



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.

© Environment Agency, 2006. (Produced by the Environment Agency's Science Group)

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

All rights reserved. You will not modify, reverse compile or otherwise dis-assemble the worksheet.

Liability: The Environment Agency does not promise that the worksheet will provide any particular facilities or functions. You must ensure that the worksheet meets your needs and you remain solely responsible for the competent use of the worksheet. You are entirely responsible for the consequences of any use of the worksheet and the Agency provides no warranty about the fitness for purpose or performance of any part of the worksheet. We do not promise that the media will always be free from defects, computer viruses, software locks or other similar code or that the operation of the worksheet will be uninterrupted or error free. You should carry out all necessary virus checks prior to installing on your computing system.

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:	Cardiff Road		
Site Address:	Reading		
Completed by:	PDM		
Date:	10-May-19	Version:	1
Contaminant	1,1, Dichloroethane		
Target Concentration (C _T)	0.03	mg/l	Origin of C _T : WHO

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.

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters

Variable	Value	Unit	Source
Contaminant	1,1-Dichloroethane		from Level 1
Target Concentration	0.03	mg/l	from Level 1
Dilution Factor	1.04E+00		from Level 2

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

Ogata Banks	Equations in HRA publication
-------------	------------------------------

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

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Enter source concentration

Variable	Value	Unit	Source of parameter value
Enter soil concentration	0.01	mg/kg	
Half life for degradation of contaminant in water	5.00E+02	days	Nobel Morgan The Effect of Contaminants C0
Calculated decay rate	1.39E-03	days ⁻¹	calculated
Width of plume in aquifer at source	1.00E+01	m	from Level 2
Plume thickness in aquifer at source	5.00E+01	m	from Level 2
Bulk density of aquifer materials	1.60E+00	g/cm ³	site data
Effective porosity of aquifer	4.24E-01	fraction	porosity cal
Hydraulic gradient	5.76E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	1.58E-03	m/d	from Level 2
Distance to compliance point	2.00E+01	m	Estimated Depth to water table
Distance (lateral) to compliance point perpendicular to flow direction		m	
Distance (depth) to compliance point perpendicular to flow direction		m	
Time since pollutant entered groundwater	9.90E+99	days	time variant options only

Parameters values determined from options

Partition coefficient	Kd	5.70E-03	l/kg	see options
Longitudinal dispersivity	ax	20.000	m	see options
Transverse dispersivity	az	10.000	m	see options
Vertical dispersivity	ay	1.000	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	2.15E-04 m/d
Retardation factor	Rf	1.02E+00
Decay rate used	λ	1.36E-03 d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	5.76E-02
Rate of contaminant flow due to retardation	u	2.10E-04 m/d
Ratio of Compliance Point to Source Concentration	C ₁₀ /C ₀	3.77E-06
Attenuation factor (C ₁₀ /C ₀)	AF	2.65E+05
Calculated soil leachate concentration	Co	3.91E-02 mg/l

Remedial Targets

Level 3 Remedial Target	8.25E+03	mg/l	For comparison with measured pore water concentration.
Ogata Banks	2.11E+03	mg/kg	This assumes Level 1 Remedial Target is based on Target Concentration.
Distance to compliance point	20	m	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₁₀ /C ₀	3.77E-06	Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	1.00E-04	fraction
Organic carbon partition coefficient	Koc	5.70E+01	l/kg
Sorption coefficient for related species	K _{oc,s}		l/kg
Sorption coefficient for ionised species	K _{oc,i}		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	5.70E-03	l/kg

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

User defined values for dispersivity

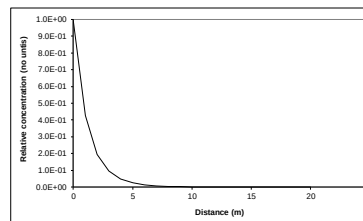
Enter value	Calc value	Xu & Eckstein	
2.00E+01	2.00E+00	1.57E+00	m
1.00E+01	2.00E-01	1.57E-01	m
1.00E+00	3.00E-02	1.67E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2-4.5}$; $az = ax/10$, $ay = ax/100$ are assumed

Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃⁻, SO₄²⁻ etc than an alternative solution should be used



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

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks

Distance	concentration (No units)	Concentration mg/l
0	1.0E+00	3.77E-02
1.0	4.28E-01	1.61E-02
2.0	1.93E-01	7.26E-03
3.0	9.43E-02	3.56E-03
4.0	4.82E-02	1.82E-03
5.0	2.53E-02	9.55E-04
6.0	1.35E-02	5.10E-04
7.0	7.30E-03	2.75E-04
8.0	3.98E-03	1.50E-04
9.0	2.19E-03	8.24E-05
10.0	1.21E-03	4.55E-05
11.0	6.70E-04	2.53E-05
12.0	3.73E-04	1.41E-05
13.0	2.08E-04	7.86E-06
14.0	1.17E-04	4.41E-06
15.0	6.56E-05	2.47E-06
16.0	3.69E-05	1.39E-06
17.0	2.08E-05	7.85E-07
18.0	1.18E-05	4.44E-07
19.0	6.65E-06	2.51E-07
20.0	3.77E-06	1.42E-07

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

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

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

Site being assessed: Cardiff Road

Completed by: PDM

Date: #####

Version: 1

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Variable	Value	Unit	Source
Contaminant	1,1, Dichloroethane		from Level 1
Target Concentration	3.00E-02	mg/l	from Level 1

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

Ogata Banks	Equations in HRA publication
-------------	------------------------------

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

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

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

			Source of parameter value
Initial contaminant concentration in groundwater at plume core	C ₀	9.40E-03	mg/l Site data
Half life for degradation of contaminant in water	t _{1/2}	5.00E+02	days Nobel Morgan The Effect of Contaminant
Calculated decay rate	λ	1.39E-03	days ⁻¹ Estimated from site data
Width of plume in aquifer at source (perpendicular to flow)	Sz	2.00E+01	m calculated from soil
Plume thickness at source	Sy	4.00E+01	m Estimated from site data
Saturated aquifer thickness	da	5.00E+01	m Site data
Bulk density of aquifer materials	ρ	1.60E+00	g/cm ³ porosity calc
Effective porosity of aquifer	n	4.24E-01	fraction Site data
Hydraulic gradient	i	1.80E-03	fraction Consim inputs for middle chalk vertical
Hydraulic conductivity of aquifer	K	1.58E-03	m/d Downgradient site boundary
Distance to compliance point	x	2.00E+01	m
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m
Time since pollutant entered groundwater	t	9.90E+99	days time variant options only
Parameters values determined from options			
Partition coefficient	Kd	5.70E-03	l/kg see options
Longitudinal dispersivity	ax	2.00E+00	m see options
Transverse dispersivity	az	2.00E-01	m see options
Vertical dispersivity	ay	2.00E-02	m see options

Calculated Parameters

Variable		
Groundwater flow velocity	v	6.71E-06 m/d
Retardation factor	Rf	1.02E+00 fraction
Decay rate used	λ	1.36E-03 d ⁻¹
Rate of contaminant flow due to retardation	u	6.57E-06 m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{ED}	6.59E-89 mg/l
Attenuation factor (one way vertical dispersion, COICED)	AF	1.43E+86

Remedial Targets

Remedial Target	4.28E+84	mg/l	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	20	m	
Concentration of contaminant at compliance point	C _{ED} /C ₀	6.59E-89	mg/l Ogata Banks
after		9.9E+99	days

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)		
Soil water partition coefficient	Kd	l/kg
Entry for non-polar organic chemicals (option)		
Fraction of organic carbon in aquifer	foc	fraction 1.00E-04
Organic carbon partition coefficient	Koc	l/kg 5.70E+01
Entry for ionic organic chemicals (option)		
Sorption coefficient for related species	K _{oc,n}	l/kg
Sorption coefficient for ionised species	K _{oc,i}	l/kg
pH value	pH	
acid dissociation constant	pKa	
Fraction of organic carbon in aquifer	foc	fraction
Soil water partition coefficient	Kd	5.70E-03 l/kg

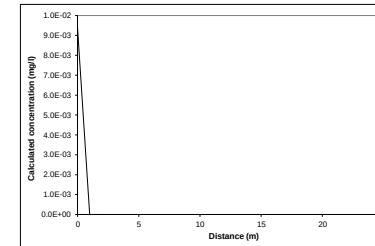
Define dispersivity (click brown cell and use pull down list)

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

	Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	ax	2.00E+01	2.00E+00	1.57E+00 m
Transverse dispersivity	az	1.00E+01	2.00E-01	1.57E-01 m
Vertical dispersivity	ay	5.00E+01	2.00E-02	1.57E-02 m

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 * x, az = 0.01 * x, ay = 0.001 * x
Xu & Eckstein (1995) report ax = 0.83(log₁₀x)^{0.414}; az = ax/10, ay = ax/100 are assumed



Calculated concentrations for distance-concentration graph

Ogata Banks

From calculation sheet

Distance	Concentration
	mg/l
0	9.4E-03
1.0	4.63E-07
2.0	2.28E-11
3.0	1.12E-15
4.0	5.53E-20
5.0	2.72E-24
6.0	1.34E-28
7.0	6.60E-33
8.0	3.25E-37
9.0	1.60E-41
10.0	7.87E-46
11.0	3.88E-50
12.0	1.91E-54
13.0	9.40E-59
14.0	4.63E-63
15.0	2.28E-67
16.0	1.12E-71
17.0	5.53E-76
18.0	2.72E-80
19.0	1.34E-84
20.0	6.59E-89

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

Note

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

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

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

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

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

Site being assessed: Cardiff Road
Completed by: PDM
Date: #####
Version: 1



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.

© Environment Agency, 2006. (Produced by the Environment Agency's Science Group)

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

All rights reserved. You will not modify, reverse compile or otherwise dis-assemble the worksheet.

Liability: The Environment Agency does not promise that the worksheet will provide any particular facilities or functions. You must ensure that the worksheet meets your needs and you remain solely responsible for the competent use of the worksheet. You are entirely responsible for the consequences of any use of the worksheet and the Agency provides no warranty about the fitness for purpose or performance of any part of the worksheet. We do not promise that the media will always be free from defects, computer viruses, software locks or other similar code or that the operation of the worksheet will be uninterrupted or error free. You should carry out all necessary virus checks prior to installing on your computing system.

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:	Cardiff Road		
Site Address:	Reading		
Completed by:	PDM		
Date:	10-May-19	Version:	1
Contaminant	1 3 Dichlorobenzene		
Target Concentration (C _T)	1	mg/l	Origin of C _T : WHO value of 1000µg/l for

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.

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters

Variable	Value	Unit	Source
Contaminant	1,3 Dichlorobenzene		from Level 1
Target Concentration	1	mg/l	from Level 1
Dilution Factor	1.04E+00		from Level 2

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

Ogata Banks	Equations in HRA publication
-------------	------------------------------

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

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Enter source concentration

Variable	Value	Unit	Source of parameter value
Enter soil concentration	0.01	mg/kg	
Half life for degradation of contaminant in water	3.60E+02	days	Howard, Boethling Farvis et al Handbook of
Calculated decay rate	1.93E-03	days ⁻¹	calculated
Width of plume in aquifer at source	1.00E+01	m	from Level 2
Plume thickness in aquifer at source	5.00E+01	m	from Level 2
Bulk density of aquifer materials	1.60E+00	g/cm ³	site data
Effective porosity of aquifer	4.24E-01	fraction	porosity cal
Hydraulic gradient	5.76E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	1.58E-03	m/d	from Level 2
Distance to compliance point	2.00E+01	m	Estimated Depth to water table
Distance (lateral) to compliance point perpendicular to flow direction		m	
Distance (depth) to compliance point perpendicular to flow direction		m	
Time since pollutant entered groundwater	9.90E+99	days	time variant options only

Parameters values determined from options

Partition coefficient	Kd	8.51E-02	l/kg	see options
Longitudinal dispersivity	ax	20.000	m	see options
Transverse dispersivity	az	10.000	m	see options
Vertical dispersivity	ay	1.000	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	2.15E-04 m/d
Retardation factor	Rf	1.32E+00
Decay rate used	λ	1.46E-03 d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	5.76E-02
Rate of contaminant flow due to retardation	u	1.63E-04 m/d
Ratio of Compliance Point to Source Concentration	C _{iw} /C ₀	4.97E-07
Attenuation factor (C _{iw} /C ₀)	AF	2.01E+06
Calculated soil leachate concentration	Co	2.98E-02 mg/l

Remedial Targets

Level 3 Remedial Target	2.08E+06	mg/l	For comparison with measured pore water concentration.
Ogata Banks	6.98E+05	mg/kg	This assumes Level 1 Remedial Target is based on Target Concentration.
Distance to compliance point	20	m	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C _{iw} /C ₀	4.97E-07	Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient

Kd

l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer

foc

1.00E-04 fraction

Organic carbon partition coefficient

Koc

8.51E+02 l/kg

Sorption coefficient for related species

K_{oc,s}

l/kg

Sorption coefficient for ionised species

K_{oc,i}

l/kg

pH value

pH

Acid dissociation constant

pKa

Fraction of organic carbon in aquifer

foc

fraction

Soil water partition coefficient

Kd

8.51E-02 l/kg

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

User defined values for dispersivity

Enter value Calc value Xu & Eckstein

2.00E+01 2.00E+00 1.57E+00 m

1.00E+01 2.00E-01 1.57E-01 m

1.00E+00 1.00E-01 1.57E-02 m

Longitudinal dispersivity ax

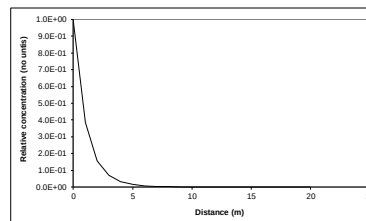
Transverse dispersivity az

Vertical dispersivity ay

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀x)^{-0.434}; az = ax/10, ay = ax/100 are assumed

Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃⁻, SO₄²⁻ etc than an alternative solution should be used

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

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks

From calculation sheet

Relative

Distance	concentration (No units)	Concentration mg/l
0	1.0E+00	2.88E-02
1.0	3.87E-01	1.11E-02
2.0	1.57E-01	4.53E-03
3.0	6.96E-02	2.00E-03
4.0	3.22E-02	9.26E-04
5.0	1.53E-02	4.39E-04
6.0	7.36E-03	2.12E-04
7.0	3.59E-03	1.03E-04
8.0	1.77E-03	5.10E-05
9.0	8.79E-04	2.53E-05
10.0	4.39E-04	1.26E-05
11.0	2.20E-04	6.33E-06
12.0	1.11E-04	3.19E-06
13.0	5.59E-05	1.61E-06
14.0	2.83E-05	8.15E-07
15.0	1.44E-05	4.14E-07
16.0	7.30E-06	2.10E-07
17.0	3.72E-06	1.07E-07
18.0	1.90E-06	5.47E-08
19.0	9.71E-07	2.80E-08
20.0	4.97E-07	1.43E-08

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

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

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

Site being assessed: Cardiff Road

Completed by: PDM

Date: #####

Version: 1

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Variable Value Unit Source

Contaminant **1 3 Dichlorobenzene** from Level 1
Target Concentration **C_T** **1.00E+00** mg/l from Level 1

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

Ogata Banks Equations in HRA publication

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

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

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

		Source of parameter value	
Initial contaminant concentration in groundwater at plume core	C ₀	9.40E-03	mg/l
Half life for degradation of contaminant in water	t _{1/2}	3.60E+02	days
Calculated decay rate	λ	1.93E-03	days ⁻¹
Width of plume in aquifer at source (perpendicular to flow)	Sz	2.00E+01	m
Plume thickness at source	Sy	4.00E+01	m
Saturated aquifer thickness	da	5.00E+01	m
Bulk density of aquifer materials	ρ	1.60E+00	g/cm ³
Effective porosity of aquifer	n	4.24E-01	fraction
Hydraulic gradient	i	1.80E-03	fraction
Hydraulic conductivity of aquifer	K	1.58E-03	m/d
Distance to compliance point	x	2.00E+01	m
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m
Time since pollutant entered groundwater	t	9.90E+99	days
Parameters values determined from options			
Partition coefficient	Kd	8.51E-02	l/kg
Longitudinal dispersivity	ax	2.00E+00	m
Transverse dispersivity	az	2.00E-01	m
Vertical dispersivity	av	2.00E-02	m

Calculated Parameters

Variable		
Groundwater flow velocity	v	6.71E-06 m/d
Retardation factor	Rf	1.32E+00
Decay rate used	λ	1.46E-03 d ⁻¹
Rate of contaminant flow due to retardation	u	5.08E-06 m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{ED}	1.15E-104 mg/l
Attenuation factor (one way vertical dispersion, COICED)	AF	8.17E+101

Remedial Targets

Remedial Target	8.17E+101	mg/l	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	20	m	
Concentration of contaminant at compliance point after	C _{ED} /C ₀	1.15E-104	mg/l
		9.9E+99	days

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

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

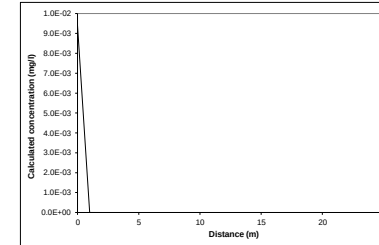
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)
Soil water partition coefficient Kd l/kg
Entry for non-polar organic chemicals (option)
Fraction of organic carbon in aquifer f_{oc} 1.00E-04 fraction
Organic carbon partition coefficient K_{oc} 8.51E+02 l/kg
Entry for ionic organic chemicals (option)
Sorption coefficient for related species K_{oc,n} l/kg
Sorption coefficient for ionised species K_{oc,i} l/kg
pH value pH
acid dissociation constant pKa
Fraction of organic carbon in aquifer f_{oc} fraction
Soil water partition coefficient Kd 8.51E-02 l/kg

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

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

Longitudinal dispersivity ax 2.00E+01 2.00E+00 1.57E+00 m
Transverse dispersivity az 1.00E+01 2.00E-01 1.57E-01 m
Vertical dispersivity ay 5.00E+01 2.00E-02 1.57E-02 m
Note values of dispersivity must be > 0
For calculated value, assumes ax = 0.1 * x, az = 0.01 * x, ay = 0.001 * x
Xu & Eckstein (1995) report ax = 0.83(log₁₀x)^{0.414}; az = ax/10, ay = ax/100 are assumed



Calculated concentrations for distance-concentration graph

Ogata Banks

From calculation sheet

Distance	Concentration
	mg/l
0	9.4E-03
1.0	7.54E-08
2.0	6.05E-13
3.0	4.86E-18
4.0	3.90E-23
5.0	3.13E-28
6.0	2.51E-33
7.0	2.01E-38
8.0	1.62E-43
9.0	1.30E-48
10.0	1.04E-53
11.0	8.35E-59
12.0	6.70E-64
13.0	5.37E-69
14.0	4.31E-74
15.0	3.46E-79
16.0	2.78E-84
17.0	2.23E-89
18.0	1.79E-94
19.0	1.43E-99
20.0	1.15E-104

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

Note

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

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

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

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

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

Site being assessed: Cardiff Road
Completed by: PDM
Date: #####
Version: 1



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.

© Environment Agency, 2006. (Produced by the Environment Agency's Science Group)

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

All rights reserved. You will not modify, reverse compile or otherwise dis-assemble the worksheet.

Liability: The Environment Agency does not promise that the worksheet will provide any particular facilities or functions. You must ensure that the worksheet meets your needs and you remain solely responsible for the competent use of the worksheet. You are entirely responsible for the consequences of any use of the worksheet and the Agency provides no warranty about the fitness for purpose or performance of any part of the worksheet. We do not promise that the media will always be free from defects, computer viruses, software locks or other similar code or that the operation of the worksheet will be uninterrupted or error free. You should carry out all necessary virus checks prior to installing on your computing system.

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:	Cardiff Road		
Site Address:	Reading		
Completed by:	PDM		
Date:	10-May-19	Version:	1
Contaminant	Cis 1,1 Dichloroethene		
Target Concentration (C _T)	0.05	mg/l	Origin of C _T : EQS (freshwater) and WHO Drinking Water

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.

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters

Contaminant	C ₁	Cis 1,1 Dichloroethene	from Level 1
Target Concentration	DF	0.05	mg/l from Level 1
Dilution Factor	DF	1.04E+00	from Level 2

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

Ogata Banks	Equations in HRA publication
-------------	------------------------------

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

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Enter source concentration

Enter soil concentration	Variable	Value	Unit	Source of parameter value
Half life for degradation of contaminant in water	t _{1/2}	0.01	mg/kg	Soil concentration as mg/kg
Calculated decay rate	λ	3.00E+03	days	Nobel Morgan The Effect of Contaminants C ₀
Width of plume in aquifer at source	Sz	2.31E-04	days ⁻¹	calculated
Plume thickness in aquifer at source	Sy	1.00E+01	m	from Level 2
Bulk density of aquifer materials	ρ	5.00E+01	m	from Level 2
Effective porosity of aquifer	n	1.60E+00	g/cm ³	site date
Hydraulic gradient	i	4.24E-01	fraction	porosity cal
Hydraulic conductivity of saturated aquifer	K	5.76E-02	fraction	from Level 2 (adjusted)
Distance to compliance point	x	1.58E-03	mld	from Level 2
Distance (lateral) to compliance point perpendicular to flow direction	z	2.00E+01	m	Estimated Depth to water table
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	9.90E+99	days	time variant options only

Parameters values determined from options

Partition coefficient	Kd	5.70E-03	l/kg	see options
Longitudinal dispersivity	ax	20.000	m	see options
Transverse dispersivity	az	10.000	m	see options
Vertical dispersivity	ay	1.000	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Groundwater flow velocity	v	2.15E-04	m/d
Retardation factor	Rf	1.02E+00	fraction
Decay rate used	λ	2.26E-04	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	5.76E-02	fraction
Rate of contaminant flow due to retardation	u	2.10E-04	m/d
Ratio of Compliance Point to Source Concentration	C ₁₀ /C ₀	3.07E-03	fraction
Attenuation factor (C ₁₀ /C ₀)	AF	3.25E+02	fraction
Calculated soil leachate concentration	C ₀	3.88E-02	mg/l

Remedial Targets

Level 3 Remedial Target	1.69E+01	mg/l	For comparison with measured pore water concentration.
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	4.35E+00	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	20	m	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C ₁₀ /C ₀	3.07E-03	fraction
			Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry If specify partition coefficient (option)

Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	1.00E-04	fraction
Organic carbon partition coefficient	Koc	5.70E+01	l/kg
Sorption coefficient for related species	K _{oc,1}		l/kg
Sorption coefficient for ionised species	K _{oc,i}		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	5.70E-03	l/kg

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

User defined values for dispersivity

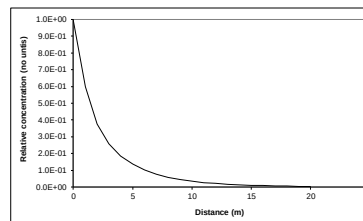
Longitudinal dispersivity	ax	Enter value	Calc value	Xu & Eckstein	m
Transverse dispersivity	az	2.00E+01	2.00E+00	1.97E+00	m
Vertical dispersivity	ay	1.00E+01	2.00E-01	1.97E-01	m
		1.00E+00	3.00E-02	1.67E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log₁₀x)^{-0.434}; az = ax/10, ay = ax/100 are assumed

Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃⁻, SO₄²⁻ etc than an alternative solution should be used



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

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks

Distance	concentration (No units)	Concentration mg/l
0	1.0E+00	3.74E-02
1.0	5.98E-01	2.24E-02
2.0	3.76E-01	1.41E-02
3.0	2.58E-01	9.65E-03
4.0	1.84E-01	6.90E-03
5.0	1.35E-01	5.06E-03
6.0	1.01E-01	3.78E-03
7.0	7.63E-02	2.85E-03
8.0	5.81E-02	2.18E-03
9.0	4.46E-02	1.67E-03
10.0	3.45E-02	1.29E-03
11.0	2.67E-02	1.00E-03
12.0	2.08E-02	7.80E-04
13.0	1.63E-02	6.09E-04
14.0	1.27E-02	4.77E-04
15.0	1.00E-02	3.75E-04
16.0	7.88E-03	2.95E-04
17.0	6.21E-03	2.33E-04
18.0	4.91E-03	1.84E-04
19.0	3.88E-03	1.45E-04
20.0	3.07E-03	1.15E-04

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

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

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

Site being assessed:	Cardiff Road
Completed by:	PDM
Date:	#####
Version:	1

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Variable Value Unit Source

Contaminant **Cis 1,1 Dichloroethene** from Level 1
Target Concentration **C_T** **5.00E-02** mg/l from Level 1

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

Ogata Banks Equations in HRA publication

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

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

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

		Source of parameter value	
Initial contaminant concentration in groundwater at plume core	C ₀	5.70E-03	mg/l Site data
Half life for degradation of contaminant in water	t _{1/2}	3.00E+03	days Nobel Morgan The Effect of Contaminant
Calculated decay rate	λ	2.31E-04	days ⁻¹ Estimated from site data
Width of plume in aquifer at source (perpendicular to flow)	Sz	2.00E+01	m calculated from soil
Plume thickness at source	Sy	4.00E+01	m Estimated from site data
Saturated aquifer thickness	da	5.00E+01	m Site data
Bulk density of aquifer materials	ρ	1.60E+00	g/cm ³ porosity calc
Effective porosity of aquifer	n	4.24E-01	fraction Site data
Hydraulic gradient	i	1.80E-03	fraction Consim inputs for middle chalk vertical
Hydraulic conductivity of aquifer	K	1.58E-03	m/d Downgradient site boundary
Distance to compliance point	x	2.00E+01	m
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m
Time since pollutant entered groundwater	t	9.90E+99	days time variant options only
Parameters values determined from options			
Partition coefficient	Kd	5.70E-03	l/kg see options
Longitudinal dispersivity	ax	2.00E+00	m see options
Transverse dispersivity	az	2.00E-01	m see options
Vertical dispersivity	av	2.00E-02	m see options

Calculated Parameters Variable

Groundwater flow velocity	v	6.71E-06	m/d
Retardation factor	Rf	1.02E+00	fraction
Decay rate used	λ	2.26E-04	d ⁻¹
Rate of contaminant flow due to retardation	u	6.57E-06	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{ED}	6.52E-37	mg/l
Attenuation factor (one way vertical dispersion, COICED)	AF	8.75E+33	

Remedial Targets

Remedial Target	4.37E+32	mg/l	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	20	m	
Concentration of contaminant at compliance point	C _{ED} /C ₀	6.52E-37	mg/l Ogata Banks
after		9.9E+99	days

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

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

Calculate for non-polar organic chemicals

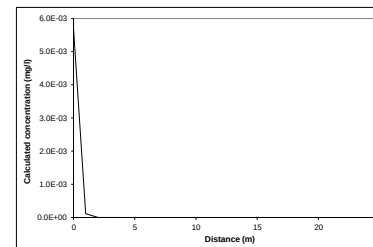
Entry if specify partition coefficient (option)
Soil water partition coefficient Kd l/kg
Entry for non-polar organic chemicals (option)
Fraction of organic carbon in aquifer f_{oc} 1.00E-04 fraction
Organic carbon partition coefficient K_{oc} 5.70E+01 l/kg
Entry for ionic organic chemicals (option)
Sorption coefficient for related species K_{oc,n} l/kg
Sorption coefficient for ionised species K_{oc,i} l/kg
pH value pH
acid dissociation constant pKa
Fraction of organic carbon in aquifer f_{oc} fraction
Soil water partition coefficient Kd 5.70E-03 l/kg

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

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

	Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	ax	2.00E+01	2.00E+00	1.57E+00
Transverse dispersivity	az	1.00E+01	2.00E-01	1.57E-01
Vertical dispersivity	ay	3.00E+01	2.00E-02	1.57E-02

Note values of dispersivity must be > 0
For calculated value, assumes ax = 0.1 * x, az = 0.01 * x, ay = 0.001 * x
Xu & Eckstein (1995) report ax = 0.83(log₁₀x)^{0.414}; az = ax/10, ay = ax/100 are assumed



Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	5.7E-03
1.0	1.14E-04
2.0	2.30E-06
3.0	4.62E-08
4.0	9.28E-10
5.0	1.86E-11
6.0	3.74E-13
7.0	7.52E-15
8.0	1.51E-16
9.0	3.03E-18
10.0	6.10E-20
11.0	1.22E-21
12.0	2.46E-23
13.0	4.94E-25
14.0	9.93E-27
15.0	1.99E-28
16.0	4.00E-30
17.0	8.04E-32
18.0	1.62E-33
19.0	3.25E-35
20.0	6.52E-37

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

Note

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

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

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

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

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

Site being assessed: Cardiff Road
Completed by: PDM
Date: #####
Version: 1



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.

© Environment Agency, 2006. (Produced by the Environment Agency's Science Group)

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

All rights reserved. You will not modify, reverse compile or otherwise dis-assemble the worksheet.

Liability: The Environment Agency does not promise that the worksheet will provide any particular facilities or functions. You must ensure that the worksheet meets your needs and you remain solely responsible for the competent use of the worksheet. You are entirely responsible for the consequences of any use of the worksheet and the Agency provides no warranty about the fitness for purpose or performance of any part of the worksheet. We do not promise that the media will always be free from defects, computer viruses, software locks or other similar code or that the operation of the worksheet will be uninterrupted or error free. You should carry out all necessary virus checks prior to installing on your computing system.

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:	Cardiff Road		
Site Address:	Reading		
Completed by:	PDM		
Date:	10-May-19	Version:	1
Contaminant	Trichloroethene		
Target Concentration (C _T)	0.01	mg/l	Origin of C _T : EQS (freshwater) and UK DWS

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.

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters

Variable	Value	Unit	Source
Contaminant	Trichloroethene		from Level 1
Target Concentration	0.01	mg/l	from Level 1
Dilution Factor	1.04E+00		from Level 2

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

Ogata Banks	Equations in HRA publication
-------------	------------------------------

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

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Enter source concentration

Variable	Value	Unit	Source of parameter value
Enter soil concentration	0.01	mg/kg	
Half life for degradation of contaminant in water	1.00E+03	days	Nobel Morgan The Effect of Contaminants C0
Calculated decay rate	6.93E-04	days ⁻¹	calculated
Width of plume in aquifer at source	1.00E+01	m	from Level 2
Plume thickness in aquifer at source	5.00E+01	m	from Level 2
Bulk density of aquifer materials	1.60E+00	g/cm ³	site date
Effective porosity of aquifer	4.24E-01	fraction	porosity cal
Hydraulic gradient	5.76E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	1.58E-03	m/d	from Level 2
Distance to compliance point	2.00E+01	m	Estimated Depth to water table
Distance (lateral) to compliance point perpendicular to flow direction		m	
Distance (depth) to compliance point perpendicular to flow direction		m	
Time since pollutant entered groundwater	9.90E+99	days	time variant options only

Parameters values determined from options

Partition coefficient	Kd	1.41E-02	l/kg	see options
Longitudinal dispersivity	ax	20.000	m	see options
Transverse dispersivity	az	10.000	m	see options
Vertical dispersivity	ay	1.000	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	2.15E-04 m/d
Retardation factor	Rf	1.05E+00
Decay rate used	λ	6.58E-04 d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	5.76E-02
Rate of contaminant flow due to retardation	u	2.04E-04 m/d
Ratio of Compliance Point to Source Concentration	C _{iw} /C ₀	1.04E-04
Attenuation factor (C _{iw} /C ₀)	AF	9.58E+03
Calculated soil leachate concentration	Co	3.75E-02 mg/l

Remedial Targets

Level 3 Remedial Target	9.93E+01	mg/l	For comparison with measured pore water concentration.
Ogata Banks			This assumes Level 1 Remedial Target is based on Target Concentration.
	2.65E+01	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	20	m	assumes Level 1 Remedial Target calculated from soil-water
Ratio of Compliance Point to Source Concentration	C _{iw} /C ₀	1.04E-04	partitioning equation.
			Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry If specify partition coefficient (option)

Soil water partition coefficient	Kd		l/kg
Fraction of organic carbon in aquifer	foc	1.00E-04	fraction
Organic carbon partition coefficient	Koc	1.41E+02	l/kg
Sorption coefficient for related species	K _{oc,s}		l/kg
Sorption coefficient for ionised species	K _{oc,i}		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.41E-02	l/kg

Entry for non-polar organic chemicals (option)

Entry for ionic organic chemicals (option)

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

User defined values for dispersivity

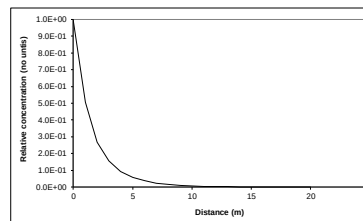
	Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	ax	2.00E+01	2.00E+00	1.97E+00 m
Transverse dispersivity	az	1.00E+01	2.00E-01	1.97E-01 m
Vertical dispersivity	ay	1.00E+00	3.00E-02	1.67E-02 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{-0.434}$; $az = ax/10$, $ay = ax/100$ are assumed

Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O₂, NO₃⁻, SO₄²⁻ etc than an alternative solution should be used



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

Calculated (relative) concentrations for distance-concentration graph

Distance	concentration (No units)	Concentration mg/l
0	1.0E+00	3.62E-02
1.0	5.05E-01	1.83E-02
2.0	2.68E-01	9.71E-03
3.0	1.55E-01	5.61E-03
4.0	9.37E-02	3.39E-03
5.0	5.81E-02	2.10E-03
6.0	3.66E-02	1.32E-03
7.0	2.33E-02	8.44E-04
8.0	1.50E-02	5.44E-04
9.0	9.74E-03	3.52E-04
10.0	6.35E-03	2.30E-04
11.0	4.16E-03	1.51E-04
12.0	2.74E-03	9.90E-05
13.0	1.81E-03	6.53E-05
14.0	1.19E-03	4.32E-05
15.0	7.92E-04	2.86E-05
16.0	5.26E-04	1.90E-05
17.0	3.50E-04	1.27E-05
18.0	2.34E-04	8.45E-06
19.0	1.56E-04	5.64E-06
20.0	1.04E-04	3.77E-06

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

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

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

Site being assessed:	Cardiff Road
Completed by:	PDM
Date:	#####
Version:	1

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Variable Value Unit Source

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

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

Ogata Banks Equations in HRA publication

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

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

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

		Source of parameter value	
Initial contaminant concentration in groundwater at plume core	C ₀	9.40E-03	mg/l Site data
Half life for degradation of contaminant in water	t _{1/2}	1.00E+03	days Nobel Morgan The Effect of Contaminant
Calculated decay rate	λ	6.93E-04	days ⁻¹ Estimated from site data
Width of plume in aquifer at source (perpendicular to flow)	Sz	2.00E+01	m calculated from soil
Plume thickness at source	Sy	4.00E+01	m Estimated from site data
Saturated aquifer thickness	da	5.00E+01	m Site data
Bulk density of aquifer materials	ρ	1.60E+00	g/cm ³ porosity calc
Effective porosity of aquifer	n	4.24E-01	fraction Site data
Hydraulic gradient	i	1.80E-03	fraction Consim inputs for middle chalk vertical
Hydraulic conductivity of aquifer	K	1.58E-03	m/d Downgradient site boundary
Distance to compliance point	x	2.00E+01	m
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m
Time since pollutant entered groundwater	t	9.90E+99	days time variant options only
Parameters values determined from options			
Partition coefficient	Kd	1.41E-02	l/kg see options
Longitudinal dispersivity	ax	2.00E+00	m see options
Transverse dispersivity	az	2.00E-01	m see options
Vertical dispersivity	ay	2.00E-02	m see options

Calculated Parameters Variable

Groundwater flow velocity	v	6.71E-06	m/d
Retardation factor	Rf	1.05E+00	fraction
Decay rate used	λ	6.58E-04	d ⁻¹
Rate of contaminant flow due to retardation	u	6.37E-06	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C _{ED}	4.68E-63	mg/l
Attenuation factor (one way vertical dispersion, COICED)	AF	2.01E+60	

Remedial Targets

Remedial Target	2.01E+58	mg/l	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	20	m	
Concentration of contaminant at compliance point	C _{ED} /C ₀	4.68E-63	mg/l Ogata Banks
after		9.9E+99	days

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

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

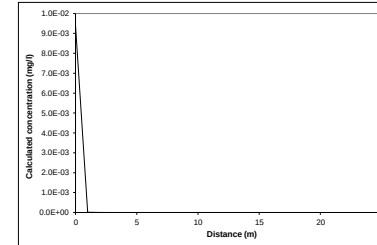
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)
Soil water partition coefficient K_d l/kg
Entry for non-polar organic chemicals (option)
Fraction of organic carbon in aquifer f_{oc} 1.00E-04 fraction
Organic carbon partition coefficient K_{oc} 1.41E+02 l/kg
Entry for ionic organic chemicals (option)
Sorption coefficient for related species K_{oc,n} l/kg
Sorption coefficient for ionised species K_{oc,i} l/kg
pH value pH
acid dissociation constant pKa
Fraction of organic carbon in aquifer f_{oc} fraction
Soil water partition coefficient K_d 1.41E-02 l/kg

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

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

Longitudinal dispersivity ax 2.00E+01 2.00E+00 1.57E+00 m
Transverse dispersivity az 1.00E+01 2.00E-01 1.57E-01 m
Vertical dispersivity ay 5.00E+01 2.00E-02 1.57E-02 m
Note values of dispersivity must be > 0
For calculated value, assumes ax = 0.1 * x, az = 0.01 * x, ay = 0.001 * x
Xu & Eckstein (1995) report ax = 0.83(log₁₀x)^{0.414}; az = ax/10, ay = ax/100 are assumed



Calculated concentrations for distance-concentration graph

Ogata Banks

From calculation sheet

Distance Concentration

Distance	Concentration
0	9.4E-03
1.0	9.08E-06
2.0	8.77E-09
3.0	8.47E-12
4.0	8.18E-15
5.0	7.90E-18
6.0	7.63E-21
7.0	7.36E-24
8.0	7.11E-27
9.0	6.87E-30
10.0	6.63E-33
11.0	6.41E-36
12.0	6.19E-39
13.0	5.97E-42
14.0	5.77E-45
15.0	5.57E-48
16.0	5.38E-51
17.0	5.20E-54
18.0	5.02E-57
19.0	4.85E-60
20.0	4.68E-63

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

Note

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

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

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

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

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

Site being assessed: Cardiff Road
Completed by: PDM
Date: #####
Version: 1



Enzygo specialise in a wide range of technical services:

Property and Sites
Waste and Mineral Planning
Waste Technologies and Renewables
Landscape and Visual Impact
Environmental Assessment Co-ordination
Hydrology and Flood Risk
Waste Contract Procurement
Noise and Vibration
Environmental Permitting and Regulation
Development Planning & Policy
Ecology Services
Contaminated Land and Geotechnical
Traffic and Transportation
Planning Services

BRISTOL OFFICE

The Byre,
Woodend Lane,
Cromhall,
Gloucestershire GL12 8AA
Tel: 01454 269 237

SHEFFIELD OFFICE

Samuel House,
5 Fox Valley Way,
Stocksbridge,
Sheffield S36 2AA
Tel: 0114 321 5151

MANCHESTER OFFICE

76 King Street,
Manchester,
M2 4NH
Tel: 0161 413 6444

Please visit our website for more information.

enzygo.com