

## Hydrogeological risk assessment for land contamination Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

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

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

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

<u>Details to be completed for each assessment</u>			
<b>Site Name:</b>	Fassaroe - Site 2		
<b>Site Address:</b>	Fassaroe Co. Wicklow		
<b>Completed by:</b>	Adrian Green	<b>Version:</b>	1
<b>Date:</b>	04-May-18		
<b>Contaminant</b>	Ammonia	<b>Origin of C<sub>T</sub>:</b>	Surface Water EQS & GW GTV
<b>Target Concentration (C<sub>T</sub>)</b>	0.065 mg/l		

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 2 - Soil

Contaminant Target concentration **C<sub>T</sub>** **Ammonia** from Level 1  
**0.065** mg/l from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

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

**Input Parameters** Variable Value Unit Source of parameter value

Standard entry

Infiltration Inf 1.84E-04 m/d  
 Area of contaminant source A 4.21E+04 m<sup>2</sup>

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow L 3.40E+02 m  
 Saturated aquifer thickness da 3.00E+01 m  
 Hydraulic Conductivity of aquifer in which dilution occurs K 1.00E+01 m/d  
 Hydraulic gradient of water table i 1.50E-01 fraction  
 Width of contaminant source perpendicular to groundwater flow w 1.35E+02 m  
 Background concentration of contaminant in groundwater beneath site Cu 0.00E+00 mg/l  
 Define mixing zone depth by specifying or calculating depth (using pull down list)  
 Enter mixing zone thickness Mz  
 Calculated mixing zone thickness Mz 3.00E+01 m

Not used in calculation

**Calculated Parameters**

Dilution Factor	DF	7.22E+02
Level 2 Remedial Target		4.69E+01 mg/l or 0.00E+00 mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration  
 For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor) Cc 0.00E+00 mg/l  
 Calculated concentration within receptor (dilution only) 0.00E+00 mg/l 0

Site being assessed: Fassaroe - Site 2  
 Completed by: Adrian Green  
 Date: 04-May-18  
 Version: 1

Remedial Targets Worksheet , Release 3.2



Level 3 - Soil

See Note

Input Parameters	Variable	Value	Unit	Source
Contaminant		Ammonia		from Level 1
Target Concentration	C <sub>T</sub>	0.065	mg/l	from Level 1
Dilution Factor	DF	7.22E+02		from Level 2

Enter method of defining partition co-efficient (using pull down list)  
Calculate for ionic organic chemicals (acids)

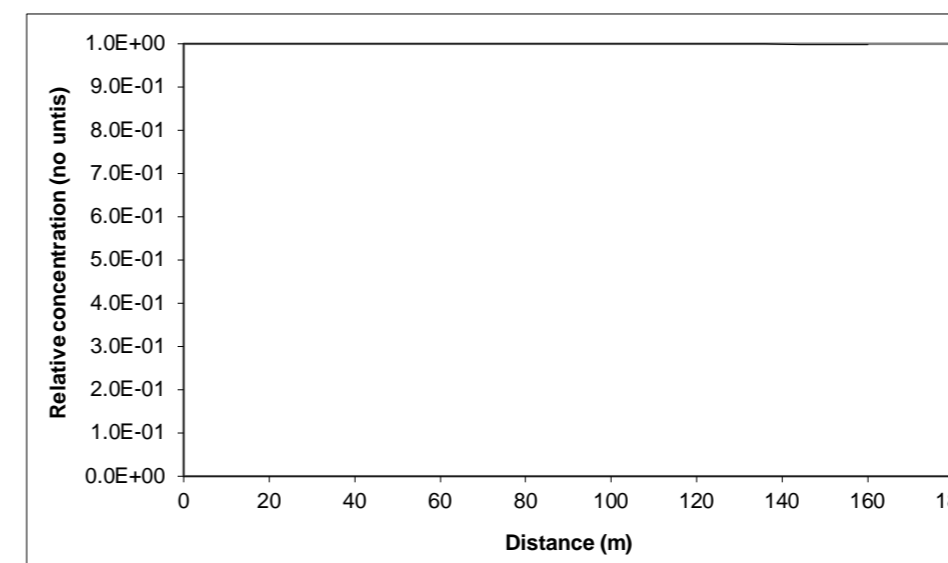
Select analytical solution (click on brown cell below, then on pull-down menu)

Domenico - Steady state 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

Soil water partition coefficient	K <sub>d</sub>		l/kg
Fraction of organic carbon in aquifer	f <sub>oc</sub>		fraction
Organic carbon partition coefficient	K <sub>oc</sub>		l/kg
Sorption coefficient for related species	K <sub>oc,n</sub>	0.00E+00	l/kg
Sorption coefficient for ionised species	K <sub>oc,i</sub>	0.00E+00	l/kg
pH value	pH		
Acid dissociation constant	pKa	0.00E+00	
Fraction of organic carbon in aquifer	f <sub>oc</sub>	0.00E+00	fraction
Soil water partition coefficient	K <sub>d</sub>	0.00E+00	l/kg



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

Calculated (relative) concentrations for distance-concentration graph

Distance	concentration (No units)	Concentration mg/l
0	1.0E+00	4.24E-01
8.0	1.00E+00	4.24E-01
16.0	1.00E+00	4.24E-01
24.0	1.00E+00	4.24E-01
32.0	1.00E+00	4.24E-01
40.0	1.00E+00	4.24E-01
48.0	1.00E+00	4.24E-01
56.0	1.00E+00	4.24E-01
64.0	1.00E+00	4.24E-01
72.0	1.00E+00	4.24E-01
80.0	1.00E+00	4.24E-01
88.0	1.00E+00	4.24E-01
96.0	1.00E+00	4.24E-01
104.0	1.00E+00	4.24E-01
112.0	1.00E+00	4.24E-01
120.0	9.99E-01	4.24E-01
128.0	9.99E-01	4.23E-01
136.0	9.99E-01	4.23E-01
144.0	9.98E-01	4.23E-01
152.0	9.98E-01	4.23E-01
160.0	9.97E-01	4.23E-01

Variable	Value	Unit	Source of parameter value
Soil leachate concentration as mg/l			
Enter soil leachate concentration	306	mg/l	
Half life for degradation of contaminant in water	1.00E+99	days	
Calculated decay rate	6.93E-100	days <sup>-1</sup>	calculated
Width of plume in aquifer at source	1.35E+02	m	from Level 2
Plume thickness in aquifer at source	3.00E+01	m	from Level 2
Bulk density of aquifer materials	1.50E+00	g/cm <sup>3</sup>	
Effective porosity of aquifer	1.00E-01	fraction	
Hydraulic gradient	1.50E-01	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	1.00E+01	m/d	from Level 2
Distance to compliance point	1.60E+02	m	
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	7.30E+03	days	time variant options only
Parameters values determined from options			
Partition coefficient	0.00E+00	l/kg	see options
Longitudinal dispersivity	16.000	m	see options
Transverse dispersivity	1.600	m	see options
Vertical dispersivity	0.160	m	see options

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

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

	Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	ax	0.00E+00	1.60E+01	5.99E+00 m
Transverse dispersivity	az	0.00E+00	1.60E+00	5.99E-01 m
Vertical dispersivity	ay	0.00E+00	1.60E-01	5.99E-02 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log<sub>10</sub>x)<sup>2.414</sup>; az = ax/10, ay = ax/100 are assumed

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Groundwater flow velocity	v	1.50E+01	m/d
Retardation factor	Rf	1.00E+00	fraction
Decay rate used	λ	6.93E-100	d <sup>-1</sup>
Hydraulic gradient used in aquifer flow down-gradient	i	1.50E-01	fraction
Rate of contaminant flow due to retardation	u	1.50E+01	m/d
Ratio of Compliance Point to Source Concentration	C <sub>ED</sub> /C <sub>0</sub>	9.97E-01	fraction
Attenuation factor (C <sub>0</sub> /C <sub>ED</sub> )	AF	1.00E+00	fraction
Soil leachate concentration	C <sub>0</sub>	3.06E+02	

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 O<sub>2</sub>, NO<sub>3</sub>, SO<sub>4</sub> etc then an alternative solution should be used

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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:	Fassaroe - Site 2
Completed by:	Adrian Green
Date:	#####
Version:	1

Remedial Targets

Level 3 Remedial Target	4.71E+01	mg/l	For comparison with measured pore water concentration.
Domenico - Steady state	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	0.00E+00	mg/kg	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Distance to compliance point	160	m	
Ratio of Compliance Point to Source Concentration	C <sub>ED</sub> /C <sub>0</sub>	9.97E-01	fraction 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

R&D Publication 20 Remedial Targets Worksheet, Release 3.2



Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant	Ammonia	from Level 1
Target Concentration	C <sub>T</sub> 6.50E-02	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 1 direction

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

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

Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C <sub>0</sub> 4.24E-01	mg/l	
Half life for degradation of contaminant in water	t <sub>1/2</sub> 1.00E+99	days	
Calculated decay rate	λ 6.93E-100	days <sup>-1</sup>	
Width of plume in aquifer at source (perpendicular to flow)	Sz 1.35E+02	m	
Plume thickness at source	Sy 2.98E+01	m	
Saturated aquifer thickness	da 3.00E+01	m	
Bulk density of aquifer materials	ρ 1.50E+00	g/cm <sup>3</sup>	
Effective porosity of aquifer	n 1.00E-01	fraction	
Hydraulic gradient	i 1.50E-01	fraction	
Hydraulic conductivity of aquifer	K 1.00E+01	m/d	
Distance to compliance point	x 1.60E+02	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t 7.30E+03	days	time variant options only
<i>Parameters values determined from options</i>			
Partition coefficient	Kd 0.00E+00	l/kg	see options
Longitudinal dispersivity	ax 1.60E+01	m	see options
Transverse dispersivity	az 1.60E+00	m	see options
Vertical dispersivity	ay 1.60E-01	m	see options

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v 1.50E+01	m/d
Retardation factor	Rf 1.00E+00	fraction
Decay rate used	λ 6.93E-100	d <sup>-1</sup>
Rate of contaminant flow due to retardation	u 1.50E+01	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C <sub>ED</sub> 4.23E-01	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF 1.00E+00	

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

User specified value for partition coefficient

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

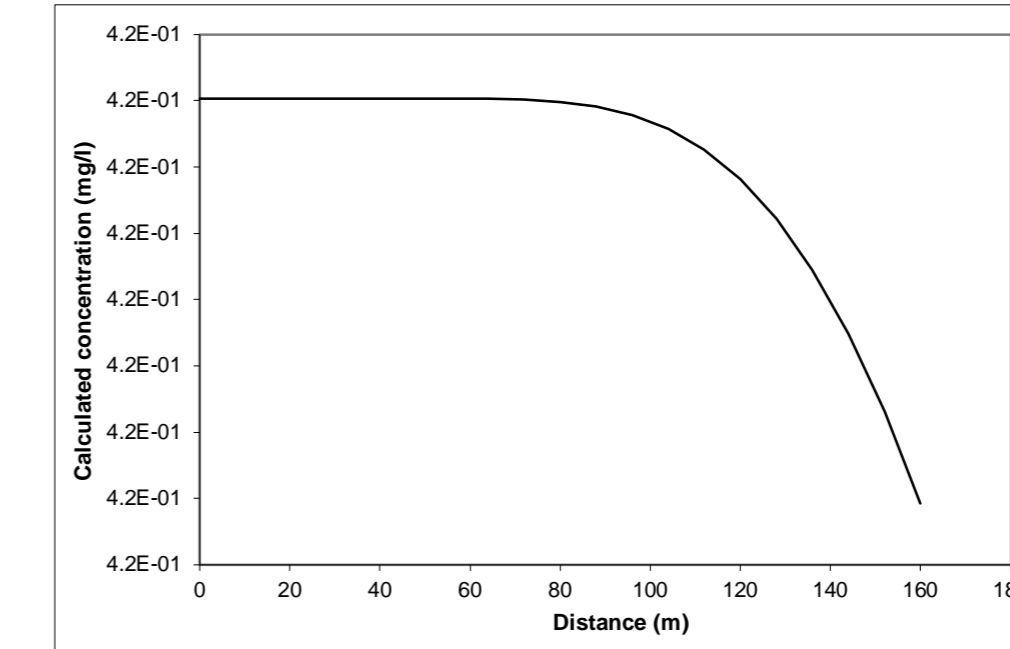
Define dispersivity (click brown cell and use pull down list)

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

Enter value	Calc value	Xu & Eckstein	m
ax 0.00E+00	1.60E+01	5.99E+00	m
az 0.00E+00	1.60E+00	5.99E-01	m
ay 0.00E+00	1.60E-01	5.99E-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(log<sub>10</sub>x)<sup>2.414</sup>; az = ax/10, ay = ax/100 are assumed

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Calculated concentrations for distance-concentration graph

Domenico - Steady state  
From calculation sheet

Distance	Concentration
0	4.2E-01
8.0	4.24E-01
16.0	4.24E-01
24.0	4.24E-01
32.0	4.24E-01
40.0	4.24E-01
48.0	4.24E-01
56.0	4.24E-01
64.0	4.24E-01
72.0	4.24E-01
80.0	4.24E-01
88.0	4.24E-01
96.0	4.24E-01
104.0	4.24E-01
112.0	4.24E-01
120.0	4.24E-01
128.0	4.23E-01
136.0	4.23E-01
144.0	4.23E-01
152.0	4.23E-01
160.0	4.23E-01

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 O<sub>2</sub>, NO<sub>3</sub>, SO<sub>4</sub> etc than an alternative solution should be used

Site being assessed:	Fassaroe - Site 2
Completed by:	Adrian Green
Date:	#####
Version:	1

Remedial Targets

Remedial Target	Value	Unit	Notes
Domenico - Steady state	6.52E-02	mg/l	For comparison with measured groundwater concentration.
Distance to compliance point	160	m	
Concentration of contaminant at compliance point	C <sub>ED</sub> /C <sub>0</sub> 4.23E-01	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.



## Hydrogeological risk assessment for land contamination Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

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

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

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

<u>Details to be completed for each assessment</u>			
<b>Site Name:</b>	Fassaroe - Site 2		
<b>Site Address:</b>	Fassaroe Co. Wicklow		
<b>Completed by:</b>	Adrian Green	<b>Version:</b>	1
<b>Date:</b>	04-May-18		
<b>Contaminant</b>	Ammonia	<b>Origin of C<sub>T</sub>:</b>	Surface Water EQS & GW GTV
<b>Target Concentration (C<sub>T</sub>)</b>	0.065 mg/l		

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.

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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 2 - Soil

Contaminant Target concentration **C<sub>T</sub>** **Ammonia** from Level 1  
**0.065** mg/l from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

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

**Input Parameters** Variable Value Unit Source of parameter value

Standard entry

Infiltration	Inf	1.57E-03	m/d	
Area of contaminant source	A	4.21E+04	m <sup>2</sup>	

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow	L	3.40E+02	m	
Saturated aquifer thickness	da	3.00E+01	m	
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.00E+01	m/d	
Hydraulic gradient of water table	i	1.50E-01	fraction	
Width of contaminant source perpendicular to groundwater flow	w	1.35E+02	m	
Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l	
		<b>Calculate</b>		
Enter mixing zone thickness	Mz		m	
Calculated mixing zone thickness	Mz	3.00E+01	m	

Not used in calculation

**Calculated Parameters**

Dilution Factor	DF	8.53E+01	
Level 2 Remedial Target		5.54E+00	mg/l
		or	
		0.00E+00	mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration  
 For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Fassaroe - Site 2
Completed by:	Adrian Green
Date:	04-May-18
Version:	1

Remedial Targets Worksheet , Release 3.2



Level 3 - Soil

See Note

Input Parameters	Variable	Value	Unit	Source
Contaminant		Ammonia		from Level 1
Target Concentration	C <sub>T</sub>	0.065	mg/l	from Level 1
Dilution Factor	DF	8.53E+01		from Level 2

Enter method of defining partition co-efficient (using pull down list)  
Calculate for ionic organic chemicals (acids)

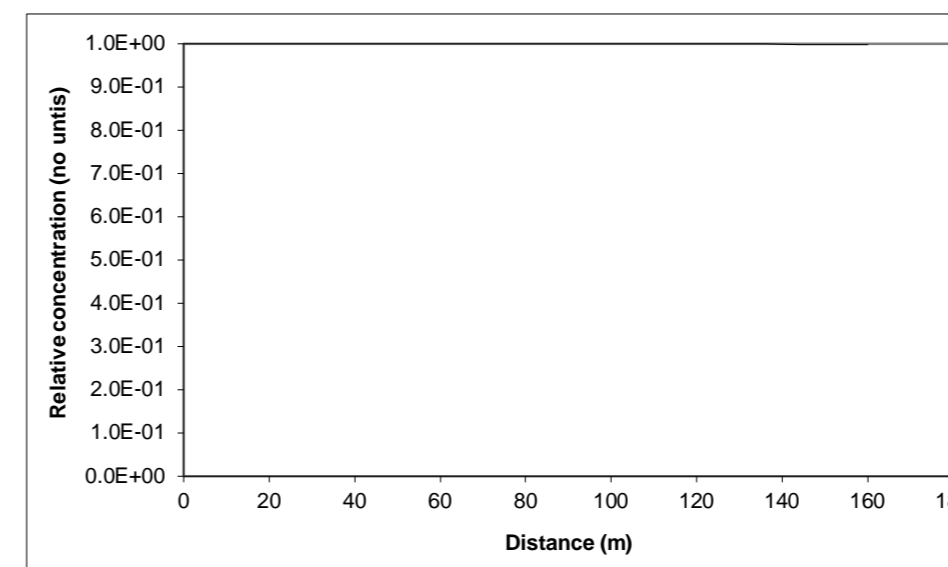
Select analytical solution (click on brown cell below, then on pull-down menu)

Domenico - Steady state 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

Soil water partition coefficient	Kd		l/kg
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Sorption coefficient for related species	K <sub>oc,n</sub>	0.00E+00	l/kg
Sorption coefficient for ionised species	K <sub>oc,i</sub>	0.00E+00	l/kg
pH value	pH		
Acid dissociation constant	pKa	0.00E+00	
Fraction of organic carbon in aquifer	foc	0.00E+00	fraction
Soil water partition coefficient	Kd	0.00E+00	l/kg



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

Calculated (relative) concentrations for distance-concentration graph

Distance	concentration (No units)	Concentration mg/l
0	1.0E+00	3.59E+00
8.0	1.00E+00	3.59E+00
16.0	1.00E+00	3.59E+00
24.0	1.00E+00	3.59E+00
32.0	1.00E+00	3.59E+00
40.0	1.00E+00	3.59E+00
48.0	1.00E+00	3.59E+00
56.0	1.00E+00	3.59E+00
64.0	1.00E+00	3.59E+00
72.0	1.00E+00	3.59E+00
80.0	1.00E+00	3.59E+00
88.0	1.00E+00	3.59E+00
96.0	1.00E+00	3.59E+00
104.0	1.00E+00	3.59E+00
112.0	1.00E+00	3.59E+00
120.0	9.99E-01	3.59E+00
128.0	9.99E-01	3.58E+00
136.0	9.99E-01	3.58E+00
144.0	9.98E-01	3.58E+00
152.0	9.98E-01	3.58E+00
160.0	9.97E-01	3.58E+00

Variable	Value	Unit	Source of parameter value
Soil leachate concentration as mg/l			
Enter soil leachate concentration	306	mg/l	
Half life for degradation of contaminant in water	1.00E+99	days	
Calculated decay rate	6.93E-100	days <sup>-1</sup>	calculated
Width of plume in aquifer at source	1.35E+02	m	from Level 2
Plume thickness in aquifer at source	3.00E+01	m	from Level 2
Bulk density of aquifer materials	1.50E+00	g/cm <sup>3</sup>	
Effective porosity of aquifer	1.00E-01	fraction	
Hydraulic gradient	1.52E-01	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	1.00E+01	m/d	from Level 2
Distance to compliance point	1.60E+02	m	
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	7.30E+03	days	time variant options only
Parameters values determined from options			
Partition coefficient	0.00E+00	l/kg	see options
Longitudinal dispersivity	16.000	m	see options
Transverse dispersivity	1.600	m	see options
Vertical dispersivity	0.160	m	see options

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

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

	Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	ax	0.00E+00	1.60E+01	5.59E+00 m
Transverse dispersivity	az	0.00E+00	1.60E+00	5.59E-01 m
Vertical dispersivity	ay	0.00E+00	1.60E-01	5.59E-02 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log<sub>10</sub>x)<sup>2.414</sup>; az = ax/10, ay = ax/100 are assumed

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Groundwater flow velocity	v	1.52E+01	m/d
Retardation factor	Rf	1.00E+00	fraction
Decay rate used	λ	6.93E-100	d <sup>-1</sup>
Hydraulic gradient used in aquifer flow down-gradient	i	1.52E-01	fraction
Rate of contaminant flow due to retardation	u	1.52E+01	m/d
Ratio of Compliance Point to Source Concentration	C <sub>ED</sub> /C <sub>0</sub>	9.97E-01	fraction
Attenuation factor (C <sub>0</sub> /C <sub>ED</sub> )	AF	1.00E+00	fraction
Soil leachate concentration	C <sub>0</sub>	3.06E+02	

Remedial Targets

Level 3 Remedial Target	5.56E+00	mg/l	For comparison with measured pore water concentration.
Domenico - Steady state	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	0.00E+00	mg/kg	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Distance to compliance point	160	m	
Ratio of Compliance Point to Source Concentration	C <sub>ED</sub> /C <sub>0</sub>	9.97E-01	fraction Domenico - Steady state

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 O<sub>2</sub>, NO<sub>3</sub>, SO<sub>4</sub> etc then an alternative solution should be used

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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:	Fassaroe - Site 2
Completed by:	Adrian Green
Date:	#####
Version:	1

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

R&D Publication 20 Remedial Targets Worksheet, Release 3.2



Level 3 - Groundwater See Note

Input Parameters (using pull down menu) Variable Value Unit Source

Contaminant	Ammonia	from Level 1
Target Concentration	C <sub>T</sub> 6.50E-02	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 1 direction**

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

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

Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C <sub>0</sub> 3.06E+02	mg/l	
Half life for degradation of contaminant in water	t <sub>1/2</sub> 1.00E+99	days	
Calculated decay rate	λ 6.93E-100	days <sup>-1</sup>	
Width of plume in aquifer at source (perpendicular to flow)	Sz 1.35E+02	m	
Plume thickness at source	Sy 2.98E+01	m	
Saturated aquifer thickness	da 3.00E+01	m	
Bulk density of aquifer materials	ρ 1.50E+00	g/cm <sup>3</sup>	
Effective porosity of aquifer	n 1.00E-01	fraction	
Hydraulic gradient	i 1.50E-01	fraction	
Hydraulic conductivity of aquifer	K 1.00E+01	m/d	
Distance to compliance point	x 1.60E+02	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t 7.30E+03	days	time variant options only
<i>Parameters values determined from options</i>			
Partition coefficient	Kd 0.00E+00	l/kg	see options
Longitudinal dispersivity	ax 1.60E+01	m	see options
Transverse dispersivity	az 1.60E+00	m	see options
Vertical dispersivity	ay 1.60E-01	m	see options

Calculated Parameters Variable

Groundwater flow velocity	v	1.50E+01	m/d
Retardation factor	Rf	1.00E+00	fraction
Decay rate used	λ	6.93E-100	d <sup>-1</sup>
Rate of contaminant flow due to retardation	u	1.50E+01	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C <sub>ED</sub>	3.05E+02	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	AF	1.00E+00	

Remedial Targets

Remedial Target	Value	Unit	Notes
Domenico - Steady state	6.52E-02	mg/l	For comparison with measured groundwater concentration.
Distance to compliance point	160	m	
Concentration of contaminant at compliance point	C <sub>ED</sub> /C <sub>0</sub> 3.05E+02	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)

User specified value for partition coefficient

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

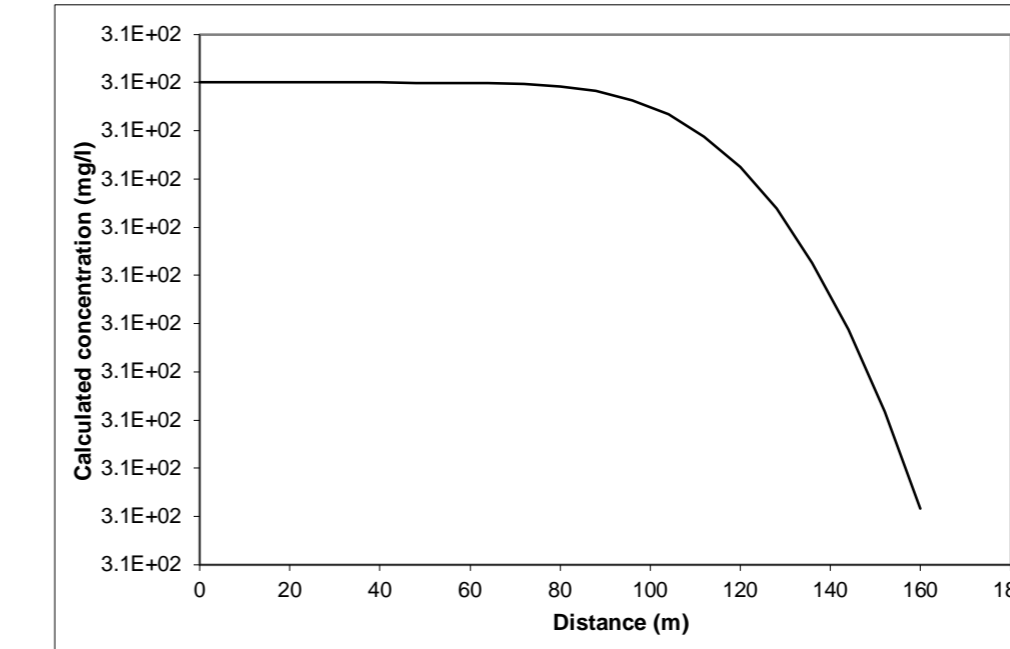
Define dispersivity (click brown cell and use pull down list)

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

Enter value	Calc value	Xu & Eckstein	m
ax	0.00E+00	1.60E+01	5.99E+00
az	0.00E+00	1.60E+00	5.99E-01
ay	0.00E+00	1.60E-01	5.99E-02

Note values of dispersivity must be > 0  
For calculated value, assumes ax = 0.1 \* x, az = 0.01 \* x, ay = 0.001 \* x  
Xu & Eckstein (1995) report ax = 0.83(log<sub>10</sub>x)<sup>2.414</sup>; az = ax/10, ay = ax/100 are assumed

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Calculated concentrations for distance-concentration graph

Domenico - Steady state  
From calculation sheet

Distance	Concentration
0	3.1E+02
8.0	3.06E+02
16.0	3.06E+02
24.0	3.06E+02
32.0	3.06E+02
40.0	3.06E+02
48.0	3.06E+02
56.0	3.06E+02
64.0	3.06E+02
72.0	3.06E+02
80.0	3.06E+02
88.0	3.06E+02
96.0	3.06E+02
104.0	3.06E+02
112.0	3.06E+02
120.0	3.06E+02
128.0	3.06E+02
136.0	3.06E+02
144.0	3.05E+02
152.0	3.05E+02
160.0	3.05E+02

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 O<sub>2</sub>, NO<sub>3</sub>, SO<sub>4</sub> etc than an alternative solution should be used

Site being assessed:	Fassaroe - Site 2
Completed by:	Adrian Green
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.**

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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)**

<u>Details to be completed for each assessment</u>			
<b>Site Name:</b>	Fassaroe - Site 3a		
<b>Site Address:</b>	Fassaroe Co. Wicklow		
<b>Completed by:</b>	Adrioan Green	<b>Version:</b>	1
<b>Date:</b>	04-May-18		
<b>Contaminant</b>	Ammonia	<b>Origin of C<sub>T</sub>:</b>	Surface Water EQS & GW GTV
<b>Target Concentration (C<sub>T</sub>)</b>	0.175	mg/l	

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 2 - Soil

Contaminant Target concentration **C<sub>T</sub>** **Ammonia** from Level 1  
**0.175** mg/l from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

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

**Input Parameters** Variable Value Unit Source of parameter value

Standard entry

Infiltration	Inf	1.84E-04	m/d	
Area of contaminant source	A	2.65E+04	m <sup>2</sup>	

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow	L	2.19E+02	m	
Saturated aquifer thickness	da	3.00E+01	m	
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.00E+01	m/d	
Hydraulic gradient of water table	i	5.00E-02	fraction	
Width of contaminant source perpendicular to groundwater flow	w	1.06E+02	m	
Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l	
Define mixing zone depth by specifying or calculating depth (using pull down list)		<b>Calculate</b>		
Enter mixing zone thickness	Mz		m	
Calculated mixing zone thickness	Mz	2.33E+01	m	

Not used in calculation

**Calculated Parameters**

Dilution Factor	DF	2.90E+02	
Level 2 Remedial Target		5.08E+01 mg/l or 0.00E+00 mg/kg	

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration  
 For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Fassaroe - Site 3a
Completed by:	Adriano Green
Date:	04-May-18
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Ammonia		from Level 1
Target Concentration	C <sub>T</sub>	0.175	mg/l	from Level 1
Dilution Factor	DF	2.90E+02		from Level 2

Enter method of defining partition co-efficient (using pull down list)  
Calculate for ionic organic chemicals (acids)

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

Domenico - Steady state 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 pollutants in all phases (e.g. field derived value.)

Variable	Value	Unit	Source of parameter value
Soil leachate concentration as mg/l			
Enter soil leachate concentration	366	mg/l	
Half life for degradation of contaminant in water	1.00E+99	days	
Calculated decay rate	6.93E-100	days <sup>-1</sup>	calculated
Width of plume in aquifer at source	1.06E+02	m	from Level 2
Plume thickness in aquifer at source	2.33E+01	m	from Level 2
Bulk density of aquifer materials	1.50E+00	g/cm <sup>3</sup>	
Effective porosity of aquifer	1.00E-01	fraction	
Hydraulic gradient	5.02E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	1.00E+01	m/d	from Level 2
Distance to compliance point	9.60E+01	m	
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	7.30E+03	days	time variant options only
Parameters values determined from options			
Partition coefficient	0.00E+00	l/kg	see options
Longitudinal dispersivity	9.600	m	see options
Transverse dispersivity	0.960	m	see options
Vertical dispersivity	0.096	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	5.02E+00	m/d
Retardation factor	1.00E+00	fraction
Decay rate used	6.93E-100	d <sup>-1</sup>
Hydraulic gradient used in aquifer flow down-gradient	5.02E-02	fraction
Rate of contaminant flow due to retardation	5.02E+00	m/d
Ratio of Compliance Point to Source Concentration	1.00E+00	fraction
Attenuation factor (C <sub>0</sub> /C <sub>ED</sub> )	1.00E+00	fraction
Soil leachate concentration	3.66E+02	

Remedial Targets

Level 3 Remedial Target	5.08E+01	mg/l	For comparison with measured pore water concentration.
Domenico - Steady state	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	0.00E+00	mg/kg	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Distance to compliance point	96	m	
Ratio of Compliance Point to Source Concentration	C <sub>ED</sub> /C <sub>0</sub>	1.00E+00	fraction Domenico - Steady state

Soil water partition coefficient	Kd		l/kg
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Sorption coefficient for related species	K <sub>oc,n</sub>	0.00E+00	l/kg
Sorption coefficient for ionised species	K <sub>oc,i</sub>	0.00E+00	l/kg
pH value	pH		
Acid dissociation constant	pKa	0.00E+00	
Fraction of organic carbon in aquifer	foc	0.00E+00	fraction
Soil water partition coefficient	Kd	0.00E+00	l/kg

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

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

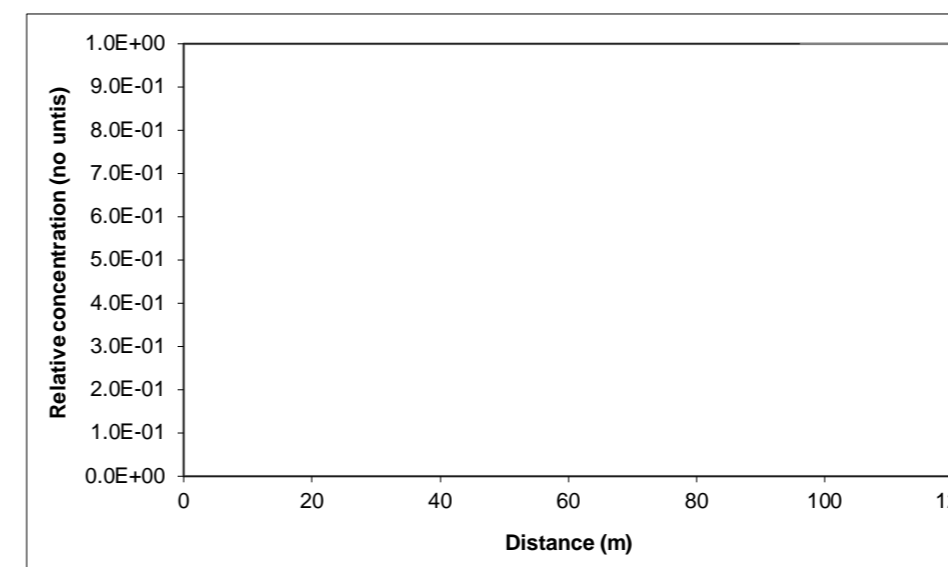
	Enter value	Calc value	Xu & Eckstein		
Longitudinal dispersivity	ax	0.00E+00	9.60E+00	4.33E+00	m
Transverse dispersivity	az	0.00E+00	9.60E-01	4.33E-01	m
Vertical dispersivity	ay	0.00E+00	9.60E-02	4.33E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log<sub>10</sub>x)<sup>2-414</sup>; 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 O<sub>2</sub>, NO<sub>3</sub>, SO<sub>4</sub> etc then 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

Domenico - Steady state

Distance	Relative concentration (No units)	Concentration mg/l
0	1.00E+00	1.26E+00
4.8	1.00E+00	1.26E+00
9.6	1.00E+00	1.26E+00
14.4	1.00E+00	1.26E+00
19.2	1.00E+00	1.26E+00
24.0	1.00E+00	1.26E+00
28.8	1.00E+00	1.26E+00
33.6	1.00E+00	1.26E+00
38.4	1.00E+00	1.26E+00
43.2	1.00E+00	1.26E+00
48.0	1.00E+00	1.26E+00
52.8	1.00E+00	1.26E+00
57.6	1.00E+00	1.26E+00
62.4	1.00E+00	1.26E+00
67.2	1.00E+00	1.26E+00
72.0	1.00E+00	1.26E+00
76.8	1.00E+00	1.26E+00
81.6	1.00E+00	1.26E+00
86.4	1.00E+00	1.26E+00
91.2	1.00E+00	1.26E+00
96.0	1.00E+00	1.26E+00

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:	Fassaroe - Site 3a
Completed by:	Adrian Green
Date:	#####
Version:	1

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

R&D Publication 20 Remedial Targets Worksheet, Release 3.2



Level 3 - Groundwater See Note

Input Parameters (using pull down menu) Variable Value Unit Source

Contaminant	Ammonia	from Level 1
Target Concentration	C <sub>T</sub> 1.75E-01	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**

Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C <sub>0</sub> 3.66E+02	mg/l	
Half life for degradation of contaminant in water	t <sub>1/2</sub> 1.00E+99	days	
Calculated decay rate	λ 6.93E-100	days <sup>-1</sup>	
Width of plume in aquifer at source (perpendicular to flow)	Sz 1.06E+02	m	
Plume thickness at source	Sy 2.39E+01	m	
Saturated aquifer thickness	da 3.00E+01	m	
Bulk density of aquifer materials	ρ 1.50E+00	g/cm <sup>3</sup>	
Effective porosity of aquifer	n 1.00E-01	fraction	
Hydraulic gradient	i 5.00E-02	fraction	
Hydraulic conductivity of aquifer	K 1.00E+01	m/d	
Distance to compliance point	x 9.60E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t 7.30E+03	days	time variant options only
<i>Parameters values determined from options</i>			
Partition coefficient	Kd 0.00E+00	l/kg	see options
Longitudinal dispersivity	ax 9.60E+00	m	see options
Transverse dispersivity	az 9.60E-01	m	see options
Vertical dispersivity	ay 9.60E-02	m	see options

Calculated Parameters Variable

Groundwater flow velocity	v	5.00E+00	m/d
Retardation factor	Rf	1.00E+00	fraction
Decay rate used	λ	6.93E-100	d <sup>-1</sup>
Rate of contaminant flow due to retardation	u	5.00E+00	m/d
Contaminant concentration at distance x, assuming two-way vertical dispersion	C <sub>ED</sub>	3.64E+02	mg/l
Attenuation factor (two way vertical dispersion, CO/CED)	AF	1.01E+00	

Remedial Targets

Remedial Target	Value	Unit	Notes
Domenico - Steady state	1.76E-01	mg/l	For comparison with measured groundwater concentration.
Distance to compliance point	96	m	
Concentration of contaminant at compliance point	C <sub>ED</sub> /C <sub>0</sub> 3.64E+02	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)

User specified value for partition coefficient

Entry if specify partition coefficient (option)		
Soil water partition coefficient	Kd	0.00E+00 l/kg
Entry for non-polar organic chemicals (option)		
Fraction of organic carbon in aquifer	foc	fraction
Organic carbon partition coefficient	Koc	l/kg
Entry for ionic organic chemicals (option)		
Sorption coefficient for related species	K <sub>oc,i</sub>	l/kg
Sorption coefficient for ionised species	K <sub>oc,i</sub>	l/kg
pH value	pH	
acid dissociation constant	pKa	
Fraction of organic carbon in aquifer	foc	fraction
Soil water partition coefficient	Kd	0.00E+00 l/kg

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

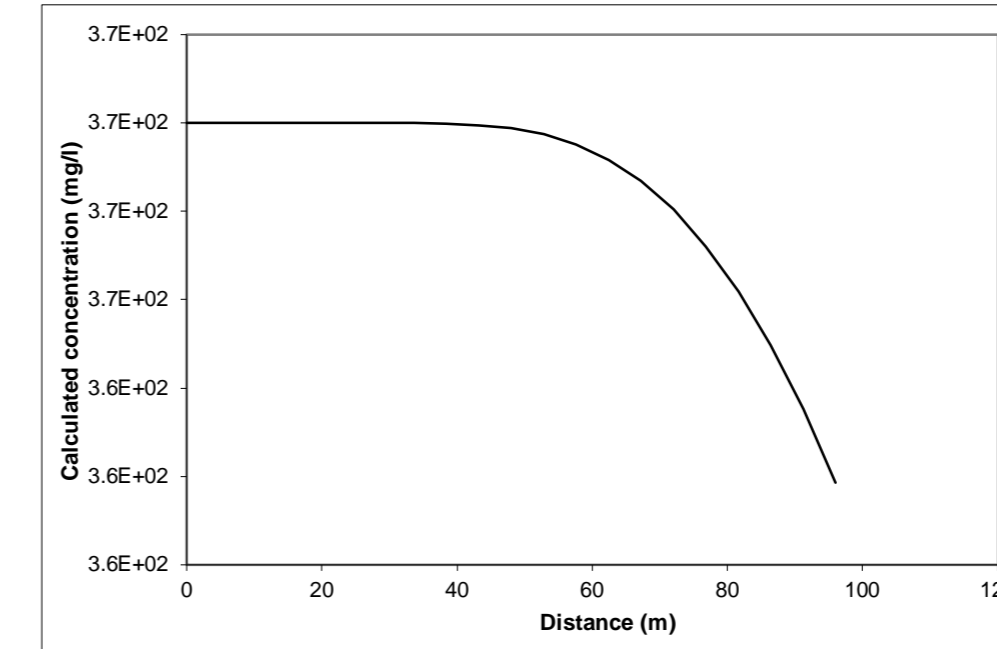
Dispersivities 10%, 1%, 0.1% of pathway length

Enter value	Calc value	Xu & Eckstein	m
ax	0.00E+00	9.60E+00	4.33E+00
az	0.00E+00	9.60E-01	4.33E-01
ay	0.00E+00	9.60E-02	4.33E-02

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 \* x, az = 0.01 \* x, ay = 0.001 \* x  
Xu & Eckstein (1995) report ax = 0.83(log<sub>10</sub>x)<sup>2.414</sup>; az = ax/10, ay = ax/100 are assumed

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Calculated concentrations for distance-concentration graph

Domenico - Steady state  
From calculation sheet

Distance	Concentration
	mg/l
0	3.7E+02
4.8	3.66E+02
9.6	3.66E+02
14.4	3.66E+02
19.2	3.66E+02
24.0	3.66E+02
28.8	3.66E+02
33.6	3.66E+02
38.4	3.66E+02
43.2	3.66E+02
48.0	3.66E+02
52.8	3.66E+02
57.6	3.66E+02
62.4	3.66E+02
67.2	3.66E+02
72.0	3.66E+02
76.8	3.65E+02
81.6	3.65E+02
86.4	3.65E+02
91.2	3.64E+02
96.0	3.64E+02

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 O<sub>2</sub>, NO<sub>3</sub>, SO<sub>4</sub> etc than an alternative solution should be used

Site being assessed:	Fassaroe - Site 3a
Completed by:	Adriano Green
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.**

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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)**

<b>Details to be completed for each assessment</b>			
<b>Site Name:</b>	Fassaroe - Site 3b		
<b>Site Address:</b>	Fassaroe Co. Wicklow		
<b>Completed by:</b>	Adrian Green	<b>Version:</b>	1
<b>Date:</b>	04-May-18		
<b>Contaminant</b>	Ammonia	<b>Origin of C<sub>T</sub>:</b>	Surface Water EQS & GW GTV
<b>Target Concentration (C<sub>T</sub>)</b>	0.065	mg/l	

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 2 - Soil

Contaminant Target concentration **C<sub>T</sub>** **Ammonia** from Level 1  
**0.065** mg/l from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

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

**Input Parameters** Variable Value Unit Source of parameter value

Standard entry

Infiltration Inf 1.84E-04 m/d  
 Area of contaminant source A 6.60E+03 m<sup>2</sup>

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow L 8.50E+01 m  
 Saturated aquifer thickness da 3.50E+01 m  
 Hydraulic Conductivity of aquifer in which dilution occurs K 1.00E+01 m/d  
 Hydraulic gradient of water table i 2.00E-02 fraction  
 Width of contaminant source perpendicular to groundwater flow w 6.50E+01 m  
 Background concentration of contaminant in groundwater beneath site Cu 0.00E+00 mg/l  
 Define mixing zone depth by specifying or calculating depth (using pull down list)  
 Enter mixing zone thickness Mz  
 Calculated mixing zone thickness Mz 9.07E+00 m

Not used in calculation

**Calculated Parameters**

Dilution Factor	DF	1.17E+02
Level 2 Remedial Target		7.62E+00 mg/l or 0.00E+00 mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration  
 For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor) Cc 0.00E+00 mg/l  
 Calculated concentration within receptor (dilution only) 0.00E+00 mg/l 0

Site being assessed:	Fassaroe - Site 3b
Completed by:	Adrian Green
Date:	04-May-18
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note



Input Parameters	Variable	Value	Unit	Source
Contaminant		Ammonia		from Level 1
Target Concentration	C <sub>T</sub>	0.065	mg/l	from Level 1
Dilution Factor	DF	1.17E+02		from Level 2

Enter method of defining partition co-efficient (using pull down list)  
Calculate for ionic organic chemicals (acids)

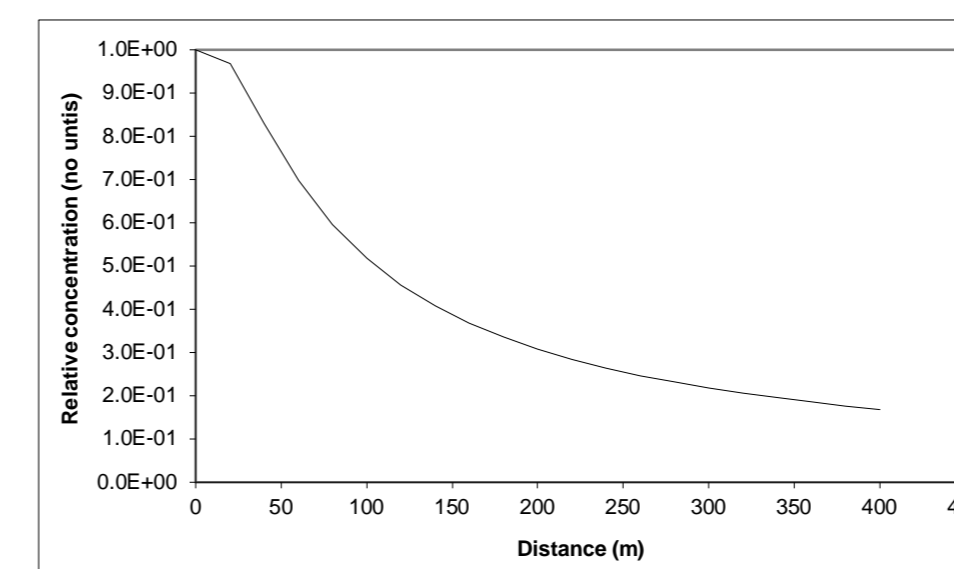
Select analytical solution (click on brown cell below, then on pull-down menu)

Domenico - Steady state 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

Soil water partition coefficient	Kd		l/kg
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Sorption coefficient for related species	K <sub>oc,n</sub>	0.00E+00	l/kg
Sorption coefficient for ionised species	K <sub>oc,i</sub>	0.00E+00	l/kg
pH value	pH		
Acid dissociation constant	pKa	0.00E+00	
Fraction of organic carbon in aquifer	foc	0.00E+00	fraction
Soil water partition coefficient	Kd	0.00E+00	l/kg



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

Calculated (relative) concentrations for distance-concentration graph

Distance	concentration (No units)	Concentration mg/l
0	1.0E+00	4.83E+00
20.0	9.67E-01	4.67E+00
40.0	8.30E-01	4.01E+00
60.0	6.98E-01	3.37E+00
80.0	5.95E-01	2.88E+00
100.0	5.17E-01	2.50E+00
120.0	4.56E-01	2.20E+00
140.0	4.07E-01	1.97E+00
160.0	3.67E-01	1.78E+00
180.0	3.35E-01	1.62E+00
200.0	3.07E-01	1.49E+00
220.0	2.84E-01	1.37E+00
240.0	2.64E-01	1.28E+00
260.0	2.47E-01	1.19E+00
280.0	2.31E-01	1.12E+00
300.0	2.18E-01	1.05E+00
320.0	2.06E-01	9.95E-01
340.0	1.95E-01	9.43E-01
360.0	1.85E-01	8.96E-01
380.0	1.77E-01	8.53E-01
400.0	1.69E-01	8.15E-01

Variable	Value	Unit	Source of parameter value
Soil leachate concentration as mg/l			
Enter soil leachate concentration	567	mg/l	
Half life for degradation of contaminant in water	1.00E+99	days	
Calculated decay rate	6.93E-100	days <sup>-1</sup>	calculated
Width of plume in aquifer at source	6.50E+01	m	from Level 2
Plume thickness in aquifer at source	9.07E+00	m	from Level 2
Bulk density of aquifer materials	1.50E+00	g/cm <sup>3</sup>	
Effective porosity of aquifer	1.00E-01	fraction	
Hydraulic gradient	2.02E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	1.00E+01	m/d	from Level 2
Distance to compliance point	4.00E+02	m	
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	7.30E+03	days	time variant options only
Parameters values determined from options			
Partition coefficient	0.00E+00	l/kg	see options
Longitudinal dispersivity	40.000	m	see options
Transverse dispersivity	4.000	m	see options
Vertical dispersivity	0.400	m	see options

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

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

	Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	ax	4.00E+01	8.35E+00	m
Transverse dispersivity	az	4.00E+00	8.35E-01	m
Vertical dispersivity	ay	4.00E-01	8.35E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log<sub>10</sub>x)<sup>2.414</sup>; az = ax/10, ay = ax/100 are assumed

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Groundwater flow velocity	v	2.02E+00	m/d
Retardation factor	Rf	1.00E+00	fraction
Decay rate used	λ	6.93E-100	d <sup>-1</sup>
Hydraulic gradient used in aquifer flow down-gradient	i	2.02E-02	fraction
Rate of contaminant flow due to retardation	u	2.02E+00	m/d
Ratio of Compliance Point to Source Concentration	C <sub>ED</sub> /C <sub>0</sub>	1.69E-01	fraction
Attenuation factor (C <sub>0</sub> /C <sub>ED</sub> )	AF	5.93E+00	fraction
Soil leachate concentration	C <sub>0</sub>	5.67E+02	

Remedial Targets

Level 3 Remedial Target	4.52E+01	mg/l	For comparison with measured pore water concentration.
Domenico - Steady state	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	0.00E+00	mg/kg	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Distance to compliance point	400	m	
Ratio of Compliance Point to Source Concentration	C <sub>ED</sub> /C <sub>0</sub>	1.69E-01	fraction Domenico - Steady state

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 O<sub>2</sub>, NO<sub>3</sub>, SO<sub>4</sub> etc then an alternative solution should be used

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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:	Fassaroe - Site 3b
Completed by:	Adrian Green
Date:	#####
Version:	1

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

R&D Publication 20 Remedial Targets Worksheet, Release 3.2



Level 3 - Groundwater See Note

Input Parameters (using pull down menu) Variable Value Unit Source

Contaminant	Ammonia	from Level 1
Target Concentration	C <sub>T</sub> 6.50E-02	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**

Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C <sub>0</sub> 5.67E+02	mg/l	
Half life for degradation of contaminant in water	t <sub>1/2</sub> 1.00E+99	days	
Calculated decay rate	λ 6.93E-100	days <sup>-1</sup>	
Width of plume in aquifer at source (perpendicular to flow)	Sz 6.50E+01	m	
Plume thickness at source	Sy 9.66E+00	m	
Saturated aquifer thickness	da 3.50E+01	m	
Bulk density of aquifer materials	ρ 1.50E+00	g/cm <sup>3</sup>	
Effective porosity of aquifer	n 1.00E-01	fraction	
Hydraulic gradient	i 2.00E-02	fraction	
Hydraulic conductivity of aquifer	K 1.00E+01	m/d	
Distance to compliance point	x 4.00E+02	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t 7.30E+03	days	time variant options only
<i>Parameters values determined from options</i>			
Partition coefficient	Kd 0.00E+00	l/kg	see options
Longitudinal dispersivity	ax 4.00E+01	m	see options
Transverse dispersivity	az 4.00E+00	m	see options
Vertical dispersivity	ay 4.00E-01	m	see options

Calculated Parameters Variable

Groundwater flow velocity	v	2.00E+00	m/d
Retardation factor	Rf	1.00E+00	fraction
Decay rate used	λ	6.93E-100	d <sup>-1</sup>
Rate of contaminant flow due to retardation	u	2.00E+00	m/d
Contaminant concentration at distance x, assuming two-way vertical dispersion	C <sub>ED</sub>	5.24E+01	mg/l
Attenuation factor (two way vertical dispersion, CO/CED)	AF	1.08E+01	

Remedial Targets

Remedial Target	Value	Unit	Notes
Domenico - Steady state	7.03E-01	mg/l	For comparison with measured groundwater concentration.
Distance to compliance point	400	m	
Concentration of contaminant at compliance point	C <sub>ED</sub> /C <sub>0</sub> 5.24E+01	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)

User specified value for partition coefficient

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

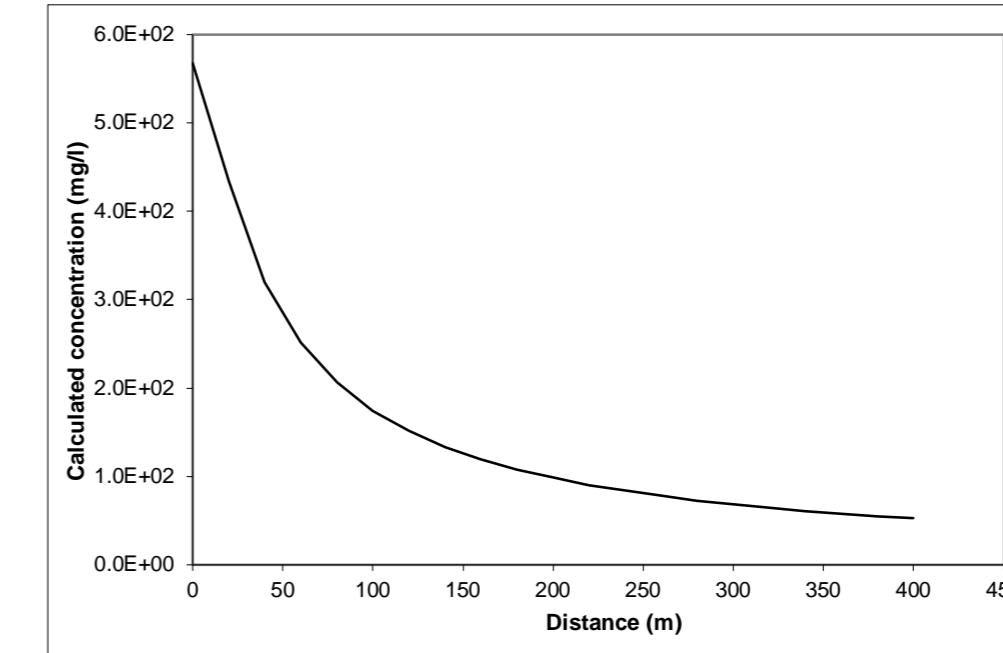
Define dispersivity (click brown cell and use pull down list)

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

Variable	Enter value	Calc value Xu & Eckstein	Unit
Longitudinal dispersivity	ax 0.00E+00	4.00E+01	8.35E+00 m
Transverse dispersivity	az 0.00E+00	4.00E+00	8.35E-01 m
Vertical dispersivity	ay 0.00E+00	4.00E-01	8.35E-02

Note values of dispersivity must be > 0  
For calculated value, assumes ax = 0.1 \* x, az = 0.01 \* x, ay = 0.001 \* x  
Xu & Eckstein (1995) report ax = 0.83(log<sub>10</sub>x)<sup>2.414</sup>; az = ax/10, ay = ax/100 are assumed

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Calculated concentrations for distance-concentration graph

Domenico - Steady state  
From calculation sheet

Distance	Concentration
	mg/l
0	5.7E+02
20.0	4.34E+02
40.0	3.20E+02
60.0	2.51E+02
80.0	2.06E+02
100.0	1.75E+02
120.0	1.51E+02
140.0	1.33E+02
160.0	1.19E+02
180.0	1.08E+02
200.0	9.84E+01
220.0	9.04E+01
240.0	8.37E+01
260.0	7.79E+01
280.0	7.28E+01
300.0	6.84E+01
320.0	6.45E+01
340.0	6.10E+01
360.0	5.78E+01
380.0	5.50E+01
400.0	5.24E+01

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 O<sub>2</sub>, NO<sub>3</sub>, SO<sub>4</sub> etc than an alternative solution should be used

Site being assessed:	Fassaroe - Site 3b
Completed by:	Adrian Green
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.**

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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)**

<u>Details to be completed for each assessment</u>			
<b>Site Name:</b>	Fassaroe - Site 3b		
<b>Site Address:</b>	Fassaroe Co. Wicklow		
<b>Completed by:</b>	Adrian Green	<b>Version:</b>	1
<b>Date:</b>	04-May-18		
<b>Contaminant</b>	Ammonia	<b>Origin of C<sub>T</sub>:</b>	Surface Water EQS & GW GTV
<b>Target Concentration (C<sub>T</sub>)</b>	0.065	mg/l	

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 2 - Soil

Contaminant Target concentration **C<sub>T</sub>** **Ammonia** from Level 1  
**0.065** mg/l from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

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

**Input Parameters** Variable Value Unit Source of parameter value

Standard entry

Infiltration Inf 1.57E-03 m/d  
 Area of contaminant source A 6.60E+03 m<sup>2</sup>

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow L 8.50E+01 m  
 Saturated aquifer thickness da 3.50E+01 m  
 Hydraulic Conductivity of aquifer in which dilution occurs K 1.00E+01 m/d  
 Hydraulic gradient of water table i 2.00E-02 fraction  
 Width of contaminant source perpendicular to groundwater flow w 6.50E+01 m  
 Background concentration of contaminant in groundwater beneath site Cu 0.00E+00 mg/l  
 Define mixing zone depth by specifying or calculating depth (using pull down list)  
 Enter mixing zone thickness Mz  
 Calculated mixing zone thickness Mz 9.66E+00 m

Not used in calculation

**Calculated Parameters**

Dilution Factor	DF	1.55E+01
Level 2 Remedial Target		1.01E+00 mg/l or 0.00E+00 mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration  
 For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor) Cc 0.00E+00 mg/l  
 Calculated concentration within receptor (dilution only) 0.00E+00 mg/l 0

Site being assessed:	Fassaroe - Site 3b
Completed by:	Adrian Green
Date:	04-May-18
Version:	1

Remedial Targets Worksheet , Release 3.2



Level 3 - Soil

See Note

Input Parameters	Variable	Value	Unit	Source
Contaminant		Ammonia		from Level 1
Target Concentration	C <sub>T</sub>	0.065	mg/l	from Level 1
Dilution Factor	DF	1.55E+01		from Level 2

Enter method of defining partition co-efficient (using pull down list)  
Calculate for ionic organic chemicals (acids)

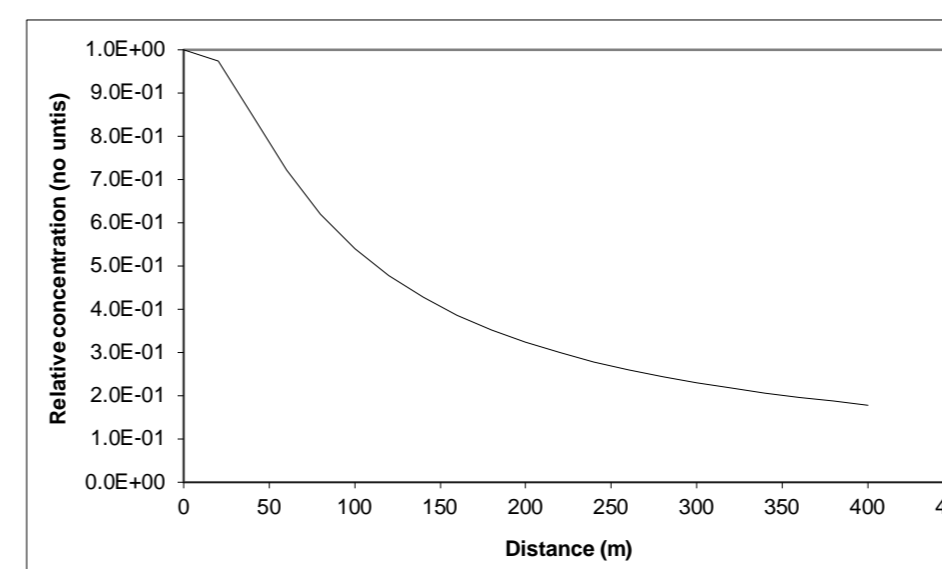
Select analytical solution (click on brown cell below, then on pull-down menu)

Domenico - Steady state 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

Soil water partition coefficient	Kd		l/kg
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Sorption coefficient for related species	K <sub>oc,n</sub>	0.00E+00	l/kg
Sorption coefficient for ionised species	K <sub>oc,i</sub>	0.00E+00	l/kg
pH value	pH		
Acid dissociation constant	pKa	0.00E+00	
Fraction of organic carbon in aquifer	foc	0.00E+00	fraction
Soil water partition coefficient	Kd	0.00E+00	l/kg



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

Calculated (relative) concentrations for distance-concentration graph

Domenico - Steady state  
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	3.66E+01
20.0	9.74E-01	3.57E+01
40.0	8.49E-01	3.11E+01
60.0	7.21E-01	2.64E+01
80.0	6.19E-01	2.27E+01
100.0	5.39E-01	1.98E+01
120.0	4.77E-01	1.75E+01
140.0	4.27E-01	1.56E+01
160.0	3.86E-01	1.41E+01
180.0	3.52E-01	1.29E+01
200.0	3.24E-01	1.19E+01
220.0	2.99E-01	1.10E+01
240.0	2.79E-01	1.02E+01
260.0	2.60E-01	9.54E+00
280.0	2.44E-01	8.95E+00
300.0	2.30E-01	8.43E+00
320.0	2.18E-01	7.97E+00
340.0	2.06E-01	7.56E+00
360.0	1.96E-01	7.18E+00
380.0	1.87E-01	6.85E+00
400.0	1.78E-01	6.54E+00

Variable	Value	Unit	Source of parameter value
Soil leachate concentration as mg/l			
Enter soil leachate concentration	567	mg/l	
Half life for degradation of contaminant in water	1.00E+99	days	
Calculated decay rate	6.93E-100	days <sup>-1</sup>	calculated
Width of plume in aquifer at source	6.50E+01	m	from Level 2
Plume thickness in aquifer at source	9.66E+00	m	from Level 2
Bulk density of aquifer materials	1.50E+00	g/cm <sup>3</sup>	
Effective porosity of aquifer	1.00E-01	fraction	
Hydraulic gradient	2.14E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	1.00E+01	m/d	from Level 2
Distance to compliance point	4.00E+02	m	
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	7.30E+03	days	time variant options only
Parameters values determined from options			
Partition coefficient	0.00E+00	l/kg	see options
Longitudinal dispersivity	40.000	m	see options
Transverse dispersivity	4.000	m	see options
Vertical dispersivity	0.400	m	see options

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

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

	Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	ax	4.00E+01	8.35E+00	m
Transverse dispersivity	az	4.00E+00	8.35E-01	m
Vertical dispersivity	ay	4.00E-01	8.35E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log<sub>10</sub>x)<sup>2.414</sup>; 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 O<sub>2</sub>, NO<sub>3</sub>, SO<sub>4</sub> etc then an alternative solution should be used

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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:	Fassaroe - Site 3b
Completed by:	Adrian Green
Date:	#####
Version:	1

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Groundwater flow velocity	v	2.14E+00	m/d
Retardation factor	Rf	1.00E+00	fraction
Decay rate used	λ	6.93E-100	d <sup>-1</sup>
Hydraulic gradient used in aquifer flow down-gradient	i	2.14E-02	fraction
Rate of contaminant flow due to retardation	u	2.14E+00	m/d
Ratio of Compliance Point to Source Concentration	C <sub>ED</sub> /C <sub>0</sub>	1.78E-01	fraction
Attenuation factor (C <sub>0</sub> /C <sub>ED</sub> )	AF	5.61E+00	fraction
Soil leachate concentration	C <sub>0</sub>	5.67E+02	

Remedial Targets

Level 3 Remedial Target	5.64E+00	mg/l	For comparison with measured pore water concentration.
Domenico - Steady state	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	0.00E+00	mg/kg	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Distance to compliance point	400	m	
Ratio of Compliance Point to Source Concentration	C <sub>ED</sub> /C <sub>0</sub>	1.78E-01	fraction 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

R&D Publication 20 Remedial Targets Worksheet, Release 3.2



Level 3 - Groundwater See Note

Input Parameters (using pull down menu) Variable Value Unit Source

Contaminant	Ammonia	from Level 1
Target Concentration	C <sub>T</sub> 6.50E-02	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**

Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C <sub>0</sub> 3.66E+01	mg/l	
Half life for degradation of contaminant in water	t <sub>1/2</sub> 1.00E+99	days	
Calculated decay rate	λ 6.93E-100	days <sup>-1</sup>	
Width of plume in aquifer at source (perpendicular to flow)	Sz 6.50E+01	m	
Plume thickness at source	Sy 9.66E+00	m	
Saturated aquifer thickness	da 3.50E+01	m	
Bulk density of aquifer materials	ρ 1.50E+00	g/cm <sup>3</sup>	
Effective porosity of aquifer	n 1.00E-01	fraction	
Hydraulic gradient	i 2.00E-02	fraction	
Hydraulic conductivity of aquifer	K 1.00E+01	m/d	
Distance to compliance point	x 4.00E+02	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t 7.30E+03	days	time variant options only
<i>Parameters values determined from options</i>			
Partition coefficient	Kd 0.00E+00	l/kg	see options
Longitudinal dispersivity	ax 4.00E+01	m	see options
Transverse dispersivity	az 4.00E+00	m	see options
Vertical dispersivity	ay 4.00E-01	m	see options

Calculated Parameters Variable

Groundwater flow velocity	v	2.00E+00	m/d
Retardation factor	Rf	1.00E+00	fraction
Decay rate used	λ	6.93E-100	d <sup>-1</sup>
Rate of contaminant flow due to retardation	u	2.00E+00	m/d
Contaminant concentration at distance x, assuming two-way vertical dispersion	C <sub>ED</sub>	3.38E+00	mg/l
Attenuation factor (two way vertical dispersion, CO/CED)	AF	1.08E+01	

Remedial Targets

Remedial Target	Value	Unit	Notes
Domenico - Steady state	7.03E-01	mg/l	For comparison with measured groundwater concentration.
Distance to compliance point	400	m	
Concentration of contaminant at compliance point	C <sub>ED</sub> /C <sub>0</sub> 3.38E+00	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)

User specified value for partition coefficient

Entry if specify partition coefficient (option)	Kd	0.00E+00	l/kg
Soil water partition coefficient	Kd	0.00E+00	l/kg
Entry for non-polar organic chemicals (option)	foc		fraction
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)	K <sub>oc,i</sub>		l/kg
Sorption coefficient for related species	K <sub>oc,i</sub>		l/kg
Sorption coefficient for ionised species	pH		
pH value	pKa		
acid dissociation constant	foc		fraction
Fraction of organic carbon in aquifer	Kd	0.00E+00	l/kg
Soil water partition coefficient	Kd	0.00E+00	l/kg

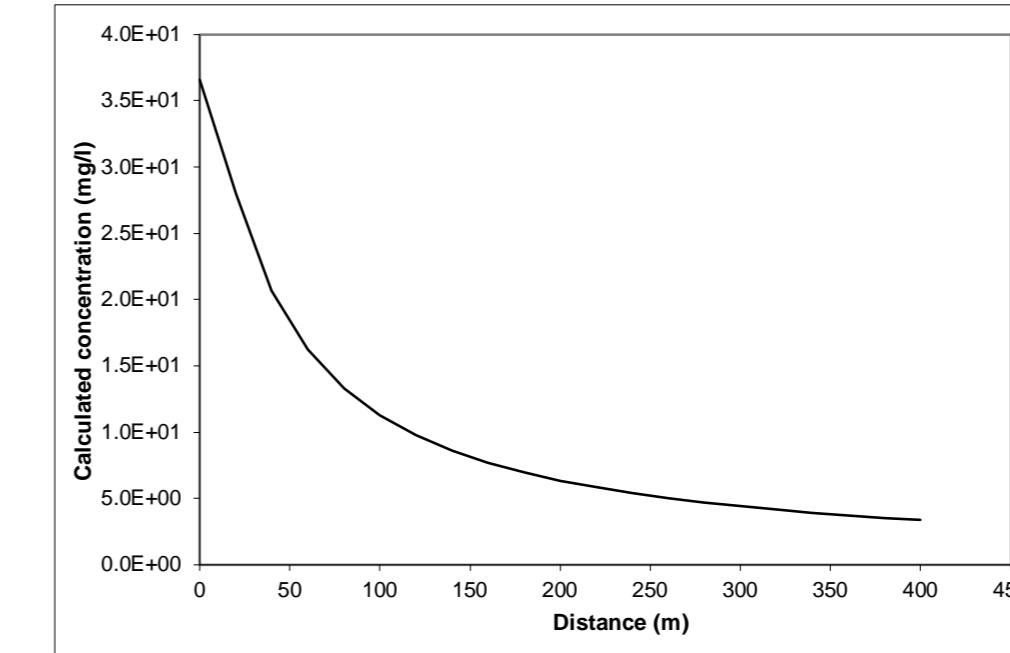
Define dispersivity (click brown cell and use pull down list)

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

Enter value	Calc value Xu & Eckstein	m
ax 0.00E+00	4.00E+01	8.35E+00
az 0.00E+00	4.00E+00	8.35E-01
ay 0.00E+00	4.00E-01	8.35E-02

Note values of dispersivity must be > 0  
For calculated value, assumes ax = 0.1 \* x, az = 0.01 \* x, ay = 0.001 \* x  
Xu & Eckstein (1995) report ax = 0.83(log<sub>10</sub>x)<sup>2.414</sup>; az = ax/10, ay = ax/100 are assumed

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Calculated concentrations for distance-concentration graph

Domenico - Steady state

From calculation sheet

Distance	Concentration
	mg/l
0	3.7E+01
20.0	2.80E+01
40.0	2.07E+01
60.0	1.62E+01
80.0	1.33E+01
100.0	1.13E+01
120.0	9.75E+00
140.0	8.60E+00
160.0	7.69E+00
180.0	6.95E+00
200.0	6.35E+00
220.0	5.84E+00
240.0	5.40E+00
260.0	5.03E+00
280.0	4.70E+00
300.0	4.41E+00
320.0	4.16E+00
340.0	3.93E+00
360.0	3.73E+00
380.0	3.55E+00
400.0	3.38E+00

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 O<sub>2</sub>, NO<sub>3</sub>, SO<sub>4</sub> etc than an alternative solution should be used

Site being assessed:	Fassaroe - Site 3b
Completed by:	Adrian Green
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.**

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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)**

<u>Details to be completed for each assessment</u>			
Site Name:	Fassaroe - Site 3c		
Site Address:	Fassaroe Co. Wicklow		
Completed by:	Adrian Green	Version:	1
Date:	04-May-18		
Contaminant	Ammonia	Origin of C <sub>T</sub> :	Surface Water EQS & GW GTV
Target Concentration (C <sub>T</sub> )	0.065 mg/l		

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 2 - Soil

Contaminant Target concentration **C<sub>T</sub>** **Ammonia** from Level 1  
**0.065** mg/l from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

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

**Input Parameters** Variable Value Unit Source of parameter value

Standard entry

Infiltration	Inf	1.84E-04	m/d	
Area of contaminant source	A	8.70E+03	m <sup>2</sup>	

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow	L	1.13E+02	m	
Saturated aquifer thickness	da	2.50E+01	m	
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.00E+01	m/d	
Hydraulic gradient of water table	i	1.20E-01	fraction	
Width of contaminant source perpendicular to groundwater flow	w	6.00E+01	m	
Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l	
		<b>Calculate</b>		
Enter mixing zone thickness	Mz		m	
Calculated mixing zone thickness	Mz	1.20E+01	m	

Not used in calculation

**Calculated Parameters**

Dilution Factor	DF	6.94E+02
Level 2 Remedial Target		4.51E+01 mg/l or 0.00E+00 mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration  
 For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Fassaroe - Site 3c
Completed by:	Adrian Green
Date:	04-May-18
Version:	1

Remedial Targets Worksheet , Release 3.2



Level 3 - Soil

See Note

Input Parameters	Variable	Value	Unit	Source
Contaminant		Ammonia		from Level 1
Target Concentration	C <sub>T</sub>	0.065	mg/l	from Level 1
Dilution Factor	DF	6.94E+02		from Level 2

Enter method of defining partition co-efficient (using pull down list)  
Calculate for ionic organic chemicals (acids)

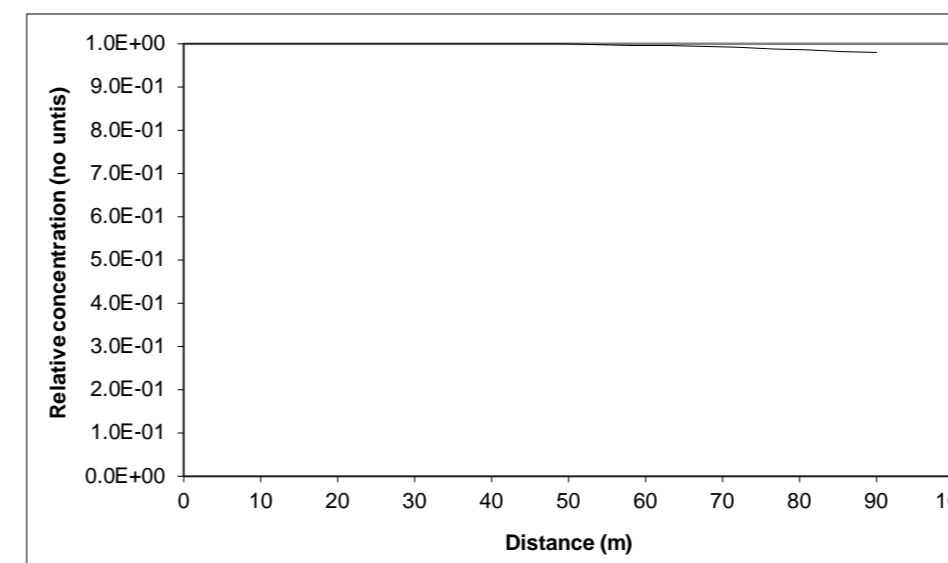
Select analytical solution (click on brown cell below, then on pull-down menu)

Domenico - Steady state 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

Soil water partition coefficient	Kd		l/kg
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Sorption coefficient for related species	K <sub>oc,n</sub>	0.00E+00	l/kg
Sorption coefficient for ionised species	K <sub>oc,i</sub>	0.00E+00	l/kg
pH value	pH		
Acid dissociation constant	pKa	0.00E+00	
Fraction of organic carbon in aquifer	foc	0.00E+00	fraction
Soil water partition coefficient	Kd	0.00E+00	l/kg



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

Calculated (relative) concentrations for distance-concentration graph

Distance	concentration (No units)	Concentration mg/l
0	1.0E+00	2.93E-01
4.5	1.00E+00	2.93E-01
9.0	1.00E+00	2.93E-01
13.5	1.00E+00	2.93E-01
18.0	1.00E+00	2.93E-01
22.5	1.00E+00	2.93E-01
27.0	1.00E+00	2.93E-01
31.5	1.00E+00	2.93E-01
36.0	1.00E+00	2.93E-01
40.5	1.00E+00	2.92E-01
45.0	9.99E-01	2.92E-01
49.5	9.98E-01	2.92E-01
54.0	9.98E-01	2.92E-01
58.5	9.96E-01	2.91E-01
63.0	9.95E-01	2.91E-01
67.5	9.93E-01	2.91E-01
72.0	9.91E-01	2.90E-01
76.5	9.88E-01	2.89E-01
81.0	9.85E-01	2.88E-01
85.5	9.82E-01	2.87E-01
90.0	9.79E-01	2.86E-01

Variable	Value	Unit	Source of parameter value
Soil leachate concentration as mg/l			
Enter soil leachate concentration	203	mg/l	
Half life for degradation of contaminant in water	1.00E+99	days	
Calculated decay rate	6.93E-100	days <sup>-1</sup>	calculated
Width of plume in aquifer at source	6.00E+01	m	from Level 2
Plume thickness in aquifer at source	1.20E+01	m	from Level 2
Bulk density of aquifer materials	1.50E+00	g/cm <sup>3</sup>	
Effective porosity of aquifer	1.00E-01	fraction	
Hydraulic gradient	1.20E-01	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	1.00E+01	m/d	from Level 2
Distance to compliance point	9.00E+01	m	
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	7.30E+03	days	time variant options only
Parameters values determined from options			
Partition coefficient	0.00E+00	l/kg	see options
Longitudinal dispersivity	9.000	m	see options
Transverse dispersivity	0.900	m	see options
Vertical dispersivity	0.090	m	see options

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

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

	Enter value	Calc value	Xu & Eckstein
Longitudinal dispersivity	ax	9.00E+00	4.18E+00 m
Transverse dispersivity	az	9.00E-01	4.18E-01 m
Vertical dispersivity	ay	9.00E-02	4.18E-02 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log<sub>10</sub>x)<sup>2.414</sup>; 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 O<sub>2</sub>, NO<sub>3</sub>, SO<sub>4</sub> etc then an alternative solution should be used

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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:	Fassaroe - Site 3c
Completed by:	Adrian Green
Date:	#####
Version:	1

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	1.20E+01	m/d
Retardation factor	1.00E+00	fraction
Decay rate used	6.93E-100	d <sup>-1</sup>
Hydraulic gradient used in aquifer flow down-gradient	1.20E-01	fraction
Rate of contaminant flow due to retardation	1.20E+01	m/d
Ratio of Compliance Point to Source Concentration	9.79E-01	fraction
Attenuation factor (C <sub>0</sub> /C <sub>ED</sub> )	1.02E+00	fraction
Soil leachate concentration	2.03E+02	

Remedial Targets

Level 3 Remedial Target	4.61E+01	mg/l	For comparison with measured pore water concentration.
Domenico - Steady state	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	0.00E+00	mg/kg	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Distance to compliance point	90	m	
Ratio of Compliance Point to Source Concentration	C <sub>ED</sub> /C <sub>0</sub>	9.79E-01	fraction 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

R&D Publication 20 Remedial Targets Worksheet, Release 3.2



Level 3 - Groundwater See Note

Input Parameters (using pull down menu) Variable Value Unit Source

Contaminant	Ammonia	from Level 1
Target Concentration	C <sub>T</sub> 6.50E-02	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**

Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C <sub>0</sub> 2.03E+02	mg/l	
Half life for degradation of contaminant in water	t <sub>1/2</sub> 1.00E+99	days	
Calculated decay rate	λ 6.93E-100	days <sup>-1</sup>	
Width of plume in aquifer at source (perpendicular to flow)	Sz 6.00E+01	m	
Plume thickness at source	Sy 1.21E+01	m	
Saturated aquifer thickness	da 2.50E+01	m	
Bulk density of aquifer materials	ρ 1.50E+00	g/cm <sup>3</sup>	
Effective porosity of aquifer	n 1.00E-01	fraction	
Hydraulic gradient	i 1.20E-01	fraction	
Hydraulic conductivity of aquifer	K 1.00E+01	m/d	
Distance to compliance point	x 9.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t 7.30E+03	days	time variant options only
<i>Parameters values determined from options</i>			
Partition coefficient	Kd 0.00E+00	l/kg	see options
Longitudinal dispersivity	ax 9.00E+00	m	see options
Transverse dispersivity	az 9.00E-01	m	see options
Vertical dispersivity	ay 9.00E-02	m	see options

Calculated Parameters Variable

Groundwater flow velocity	v	1.20E+01	m/d
Retardation factor	Rf	1.00E+00	fraction
Decay rate used	λ	6.93E-100	d <sup>-1</sup>
Rate of contaminant flow due to retardation	u	1.20E+01	m/d
Contaminant concentration at distance x, assuming two-way vertical dispersion	C <sub>ED</sub>	1.73E+02	mg/l
Attenuation factor (two way vertical dispersion, CO/CED)	AF	1.17E+00	

Remedial Targets

Remedial Target	Value	Unit	Notes
Domenico - Steady state	7.63E-02	mg/l	For comparison with measured groundwater concentration.
Distance to compliance point	90	m	
Concentration of contaminant at compliance point	C <sub>ED</sub> /C <sub>0</sub> 1.73E+02	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)

User specified value for partition coefficient

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

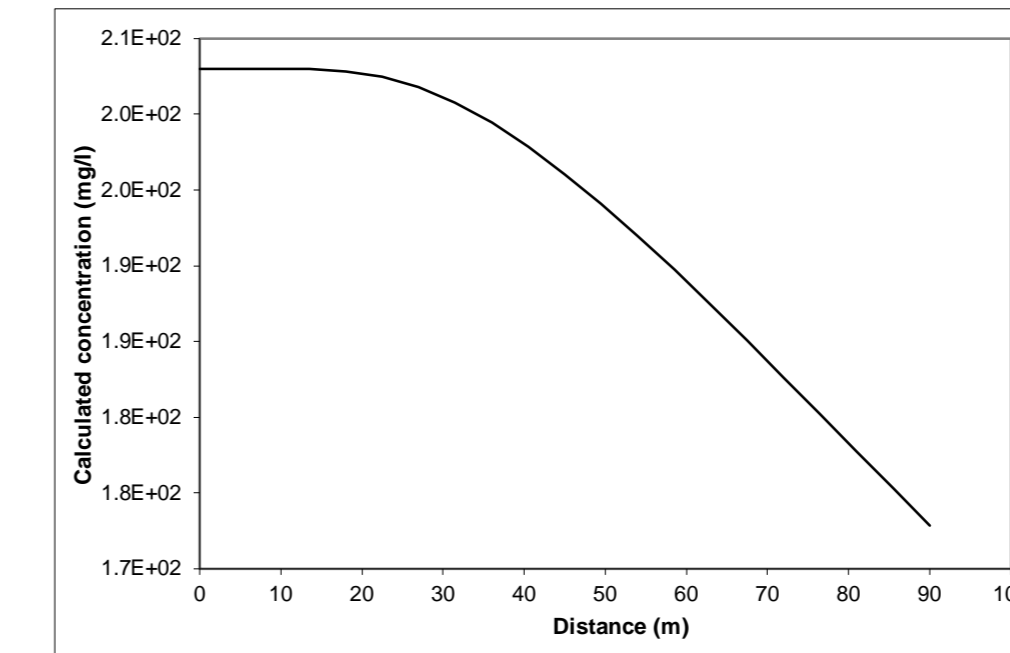
Define dispersivity (click brown cell and use pull down list)

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

Dispersivity	ax	az	ay	Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	ax			0.00E+00	9.00E+00	4.18E+00	m
Transverse dispersivity	az			0.00E+00	9.00E-01	4.18E-01	m
Vertical dispersivity	ay			0.00E+00	9.00E-02	4.18E-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(log<sub>10</sub>x)<sup>2.414</sup>; az = ax/10, ay = ax/100 are assumed

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

Note

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

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

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

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

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O<sub>2</sub>, NO<sub>3</sub>, SO<sub>4</sub> etc than an alternative solution should be used

Site being assessed:	Fassaroo - Site 3c
Completed by:	Adrian Green
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.**

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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)**

<u>Details to be completed for each assessment</u>			
<b>Site Name:</b>	Fassaroe - Site 3c		
<b>Site Address:</b>	Fassaroe Co. Wicklow		
<b>Completed by:</b>	Adrian Green	<b>Version:</b>	1
<b>Date:</b>	04-May-18		
<b>Contaminant</b>	Ammonia	<b>Origin of C<sub>T</sub>:</b>	Surface Water EQS & GW GTV
<b>Target Concentration (C<sub>T</sub>)</b>	0.065	mg/l	

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 2 - Soil

Contaminant Target concentration **C<sub>T</sub>** **Ammonia** from Level 1  
**0.065** mg/l from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

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

**Input Parameters** Variable Value Unit Source of parameter value

Standard entry

Infiltration Inf 1.57E-03 m/d  
 Area of contaminant source A 8.70E+03 m<sup>2</sup>

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow L 1.13E+02 m  
 Saturated aquifer thickness da 2.50E+01 m  
 Hydraulic Conductivity of aquifer in which dilution occurs K 1.00E+01 m/d  
 Hydraulic gradient of water table i 1.20E-01 fraction  
 Width of contaminant source perpendicular to groundwater flow w 6.00E+01 m  
 Background concentration of contaminant in groundwater beneath site Cu 0.00E+00 mg/l  
 Define mixing zone depth by specifying or calculating depth (using pull down list)  
 Enter mixing zone thickness Mz  
 Calculated mixing zone thickness Mz 1.21E+01 m

Not used in calculation

**Calculated Parameters**

Dilution Factor	DF	8.29E+01
Level 2 Remedial Target		5.39E+00 mg/l or 0.00E+00 mg/kg

For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration  
 For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor) Cc 0.00E+00 mg/l  
 Calculated concentration within receptor (dilution only) 0.00E+00 mg/l 0

Site being assessed:	Fassaroe - Site 3c
Completed by:	Adrian Green
Date:	04-May-18
Version:	1

Remedial Targets Worksheet , Release 3.2



Level 3 - Soil

See Note

Input Parameters	Variable	Value	Unit	Source
Contaminant		Ammonia		from Level 1
Target Concentration	C <sub>T</sub>	0.065	mg/l	from Level 1
Dilution Factor	DF	8.29E+01		from Level 2

Enter method of defining partition co-efficient (using pull down list)  
Calculate for ionic organic chemicals (acids)

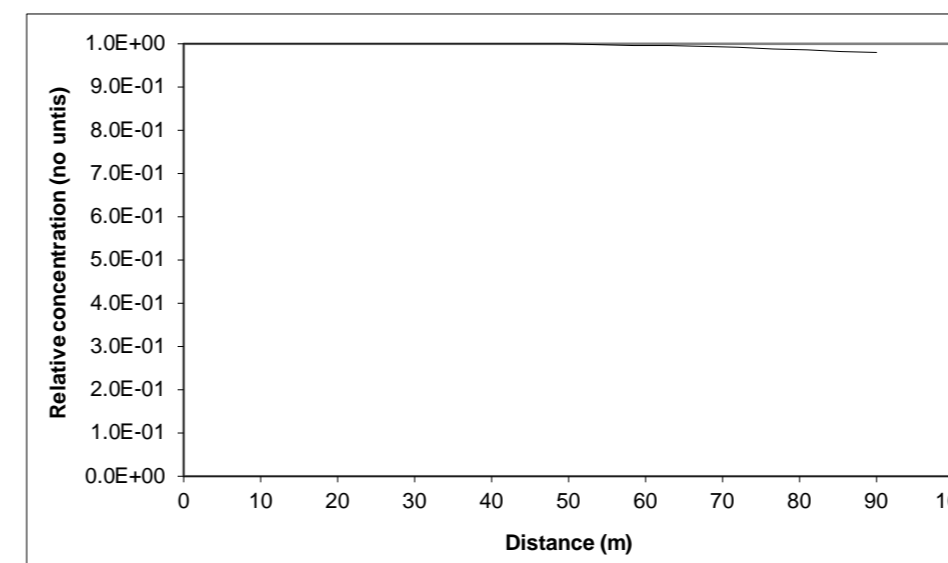
Select analytical solution (click on brown cell below, then on pull-down menu)

Domenico - Steady state 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

Soil water partition coefficient	Kd		l/kg
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Sorption coefficient for related species	K <sub>oc,n</sub>	0.00E+00	l/kg
Sorption coefficient for ionised species	K <sub>oc,i</sub>	0.00E+00	l/kg
pH value	pH		
Acid dissociation constant	pKa	0.00E+00	
Fraction of organic carbon in aquifer	foc	0.00E+00	fraction
Soil water partition coefficient	Kd	0.00E+00	l/kg



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

Calculated (relative) concentrations for distance-concentration graph

Distance	concentration (No units)	Concentration mg/l
0	1.0E+00	2.45E+00
4.5	1.00E+00	2.45E+00
9.0	1.00E+00	2.45E+00
13.5	1.00E+00	2.45E+00
18.0	1.00E+00	2.45E+00
22.5	1.00E+00	2.45E+00
27.0	1.00E+00	2.45E+00
31.5	1.00E+00	2.45E+00
36.0	1.00E+00	2.45E+00
40.5	1.00E+00	2.45E+00
45.0	9.99E-01	2.45E+00
49.5	9.98E-01	2.45E+00
54.0	9.98E-01	2.44E+00
58.5	9.96E-01	2.44E+00
63.0	9.95E-01	2.44E+00
67.5	9.93E-01	2.43E+00
72.0	9.91E-01	2.43E+00
76.5	9.88E-01	2.42E+00
81.0	9.86E-01	2.41E+00
85.5	9.82E-01	2.41E+00
90.0	9.79E-01	2.40E+00

Variable	Value	Unit	Source of parameter value
Soil leachate concentration as mg/l			
Enter soil leachate concentration	203	mg/l	
Half life for degradation of contaminant in water	1.00E+99	days	
Calculated decay rate	6.93E-100	days <sup>-1</sup>	calculated
Width of plume in aquifer at source	6.00E+01	m	from Level 2
Plume thickness in aquifer at source	1.21E+01	m	from Level 2
Bulk density of aquifer materials	1.50E+00	g/cm <sup>3</sup>	
Effective porosity of aquifer	1.00E-01	fraction	
Hydraulic gradient	1.21E-01	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	1.00E+01	m/d	from Level 2
Distance to compliance point	9.00E+01	m	
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	7.30E+03	days	time variant options only
Parameters values determined from options			
Partition coefficient	0.00E+00	l/kg	see options
Longitudinal dispersivity	9.000	m	see options
Transverse dispersivity	0.900	m	see options
Vertical dispersivity	0.090	m	see options

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

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

	Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	ax	0.00E+00	9.00E+00	4.18E+00 m
Transverse dispersivity	az	0.00E+00	9.00E-01	4.18E-01 m
Vertical dispersivity	ay	0.00E+00	9.00E-02	4.18E-02 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83(log<sub>10</sub>x)<sup>2.414</sup>; az = ax/10, ay = ax/100 are assumed

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Groundwater flow velocity	v	1.21E+01	m/d
Retardation factor	Rf	1.00E+00	fraction
Decay rate used	λ	6.93E-100	d <sup>-1</sup>
Hydraulic gradient used in aquifer flow down-gradient	i	1.21E-01	fraction
Rate of contaminant flow due to retardation	u	1.21E+01	m/d
Ratio of Compliance Point to Source Concentration	C <sub>ED</sub> /C <sub>0</sub>	9.79E-01	fraction
Attenuation factor (C <sub>0</sub> /C <sub>ED</sub> )	AF	1.02E+00	fraction
Soil leachate concentration	C <sub>0</sub>	2.03E+02	

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 O<sub>2</sub>, NO<sub>3</sub>, SO<sub>4</sub> etc then an alternative solution should be used

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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.

Remedial Targets

Level 3 Remedial Target	5.50E+00	mg/l	For comparison with measured pore water concentration.
Domenico - Steady state	or		This assumes Level 1 Remedial Target is based on Target Concentration.
	0.00E+00	mg/kg	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Distance to compliance point	90	m	
Ratio of Compliance Point to Source Concentration	C <sub>ED</sub> /C <sub>0</sub>	9.79E-01	fraction Domenico - Steady state

Site being assessed:	Fassaroe - Site 3c
Completed by:	Adrian Green
Date:	#####
Version:	1

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

R&D Publication 20 Remedial Targets Worksheet, Release 3.2



Level 3 - Groundwater See Note

Input Parameters (using pull down menu) Variable Value Unit Source

Contaminant	Ammonia	from Level 1
Target Concentration	C <sub>T</sub> 6.50E-02	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

Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C <sub>0</sub> 2.04E+02	mg/l	
Half life for degradation of contaminant in water	t <sub>1/2</sub> 1.00E+99	days	
Calculated decay rate	λ 6.93E-100	days <sup>-1</sup>	
Width of plume in aquifer at source (perpendicular to flow)	Sz 6.00E+01	m	
Plume thickness at source	Sy 1.21E+01	m	
Saturated aquifer thickness	da 2.50E+01	m	
Bulk density of aquifer materials	ρ 1.50E+00	g/cm <sup>3</sup>	
Effective porosity of aquifer	n 1.00E-01	fraction	
Hydraulic gradient	i 1.20E-01	fraction	
Hydraulic conductivity of aquifer	K 1.00E+01	m/d	
Distance to compliance point	x 9.00E+01	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	m	
Distance (depth) to compliance point perpendicular to flow direction	y	m	
Time since pollutant entered groundwater	t 7.30E+03	days	time variant options only
<i>Parameters values determined from options</i>			
Partition coefficient	Kd 0.00E+00	l/kg	see options
Longitudinal dispersivity	ax 9.00E+00	m	see options
Transverse dispersivity	az 9.00E-01	m	see options
Vertical dispersivity	ay 9.00E-02	m	see options

Calculated Parameters Variable

Groundwater flow velocity	v	1.20E+01	m/d
Retardation factor	Rf	1.00E+00	fraction
Decay rate used	λ	6.93E-100	d <sup>-1</sup>
Rate of contaminant flow due to retardation	u	1.20E+01	m/d
Contaminant concentration at distance x, assuming two-way vertical dispersion	C <sub>ED</sub>	1.74E+02	mg/l
Attenuation factor (two way vertical dispersion, CO/CED)	AF	1.17E+00	

Remedial Targets

Remedial Target	Value	Unit	Notes
Domenico - Steady state	7.63E-02	mg/l	For comparison with measured groundwater concentration.
Distance to compliance point	90	m	
Concentration of contaminant at compliance point	C <sub>ED</sub> /C <sub>0</sub> 1.74E+02	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)

User specified value for partition coefficient

Entry if specify partition coefficient (option)		
Soil water partition coefficient	Kd	0.00E+00 l/kg
Entry for non-polar organic chemicals (option)		
Fraction of organic carbon in aquifer	foc	fraction
Organic carbon partition coefficient	Koc	l/kg
Entry for ionic organic chemicals (option)		
Sorption coefficient for related species	K <sub>oc,i</sub>	l/kg
Sorption coefficient for ionised species	K <sub>oc,i</sub>	l/kg
pH value	pH	
acid dissociation constant	pKa	
Fraction of organic carbon in aquifer	foc	fraction
Soil water partition coefficient	Kd	0.00E+00 l/kg

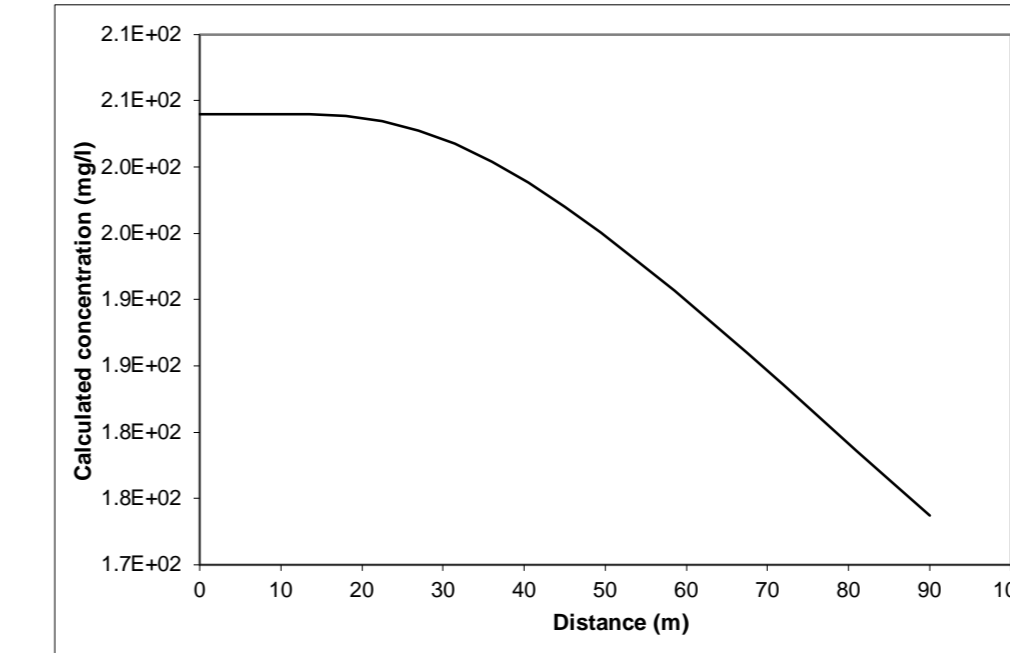
Define dispersivity (click brown cell and use pull down list)

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

Variable	Enter value	Calc value	Xu & Eckstein	Unit
Longitudinal dispersivity	ax	9.00E+00	4.18E+00	m
Transverse dispersivity	az	9.00E-01	4.18E-01	m
Vertical dispersivity	ay	9.00E-02	4.18E-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(log<sub>10</sub>x)<sup>2.414</sup>; az = ax/10, ay = ax/100 are assumed

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

Note

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

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

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

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O<sub>2</sub>, NO<sub>3</sub>, SO<sub>4</sub> etc than an alternative solution should be used

Site being assessed:	Fassaroe - Site 3c
Completed by:	Adrian Green
Date:	#####
Version:	1

Calculated concentrations for distance-concentration graph

Domenico - Steady state  
From calculation sheet

Distance	Concentration
	mg/l
0	2.04E+02
4.5	2.04E+02
9.0	2.04E+02
13.5	2.04E+02
18.0	2.04E+02
22.5	2.03E+02
27.0	2.03E+02
31.5	2.02E+02
36.0	2.00E+02
40.5	1.99E+02
45.0	1.97E+02
49.5	1.95E+02
54.0	1.93E+02
58.5	1.91E+02
63.0	1.88E+02
67.5	1.86E+02
72.0	1.84E+02
76.5	1.81E+02
81.0	1.79E+02
85.5	1.76E+02
90.0	1.74E+02