the conceptual site model.

Where a surface water body is involved, then Environmental Quality Standards (EQS) are the relevant assessment criteria as they are designed to be protective of surface water ecology.

Where a public water supply or a Principal aquifer is involved, then the standards defined in The Water Supply (Water Quality) Regulations⁽²⁾ are the primary source of assessment criteria. The Private Water Supplies Regulations⁽³⁾ may also be applicable in some cases. For instances where there are no UK assessment criteria, then the World Health Organisation (WHO) drinking water guidelines⁽⁴⁾ may be used.

This appendix presents the generic assessment criteria (GAC) that RSK considers suitable for assessing risks to controlled waters for our most commonly encountered determinants. A full list of EQS for England and Wales are included in The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015.

The RSK GAC for controlled waters are presented in **Table 1** and **Table 2**. In line with the Environment Agency's Remedial Targets Methodology, the GAC for controlled waters are termed 'target concentrations'.

The appropriate target concentrations should be selected with consideration to:

- the site conceptual model (i.e. the receptor at potential risk);
- whether the substance is already present in groundwater at the site;
- whether or not the substance is classified as a priority hazardous substance under the Priority Substances Directive (2013/39/EC) (see above), or as a hazardous substance according to the current list of JAGDAG determinations⁽⁵⁾; and
- background concentrations in the aquifer (if applicable).

It is important to remember that the WFD and Environment Agency guidance^(1 & 1a) support a sustainable, risk-based approach be applied to groundwater contamination. Exceedance of any target concentration does not necessarily imply that an unacceptable risk exists or that remediation is inevitably required.

Target concentrations shaded in green are <u>statutory values</u>	Target concentrations shaded in orange are <u>non-statutory values</u>
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Note: Units µg/l throughout (unless otherwise stated)

Table 1: Target concentrations for controlled waters (excluding TPH CWG fractions)

Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors ⁽⁵⁾	Surface water receptors ⁽⁶⁾		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
Metals & other inorganics						
Hazardous substance	Specific pollutant	Arsenic	-	10 ⁽²⁾	50 ^(6a)	25 ^(6a)
Non-hazardous pollutant	Priority substance	Cadmium	0.1 ⁽⁷⁾	5 ⁽²⁾	≤0.08, 0.08, 0.09, 0.15, 0.25 ^(6b)	0.2 ^(6a)
(Not determined)	-	Chromium (total)	-	50 ⁽²⁾	8.1 Sum values for chromium III and VI	-
(Not determined)	Specific pollutant	Chromium (III)	-	Use value for total chromium	4.7 ^(6a)	-
Hazardous substance	Specific pollutant	Chromium (VI)			3.4 ^(6a)	0.6 ^(6a)

Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors ⁽⁵⁾	Surface water receptors ⁽⁶⁾		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
(Not determined)	Specific pollutant	Copper	-	2,000 ⁽²⁾	1 bioavailable ^(6a)	3.76 dissolved, where DOC ≤1mg/l ^(6a)
						3.76µg/l + (2.677µg/l x ((DOC/2) – 0.5µg/l)) dissolved, where DOC >1mg/l ^(6a)
Hazardous substance	Priority substance	Lead	-	10 ⁽²⁾	1.2 bioavailable ^(6a)	1.3 ^(6a)
Hazardous substance	Priority hazardous substance	Mercury	0.01 ⁽⁷⁾	1 ⁽²⁾	0.07 ^(6c)	0.07 ^(6c)
Non-hazardous pollutant	Priority substance	Nickel	-	20 ⁽²⁾	4.0 bioavailable ^(6a)	8.6 ^(6a)
Non-hazardous pollutant	-	Selenium	-	10 ⁽²⁾	-	-
Non-hazardous pollutant	Specific pollutant	Zinc	-	3,000 ⁽⁸⁾	10.9 bioavailable ^(6a)	6.8 dissolved ^(6a)
(Not determined)	Specific pollutant	Iron	-	200 ⁽²⁾	1000 ^(6a) *1	1000 ^(6a) *1
(Not determined)	Specific pollutant	Manganese	-	50 ⁽²⁾ (0.05mg/l)	123 bioavailable ^(6a) (0.123mg/l)	-
(Not determined)	-	Aluminium	-	200 ⁽²⁾	-	-

Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors ⁽⁵⁾	Surface water receptors ⁽⁶⁾		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
Hazardous substance	Priority hazardous substance	Tributyltin compounds (Tributyltin-cation)	0.001 ⁽⁷⁾	-	0.0002 ^(6a)	0.0002 ^(6a)
(Not determined)	-	Sodium	-	200,000 ⁽²⁾ (200 mg/l)	-	-
Non-hazardous pollutant	Specific pollutant	Cyanide (Hydrogen cyanide)	-	50 ⁽²⁾ (0.05 mg/l)	1 ^(6a) (0.001 mg/l)	1 ^(6a) (0.001 mg/l)
Non-hazardous pollutant	-	Total ammoniacal nitrogen ^s	-	500 ⁽²⁾ (0.5 mg/l) as NH ₄ (472 expressed as NH ₃ ; 389 expressed as N)	300 ^(6f) (0.3 mg/l) as N (364 expressed as NH ₃ ; 386 expressed as NH ₄)	-
Non-hazardous pollutant	Specific pollutant	Ammonia un-ionised (equilibrium ratio calculated) (NH ₃)	-	-	-	21 ^(6a) (0.021 mg/l)
Non-hazardous pollutant	Specific pollutant	Chlorine	-	-	2 ^(6a) (0.002 mg/l)	10 ^(6d) (0.01 mg/l)
(Not determined)	-	Chloride	-	250,000 ⁽²⁾ (250 mg/l)	-	-
(Not determined)	-	Sulphate	-	250,000 ⁽²⁾ (250 mg/l)	-	-
(Not determined)	-	Nitrate (as NO ₃)	-	50,000 ⁽²⁾ (50 mg/l)	-	-

Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors ⁽⁵⁾	Surface water receptors ⁽⁶⁾		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
(Not determined)	-	Nitrite (as NO ₂)	-	500 ⁽²⁾ (0.5 mg/l)	10 ⁽⁹⁾ (0.01 mg/l)	-
Volatile organic compounds (VOC)						
Non-hazardous pollutant	Other pollutant	Tetrachloroethene (tetrachloroethylene; PCE)	0.1 ⁽⁷⁾	10 ⁽²⁾ sum of TCE and PCE	10 ^(6a)	10 ^(6a)
Hazardous substance	Other pollutant	Trichloroethene (trichloroethylene; TCE)	0.1 ⁽⁷⁾		10 ^(6a)	10 ^(6a)
Hazardous substance (1,1,2,2-tetra - chloroethane)	Specific pollutant	Tetrachloroethane	-	-	140 ^(6a)	-
Hazardous substance	Other pollutant	Carbon tetrachloride (tetrachloromethane)	0.1 ⁽⁷⁾	3.0 ⁽²⁾	12 ^(6a)	12 ^(6a)
Non-hazardous pollutant	Priority substance	1,2-Dichloroethane	1.0 ⁽⁷⁾	3.0 ⁽²⁾	10 ^(6a)	10 ^(6a)
Non-hazardous pollutant	-	1.2-Dichloroethene (DCE) sum of cis and trans	-	50.0 ⁽⁴⁾	-	-
Hazardous substance	-	Vinyl chloride (chloroethene, chloroethylene)	-	0.5 ⁽²⁾	-	-
Non-hazardous pollutant	Priority substance	Dichloromethane	-	20 ⁽⁴⁾	20 ^(6a)	20 ^(6a)

Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors ⁽⁵⁾	Surface water receptors ⁽⁶⁾		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
Non-hazardous pollutant	Priority substance	Trichlorobenzenes	0.01 ⁽⁷⁾	-	0.4 ^(6a)	0.4 ^(6a)
Hazardous substance	Priority substance	Trichloromethane (Chloroform)	0.1 ⁽⁷⁾	100 ^(2a) (sum of trihalomethanes – chloroform, bromform, dibromochloromethane, bromodichloromethane)	2.5 ^(6a)	2.5 ^(6a)
(Not determined)	-	Bromoform	-		-	-
(Not determined)	-	Dibromochloromethane	-		-	-
(Not determined)	-	Bromodichloromethane	-		-	-
Non-hazardous pollutant	Priority hazardous substance	Di(2-ethylhexyl) phthalate (bis(2-ethylhexyl) phthalate, DEHP)	-	8 ⁽⁴⁾	1.3 ^(6a)	1.3 ^(6a)
(Not determined)	Specific pollutant	Benzyl butyl phthalate	-	-	7.5 ^(6a)	0.75 ^(6e)
Hazardous substance	Priority hazardous substance	Hexachlorobutadiene (as a pesticide, but reported in a VOC suite)	0.005 ⁽⁷⁾	0.1 ⁽²⁾	0.6 ^(6c)	0.6 ^(6c)
Semi-volatile organic compounds (SVOC)						
(Not determined) Not to be confused with acenaphthene, which is a hazardous substance	-	Acenaphthylene (Aro EC12-EC16)	-	-	5.8 ⁽¹⁰⁾	
Hazardous substance	Priority hazardous substance	Anthracene (Aro EC16-EC21)	-	-	0.1 ^(6a)	0.1 ^(6a)

Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors ⁽⁵⁾	Surface water receptors ⁽⁶⁾		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
Non-hazardous pollutant	Priority substance	Naphthalene (Aro EC10-EC12)	-	-	2 ^(6a)	2 ^(6a)
Hazardous substance	Priority substance	Fluoranthene (Aro EC21-EC35) not used as an indicator for this EC band	-	-	0.0063 ^(6a)	0.0063 ^(6a)
Hazardous substance(s)	Priority hazardous substance(s)	Benzo(a)pyrene (Aro EC21-EC35)	-	0.01 ⁽²⁾	0.00017 ^(6a)	0.00017 ^(6a)
		Benzo(b)fluoranthene (Aro EC21-EC35)	-	0.1 ⁽²⁾ sum of the concentration of the four specified compounds	No EQS for these substances. B(a)P should be used as the indicator compound instead.	
		Benzo(k)fluoranthene (Aro EC21-EC35)	-			
		Benzo(g,h,i)perylene (Aro EC21-EC35)	-			
		Indeno(1,2,3-cd) pyrene (Aro EC21-EC35)	-			
Non-hazardous pollutant	Specific pollutant	Phenol	-	-	7.7 ^(6a)	7.7 ^(6a)
Hazardous substance	Specific pollutant	2,4-Dichlorophenol	0.1 ⁽⁷⁾	-	4.2 ^(6a)	0.42 ^(6a)

Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors ⁽⁵⁾	Surface water receptors ⁽⁶⁾		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
Hazardous substance	Priority substance	Pentachloro-phenol (PCP) (as a pesticide, but reported in an SVOC suite)	0.1 ⁽⁷⁾	0.1 ⁽²⁾	0.4 ^(6a)	0.4 ^(6a)
Petroleum hydrocarbons						
Hazardous substance	-	Total petroleum hydrocarbons	-	See Table 2 for individual (non-statutory) TPH CWG fractions with respect to drinking water receptors	See individual risk driving compounds (i.e. BTEX and PAH) for specific EQS	
Hazardous substance	Priority substance	Benzene (Aro EC5-EC7)	1 ⁽⁷⁾	1 ⁽²⁾	10 ^(6a)	8 ^(6a)
Hazardous substance	Specific pollutant	Toluene (Aro EC7-EC8)	4 ⁽⁷⁾	700 ⁽⁴⁾	74 ^(6a)	74 ^(6a)
Hazardous substance	-	Ethylbenzene (Aro EC8-EC10)	-	300 ⁽⁴⁾	300 ⁽¹¹⁾	-
Hazardous substance	-	Xylenes (Aro EC8-EC10)	3 ⁽⁷⁾	500 ⁽⁴⁾	30 ⁽¹¹⁾	-
Non-hazardous pollutant	-	Methyl tertiary butyl ether (MTBE)	-	15 ⁽¹²⁾	-	

Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors ⁽⁵⁾	Surface water receptors ⁽⁶⁾		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
Pesticides, fungicides, insecticides and herbicides						
(Not determined) – assume to be Hazardous Substance as per below	-	Total pesticides	-	0.5 ⁽²⁾	-	-
(Not determined) - assume to be Hazardous Substance as per below	-	Other individual pesticides (unless otherwise detailed below)	-	0.1 ⁽²⁾	-	-
Hazardous substance(s)	Other pollutant (Cyclodiene pesticides)	Aldrin	0.003 ⁽⁷⁾	0.03 ⁽²⁾	0.01 ^(6a) (sum of all four)	0.005 ^(6a) (sum of all four)
		Dieldrin	0.003 ⁽⁷⁾	0.03 ⁽²⁾		
		Endrin	0.003 ⁽⁷⁾	0.1 ^(2b) ('other individual pesticide')		
		Isodrin*2	0.003 ⁽⁷⁾	0.1 ^(2b) ('other individual pesticide')		
Hazardous substance	Other pollutant	DDT (total)	0.002 ⁽⁷⁾	0.1 ⁽²⁾ ('other individual pesticide')	0.025 ^(6a)	0.025 ^(6a)
Hazardous substance	Specific pollutant	Carbendazim	-	0.1 ⁽²⁾ ('other individual pesticide')	0.15 ^(6a)	-

Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors ⁽⁵⁾	Surface water receptors ⁽⁶⁾		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
Hazardous substance	Specific pollutant	Chlorothalonil	-	0.1 ⁽²⁾ (‘other individual pesticide’)	0.035 ^(6a)	-
Hazardous substance	Priority substance	Cypermethrin	-	0.1 ⁽²⁾ (‘other individual pesticide’)	8.0E ^{-5(6a)}	8.0E ^{-6(6a)}
Hazardous substance	Specific pollutant	Dimethoate	0.01 ⁽⁷⁾	0.1 ⁽²⁾ (‘other individual pesticide’)	0.48 ^(6a)	0.48 ^(6a)
(Not determined)	Specific pollutant	Glyphosate	-	0.1 ⁽²⁾ (‘other individual pesticide’)	196 ^(6a)	196 ^(6a)
Hazardous substance	Specific pollutant	Linuron	-	0.1 ⁽²⁾ (‘other individual pesticide’)	0.5 ^(6a)	0.5 ^(6a)
Non-hazardous pollutant	Specific pollutant	Mecoprop	0.04 ⁽⁷⁾	0.1 ⁽²⁾ (‘other individual pesticide’)	18 ^(6a)	18 ^(6a)
Non-hazardous pollutant	Specific pollutant	Methiocarb	-	0.1 ⁽²⁾ (‘other individual pesticide’)	0.01 ^(6a)	-
Non-hazardous pollutant	Specific pollutant	Pendimethalin	-	0.1 ⁽²⁾ (‘other individual pesticide’)	0.3 ^(6a)	-

Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors ⁽⁵⁾	Surface water receptors ⁽⁶⁾		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
Hazardous substance	Specific pollutant	Permethrin	0.001 ⁽⁷⁾	0.1 ⁽²⁾ (‘other individual pesticide’)	0.001 ^(6a)	0.0002 ^(6a)
Hazardous substance	Priority substance	Alachlor	-	0.1 ⁽²⁾ (‘other individual pesticide’)	0.3 ^(6a)	0.3 ^(6a)
Hazardous substance	Priority substance	Atrazine	0.03 ⁽⁷⁾	100 ⁽⁴⁾ (‘other individual pesticide’)	0.6 ^(6a)	0.6 ^(6a)
Hazardous substance	Priority substance	Diuron	-	0.1 ⁽²⁾ (‘other individual pesticide’)	0.2 ^(6a)	0.2 ^(6a)
Hazardous substance	Priority hazardous substance	Endosulphan	0.005 ⁽⁷⁾	0.1 ⁽²⁾ (‘other individual pesticide’)	0.005 ^(6a)	0.0005 ^(6a)
Non-hazardous pollutant	Priority substance	Isoproturon	-	0.1 ⁽²⁾ (‘other individual pesticide’)	0.3 ^(6a)	0.3 ^(6a)
Hazardous substance	Priority substance	Simazine	0.03 ⁽⁷⁾	0.1 ⁽²⁾ (‘other individual pesticide’)	1 ^(6a)	1 ^(6a)
Hazardous substance	Priority hazardous substance	Trifluralin	0.01 ⁽⁷⁾	0.1 ⁽²⁾ (‘other individual pesticide’)	0.03 ^(6a)	0.03 ^(6a)



Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors ⁽⁵⁾	Surface water receptors ⁽⁶⁾		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
Hazardous substance	Priority substance	Dichlorvos	-	0.1 ⁽²⁾ (‘other individual pesticide’)	6.0E ^{-4(6a)}	6.0E ^{-5(6a)}
Hazardous substance	Priority substance	Heptachlor and heptachlor epoxide	-	0.03 ⁽²⁾	2.0E ^{-7(6a)}	1.0E ^{-08(6a)}
Miscellaneous						
(Not determined)	Specific pollutant	Triclosan (antibacterial agent)	-	-	0.1 ^(6a)	0.1 ^(6a)
Hazardous substance	Priority hazardous substance	Perfluoro-octane sulfonic acid (and its derivatives) (PFOS)	-	-	6.5E ^{-4(6a)}	1.3E ^{-4(6a)}
Hazardous substance	Priority hazardous substance	Hexabromo cyclododecane (HBCDD)	-	-	0.0016 ^(6a)	0.0008 ^(6a)



Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors ⁽⁵⁾	Surface water receptors ⁽⁶⁾		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
Notes:						
‘-’ A target concentration is not available.						
§Please note that total ammonia (NH ₄ ⁺ and NH ₃) is equivalent to ammoniacal nitrogen in laboratory reports						
*1 Please note that although iron is listed in the 2015 Direction as 1.000 µg/l, the EQS remains at 1mg/l in Scotland and it is assumed this is an error and should read either 1,000 or 1000µg/l.						
*2 Please note that although Isodrin is not listed in name within the group of “Cyclodiene pesticides” in Table 1 of Schedule 3 Part 3 of the 2015 Direction ⁽⁶⁾ , the CAS number for Isodrin (465-73-6) <u>is</u> listed and therefore it is assumed that it has been missed off the named list of substances.						
*3 Total petroleum hydrocarbons is used for consistency, but is an analytical method-defined measurement for a mixture of hydrocarbons subject to environmental analysis ¹¹ .						
“Bioavailable” in relation to copper, zinc, nickel and manganese (but not lead) is the generic EQSbioavailable ^(6a) derived from the Metal Bioavailability Assessment Tool (M-BAT) developed by the Water Framework Directive UK Technical Advisory Group (WFDTAG). Exceedance of this value should prompt a site-specific assessment using the M-BAT with pH, DOC and Ca to derive a site-specific EQS termed the PNEC _{dissolved} . http://www.wfduk.org/resources/rivers-lakes-metal-bioavailability-assessment-tool-m-bat .						
For zinc, if there is an exceedance of the EQSbioavailable in an initial GQRA, Tier 2 required that the EQS for zinc should also have the ambient background concentration of zinc added as well						

Table 2: World Health Organization (WHO) guide values for TPH CWG fractions in drinking water⁽¹³⁾ (as referenced in CL:AIRE, 2017⁽¹¹⁾)

TPH CWG fraction	WHO guide value for drinking water ⁽¹³⁾ (µg/l)
Aliphatic fractions:	
Aliphatic EC5-EC6	15,000
Aliphatic >EC6-EC8	15,000
Aliphatic >EC8-EC10	300
Aliphatic >EC10-EC12	300
Aliphatic >EC12-EC16	300
Aliphatic >EC16-EC21	-
Aliphatic >EC21-EC35	-
Aromatic fractions:	
Aromatic EC5-EC6	10 (benzene)
Aromatic >EC6-EC8	700 (toluene)
Aromatic >EC8-EC10	300 (ethyl benzene) 500 (xylenes)
Aromatic >EC10-EC12	90
Aromatic >EC12-EC16	90
Aromatic >EC16-EC21	90
Aromatic >EC21-EC35	90
Reference: World Health Organisation (WHO), 2008. Petroleum products in drinking-water. Background document for development of WHO guidelines for drinking water quality. WHO/SDE/WSH/05.08/123. World Health Organisation, Geneva ⁽¹³⁾ .	

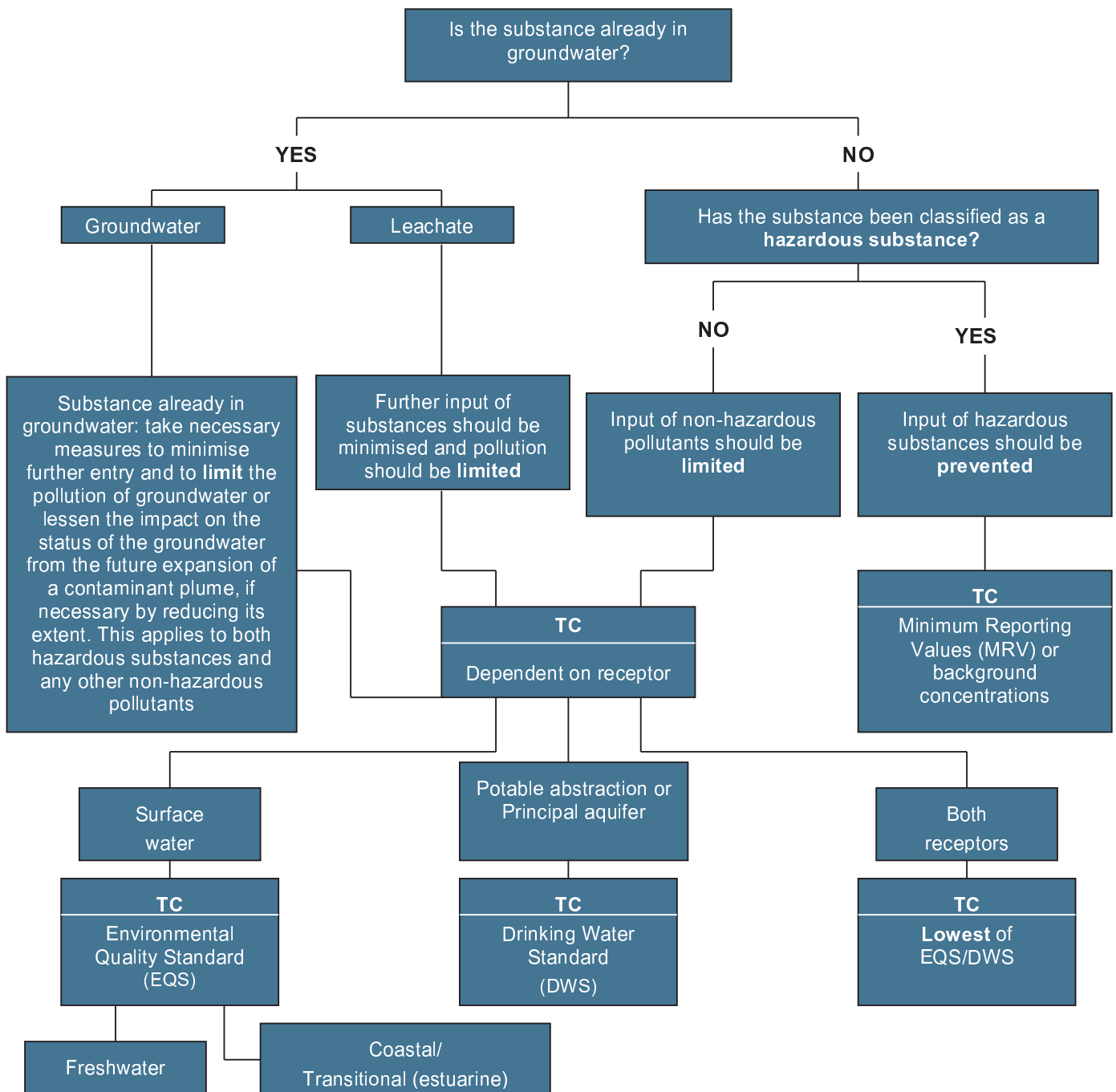
References

1. Environment Agency (2018), 'The Environment Agency's approach to groundwater protection', version 1.2, February 2018 (formerly contained within GP3).
<https://www.gov.uk/government/collections/groundwater-protection>
- 1a. Environment Agency (2017), 'Land contamination groundwater compliance points: quantitative risk assessments', March 2017 (formerly contained within GP3) [accessed 29 March 2017].
<https://www.gov.uk/government/collections/groundwater-protection>
2. The Water Supply (Water Quality) Regulations 2016 (SI 2016/619)
 - 2a. Sum of chloroform, bromoform, dibromochloromethane and bromodichloromethane
 - 2b. Standard applies to individual pesticides except aldrin, dieldrin, heptachlor and heptachlor epoxide, for which a separate standard is defined.
3. The Private Water Supplies (England) Regulations 2016. SI 2016 / 618
4. WHO (2011), *Guidelines for drinking-water quality*, 4th edn
5. JAGDAG hazard substance determinations (January 2019): This list contains substances that are determined to be hazardous substances or non-hazardous pollutants for the purposes of the groundwater directive 2006/118/EC. <https://www.wfduk.org/stakeholders/jagdag> [accessed 1 February 2021]
The absence of an assessment or substance from the list means an assessment has not been completed and is therefore presented as 'Not determined'. For further details on how substances are assessed, see the Joint Agencies Groundwater Directive Advisory Group (JAGDAG) 'Methodology for the determination of hazardous substances in groundwater for the purposes of the groundwater directive 2006/118/EC' which is available from the JAGDAG website. The methodology is a UK –wide framework that sets criteria for how to assess whether a substance is a hazardous substances in groundwater.
6. The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015.
 - 6a. The EQS for these substances are based on a "long term mean" or an "annual average (AA)" EQS.
 - 6b. For cadmium and its compounds the EQS values vary depending on the hardness of the water as specified in five class categories (Class 1: < 40 mg CaCO₃/l, Class 2: 40 to < 50 mg CaCO₃/l, Class 3: 50 to < 100 mg CaCO₃/l, Class 4: 100 to < 200 mg CaCO₃/l and Class 5: ≥ 200 mg CaCO₃/l).
 - 6c. The EQS for Mercury and hexachlorobutadiene are based on a "maximum acceptable concentration (MAC)" EQS in absence of an "annual average (AA)" EQS.
 - 6d. The EQS for chlorine in saltwater is based on the 95th percentile concentration of total residual oxidant, which refers to the sum of all oxidising agents existing in water, expressed as available chlorine.
 - 6e. The recommended saltwater standard is derived using a safety factor of 100. Where the standard is failed, it is recommended that supporting evidence of ecological damage should be obtained before committing to expensive action.
 - 6f. EQS for total ammonia is as per Schedule 3, Part 1, Table 7 of of the above directions. EQS applies to river types 1, 2 and 4 and 6 (namely upland and low alkalinity). The EQS for a lowland and high alkalinity rivers (types 3, 5 and 7) is 600µg/l (0.6mg/l).

Additional information on the Metal Bioavailability Assessment Tool (M-BAT) is available at <http://www.wfduk.org/resources/rivers-lakes-metal-bioavailability-assessment-tool-m-bat>

7. Minimum reporting values listed at <https://www.gov.uk/government/publications/values-for-groundwater-risk-assessments/hazardous-substances-to-groundwater-minimum-reporting-values> (updated 13 January 2017; accessed 29 March 2017). Note target concentration for xylenes is 3 µg/l each for o-xylene and m/p xylene as it may not be possible to separate m- and p-xylene; 135 tcb, 124 tcb, 123 tcb each to 0.01 µg/l)
8. The Surface Waters (Abstraction for Drinking Water) (Classification) Regulations 1996 (as amended). SI 1996 / 3001
9. Council Directive on the Quality of Fresh Waters Needing Protection or Improvement in Order to Support Fish Life (Freshwater Fish Directive) (78/659/EEC)
10. WRc plc (2002), R&D Technical Report P45.
11. CL:AIRE, 2017. Petroleum Hydrocarbons in Groundwater: Guidance on assessing petroleum hydrocarbons using existing hydrogeological risk assessment methodologies. V1.1.
12. Drinking Water Inspectorate (London, UK). Environmental Information Request on MTBE in drinking water. Ref. DWI 1/10/18; dated 28 November 2006. Value is based on the odour threshold for MTBE, which is lower than a health-based guideline value
13. World Health Organisation (WHO), 2008. Petroleum products in drinking-water. Background document for development of WHO guidelines for drinking water quality. WHO/SDE/WSH/05.08/123. World Health Organisation, Geneva. [accessed 29 March 2017] http://www.who.int/water_sanitation_health/dwq/chemicals/petroleumproducts_2add_june2008.pdf

FLOW CHART TO ASSIST WITH SELECTION OF TARGET CONCENTRATIONS



TC = Target concentration

When leachate is being assessed the 'compliance point' is the groundwater body. Therefore dilution within the groundwater body may be applied with caution before comparing with the TC.

When directly assessing a receptor, e.g., a river, the appropriate TC should be selected.



APPENDIX E

MODEL INPUT PARAMETERS

MODEL INPUT PARAMETERS

Input parameters for the controlled waters DQRA, along with justification for each input parameter are presented in Table A and Table B below:

Table A: Input parameters for controlled waters assessment – soil source

Parameter	Value	Justification
Level 1 Parameters - MG gravelly sand/sandy gravel + Till (very soft to stiff sandy gravelly clay)		
Water filled porosity	0.252	Literature values for total porosity from Consim for sand (0.31-0.46), gravel (0.24-0.46) results in a geometric mean of 0.36. This value is then split in line with SR3 sandy loam which uses 70% and 30% of total porosity as the water and air filled porosity values respectively (water 0.252, air 0.106).
Air filled porosity	0.106	
Bulk density	1.78	Site specific data (average of 5 values).
Fraction of organic carbon (foc)	0.0506	Taken as average from made ground sample analysis at WS301 to WS309.
Level 2 Parameters		
Infiltration (m/day)	4.74x10E-04	Value of 173mm/year taken from 4328-ROC-ZZ-XX-DR-ES-ES208 Rev.01 based on data for the climate period 1991-2000, the annual rainfall at the Woodford station is estimated 864.40mm/year, the UK average evapo-transpiration losses are typically 40%. Approximately 95% of the site is anticipated to be hardstanding and / or covered by buildings, thus increasing runoff; conservatively the overall infiltration (aquifer recharge) has been estimated to be approximately 20% of the total rainfall (~173 mm/year or 4.74x10E-04 m/day).
Length of source in direction of groundwater flow (m)	25	Taken from Drawing TCE contamination (soil) 4328-ROC-ZZ-XX-DR-ES-ES208 Rev.01, considering the minimum potential remedial extent and the extent of historic bolt works in a direction parallel to the groundwater flow.
Width of source perpendicular to groundwater flow (m)	75	Taken as the width of the footprint of the historic boltworks (shown on Figure 4328-ROC-ZZ-XX-DR-ES-ES208 in Appendix A of the RoC Phase 2 report) in the south of Plot NT02 extending into the southwest of Plot NT03 perpendicular to the groundwater flow, at the south boundary of the site.
Saturated aquifer thickness (m)	6.81	Where proven the thickness of the CHES in Plots NT02 and NT03 was 4.9 to 13.8 m with an average thickness of 9.3 m. The average elevation of the base of the CHES at these boreholes is 20.23 m AOD and the average groundwater elevation in the

Parameter	Value	Justification
		CHES from the 2023 monitoring rounds is 27.04 m AOD. This gives an average saturated aquifer thickness of (27.04 minus 20.23) 6.81 m
Hydraulic conductivity of aquifer (m/d)	0.82	Hydraulic conductivity testing on site in the CHES at RBH203, RBH301, RBH302, RBH303, RBH503 and RBH505 gave a range of 5.01E-06 to 1.76E-05 m/sec, with a geometric mean of 6.17x10E-06 m/sec or 0.82 m/day. These values lie between reported CONSIM literature values for a solid sandstone of 3x10E-10 m/s and 6x10E-06 m/s and a sand of 1x10E-07 m/s and 6x10E-03 m/s, consistent with groundwater flow within a weathered sandstone. As such, the geometric mean has been adopted within the model set up.
Hydraulic gradient of water table (-)	0.0066	The hydraulic gradients calculated for the CHES between LKBH03 and LKBH01, RBH203 and RBH503 and between RBH502 P1 and RBH505 P1 ranged between 0.0030 and 0.0096 with an average of 0.0066 as shown in Section 4.3.2 of the DQRA report.
Level 3 Parameters – Chester Formation - Sandstone		
Effective porosity of aquifer (-)	0.27	Taken as average of geometric mean for literature value for a fine to medium sandstone effective porosity of 0.02-0.41, arithmetic mean 0.21-0.27 and coarse sand 0.18-0.43, arithmetic mean 0.30. Geomean calculated mid point sandstone means 0.24 and 0.3 for sand gives 0.27 effective porosity. Literature source: McWhorter, D.B., and D.K. Sunada, "Ground-Water Hydrology and. Hydraulics," 1948, (1984 reprint) (1977 1st edition).
Bulk density of aquifer materials (g/cm ³)	2.14	Average value from Consim literature range for sandstone.
Fraction of organic carbon (foc)	0.0039	Taken as average from sandstone sample analysis at WS30, WS303 and WS304.
Distance to compliance point (m)	50 m	Distance from soil source area to the down gradient site boundary.
Degradation half life (days)		Based on groundwater monitoring data an aerobic degradation half-life has been selected for modelling. High groundwater degradation rate literature values taken from Handbook of Environmental Degradation Rates, Howard et al, 1991.

Table B: Input parameters for controlled waters assessment – Groundwater source

Parameter	Value	Justification
Width of plume in aquifer at source (m)	75	Groundwater source: 75.00 m wide by 25.00 m length source area representing the plume core underlying the TCE soil source.
Plume thickness at source (m)	6.81	Conservatively set as the saturated aquifer thickness of 6.81 since TCE is heavier than water and will likely migrate to the base of the CHES.
Saturated aquifer thickness (m)	6.81	Where proven the thickness of the CHES in Plots NT02 and NT03 was 4.9 to 13.8 m with an average thickness of 9.3 m. The average elevation of the base of the CHES at these boreholes is 20.23 m AOD and the average groundwater elevation in the CHES from the 2023 monitoring rounds is 27.04 m AOD. This gives an average saturated aquifer thickness of (27.04 minus 20.23) 6.81 m.
Aquifer Bulk density of aquifer materials (g/cm ³)	2.14	Average value from Consim literature range for sandstone.
Effective porosity of aquifer (ad.)	0.27	Taken as average of geometric mean for literature value for a fine to medium sandstone effective porosity of 0.02-0.41, arithmetic mean 0.21-0.27 and coarse sand 0.18-0.43, arithmetic mean 0.30. Geomean calculated mid point sandstone means 0.24 and 0.3 for sand gives 0.27 effective porosity. Literature source: McWhorter, D.B., and D.K. Sunada, "Ground-Water Hydrology and. Hydraulics," 1948, (1984 reprint) (1977 1st edition).
Hydraulic gradient (ad.)	0.0066	The hydraulic gradients calculated for the CHES between LKBH03 and LKBH01, RBH203 and RBH503 and between RBH502 P1 and RBH505 P1 ranged between 0.0030 and 0.0096 with an average of 0.0066 as shown in Section 4.3.2 of the DQRA report.
Hydraulic conductivity (m/day)	0.82	Hydraulic conductivity testing on site in the CHES at RBH203, RBH301, RBH302, RBH303, RBH503 and RBH505 gave a range of 5.01E-06 to 1.76E-05 m/sec, with a geometric mean of 6.17x10E-06 m/sec or 0.82 m/day. These values lie between reported CONSIM literature values for a solid sandstone of 3x10E-10 m/s and 6x10E-06 m/s and a sand of 1x10E-07 m/s and 6x10E-03 m/s, consistent with groundwater flow within a weathered sandstone. As such, the geometric mean has been adopted within the model set up.

Parameter	Value	Justification
Fraction of organic carbon (foc)	0.0039	Taken as average from sandstone sample analysis at WS301 (4.5 m bgl), WS303 (3.1 m bgl) and WS304 (3.5m bgl).
Distance to compliance point (m)	50	Distance from soil source area/ area of maximum groundwater concentrations to the down gradient site boundary.
Degradation half life (days)	Based on groundwater monitoring data an aerobic degradation half-life has been selected for modelling. High groundwater degradation rate literature values taken from Handbook of Environmental Degradation Rates, Howard et al, 1991.	



APPENDIX F

QUANTITATIVE MODELLING RESULTS

[illegible]

Input Parameters for RTM Worksheets for Controlled Waters Risk Assessment
for a Soil Source in the Unsaturated Zone

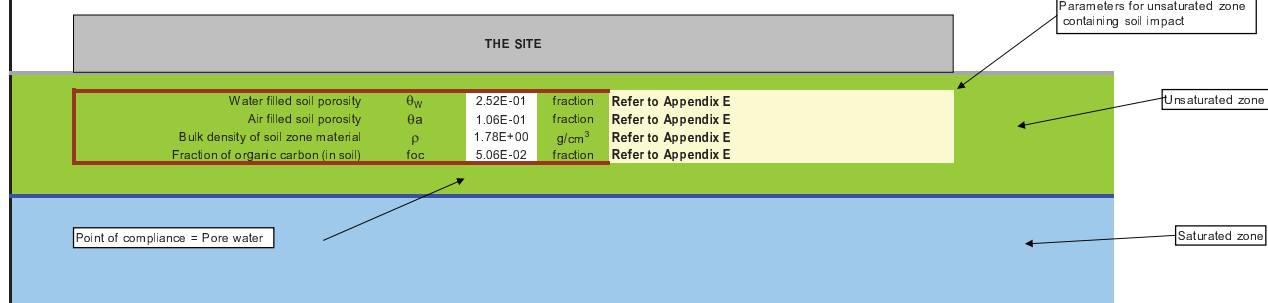


Site Name: Plot NT02 Dantzig Street
Site Address: Plot NT02 Dantzig Street

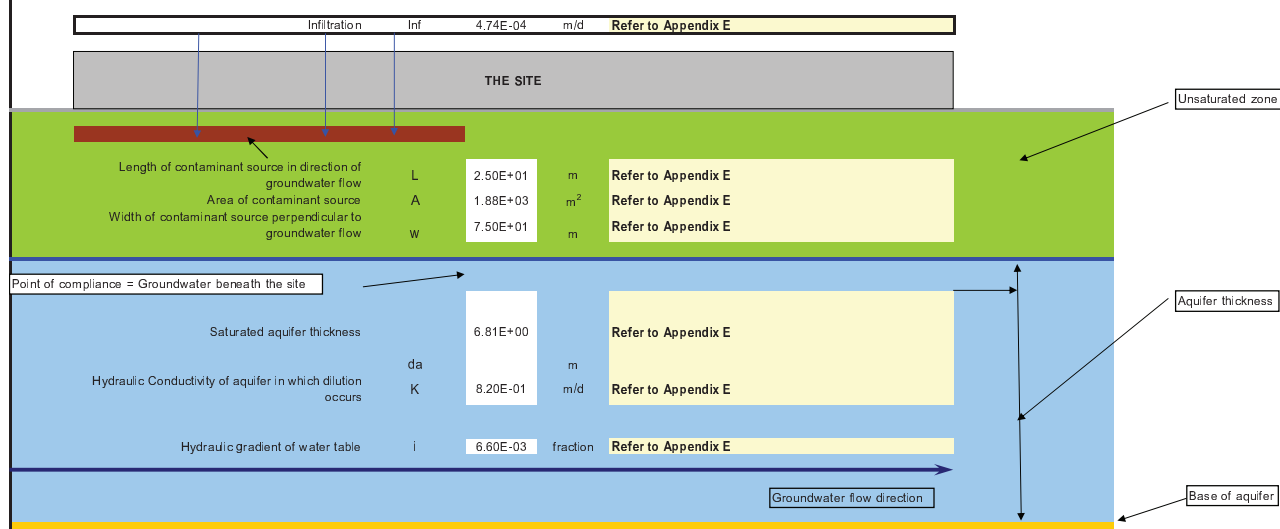
Completed by: Laura Aspinall
Date: 12-Dec-23

Version: Controlled waters risk assessment

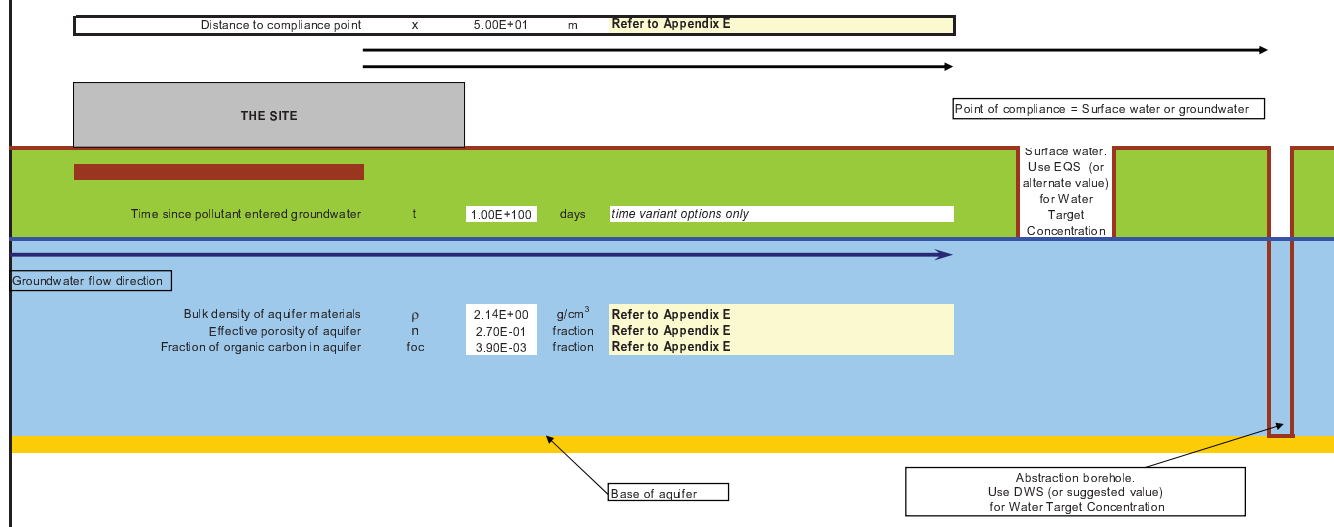
Level 1 soil inputs



Level 2 soil inputs



Level 3 soil inputs



Input Parameters for RTM Worksheets for Controlled Waters Risk Assessment for a Dissolved Phase Source in Groundwater



Site Name: Plot NT02 Dantzie Street
Site Address: Plot NT02 Dantzie Street

Completed by: Laura Aspinall
Date: 12-Dec-23

Version: Controlled waters risk assessment

Level 3 groundwater inputs

Distance (lateral) to compliance point perpendicular to flow direction
Distance (depth) to compliance point perpendicular to flow direction

z

m

Value is 0

y

m

Value is 0

Distance to compliance point

x

5.00E+01

m

Refer to Appendix E

THE SITE

Time since pollutant entered groundwater
Hydraulic gradient

t

1.00E+00

days

time variant options only

Hydraulic gradient

i

6.60E-03

fraction

Refer to Appendix E

Point of compliance = Surface water or groundwater

Surface water. Use EOS (or alternate value) for Water Target Concentration

Plume thickness at source

Dissolved phase GW plume

Groundwater flow direction

Width of plume in aquifer at source (perpendicular to flow)

Sz

7.50E+01

m

Refer to Appendix E

Plume thickness at source

Sy

4.52E+00

m

Refer to Appendix E

Saturated aquifer thickness

da

6.81E+00

m

Refer to Appendix E

Bulk density of aquifer materials

ρ

2.14E+00

g/cm³

Refer to Appendix E

Effective porosity of aquifer

n

2.70E-01

fraction

Refer to Appendix E

Hydraulic conductivity of aquifer

K

8.20E-01

m/d

Refer to Appendix E

Fraction of organic carbon in aquifer

foc

3.90E-03

fraction

Refer to Appendix E

Base of aquifer

Abstraction borehole. Use DWS (or suggested value) for Water Target Concentration

Site Name:	Plot NT02 Dantzig Street
Site Address:	Plot NT02 Dantzig Street

SUMMARY OF RESULTS FROM RTM WORKSHEETS

Version: Controlled waters risk assessment

[illegible]

Site Name:		Plot NT02 Dantzic Street			
Site Address:		Plot NT02 Dantzic Street			
SUMMARY OF RESULTS FROM RTM WORKSHEETS		Version: Controlled waters risk assessment			
TABLE Z		PREDICTED CONCENTRATION AT POINT OF COMPLIANCE			
Contaminant	Target Concentration (C _T) mg/l	Level 1 Soil Impact (mg/l)	Level 2 Soil Impact mg/l)	Level 3 Soil Impact (mg/l)	Level 3 Groundwater Impact (mg/l)
Trichloroethene (TCE)	0.01	1.55E-01	5.05E-02	2.55E-02	2.11E-01
Carbon tetrachloride (tetrachloroethene)	0.003	3.02E-03	9.85E-04	6.08E-05	5.33E-03
Cis/trans 1,2-dichloroethene (DCE)	0.05	0.00E+00	0.00E+00	0.00E+00	3.34E-01
Vinyl Chloride (chloroethene)	0.0005	0.00E+00	0.00E+00	0.00E+00	5.18E-03

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Trichloroethene (TCE)		from Level 1
Target Concentration	C _T	0.01	mg/l	from Level 1
Dilution Factor	DF	3.00E+00		from Level 2

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

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Enter source concentration			Soil concentration as mg/kg
Enter soil concentration	1	mg/kg	
Half life for degradation of contaminant in water	1.69E+03	days	
Calculated decay rate	4.11E-04	days ⁻¹	Howard et al high half life (aerobic conditions)
Width of plume in aquifer at source	7.50E+01	m	from Level 2
Plume thickness in aquifer at source	4.52E+00	m	from Level 2
Bulk density of aquifer materials	2.14E+00	g/cm ³	Refer to Appendix E
Effective porosity of aquifer	2.70E-01	fraction	Refer to Appendix E
Hydraulic gradient	9.80E-03	fraction	from Level 2 (adj) used
Hydraulic conductivity of saturated aquifer	8.25E-01	m/d	from Level 2
Distance to compliance point	5.00E+01	m	Refer to Appendix E
Distance (laterally) to compliance point perpendicular to flow direction		m	
Distance (depth) to compliance point perpendicular to flow direction		m	
Time since pollutant entered groundwater	1.00E+100	days	time variant options only
Parameters values determined from options			
Partition coefficient	5.51E-01	l/kg	see options
Longitudinal dispersivity	2.984	m	see options
Transverse dispersivity	0.298	m	see options
Vertical dispersivity	0.030	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	2.98E-02	m/d
Retardation factor	5.36E+00	fraction
Decay rate used	7.82E-05	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	9.80E-03	fraction
Rate of contaminant flow due to retardation	5.55E-03	m/d
Ratio of Compliance Point to Source Concentration	5.01E-01	fraction
Attenuation factor (C ₀ /C ₉₉)	1.99E+00	fraction
Calculated soil leachate concentration	1.55E-01	mg/l

Remedial Targets

Level 3 Remedial Target	6.08E-02	mg/l	For comparison with measured pore water concentration, This assumes Level 1 Remedial Target is based on Target Concentration.
Ogata Banks			
Distance to compliance point	4.44E-01	mg/kg	For comparison with measured soil concentration, This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	5.04E-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 coefficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient

K_d 1.0E+00 l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer

f_{oc} 3.90E-03 fraction

Organic carbon partition coefficient

K_{oc} 1.41E+02 l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species

K_{oc,L} 1.0E+00 l/kg

Sorption coefficient for ionised species

K_{oc,L} 1.0E+00 l/kg

pH value

pH 7.00 fraction

Acid dissociation constant

pK_a 7.00 fraction

Fraction of organic carbon in aquifer

f_{oc} 3.90E-03 fraction

Soil water partition coefficient

K_d 5.51E-01 l/kg

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

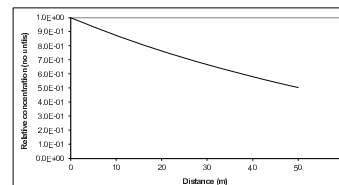
Dispersivity based on Xu & Eckstein (1995)

Variable	Value	Unit
Longitudinal dispersivity	ax	2.98E+00 m
Transverse dispersivity	az	2.98E-01 m
Vertical dispersivity	ay	2.98E-02 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.44}; az = ax/10, ay = ax/100 are assumed

Note

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

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

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration	Concentration
0	1.0E+00	5.05E-02
2.5	9.67E-01	4.89E-02
5.0	9.35E-01	4.72E-02
7.5	9.03E-01	4.57E-02
10.0	8.73E-01	4.41E-02
12.5	8.44E-01	4.27E-02
15.0	8.16E-01	4.13E-02
17.5	7.89E-01	3.99E-02
20.0	7.63E-01	3.86E-02
22.5	7.37E-01	3.73E-02
25.0	7.13E-01	3.60E-02
27.5	6.89E-01	3.48E-02
30.0	6.66E-01	3.36E-02
32.5	6.43E-01	3.25E-02
35.0	6.21E-01	3.14E-02
37.5	6.00E-01	3.03E-02
40.0	5.80E-01	2.93E-02
42.5	5.60E-01	2.83E-02
45.0	5.40E-01	2.73E-02
47.5	5.22E-01	2.64E-02
50.0	5.04E-01	2.55E-02

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: Plot NT02 Dantzic Street
 Completed by: Laura Aspinall
 Date: 13/12/2023
 Version: Controlled waters risk assessment

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Carbon tetrachloride (tetrac)		from Level 1
Target Concentration	C _T	0.003	mg/l	from Level 1
Dilution Factor	DF	3.00E+00		from Level 2

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

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Enter source concentration			
Enter soil concentration	0	mg/kg	
Half life for degradation of contaminant in water	3.60E+02	days	
Calculated decay rate	1.92E-03	days ⁻¹	calculated
Width of plume in aquifer at source	7.50E+01	m	from Level 2
Plume thickness in aquifer at source	4.52E+00	m	from Level 2
Bulk density of aquifer materials	2.14E+00	g/cm ³	Refer to Appendix E
Effective porosity of aquifer	2.70E-01	fraction	Refer to Appendix E
Hydraulic gradient	9.80E-03	fraction	from Level 2 (adj) used
Hydraulic conductivity of saturated aquifer	6.25E-01	m/d	from Level 2
Distance to compliance point	5.00E+01	m	Refer to Appendix E
Distance (laterally) to compliance point perpendicular to flow direction		m	
Distance (depth) to compliance point perpendicular to flow direction		m	
Time since pollutant entered groundwater	1.00E+100	days	time variant options only
Parameters values determined from options			
Partition coefficient	9.57E-01	l/kg	see options
Longitudinal dispersivity	2.984	m	see options
Transverse dispersivity	0.298	m	see options
Vertical dispersivity	0.030	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	2.98E-02	m/d
Retardation factor	8.59E+00	fraction
Decay rate used	2.24E-04	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	9.80E-03	fraction
Rate of contaminant flow due to retardation	3.46E-03	m/d
Ratio of Compliance Point to Source Concentration	6.18E-02	fraction
Attenuation factor (C ₀ /C ₉₉)	1.62E+01	fraction
Calculated soil leachate concentration	3.02E-03	mg/l

Remedial Targets

Level 3 Remedial Target	1.49E-01	mg/l	For comparison with measured pore water concentration, This assumes Level 1 Remedial Target is based on Target Concentration.
Ogata Banks	1.87E+00	mg/kg	For comparison with measured soil concentration, This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Distance to compliance point	50	m	
Ratio of Compliance Point to Source Concentration	C ₀ /C ₉₉	6.18E-02	fraction

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

Enter method of defining partition coefficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient

K_d

l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer

f_{oc}

fraction

Organic carbon partition coefficient

K_{oc}

l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species

K_{oc,rel}

l/kg

Sorption coefficient for ionised species

K_{oc,rel}

l/kg

pH value

pH

Acid dissociation constant

f_{oc}

fraction

Fraction of organic carbon in aquifer

K_d

l/kg

Soil water partition coefficient

K_d

l/kg

pH value

pH

Acid dissociation constant

f_{oc}

fraction

Fraction of organic carbon in aquifer

K_d

l/kg

Soil water partition coefficient

K_d

l/kg

pH value

pH

Acid dissociation constant

f_{oc}

fraction

Fraction of organic carbon in aquifer

K_d

l/kg

Soil water partition coefficient

K_d

l/kg

pH value

pH

Acid dissociation constant

f_{oc}

fraction

Fraction of organic carbon in aquifer

K_d

l/kg

Soil water partition coefficient

K_d

l/kg

pH value

pH

Acid dissociation constant

f_{oc}

fraction

Fraction of organic carbon in aquifer

K_d

l/kg

Soil water partition coefficient

K_d

l/kg

pH value

pH

Acid dissociation constant

f_{oc}

fraction

Fraction of organic carbon in aquifer

K_d

l/kg

Soil water partition coefficient

K_d

l/kg

pH value

pH

Acid dissociation constant

f_{oc}

fraction

Fraction of organic carbon in aquifer

K_d

l/kg

Soil water partition coefficient

K_d

l/kg

pH value

pH

Acid dissociation constant

f_{oc}

fraction

Fraction of organic carbon in aquifer

K_d

l/kg

Soil water partition coefficient

K_d

l/kg

pH value

pH

Acid dissociation constant

f_{oc}

fraction

Fraction of organic carbon in aquifer

K_d

l/kg

Soil water partition coefficient

K_d

l/kg

pH value

pH

Acid dissociation constant

f_{oc}

fraction

Fraction of organic carbon in aquifer

K_d

l/kg

Soil water partition coefficient

K_d

l/kg

pH value

pH

Acid dissociation constant

f_{oc}

fraction

Fraction of organic carbon in aquifer

K_d

l/kg

Soil water partition coefficient

K_d

l/kg

pH value

pH

Acid dissociation constant

f_{oc}

fraction

Fraction of organic carbon in aquifer

K_d

l/kg

Soil water partition coefficient

K_d

l/kg

pH value

pH

Acid dissociation constant

f_{oc}

fraction

Fraction of organic carbon in aquifer

K_d

l/kg

Soil water partition coefficient

K_d

l/kg

pH value

pH

Acid dissociation constant

f_{oc}

fraction

Fraction of organic carbon in aquifer

K_d

l/kg

Soil water partition coefficient

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pH value

pH

Acid dissociation constant

f_{oc}

fraction

Fraction of organic carbon in aquifer

K_d

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Soil water partition coefficient

K_d

l/kg

pH value

pH

Acid dissociation constant

f_{oc}

fraction

Fraction of organic carbon in aquifer

K_d

l/kg

Soil water partition coefficient

K_d

l/kg

pH value

pH

Acid dissociation constant

f_{oc}

fraction

Fraction of organic carbon in aquifer

K_d

l/kg

Soil water partition coefficient

K_d

l/kg

pH value

pH

Acid dissociation constant

f_{oc}

fraction

Fraction of organic carbon in aquifer

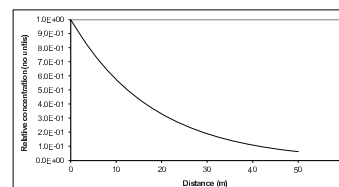
K_d

l/kg

Soil water partition coefficient

K_d

l/kg



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

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration	Concentration
0	(No units)	mg/l
2.5	1.0E+00	9.85E-04
5.0	8.70E-01	8.57E-04
7.5	7.58E-01	7.46E-04
10.0	6.59E-01	6.49E-04
12.5	5.74E-01	5.65E-04
15.0	5.00E-01	4.92E-04
17.5	4.35E-01	4.28E-04
20.0	3.79E-01	3.73E-04
22.5	3.29E-01	3.24E-04
25.0	2.87E-01	2.82E-04
27.5	2.50E-01	2.46E-04
30.0	2.17E-01	2.14E-04
32.5	1.89E-01	1.86E-04
35.0	1.64E-01	1.62E-04
37.5	1.43E-01	1.41E-04
40.0	1.24E-01	1.22E-04
42.5	1.08E-01	1.07E-04
45.0	9.41E-02	9.26E-05
47.5	8.18E-02	8.03E-05
50.0	7.11E-02	7.00E-05

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: Plot NT02 Dantzic Street
 Completed by: Laura Aspinall
 Date: 12/12/2023
 Version: Controlled waters risk assessment

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant Target Concentration C_T Trichloroethene (TCE) 1.00E-02 mg/l

From Level 1
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

Initial contaminant concentration in groundwater at plume core C_0 5.72E-01 mg/l
Half life for degradation of contaminant in water $t_{1/2}$ 1.69E+03 days
Calculated decay rate λ 4.19E-04 days⁻¹
Width of plume in aquifer at source (perpendicular to flow) S_z 7.50E+01 m
Plume thickness at source S_y 4.52E+00 m
Saturated aquifer thickness d_a 6.81E+00 m
Bulk density of aquifer materials ρ 2.14E+00 g/cm³
Effective porosity of aquifer n 2.70E-01 fraction
Hydraulic gradient i 6.60E-03 fraction
Hydraulic conductivity of aquifer K 8.20E-01 m/d
Distance to compliance point x 5.00E+01 m
Distance (laterally) 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

Parameters values determined from options

Partition coefficient K_d 5.51E-01 l/kg
Longitudinal dispersivity α_x 2.98E+00 m
Transverse dispersivity α_z 2.98E-01 m
Vertical dispersivity α_y 2.98E-02 m

Calculated Parameters

Groundwater flow velocity v 2.00E-02 m/d
Retardation factor R_f 5.36E+00 fraction
Decay rate used λ 7.62E-05 d⁻¹
Rate of contaminant flow due to retardation u 3.74E-03 m/d
Contaminant concentration at distance X, assuming one-way vertical dispersion C_{1D} 2.11E-01 mg/l
Attenuation factor (one way vertical dispersion, COCED) AF 2.71E+00

Remedial Targets

Remedial Target 2.71E-02 mg/l
Ogata Banks
Distance to compliance point 50 m
Concentration of contaminant at compliance point C_{1D}/C_0 2.11E-01 mg/l
after 1.0E+100 days 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.

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

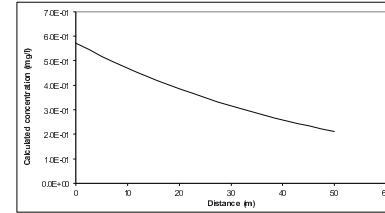
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option) K_d l/kg
Soil/water partition coefficient K_{oc} 3.00E-03 fraction
Entry for non-polar organic chemicals (option) K_{oc} 1.41E+02 l/kg
Organic carbon partition coefficient K_{oc} 1.41E+02 l/kg
Entry for ionic organic chemicals (option) K_{ow} l/kg
Sorption coefficient for related species K_{oc} l/kg
Sorption coefficient for ionised species pK_a fraction
pH value pH fraction
pKa value pK_a fraction
Fraction of organic carbon in aquifer K_d 5.51E-01 l/kg

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

Dispersivity based on Xu & Eckstein (1995)

Longitudinal dispersivity α_x 0.00E+00 5.00E+00 2.98E+00 m
Transverse dispersivity α_z 0.00E+00 5.00E+00 2.98E-01 m
Vertical dispersivity α_y 0.00E+00 5.00E+00 2.98E-02 m
Note values of dispersivity must be > 0
For calculated values, assumes $\alpha_x = 0.83 \log_{10} \alpha_z^{0.414}$; $\alpha_z = \alpha_x^{10}$, $\alpha_y = \alpha_x^{100}$ are assumed
Xu & Eckstein (1995) report $\alpha_x = 0.83 \log_{10} \alpha_z^{0.414}$; $\alpha_z = \alpha_x^{10}$, $\alpha_y = \alpha_x^{100}$ 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 t will give the steady state solution, which should be used to calculate remedial targets.

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

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

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

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet
Distance Concentration
mg/l
0 5.7E-01
2.5 5.44E-01
5.0 5.18E-01
7.5 4.93E-01
10.0 4.69E-01
12.5 4.47E-01
15.0 4.25E-01
17.5 4.02E-01
20.0 3.85E-01
22.5 3.67E-01
25.0 3.49E-01
27.5 3.32E-01
30.0 3.16E-01
32.5 3.01E-01
35.0 2.86E-01
37.5 2.72E-01
40.0 2.59E-01
42.5 2.46E-01
45.0 2.34E-01
47.5 2.22E-01
50.0 2.11E-01

Site being assessed: Pld NT02 Dantric Street
Completed by: Laura Aspinall
Date: 12/12/2023
Version: Controlled waters risk assessment

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant Target Concentration C_T Carbon tetrachloride (tetrachloroethane) 3.00E-03 mg/l from Level 1 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

Initial contaminant concentration in groundwater at plume core C_0 2.65E-01 mg/l
Half life for degradation of contaminant in water $t_{1/2}$ 3.80E+02 days
Calculated decay rate λ 1.93E-03 days⁻¹
Width of plume in aquifer at source (perpendicular to flow) S_z 7.50E+01 m
Plume thickness at source S_y 4.55E+00 m
Saturated aquifer thickness d_a 6.81E+00 m
Bulk density of aquifer materials ρ 2.14E+00 g/cm³
Effective porosity of aquifer n 2.70E-01 fraction
Hydraulic gradient i 6.60E-03 fraction
Hydraulic conductivity of aquifer K 8.20E-01 m/d
Distance to compliance point x 5.00E+01 m
Distance (laterally) 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
Parameters values determined from options

Partition coefficient K_d 9.57E-01 l/kg
Longitudinal dispersivity α_x 2.98E+00 m
Transverse dispersivity α_z 2.98E-01 m
Vertical dispersivity α_y 2.98E-02 m

Calculated Parameters

Groundwater flow velocity v 2.00E-02 m/d
Retardation factor R_f 8.55E+00 fraction
Decay rate used λ 2.24E-04 d⁻¹
Rate of contaminant flow due to retardation u 2.33E-03 m/d
Contaminant concentration at distance X, assuming one-way vertical dispersion C_{1D} 5.33E-03 mg/l
Attenuation factor (one way vertical dispersion, COCED) AF 4.97E+01

Remedial Targets

Remedial Target 1.49E-01 mg/l For comparison with measured groundwater concentration.
Ogata Banks
Distance to compliance point 50 m
Concentration of contaminant at compliance point C_{1D}/C_0 5.33E-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)

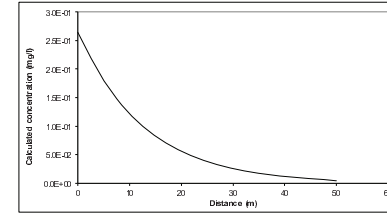
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option) K_d l/kg
Soil water partition coefficient K_{oc} 3.00E-03 fraction
Entry for non-polar organic chemicals (option) K_{oc} 2.46E+02 l/kg
Organic carbon partition coefficient K_{oc} 2.46E+02 l/kg
Entry for ionic organic chemicals (option) K_{oc} l/kg
Sorption coefficient for related species K_{oc} l/kg
Sorption coefficient for ionised species K_{oc} l/kg
pH value pH fraction
acid dissociation constant pK_a fraction
Fraction of organic carbon in aquifer f_{oc} fraction
Soil water partition coefficient K_d 9.57E-01 l/kg

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

Dispersivity based on Xu & Eckstein (1995)

Longitudinal dispersivity α_x 0.00E+00 5.00E+00 2.98E+00 m
Transverse dispersivity α_z 0.00E+00 5.00E+00 2.98E-01 m
Vertical dispersivity α_y 0.00E+00 5.00E+00 2.98E-02 m
Note values of dispersivity must be > 0
For calculated values, assumes $\alpha_x = 0.1 \times x$, $\alpha_z = 0.01 \times x$, $\alpha_y = 0.001 \times x$
Xu & Eckstein (1995) report $\alpha_x = 0.83 \log_{10} x^{0.44}$; $\alpha_z = \alpha_x/10$, $\alpha_y = \alpha_x/100$ 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 t will give the steady state solution, which should be used to calculate remedial targets.

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

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

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

Calculated concentrations for distance-concentration graph

Ogata Banks From calculation sheet
Distance Concentration mg/l
0 2.7E-01
2.5 2.18E-01
5.0 1.79E-01
7.5 1.48E-01
10.0 1.22E-01
12.5 1.00E-01
15.0 8.23E-02
17.5 6.77E-02
20.0 5.58E-02
22.5 4.59E-02
25.0 3.78E-02
27.5 3.11E-02
30.0 2.56E-02
32.5 2.10E-02
35.0 1.73E-02
37.5 1.42E-02
40.0 1.17E-02
42.5 9.61E-03
45.0 7.89E-03
47.5 6.49E-03
50.0 5.33E-03

Site being assessed: Pld NT02 Dantric Street
Completed by: Laura Aspinall
Date: 12/12/2023
Version: Controlled waters risk assessment

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant Target Concentration C_T **Chloroform, 1,2-dichloroethene** from Level 1 **5.00E-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**

Initial contaminant concentration in groundwater at plume core C_0 **6.02E-01** mg/l
Half-life for degradation of contaminant in water $t_{1/2}$ **2.89E+03** days
Calculated decay rate λ **2.41E-04** days⁻¹
Width of plume in aquifer at source (perpendicular to flow) S_z **7.50E+01** m
Plume thickness at source S_y **4.52E+00** m
Saturated aquifer thickness d_a **6.81E+00** m
Bulk density of aquifer materials ρ **2.14E+00** g/cm³
Effective porosity of aquifer n **2.70E-01** fraction
Hydraulic gradient i **6.60E-03** fraction
Hydraulic conductivity of aquifer K **8.20E-01** m/d
Distance to compliance point x **5.00E+01** m
Distance (laterally) 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
Parameters values determined from options

Calculated Parameters

Groundwater flow velocity v **2.00E-02** m/d
Retardation factor R_f **2.21E+00** fraction
Decay rate used λ **1.05E-04** d⁻¹
Rate of contaminant flow due to retardation u **9.03E-03** m/d
Contaminant concentration at distance X, assuming one-way vertical dispersion C_{1D} **3.34E-01** mg/l
Attenuation factor (one-way vertical dispersion, COCED) AF **1.80E+00**

Remedial Targets

Remedial Target **9.02E-02** mg/l for comparison with measured groundwater concentration.
Ogata Banks
Distance to compliance point **50** m
Concentration of contaminant at compliance point C_{1D}/C_0 **3.34E-01** mg/l
after **1.0E+100** days 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.

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

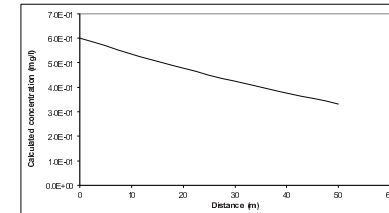
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option) K_d **3.90E-03** l/kg
Soil-water partition coefficient K_{oc} **3.90E+01** l/kg
Entry for non-polar organic chemicals (option) K_{oc} **3.90E+01** l/kg
Fraction of organic carbon in aquifer K_{oc} **3.90E+01** l/kg
Organic carbon partition coefficient K_{oc} **3.90E+01** l/kg
Entry for ionic organic chemicals (option) K_{ow} **3.90E+01** l/kg
Sorption coefficient for related species K_{ow} **3.90E+01** l/kg
Sorption coefficient for ionised species K_{ow} **3.90E+01** l/kg
pH value pH **3.90E+01** l/kg
acid dissociation constant pK_a **3.90E+01** l/kg
Fraction of organic carbon in aquifer f_{oc} **3.90E+01** l/kg
Soil-water partition coefficient K_d **1.52E-01** l/kg

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

Dispersivity based on Xu & Eckstein (1995)

Longitudinal dispersivity α_x **0.00E+00** m
Transverse dispersivity α_z **0.00E+00** m
Vertical dispersivity α_y **0.00E+00** m
Note values of dispersivity must be > 0
For calculated values, assumes $\alpha_x = 0.83 \log_{10} \alpha_z^{0.414}$; $\alpha_z = \alpha_x^{10}$, $\alpha_y = \alpha_x^{100}$ are assumed
Xu & Eckstein (1995) report $\alpha_x = 0.83 \log_{10} \alpha_z^{0.414}$; $\alpha_z = \alpha_x^{10}$, $\alpha_y = \alpha_x^{100}$ 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 t will give the steady state solution, which should be used to calculate remedial targets.

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

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

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

Site being assessed: Pld NT02 Dantric Street
Completed by: Laura Aspinall
Date: 12/12/2023
Version: Controlled waters risk assessment

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet
Distance Concentration mg/l
0 6.0E-01
2.5 5.85E-01
5.0 5.68E-01
7.5 5.52E-01
10.0 5.36E-01
12.5 5.21E-01
15.0 5.06E-01
17.5 4.91E-01
20.0 4.77E-01
22.5 4.63E-01
25.0 4.50E-01
27.5 4.37E-01
30.0 4.24E-01
32.5 4.12E-01
35.0 4.00E-01
37.5 3.88E-01
40.0 3.77E-01
42.5 3.66E-01
45.0 3.55E-01
47.5 3.44E-01
50.0 3.34E-01

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant Target Concentration C_T Vinyl Chloride (chloroethene) 5.00E-04 mg/l from Level 1 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

Initial contaminant concentration in groundwater at plume core C_0 4.40E-02 mg/l
Half life for degradation of contaminant in water $t_{1/2}$ 7.20E+02 days
Calculated decay rate λ 9.63E-04 days⁻¹
Width of plume in aquifer at source (perpendicular to flow) S_z 7.50E+01 m
Plume thickness at source S_y 4.52E+00 m
Saturated aquifer thickness d_a 6.81E+00 m
Bulk density of aquifer materials ρ 2.14E+00 g/cm³
Effective porosity of aquifer n 2.70E-01 fraction
Hydraulic gradient i 6.60E-03 fraction
Hydraulic conductivity of aquifer K 8.20E-01 m/d
Distance to compliance point x 5.00E+01 m
Distance (laterally) 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
Parameters values determined from options

Partition coefficient K_d 6.47E-02 l/kg
Longitudinal dispersivity α_x 2.98E+00 m
Transverse dispersivity α_z 2.98E-01 m
Vertical dispersivity α_y 2.98E-02 m

Calculated Parameters

Groundwater flow velocity v 2.00E-02 m/d
Retardation factor R_f 1.51E+00 fraction
Decay rate used λ 6.36E-04 d⁻¹
Rate of contaminant flow due to retardation u 1.32E-02 m/d
Contaminant concentration at distance X, assuming one-way vertical dispersion C_{1D} 5.18E-03 mg/l
Attenuation factor (one way vertical dispersion, COCED) AF 8.90E+00

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

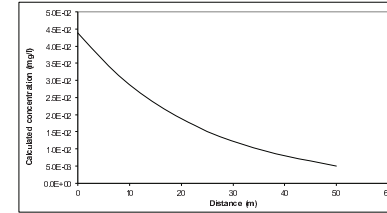
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option) K_d 6.47E-02 l/kg
Soil water partition coefficient K_{ow} 3.00E-03 fraction
Entry for non-polar organic chemicals (option) K_{oc} 1.60E+01 l/kg
Fraction of organic carbon in aquifer K_{oc} 1.60E+01 l/kg
Organic carbon partition coefficient K_{oc} 1.60E+01 l/kg
Entry for ionic organic chemicals (option) K_{oc} 1.60E+01 l/kg
Sorption coefficient for released species K_{oc} 1.60E+01 l/kg
Sorption coefficient for ionised species K_{oc} 1.60E+01 l/kg
pH value pH 6.47E-02 l/kg
pKa pKa 6.47E-02 l/kg
Fraction of organic carbon in aquifer f_{oc} 6.47E-02 l/kg
Soil water partition coefficient K_d 6.47E-02 l/kg

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

Dispersivity based on Xu & Eckstein (1995)

Longitudinal dispersivity α_x 0.00E+00 5.00E+00 2.98E+00 m
Transverse dispersivity α_z 0.00E+00 5.00E+00 2.98E-01 m
Vertical dispersivity α_y 0.00E+00 5.00E+00 2.98E-02 m
Note values of dispersivity must be > 0
For calculated values, assumes $\alpha_x = 0.83 \log_{10} \alpha_z^{0.414}$; $\alpha_z = \alpha_x^{10}$, $\alpha_y = \alpha_x^{100}$ are assumed
Xu & Eckstein (1995) report $\alpha_x = 0.83 \log_{10} \alpha_z^{0.414}$; $\alpha_z = \alpha_x^{10}$, $\alpha_y = \alpha_x^{100}$ 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 t will give the steady state solution, which should be used to calculate remedial targets.

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

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

Calculated concentrations for distance-concentration graph

Ogata Banks From calculation sheet
Distance Concentration mg/l
0 4.40E-02
2.5 3.96E-02
5.0 3.56E-02
7.5 3.20E-02
10.0 2.87E-02
12.5 2.58E-02
15.0 2.32E-02
17.5 2.09E-02
20.0 1.88E-02
22.5 1.69E-02
25.0 1.52E-02
27.5 1.36E-02
30.0 1.22E-02
32.5 1.10E-02
35.0 9.88E-03
37.5 8.88E-03
40.0 7.97E-03
42.5 7.16E-03
45.0 6.43E-03
47.5 5.77E-03
50.0 5.18E-03

Remedial Targets

Remedial Target 4.25E-03 mg/l for comparison with measured groundwater concentration.
Ogata Banks
Distance to compliance point 50 m
Concentration of contaminant at compliance point C_{1D}/C_0 5.18E-03 mg/l
after 1.0E+100 days 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.

Site being assessed: Pld NT02 Dantric Street
Completed by: Laura Aspinall
Date: 12/12/2023
Version: Controlled waters risk assessment



APPENDIX G

SENSITIVITY ANALYSIS RESULTS

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Trichloroethene (TCE)		from Level 1
Target Concentration	C _T	0.01	mg/l	from Level 1
Dilution Factor	DF	3.00E+00		from Level 2

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

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Enter soil concentration			Soil concentration as mg/kg
Half life for degradation of contaminant in water	1	mg/kg	
Calculated decay rate	1.69E+03	days	
Width of plume in aquifer at source	4.11E-04	days	Howard et al high half life (aerobic conditions)
Plume thickness in aquifer at source	7.50E+01	m	from Level 2
Bulk density of aquifer materials	4.52E+00	m	from Level 2
Effective porosity of aquifer	2.14E+00	g/cm ³	Refer to Appendix E
Hydraulic gradient	2.70E-01	fraction	Refer to Appendix E
Hydraulic conductivity of saturated aquifer	9.80E-03	fraction	from Level 2 (ad) used
Distance to compliance point	9.84E-01	m	from Level 2
Distance (laterally) to compliance point perpendicular to flow direction	5.00E+01	m	Refer to Appendix E
Distance (depth) to compliance point perpendicular to flow direction		m	
Time since pollutant entered groundwater		m	
Parameters values determined from options	1.00E+100	days	time variant options only
Partition coefficient	5.51E-01	W/kg	see options
Longitudinal dispersivity	2.984	m	see options
Transverse dispersivity	0.298	m	see options
Vertical dispersivity	0.030	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	3.57E-02	m/d
Retardation factor	5.36E+00	fraction
Decay rate used	7.82E-05	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	9.80E-03	fraction
Rate of contaminant flow due to retardation	6.66E-03	m/d
Ratio of Compliance Point to Source Concentration	5.62E-01	fraction
Attenuation factor (C ₀ /C ₉₉)	1.78E+00	fraction
Calculated soil leachate concentration	1.55E-01	mg/l

Remedial Targets

Level 3 Remedial Target	5.62E-02	mg/l	For comparison with measured pore water concentration, This assumes Level 1 Remedial Target is based on Target Concentration.
Ogata Banks	3.98E-01	mg/kg	For comparison with measured soil concentration, This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Distance to compliance point	50	m	
Ratio of Compliance Point to Source Concentration	C ₀ /C ₉	5.62E-01	fraction

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

Enter method of defining partition coefficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient

K_d

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer

f_{oc}

Organic carbon partition coefficient

K_{oc}

Entry for ionic organic chemicals (option)

Sorption coefficient for related species

K_{oc,L}

Sorption coefficient for ionised species

K_{oc,L}

pH value

pH

Acid dissociation constant

pK_a

Fraction of organic carbon in aquifer

f_{oc}

Soil water partition coefficient

K_d

Longitudinal dispersivity

ax

Transverse dispersivity

az

Vertical dispersivity

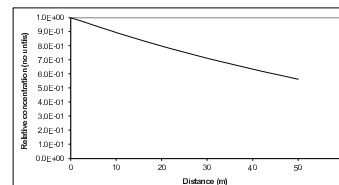
ay

Note values of dispersivity must be > 0

Xu & Eckstein (1999) report ax = 0.83(log₁₀)^{2.44}; az = ax/10, ay = ax/100 are assumed

Note

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



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

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration	Concentration
0	1.0E+00	5.05E-02
2.5	9.72E-01	4.91E-02
5.0	9.45E-01	4.76E-02
7.5	9.18E-01	4.64E-02
10.0	8.93E-01	4.51E-02
12.5	8.68E-01	4.39E-02
15.0	8.43E-01	4.26E-02
17.5	8.20E-01	4.14E-02
20.0	7.97E-01	4.03E-02
22.5	7.74E-01	3.91E-02
25.0	7.53E-01	3.80E-02
27.5	7.31E-01	3.70E-02
30.0	7.11E-01	3.59E-02
32.5	6.91E-01	3.49E-02
35.0	6.71E-01	3.39E-02
37.5	6.52E-01	3.29E-02
40.0	6.33E-01	3.20E-02
42.5	6.14E-01	3.11E-02
45.0	5.96E-01	3.01E-02
47.5	5.79E-01	2.92E-02
50.0	5.62E-01	2.84E-02

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: Plot NT02 Dantzic Street
Completed by: Laura Aspinall
Date: 12/12/2023
Version: Controlled waters risk assessment

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Trichloroethene (TCE)		from Level 1
Target Concentration	C _T	0.01	mg/l	from Level 1
Dilution Factor	DF	3.00E+00		from Level 2

Enter method of defining partition coefficient (using pull down list)
Calculate for non-polar organic chemicals

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

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Enter soil concentration			Soil concentration as mg/kg
Enter soil concentration	1	mg/kg	
Half life for degradation of contaminant in water	1.69E+03	days	
Calculated decay rate	4.11E-04	days ⁻¹	Howard et al high half life (aerobic conditions)
Width of plume in aquifer at source	7.50E+01	m	from Level 2
Plume thickness in aquifer at source	4.52E+00	m	from Level 2
Bulk density of aquifer materials	2.14E+00	g/cm ³	Refer to Appendix E
Effective porosity of aquifer	2.70E-01	fraction	Refer to Appendix E
Hydraulic gradient	9.80E-03	fraction	from Level 2 (adj) used
Hydraulic conductivity of saturated aquifer	6.56E-01	m/d	from Level 2
Distance to compliance point	5.00E+01	m	Refer to Appendix E
Distance (laterally) to compliance point perpendicular to flow direction		m	
Distance (depth) to compliance point perpendicular to flow direction		m	
Time since pollutant entered groundwater	1.00E+100	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	5.51E-01	l/kg see options
Longitudinal dispersivity	ax	2.984	m see options
Transverse dispersivity	az	0.298	m see options
Vertical dispersivity	ay	0.030	m see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	2.38E-02	m/d
Retardation factor	5.36E+00	fraction
Decay rate used	7.82E-05	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	9.80E-03	fraction
Rate of contaminant flow due to retardation	4.44E-03	m/d
Ratio of Compliance Point to Source Concentration	C _{CP} /C _S	4.28E-01
Attenuation factor (C _{CP} /C _{SP})	AF	2.33E+00
Calculated soil leachate concentration	C _o	1.55E-01

Remedial Targets

Level 3 Remedial Target	7.15E-02	mg/l	For comparison with measured pore water concentration, This assumes Level 1 Remedial Target is based on Target Concentration.
Ogata Banks	5.22E-01	mg/kg	For comparison with measured soil concentration, This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Distance to compliance point	50	m	
Ratio of Compliance Point to Source Concentration	C _{CP} /C _S	4.28E-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

Entry if specify partition coefficient (option)

Soil water partition coefficient

Kd

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer

foc

Organic carbon partition coefficient

Koc

Entry for ionic organic chemicals (option)

Sorption coefficient for related species

K_{oc,L}

Sorption coefficient for ionised species

K_{oc,L}

pH value

pH

Acid dissociation constant

pKa

Fraction of organic carbon in aquifer

foc

Soil water partition coefficient

Kd

pH value

pH

Acid dissociation constant

pKa

Fraction of organic carbon in aquifer

foc

Soil water partition coefficient

Kd

pH value

pH

Acid dissociation constant

pKa

Fraction of organic carbon in aquifer

foc

Soil water partition coefficient

Kd

pH value

pH

Acid dissociation constant

pKa

Fraction of organic carbon in aquifer

foc

Soil water partition coefficient

Kd

pH value

pH

Acid dissociation constant

pKa

Fraction of organic carbon in aquifer

foc

Soil water partition coefficient

Kd

pH value

pH

Acid dissociation constant

pKa

Fraction of organic carbon in aquifer

foc

Soil water partition coefficient

Kd

pH value

pH

Acid dissociation constant

pKa

Fraction of organic carbon in aquifer

foc

Soil water partition coefficient

Kd

pH value

pH

Acid dissociation constant

pKa

Fraction of organic carbon in aquifer

foc

Soil water partition coefficient

Kd

pH value

pH

Acid dissociation constant

pKa

Fraction of organic carbon in aquifer

foc

Soil water partition coefficient

Kd

pH value

pH

Acid dissociation constant

pKa

Fraction of organic carbon in aquifer

foc

Soil water partition coefficient

Kd

pH value

pH

Acid dissociation constant

pKa

Fraction of organic carbon in aquifer

foc

Soil water partition coefficient

Kd

pH value

pH

Acid dissociation constant

pKa

Fraction of organic carbon in aquifer

foc

Soil water partition coefficient

Kd

pH value

pH

Acid dissociation constant

pKa

Fraction of organic carbon in aquifer

foc

Soil water partition coefficient

Kd

pH value

pH

Acid dissociation constant

pKa

Fraction of organic carbon in aquifer

foc

Soil water partition coefficient

Kd

pH value

pH

Acid dissociation constant

pKa

Fraction of organic carbon in aquifer

foc

Soil water partition coefficient

Kd

pH value

pH

Acid dissociation constant

pKa

Fraction of organic carbon in aquifer

foc

Soil water partition coefficient

Kd

pH value

pH

Acid dissociation constant

pKa

Fraction of organic carbon in aquifer

foc

Soil water partition coefficient

Kd

pH value

pH

Acid dissociation constant

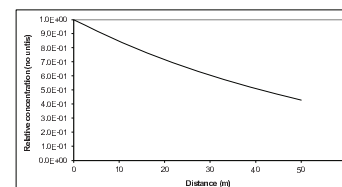
pKa

Fraction of organic carbon in aquifer

foc

Soil water partition coefficient

Kd



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

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration	Concentration
0	1.0E+00	5.05E-02
2.5	9.59E-01	4.85E-02
5.0	9.20E-01	4.65E-02
7.5	8.82E-01	4.46E-02
10.0	8.46E-01	4.27E-02
12.5	8.11E-01	4.10E-02
15.0	7.78E-01	3.93E-02
17.5	7.46E-01	3.77E-02
20.0	7.15E-01	3.61E-02
22.5	6.86E-01	3.47E-02
25.0	6.57E-01	3.32E-02
27.5	6.30E-01	3.19E-02
30.0	6.04E-01	3.05E-02
32.5	5.79E-01	2.93E-02
35.0	5.55E-01	2.81E-02
37.5	5.32E-01	2.69E-02
40.0	5.09E-01	2.58E-02
42.5	4.88E-01	2.47E-02
45.0	4.67E-01	2.36E-02
47.5	4.47E-01	2.26E-02
50.0	4.28E-01	2.17E-02

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: Plot NT02 Dantic Street
Completed by: Laura Aspinall
Date: 12/12/2023
Version: Controlled waters risk assessment

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

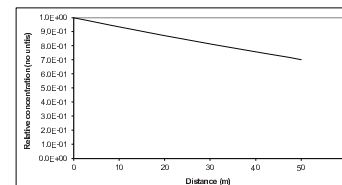
See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Trichloroethene (TCE)		from Level 1
Target Concentration	C _T	0.01	mg/l	from Level 1
Dilution Factor	DF	3.00E+00		from Level 2

Enter method of defining partition coefficient (using pull down list)
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)
Soil water partition coefficient
K_d [fraction]
Entry for non-polar organic chemicals (option)
Fraction of organic carbon in aquifer
f_{oc} [fraction]
Organic carbon partition coefficient
K_{oc} [fraction]
Entry for ionic organic chemicals (option)
Sorption coefficient for related species
K_{ow} [fraction]
Sorption coefficient for ionised species
pH value
pH
Acid dissociation constant
pK_a [fraction]
Fraction of organic carbon in aquifer
f_{oc} [fraction]



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

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	5.05E-02
2.5	9.83E-01	4.97E-02
5.0	9.66E-01	4.89E-02
7.5	9.50E-01	4.80E-02
10.0	9.33E-01	4.72E-02
12.5	9.17E-01	4.64E-02
15.0	9.02E-01	4.56E-02
17.5	8.86E-01	4.48E-02
20.0	8.71E-01	4.40E-02
22.5	8.56E-01	4.32E-02
25.0	8.41E-01	4.25E-02
27.5	8.27E-01	4.18E-02
30.0	8.12E-01	4.11E-02
32.5	7.98E-01	4.03E-02
35.0	7.84E-01	3.96E-02
37.5	7.70E-01	3.89E-02
40.0	7.56E-01	3.82E-02
42.5	7.42E-01	3.75E-02
45.0	7.29E-01	3.68E-02
47.5	7.15E-01	3.61E-02
50.0	7.02E-01	3.55E-02

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

Ogata Banks Equations in HRA publication

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

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter soil concentration	1	mg/kg	
Half life for degradation of contaminant in water	1.69E+03	days	
Calculated decay rate	4.11E-04	days ⁻¹	Howard et al high half life (aerobic conditions)
Width of plume in aquifer at source	7.50E+01	m	from Level 2
Plume thickness in aquifer at source	4.52E+00	m	from Level 2
Bulk density of aquifer materials	2.14E+00	g/cm ³	Refer to Appendix E
Effective porosity of aquifer	2.70E-01	fraction	Refer to Appendix E
Hydraulic gradient	9.89E-03	fraction	from Level 2 (adj) used
Hydraulic conductivity of saturated aquifer	1.64E+00	m/d	from Level 2
Distance to compliance point	5.00E+01	m	Refer to Appendix E
Distance (laterally) to compliance point perpendicular to flow direction		m	
Distance (depth) to compliance point perpendicular to flow direction		m	
Time since pollutant entered groundwater	1.00E+100	days	time variant options only
Parameters values determined from options			
Partition coefficient	5.51E-01	l/kg	see options
Longitudinal dispersivity	2.984	m	see options
Transverse dispersivity	0.298	m	see options
Vertical dispersivity	0.030	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	5.99E-02	m/d
Retardation factor	5.36E+00	fraction
Decay rate used	7.82E-05	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	9.89E-03	fraction
Rate of contaminant flow due to retardation	1.11E-02	m/d
Ratio of Compliance Point to Source Concentration	7.02E-01	fraction
Attenuation factor (C ₀ /C ₉₀)	1.42E+00	fraction
Calculated soil leachate concentration	1.55E-01	mg/l

Remedial Targets

Level 3 Remedial Target	4.37E-02	mg/l	For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration.
Ogata Banks			
Distance to compliance point	50	m	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₉₀ /C ₀	7.02E-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.

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

Xu & Eckstein (1999) report $ax = 0.83(\log_{10})^{2.44}$; $az = ax/10$, $ay = ax/100$ are assumed

Enter value

Calc value

Xu & Eckstein

ax

az

ay

2.98E+00

2.98E-01

2.98E-02

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: Plot NT02 Dantzic Street
Completed by: Laura Aspinall
Date: 12/12/2023
Version: Controlled waters risk assessment

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Trichloroethene (TCE)		from Level 1
Target Concentration	C _T	0.01	mg/l	from Level 1
Dilution Factor	DF	3.00E+00		from Level 2

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

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Enter source concentration			Soil concentration as mg/kg
Enter soil concentration	1	mg/kg	
Half life for degradation of contaminant in water	1.69E+03	days	
Calculated decay rate	4.11E-04	days ⁻¹	Howard et al high half life (aerobic conditions)
Width of plume in aquifer at source	7.50E+01	m	from Level 2
Plume thickness in aquifer at source	4.52E+00	m	from Level 2
Bulk density of aquifer materials	2.14E+00	g/cm ³	Refer to Appendix E
Effective porosity of aquifer	3.24E-01	fraction	Refer to Appendix E
Hydraulic gradient	9.80E-03	fraction	from Level 2 (adj) used
Hydraulic conductivity of saturated aquifer	6.25E-01	m/d	from Level 2
Distance to compliance point	5.00E+01	m	Refer to Appendix E
Distance (laterally) to compliance point perpendicular to flow direction		m	
Distance (depth) to compliance point perpendicular to flow direction		m	
Time since pollutant entered groundwater	1.00E+100	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	5.51E-01	l/kg see options
Longitudinal dispersivity	ax	2.984	m see options
Transverse dispersivity	az	0.298	m see options
Vertical dispersivity	ay	0.030	m see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	2.48E-02	m/d
Retardation factor	4.64E+00	fraction
Decay rate used	9.01E-05	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	9.80E-03	fraction
Rate of contaminant flow due to retardation	5.35E-03	m/d
Ratio of Compliance Point to Source Concentration	C _{CP} /C _S	4.42E-01
Attenuation factor (C _{CP} /C _{SP})	AF	2.20E+00
Calculated soil leachate concentration	Co	1.55E-01

Remedial Targets

Level 3 Remedial Target	6.93E-02	mg/l	For comparison with measured pore water concentration, This assumes Level 1 Remedial Target is based on Target Concentration.
Ogata Banks	or		
Distance to compliance point	50	m	For comparison with measured soil concentration, This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C _{CP} /C _S	4.42E-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 coefficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer

Organic carbon partition coefficient

Entry for ionic organic chemicals (option)

Sorption coefficient for related species

Sorption coefficient for ionised species

pH value

Acid dissociation constant

Fraction of organic carbon in aquifer

Soil water partition coefficient

Kd

5.51E-01

l/kg

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

Dispersivity based on Xu & Eckstein (1995)

Longitudinal dispersivity

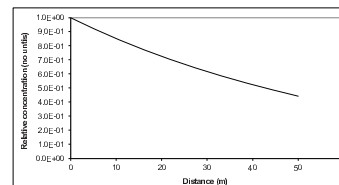
Transverse dispersivity

Vertical dispersivity

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.44}; az = ax/10, ay = ax/100 are assumed

Note

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

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

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration	Concentration
0	1.0E+00	5.05E-02
2.5	9.60E-01	4.85E-02
5.0	9.23E-01	4.66E-02
7.5	8.86E-01	4.48E-02
10.0	8.51E-01	4.30E-02
12.5	8.17E-01	4.13E-02
15.0	7.85E-01	3.97E-02
17.5	7.54E-01	3.81E-02
20.0	7.24E-01	3.66E-02
22.5	6.96E-01	3.52E-02
25.0	6.68E-01	3.38E-02
27.5	6.41E-01	3.24E-02
30.0	6.16E-01	3.11E-02
32.5	5.91E-01	2.99E-02
35.0	5.68E-01	2.87E-02
37.5	5.45E-01	2.75E-02
40.0	5.23E-01	2.64E-02
42.5	5.01E-01	2.53E-02
45.0	4.81E-01	2.43E-02
47.5	4.61E-01	2.33E-02
50.0	4.42E-01	2.24E-02

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: Plot NT02 Dantzic Street
Completed by: Laura Aspinall
Date: 12/12/2023
Version: Controlled waters risk assessment

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Trichloroethene (TCE)		from Level 1
Target Concentration	C _T	0.01	mg/l	from Level 1
Dilution Factor	DF	3.00E+00		from Level 2

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

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Enter source concentration			
Enter soil concentration	1	mg/kg	
Half life for degradation of contaminant in water	1.69E+03	days	
Calculated decay rate	4.11E-04	days ⁻¹	calculated
Width of plume in aquifer at source	7.50E+01	m	from Level 2
Plume thickness in aquifer at source	4.52E+00	m	from Level 2
Bulk density of aquifer materials	2.14E+00	g/cm ³	Refer to Appendix E
Effective porosity of aquifer	2.16E-01	fraction	Refer to Appendix E
Hydraulic gradient	9.80E-03	fraction	from Level 2 (adj) used
Hydraulic conductivity of saturated aquifer	8.20E-01	m/d	from Level 2
Distance to compliance point	5.00E+01	m	Refer to Appendix E
Distance (laterally) to compliance point perpendicular to flow direction		m	
Distance (depth) to compliance point perpendicular to flow direction		m	
Time since pollutant entered groundwater	1.00E+100	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	5.51E-01	l/kg see options
Longitudinal dispersivity	ax	2.984	m see options
Transverse dispersivity	az	0.298	m see options
Vertical dispersivity	ay	0.030	m see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	3.72E-02	m/d
Retardation factor	6.46E+00	fraction
Decay rate used	6.50E-05	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	9.80E-03	fraction
Rate of contaminant flow due to retardation	5.70E-03	m/d
Ratio of Compliance Point to Source Concentration	C ₂₀ /C ₀	5.74E-01
Attenuation factor (C ₂₀ /C ₀)	AF	1.74E+00
Calculated soil leachate concentration	C ₀	1.55E-01

Remedial Targets

Level 3 Remedial Target	5.34E-02	mg/l	For comparison with measured pore water concentration, This assumes Level 1 Remedial Target is based on Target Concentration.
Ogata Banks	3.89E-01	mg/kg	For comparison with measured soil concentration, This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Distance to compliance point	50	m	
Ratio of Compliance Point to Source Concentration	C ₂₀ /C ₀	5.74E-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 coefficient (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

fraction

Organic carbon partition coefficient

Koc

l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species

K_{oc,L}

l/kg

Sorption coefficient for ionised species

K_{oc,L}

l/kg

pH value

pH

fraction

Acid dissociation constant

pKa

fraction

Fraction of organic carbon in aquifer

foc

fraction

Soil water partition coefficient

Kd

l/kg

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

Dispersivity based on Xu & Eckstein (1995)

Longitudinal dispersivity

ax

m

Transverse dispersivity

az

m

Vertical dispersivity

ay

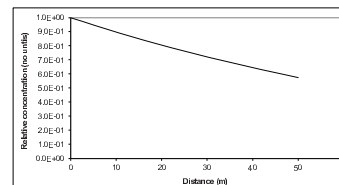
m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report $ax = 0.83(\log_{10})^{2.44}$; $az = ax/10$, $ay = ax/100$ are assumed

Note

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



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

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	5.05E-02
2.5	9.73E-01	4.92E-02
5.0	9.47E-01	4.79E-02
7.5	9.21E-01	4.66E-02
10.0	8.97E-01	4.53E-02
12.5	8.72E-01	4.41E-02
15.0	8.49E-01	4.29E-02
17.5	8.26E-01	4.18E-02
20.0	8.04E-01	4.06E-02
22.5	7.82E-01	3.95E-02
25.0	7.61E-01	3.85E-02
27.5	7.40E-01	3.74E-02
30.0	7.20E-01	3.64E-02
32.5	7.00E-01	3.54E-02
35.0	6.81E-01	3.44E-02
37.5	6.62E-01	3.35E-02
40.0	6.44E-01	3.25E-02
42.5	6.26E-01	3.16E-02
45.0	6.08E-01	3.07E-02
47.5	5.91E-01	2.99E-02
50.0	5.74E-01	2.90E-02

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: Plot NT02 Dantzic Street
Completed by: Laura Aspinall
Date: 12/12/2023
Version: Controlled waters risk assessment

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Trichloroethene (TCE)		from Level 1
Target Concentration	C _T	0.01	mg/l	from Level 1
Dilution Factor	DF	3.00E+00		from Level 2

Enter method of defining partition coefficient (using pull down list)
Calculate for non-polar organic chemicals

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

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Enter source concentration			Soil concentration as mg/kg
Enter soil concentration	1	mg/kg	
Half life for degradation of contaminant in water	1.69E+03	days	
Calculated decay rate	4.11E-04	days ⁻¹	Howard et al high half life (aerobic conditions)
Width of plume in aquifer at source	9.00E+01	m	from Level 2
Plume thickness in aquifer at source	4.52E+00	m	from Level 2
Bulk density of aquifer materials	2.14E+00	g/cm ³	Refer to Appendix E
Effective porosity of aquifer	2.70E-01	fraction	Refer to Appendix E
Hydraulic gradient	9.80E-03	fraction	from Level 2 (adj) used
Hydraulic conductivity of saturated aquifer	8.25E-01	m/d	from Level 2
Distance to compliance point	5.00E+01	m	Refer to Appendix E
Distance (laterally) to compliance point perpendicular to flow direction		m	
Distance (depth) to compliance point perpendicular to flow direction		m	
Time since pollutant entered groundwater	1.00E+100	days	time variant options only
Parameters values determined from options			
Partition coefficient	5.51E-01	l/kg	see options
Longitudinal dispersivity	2.984	m	see options
Transverse dispersivity	0.298	m	see options
Vertical dispersivity	0.030	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	2.98E-02	m/d
Retardation factor	5.36E+00	fraction
Decay rate used	7.82E-05	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	9.80E-03	fraction
Rate of contaminant flow due to retardation	5.55E-03	m/d
Ratio of Compliance Point to Source Concentration	5.01E-01	fraction
Attenuation factor (C ₀ /C ₉₉)	1.99E+00	fraction
Calculated soil leachate concentration	1.55E-01	mg/l

Remedial Targets

Level 3 Remedial Target	6.08E-02	mg/l	For comparison with measured pore water concentration, This assumes Level 1 Remedial Target is based on Target Concentration.
Ogata Banks			
Distance to compliance point	4.44E-01	mg/kg	For comparison with measured soil concentration, This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
	50	m	

Ratio of Compliance Point to Source Concentration C₀/C₉₉ 5.04E-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

Entry if specify partition coefficient (option)

Soil water partition coefficient

K_d 1.0E+00 l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer

f_{oc} 3.90E-03 fraction

Organic carbon partition coefficient

K_{oc} 1.41E+02 l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species

K_{oc,L} 1.0E+00 l/kg

Sorption coefficient for ionised species

K_{oc,L} 1.0E+00 l/kg

pH value

pH 7.00

Acid dissociation constant

pK_a 4.00

Fraction of organic carbon in aquifer

f_{oc} 3.90E-03 fraction

Soil water partition coefficient

K_d 5.51E-01 l/kg

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

Dispersivity based on Xu & Eckstein (1995)

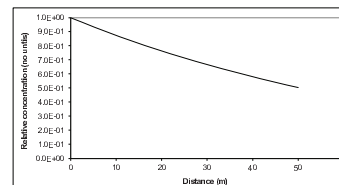
		Enter value	Calc value Xu & Eckstein	
Longitudinal dispersivity	ax	0.00E+00	5.00E+00	2.98E+00 m
Transverse dispersivity	az	0.00E+00	5.00E-01	2.98E-01 m
Vertical dispersivity	ay	0.00E+00	5.00E-02	2.98E-02 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.44}; az = ax/10, ay = ax/100 are assumed

Note

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



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

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	5.05E-02
2.5	9.67E-01	4.89E-02
5.0	9.35E-01	4.72E-02
7.5	9.03E-01	4.57E-02
10.0	8.73E-01	4.41E-02
12.5	8.44E-01	4.27E-02
15.0	8.16E-01	4.13E-02
17.5	7.89E-01	3.99E-02
20.0	7.63E-01	3.86E-02
22.5	7.37E-01	3.73E-02
25.0	7.13E-01	3.60E-02
27.5	6.89E-01	3.48E-02
30.0	6.66E-01	3.36E-02
32.5	6.43E-01	3.25E-02
35.0	6.21E-01	3.14E-02
37.5	6.00E-01	3.03E-02
40.0	5.80E-01	2.93E-02
42.5	5.60E-01	2.83E-02
45.0	5.40E-01	2.73E-02
47.5	5.22E-01	2.64E-02
50.0	5.04E-01	2.55E-02

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: Plot NT02 Dantzic Street
Completed by: Laura Aspinall
Date: 13/12/2023
Version: Controlled waters risk assessment

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

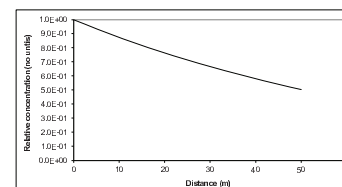


Input Parameters	Variable	Value	Unit	Source
Contaminant		Trichloroethene (TCE)		from Level 1
Target Concentration	C _T	0.01	mg/l	from Level 1
Dilution Factor	DF	3.00E+00		from Level 2

Enter method of defining partition coefficient (using pull down list)
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)
Soil water partition coefficient
Entry for non-polar organic chemicals (option)
Fraction of organic carbon in aquifer
Organic carbon partition coefficient
Entry for ionic organic chemicals (option)
Sorption coefficient for related species
Sorption coefficient for ionised species
pH value
Acid dissociation constant
Fraction of organic carbon in aquifer
Soil water partition coefficient

K _d		fraction
K _{oc}	3.90E-03	fraction
K _{oc}	1.41E+02	fraction
K _{ow}		fraction
K _{ow}		fraction
pH		fraction
pKa		fraction
f _{oc}		fraction
K _d	5.51E-01	fraction



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

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration	Concentration
0	1.0E+00	5.05E-02
2.5	9.67E-01	4.89E-02
5.0	9.35E-01	4.72E-02
7.5	9.03E-01	4.57E-02
10.0	8.73E-01	4.41E-02
12.5	8.44E-01	4.27E-02
15.0	8.16E-01	4.13E-02
17.5	7.89E-01	3.99E-02
20.0	7.63E-01	3.86E-02
22.5	7.37E-01	3.73E-02
25.0	7.13E-01	3.60E-02
27.5	6.89E-01	3.48E-02
30.0	6.66E-01	3.36E-02
32.5	6.43E-01	3.25E-02
35.0	6.21E-01	3.14E-02
37.5	6.00E-01	3.03E-02
40.0	5.80E-01	2.93E-02
42.5	5.60E-01	2.83E-02
45.0	5.40E-01	2.73E-02
47.5	5.22E-01	2.64E-02
50.0	5.04E-01	2.55E-02

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			
Enter soil concentration	1	mg/kg	
Half life for degradation of contaminant in water	1.65E+03	days	
Calculated decay rate	4.11E-04	days ⁻¹	Howard et al high half life (aerobic conditions)
Width of plume in aquifer at source	5.00E+01	m	from Level 2
Plume thickness in aquifer at source	4.52E+00	m	from Level 2
Bulk density of aquifer materials	2.14E+00	g/cm ³	Refer to Appendix E
Effective porosity of aquifer	2.70E-01	fraction	Refer to Appendix E
Hydraulic gradient	9.80E-03	fraction	from Level 2 (adj) used
Hydraulic conductivity of saturated aquifer	8.25E-01	m/d	from Level 2
Distance to compliance point	5.00E+01	m	Refer to Appendix E
Distance (laterally) to compliance point perpendicular to flow direction		m	
Distance (depth) to compliance point perpendicular to flow direction		m	
Time since pollutant entered groundwater	1.00E+100	days	time variant options only
Parameters values determined from options			
Partition coefficient	5.51E-01	fraction	see options
Longitudinal dispersivity	2.984	m	see options
Transverse dispersivity	0.298	m	see options
Vertical dispersivity	0.030	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	2.98E-02	m/d
Retardation factor	5.36E+00	fraction
Decay rate used	7.82E-05	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	9.80E-03	fraction
Rate of contaminant flow due to retardation	5.55E-03	m/d
Ratio of Compliance Point to Source Concentration	5.01E-01	fraction
Attenuation factor (C ₀ /C ₉₉)	1.99E+00	fraction
Calculated soil leachate concentration	1.55E-01	mg/l

Remedial Targets

Level 3 Remedial Target	6.08E-02	mg/l	For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration.
Ogata Banks	4.44E-01	mg/kg	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Distance to compliance point	50	m	

Ratio of Compliance Point to Source Concentration C₀/C₉₉ 5.04E-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.

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

Xu & Eckstein (1999) report ax = 0.83(log₁₀)^{2.44}; az = ax/10, ay = ax/100 are assumed

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Remedial Targets Worksheet , Release 3.2



Level 2 - Soil

Contaminant Target concentration C_T **Trichloroethene (TCE)** from Level 1
0.01 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 contamination' (Environment Agency 2006)

Input Parameters		Variable	Value	Unit	Source of parameter value
(Click on the greyed-out cells)					
Standard entry					
	Infiltration	Inf	4.74E-04	m/d	Refer to Appendix E
	Area of contaminant source	A	1.88E+03	m ²	Refer to Appendix E
Entry for groundwater flow below site					
	Length of contaminant source in direction of groundwater flow	L	2.50E+01	m	Refer to Appendix E
	Saturated aquifer thickness	da	6.81E+00	m	Refer to Appendix E
	Hydraulic Conductivity of aquifer in which dilution occurs	K	8.20E-01	m/d	Refer to Appendix E
	Hydraulic gradient of water table	i	7.92E-03	fraction	Refer to Appendix E
	Width of contaminant source perpendicular to groundwater flow	w	7.50E+01	m	Refer to Appendix E
	Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l	Assume background water not impacted
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	4.25E+00	m	

Calculated Parameters

Dilution Factor	DF	3.33E+00		
Level 2 Remedial Target		3.33E-02	mg/l	For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration
		or		
		2.43E-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	Comment
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed: Plot NT02 Dantzic Street
Completed by: Laura Aspirall
Date: 12-Dec-23
Version: Controlled waters risk assessment

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Trichloroethene (TCE)		from Level 1
Target Concentration	C _T	0.01	mg/l	from Level 1
Dilution Factor	DF	3.33E+00		from Level 2

Enter method of defining partition coefficient (using pull down list)
Calculate for non-polar organic chemicals

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

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Enter source concentration			Soil concentration as mg/kg
Enter soil concentration	1	mg/kg	
Half life for degradation of contaminant in water	1.69E+03	days	
Calculated decay rate	4.11E-04	days ⁻¹	Howard et al high half life (aerobic conditions)
Width of plume in aquifer at source	7.50E+01	m	from Level 2
Plume thickness in aquifer at source	4.29E+00	m	from Level 2
Bulk density of aquifer materials	2.14E+00	g/cm ³	Refer to Appendix E
Effective porosity of aquifer	2.70E-01	fraction	Refer to Appendix E
Hydraulic gradient	1.13E-02	fraction	from Level 2 (adj) used
Hydraulic conductivity of saturated aquifer	6.25E-01	m/d	from Level 2
Distance to compliance point	5.00E+01	m	Refer to Appendix E
Distance (laterally) to compliance point perpendicular to flow direction		m	
Distance (depth) to compliance point perpendicular to flow direction		m	
Time since pollutant entered groundwater	1.00E+100	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	5.51E-01	l/kg see options
Longitudinal dispersivity	ax	2.964	m see options
Transverse dispersivity	az	0.298	m see options
Vertical dispersivity	ay	0.030	m see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	3.44E-02	m/d
Retardation factor	5.36E+00	fraction
Decay rate used	7.82E-05	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	1.13E-02	fraction
Rate of contaminant flow due to retardation	6.41E-03	m/d
Ratio of Compliance Point to Source Concentration	5.47E-01	fraction
Attenuation factor (C ₀ /C ₉₉)	1.83E+00	fraction
Calculated soil leachate concentration	Co	1.55E-01

Remedial Targets

Level 3 Remedial Target	6.08E-02	mg/l	For comparison with measured pore water concentration, This assumes Level 1 Remedial Target is based on Target Concentration.
Ogata Banks	4.44E-01	mg/kg	For comparison with measured soil concentration, This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Distance to compliance point	50	m	

Ratio of Compliance Point to Source Concentration C₉₉/C₀ 5.47E-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

Entry if specify partition coefficient (option)

Soil water partition coefficient

Kd

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer

foc

Organic carbon partition coefficient

Koc

Entry for ionic organic chemicals (option)

Sorption coefficient for related species

K_{oc,rel}

Sorption coefficient for ionised species

K_{oc,i}

pH value

pH

Acid dissociation constant

pKa

Fraction of organic carbon in aquifer

foc

Soil water partition coefficient

Kd

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

Dispersivity based on Xu & Eckstein (1995)

Longitudinal dispersivity

ax

Transverse dispersivity

az

Vertical dispersivity

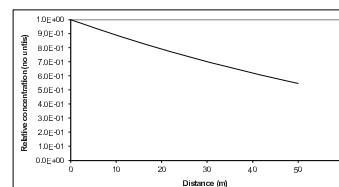
ay

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀)^{2.44}; az = ax/10, ay = ax/100 are assumed

Note

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



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

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration	Concentration
0	(No units)	mg/l
2.5	1.0E+00	4.69E-02
5.0	9.71E-01	4.52E-02
7.5	9.43E-01	4.39E-02
10.0	9.15E-01	4.26E-02
12.5	8.89E-01	4.14E-02
15.0	8.63E-01	4.02E-02
17.5	8.38E-01	3.90E-02
20.0	8.14E-01	3.79E-02
22.5	7.90E-01	3.68E-02
25.0	7.67E-01	3.57E-02
27.5	7.45E-01	3.47E-02
30.0	7.23E-01	3.36E-02
32.5	7.01E-01	3.26E-02
35.0	6.80E-01	3.17E-02
37.5	6.60E-01	3.07E-02
40.0	6.40E-01	2.98E-02
42.5	6.21E-01	2.89E-02
45.0	6.01E-01	2.80E-02
47.5	5.83E-01	2.71E-02
50.0	5.65E-01	2.63E-02
	5.47E-01	2.55E-02

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: Plot NT02 Dantzic Street
Completed by: Laura Aspinall
Date: 12/12/2023
Version: Controlled waters risk assessment

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil



Contaminant Target concentration C_T **Trichloroethene (TCE)** from Level 1
0.01 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 contamination' (Environment Agency 2006)

Input Parameters		Variable	Value	Unit	Source of parameter value
(Click on the greyed-out cells)					
Standard entry					
	Infiltration	Inf	4.74E-04	m/d	Refer to Appendix E
	Area of contaminant source	A	1.88E+03	m ²	Refer to Appendix E
Entry for groundwater flow below site					
	Length of contaminant source in direction of groundwater flow	L	2.50E+01	m	Refer to Appendix E
	Saturated aquifer thickness	da	6.81E+00	m	Refer to Appendix E
	Hydraulic Conductivity of aquifer in which dilution occurs	K	8.20E-01	m/d	Refer to Appendix E
	Hydraulic gradient of water table	i	5.28E-03	fraction	Refer to Appendix E
	Width of contaminant source perpendicular to groundwater flow	w	7.50E+01	m	Refer to Appendix E
	Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l	Assume background water not impacted
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	4.90E+00	m	

Calculated Parameters

Dilution Factor	DF	2.79E+00		
Level 2 Remedial Target		2.79E-02	mg/l	For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration
		or		
		2.04E-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	Comment
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Plot NT02 Dantzic Street
Completed by:	Laura Aspinall
Date:	12-Dec-23
Version:	Controlled waters risk assessment

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Trichloroethene (TCE)		from Level 1
Target Concentration	C _T	0.01	mg/l	from Level 1
Dilution Factor	DF	2.79E+00		from Level 2

Enter method of defining partition coefficient (using pull down list)
Calculate for non-polar organic chemicals

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

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Enter source concentration			Soil concentration as mg/kg
Enter soil concentration	1	mg/kg	
Half life for degradation of contaminant in water	1.69E+03	days	
Calculated decay rate	4.11E-04	days ⁻¹	Howard et al high half life (aerobic conditions)
Width of plume in aquifer at source	7.50E+01	m	from Level 2
Plume thickness in aquifer at source	4.90E+00	m	from Level 2
Bulk density of aquifer materials	2.14E+00	g/cm ³	Refer to Appendix E
Effective porosity of aquifer	2.70E-01	fraction	Refer to Appendix E
Hydraulic gradient	8.23E-03	fraction	from Level 2 (adj) used
Hydraulic conductivity of saturated aquifer	6.23E-01	m/d	from Level 2
Distance to compliance point	5.00E+01	m	Refer to Appendix E
Distance (laterally) to compliance point perpendicular to flow direction		m	
Distance (depth) to compliance point perpendicular to flow direction		m	
Time since pollutant entered groundwater	1.00E+100	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	5.51E-01	l/kg see options
Longitudinal dispersivity	ax	2.984	m see options
Transverse dispersivity	az	0.298	m see options
Vertical dispersivity	ay	0.030	m see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	2.50E-02	m/d
Retardation factor	5.36E+00	fraction
Decay rate used	7.82E-05	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	8.23E-03	fraction
Rate of contaminant flow due to retardation	4.86E-03	m/d
Ratio of Compliance Point to Source Concentration	C _{CP} /C _S	4.47E-01
Attenuation factor (C _{CP} /C _{SP})	AF	2.24E+00
Calculated soil leachate concentration	C _o	1.55E-01

Remedial Targets

Level 3 Remedial Target	6.24E-02	mg/l	For comparison with measured pore water concentration, This assumes Level 1 Remedial Target is based on Target Concentration.
Ogata Banks			
Distance to compliance point	4.56E-01	mg/kg	For comparison with measured soil concentration, This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
	50	m	
Ratio of Compliance Point to Source Concentration	C _{CP} /C _S	4.47E-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

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

3.90E-03

fraction

Organic carbon partition coefficient

Koc

1.41E+02

l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species

K_{oc,L}

l/kg

Sorption coefficient for ionised species

K_{ow,L}

l/kg

pH value

pH

fraction

Acid dissociation constant

pKa

fraction

Fraction of organic carbon in aquifer

foc

fraction

Soil water partition coefficient

Kd

5.51E-01

l/kg

pH value

pH

fraction

Acid dissociation constant

pKa

fraction

Fraction of organic carbon in aquifer

foc

fraction

Soil water partition coefficient

Kd

5.51E-01

l/kg

pH value

pH

fraction

Acid dissociation constant

pKa

fraction

Fraction of organic carbon in aquifer

foc

fraction

Soil water partition coefficient

Kd

5.51E-01

l/kg

pH value

pH

fraction

Acid dissociation constant

pKa

fraction

Fraction of organic carbon in aquifer

foc

fraction

Soil water partition coefficient

Kd

5.51E-01

l/kg

pH value

pH

fraction

Acid dissociation constant

pKa

fraction

Fraction of organic carbon in aquifer

foc

fraction

Soil water partition coefficient

Kd

5.51E-01

l/kg

pH value

pH

fraction

Acid dissociation constant

pKa

fraction

Fraction of organic carbon in aquifer

foc

fraction

Soil water partition coefficient

Kd

5.51E-01

l/kg

pH value

pH

fraction

Acid dissociation constant

pKa

fraction

Fraction of organic carbon in aquifer

foc

fraction

Soil water partition coefficient

Kd

5.51E-01

l/kg

pH value

pH

fraction

Acid dissociation constant

pKa

fraction

Fraction of organic carbon in aquifer

foc

fraction

Soil water partition coefficient

Kd

5.51E-01

l/kg

pH value

pH

fraction

Acid dissociation constant

pKa

fraction

Fraction of organic carbon in aquifer

foc

fraction

Soil water partition coefficient

Kd

5.51E-01

l/kg

pH value

pH

fraction

Acid dissociation constant

pKa

fraction

Fraction of organic carbon in aquifer

foc

fraction

Soil water partition coefficient

Kd

5.51E-01

l/kg

pH value

pH

fraction

Acid dissociation constant

pKa

fraction

Fraction of organic carbon in aquifer

foc

fraction

Soil water partition coefficient

Kd

5.51E-01

l/kg

pH value

pH

fraction

Acid dissociation constant

pKa

fraction

Fraction of organic carbon in aquifer

foc

fraction

Soil water partition coefficient

Kd

5.51E-01

l/kg

pH value

pH

fraction

Acid dissociation constant

pKa

fraction

Fraction of organic carbon in aquifer

foc

fraction

Soil water partition coefficient

Kd

5.51E-01

l/kg

pH value

pH

fraction

Acid dissociation constant

pKa

fraction

Fraction of organic carbon in aquifer

foc

fraction

Soil water partition coefficient

Kd

5.51E-01

l/kg

pH value

pH

fraction

Acid dissociation constant

pKa

fraction

Fraction of organic carbon in aquifer

foc

fraction

Soil water partition coefficient

Kd

5.51E-01

l/kg

pH value

pH

fraction

Acid dissociation constant

pKa

fraction

Fraction of organic carbon in aquifer

foc

fraction

Soil water partition coefficient

Kd

5.51E-01

l/kg

pH value

pH

fraction

Acid dissociation constant

pKa

fraction

Fraction of organic carbon in aquifer

foc

fraction

Soil water partition coefficient

Kd

5.51E-01

l/kg

pH value

pH

fraction

Acid dissociation constant

pKa

fraction

Fraction of organic carbon in aquifer

foc

fraction

Soil water partition coefficient

Kd

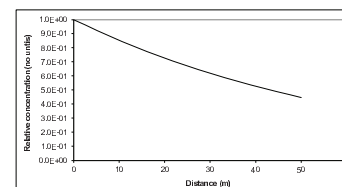
5.51E-01

l/kg

pH value

pH

fraction



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

Calculated (relative) concentrations for distance-concentration graph

Distance	Relative concentration	Concentration
0	1.0E+00	5.59E-02
2.5	9.61E-01	5.33E-02
5.0	9.23E-01	5.12E-02
7.5	8.87E-01	4.92E-02
10.0	8.52E-01	4.73E-02
12.5	8.19E-01	4.54E-02
15.0	7.86E-01	4.36E-02
17.5	7.56E-01	4.19E-02
20.0	7.26E-01	4.03E-02
22.5	6.97E-01	3.87E-02
25.0	6.70E-01	3.72E-02
27.5	6.44E-01	3.57E-02
30.0	6.18E-01	3.43E-02
32.5	5.94E-01	3.30E-02
35.0	5.71E-01	3.17E-02
37.5	5.48E-01	3.04E-02
40.0	5.26E-01	2.92E-02
42.5	5.05E-01	2.80E-02
45.0	4.85E-01	2.69E-02
47.5	4.66E-01	2.58E-02
50.0	4.47E-01	2.48E-02

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: Plot NT02 Dantzic Street
Completed by: Laura Aspinall
Date: 12/12/2023
Version: Controlled waters risk assessment

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Trichloroethene (TCE)		from Level 1
Target Concentration	C _T	0.01	mg/l	from Level 1
Dilution Factor	DF	3.00E+00		from Level 2

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

Ogata Banks	Equations in HRA publication
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Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Variable	Value	Unit	Source of parameter value
Enter soil concentration			Soil concentration as mg/kg
Half life for degradation of contaminant in water	1	mg/kg	
Calculated decay rate	3.21E+02	days	
Width of plume in aquifer at source	2.11E-03	days	calculated
Plume thickness in aquifer at source	7.50E+01	m	from Level 2
Bulk density of aquifer materials	4.52E+00	m	from Level 2
Effective porosity of aquifer	2.14E+00	g/cm ³	Refer to Appendix E
Hydraulic gradient	2.70E-01	fraction	Refer to Appendix E
Hydraulic conductivity of saturated aquifer	9.80E-03	fraction	from Level 2 (adj) used
Distance to compliance point	8.25E-01	m	from Level 2
Distance (laterally) to compliance point perpendicular to flow direction	5.00E+01	m	Refer to Appendix E
Distance (depth) to compliance point perpendicular to flow direction		m	
Time since pollutant entered groundwater		m	
Distance (depth) to compliance point perpendicular to flow direction	1.00E+100	days	time variant options only
Parameters values determined from options			
Partition coefficient	Kd	5.51E-01	l/kg see options
Longitudinal dispersivity	ax	2.984	m see options
Transverse dispersivity	az	0.298	m see options
Vertical dispersivity	ay	0.030	m see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	2.98E-02	m/d
Retardation factor	5.36E+00	fraction
Decay rate used	4.03E-04	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	9.80E-03	fraction
Rate of contaminant flow due to retardation	5.55E-03	m/d
Ratio of Compliance Point to Source Concentration	4.62E-02	fraction
Attenuation factor (C ₀ /C ₉₉)	2.17E+01	fraction
Calculated soil leachate concentration	1.55E-01	mg/l

Remedial Targets

Level 3 Remedial Target	6.64E-01	mg/l	For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration.
Ogata Banks			
Distance to compliance point	48.4E+00	mg/kg	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
	50	m	

Ratio of Compliance Point to Source Concentration C₀/C₉₉ 4.62E-02 fraction Ogata Banks

Enter method of defining partition coefficient (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

fraction

Organic carbon partition coefficient

Koc

l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species

K_{oc,rel}

l/kg

Sorption coefficient for ionised species

K_{oc,i}

l/kg

pH value

pH

fraction

Acid dissociation constant

foc

fraction

Fraction of organic carbon in aquifer

Kd

l/kg

Soil water partition coefficient

Kd

l/kg

pH value

foc

fraction

Acid dissociation constant

foc

fraction

Fraction of organic carbon in aquifer

Kd

l/kg

Soil water partition coefficient

Kd

l/kg

pH value

foc

fraction

Acid dissociation constant

foc

fraction

Fraction of organic carbon in aquifer

Kd

l/kg

Soil water partition coefficient

Kd

l/kg

pH value

foc

fraction

Acid dissociation constant

foc

fraction

Fraction of organic carbon in aquifer

Kd

l/kg

Soil water partition coefficient

Kd

l/kg

pH value

foc

fraction

Acid dissociation constant

foc

fraction

Fraction of organic carbon in aquifer

Kd

l/kg

Soil water partition coefficient

Kd

l/kg

pH value

foc

fraction

Acid dissociation constant

foc

fraction

Fraction of organic carbon in aquifer

Kd

l/kg

Soil water partition coefficient

Kd

l/kg

pH value

foc

fraction

Acid dissociation constant

foc

fraction

Fraction of organic carbon in aquifer

Kd

l/kg

Soil water partition coefficient

Kd

l/kg

pH value

foc

fraction

Acid dissociation constant

foc

fraction

Fraction of organic carbon in aquifer

Kd

l/kg

Soil water partition coefficient

Kd

l/kg

pH value

foc

fraction

Acid dissociation constant

foc

fraction

Fraction of organic carbon in aquifer

Kd

l/kg

Soil water partition coefficient

Kd

l/kg

pH value

foc

fraction

Acid dissociation constant

foc

fraction

Fraction of organic carbon in aquifer

Kd

l/kg

Soil water partition coefficient

Kd

l/kg

pH value

foc

fraction

Acid dissociation constant

foc

fraction

Fraction of organic carbon in aquifer

Kd

l/kg

Soil water partition coefficient

Kd

l/kg

pH value

foc

fraction

Acid dissociation constant

foc

fraction

Fraction of organic carbon in aquifer

Kd

l/kg

Soil water partition coefficient

Kd

l/kg

pH value

foc

fraction

Acid dissociation constant

foc

fraction

Fraction of organic carbon in aquifer

Kd

l/kg

Soil water partition coefficient

Kd

l/kg

pH value

foc

fraction

Acid dissociation constant

foc

fraction

Fraction of organic carbon in aquifer

Kd

l/kg

Soil water partition coefficient

Kd

l/kg

pH value

foc

fraction

Acid dissociation constant

foc

fraction

Fraction of organic carbon in aquifer

Kd

l/kg

Soil water partition coefficient

Kd

l/kg

pH value

foc

fraction

Acid dissociation constant

foc

fraction

Fraction of organic carbon in aquifer

Kd

l/kg

Soil water partition coefficient

Kd

l/kg

pH value

foc

fraction

Acid dissociation constant

foc

fraction

Fraction of organic carbon in aquifer

Kd

l/kg

Soil water partition coefficient

Kd

l/kg

pH value

foc

fraction

Acid dissociation constant

foc

fraction

Fraction of organic carbon in aquifer

Kd

l/kg

Soil water partition coefficient

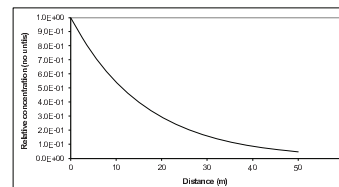
Kd

l/kg

pH value

foc

fraction



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

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks	From calculation sheet	Relative concentration	Concentration
Distance	concentration	(No units)	mg/l
0	1.0E+00	5.05E-02	
2.5	8.58E-01	4.34E-02	
5.0	7.38E-01	3.72E-02	
7.5	6.31E-01	3.19E-02	
10.0	5.42E-01	2.74E-02	
12.5	4.65E-01	2.35E-02	
15.0	3.98E-01	2.01E-02	
17.5	3.42E-01	1.73E-02	
20.0	2.93E-01	1.48E-02	
22.5	2.52E-01	1.27E-02	
25.0	2.16E-01	1.09E-02	
27.5	1.85E-01	9.39E-03	
30.0	1.59E-01	8.02E-03	
32.5	1.36E-01	6.89E-03	
35.0	1.17E-01	5.90E-03	
37.5	1.00E-01	5.05E-03	
40.0	8.57E-02	4.33E-03	
42.5	7.34E-02	3.71E-03	
45.0	6.29E-02	3.16E-03	
47.5	5.38E-02	2.72E-03	
50.0	4.62E-02	2.33E-03	

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

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

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

Site being assessed: Plot NT02 Dantzic Street
Completed by: Laura Aspinall
Date: 12/12/2023
Version: Controlled waters risk assessment

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Trichloroethene (TCE)	from Level 1
Target Concentration	1.00E+02	mg/l from Level 1

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

Ogata Banks	Equations in HRA publication
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Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

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

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

Initial contaminant concentration in groundwater at plume core	C ₀	5.72E+01	mg/l	Source of parameter value
Half life for degradation of contaminant in water	t _{1/2}	1.69E+03	days	Maximum concentration (RSH-203 on 04/10/2022)
Calculated decay rate	λ	4.19E-04	days ⁻¹	Howard et al high half-life (aerobic conditions)
Width of plume in aquifer at source (perpendicular to flow)	Sz	7.50E+01	m	Refer to Appendix E
Plume thickness at source	Sy	4.52E+00	m	Refer to Appendix E
Saturated aquifer thickness	da	6.81E+00	m	Refer to Appendix E
Bulk density of aquifer materials	ρ	2.14E+00	g/cm ³	Refer to Appendix E
Effective porosity of aquifer	n	2.70E-01	fraction	Refer to Appendix E
Hydraulic gradient	i	6.69E-03	fraction	Refer to Appendix E
Hydraulic conductivity of aquifer	K	9.84E+01	m/d	Refer to Appendix E
Distance to compliance point	x	5.00E+01	m	Refer to Appendix E
Distance (laterally) to compliance point perpendicular to flow direction	z	0.00E+00	m	Value is 0
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	Value is 0
Time since pollutant entered groundwater	t	1.00E+100	days	time variant options only

Parameters values determined from options

Partition coefficient	K _d	5.51E+01	l/kg	see options
Longitudinal dispersivity	α _x	2.98E+00	m	see options
Transverse dispersivity	α _z	2.98E+01	m	see options
Vertical dispersivity	α _y	2.98E+02	m	see options

Calculated Parameters

Groundwater flow velocity	v	2.41E+02	m/d
Retardation factor	R _f	5.36E+00	fraction
Decay rate used	λ	7.62E-05	d ⁻¹
Rate of contaminant flow due to retardation	u	4.48E+03	m/d
Contaminant concentration at distance X, assuming one-way vertical dispersion	C _{1D}	2.47E+01	mg/l
Attenuation factor (one way vertical dispersion, COCED)	AF	2.32E+00	

Remedial Targets

Remedial Target	2.32E+02	mg/l	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	50	m	
Concentration of contaminant at compliance point	C _{1D} /C ₀	2.47E+01	mg/l Ogata Banks
after	1.0E+100	days	

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

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

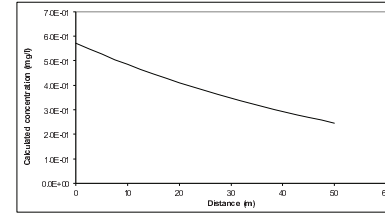
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)	K _d	l/kg
Soil water partition coefficient		
Entry for non-polar organic chemicals (option)	f _{oc}	3.00E-03 fraction
Fraction of organic carbon in aquifer		
Organic carbon partition coefficient	K _{oc}	1.41E+02 l/kg
Entry for ionic organic chemicals (option)		
Sorption coefficient for related species	K _{ow}	l/kg
Sorption coefficient for ionised species	K _{oc,i}	l/kg
pH value	pH	
acid dissociation constant	pK _a	
Fraction of organic carbon in aquifer	f _{oc}	fraction
Soil water partition coefficient	K _d	5.51E+01 l/kg

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

Dispersivity based on Xu & Eckstein (1995)

Longitudinal dispersivity	α _x	Enter value	Calc. value Xu & Eckstein	m
Transverse dispersivity	α _z	0.00E+00	5.00E+01	2.98E+00 m
Vertical dispersivity	α _y	0.00E+00	5.00E+01	2.98E+01 m
		0.00E+00	5.00E+01	2.98E+02 m
Note values of dispersivity must be > 0				
For calculated values, assumes α _x = 0.1 * x, α _z = 0.01 * x, α _y = 0.001 * x				
Xu & Eckstein (1995) report α _x = 0.83(log ₁₀ x) ^{0.44} ; α _z = α _x /10, α _y = α _x /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 t will give the steady state solution, which should be used to calculate remedial targets.

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

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

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

Site being assessed:	Plot NT02 Dantric Street
Completed by:	Laura Aspinall
Date:	12/12/2023
Version:	Controlled waters risk assessment

Calculated concentrations for distance-concentration graph

Ogata Banks		mg/l
From calculation sheet		
Distance	Concentration	
0	5.7E+01	
2.5	5.69E+01	
5.0	5.60E+01	
7.5	5.05E+01	
10.0	4.84E+01	
12.5	4.65E+01	
15.0	4.46E+01	
17.5	4.28E+01	
20.0	4.10E+01	
22.5	3.94E+01	
25.0	3.78E+01	
27.5	3.62E+01	
30.0	3.47E+01	
32.5	3.33E+01	
35.0	3.19E+01	
37.5	3.06E+01	
40.0	2.93E+01	
42.5	2.81E+01	
45.0	2.69E+01	
47.5	2.58E+01	
50.0	2.47E+01	

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant Target Concentration	C _T	Trichloroethene (TCE)	1.00E+02	mg/l	from Level 1 from Level 1
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Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

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

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

Initial contaminant concentration in groundwater at plume core	C ₀	5.72E+01	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	1.69E+03	days	
Calculated decay rate	λ	4.19E-04	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	7.50E+01	m	Refer to Appendix E
Plume thickness at source	Sy	4.52E+00	m	Refer to Appendix E
Saturated aquifer thickness	da	6.81E+00	m	Refer to Appendix E
Bulk density of aquifer materials	ρ	2.14E+00	g/cm ³	Refer to Appendix E
Effective porosity of aquifer	n	2.70E-01	fraction	Refer to Appendix E
Hydraulic gradient	i	6.69E-03	fraction	Refer to Appendix E
Hydraulic conductivity of aquifer	K	6.56E+01	m/d	Refer to Appendix E
Distance to compliance point	x	5.00E+01	m	Refer to Appendix E
Distance (laterally) to compliance point perpendicular to flow direction	z	0.00E+00	m	Value is 0
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	Value is 0
Time since pollutant entered groundwater	t	1.00E+100	days	time variant options only

Parameters values determined from options

Partition coefficient	K _d	5.51E+01	l/kg	see options
Longitudinal dispersivity	α _x	2.98E+00	m	see options
Transverse dispersivity	α _z	2.98E+01	m	see options
Vertical dispersivity	α _y	2.98E+02	m	see options

Calculated Parameters

Groundwater flow velocity	v	1.60E+02	m/d	
Retardation factor	R _f	5.36E+00	fraction	
Decay rate used	λ	7.62E-05	d ⁻¹	
Rate of contaminant flow due to retardation	u	2.99E+03	m/d	
Contaminant concentration at distance X, assuming one-way vertical dispersion	C _{0D}	1.68E+01	mg/l	
Attenuation factor (one way vertical dispersion, COCED)	AF	3.41E+00		

Remedial Targets

Remedial Target	3.41E+02	mg/l	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	50	m	
Concentration of contaminant at compliance point	C _{0D} C ₀	1.68E+01	mg/l
after		1.0E+100	days
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.

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

Calculate for non-polar organic chemicals

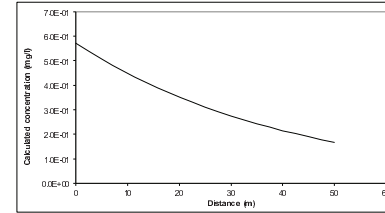
Entry if specify partition coefficient (option)	K _d		l/kg
Soil/water partition coefficient			
Entry for non-polar organic chemicals (option)	f _{oc}	3.00E-03	fraction
Fraction of organic carbon in aquifer			
Organic carbon partition coefficient	K _{oc}	1.41E+02	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	K _{ow}		l/kg
Sorption coefficient for ionised species	K _{oc,i}		l/kg
pH value	pH		
acid dissociation constant	pK _a		
Fraction of organic carbon in aquifer	f _{oc}		fraction
Soil/water partition coefficient	K _d	5.51E+01	l/kg

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

Dispersivity based on Xu & Eckstein (1995)

Longitudinal dispersivity	α _x	Enter value	Calc. value Xu & Eckstein	m
Transverse dispersivity	α _z	0.00E+00	5.00E+01	2.98E+00
Vertical dispersivity	α _y	0.00E+00	5.00E+01	2.98E+01
		0.00E+00	5.00E+01	2.98E+02

Note values of dispersivity must be > 0
For calculated values, assumes α_x = 0.1 * x, α_z = 0.01 * x, α_y = 0.001 * x
Xu & Eckstein (1995) report α_x = 0.83(log₁₀ x)^{0.44}; α_z = α_x/10, α_y = α_x/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 t will give the steady state solution, which should be used to calculate remedial targets.

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

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

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

Site being assessed:	Plot NT02 Dantric Street
Completed by:	Laura Aspinall
Date:	12/12/2023
Version:	Controlled waters risk assessment

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant Target Concentration C_T Trichloroethene (TCE) 1.00E-02 mg/l

From Level 1
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

Initial contaminant concentration in groundwater at plume core C_0 5.72E-01 mg/l
Half life for degradation of contaminant in water $t_{1/2}$ 1.69E+03 days
Calculated decay rate λ 4.19E-04 days⁻¹
Width of plume in aquifer at source (perpendicular to flow) S_z 7.50E+01 m
Plume thickness at source S_y 4.52E+00 m
Saturated aquifer thickness d_a 6.81E+00 m
Bulk density of aquifer materials ρ 2.14E+00 g/cm³
Effective porosity of aquifer n 2.70E-01 fraction
Hydraulic gradient i 6.60E-03 fraction
Hydraulic conductivity of aquifer K 1.64E+00 m/d
Distance to compliance point x 5.00E+01 m
Distance (laterally) 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

Parameters values determined from options

Partition coefficient K_d 5.51E-01 l/kg
Longitudinal dispersivity α_x 2.98E+00 m
Transverse dispersivity α_z 2.98E-01 m
Vertical dispersivity α_y 2.98E-02 m

Calculated Parameters

Groundwater flow velocity v 4.01E-02 m/d
Retardation factor R_f 5.36E+00 fraction
Decay rate used λ 7.62E-05 d⁻¹
Rate of contaminant flow due to retardation u 7.47E-03 m/d
Contaminant concentration at distance X, assuming one-way vertical dispersion C_{1D} 3.41E-01 mg/l
Attenuation factor (one way vertical dispersion, COCED) AF 1.68E+00

Remedial Targets

Remedial Target 1.68E-02 mg/l
Ogata Banks
Distance to compliance point 50 m
Concentration of contaminant at compliance point C_{1D}/C_0 3.41E-01 mg/l
after 1.0E+100 days 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.

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

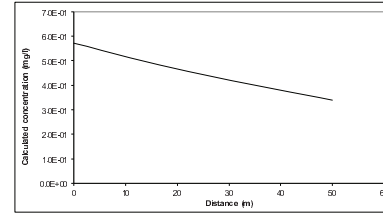
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option) K_d 5.51E-01 l/kg
Soil water partition coefficient K_{oc} 3.00E-03 fraction
Entry for non-polar organic chemicals (option) K_{oc} 1.41E+02 l/kg
Organic carbon partition coefficient K_{oc} 1.41E+02 l/kg
Entry for ionic organic chemicals (option) K_{oc} 1.41E+02 l/kg
Sorption coefficient for related species K_{oc} 1.41E+02 l/kg
Sorption coefficient for ionised species K_{oc} 1.41E+02 l/kg
pH value pH 7.5
acid dissociation constant pK_a 10.0
Fraction of organic carbon in aquifer f_{oc} 0.001
Soil water partition coefficient K_d 5.51E-01 l/kg

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

Dispersivity based on Xu & Eckstein (1995)

Longitudinal dispersivity α_x 2.98E+00 m
Transverse dispersivity α_z 2.98E-01 m
Vertical dispersivity α_y 2.98E-02 m
Note values of dispersivity must be > 0
For calculated values, assumes $\alpha_x = 0.83 \log_{10} \alpha_z^{0.414}$; $\alpha_z = \alpha_x^{10}$, $\alpha_y = \alpha_x^{100}$ are assumed
Xu & Eckstein (1995) report $\alpha_x = 0.83 \log_{10} \alpha_z^{0.414}$; $\alpha_z = \alpha_x^{10}$, $\alpha_y = \alpha_x^{100}$ 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 t will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared

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

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

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

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet
Distance Concentration
0 5.7E-01 mg/l
2.5 5.58E-01
5.0 5.44E-01
7.5 5.30E-01
10.0 5.17E-01
12.5 5.04E-01
15.0 4.91E-01
17.5 4.79E-01
20.0 4.67E-01
22.5 4.55E-01
25.0 4.44E-01
27.5 4.32E-01
30.0 4.22E-01
32.5 4.11E-01
35.0 4.00E-01
37.5 3.90E-01
40.0 3.80E-01
42.5 3.70E-01
45.0 3.60E-01
47.5 3.51E-01
50.0 3.41E-01

Site being assessed: Pld NT02 Dantric Street
Completed by: Laura Aspinall
Date: 12/12/2023
Version: Controlled waters risk assessment

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant Target Concentration C_T Trichloroethene (TCE) 1.00E+02 mg/l from Level 1 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

Initial contaminant concentration in groundwater at plume core C_0 5.72E+01 mg/l
Half life for degradation of contaminant in water $t_{1/2}$ 1.69E+03 days
Calculated decay rate λ 4.19E-04 days⁻¹
Width of plume in aquifer at source (perpendicular to flow) S_z 7.50E+01 m
Plume thickness at source S_y 4.52E+00 m
Saturated aquifer thickness d_a 6.81E+00 m
Bulk density of aquifer materials ρ 2.14E+00 g/cm³
Effective porosity of aquifer n 3.24E-01 fraction
Hydraulic gradient i 6.60E-03 fraction
Hydraulic conductivity of aquifer K 8.20E+01 m/d
Distance to compliance point x 5.00E+01 m
Distance (laterally) 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
Parameters values determined from options

Calculated Parameters

Groundwater flow velocity v 1.67E-02 m/d
Retardation factor R_f 4.64E+00 fraction
Decay rate used λ 9.04E-05 d⁻¹
Rate of contaminant flow due to retardation u 3.60E-03 m/d
Contaminant concentration at distance X, assuming one-way vertical dispersion C_{1D} 1.75E+01 mg/l
Attenuation factor (one way vertical dispersion, COCED) AF 3.28E+00

Remedial Targets

Remedial Target 3.26E+02 mg/l For comparison with measured groundwater concentration.
Ogata Banks
Distance to compliance point 50 m
Concentration of contaminant at compliance point C_{1D}/C_0 1.75E+01 mg/l Ogata Banks
after 1.0E+100 days

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

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

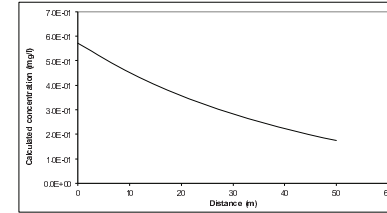
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option) K_d 5.51E-01 l/kg
Soil/water partition coefficient
Entry for non-polar organic chemicals (option) f_{oc} 3.00E-03 fraction
Fraction of organic carbon in aquifer
Organic carbon partition coefficient K_{oc} 1.41E+02 l/kg
Entry for ionic organic chemicals (option) K_{ow} 1.41E+02 l/kg
Sorption coefficient for related species
Sorption coefficient for ionised species $K_{oc,i}$ 1.41E+02 l/kg
pH value pH 7.5
acid dissociation constant pK_a 10.0
Fraction of organic carbon in aquifer f_{oc} 3.00E-03 fraction
Soil/water partition coefficient K_d 5.51E-01 l/kg

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

Dispersivity based on Xu & Eckstein (1995)

Longitudinal dispersivity α_x 0.00E+00 5.00E+01 2.98E+00 m
Transverse dispersivity α_z 0.00E+00 5.00E+01 2.98E+01 m
Vertical dispersivity α_y 0.00E+00 5.00E+01 2.98E+02 m
Note values of dispersivity must be > 0
For calculated values, assumes $\alpha_x = 0.1 \times \lambda$, $\alpha_z = 0.01 \times \lambda$, $\alpha_y = 0.001 \times \lambda$
Xu & Eckstein (1995) report $\alpha_x = 0.83(\log_{10} \lambda)^{0.44}$; $\alpha_z = \alpha_x/10$, $\alpha_y = \alpha_x/100$ 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 t will give the steady state solution, which should be used to calculate remedial targets.

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

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

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

Calculated concentrations for distance-concentration graph

Ogata Banks From calculation sheet
Distance Concentration mg/l
0 5.7E-01
2.5 5.39E-01
5.0 5.09E-01
7.5 4.80E-01
10.0 4.52E-01
12.5 4.27E-01
15.0 4.02E-01
17.5 3.79E-01
20.0 3.58E-01
22.5 3.37E-01
25.0 3.18E-01
27.5 3.00E-01
30.0 2.83E-01
32.5 2.67E-01
35.0 2.51E-01
37.5 2.37E-01
40.0 2.23E-01
42.5 2.10E-01
45.0 1.98E-01
47.5 1.86E-01
50.0 1.75E-01

Site being assessed: Pld NT02 Dantric Street
Completed by: Laura Aspinall
Date: 12/12/2023
Version: Controlled waters risk assessment

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Trichloroethene (TCE)	from Level 1
Target Concentration	1.00E-02	mg/l from Level 1

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

Ogata Banks	Equations in HRA publication
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Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

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

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

Initial contaminant concentration in groundwater at plume core	C ₀	5.72E-01	mg/l
Half life for degradation of contaminant in water	t _{1/2}	1.69E+03	days
Calculated decay rate	λ	4.19E-04	days ⁻¹
Width of plume in aquifer at source (perpendicular to flow)	Sz	7.50E+01	m
Plume thickness at source	Sy	4.52E+00	m
Saturated aquifer thickness	da	6.81E+00	m
Bulk density of aquifer materials	ρ	2.14E+00	g/cm ³
Effective porosity of aquifer	n	2.19E-01	fraction
Hydraulic gradient	i	6.60E-03	fraction
Hydraulic conductivity of aquifer	K	8.20E-01	m/d
Distance to compliance point	x	5.00E+01	m
Distance (laterally) 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

Parameters values determined from options

Partition coefficient	K _d	5.51E-01	l/kg	see options
Longitudinal dispersivity	α _x	2.98E+00	m	see options
Transverse dispersivity	α _z	2.98E-01	m	see options
Vertical dispersivity	α _y	2.98E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	2.51E-02	m/d
Retardation factor	R _f	6.46E+00	fraction
Decay rate used	λ	6.50E-05	d ⁻¹
Rate of contaminant flow due to retardation	u	3.88E-03	m/d
Contaminant concentration at distance X, assuming one-way vertical dispersion	C _{1D}	2.55E-01	mg/l
Attenuation factor (one way vertical dispersion, COCED)	AF	2.24E+00	

Remedial Targets

Remedial Target	2.24E-02	mg/l	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	50	m	
Concentration of contaminant at compliance point	C _{1D} /C ₀	2.55E-01	mg/l Ogata Banks
after	1.0E+100	days	

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

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

Calculate for non-polar organic chemicals

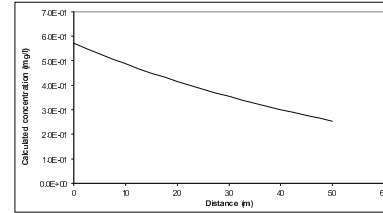
Entry if specify partition coefficient (option)	K _d	l/kg
Soil water partition coefficient		
Entry for non-polar organic chemicals (option)	f _{oc}	3.00E-03 fraction
Fraction of organic carbon in aquifer		
Organic carbon partition coefficient	K _{oc}	1.41E+02 l/kg
Entry for ionic organic chemicals (option)		
Sorption coefficient for related species	K _{ow}	l/kg
Sorption coefficient for ionised species	K _{oc,i}	l/kg
pH value	pH	
acid dissociation constant	pK _a	
Fraction of organic carbon in aquifer	f _{oc}	fraction
Soil water partition coefficient	K _d	5.51E-01 l/kg

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

Dispersivity based on Xu & Eckstein (1995)

Longitudinal dispersivity	α _x	Enter value	Calc. value Xu & Eckstein, m
Transverse dispersivity	α _z	0.00E+00	5.00E+01 2.98E+00 m
Vertical dispersivity	α _y	0.00E+00	5.00E-01 2.98E-01 m
		0.00E+00	5.00E-02 2.98E-02 m

Note values of dispersivity must be > 0
For calculated values, assumes α_x = 0.1 * x, α_z = 0.01 * x, α_y = 0.001 * x
Xu & Eckstein (1995) report α_x = 0.83(log₁₀ x)^{0.44}; α_z = α_x/10, α_y = α_x/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 t it will give the steady state solution, which should be used to calculate remedial targets.

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

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

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

Site being assessed: Pld NT02 Dantric Street
Completed by: Laura Aspinall
Date: 12/12/2023
Version: Controlled waters risk assessment

Calculated concentrations for distance-concentration graph

Ogata Banks		mg/l
From calculation sheet		
Distance	Concentration	
0	5.7E-01	
2.5	5.50E-01	
5.0	5.28E-01	
7.5	5.07E-01	
10.0	4.88E-01	
12.5	4.68E-01	
15.0	4.50E-01	
17.5	4.32E-01	
20.0	4.16E-01	
22.5	3.99E-01	
25.0	3.84E-01	
27.5	3.68E-01	
30.0	3.54E-01	
32.5	3.40E-01	
35.0	3.26E-01	
37.5	3.13E-01	
40.0	3.01E-01	
42.5	2.89E-01	
45.0	2.77E-01	
47.5	2.66E-01	
50.0	2.55E-01	

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant Target Concentration C_T Trichloroethene (TCE) 1.00E-02 mg/l from Level 1 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

Initial contaminant concentration in groundwater at plume core C_0 5.72E-01 mg/l
Half life for degradation of contaminant in water $t_{1/2}$ 1.69E+03 days
Calculated decay rate λ 4.19E-04 days⁻¹
Width of plume in aquifer at source (perpendicular to flow) S_z 9.00E+01 m
Plume thickness at source S_y 4.52E+00 m
Saturated aquifer thickness d_a 6.81E+00 m
Bulk density of aquifer materials ρ 2.14E+00 g/cm³
Effective porosity of aquifer n 2.70E-01 fraction
Hydraulic gradient i 6.60E-03 fraction
Hydraulic conductivity of aquifer K 8.20E-01 m/d
Distance to compliance point x 5.00E+01 m
Distance (laterally) 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
Parameters values determined from options

Calculated Parameters

Groundwater flow velocity v 2.00E-02 m/d
Retardation factor R_f 5.36E+00 fraction
Decay rate used λ 7.62E-05 d⁻¹
Rate of contaminant flow due to retardation u 3.74E-03 m/d
Contaminant concentration at distance X, assuming one-way vertical dispersion C_{1D} 2.11E-01 mg/l
Attenuation factor (one way vertical dispersion, COCED) AF 2.71E+00

Remedial Targets

Remedial Target 2.71E-02 mg/l for comparison with measured groundwater concentration.
Ogata Banks
Distance to compliance point 50 m
Concentration of contaminant at compliance point C_{1D}/C_0 2.11E-01 mg/l Ogata Banks
after 1.0E+100 days

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

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

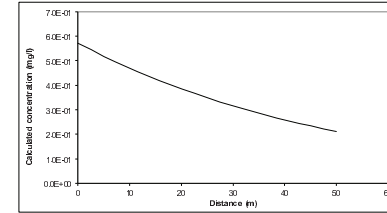
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option) K_d 5.51E-01 l/kg
Soil/water partition coefficient
Entry for non-polar organic chemicals (option) f_{oc} 3.00E-03 fraction
Fraction of organic carbon in aquifer
Organic carbon partition coefficient K_{oc} 1.41E+02 l/kg
Entry for ionic organic chemicals (option) K_{ow} 1.41E+02 l/kg
Sorption coefficient for related species
Sorption coefficient for ionised species $K_{oc,i}$ 1.41E+02 l/kg
pH value pH 7.5
acid dissociation constant pK_a 10.0
Fraction of organic carbon in aquifer f_{oc} 3.00E-03 fraction
Soil/water partition coefficient K_d 5.51E-01 l/kg

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

Dispersivity based on Xu & Eckstein (1995)

Longitudinal dispersivity α_x 0.00E+00 m
Transverse dispersivity α_z 0.00E+00 m
Vertical dispersivity α_y 0.00E+00 m
Note values of dispersivity must be > 0
For calculated values, assumes $\alpha_x = 0.83(\log_{10} \alpha_z)^{2.44}$; $\alpha_z = \alpha_x/10$, $\alpha_y = \alpha_x/100$ are assumed
Xu & Eckstein (1995) report $\alpha_x = 0.83(\log_{10} \alpha_z)^{2.44}$; $\alpha_z = \alpha_x/10$, $\alpha_y = \alpha_x/100$ 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 t will give the steady state solution, which should be used to calculate remedial targets.

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

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

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

Calculated concentrations for distance-concentration graph

Ogata Banks From calculation sheet
Distance Concentration mg/l
0 5.7E-01
2.5 5.44E-01
5.0 5.18E-01
7.5 4.93E-01
10.0 4.69E-01
12.5 4.47E-01
15.0 4.25E-01
17.5 4.02E-01
20.0 3.85E-01
22.5 3.67E-01
25.0 3.49E-01
27.5 3.32E-01
30.0 3.16E-01
32.5 3.01E-01
35.0 2.86E-01
37.5 2.72E-01
40.0 2.59E-01
42.5 2.46E-01
45.0 2.34E-01
47.5 2.22E-01
50.0 2.11E-01

Site being assessed: Pld NT02 Dantric Street
Completed by: Laura Aspinall
Date: 12/12/2023
Version: Controlled waters risk assessment

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant Target Concentration C_T Trichloroethene (TCE) 1.00E+02 mg/l

from Level 1
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

Initial contaminant concentration in groundwater at plume core C_0 5.72E+01 mg/l
Half life for degradation of contaminant in water $t_{1/2}$ 1.69E+03 days
Calculated decay rate λ 4.19E-04 days⁻¹
Width of plume in aquifer at source (perpendicular to flow) S_z 6.00E+01 m
Plume thickness at source S_y 4.52E+00 m
Saturated aquifer thickness d_a 6.81E+00 m
Bulk density of aquifer materials ρ 2.14E+00 g/cm³
Effective porosity of aquifer n 2.70E-01 fraction
Hydraulic gradient i 6.60E-03 fraction
Hydraulic conductivity of aquifer K 8.20E-01 m/d
Distance to compliance point x 5.00E+01 m
Distance (laterally) 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

Parameters values determined from options

Partition coefficient K_d 5.51E-01 l/kg
Longitudinal dispersivity α_x 2.98E+00 m
Transverse dispersivity α_z 2.98E-01 m
Vertical dispersivity α_y 2.98E-02 m

Calculated Parameters

Groundwater flow velocity v 2.00E-02 m/d
Retardation factor R_f 5.36E+00 fraction
Decay rate used λ 7.62E-05 d⁻¹
Rate of contaminant flow due to retardation u 3.74E-03 m/d
Contaminant concentration at distance X, assuming one-way vertical dispersion C_{1D} 2.11E-01 mg/l
Attenuation factor (one way vertical dispersion, COCED) AF 2.71E+00

Remedial Targets

Remedial Target 2.71E+02 mg/l
Ogata Banks
Distance to compliance point 50 m
Concentration of contaminant at compliance point C_{1D}/C_0 2.11E-01 mg/l
after 1.0E+100 days 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.

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

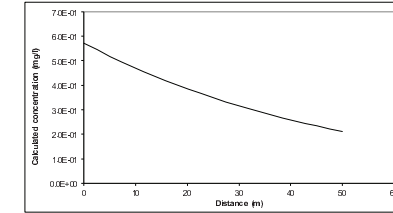
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option) K_d l/kg
Soil water partition coefficient K_{oc} 3.00E-03 fraction
Entry for non-polar organic chemicals (option) K_{oc} 1.41E+02 l/kg
Organic carbon partition coefficient K_{oc} 1.41E+02 l/kg
Entry for ionic organic chemicals (option) K_{ow} l/kg
Sorption coefficient for related species K_{oc} l/kg
Sorption coefficient for ionised species pH pH
acid dissociation constant pK_a fraction
Fraction of organic carbon in aquifer f_{oc} 5.51E-01 l/kg

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

Dispersivity based on Xu & Eckstein (1995)

Longitudinal dispersivity α_x 0.00E+00 5.00E+00 2.98E+00 m
Transverse dispersivity α_z 0.00E+00 5.00E-01 2.98E-01 m
Vertical dispersivity α_y 0.00E+00 5.00E-02 2.98E-02 m
Note values of dispersivity must be > 0
For calculated value, assumes $\alpha_x = 0.83(\log_{10} \alpha_x)^{2.44}$; $\alpha_z = \alpha_x/10$, $\alpha_y = \alpha_x/100$ are assumed
Xu & Eckstein (1995) report $\alpha_x = 0.83(\log_{10} \alpha_x)^{2.44}$; $\alpha_z = \alpha_x/10$, $\alpha_y = \alpha_x/100$ 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 t will give the steady state solution, which should be used to calculate remedial targets.

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

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

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

Site being assessed: Pld NT02 Dantric Street
Completed by: Laura Aspinall
Date: 12/12/2023
Version: Controlled waters risk assessment

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet
Distance Concentration mg/l
0 5.7E-01
2.5 5.44E-01
5.0 5.18E-01
7.5 4.93E-01
10.0 4.69E-01
12.5 4.47E-01
15.0 4.25E-01
17.5 4.02E-01
20.0 3.85E-01
22.5 3.67E-01
25.0 3.49E-01
27.5 3.32E-01
30.0 3.16E-01
32.5 3.01E-01
35.0 2.86E-01
37.5 2.72E-01
40.0 2.59E-01
42.5 2.46E-01
45.0 2.34E-01
47.5 2.22E-01
50.0 2.11E-01

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Trichloroethene (TCE)	from Level 1
Target Concentration	$1.00E-02$	from Level 1
C_T	mg/l	

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

Ogata Banks	Equations in HRA publication
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Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

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

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

Initial contaminant concentration in groundwater at plume core	C_0	$5.72E-01$	mg/l	Source of parameter value
Half life for degradation of contaminant in water	$t_{1/2}$	$1.69E+03$	days	Maximum concentration (RSH-203 on 04/10/2022)
Calculated decay rate	λ	$4.19E-04$	days ⁻¹	Howard et al high half-life (aerobic conditions)
Width of plume in aquifer at source (perpendicular to flow)	S_z	$7.50E+01$	m	Refer to Appendix E
Plume thickness at source	S_y	$4.52E+00$	m	Refer to Appendix E
Saturated aquifer thickness	d_a	$6.81E+00$	m	Refer to Appendix E
Bulk density of aquifer materials	ρ	$2.14E+00$	g/cm ³	Refer to Appendix E
Effective porosity of aquifer	n	$2.70E-01$	fraction	Refer to Appendix E
Hydraulic gradient	i	$7.92E-03$	fraction	Refer to Appendix E
Hydraulic conductivity of aquifer	K	$8.20E-01$	m/d	Refer to Appendix E
Distance to compliance point	x	$5.00E+01$	m	Refer to Appendix E
Distance (laterally) to compliance point perpendicular to flow direction	z	$0.00E+00$	m	Value is 0
Distance (depth) to compliance point perpendicular to flow direction	y	$0.00E+00$	m	Value is 0
Time since pollutant entered groundwater	t	$1.00E+100$	days	time variant options only

Parameters values determined from options

Partition coefficient	K_d	$5.51E-01$	l/kg	see options
Longitudinal dispersivity	α_x	$2.98E+00$	m	see options
Transverse dispersivity	α_z	$2.98E-01$	m	see options
Vertical dispersivity	α_y	$2.98E-02$	m	see options

Calculated Parameters

Groundwater flow velocity	v	$2.41E-02$	m/d
Retardation factor	R_f	$5.36E+00$	fraction
Decay rate used	λ	$7.62E-05$	d ⁻¹
Rate of contaminant flow due to retardation	u	$4.48E-03$	m/d
Contaminant concentration at distance X, assuming one-way vertical dispersion	C_{1D}	$2.47E-01$	mg/l
Attenuation factor (one way vertical dispersion, COCED)	AF	$2.32E+00$	

Remedial Targets

Remedial Target	$2.32E-02$	mg/l	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	50	m	
Concentration of contaminant at compliance point	C_{1D}/C_0	$2.47E-01$	mg/l
after	$1.0E+100$	days	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 $9.9E+99$.

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

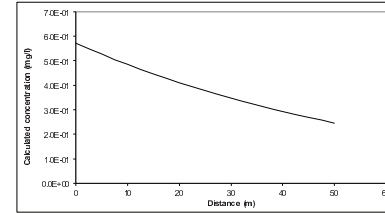
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)	K_d	l/kg
Soil/water partition coefficient		
Entry for non-polar organic chemicals (option)	f_{oc}	fraction
Fraction of organic carbon in aquifer		
Organic carbon partition coefficient	K_{oc}	l/kg
Entry for ionic organic chemicals (option)		
Sorption coefficient for related species	K_{ow}	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	f_{oc}	fraction
Soil/water partition coefficient	K_d	$5.51E-01$ l/kg

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

Dispersivity based on Xu & Eckstein (1995)

Longitudinal dispersivity	α_x	Enter value	Calc. value Xu & Eckstein	m
Transverse dispersivity	α_z	$0.00E+00$	$5.00E+01$	$2.98E+00$ m
Vertical dispersivity	α_y	$0.00E+00$	$5.00E-01$	$2.98E-01$ m
		$0.00E+00$	$5.00E-02$	$2.98E-02$ m
Note values of dispersivity must be > 0				
For calculated values, assumes $\alpha_x = 0.1 \times x$, $\alpha_z = 0.01 \times x$, $\alpha_y = 0.001 \times x$				
Xu & Eckstein (1995) report $\alpha_x = 0.83(\log_{10} x)^{0.44}$; $\alpha_z = \alpha_x/10$, $\alpha_y = \alpha_x/100$ 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 t will give the steady state solution, which should be used to calculate remedial targets.

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

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

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

Site being assessed:	Plot NT02 Dantric Street
Completed by:	Laura Aspinall
Date:	12/12/2023
Version:	Controlled waters risk assessment

Calculated concentrations for distance-concentration graph

Ogata Banks		mg/l
From calculation sheet		
Distance	Concentration	
0	$5.7E-01$	
2.5	$5.69E-01$	
5.0	$5.60E-01$	
7.5	$5.50E-01$	
10.0	$4.84E-01$	
12.5	$4.65E-01$	
15.0	$4.46E-01$	
17.5	$4.28E-01$	
20.0	$4.10E-01$	
22.5	$3.94E-01$	
25.0	$3.78E-01$	
27.5	$3.62E-01$	
30.0	$3.47E-01$	
32.5	$3.33E-01$	
35.0	$3.19E-01$	
37.5	$3.06E-01$	
40.0	$2.93E-01$	
42.5	$2.81E-01$	
45.0	$2.69E-01$	
47.5	$2.58E-01$	
50.0	$2.47E-01$	

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant Target Concentration	C _T	Trichloroethene (TCE)	1.00E+02	mg/l	from Level 1 from Level 1
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Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks	Equations in HRA publication
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Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

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

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	5.72E-01	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	1.69E+03	days	
Calculated decay rate	λ	4.19E-04	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	7.50E+01	m	Refer to Appendix E
Plume thickness at source	Sy	4.52E+00	m	Refer to Appendix E
Saturated aquifer thickness	da	6.81E+00	m	Refer to Appendix E
Bulk density of aquifer materials	ρ	2.14E+00	g/cm ³	Refer to Appendix E
Effective porosity of aquifer	n	2.70E-01	fraction	Refer to Appendix E
Hydraulic gradient	i	5.28E-03	fraction	Refer to Appendix E
Hydraulic conductivity of aquifer	K	8.20E-01	m/d	Refer to Appendix E
Distance to compliance point	x	5.00E+01	m	Refer to Appendix E
Distance (laterally) to compliance point perpendicular to flow direction	z	0.00E+00	m	Value is 0
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	Value is 0
Time since pollutant entered groundwater	t	1.00E+100	days	time variant options only

Parameters values determined from options

Partition coefficient	K _d	5.51E-01	l/kg	see options
Longitudinal dispersivity	α _x	2.98E+00	m	see options
Transverse dispersivity	α _z	2.98E-01	m	see options
Vertical dispersivity	α _y	2.98E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	1.60E-02	m/d
Retardation factor	R _f	5.36E+00	fraction
Decay rate used	λ	7.62E-05	d ⁻¹
Rate of contaminant flow due to retardation	u	2.99E-03	m/d
Contaminant concentration at distance X, assuming one-way vertical dispersion	C _{0D}	1.68E-01	mg/l
Attenuation factor (one way vertical dispersion, COCED)	AF	3.41E+00	

Remedial Targets

Remedial Target	3.41E+02	mg/l	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	50	m	
Concentration of contaminant at compliance point	C _{0D} C ₀	1.68E-01	mg/l
after	1.0E+100	days	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.

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

Calculate for non-polar organic chemicals

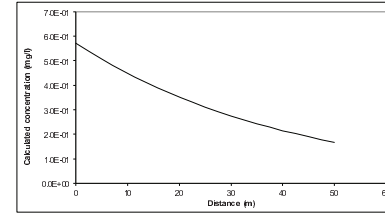
Entry if specify partition coefficient (option)	K _d	l/kg
Soil water partition coefficient		
Entry for non-polar organic chemicals (option)	f _{oc}	3.00E-03 fraction
Fraction of organic carbon in aquifer		
Organic carbon partition coefficient	K _{oc}	1.41E+02 l/kg
Entry for ionic organic chemicals (option)		
Sorption coefficient for related species	K _{ow}	l/kg
Sorption coefficient for ionised species	K _{oc,i}	l/kg
pH value	pH	
acid dissociation constant	pK _a	
Fraction of organic carbon in aquifer	f _{oc}	fraction
Soil water partition coefficient	K _d	5.51E-01 l/kg

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

Dispersivity based on Xu & Eckstein (1995)

Longitudinal dispersivity	α _x	Enter value	Calc. value Xu & Eckstein	m
Transverse dispersivity	α _z	0.00E+00	5.00E+01	2.98E+00 m
Vertical dispersivity	α _y	0.00E+00	5.00E-01	2.98E-01 m
		0.00E+00	5.00E-02	2.98E-02 m

Note values of dispersivity must be > 0
For calculated values, assumes α_x = 0.1 * x, α_z = 0.01 * x, α_y = 0.001 * x
Xu & Eckstein (1995) report α_x = 0.83(log₁₀ x)^{0.44}; α_z = α_x/10, α_y = α_x/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 t it will give the steady state solution, which should be used to calculate remedial targets.

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

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

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

Site being assessed: Pld NT02 Dantric Street

Completed by: Laura Aspinall

Date: 12/12/2023

Version: Controlled waters risk assessment

Calculated concentrations for distance-concentration graph

Distance	Concentration
0	5.7E-01
2.5	5.38E-01
5.0	5.06E-01
7.5	4.76E-01
10.0	4.48E-01
12.5	4.22E-01
15.0	3.97E-01
17.5	3.73E-01
20.0	3.51E-01
22.5	3.30E-01
25.0	3.11E-01
27.5	2.92E-01
30.0	2.75E-01
32.5	2.59E-01
35.0	2.43E-01
37.5	2.29E-01
40.0	2.15E-01
42.5	2.02E-01
45.0	1.90E-01
47.5	1.78E-01
50.0	1.68E-01

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant Target Concentration C_T Trichloroethene (TCE) 1.00E-02 mg/l

From Level 1
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

Initial contaminant concentration in groundwater at plume core C_0 5.72E-01 mg/l
Half life for degradation of contaminant in water $t_{1/2}$ 3.21E+02 days
Calculated decay rate λ 2.19E-03 days⁻¹
Width of plume in aquifer at source (perpendicular to flow) S_z 7.50E+01 m
Plume thickness at source S_y 4.52E+00 m
Saturated aquifer thickness d_a 6.81E+00 m
Bulk density of aquifer materials ρ 2.14E+00 g/cm³
Effective porosity of aquifer n 2.70E-01 fraction
Hydraulic gradient i 6.60E-03 fraction
Hydraulic conductivity of aquifer K 8.20E-01 m/d
Distance to compliance point x 5.00E+01 m
Distance (laterally) 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

Parameters values determined from options

Partition coefficient K_d 5.51E-01 l/kg
Longitudinal dispersivity α_x 2.98E+00 m
Transverse dispersivity α_z 2.98E-01 m
Vertical dispersivity α_y 2.98E-02 m

Calculated Parameters

Groundwater flow velocity v 2.00E-02 m/d
Retardation factor R_f 5.36E+00 fraction
Decay rate used λ 4.03E-04 d⁻¹
Rate of contaminant flow due to retardation u 3.74E-03 m/d
Contaminant concentration at distance X, assuming one-way vertical dispersion C_{1D} 7.78E-03 mg/l
Attenuation factor (one way vertical dispersion, COCED) AF 7.35E+01

Remedial Targets

Remedial Target 7.35E-01 mg/l
Ogata Banks
Distance to compliance point 50 m
Concentration of contaminant at compliance point C_{1D}/C_0 7.78E-03 mg/l
after 1.0E+100 days 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.

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

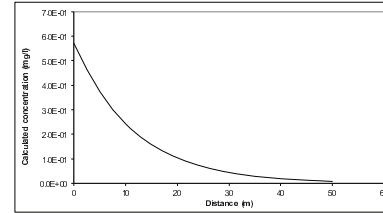
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option) K_d 5.51E-01 l/kg
Soil/water partition coefficient K_{oc} 3.00E-03 fraction
Entry for non-polar organic chemicals (option) K_{oc} 1.41E+02 l/kg
Fraction of organic carbon in aquifer K_{oc} 1.41E+02 l/kg
Organic carbon partition coefficient K_{oc} 1.41E+02 l/kg
Entry for ionic organic chemicals (option) K_{oc} 1.41E+02 l/kg
Sorption coefficient for related species K_{oc} 1.41E+02 l/kg
Sorption coefficient for ionised species K_{oc} 1.41E+02 l/kg
pH value pH 7.00
acid dissociation constant pK_a 7.00
Fraction of organic carbon in aquifer f_{oc} 0.001

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

Dispersivity based on Xu & Eckstein (1995)

Longitudinal dispersivity α_x 2.98E+00 m
Transverse dispersivity α_z 2.98E-01 m
Vertical dispersivity α_y 2.98E-02 m
Note values of dispersivity must be > 0
For calculated values, assumes $\alpha_x = 0.83 \log_{10} \alpha_z^{0.414}$; $\alpha_z = \alpha_x^{10}$, $\alpha_y = \alpha_x^{100}$ are assumed
Xu & Eckstein (1995) report $\alpha_x = 0.83 \log_{10} \alpha_z^{0.414}$; $\alpha_z = \alpha_x^{10}$, $\alpha_y = \alpha_x^{100}$ 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 t will give the steady state solution, which should be used to calculate remedial targets.

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

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

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

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet
Distance Concentration
mg/l
0 5.72E-01
2.5 4.62E-01
5.0 3.73E-01
7.5 3.01E-01
10.0 2.43E-01
12.5 1.96E-01
15.0 1.58E-01
17.5 1.27E-01
20.0 1.03E-01
22.5 8.30E-02
25.0 6.70E-02
27.5 5.40E-02
30.0 4.36E-02
32.5 3.52E-02
35.0 2.84E-02
37.5 2.29E-02
40.0 1.84E-02
42.5 1.49E-02
45.0 1.20E-02
47.5 9.65E-03
50.0 7.78E-03

Site being assessed: Pld NT02 Dantric Street
Completed by: Laura Aspinall
Date: 12/12/2023
Version: Controlled waters risk assessment

APPENDIX H

MODEL CALIBRATION

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	Trichloroethene (TCE)		from Level 1
Target Concentration	1.00E-02	mg/l	from Level 1

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

Ogata Banks	Equations in HRA publication
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Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

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

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	2.00E-01	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	1.65E+03	days	
Calculated decay rate	λ	4.19E-04	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	7.59E+01	m	Refer to Appendix E
Plume thickness at source	Sy	4.52E+00	m	Refer to Appendix E
Saturated aquifer thickness	da	6.81E+00	m	Refer to Appendix E
Bulk density of aquifer materials	ρ	2.14E+00	g/cm ³	Refer to Appendix E
Effective porosity of aquifer	n	2.70E-01	fraction	Refer to Appendix E
Hydraulic gradient	i	6.60E-03	fraction	Refer to Appendix E
Hydraulic conductivity of aquifer	K	8.20E-01	m/d	Refer to Appendix E
Distance to compliance point	x	4.00E+01	m	Refer to Appendix E
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	Value is 0
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	Value is 0
Time since pollutant entered groundwater	t	1.00E+100	days	time variant options only
Parameters values determined from options				
Partition coefficient	Kd	5.51E-01	l/kg	see options
Longitudinal dispersivity	ax	2.59E+00	m	see options
Transverse dispersivity	ay	2.59E-01	m	see options
Vertical dispersivity	ay	2.59E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	2.00E-02	m/d
Retardation factor	Rf	5.96E+00	fraction
Decay rate used	λ	7.82E-05	d ⁻¹
Rate of contaminant flow due to retardation	u	3.74E-03	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{ED}	9.01E-02	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	2.22E+00	

Remedial Targets

Remedial Target	2.22E-02	mg/l	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	40	m	
Concentration of contaminant at compliance point	C _{ED} /C ₀	9.01E-02	mg/l Ogata Banks
after	1.0E+100	days	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target. The recommended value for time when calculating the remedial target is 9.95E+99.

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

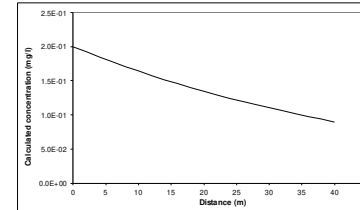
Calculate for non-polar organic chemicals

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	f _{oc}	3.90E-03 fraction
Organic carbon partition coefficient	K _{oc}	1.41E+02 l/kg
Entry for ionic organic chemicals (option)		
Sorption coefficient for related species	K _{oc,n}	l/kg
Sorption coefficient for ionised species	K _{oc,i}	l/kg
pH value	pH	
acid dissociation constant	pKa	
Fraction of organic carbon in aquifer	f _{oc}	fraction
Soil water partition coefficient	Kd	5.51E-01 l/kg

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

Dispersivity based on Xu & Eckstein (1995)

Longitudinal dispersivity	ax	Enter value	Calc value Xu & Eckstein	m
Transverse dispersivity	az	0.00E+00	4.00E-01	2.59E+00 m
Vertical dispersivity	ay	0.00E+00	4.00E-01	2.59E-01 m
Note values of dispersivity must be > 0		0.00E+00	4.00E-01	2.59E-02
For calculated values, assumes ax = 0.1 * x, az = 0.01 * x, ay = 0.001 * x				
Xu & Eckstein (1995) report ax = 0.83(log ₁₀ x) ^{0.14} ; az = ax/10, ay = ax/100 are assumed				



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

Note

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

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

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

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

Site being assessed: Plot N702 Dantzic Street
Completed by: Laura Aspinall
Date: 12/12/2023
Version: Controlled waters risk assessment

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet
Distance Concentration

	mg/l
0	2.0E-01
2.0	1.92E-01
4.0	1.85E-01
6.0	1.77E-01
8.0	1.71E-01
10.0	1.64E-01
12.0	1.58E-01
14.0	1.51E-01
16.0	1.45E-01
18.0	1.40E-01
20.0	1.34E-01
22.0	1.29E-01
24.0	1.24E-01
26.0	1.19E-01
28.0	1.15E-01
30.0	1.10E-01
32.0	1.06E-01
34.0	1.02E-01
36.0	9.76E-02
38.0	9.38E-02
40.0	9.01E-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	Trichloroethene (TCE)		from Level 1
Target Concentration	1.00E-02	mg/l	from Level 1

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

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

Initial contaminant concentration in groundwater at plume core	C ₀	4.18E-01	mg/l	
Half life for degradation of contaminant in water	t _{1/2}	1.65E+03	days	
Calculated decay rate	λ	4.19E-04	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	7.59E+01	m	Refer to Appendix E
Plume thickness at source	Sy	4.52E+00	m	Refer to Appendix E
Saturated aquifer thickness	da	6.81E+00	m	Refer to Appendix E
Bulk density of aquifer materials	p	2.14E+00	g/cm ³	Refer to Appendix E
Effective porosity of aquifer	n	2.70E-01	fraction	Refer to Appendix E
Hydraulic gradient	i	6.60E-03	fraction	Refer to Appendix E
Hydraulic conductivity of aquifer	K	8.20E-01	m/d	Refer to Appendix E
Distance to compliance point	x	4.80E+01	m	Refer to Appendix E
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	Value is 0
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	Value is 0
Time since pollutant entered groundwater	t	1.00E+100	days	time variant options only
Parameters values determined from options				
Partition coefficient	Kd	5.51E-01	l/kg	see options
Longitudinal dispersivity	ax	2.91E+00	m	see options
Transverse dispersivity	ay	2.91E-01	m	see options
Vertical dispersivity	ay	2.91E-02	m	see options

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	2.00E-02 m/d
Retardation factor	Rf	5.39E+00
Decay rate used	λ	7.82E-05 d ⁻¹
Rate of contaminant flow due to retardation	u	3.74E-03 m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{ED}	1.61E-01 mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	2.50E+00

Remedial Targets

Remedial Target	2.60E-02	mg/l	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	48	m	
Concentration of contaminant at compliance point	C _{ED} /C ₀	1.61E-01	mg/l Ogata Banks
after		1.0E+100	days

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	3.90E-03	fraction
Organic carbon partition coefficient	Koc	1.41E+02	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	K _{oc,n}		l/kg
Sorption coefficient for ionised species	K _{oc,i}		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	5.51E-01	l/kg

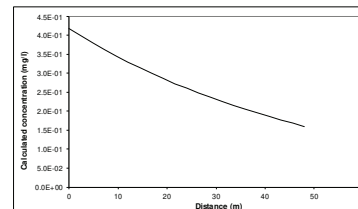
Define dispersivity (click brown cell and use pull down list)

Dispersivity based on Xu & Eckstein (1995)

		Enter value	Calc value Xu & Eckstein	m
Longitudinal dispersivity	ax	0.00E+00	4.80E-01	2.91E+00
Transverse dispersivity	az	0.00E+00	4.80E-01	2.91E-01
Vertical dispersivity	ay	0.00E+00	4.80E-02	2.91E-02
Note values of dispersivity must be > 0				
For calculated value, assumes $\alpha_x = 0.1 \times$, $\alpha_z = 0.01 \times$, $\alpha_y = 0.001 \times$				
Xu & Eckstein (1995) report $\alpha_x = 0.83(\log_{10})^{2.414}$; $\alpha_z = \alpha_x/10$, $\alpha_y = \alpha_x/100$ are assumed				

Note values of dispersivity must be > 0

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

Xu & Eckstein (1995) report ax = 0.83(log₁₀x)^{2.14}; az = ax/10, ay = ax/100 are assumed

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

Note

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

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

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

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

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

Site being assessed: Plot N702 Dantzic Street
Completed by: Laura Aspinall
Date: 12/12/2023
Version: Controlled waters risk assessment

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	4.2E-01
2.4	3.99E-01
4.8	3.80E-01
7.2	3.63E-01
9.6	3.46E-01
12.0	3.30E-01
14.4	3.14E-01
16.8	3.00E-01
19.2	2.86E-01
21.6	2.73E-01
24.0	2.60E-01
26.4	2.48E-01
28.8	2.36E-01
31.2	2.25E-01
33.6	2.15E-01
36.0	2.05E-01
38.4	1.95E-01
40.8	1.86E-01
43.2	1.77E-01
45.6	1.69E-01
48.0	1.61E-01



APPENDIX I

RTV SOILS AND GROUNDWATER SCREENING

Comparison of RTVs against measured concentrations in soil



COPC	Lab sample ID	22/07379/8	23/09425/2	23/09425/5	23/09491/7	23/09491/2	23/09491/3	23/09229/2	23/09229/4	23/09229/5	23/09229/6	23/10932/9	23/10932/10	23/11040/1	23/11040/4	23/10932/4	23/10932/7	23/10932/12	23/10932/13	23/10932/14	23/10932/2	22/07002/5	22/07002/2
	Borehole ID	RBH203	RBH401	RBH401	RBH401	RBH402	RBH402	RBH403	RBH403	RBH403	RBH403	RBH501	RBH501	RBH502	RBH502	RBH503	RBH503	RBH504	RBH504	RBH504	RBH505	TP202	TP203
	Depth to top	3	6.5	15	1	1.5	3.7	3.5	6	9.9	10.2	0.8	2	1	4.5	1.2	4	1.5	1.9	3.1	2.1	0.5	0.3
	Depth to bottom																						
	Date sampled	25/07/2022	20/09/2023	21/09/2023	20/09/2023	19/09/2023	19/09/2023	13/09/2023	14/09/2023	14/09/2023	14/09/2023	01/11/2023	01/11/2023	03/11/2023	07/11/2023	31/10/2023	31/10/2023	02/11/2023	02/11/2023	02/11/2023	31/10/2023	13/07/2022	12/07/2022
	Sample type																						
	RTV (mg/kg)																						
Trichloroethene	0.224	0.006	<0.025	<0.001	<0.025	<0.001	<0.025	<0.025	<0.025	<0.025	<0.001	0.151	<0.001	0.018	0.011	<0.001	<0.001	0.049	0.009	0.007	<0.001	0.012	<0.001
Carbon tetrachloride	0.116	<0.001	<0.025	<0.001	<0.025	<0.001	<0.025	<0.025	<0.025	<0.025	<0.001	<0.001	<0.001	0.002	0.028	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Notes:

LMDL Laboratory method detection limit

COPC Contaminant of potential concern

DQRA Detailed quantitative risk assessment

< Result less than the LM DL

RTV Remedial target value

- COPC not analysed

Measured concentration in excess of RTV

Comparison of RTVs against measured concentrations in soil



COPC	Lab sample ID	22/0721/6	22/0721/5	22/0721/2	22/0721/8	23/03693/3	23/03693/1	22/07379/1	22/07379/2	22/07002/6	22/07379/6	23/03602/17	23/03602/18	23/03602/19	23/03602/20	23/03602/21	23/03602/13	23/03602/14	23/03602/15	23/03602/16	23/03602/1	23/03602/2	23/03602/3
	Borehole ID	TP214	TP215	TP216	TP218	TP307	TP310	WS202	WS203	WS204	WS210	WS301	WS301	WS301	WS301	WS301	WS302	WS302	WS302	WS302	WS303	WS303	WS303
	Depth to top	0.8	1	0.6	0.5	0.6	0.5	1.5	0.5	0.4	0.5	0.5	1.5	2.5	3.5	4.5	0.5	1.5	2.5	3.5	0.4	1.2	1.8
	Depth to bottom																						
	Date sampled	18/07/2022	18/07/2022	18/07/2022	19/07/2022	12/04/2023	12/04/2023	21/07/2022	21/07/2022	13/07/2022	22/07/2022	04/04/2023	04/04/2023	04/04/2023	04/04/2023	04/04/2023	04/04/2023	04/04/2023	04/04/2023	04/04/2023	03/04/2023	03/04/2023	03/04/2023
	Sample type																						
	RTV (mg/kg)																						
Trichloroethene	0.234	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.09	<0.001	<0.001	0.067	0.036	0.017	0.043	<0.001	0.004	0.602	0.021	0.094	0.015	0.036	0.007
Carbon tetrachloride	0.136	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	<0.001	<0.001	0.003	<0.001	<0.001	<0.025	0.001	0.006	<0.001	<0.025	<0.001

Notes:

LMDL Laboratory method detection limit

COPC Contaminant of potential concern

DQRA Detailed quantitative risk assessment

< Result less than the LMDL

RTV Remedial target value

- COPC not analysed

Measured concentration in excess of RTV



COPC	Lab sample ID	23/03602/4	23/03602/28	23/03602/30	23/03602/32	23/03602/33	23/03602/5	23/03602/6	23/03602/25	23/03602/26	23/03602/27	23/03602/34	23/03602/7	23/03602/8	23/03602/9	23/03602/10	23/03602/11	23/03602/12	23/03693/8	23/03602/35	23/03602/36	23/03958/3	23/03602/37	
	Borehole ID	WS303	WS304	WS304	WS304	WS304	WS305	WS305	WS306	WS306	WS306	WS307	WS308	WS308	WS308	WS309	WS309	WS309	WS309	WS310	WS311	WS311	WS312	
	Depth to top	3.1	0.5	1.5	2.5	3.5	0.5	1	0.5	1.5	2.5	0.4	0.6	1	2	0.7	1.9	2.5	0.4	0.4	1.8	0.6		
	Depth to bottom																							
	Date sampled	03/04/2023	04/04/2023	04/04/2023	04/04/2023	04/04/2023	03/04/2023	03/04/2023	04/04/2023	04/04/2023	04/04/2023	04/04/2023	03/04/2023	03/04/2023	03/04/2023	03/04/2023	03/04/2023	03/04/2023	03/04/2023	11/04/2023	05/04/2023	05/04/2023	20/04/2023	05/04/2023
	Sample type																							
	RTV (mg/kg)																							
Trichloroethene	0.224	<0.025	0.23	0.016	0.074	0.043	0.06	0.427	0.098	0.15	0.006	0.066	0.569	1.13	0.039	0.072	0.015	0.003	<0.001	0.001	<0.001	<0.001	<0.025	
Carbon tetrachloride	0.116	<0.025	0.004	<0.001	0.004	0.002	0.002	0.009	<0.001	<0.002	<0.001	<0.002	0.034	0.038	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	

Notes:

LMDL Laboratory method detection limit

COPC Contaminant of potential concern

DQRA Detailed quantitative risk assessment

< Result less than the LM DL

RTV Remedial target value

- COPC not analysed

Measured concentration in excess of RTV

Comparison of RTVs against measured concentrations in soil



COPC	Lab sample ID	23/03602/38	Maximum concentration detected in soil (mg/kg)	Total No. of soil samples analysed	Number of detects in soil above the RTV
	Borehole ID	WS312			
	Depth to top	1			
	Depth to bottom				
	Date sampled	05/04/2023			
	Sample type				
	RTV (mg/kg)				
Trichloroethene	0.224	<0.001	1.13	67	9
Carbon tetrachloride	0.116	<0.001	0.038	67	0

Notes:
 LMDL Laboratory method detection limit
 COPC Contaminant of potential concern
 DQRA Detailed quantitative risk assessment
 < Result less than the LMDL
 RTV Remedial target value
 - COPC not analysed
 Measured concentration in excess of RTV

Comparison of RTVs against measured concentrations in groundwater



COPC	Lab sample ID	22/09651/12	22/09651/13	23/00479/2	22/09831/2	23/00479/3	23/04296/7	23/04477/5	22/09651/1	22/09651/2	22/09651/5	22/09831/1	23/00479/1	23/04296/6	23/04477/4	23/11247/1	23/04296/1	23/04477/1	23/04296/2	23/04477/2	23/11247/2
	Borehole ID	LK BH01	LK BH01 (2) Duplicate	LK BH01	LK BH03	LK BH03	LK BH03	LK BH03	RBH201	RBH201 (2) Duplicate	RBH203	RBH203	RBH203	RBH203	RBH203	RBH203	RBH301	RBH301	RBH302	RBH302	
	Depth to top	13	5.4	10	7.45	7.6	7.6	22	22	13	10	7.4	7.6	7.6	14.9	5.65	5.7	7.5	7.5	10.65	
	Depth to bottom																				
	Date sampled	27/09/2022	27/09/2022	19/01/2023	04/10/2022	19/01/2023	04/05/2023	10/05/2023	27/09/2022	27/09/2022	27/09/2022	04/10/2022	19/01/2023	04/05/2023	10/05/2023	13/11/2023	04/05/2023	10/05/2023	04/05/2023	10/05/2023	13/11/2023
	Sample type																				
	RTV (µg/l)																				
Trichloroethene (TCE)	27.1	2	2	2	250	80	43	39	<1	<1	480	572	418	214	200	215	<1	<1	4	3	2
Carbon tetrachloride (tetrachloromethane)	149	<1	<1	3	58	73	53	48	<1	<1	95	104	265	164	107	84	<1	<1	207	159	142
Cis/trans 1,2-dichloroethene (DCE)	90	490	485	602	3	6	3	4	4	<1	2	2	4	4	3	4	86	102	1	1	<1
Vinyl Chloride (chloroethene)	4.25	16	15	11	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	2	1	<1	<1	<1

Notes:

- LMDL Laboratory method detection limit
- COPC Contaminant of potential concern
- DQRA Detailed quantitative risk assessment
- < Result less than the LMDL
- RTV Remedial target value
- COPC not analysed
- Measured concentration in excess of RTV

Comparison of RTVs against measured concentrations in groundwater



COPC	Lab sample ID	23/11247/3	23/11247/4	23/11247/9	23/11487/1	23/11247/5	23/11247/7	23/11247/10	23/11247/6	23/11247/8	22/09651/3	22/09651/4	23/04296/3	23/04477/3	23/04296/4	23/04510/1	23/11247/11	23/04296/5	23/04510/2	22/08782/1	22/09651/7	22/08782/2
	Borehole ID	RBH501	RBH502 P1	RBH502 P2	BH502 P2	RBH503	RBH505 P1	RBH505 P2	RBH504	WS311	RBH202	RBH202 (2)	RBH303	RBH303	RBH305	RBH305	RBH305	RBH306	RBH306	BH205	RBH205	BH206
	Depth to top	13.7	15.8	18.9	18.9	8.7	11.2	13.7	10.7	1	23	23	7.05	7.1	6.5	6.5	7	6	6	6.5	22	7
	Depth to bottom																					
	Date sampled	13/11/2023	13/11/2023	13/11/2023	20/11/2023	13/11/2023	13/11/2023	13/11/2023	13/11/2023	13/11/2023	27/09/2022	27/09/2022	04/05/2023	10/05/2023	04/05/2023	11/05/2023	13/11/2023	04/05/2023	11/05/2023	02/09/2022	27/09/2022	02/09/2022
	Sample type																					
	RTV (µg/l)																					
Trichloroethene (TCE)	273	27	3		4	<1	<1	<1	17	<1	4	3	377	221	3	<1	<1	<1	<1	<1	<1	<1
Carbon tetrachloride (tetrachloromethane)	149	17	24		<1	<1	<1	<1	14	<1	<1	<1	38	22	2	<1	<1	<1	<1	<1	<1	<1
Cis/trans 1,2-dichloroethene (DCE)	90	2	<1		80	100	<1	<1	151	<1	<1	<1	81	84	<1	<1	<1	<1	<1	<1	<1	<1
Vinyl Chloride (chloroethene)	4.25	<1	<1		<1	44	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Notes:

- LMDL Laboratory method detection limit
- COPC Contaminant of potential concern
- DQRA Detailed quantitative risk assessment
- < Result less than the LMDL
- RTV Remedial target value
- COPC not analysed
- Measured concentration in excess of RTV

Comparison of RTVs against measured concentrations in groundwater



COPC	Lab sample ID	22/09132/1	22/09651/8	22/09132/3	22/09651/9	22/09132/2	22/09651/10	22/09132/4	22/09651/11	Maximum concentration detected in groundwater (mg/l)	Total No. of groundwater samples analysed	Number of detects in groundwater above the RTV
	Borehole ID	RBH207	RBH207	RBH208	RBH208	RBH209	RBH209	RBH210	RBH210			
	Depth to top	22	22.5	15.5	21.5	21.5	15.5	22	22			
	Depth to bottom											
	Date sampled	14/09/2022	27/09/2022	14/09/2022	27/09/2022	14/09/2022	27/09/2022	14/09/2022	27/09/2022			
	Sample type											
	RTV (µg/l)											
Trichloroethene (TCE)	27.1	<1	<1	<1	<1	<1	<1	<1	<1	572	48	12
Carbon tetrachloride (tetrachloromethane)	149	<1	<1	<1	<1	<1	<1	<1	<1	265	48	4
Cis/trans 1,2-dichloroethene (DCE)	90	<1	<1	<1	<1	<1	<1	<1	<1	602	48	6
Vinyl Chloride (chloroethene)	4.25	<1	<1	<1	<1	<1	<1	<1	<1	44	48	4

Notes:

LMDL Laboratory method detection limit

COPC Contaminant of potential concern

DQRA Detailed quantitative risk assessment

< Result less than the LMDL

RTV Remedial target value

- COPC not analysed

Measured concentration in excess of RTV