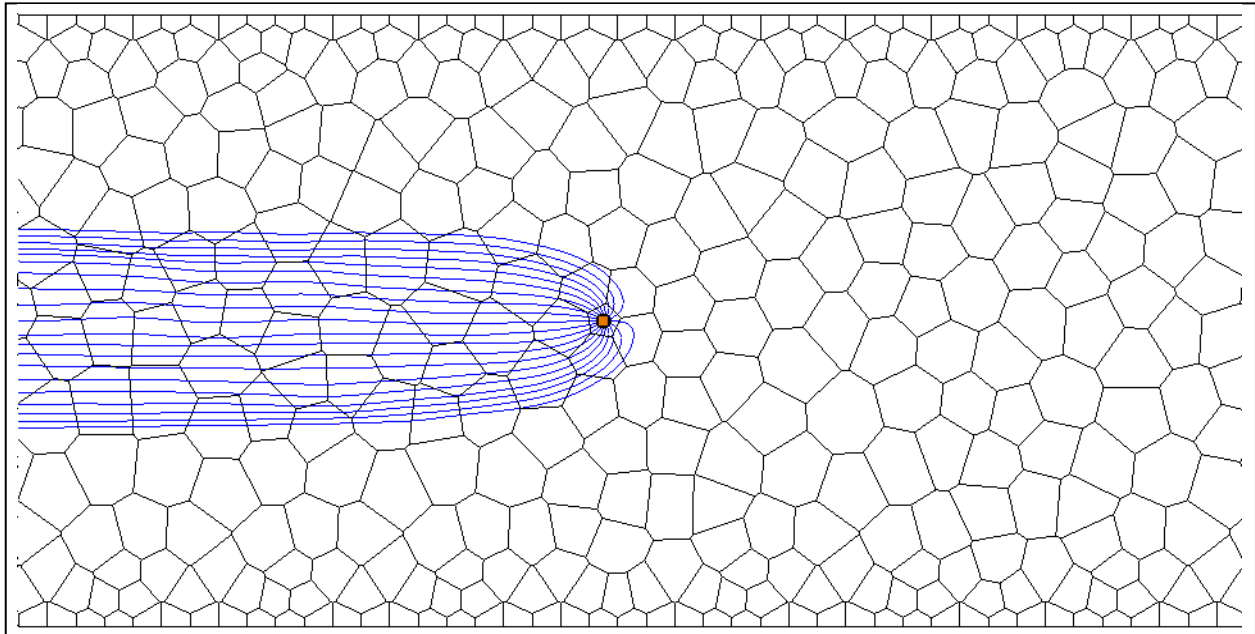*GMS 10.2 Tutorial*

mod-PATH3DU

A particle tracking program for MODFLOW-USG

Objectives

Become familiar with GMS's interface for mod-PATH3DU.

Prerequisite Tutorials	Required Components	Time
• MODPATH	• MODFLOW-USG • MP3DU	• 15–30 minutes

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1   Introduction

The mod-PATH3DU model is a particle tracking program written by Chris Muffles at SS Papadopulos. It is similar to MODPATH but it can work with unstructured grids and MODFLOW-USG. Be familiar with the MODPATH tutorial before starting this tutorial.

This tutorial will start with opening a model containing a MODFLOW-USG model. A native text copy of the model will then be saved and MODFLOW will run on the native text. Next, a new backward tracking mod-PATH3DU model with points at the well will be created following by saving the new model, running mod-PATH3DU, and reading the solution. Finally, 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 the *File* / **New** command to ensure that the program settings are restored to their default state.

2   Opening an Existing Model

Next is open a MODFLOW-USG model which is based off of an example problem included with mod-PATH3DU. It is a one-layer, voronoi model as shown in Figure 1.
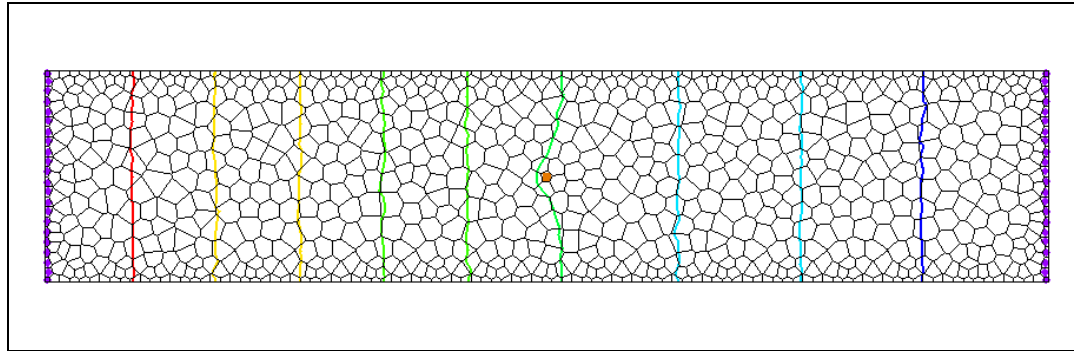
Figure 1   Nested grid example included with MODFLOW-USG.

Flow is from left to right with the cells on the left side set as constant head cells with a value of 50.0, and cells on the right side set as constant head cells with a value of 49.0. There is one CLN well in the middle of the model that extracts water from the model.

1. Select the **Open** 📂 macro to bring up the *Open* dialog.

2. In the dialog, locate and open the directory entitled *Tutorials\MP3DU\VoronoiModel*.

3. Select the file named "voronoi.gpr" and click **Open**.

Next save the project with a new name.

4. Select the *File |* **Save As** menu command to open the *Save As* dialog.

5. Change the *File name* to "mp3du.gpr".

6. Click **Save** to create a new project file.

3   Save a Text Copy

mod-PATH3DU reads MODFLOW files and uses it's own internal version of MODFLOW to do so. Therefore it cannot read the GMS formatted MODFLOW files which use HDF5 to store array data. Save a native text copy of the MODFLOW simulation for use by mod-PATH3DU.

1. In the Project Explorer, double-click on the "Global" item to bring up the *MODFLOW Global/Basic Package* dialog.

2. In the dialog, look in the *MODFLOW version* section and turn on the *Save native text copy* option.

3. Click **OK** to close the *MODFLOW Global/Basic Package* dialog.

4. Select *File |* **Save** so that the text copy of MODFLOW will be saved.

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

4   Run MODFLOW

It's necessary to run MODFLOW and generate a solution for the native text copy version of the model. The typical way to run MODFLOW uses the GMS formatted copy of the model, so MODFLOW needs to run in a different way.

1. Select the *MODFLOW | Advanced |* **Run MODFLOW Dialog** menu command. The *Run Modflow* dialog will appear.

2. In the dialog under *MODFLOW version,* turn on the *USG* option.

3. Click the **Name file** 📂 button to bring up an *Open* dialog.

4. Navigate up one directory and open the *voronoi_MODFLOW-voronoi_text* folder.

5. Select the "voronoi.mfn" file and click **Open** to close the *Open* dialog.
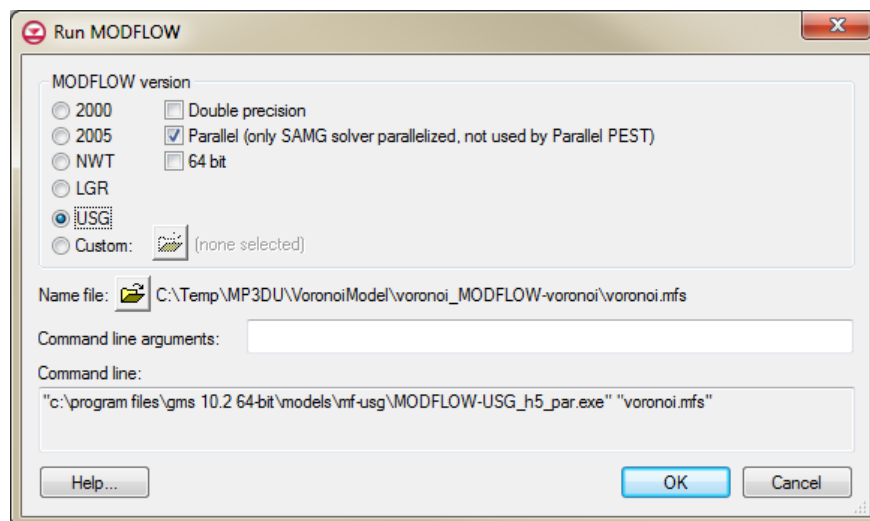

Figure 2   Run MODFLOW dialog.

6. In the *Run MODFLOW* dialog, click **OK** to run MODFLOW.

MODFLOW runs in a command window. It should just take a second or two to finish.

7. When MODFLOW finishes running, close the command window by pressing any key.

> *i* The *MODFLOW | Advanced |* **Run MODFLOW Dialog** menu command can be used to run MODFLOW using any version of MODFLOW on any name file.

5   Create a Backward Tracking mod-PATH3DU Model

Next to create the mod-PATH3DU model.

1. In the Project Explorer, right-click on the "voronoi" item and select the **New mod-PATH3DU** menu item. This adds a new voronoi mod-PATH3DU model to the Project Explorer.

2. Right-click on the new mod-PATH3DU model and select the **Rename** command.

3. Change the item name to "backward".

5.1   Add Starting Locations

1. Right-click the "backward" mod-PATH3DU model and select the **Create Particles at Wells** command. The *Generate Particles at Wells* dialog should appear as in Figure 3.
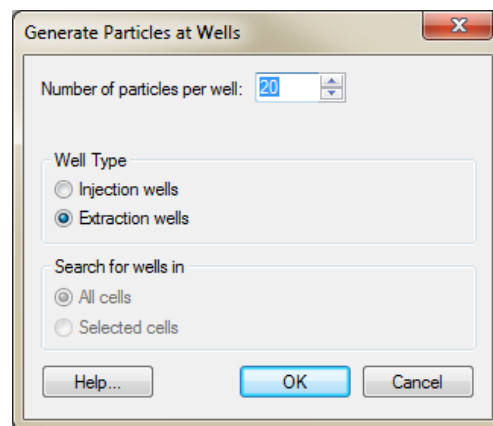

Figure 3   *Generate Particles at Wells dialog.*

2. Accept the defaults and click **OK** to close the *Generate Particles at Wells* dialog

> Startling locations can be generated at wells using the **Create Particles at Wells** command.

Some users may be familiar with the MODPATH interface and the way that GMS automatically runs MODPATH. If using MODPATH normally, at this point GMS would automatically save and run MODPATH and read in the pathlines.

GMS does not automatically run mod-PATH3DU. It must be done it manually. This will be done it in the next section.

> mod-PATH3DU does not run automatically like MODPATH.

3. Using the mouse wheel or the **Zoom** tool, zoom in on the cell containing the well.

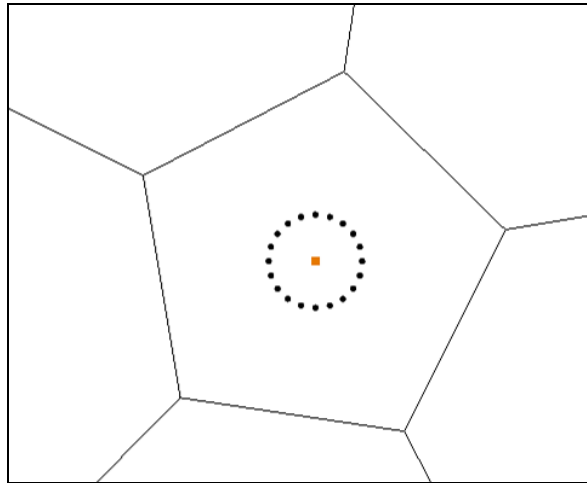Notice the ring of starting locations created around the well.

Figure 4   Ring of starting locations created around the well

4. Click on the **Frame** macro to return the previous view.

5.2   Change to Backward Tracking

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

1. Right-click the "backward" model and select the **Options** command to bring up the *mod-PATH3DU Options* dialog.

2. In the dialog, click on the *Tracking Direction* column and change the option to "(2) Backward".

3. Click **OK** to exit the *mod-PATH3DU Options* dialog.

6   Save and Run mod-PATH3DU

Next is to save and run mod-PATH3DU.

1. Click the **Save** macro. This saves the project including the mod-PATH3DU input files.

2. Right-click the "backward" model and select the **Run mod-PATH3DU** command. The *Run Model* dialog will appear.

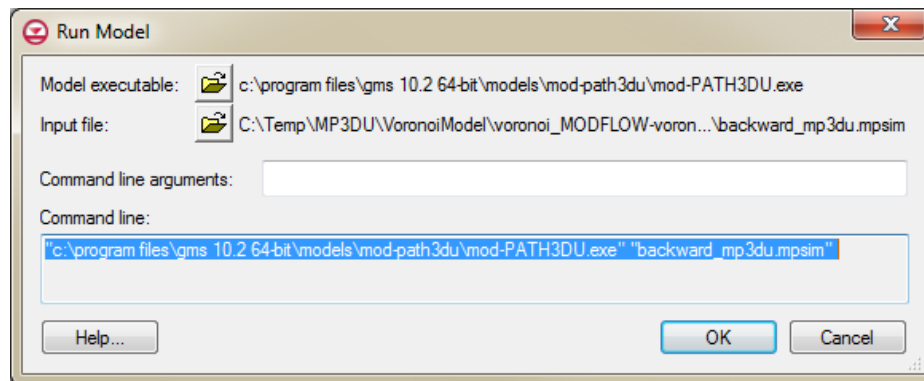3. Accept the defaults and click **OK** to close the *Run Model* dialog.

Figure 5   Run Model dialog.

mod-PATH3DU should run in a command window and finish in a few seconds. If all goes well there should be a line at the bottom of the window saying "End of mod-PATH3DU simulation. Normal termination".

GMS uses a model wrapper dialog when running most models, but there is not yet a model wrapper dialog set up for running mod-PATH3DU.
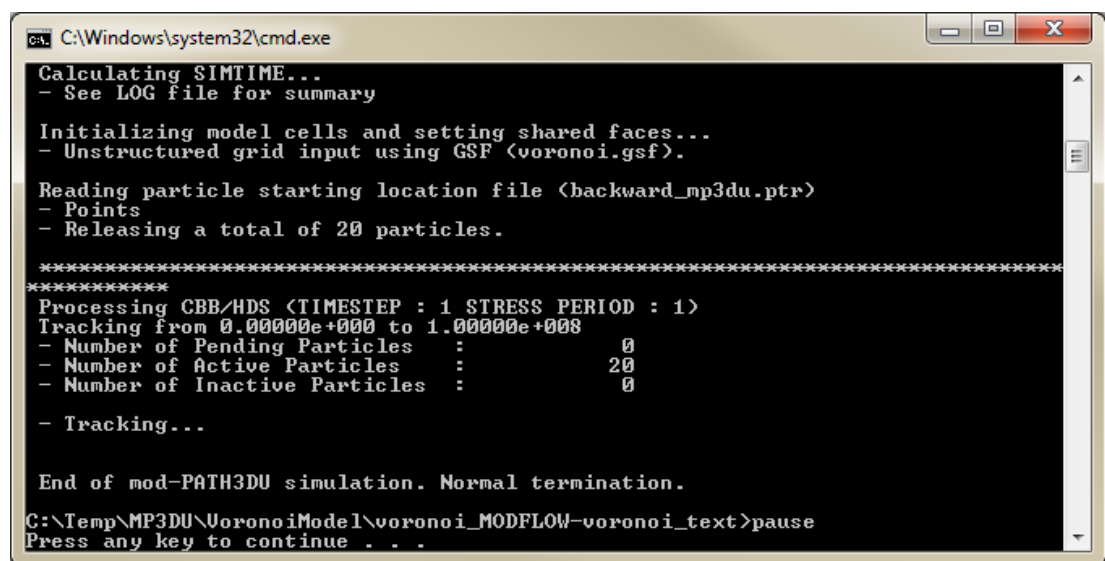

Figure 6   mod-PATH3DU running in a command window.

4. When mod-PATH3DU finishes, press any key to close the command window.

7   Reading the Solution

Next to read in the pathline solution that was generated.

1. Right-click the "backward" model and select the **Read Solution** command to bring up the *Open mod-PATH3DU Pathline File* dialog.

2. Locate the file "backward_mp3du.ptl" and click **Open**.

GMS reads the pathline file and displays the pathlines. The result should be something like Figure 7.
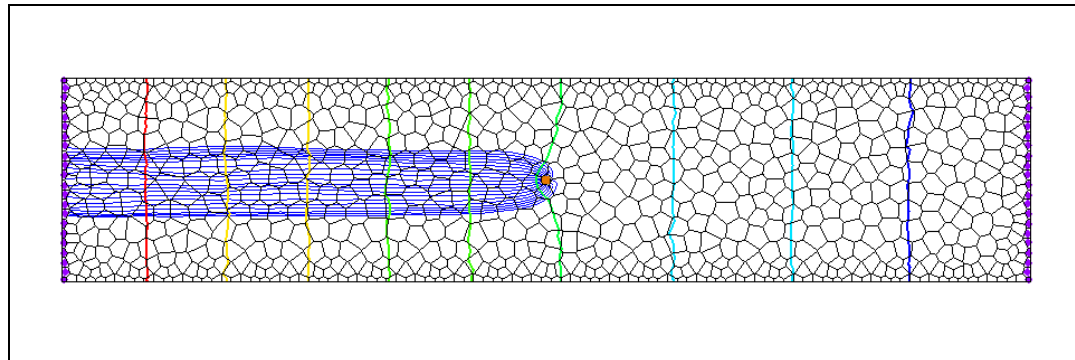

Figure 7   Pathline solution showing pathlines tracking backward from the well.

If desired, zoom in and examine the pathlines.

3. Click the **Save** macro to save the project with the solution.

> *The solution must be read manually with mod-PATH3DU.*

8   Create a Forward Tracking mod-PATH3DU Model

Now to create another mod-PATH3DU model with starting locations on the left edge of the model that track forward.

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

1. In the Project Explorer, right-click on the "voronoi" item and select the **New mod-PATH3DU** menu item.

2. Right-click on the new mod-PATH3DU model and select the **Rename** command.

3. Change the item name to "forward".

8.1   Add Starting Locations

1. Using the mouse wheel or the **Zoom** tool, zoom in on the left side of the UGrid.

2. Using the **Select Cells** tool, drag a box that selects the cells on the left side of the grid in the area where the existing pathlines are, as shown in Figure 8. Include some cells above and below the existing pathlines. If more cells are selected than just the ones on the edge, that's fine.
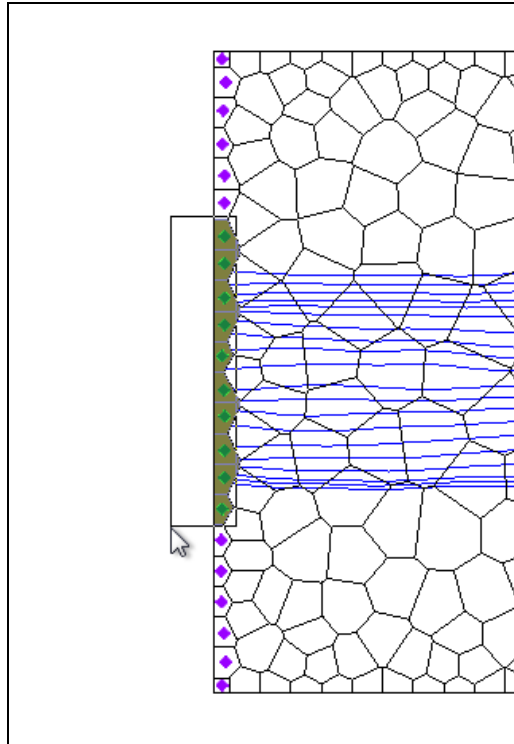
Figure 8   Selecting cells on the left side of the UGrid.

3. Right-click on any of the selected cells and select the **Create mod-PATH3DU Particles** command. The *Generate Particles* dialog will appear.

4. In the *Generate Particles* dialog, move the slider at the top of the dialog to the right until the *Number of particles* is "4".

5. Click **OK** to close the *Generate Particles* dialog.

Each cell now contains up to four starting locations. If desired, zoom in and see how GMS arranged the starting locations. Because voronoi cells are irregularly shaped, some cells will end up with fewer particles because GMS creates them in a square pattern using the cell extents as a guide, and then eliminates particles that end up outside the cell borders.

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

9 Save and Run mod-PATH3DU

The next process is to save and run mod-PATH3DU.

1. Click the **Save** 💾 macro.

2. Right-click the "forward" model and select the **Run mod-PATH3DU** command. A *Run Model* dialog will appear.

3.   Accept the defaults and click **OK** to close the *Run Model* dialog.

4.   When mod-PATH3DU finishes, press any key to close the command window.

10   Reading the Solution

Next is to read in the pathline solution that was generated.

1.   Right-click the "forward" model and select the **Read Solution** command to bring up the *Open mod-PATH3DU Pathline File* dialog.

2.   Locate the file "forward_mp3du.ptl" and click **Open**.

GMS reads the pathline file and displays the pathlines. The main graphics window should resemble Figure 9. The display might look somewhat different if a different set of cells on the left of the model were selected.
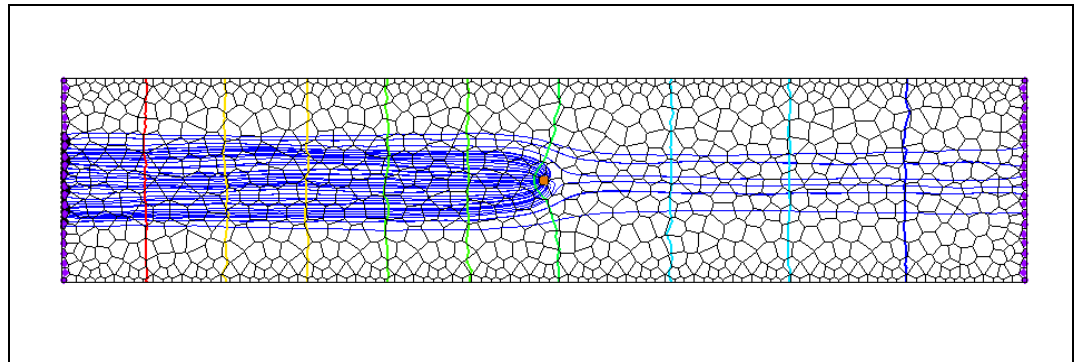

Figure 9   Pathline solution showing pathlines tracking backward from the well.

3.   Click the **Save** 💾 macro to save the project with the solution.

If desired, zoom in and examine the pathlines.

11   Examine the Solution

Let's take a closer look at the pathlines.

1.   Turn off the "backward" model.
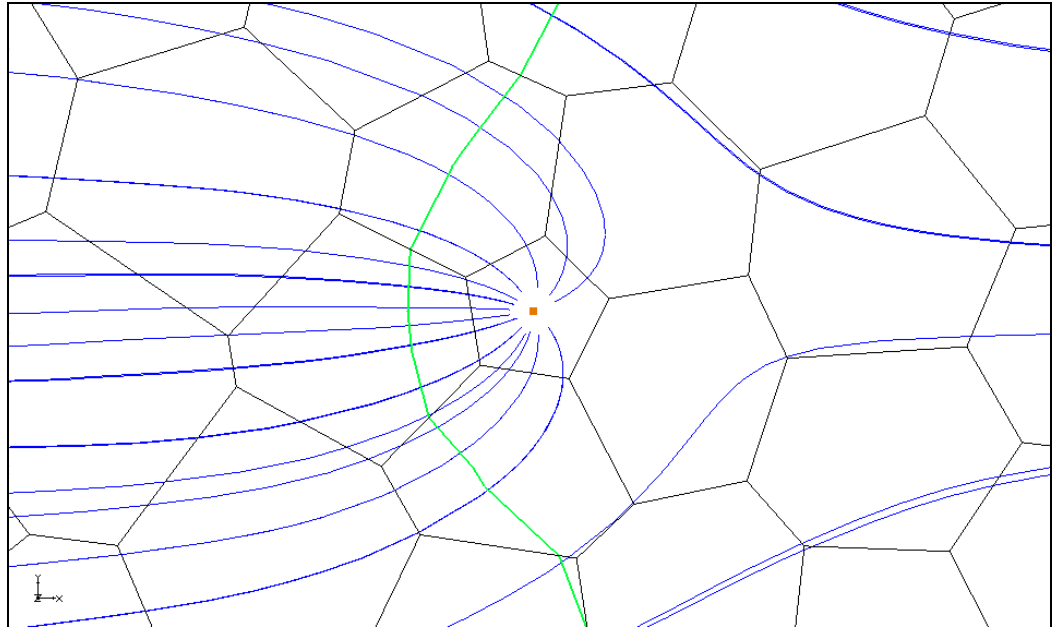
2.   **Zoom** 🔍 in on the well.

Figure 10   Forward tracking pathlines around the well.

Notice that some pathlines were captured by the well and some continued to flow past the well.

3. Click on the **Frame** 🔍 macro.

4. Click the **Display Options** 📦 macro to bring up the *Display Options* dialog.

5. With "UGrid Data" selected in the list on the left, click on the *Particles* tab on the right.

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

6. Turn on *Direction arrows*.

7. Click **OK** to close the *Display Options* dialog. Note the flow direction is now shown.

12   Conclusion

This concludes the tutorial. Here are some of the key concepts in this tutorial:

*   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 using any version of MODFLOW on any name file.

- Startling locations can be generated at wells using the **Create Particles at Wells** command.

- mod-PATH3DU does not run automatically like MODPATH.

- The solution must be read manually for mod-PATH3DU.

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

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