3D Example for **SUTRA**

BF

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This is a simple 3D example intended for illustration and user practice. It involves a *steady-state flow and steady-state transport* simulation representing a simple diving plume from a localized surface source of solute. The fluid has constant density, and all hydrologic properties are constant. (This example is also used in the **SutraPlot** manual.) It is similar to a problem considered by Burnett and Frind (1987) and shown in their Figure 9b. The original problem considered transient transport, while this example simulates steady-state transport.

The dimensions of the model domain (z vertically upward) are:
in x: 200. m
in y: 30. m
in z: 21. m at x=0, and 20. m at x=200. m
The top surface of the model domain is a plane with a slight dip that roughly follows the water table.

The main parameter values are:

Hydraulic conductivity	1.0 m/d (1.16 x 10^{-5} m/s)
Porosity	0.35
Solute diffusivity	1.0 x 10^{-9} m^2/s
Longitudinal dispersivity	3.0 m
Transverse dispersivity	0.1 m
Recharge	0.3 m/yr = 9.5 x 10^{-9} (m^3/s)/ (m^2 of top surface)

Boundary Conditions:

While the original Burnett and Frind (1987) top boundary condition was a ¼ cosine-shaped specified head, BF instead has a constant areal recharge specified over the entire top based on an equivalent approximate recharge rate that was given by Burnett and Frind (1987). The vertical outflow face (at x=200. m) has a specified head of zero, and all other sides of the 3D domain are closed to flow.

Initial Conditions:

Initial conditions for this example are arbitrary, because only the steady-state head and concentration solution are sought. Both initial head and initial concentration are set to zero.

Mesh:

The mesh consists of 24000 evenly-spaced elements (40 in x, 30 in y, and 20 in z). The CG solver is used to solve for steady flow (takes about 90 iterations) and the GMRES solver is used to solve for steady transport (takes about 10 iterations).

Simulation:

The run takes about one minute on a PC with a 300 Mhz Pentium II processor running Windows NT 4.0 and about 8 seconds on a PC with a 2GHz Xeon processor; it uses about 49 Mbytes of RAM.

***SUTRA** files:*

> input :
> *BF3D.inp*, *BF3D.ics*, and SUTRA.FIL
>
> output:
> *BF3D.smy*, *BF3D.lst*, *BF3D.rst*, *BF3D.nod*, *BF3D.ele*, and *BF3D.obs*

Preprocessing:

Two approaches are provided, one using **SutraPrep** and the other using **SutraGUI.**

All of the files required for using **SutraPrep**, including the input file, *BF3D.prp*, for creating this mesh (using one block) are included in a directory below *BF3D*. Detailed instructions may be found there, and a brief description is given here.

The model was set up using **SutraPrep** with a zero-concentration recharge source at the top surface and specified heads at the outflow face. The non-zero concentration of the fluid source nodes in the starting area for the plume may be placed in the main input file, *BF3D.inp*, by hand. This requires replacing the zero values created by **SutraPrep** at the 24 nodes representing the starting area with the value 1.0.

> Users are encouraged to download and install **SutraPrep** and try to recreate the input data for this example. Note that to save some manual editing work, the **SutraPrep** option to read some data from an existing *.inp* file (i.e. the *BF3D.inp* file that was downloaded) may be used to load some of the required data into the new *.inp* file that will be created by **SutraPrep**. The file *BF3D.prp* is already set up to load existing data. To see what **SutraPrep** generates when there is no existing input file, simply remove the *BF3D.inp* file name from *BF3D.prp*.

The ArgusONE setup file, *BF3D.mmb*, is included for use with **SutraGUI**. In **SutraGUI**, this problem uses a vertically-aligned mesh with one unit. The top of the model is assigned an elevation, given as a linear function of x. Recharge is specified as a constant background value in the expression dialog for the specific_source parameter of the Sources of Fluid Top information layer with zero concentration of inflow. The small area of contaminated recharge at the surface is specified by a closed contour enclosing this region in the same information layer where the background concentration value of zero is over-ridden with a value of one. The outflow face is specified as a solid object containing constant head of zero in the information layer, Specified Hydraulic Head Solids1.

Results:

Steady-state results are reported for both hydraulic head and concentration.

Postprocessing:

The match of specified and calculated pressures may be checked using **CheckMatchBC**.

Spatial distributions of results may be viewed with both **SutraPlot** and **ModelViewer**.

> For **SutraPlot**, a setup file, *BF3D.spl*, is provided that shows the steady-state 2D concentration contours in a vertical slice through the plume at y = 0. m.
>
> For **ModelViewer**, a setup file, *BF3D.mv*, is provided for viewing the results with a solid for concentration and flow vectors shown in the rear vertical sheet of elements.

Suggestions:

The user is also encouraged to modify the input data to run transient transport for comparison with Figure 9b of Burnett and Frind (1987), which shows an elapsed time of 12000 days after 40 time steps. This requires changes to only two lines in the *BF3D.inp* file (or simple changes in **SutraGUI**). However, as the recharge rate is given to only one significant figure by Burnett and Frind (1987), and as the top boundary condition is not equivalent, the position of the contours simulated with SUTRA cannot be exactly matched with those published.

Reference:

Burnett, R.D., and Frind, E.O., 1987, Simulation of contaminant transport in three dimensions 2. dimensionality effects, Water Resources Research, 23(4), 695-705.