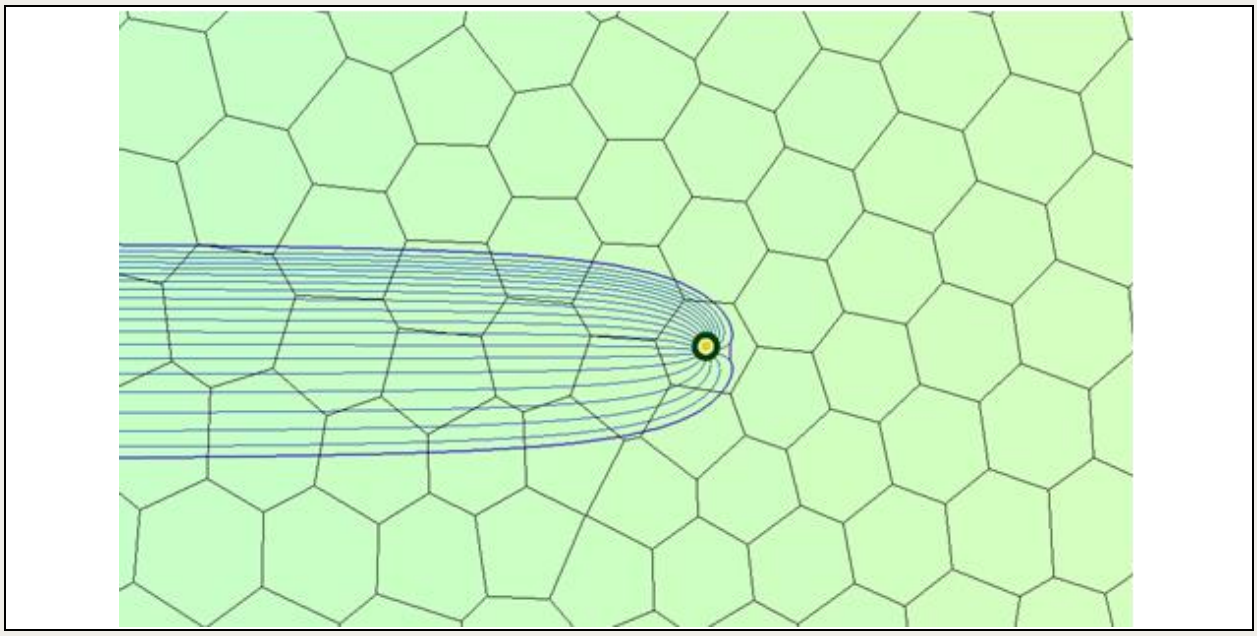
GMS 10.9 Tutorial

Mod-PATH3DU

A particle tracking program for MODFLOW-USG



Objectives

This tutorial gives an overview of GMS's interface for mod-PATH3DU.

Prerequisite Tutorials

- MODPATH

Required Components

- GMS Core
- MODFLOW Interface
- MODPATH/MP3DU Interface

Time

- 15–30 minutes

1 Introduction

The mod-PATH3DU model is a particle-tracking program written by Chris Muffles at S.S. Papadopulos & Associates. It is compatible with both structured and unstructured grids, as well as MODFLOW-USG. Given its similarity to MODPATH, it is recommended to become familiar with the MODPATH tutorial before starting this one.

This tutorial begins by opening a model that includes a MODFLOW-USG simulation, saving a native text copy of the model, and running MODFLOW on the saved text file. A new backward tracking mod-PATH3DU model will then be created, with tracking points placed at the well. The new model will be saved, mod-PATH3DU will be run, and the solution will be imported. Lastly, a new forward tracking mod-PATH3DU model with points on the side will be created.

1.1 Getting Started

To start:

1. If necessary, launch GMS.
2. If GMS is already running, select *File* | **New** to ensure that the program settings are restored to their default state.

2 Opening an Existing Model

The first step is to open a MODFLOW-USG model based on the example problem included with mod-PATH3DU. It is a one-layer Voronoi model, where flow moves from left to right. The cells on the left side are assigned a constant head cells value of “50.0”, while the cells on the right side are assigned a constant head value of “49.0”. A single CLN well, located in the center of the model, extracts water. Transparent, continuous, color-filled contours of head are enabled for visualization.

1. Click **Open** to bring up the *Open* dialog.
2. Select “Project Files (*.gpr)” from the *Files of type* drop-down.
3. Browse to the *\VoronoiModel\VoronoiModel* folder and select “Voronoi.gpr”.
4. Click **Open** to import the project and exit the *Open* dialog.

The project should appear similar to Figure 1.

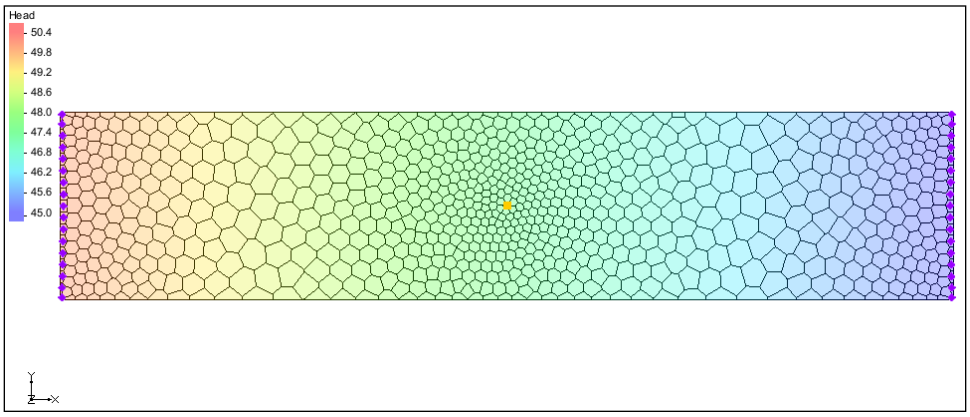


Figure 1 Starting MODFLOW-USG model from mod-PATH3DU examples

To save the project with a new name:

5. Select *File* | **Save As…** to open the *Save As* dialog.
6. Select "Project Files (*.gpr)" from the *Save as type* drop-down.
7. Enter "mp3du.gpr" as the *File name*.
8. Click **Save** to save the project under the new name and close the *Save As* dialog.

3 Saving a Native Text Copy

Since mod-PATH3DU reads MODFLOW files and uses its own internal version of MODFLOW, it cannot read GMS-formatted MODFLOW files that store array data in HDF5 format. As a result, it is necessary to save a native text copy of the MODFLOW simulation to be used by mod-PATH3DU.

1. In the Project Explorer, double-click on the "Global" package to bring up the *MODFLOW Global/Basic Package* dialog.
2. In the *MODFLOW version* section, turn on *Save native text copy*.
3. Click **OK** to close the *MODFLOW Global/Basic Package* dialog.
4. **Save** the project so that the text copy of MODFLOW will be saved.

mod-PATH3DU requires a native text version of the MODFLOW model.

4 Running MODFLOW

MODFLOW must be run again to generate a solution for the native text copy of the model. Since the typical approach involves running MODFLOW using the GMS-formatted version of the model, it will be necessary to run MODFLOW differently for this step.

1. Select *MODFLOW* | *Advanced* | **Run MODFLOW Dialog…** to bring up the *Run MODFLOW* dialog.

2. In the *MODFLOW version* section, turn on *USG*.
3. Click **Name file** to bring up the *Open* dialog.
4. Navigate to the *mp3du_MODFLOW-Voronoi* folder.
5. Select “mp3du.mfn” and click **Open** to exit the *Open* dialog.

The dialog should appear similar to Figure 2.

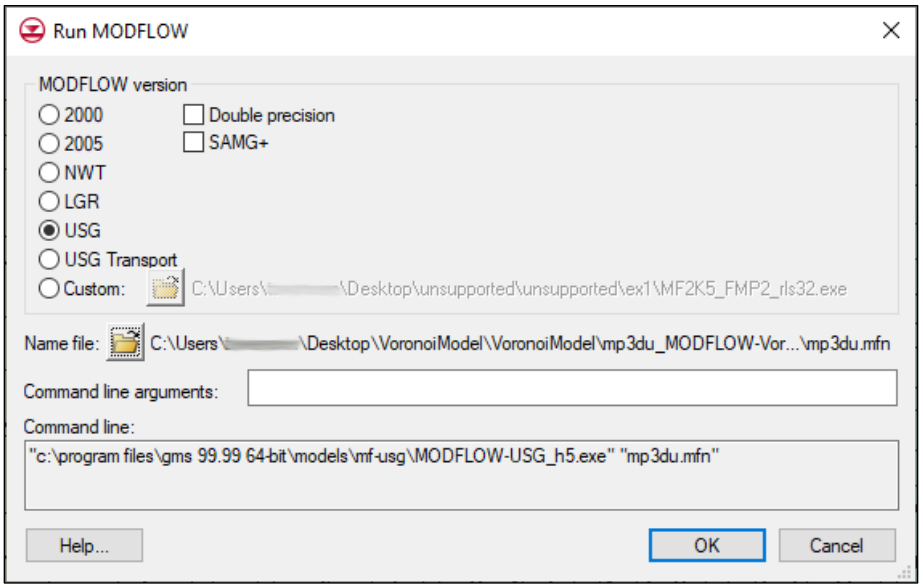


Figure 2 Run MODFLOW dialog

6. Click **OK** to exit the *Run MODFLOW* dialog and bring up a command prompt window.
7. When MODFLOW finishes running, close the command window by pressing any key.

The *MODFLOW* | *Advanced* | **Run MODFLOW Dialog…** menu command allows MODFLOW to be run using any version of MODFLOW on any specified file name.

5 Creating a Backward Tracking mod-PATH3DU Model

The next step is to create the mod-PATH3DU model.

1. In the Project Explorer, right-click the “ Voronoi” item and select **New mod-PATH3DU…** to create a new “ Voronoi” mod-PATH3DU model.
2. Right-click the “ Voronoi” simulation and select **Rename**.
3. Enter “backward” and press *Enter* to set the new name.

5.1 Adding Starting Locations

1. Right-click “ backward” and select **Create Particles at Wells…** to bring up the *Generate Particles at Wells* dialog.

2. Click **OK** to accept the defaults and close the *Generate Particles at Wells* dialog.

Starting locations can be generated at wells using the **Create Particles at Wells…** command.

When using MODPATH, GMS would typically save and run MODPATH automatically, importing the pathlines. However, since GMS does not automatically run mod-PATH3DU, this must be done manually. The process for running mod-PATH3DU will be covered in the next section.

mod-PATH3DU does not run automatically, unlike MODPATH.

3. **Zoom** in to the cell containing the well.

Notice the ring of starting locations created around the well (Figure 3).

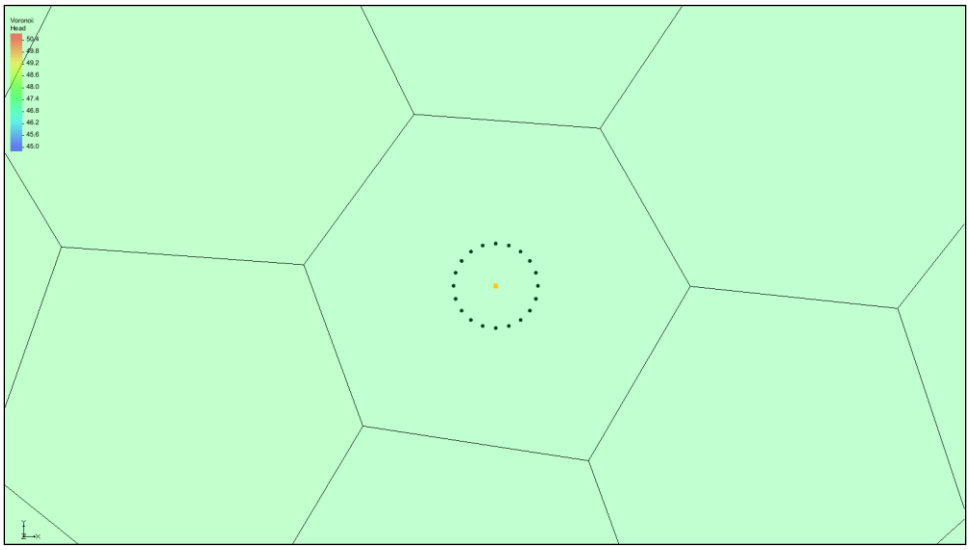


Figure 3 Ring of starting locations created around the well

4. **Frame** the project to return to the previous view.

5.2 Changing to Backward Tracking

With starting locations at the well, the next task is creating a backward tracking simulation.

1. Right-click "backward" and select **Options…** to bring up the *mod-PATH3DU Options* dialog.
2. Select "Options" from the list on the left.
3. From the *DIRECTION* drop-down, select "Backward" (Figure 4).
4. Click **OK** to exit the *mod-PATH3DU Options* dialog.

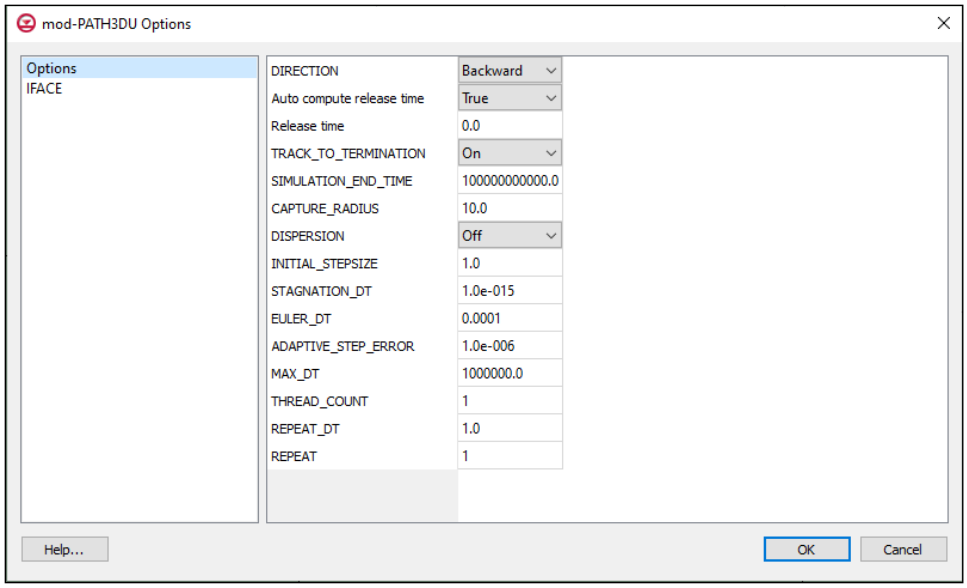


Figure 4 Selecting the direction

6 Saving and Running mod-PATH3DU

Before running mod-PATH3DU, the changes must be saved.

1. **Save** the project. This will include the mod-PATH3DU input files.
2. Right-click "backward" and select **Run mod-PATH3DU** to bring up the *MP3DU* model wrapper dialog (Figure 5).

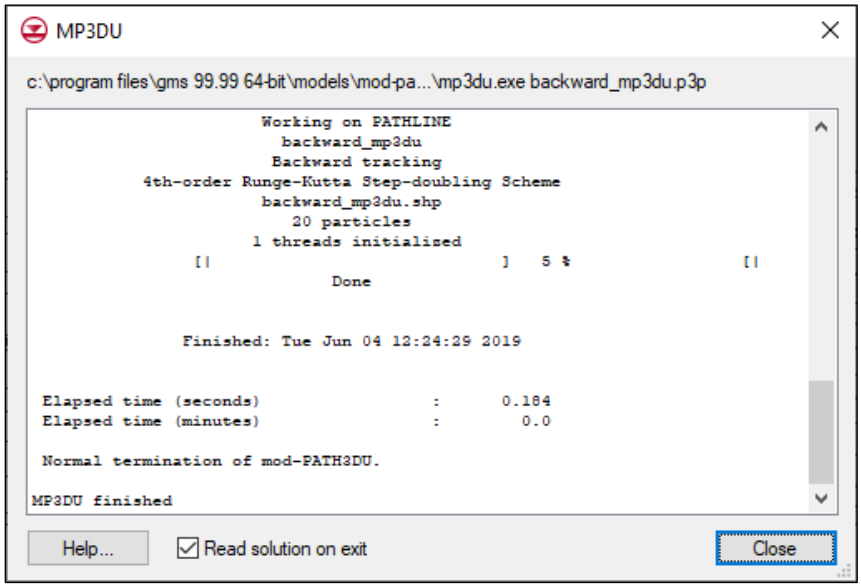


Figure 5 mod-PATH3DU model wrapper

When mod-PATH3DU finishes, the line "Normal termination of mod-PATH3DU." should appear near the bottom of the *MP3DU* model wrapper dialog.

3. When mod-PATH3DU finishes, make sure *Read solution on exit* is turned on and click **Close** to exit the *MP3DU* model wrapper dialog.

GMS will import the pathline solution file and display the pathlines. The result should appear similar to Figure 6.

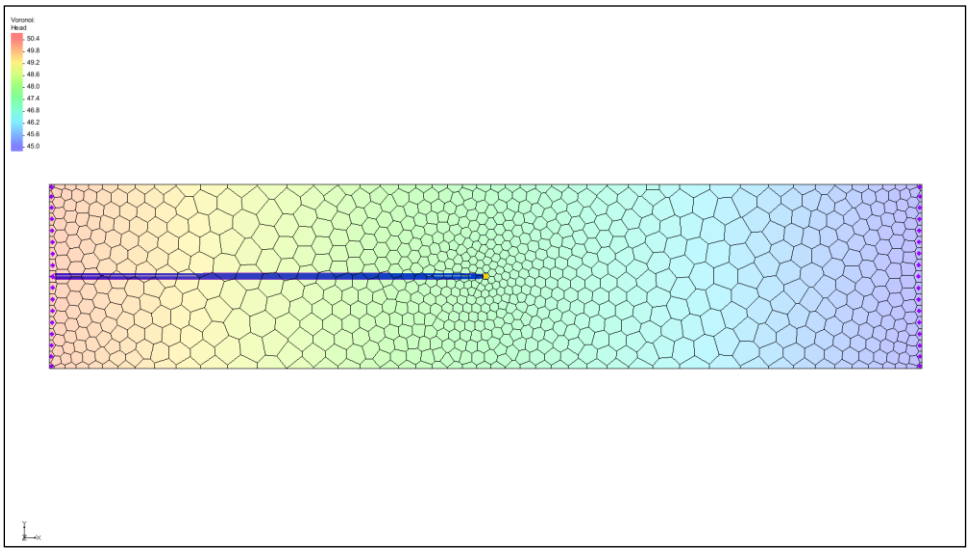


Figure 6 Pathline solution showing pathlines tracking backward from the well

4. If desired, **Zoom** in and examine the pathlines.
5. Click the **Save** macro to save the project with the solution.

7 Creating a Forward Tracking mod-PATH3DU Model

To create a new mod-PATH3DU model with starting locations along the left edge of the model that track forward:

1. In the Project Explorer, right-click "Voronoi" and select **New mod-PATH3DU…** to create a new "Voronoi" mod-PATH3DU model.
2. Right-click "Voronoi" and select **Rename**.
3. Enter "forward" and press *Enter* to set the new name.

Multiple mod-PATH3DU simulations can exist in GMS at the same time.

7.1 Adding Starting Locations

1. **Zoom** in on the left side of the UGrid.
2. Using the **Select Cells** tool, hold down the *Shift* key and select the five cells along the left side of the grid, in the area where the existing pathlines are located (Figure 7).

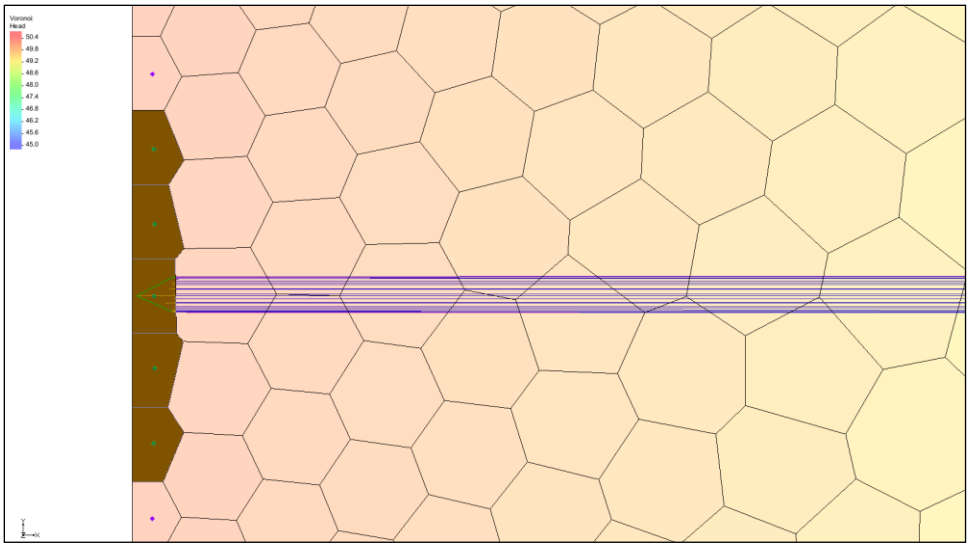


Figure 7 Selected cells on the left side of the UGrid

3. Right-click on any of the selected cells and select **Create mod-PATH3DU Particles…** to bring up the *Generate Particles* dialog.
4. Under *Number of particles*, adjust the slider to "4".
5. Click **OK** to close the *Generate Particles* dialog.

Each cell now contains up to four starting locations (Figure 8).

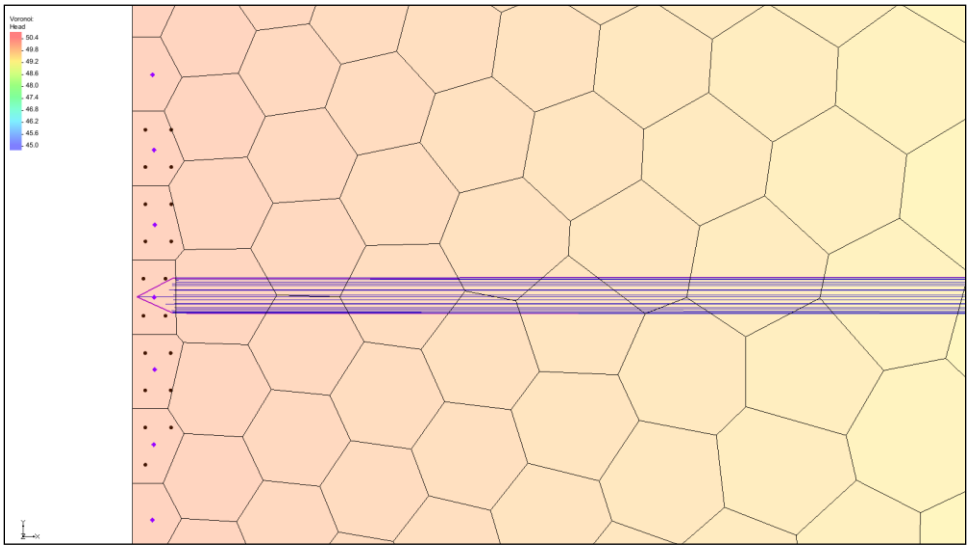


Figure 8 Starting locations in the selected cells

6. If desired, **Zoom** in and see how GMS arranged the starting locations.

Because Voronoi cells are irregularly shaped, some cells may end up with fewer particles. This occurs because GMS generates particles in a square pattern based on the cell extents as a guide, and then eliminates particles that fall outside the cell borders.

Starting locations can be created inside cells by selecting cells and using the **Create mod-PATH3DU Particles…** command.

8 Saving and Running mod-PATH3DU

Before running mod-PATH3DU again, it is recommended to save the project.

1. **Save** the project.
2. Right-click "forward" and select **Run mod-PATH3DU** to bring up the *MP3DU* model wrapper dialog.
3. When mod-PATH3DU finishes, make sure *Read solution on exit* is turned on and click **Close** to exit the *MP3DU* model wrapper dialog.

GMS then imports the pathline solution file and displays the path lines (Figure 9).

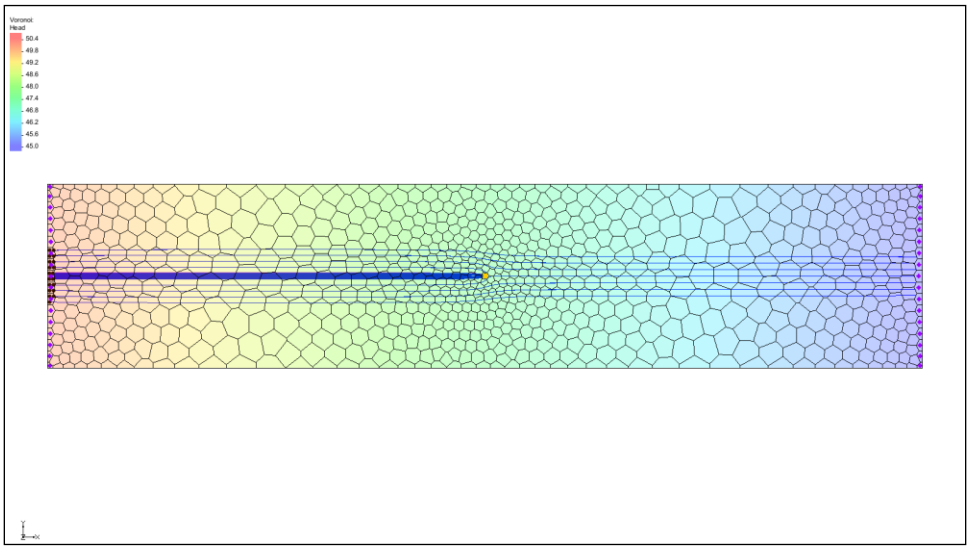


Figure 9 Pathline solution showing pathlines tracking backward from the well

4. If desired, **Zoom** in and examine the pathlines.
5. **Save** the project with the solution.

9 Examining the Solution

To take a closer look at the pathlines:

1. In the Project Explorer, turn off the "backward" simulation.
2. **Zoom** in on the well (Figure 10).

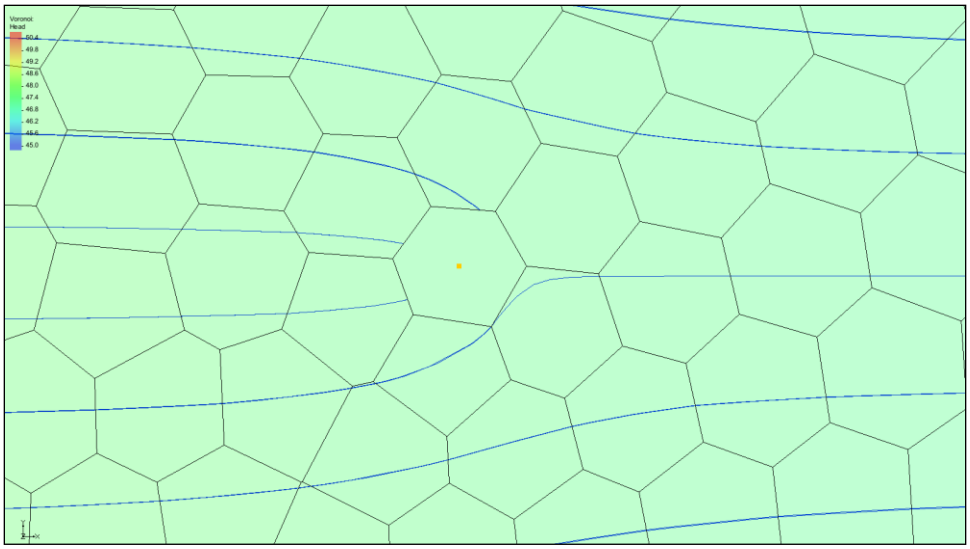


Figure 10 Forward tracking pathlines around the well

3. **Frame** the project.
4. Click **Display Options** to bring up the *Display Options* dialog.
5. Select “UGrid: Voronoi – [Active]” from the list on the left.
6. Turn on *Define UGrid specific options*.
7. Under the *Particles* tab, turn on *Direction arrows.*

A number of other display options related to starting locations and pathlines are available here.

8. Click **OK** to close the *Display Options* dialog.

Flow direction is now shown (Figure 11).

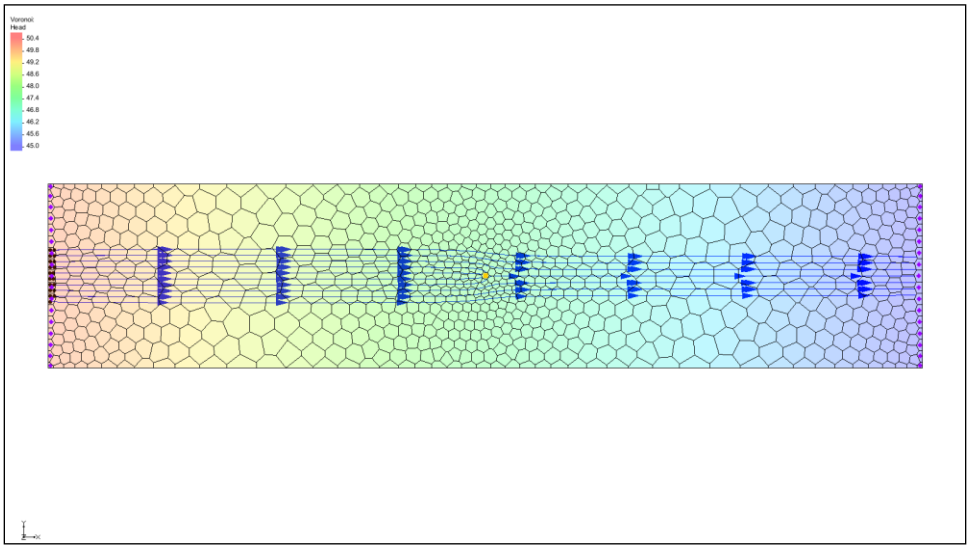


Figure 11 Flow direction arrows are visible

10 Conclusion

This concludes the “mod-PATH3DU” tutorial. The following key concepts were discussed and demonstrated:

- GMS includes an interface to mod-PATH3DU
- mod-PATH3DU requires a native text version of the MODFLOW model
- The *MODFLOW* | *Advanced* | **Run MODFLOW Dialog…** menu command can be used to run MODFLOW with any version of MODFLOW on any specified file
- Starting locations can be generated at wells using the **Create Particles at Wells…** command
- mod-PATH3DU does not run automatically like MODPATH
- Multiple mod-PATH3DU simulations can exist in GMS simultaneously
- Starting locations can be created inside cells by selecting cells and using the **Create mod-PATH3DU Particles…** command