

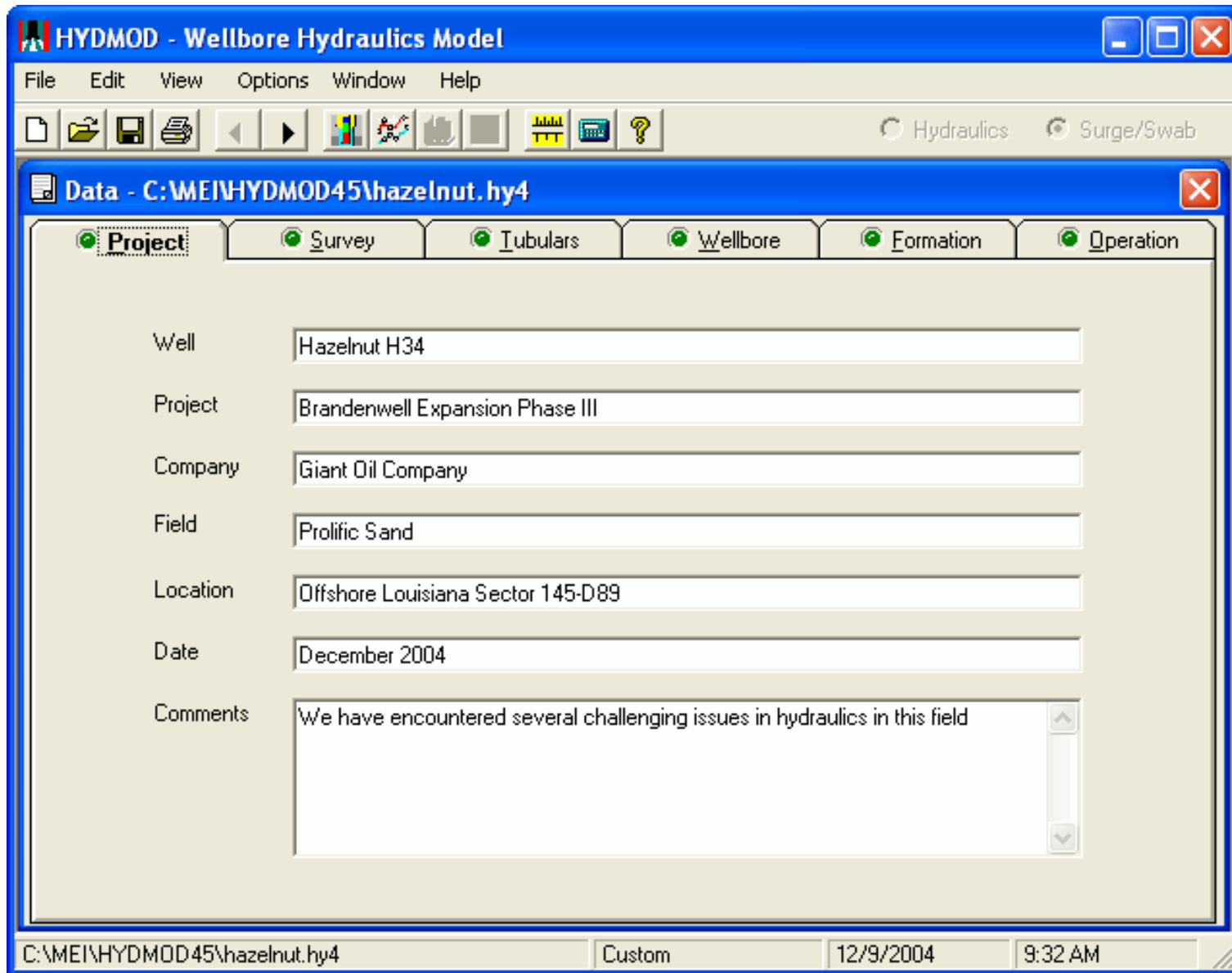
HYDMOD – Wellbore Hydraulics Model

accurately models drilling hydraulics in detail. From surge and swab to nozzle design, the program covers almost every aspect of hydraulics design. A variety of advanced features help engineers quickly optimize wellbore hydraulics.

HYDMOD's many powerful features include:

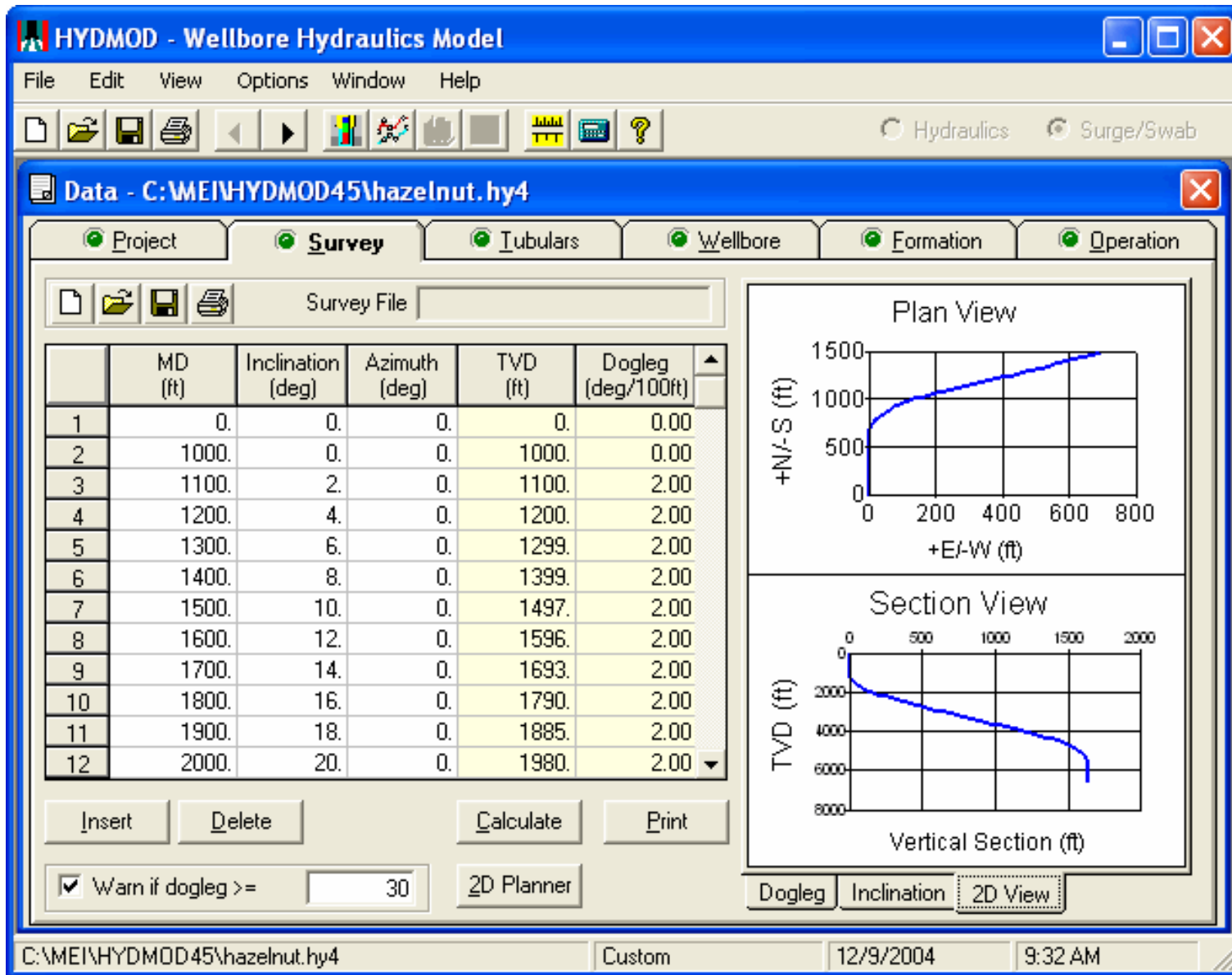
- models vertical, deviated and horizontal wells
- allows multiple casing and wellbore sizes
- calculates flow patterns and frictional pressure drops
- models surge/swab and cuttings transport
- calculates pressure drops in slim annuli

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.



HYDMOD

HYDMOD is a user-friendly hydraulics package with a variety of powerful features. The first input screen, the **Project** page, stores documentation to identify specific clients, wells, fields, etc.



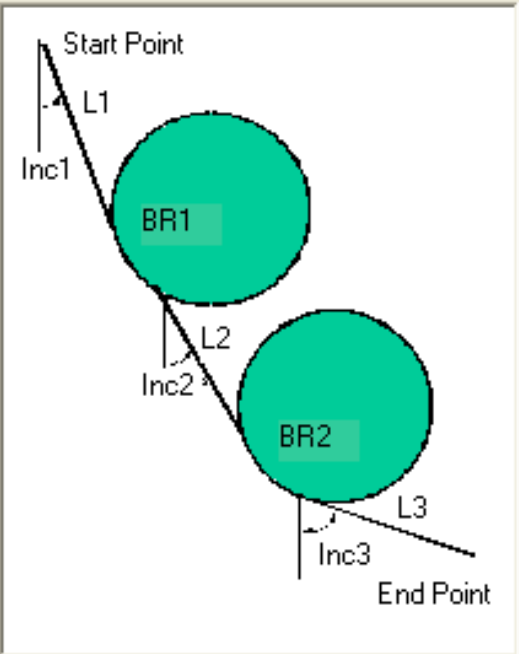
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The **Survey** page is for entering the wellbore survey that describes the well trajectory. Data may be entered manually, imported, exported, or copied from a spreadsheet. Don't have a survey? Create one quickly with the handy 2D Planner utility.

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):

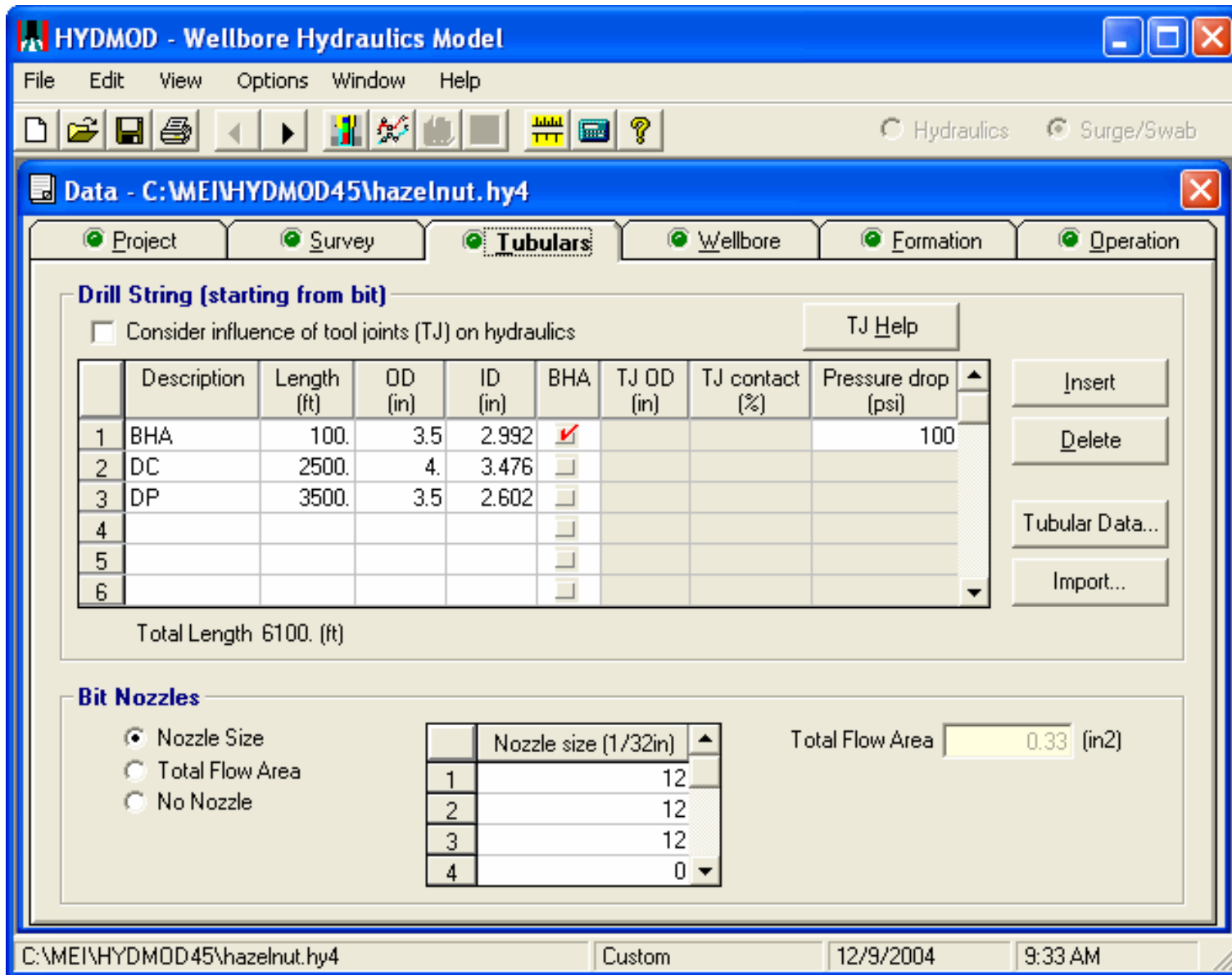
	MD (ft)	Inc (deg)	Azi (deg)	TVD (ft)	N/S (ft)	E/W (ft)	Build Rate (deg/100ft)	Section Length (ft)
1	0.00	5.00	4.29	0.0	0.0	0.0	n/a	n/a
2	893.9	5.00	4.29	890.5	77.7	5.8	0.00	893.9
3	2012.7	60.00	4.29	1798.2	654.4	49.1	4.92	1118.8
4	2662.7	60.00	4.29	2123.2	1215.7	91.2	0.00	650.0
5	2962.7	90.00	4.29	2200.0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

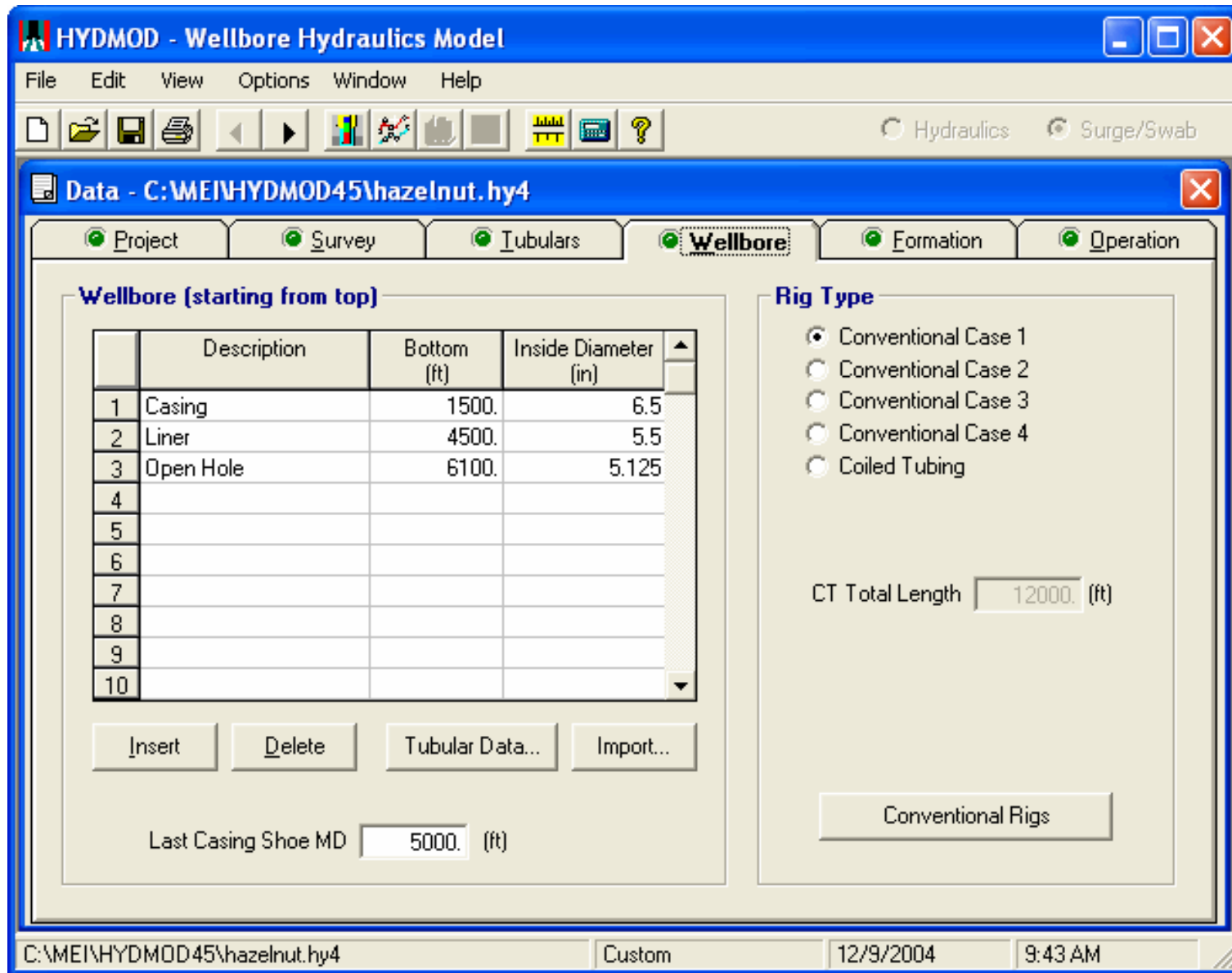
Accept

Cancel

The **2D Well Planner** creates simple or complex well surveys. Choose the basic well shape and enter starting values for the primary geometric parameters. After creation, the new survey is automatically exported back to the Survey page.



Drillstring components are specified on the **Tubulars** page. The drillstring may be divided into as many as 20 components. Enter specific sizes for bit nozzles or total flow area through the bit.



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The **Wellbore** page is used to describe the geometry of the annulus. Up to 20 wellbore IDs may be specified. Several rig cases are provided with typical standpipe and kelly IDs and lengths. Coiled-tubing rigs may be selected in addition to conventional rigs.

Tubular Database

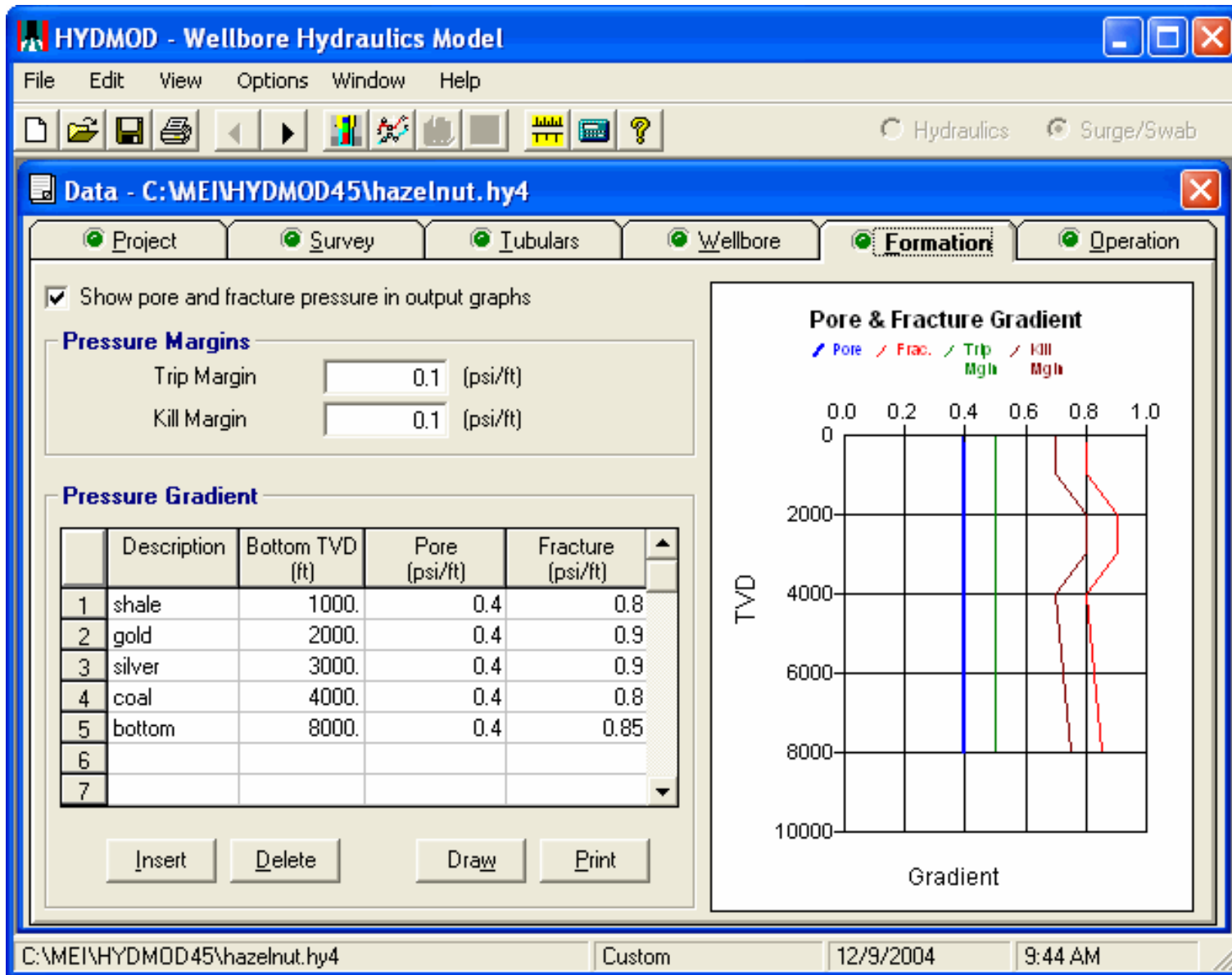
Pipe Class: Pipe OD (in):

	Class	Nominal Size (in)	Pipe ID (in)	Nominal Weight (lb/ft)	Adjusted Weight (lb/ft)	Grade	Upset	Thr
1	DP New	5.5	4.778	21.9	23.8	E-75	IEU	FH
2	DP New	5.5	4.67	24.7	26.3	E-75	IEU	FH
3	DP New	5.5	4.778	21.9	24.4	X-95	IEU	FH
4	DP New	5.5	4.67	24.7	27.8	X-95	IEU	FH
5	DP New	5.5	4.778	21.9	25.3	G-105	IEU	FH
6	DP New	5.5	4.67	24.7	27.8	G-105	IEU	FH
7	DP New	5.5	4.778	21.9	26.4	S-135	IEU	FH
8	DP New	5.5	4.67	24.7	28.9	S-135	IEU	FH

Editor... Print Apply Cancel

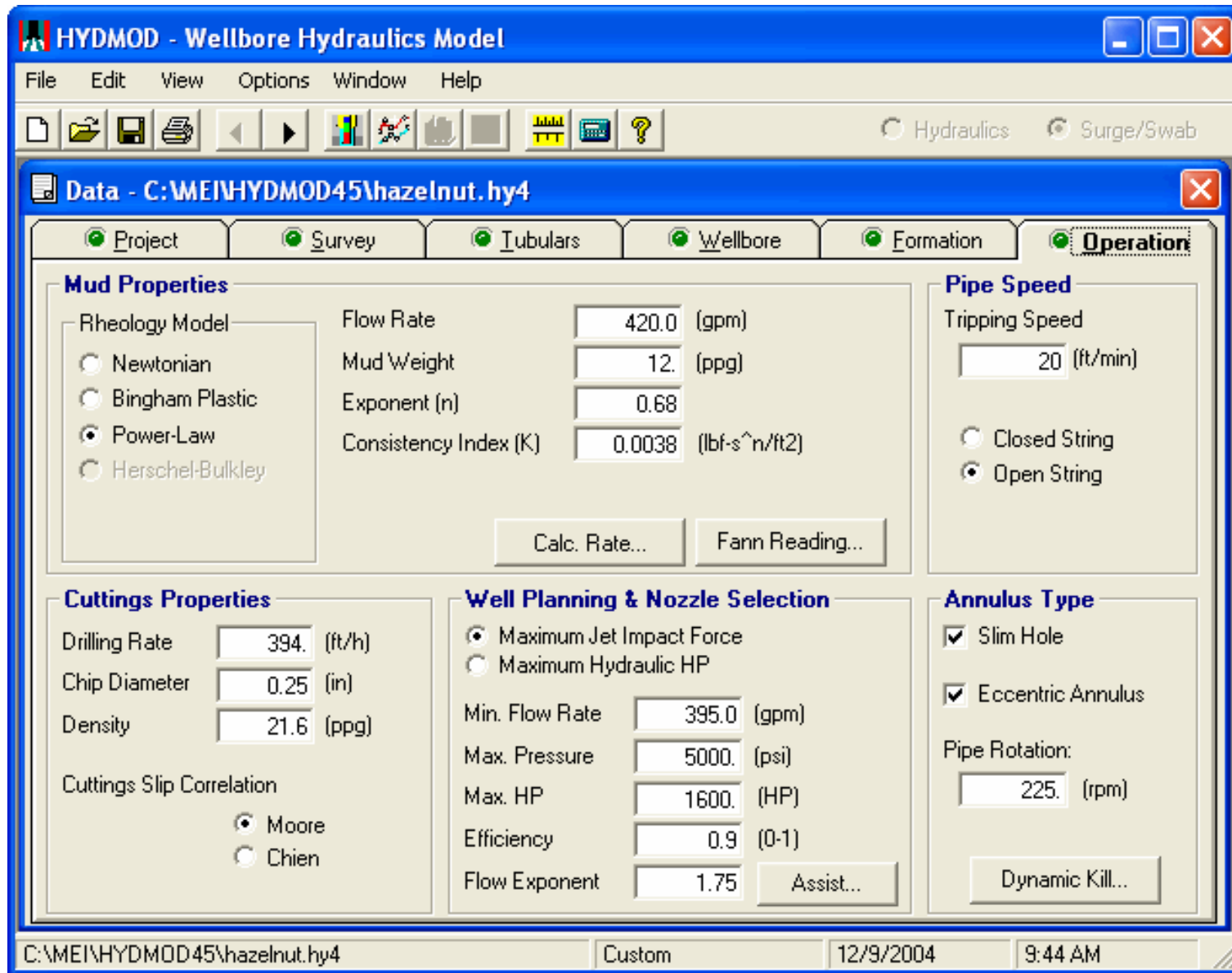
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All Maurer Technology programs include an extensive tubular database that may be edited/customized. This feature avoids the need to look up drillstring component sizes, weights, IDs, etc. each time.



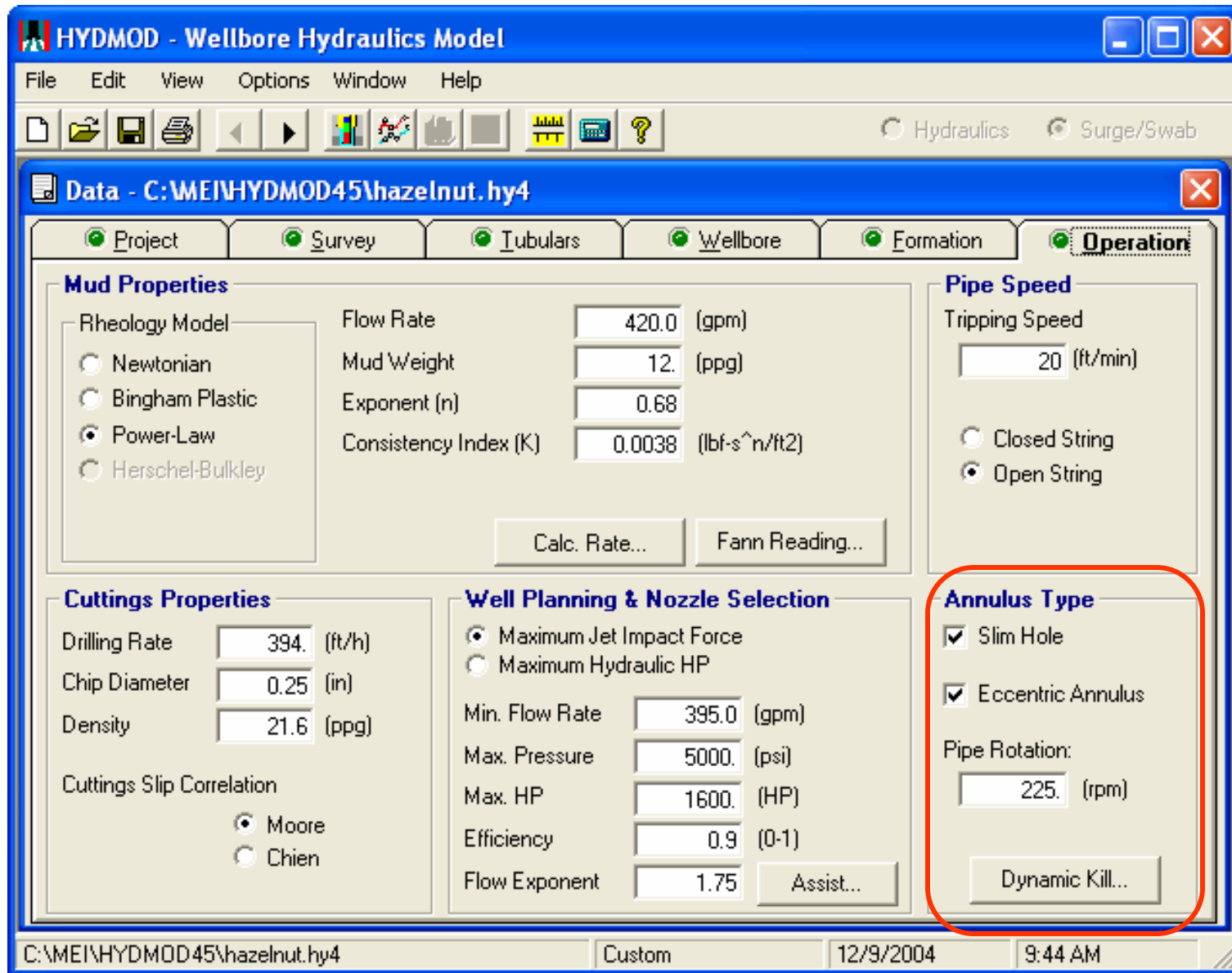
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The **Formation** page lists pore- and fracture-pressure data. These are displayed in the graph for immediate review. Up to 100 pore/fracture pressures (or gradients) may be entered into the table. If available, these data will be shown in output graphs next to predicted wellbore pressures.



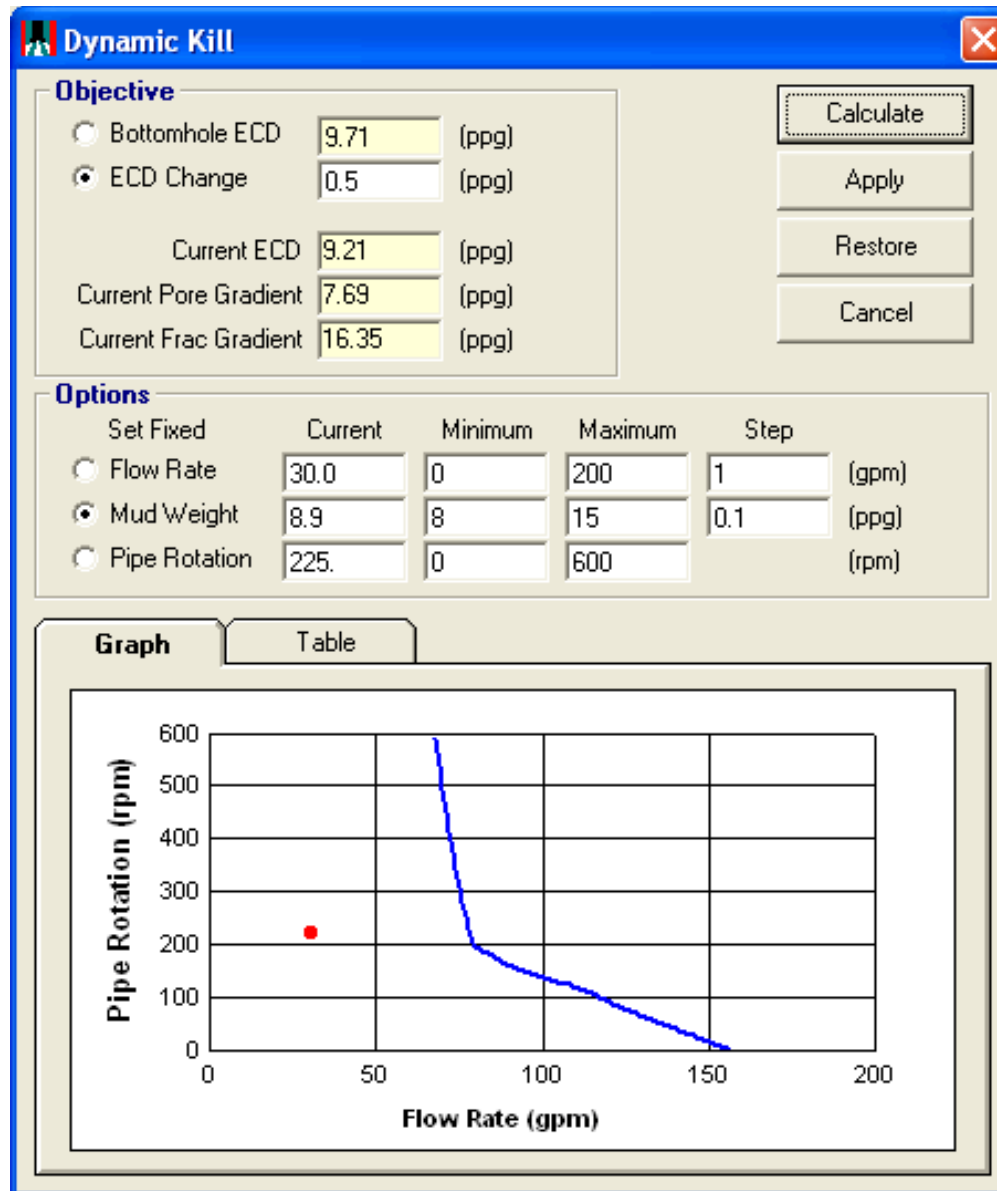
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Hydraulics options are selected on the **Operation** page. Four rheology models are provided, including Herschel-Bulkley. Bit hydraulics may be optimized using either of two criteria: maximum jet impact force or maximum hydraulic HP.

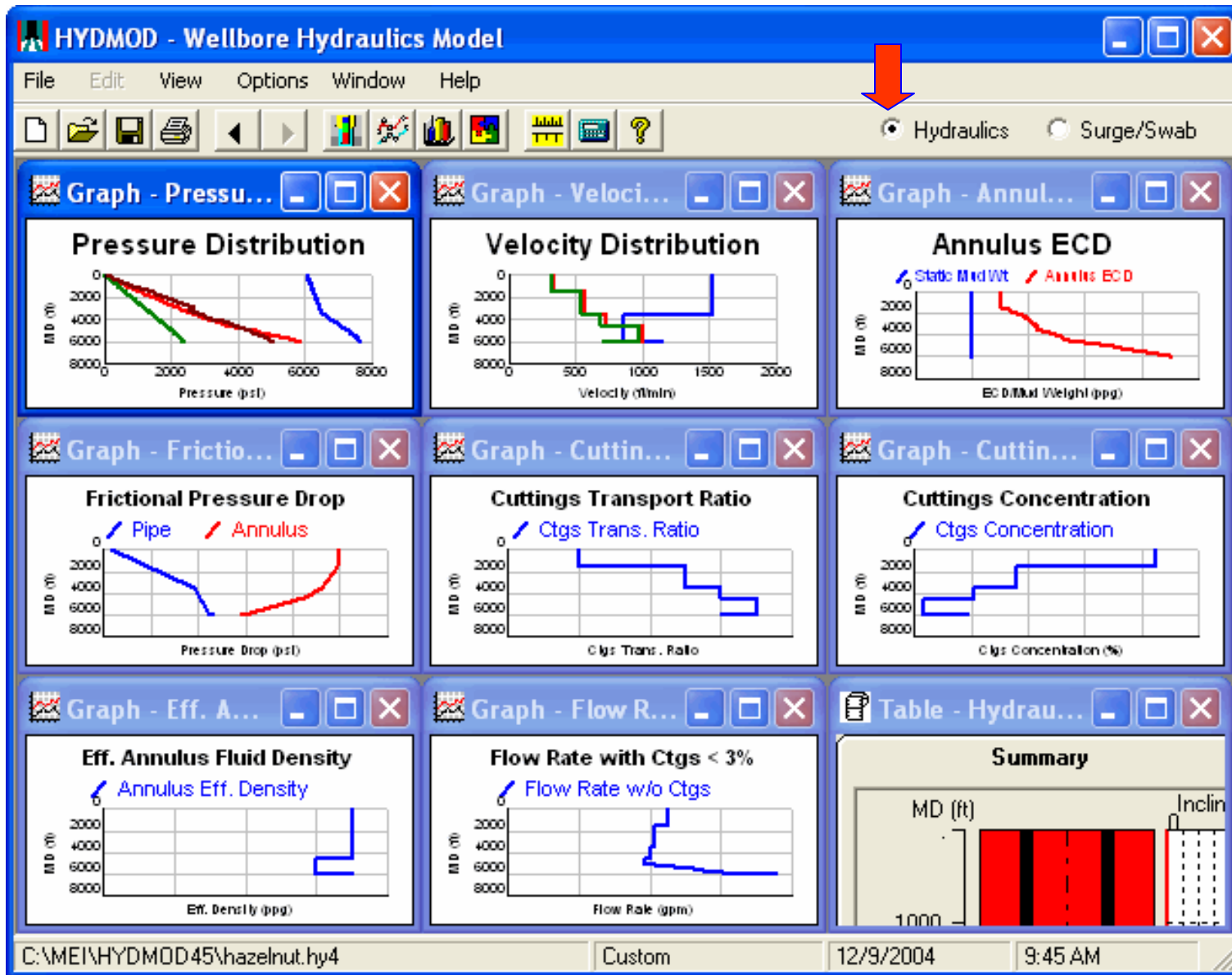


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A new feature in HYDMOD is calculation of pressure losses and ECD in **slim-hole wellbores**. Narrow annuli can significantly impact hydraulics. Special correlations are now included for these situations.

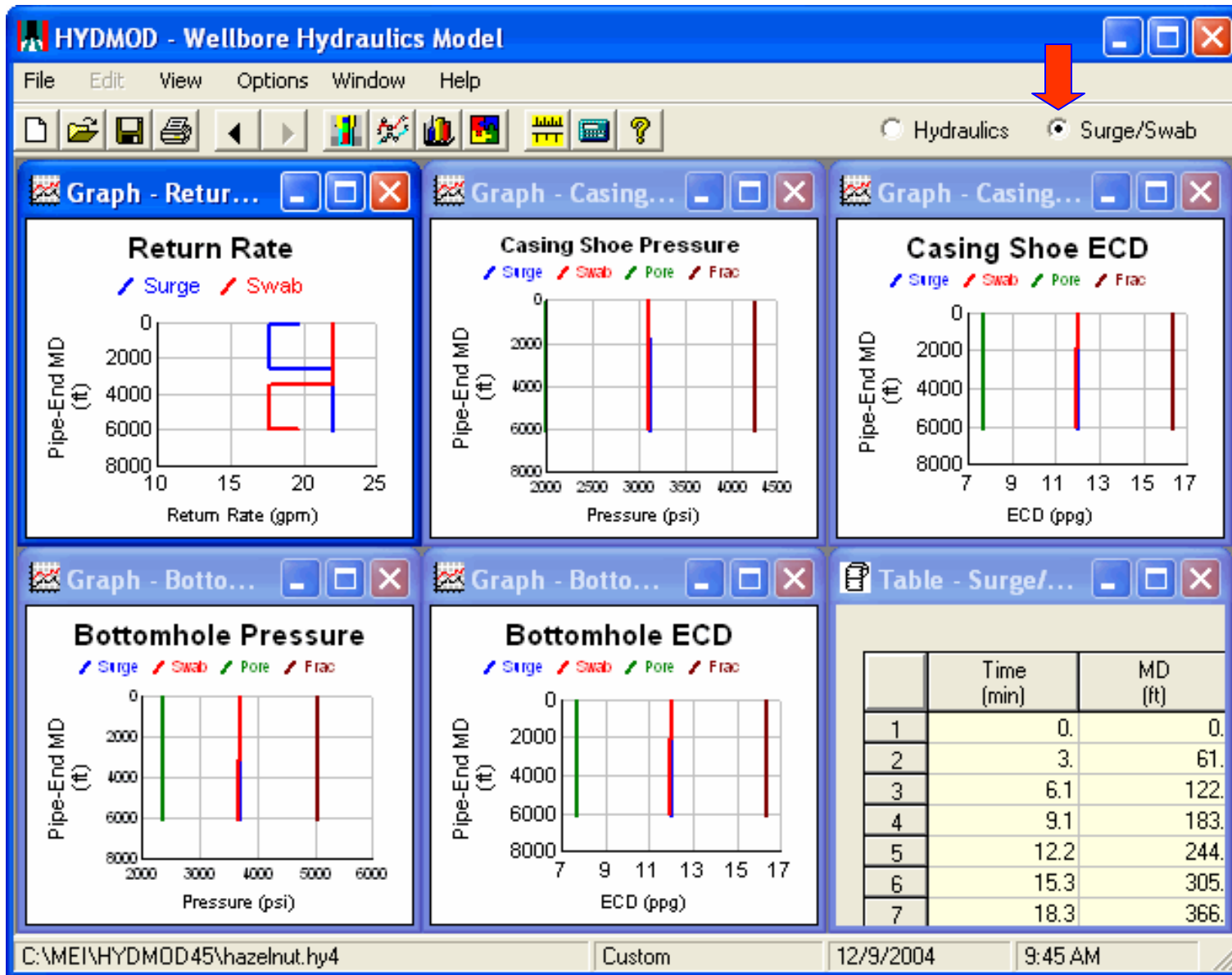


The new **Dynamic Kill** utility is useful for planning operations in slim holes. Pressure/ECD at the bottom of the hole can be adjusted for maintaining well control by changing flow rate, mud weight, or pipe rotary speed. The graphs show ways to achieve desired bottom-hole conditions.



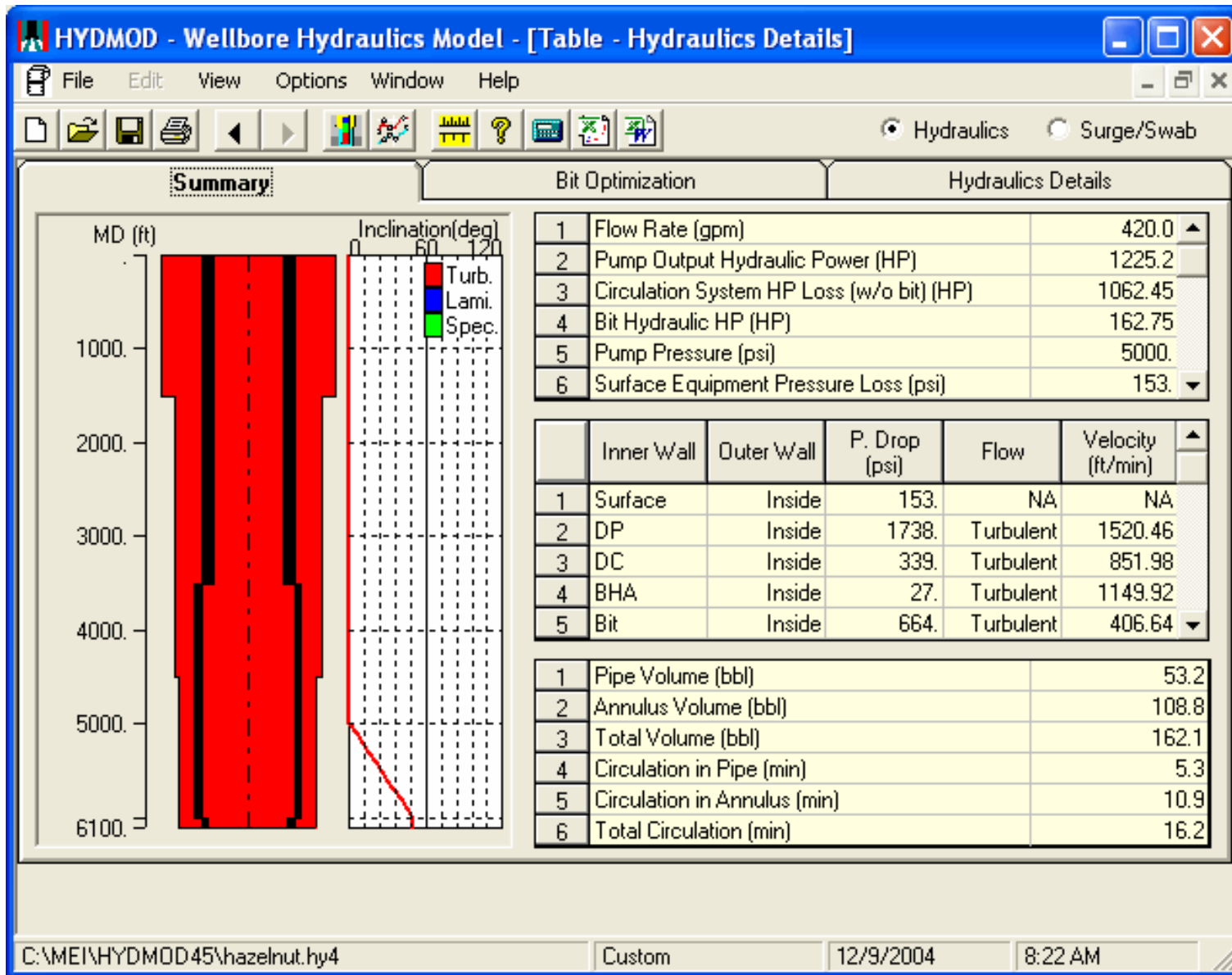
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After all required input data are input, the **Output** window is loaded. A great variety of output types and formats are available for review and comparison. Nine graphics windows are displayed under the primary Hydraulics option.



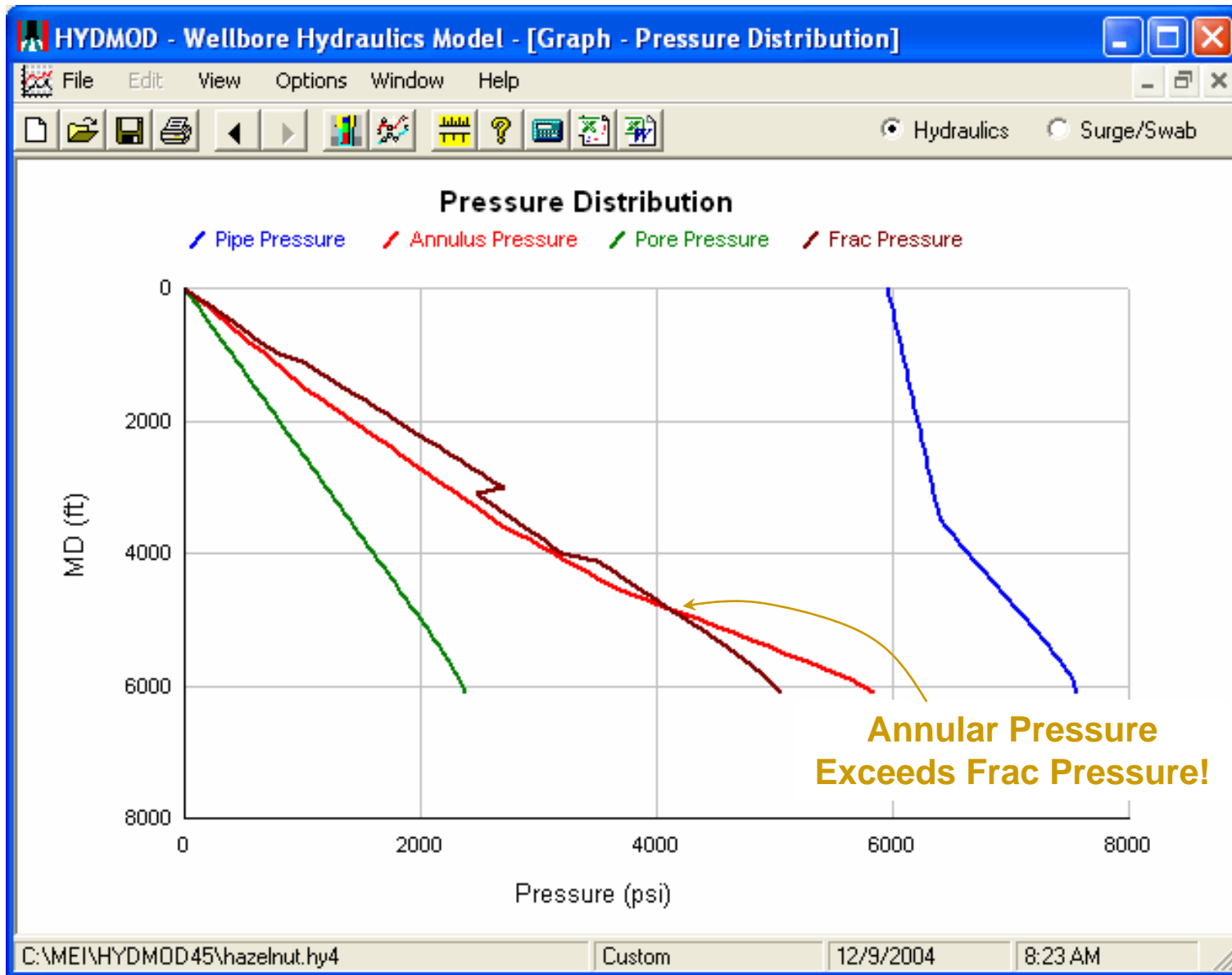
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A second set of output graphs and tables is accessed by selecting the Surge/Swab option. These graphs describe the impact of pipe movement on downhole pressures.



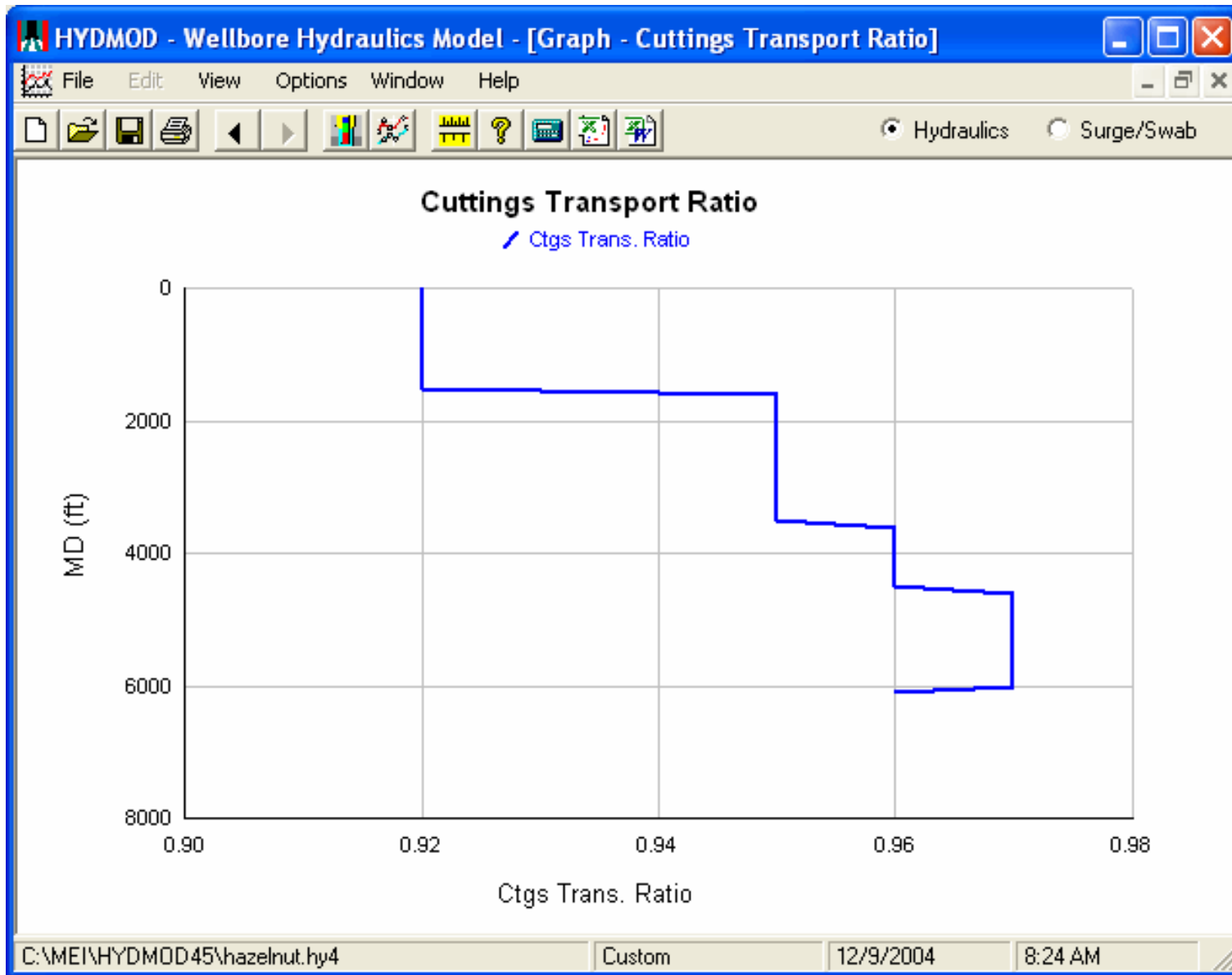
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Example output graphs are shown in the next few slides. In the Hydraulics Details window, flow patterns of turbulent or laminar flow are displayed along the wellbore along with basic output data.



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Pressure profiles inside the drill pipe (blue) and in the annulus (red) are displayed along with pore-pressure (green) and fracture-pressure (purple) curves. Dangerous drilling conditions are highlighted and noted quickly.



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Cuttings slip velocity and transport ratio can be calculated along the wellbore. These are excellent indicators of how effectively the hole is being cleaned of cuttings.

HYDMOD - Wellbore Hydraulics Model - [Table - Hydraulics Details]

File Edit View Options Window Help

Hydraulics Surge/Swab

Summary **Bit Optimization** Hydraulics Details

Optimum Flow Rate (gpm)	395.0	Max. Jet Impact Force
Optimum Total Flow Area (in ²)	0.39	
Optimum System Pressure Drop (psi)	3894.	
Optimum Bit Pressure Drop (psi)	1106.	
Optimum Bit HHP (HP)	254.81	
Optimum Nozzle Velocity (ft/s)	320.89	
Optimum Jet Impact Force (lbf)	1479	
Optimum Hole Impact Pressure (psi)	38.	

Total Flow Area (in²)

Two Nozzles (in ²)	Area Vari.	Three Nozzles (in ²)	Area Vari.	Four Nozzles (in ²)	Area Vari.	Five Nozzles (in ²)	Area Vari.
16+16	1	12+13+14		11+11+11+12		9+9+10+11+11	-1
14+16	-11	13+13+13		10+10+12+12	-4	9+10+10+10+11	-1
15+15	-12	13+13+14	5	11+11+12+12	4	10+10+10+10+10	-2
		13+14+14	10	10+11+11+12	-4	10+10+10+10+11	2
		14+14+14	16	11+11+11+11	-5	10+10+10+11+11	7

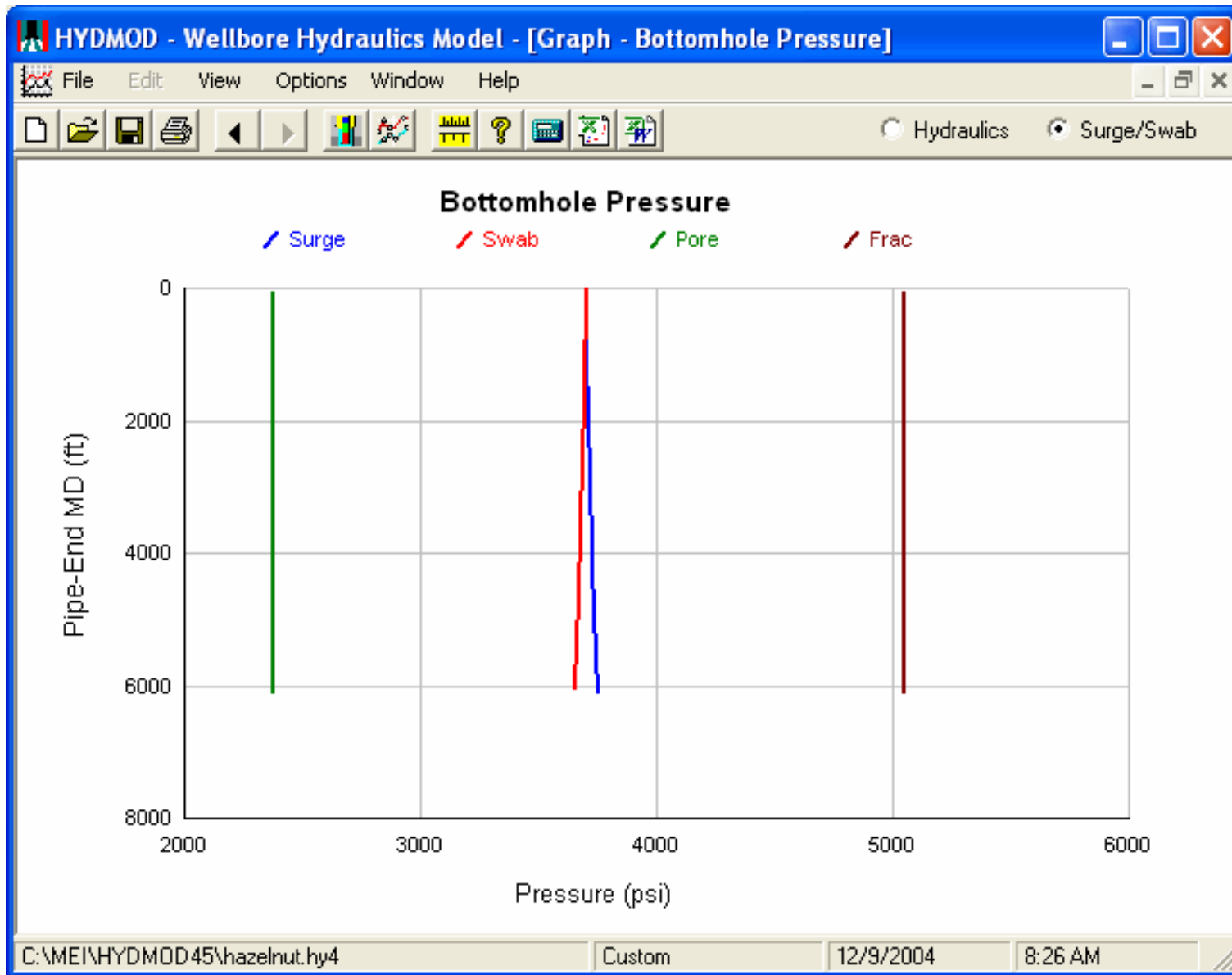
Trial and Error (input any combination of nozzle sizes)

ID (1/32in)	ID (1/32in)	ID (1/32in)	ID (1/32in)	ID (1/32in)	ID (1/32in)	ID (1/32in)	ID (1/32in)	ID (1/32in)	ID (1/32in)	ID (1/32in)	Area (in ²)	Vari. (%)

C:\MEI\HYDMOD45\hazelnut.hy4 Custom 12/9/2004 8:25 AM

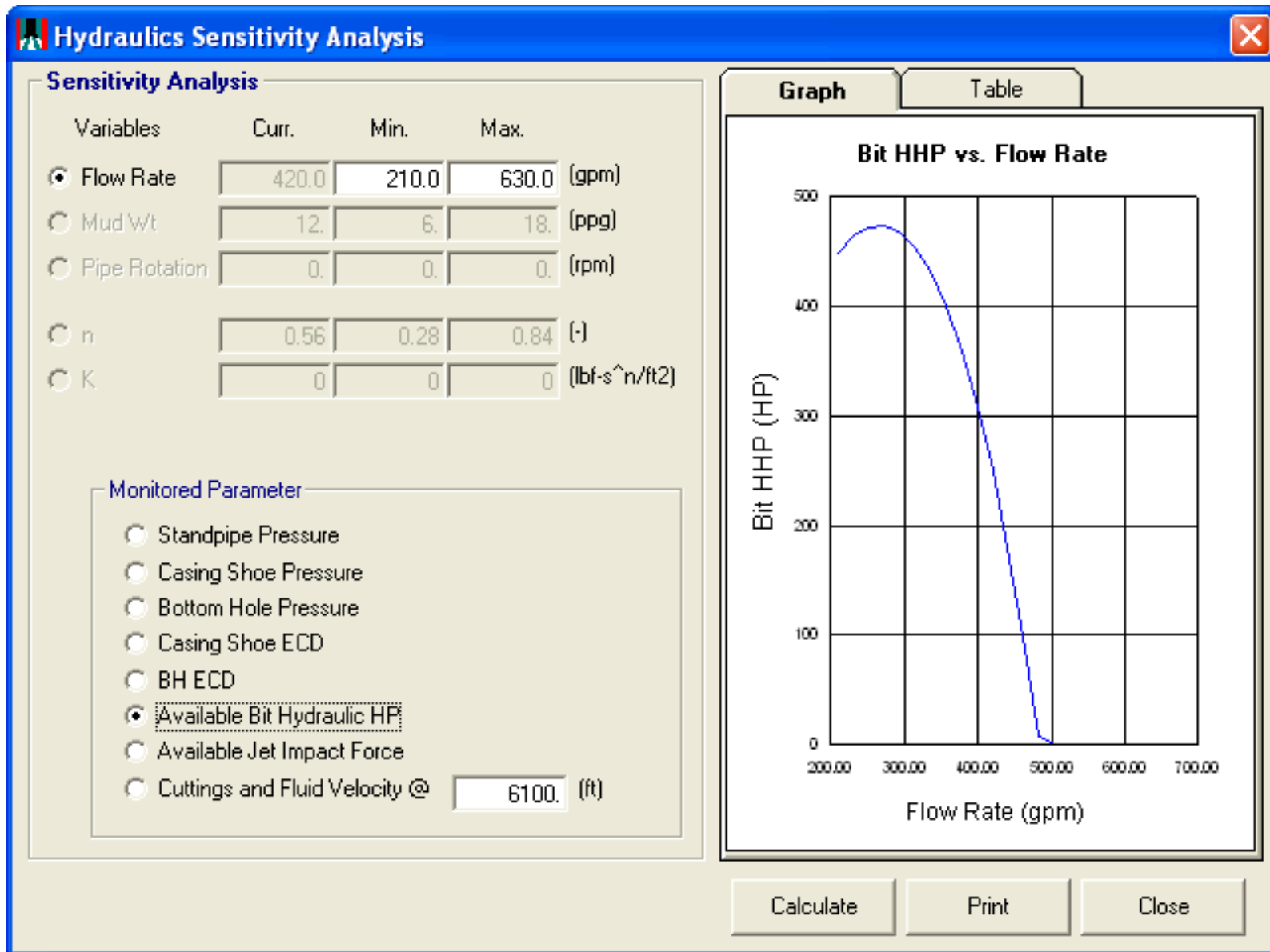
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Bit-nozzle selection is greatly simplified with the **HYDMOD** Bit Optimization Report. Optimization can be based on the maximization of jet impact force or hydraulic horsepower.



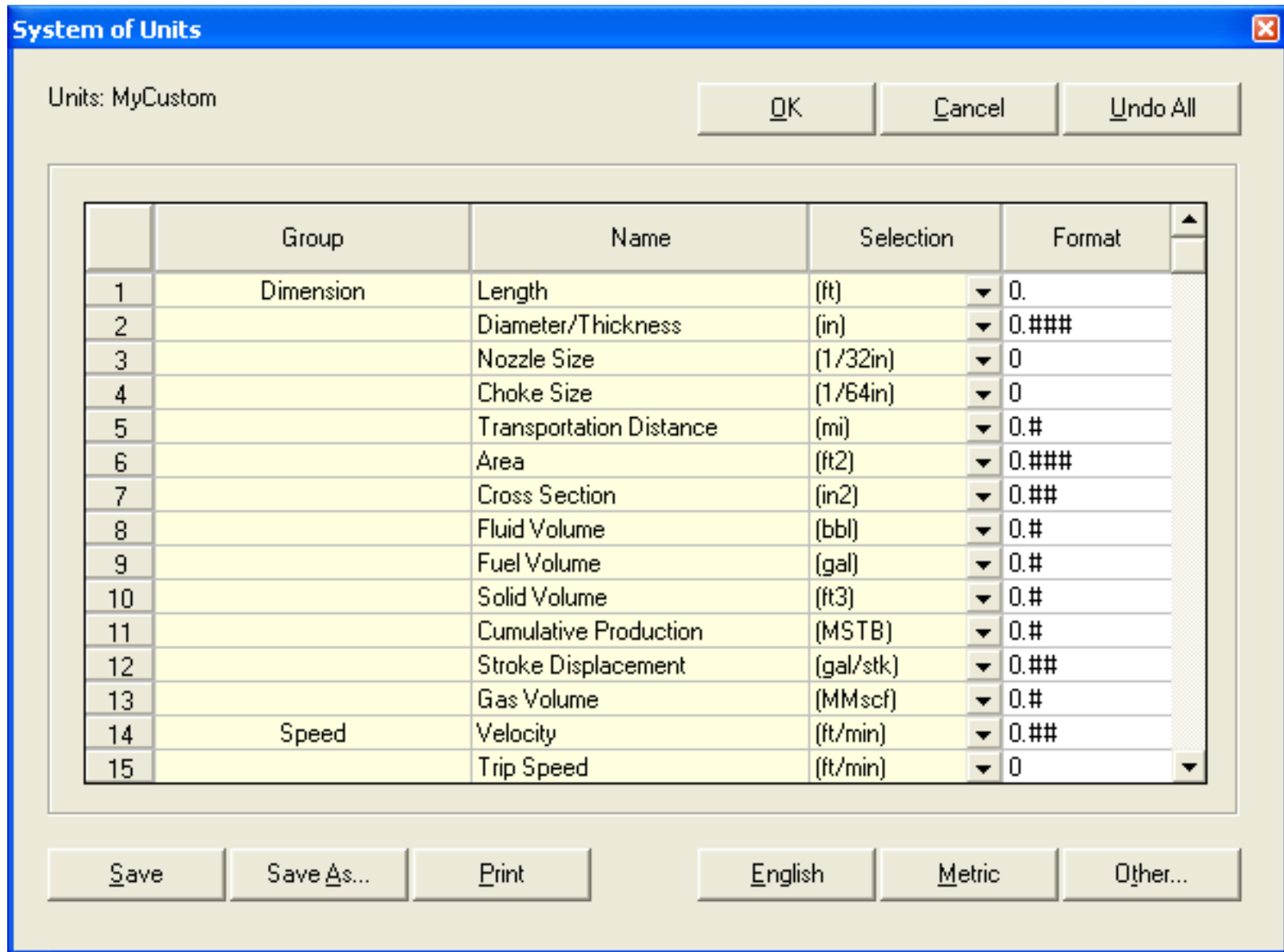
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Surge and swab pressures are dynamic pressure events caused by movement of the drillstring. The impact of surge and swab on casing-shoe or bottom-hole pressures can be checked quickly at the maximum anticipated tripping speeds.



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The **Sensitivity Analysis** is an important output utility. It can be used to test the impact of changes in any of several hydraulics parameters. This type of analysis can quickly demonstrate which parameter(s) must be most precisely measured and controlled in the field.



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.

Help for HYDMOD

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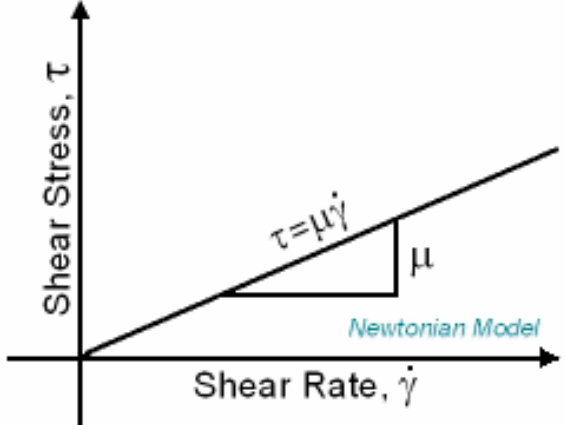
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Fluid Models

The rheological models most commonly used in the drilling/boring industry to describe fluid behavior are the Newtonian, Bingham plastic and power-law models. These fluid models can be used to calculate frictional pressure drops, cuttings-carrying capacity, swab and surge pressures, etc. The fluid models provided in **HYDMOD** are largely based on equations derived in Applied Drilling Engineering (Bourgoyne et al., 1991) and API SPEC 10.

Newtonian Fluid Model

Newtonian fluids are those for which shear stress is directly proportional to shear rate. Examples of Newtonian fluids are water, air, nitrogen, glycerin, and light oil. A single parameter, viscosity, characterizes these fluids.



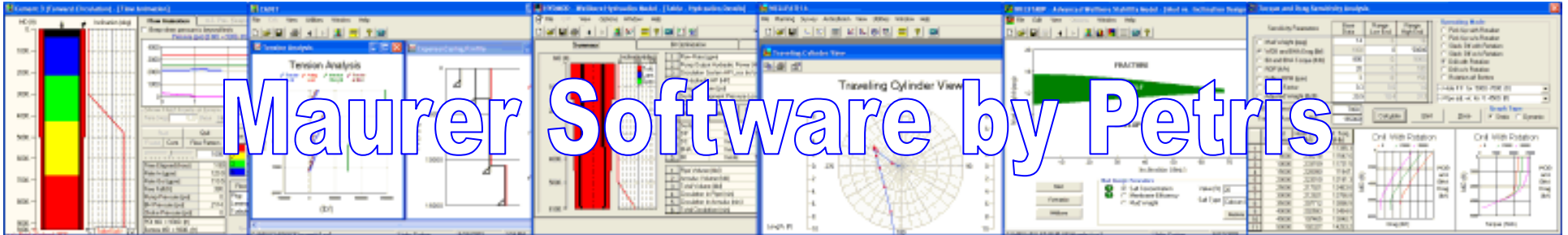
Newtonian fluid rheology is defined by the equation below.

$$\tau = \mu \dot{\gamma}$$

where:

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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 **HYDMOD**

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