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WhAEM™ Quick Start Guide

This guide is *limited to some basic program functions*, just to get you started. More detailed guidance is found in the WhAEM integrated and context sensitive Help system and numerous pdf documents focusing on specific WhAEM features and functionalities.

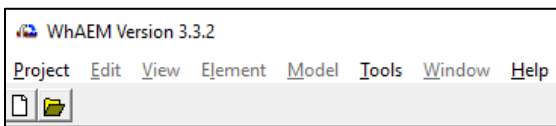
Installing WhAEM

If already successfully installed proceed to the next section: Trying out WhAEM. Go to <https://www.epa.gov/ceam/wellhead-analytic-element-model-whaem> and under the Download Files area click on WhAEM 332 Install. Save and run the file whaem_332_setup.exe, and follow the instructions. Note: You must have full administrative privileges to successfully install this program. Contact your IT department if in doubt.

Note: Some networked machines store the “Documents” folder (default installation target for the “WhAEM projects” folder) on a network drive with limited access. This could interfere with proper program operation. In that case you may simply move the WhAEM Projects folder to an area on your machine where you do have full access privileges, such as the Desktop folder. After starting WhAEM you would have to navigate to that new folder location.

Trying out WhAEM

Click on the Windows Start Icon in the lower left dock, and select WhAEM to start the program. The status bar on top of the WhAEM window displays the version number.

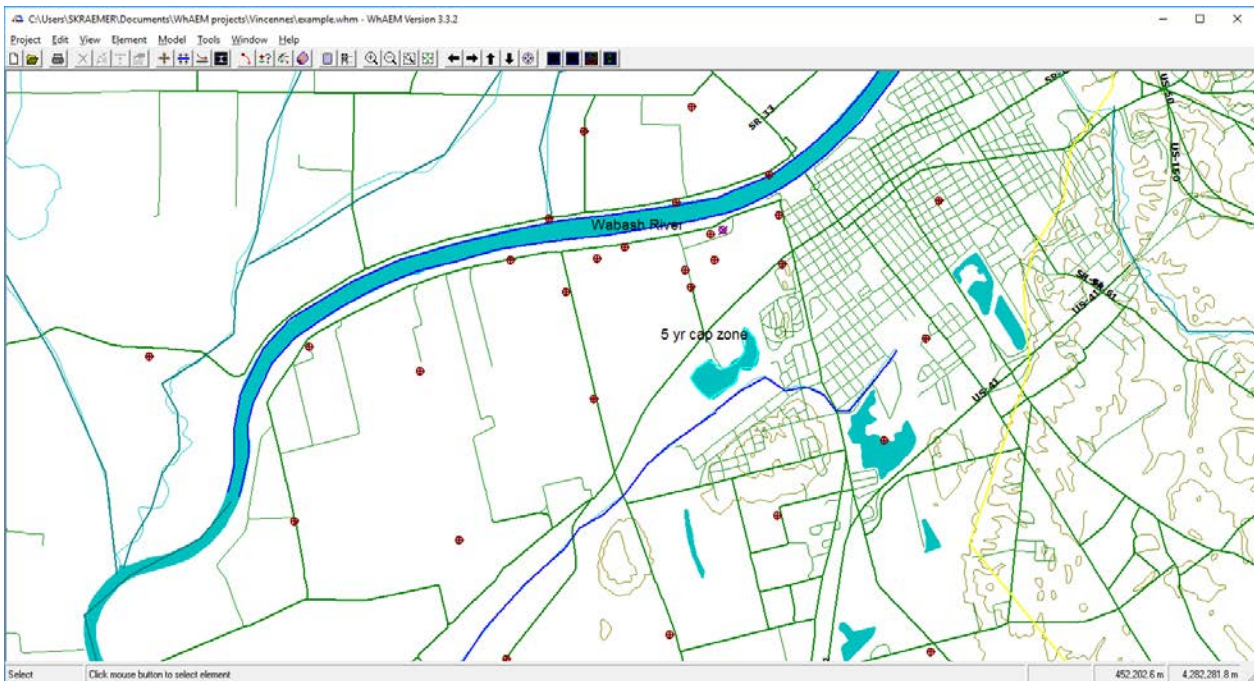
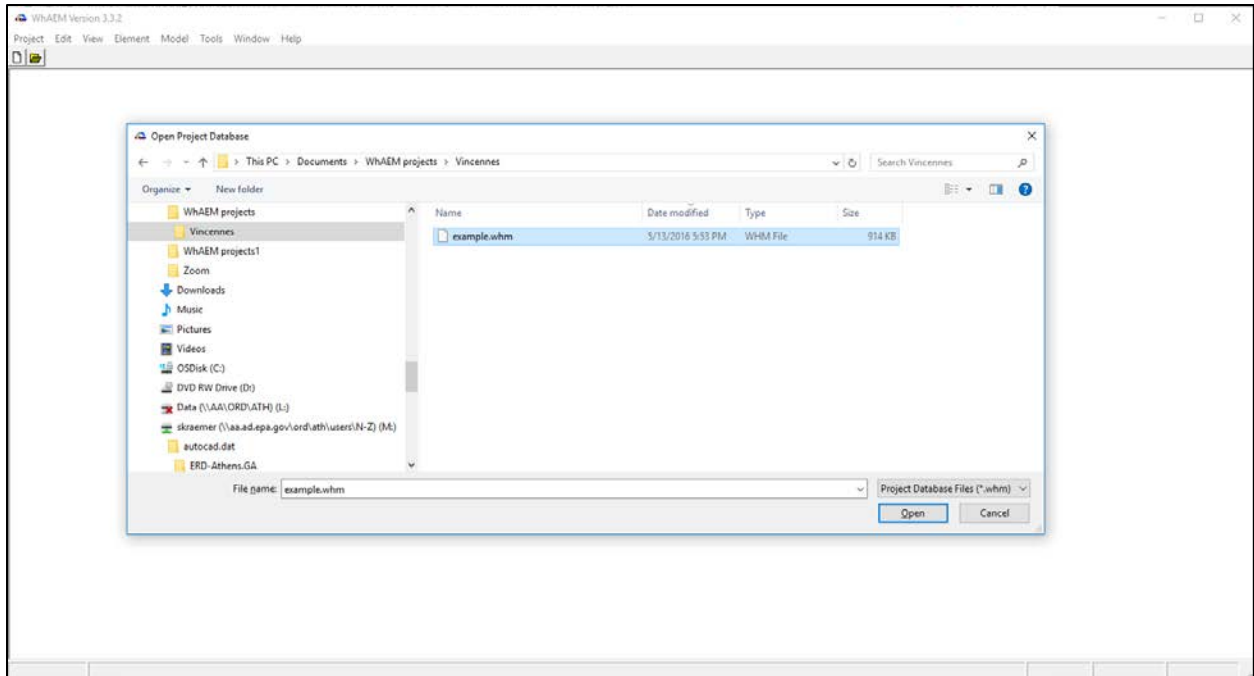


Open example.whm

Click on the open project icon (yellow folder) below the WhAEM menus and in the *Open Project Database* dialog navigate to the folder *WhAEM Projects* (default is in the Documents folder) and then the Vincennes folder, and click on *example.whm* and click on *Open*, see below.

After clicking on *Open* you should see the following screen:

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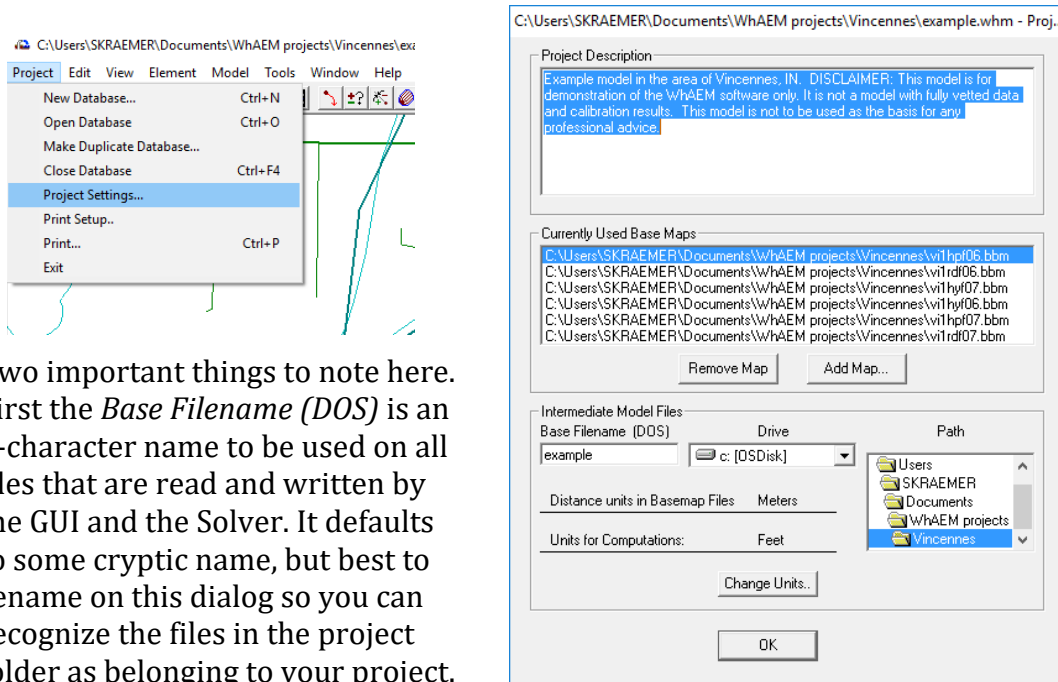
Several things happened upon loading the project file example.whm. First of all a base map appears with on top of it a layout of line-sink strings (green, blue, and dark red lines) representing streams and their tributaries. “Test Points” (red circles with + sign inside) are representing observation wells in which the head is known. Also visible is a boundary between the highly permeable outwash of Wabash river (thick blue stream through the center of the image) and the surrounding low

permeable uplands as a yellow line. All *WhAEM* menus below the top status bar have now become active and finally, a series of “smart icons” appears below these menus that offer shortcuts to various frequently used menu items.

Check project settings

If you move your mouse over the base map you may notice that the world coordinates of the mouse position are updated on the lower right bottom of the screen (make sure the *WhAEM* window has the focus – click on it if the coordinates don’t update). The base map in this example project is a set of “BBM” files (Binary Base Map) that are derived from USGS DLG files. The world coordinates for these maps are in UTM, which has its origin at the equator and measures distances in meters.

Click on the *Project* menu and then on *Project Settings...*



Two important things to note here. First the *Base Filename (DOS)* is an 8-character name to be used on all files that are read and written by the GUI and the Solver. It defaults to some cryptic name, but best to rename on this dialog so you can recognize the files in the project folder as belonging to your project. Also note that there are two different units in use: *Units for Computations* and *Distance units in Basemap Files*. The first is set to feet, which means that all data is entered in feet and days. For instance, heads in feet and hydraulic conductivity in feet per day, etc. The *Distance units in Basemap Files* is set to meters since the base maps in use are using UTM world coordinates. In case you would use a base map with distances in feet (e.g. state plane coordinates) this setting has to be changed to feet, of course.

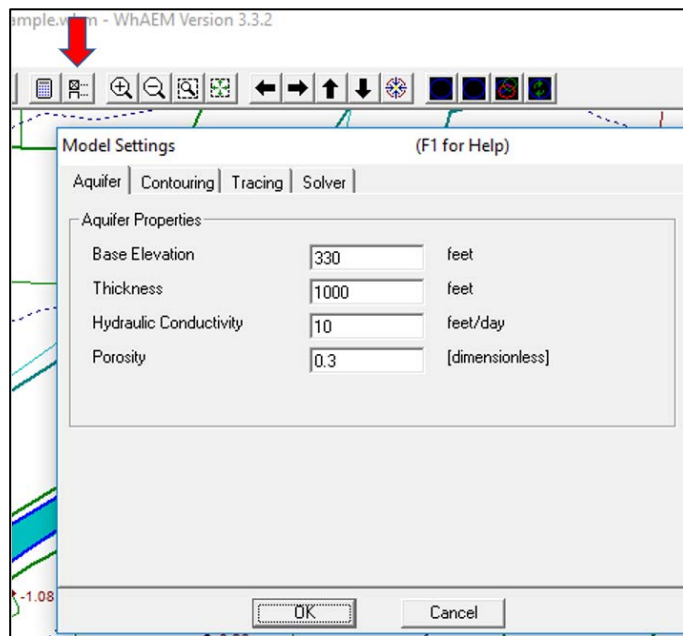
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Check Model Settings

Click on the smart icon to the right of the calculator icon (in the image below just above the upper left corner of the Model Settings dialog).

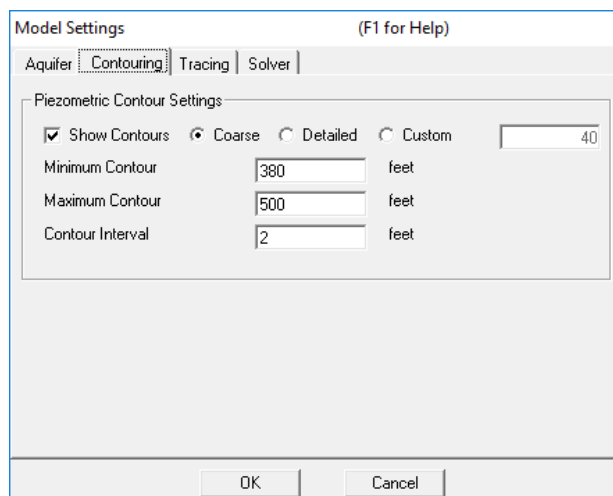
Aquifer tab

In the image the focus is on the *Aquifer* tab (clicking on the tabs will change the focus). Here we see that aquifer parameters that have been entered. The *Thickness* is set to 400, which means that the aquifer top is 400 feet above the aquifer *Base Elevation*, which is set at 330 feet. If the groundwater elevations are below the aquifer top (below 730 feet in this case) the aquifer is treated as unconfined. The aquifer top setting does not interfere with any recharge that is defined (seen later).



Contouring tab

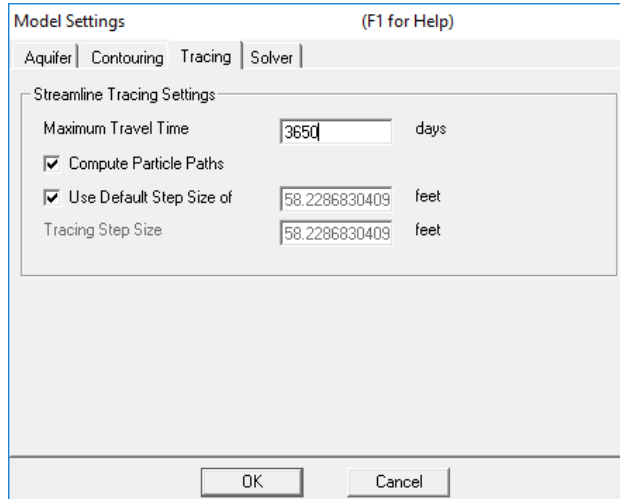
After clicking on the *Contouring* tab we see that *Compute Contours* is checked and that *Heads* is checked. Under *Contour Levels* we see that the minimum contour displayed won't be less than 380 feet and the maximum contour displayed won't be more than 500 feet. Contours will be plotted with an interval of 2 feet. Under *Grid Resolution* we find that *Course* is checked, which means that 40 grid points will be distributed horizontally in the window (*Detailed* would mean 80 grid points). The vertical grid spacing is the same so that the vertical number of points will depend on the window's aspect ratio.



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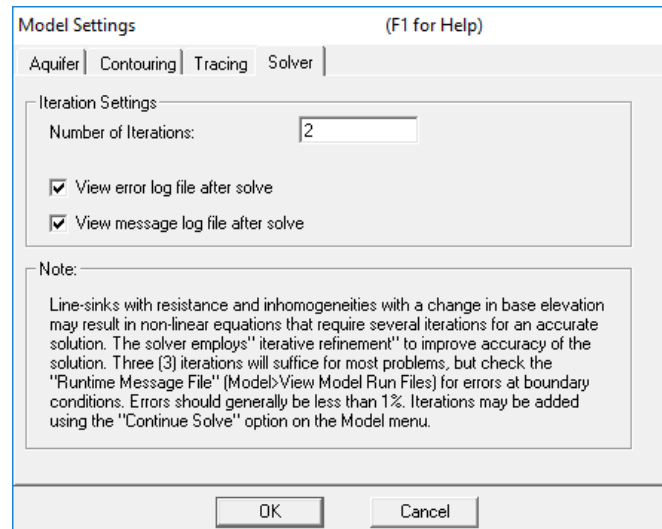
Tracing tab

After clicking on the *Tracing* tab we see that *Compute Particle Paths* is checked with the use of a *Default Step Size*, which is based on the window size. Also note that the maximum travel time of a particle trace is 3650 days (~10 years). This means that if the groundwater travel time along a path line becomes longer than 3650 days the trace will be aborted. For Time-of-Travel (TOT) Capture Zone delineation the *Maximum Time of Travel* may be set to 1825 days for a five-year TOT.



Solver tab

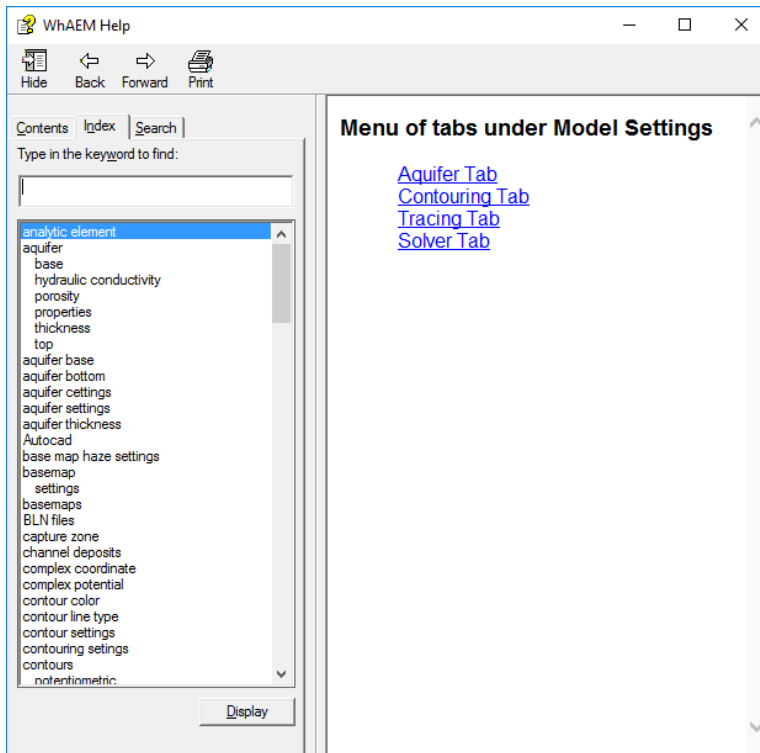
After clicking on the *Solver* tab we see that the *Number of Iterations (inner loop)* is set to 2. Some iterations are necessary because of non-linearities in the groundwater flow problem.



Context sensitive Help

We will check one more thing before proceeding to solve this groundwater flow problem. While the focus is still on the Solver tab press the function key F1. A context sensitive Help screen comes up, see image below, which provides access to all five Model Settings tabs. By clicking on any of the links under the word Settings to the right of the menu panel a detailed explanation of the options on the tab will be displayed.

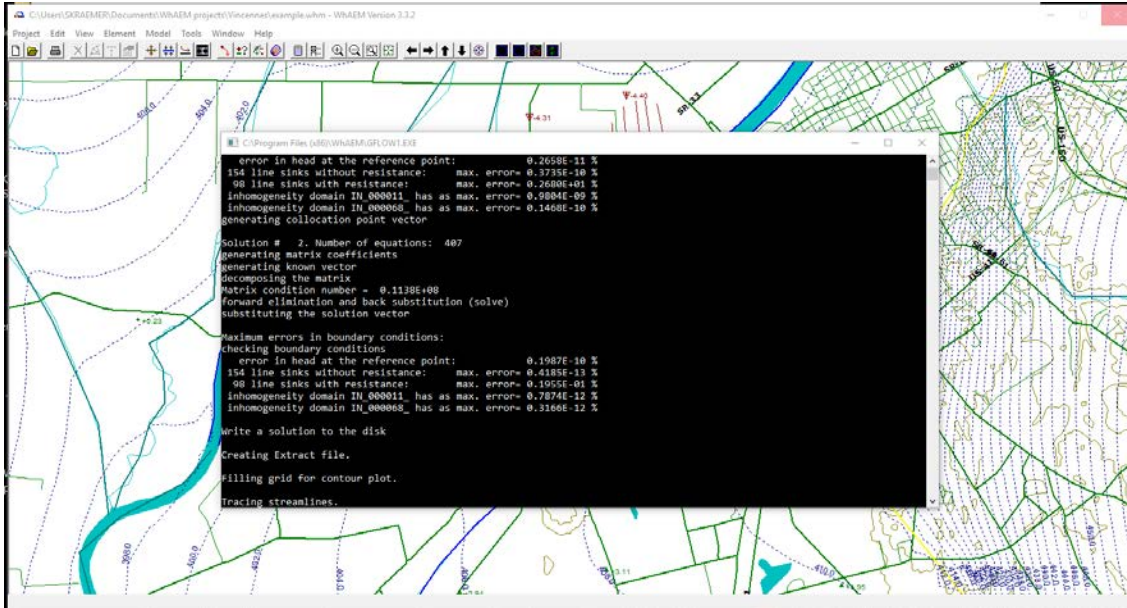
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Solving the groundwater flow problem

Now let's try to create a groundwater flow solution. Click on the calculator icon to the left of the *Model Settings* icon we used earlier. The GUI will launch the DOS program GFLOW1.EXE, which is the Solver. A DOS box will open and various messages will scroll inside that box, see image below.

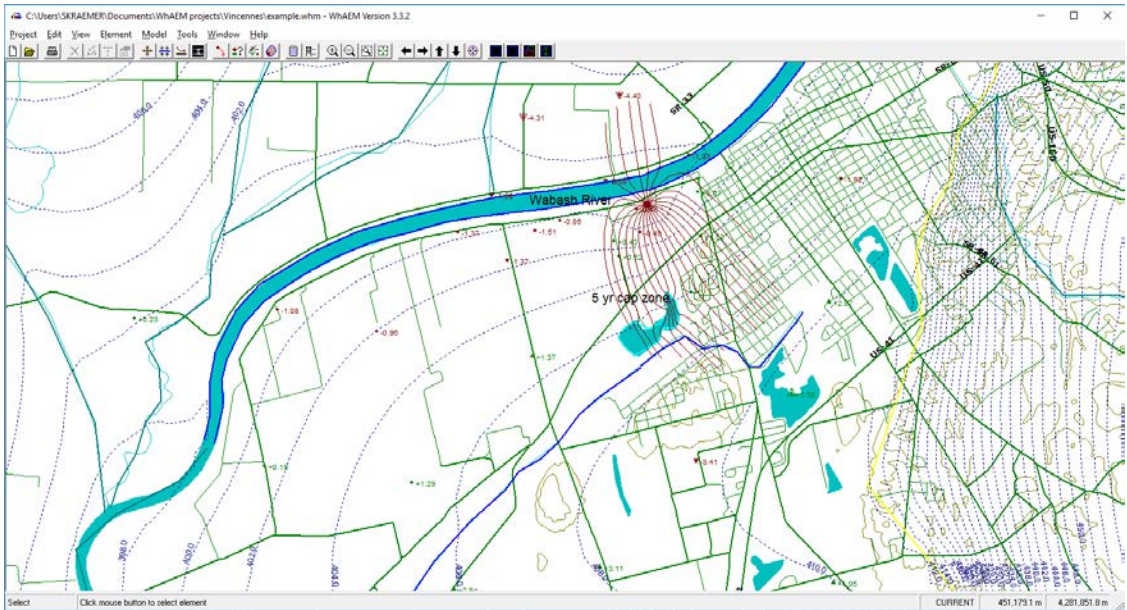
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These messages are stored in the file *Message.log* and will be displayed in *Notepad* at the end of the Solver run after the DOS box closes and disappears.

We see that the errors at internal model boundaries (boundary conditions) are all well below a percent, often near machine accuracy.

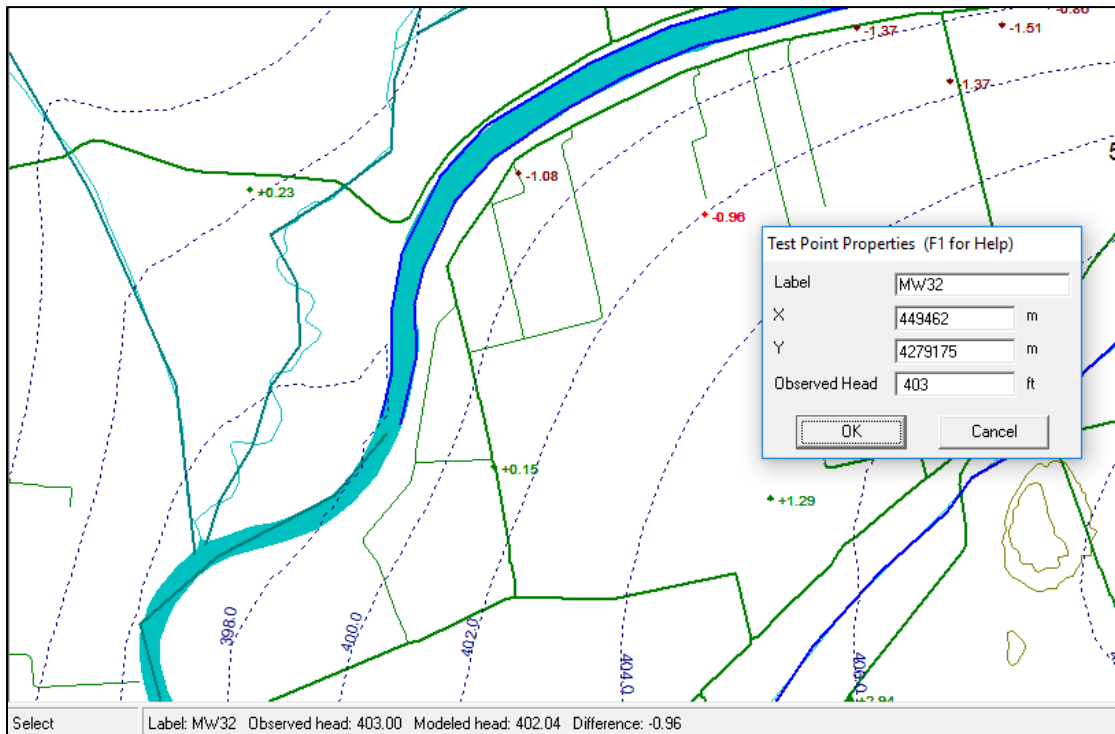
After we click away the *Message.log* file we can look at the graphical results generated by the Solver, see image below.



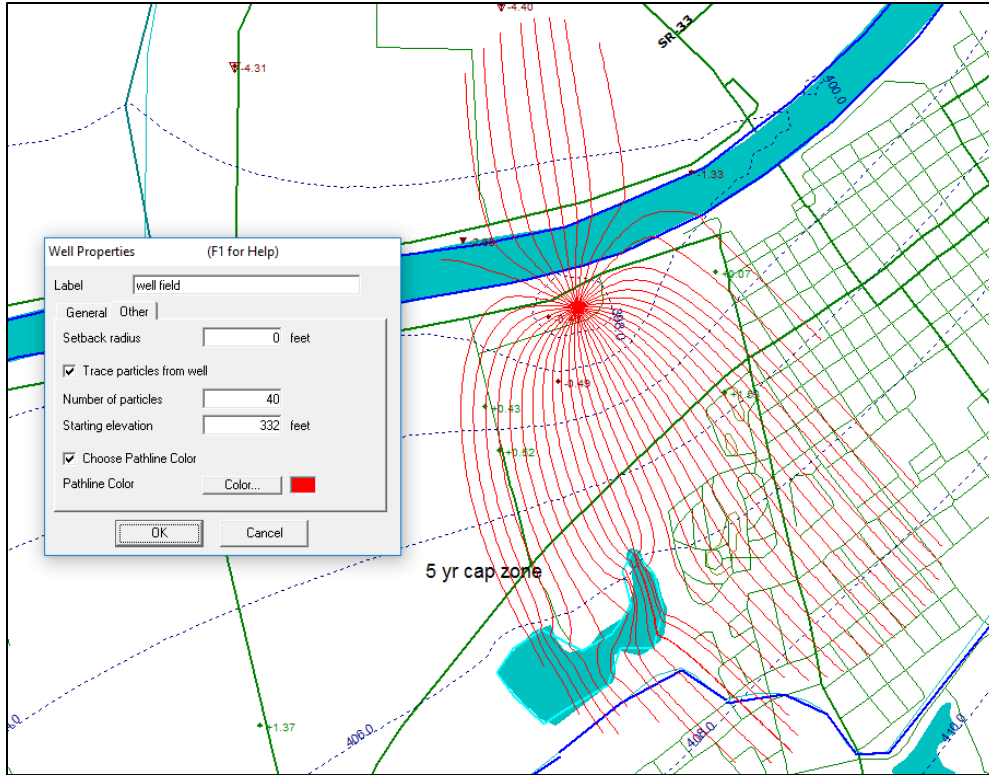
We see potentiometric contours (blue dotted lines), path lines (red), and we also see that the *Test Points* have been replaced by small triangles that are pointing upward

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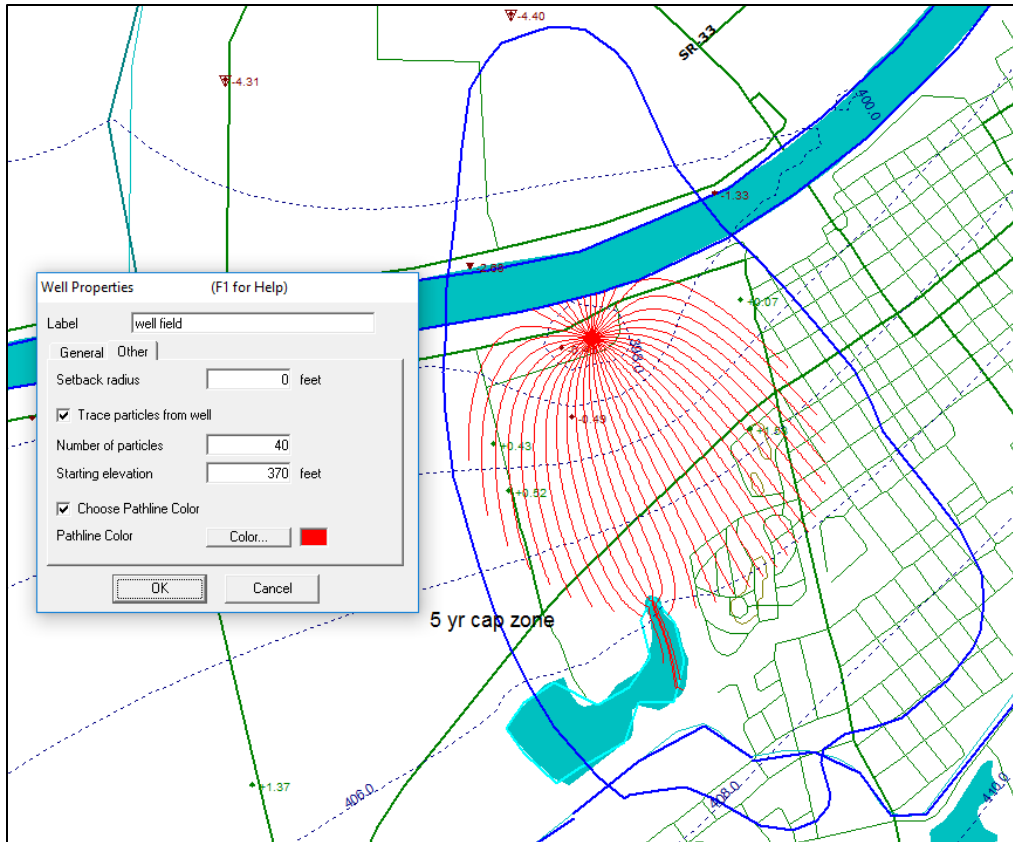
or downward. Below I show the data box that appears after double clicking the test point (highlighted in red) just above the left upper corner of the *Test Point Properties* dialog. We see that the *Test Point* is a *Piezometer* with an observed head of 403 feet. The calculated head is 402.04 feet, see the status bar at the bottom of the *WhAEM* window and image below.



In the image below we have zoomed in on the well near Wabash River for which path lines have been traced backward in time. After double clicking on the well and selecting the tab *Other* we see that 40 particles have been released evenly distributed around the well and traced backward in time. The particles have been released at elevation 332 feet, which is 2 feet above the aquifer bottom. Since we had selected a maximum travel time of 10 years (on the *Model Settings Tracing* tab), the traces define a 10-year TOT capture zone for the well. Note that this capture zone extends across the Wabash River.



It is noted that while *WhAEM* is a so-called Dupuit-Forchheimer model, hence only solving for flow in the horizontal plane, it does support (approximate) vertical flow calculations that make it possible to trace path lines in 3D space. In this case the well pumps water from across the Wabash River close to the aquifer base. Water that enters the well at a higher elevation will come from the Wabash River itself as is demonstrated in the image below where the particles are released higher up around the well, at elevation 370 feet, and the trace back in time ends at the boundary of Wabash River. Hence, water entering the upper portion of the well screen, opposite the river, comes from the river.



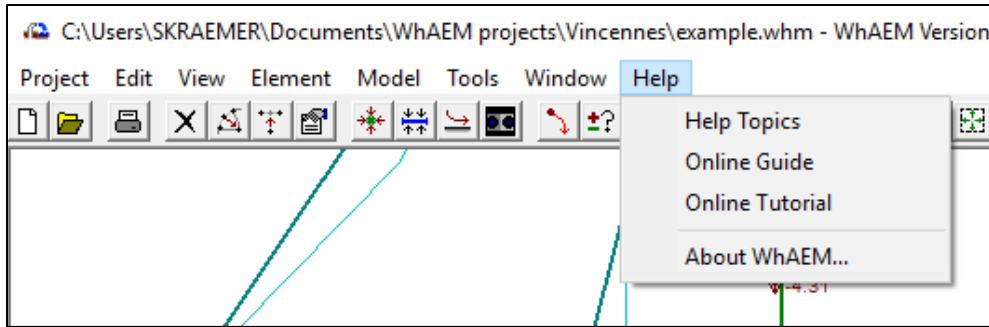
There is much more to explore

There is a lot more to be explored, however. You may click on individual line-sinks along streams and explore their settings. You may click on the yellow polyline, seen a few images earlier, that defines the transition from the permeable outwash aquifer to the much less permeable uplands. The yellow polyline is part of a polygon that is in WhAEM parlance an “inhomogeneity.” Inhomogeneities are used to redefine the hydraulic conductivity, aquifer base elevation, and porosity. They are also used to add areal recharge due to precipitation. There are numerous other features and tools to improve model realism and help you to create and inspect that model. These include horizontal flow barriers. Tools include various import and export functions, graphical overlays.

Ready to create your own model?

Before you set out to create your own model in your own area of interest it is suggested you consult two more documents that are accessible from the *Help* menu and that offer support with setting up your first model, see image below.

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Click on *Help* and then click on *Online Guide* for a discussion of the various steps needed to create a model. You may also open the *Online Tutorial* from the *Help* menu, which actually leads you step by step through an example project based on the *example.whm* project we just explored in this *WhAEM* Quick Start Guide.

The EPA Report “Working with WhAEM’ which goes into further detail on the hypothetical wellfield case study is available for download from the project webpage <https://www.epa.gov/ceam/wellhead-analytic-element-model-whaem>