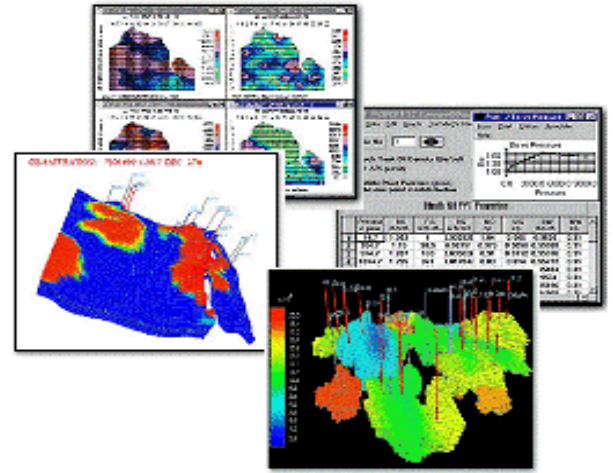


EXODUS

Reservoir Simulator for Microsoft Windows™
with Automatic History Matching Capability



*We've been delivering this Windows based simulator to clients since 1992.
It works, and it works well!*

Simulator Applications

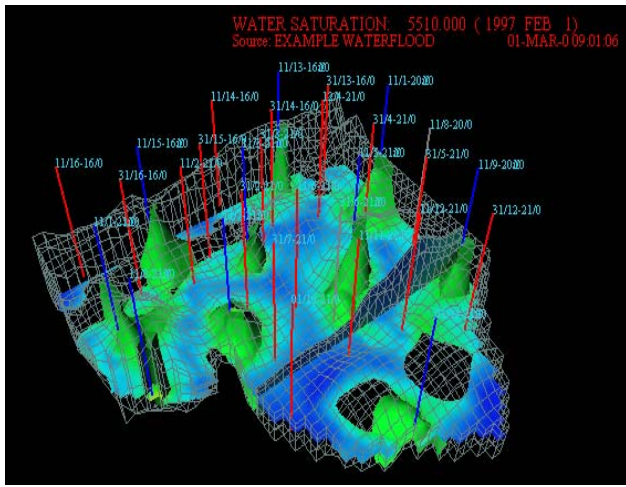
- ▶ Full field modelling, pattern elements simulation, or single well performance.
- ▶ Black Oil, water flood and gas re-injection. Gas condensate reservoirs. Tight gas and shale modeling.
- ▶ Coupled Surface Dry Gas Gathering Network (Compressors, Looped Lines)
- ▶ Pseudo-miscible hydrocarbon recovery processes.
- ▶ Polymer flood and tracer tracking.
- ▶ Alkaline Surfactant Polymer enhanced recovery.
- ▶ Transient Pressure Analysis.
- ▶ Multizone Hydraulic Fracture Modelling ([SPE 74361](#)).
- ▶ Horizontal well appraisal.
- ▶ Enhanced coal bed methane appraisal ([SPE 75672](#)).
- ▶ Economic comparison of cases.

Simulator Features

- ▶ Radial and Cartesian Coordinates. Corner Point Geometry. Local Grid Refinement.
- ▶ Fully Implicit K-value Compositional Formulation.
- ▶ Dual Porosity / Dual Permeability for Naturally Fractured Reservoirs.
- ▶ Arbitrary Neighbour Connections.
- ▶ Fast, user independent, iterative sparse matrix solver.
- ▶ Optional Nine-Point Transmissibilities.
- ▶ Multiple relative permeability sets. Areally variable fluid contacts.
- ▶ Carter Tracy Analytical Aquifer.
- ▶ Vertical, inclined, or horizontal wells.
- ▶ Prioritization of well locations for automatic workovers. Simultaneous well constraints for oil, gas, water, liquid, and equivalent reservoir volume rates, flowing bottom hole pressure, and well head pressure
- ▶ Fully coupled multiphase pressure loss correlations for any well.
- ▶ Multiple well segments to well head. Optional VFP tables for pressure loss.
- ▶ Gathering Centres for well grouping. Constraints for production, injection, and voidage replacement for gas and water injection.
- ▶ Metric or Field Units. Conversion to user choices. Optional calendar dates.
- ▶ Time or stress dependent permeability and porosity modification.
- ▶ Any user defined historical series for comparison with simulation output.
- ▶ Import data from other selected simulators and mapping programs.
- ▶ Surface Gas Gathering network models one or more pipeline systems producing from one or more reservoirs. Each network may have looped, parallel segments, compressors, chokes, multiple offtake points and contracts.

▶ Full Featured ▶ Affordable ▶ 3-D Graphics ▶ User Friendly ▶ Superior Support

T.T. & Associates Inc.



"Exodus is elegant and extremely easy to use. The graphics are superb and execute flawlessly"

- Dr. S.M. Farouq Ali

User Friendly features

- ✓ Graphical User Interface. Point and click with mouse to select options from command buttons, drop down menus, and check boxes.
- ✓ Full On-line Help. Instant hints on each form or request detailed description of menu items for each displayed form. Search Help file for topics or keywords. Print any selected topic(s).
- ✓ Spreadsheet-type data entry forms with in-line data cell editing. Edit functions such as copy and paste, fill down, fill right, and undo. Exchange data with other Windows applications.
- ✓ Monitor flood fronts and performance of wells with post processing programs such as Grid Display, Well Charts and Well Report while the run is still processing. Stack up multiple cases for batch processing.
- ✓ Lotus ScreenCam™ movies for learning how to use Exodus.

Price

Exodus is competitively priced based on the number of active grid cells. Purchase only the version that will fit your reservoir problems, and upgrade for the difference in price when necessary. Leases available.

Rapid History Matching with Sub Models and Flux Boundary Conditions

Use the Pre-processor to subdivide a full field reservoir into multiple sub-regions with a few mouse clicks.

Run the full field model to save all necessary boundary conditions for the sub-regions.

Run each of the sub-region models independently and history match by changing grid cell values in the sub-region model. Use Automatic History Matching if desired.

Merge the sub-regions back to the full field model with a few clicks of Pre-Processor options.

Repeat if necessary with different sub-regions. The sub-region models run in a fraction of the full field model time.

Automatic History Matching Controller

- Available for matching pressures, GOR and WOR for black oil reservoirs, and pressures for gas reservoirs
- Non-linear regression analysis to find parameter values that will result in a reservoir description that will match field history.
- Use porosity, directional permeability and relative permeabilities as parameters.
- Define regions where parameters may be modified. Define parameter value as constant or factor of original values. Set minimum and maximum values for parameter changes.
- Monitor progress of regression during run using Well Charts, Grid Display Utility, Well Report Utility.

System Requirements

Microsoft Windows™ XP, Vista or "7"

Network Versions Available

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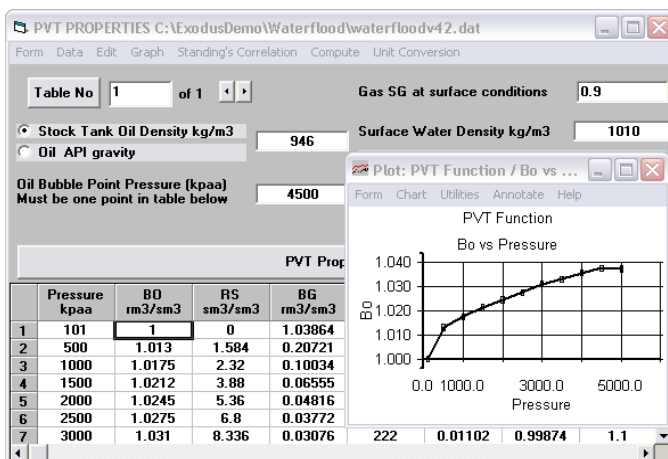
Exodus Reservoir Simulator

Pre Processing Modules

Quickly and effectively digitize map data, build simulation grids over maps, infill to get grid properties, import production and pressure history, build complete simulation data sets with comprehensive error checking, all with interactive, user friendly, graphical user interfaces.

PRE-PROCESSOR

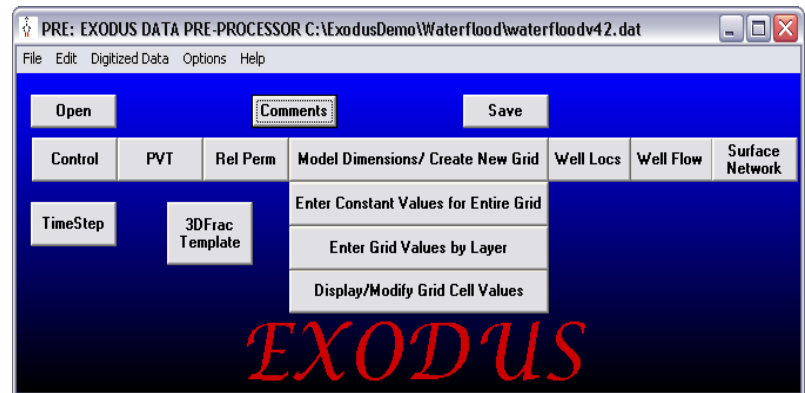
- ▶ A graphical interface to create, view and edit Data Sets with full Microsoft Windows features (menus, tabular entry, mouse control, data exchange) and comprehensive error checking.
- ▶ Display and modify tabular values in spreadsheet format.
- ▶ Correlations for PVT and relative permeabilities. Automatic normalization and de-normalization for scaling of end points.



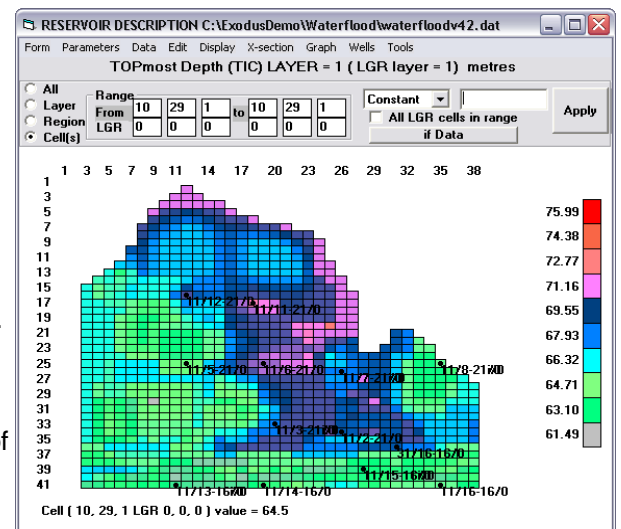
- ▶ Interactively build grid over digitized maps. Rotate, stretch, move grid lines with mouse. Infill digitized layer maps to obtain grid cell values.
- ▶ Enter grid cell data directly or from digitized maps. Import digital maps from many other mapping programs.

Modify grid cell values with edit functions (add, multiply, constant). Enter complex formulae to compute grid cell values from other grid cell values with conditional statements. Enter values by layer or as constant for all cells. Synchronized 2D and 3D displays

- ▶ Corner Point Geometry Grid. Display shape of cells.
- ▶ Obtain cell values from well point values, then infill non-well cells.
- ▶ Group cells into regions for editing operations (e.g. facies)
- ▶ Colour cells with user selected palette. Obtain shaded contours of grid cell values. Superimpose digitized maps. Display xy, xz, yz cross-sections.



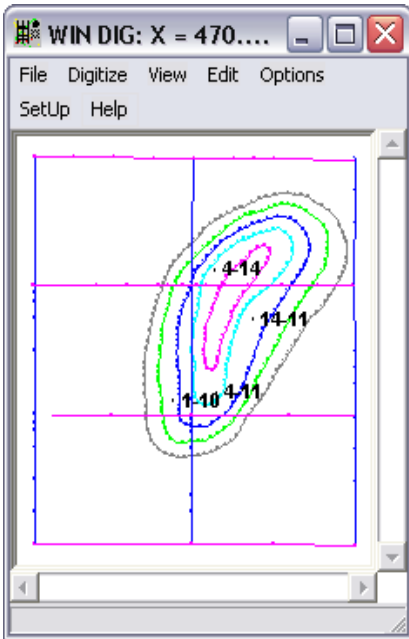
- ▶ Automatically compute and modify non-neighbour fault connections and pinch-out transmissibilities.
- ▶ Locally refine grid cells with a couple of mouse clicks.
- ▶ Automatically obtain total and partial well perforation locations from completion intervals, and well deviation surveys.
- ▶ Enter well production/injection data on a well by well basis (displayed all time data for a well or vice-versa).
- ▶ Import historical production values from commercial production history databases.
- ▶ Built in aquifer influence functions.
- ▶ Request simulator output at rate changes for DST modeling etc.
- ▶ Templates to build Dual porosity, Dual Permeability Models, Single Well Hydraulic Fracture Models,



Exodus Pre Processing Modules.....

WIN-DIG

- ▶ Digitize paper maps using a variety of digitizers, or digitize scanned bitmaps into the format for Exodus import.
- ▶ Transform digitized files from other mapping applications into the format for Exodus import.
- ▶ Interactively edit line contours or well points.



Historical Data Input

- ▶ Import Production History and Pressure History Data from external production history databases.
- ▶ Create User Defined History Data files for any time and any observation.
- ▶ Use Historical Data files for comparison against simulation results.
- ▶ Export production history to Preprocessor data file.

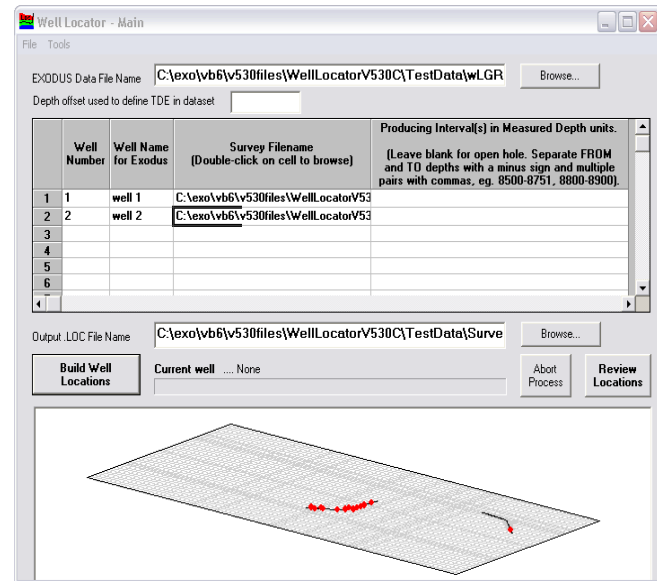
	Year	Month	Month Oil Prod m3	Month Gas Prod e3m3	Month Water Prod m3	Cum Oil m3	Cum Gas e3m3	Cum Water m3
1	1980	9	223.7	30.1	0	223.7	30.1	0
2	1980	10	185.6	16.8	0	409.3	46.9	0
3	1980	11	139.9	13.8	0	549.2	60.7	0
4	1980	12	161.6	19.7	0	710.8	80.4	0
5	1981	1	158.7	19.4	0	869.5	99.8	0
6	1981	2	178.2	18	0	1047.7	117.8	0
7	1981	3	157	15.6	0	1204.7	133.4	0
8	1981	4	106.3	8.7	0	1311	142.1	0
9	1981	5	153.7	15.8	0	1464.7	157.9	0
10	1981	6	147.8	15.3	0	1612.5	173.2	0

Well Deviation Survey to Well Locations

Identify well location cells from the trajectory of the well given the grid cell model and well coordinates or deviation survey.

The perforation fraction of the well locations will be computed using the open interval of the well and the length of wellbore in the cells.

Multiple wells can be batch processed.



Custom utilities to convert data files from other simulation software are available.

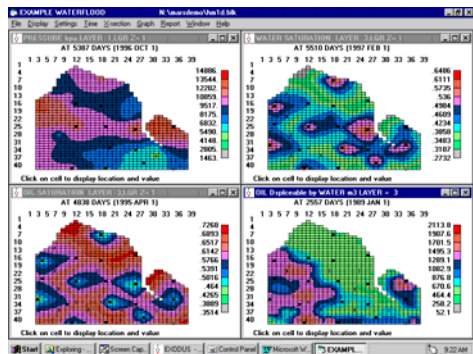
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Exodus Reservoir Simulator

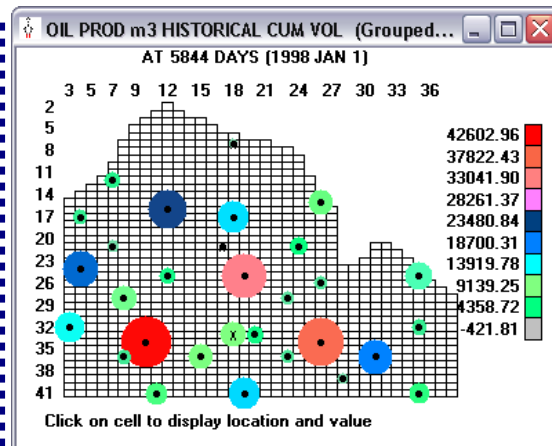
Post Processing Modules

Grid Display Utility



- ▶ During or after a run, display multiple windows of 2D colour maps of any grid cell values using automatic or user defined color palettes and value ranges.
- ▶ Show multiple cases, multiple views for different times/parameters and/or cross-sections (layers).
- ▶ Formulae to compute new display parameters for comparison of cases or difference in parameter values with time
- ▶ All these views can be manipulated, interrogated, printed or animated independently (user selectable time intervals) or synchronized.
- ▶ Display XY, XZ, YZ cross-sections. Define and show arbitrary cross-sections. Group layer values into single zone values for display.

- ▶ Simultaneously display a 3D view with 2D display. Interactively alter, rotate, zoom 3D view independently or synchronize animation with 2D view.
- ▶ Zoom/ Unzoom/ Pan option.
- ▶ Shaded contours of cell values.
- ▶ Display locally refined grid cell values. Cross-sections of locally refined cells.
- ▶ Display well locations and well names as a function of time.
- ▶ Superimpose digitized maps over computed grid cell values.
- ▶ Cell value enquiry, text values displayed in cells in selected font. Export all values to spreadsheet.
- ▶ Initial values of Porosity, Permeability, Depth, Thickness, Pore volumes.
- ▶ Time dependent values of pressure; oil, gas and water saturations; ternary phase saturations; volumes of fluids-in-place; displaceable volumes of oil.
- ▶ Define arbitrary regions before, or after, a run and display oil-in-place, average pressure, production rates and cumulatives, migration and percent recovery.



- ▶ Bubble maps for historical data or calculated discrepancies. Animate bubble maps with time.
- ▶ Graph cross-section values or cell values with time.
- ▶ Display well charts simultaneously of selected wells with 2D views.
- ▶ Display detailed migration statistics for user defined regions built either before or after the run. Interactively select reporting regions.
- ▶ Debugging aids to assist in identifying regions with convergence problems and to show where changes are needed in subsequent history matching runs.

Well Report Utility

- ▶ Customize well summary reports from simulation runs.
- ▶ Choose from over 40 report parameters.
- ▶ User defined units for any report parameter.
- ▶ Create and save user defined tabular format.
- ▶ Interactively define groups of wells and well fraction
- ▶ Report by well/group/field for all times and parameters.
- ▶ Report at any time for any or all wells and parameters (by completion cell if desired).
- ▶ Report for selected parameters, all wells/groups and all times.
- ▶ Report at any time for any or all wells and parameters (by completion cell if desired).

- ▶ Immediately graph current report. User definable placement of series on axes.
- ▶ Summaries for groups of wells, and field. Print or copy and paste report to a spreadsheet or word processor.

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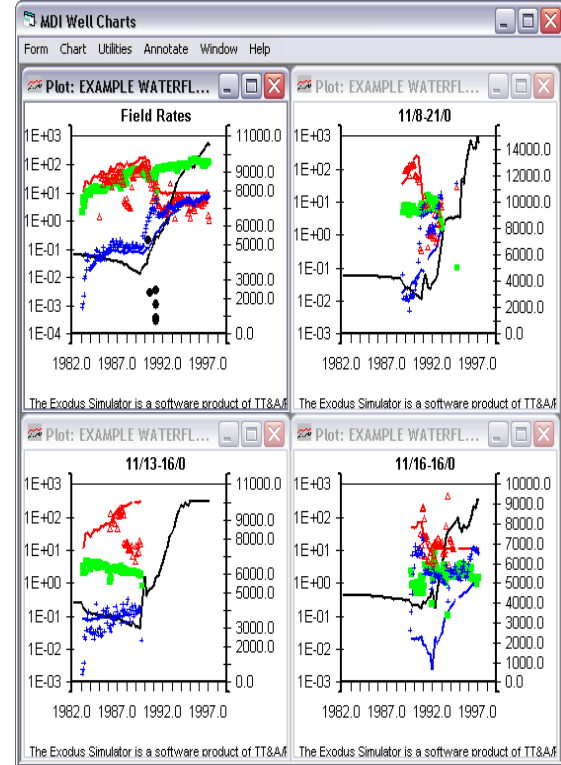
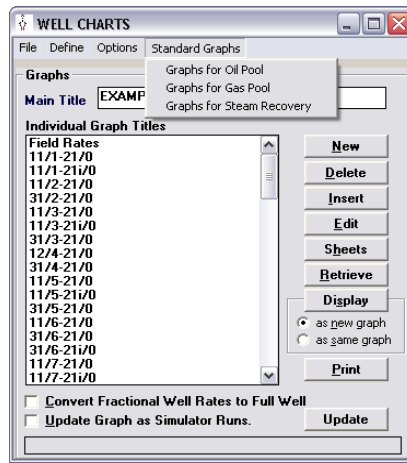
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Exodus Post Processing Modules.....

Well Charts

- ▶ Produces graphs of well performance from simulation cases, production history data and pressure history. Automatic update as simulator executes in background.
- ▶ Quickly generate graphs from standard default graph types.
- ▶ Select from over 40 series options such as rates, ratios, cumulatives, well pressures, % recoveries etc.
- ▶ User defined units for any series.
- ▶ Compare simulated with historical values. Compare many wells on the same graph. Compare several runs on one graph. Group wells to create a graph series.
- ▶ Plot any series on X, left Y and right Y axes with appropriate scaling. Plot as many as 30 series on a graph.

- ▶ Annotate, change fonts, log or linear scales, automatic or custom linestyles and colours, tick marks, grid lines.
- ▶ Use the template facility to build graphs for all wells from one well graph.
- ▶ Multiple child windows of chart displays.



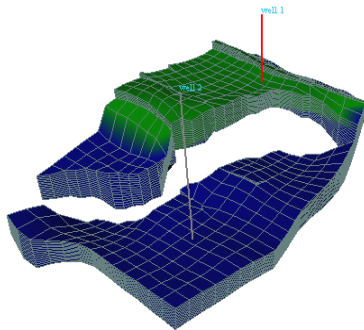
Network Report Utility

- ▶ At each output, report on selected offtake points, nodes and segments.
- ▶ Report on selected offtakes at selected times, the offtake pressure, rate and cumulative.
- ▶ Report on selected nodes at selected times, the node pressure and node flux.
- ▶ Report on selected segments at selected times, the segment pressures and rates, compressor horsepower.
- ▶ Display a graphical view of the network system, coloured by node pressures or segment rate at any time and animate.

Pre Tax Economics

Compare DCF of several production scenarios with different capital, price and operating costs.

3 Dimensional Visualization



- ▶ Display 3-D views of the reservoir for parameters (e.g. porosity, permeability) and time dependent values of pressure, fluid saturations, fluid volumes in place.
- ▶ Pan, rotate, zoom the 3-D views. Show multiple cross-sections and isosurfaces. Interrogate cell values.
- ▶ Clip layers, rows and columns.
- ▶ "See" your reservoir produce. Start, stop and resume animation of all the views. Show well locations as they are drilled. Make cells visible only if they are in a specified data range and animate with time. Useful for water coning, front tracking, tracer animation etc.
- ▶ Alter the 3-D view by cutouts, shifting, spreading out or separating layers or cross-sections. Apply clipping or change the visible range of layers or cross-sections.
- ▶ Print or export image to bitmap files for import to other graphical programs.