Nimue beta

3D MODFLOW VISUALIZER

DECISION THEATER™
ARIZONA STATE UNIVERSITY

ASU ARIZONA STATE UNIVERSITY
IRA A. FULTON SCHOOL OF ENGINEERING
HIGH PERFORMANCE COMPUTING

Nimue - 3D MODFLOW Visualizer

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1 Introduction to Nimue beta

WELCOME TO NIMUE beta

Nimue (pronounced nee-moo-wey) is an open source visualization software package designed to view groundwater modeling data outputted from MODFLOW, the hydrogeology industry standard software for groundwater modeling. Nimue is designed specifically for managers and decision makers. Today's software products available for viewing MODFLOW data sets require the technical skills of a hydrologist. Usually this is not problematic because a hydrologist is using the same software for modeling groundwater scenarios as it is to present the results.

Working with local and regional water managers in central Arizona has shown that a more intuitive viewer which facilitates policy decision making is important when a regional stakeholder group is looking at various scenarios. A user-friendly visualization can provide decision makers a flexible venue for investigating scientific information. Furthermore, the 3D capabilities provided in this framework allow stakeholders of all backgrounds to understand the information in ways that are not available in today's commercial viewers.

Nimue Quick Facts:

- Easy viewing and navigation in three dimensions of MODFLOW data
- Ability to import geographic data
- Animation feature runs through time steps of data
- Interactive cross-section generation that cuts across data surfaces
- Convenient creation of 3D fly-through of data
- Quick export of images from viewer

Hardware Requirements

Nimue is a sophisticated software visualization package and therefore requires a computer with 3D rendering capabilities.

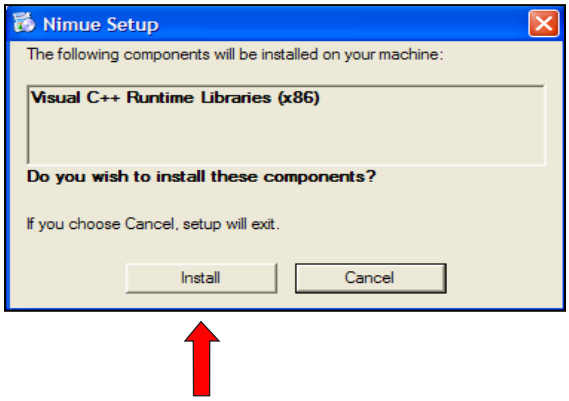
Recommended system hardware:

- Intel Dual Pentium 4 2.6GHz or faster
- 512 RAM (1GB recommended)
- 256 MB 3D graphics card
- Microsoft Windows XP or later
- CD-ROM drive (for installation disc)
- 65 MB disk space

INSTALLATION GUIDE

The following steps detail the installation instructions for Nimue.

- Insert the Nimue CD-ROM into your computer.
- Double click “My Computer”, and then double click on your CD drive icon to view the disc contents.
- Double click the “Nimue.exe” file to begin the installation process.
- This will automatically launch the WinZip Self-Extractor program.

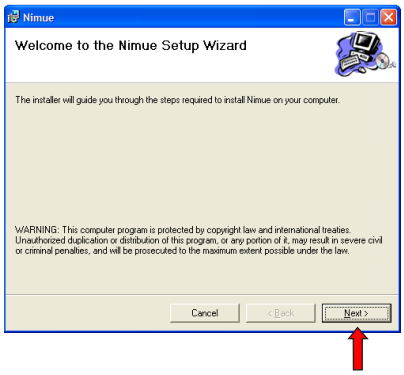


- When prompted to install the “Visual C++ Runtime Libraries”, choose install. This is necessary to enable Nimue to run.

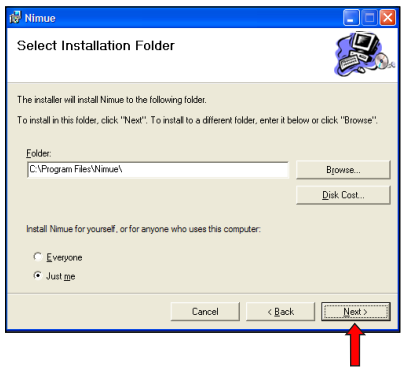
“WELCOME TO THE NIMUE SETUP WIZARD”

The following steps will complete the Nimue installation on your computer.

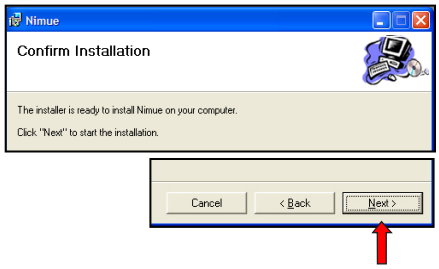
- After the Visual C++ Runtime Libraries have been installed, the Nimue Setup Wizard will open. Click on “Next” to continue.



- Choose a location to install the program to. The default location will install to your Program Files. Click on “Browse” to change the install location.
- You can also choose which accounts on your computer can use Nimue by switching the “Everyone” or “Just Me” option.



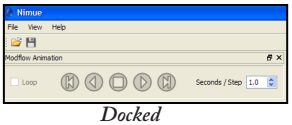
- The final step is to choose “Next” when the “Confirm Installation” screen pops up.



- This completes the installation of Nimue on your computer.

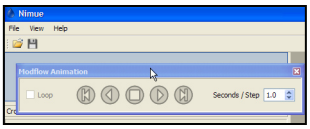
2 Getting Started

The MODFLOW environment essentially has two sections: the main viewing window and many small modules that perform specific functions. These modules are "dockable", meaning they can be moved and adjusted to fit the needs of a particular session. Because of this, modules can be scaled down to fit on smaller screens, or removed altogether.



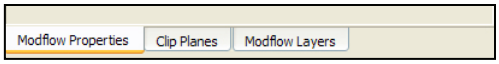
Docked

To move a module window, click and drag the module window title bar until the window snaps out of place. When the module is moved over space that it can dock to the space below will be highlighted in blue. Modules can remain independent of other docked windows if moved to an open space on the screen.



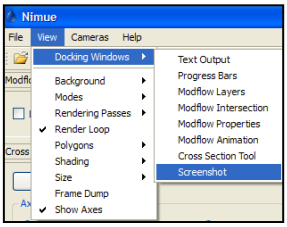
Un-docked

MODFLOW modules can also be arranged in tabs, making organization easier and free up window space.
To create a module tab, drag the window over the same space as another module until the space below is highlighted in blue. Releasing the window will automatically dock the module. This process can easily be reversed by dragging the desired module away from its current position.



Tabs

Closing module windows will remove them from the current session. At any point however, module windows can be returned by navigating the "View" menu and selecting "Docking Windows".



Docking Windows Menu

NAVIGATION:

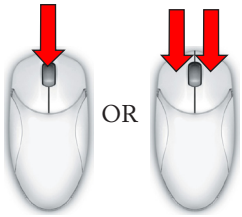
Mouse Controls:

Left mouse button:

Click and hold to rotate the entire model around a center axis.

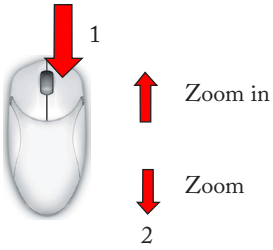
Middle mouse button OR both mouse buttons:

Click and hold the middle mouse button or click and hold both the left and right buttons to "grab" and move the model along a single axis.



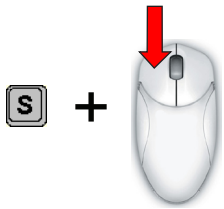
Right mouse button:

Click and hold, then move mouse forward or backward to zoom in/out.



"S" key plus left mouse button:

Push the "s" key then click and hold the left mouse button to define a new center location for the rotation axis. Press "f" to return to the default center location.



Key Commands:

Arrow Keys - Rotates the scene 45 in the direction pressed.

Spacebar - Resets the camera orientation to the default position. X axis will move to a horizontal position. The zoom level is not changed when spacebar is pushed.

F – Returns model to default view. (Must be pressed once after loading new MODFLOW file to bring the model into view)

H – Toggles the wire frame and shaded rendering settings together.

P - Toggles the points rendering view on or off.

W – Toggles the wire frame view mode on or off.

IMPORTING DATA:

From the file menu you can open existing Nimue projects, or create a new project by choosing

- File > New > MODFLOW Document

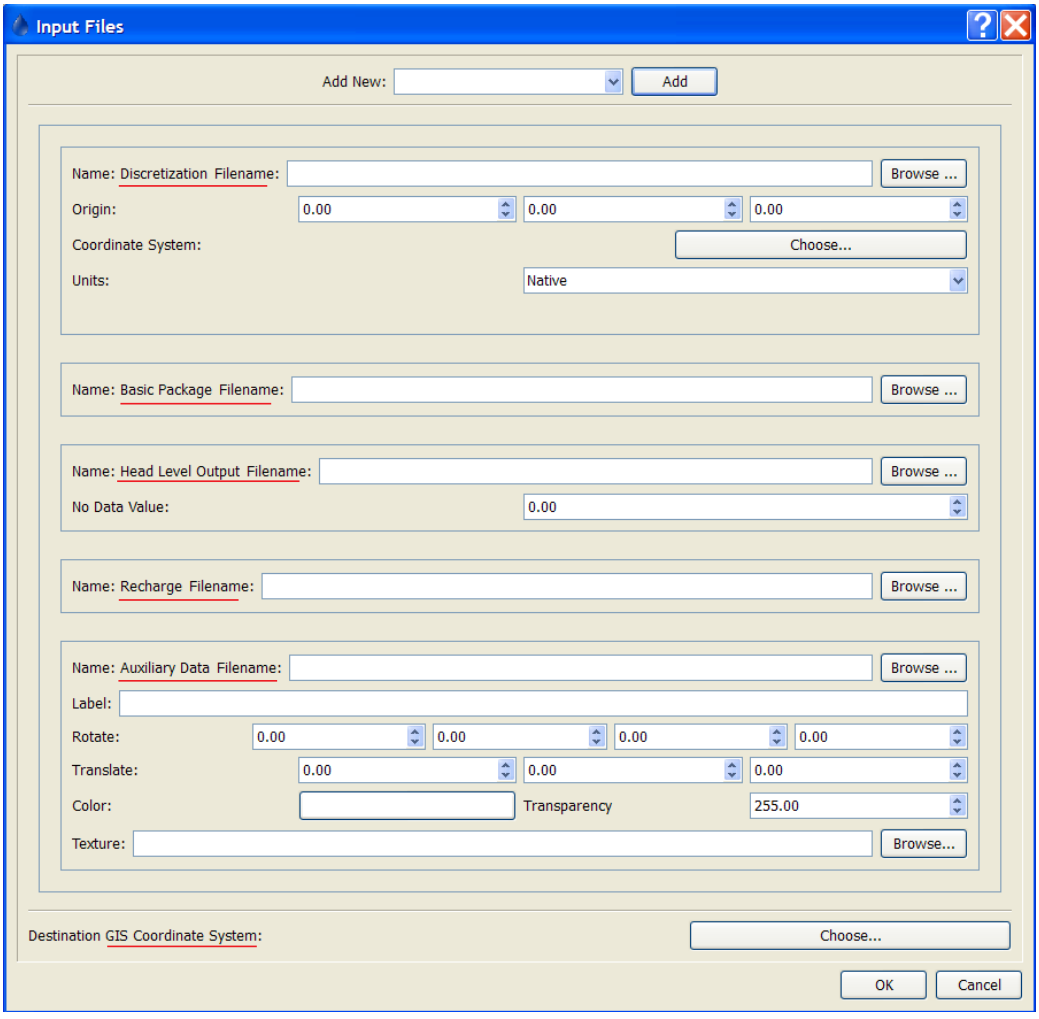
or

- File > Scene > Document

Nimue models are built from a combination of different MODFLOW data sets. These include:

- Discretization files (.dis)
- Basic Package files (.ba6)
- Head Level Output files
- Recharge file (.rch)
- Auxiliary Data
- GIS Coordinate System

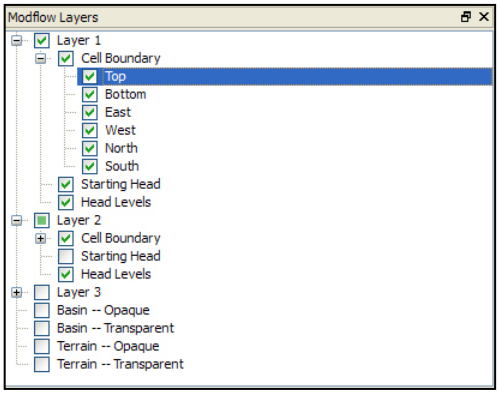
Descriptions of each of these file types can be found in Chapter 4.



MODULES

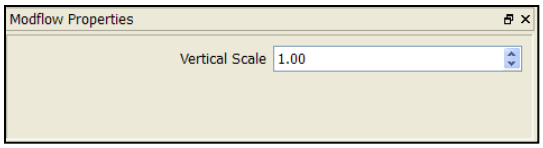
MODFLOW Layers (Table of Contents):

The "MODFLOW Layers" window allows you to toggle which data sets to view on and off. Top level layers can be expanded to view their contents by clicking on the + box. Each sub-layer can be turned on or off by clicking the box beside the name.



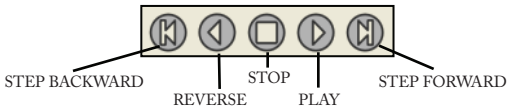
MODFLOW Properties:

Vertical Scale: Set the vertical scale for terrain in your model. Units correspond to settings found in the loaded MODFLOW data. Scale is from 1-99.



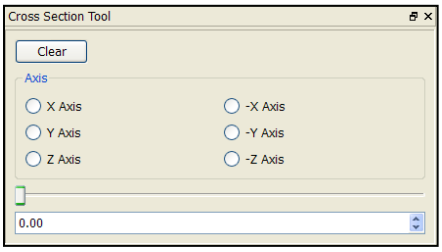
MODFLOW Animation:

The animation module serves as the controls for animation sets found in the loaded MODFLOW data. The buttons function much like a video player. Time steps for animations can be seen at the bottom left of the scene window.



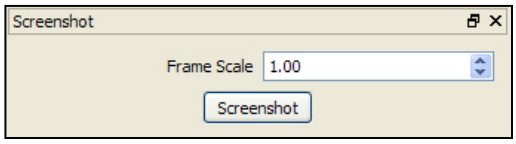
Cross Section Tool:

This function allows you to slice your models to create cross-sectional views of your data. Choose the axis from which you want to cut the model using the radio buttons, then enter the appropriate UTM coordinate in the box or move the slide bar to create a rectangular plane that intersects the model.



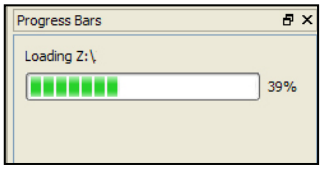
Screen shot:

This function will create a screen capture of the scene. Once you click "Screenshot", a window will pop up that allows you to create a file name and navigate to the correct directory where you can save the document. You can save screen captures as .bmp, .jpeg, and .png files. The Frame Scale option will multiply the resolution by the selected factor. While you can choose a scale from 1-99, images scaled larger than a factor of 10 may be too large to export.



Progress Bars:

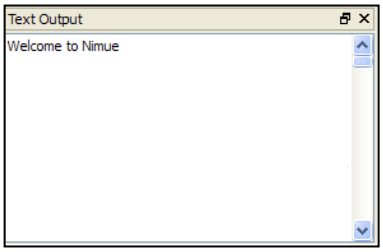
When loading a file, this window provides visual feedback on the progress. This can come in handy when dealing with particularly large data sets. When no files are being loaded, this window will appear empty.



Text Output:

This window provides program status. Examples of typical messages include:

- MODFLOW data loading status
- Software version information
- Availability of plug-ins
- Error messages



3 Operations

FILE MENU

New:

- MODFLOW Document - This opens the import dialog.
- Scene Document - Opens a blank scene. Drag and drop OSG files onto the new scene to load.

Open:

Use when loading existing MODFLOW documents.

Save/Save As:

Export:

- Image - Exports the scene as a raster. (.jp g, .bmp, .png, .rgba)
- Model - Exports all data into the native file formats for Open Scene Graph. (.ive, .osg)
- Scene - If you are including a cross section that cuts your model data and wish to preserve this in the exported model, select "export scene". This option exports model data in the native file formats for Open Scene Graph. (.ive, .osg)

VIEW MENU

Background:

Use this option to change the color shading of your background. Selecting different colors for different corners will create gradient shades between them.

Modes:

Navigate: The default navigation with mouse control.

Pick: Enables the use of the right mouse button to bring up an options menu.

Seek: Centers the scene where the mouse is clicked.

Rendering Passes:

This selection increases the resolution of the output screen shots from the Frame Dump option. A higher number will create more instances of exported frames.

Render Loop:

Render Loop allows for continuous redrawing of the scene. This function is only necessary when using Open Scene Graph documents, and therefore does not apply to MODFLOW data.

Polygons:

Specifies how polygons in the model will appear

- Filled – the default setting where all features are visible
- Hidden Lines – Turns off filled polygons to show hidden lines and removes shading
- Wire Frame – Switches to viewing only polygon vertices and their connecting lines
- Points – Switches to showing only polygon vector points.

Shading:

Changes the triangle size of the terrain layer. Smooth renders terrain polygons at a fine level, and flat will reduce the terrain to a course level.

Size:

Choose from several common resolution settings for the render window, or enter a custom window size.

Frame Dump:

Frame Dump will export an image continuously to a defined location on your computer. The Rendering Passes menu controls how often the scene image is saved. To begin the process, click "Frame Dump" in the View menu. The Text Output module will display the image file currently being written. To stop the process, choose "Frame Dump" again. It should be noted that if the Frame Dump process is left on, files will be written to the hard drive until no space remains. The appropriate location to save frames should be outside of the Nimue program folder. Additionally, make sure the folder you choose to save frames to does not contain spaces in the name. For example, "SaveFrames", not "Save Frames".

Show Axes:

Toggles the view of the X, Y, and Z axis in the lower left corner of the scene.

CAMERAS

The camera menu functions allow the user to save specific views of their data loaded in the window. This function is useful for saving perspectives that highlight elements of your data. Each camera path can store many perspective views. The collection of perspective shots can further be used to generate flights between perspective views. These functions can be particularly useful for presenting data.

New Path

Creates a new blank camera file with the extension *.cpf. In order to create new camera paths, you must first click "New Path." When you have set the correct perspective view in the window that you want to save, click "Append." Clicking Append saves the first camera in your new Camera Path.

Once you have appended a new view to the camera path, you can go back to that view by navigating to "Cameras" in the menu. The first perspective saved will be called "Camera 0". The next camera view saved will be called "Camera 1".

Open Path

If you have existing camera paths saved with the extension *.cpf, you may open that file by clicking "Open Path" and navigating to the directory where you have saved your *.cpf file.

Save Path

Once you have created a camera path using "New Path" it will not be saved unless you click "Save Path." You may navigate to anywhere you would like to store your *.cpf file.

Save Path As

You may save your camera paths either by clicking "Save Path" or "Save Path As." Using "Save Path As" allows the user to save a new camera path or existing camera path as another name or in another directory.

Export Movie

This function is currently grayed out and will be available in Nimue 2.0.

Append

Use Append to create a new camera view to be saved in your camera path. Each time you use Append, it will create a new camera view and append it to the list of cameras in the "Cameras" drop down.

Prepend

Use Prepend to create a new camera view to be saved in your camera path. Each time you use Prepend, it will create a new camera view and add it to the beginning of the list of cameras in the "Cameras" drop down.

Close

The Close function adds a camera to the end of your list of camera views that is identical to your first camera view, Camera 0. This function is useful when using the "Play Forward" and "Play Backward" functions.

Play Forward

When clicking on "Play Forward" the scene will animate by flying from camera to camera in your set of camera views. "Play Forward" will run from Camera 0 to the end of your list in order.

Play Backward

When clicking on "Play Backward" the scene will animate by flying from camera to camera in your set of camera views. "Play Backward" will run from your last Camera to Camera 0 in reverse order.

Stop

The Stop menu will only be active when Nimue is in Play Forward or Play Backward. It will stop the flight between camera views at any time.

Degree

Degree determines the nature of flight between cameras when using Play Forward or Play Backward. For example, 1 = linear flight path,

3= cubic flight path. Experiment with these options to find your preference for flying between cameras.

Step Size

This function controls the speed of flight between cameras. The numbers represent relative speeds of flight between one camera to another.

Camera Paths

If you have opened more than one *.cpf document, you can switch between them by checking them in the Camera Paths drop down.

HELP

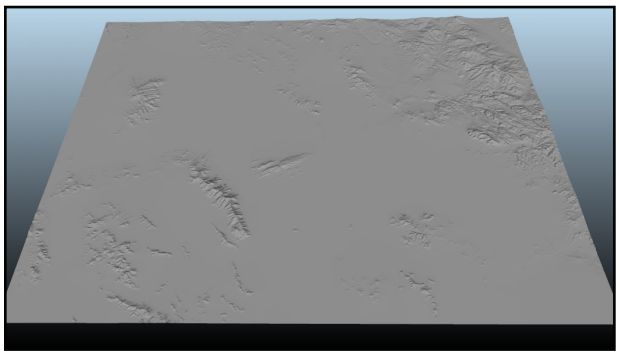
The Help menu contains a link that will open this user manual.

4 Model Data

GEOGRAPHIC DATA

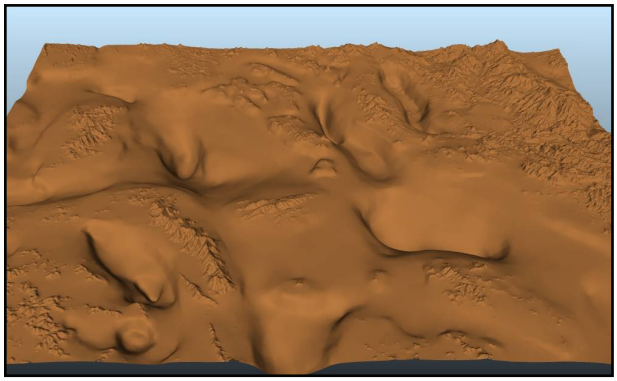
Terrain

Included in this version of Nimue is the topographic of the Salt River Valley in central Arizona, originally obtained from the US Geological Survey Seamless website (http://seamless.usgs.gov) as a digital elevation model (DEM). It has been converted into an OpenSceneGraph file here.



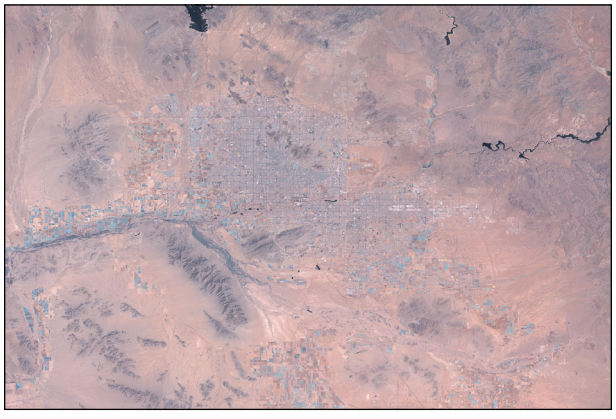
Subsurface Bedrock

Included in this version of Nimue is the subsurface bedrock topography expressing the basin and range topography of the Salt River Valley. The data originates from Oppenheimer and Sumner (1980). This data was processed using ArcMap and ArcScene to convert vector contours into a raster surface, and then merged to the surface bedrock from the USGS DEM by Jessica Block. It was then converted into an OpenSceneGraph file.



Imagery

Included in this version of Nimue is the 2005 LANDSAT imagery from NASA's Onearth website (http://onearth.jpl.nasa.gov/). It is being used as the texture for the terrain listed above. Overlaying the imagery are the major highways through central Arizona.



Surface Water Canals

One of the key components to water use is water delivery infrastructure. Nimue includes vector line files for the surface water canals of the Salt River Valley including the canals for CAP and SRP. This data comes from the Arizona Water Banking Authority GIS Database for Phoenix and Tucson Active Management Areas.

Recharge Locations

This point dataset includes most of the recharge locations in the Salt River Valley. This dataset also comes from the Arizona Water Banking Authority GIS Database for Phoenix and Tucson Active Management Areas.

MODFLOW FILE DESCRIPTIONS

Nimue supports the following MODFLOW documents:

Discretization File (SRV model extension *.dis):

Defines the number of model layers, rows, and columns (3 layers, 62 rows, 90 columns), the model length unites (feet), the model time units (days), the number and length of stress periods (20 years and 365 days). It also assigns the thickness of every layer by defining the model surface elevation, bottom of layer 1 (Upper Alluvial Unit), bottom of layer 2 (Middle Alluvial Unit), and bottom of layer 3 (Lower Alluvial Unit) for every active cell.

Basic File (SRV model extension *.ba6):

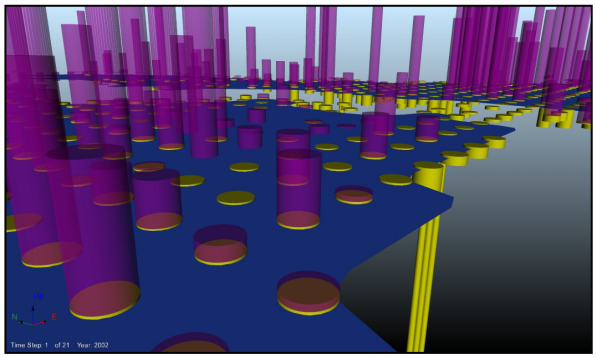
Defines the active model array and the starting heads.

Block-Centered Flow File (BCF) (SRV model extension: *.bc6)

Defines the model layer type, turns on rewriting capability, and assigns hydraulic properties to each active model cell. The layer type flag in the BCF package defines how the transmissivity for each model cell is calculated. The hydraulic conductivity, primary and secondary storage (when applicable), and the vertical hydraulic conductivity (Vcont) are assigned using the BCF package.

Well File (SRV model extension *.wel)

Simulates pumpage, recharge, and groundwater flux into and out of the model for each stress period. Negative values represent well pumpage that is distributed by cell and layer or estimated groundwater underflow out of the model along selected model boundaries. Positive pumpage values represent specified mountain front recharge, ephemeral stream recharge, and underflow into the model along some of the model boundaries. This file is known by Nimue as the "pumping" and is added to the MODFLOW layers view by listing in each layer that has associated. It is displayed in Nimue by vertical cylinders. Water being taken out of the ground is represented by cylinders pointing up. Recharge is represented by cylinders pointing below the land surface. When importing a pumping file, the user may choose which color to display the cylinders.



Example recharge and well data. The purple cylinders indicate well data pumpage volume and the yellow cylinders indicate recharge volume.

Recharge File (SRV model extension *.rch)

The Recharge file applies aerial recharge to cells within the model. The source of aerial recharge includes natural recharge (mountain-front and stream infiltration) and incidental recharge (agricultural, artificial, and urban). Recharge cylinders are represented by cylinders pointing below the land surface.

REFERENCES

Corkhill, E.F. and S. Corell, A Regional Groundwater Flow Model of the Salt River Valley – Phase I, Phoenix Active Management Area, Hydrogeologic Framework and Basic Data Report, Modeling Report No. 6, Arizona Department of Water Resources, 1993.

Corell, S.W. and E.F. Corkhill, A Regional Groundwater Flow Model of the Salt River Valley – Phase II; Phoenix Active Management Area, Numerical Model, Calibration, and Recommendations, Modeling Report No. 8, Arizona Department of Water Resources, 1994.

Gray, S.T., Bettancourt, J.L., Fastie, C.L., and Jackson, S.T., Patterns and sources of multidecadal oscillations in drought-sensitive tree-ring records from the central and southern Rocky Mountains, Geophysical Research Letters, 30(6), pp.49-49, 2003.

Oppenheimer, J.M., and J.S. Sumner, Depth-to-Bedrock Map, Basin and Range Province, Arizona, scale 1:1,000,000, Laboratory of Geo physics, University of Arizona, 1980.

US Bureau of Reclamation, Arizona Water Banking Authority GIS Database for Phoenix and Tucson Active Management Areas, 2004.

US Geological Survey, 30-meter Digital Elevation Model, Seamless Website: http://seamless.usgs.gov