

APPENDIX A

Worksheets



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.1

Date of Workbook Issue: October 2006

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).

Details to be completed for each assessment

Site Name:	Travis Perkins Depot		
Site Address:	Pier Road, Littlehampton, West Sussex		
Completed by:	Craig Bulga	Version:	1.1
Date:	05-Nov-08		
Contaminant	Arsenic		
Target Concentration (C_T)	0.025	mg/l	Origin of C_T : EQS for Freshwaters

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.

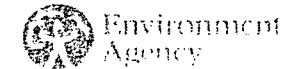
Data carried forward from an earlier worksheet are identified by a light green background

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 3.1

Level 1 - Soil



Select the method of calculating the soil water
Partition Co-efficient by using the pull down menu
below

User specified value for partition coefficient

Contaminant
Target concentration C_T

Arsenic
0.025 mg/l

Input Parameters Variable Value Unit Source of parameter value

Standard entry

Water filled soil porosity θ_w 2.40E-01 fraction
Air filled soil porosity θ_a 3.00E-01 fraction
Bulk density of soil zone material ρ 1.60E+00 g/cm³
Henry's Law constant H 0.00E+00 dimensionless

CLEA UK Default for Sandy Soils
CLEA UK Default for Sandy Soils
CLEA UK Default for Sandy Soils
n/a

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a
selected target concentration and theoretical calculation of soil water partitioning.
Three options are included for determining the partition coefficient.
The measured soil concentration as mg/kg should be compared with the Level 1
remedial target to determine the need for further action.

Entry if specify partition coefficient (option)

Soil water partition coefficient Kd 1.17E+02 l/kg

Consim Files

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil) foc
Organic carbon partition coefficient Koc

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species $K_{oc,n}$ l/kg
Sorption coefficient for ionised species $K_{oc,i}$ l/kg
pH value pH pH units
Acid dissociation constant pKa
Fraction of organic carbon (in soil) foc

Soil water partition coefficient used in Level Assessment Kd 1.17E+02 l/kg Specified value

Level 1 Remedial Target

Level 1 Remedial Target	2.93E+00	mg/kg	(for comparison with soil analyses)
	or		
	0.025	mg/l	(for comparison with leachate test results)

Site being assessed	Travis Perkins Depot
Completed by	Craig Bulga
Date	05-Nov-08
Version	1.1

Remedial Targets Worksheet , Release 3.1

Level 2 - Soil



Contaminant
Target concentration

C_T

Arsenic
0.025 mg/l

from Level 1
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	4.90E-06	m/d	Met Office Data
Area of contaminant source	A	2.50E+02	m ²	Site Measurement
				Not used in calculation
Entry for groundwater flow below site				
Length of contaminant source in direction of groundwater flow	L	2.50E+01	m	Site Measurement
Saturated aquifer thickness	da	3.11E+00	m	Site Measurement
Hydraulic Conductivity of aquifer in which dilution occurs	K	2.33E-01	m/d	Site Measurement
Hydraulic gradient of water table	i	2.42E-02	fraction	Site Measurement
Width of contaminant source perpendicular to groundwater flow	w	1.00E+01	m	Site Measurement
Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l	Site Measurement
				Not used in calculation
Define mixing zone depth by specifying or calculating depth (using pull down list)		Calculate		
Enter mixing zone thickness	Mz		m	
Calculated mixing zone thickness	Mz	2.67E+00	m	

Calculated Parameters

Dilution Factor	DF	1.24E+02	
Level 2 Remedial Target		3.10E+00	mg/l
		or	
		3.63E+02	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)

C_c

0.00E+00 mg/l

Calculated concentration within receptor (dilution only)

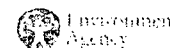
0.00E+00 mg/l 0

Site being assessed: Travis Perkins Depot
Completed by: Craig Bulge
Date: 05-Nov-08
Version: 1.1

Remedial Targets Worksheet, Release 3.1

Level 3 - Soil

See Note



Input Parameters Variable Value Unit Source

Contaminant	Arsenic		from Level 1
Target Concentration	C ₁	0.025	mg/l from Level 1
Dilution Factor	DF	1.24E+02	from Level 2

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

Ogata Banks Equations in HRA publication

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

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

Variable	Value	Unit	Source of parameter value
Enter source concentration			Soil concentration as mg/kg
Enter soil concentration	30	mg/kg	
Half life for degradation of contaminant in water	9.00E+99	days	
Calculated decay rate	7.70E-101	days	calculated
Width of plume in aquifer at source	1.00E+01	m	from Level 2
Plume thickness in aquifer at source	2.67E+00	m	from Level 2
Bulk density of aquifer materials	1.60E+00	g/cm ³	CLEA UK Default for Sandy Soils
Effective porosity of aquifer	3.00E-01	fraction	EA recommended value
Hydraulic gradient	2.44E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	2.33E-01	m/d	from Level 2
Distance (lateral) to compliance point perpendicular to flow direction	5.00E+01	m	
Distance (depth) to compliance point perpendicular to flow direction		m	
Time since pollutant entered groundwater	1.00E+99	days	time variant options only
Partition coefficient	1.17E+02	l/kg	see options
Longitudinal dispersivity	5.000	m	see options
Transverse dispersivity	0.500	m	see options
Vertical dispersivity	0.050	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters Variable

Groundwater flow velocity	v	1.90E-02	m/d
Retardation factor	Rf	6.25E+02	fraction
Decay rate used	λ	1.23E-103	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	i	2.44E-02	fraction
Rate of contaminant flow due to retardation	u	3.04E-05	m/d
Ratio of Compliance Point to Source Concentration	C ₁ /C ₀	3.99E-01	fraction
Attenuation factor (C ₁ /C ₀)	AF	2.50E+00	fraction
Calculated soil leachate concentration	C ₀	2.56E-01	mg/l

Remedial Targets

Level 3 Remedial Target	7.76E+00	mg/l	For comparison with measured pore water concentration
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration
	8.08E+02	mg/kg	For comparison with measured soil concentration. This
Distance to compliance point	50	m	assumes Level 1 Remedial Target calculated from soil-water partitioning equation
Ratio of Compliance Point to Source Concentration	C ₁ /C ₀	3.99E-01	fraction Ogata Banks

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

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

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient K_d 1.17E+02 l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} fractionOrganic carbon partition coefficient K_{oc} l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species K_{ow} l/kgSorption coefficient for ionised species K_{ow} l/kg

pH value pH

Acid dissociation constant pKa

Fraction of organic carbon in aquifer f_{oc} fractionSoil water partition coefficient K_d 1.17E+02 l/kg

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

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

Longitudinal dispersivity α_L Enter value Calc value Xu & EcksteinTransverse dispersivity α_T 5.00E-01 5.00E-01 mVertical dispersivity α_V 5.00E-02 5.00E-02 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report α_L = 0.83(log α_L)^{1.111}, α_T = α_L/10, α_V = α_L/100 are assumed

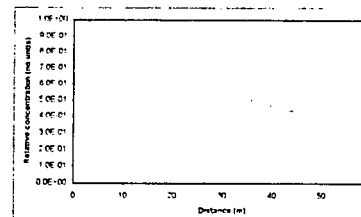
Note

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If

degradation is best described by an electron limited

degradation such as oxidation by O₂, NO₃, SO₄ etc than an

alternative solution should be used



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

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks

From calculation sheet

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	2.07E-03
2.5	9.98E-01	2.06E-03
5.0	9.74E-01	2.01E-03
7.5	9.30E-01	1.92E-03
10.0	8.79E-01	1.82E-03
12.5	8.28E-01	1.71E-03
15.0	7.80E-01	1.61E-03
17.5	7.34E-01	1.52E-03
20.0	6.93E-01	1.43E-03
22.5	6.55E-01	1.35E-03
25.0	6.20E-01	1.26E-03
27.5	5.89E-01	1.22E-03
30.0	5.60E-01	1.16E-03
32.5	5.33E-01	1.10E-03
35.0	5.09E-01	1.05E-03
37.5	4.87E-01	1.01E-03
40.0	4.67E-01	9.64E-04
42.5	4.48E-01	9.25E-04
45.0	4.30E-01	8.89E-04
47.5	4.14E-01	8.56E-04
50.0	3.99E-01	8.25E-04

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

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

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

Site being assessed: A. Travel Park, Dorset
Completed by: Craig Budge
Date: 12/11/08
Version: 1.1

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant: Arsenic
 Target Concentration: C_1 $2.50E-02$ mg/l
 Source: from Level 1

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

Ogata Banks Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

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

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

Initial contaminant concentration in groundwater at plume core C_0 $7.20E-02$ mg/l
 Half life for degradation of contaminant in water $t_{1/2}$ $9.00E+09$ days
 Calculated decay rate λ $7.70E-101$ days⁻¹
 Width of plume in aquifer at source (perpendicular to flow) S_z $1.00E+01$ m
 Plume thickness at source S_y $3.01E+00$ m
 Saturated aquifer thickness d_a $3.11E+00$ m
 Bulk density of aquifer materials ρ $1.60E+00$ g/cm³
 Effective porosity of aquifer n $3.00E-01$ fraction
 Hydraulic gradient i $2.42E-02$ m/d
 Hydraulic conductivity of aquifer K $2.33E-01$ m
 Distance to compliance point x $5.00E-01$ m
 Distance (laterally) to compliance point perpendicular to flow direction z $0.00E+00$ m
 Distance (depth) to compliance point perpendicular to flow direction y $0.00E+00$ m
 Time since pollutant entered groundwater t $1.00E+100$ days

Parameters values determined from options

Partition coefficient K_d $1.17E-02$ l/kg
 Longitudinal dispersivity α_x $5.00E+00$ m
 Transverse dispersivity α_z $5.00E-01$ m
 Vertical dispersivity α_y $5.00E-02$ m

Calculated Parameters

Groundwater flow velocity v $1.89E-02$ m/d
 Retardation factor R $8.75E+02$ fraction
 Decay rate used λ $1.23E-103$ d⁻¹
 Rate of contaminant flow due to retardation u $3.01E-05$ m/d
 Contaminant concentration at distance x , assuming one-way vertical dispersion C_{1D} $3.08E-02$ mg/l
 Attenuation factor (one way vertical dispersion, COCED) AF $2.34E+00$

Remedial Targets

Remedial Target: $5.89E-02$ mg/l
 Ogata Banks
 Distance to compliance point: 50 m
 Concentration of contaminant at compliance point C_{1D}/C_2 $3.08E-02$ mg/l
 after $1.0E+100$ days

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
 The recommended value for time when calculating the remedial target is $9.0E+09$.

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

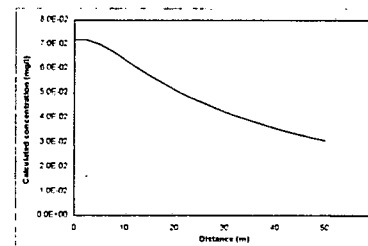
User specified value for partition coefficient

Entry if specify partition coefficient (option) K_d $1.17E-02$ l/kg
 Soil water partition coefficient
 Entry for non-polar organic chemicals (option)
 Fraction of organic carbon in aquifer f_{oc} fraction
 Organic carbon partition coefficient K_{oc} fraction
 Entry for ionic organic chemicals (option)
 Sorption coefficient for mixed species K_{ow} l/kg
 pH value pH l/kg
 acid dissociation constant pK_a l/kg
 Fraction of organic carbon in aquifer f_{oc} fraction
 Soil water partition coefficient K_d $1.17E-02$ l/kg

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

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

Longitudinal dispersivity α_x Enter value Calc value Xu & Eckstein m
 Transverse dispersivity α_z $5.00E-02$ m
 Vertical dispersivity α_y $5.00E-02$ m
 Note: values of dispersivity must be > 0
 For calculated value assumes $\alpha_x = 0.1 \cdot x$, $\alpha_z = 0.01 \cdot z$, $\alpha_y = 0.001 \cdot y$
 Xu & Eckstein (1995) report $\alpha_x = 0.83(\log u)^{2.11}$, $\alpha_z = \alpha_x/10$, $\alpha_y = \alpha_z/100$ are assumed



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

Note

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

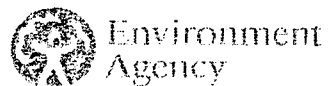
By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

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

Note: if contaminant is not subject to first order degradation, then set half life as $9.0E+09$.

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

Any being followed: Travis Penfold Dept.
 Completed by: Craig Budge
 Date: 11/12/2008
 Version: 1.0



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.1

Date of Workbook Issue: October 2006

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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:	Travis Perkins Depot		
Site Address:	Pier Road, Littlehampton, West Sussex		
Completed by:	Craig Bulga		
Date:	05-Nov-08	Version:	1.1
Contaminant	Aromatic C10-C12		
Target Concentration (C _T)	0.0125	mg/l	Origin of C _T : 1/4 SWAD - Dissolved and Emulsified Hydrocarbons

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 3.1

Level 1 - Soil

Environment
Agency

Select the method of calculating the soil water
Partition Co-efficient by using the pull down menu
below

Calculate for non-polar organic chemicals

Contaminant
Target concentration

C_T

Aromatic C10-C12

0.0125 mg/l

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Water filled soil porosity

θ_w

2.40E-01

fraction

CLEA UK Default for Sandy Soils

Air filled soil porosity

θ_a

3.00E-01

fraction

CLEA UK Default for Sandy Soils

Bulk density of soil zone material

ρ

1.60E+00

g/cm³

CLEA UK Default for Sandy Soils

Henry's Law constant

H

6.10E-03

dimensionless

TPH CWG Volume 3

Entry if specify partition coefficient (option)

Soil water partition coefficient

K_d

l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil)

f_{oc}

2.00E-03

fraction

Consim Files

Organic carbon partition coefficient

K_{oc}

1.29E+03

l/kg

TPH CWG Volume 3

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species

K_{oc,n}

l/kg

Sorption coefficient for ionised species

K_{oc,i}

l/kg

pH value

pH

pH units

Acid dissociation constant

pK_a

Fraction of organic carbon (in soil)

f_{oc}

fraction

Soil water partition coefficient used in Level Assessment

K_d

2.58E+00

l/kg

Calculated value

Level 1 Remedial Target

Level 1 Remedial Target

3.41E-02

mg/kg

(for comparison with soil analyses)

or

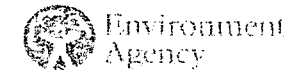
0.0125

mg/l

(for comparison with leachate test results)

Site being assessed: Travis Perkins Depot
Completed by: Craig Bulda
Date: 05-Nov-08
Version: 1.1

Remedial Targets Worksheet, Release 3.1



Level 2 - Soil

Contaminant Target concentration C_T **Aromatic C10-C12** from Level 1
0.0125 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)

Standard entry	Input Parameters	Variable	Value	Unit	Source of parameter value
	Infiltration	Inf	4.90E-06	m/d	Met Office Data
	Area of contaminant source	A	2.50E+02	m ²	Site Measurement
					Not used in calculation
Entry for groundwater flow below site					
	Length of contaminant source in direction of groundwater flow	L	2.50E+01	m	Site Measurement
	Saturated aquifer thickness	da	3.11E+00	m	Site Measurement
	Hydraulic Conductivity of aquifer in which dilution occurs	K	2.33E-01	m/d	Site Measurement
	Hydraulic gradient of water table	i	2.42E-02	fraction	Site Measurement
	Width of contaminant source perpendicular to groundwater flow	w	1.00E+01	m	Site Measurement
	Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l	Site Measurement
					Not used in calculation
	Define mixing zone depth by specifying or calculating depth (using pull down list)		Calculate		
	Enter mixing zone thickness	Mz		m	
	Calculated mixing zone thickness	Mz	2.67E+00	m	

Calculated Parameters

Dilution Factor	DF	1.24E+02	
Level 2 Remedial Target		1.55E+00	mg/l
		or	
		4.23E+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

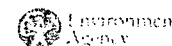
Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed	Travis Perkins Depot
Completed by	Craig Bulga
Date	05-Nov-08
Version	1.1

Remedial Targets Worksheet, Release 3.1

Level 3 - Soil

See Note



Input Parameters Variable Value Unit Source

Contaminant Aromatic C10-C12 from Level 1
Target Concentration C_T 0.0175 mg/l from Level 1
Dilution Factor DF 1.24E+02 from Level 2

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

Ogata Banks Equations in HRA publication

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

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

Variable	Value	Unit	Source of parameter value
Enter source concentration			
Enter soil concentration	12	mg/kg	Howard
Half life for degradation of contaminant in water $t_{1/2}$	2.56E+02	days	calculated
Calculated decay rate λ	2.69E-03	days ⁻¹	calculated
Width of plume in aquifer at source S_z	1.00E+01	m	from Level 2
Plume thickness in aquifer at source S_y	2.67E+00	m	from Level 2
Bulk density of aquifer materials ρ	1.60E+00	g/cm ³	CLEA UK Default for Sandy Soils
Effective porosity of aquifer n	3.00E-01	fraction	EA recommended value
Hydraulic gradient I	2.44E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer K	2.33E-01	m/d	from Level 2
Distance (lateral) to compliance point perpendicular to flow direction x	5.00E+01	m	
Distance (depth) to compliance point perpendicular to flow direction z		m	
Time since pollutant entered groundwater t	1.00E+99	days	time variant options only
Parameters values determined from options			
Partition coefficient K_d	2.56E+00	l/kg	see options
Longitudinal dispersivity α_x	5.000	m	see options
Transverse dispersivity α_z	0.500	m	see options
Vertical dispersivity α_v	0.050	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters Variable

Variable	Value	Unit
Groundwater flow velocity v	1.90E-02	m/d
Retardation factor R_f	1.47E+01	fraction
Decay rate used λ	1.82E-04	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient I	2.44E-02	fraction
Rate of contaminant flow due to retardation u	1.29E-03	m/d
Ratio of Compliance Point to Source Concentration C_{CP}/C_0	3.33E-03	fraction
Attenuation factor (C_{CP}/C_0) AF	3.81E+02	fraction
Calculated soil leachate concentration C_0	4.40E+00	mg/l

Remedial Targets

Variable	Value	Unit	Source
Level 3 Remedial Target	4.86E+02	mg/l	For comparison with measured pore water concentration
Ogata Banks	1.27E+03	mg/kg	This assumes Level 1 Remedial Target is based on Target Concentration
Distance to compliance point	50	m	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation
Ratio of Compliance Point to Source Concentration C_{CP}/C_0	3.33E-03	fraction	Ogata Banks

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)
Soil-water partition coefficient K_d 1/kg
Entry for non-polar organic chemicals (option)
Fraction of organic carbon in aquifer f_{oc} 2.00E-03 fraction
Organic carbon partition coefficient K_{oc} 1.29E+03 l/kg
Entry for ionic organic chemicals (option)
Sorption coefficient for related species K_{ow} 1/kg
Sorption coefficient for ionised species K_{ow} 1/kg
pH value pH 1/kg
Acid dissociation constant pKa 1/kg
Fraction of organic carbon in aquifer f_{oc} fraction

Soil water partition coefficient K_d 2.56E+00 l/kg

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

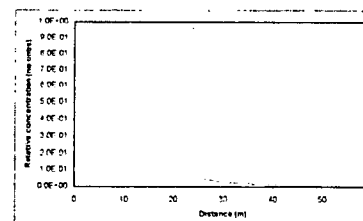
Dispersivities 10%, 1%, 0.1% of pathway length

Enter value	Calc value	Xu & Eckstein
α_x	5.00E+00	m
α_z	5.00E+01	m
α_y	5.00E+02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report $\alpha_x = 0.83(\log_{10} K_d)^{1.11}$, $\alpha_z = \alpha_x/10$, $\alpha_y = \alpha_x/100$ 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_2 , NO_3^- , SO_4^{2-} etc than an alternative solution should be used.



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

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks

From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	3.55E-02
2.5	7.85E-01	2.79E-02
5.0	6.04E-01	2.14E-02
7.5	4.54E-01	1.61E-02
10.0	3.38E-01	1.20E-02
12.5	2.50E-01	8.88E-03
15.0	1.85E-01	6.58E-03
17.5	1.37E-01	4.88E-03
20.0	1.02E-01	3.62E-03
22.5	7.59E-02	2.70E-03
25.0	5.66E-02	2.01E-03
27.5	4.23E-02	1.50E-03
30.0	3.17E-02	1.12E-03
32.5	2.37E-02	8.43E-04
35.0	1.78E-02	6.33E-04
37.5	1.34E-02	4.77E-04
40.0	1.01E-02	3.60E-04
42.5	7.65E-03	2.72E-04
45.0	5.79E-03	2.05E-04
47.5	4.38E-03	1.56E-04
50.0	3.33E-03	1.18E-04

This sheet calculates the Level 3 remedial target for soils (mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source. Three solution methods are included: the preferred option is Ogata Banks. By setting a long travel time (e.g. 9.9E99) 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: Travis Perkins Depot
Completed by: Craig Briggs
Date: 11/12/2008
Version: 3.1

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Contaminant: Aromatic C10-C12 from Level 1
 Target Concentration: C_T 1.25E-02 mg/l from Level 1

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

Ogata Banks Equations in HRA publication

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

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

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

Initial contaminant concentration in groundwater at plume core C_0 4.90E-02 mg/l Site Measurement
 Half life for degradation of contaminant in water $t_{1/2}$ 2.58E+02 days Howard
 Calculated decay rate λ 2.69E-03 days⁻¹
 Width of plume in aquifer at source (perpendicular to flow) S_z 1.00E+01 m Site Measurement
 Plume thickness at source S_y 3.01E+00 m Site Measurement
 Saturated aquifer thickness d_0 3.11E+00 m Site Measurement
 Bulk density of aquifer materials ρ 1.60E+00 g/cm³ CLEA UK Default
 Effective porosity of aquifer n 3.00E-01 fraction EA recommended value
 Hydraulic gradient i 2.42E-02 fraction Site Measurement
 Hydraulic conductivity of aquifer K 2.33E-01 m/d Site Measurement
 Distance (lateral) to compliance point perpendicular to flow direction x 5.00E+01 m
 Distance (depth) to compliance point perpendicular to flow direction z 0.00E+00 m
 Time since pollutant entered groundwater t 1.00E+100 days time variant options only

Parameters values determined from options
 Partition coefficient K_d 2.58E+00 l/kg see options
 Longitudinal dispersivity α_x 5.00E+00 m see options
 Transverse dispersivity α_z 5.00E-01 m see options
 Vertical dispersivity α_y 5.00E-02 m see options

Calculated Parameters

Groundwater flow velocity v 1.85E-02 m/d
 Retardation factor Rf 1.47E+01 fraction
 Decay rate used λ 1.85E-04 d⁻¹
 Rate of contaminant flow due to retardation u 1.28E-03 m/s
 Contaminant concentration at distance x , assuming one-way vertical dispersion C_D 1.70E-04 mg/l
 Attenuation factor (one way vertical dispersion, CO/CED) AF 2.89E+02

Remedial Targets

Remedial Target 3.61E+00 mg/l For comparison with measured groundwater concentration
 Ogata Banks
 Distance to compliance point 50 m
 Concentration of contaminant at compliance point C_D/C_0 1.70E-04 mg/l Ogata Banks
 after 1.0E+100 days

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

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

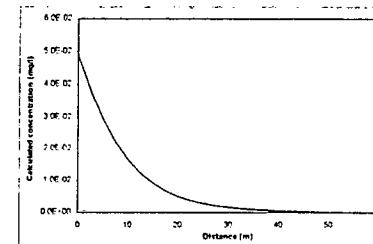
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)
 Soil water partition coefficient K_d 2.58E+00 l/kg
 Entry for non-polar organic chemicals (option)
 Fraction of organic carbon in aquifer f_{oc} 2.00E-03 fraction
 Organic carbon partition coefficient K_{oc} 1.29E+03 l/kg
 Entry for ionic organic chemicals (option)
 Sorption coefficient for related species K_{ow} 1 kg
 Sorption coefficient for ionised species K_{ow} 1 kg
 pH value pH 7
 acid dissociation constant pKa 7
 Fraction of organic carbon in aquifer f_{oc} 2.00E-03 fraction
 Soil water partition coefficient K_d 2.58E+00 l/kg

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

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

Longitudinal dispersivity α_x 5.00E+00 m
 Transverse dispersivity α_z 5.00E-01 m
 Vertical dispersivity α_y 5.00E-02 m
 Note: values of dispersivity must be > 0
 For calculated value, assumes $\alpha_x = 0.1 \cdot x$, $\alpha_z = 0.01 \cdot z$, $\alpha_y = 0.001 \cdot y$
 Xu & Eckstein (1995) report $\alpha_x = 0.83(\log_{10} x)^{1.14}$, $\alpha_z = \alpha_x/10$, $\alpha_y = \alpha_x/100$ are assumed



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

Note

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

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

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

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

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

Site being assessed: 27-16-16 Petlink Drive
 Compiled by: Craig Gudge
 Date: 11/12/2008
 Version: 3.1



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.1

Date of Workbook Issue: October 2006

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

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

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

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

Details to be completed for each assessment

Site Name:	Travis Perkins Depot		
Site Address:	Pier Road, Littlehampton, West Sussex		
Completed by:	Craig Bulga		
Date:	05-Nov-08	Version:	1.1
Contaminant	Aromatic C12-C16		
Target Concentration (C _T)	0.0125	mg/l	Origin of C _T : 1/4 SWAD - Dissolved and Emulsified Hydrocarbons

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.

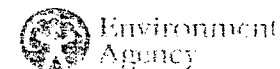
Data carried forward from an earlier worksheet are identified by a light green background

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 3.1

Level 1 - Soil



Select the method of calculating the soil water
Partition Co-efficient by using the pull down menu
below

Calculate for non-polar organic chemicals

Contaminant
Target concentration C_T

Aromatic C12-C16
0.0125 mg/l

Input Parameters Variable Value Unit Source of parameter value

Standard entry

Water filled soil porosity θ_w 2.40E-01 fraction
Air filled soil porosity θ_a 3.00E-01 fraction
Bulk density of soil zone material ρ 1.60E+00 g/cm³
Henry's Law constant H 3.21E-03 dimensionless

CLEA UK Default for Sandy Soils

CLEA UK Default for Sandy Soils

CLEA UK Default for Sandy Soils

TPH CWG Volume 3

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a
selected target concentration and theoretical calculation of soil water partitioning.
Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1
remedial target to determine the need for further action.

Entry if specify partition coefficient (option)

Soil water partition coefficient K_d

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil) f_{oc} 2.00E-03 fraction
Organic carbon partition coefficient K_{oc} 7.08E+03 l/kg

Consim Files

TPH CWG Volume 3

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species $K_{oc,n}$ l/kg
Sorption coefficient for ionised species $K_{oc,i}$ l/kg
pH value pH pH units
Acid dissociation constant pKa
Fraction of organic carbon (in soil) f_{oc} fraction

Soil water partition coefficient used in Level Assessment K_d 1.42E+01 l/kg

Calculated value

Level 1 Remedial Target

Level 1 Remedial Target 1.79E-01 mg/kg
or
0.0125 mg/l

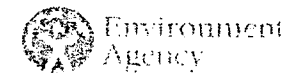
(for comparison with soil analyses)

(for comparison with leachate test results)

Site being assessed: Travis Perkins Depot
Completed by: Craig Bulga
Date: 05-Nov-08
Version: 1.1

Remedial Targets Worksheet , Release 3.1

Level 2 - Soil

Contaminant
Target concentrationC_TAromatic C12-C16
0.0125

mg/l

from Level 1
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)

Standard entry

Input Parameters

Variable

Value

Unit

Source of parameter value

Infiltration
Area of contaminant sourceInf
A4.90E-06
2.50E+02m/d
m²

Met Office Data

Site Measurement

Not used in calculation

Entry for groundwater flow below site

Length of contaminant source in direction of groundwater flow

L

2.50E+01

m

Site Measurement

Saturated aquifer thickness

da

3.11E+00

m

Site Measurement

Hydraulic Conductivity of aquifer in which dilution occurs

K

2.33E-01

m/d

Site Measurement

Hydraulic gradient of water table

i

2.42E-02

fraction

Site Measurement

Width of contaminant source perpendicular to groundwater flow

w

1.00E+01

m

Site Measurement

Background concentration of contaminant in groundwater beneath site

Cu

0.00E+00

mg/l

Site Measurement

Not used in calculation

Define mixing zone depth by specifying or calculating depth (using pull down list)

Calculate

Enter mixing zone thickness

Mz

m

Calculated mixing zone thickness

Mz

2.67E+00

m

Calculated Parameters

Dilution Factor

DF

1.24E+02

Level 2 Remedial Target

1.55E+00

mg/l

or

2.22E+01

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: Travis Perkins Depot
Completed by: Craig Bulga
Date: 05-Nov-08
Version: 1.1

Remedial Targets Worksheet, Release 3.1

Level 3 - Soil

See Note

Input Parameters	Variable	Value	Unit	Source
Contaminant		Aromatic C12-C16		from Level 1
Target Concentration	C _T	0.0125	mg/l	from Level 1
Dilution Factor	DF	1.24E+02		from Level 2

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

Ogata Banks

Equations in HRA publication

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

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

Variable	Value	Unit	Source of parameter value
Enter source concentration			
Enter soil concentration			
Half life for degradation of contaminant in water	12	mg/kg	
Calculated decay rate	2.04E-02	days	Howard
Width of plume in aquifer at source	3.40E-03	days ⁻¹	calculated
Plume thickness in aquifer at source	1.00E-01	m	from Level 2
Bulk density of aquifer materials	2.67E-00	m	from Level 2
Effective porosity of aquifer	1.60E+00	g/cm ³	CLEA UK Default for Sandy Soils
Hydraulic gradient	3.00E-01	fraction	EA recommended value
Hydraulic conductivity of saturated aquifer	2.44E-02	fraction	from Level 2 (adjusted)
Distance to compliance point	2.33E-01	m/d	from Level 2
Distance (lateral) to compliance point perpendicular to flow direction	5.00E+01	m	
Distance (depth) to compliance point perpendicular to flow direction		m	
Time since pollutant entered groundwater	1.00E+99	days	time variant options only
Parameters values determined from options			
Partition coefficient	1.42E+01	l/kg	see options
Longitudinal dispersivity	5.000	m	see options
Transverse dispersivity	0.500	m	see options
Vertical dispersivity	0.050	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	1.90E-02	m/d
Retardation factor	7.65E+01	fraction
Decay rate used	4.44E-05	d ⁻¹
Hydraulic gradient used in aquifer flow down gradient	2.44E-02	fraction
Rate of contaminant flow due to retardation	2.46E-04	m/d
Rate of Compliance Point to Source Concentration	1.33E-03	fraction
Attenuation factor (C ₀ /C ₁₀₀)	7.50E+02	fraction
Calculated soil leachate concentration	8.39E-01	mg/l

Remedial Targets

Level 3 Remedial Target	1.16E+03	mg/l	For comparison with measured pore water concentration
Ogata Banks	or		This assumes Level 1 Remedial Target is based on Target Concentration
Distance to compliance point	1.68E+04	mg/kg	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation
Ratio of Compliance Point to Source Concentration	50	m	Ogata Banks
C ₀ /C ₁₀₀	1.33E-03	fraction	

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

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient K_d 1 kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} 2.00E-03 fractionOrganic carbon partition coefficient K_{oc} 7.00E+03 l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species K_{ow} 1 kgSorption coefficient for ionised species K_{ow} 1 kg

pH value pH 7

Acid dissociation constant pK_a 7Fraction of organic carbon in aquifer f_{oc} fractionSoil water partition coefficient K_d 1.42E+01 l/kg

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

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

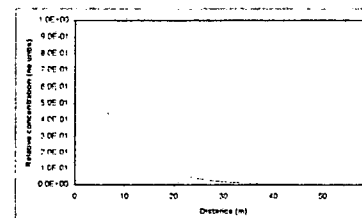
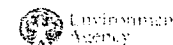
	Enter value	Calc value	Xu & Eckstein
Longitudinal dispersivity	ax	5.00E+00	m
Transverse dispersivity	az	5.00E-01	m
Vertical dispersivity	ay	5.00E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = 0.83/(log₁₀ L)^{0.425}, az = ax/10, ay = ax/100 are assumed

Note

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



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

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks

From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	6.77E-03
2.5	7.51E-01	5.08E-03
5.0	5.51E-01	3.73E-03
7.5	3.95E-01	2.68E-03
10.0	2.81E-01	1.90E-03
12.5	1.99E-01	1.35E-03
15.0	1.41E-01	9.53E-04
17.5	9.98E-02	6.75E-04
20.0	7.08E-02	4.79E-04
22.5	5.03E-02	3.40E-04
25.0	3.58E-02	2.42E-04
27.5	2.56E-02	1.73E-04
30.0	1.83E-02	1.24E-04
32.5	1.31E-02	8.85E-05
35.0	9.41E-03	6.36E-05
37.5	6.76E-03	4.52E-05
40.0	4.87E-03	3.30E-05
42.5	3.52E-03	2.38E-05
45.0	2.54E-03	1.72E-05
47.5	1.84E-03	1.24E-05
50.0	1.33E-03	9.02E-06

This sheet calculates the Level 3 remedial target for soil/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. 9.9E99) 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: Trenton Perkins, Donal
Completed by: Craig Bullock
Date: 11/12/2008
Version: 1.1

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

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

Contaminant Aromatic C12-C16 from Level 1
 Target Concentration C_T 1.25E-02 mg/l from Level 1

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

Ogata Banks Equations in HRA publication

Approach for simulating vertical dispersion Simulate vertical dispersion in 1 direction

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

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

Initial contaminant concentration in groundwater at plume core C_0 0.40E-02 mg/l Site Measurement
 Half life for degradation of contaminant in water $t_{1/2}$ 2.04E-02 days Howard
 Calculated decay rate λ 3.40E-03 days⁻¹
 Width of plume in aquifer at source (perpendicular to flow) S_z 1.00E-01 m Site Measurement
 Plume thickness at source S_y 3.01E-01 m Site Measurement
 Saturated aquifer thickness d_a 3.11E-01 m Site Measurement
 Bulk density of aquifer materials n 1.60E-01 g/cm³ CLEA UK Default
 Effective porosity of aquifer n 3.00E-01 fraction EA recommended value
 Hydraulic gradient i 2.42E-02 fraction Site Measurement
 Hydraulic conductivity of aquifer K 2.33E-01 m/d Site Measurement
 Distance to compliance point x 5.00E-01 m Site Measurement
 Distance (laterally) to compliance point perpendicular to flow direction z 0.00E+00 m
 Distance (depth) to compliance point perpendicular to flow direction y 0.00E+00 m
 Time since pollutant entered groundwater t 1.00E+00 days time variant options only
 Parameters values determined from options
 Partition coefficient K_d 1.42E-01 l/kg see options
 Longitudinal dispersivity α_x 5.00E-01 m see options
 Transverse dispersivity α_z 5.00E-01 m see options
 Vertical dispersivity α_y 5.00E-02 m see options

Calculated Parameters Variable

Groundwater flow velocity v 1.88E-02 m/d
 Retardation factor R_f 7.65E-01 fraction
 Decay rate used λ 4.44E-05 d⁻¹
 Rate of contaminant flow due to retardation U 2.46E-04 m/d
 Contaminant concentration at distance x assuming one-way vertical dispersion C_{1D} 1.16E-04 mg/l
 Attenuation factor (one way vertical dispersion, COICED) AF 7.25E-02

Remedial Targets

Remedial Target 0.06E+00 mg/l For comparison with measured groundwater concentration
 Ogata Banks
 Distance to compliance point 50 m
 Concentration of contaminant at compliance point after C_{1D}/C_T 1.16E-04 mg/l Ogata Banks
 after 1.0E+00 days

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

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

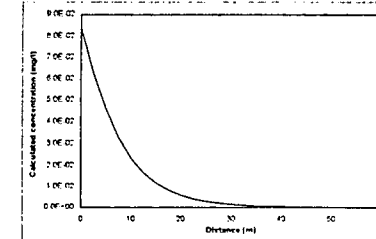
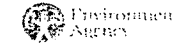
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)
 Soil water partition coefficient K_d 1.42E-01 l/kg
 Entry for non-polar organic chemicals (option)
 Fraction of organic carbon in aquifer f_{oc} 2.00E-03 fraction
 Organic carbon partition coefficient K_{oc} 7.08E-03 l/kg
 Entry for ionic organic chemicals (option)
 Sorption coefficient for related species K_{ow} 1.42E-01 l/kg
 Sorption coefficient for ionised species K_{ow} 1.42E-01 l/kg
 pH value pH
 acid dissociation constant pK_a
 Fraction of organic carbon in aquifer f_{oc}
 Soil water partition coefficient K_d 1.42E-01 l/kg

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

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

Longitudinal dispersivity α_x 5.00E-01 m
 Transverse dispersivity α_z 5.00E-01 m
 Vertical dispersivity α_y 5.00E-02 m
 Note: values of dispersivity must be > 0
 For calculated value, assumes $\alpha_x = 0.1 \times L$, $\alpha_z = 0.01 \times L$, $\alpha_y = 0.001 \times L$
 Xu & Eckstein (1995) report $\alpha_x = 0.53(\log_{10} L)^{1.1}$, $\alpha_z = \alpha_x/10$, $\alpha_y = \alpha_x/100$ are assumed



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

Calculated concentrations for distance-concentration graph

Ogata Banks

From calculation sheet

Distance	Concentration
0	8.4E-02
2.5	6.30E-02
5.0	4.61E-02
7.5	3.31E-02
10.0	2.36E-02
12.5	1.67E-02
15.0	1.19E-02
17.5	8.46E-03
20.0	6.03E-03
22.5	4.30E-03
25.0	3.07E-03
27.5	2.20E-03
30.0	1.58E-03
32.5	1.13E-03
35.0	8.14E-04
37.5	5.86E-04
40.0	4.23E-04
42.5	3.05E-04
45.0	2.21E-04
47.5	1.60E-04
50.0	1.16E-04

Note

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

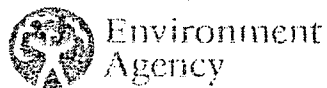
By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

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

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

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

Site being assessed: C. Trunk Perkins Depot
 Compiled by: C. Trunk Perkins Depot
 Date: 11/12/2008
 Version: 3.1



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.1

Date of Workbook Issue: October 2006

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).

Details to be completed for each assessment

Site Name:	Travis Perkins Depot		
Site Address:	Pier Road, Littlehampton, West Sussex		
Completed by:	Craig Bulga		
Date:	05-Nov-08	Version:	1.1
Contaminant	Aromatic C16-C21		
Target Concentration (C _T)	0.0125	mg/l	Origin of C _T : 1/4 SWAD - Dissolved and Emulsified Hydrocarbons

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.

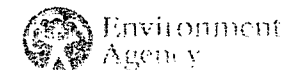
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.

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 3.1



Level 1 - Soil

Select the method of calculating the soil water
Partition Co-efficient by using the pull down menu
below

Calculate for non-polar organic chemicals

Contaminant
Target concentration C_T

Aromatic C16-C21
0.0125 mg/l

Input Parameters Variable Value Unit Source of parameter value

Standard entry

Water filled soil porosity θ_w 2.40E-01 fraction

Air filled soil porosity θ_a 3.00E-01 fraction

Bulk density of soil zone material ρ 1.60E+00 g/cm³

Henry's Law constant H 4.66E-05 dimensionless

Entry if specify partition coefficient (option)

Soil water partition coefficient K_d

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil) f_{oc} 2.00E-03 fraction

Organic carbon partition coefficient K_{oc} 1.02E+06 l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species $K_{oc,n}$ l/kg

Sorption coefficient for ionised species $K_{oc,i}$ l/kg

pH value pH pH units

Acid dissociation constant pK_a

Fraction of organic carbon (in soil) f_{oc} fraction

Soil water partition coefficient used in Level Assessment K_d 2.05E+03 l/kg Calculated value

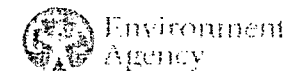
Level 1 Remedial Target

Level 1 Remedial Target 2.56E+01 mg/kg (for comparison with soil analyses)

or
0.0125 mg/l (for comparison with leachate test results)

Site being assessed: Travis Perkins Depot
Completed by: Craig Bulga
Date: 05-Nov-08
Version: 1.1

Remedial Targets Worksheet, Release 3.1



Level 2 - Soil

Contaminant Target concentration C_T **Aromatic C16-C21** from Level 1
0.0125 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	4.90E-06	m/d	Met Office Data
Area of contaminant source	A	2.50E+02	m ²	Site Measurement
				Not used in calculation
Entry for groundwater flow below site				
Length of contaminant source in direction of groundwater flow	L	2.50E+01	m	Site Measurement
Saturated aquifer thickness	da	3.11E+00	m	Site Measurement
Hydraulic Conductivity of aquifer in which dilution occurs	K	2.33E-01	m/d	Site Measurement
Hydraulic gradient of water table	i	2.42E-02	fraction	Site Measurement
Width of contaminant source perpendicular to groundwater flow	w	1.00E+01	m	Site Measurement
Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l	Site Measurement
				Not used in calculation
Define mixing zone depth by specifying or calculating depth (using pull down list)		Calculate		
Enter mixing zone thickness	Mz		m	
Calculated mixing zone thickness	Mz	2.67E+00	m	

Calculated Parameters

Dilution Factor	DF	1.24E+02
Level 2 Remedial Target		1.55E+00 mg/l or 3.17E+03 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:	Travis Perkins Depot
Completed by:	Craig Bulga
Date:	05-Nov-08
Version:	1.1

Remedial Targets Worksheet, Release 3.1

Level 3 - Soil

See Note

Input Parameters	Variable	Value	Unit	Source
Contaminant		Aromatic C16-C21		from Level 1
Target Concentration	C _T	0.0125	mg/l	from Level 1
Dilution Factor	DF	1.24E+02		from Level 2

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

Ogata Banks

Equations in HRA publication

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

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

Variable	Value	Unit	Source of parameter value
Soil concentration as mg/kg			
Enter source concentration			
Enter soil concentration	64	mg/kg	Howard
Half life for degradation of contaminant in water	1.05E+03	days	Howard
Calculated decay rate	6.54E-04	days ⁻¹	calculated
Width of plume in aquifer at source	1.00E+01	m	from Level 2
Plume thickness in aquifer at source	2.67E+00	m	from Level 2
Bulk density of aquifer materials	1.60E+00	g/cm ³	CLEA UK Default for Sandy Soils
Effective porosity of aquifer	3.00E-01	fraction	EA recommended value
Hydraulic gradient	2.44E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	2.33E-01	m/d	from Level 2
Distance to compliance point	5.00E+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	1.00E+09	days	time variant options only
Parameters values determined from options			
Partition coefficient	2.05E+03	l/kg	see options
Longitudinal dispersivity	5.000	m	see options
Transverse dispersivity	0.500	m	see options
Vertical dispersivity	0.050	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	1.90E-02	m/d
Retardation factor	1.00E+04	fraction
Decay rate used	5.99E-08	d ⁻¹
Hydraulic gradient used in aquifer flow down-gradient	2.44E-02	fraction
Rate of contaminant flow due to retardation	1.74E-06	m/d
Ratio of Compliance Point to Source Concentration	6.92E-02	fraction
Attenuation factor (C ₀ /C _s)	1.12E+01	fraction
Calculated soil leachate concentration	3.13E-02	mol/l

Remedial Targets

Level 3 Remedial Target	1.74E+01	mg/l
Ogata Banks	3.55E+04	mg/kg
Distance to compliance point	50	m
Ratio of Compliance Point to Source Concentration	C ₀ /C _s	6.92E-02

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
partitioning equation
Ogata Banks

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

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient K_d 1/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer f_{oc} 2.00E-03 fractionOrganic carbon partition coefficient K_{oc} 1.02E+05 l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species K_{ow} 1/kgSorption coefficient for ionised species K_{ow} 1/kg

pH value pH 7.5

Acid dissociation constant pK_a 1/kgFraction of organic carbon in aquifer f_{oc} fractionSoil water partition coefficient K_d 2.05E+03 l/kg

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

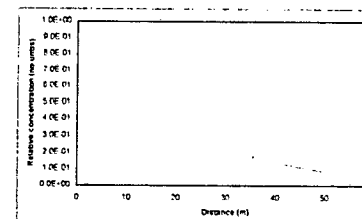
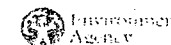
Dispersivities 10%, 1%, 0.1% of pathway length

Longitudinal dispersivity a_x 5.00E+00 mTransverse dispersivity a_y 5.00E-01 mVertical dispersivity a_z 5.00E-02 m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report a_x = 0.83(log₁₀)^{1.111}, a_y = a_x/10, a_z = a_x/100 are assumed

Note

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

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

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks

From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	2.57E-04
2.5	9.26E-01	2.34E-04
5.0	8.39E-01	2.12E-04
7.5	7.43E-01	1.87E-04
10.0	6.52E-01	1.64E-04
12.5	5.68E-01	1.44E-04
15.0	4.97E-01	1.26E-04
17.5	4.35E-01	1.10E-04
20.0	3.80E-01	9.60E-05
22.5	3.34E-01	8.42E-05
25.0	2.93E-01	7.40E-05
27.5	2.58E-01	6.51E-05
30.0	2.28E-01	5.75E-05
32.5	2.01E-01	5.08E-05
35.0	1.78E-01	4.50E-05
37.5	1.58E-01	4.00E-05
40.0	1.41E-01	3.55E-05
42.5	1.25E-01	3.15E-05
45.0	1.12E-01	2.82E-05
47.5	9.98E-02	2.52E-05
50.0	8.92E-02	2.25E-05

This sheet calculates the Level 3 remedial target for soil (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+09

Site being assessed: C16/C21
Completed by: Craig Burge
Date: 22/09/08
Version: 1.0

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Variable	Value	Unit	Source
Contaminant	Aromatic C16-C21		from Level 1
Target Concentration	1.25E-02	mg/l	from Level 1

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

Ogata Banks Equations in HRA publication

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

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

Approach for simulating degradation of pollutants:

Apply degradation rate to dissolved pollutants only

Initial contaminant concentration in groundwater at plume core	C ₀	4.10E-02	mg/l	Site Measurement
Half life for degradation of contaminant in water	t _{1/2}	1.00E+03	days	Site Measurement
Calculated decay rate	λ	6.54E-04	days ⁻¹	Site Measurement
Width of plume in aquifer at source (perpendicular to flow)	S _z	1.00E+01	m	Site Measurement
Plume thickness at source	S _y	3.01E+00	m	Site Measurement
Saturated aquifer thickness	d ₀	3.11E+00	m	Site Measurement
Bulk density of aquifer materials	ρ	1.60E+00	g/cm ³	Site Measurement
Effective porosity of aquifer	n	3.00E-01	fraction	Site Measurement
Hydraulic gradient	i	2.42E-02	fraction	Site Measurement
Hydraulic conductivity of aquifer	K	2.33E-01	m/d	Site Measurement
Distance to compliance point	x	5.00E+01	m	Site Measurement
Distance (laterally) to compliance point perpendicular to flow direction	z	0.00E+00	m	Site Measurement
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	Site Measurement
Time since pollutant entered groundwater	t	1.00E+100	days	time variant options only
Partition coefficient	K _d	2.05E+03	l/kg	see options
Longitudinal dispersivity	α _L	5.00E+00	m	see options
Transverse dispersivity	α _T	5.00E-01	m	see options
Vertical dispersivity	α _V	5.00E-02	m	see options

Calculated Parameters

Groundwater flow velocity	v	1.88E-02	m/d
Retardation factor	R _f	1.09E+04	fraction
Decay rate used	λ	5.99E-08	d ⁻¹
Rate of contaminant flow due to retardation	u	1.72E-06	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C ₁₀	3.88E-03	mg/l
Attenuation factor (one way vertical dispersion, COCED)	AF	1.04E+01	

Remedial Targets

Remedial Target	1.32E-01	mg/l	For comparison with measured groundwater concentration
Ogata Banks			
Distance to compliance point	50	m	
Concentration of contaminant at compliance point	C ₁₀ /C ₀	3.88E-03	mg/l Ogata Banks
after	1.0E+100	days	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.0E+99

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

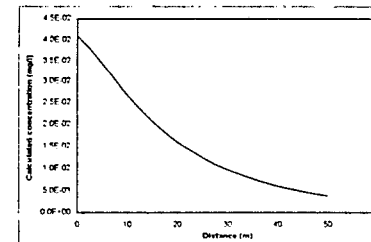
Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)	K _d		l/kg
Soil water partition coefficient			
Entry for non-polar organic chemicals (option)	f _{oc}	2.00E-03	fraction
Fraction of organic carbon in aquifer			
Organic carbon partition coefficient	K _{oc}	1.02E+06	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	K _{ow}		l/kg
Sorption coefficient for ionised species	K _{ow}		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	f _{oc}		fraction
Soil water partition coefficient	K _d	2.05E+03	l/kg

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

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

Longitudinal dispersivity	α _L	5.00E+00	m
Transverse dispersivity	α _T	5.00E-01	m
Vertical dispersivity	α _V	5.00E-02	m
Note values of dispersivity must be > 0			
For calculated value, assumes α _L = 0.1 * x, α _T = 0.01 * x, α _V = 0.001 * x			
Xu & Eckstein (1995) report α _L = 0.53 log μ ^{1/3} , α _T = α _L /10, α _V = α _L /100 are assumed			



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

Note

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

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

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

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

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

By being assessed - Triax Parfums Depot
Completed by: Craig Bulgin
Date: 15/04/2008
Version: 1.0

Calculated concentrations for distance-concentration graph

Ogata Banks

From calculation sheet

Distance	Concentration
	mg/l
0	4.1E-02
2.5	3.80E-02
5.0	3.44E-02
7.5	3.05E-02
10.0	2.68E-02
12.5	2.35E-02
15.0	2.06E-02
17.5	1.81E-02
20.0	1.60E-02
22.5	1.41E-02
25.0	1.24E-02
27.5	1.10E-02
30.0	9.72E-03
32.5	8.62E-03
35.0	7.66E-03
37.5	6.81E-03
40.0	6.07E-03
42.5	5.42E-03
45.0	4.84E-03
47.5	4.33E-03
50.0	3.88E-03



Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.1

Date of Workbook Issue: October 2006

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).

Details to be completed for each assessment

Site Name:	Travis Perkins Depot		
Site Address:	Pier Road, Littlehampton, West Sussex		
Completed by:	Craig Bulga		
Date:	05-Nov-08	Version:	1.1
Contaminant	Aromatic C21-C35		
Target Concentration (C _T)	0.0125	mg/l	Origin of C _T : 1/4 SWAD - Dissolved and Emulsified Hydrocarbons

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 3.1

Environment
Agency

Level 1 - Soil

Select the method of calculating the soil water
Partition Co-efficient by using the pull down menu
below

Calculate for non-polar organic chemicals

Contaminant
Target concentration

C_T

Aromatic C21-C35
0.0125 mg/l

Input Parameters

Variable

Value

Unit

Source of parameter value

Standard entry

Water filled soil porosity

θ_w

2.40E-01

fraction

CLEA UK Default for Sandy Soils

Air filled soil porosity

θ_a

3.00E-01

fraction

CLEA UK Default for Sandy Soils

Bulk density of soil zone material

ρ

1.60E+00

g/cm³

CLEA UK Default for Sandy Soils

Henry's Law constant

H

5.77E-06

dimensionless

TPH CWG Volume 3

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a
selected target concentration and theoretical calculation of soil water partitioning.
Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1
remedial target to determine the need for further action.

Entry if specify partition coefficient (option)

Soil water partition coefficient

K_d

l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon (in soil)

f_{oc}

2.00E-03

fraction

Consim Files

Organic carbon partition coefficient

K_{oc}

1.58E+06

l/kg

TPH CWG Volume 3

Entry for ionic organic chemicals (option)

Sorption coefficient for neutral species

K_{oc,n}

l/kg

Sorption coefficient for ionised species

K_{oc,i}

l/kg

pH value

pH

pH units

Acid dissociation constant

pK_a

Fraction of organic carbon (in soil)

f_{oc}

fraction

Soil water partition coefficient used in Level Assessment

K_d

3.16E+03

l/kg

Calculated value

Level 1 Remedial Target

Level 1 Remedial Target

3.95E+01

mg/kg

(for comparison with soil analyses)

or

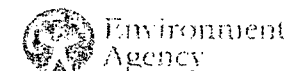
0.0125

mg/l

(for comparison with leachate test results)

Site being assessed: Travis Perkins Depot
Completed by: Craig Bulga
Date: 05-Nov-08
Version: 1.1

Remedial Targets Worksheet , Release 3.1



Level 2 - Soil

Contaminant Target concentration C_T **Aromatic C21-C35** from Level 1
0.0125 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)

Standard entry	Input Parameters	Variable	Value	Unit	Source of parameter value
	Infiltration	Inf	4.90E-06	m/d	Met Office Data
	Area of contaminant source	A	2.50E+02	m ²	Site Measurement Not used in calculation
Entry for groundwater flow below site	Length of contaminant source in direction of groundwater flow	L	2.50E+01	m	Site Measurement
	Saturated aquifer thickness	da	3.11E+00	m	Site Measurement
	Hydraulic Conductivity of aquifer in which dilution occurs	K	2.33E-01	m/d	Site Measurement
	Hydraulic gradient of water table	i	2.42E-02	fraction	Site Measurement
	Width of contaminant source perpendicular to groundwater flow	w	1.00E+01	m	Site Measurement Not used in calculation
	Background concentration of contaminant in groundwater beneath site	Cu	0.00E+00	mg/l	Site Measurement
	Define mixing zone depth by specifying or calculating depth (using pull down list)		Calculate		
	Enter mixing zone thickness	Mz		m	
	Calculated mixing zone thickness	Mz	2.67E+00	m	

Calculated Parameters

Dilution Factor	DF	1.24E+02		
Level 2 Remedial Target		1.55E+00	mg/l	For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration
		or		
		4.90E+03	mg/kg	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water

Additional option

Calculation of impact on receptor

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

Site being assessed:	Travis Perkins Depot
Completed by:	Craig Bulga
Date:	05-Nov-08
Version:	1.1

Remedial Targets Worksheet, Release 3.1

Level 3 - Soil

See Note

Input Parameters	Variable	Value	Unit	Source
Contaminant		Aromatic C21-C35		from Level 1
Target Concentration	C_T	0.0125	mg/l	from Level 1
Dilution Factor	DF	1.24E+02		from Level 2

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

Ogata Banks

Equations in HRA publication

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

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

Variable	Value	Unit	Source of parameter value
Enter source concentration			Soil concentration as mg/kg
Enter soil concentration	320	mg/kg	
Half life for degradation of contaminant in water	1.30E+03	days	Howard
Calculated decay rate	5.33E-04	days ⁻¹	calculated
Width of plume in aquifer at source	1.00E+01	m	from Level 2
Plume thickness in aquifer at source	2.67E+00	m	from Level 2
Bulk density of aquifer materials	1.60E+00	g/cm ³	CLEA UK Default for Sandy Soils
Effective porosity of aquifer	3.00E-01	fraction	EA recommended value
Hydraulic gradient	2.44E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	2.33E-01	m/d	from Level 2
Distance to compliance point	5.00E+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	1.00E+99	days	time variant options only
Partition coefficient	3.16E+03	l/kg	see options
Longitudinal dispersivity	5.000	m	see options
Transverse dispersivity	0.500	m	see options
Vertical dispersivity	0.050	m	see options

Parameter values should be checked against Level 1 and 2

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	1.90E-02	m/d
Retardation factor	1.69E+04	fraction
Decay rate used	3.16E-08	d ⁻¹
Hydraulic gradient used in aquifer flow down gradient	2.44E-02	fraction
Rate of contaminant flow due to retardation	1.13E-09	m/d
Ratio of Compliance Point to Source Concentration	1.14E-01	fraction
Attenuation factor (C_T/C_{T0})	8.73E+00	fraction
Calculated soil leachate concentration	1.01E-01	mg/l

Remedial Targets

Level 3 Remedial Target	1.35E+01	mg/l
Ogata Banks	or	
Distance to compliance point	4.28E+04	mg/kg
Ratio of Compliance Point to Source Concentration	1.14E-01	fraction

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 partitioning equation
Ogata Banks

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

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

Entry if specify partition coefficient (option)		
Soil water partition coefficient	Kd	1/kg
Entry for non-polar organic chemicals (option)		
Fraction of organic carbon in aquifer	foc	2.00E-03 fraction
Organic carbon partition coefficient	Koc	1.58E+06 l/kg
Entry for ionic organic chemicals (option)		
Sorption coefficient for related species	K _{ow}	1/kg
Sorption coefficient for ionised species	K _{ow}	1/kg
pH value	pH	
Acid dissociation constant	pKa	
Fraction of organic carbon in aquifer	foc	fraction
Soil water partition coefficient	Kd	3.16E+03 l/kg

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

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

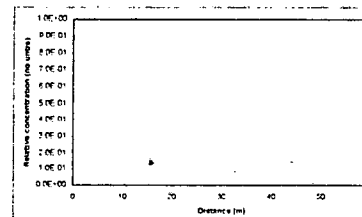
Enter value	Calc value	Xu & Eckstein
Longitudinal dispersivity	ax	5.00E+00 m
Transverse dispersivity	az	5.00E-01 m
Vertical dispersivity	ay	5.00E-02 m

Note values of dispersivity must be > 0

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

Note

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

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	8.17E-04
2.5	9.38E-01	7.66E-04
5.0	8.60E-01	7.03E-04
7.5	7.71E-01	6.30E-04
10.0	6.85E-01	5.60E-04
12.5	6.06E-01	4.95E-04
15.0	5.35E-01	4.39E-04
17.5	4.74E-01	3.88E-04
20.0	4.20E-01	3.43E-04
22.5	3.73E-01	3.05E-04
25.0	3.32E-01	2.71E-04
27.5	2.86E-01	2.42E-04
30.0	2.65E-01	2.16E-04
32.5	2.37E-01	1.94E-04
35.0	2.12E-01	1.74E-04
37.5	1.91E-01	1.56E-04
40.0	1.72E-01	1.40E-04
42.5	1.55E-01	1.27E-04
45.0	1.40E-01	1.14E-04
47.5	1.26E-01	1.03E-04
50.0	1.14E-01	9.35E-05

This sheet calculates the Level 3 remedial target for soils (mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source. Three solution methods are included. The preferred option is Ogata Banks. By setting a long travel time (e.g. 9.9E99) 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: Trends Perkins Decol
Completed by: Chris Biles
Date: 11/12/2008
Version: 1.1

R&D Publication 20 Remedial Targets Worksheet, Release 3.1

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Variable	Value	Unit	Source
Contaminant	Aromatic C21-C35		from Level 1
Target Concentration	C _T	1.28E-02	mg/l from Level 1

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

Variable	Value	Unit	Source
Approach for simulating vertical dispersion:	Ogata Banks		Equations in HRA publication

Approach for simulating vertical dispersion:

Simulate vertical dispersion in 1 direction

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

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

Variable	Value	Unit	Source
Initial contaminant concentration in groundwater at plume core	C ₀	9.70E-02	mg/l Site Measurement
Half life for degradation of contaminant in water	t _{1/2}	1.30E+03	days Howard
Calculated decay rate	λ	5.33E-04	days ⁻¹
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.00E+01	m Site Measurement
Plume thickness at source	Sy	3.01E+00	m Site Measurement
Saturated aquifer thickness	da	3.11E+00	m Site Measurement
Bulk density of aquifer materials	ρ _b	1.60E+00	g/cm ³ CLEA UK Default
Effective porosity of aquifer	n	3.00E-01	fraction EA recommended value
Hydraulic gradient	i	2.42E-02	fraction Site Measurement
Hydraulic conductivity of aquifer	K	2.33E-01	m/d Site Measurement
Distance (laterally) to compliance point perpendicular to flow direction	x	5.00E+01	m
Distance (depth) to compliance point perpendicular to flow direction	z	0.00E+00	m
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m
Time since pollutant entered groundwater	t	1.00E+100	days time variant options only

Parameters values determined from options

Variable	Value	Unit	Source
Partition coefficient	K _d	3.18E+03	l/kg see options
Longitudinal dispersivity	α _x	5.00E+00	m see options
Transverse dispersivity	α _z	5.00E-01	m see options
Vertical dispersivity	α _y	5.00E-02	m see options

Calculated Parameters

Variable	Value	Unit
Groundwater flow velocity	v	1.88E-02 m/d
Retardation factor	Rf	1.69E+04
Decay rate used	λ	3.16E-06 d ⁻¹
Rate of contaminant flow due to retardation	U	1.12E-06 m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C ₀	1.18E-02 mg/l
Attenuation factor (one way vertical dispersion, CO/CE)	AF	8.23E+08

Remedial Targets

Remedial Target	Value	Unit	Source
Remedial Target	1.03E-01	mg/l	For comparison with measured groundwater concentration.
Ogata Banks			
Distance to compliance point	50	m	
Concentration of contaminant at compliance point after	C ₀ /C _T	1.18E-02 mg/l	Ogata Banks
	1.0E+100	days	

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

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

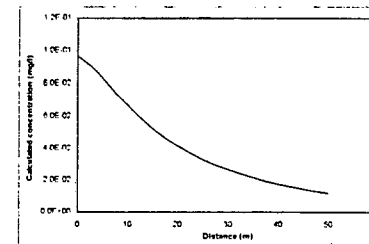
Calculate for non-polar organic chemicals

Variable	Value	Unit	Source
Entry if specify partition coefficient (option)	K _d	3.18E+03	l/kg
Soil water partition coefficient	K _d	3.18E+03	l/kg
Entry for non-polar organic chemicals (option)	f _{oc}	2.00E-03	fraction
Fraction of organic carbon in aquifer	f _{oc}	1.58E+06	l/kg
Organic carbon partition coefficient	K _{oc}	1.58E+06	l/kg
Entry for ionic organic chemicals (option)	K _{ow}	1.58E+06	l/kg
Sorption coefficient for retained species	K _{ow}	1.58E+06	l/kg
pH value	pH	7.5	
acid dissociation constant	pK _a	7.5	
Fraction of organic carbon in aquifer	f _{oc}	1.58E+06	l/kg
Soil water partition coefficient	K _d	3.18E+03	l/kg

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

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

Variable	Value	Unit	Source
Longitudinal dispersivity	α _x	5.00E+00	m
Transverse dispersivity	α _z	5.00E-01	m
Vertical dispersivity	α _y	5.00E-02	m
Note values of dispersivity must be > 0			
For calculated value, assumes α _x = 0.1 * x, α _z = 0.01 * z, α _y = 0.001 * y			
Xu & Eckstein (1995) report α _x = 0.83 log(ρ _b) ^{1/2} , α _z = α _x /10, α _y = α _x /100 are assumed			



Calculated concentrations for distance-concentration graph

Ogata Banks

From calculation sheet

Distance	Concentration
0	9.7E-02
2.5	9.09E-02
5.0	8.34E-02
7.5	7.48E-02
10.0	6.67E-02
12.5	5.93E-02
15.0	5.27E-02
17.5	4.69E-02
20.0	4.17E-02
22.5	3.72E-02
25.0	3.33E-02
27.5	2.98E-02
30.0	2.67E-02
32.5	2.40E-02
35.0	2.16E-02
37.5	1.95E-02
40.0	1.78E-02
42.5	1.59E-02
45.0	1.44E-02
47.5	1.30E-02
50.0	1.18E-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 9.9E+99.

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

Site being assessed: Travis Perkins Depot
 Compiled by: Craig Budge
 Date: 11/12/2008
 Version: 3.1