

POLLUTE

Version 8

Example 5: Hydraulic Trap - Finite Mass Source



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Description

This example illustrates the use of the program for the case where there is a hydraulic trap (i.e., flow is into the landfill). The parameters are essentially the same as in Case 4, (where there was a finite mass source with a leachate collection system and a fixed outflow base) except that the Darcy velocity has been changed and the base aquifer is now assumed to be only 1 m thick with a porosity of 0.35 and is underlain by a low permeability layer. We also now choose to ignore the width of the landfill and take $W = 1$ m. This is the same as modeling a 1 m strip through the landfill. This width, W , has no effect on the results.

The calculation and values for the Reference Height of Leachate is the same as in Case 4. Again it is assumed that the average infiltration through the cover, (q_0) is 0.3 m/a. For this example the Darcy velocity (v_a) into the base of the landfill is assumed to be -0.001 m/a. The negative value for the Darcy velocity implies that the flow is upward. Neglecting the small volume of groundwater collected the average Volume of Leachate Collected (Q_c) is:

$$Q_c = q_0 = 0.3 \text{ m/a}$$

In this example the inflow in the aquifer at the up gradient edge of the landfill will be 4 m/a and the outflow at the down gradient edge (v_b) is then:

$$v_b = v_b(\text{in}) + v_a * L/h = 4 - 200 * 0.001 = 3.8 \text{ m/a}$$

The following parameters are assumed for the example:

Property	Symbol	Value	Units
Darcy Velocity	v_a	0.001	m/a
Diffusion Coefficient	D	0.01	m^2/a
Distribution Coefficient	K_d	0	cm^3/g
Soil Porosity	n	0.4	-
Dry Density		1.5	g/cm^3
Soil Layer Thickness	H	4	m
Number of Sub-layers		4	-
Source Concentration	c_o	1000	mg/L
Rate of Increase in c_o	c_r	0	mg/L/a
Ref. Height of Leachate	H_r	7.5	m
Volume Collected	Q_c	0.3	m/a
Landfill Length	L	200	m
Landfill Width	W	1	m
Thickness of Aquifer	h	1	m
Porosity of Aquifer	n_b	0.35	
Base Outflow Velocity	v_b	6	m/a

Data Entry

Open the Examples project and open Case 5.

General Tab

General Information

Model Title: Maximum Depth:

Darcy Velocity:

Laplace Transform Parameters

TAU: N: SIG: RNU:

Run Parameters

Output Units
 Time Units: Depth Units: Concentration Units:

All Depths Specified Depths Concentrations at Specified Times Maximum Concentrations

Search Depth:

Accuracy (%):

Number of Iterations:

Lower Time Limit:

Upper Time Limit:

The general data for this example is the same as in Case 4, except for the Darcy velocity. To edit the Darcy velocity click on the General tab. The Darcy velocity of -0.001 m/a can be specified.

Layers Tab

Name	Sublayers	Thickness	Thickness Units	Dry Density	Density Units	Porosity	Hydrodynamic Dispersion Coefficient	Dispersion Units	Distribution Coefficient	Distribution Units	Fractures	Symbol
Aquitar	4	4	m	1.5	g/cm ³	0.4	0.01	m ² /a	0	cm ³ /g	None	

The layer data for this model is the same as that in Case 4.

Boundaries Tab

Run Auto On Off Save Save As

General Layers Boundaries Special Features Subsurface Model

Click to run the model

Top Boundary

Zero Flux

Constant Concentration

Finite Mass

Initial Source Concentration: 1000 mg/L

Rate of Concentration Increase: 0 mg/L/yr

Volume of Leachate Collected: 0.3 m/a

Specify

Reference Height of Leachate Waste Properties

Reference Height of Leachate: 7.5 m

Bottom Boundary

Zero Flux

Constant Concentration

Fixed Outflow Velocity

Infinite Thickness

Landfill Length: 200 m

Landfill Width: 1 m

Base Thickness: 1 m

Base Porosity: 0.35

Base Outflow Velocity: 3.8 m/a

Base Symbol

The boundary conditions for the model can be specified on the Boundaries tab. In this example, the top boundary has a finite mass and the bottom boundary is represented as an aquifer with a fixed outflow velocity.

Model Execution



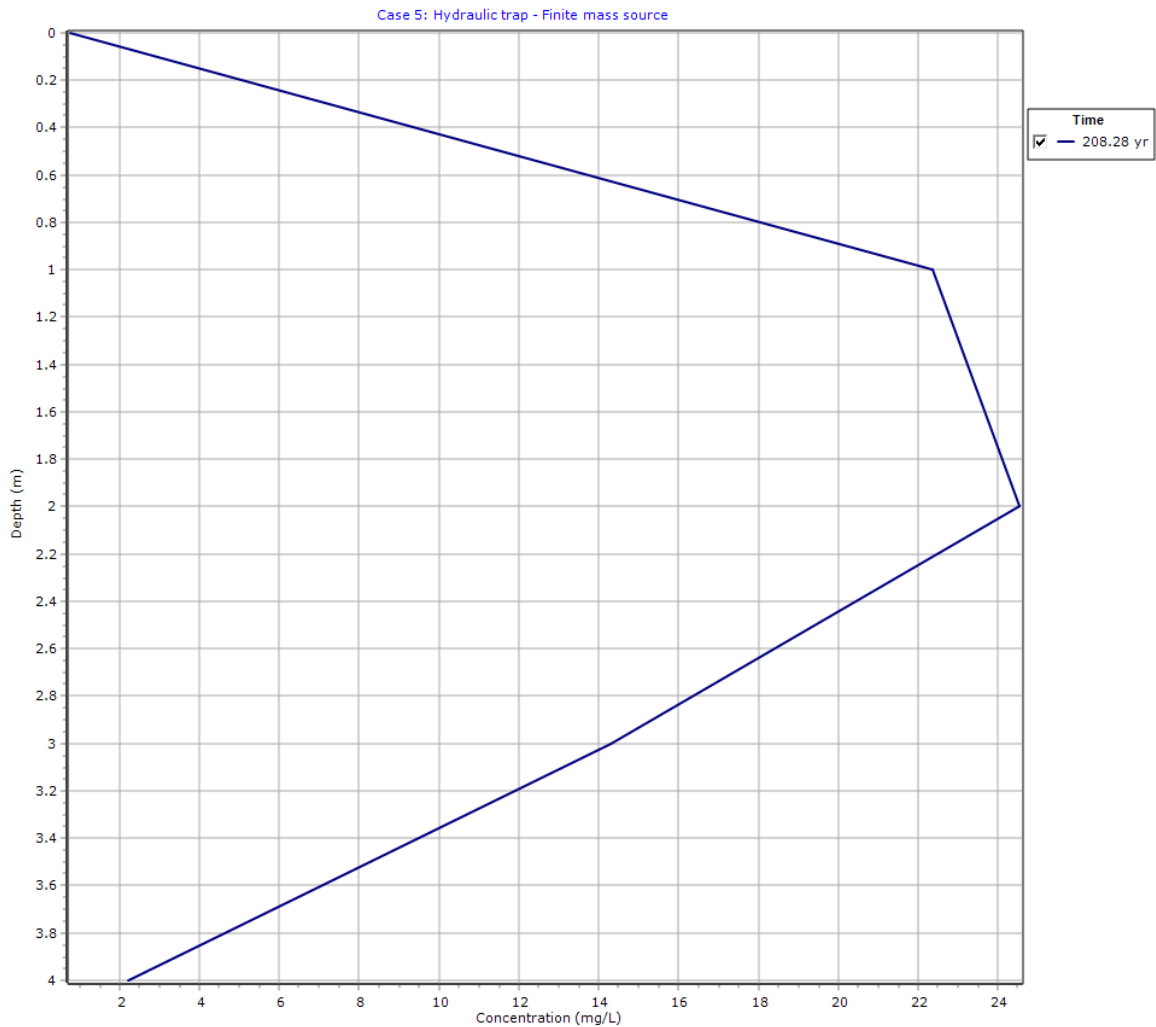
To run the model and calculate the concentrations press the Run button on the toolbar.

Model Output

After the model has been executed, the output for the model will be displayed.

Depth vs Concentration

The Depth vs Concentration chart can be displayed by selecting the Depth vs Concentration item for the Chart Type.



Output Listing

To display the output as a text listing that will show the calculated concentrations as numbers, click on the List tab. The peak at 208 years was found, even though the upper time limit specified by the user was 400 years. The peak concentration in the aquifer at the down gradient edge of the landfill is only about 2 mg/L, compared to the initial source concentration of 1000 mg/L. This peak is reached after 208 years. Thus with a working hydraulic trap some contaminant reaches the base aquifer despite the inward gradient, however for this diffusion coefficient and combination of parameters the impact is negligible.

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Case 5: Hydraulic trap - Finite mass source

THE DARCY VELOCITY (Flux) THROUGH THE LAYERS $V_a = -0.001$ m/year

Layer Properties

Layer	Thickness	Number of Sublayers	Coefficient of Hydrodynamic Dispersion	Matrix Porosity	Distributon Coefficient	Dry Density
Aquitard	4 m	4	0.01 m ² /a	0.4	0 cm ³ /g	1.5 g/cm ³

Boundary Conditions

Finite Mass Top Boundary

Initial Concentration = 1000 mg/L
 Rate of Increase = 0 mg/L/yr
 Volume of Leachate Collected = 0.3 m/a
 Thickness of Waste = 0 m
 Waste Density = 0 kg/m³
 Proportion of Mass = 0
 Volumetric Water Content = 0
 Conversion Rate Half Life = 0 year
 Reference Height of Leachate = 7.5 m

Fixed Outflow Bottom Boundary

Landfill Length = 200 m
 Landfill Width = 1 m
 Base Thickness = 1 m
 Base Porosity = 0.35
 Base Outflow Velocity = 3.8 m/a

Laplace Transform Parameters

TAU = 7 N = 20 SIG = 0 RNU = 2

Maximum Base Concentration Parameters

Depth to Search = 4 m
 Lower Time Limit = 25 year
 Upper Time Limit = 400 year
 Base Concentration Accuracy = 0.01
 Maximum Search Attempts = 25

Maximum Base Concentration and Time of Occurrence

Time yr	Depth m	Concentration mg/L	Preceeding Time	Preceeding Concentration	Exceeding Time	Exceeding Concentration
2.0828E+02	0.0000E+00	7.7427E-01				
	1.0000E+00	2.2363E+01				
	2.0000E+00	2.4529E+01				
	3.0000E+00	1.4300E+01				
	4.0000E+00	2.2199E+00	2.0800E+02	2.2199E+00	2.0857E+02	2.2198E+00

Number of Search Attempts = 8

NOTICE

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