

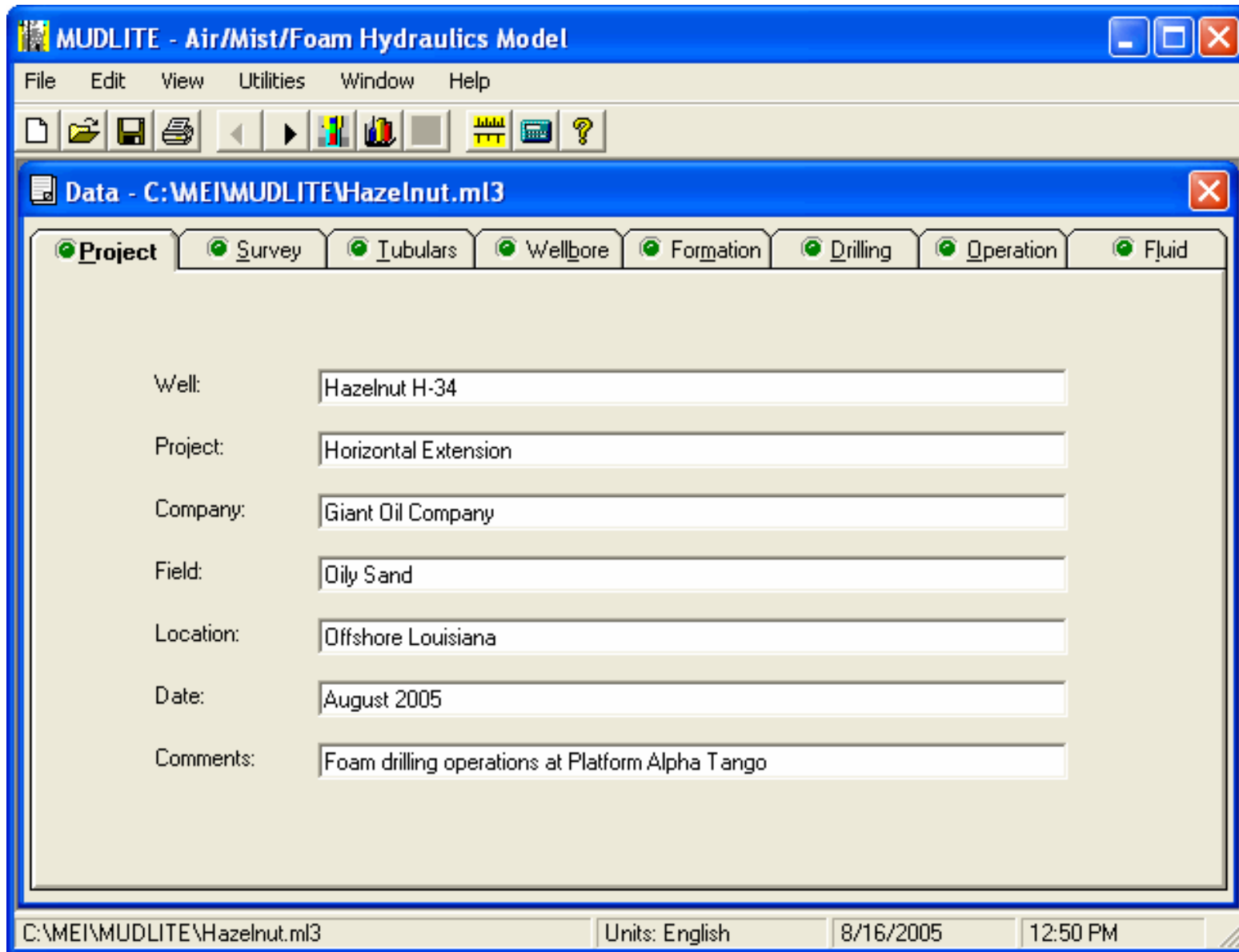
MUDLITE – Air/Mist/Foam Hydraulics Model

is a world-class engineering tool for planning and analyzing air/mist/foam and flow-drilling underbalanced drilling and completion operations.

Features of this powerful underbalanced hydraulics package include:

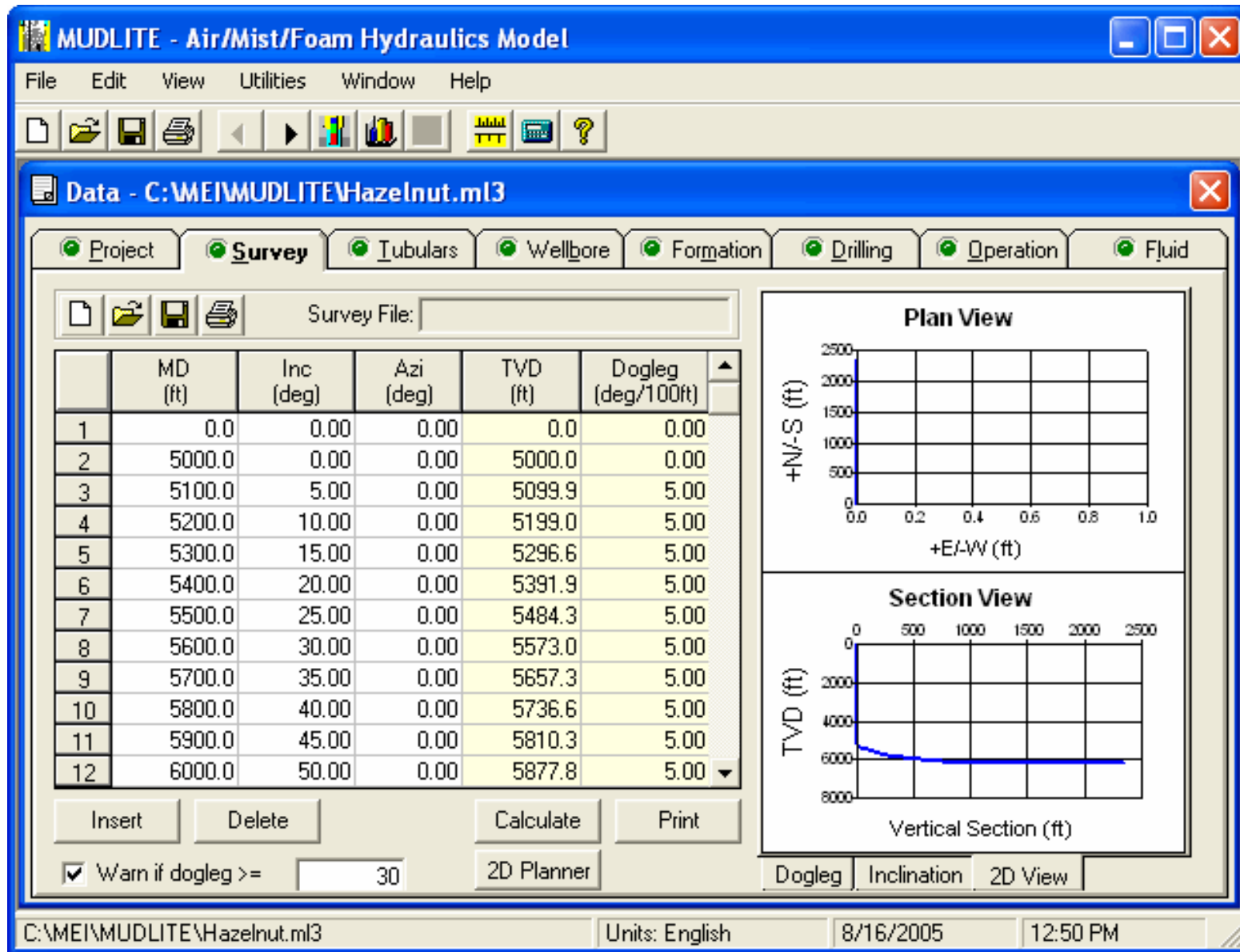
- calculates velocity, pressure and density profiles
- models coiled-tubing operations
- handles 3D wellbores
- considers fluid influxes and parasite strings
- designs jet subs for optimized flow rates
- includes pressure-matching window for calibrating input parameters with field data

NOTE: Computer screens within this PDF document may appear slightly distorted. This is due to limitations in the Adobe Acrobat Viewer when displaying graphics. To clearly view details in the graphics, zoom in or print the document.



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Input data are easily entered on eight pages. The first input page (**Project**) includes basic project information/documentation. This information is shown on printouts.



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The **Survey** page is for entering the wellbore survey that describes the well trajectory. Data (up to 600 survey points) may be entered manually or copied from a spreadsheet.

2D Well Planner

2D Plan

Build/Build
 Build/Drop
 Build/Hold

Target

TVD/NS/EW
 TVD/Horizontal Distance/Azi

TVD (ft):
 N/S (ft):
 E/W (ft):

Planning

	Unknowns (Select 2)	Value
Inc1 (deg)	<input type="checkbox"/>	5
L1 (KOP) (ft)	<input checked="" type="checkbox"/>	
BR1 (deg/100ft)	<input checked="" type="checkbox"/>	
Inc2 (deg)	<input type="checkbox"/>	60
L2 (ft)	<input type="checkbox"/>	650
BR2 (deg/100ft)	<input type="checkbox"/>	10
Inc3 (deg)	<input type="checkbox"/>	90
L3 (ft)	<input type="checkbox"/>	500

Survey Interval

Straight Section (ft):
 Curve Section (ft):

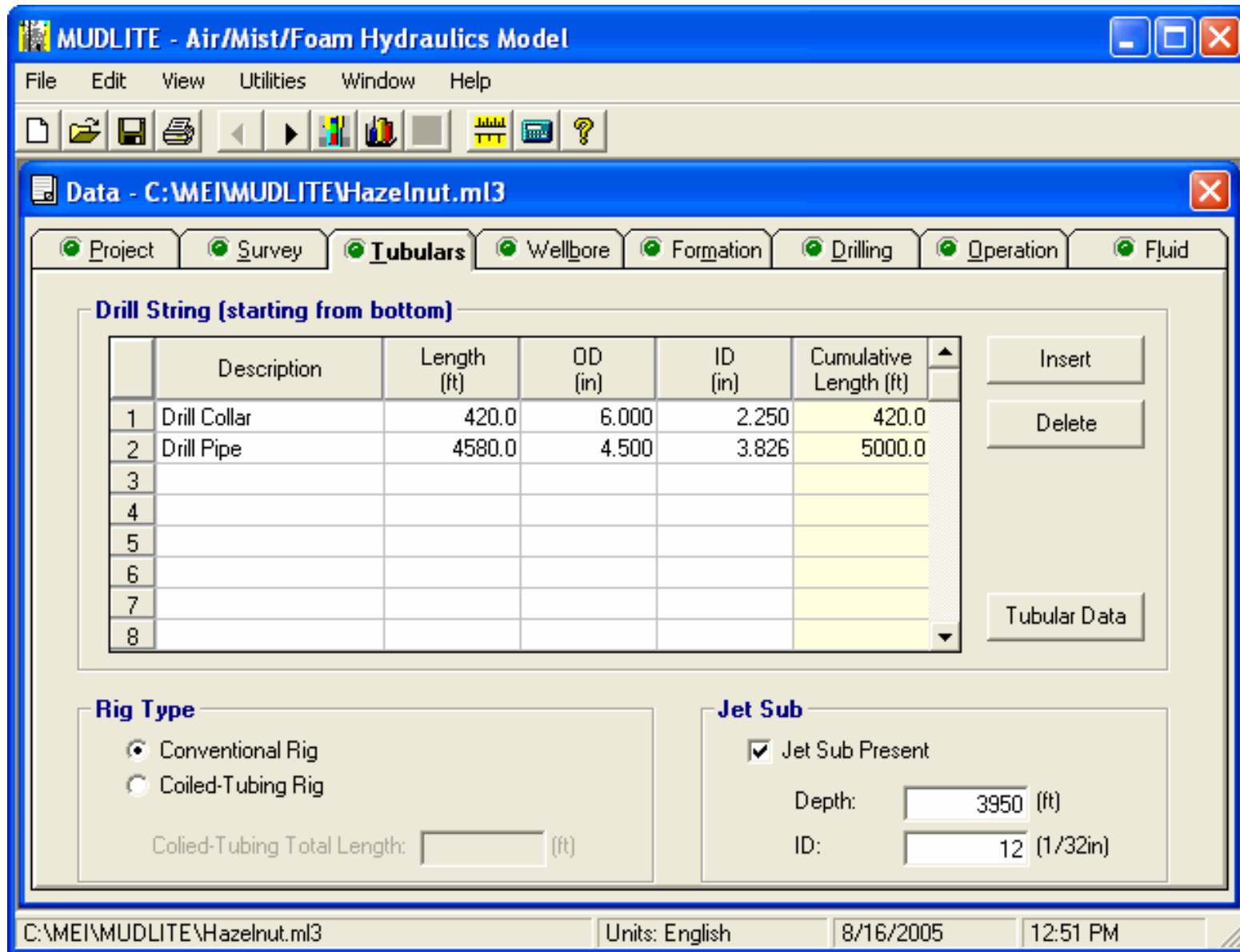
	MD (ft)	Inc (deg)	Azi (deg)	TVD (ft)	N/S (ft)	E/W (ft)	Build Rate (deg/100ft)	Section Length (ft)
1	0.00	5.00	4.29	0.0	0.0	0.0	n/a	n/a
2	893.9	5.00	4.29	890.5	77.7	5.8	0.00	893.9
3	2012.7	60.00	4.29	1798.2	654.4	49.1	4.92	1118.8
4	2662.7	60.00	4.29	2123.2	1215.7	91.2	0.00	650.0
5	2962.7	90.00	4.29	2200.0	2193.8	164.5	10.00	300.0
6	3462.7	90.00	4.29	2200.0	2000.0	150.0	0.00	500.0

Calculate

Accept

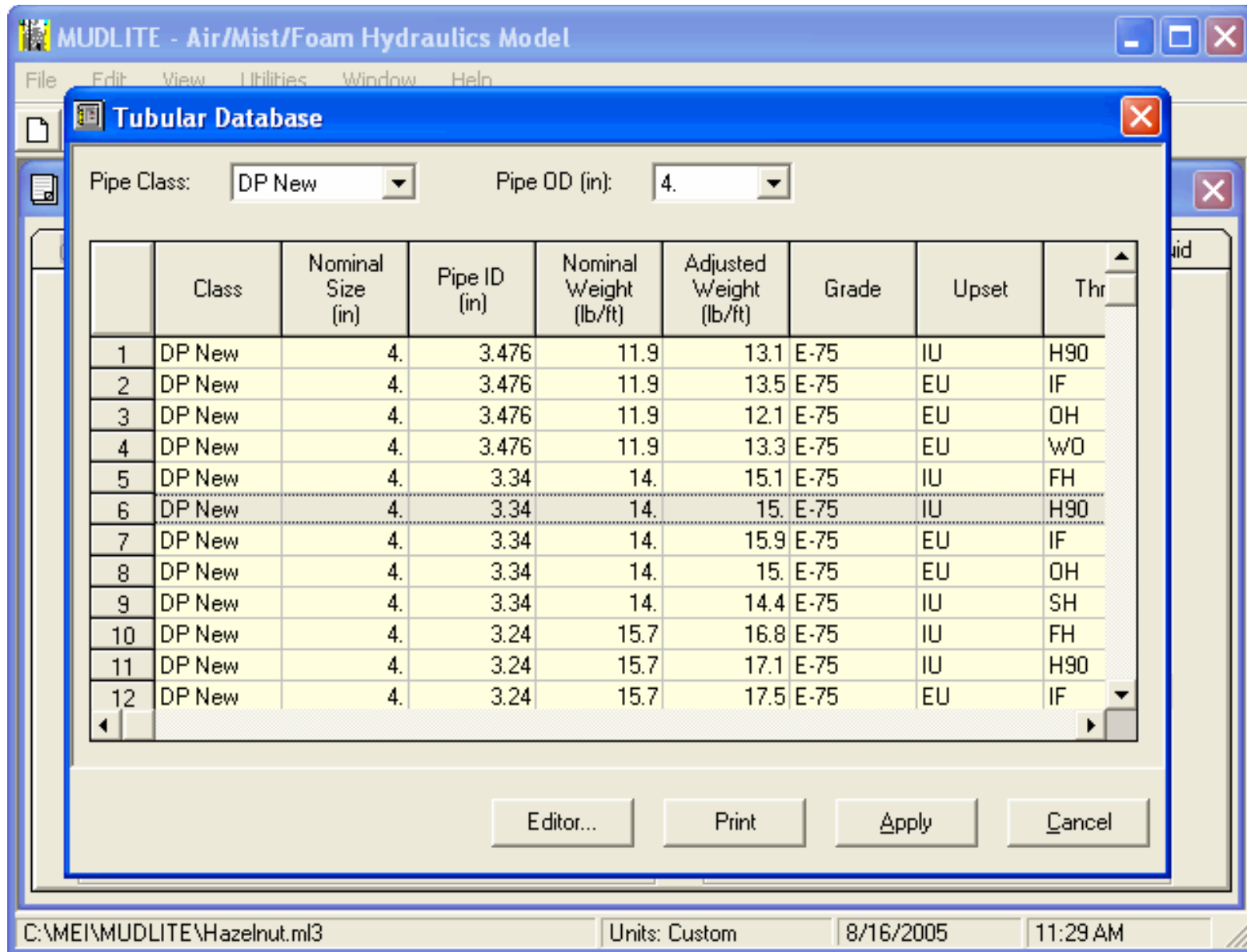
Cancel

Don't have a survey? The **2D Well Planner** utility allows you to quickly create simple or complicated well surveys. Choose the basic well shape and enter starting values for the primary geometric parameters.



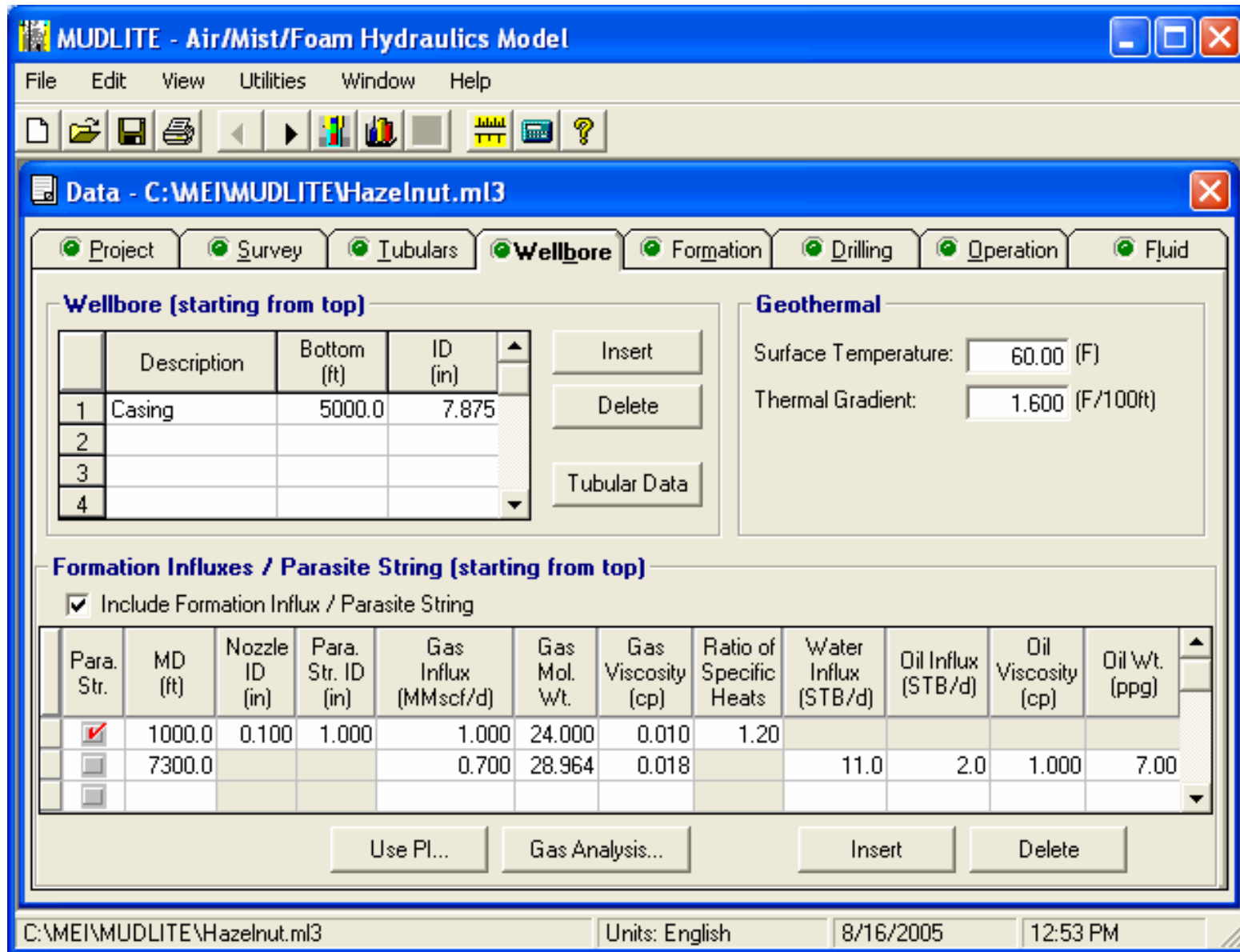
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Drillstring components are specified on the **Tubulars** page. The drillstring may be divided into as many as 20 components. For coiled-tubing rigs, pressure drops in the reel are taken into account.



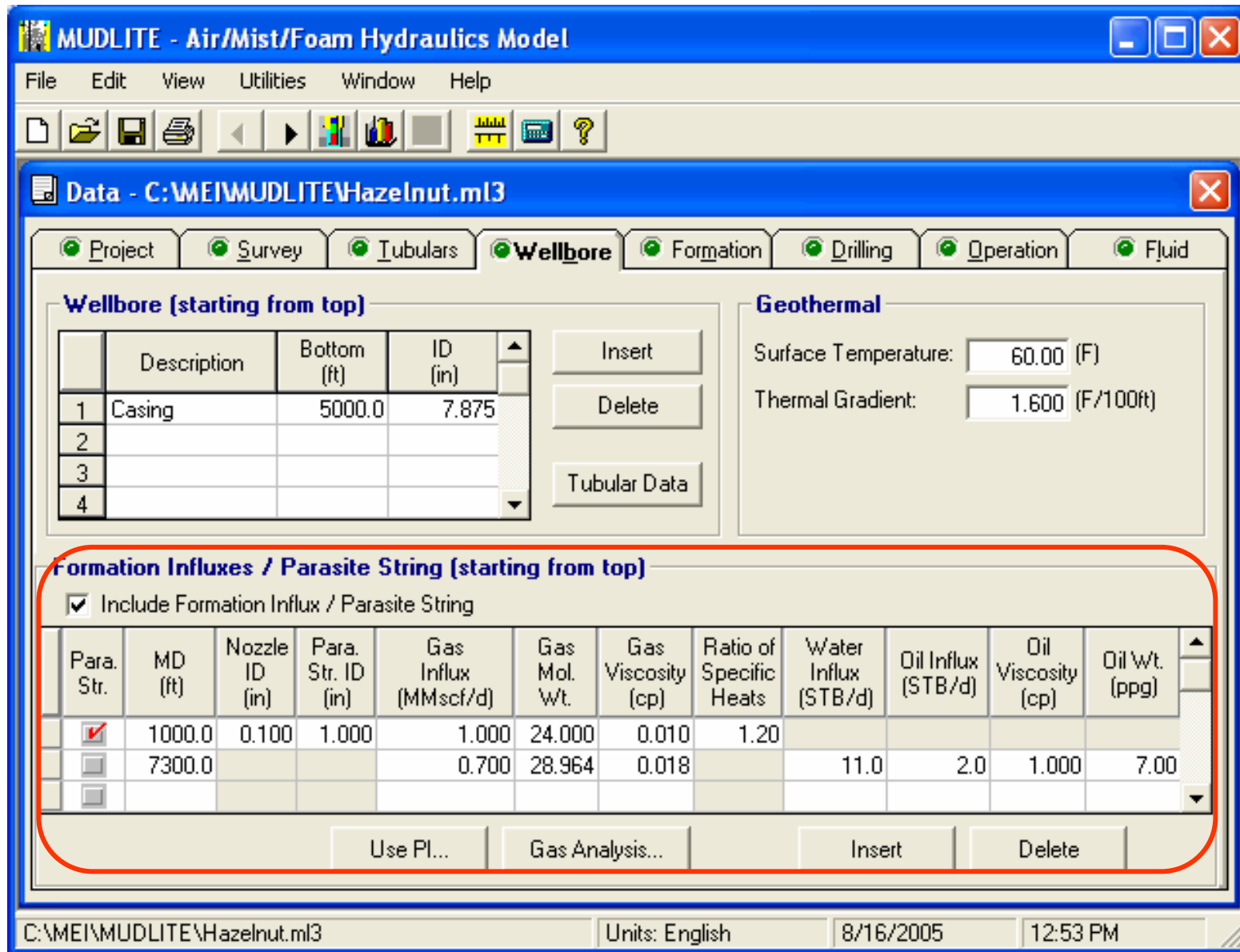
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All Maurer programs include an extensive tubular database that may be edited/customized. This convenient feature avoids the need to look up drillstring or casing size, weight, ID, etc. each time new data are entered.



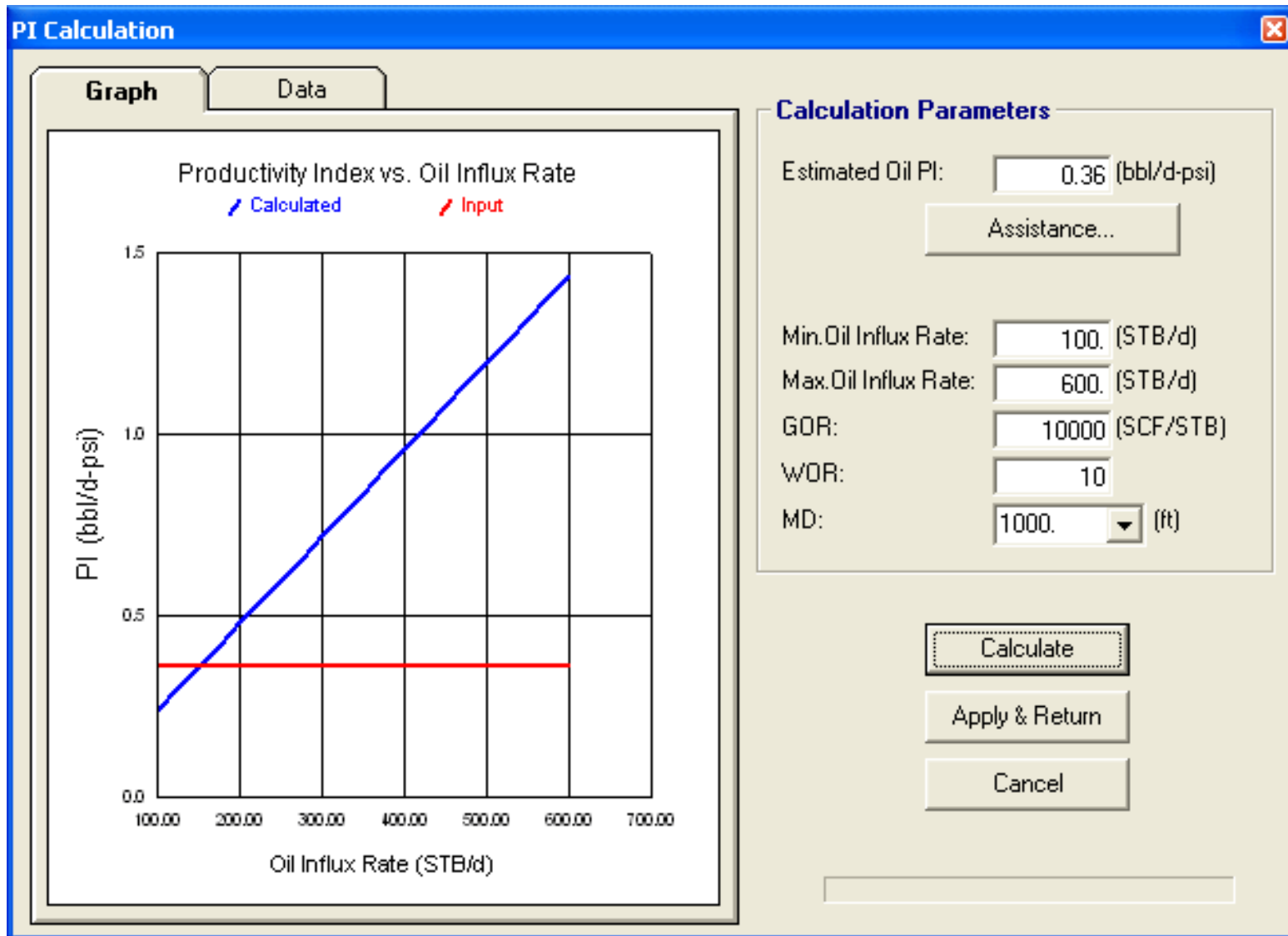
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Wellbore geometry is entered on the **Wellbore** page. Temperature profile is specified to account for the impact of temperature on hydraulics.



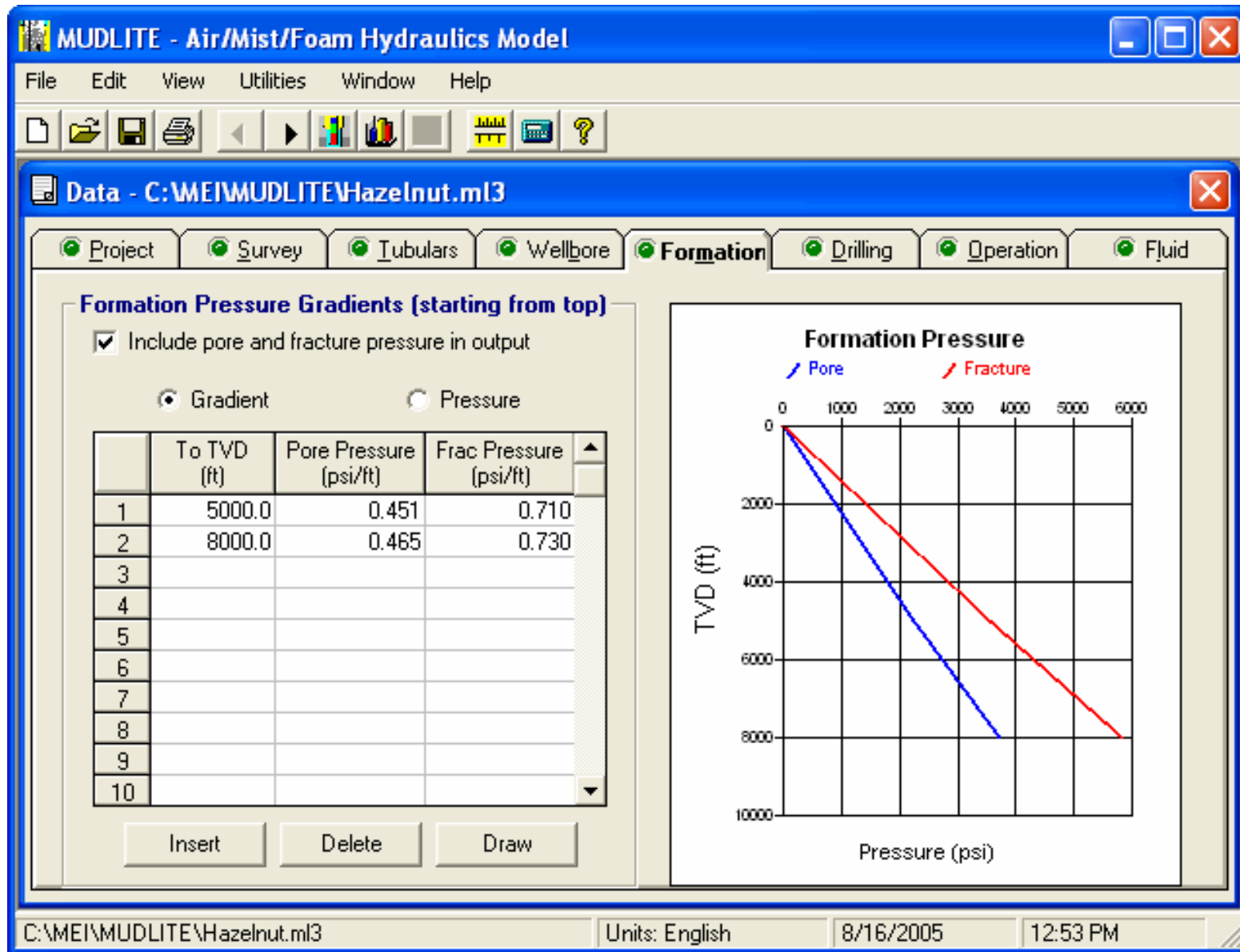
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Fluid influxes from the formation can also be modeled, with up to six influx points. This function is also used for parasite strings, a common method to inject gas downhole to lighten the hydrostatic head on the formation.



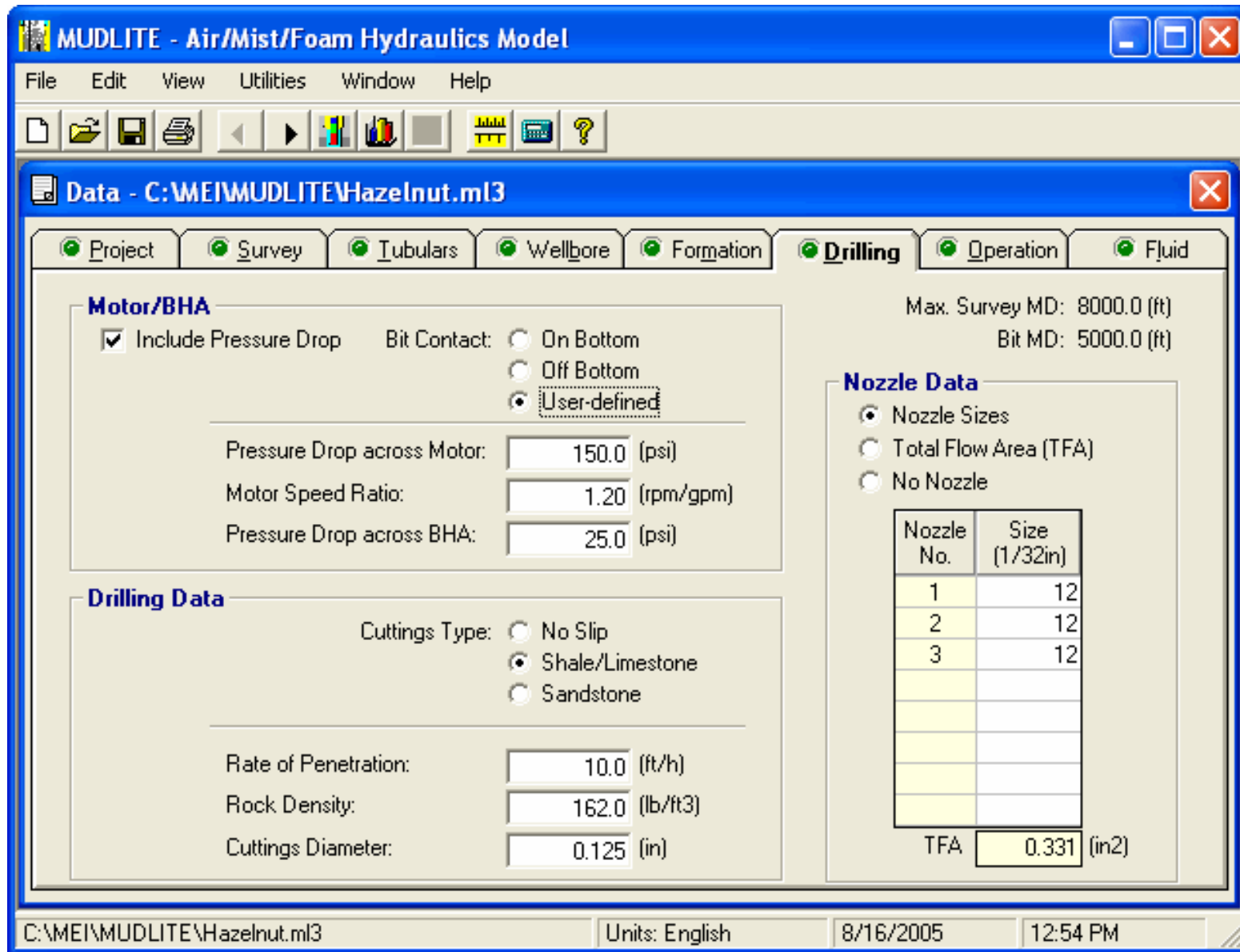
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A special utility helps estimate influx rates from the formation. Enter PI (productivity index) if known. If unknown, access the PI Calculation utility. After calculation, estimated values for gas influx rate, water influx rate, and oil influx rate are automatically copied into the Formation Influxes table.



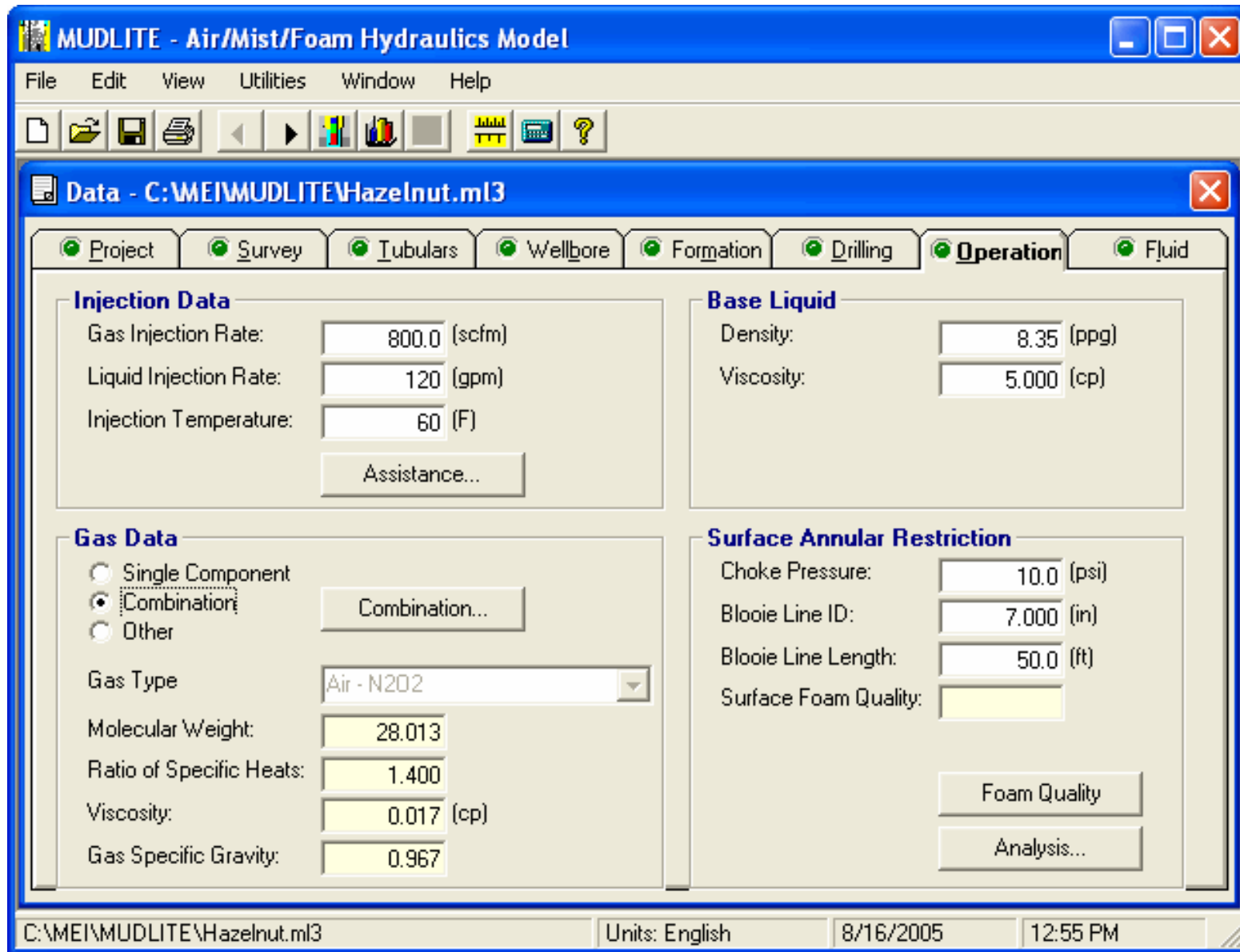
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The **Formation** page lists pore and fracture pressures for each formation. These gradients will be shown along with fluid pressures in the Pressure Profile graph in the output window.



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Drilling parameters are entered on the **Drilling** page. These include drilling ROP, cuttings size, and bit nozzle size.



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Hydraulics data are input on the **Operation** page. These include gas/liquid injection rates, gas/liquid properties, and choke pressure. Convenient utilities (shown on next three slides) help you estimate these parameters.

Fluid Velocity Required for Hole Cleaning

Calculation Parameters		Circulating Medium	
Gas Name:	Air	<input type="radio"/> Normal Mud	?
Gas Molecular Wt.:	28.964	<input type="radio"/> Aerated Mud	?
Surface Temperature:	60. (F)	<input type="radio"/> Foam	?
Geothermal Gradient:	1.6 (F/100ft)	<input checked="" type="radio"/> Mist	?
Rate of Penetration:	10. (ft/h)	<input type="radio"/> Air	?
Choke Pressure:	10. (psi)	Estimated Liquid Rate:	10. (gpm)
Rock Density:	161.7 (lb/ft3)	Air Speed...	
Recommended Value(s)		Calculate	
Gas Injection Rate:	1708.32 (scfm)	Apply & Return	
Liquid Injection Rate:	10. (gpm)	Cancel	

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Click [Assistance...] for help with fluid design. This opens the **Fluid Velocity Required for Hole Cleaning** window. This allows you to quickly estimate gas and/or liquid injection rates that will keep the hole clean.

Hydrocarbon Analysis

Select Component(s)

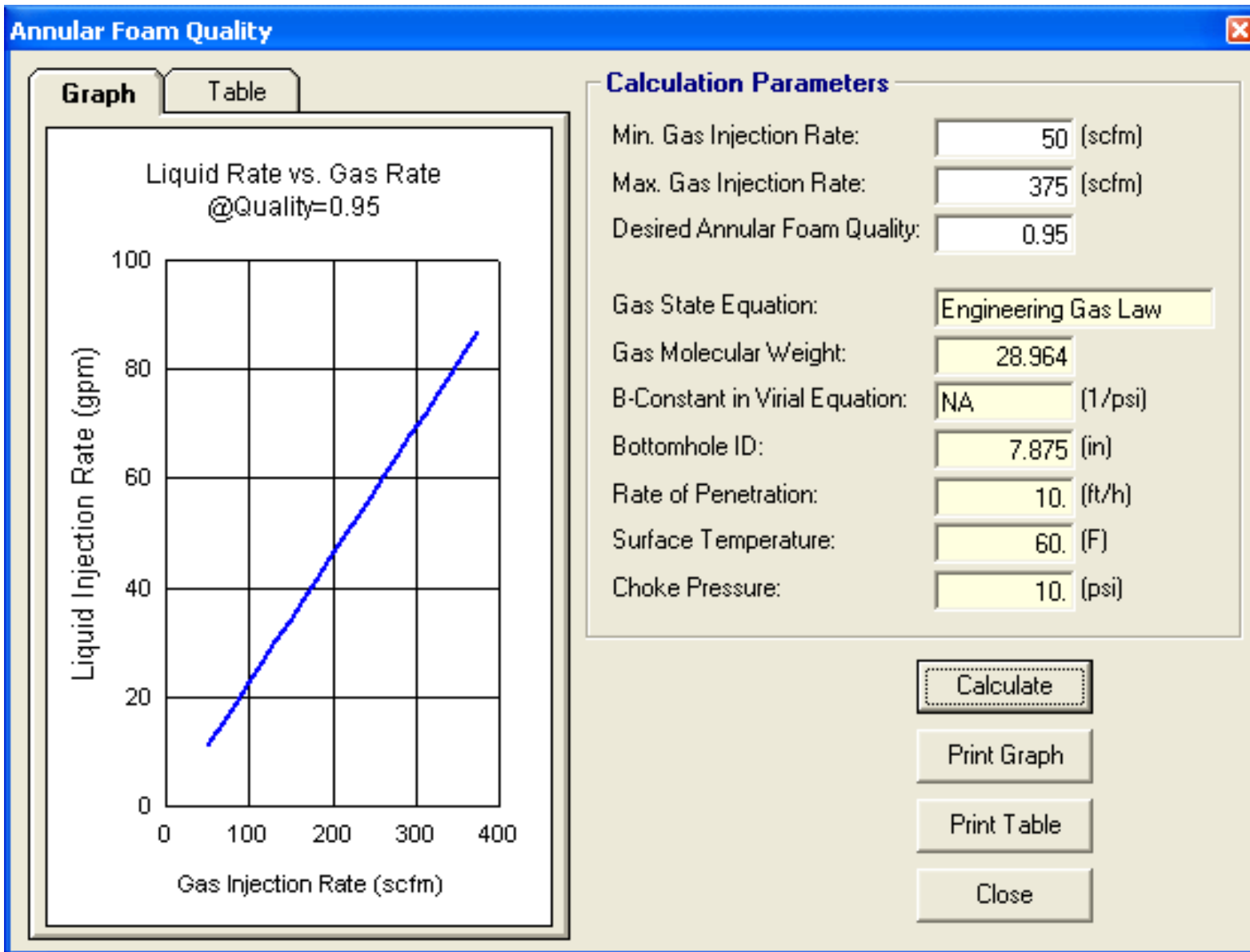
Ethyl Alcohol	C2H6O
Carbon Monoxide	CO
Carbon Dioxide	CO2
Hydrogen Sulfide	H2S
Sulfur Dioxide	SO2
Ammonia	NH3
Air	N2O2
Hydrogen	H2
Oxygen	O2
Nitrogen	N2

Apply & Return
Cancel
Clear All
Remove

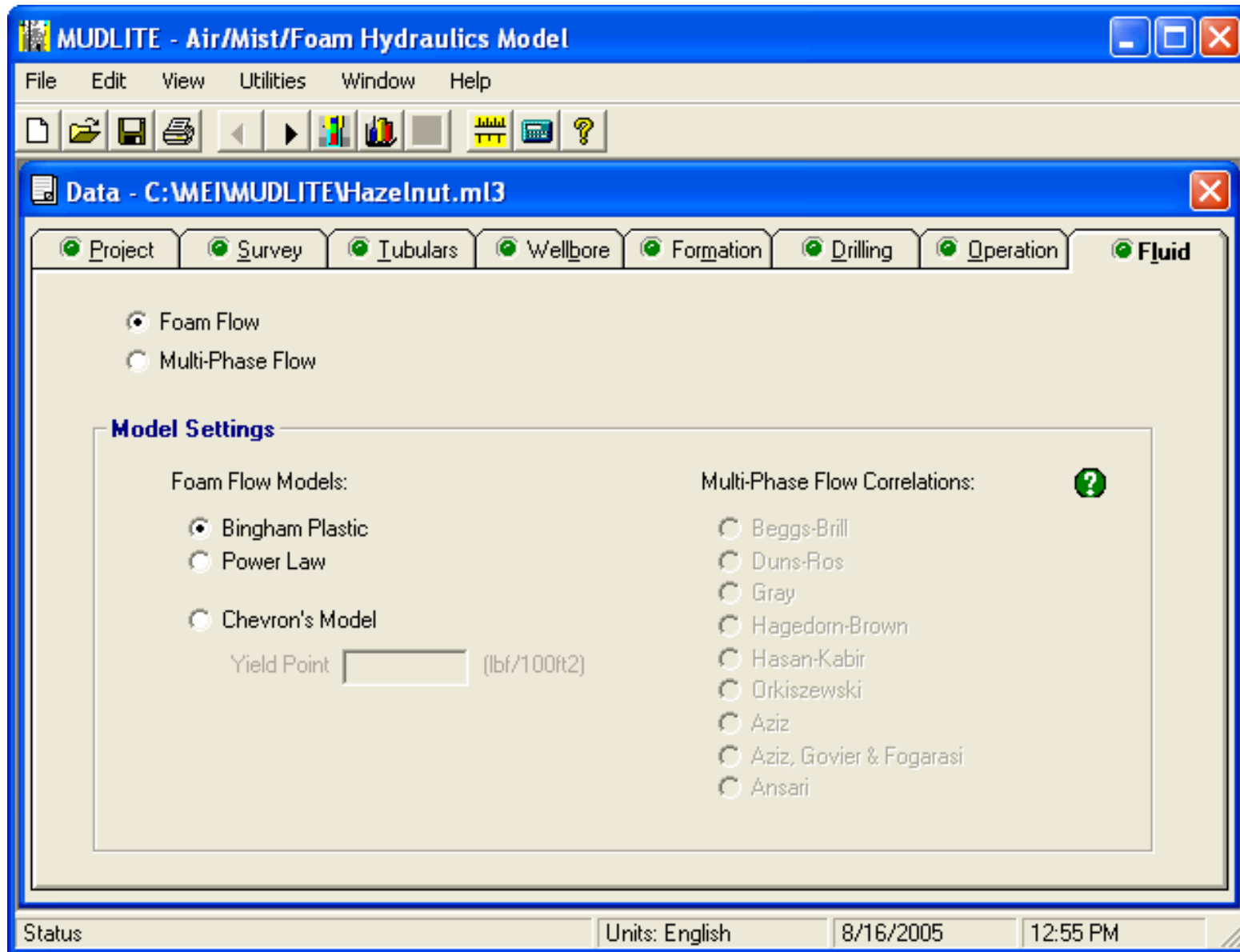
#	Component Name	Formula	Molecular Weight	Ratio of Specific Heats	Viscosity (cp)	Critical Pressure (psi)	Critical Temp. (R)	Gas Specific Gravity	Mole Percent (%)
1	Methane	CH4	16.043	1.307	0.0107	668.	343.32	0.554	5
2	Hydrogen Sulfide	H2S	34.076	1.324	0.0086	1306.	672.60	1.176	12
3	Air	N2O2	28.964	1.400	0.0091	547.	238.60	1.000	83
4									
5									
6									
7									
8									
9									
10									
Bobaloo gas			28.931	1.386	0.00912	644.	295.92	0.999	100.00
Type in Name (optional)			Mixture Properties				Total (%)		

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Click [Combination...] to access the **Gas Combination** utility for determining the composite properties of combinations of gases. Data for several common gases are included.

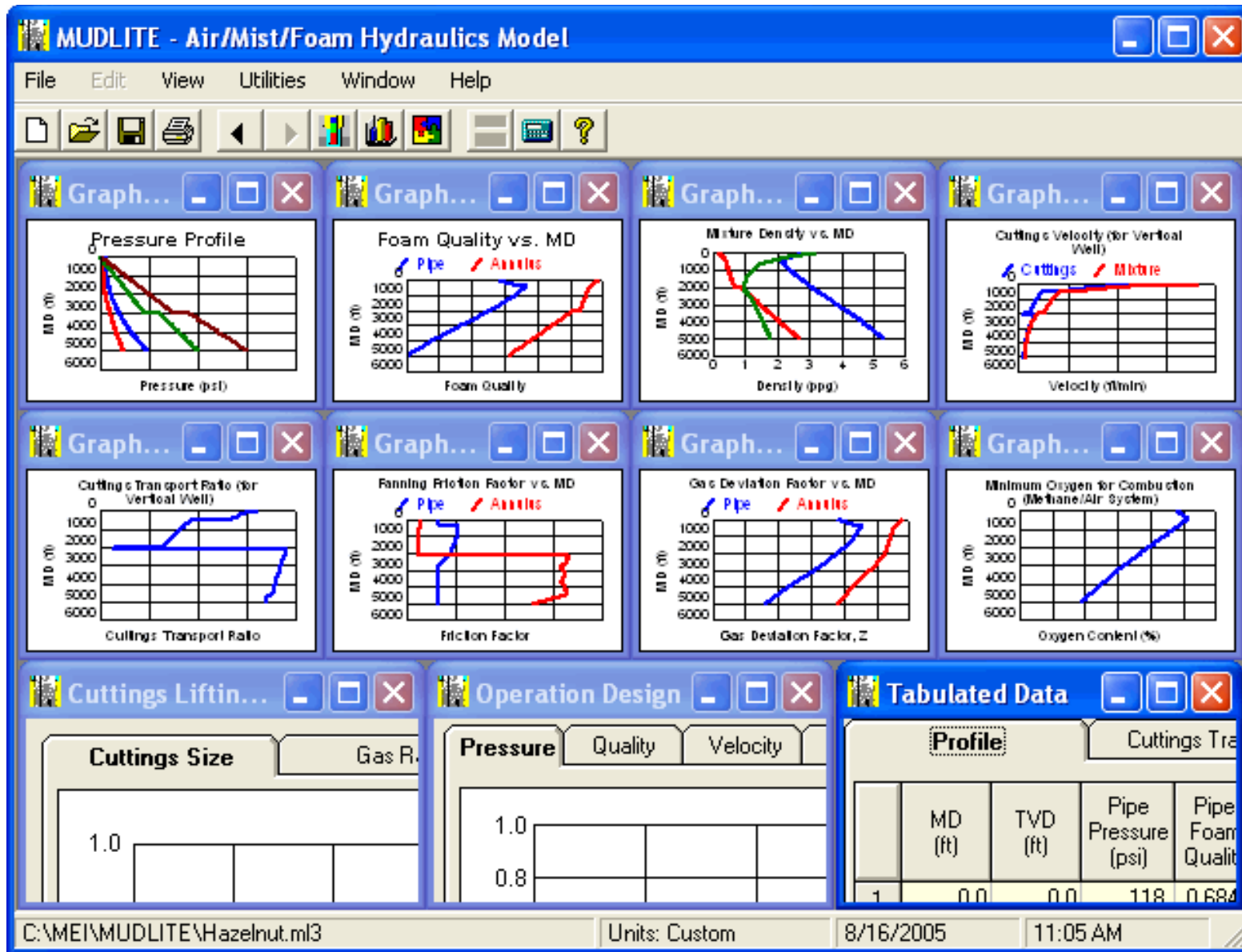


If you need help calculating foam quality at the surface, click [Analysis...] to open the **Annular Foam Quality** window. Gas injection rates will be paired with corresponding liquid injection rates that will achieve the foam quality you specify.



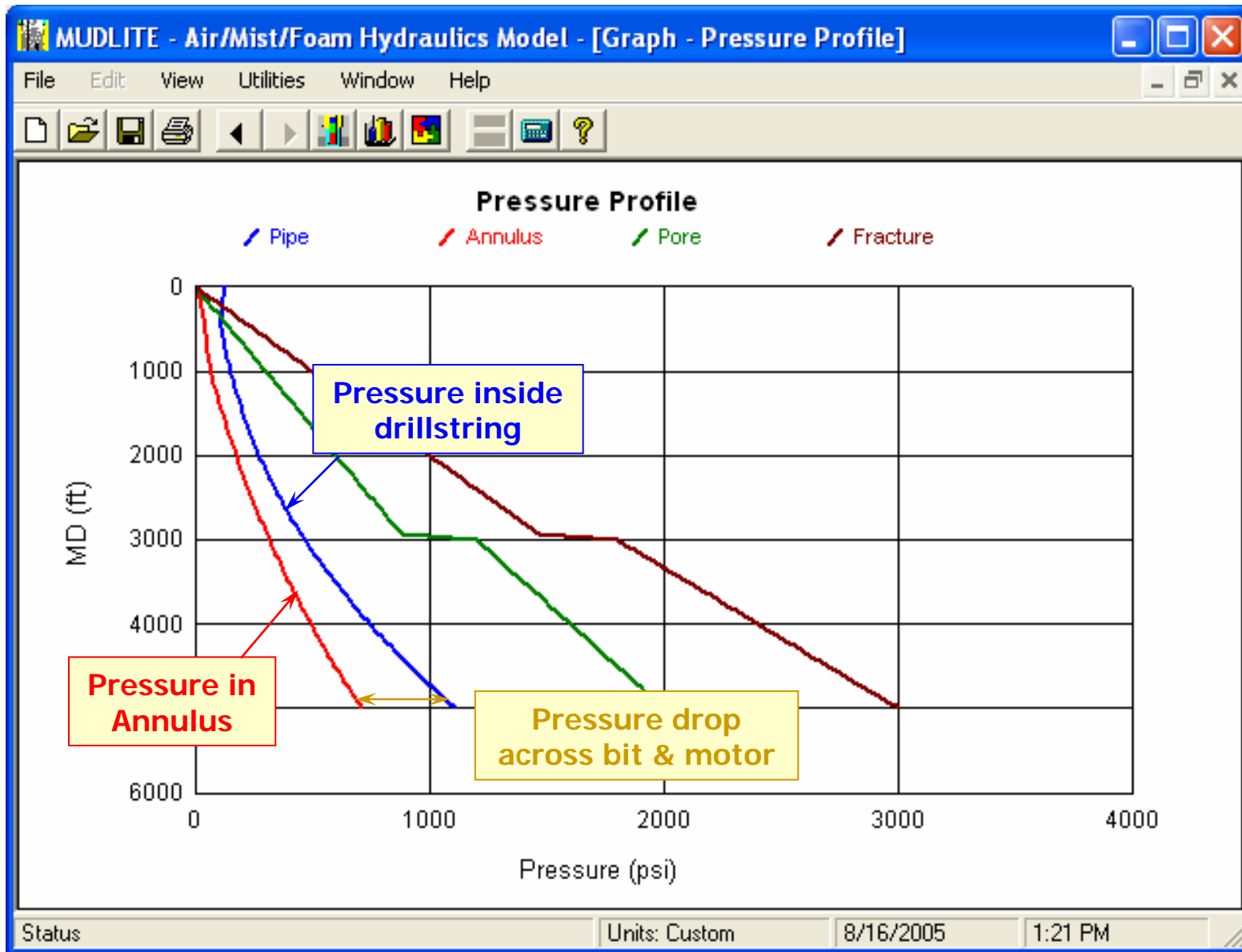
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On the **Fluid** page, select “Foam” for foamed fluids or “Multiphase Flow” for aerated fluids or mists. For multiphase fluids, several multiphase flow correlations are available for predicting tubing/annulus pressure drops.



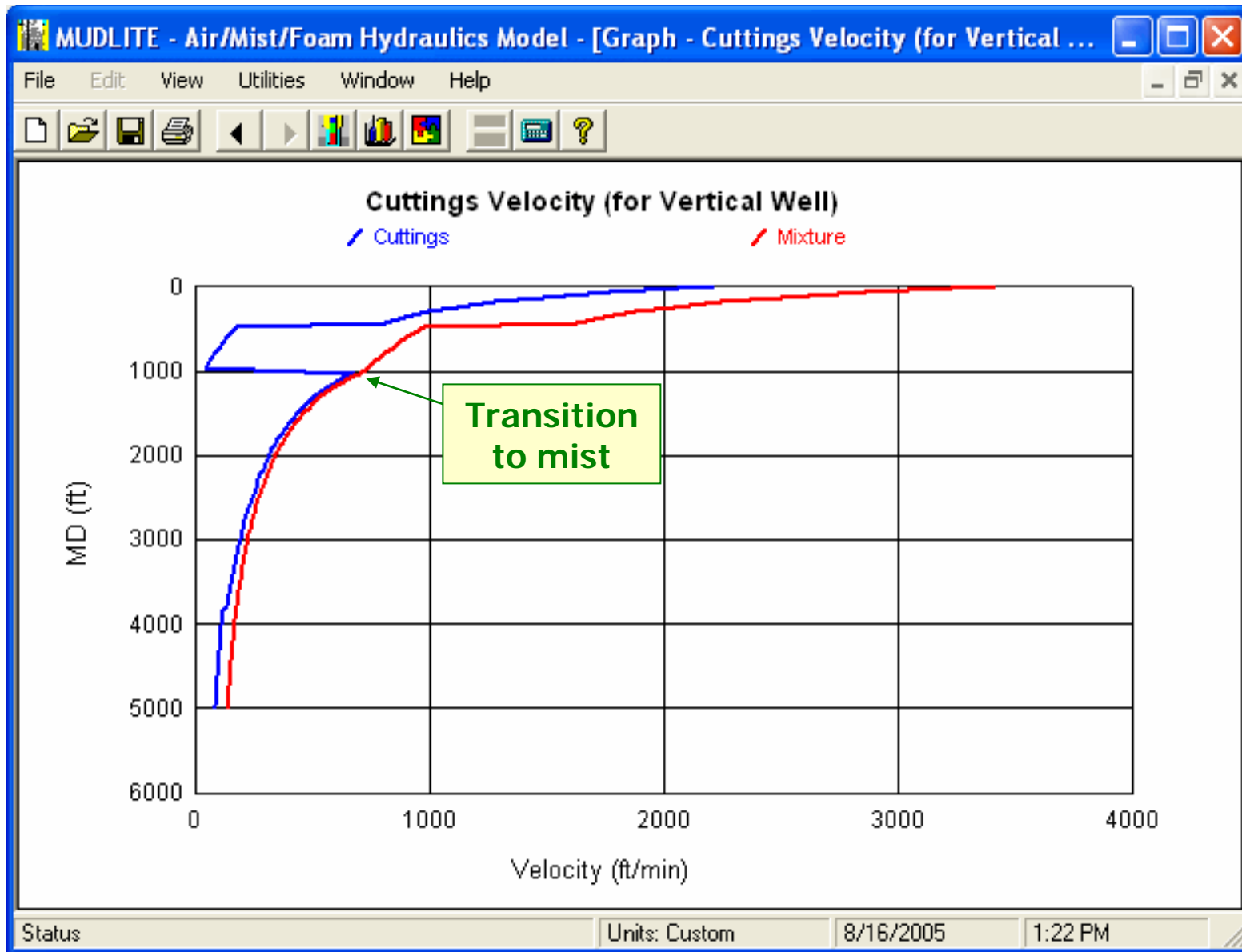
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After all required input data are input, you can immediately calculate and view the results. A variety of output types and formats are available for review and comparison in the main Output window. Each is designed to help you solve problems in your UB operations.



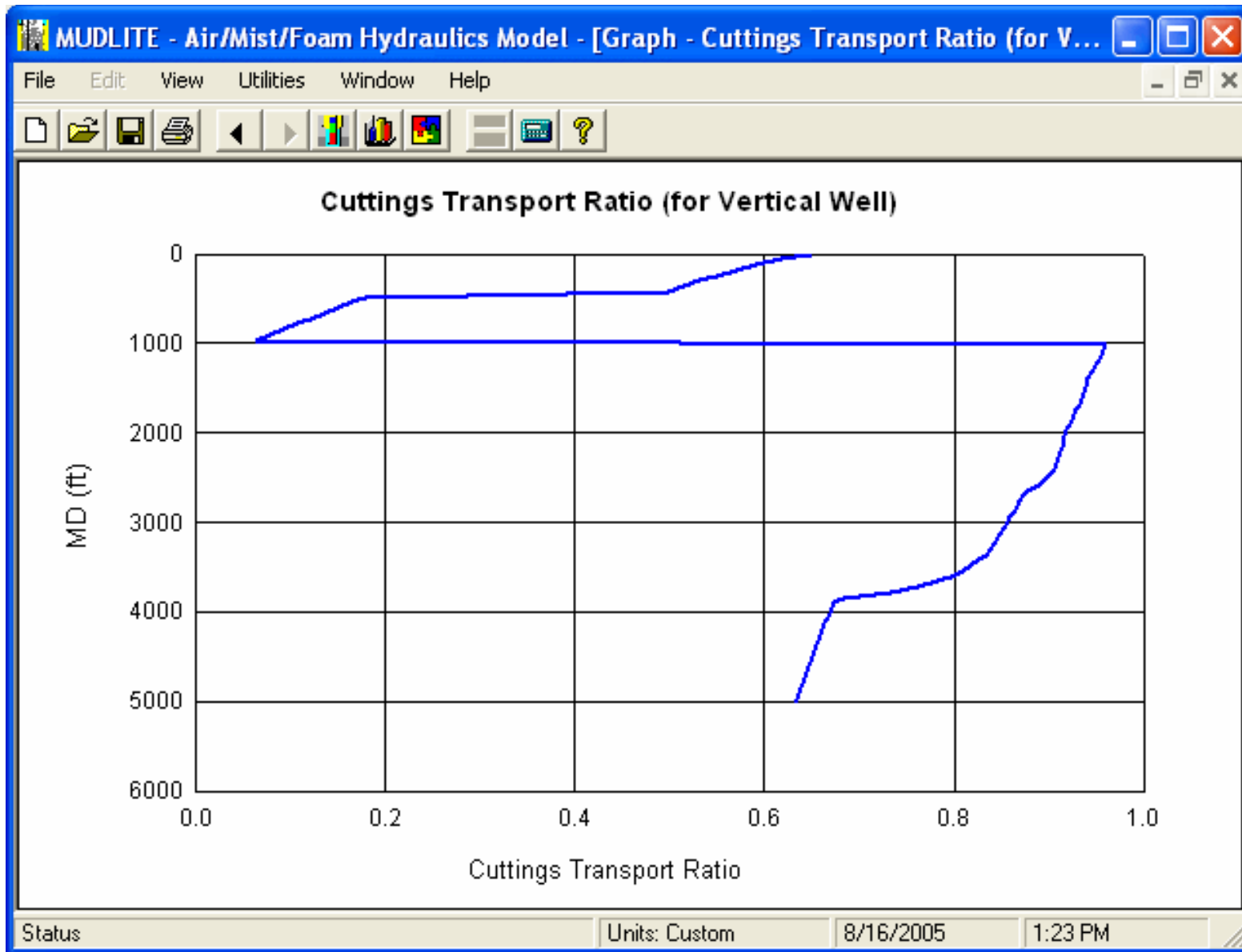
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The **Pressure Profile** graph summarizes pressures throughout the flow path. Note how the annular pressure profile changes for this example case at about 1200 ft MD as the foam transitions to a mist.



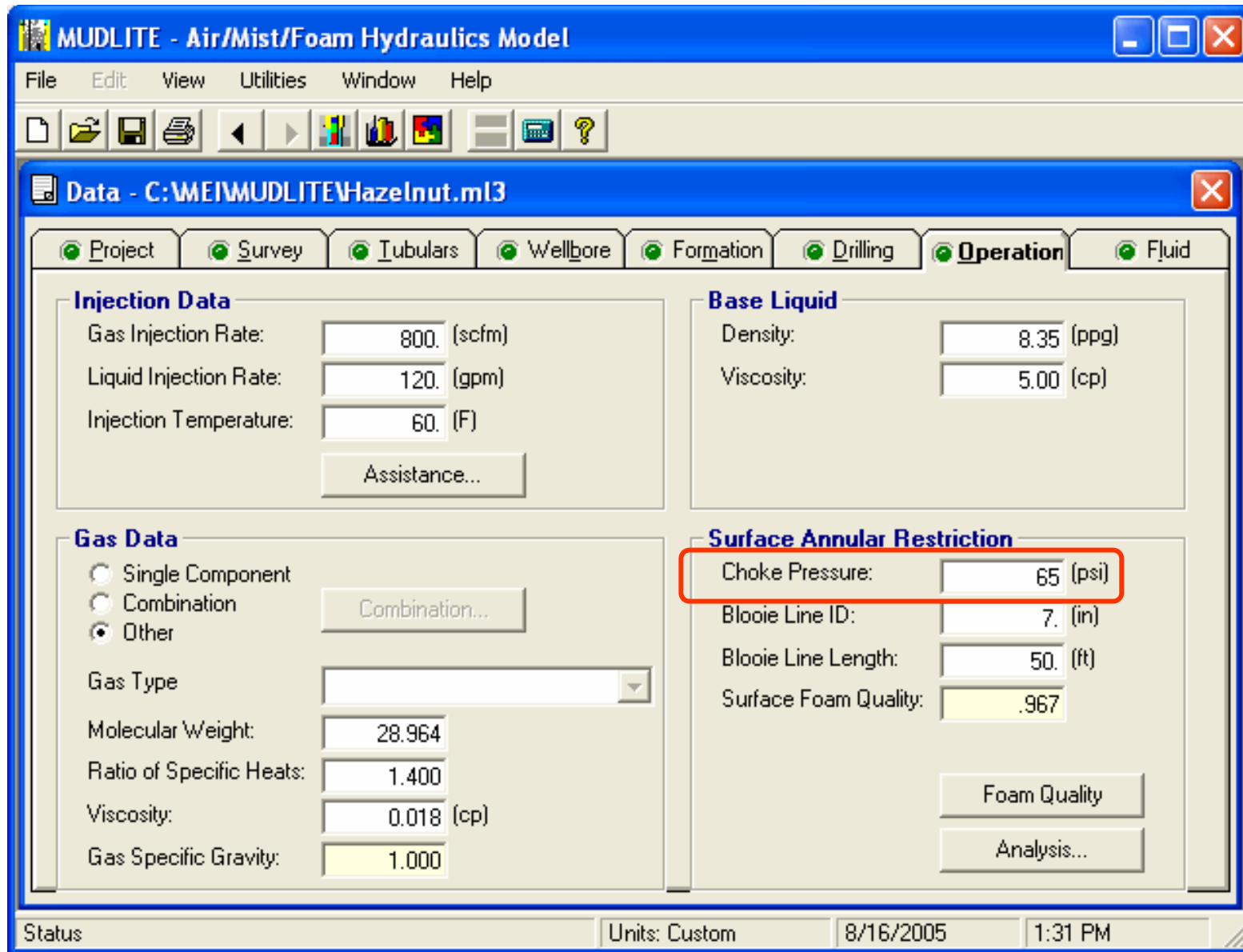
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Cuttings velocity varies along the flow path due to changing hydraulic conditions and geometry. Cuttings velocity drops dramatically at the foam/mist transition. This signals a potential problem.



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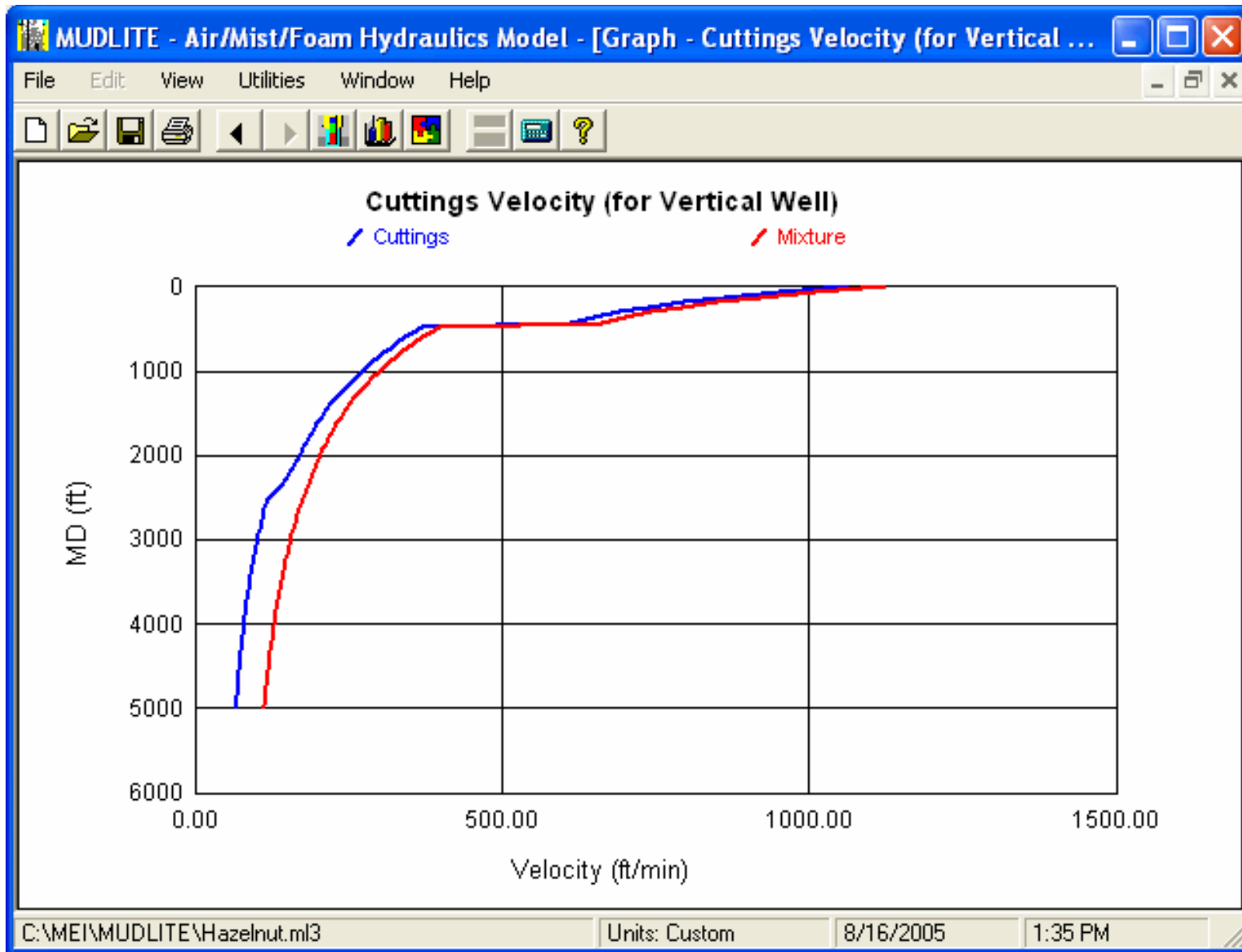
This hole-cleaning problem at the foam/mist transition is also well illustrated in the **Cuttings Transport Ratio** graph.



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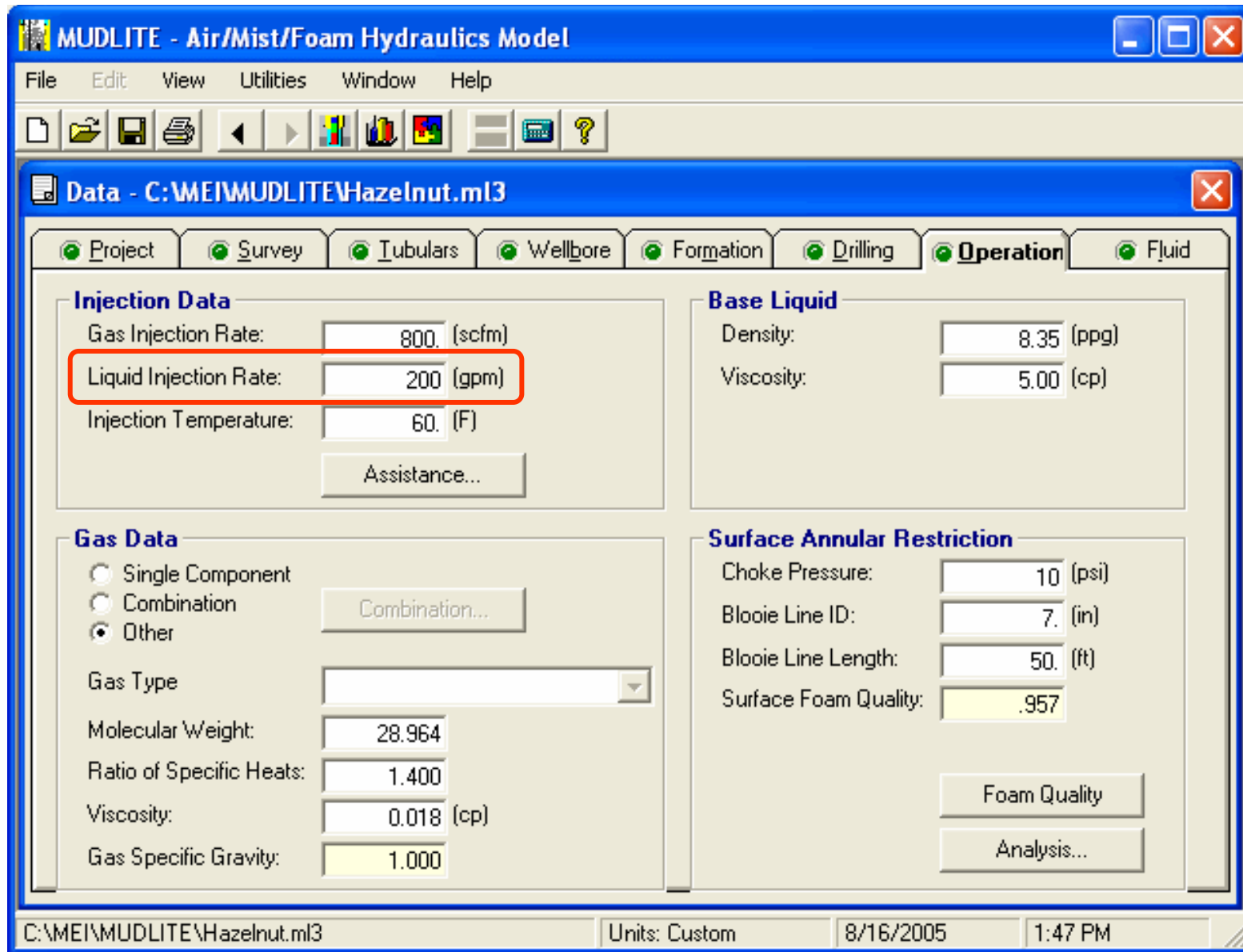
How can we remedy this situation? One approach is to increase the choke pressure, which will help keep the foam intact in the annulus. If we increase the choke pressure from 10 to 65 psi and rerun the calculations...

Slide
21 of 30



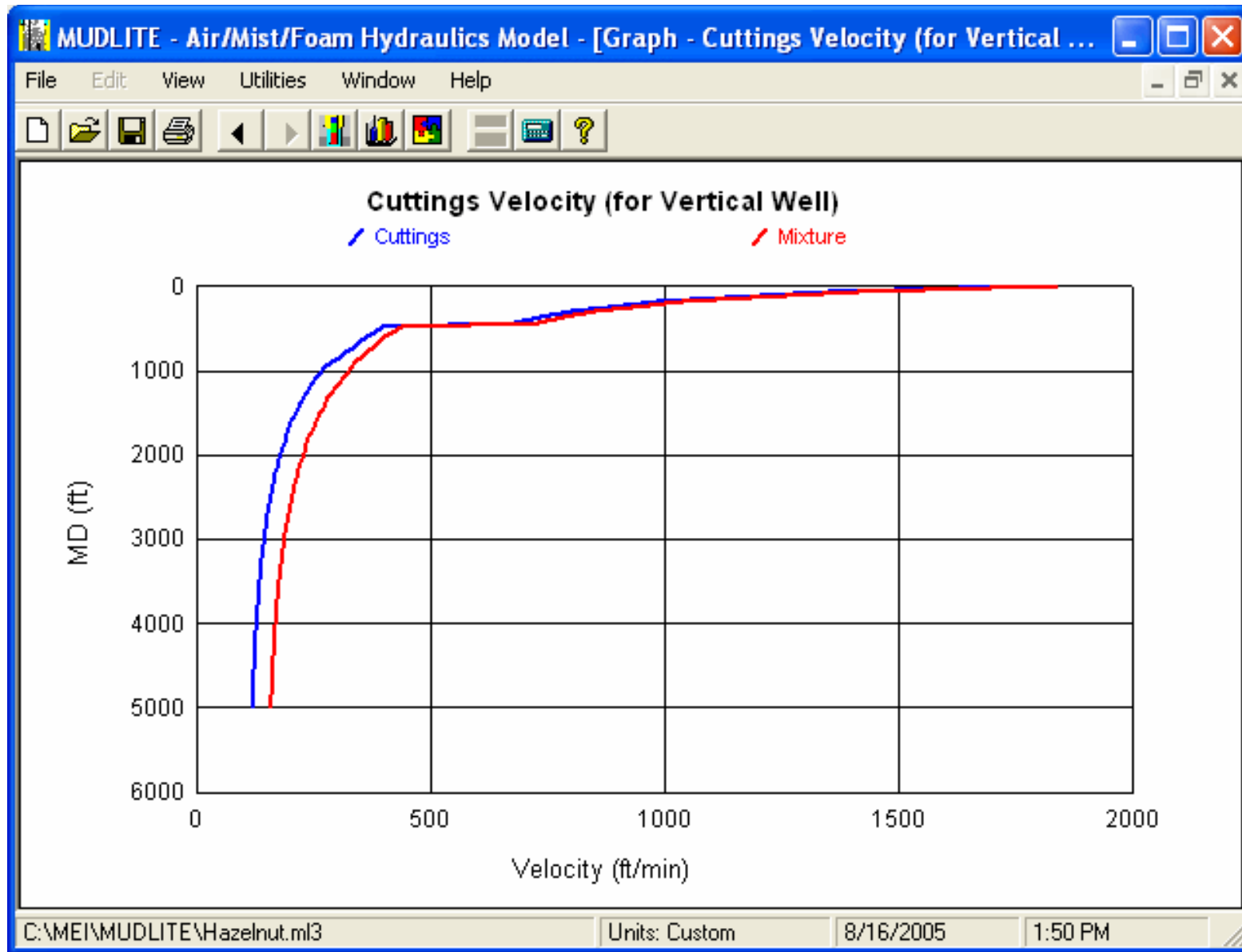
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...the problem is solved! The fluid velocity and cuttings velocity are now approximately equal throughout the entire annular path.



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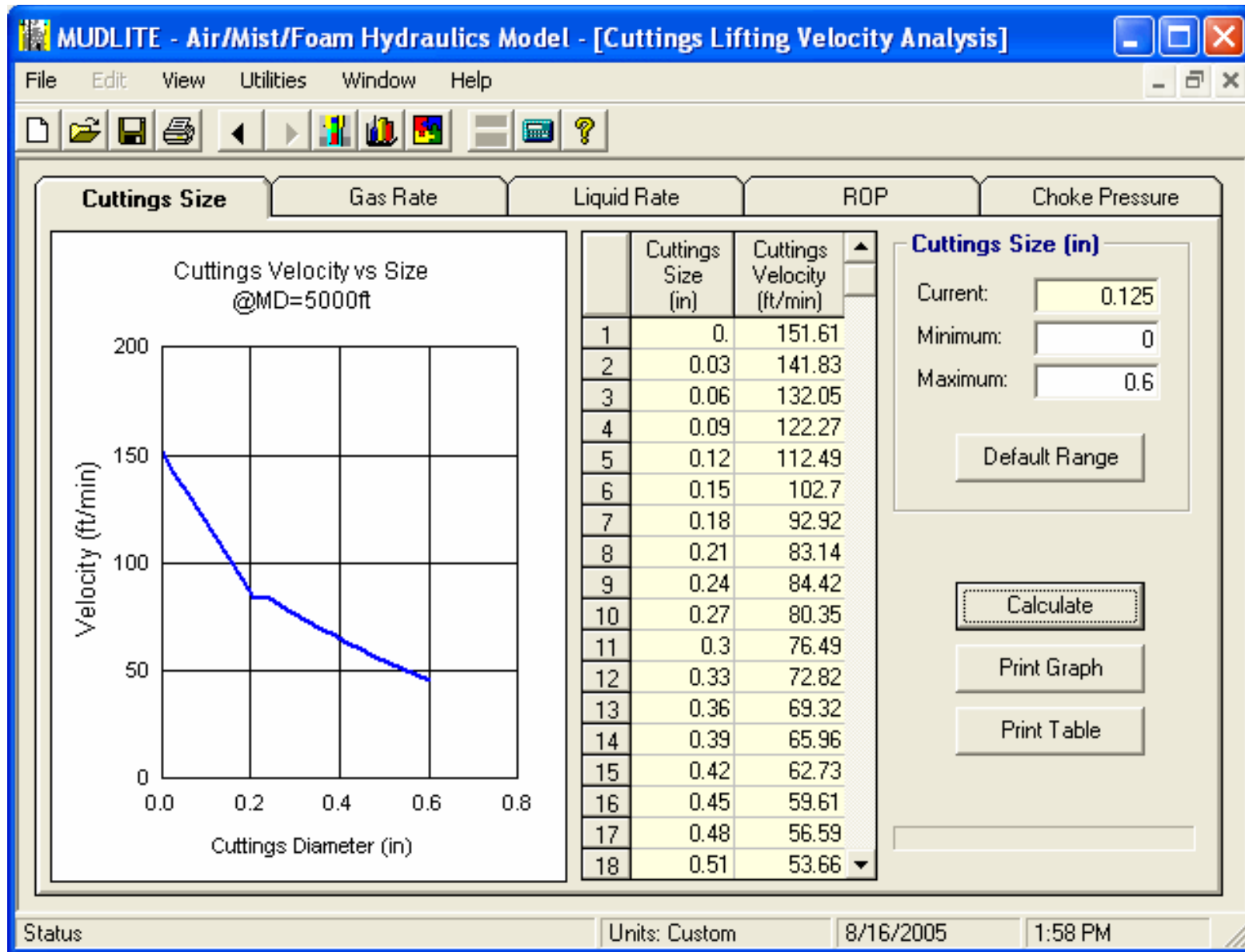
What other aspect(s) of the design could we change to solve our problem? Another approach is to increase the liquid rate, which will also maintain foam above its transition point higher in the annulus. If we increase the liquid injection rate from 120 to 200 gpm and recalculate...



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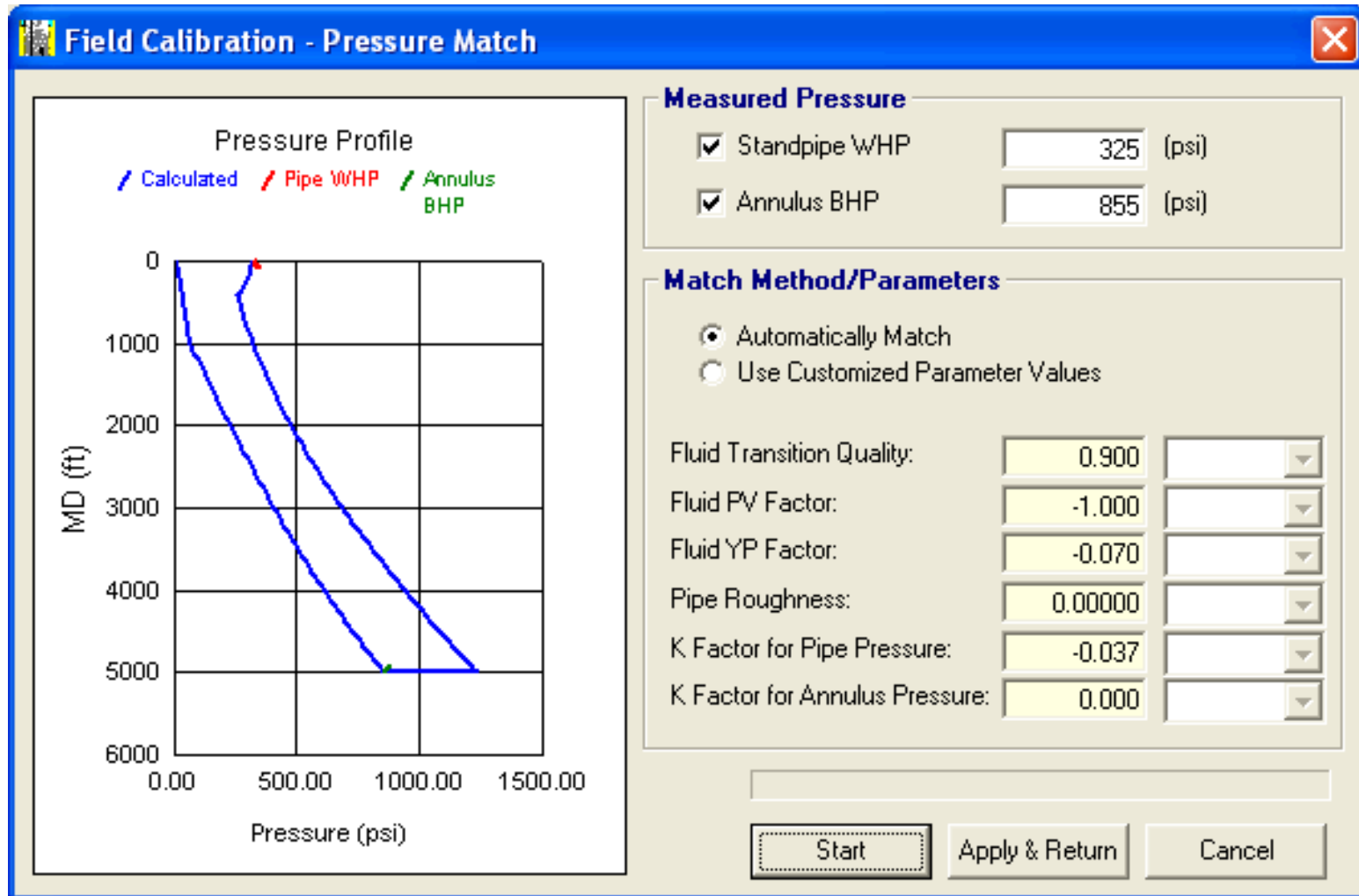
...again, problem solved!

MUDLITE allows you to quickly and efficiently address these types of issues and to develop a range of practical solutions before you go to the field.



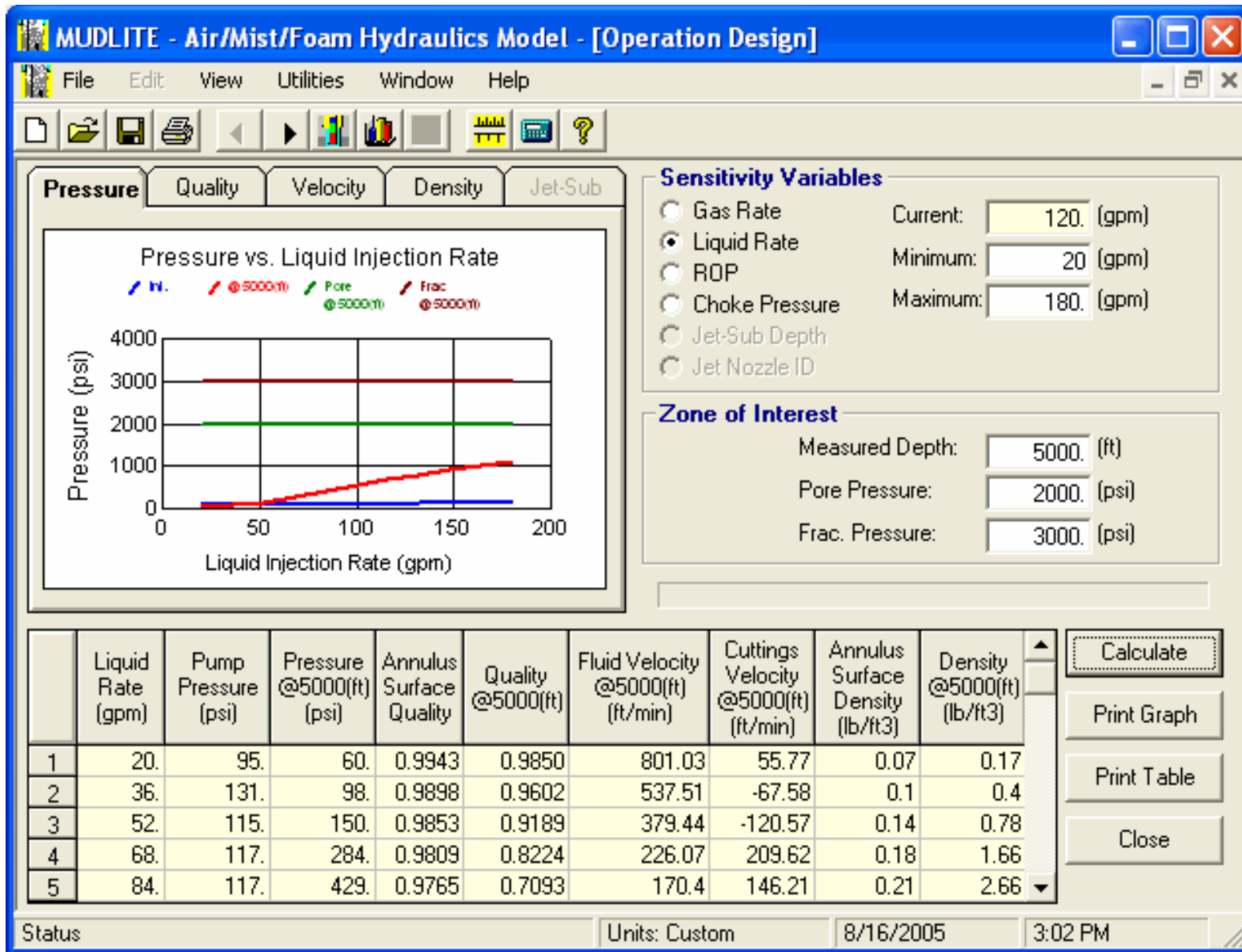
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The **Cuttings Lifting Velocity Analysis** window is used to quickly review the influence of various parameters on cuttings-lifting velocity. You can vary (1) cuttings size, (2) gas rate, (3) liquid rate, (4) rate of penetration, and (5) choke pressures.



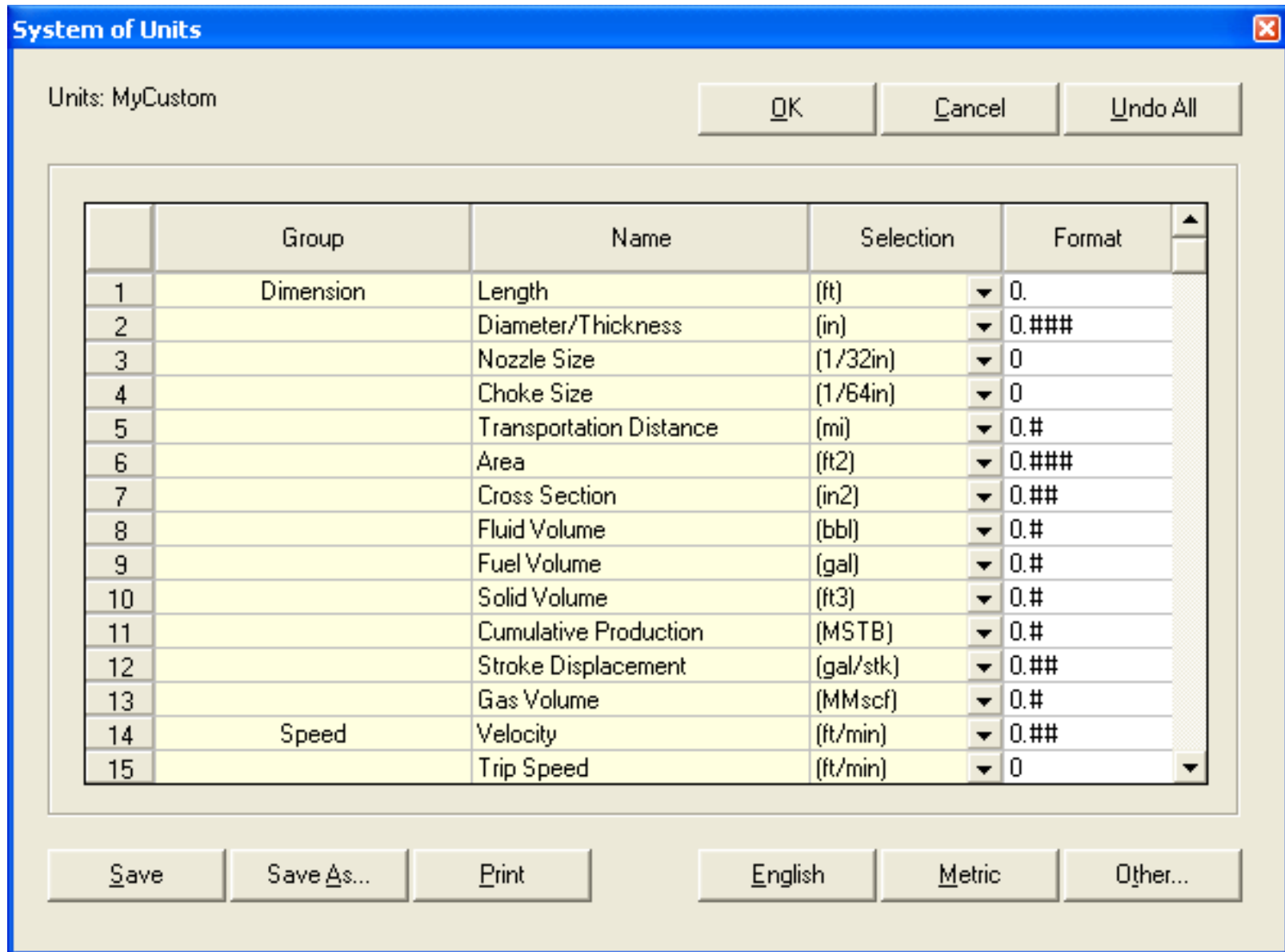
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The **Pressure Matching** window is another highly useful utility for adjusting input parameters so that calculated results match measured data from the field. Matching can be performed automatically or manually (your best guess, test, better guess, etc.). These matched hydraulics parameters are then incorporated into future calculations for similar conditions.

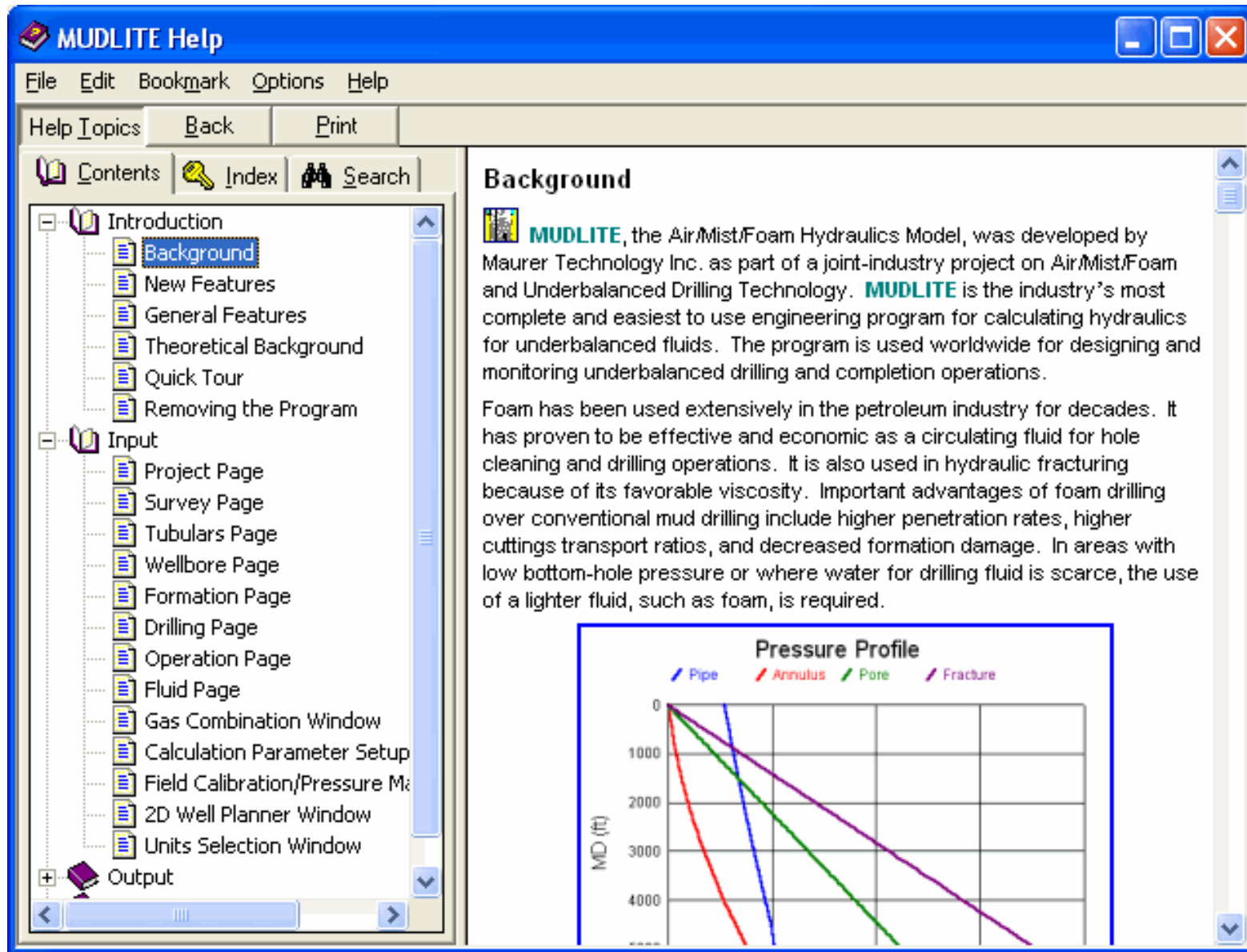


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The **Operation Design** utility allows you to observe the effect of changes in air and liquid injection rates and choke pressures. These are variables that can be changed in the field if problems occur, so they have been combined into this utility for planning and trouble-shooting wells.

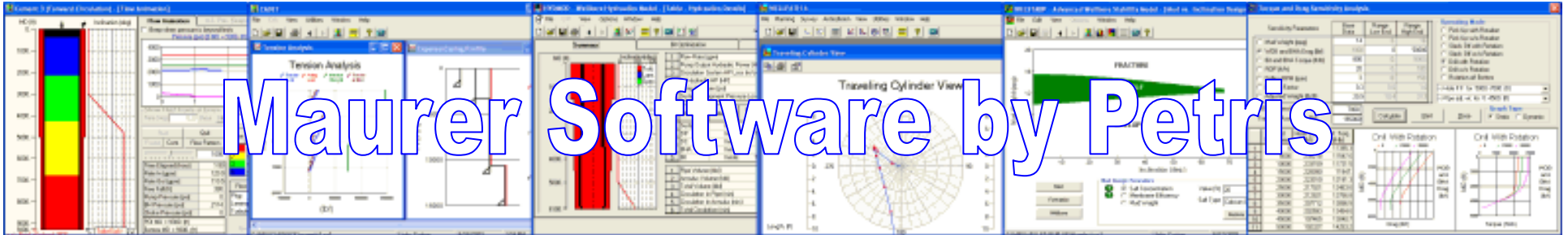


Units for input and output displays are easy to select and customize. Choose between the default metric or English systems, or a custom combination of units (for example, depth in meters, hole size in inches). Custom systems are saved and automatically recalled in future sessions.



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A comprehensive **On-Line Help System** is also provided. Tips on program operation, program structure, and basic theoretical background are immediately available at the click of a button.



Thanks for your interest in **MUDLITE**

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