



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

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

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

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

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

Details to be completed for each assessment

Site Name:	sladen mill: receptor-river roch		
Site Address:	halifax rd, littleborough		
Completed by:	tjb	Version:	3.2
Date:	12th apr 24		
Contaminant	PFOA (total)		
Target Concentration (C _T)	1.00E-04	mg/l	Origin of C _T : EQS freshwater based upon drinking water standards

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparison with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).

Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.

Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.

Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

Data carried forward from an earlier worksheet are identified by a light green background

It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

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

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	PFOA (total)		from Level 1
Target Concentration	C _T	1.00E-04	mg/l from Level 1

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

Domenico - Steady state Equations in HRA publication

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 2 directions

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

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	1.57E-04	mg/l	mean groundwater PFOA
Half life for degradation of contaminant in water	t _{1/2}	9.00E+99	days	no degradation
Calculated decay rate	λ	7.70E-101	days ⁻¹	
Width of plume in aquifer at source (perpendicular to flow)	Sz	2.00E+02	m	site width
Plume thickness at source	Sy	7.00E+01	m	site depth
Saturated aquifer thickness	da	7.10E+01	m	assume 71 m (site width)
Bulk density of aquifer materials	p	2.50E+00	g/cm ³	porosity calc
Effective porosity of aquifer	n	1.40E-01	fraction	porosity calc
Hydraulic gradient	i	1.50E-03	fraction	1 m in 650m
Hydraulic conductivity of aquifer	K	5.00E-04	m/d	mean lower coal measures
Distance to compliance point	x	6.50E+02	m	river roch adjacent Site
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+100	days	time variant options only
Parameters values determined from options				
Partition coefficient	Kd	2.44E-01	l/kg	see options
Longitudinal dispersivity	ax	6.50E+01	m	see options
Transverse dispersivity	az	6.50E+00	m	see options
Vertical dispersivity	ay	6.50E-01	m	see options

Calculated Parameters

Variable

Groundwater flow velocity	v	5.36E-06	m/d
Retardation factor	Rf	5.36E+00	fraction
Decay rate used	λ	1.44E-101	d ⁻¹
Rate of contaminant flow due to retardation	u	1.00E-06	m/d
Contaminant concentration at distance x, assuming two-way vertical dispersion	C ₁₀	8.76E-05	mg/l
Attenuation factor (two way vertical dispersion, CO/CED)	AF	1.79E+00	

Remedial Targets

Remedial Target	1.79E-04	mg/l	For comparison with measured groundwater concentration.
Domenico - Steady state			
Distance to compliance point	650	m	
Concentration of contaminant at compliance point	C ₁₀ /C ₀	8.76E-05	mg/l Domenico - Steady state

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



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

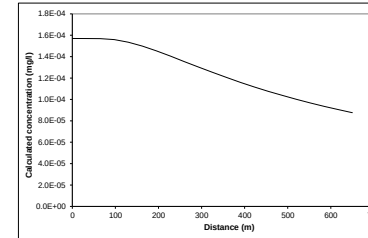
Calculate for ionic organic chemicals (acids)

Entry if specify partition coefficient (option)	Kd		l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)	foc		fraction
Fraction of organic carbon in aquifer			
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	K _{oc,n}	0.00E+00	l/kg
Sorption coefficient for ionised species	K _{oc,i}	2.44E-01	l/kg
pH value	pH	7.70E+00	
acid dissociation constant	pKa	3.20E+00	
Fraction of organic carbon in aquifer	foc	2.10E-02	fraction
Soil water partition coefficient	Kd	2.44E-01	l/kg

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

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

	Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	ax	6.50E+01	6.50E+01	6.50E+01
Transverse dispersivity	az	6.50E+00	6.50E+00	6.50E+00
Vertical dispersivity	ay	6.50E-01	6.50E-01	6.50E-01
Note values of dispersivity must be > 0				
For calculated value, assumes ax = 0.1 * x, az = 0.01 * x, ay = 0.001 * x				
Xu & Eckstein (1995) report ax = 0.83(log ₁₀ x) ^{-0.414} ; az = ax/10, ay = ax/100 are assumed				



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

Note

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

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

The measured groundwater concentration should be compared

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

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

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

Site being assessed: sladen mill, receptor-river roch
Completed by: qb
Date: 12th apr 24
Version: 3.2

Calculated concentrations for distance-concentration graph

Domenico - Steady state
From calculation sheet
Distance Concentration

	mg/l
0	1.6E-04
32.5	1.57E-04
65.0	1.57E-04
97.5	1.56E-04
130.0	1.54E-04
162.5	1.50E-04
195.0	1.45E-04
227.5	1.41E-04
260.0	1.35E-04
292.5	1.30E-04
325.0	1.25E-04
357.5	1.21E-04
390.0	1.16E-04
422.5	1.12E-04
455.0	1.08E-04
487.5	1.04E-04
520.0	1.00E-04
552.5	9.67E-05
585.0	9.35E-05
617.5	9.05E-05
650.0	8.76E-05

Porosity Calculator

These results are not carried through to any of the other worksheets

DRY BULK DENSITY DATA

Variable	Value	Unit	justification
Natural Moisture Content	8.35	% wt	(Change this number only if you have specific information)
Particle Density	2.65	tonnes/m ³	
Dry Bulk Density	2.17	tonnes/m ³	
Calculated Parameters			
Voids Ratio	0.22	fraction	
Initial Saturation	100.00	%	
Total porosity	0.181	fraction	
Air Filled Porosity	0.000	fraction	
Water Filled Porosity	0.181	fraction	

WET BULK DENSITY DATA

Variable	Value	Unit	
Moisture Content	3.77	% wt	(Change this number only if you have specific information)
Particle Density	2.65	tonnes/m ³	
Actual (wet) Bulk Density (i.e. at natural MC)	2.50	tonnes/m ³	
Calculated Parameters			
Voids Ratio	0.10	fraction	
dry bulk density	2.41	tonnes/m ³	
Initial Saturation	100.00	%	
Total porosity	0.091	fraction	
Air Filled Porosity	0.000	fraction	
Water Filled Porosity	0.091	fraction	

Simple hydrogeological calculations

(These are not specific to, or required in, the Remedial Targets Methodology)

Parameter	symbol	unit	justification
Hydraulic conductivity	K	5.00E-04 m/d	Banks & Jones, BGS 2021
Hydraulic gradient	i	1.50E-03 unitless	1 m head in 650 m
Effective porosity of aquifer	n	1.40E-01 fraction	porosity calculator
Thickness of saturated aquifer	b	7.10E+01 m	site depth
Width of aquifer perpendicular to flow	w	2.00E+02 m	site length
Distance to receptor	x	6.50E+02 m	0.65 km to roch valley
Bulk density of aquifer materials	ρ	2.50E+00 g/cm ³	
Soil-water partition co-efficient	Kd	1.80E+00 l/kg	PFAs non sorb
Retardation factor of pollutant	R	3.31E+01	

Groundwater flow velocity	v(GW)	6.20E-11 m/s	5.36E-06 m/day	1.96E-03 m/year
Time for groundwater to reach receptor	t(GW)	1.05E+13 seconds	1.21E+08 days	3.32E+05 years
Rate of groundwater flow through aquifer	Q	1.23E-07 m ³ /s	1.07E-02 m ³ /day	3.89E+00 m ³ /year

Contaminant flow velocity	v(contam)	1.87E-12 m/s	1.62E-07 m/day	5.90E-05 m/year
Time for contaminant to reach receptor	t(contam)	3.47E+14 seconds	4.02E+09 days	1.10E+07 years