Visual MODFLOW V 4.3

Visual MODFLOW is the industry standard in three-dimensional groundwater flow and contaminant transport modeling software.

With the ability to simulate groundwater and surface water interactions and the added capability of calculating changes to groundwater chemistry, groundwater professionals now have a complete set of tools necessary for addressing water quality, groundwater supply, and source water protection initiatives.

**MODFLOW-2000** - world standard for groundwater flow simulations
**MODFLOW-2005** - three-dimensional finite-difference groundwater-model, 2005 version
**MODPATH** - standard package for forward and reverse particle tracking
**Zone Budget** - for sub-regional water budget calculations
**MNW (Multi-Node Well)** - designed to help simulate wells with well screens that span multiple layers.
**MT3DMS** - for multi-species contaminant transport simulations
**MT3D99** - an enhanced version of MT3DMS, that includes support for implicit solver, TVD Solution scheme, dual-porosity advection-diffusion, Non-equilibrium Sorption and Monod Kinetics, and Multispecies Reactions, including First-Order Parent-Daughter chain reactions, and Instantaneous Reactions among species.
**RT3D** - for reactive transport simulations
**Stream Routing Package** - suited for simulating the effects of surface water/groundwater interactions

Add-on software:

**MODFLOW-SURFACT** - Three-dimensional finite-difference variably-saturated flow or soil vapor flow simulations (supports flow only)

Use MT3DMS to determine contaminant transport through an aquifer
Use the stream routing package for groundwater/surface water interaction
With Visual MODFLOW, you have all the tools necessary to:

- Graphically assign model grids, properties and boundaries
- Visualize model input parameters
- Run the flow, pathline, and transport simulations
- Manually calibrate the model
- Produce professional reports

**Visual MODFLOW Product Details Overview**

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<tr>
<th>About The Interface</th>
<th>Specifically designed to increase modeling productivity and decrease complexities typically associated with building three-dimensional groundwater flow and contaminant transport models. The interface is divided into three separate modules; Input, Run and Output.</th>
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<tr>
<td>Building The Model</td>
<td>Logical structure and layout eliminates the difficulties of building the input data file for a groundwater flow and/or transport model by guiding the user through the sequence of steps necessary to build a model.</td>
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<tr>
<td>Running The Simulation</td>
<td>Allows the user to select and modify the various flow and transport run-time options and start the model calculations using the Win32 MODFLOW Suite directly from within the modeling environment.</td>
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<tr>
<td>Displaying And Interpreting Results</td>
<td>Visual MODFLOW Premium automatically reads the results created from each successful simulation and provides a comprehensive selection of graphical formats for displaying full-color results in plan view and cross-sectional views.</td>
</tr>
<tr>
<td>Calibrating The Model</td>
<td>An extensive selection of built-in model calibration plots and statistical summaries give you with all the interpretation capabilities you need to properly and thoroughly analyze the model calibration data.</td>
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**Compare the different versions of Visual MODFLOW**

<table>
<thead>
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<th>Module</th>
<th>Visual MODFLOW</th>
<th>Visual MODFLOW Professional</th>
<th>Visual MODFLOW Premium</th>
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<tr>
<td>MODFLOW 96/2000/2005</td>
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<td>MODPATH</td>
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</table>
At Schlumberger Water Services, our goal is to develop powerful, yet easy-to-use software that meets the needs of groundwater and environmental professionals around the world. Visual MODFLOW is an excellent example of how we have accomplished this goal by making groundwater modeling accessible for any hydrogeologist or engineer who is familiar with the basic concepts and limitations of groundwater modeling.

**Professional Applications of Visual MODFLOW:**

- Predict impacts from saltwater intrusion from over pumping in coastal regions
- Delineate well capture zones for municipal drinking water supplies
- Design and optimize pumping well locations for dewatering projects
- Evaluate groundwater remediation systems (pump & treat, funnel & gate, etc.)
- Simulate natural attenuation of contaminated groundwater
Estimate the reductive dechlorination of TCE, PCE and DCE in groundwater
Determine contaminant fate and exposure pathways for risk assessment

**A regional-scale groundwater flow model for the Leon-Chinandega aquifer, Nicaragua**
Heyddy Calderón Palma and Laurence R. Bentley

Hydrogeology Journal - June 6 2007

**Abstract**

Groundwater flow in the Leon-Chinandega aquifer was simulated using transient and steady-state numerical models. This unconfined aquifer is located in an agricultural plain in northwest Nicaragua. Previous studies were restricted to MORE...

**Vertical migration of municipal wastewater in deep injection well systems, South Florida, USA**
Robert G. Maliva, Weixing Guo and Thomas Missimer

Hydrogeology Journal - 24 April 2007

**Abstract**

Deep well injection is widely used in South Florida, USA for wastewater disposal largely because of the presence of an injection zone ("boulder zone" of Floridan Aquifer System) that is capable of accepting very large quantities of fluids, in some wells over 75,000 m3/day. MORE...

**Visual MODFLOW Pro Case Studies:**

*Water Resource Management for Mining*
*Tailings Pond Evaluation and Impact Assessment*

**ABOUT THE INTERFACE**

When you open or create a file, you will be able to seamlessly switch between these modules to build or modify the model input parameters, run the simulations, and display results.

**The Display Control Buttons**

The ability to quickly and easily switch between plan view and cross-section display of the model is a powerful feature that allows the user to gain a better perspective on the three-dimensional aspects of the model.
input parameters and simulation results.

**The Navigator Cube**

The Navigator Cube provides a three dimensional schematic representation of the model grid and layers and is also a quick visual reference of your active position within the model domain. Also, the active mouse location (X,Y,Z model co-ordinates and I, J, K grid coordinates) are interactively displayed below the navigator cube as you move the mouse around the screen.

**Cell Inspector**

The Cell Inspector is used to inspect selected model parameter values on a cell-by-cell basis. Model parameters that may be viewed in the Cell Inspector include:

- Grid Position
- Model Position
- World Position
- Properties (Kx, Ky, Kz, Specific Yield, Specific Storage, Effective Porosity, Initial Head, and Initial Concentration values)
- Boundary Conditions
- Output

**BUILDING THE MODEL**

**Project Wizard**

Improved project creation wizard helps you to choose the optimal numeric engines to meet your project objectives. You can also import MODFLOW-2000, MODFLOW-96, and MODFLOW-88 data sets.

**Site Map Layers**

Load site maps and overlay on your model. Supported formats included AutoCAD (.DXF), Shapefiles (.SHP), and Raster images (.BMP, .JPG, .GIF).

**Grid Design**

Visual MODFLOW allows you to rotate the model domain over the site map (.DXF or .BMP format) to align the model grid with the site characteristics and groundwater flow direction. The finite difference grid can be modified by adding, deleting, moving and automatically refining rows, columns and layers.

**Automatic Grid Smoothing**

Use the cell inspector tool to view input and output values for each grid cell.

Use MT3DMS to determine contaminant transport through an aquifer.

Use the Stream Routing package for groundwater/surface water interaction.
It is important to design the model grid with proper spacing to give you the level of detail needed, while maintaining the numerical stability required for the solution to converge. Automatic grid smoothing is used to identify and fix regions of the grid which are poorly designed and optimize the transition from small to large grid spacing.

**Importing Layer Elevations**

Since most aquifers are not 'flat' layers, Visual MODFLOW allows you to import layer surface data from ASCII (X,Y,Z), Surfer (GRD), USGS DEM (.DEM), ESRI (.GRD), MapInfo (.GRD). Import and interpolate layer elevation data from XYZ ASCII files (TXT), MS Access Database (MDB), MS Excel (XLS), and ESRI Point Shape files (SHP).

During interpolation, there is an option to specify control points, manipulating the interpolation. For a selected layer surface, you may also define its elevation, by specifying an elevation, or a layer thickness, or a constant slope using three X,Y,Z points, or strike and dip method.

**Grid Cell Elevation Editor**

This tool allows you to modify the individual elevations of each cell using an array editor to modify the elevation value. The cell elevations can also be modified in cross-section using 'drag-and-drop' methods to stretch or compress a cell thickness.

**Pumping Wells**

Pumping wells or injection wells can be added, deleted, copied or moved using the intuitive well edit tools that allow you to graphically delineate the well screen interval and enter or import real-time pumping schedules from an ASCII text file. For sites with many pumping wells, Visual MODFLOW can also import all relevant pumping well data.

Import wells from txt, vc, shp, XLS and MDB.

Multiple well screens for a single well are easily accommodated while the pumping rate distribution between layers is automatically calculated based on the transmissivity of the layers through which it is screened.

**Observation Wells**

Visual MODFLOW is the only MODFLOW modeling environment that allows you to assign multi-level observation wells, just like ones you have in the field. In addition, Visual MODFLOW is the only modeling software package that allows you to group the observation points into one or more observation groups. This grouping feature is used for interpreting the calibration data for an isolated section(s) of your model domain.

**Properties**
Visual MODFLOW separates the model properties into two distinct categories:

**Flow Properties**

Those physical model properties affecting the groundwater flow simulation. Flow properties include; hydraulic conductivity (Kx, Ky, and Kz), specific storage (Ss), specific yield (Sy), porosity and initial heads.

**Transport Properties**

Those physical and chemical model properties affecting the fate, migration and degradation of a contaminant plume in groundwater, or adsorbed to the soil. Transport properties include; dispersion (Dx, Dy and Dz), bulk density, distribution coefficient (Kd), decay constants, initial concentrations.

Properties can be interpolated from XYZ ASCII files (TXT), MS Access Database (MDB), MS Excel (XLS), and ESRI Point Shape files (SHP). Interpolation options include Natural Neighbor, Kriging, and Inverse Distance.

Import property zones from ESR and polygon (.SHP) files.

**Boundary Conditions**

MODFLOW boundary conditions supported by Visual MODFLOW include both steady-state and transient Constant Heads, Rivers, General Heads, Drains, Recharge and Evapotranspiration. The Horizontal Flow Barrier package is also supported.

Visual MODFLOW also supports all contaminant transport boundary conditions available for the latest versions of MT3D including MT3DMS for multi-species transport, and RT3D for reactive transport and natural attenuation simulation. These include constant, recharge, or evapotranspiration concentration, and point source.

For transient simulations, real-time schedules of boundary condition values can be entered directly or imported into the time schedule from an ASCII text file. Recharge and evapotranspiration boundary conditions can be imported from ESRI polygon shapefiles.

**Particles**

Forward or backward tracking particles can be easily assigned for determining advective transport, preferred flow pathways and delineating well capture zones. Visual MODFLOW's intuitive graphical tools allow you to easily assign single particles, lines of particles and a circle of particles anywhere in your model domain.

**Zone Budget**

The Zone Budget package allows you to produce zone-to-zone flow
summaries for regions of interest in your model domain. Define zone budget flow observations, such as baseflow to a stream, or flux across a boundary, which can be used for calibrating the groundwater flow model against data other than just head measurements.

**Enviro-Base Pro**

Visual MODFLOW now integrates Enviro-Base Pro - an all-in-one database designed to house a variety of referenced property information used when developing groundwater models. Enviro-Base Pro enables you to consolidate your technical references into one package that can be easily launched, searched and updated.

**RUNNING THE SIMULATION**

**The Run Settings**

Visual MODFLOW Pro allows you to customize the MODFLOW run settings including:

- Initial head estimates (import from ASCII or Surfer, or previous run). Option to calculate VCONT from ground elevation or initial heads
- Number of time-steps and time-step multiplier
- Solver selection and convergence settings
- Recharge layer settings
- Layer-types (e.g. confined, unconfined)
- Rewetting options, including option to maintain a minimum saturated thickness for dry cells and to specify a head value in these cells equivalent to the cell bottom elevation.
- Anisotropy option

**MT3D run settings include:**

- Initial concentrations (import from ASCII or Surfer)
- Solver and advection package settings (UFD, TVD, MOC, MMOC, HMOC)
- Simulation output times

**Advanced Settings**

For the advanced users of MODFLOW, you can substitute your own manually created input data files for any MODFLOW by using the Advanced Settings. The Advanced Settings allows you to specify which files you will use from Visual MODFLOW, and which files you will substitute.

**Batch Runs**

Using Visual MODFLOW, you can easily set up a batch file to run several
models in succession. This powerful feature allows you to create multiple versions of the same model and run them while you are doing other tasks.

The Win32 MODFLOW Suite

Visual MODFLOW Pro includes the Win32 MODFLOW Suite with MODFLOW-2000, MODPATH, Zone Budget, MT3DMS and RT3D compiled to run as true Windows, 32-Bit applications. This unique and powerful modeling utility actually provides you with the ability to control the numerical solution process by manipulating the solver parameters and convergence criteria while the solution is in progress. In addition, it provides a real-time graphical display of the solution convergence data and a detailed graphical summary of the Zone Budget results.

After each successful run has completed, the Win32 MODFLOW Suite automatically produces all of the necessary files required for you to analyze and interpret the results, and produce full-color, report-quality graphical presentations using Visual MODFLOW post-processing graphical features.

ADD-ON PACKAGES

MIKE 11

MIKE 11, developed by DHI, is a world-recognized surface water modeling package designed for simulating the hydrodynamic conditions found in rivers, lakes, reservoirs, and irrigation canals. Visual MODFLOW Pro and MIKE 11 are now available as a fully coupled, groundwater and surface water simulation environment. This impressive combination represents the only truly conjunctive groundwater/surface water model combining USGS MODFLOW 2000 and DHI’s MIKE 11. Ideally suited for:

- Analyzing the hydraulic connection between rivers, streams, and aquifer systems
- Determining groundwater base-flow and potential impacts to ecologically sensitive areas
- Calculating infiltration rates from surface water to groundwater during rainfall events
- Developing comprehensive watershed management plans

MODFLOW-SURFACT

MODFLOW-SURFACT is a three-dimensional finite-difference flow and transport program containing many advancements and improvements over the standard public-domain versions of MODFLOW.

With more robust solution methods and enhanced simulation capabilities for handling complex saturated/unsaturated subsurface flow and transport processes, MODFLOW-SURFACT is specifically designed to address the
many limitations and short-comings of the standard MODFLOW codes.

Use MODFLOW-SURFACT when simulating:

- Multiple water tables, or perched water table systems
- Steep water table gradients crossing multiple model layers
- Over-pumped wells screened across multiple model layers
- Surface water infiltration through the vadose zone to the water table
- Large water table fluctuations causing desaturation/resaturation of grid cells
- Soil vapor flow through the unsaturated zone

DISPLAYING AND INTERPRETING RESULTS

In order to get the most out of the model that you build, it is critical that you have the tools necessary to properly analyze the results.

Contouring and Color Maps

Visual MODFLOW creates detailed contour maps of modeling results including:

- Heads, drawdown and multi-species concentrations
- Water table elevations/depth and net recharge
- Head difference between layers and flux between layers

High-quality color shaded contouring is also available for creating presentation quality color maps of all contoured results.

Flow Velocity Vectors and Pathlines

Visual MODFLOW displays flow velocity vectors and flow pathlines. Flow velocity vectors can be used to effectively illustrate the direction and magnitude of groundwater flow velocity throughout the model domain.

Export Options

Export model display to Raster image format (.BMP, .JPG, .TIF, .PNG, .TIF), or AutoCAD (.DXF) in model or world co-ordinates

Export contour lines, velocity vector maps, and pathline locations to ESRI Shapefile (.SHP) in model or world co-ordinates

Export a wide variety of gridded data to ASCII .TXT, Surfer .GRD, or
TecPlot (.DAT)

Mass Budgets for Flow and Transport

Visual MODFLOW produces detailed tabular and graphical reports of the mass balances for both the flow and mass transport simulations. These reports provide global and local summaries of the mass inflows and outflow from the system, or from a localized region of the model.

Printing

Visual MODFLOW prints full-color, high-resolution graphics to any printer or plotter supported by Windows. The graphical display of the simulation results and/or input files can be printed in portrait or landscape format as a full-page image or with a title block that describes the details of the model and the results being displayed. Color-shaded contours can be printed with or without a color legend.

Visual MODFLOW also prints the on-screen display to several graphics file formats and exports results to ASCII files in two or three dimensional format.

CALIBRATING THE MODEL

Tools for Manual Calibration

An extensive set of built-in model calibration plotting utilities and statistical calculations help you properly evaluate the modeling results and interpret the calibration data. Comprehensive calibration plotting utilities and statistical summaries provide you with all the graphical interpretation tools you need to properly and thoroughly analyze the model calibration data.

Visual MODFLOW allows you to assign multi-level observation wells and group the observation points for isolated analysis of local model regions.

For each simulation Visual MODFLOW calculates the following calibration statistics:

- Mean Error
- Mean Absolute Error
- Standard Error of the Estimate
- Root Mean Error
- Normalized Root Mean Error

These statistics can be calculated for all observations, or just for selected groups of observation points (as defined by the user). The calibration plotting options provided include:
Scatter plot of calculated vs. observed data
Histogram of calibration residuals
Time-series plot of calculated and observed data
Time-series plot of calibration statistics
Bubble plot of calibration residuals

All plots can be exported to common image format (.BMP, .JPG, .TIF, .PNG), and the plot data can be exported to .ASCII for further analysis.

**SYSTEM REQUIREMENTS**

Supported on Windows 2000 SP4, Windows XP Pro SP2, and Windows Vista (Business, Enterprise and Ultimate)
- RAM: 512MB and 1GB (or more) would be recommended
- Hard drive space: 200MB
- A minimum screen resolution of 1024 X 768
- A Microsoft compatible mouse
- Microsoft Framework 2.0 installed