5.3 Sources

5.3.1 Modelled source area

Trichloroethene 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, cis and trans-1,2-dichloroethene and vinyl chloride and carbon tetrachloride present as a dissolved phase plume within the underlying Chester Formation. 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: 38.00 m wide by 25.00 m length source area covering the southern area of the site within the footprint of the historic boltworks;
- groundwater source: 38.00 m wide by 25.00 m length source area representing the plume core underlying the TCE soil source.

It is noted that cis and trans-1,2-dichloroethene and vinyl chloride were detected further down gradient than the TCE plume core at LKBH01 and RBH301 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.

Cis and trans-1,2-dichloroethene and vinyl chloride were not detected in soils and therefore will be included within modelling of the groundwater source only.

5.4 Selection of compliance point

TCE is designated as a hazardous substance 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 50.00 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 21 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**.

The maximum concentrations associated with the historic unsaturated soil data collected from the site and maximum dissolved phase COPC concentrations in groundwater from the five groundwater monitoring events have been used to conservatively represent the source areas. The selected input concentrations and target concentrations for each contaminant are presented in **Table 9.**

Table 9: 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 1.0m bgl 03/04/2023	0.01
Carbon tetrachloride	0.038 mg/kg	WS308 1.0m 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	0.602 mg/l**	LK BH01 19/01/2023	0.05
vinyl chloride	0.016 mg/l	LK BH01 27/09/2022	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 vinyl chloride at down gradient 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. Therefore, 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 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 D**. 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 E,** 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 10.**

Table 10: 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	**0.0173**	52
Carbon tetrachloride	0.003	1.28E-05	81
Dissolved phase assessment			
Trichloroethene (TCE)	0.01	**0.105**	52
Carbon tetrachloride	0.003	5.14E-04	81
cis and trans-1,2-dichloroethene	0.05	**0.219**	23
vinyl chloride	0.0005	4.64E-04	17
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 50m compliance point with concentrations of carbon tetrachloride predicted to be 2 orders of magnitude below the target concentration. The

predicted concentrations of trichloroethene fall below the defined target concentration for soil leaching at a distance of 75.00 m (0.0097 mg/l).

Groundwater source

For the groundwater source based on maximum recorded groundwater concentrations, the predicted concentrations of trichloroethene and dichloroethane at the 50 m compliance point exceed their respective target concentrations by an order of magnitude. Vinyl chloride is predicted to be at a concentration marginally under the DWS and carbon tetrachloride is predicted to be below the DWS by an order of magnitude.

The predicted concentrations of trichloroethene and dichloroethene fall below the defined target concentration for the groundwater source at a distance of 125 m with concentrations of 0.00915 mg/l for TCE and 0.0467 mg/l for DCE.

5.9 Sensitivity analysis

Sensitivity analysis has been undertaken on trichloroethene 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 11** and **Table 12** (and presented in full in **Appendix F).** The assessment examines the model sensitivity to five key aquifer property parameters utilised in the groundwater assessment.

Table 11: Sensitivity analysis (soil leaching assessment)

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 +/- one order of magnitude		
Original	1.0248	**0.0173**
+ one order of magnitude	10.248	**0.0106**
- one order of magnitude	0.10248	0.0004
Effective porosity (ad.): Data range +/- 20%		
Original	0.365	**0.0173**
+ 20%	0.438	**0.0140**
- 20 %	0.292	**0.0214**
Width of source (m): Data range +/- 20%		
Original	38	**0.0173**
+ 20%	45.6	**0.0173**
-20%	30.4	**0.0172**
Hydraulic gradient: Data range +/- 20%		
Original	0.004	**0.0173**

Parameter	Value	Predicted concentration at 50.00 m compliance point (mg/l) – Dissolved phase assessment
Trichloroethene target concentration: 0.01 mg/l		
+ 20%	0.0048	**0.0187**
-20%	0.0032	**0.0151**
Degradation rate: Data range aerobic/anaerobic		
Original - aerobic	1653 days	**0.0173**
anaerobic	321 days	0.0004
Notes: **1.23E-01 –** Predicted concentration at the 50 m compliance point predicted to be in excess of the target concentration.		

Table 12: Sensitivity analysis (dissolved phase assessment)

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 +/- one order of magnitude		
Original	1.0248	**0.105**
+ one order of magnitude	10.248	**0.475**
-one order of magnitude	0.10248	0.00000758
Effective porosity (ad.): Data range +/- 20%		
Original	0.365	**0.105**
+ 20%	0.438	**0.0773**
- 20%	0.292	**0.144**
Source width (m): Data range +/- 20%		
Original	38	**0.105**
+20%	45.6	**0.105**
-20%	30.4	**0.104**
Hydraulic gradient: Data range +/- 20%		
Original	0.004	**0.105**
+20%	0.0048	**0.136**
-20%	0.0032	**0.0717**
Degradation rate: Data range aerobic/anaerobic		
Original - aerobic	1653 days	**0.105**
anaerobic	321 days	0.0006

Parameter	Value	Predicted concentration at 50.00 m compliance point (mg/l) – Dissolved phase assessment
Trichloroethene target concentration: 0.01 mg/l		
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 an order of magnitude, results in a slight reduction in trichloroethene concentration, however it is of the same order of magnitude. A decrease of hydraulic conductivity by an order of magnitude indicates a decrease in trichloroethene concentrations by 2 orders of magnitude.

For hydraulic conductivity in the dissolved phase assessment, an increase in hydraulic conductivity by an order of magnitude, results in an increase in trichloroethene concentrations but of the same order of magnitude. A decrease in hydraulic conductivity by an order of magnitude results in a decrease in trichloroethene concentrations by several orders of magnitude.

The hydraulic conductivity value used it the RTM assessment model has been derived from the geometric mean of the range of Consim literature values for a sandstone bedrock and the upper value obtained from field tests. It is noted that the limited hydraulic conductivity testing undertaken on site to date provides a single data set from only two monitoring wells RBH203 and RBH301 both installed within the upper sandstone bedrock layer.

Further testing to provide more site-specific hydraulic conductivity values would be recommended in order to derive a more accurate site-specific value. Furthermore, testing within boreholes installed within the Manchester Marl bedrock would be advised, as currently the model may be conservative.

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 ~19% decrease in predicted TCE concentration and a decrease in effective porosity of 20% resulting in a ~23% 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 ~26% decrease in predicted TCE concentration and a decrease in effective porosity of 20% resulting in a ~37% increase in predicted TCE concentration.

The modelled parameter value for effective porosity was taken as average 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. If future conductivity testing reports lower values due to the presence of marl it may be necessary to adjust the effective porosity accordingly.

Source width

Source width was included in the sensitivity analysis due to the uncertainty around the extent of the soil source potentially extending to the east into the southwestern corner of Plot NT03. However, the analysis shows that this is not a sensitive input parameter within the model, with only marginal (<1%) changes in predicted TCE concentrations at the 50m compliance point with changed 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 a ~8% increase in predicted TCE concentration and a decrease in hydraulic gradient of 20% resulting in a ~13% 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 ~30% increase in predicted TCE concentration and a decrease in hydraulic gradient of 20% resulting in a ~32% decrease in predicted TCE concentration.

The hydraulic gradient value used within the model was based on a single set of groundwater monitoring from June 2023. As discussed in **Section 4.3** this was the only available data set that included monitoring wells from both phases of SI. Further rounds of groundwater monitoring are recommended in order to provide more confidence in the hydraulic gradient used within the model, taking into account seasonal and weather variations.

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 50m compliance point by two orders of magnitude for the soil leaching model and by three orders of magnitude for the dissolved phase model. In both cases, predicted concentrations are below the target concentration at a distance of 50m.

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, down gradient of the TCE plume core, indicates that some degree of anaerobic degradation may be occurring.

Conclusions

Sensitivity analysis has shown that the model is particularly sensitive to hydraulic conductivity and hydraulic gradient. Due to the limited site-specific data currently available, it is recommended that further rounds of groundwater monitoring and conductivity testing are undertaken in order to provide more robust site specific values.

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.

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, measured concentrations of COPC in groundwater sampled from down gradient well LKBH01 of 0.002mg/l on 19/01/2023 were compared to the model's predicted concentration, based on a compliance point distance of 50 m (approximate distance between RBH203 and LKBH01), and an initial source concentration of 0.418 mg/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 G** and summarised in **Table 13.**

Table 13: Predicted concentrations at LKBH01

COPC	Concentration at RBH203 (mg/l)	Concentration at RBH203 (mg/l)	Predeicted concentration at 50m compliance point (distance from RBH203 to LKBH01)	Travel time (years)
Trichloroethene (TCE)	0.418	0.002	0.0767	52

The modelled results at LKBH01 are an order of magnitude higher than those recorded in groundwater, indicating that the model may be over predicting down gradient concentrations, likely due to the observed degradation to DCE and VC. As discussed in the sensitivity analysis, the most sensitive model parameters are the hydraulic conductivity, hydraulic gradient and the degradation rates and further groundwater monitoring and conductivity testing is recommended to provide more robust site-specific values for modelling. It is considered that there is not sufficient certainty in these model parameters to reliably calculate site specific degradation rates at this time, however, the model calibration check above indicates that there is currently a high degree of conservatism in the model.

5.10 Remedial target values (RTV)

Whilst it is noted some uncertainties remain at present regarding the characterisation of the sites hydrogeological condition, specifically relating to hydraulic connectivity assumptions and groundwater flow gradients; the following “Preliminary” 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 regarding the above concerns, the values provided in Table 14will be more conservative and will require further refinement at such time when the current program of site monitoring works has concluded. It is then envisaged this report and modelling assessment will be updated to reflect this more comprehensive dataset.

The remedial targets presented in **Table 14** have been compared to the soil and groundwater results in **Appendix H**. The selected soil and groundwater RTV are the level 2 soil remedial targets and level 3 groundwater targets respectively.

Table 14: 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)	0.210	WS305 1.0m bgl (0.427) WS308 0.6 & 1.0m bgl (max 1.13)	0.0545	LKBH03 (max 0.250), RBH203 (max 0.572), RBH303 (max 0.277)
Carbon tetrachloride	0.108	NR	1.55	NR
cis and trans-1,2-dichloroethene	NA	NA	0.138	LKBH01 (max 0.602)
vinyl chloride	NA	NA	0.0172	NR
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 WS305 and WS308 in the south of Plot NT02 and three exceedances at for groundwater at LKBH03, RBH203 and RBH303 located in the south of Plot NT02 and approximately 5m beyond the eastern site boundary within Plot NT03. An exceedance of the is also reported in groundwater for DCE at LKBH01 in the north of the site.

5.11 Uncertainty

Remaining uncertainties and data gaps in the refined conceptual site model have been identified in **Table 15** overleaf along with the key implications.

Table 15: Uncertainties and implications

Item	Details	Implications
Groundwater monitoring data	Only one full round of groundwater monitoring of boreholes from both phases of RoC SI undertaken to date (June 2023).	Hydraulic gradient used within the model is based on a single dataset and thus does not account for seasonal variation. The model has been found to be particularly sensitive to the hydraulic gradient. Further monitoring wors should be completed to allow a more robust determination of hydrogeological conditions
Hydraulic conductivity	Hydraulic conductivity values measured in only two boreholes installed within the bedrock – both installed within the shallow Chester sandstone formation. No testing has been undertaken on wells installed within the marl or deeper sandstone	Due to the limited availability of site specific data, there is some uncertainty in the value used within the model. The model is shown to be highly sensitive to hydraulic conductivity. As with groundwater level monitoring, hydraulic connectivity testing should be completed within the Manchester Marls bedrock to allow the use of site-specific values within the RTM model
Areas of the site with limited investigation	Access constraints due to current site usage have resulted in limited site investigation in some areas	The extent of the TCE soil source is currently uncertain and groundwater results indicate that it may extend beyond the eastern boundary of Plot NT02 into Plot NT03. This would be consistent with the footprint of the historic bolt works (possible historic source of TCE) which extends into the southwestern corner of Plot NT03 as shown on RoC figure 4328-ROC-ZZ-XX-DR-ES-ES208. However, sensitivity analysis showed minimal sensitivity to source dimensions.

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.
- Sensitivity analysis indicates that the model is particularly sensitive to hydraulic conductivity, hydraulic gradient and degradation rates for which there is currently limited site-specific data available, and it is recommended that additional monitoring works are undertaken to address these uncertainties. However, it is noted that model calibration

against TCE concentrations detected at down gradient borehole LKBH01 indicates that the current model setup is likely to be highly conservative.

- Groundwater samples from monitoring wells close to the down gradient boundary, report low concentrations of TCE in the sandstone aquifer below drinking water standards indicating that in the site's current layout with warehouse buildings covering the main source area, limiting ongoing leaching, TCE is unlikely to be significantly impacting the wider principal aquifer. However, TCE daughter products DCE and VC are reported to exceed the DWS in the north of the site close to the down gradient boundary and DCE concentrations are predicted to exceed the DWS at 50m.
- Whilst it is acknowledged that there is some degree of uncertainty in the current model inputs and predicted concentrations, since model calibration indicates that the model is highly conservative, 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.
- Currently there are no recorded groundwater abstractions within 500m 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

The results from the soil leaching and dissolved phase assessments indicate that predicted concentrations of TCE, DCE and carbon tetrachloride at a theoretical compliance point 50.00 m down gradient of the site exceed the 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 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.

Following detailed review of the available information there remains some uncertainty associated with the refined conceptual site model. The key uncertainty identified is considered to relate to the complex hydrogeology underlying the site and specifically the aquifer model input parameters hydraulic conductivity and gradient and full extents of the TCE soil source area which may extend off-site to the east beneath adjacent Plot NT03.

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

6.2 Recommendations

The following recommendations are made for further assessment to refine the DQRA/remediation of the site to address the risks identified above and to address remaining uncertainties:

- Copies of this report, along with the RoC Consulting Phase 2 Site Investigation should be provided to the regulatory authorities to review and provide comment. Any comments received from these regulators should be taken into account when completing any further model runs.
- On going groundwater monitoring of wells installed during all phases of ground investigations should be continued so that a more reflective indication of groundwater levels and flow gradients can be obtained
- Further hydraulic conductivity testing should be completed on wells installed into the Manchester Marls formation to allow the use of site-specific values within the RTM model
- The RTM model has indicated the values in groundwater for TCE contaminants are correspondingly higher than would be anticipated given evidence in soil, it is likely the most significantly impacted soils are yet to be identified. Given current access constraints at the time of site investigations, particularly associated with a live HP gas main on site and leisure operations in northern warehouse of Plot NT02, it may be prudent for the supplementary sampling of soils following vacant possession of the site and demolition to allow refinement of overall plume extents and associated remediation costs.

- This report and associated RTM model should be revisited and updated to reflect new permeability and groundwater level monitoring data obtained from site with a view to the refinement of some the assumptions currently made and allow more appropriate site specific RTV's to be derived for soils and groundwaters.
- 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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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, dated 26 June 2023. 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.

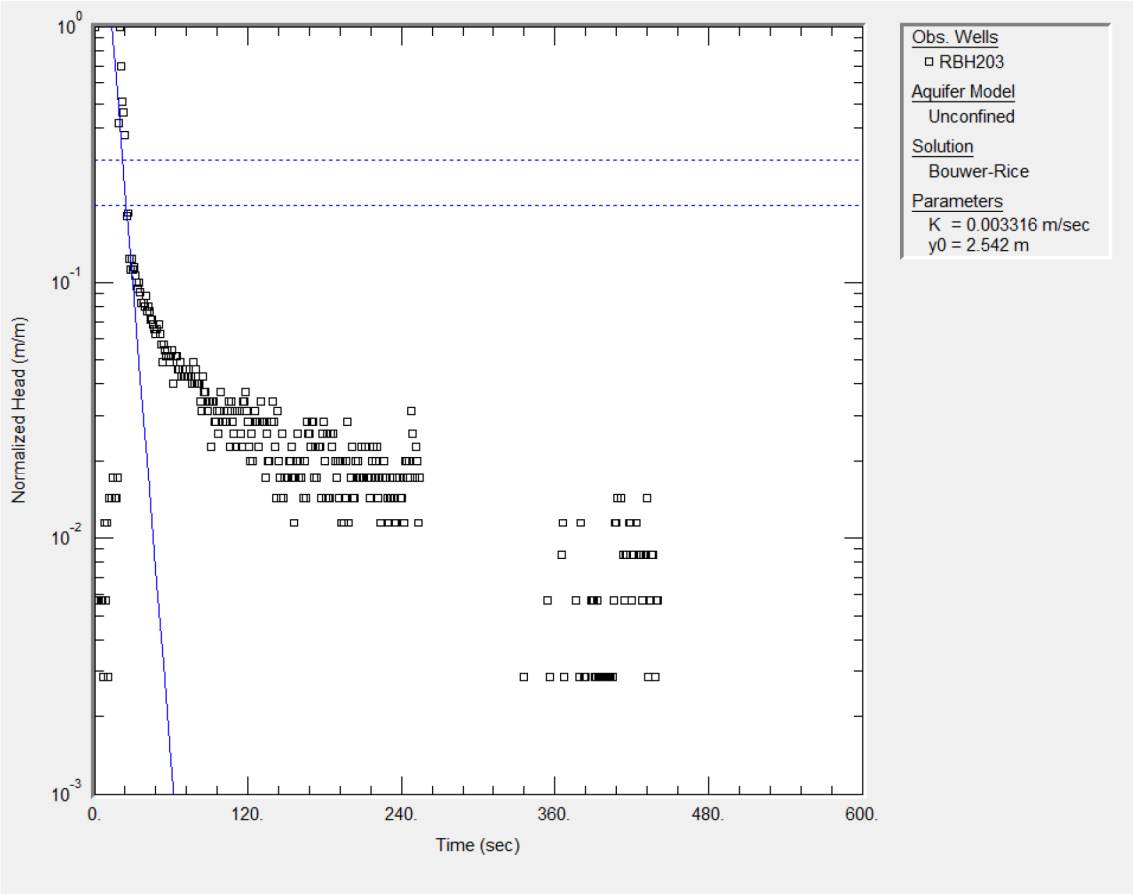
9. Any site drawing(s) provided in this report is (are) not meant to be an accurate base plan but is (are) used to present the general relative locations of features on, and surrounding, the site. Features (intrusive and sample locations etc) annotated on site plans are not drawn to scale but are centred 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.

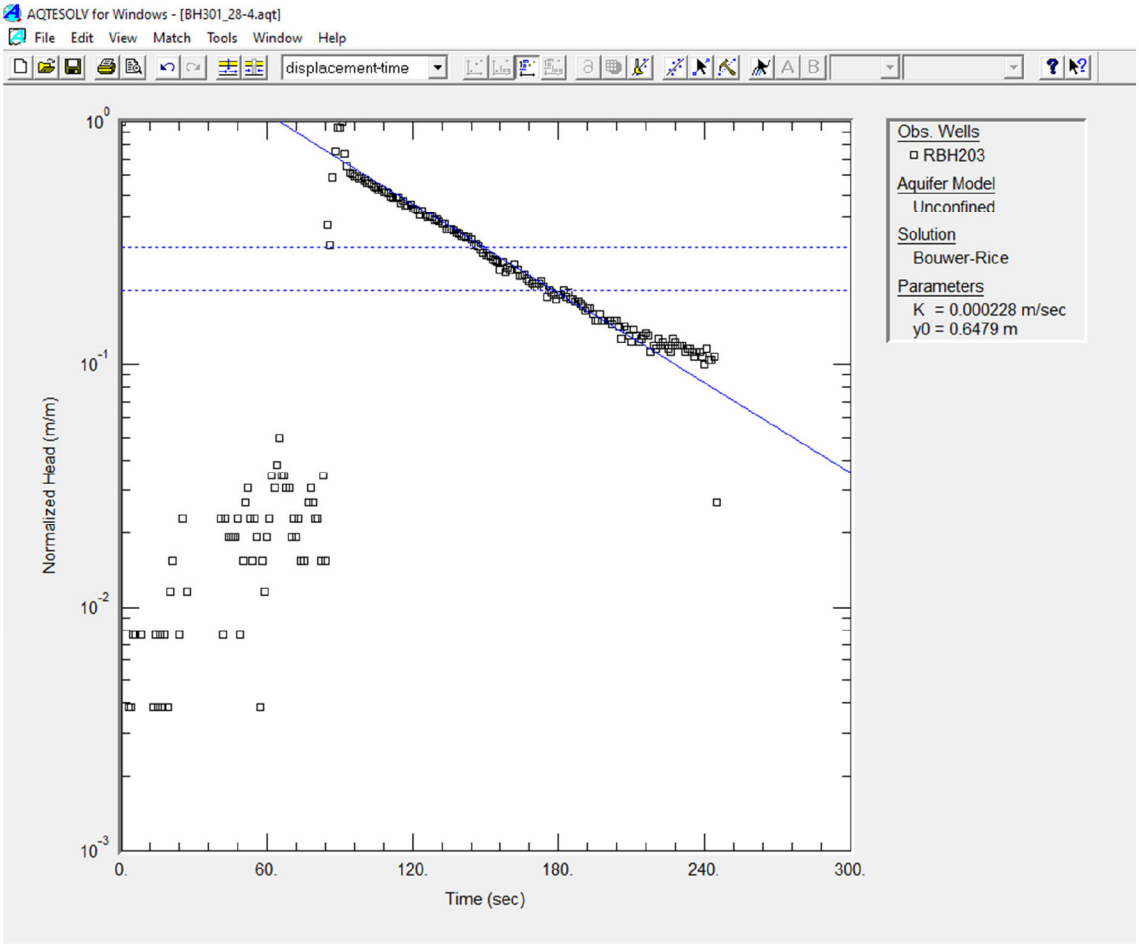
11. Asbestos is often observed to be present in soils in discrete areas. Whilst asbestos-containing materials may have been locally encountered during the fieldworks or supporting laboratory analysis, the history of brownfield and demolition sites indicates that asbestos fibres may be present more widely 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



CHES: Very weak reddish brown fine grained SANDSTONE inter-bedded with bands of fine sand. Joints are horizontal closely Spaced, with layers of weathered rock recovered as sand at response zone.



CHES: Reddish brown fine to medium grained SANDSTONE (CHESTER FORMATION); no description of weathering, fractures or layers at higher permeability.

APPENDIX C
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 statutory values	Target concentrations shaded in orange are non-statutory values

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[6ε]
(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[6ε]

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)			
			Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
Groundwater receptors[5]	Surface water receptors[6]				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[$]	-	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 - choloroethane)*	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[6ε]
(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[6ε]
(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[6ε]

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)			
					EQS or best equivalent	
Groundwater receptors[5]	Surface water receptors[6]		Minimum reporting value	UK drinking water standard (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[6ε]
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) **is** 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

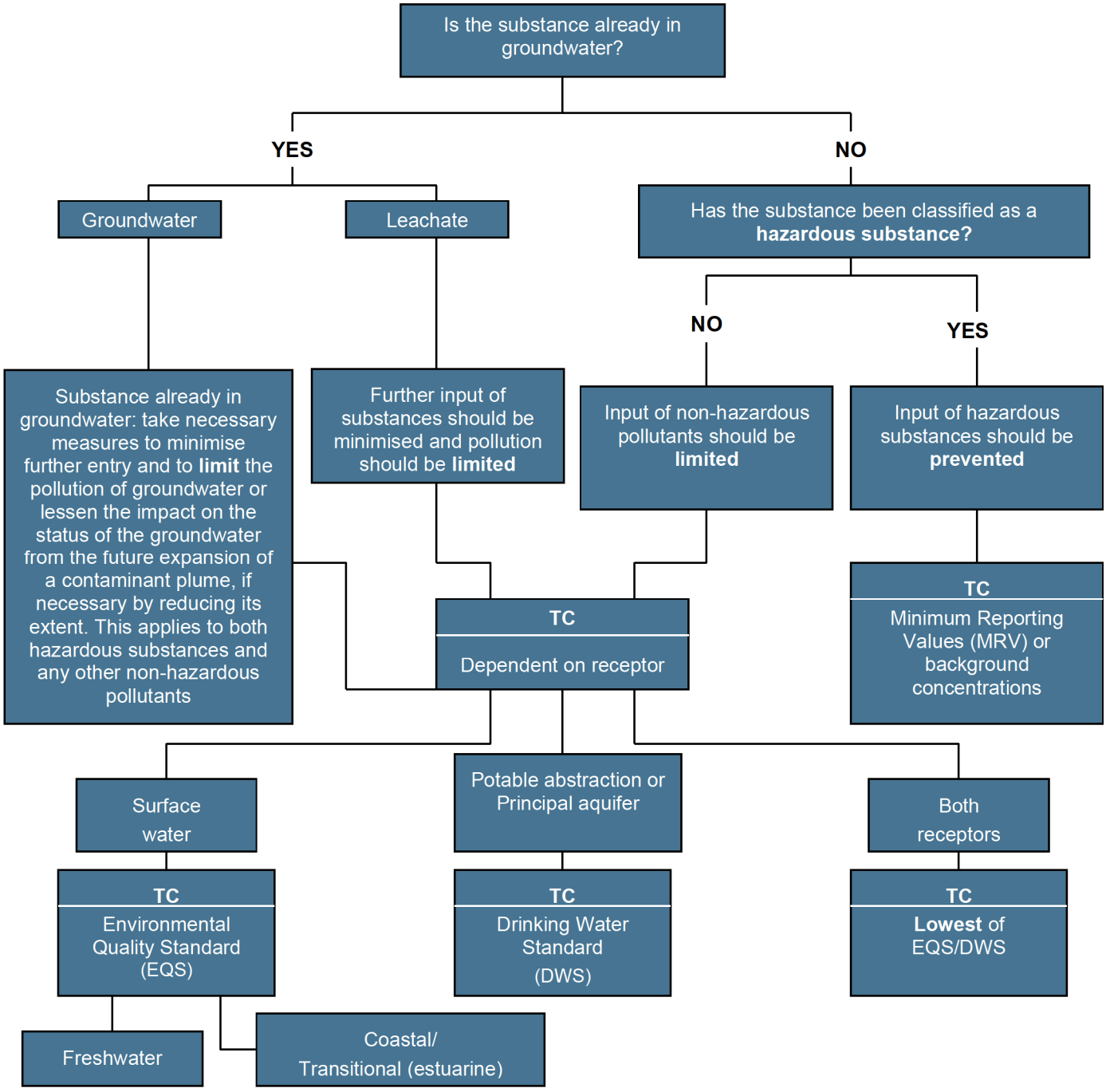
1a. Environment Agency (2017), 'Land contamination groundwater compliance points: quantitative risk assessments', March 2017 (formerly contained within GP3) [accessed 29 March 2017]. https://www.gov.uk/government/collections/groundwater-protection

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 D
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	0.37	RSK Literature values spreadsheet: Averaged value (Conner 1999); gravel porosity assumed 0.2. A value of 0.356 is obtained with the RTM porosity calculator, using a site-specific moisture content value of 20 (average of 5 values)
Air filled porosity	0.003	RTM porosity calculator (total porosity 0.36; water filled porosity 0.356)
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)	173 mm/year	Value of 173 mm/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)
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)	38	Taken as the Plot NT02 width perpendicular to the groundwater flow, at the south boundary of the site.
Saturated aquifer thickness (m)	20.69	The saturated aquifer thickness at the source can be assumed as above (8.30 m); however, the CHES

Parameter	Value	Justification
		and MM have some hydraulic interconnections based on their piezometry. At borehole RBH201 (north boundary of Plot NT02), screened in the CHES and MM, terminated in the MM (with interbedded thick bands of permeable sandstones) at 6.03 mAOD, with an average head of 26.72 in the period September 2022-January 2023, the aquifer thickness can be estimated to be 20.69 m.
Hydraulic conductivity of aquifer (m/d)	1.025	The tests indicate hydraulic conductivities for these deposits ranging between 19.70 m/day and 286.50 m/day, which falls above the literature range for sandstone in the Consim database of 2.59E-05 and 5.18E-01 m/day but within the Consim range for a coarse sand of 7.78E-02 to 5.18E+02. The value of K initially chosen for modelling has been derived from the geometric mean of the range of Consim literature values and the upper field test value. This gives a value of 1.025; this will be subject to sensitivity tests to establish the model sensitivity to this aquifer parameter.
Hydraulic gradient of water table (-)	0.004	Calculated from the average hydraulic head in the period April-June 2023 at boreholes LKBH03 (26.91 mAOD) and borehole LKBH01 (26.63mAOD) over a distance of 67.00 m. The piezometry in the PlotNT2 area is controlled by the low hydraulic head points at RBH202 and RBH205; however, the western part of the plot is less affected by this feature and is considered to be representative of the general NNW groundwater flow direction towards the River Irk.
Level 3 Parameters – Chester Formation - Sandstone		
Effective porosity of aquifer (-)	0.365	Taken as average of geometric mean for literature value for sandstone 0.34 (range 0.14-0.49) and coarse sand 0.39 (range 0.31-0.46) McWhorter, D.B., and D.K. Sunada, "Ground-Water Hydrology and. Hydraulics," 1948, (1984 reprint) (1977 1st edition)

Parameter	Value	Justification
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)	50.00 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
Initial Contaminant Concentration in Groundwater (mg/l)	0.572	Maximum TCE concentration detected in the Chester Fm aquifer (RBH203, 04/10/2022).
Width of plume in aquifer at source (m)	38m	Taken as the Plot NT02 width perpendicular to the groundwater flow, at the south boundary of the site.
Plume thickness at source (m)	8.3	The TCE source most representative hole is RBH203, screened in the CHES Formation (encountered up to 18.52mAOD) and terminated at 14.09mAOD in the MM Formation; its average hydraulic head is 28.82mAOD in the period May-June 2023. Assuming that, at the source, the dissolved TCE would mainly develop within the more permeable CHES sandstone, and the TCE vertical migration would be inhibited by the less permeable MM, the plume thickness at source is calculated to be 8.3m.
Saturated aquifer thickness (m)	20.69	The saturated aquifer thickness at the source can be assumed as above (8.3m); however, the CHES and MM have some hydraulic interconnections based on their piezometry. At borehole RBH201 (north boundary of Plot NT02), screened in the CHES and MM, terminated in the MM (with interbedded thick bands of permeable sandstones) at 6.03mAOD, with an average head of 26.72 in the period September 2022-January 2023, the aquifer thickness can be estimated to be 20.69m.
Aquifer Bulk density of aquifer materials (g/cm^3)	2.14	Average value from Consim literature range for sandstone
Effective porosity of aquifer (ad.)	0.365	Taken as average of geometric mean for literature value for sandstone 0.34 (range 0.14-0.49) and coarse sand 0.39 (range 0.31-0.46) McWhorter, D.B., and D.K. Sunada, "Ground-Water Hydrology and. Hydraulics," 1948, (1984 reprint) (1977 1st edition)
Hydraulic gradient (ad.)	0.004	Calculated from the average hydraulic head in the period April-June 2023 at boreholes LKBH03 (26.91mAOD) and borehole LKBH01 (26.63mAOD) over a distance of 66.96m. The piezometry in the PlotNT2 area is controlled by the low hydraulic head points at RBH202 and RBH205; however, the western part of the plot is less affected by this feature and is considered to be representative of the general NNW groundwater flow direction towards the River Rye.
Hydraulic conductivity (m/d)	1.025	The tests indicate hydraulic conductivities for these deposits ranging between 19.70 m/day and 286.50 m/day, which falls above the literature range for sandstone in the Consim database of 2.59E-05 and 5.18E-01 m/day but within the Consim range for a coarse sand of 7.78E-02 to 5.18E+02 which likely

Parameter	Value	Justification
		better represents the description of the weathered sandstone. The value of K initially chosen for modelling has been derived from the geometric mean of the range of Consim literature values and the upper field test value. This gives a value of 1.025; this will be subject to sensitivity tests to establish the model sensitivity to this aquifer parameter.
Fraction of organic carbon (foc)	0.0039	Taken as average from sandstone sample analysis at WS301 (4.5 mbgl), WS303 (3.1 mbgl) and WS304 (3.5mbgl)
Distance to compliance point (m)	50	Distance from soil source area/ area of maximum groundwater concentrations to the down gradient site boundary

APPENDIX E
QUANTITATIVE MODELLING RESULTS

Site Name:	Plot NT02 Dantzic Street	Completed by: Emma Atkinson
Site Address:	Plot NT02 Dantzic Street	Date: 13-Jul-23

SITE SPECIFIC INPUTS FOR INDIVIDUAL SUBSTANCES — Version: Controlled waters risk assessment

Table W

Contaminant	Target Concentration (CT) mg/l	Origin of CT:	Soil Source for Impact on Groundwater: Soil concentration for Level 3 soil sheet and soil impact results sheet (mg/kg)	Soil Source for Impact on Groundwater: Comment on soil source concentrations for Level 3 soil sheet and soil impact results	Soil Source for Impact on Groundwater: Option: Concentration of contaminant in contaminated discharge entering receptor (mg/l)	Soil Source for Impact on Groundwater: Comment on concentration of contaminant in contaminated discharge (entering receptor)	Soil Source for Impact on Groundwater: Option: Background concentration of contaminant in groundwater beneath site (mg/l)	Soil Source for Impact on Groundwater: Justification of background concentration of contaminant in groundwater beneath site	Groundwater Source (Level 3 Groundwater): Initial contaminant concentration in groundwater at plume core (mg/l)	Groundwater Source (Level 3 Groundwater): Comment on groundwater source concentrations
Trichloroethene (TCE)	**0.01**	**Drinking Water Standards (DWS)**	1.13	Maximum concentration (WS308at 1.00 m bgl on 03/04/2023)	0.00E+00	Comment	0.00E+00	Assume background water not impacted	0572	Maximum concentration (RBH203 on 04/10/2022)
Carbon tetrachloride (tetrachloromethane)	**0.003**	**Drinking Water Standards (DWS)**	0.038	Maximum concentration (WS308at 1.00 m bgl on 03/04/2023)	0.00E+00	Comment	0.00E+00	Assume background water not impacted	0265	Maximum concentration RBH203 19/01/2023
Cis/trans 1,2-dichloroethene (DCE)	**0.05**	**Drinking Water Standards (DWS)**	0	Not detected in soils	0.00E+00	Comment	0.00E+00	Assume background water not impacted	0602	Maximum concentration LK BH01 19/01/2023
Vinyl Chloride (chloroethene)	**0.0005**	**Drinking Water Standards (DWS)**	0	Not detected in soils	0.00E+00	Comment	0.00E+00	Assume background water not impacted	0016	Maximum concentration LK BH01 27/09/2022

Site Name:	Plot NT02 Dantzic Street	Completed by: Emma Atkinson
Site Address:	Plot NT02 Dantzic Street	Date: 13-Jul-23

Table X — Version: Controlled waters risk assessment

SUBSTANCE SPECIFIC INPUTS FOR INDIVIDUAL SUBSTANCES

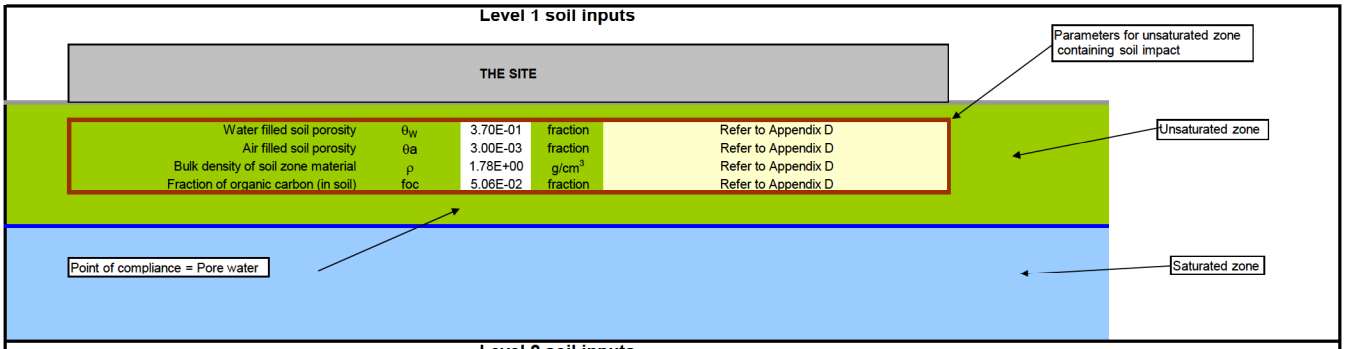
Contaminant	Organic carbon partition coefficient (Koc)	Source of Koc	Henry's Law constant (dimensionless)	Source of Henry's Law	Half life for degradation of contaminant in water (d)	Source of Half Life - Howard et al 1991, Handbook of Environmental Degradation Rates and CONSIM
Trichloroethene (*CE)	1.41E+02	SR7	1.87E-01	SR7	1.65E+03	*Howard et al high half life (aeraic conditions)*
Carbon tetrachloride (tetrachloromethane)	2.46E+02	SR7	5.82E-01	SR7	3.60E+02	*Howard et al max aerobic rate (more conservative)*
Cis/trans 1,2-dichloroethene (DCE)	3.90E+01	ConSim	3.87E-01	ConSim	2.88E+03	*Howard et al high half life (aeraic conditions)*
Vinyl Chloride (chloroethene)	1.66E+01	SR7	7.47E-01	SR7	7.20E+02	*Howard et al high aneerobc half life*

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

Site Name: Plot NT02 Dantzic Street
Site Address: Plot NT02 Dantzic Street

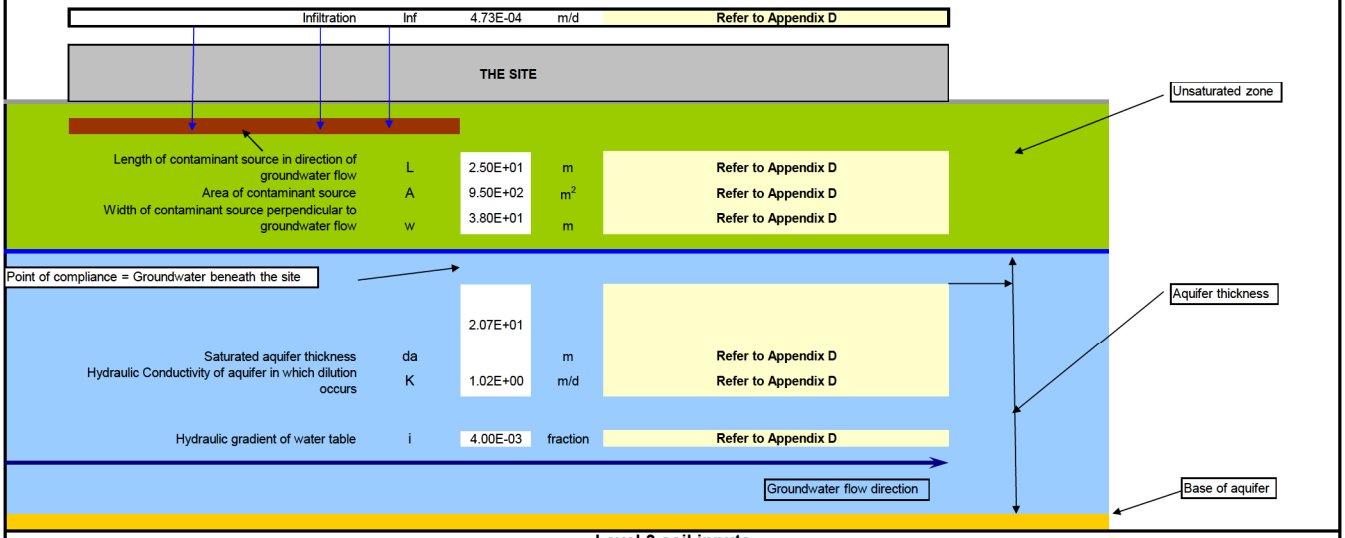
Completed by: Emma Atkinson
Date: 13-Jul-23 **Version:** Controlled waters risk assessment

Level 1 soil inputs



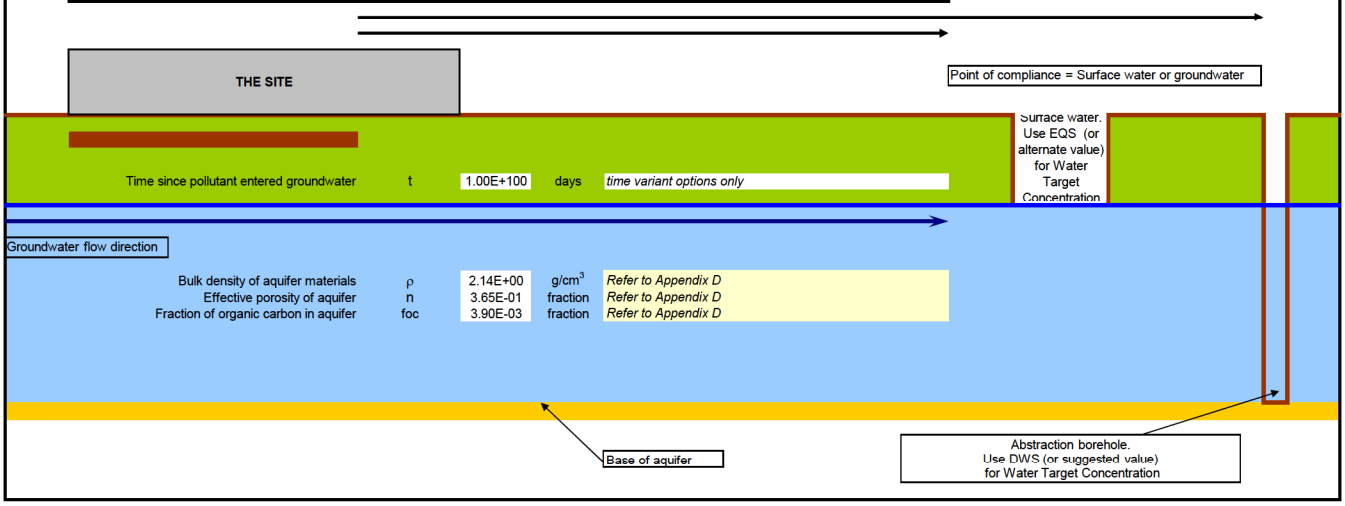
Water filled soil porosity	θ_w	3.70E-01	fraction	Refer to Appendix D
Air filled soil porosity	θ_a	3.00E-03	fraction	Refer to Appendix D
Bulk density of soil zone material	ρ	1.78E+00	g/cm^3	Refer to Appendix D
Fraction of organic carbon (in soil)	foc	5.06E-02	fraction	Refer to Appendix D

Level 2 soil inputs



Infiltration	Inf	4.73E-04	m/d	Refer to Appendix D
Length of contaminant source in direction of groundwater flow	L	2.50E+01	m	Refer to Appendix D
Area of contaminant source	A	9.50E+02	m^2	Refer to Appendix D
Width of contaminant source perpendicular to groundwater flow	w	3.80E+01	m	Refer to Appendix D
		2.07E+01		
Saturated aquifer thickness	da		m	Refer to Appendix D
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.02E+00	m/d	Refer to Appendix D
Hydraulic gradient of water table	i	4.00E-03	fraction	Refer to Appendix D

Level 3 soil inputs



Distance to compliance point	x	5.00E+01	m	*Refer to Appendix D*
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Bulk density of aquifer materials	ρ	2.14E+00	g/cm^3	*Refer to Appendix D*
Effective porosity of aquifer	n	3.65E-01	fraction	*Refer to Appendix D*
Fraction of organic carbon in aquifer	foc	3.90E-03	fraction	*Refer to Appendix D*

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

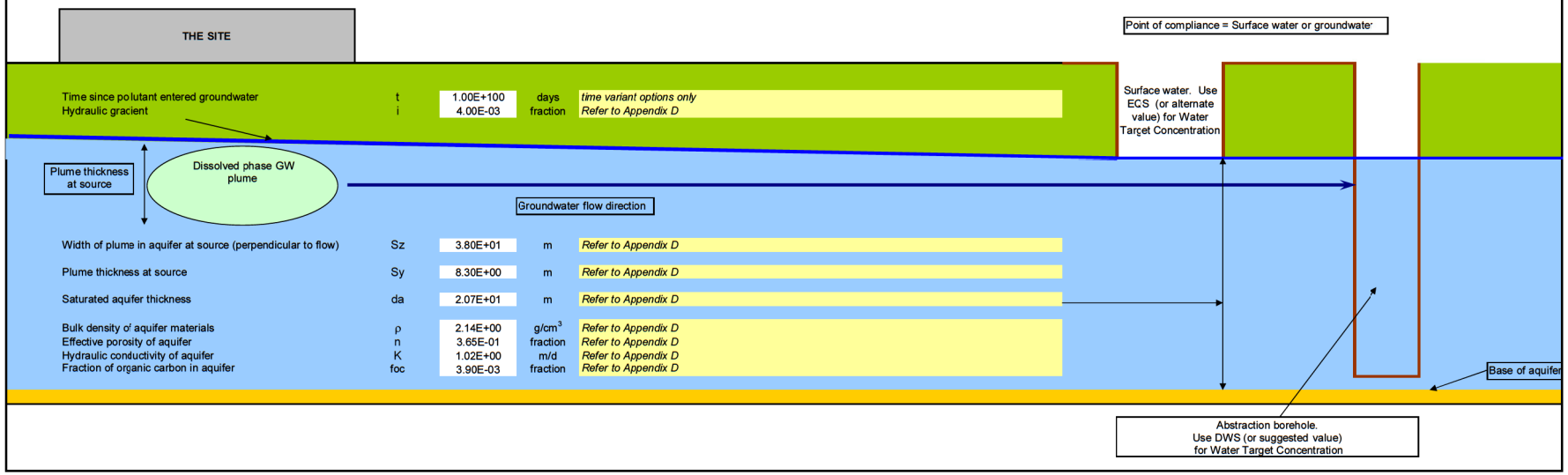
RSK GEOSCIENCES

Site Name: Plot NT02 Dantzic Street
Site Address: Plot NT02 Dantzic Street

Completed by: Emma Atkinson
Date: 13-Jul-23 **Version:** Controlled waters risk assessment

Level 3 groundwater inputs

Distance (lateral) to compliance point perpendicular to flow direction	z	[redacted]	m	*Value is 0*
Distance (depth) to compliance point perpendicular to flow direction	y		m	*Value is 0*
Distance to compliance point	x	5.00E+01	m	*Refer to Appendix D*



Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Hydraulic gradient	i	4.00E-03	fraction	*Refer to Appendix D*
Width of plume in aquifer at source (perpendicular to flow)	Sz	3.80E+01	m	*Refer to Appendix D*
Plume thickness at source	Sy	8.30E+00	m	*Refer to Appendix D*
Saturated aquifer thickness	da	2.07E+01	m	*Refer to Appendix D*
Bulk density of aquifer materials	ρ	2.14E+00	g/cm^3	*Refer to Appendix D*
Effective porosity of aquifer	n	3.65E-01	fraction	*Refer to Appendix D*
Hydraulic conductivity of aquifer	K	1.02E+00	m/d	*Refer to Appendix D*
Fraction of organic carbon in aquifer	foc	3.90E-03	fraction	*Refer to Appendix D*

Site Name: Plot NT02 Dantzic Street
Site Address: Plot NT02 Dantzic Street

SUMMARY OF RESULTS FROM RTM WORKSHEETS Version: Controlled waters risk assessment

TABLE Y		Remedial Targets for a Soil Source (soil & pore water concentrations)						Groundwater Source	Groundwater Source
Contaminant	Target Concentration (C_T) mg/l	Level 1 Remedial Target (soil concentrations) (mg/kg)	Level 1 Remedial Target (pore water and leachate) (mg/l)	Level 2 Remedial Target (soil concentrations) (mg/kg)	Level 2 Remedial Target (pore water and leachate) (mg/l)	Level 3 Remedial Target (soil concentrations) (mg/kg)	Level 3 Remedial Target (pore water and leachate) (mg/l)	Level 3 Remedial Target (groundwater concentrations) (mg/l)	Time for contaminant to reach receptor (years)
Trichloroethene (TCE)	0.01	7.35E-02	0.01	2.10E-01	2.85E-02	6.54E-01	8.89E-02	5.45E-02	52
Carbon tetrachloride (tetrachlorc	0.003	3.79E-02	0.003	1.08E-01	8.55E-03	8.88E+00	7.03E-01	1.55E+00	81
Cis/trans 1,2-dichloroethene (DC	0.05	1.09E-01	0.05	3.11E-01	1.43E-01	6.09E-01	2.79E-01	1.38E-01	23
Vinyl Chloride (chloroethene)	0.0005	5.25E-04	0.0005	1.50E-03	1.43E-03	1.70E-02	1.62E-02	1.72E-02	17

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	1.54E-01	5.39E-02	1.73E-02	1.05E-01
Carbon tetrachloride (tetrachlor	0.003	3.01E-03	1.06E-03	1.28E-05	5.14E-04
Cis/trans 1,2-dichloroethene (DC	0.05	0.00E+00	0.00E+00	0.00E+00	2.19E-01
Vinyl Chloride (chloroethene)	0.0005	0.00E+00	0.00E+00	0.00E+00	4.64E-04

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

RSK GEOSCIENCES

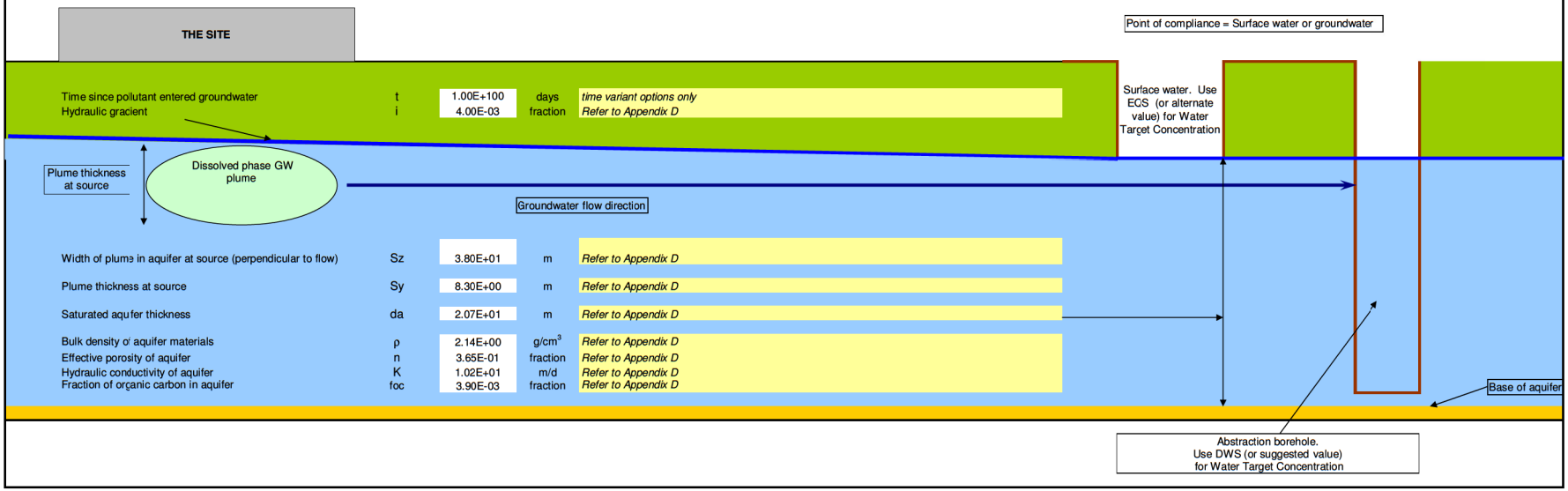
Site Name: Plot NT02 Dantzic Street
Site Address: Plot NT02 Dantzic Street

Completed by: Emma Atkinson
Date: 13-Jul-23

Version: Sensitivity analysis - hydraulic conductivity (+ an order of magnitude)

Level 3 groundwater inputs

Distance (lateral) to compliance point perpendicular to flow direction	z	[redacted]	m	*Value is 0*
Distance (depth) to compliance point perpendicular to flow direction	y		m	*Value is 0*
Distance to compliance point	x	5.00E+01	m	*Refer to Appendix D*
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Hydraulic gradient	i	4.00E-03	fraction	*Refer to Appendix D*
Width of plume in aquifer at source (perpendicular to flow)	Sz	3.80E+01	m	*Refer to Appendix D*
Plume thickness at source	Sy	8.30E+00	m	*Refer to Appendix D*
Saturated aquifer thickness	da	2.07E+01	m	*Refer to Appendix D*
Bulk density of aquifer materials	ρ	2.14E+00	g/cm^3	*Refer to Appendix D*
Effective porosity of aquifer	n	3.65E-01	fraction	*Refer to Appendix D*
Hydraulic conductivity of aquifer	K	1.02E+01	m/d	*Refer to Appendix D*
Fraction of organic carbon in aquifer	foc	3.90E-03	fraction	*Refer to Appendix D*



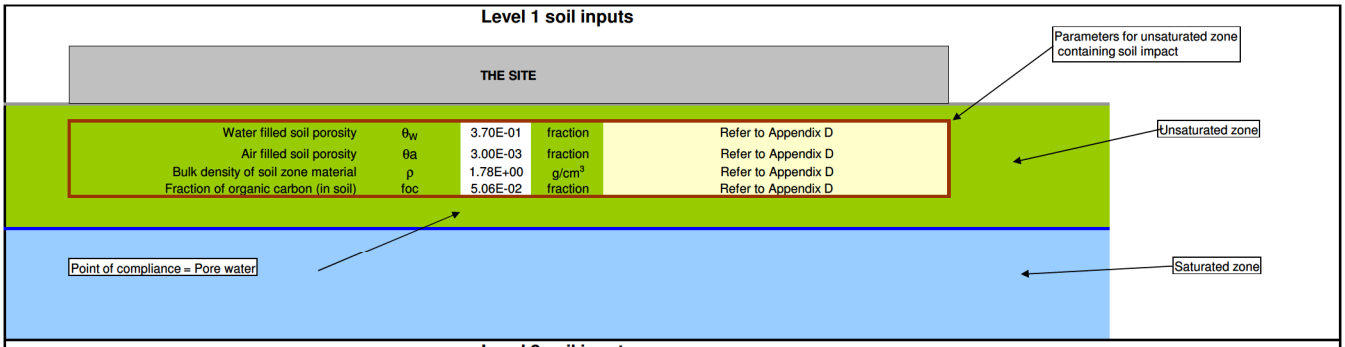
Input Parameters for RTM Worksheets for Controlled Waters Risk Assessr for a Soil Source in the Unsaturated Zone

RSK GEOSCIENCES

Site Name: Plot NT02 Dantzic Street
Site Address: Plot NT02 Dantzic Street

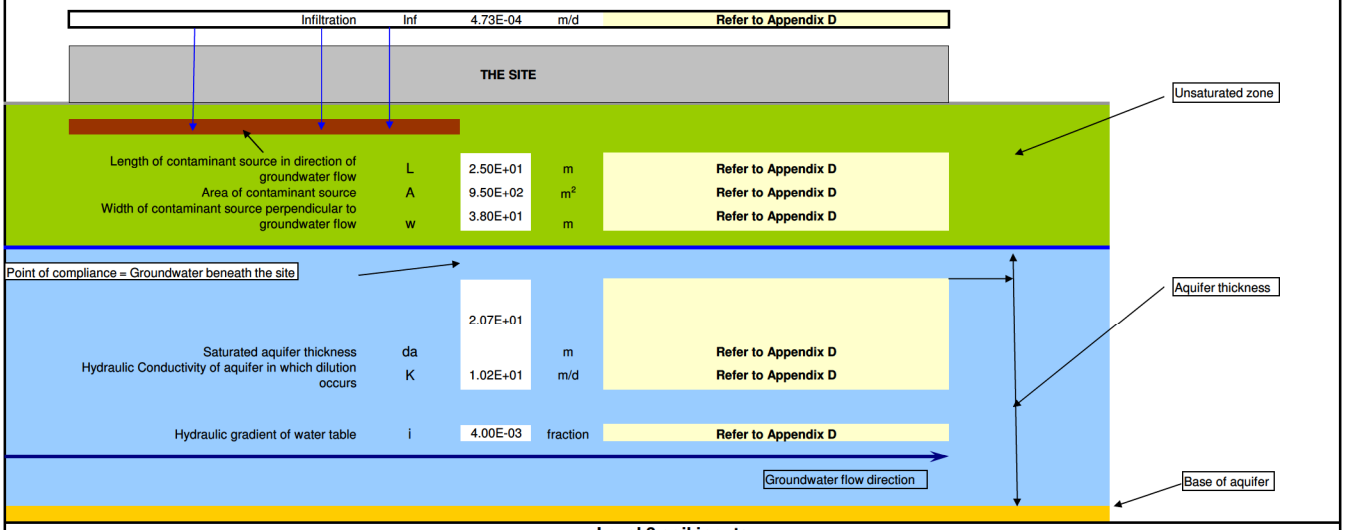
Completed by: Emma Atkinson
Date: 13-Jul-23
Version: Sensitivity analysis - hydraulic conductivity (+ an order of magnitude)

Level 1 soil inputs



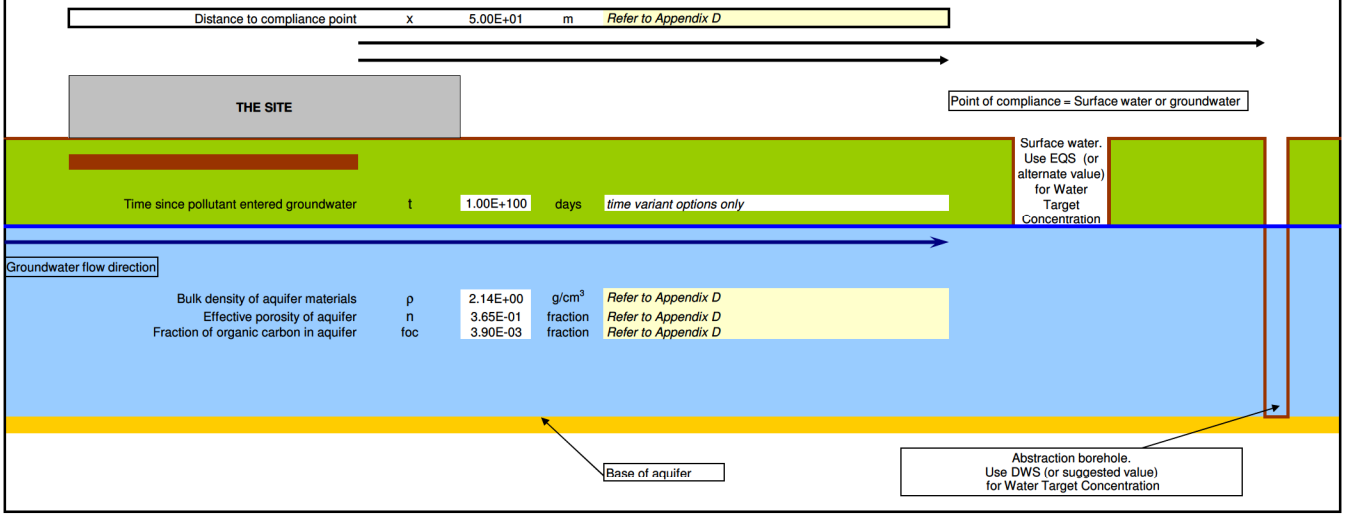
Water filled soil porosity	θ_w	3.70E-01	fraction	Refer to Appendix D
Air filled soil porosity	θa	3.00E-03	fraction	Refer to Appendix D
Bulk density of soil zone material	ρ	1.78E+00	g/cm^3	Refer to Appendix D
Fraction of organic carbon (in soil)	foc	5.06E-02	fraction	Refer to Appendix D

Level 2 soil inputs



Infiltration	Inf	4.73E-04	m/d	**Refer to Appendix D**
Length of contaminant source in direction of groundwater flow	L	2.50E+01	m	**Refer to Appendix D**
Area of contaminant source	A	9.50E+02	m^2	**Refer to Appendix D**
Width of contaminant source perpendicular to groundwater flow	w	3.80E+01	m	**Refer to Appendix D**
Saturated aquifer thickness	da	2.07E+01	m	**Refer to Appendix D**
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.02E+01	m/d	**Refer to Appendix D**
Hydraulic gradient of water table	i	4.00E-03	fraction	**Refer to Appendix D**

Level 3 soil inputs



Distance to compliance point	x	5.00E+01	m	*Refer to Appendix D*
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Bulk density of aquifer materials	ρ	2.14E+00	g/cm^3	*Refer to Appendix D*
Effective porosity of aquifer	n	3.65E-01	fraction	*Refer to Appendix D*
Fraction of organic carbon in aquifer	foc	3.90E-03	fraction	*Refer to Appendix D*

RSK GEOSCIENCES

Site Name: Plot NT02 Dantzic Street
Site Address: Plot NT02 Dantzic Street

SUMMARY OF RESULTS FROM RTM WORKSHEETS **Version:** Sensitivity analysis - hydraulic conductivity (+ an order of magnitude)

TABLE Y		Remedial Targets for a Soil Source (soil & pore water concentrations)						Groundwater Source	Groundwater Source
Contaminant	Target Concentration (C_T) mg/l	Level 1 Remedial Target (soil concentrations) (mg/kg)	Level 1 Remedial Target (pore water and leachate) (mg/l)	Level 2 Remedial Target (soil concentrations) (mg/kg)	Level 2 Remedial Target (pore water and leachate) (mg/l)	Level 3 Remedial Target (soil concentrations) (mg/kg)	Level 3 Remedial Target (pore water and leachate) (mg/l)	Level 3 Remedial Target (groundwater concentrations) (mg/l)	Time for contaminant to reach receptor (years)
Trichloroethene (TCE)	0.01	7.35E-02	0.01	8.21E-01	1.12E-01	1.07E+00	1.45E-01	1.20E-02	5

Site Name:	**Plot NT02 Dantzic Street**
Site Address:	**Plot NT02 Dantzic Street**

SUMMARY OF RESULTS FROM RTM WORKSHEETS **Version:** **Sensitivity analysis - hydraulic conductivity (+ an order of magnitude)**

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	1.54E-01	1.38E-02	1.06E-02	4.75E-01

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

RSK GEOSCIENCES

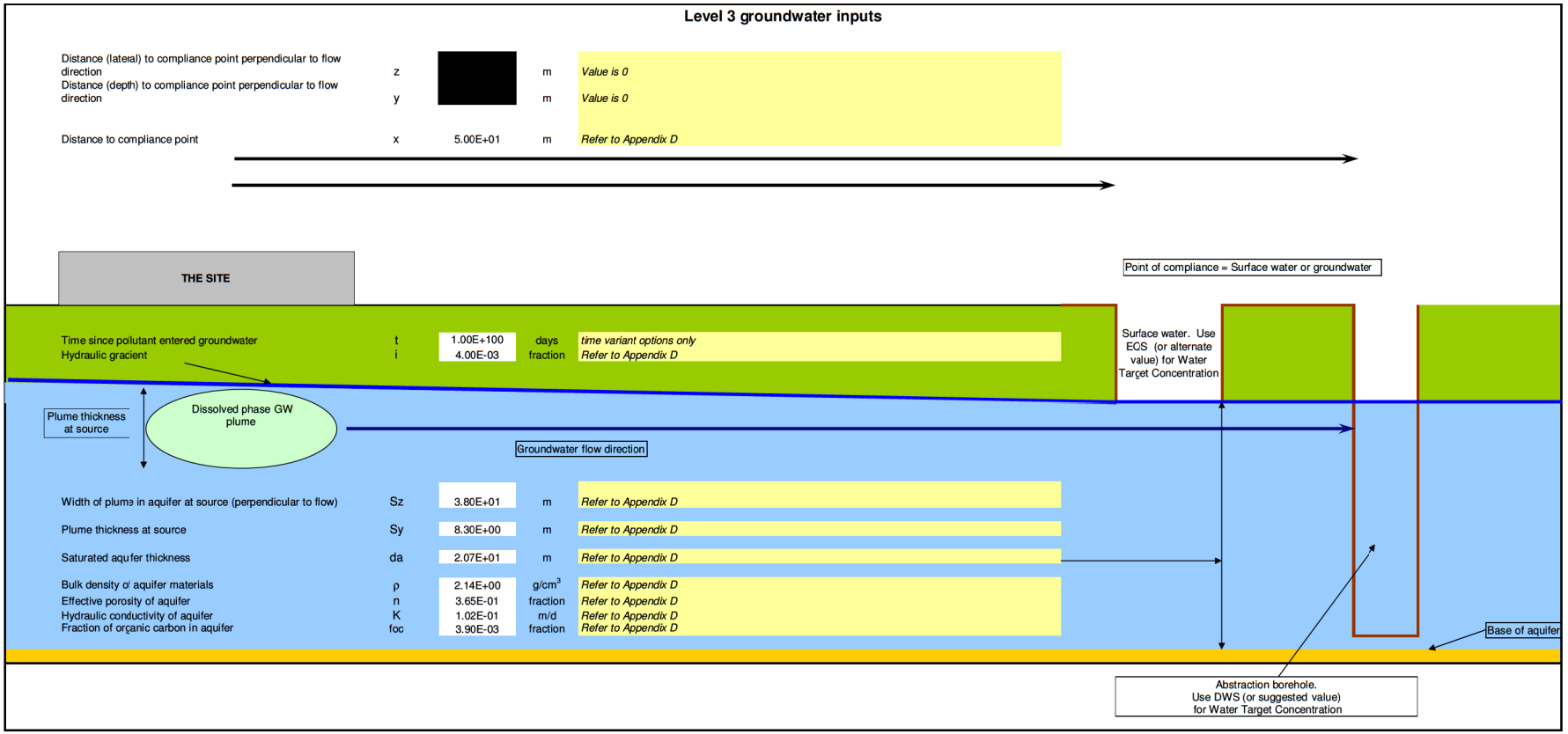
Site Name: Plot NT02 Dantzic Street
Site Address: Plot NT02 Dantzic Street

Completed by: Emma Atkinson
Date: 13-Jul-23

Version: Sensitivity analysis - hydraulic conductivity (- an order of magnitude)

Level 3 groundwater inputs

Distance (lateral) to compliance point perpendicular to flow direction	z	[redacted]	m	*Value is 0*
Distance (depth) to compliance point perpendicular to flow direction	y		m	*Value is 0*
Distance to compliance point	x	5.00E+01	m	*Refer to Appendix D*
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Hydraulic gradient	i	4.00E-03	fraction	*Refer to Appendix D*
Width of plume in aquifer at source (perpendicular to flow)	Sz	3.80E+01	m	*Refer to Appendix D*
Plume thickness at source	Sy	8.30E+00	m	*Refer to Appendix D*
Saturated aquifer thickness	da	2.07E+01	m	*Refer to Appendix D*
Bulk density of aquifer materials	ρ	2.14E+00	g/cm^3	*Refer to Appendix D*
Effective porosity of aquifer	n	3.65E-01	fraction	*Refer to Appendix D*
Hydraulic conductivity of aquifer	K	1.02E-01	m/d	*Refer to Appendix D*
Fraction of organic carbon in aquifer	foc	3.90E-03	fraction	*Refer to Appendix D*



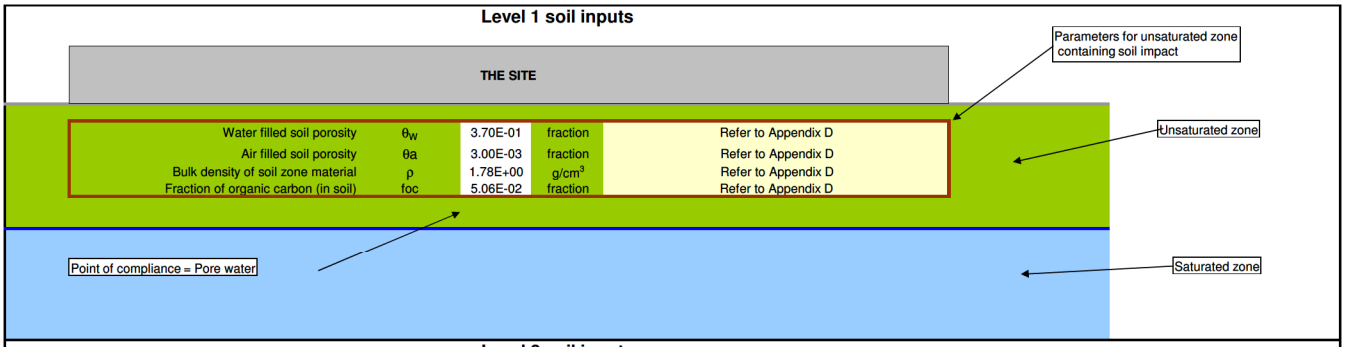
Input Parameters for RTM Worksheets for Controlled Waters Risk Assessr for a Soil Source in the Unsaturated Zone

RSK GEOSCIENCES

Site Name: Plot NT02 Dantzic Street
Site Address: Plot NT02 Dantzic Street

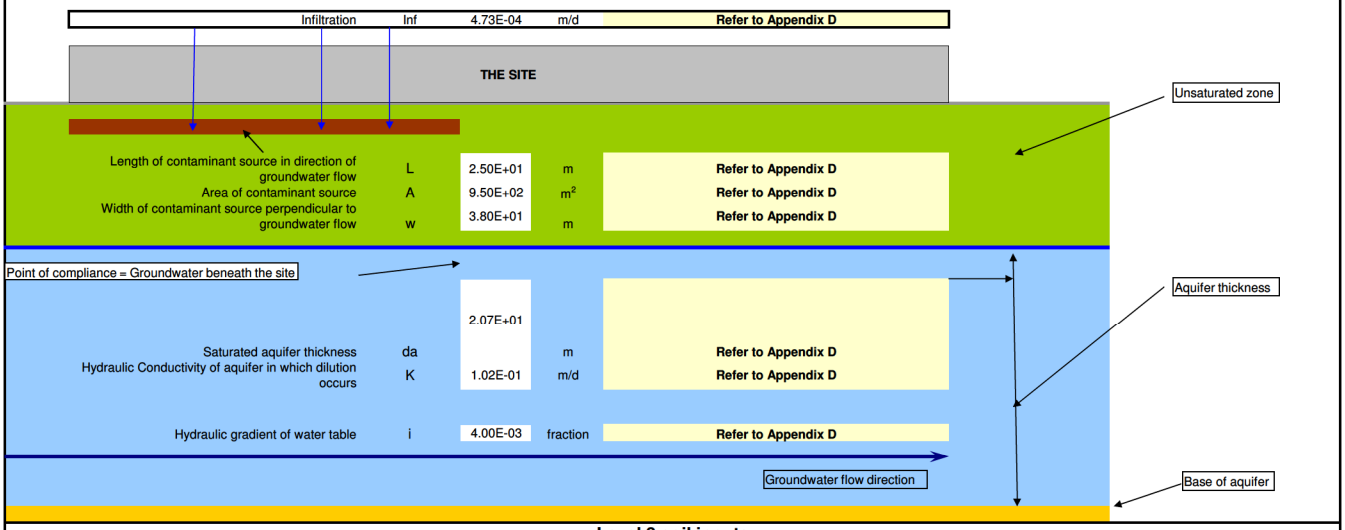
Completed by: Emma Atkinson
Date: 13-Jul-23
Version: Sensitivity analysis - hydraulic conductivity (- an order of magnitude)

Level 1 soil inputs



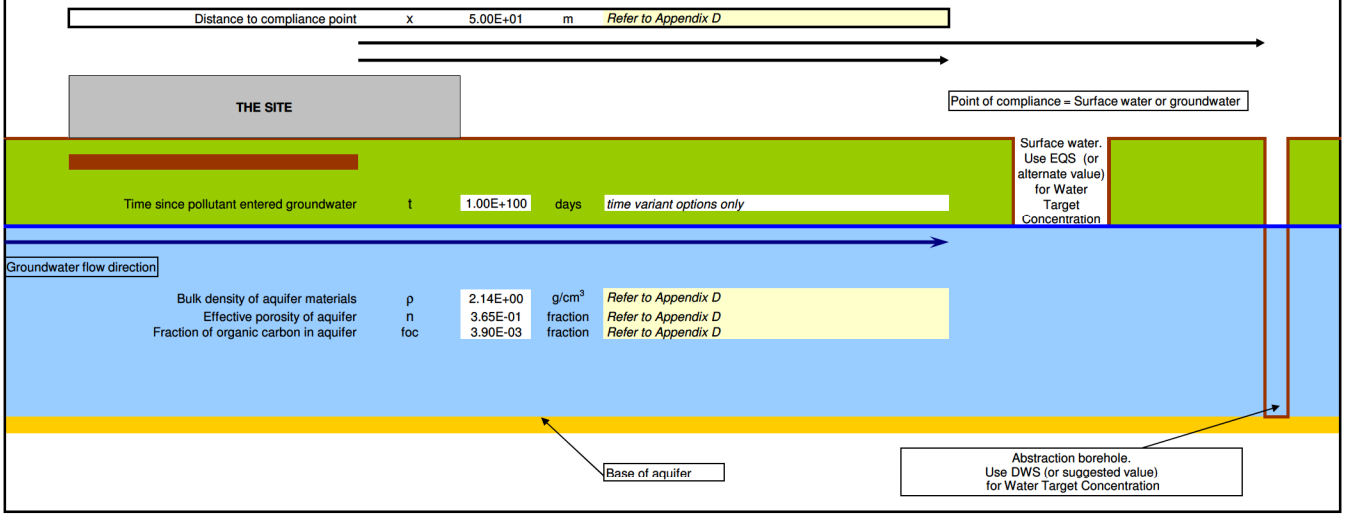
Water filled soil porosity	θ_w	3.70E-01	fraction	Refer to Appendix D
Air filled soil porosity	θa	3.00E-03	fraction	Refer to Appendix D
Bulk density of soil zone material	ρ	1.78E+00	g/cm^3	Refer to Appendix D
Fraction of organic carbon (in soil)	foc	5.06E-02	fraction	Refer to Appendix D

Level 2 soil inputs



Infiltration	Inf	4.73E-04	m/d	**Refer to Appendix D**
Length of contaminant source in direction of groundwater flow	L	2.50E+01	m	**Refer to Appendix D**
Area of contaminant source	A	9.50E+02	m^2	**Refer to Appendix D**
Width of contaminant source perpendicular to groundwater flow	w	3.80E+01	m	**Refer to Appendix D**
Saturated aquifer thickness	da	2.07E+01	m	**Refer to Appendix D**
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.02E-01	m/d	**Refer to Appendix D**
Hydraulic gradient of water table	i	4.00E-03	fraction	**Refer to Appendix D**

Level 3 soil inputs



Distance to compliance point	x	5.00E+01	m	*Refer to Appendix D*
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Bulk density of aquifer materials	ρ	2.14E+00	g/cm^3	*Refer to Appendix D*
Effective porosity of aquifer	n	3.65E-01	fraction	*Refer to Appendix D*
Fraction of organic carbon in aquifer	foc	3.90E-03	fraction	*Refer to Appendix D*

RSK GEOSCIENCES

Site Name: Plot NT02 Dantzic Street
Site Address: Plot NT02 Dantzic Street

SUMMARY OF RESULTS FROM RTM WORKSHEETS Version: Sensitivity analysis - hydraulic conductivity (- an order of magnitude)

TABLE Y		Remedial Targets for a Soil Source (soil & pore water concentrations)						Groundwater Source	Groundwater Source
Contaminant	Target Concentration (C_T) mg/l	Level 1 Remedial Target (soil concentrations) (mg/kg)	Level 1 Remedial Target (pore water and leachate) (mg/l)	Level 2 Remedial Target (soil concentrations) (mg/kg)	Level 2 Remedial Target (pore water and leachate) (mg/l)	Level 3 Remedial Target (soil concentrations) (mg/kg)	Level 3 Remedial Target (pore water and leachate) (mg/l)	Level 3 Remedial Target (groundwater concentrations) (mg/l)	Time for contaminant to reach receptor (years)
Trichloroethene (TCE)	0.01	7.35E-02	0.01	1.20E-01	1.63E-02	2.63E+01	3.84E+00	7.55E+02	518

Site Name:	**Plot NT02 Dantzic Street**
Site Address:	**Plot NT02 Dantzic Street**

SUMMARY OF RESULTS FROM RTM WORKSHEETS **Version:** **Sensitivity analysis - hydraulic conductivity (- an order of magnitude)**

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	1.54E-01	9.43E-02	4.00E-04	7.58E-06

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

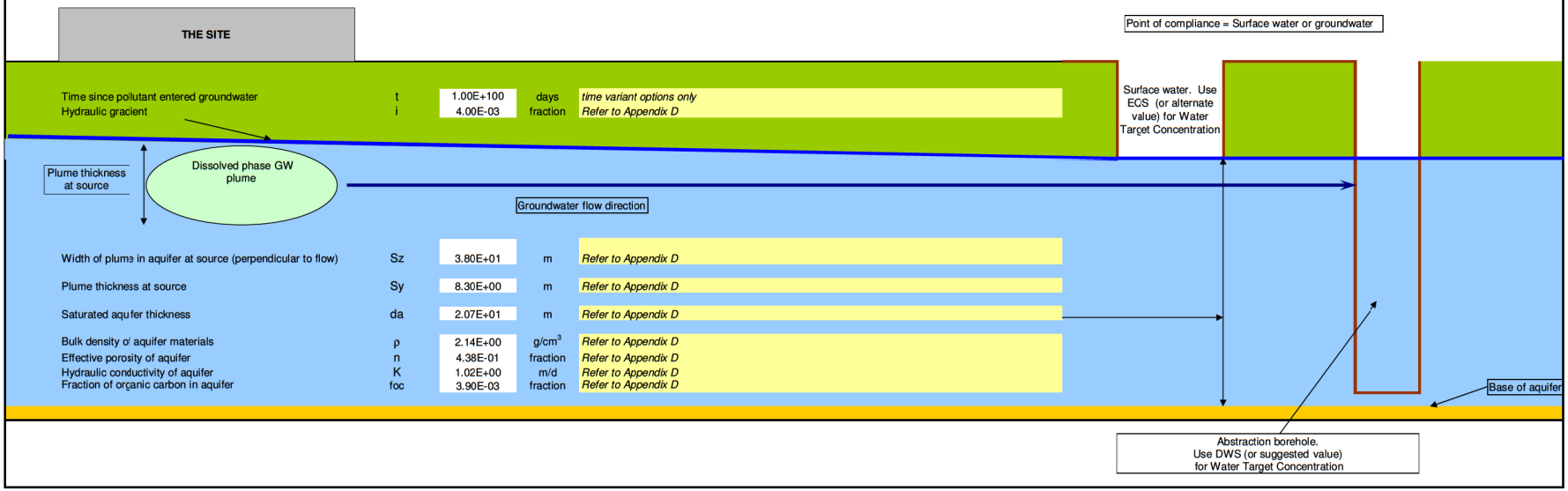
RSK GEOSCIENCES

Site Name: Plot NT02 Dantzic Street
Site Address: Plot NT02 Dantzic Street

Completed by: Emma Atkinson
Date: 13-Jul-23
Version: Sensitivity analysis- effective porosity (+ 20%)

Level 3 groundwater inputs

Distance (lateral) to compliance point perpendicular to flow direction	z	[redacted]	m	*Value is 0*
Distance (depth) to compliance point perpendicular to flow direction	y		m	*Value is 0*
Distance to compliance point	x	5.00E+01	m	*Refer to Appendix D*
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Hydraulic gradient	i	4.00E-03	fraction	*Refer to Appendix D*
Width of plume in aquifer at source (perpendicular to flow)	Sz	3.80E+01	m	*Refer to Appendix D*
Plume thickness at source	Sy	8.30E+00	m	*Refer to Appendix D*
Saturated aquifer thickness	da	2.07E+01	m	*Refer to Appendix D*
Bulk density of aquifer materials	ρ	2.14E+00	g/cm^3	*Refer to Appendix D*
Effective porosity of aquifer	n	4.38E-01	fraction	*Refer to Appendix D*
Hydraulic conductivity of aquifer	K	1.02E+00	m/d	*Refer to Appendix D*
Fraction of organic carbon in aquifer	foc	3.90E-03	fraction	*Refer to Appendix D*



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

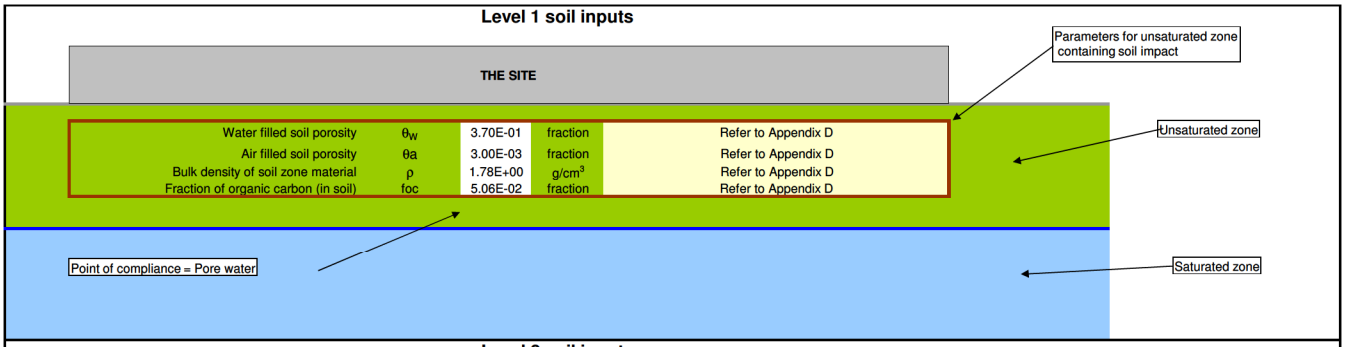
RSK GEOSCIENCES

Site Name: Plot NT02 Dantzic Street
Site Address: Plot NT02 Dantzic Street

Completed by: Emma Atkinson

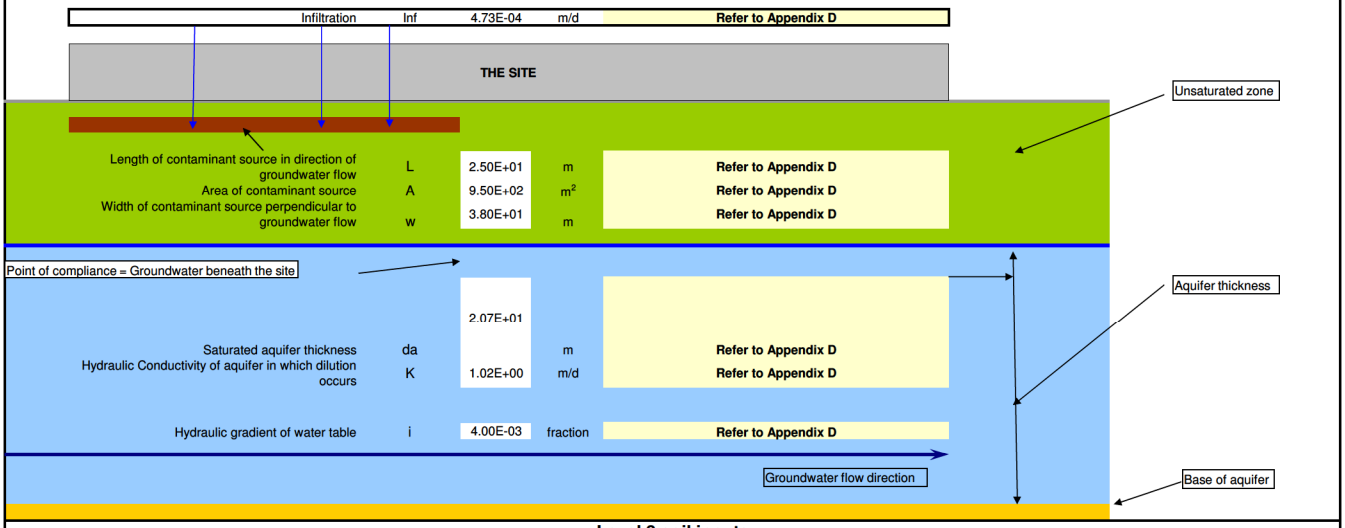
Date: 13-Jul-23 **Version:** Sensitivity analysis- effective porosity (+ 20%)

Level 1 soil inputs



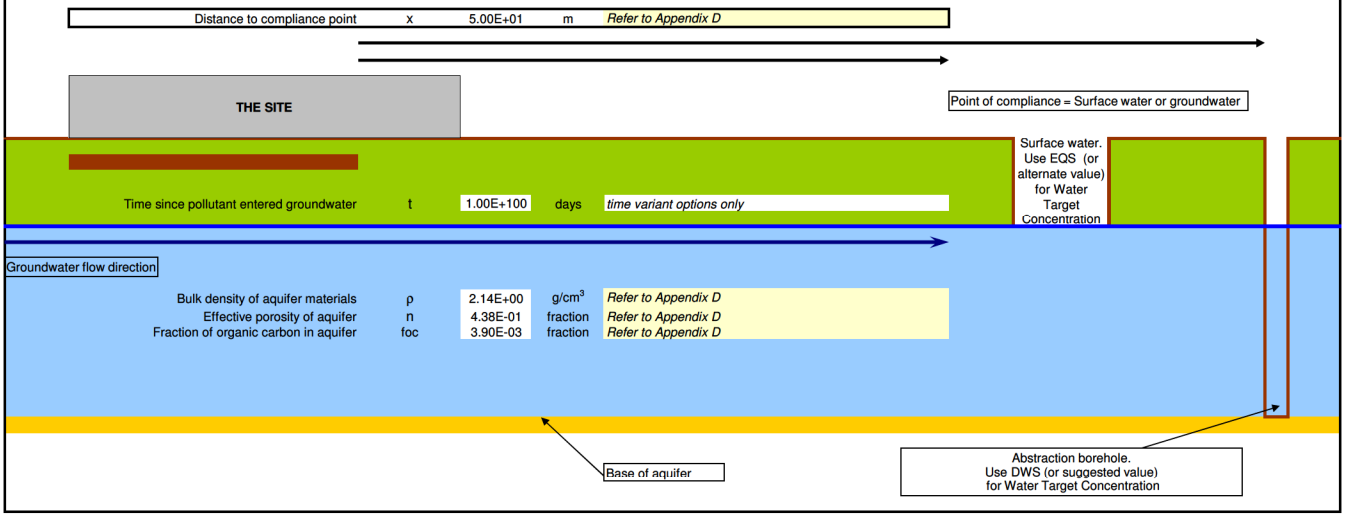
Water filled soil porosity	θ_w	3.70E-01	fraction	Refer to Appendix D
Air filled soil porosity	θa	3.00E-03	fraction	Refer to Appendix D
Bulk density of soil zone material	ρ	1.78E+00	g/cm^3	Refer to Appendix D
Fraction of organic carbon (in soil)	foc	5.06E-02	fraction	Refer to Appendix D

Level 2 soil inputs



Infiltration	Inf	4.73E-04	m/d	**Refer to Appendix D**
Length of contaminant source in direction of groundwater flow	L	2.50E+01	m	**Refer to Appendix D**
Area of contaminant source	A	9.50E+02	m^2	**Refer to Appendix D**
Width of contaminant source perpendicular to groundwater flow	w	3.80E+01	m	**Refer to Appendix D**
Saturated aquifer thickness	da	2.07E+01	m	**Refer to Appendix D**
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.02E+00	m/d	**Refer to Appendix D**
Hydraulic gradient of water table	i	4.00E-03	fraction	**Refer to Appendix D**

Level 3 soil inputs



Distance to compliance point	x	5.00E+01	m	*Refer to Appendix D*
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Bulk density of aquifer materials	ρ	2.14E+00	g/cm^3	*Refer to Appendix D*
Effective porosity of aquifer	n	4.38E-01	fraction	*Refer to Appendix D*
Fraction of organic carbon in aquifer	foc	3.90E-03	fraction	*Refer to Appendix D*

RSK GEOSCIENCES

Site Name: Plot NT02 Dantzic Street
Site Address: Plot NT02 Dantzic Street

SUMMARY OF RESULTS FROM RTM WORKSHEETS Version: Sensitivity analysis- effective porosity (+ 20%)

TABLE Y		Remedial Targets for a Soil Source (soil & pore water concentrations)						Groundwater Source	Groundwater Source
Contaminant	Target Concentration (C_T) mg/l	Level 1 Remedial Target (soil concentrations) (mg/kg)	Level 1 Remedial Target (pore water and leachate) (mg/l)	Level 2 Remedial Target (soil concentrations) (mg/kg)	Level 2 Remedial Target (pore water and leachate) (mg/l)	Level 3 Remedial Target (soil concentrations) (mg/kg)	Level 3 Remedial Target (pore water and leachate) (mg/l)	Level 3 Remedial Target (groundwater concentrations) (mg/l)	Time for contaminant to reach receptor (years)
Trichloroethene (TCE)	0.01	7.35E-02	0.01	2.10E-01	2.85E-02	8.07E-01	1.10E-01	7.40E-02	54

Site Name:	**Plot NT02 Dantzic Street**				
Site Address:	**Plot NT02 Dantzic Street**				
SUMMARY OF RESULTS FROM RTM WORKSHEETS			**Version:**	**Sensitivity analysis- effective porosity (+ 20%)**	
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	1.54E-01	5.39E-02	1.40E-02	7.73E-02

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

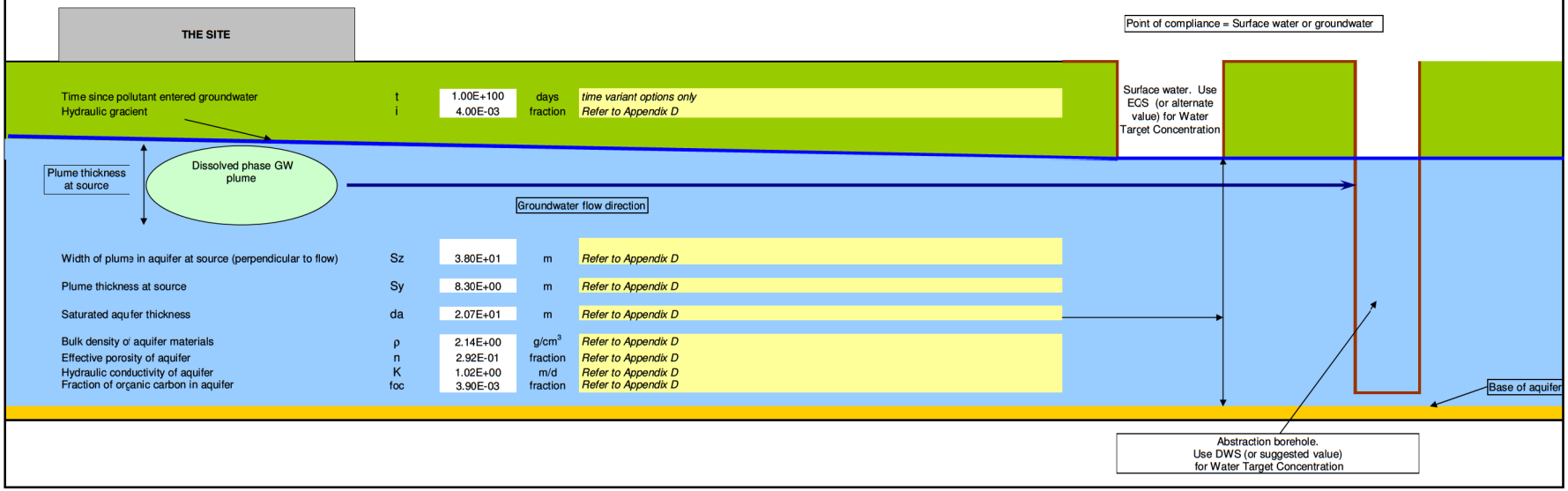
RSK GEOSCIENCES

Site Name: Plot NT02 Dantzic Street
Site Address: Plot NT02 Dantzic Street

Completed by: Emma Atkinson
Date: 13-Jul-23
Version: Sensitivity analysis- effective porosity (- 20%)

Level 3 groundwater inputs

Distance (lateral) to compliance point perpendicular to flow direction	z	[redacted]	m	*Value is 0*
Distance (depth) to compliance point perpendicular to flow direction	y		m	*Value is 0*
Distance to compliance point	x	5.00E+01	m	*Refer to Appendix D*
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Hydraulic gradient	i	4.00E-03	fraction	*Refer to Appendix D*
Width of plume in aquifer at source (perpendicular to flow)	Sz	3.80E+01	m	*Refer to Appendix D*
Plume thickness at source	Sy	8.30E+00	m	*Refer to Appendix D*
Saturated aquifer thickness	da	2.07E+01	m	*Refer to Appendix D*
Bulk density of aquifer materials	ρ	2.14E+00	g/cm^3	*Refer to Appendix D*
Effective porosity of aquifer	n	2.92E-01	fraction	*Refer to Appendix D*
Hydraulic conductivity of aquifer	K	1.02E+00	m/d	*Refer to Appendix D*
Fraction of organic carbon in aquifer	foc	3.90E-03	fraction	*Refer to Appendix D*



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

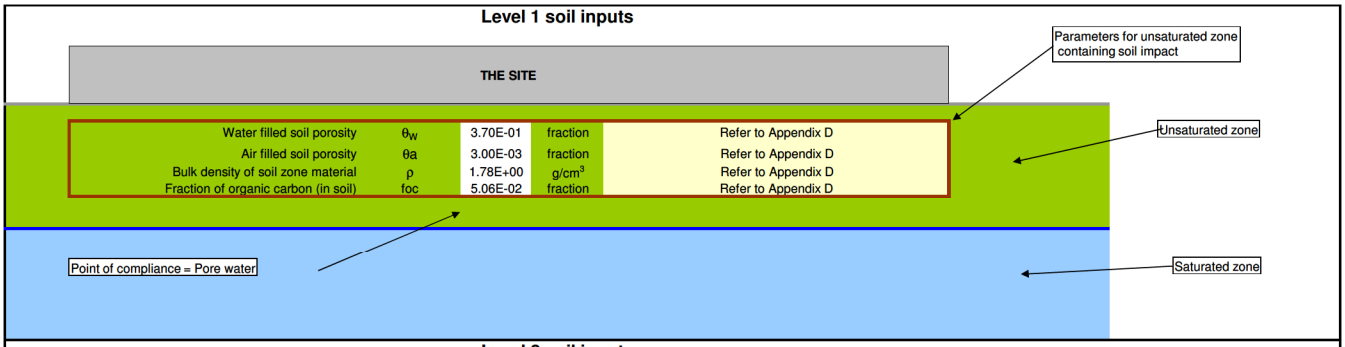
RSK GEOSCIENCES

Site Name: Plot NT02 Dantzic Street
Site Address: Plot NT02 Dantzic Street

Completed by: Emma Atkinson

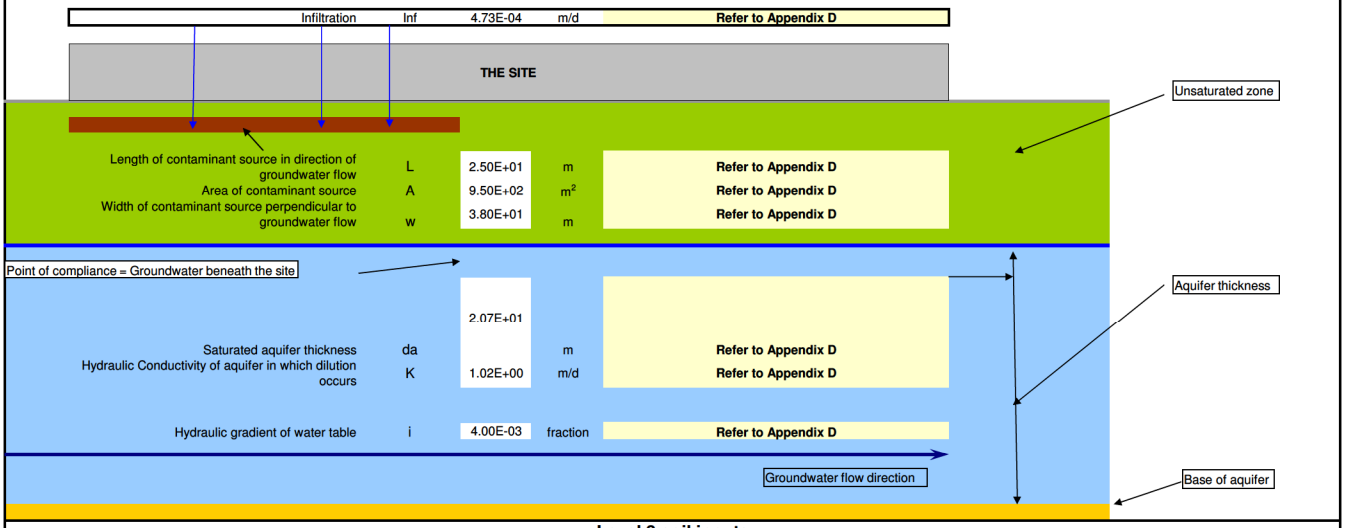
Date: 13-Jul-23 **Version:** Sensitivity analysis- effective porosity (- 20%)

Level 1 soil inputs



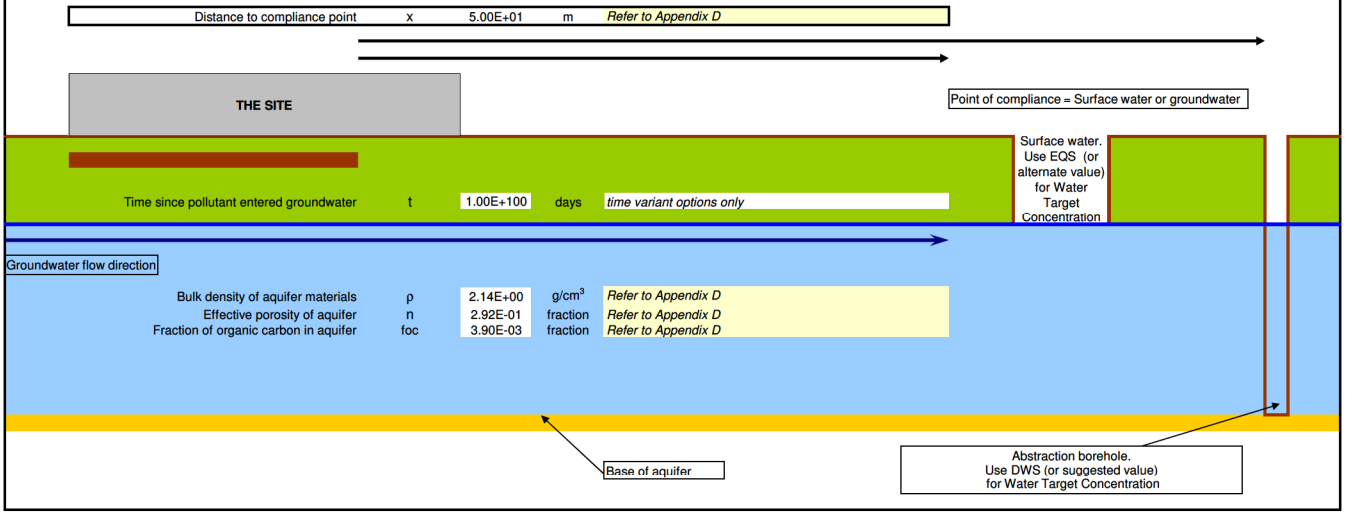
Water filled soil porosity	θ_w	3.70E-01	fraction	Refer to Appendix D
Air filled soil porosity	θa	3.00E-03	fraction	Refer to Appendix D
Bulk density of soil zone material	ρ	1.78E+00	g/cm^3	Refer to Appendix D
Fraction of organic carbon (in soil)	foc	5.06E-02	fraction	Refer to Appendix D

Level 2 soil inputs



Infiltration	Inf	4.73E-04	m/d	**Refer to Appendix D**
Length of contaminant source in direction of groundwater flow	L	2.50E+01	m	**Refer to Appendix D**
Area of contaminant source	A	9.50E+02	m^2	**Refer to Appendix D**
Width of contaminant source perpendicular to groundwater flow	w	3.80E+01	m	**Refer to Appendix D**
Saturated aquifer thickness	da	2.07E+01	m	**Refer to Appendix D**
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.02E+00	m/d	**Refer to Appendix D**
Hydraulic gradient of water table	i	4.00E-03	fraction	**Refer to Appendix D**

Level 3 soil inputs



Distance to compliance point	x	5.00E+01	m	*Refer to Appendix D*
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Bulk density of aquifer materials	ρ	2.14E+00	g/cm^3	*Refer to Appendix D*
Effective porosity of aquifer	n	2.92E-01	fraction	*Refer to Appendix D*
Fraction of organic carbon in aquifer	foc	3.90E-03	fraction	*Refer to Appendix D*

Site Name: Plot NT02 Dantzic Street
Site Address: Plot NT02 Dantzic Street

SUMMARY OF RESULTS FROM RTM WORKSHEETS Version: Sensitivity analysis- effective porosity (- 20%)

TABLE Y		Remedial Targets for a Soil Source (soil & pore water concentrations)						Groundwater Source	Groundwater Source
Contaminant	Target Concentration (C_T) mg/l	Level 1 Remedial Target (soil concentrations) (mg/kg)	Level 1 Remedial Target (pore water and leachate) (mg/l)	Level 2 Remedial Target (soil concentrations) (mg/kg)	Level 2 Remedial Target (pore water and leachate) (mg/l)	Level 3 Remedial Target (soil concentrations) (mg/kg)	Level 3 Remedial Target (pore water and leachate) (mg/l)	Level 3 Remedial Target (groundwater concentrations) (mg/l)	Time for contaminant to reach receptor (years)
Trichloroethene (TCE)	0.01	7.35E-02	0.01	2.10E-01	2.85E-02	5.27E-01	7.16E-02	3.98E-02	49

Site Name:	**Plot NT02 Dantzic Street**				
Site Address:	**Plot NT02 Dantzic Street**				
SUMMARY OF RESULTS FROM RTM WORKSHEETS			**Version:**	**Sensitivity analysis- effective porosity (- 20%)**	
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	1.54E-01	5.39E-02	2.14E-02	1.44E-01

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

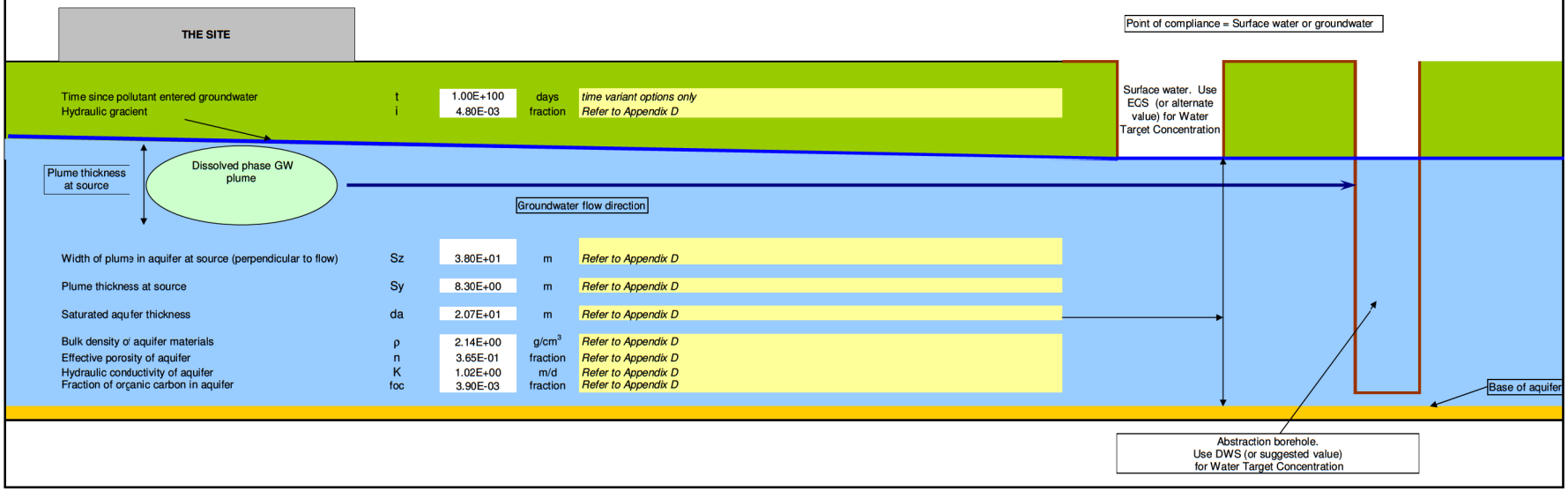
RSK GEOSCIENCES

Site Name: Plot NT02 Dantzic Street
Site Address: Plot NT02 Dantzic Street

Completed by: Emma Atkinson
Date: 13-Jul-23
Version: Sensitivity analysis- Hydraulic gradient (+ 20%)

Level 3 groundwater inputs

Distance (lateral) to compliance point perpendicular to flow direction	z	[redacted]	m	*Value is 0*
Distance (depth) to compliance point perpendicular to flow direction	y		m	*Value is 0*
Distance to compliance point	x	5.00E+01	m	*Refer to Appendix D*
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Hydraulic gradient	i	4.80E-03	fraction	*Refer to Appendix D*
Width of plume in aquifer at source (perpendicular to flow)	Sz	3.80E+01	m	*Refer to Appendix D*
Plume thickness at source	Sy	8.30E+00	m	*Refer to Appendix D*
Saturated aquifer thickness	da	2.07E+01	m	*Refer to Appendix D*
Bulk density of aquifer materials	ρ	2.14E+00	g/cm^3	*Refer to Appendix D*
Effective porosity of aquifer	n	3.65E-01	fraction	*Refer to Appendix D*
Hydraulic conductivity of aquifer	K	1.02E+00	m/d	*Refer to Appendix D*
Fraction of organic carbon in aquifer	foc	3.90E-03	fraction	*Refer to Appendix D*



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

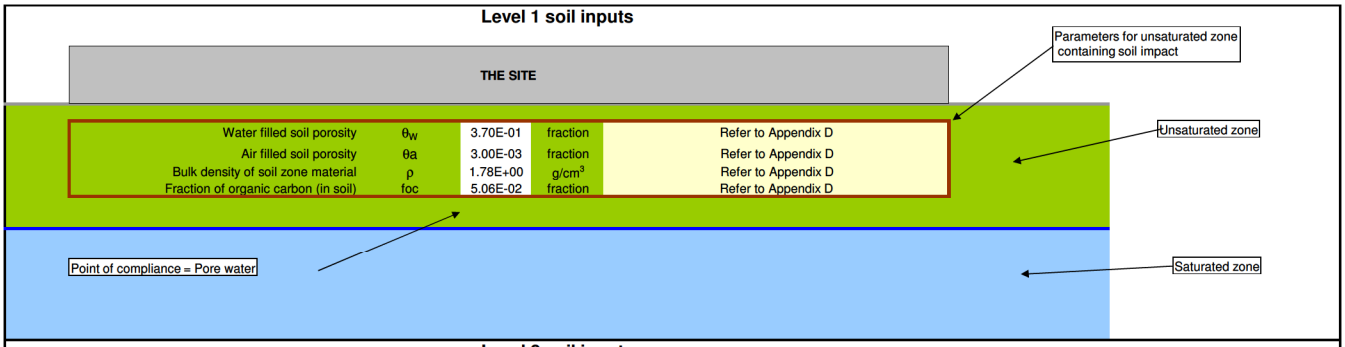
RSK GEOSCIENCES

Site Name: Plot NT02 Dantzic Street
Site Address: Plot NT02 Dantzic Street

Completed by: Emma Atkinson
Date: 13-Jul-23 **Version:**)

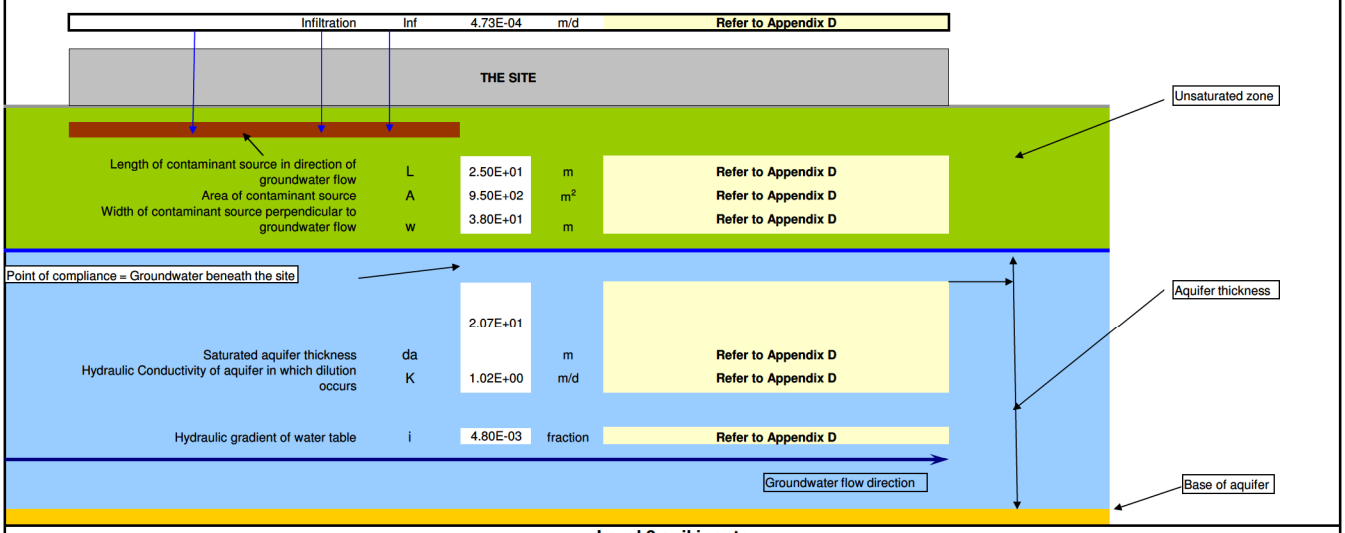
Sensitivity analysis- Hydraulic gradient (+ 20%

Level 1 soil inputs



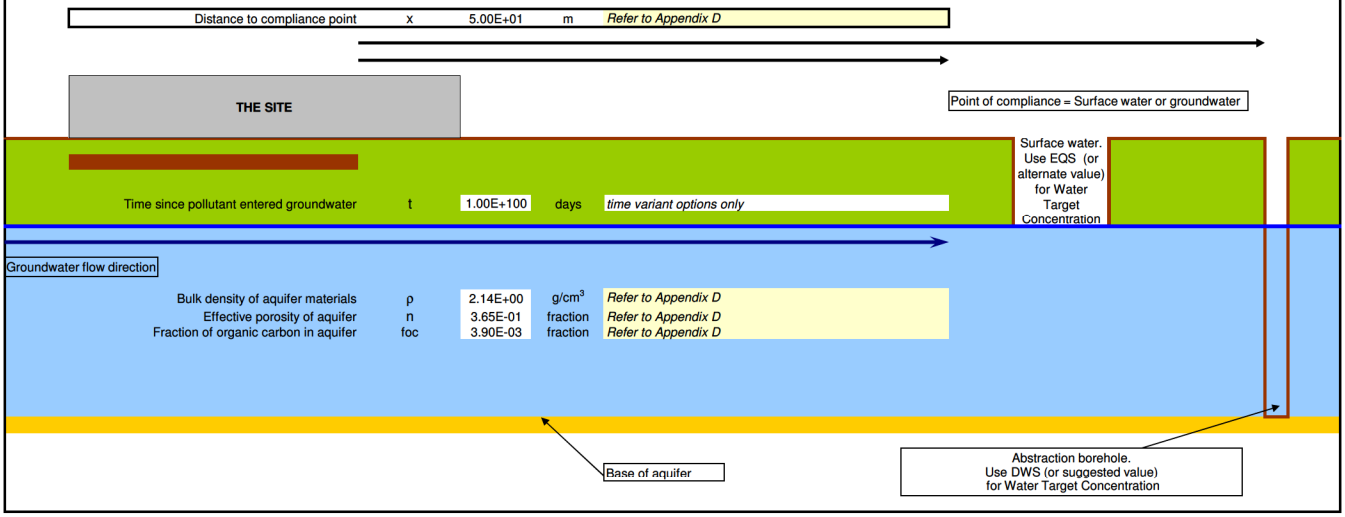
Water filled soil porosity	θ_w	3.70E-01	fraction	Refer to Appendix D
Air filled soil porosity	θa	3.00E-03	fraction	Refer to Appendix D
Bulk density of soil zone material	ρ	1.78E+00	g/cm^3	Refer to Appendix D
Fraction of organic carbon (in soil)	foc	5.06E-02	fraction	Refer to Appendix D

Level 2 soil inputs



Infiltration	Inf	4.73E-04	m/d	**Refer to Appendix D**
Length of contaminant source in direction of groundwater flow	L	2.50E+01	m	**Refer to Appendix D**
Area of contaminant source	A	9.50E+02	m^2	**Refer to Appendix D**
Width of contaminant source perpendicular to groundwater flow	w	3.80E+01	m	**Refer to Appendix D**
		2.07E+01		
Saturated aquifer thickness	da		m	**Refer to Appendix D**
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.02E+00	m/d	**Refer to Appendix D**
Hydraulic gradient of water table	i	4.80E-03	fraction	**Refer to Appendix D**

Level 3 soil inputs



Distance to compliance point	x	5.00E+01	m	*Refer to Appendix D*
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Bulk density of aquifer materials	ρ	2.14E+00	g/cm^3	*Refer to Appendix D*
Effective porosity of aquifer	n	3.65E-01	fraction	*Refer to Appendix D*
Fraction of organic carbon in aquifer	foc	3.90E-03	fraction	*Refer to Appendix D*

Site Name: Plot NT02 Dantzic Street
Site Address: Plot NT02 Dantzic Street

SUMMARY OF RESULTS FROM RTM WORKSHEETS Version: Sensitivity analysis- Hydraulic gradient (+ 20%)

TABLE Y		Remedial Targets for a Soil Source (soil & pore water concentrations)						Groundwater Source	Groundwater Source
Contaminant	Target Concentration (C_T) mg/l	Level 1 Remedial Target (soil concentrations) (mg/kg)	Level 1 Remedial Target (pore water and leachate) (mg/l)	Level 2 Remedial Target (soil concentrations) (mg/kg)	Level 2 Remedial Target (pore water and leachate) (mg/l)	Level 3 Remedial Target (soil concentrations) (mg/kg)	Level 3 Remedial Target (pore water and leachate) (mg/l)	Level 3 Remedial Target (groundwater concentrations) (mg/l)	Time for contaminant to reach receptor (years)
Trichloroethene (TCE)	0.01	7.35E-02	0.01	2.24E-01	3.04E-02	6.03E-01	8.21E-02	4.19E-02	43

Site Name:	**Plot NT02 Dantzic Street**				
Site Address:	**Plot NT02 Dantzic Street**				
SUMMARY OF RESULTS FROM RTM WORKSHEETS			**Version:**	**Sensitivity analysis- Hydraulic gradient (+ 20%)**	
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	1.54E-01	5.05E-02	1.87E-02	1.36E-01

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

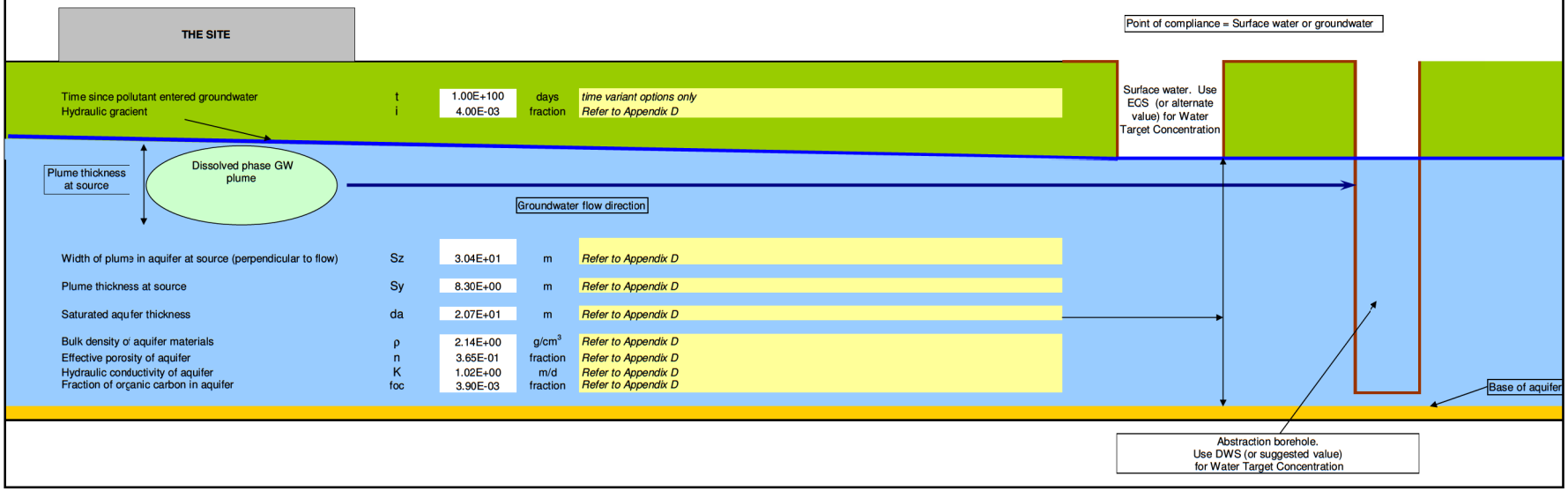
RSK GEOSCIENCES

Site Name: Plot NT02 Dantzic Street
Site Address: Plot NT02 Dantzic Street

Completed by: Emma Atkinson
Date: 13-Jul-23
Version: Sensitivity analysis- width of source (- 20%)

Level 3 groundwater inputs

Distance (lateral) to compliance point perpendicular to flow direction	z	[redacted]	m	*Value is 0*
Distance (depth) to compliance point perpendicular to flow direction	y		m	*Value is 0*
Distance to compliance point	x	5.00E+01	m	*Refer to Appendix D*
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Hydraulic gradient	i	4.00E-03	fraction	*Refer to Appendix D*
Width of plume in aquifer at source (perpendicular to flow)	Sz	3.04E+01	m	*Refer to Appendix D*
Plume thickness at source	Sy	8.30E+00	m	*Refer to Appendix D*
Saturated aquifer thickness	da	2.07E+01	m	*Refer to Appendix D*
Bulk density of aquifer materials	ρ	2.14E+00	g/cm^3	*Refer to Appendix D*
Effective porosity of aquifer	n	3.65E-01	fraction	*Refer to Appendix D*
Hydraulic conductivity of aquifer	K	1.02E+00	m/d	*Refer to Appendix D*
Fraction of organic carbon in aquifer	foc	3.90E-03	fraction	*Refer to Appendix D*



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

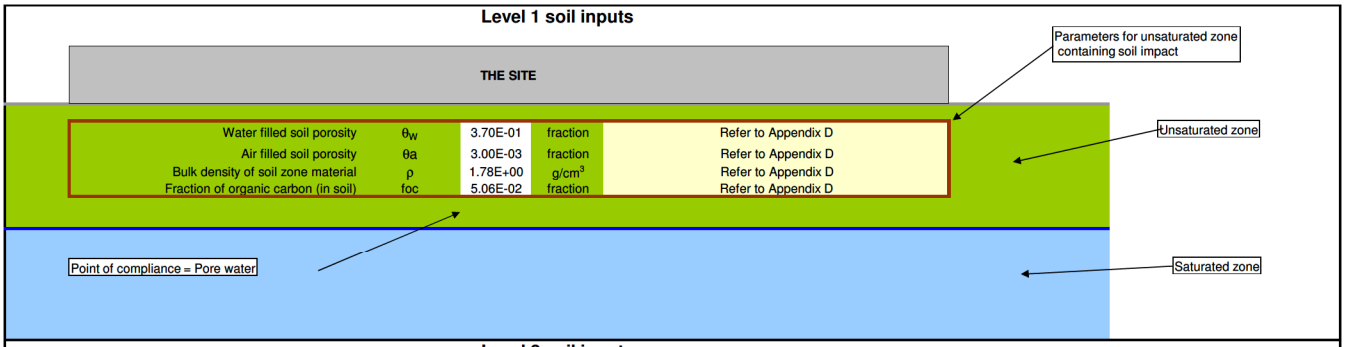
RSK GEOSCIENCES

Site Name: Plot NT02 Dantzic Street
Site Address: Plot NT02 Dantzic Street

Completed by: Emma Atkinson

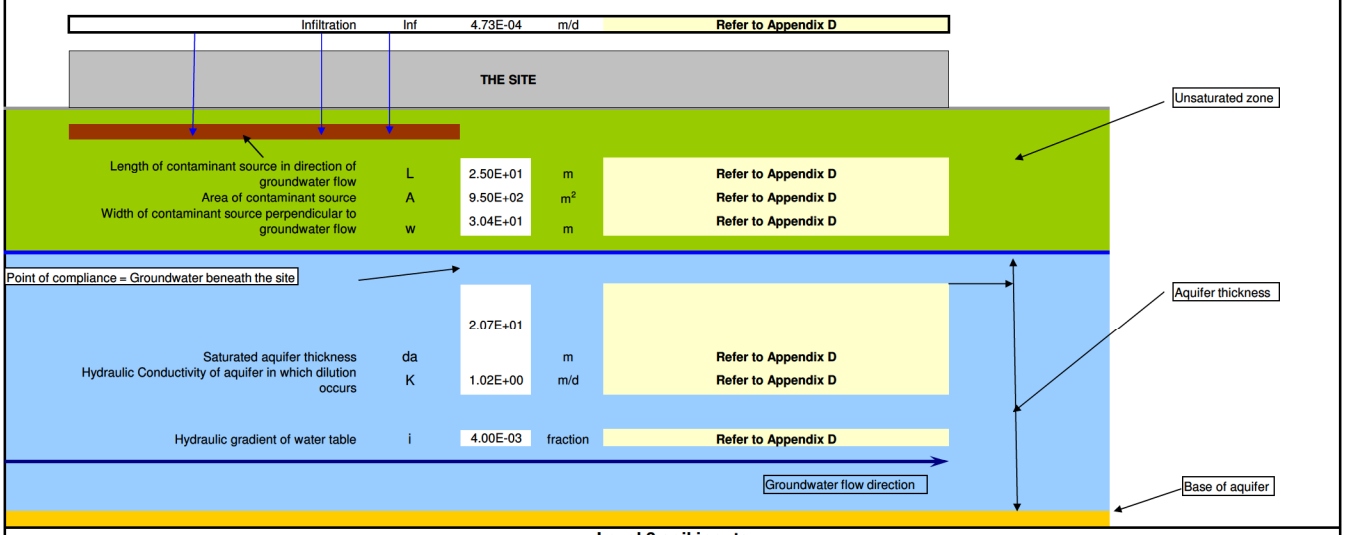
Date: 13-Jul-23 **Version:** Sensitivity analysis- width of source (- 20%)

Level 1 soil inputs



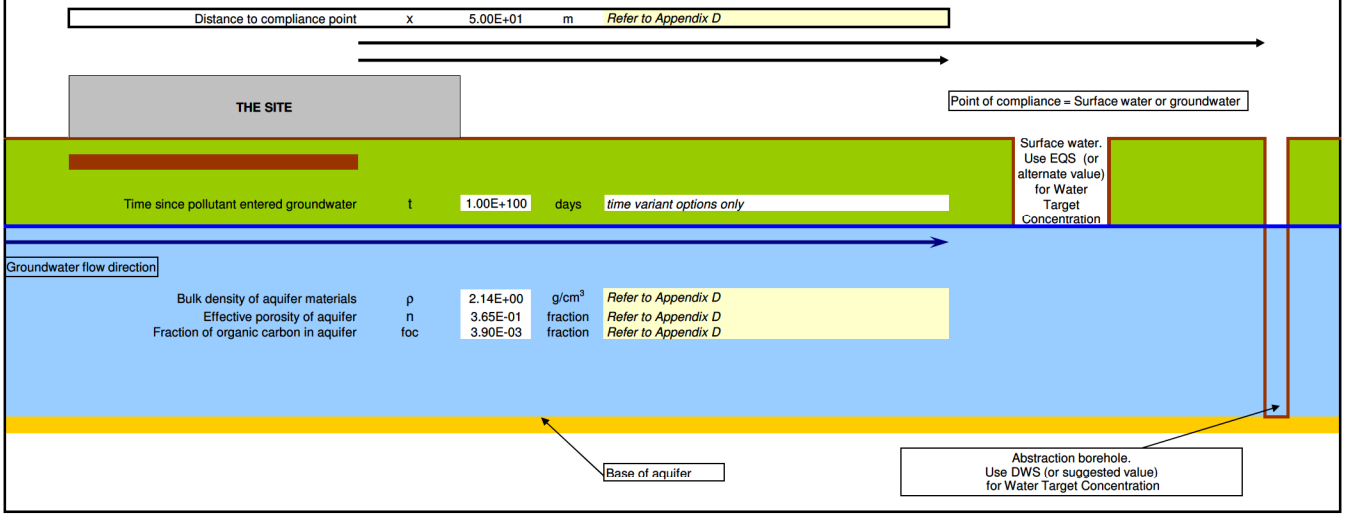
Water filled soil porosity	θ_w	3.70E-01	fraction	Refer to Appendix D
Air filled soil porosity	θa	3.00E-03	fraction	Refer to Appendix D
Bulk density of soil zone material	ρ	1.78E+00	g/cm^3	Refer to Appendix D
Fraction of organic carbon (in soil)	foc	5.06E-02	fraction	Refer to Appendix D

Level 2 soil inputs



Infiltration	Inf	4.73E-04	m/d	**Refer to Appendix D**
Length of contaminant source in direction of groundwater flow	L	2.50E+01	m	**Refer to Appendix D**
Area of contaminant source	A	9.50E+02	m^2	**Refer to Appendix D**
Width of contaminant source perpendicular to groundwater flow	w	3.04E+01	m	**Refer to Appendix D**
		2.07E+01		
Saturated aquifer thickness	da		m	**Refer to Appendix D**
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.02E+00	m/d	**Refer to Appendix D**
Hydraulic gradient of water table	i	4.00E-03	fraction	**Refer to Appendix D**

Level 3 soil inputs



Distance to compliance point	x	5.00E+01	m	*Refer to Appendix D*
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Bulk density of aquifer materials	ρ	2.14E+00	g/cm^3	*Refer to Appendix D*
Effective porosity of aquifer	n	3.65E-01	fraction	*Refer to Appendix D*
Fraction of organic carbon in aquifer	foc	3.90E-03	fraction	*Refer to Appendix D*

RSK GEOSCIENCES

Site Name: Plot NT02 Dantzic Street
Site Address: Plot NT02 Dantzic Street

SUMMARY OF RESULTS FROM RTM WORKSHEETS Version: Sensitivity analysis- width of source (- 20%)

TABLE Y		Remedial Targets for a Soil Source (soil & pore water concentrations)						Groundwater Source	Groundwater Source
Contaminant	Target Concentration (C_T) mg/l	Level 1 Remedial Target (soil concentrations) (mg/kg)	Level 1 Remedial Target (pore water and leachate) (mg/l)	Level 2 Remedial Target (soil concentrations) (mg/kg)	Level 2 Remedial Target (pore water and leachate) (mg/l)	Level 3 Remedial Target (soil concentrations) (mg/kg)	Level 3 Remedial Target (pore water and leachate) (mg/l)	Level 3 Remedial Target (groundwater concentrations) (mg/l)	Time for contaminant to reach receptor (years)
Trichloroethene (TCE)	0.01	7.35E-02	0.01	2.10E-01	2.85E-02	6.57E-01	8.94E-02	5.48E-02	52

Site Name:	**Plot NT02 Dantzic Street**				
Site Address:	**Plot NT02 Dantzic Street**				
SUMMARY OF RESULTS FROM RTM WORKSHEETS			**Version:**	**Sensitivity analysis- width of source (- 20%)**	
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	1.54E-01	5.39E-02	1.72E-02	1.04E-01

Site Name:	Plot NT02 Dantzic Street	Completed by: Emma Atkinson									Site Name:	Plot NT02 Dantzic Street	Completed by: Emma Atkinson					
Site Address:	Plot NT02 Dantzic Street	Date: 13-Jul-23									Site Address:	Plot NT02 Dantzic Street	Date: 13-Jul-23					
SITE SPECIFIC INPUTS FOR INDIVIDUAL SUBSTANCES		Version: Sensitivity analysis degradation rates anaerobic									Table X		Version: Sensitivity analysis degradation rates anaerobic					
Table W		Soil Source for Impact on Groundwater						Groundwater Source (Level 3 Groundwater)			SUBSTANCE SPECIFIC INPUTS FOR INDIVIDUAL SUBSTANCES							
Contaminant	Target Concentration (CT) mg/l	Origin of CT:	Soil concentration for Level 3 soil sheet and soil impact results sheet (mg/kg)	Comment on soil source concentrations for Level 3 soil sheet and soil impact results	Option: Concentration of contaminant in contaminated discharge entering receptor (mg/l)	Comment on concentration of contaminant in contaminated discharge (entering receptor)	Option: Background concentration of contaminant in groundwater beneath site (mg/l)	Justification of background concentration of contaminant in groundwater beneath site	Initial contaminant concentration in groundwater at plume core (mg/l)	Comment on groundwater source concentrations	Contaminant	Organic carbon partition coefficient (Koc)	Source of Koc	Henry's Law constant (dimensionless)	Source of Henry's Law	Half life for degradation of contaminant in water (d)	Source of Half Life - Howard et al 1991, Handbook of Environmental Degradation Rates and CHNSM
Trichloroethene (TCE)	**0.01**	**Drinking Water Standards (DWS)**	1.13	Maximum concentration (WS308at 1.00 m bgl on 03/04/2023)	0.00E+00	Comment	0.00E+00	Assume background water not impacted	0.572	Maximum concentration (RBH203 on 04/10/2022)	**Trichloroethene (TCE)**	1.41E+02	SR7	1.87E-01	SR7	3.21E+02	*Howard et al low half life (anaerobic conditions)*

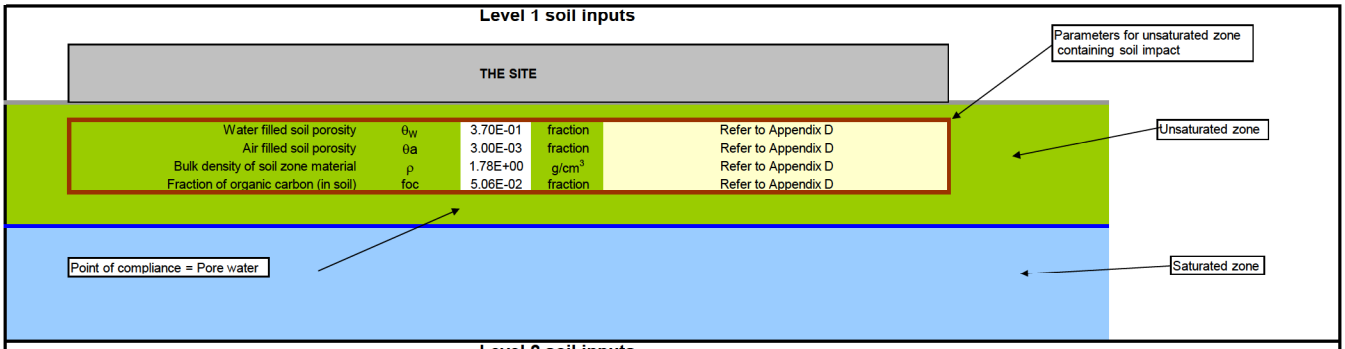
Input Parameters for RTM Worksheets for Controlled Waters Risk Assessment for a Soil Source in the Unsaturated Zone

RSK GEOSCIENCES

Site Name: Plot NT02 Dantzic Street
Site Address: Plot NT02 Dantzic Street

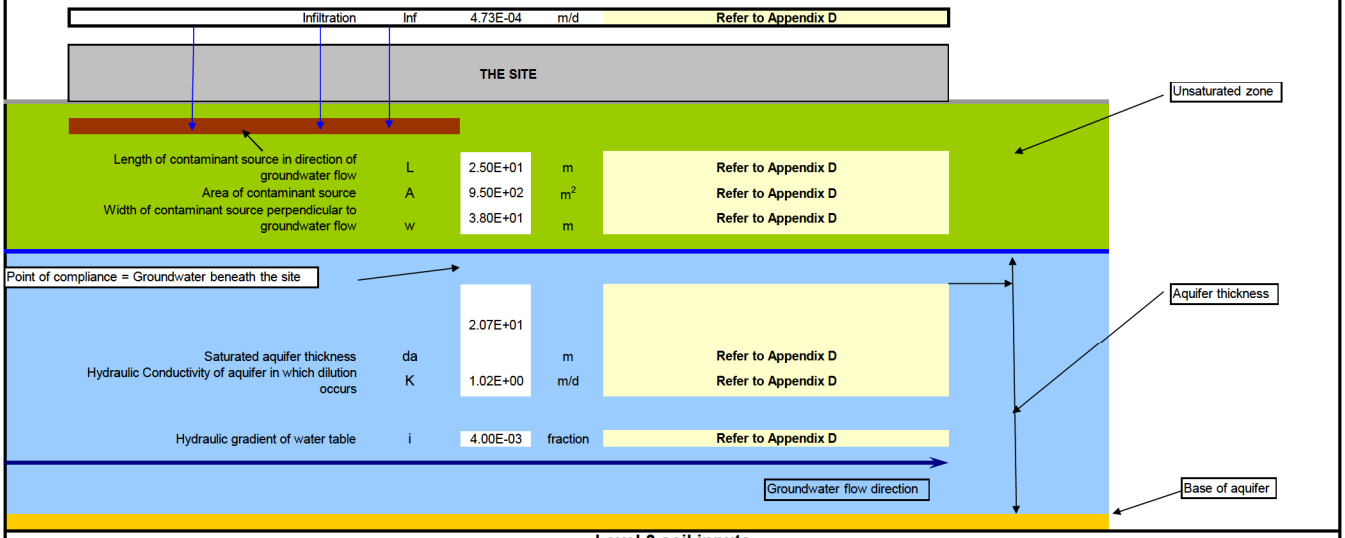
Completed by: Emma Atkinson
Date: 13-Jul-23 **Version:** Sensitivity analysis degradation rates

Level 1 soil inputs



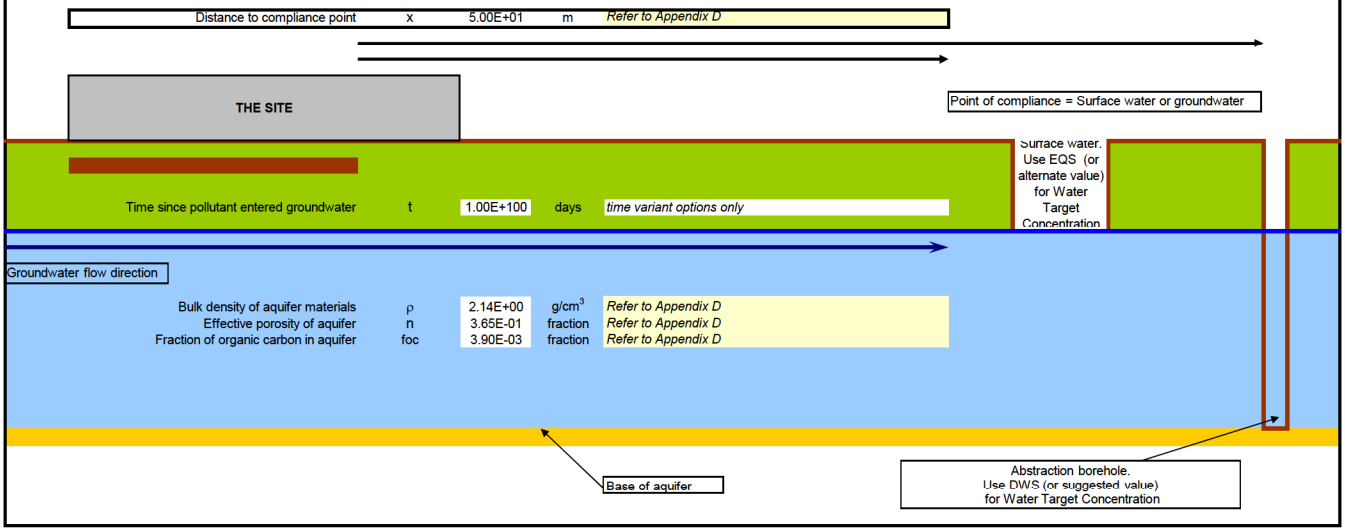
Water filled soil porosity	θ_w	3.70E-01	fraction	Refer to Appendix D
Air filled soil porosity	θ_a	3.00E-03	fraction	Refer to Appendix D
Bulk density of soil zone material	ρ	1.78E+00	g/cm^3	Refer to Appendix D
Fraction of organic carbon (in soil)	foc	5.06E-02	fraction	Refer to Appendix D

Level 2 soil inputs



Infiltration	Inf	4.73E-04	m/d	Refer to Appendix D
Length of contaminant source in direction of groundwater flow	L	2.50E+01	m	Refer to Appendix D
Area of contaminant source	A	9.50E+02	m^2	Refer to Appendix D
Width of contaminant source perpendicular to groundwater flow	w	3.80E+01	m	Refer to Appendix D
		2.07E+01		
Saturated aquifer thickness	da		m	Refer to Appendix D
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.02E+00	m/d	Refer to Appendix D
Hydraulic gradient of water table	i	4.00E-03	fraction	Refer to Appendix D

Level 3 soil inputs



Distance to compliance point	x	5.00E+01	m	*Refer to Appendix D*
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Bulk density of aquifer materials	ρ	2.14E+00	g/cm^3	*Refer to Appendix D*
Effective porosity of aquifer	n	3.65E-01	fraction	*Refer to Appendix D*
Fraction of organic carbon in aquifer	foc	3.90E-03	fraction	*Refer to Appendix D*

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

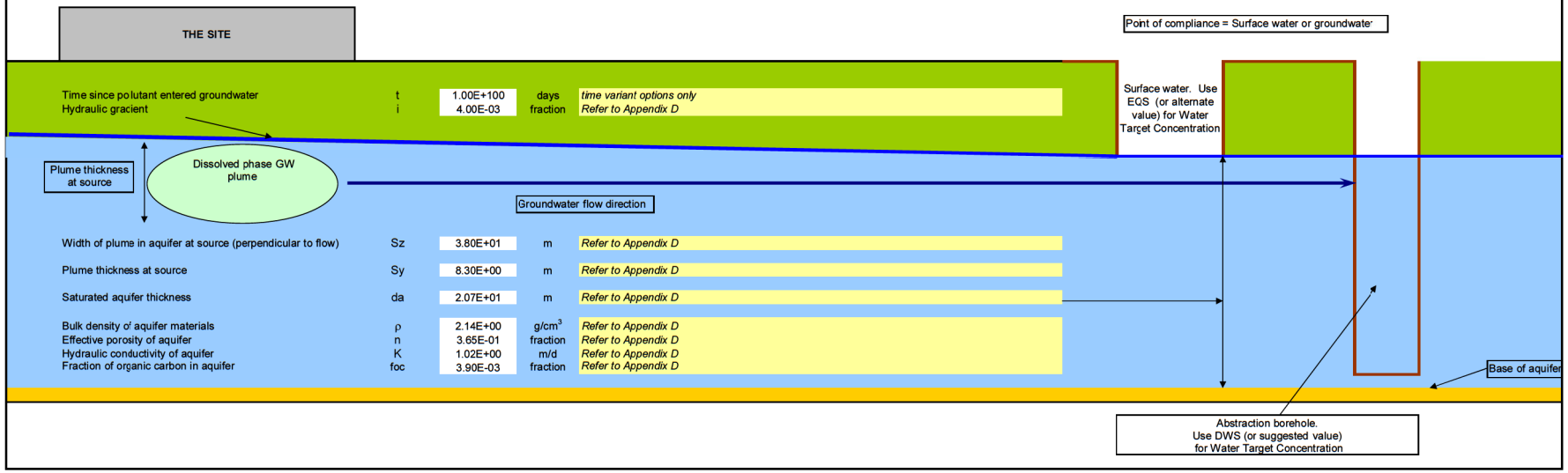
RSK GEOSCIENCES

Site Name: Plot NT02 Dantzic Street
Site Address: Plot NT02 Dantzic Street

Completed by: Emma Atkinson
Date: 13-Jul-23 **Version:** Sensitivity analysis degradation rates anaerobic

Level 3 groundwater inputs

Distance (lateral) to compliance point perpendicular to flow direction	z	[redacted]	m	*Value is 0*
Distance (depth) to compliance point perpendicular to flow direction	y		m	*Value is 0*
Distance to compliance point	x	5.00E+01	m	*Refer to Appendix D*
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Hydraulic gradient	i	4.00E-03	fraction	*Refer to Appendix D*
Width of plume in aquifer at source (perpendicular to flow)	Sz	3.80E+01	m	*Refer to Appendix D*
Plume thickness at source	Sy	8.30E+00	m	*Refer to Appendix D*
Saturated aquifer thickness	da	2.07E+01	m	*Refer to Appendix D*
Bulk density of aquifer materials	ρ	2.14E+00	g/cm^3	*Refer to Appendix D*
Effective porosity of aquifer	n	3.65E-01	fraction	*Refer to Appendix D*
Hydraulic conductivity of aquifer	K	1.02E+00	m/d	*Refer to Appendix D*
Fraction of organic carbon in aquifer	foc	3.90E-03	fraction	*Refer to Appendix D*



Site Name: Plot NT02 Dantzic Street
Site Address: Plot NT02 Dantzic Street

SUMMARY OF RESULTS FROM RTM WORKSHEETS Version: Sensitivity analysis degradation rates anaerobic

TABLE Y		Remedial Targets for a Soil Source (soil & pore water concentrations)						Groundwater Source	Groundwater Source
Contaminant	Target Concentration (C_T) mg/l	Level 1 Remedial Target (soil concentrations) (mg/kg)	Level 1 Remedial Target (pore water and leachate) (mg/l)	Level 2 Remedial Target (soil concentrations) (mg/kg)	Level 2 Remedial Target (pore water and leachate) (mg/l)	Level 3 Remedial Target (soil concentrations) (mg/kg)	Level 3 Remedial Target (pore water and leachate) (mg/l)	Level 3 Remedial Target (groundwater concentrations) (mg/l)	Time for contaminant to reach receptor (years)
Trichloroethene (TCE)	0.01	7.35E-02	0.01	2.10E-01	2.85E-02	2.66E+01	3.62E+00	9.26E+00	52

RSK GEOSCIENCES

Site Name:	**Plot NT02 Dantzic Street**
Site Address:	**Plot NT02 Dantzic Street**

SUMMARY OF RESULTS FROM RTM WORKSHEETS **Version:** **Sensitivity analysis degradation rates anaerobic**

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	1.54E-01	5.39E-02	4.24E-04	6.18E-04

APPENDIX G
MODEL CALIBRATION

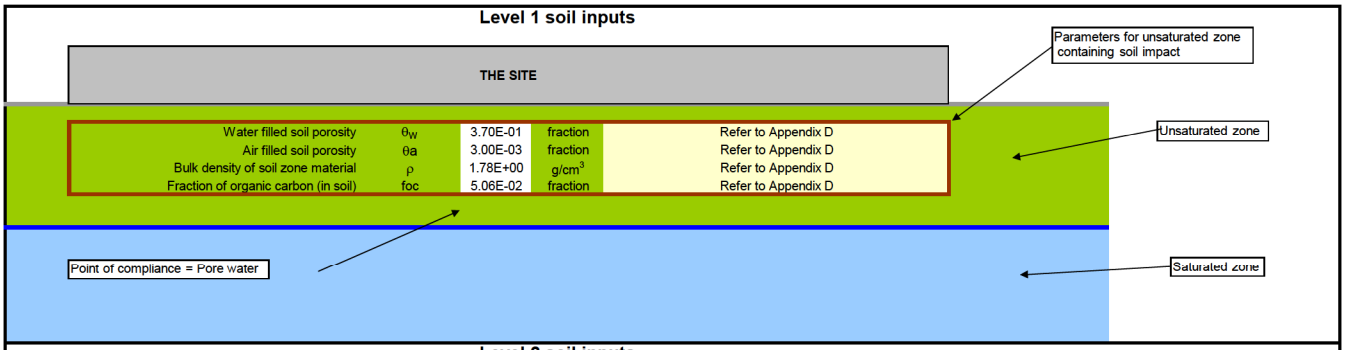
Site Name:	Plot NT02 Dantzic Street	Completed by: Emma Atkinson									Site Name:	Plot NT02 Dantzic Street	Completed by: Emma Atkinson					
Site Address:	Plot NT02 Dantzic Street	Date: 13-Jul-23									Site Address:	Plot NT02 Dantzic Street	Date: 13-Jul-23					
SITE SPECIFIC INPUTS FOR INDIVIDUAL SUBSTANCES							Version: Model calibration check RBH203 to LKBH01 19/01/2023				Table X		Version: Model calibration check RBH203 to LKBH01 19/01/2023					
Table W			Soil Source for Impact on Groundwater						Groundwater Source (Level 3 Groundwater)		SUBSTANCE SPECIFIC INPUTS FOR INDIVIDUAL SUBSTANCES							
Contaminant	Target Concentration (CT) mg/l	Origin of CT:	Soil concentration for Level 3 soil sheet and soil impact results sheet (mg/kg)	Comment on soil source concentrations for Level 3 soil sheet and soil impact results	Option: Concentration of contaminant in contaminated discharge entering receptor (mg/l)	Comment on concentration of contaminant in contaminated discharge (entering receptor)	Option: Background concentration of contaminant in groundwater beneath site (mg/l)	Justification of background concentration of contaminant in groundwater beneath site	Initial contaminant concentration in groundwater at plume core (mg/l)	Comment on groundwater source concentrations	Contaminant	Organic carbon partition coefficient (Koc)	Source of Koc	Henry's Law constant (dimensionless)	Source of Henry's Law	Half life for degradation of contaminant in water (d)	Source of Half Life - Howard et al 1991, Handbook of Environmental Degradation Rates and CONSIM
Trichloroethene (TCE)	**0.01**	**Drinking Water Standards (DWS)**	0	NA	0.00E+00	Comment	0.00E+00	Assume background water not impacted	0418	RBH203 on 19/01/2023	**Trichloroethene (^CE)**	1.41E+02	SR7	1.87E-01	SR7	1.65E+03	*Howard et al high half life (aeraic conditions)*

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

Site Name: Plot NT02 Dantzic Street
Site Address: Plot NT02 Dantzic Street

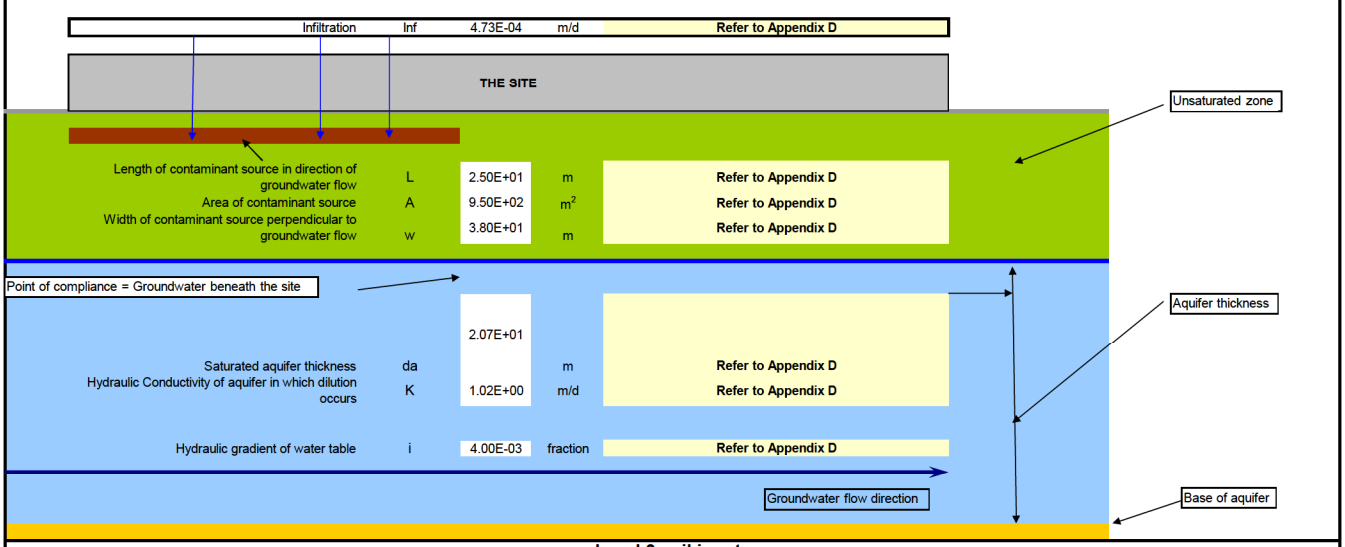
Completed by: Emma Atkinson
Date: 13-Jul-23
Version: Model calibration check RBH203 to LKBH01 19/01/2023

Level 1 soil inputs



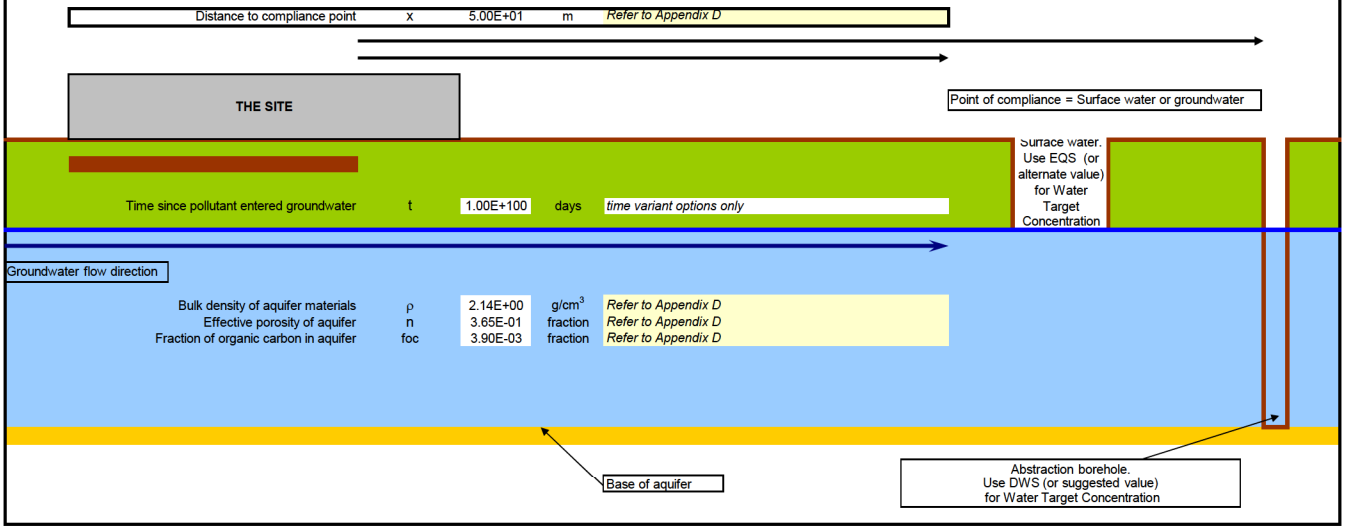
Water filled soil porosity	θ_w	3.70E-01	fraction	Refer to Appendix D
Air filled soil porosity	θa	3.00E-03	fraction	Refer to Appendix D
Bulk density of soil zone material	ρ	1.78E+00	g/cm^3	Refer to Appendix D
Fraction of organic carbon (in soil)	foc	5.06E-02	fraction	Refer to Appendix D

Level 2 soil inputs



Length of contaminant source in direction of groundwater flow	L	2.50E+01	m	Refer to Appendix D
Area of contaminant source	A	9.50E+02	m^2	Refer to Appendix D
Width of contaminant source perpendicular to groundwater flow	w	3.80E+01	m	Refer to Appendix D
Saturated aquifer thickness	da	2.07E+01	m	Refer to Appendix D
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.02E+00	m/d	Refer to Appendix D
Hydraulic gradient of water table	i	4.00E-03	fraction	Refer to Appendix D

Level 3 soil inputs



Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Bulk density of aquifer materials	ρ	2.14E+00	g/cm^3	*Refer to Appendix D*
Effective porosity of aquifer	n	3.65E-01	fraction	*Refer to Appendix D*
Fraction of organic carbon in aquifer	foc	3.90E-03	fraction	*Refer to Appendix D*

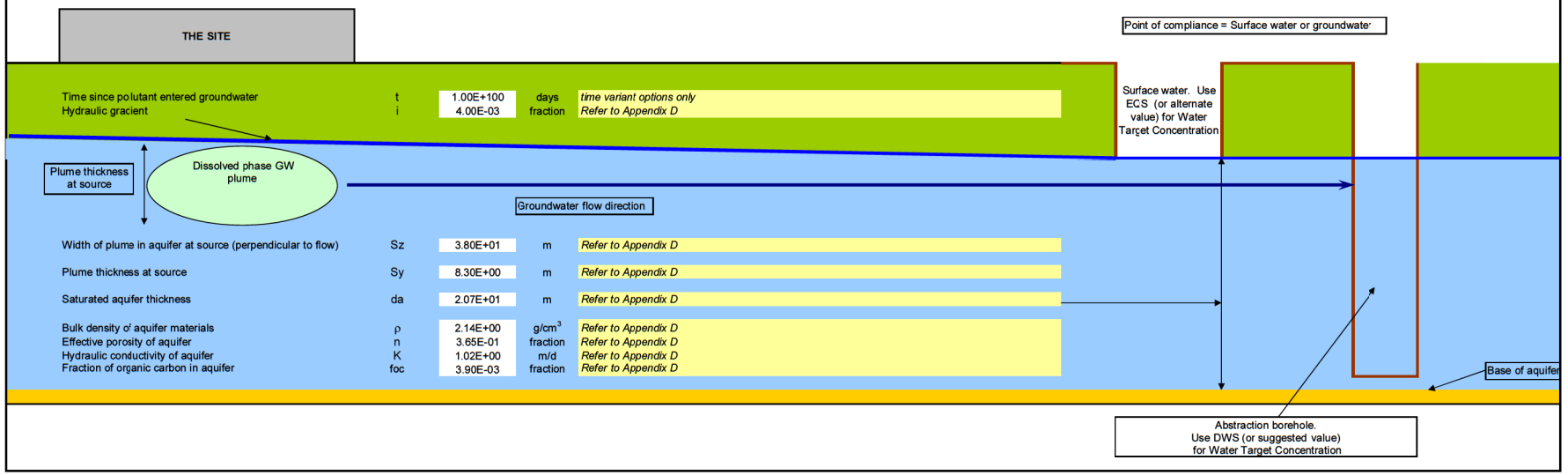
Input Parameters for RTM Worksheets for Controlled Waters Risk Assessment for a Dissolved Phase Source in Groundwater

Site Name: Plot NT02 Dantzic Street
Site Address: Plot NT02 Dantzic Street

Completed by: Emma Atkinson
Date: 13-Jul-23 **Version:** Model calibration check RBH203 to LKBH01 19/01/2023

Level 3 groundwater inputs

Distance (lateral) to compliance point perpendicular to flow direction	z	[redacted]	m	*Value is 0*
Distance (depth) to compliance point perpendicular to flow direction	y		m	*Value is 0*
Distance to compliance point	x	5.00E+01	m	*Refer to Appendix D*



Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Hydraulic gradient	i	4.00E-03	fraction	*Refer to Appendix D*
Width of plume in aquifer at source (perpendicular to flow)	Sz	3.80E+01	m	*Refer to Appendix D*
Plume thickness at source	Sy	8.30E+00	m	*Refer to Appendix D*
Saturated aquifer thickness	da	2.07E+01	m	*Refer to Appendix D*
Bulk density of aquifer materials	ρ	2.14E+00	g/cm^3	*Refer to Appendix D*
Effective porosity of aquifer	n	3.65E-01	fraction	*Refer to Appendix D*
Hydraulic conductivity of aquifer	K	1.02E+00	m/d	*Refer to Appendix D*
Fraction of organic carbon in aquifer	foc	3.90E-03	fraction	*Refer to Appendix D*

Site Name: Plot NT02 Dantzic Street
Site Address: Plot NT02 Dantzic Street

SUMMARY OF RESULTS FROM RTM WORKSHEETS Version: Model calibration check RBH203 to LKBH01 19/01/2023

TABLE Y		Remedial Targets for a Soil Source (soil & pore water concentrations)						Groundwater Source	Groundwater Source
Contaminant	Target Concentration (C_T) mg/l	Level 1 Remedial Target (soil concentrations) (mg/kg)	Level 1 Remedial Target (pore water and leachate) (mg/l)	Level 2 Remedial Target (soil concentrations) (mg/kg)	Level 2 Remedial Target (pore water and leachate) (mg/l)	Level 3 Remedial Target (soil concentrations) (mg/kg)	Level 3 Remedial Target (pore water and leachate) (mg/l)	Level 3 Remedial Target (groundwater concentrations) (mg/l)	Time for contaminant to reach receptor (years)
Trichloroethene (TCE)	0.01	7.35E-02	0.01	2.10E-01	2.85E-02	6.54E-01	8.89E-02	5.45E-02	52

Site Name:	**Plot NT02 Dantzic Street**	**Version:**	**Model calibration check RBH203 to LKBH01 19/01/2023**
Site Address:	**Plot NT02 Dantzic Street**		

SUMMARY OF RESULTS FROM RTM WORKSHEETS

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	0.00E+00	0.00E+00	0.00E+00	7.67E-02

Comparison of RTVs against measured concentrations in groundwater

COPC	Lab sample ID	22/09651/12	22/09651/13	22/09831/2	22/08782/1	22/08782/2	23/04296/7	23/04477/5	23/00479/2	23/00479/3	23/04510/2	22/09651/1	22/09651/2	22/09651/3	22/09651/4	22/09651/5	22/09831/1	23/00479/1	23/04296/6	23/04477/4	22/09651/7	22/09132/1	22/09651/8
	Borehole ID	LKBH01	LKBH01 (2) Dup	LKBH03	RBH205	RBH206	LKBH03	LK BH03	LKBH01	LKBH03	RBH306	RBH201	RBH201 (2) Dup	RBH202	RBH202 (2) Dup	RBH203	RBH203	RBH203	RBH203	RBH203	RBH205	RBH207	RBH207
	Depth to top	13	13	10	6.5	7	7.6	7.6	5.4	7.45	6	22	22	23	23	13	10	7.4	7.6	7.6	22	22	22.5
	Depth to bottom																						
	Date sampled	27/09/2022	27/09/2022	04/10/2022	02/09/2022	02/09/2022	04/05/2023	10/05/2023	19/01/2023	19/01/2023	11/05/2023	27/09/2022	27/09/2022	27/09/2022	27/09/2022	27/09/2022	04/10/2022	19/01/2023	04/05/2023	10/05/2023	27/09/2022	14/09/2022	27/09/2022
	Sample type																						
	RTV (mg/l)																						
Trichloroethene (TCE)	0.0545	0.002	0.002	0.25	<0.001	<0.001	0.043	0.039	0.002	0.08	<0.001	<0.001	<0.001	0.004	0.003	0.48	0.572	0.418	0.214	0.2	<0.001	<0.001	<0.001
Carbon tetrachloride (tetrachloromethane)	1.55	<0.001	<0.001	0.058	<0.001	<0.001	0.053	0.046	0.003	0.073	<0.001	<0.001	<0.001	<0.001	<0.001	0.095	0.104	0.265	0.164	0.107	<0.001	<0.001	<0.001
Cis/trans 1,2-dichloroethene (DCE)	0.138	0.49	0.485	0.003	<0.001	<0.001	0.003	0.004	0.602	0.006	<0.001	0.004	<0.001	<0.001	<0.001	0.002	0.002	0.004	0.004	0.003	<0.001	<0.001	<0.001
Vinyl Chloride (chloroethene)	0.0172	0.016	0.015	<0.001	<0.001	<0.001	<0.001	<0.001	0.011	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

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

Comparison of RTVs against measured concentrations in groundwater

COPC	Lab sample ID	22/09132/3	22/09651/9	22/09132/2	22/09651/10	22/09132/4	22/09651/11	23/04296/1	23/04477/1	23/04296/2	23/04477/2	23/04296/3	23/04477/3	23/04296/4	23/04510/1	23/04296/5	23/04510/3	Maximum concentration detected in groundwater (mg/l)	Total No. of groundwater samples analysed	Number of detects in groundwater above the RTV
	Borehole ID	RBH208	RBH208	RBH209	RBH209	RBH210	RBH210	RBH301	RBH301	RBH302	RBH302	RBH303	RBH303	RBH305	RBH305	RBH306	SS304			
	Depth to top	15.5	21.5	21.5	15.5	22	22	5.65	5.7	7.5	7.5	7.05	7.1	6.5	6.5	6				
	Depth to bottom																			
	Date sampled	14/09/2022	27/09/2022	14/09/2022	27/09/2022	14/09/2022	27/09/2022	04/05/2023	10/05/2023	04/05/2023	10/05/2023	04/05/2023	10/05/2023	04/05/2023	11/05/2023	04/05/2023	11/05/2023			
	Sample type																			
	RTV (mg/l)																			
Trichloroethene (TCE)	0.0545	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.003	0.277	0.221	0.003	<0.001	<0.001	<0.001	0.572	38	9
Carbon tetrachloride (tetrachloromethane)	1.55	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.207	0.159	0.038	0.022	0.002	<0.001	<0.001	<0.001	0.265	38	0
Cis/trans 1,2-dichloroethene (DCE)	0.138	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.086	0.102	0.001	0.001	0.081	0.084	<0.001	<0.001	<0.001	<0.001	0.602	38	3
Vinyl Chloride (chloroethene)	0.0172	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.016	38	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

Comparison of RTVs against measured concentrations in soil

COPC	Lab sample ID	22/07379/8	22/07002/5	22/07002/2	22/07217/6	22/07217/5	22/07217/2	22/07217/8	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
	Borehole ID	RBH203	TP202	TP203	TP214	TP215	TP216	TP218	TP307	TP310	WS202	WS203	WS204	WS210	WS301	WS301	WS301	WS301	WS301	WS302	WS302	WS302	WS302
	Depth to top	3	0.5	0.3	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
	Depth to bottom																						
	Date sampled	25/07/2022	13/07/2022	12/07/2022	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
	Sample type																						
	RTV (mg/kg)																						
Trichloroethene	0.21	0.006	0.012	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.03	<0.001	<0.001	0.067	0.026	0.017	0.043	<0.001	0.004	0.602	0.021	0.094
Carbon tetrachloride	0.108	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	<0.001	<0.001	0.003	<0.001	<0.001	<0.025	0.001	0.008

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

Comparison of RTVs against measured concentrations in soil

COPC	Lab sample ID	23/03602/1	23/03602/2	23/03602/3	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
	Borehole ID	WS303	WS303	WS303	WS303	WS304	WS304	WS304	WS304	WS305	WS305	WS306	WS306	WS306	WS307	WS308	WS308	WS308	WS309	WS309	WS309	WS309	WS310
	Depth to top	0.4	1.2	1.8	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
	Depth to bottom																						
	Date sampled	03/04/2023	03/04/2023	03/04/2023	03/04/2023	04/04/2023	04/04/2023	04/04/2023	04/04/2023	03/04/2023	03/04/2023	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	11/04/2023	05/04/2023
	Sample type																						
	RTV (mg/kg)																						
Trichloroethene	0.21	0.015	0.036	0.007	<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
Carbon tetrachloride	0.108	<0.001	<0.025	<0.001	<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

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

Comparison of RTVs against measured concentrations in soil

COPC	Lab sample ID	23/03602/36	23/03958/3	23/03602/37	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	WS311	WS311	WS312	WS312			
	Depth to top	0.4	1.8	0.6	1			
	Depth to bottom							
	Date sampled	05/04/2023	20/04/2023	05/04/2023	05/04/2023			
	Sample type							
	RTV (mg/kg)							
Trichloroethene	0.21	<0.001	<0.001	<0.025	<0.001	1.13	48	5
Carbon tetrachloride	0.108	<0.001	<0.001	<0.025	<0.001	0.038	48	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

COMPLEX CHALLENGES ...
MADE SIMPLE

APPENDIX J – SUPPORTING INFORMATION

Technical Note

Plot NT03 Network Rail Mound

for

Far East Consortium International Ltd



24/01/2023

CONTENTS

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1.0 Introduction

Further to our Phase 2 Site Investigation Report of 21 October 2022 (ref. 4328-ROC-ZZ-XX-RP-ES-P2-101), this Technical Note has been produced to further investigate the potential presence of a buried retaining wall behind the Network Rail (NR) mound located on Plot NT03.

During the previous phase of investigation several hand dug pits were completed on top of the NR mound spread along the likely alignment of any buried retaining structure, up to the boundary palisade fence with the live tracks. This included a location adjacent to the viaduct wall visible above ground in the western portion of the NR mound. Accessibility was also limited by the presence of vegetation at the time of the works. No evidence of any retaining wall was encountered during the works and the results were considered inconclusive in proving or disproving the existence of a buried retaining structure.

Therefore, further works were recommended to increase the confidence level of the presence or absence of a buried retaining structure. Permission was arranged with Network Rail to access the trackside area of the boundary fence and undertake additional hand dug inspection pits to increase the level of certainty in the potential presence of any buried retaining structure supporting the viaduct to the south of the NR mound. Hand dug trial pit positions were proposed across the entirety of length of the boundary fence covering both the northern and southern sides of the boundary fence and including the previously inaccessible eastern portion of the NR mound. These works have now been completed and the findings are detailed below.

2.0 Background Information / Site History

Plot NT03 is located off Dantzic Street, Manchester. The plot was until recently largely occupied by a topsoil mound owned by Ryan Topsoil Ltd, until this was removed in December 2022, the month preceding the works. While the southern portion of the plot is occupied by the Network Rail mound. The below extract (Figure 1) depicts the extents of the two mounds in July 2022.

Figure 1: NR Mound Extents



A review of historic mapping of this area indicates the Newtown Sidings were first constructed to the southeast of the site boundary between 1850 and 1891. Between 1891 and 1908 the sidings and railway were further extended up to the site's southern boundary and a signal box was constructed atop the current NR mound. Because the current NR mound first appears on the same map in which the railway viaduct was extended to the site boundary, it is not clear from historic records whether a new wall was constructed to support the extension of the viaduct to the site, or if the railway is supported by the mound itself at the site boundary. Similarly, the 1893 wall was not observed in this location.

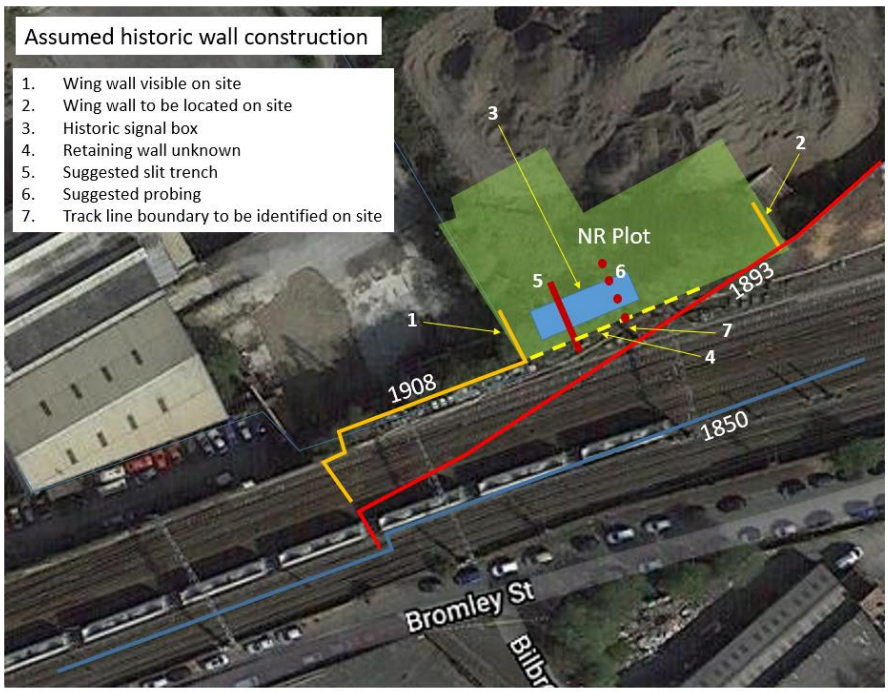
Review of aerial imagery dating from 1939 indicates a wall atop the mound but it is unclear if this wall is present below ground level mound acting as a retaining structure for the adjacent viaduct, or whether it is simply a boundary wall separating the track from the signal box. The signal box is believed to have been demolished at some point between 1968 and 1990 and the mound does not appear on maps in this period. However, mapping records dated 1980 to 1986 indicate a contour in the area of the mound indicating it was not removed along with the signal box.

Generally, the railway line and sidings elsewhere in plots NT02-04 are supported on a masonry viaduct structure along the site's southern boundary some 9 to 4.5m above the adjacent site level. It is not clear from the historic records whether this viaduct structure continues alongside the NR mound or whether it is the existing earth mound that is offering support to track level over this length.

Previous site investigations atop the mound failed to encounter any buried retaining structures. In order to satisfactorily investigate the presence or absence of a wall further work was proposed extending excavated areas south of the boundary fence and into the eastern portion of the mound.

The known information at this time, and hypothesized wall location, are illustrated in Figure 2 below. A summary of the history of the viaduct and mound, including extracts of the referenced historic maps, are provided within Appendix D of this technical note.

Figure 2: Assumed Historic Wall Construction



3.0 Site Investigation Fieldworks

Site investigation fieldworks were completed between the 9th and 11th of January 2023 by Contractors PM Sampling Ltd.

On the 9th of January the vegetation clearance was undertaken, and the site works area set up under supervision from Network Rail representatives. The site works perimeter was setup in such way as to prevent equipment toppling into track areas, or persons entering track areas. The boundary fence within the area of works was removed and temporarily made safe with Heras fencing. Upon completion of the works the palisade fencing was reinstated to an as found condition and the reinstatement approved by a NR engineer.

Information with respect to buried services was obtained from relevant providers prior to commencement of the investigation works. Network Rail also undertook a check of their service records for the site work area. Additionally, as a precaution all exploratory hole locations were scanned with a Cable Avoidance tool and Ground Penetrating Radar by the RSK Safe Ground team who specialise in service avoidance. Exploratory hole locations are presented on drawing 4328-ROC-ZZ-XX-DR-ES-ES111.

The site investigation works comprised the formation of five hand dug inspection pits to a maximum depth of 1.50mbgl using hand digging tools. Placement of the inspection pits was dictated by the most likely alignment of any retaining structure and extended excavations onto the previously inaccessible southern side of the boundary fence.

The soils encountered during excavation were described and logged by a suitably qualified engineer in accordance with BS 5930: Code of Practice for Site Investigations (the log sheets for which have been provided within Appendix B).

Services

A service trough carrying high voltage cables runs along the northern edge of the boundary fence. Network Rail have previously been consulted regarding this asset and advised that it was a live cable. No live electricity signal was detected during the works and the asset was traced along the entirety of the boundary fence using a CAT and GENNY so excavations could safely be carried out whilst avoiding the cables.

4.0 Encountered Ground Conditions

Buried Retaining Wall

Buried retaining wall structures were encountered in both HDP301 and HDP302. The similar alignment and form of the walls observed in these locations indicate that it is likely the same structure. Additionally, the form and alignment of the encountered buried walls appeared to match that of the adjacent 1893 siding wall.

Further investigations in the locations of HDP303 and 304 did not uncover further structures. Furthermore, at HDP305, which was located adjacent to the visible retaining wall in the western portion of the Network Rail mound, no evidence of any buried structures was observed.

The feature observed in HDP301 and HDP302, has been recorded through dimensional surveys and corresponds to the anticipated location of the 1893 siding wall. Extrapolating from the observed location, and as recorded on historic maps this would continue further to the southwest, outside the Network Rail approved work area. Consequently, the 1893 wall is anticipated to be present in its expected location, continuing beneath the existing tracks. Due to the method of investigation the foundation depth of this feature is unknown, as is its condition beneath the mound.

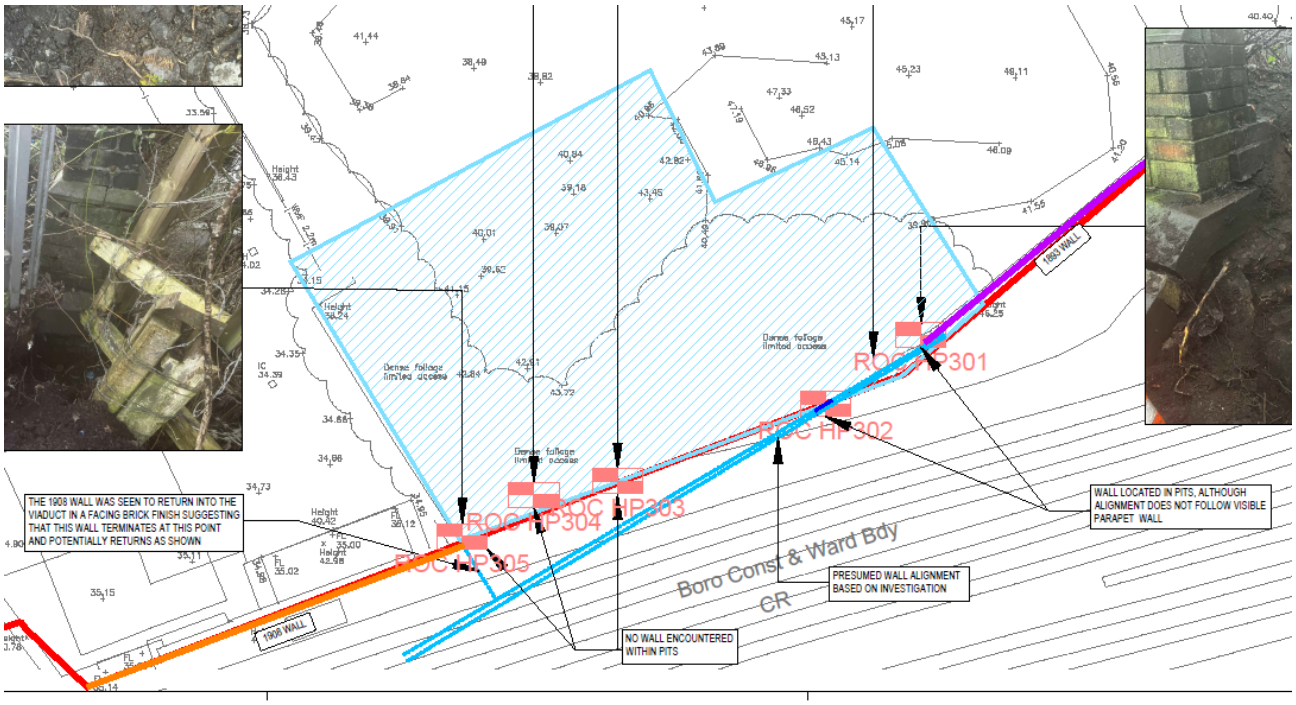
The absence of further observed features in HDP303 and 304, and in previous excavations in the vicinity, suggests that there is no evidence of the hypothesized outer 1908 wall behind the Network Rail land in this location. The absence of features in HDP305 is such that there is no evidence of a structure connecting the wall to the west of the site to the 1893 wall, although the use of facing brick at the end of the parapet wall in HDP305 might suggest otherwise. Consequently, it is feasible that there is an area of unretained land between the in front of the 1893 wall that is supported solely by the mound.

Images of the buried retaining wall and the hand dug inspection pits completed are contained within Appendix C of this technical note. Additionally drawing 4328-ROC-ZZ-XX-DR-ES-ES111 contained within Appendix A depicts the location of the exploratory holes as well as the encountered and assumed alignment of the buried retaining wall, based on dimensional surveys of the uncovered features. An extract of ES111 has been provided overleaf in figure 3.

Ground Conditions

The encountered ground conditions within the inspection pits formed as part of the investigation generally comprised a thin layer of topsoil (0.10 to 0.20mbgl) underlain by ballast material (0.30 to 0.60mbgl) which is likely overspill from the neighbouring railway tracks. This was in turn underlain by a predominantly loose slightly gravelly silty sand containing anthropogenic inclusions such as brick, coal, ballast, and railway sleepers this was encountered until the termination depth of all locations with the exception of HDP304 where reworked clay was encountered at a depth of 1.20mbgl to 1.40mbgl. No natural strata were encountered during the investigation. Log sheets have been provided for all exploratory hole locations and are contained within Appendix B.

Figure 3: NR Mound Retaining Wall Investigation (Extract from ES111)



5.0 Conclusions & Recommendations

Site investigations have uncovered a buried retaining wall structure in the eastern portion of the NR mound which runs in a roughly south-westerly direction from HDP301. This is believed to be the retaining wall visible on historic mapping dated 1893, which would not support all of the live track in this location. No clear evidence has been observed of further structures, such as the hypothesized 1908 wall, or a structure connecting the 1893 wall to the wall to the west of the site. It is therefore feasible that a volume of soil beneath the existing track side land is retained solely by the earth mound. The method of investigation of the work is such that the depth and condition of the 1893 wall remains unknown.

APPENDIX A – DRAWINGS

APPENDIX B – BOREHOLE LOGS

APPENDIX C – PHOTOGRAPHS

APPENDIX D – HISTORIC SUMMARY











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Generic assessment criteria (v-GAC) for indoor human health exposure

Background

RSK's vapour generic assessment criteria (v-GAC) are periodically revised when updated information on toxicological, land use, or receptor parameters is published.

A detailed framework for the assessment of VOC is provided in CIRIA C682[(1)], which describes the development and use of screening criteria for VOC present in soil, groundwater and soil vapour.

For soil it is recognised that for VOC, published Soil Guideline Values (SGV), Category 4 Screening Levels (C4SLs), or calculated generic assessment criteria (GAC) that include, or are specific to, indoor inhalation exposure pathways may be used as conservative screening criteria[(1)].

RSK has calculated GAC for VOC in soils for a variety of land uses using CLEA v1.071. The GACs are derived with reference to published data collated by LQM/CIEH in derivation of Suitable for Use Levels published in 2015 by Nathanial et al.,[(6)] as well as data collated by CL:AIRE, EIC and AGS [(7)]. RSK also utilise C4SLs based on Low Limits of Toxicological Concern (LLTCs) as published by CL:AIRE. For groundwater, RSK has calculated groundwater assessment criteria (GrAC) using the RBCA model (version 1.3b) updated to reflect UK guidance.

The following document summarises RSKs approach to developing GACs for soil vapour and indoor air in line with current UK guidance. A more detailed rationale is available on request.

Generic Soil Vapour Assessment Criteria (v-GAC)

RSK details herein the calculation of v-GAC to be used for screening soil vapour VOC concentrations for the protection of human health inhalation exposure within residential and commercial buildings.

The v-GAC are relevant to soil vapour VOC concentrations measured in the following scenarios:

- Open spaces, with planned future development;
- Near slab – i.e. close to, but outside, the building footprint; and
- Sub slab – i.e. directly beneath the building footprint.

It is important to note that v-GAC relate to soil vapour concentrations only.

Indoor air sampling data must be compared directly with relevant published or tolerable indoor air concentrations such as those in Table 3 or with relevant UK occupational exposure limits or air quality guideline values depending upon the purpose of the assessment.

Approach to Calculation of v-GAC

In line with recommendations[(9)] and the approach taken within the CLEA model, RSK has used the Johnson & Ettinger model[(10)] as the basis to estimate the v-GAC. Attenuation factors are calculated for the residential and commercial land uses based on building ventilation rates (Q_B) and the volumetric flow rate of soil vapour into the building (Q_{SOIL}).

The building ventilation rate Q_B has been calculated for various building types (residential and commercial) using building parameters provided in Tables 3.3 and 4.21 in SR3[(3)], and based on building air exchange rates (E_X) recommended in SR3[(3)] for residential properties (0.5 h^{-1}) and commercial properties (1.0 h^{-1}).

Values for the volumetric flow rate into the building (Q_{soil}) are stated in SR3[3], based on a combination of building parameters and soil type (crack/joint infill), and calculations provided in Appendix 1 of SR3[3], as 25 $cm^3\ s^{-1}$ and 150 $cm^3\ s^{-1}$ for the residential and commercial land uses, respectively based on default sandy loam soil properties.

The approach to calculating v-GAC taken by RSK therefore bypasses direct use of the full J&E model algorithm and uses a simple dilution relationship (Q_{soil} / Q_B), which is more conservative and suitable for screening purposes and is consistent with UK guidance and assumptions made in the derivation of SGVs [3] and other GAC [6,7].

Attenuation factors (α) have been calculated on the basis of the above and are presented in Table 1.

Table 1: α Attenuation Factors for a Variety of Residential and Commercial Buildings

Receptor	Building Living Space Height - H (m) [a]	Building Footprint A_{foot} (m^2) [a]	Building Air Exchange Rate (hr^{-1}) [a]	Building Ventilation Rate Q_B ($cm^3\ s^{-1}$) [b]	Soil Vapour Flow Rate into Building Q_{soil} ($cm^3\ s^{-1}$) [c]	Attenuation Factor - Alpha = Q_{soil}/Q_B [d]	Degree of Attenuation
Residential - Bungalow	2.4	78	0.5	22472	25	0.00096	1040
Residential - Small Terrace House	**4.8**	**28**	**0.5**	**9250**	**25**	**0.00134**	**747**
Residential - Medium/Large Terrace House	4.8	44	0.5	13694	25	0.00085	1173
Residential - Semi-Detached House	4.8	43	0.5	13417	25	0.00087	1147
Residential - Detached House	4.8	68	0.5	20361	25	0.00055	1813
Commercial - Warehouse (pre-1970)	5.2	1089	1	304222	150	0.00008	12584
Commercial - Warehouse (post-1970)	5.9	1914	1	533583	150	0.00004	25095
Commercial - Office (pre-1970)	**9.6**	**424**	**1**	**1130666**	**150**	**0.00013**	**7538**
Commercial - Office (post-1970)	13	610	1	173333	150	0.00006	17622

Notes:

[a] From Table 3.3 and 4.21, SR3[3]

[b] Equation 10.5, SR3[3]

[c] Generic flow rate, Section 10.3, SR3[3]

[d] Most conservative assumption where advection across foundation is rate limiting[8]

Calculation of v-GAC, specific to both chemical and building type, has been undertaken through division of the HCV, LLTC, or tolerable indoor air concentration as appropriate, specific to the critical receptor for a given end-use (e.g., residential or commercial), and the corresponding building-specific attenuation factor as follows:

$$\textbf{v-GAC} = \textbf{HCV} / \alpha$$

Health Criteria Values (HCV) and Tolerable Air Concentrations

The HCV and background inhalation has been taken from the relevant SGV report[12], published by Nathanial et al.,[6] EIC / CL:AIRE / AGS report[7], or from published C4SL LLTCs by CL:AIRE [13, 16, 17, 18] as appropriate.

The HCV have been amended to provide tolerable indoor air concentrations for commercial and residential scenarios as follows:

Commercial - An adult weighing 70kg and breathing 15.7m^3 air per day in accordance with the revised exposure parameters used in the SP1010 final project report for the Category 4 Screening Levels (C4SL) (Table 3.2[13]) and USEPA data[14]. Background inhalation (mean daily intake (MDI)) for an adult (Age Class 17).

Residential - A child weighing 13.3kg (average of 0-6 year old female in accordance with Table 4.6 of SR3[3]) and breathing 8.77m^3 (average daily inhalation rate for a 0-6yr old female in accordance with SP1010 final project report for the C4SL (Table 3.2[13]) and USEPA data[14]. Background inhalation (mean daily intake (MDI)) for a child (Age Classes 1-6).

The MDI for younger age groups following Table 3.4 and Section 3.4.1 of SR2[2]; are amended to reflect average daily inhalation rates in accordance with the C4SL methodology (Table 3.2[13]) and based on USEPA data[15]. The correction factors adopted for child MDI are presented in Table 2.

Table 2: Correction factors used to adjust adult MDI to younger age groups

Age Class	Body weight (kg)[1]	Inhalation rate (m^3/day)[2]	Correction factor for inhalation MDI[3]
1	5.6	5.4	0.34
2	9.8	8	0.51
3	12.7	8.9	0.57
4	15.1	10.1	0.64
5	16.9	10.1	0.64
6	19.7	10.1	0.64
17	70	15.7	-
Mean (AC1-6)	**13.3**	**8.8**	**0.56**

Notes
[1] Body weight from CLEA v1.06
[2] Inhalation rate from Table 3.2 of the SP1010 final project report for the C4SL[13]
[3] Inhalation correction factors are the ratio of the average male and female inhalation rates for each age class to the adult rate at age class 17 (age 16–59 years) and are based on the rates used by the Category 4 Screening Levels to derive the C4SLs[13],following the methodology in SR2[2].

Note on Trimethylbenzenes

It should be noted that the mean daily intake for trimethylbenzenes has been adjusted based on the average air concentration of 1,2,4-trimethylbenzene measured in 2015 at Eltham, south-east London of 0.309 ug m^{-3} and is considered by RSK to supersede the value adopted by CL:AIRE. The updated MDI results in respective inhalation HCV of 8.5 ug m^{-3} (0.0085 mg m^{-3}) for adults and 2.6 ug m^{-3} (0.0026 mg m^{-3}) for children. Due to the paucity of toxicological data for 1,2,3-trimethylbenzene and 1,3,5-trimethylbenzene the modified HCV for 1,2,4-trimethylbenzene has been adopted for all trimethylbenzenes.

Calculated tolerable air concentrations based on modified health criterion values are provided in Table 3. The values can be adopted for comparison to contaminant concentrations in ambient air.

Table 3: Tolerable Air Concentrations

Tolerable Indoor Air Concentration (mg/m^3)[1]		
VOC / SVOC	**Child (Residential)**	**Adult (Commercial)**
MTBE	1.0803	3.2064
Benzene (C4SL)	0.0050	0.0062
Toluene	2.1164	6.2362
Ethylbenzene	0.1113	0.3301
Xylenes	0.0834	0.2609
Trimethylbenzenes	0.0026	0.0085
TPH Aliphatic EC5-EC6	3.7913	11.1465
TPH Aliphatic >EC6-EC8	3.7913	11.1465
TPH Aliphatic >EC8-EC10	0.2199	0.6465
TPH Aliphatic >EC10-EC12	0.2199	0.6465
TPH Aliphatic >EC12-EC16	0.2199	0.6465
TPH Aromatic >EC8-EC9 (styrene)	0.1820	0.5350
TPH Aromatic >EC8-EC10	0.0455	0.1338
TPH Aromatic >EC10-EC12	0.0455	0.1338
TPH Aromatic >EC12-EC16	0.0455	0.1338
Acenaphthene	0.0910	0.2675
Acenaphthylene	0.0910	0.2675
Naphthalene	0.0011	0.0037
Vinyl chloride (C4SL)	0.0087	0.0255
Dichloroethane-1,2	0.0002	0.0005
Tetrachloroethene (C4SL)	0.0152	0.0478
Carbon tetrachloride	0.0025	0.0114
Trichloroethane-1,1,1	0.9099	2.6752
Trichloroethene (C4SL)	0.0018	0.0054
Tetrachloroethane 1,1,2,2 & 1,1,1,2	0.0086	0.0257
1,1,2-Trichloroethane	0.0073	0.0216
1,1-dichloroethane	0.3030	0.8915
1,1-dichloroethene	0.0864	0.2541
Chloroethane	4.3318	12.7374
Chloromethane	0.0039	0.0115
cis-1,2-dichloroethene	0.0087	0.0264
Dichloromethane	0.1781	0.5765
trans-1,2-dichloroethene	0.0253	0.0754
Trichloromethane (chloroform)	0.0570	0.1752
Mercury Elemental	0.000089	0.00027
Mercury Methyl	0.0003	0.0008

C4SL denotes value based on published inhalation Lower Limit of Toxicological Concern
TPH aromatic >C5-7 and aromatic >C7-C8 comprise benzene and toluene respectively.
[1] Inhalation HCV has taken account of background inhalation for threshold compounds only.
[2] It should be noted that the tolerable air concentrations are for a commercial land use and adult receptor based on an assumed inhalation rate of 15.7m^3/day. Air quality standards based on inhalation of 20m^3/day or workplace exposure limits may also be appropriate subject to the site circumstances.

RSK v-GAC

RSK v-GAC are presented in Table 4 for residential and commercial end-uses for common VOC and have also been calculated for common semi-volatile organic chemicals (sVOC), which may also have the potential to pose inhalation exposure risks.

RSK v-GAC listed in Table 4 have been calculated for the standard residential (small, terraced house) and commercial buildings (pre-1970's office).

Table 4: RSK v-GAC – Single Exposure Route

Volatile Organic Compound	v-GAC (mg/m^3)	
	Residential (Small Terrace House)	Commercial (Office pre-1970)
Attenuation factor	**0.00134**	**0.00013**
Methyl tert-butyl ether	807	24169
Benzene (C4SL)	3.74	47
Toluene	1580	47007
Ethylbenzene	83.1	2488
Xylenes	62.3	1967
Trimethylbenzenes	1.9	64
TPH Aliphatic EC5-EC6	2831	84020
TPH Aliphatic >EC6-EC8	2831	84020
TPH Aliphatic >EC8-EC10	164	4873
TPH Aliphatic >EC10-EC12	164	4873
TPH Aliphatic >EC12-EC16	164	4873
TPH Aromatic >EC8-EC9 (styrene)	34	1008
TPH Aromatic >EC8-EC10	34	1008
TPH Aromatic >EC10-EC12	34	1008
Phenanthrene	14	420
Pyrene	34	1008
Naphthalene	0.82	28
Vinyl chloride (C4SL)	6.5	192
1,2-Dichloroethane	0.14	4.0
Tetrachloroethene (PCE) (C4SL)	11	274
Tetrachloromethane	1.85	360
1,1,1-Trichloroethane	679	86
Trichloroethene (TCE) (C4SL)	1.36	20165
Tetrachloroethane 1,1,2,2 & 1,1,1,2	6.5	40
1,1,2-Trichloroethane	5.4	194
1,1-dichloroethane	226	163
1,1-dichloroethene	65	6720
Chloroethane	3234	1915
Chloromethane	2.9	96011
cis-1,2-dichloroethene	6.5	86
Dichloromethane	133	199
trans-1,2-dichloroethene	19	4346
Trichloromethane (chloroform)	43	568
Mercury Elemental	0.07	1320
Mercury Methyl	0.22	163

C4SL denotes value based on published inhalation Lower Limit of Toxicological Concern
TPH aromatic >C5-7 and aromatic >C7-C8 comprise benzene and toluene respectively.

RSK v-GAC are simple screening criteria, derived in line with the principles of the CLEA model and the derivation of GAC, and are considered to be suitable for use in a GQRA for the following reasons:

- Calculation of attenuation factors is based on the conservation assumption that the source lies directly beneath the foundation and that no additional depletion via diffusion occurs, i.e. attenuation is attributed solely to the dilution of soil vapour as it moves through the foundation into indoor air
- Volumetric flow rate into buildings (Q_{soil}) is based on a combination of a sandy loam soil and parameters for a standard building type used in setting GACs
- Biodegradation of VOC is not taken into account. Biodegradation of petroleum hydrocarbons can potentially attenuate soil vapour concentrations and vapour intrusion by several orders of magnitude[15]. It should be noted however that the J&E model upon which the assessment is based may not be conservative for estimation of vapour intrusion risk from chlorinated solvent VOC.

Uncertainties and Limitations of Use

The use of the J&E model[10] is considered to be inappropriate for site conditions where NAPL is present and may not be suitably precautionary with modelling chlorinated hydrocarbons. The simplified RSK approach negates these limitations provided that representative soil vapour concentrations are measured in shallow soil near to the building foundation.

Use of the v-GAC should only be undertaken with **detailed knowledge of the conceptual model and an understanding of the potential limitations in data** for the site and should be used as part of a multiple lines of evidence approach to assessing vapour intrusion. The compounds listed in tables are not exhaustive and other VOC may have the potential to pose a risk.

The v-GAC are based on a sandy loam soil type consistent with the setting of GACs and therefore may not be precautionary where granular soils (i.e. gravels and sands) are present.

v-GAC may not be relevant or suitably protective where VOC migration is dominated by ground gas (carbon dioxide and methane) pressure driven flow or where other mechanisms leading to VOC exposure from soils (e.g., ingestion, dermal, dust inhalation) are active. v-GAC may also not be relevant where the direct impact of VOC sources occurs to foundation or building structures.

The conceptual model associated with the v-GAC does not consider vapour intrusion along drainage pipes/backfill and migration into a building.

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APPENDIX K – SOURCE – PATHWAY-RECEPTOR METHODOLOGY FOR CSM

Source – Pathway-Receptor methodology for CSM.

8.0.1 The results from the intrusive Phase 2 ground investigation have been used to complete a refined assessment of risks posed by ground contamination and ground stability issues beneath the site, building on the preliminary conceptual site model (CSM) and environmental risk assessment outlined in the Phase 1 Desktop Study. The current assessment considers the above risks both in terms of the site's current arrangement and usage, as well as any potential future development (and associated construction process).

8.0.2 The assessment has been collated with reference to various statutory and non-statutory guidance documents relating to land contamination and ground stability. Specifically, the assessment has been conducted in accordance with the Environment Agency Land Contamination Risk Management (LCRM) guidance relating to the "Tier 2 Generic Quantitative Risk assessment" process (revised April 2021).

8.0.3 In accordance with this method, a refined Conceptual Site Model has been prepared based on the results of the ground investigations findings This model is based around the Source / Pathway / Receptor methodology as outlined in Figure 8.0.

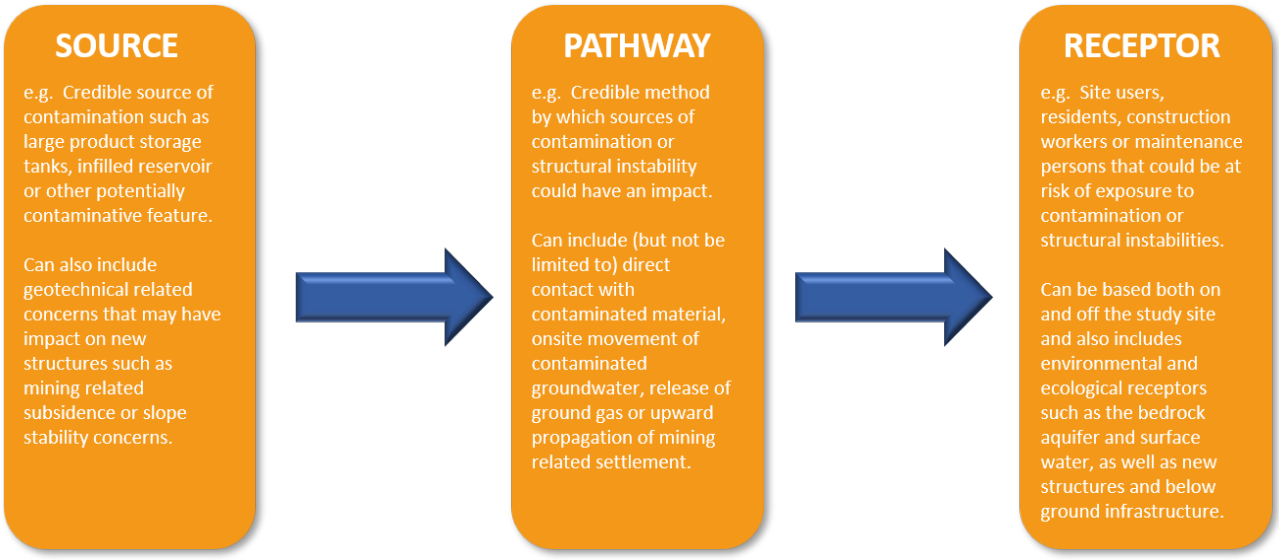


Figure 8.0 Source Pathway Receptor Diagram

8.0.4 Risk assessment is the process of collating known information on a hazard or set hazards in order to establish actual or potential risks to receptors. The receptor may be human health, controlled waters, a sensitive local ecosystem or property. Receptors can be connected (linked) with the hazard under consideration via one or several exposure pathways (e.g., the pathway of direct skin contact and oral exposure for a human health receptor

Without these three essential components of a source (hazard), a pathway and a receptor, which together constitute a pollution linkage, there is deemed to be no risk. In other words, the mere presence of a hazard at a site does not mean that there will necessarily be risks.

8.0.5 Risks are generally managed by either isolating or removing the hazard, isolating/removing the receptor, or by breaking the exposure (or linking) pathway.

8.0.6 Potential sources of contamination have been identified across the site based on the findings and the interpretation of the information obtained during all the previous ground investigations. These sources are defined based on the results from site investigation fieldworks and subsequent laboratory analysis of soil, soil gas and groundwater samples, and monitoring works. As previously discussed, the design of these investigations included judgemental elements of targeting known or suspected sources of contamination, based on the results of the Phase 1 Desktop Study as well as obtain site wide information on soil, groundwater, and ground gas.

8.0.7 The risk assessment has been completed with reference to the guidance outlined within CIRIA 552 "Contaminated land risk assessment. A good practice guide". This risk assessment methodology considers the potential consequence / severity (damage) of risks that may be present within soils in comparison with the likelihood (probability) of exposure to or and occurrence of said risk; i.e. the risk is equal to the likelihood (probability) multiplied by the severity (damage) A range of risk severity classifications are provided in Table 8.0 below, whilst Table 8.1 shows the range likelihood of risk; both Tables are based on CIRIA 552.

Table 8.0: Definition of Risk Class and Consequence

Risk Class	Definition	Example
Minor	Potential for harm, although not significant, which may result in financial loss to resolve. Ground conditions where the use of PPE would readily mitigate risks posed to human health.	Low level contamination hotspots within made ground / demolition fill materials. Stunted or impeded plant growth due to poor soil quality.
Mild	Pollution of non-sensitive water resources or damage to crops, plant growth, below ground utilities or structures.	Perched groundwater contamination overlying low permeability aquifer or aggressive sulphate concentrations in soils.
Medium	Sources of contamination identified on site have the potential to cause both long and short-term health effects on site residents / users. Alternatively (or in conjunction with) sources of contamination may have the potential to impact surface or groundwater quality or impede vegetation growth.	Elevated concentrations of hydrocarbon contamination reported within topsoil tested within residential gardens as a result of inadequate or incomplete previous remediation works. Movement of contaminated groundwater from leaking below ground storage tank into adjacent surface water course.
Severe	Sources of contamination pose a credible and acute risk to human health with potential for "Significant Harm" occurring as defined by the Part IIA of the Environmental Protection Act (1990). Alternatively (or in conjunction with risks posed to human health) sources of contamination may pose an immediate risk to controlled water resources or ecosystems.	Grossly contaminated soils are encountered or disturbed during excavation works, causing an immediate release of toxic soil vapour and leachate / contaminated groundwater flow across adjacent land.

Table 8.1: Probability Assessment

Classification	Definition
High likelihood	A credible pollutant linkage has been identified and it is very likely contaminants will impact identified receptors in both the short or long term (or is already actively doing so). The potential for harm to be caused is thus highly likely.
Likely	Pollutant linkages between the sources of contamination and identified receptors are present and it is considered likely they will become active given the right set of circumstances (e.g., contaminants currently buried below ground that are likely to be exposed or disturbed during construction / excavation works). The circumstances are such that an event is not inevitable, however it is possible in the short term and likely over the longer term.
Low likelihood	A theoretical pollutant linkage has been identified that has the potential to exposure receptors to contaminates under the correct circumstances. However, the likelihood of such an event occurring is not a certainty, even in the long term
Unlikely	There is no / minimal likelihood a pollutant linkage would occur, even over the long term.

8.0.9 Finally, Tables 8.2 and 8.3 respectively indicate how the actual nature of risk is defined and interpreted in the context of contaminated land risk assessment.

Table 8.2: Risk Definition

		Consequence			
		Severe	**Medium**	**Mild**	**Minor**
Probability	High Likelihood	Very High Risk	High Risk	Moderate Risk	Moderate / Low Risk
	Likely	High Risk	Moderate Risk	Moderate / Low Risk	Low Risk
	Low Likelihood	Moderate Risk	Moderate / Low Risk	Low Risk	Very Low Risk
	Unlikely	Moderate / Low Risk	Low Risk	Very Low Risk	

Table 8.3: Description of Risks Posed

Risk Definition	Description
Very High	Active pollutant linkages between a significant source of contamination and identified receptors have been establish and there is a high likelihood of severe harm occurring to said receptors unless immediate investigation and remediation action is not taken.
High Risk	Harm is likely to arise to receptors from an identified hazard in the short and long term. Urgent investigation of the contaminant issue will be required, and remedial treatment is likely.
Moderate Risk	The possibility of harm has been identified toward receptors under the right circumstances, although the severity of harm would be relatively mild. Further investigation of identified issues would be prudent and possible need for remedial measures in the long term.
Low Risk	It is possible harm could arise to a designated receptor from identified hazard, but it is likely (if realised) any harm would be (at worst) mild.

Very Low Risk	No significant pollutant linkages have been identified and the possibly of harm occurring to receptors is low.

8.0.10 A Preliminary desk-based risk assessment has been completed for the site utilising the current and historical environmental information available (refer to RoC Consulting report ref: 4328-ROC-ZZ-XX-RP-ES-PH1DTS).

8.0.11 The Tier 2 risk assessment process can be divided based on the receptor group in question between:

Human Health

Risks posed to human health by soil contamination (both construction persons and future site and adjacent site users).

Risks posed to human health by hazardous ground gas ingress (both construction persons and future site and adjacent users).

Controlled Waters

Risks posed to controlled waters by soil or groundwater contamination (both surface water features and bedrock aquifers).

Ecology

Risks posed to onsite and / or surrounding sensitive local ecosystems by soil or groundwater contamination, and aggressive ground chemical conditions.

Property

Risks posed to new building construction by aggressive ground chemical conditions (namely elevated sulphate concentrations).

8.0.12 It is noted the site is being developed for residential led end use without gardens but containing areas of soft landscaping. In the short term, before construction begins, Plot NT02 will also be in use as temporary event space.

8.0.13 Appropriate contamination assessments have been completed for each of the above utilising the latest statutory and non-statutory guidance documents; for details of risks posed to human health refer to Section 8.1 (soils) and Section 8.2 (ground gas), for details of risks posed to controlled waters refer to Section 8.3 and risks posed to new structures refer to Section 8.4.

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