

# Resolve Horizontal Well Model Results: Comparison With Finite Difference Simulators – SPE 7

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# Objectives

- Compare Resolve Results with those of Finite Difference Simulators for SPE 7 Results and explore effects of different Resolve Settings on the answers.
- Expand beyond SPE 7 to further validate Resolve answers and sensitivities.

# SPE 7 References

- \* Z. Chen, G. Huan, B. Li, 2004, A Benchmark Calculation of 3D Horizontal Well Simulations International Journal of Numerical Analysis and Modeling, Vol. 1, No. 2, pp. 189-201**
- \*\* L. Nghlem, D.A. Collins, R. Sharma, 1991, SPE 21221 Seventh SPE Comparative Solution Project: Modeling of Horizontal Wells in Reservoir Simulation**
- \*\*\* Single Phase Results obtained from:  
Pan System Horizontal Well Analytical Models**

# Validation Road Map of Results

- Resolve 3 Phase (Oil, Gas, and Water) Horizontal Well Results \*, \*\*
- Resolve Horizontal Well Results for Single Phase Oil and Gas Compared with Pan Analytical Model – Completed
- Resolve 3 Phase (Oil Gas and Water) Horizontal Well with Fracture Results – To Be Completed Later \*

# 3 Phase Reservoir Details

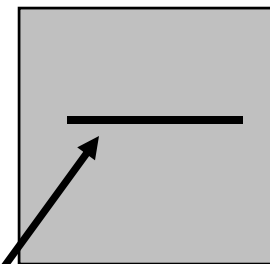
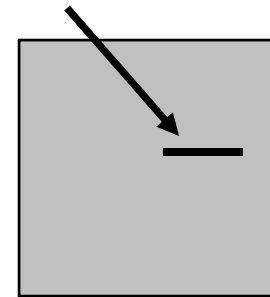
## Case Details:

- Reservoir Dimensions: 2700ft by 2700ft
- Oil Recovery by Horizontal Well in middle of Top 20ft. Thick Layer
- Six Total Layers (thickness of 20, 20, 20, 20, 30, 50ft.)
- 6th Layer has Water Injection Horizontal Well in middle of 50 ft layer
- Reservoir Porosity 0.2, Horizontal Permeability 300md, Vertical Permeability 30md

# Benchmark Cases Studied

## Run Time: 1500 Days

- 2 Different Production Well Lengths
  - 900 ft (starts at 1650ft from side boundary)
  - 2100 ft (starts at 450ft from side boundary)
  - Both Wells are 1380 ft from bottom and 1320 ft from top boundary)
- 3 Different Total Production Rates    Production Well Length 900 ft
  - 3000, 6000, and 9000 stb/day
- Case 1a – 900 ft Long, 3000 stb/day
- Case 2a – 900 ft Long, 6000 stb/day
- Case 3a – 900 ft Long, 9000 stb/day
- Case 1b – 2,100 ft Long, 3000 stb/day
- Case 2b – 2,100 ft Long, 6000 stb/day
- Case 3b – 2,100 ft Long, 9000 stb/day



Production Well Length 2100 ft

# Benchmark Case Study SPE 7

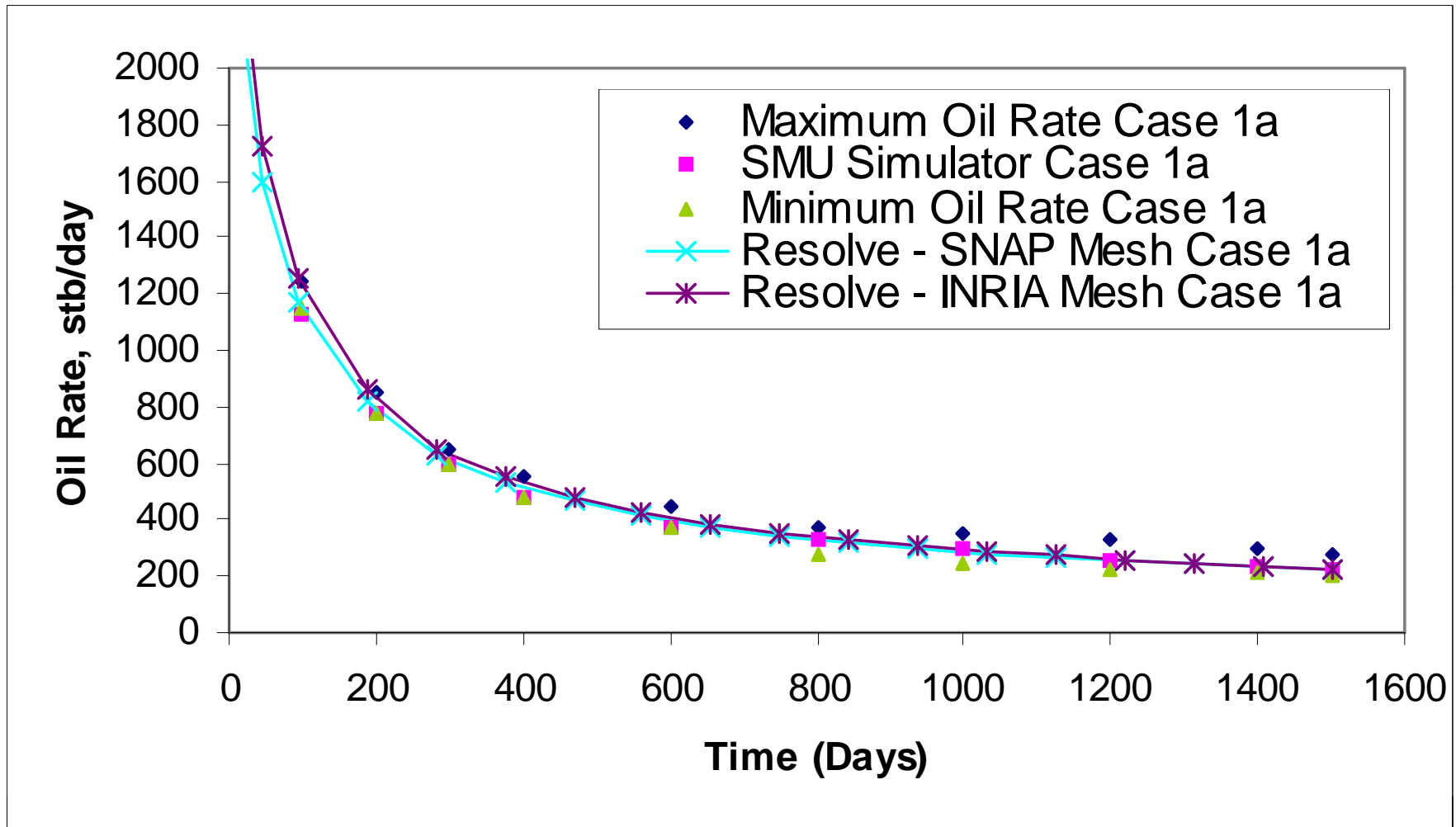
## Participants

- ARTEP
- Chevron
- CMG
- ECL
- ERC
- HOT
- INTECH
- JNOC
- Marathon
- Phillip's
- RSRC
- Shell
- Stanford
- TDC
- SMU (Cases 1-3 a&b)
- **And now:**
  - **Resolve**

# BHP at Producer – Day 1500

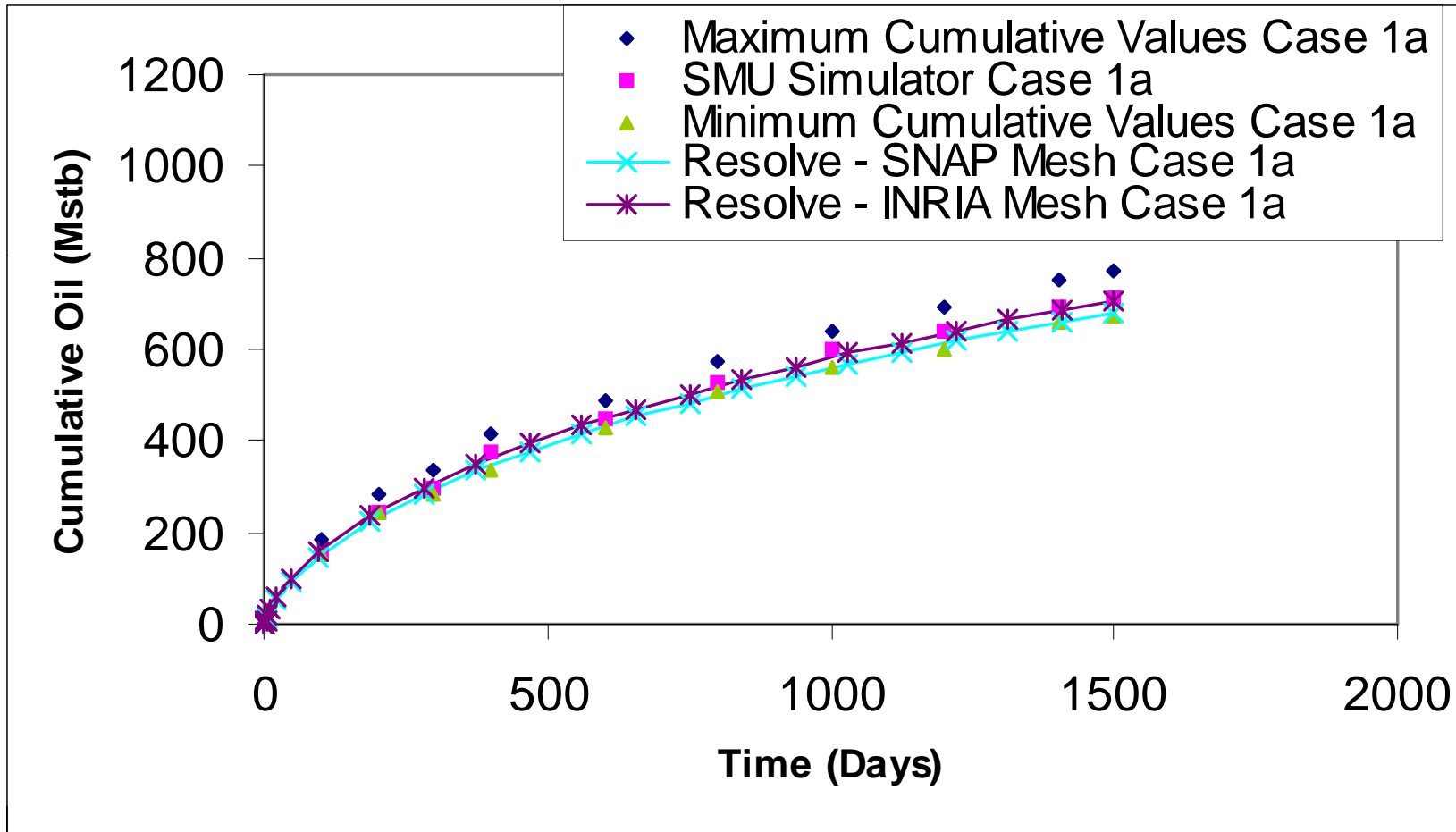
Case	1a	1b	2a	2b	3a	3b
Max	3567.8	3610.9	3444.1	3575.3	3318.9	3530.3
Mean	3476.3	3577.2	3270.9	3486.0	3060.4	3395.1
Min	3438.2	3544.4	3199.9	3454.8	2948.9	3343.4
Resolve	3413.3	3505.1	3270.0	3433.4	3136.7	3370.8
% Diff. Mean	1%	2%	0%	1%	2%	1%

# Case 1a - Oil Rate Results



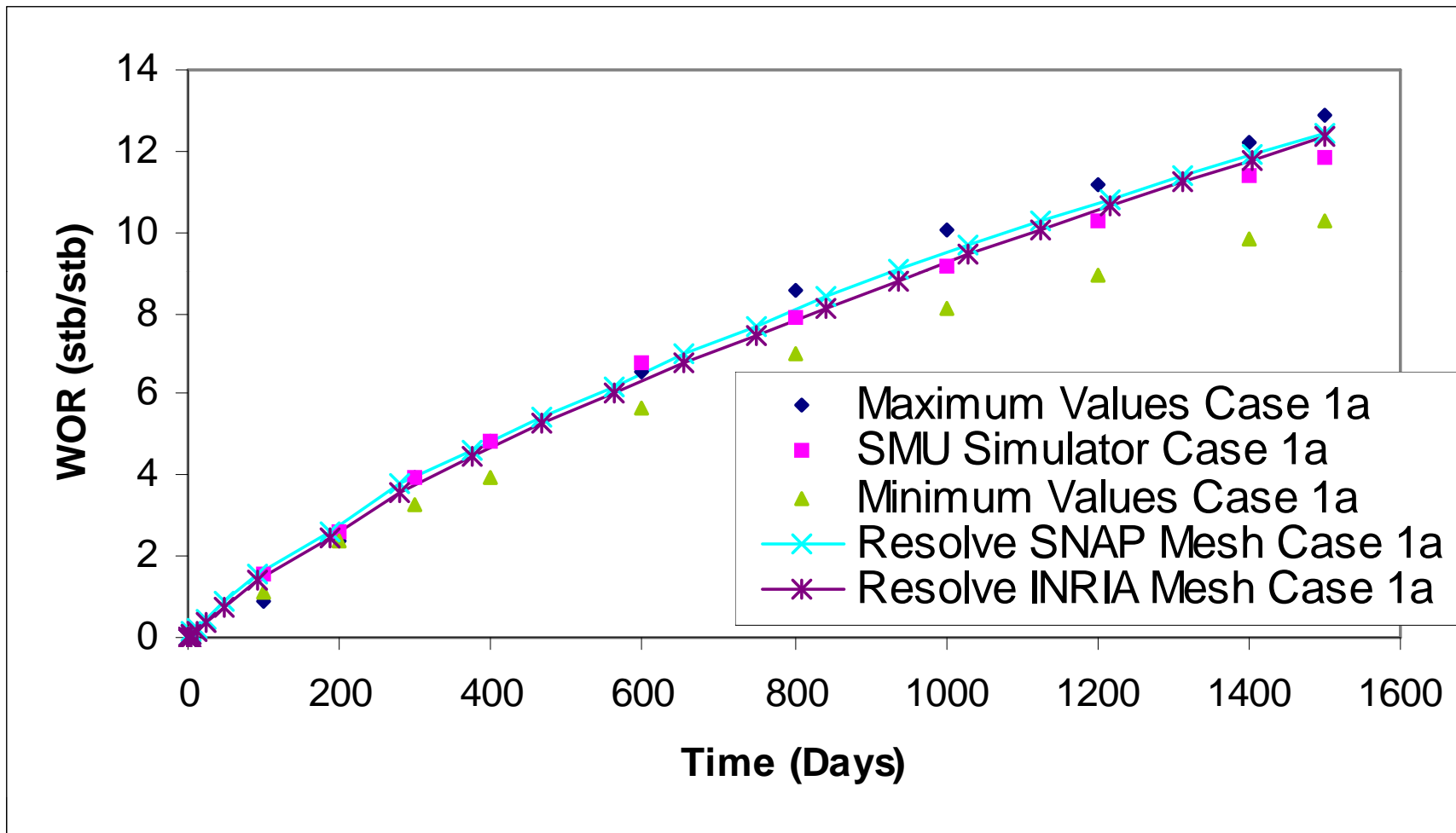
Well Length 900 ft., Total Liquid Production Rate: 3,000stb/day  
Resolve % Difference with SMU at 1500 days: 2%

# Case 1a - Cumulative Oil Results



Well Length 900 ft., Total Liquid Production Rate: 3,000stb/day  
Resolve % Difference with SMU at 1500 days: 5%

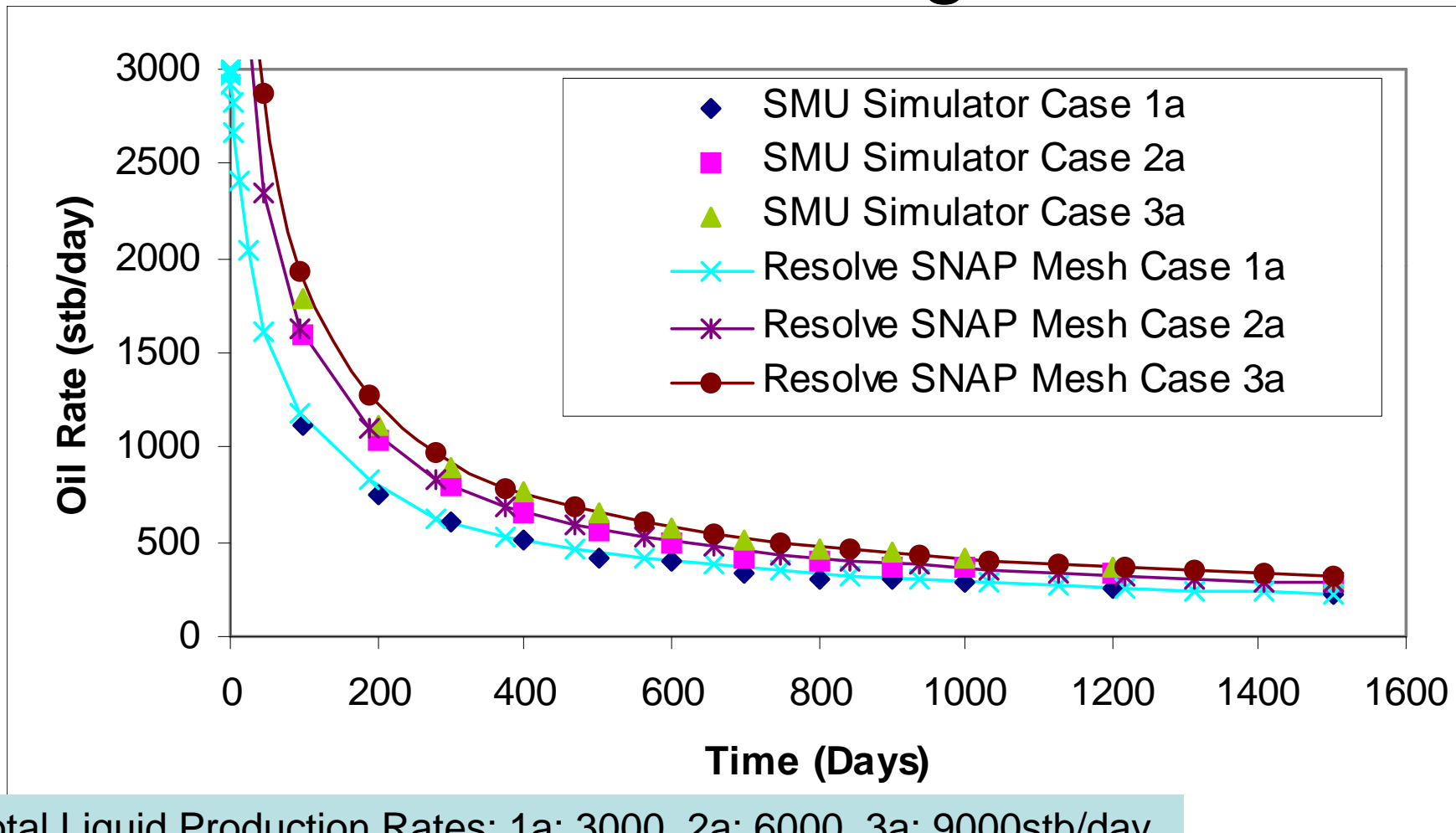
# Case 1a – WOR Results



Well Length 900 ft., Total Liquid Production Rate: 3,000stb/day  
Resolve % Difference with SMU at 1500 days: 6%

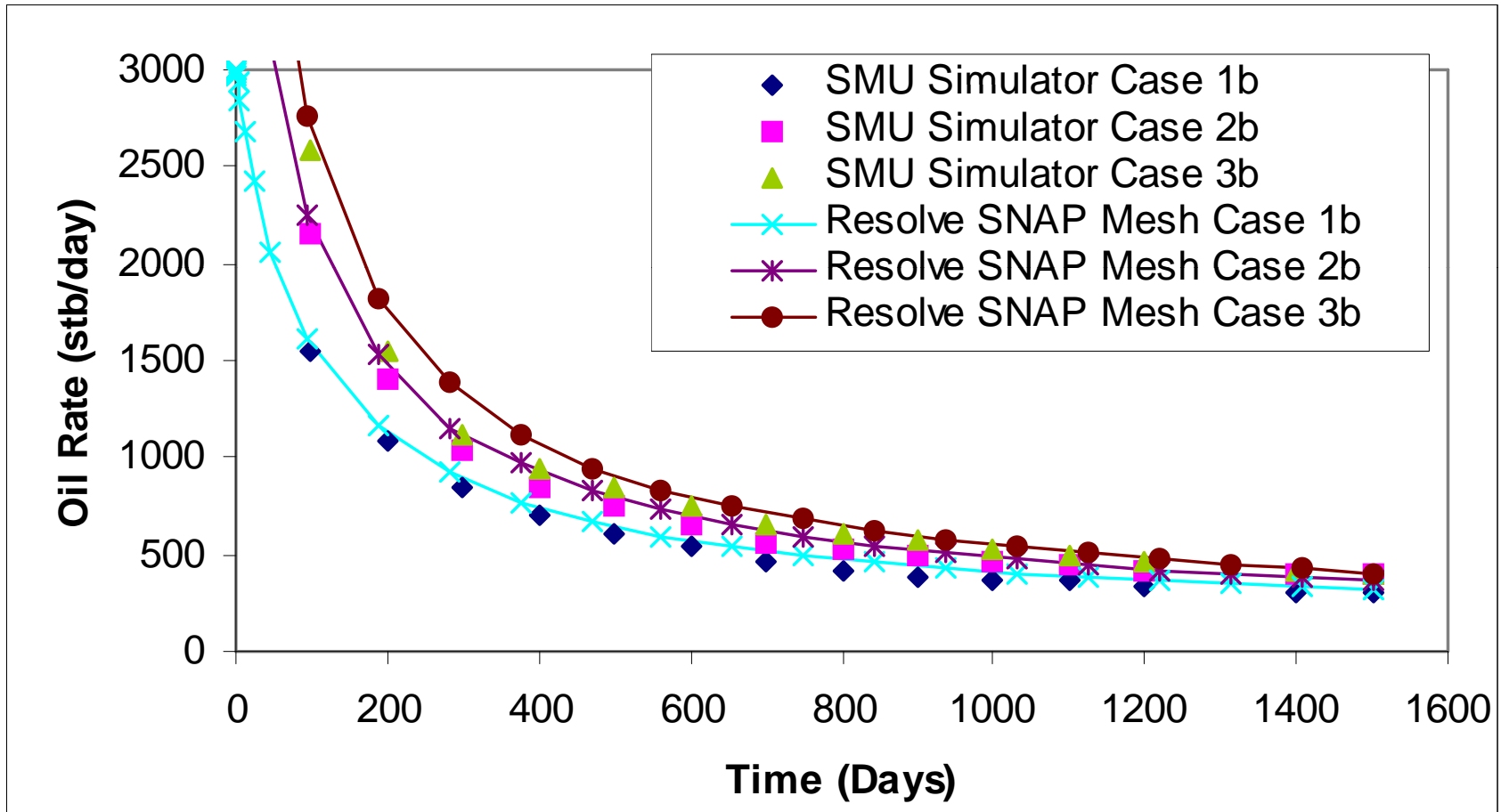
# Oil Rate Sensitivity

## Constant Well Length 900 ft



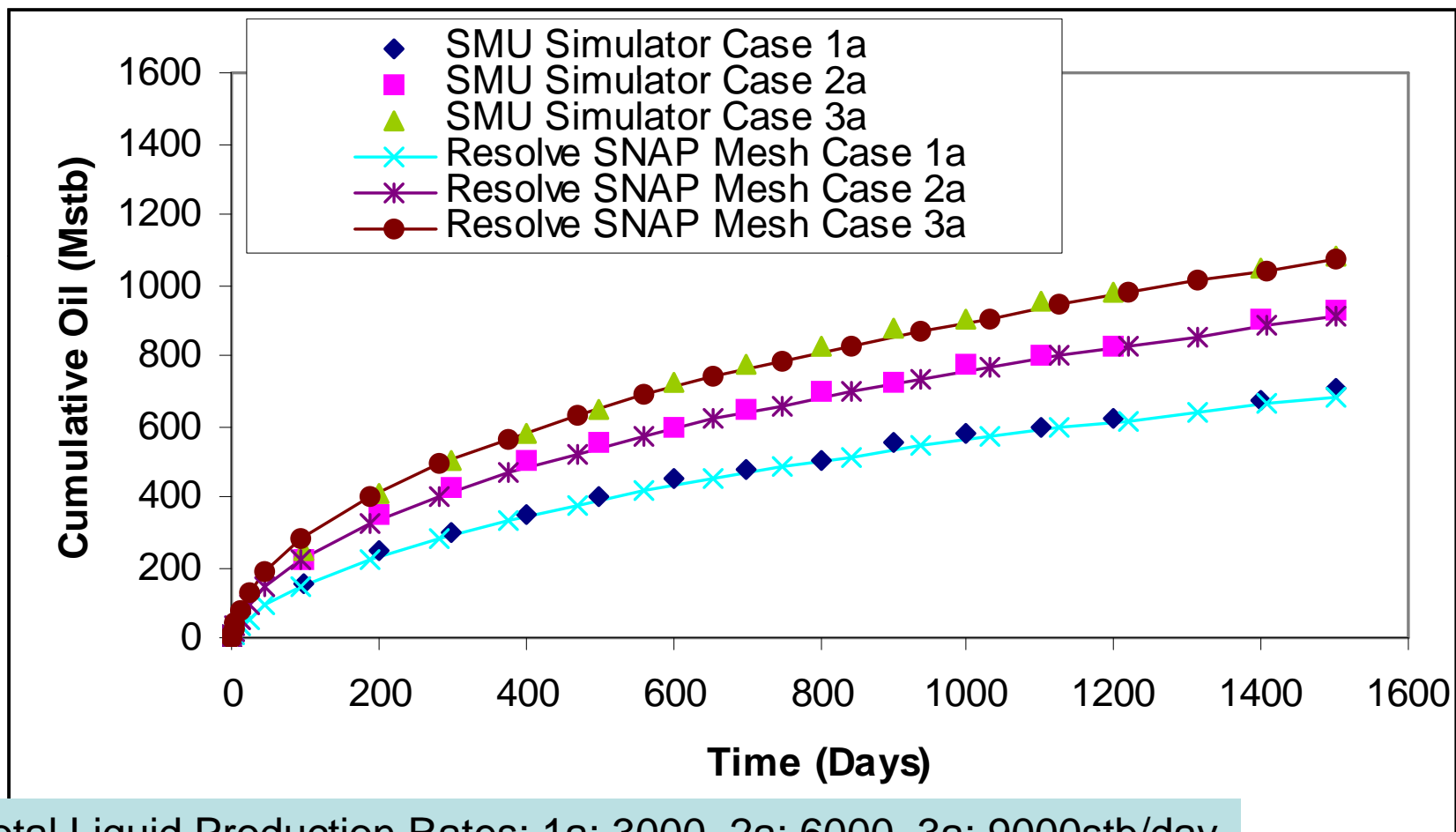
Total Liquid Production Rates: 1a: 3000, 2a: 6000, 3a: 9000stb/day  
 Resolve % Difference with SMU at 1500 days  
 Case 1a, 2a, 3a : 5%, 3%, 2%

# Oil Rate Sensitivity for Constant Well Length 2100 ft



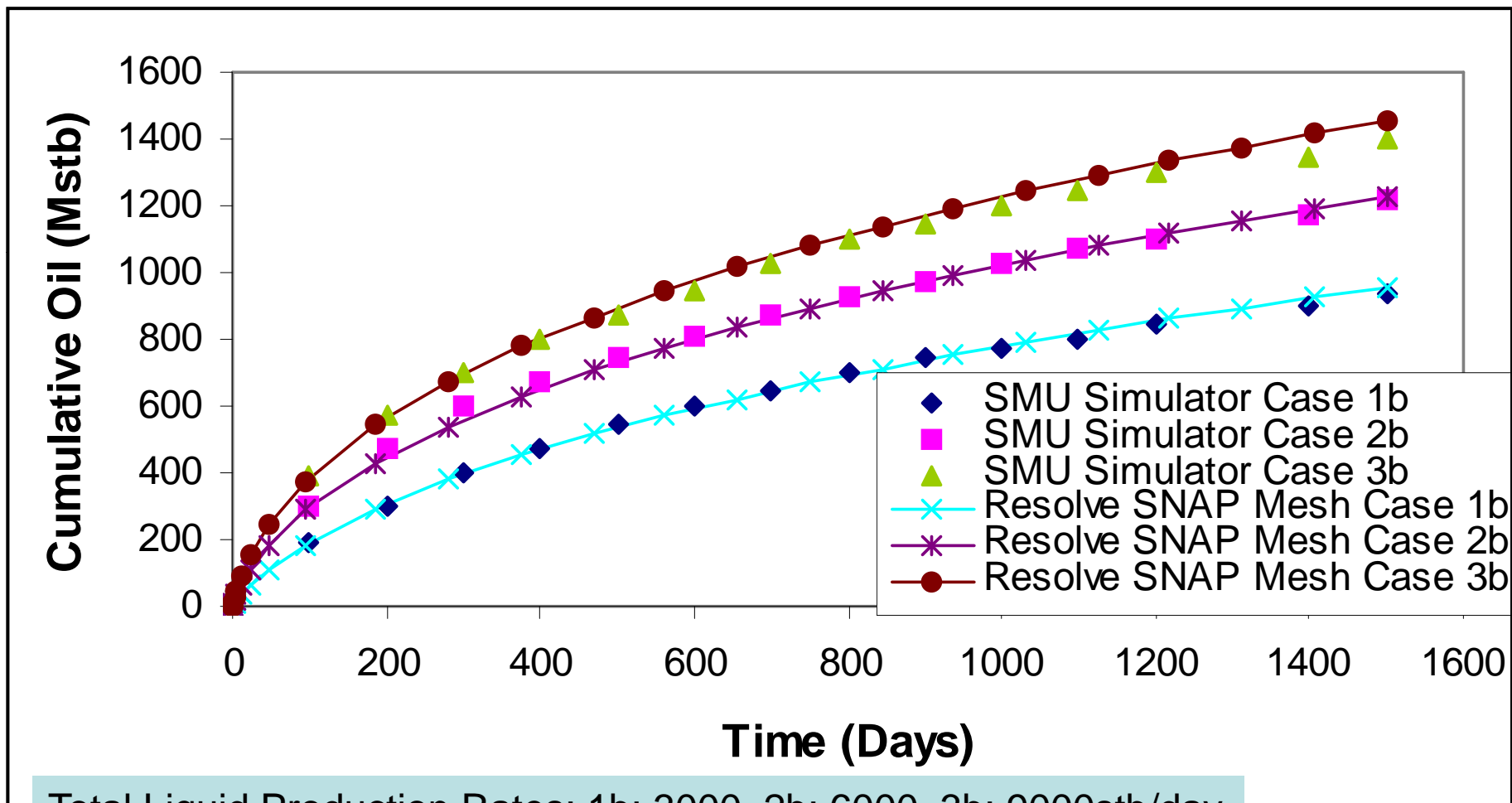
Total Liquid Production Rates: 1b: 3000, 2b: 6000, 3b: 9000stb/day  
 Resolve % Difference with SMU at 1500 days  
 Case 1b, 2b, 3b : 4%, 8%, 1%

# Cumulative Oil Production Sensitivity for Constant Well Length 900 ft



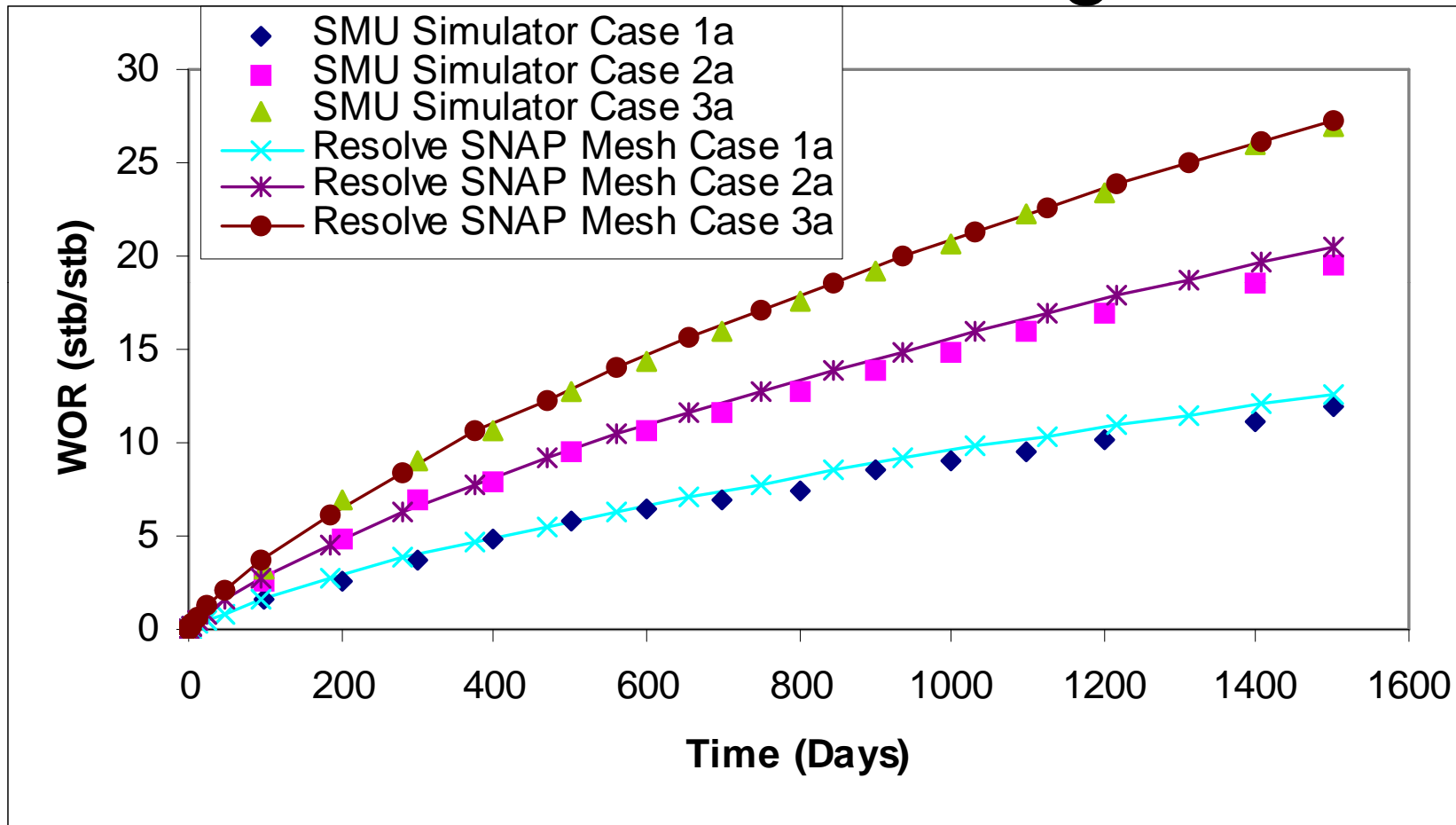
Total Liquid Production Rates: 1a: 3000, 2a: 6000, 3a: 9000stb/day  
 Resolve % Difference with SMU at 1500 days  
 Case 1a, 2a, 3a : 5%, 3%, 2%

# Cumulative Oil Production Sensitivity for Constant Well Length 2100 ft



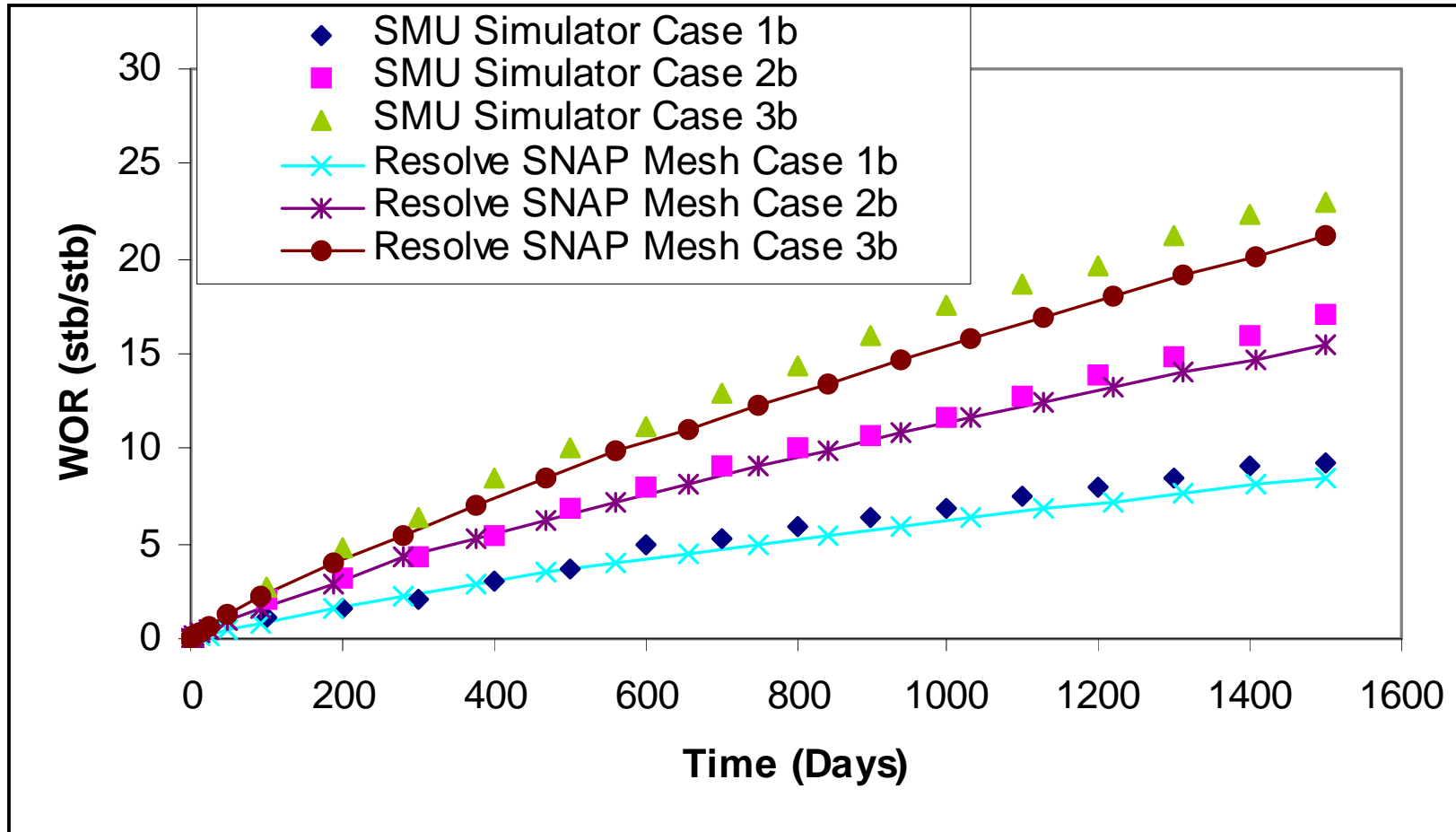
Total Liquid Production Rates: 1b: 3000, 2b: 6000, 3b: 9000stb/day  
 Resolve % Difference with SMU at 1500 days  
 Case 1b, 2b, 3b : 1%, 0%, 3%

# Water-Oil Ratio Sensitivity For Constant Well Length 900 ft



Total Liquid Production Rates: 1a: 3000, 2a: 6000, 3a: 9000stb/day  
 Resolve % Difference with SMU at 1500 days  
 Case 1a, 2a, 3a : 6%, 5%, 1%

# Water-Oil Ratio Sensitivity For Constant Well Length 2100 ft



Total Liquid Production Rates: 1b: 3000, 2b: 6000, 3b: 9000stb/day  
 Resolve % Difference with SMU at 1500 days  
 Case 1b, 2b, 3b : 6%, 8%, 7%

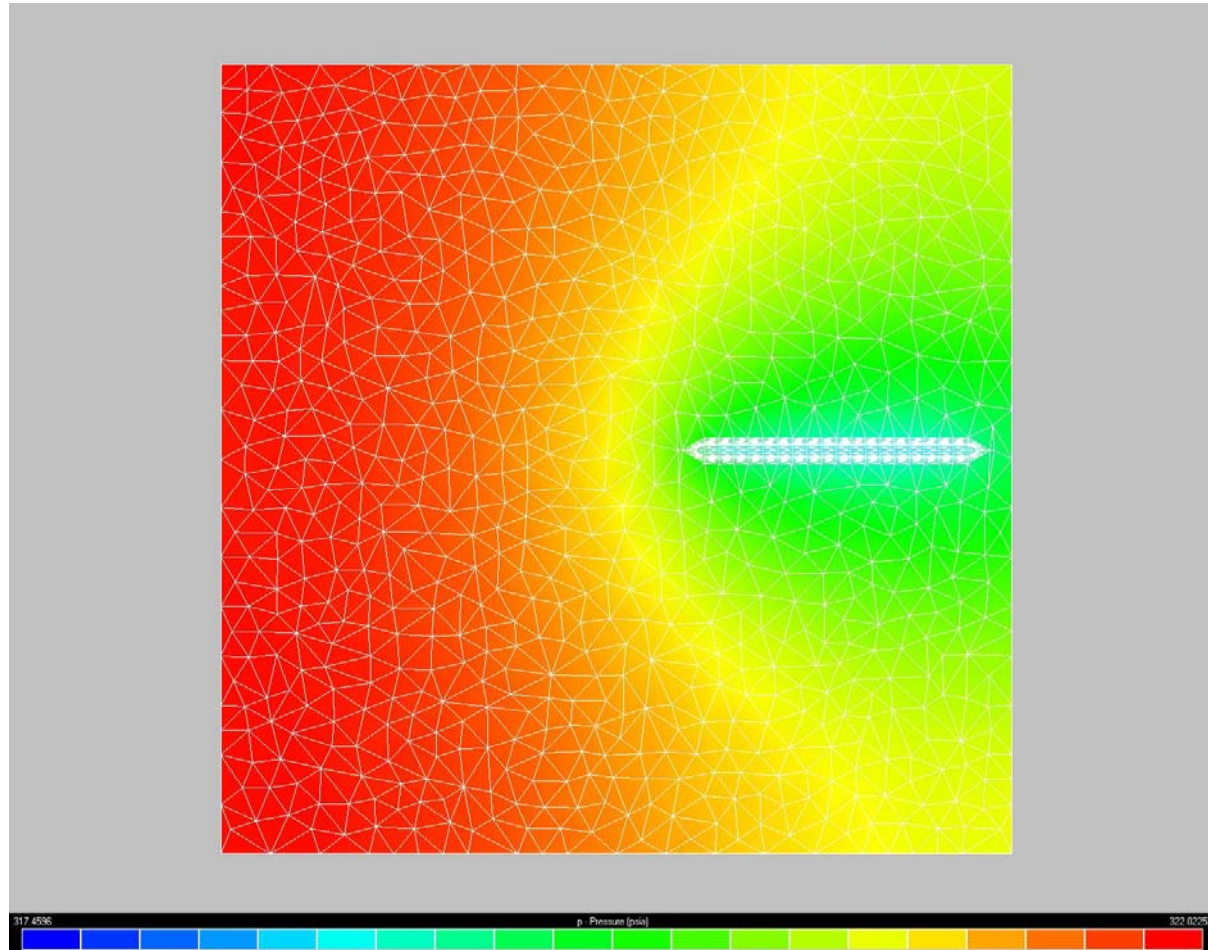
# Cumulative Oil Production (Mstb)

Case	1a	1b	2a	2b	3a	3b
Max	766.2	980.4	1045.9	1257.1	1247.0	1466.8
Mean	735.6	946.4	965.4	1217.8	1102.1	1349.1
Min	678.7	870.2	877.9	1106.1	1017.1	1222.3
Resolve	676	946	899.65	1216	1061.5	1441
% Diff. Mean	8%	0%	7%	0%	4%	7%

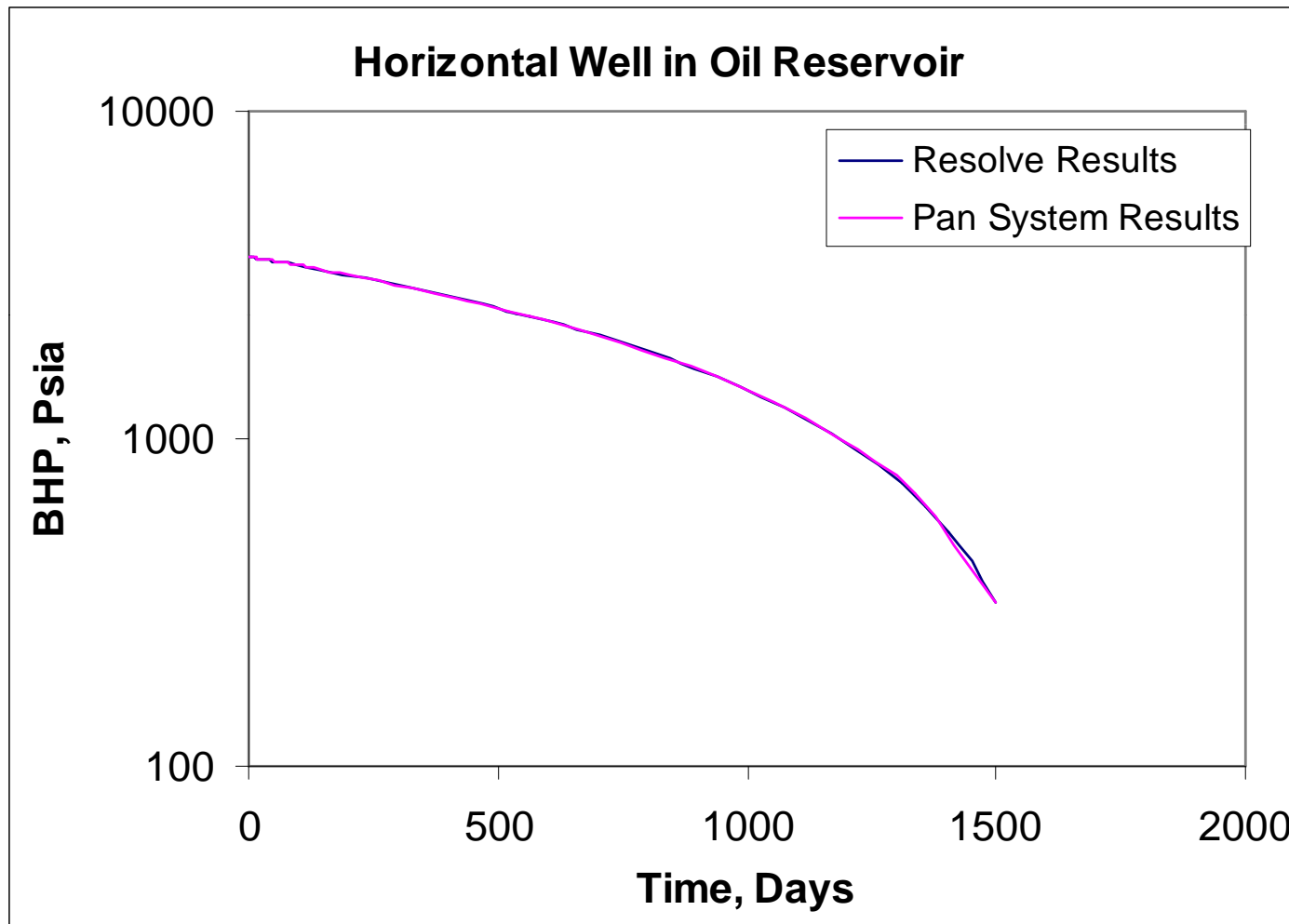
# Single Phase Oil Comparison With Pan System™

- Reservoir Size: 2700 by 2700 ft
- Reservoir Thickness: 110 ft
- Horizontal Well Length 900 ft, 10 ft from top, Parallel along x axis, starts 1650 ft from left boundary
- Well is 1380 ft from bottom and 1320 ft from top boundary
- Constant Rate of 225stb/day
- Reservoir Permeability: 300mD Horizontal and 30mD Vertical, Porosity 0.2, No Residual Water

# Single Phase Oil Pressure Profile at 1500 Days

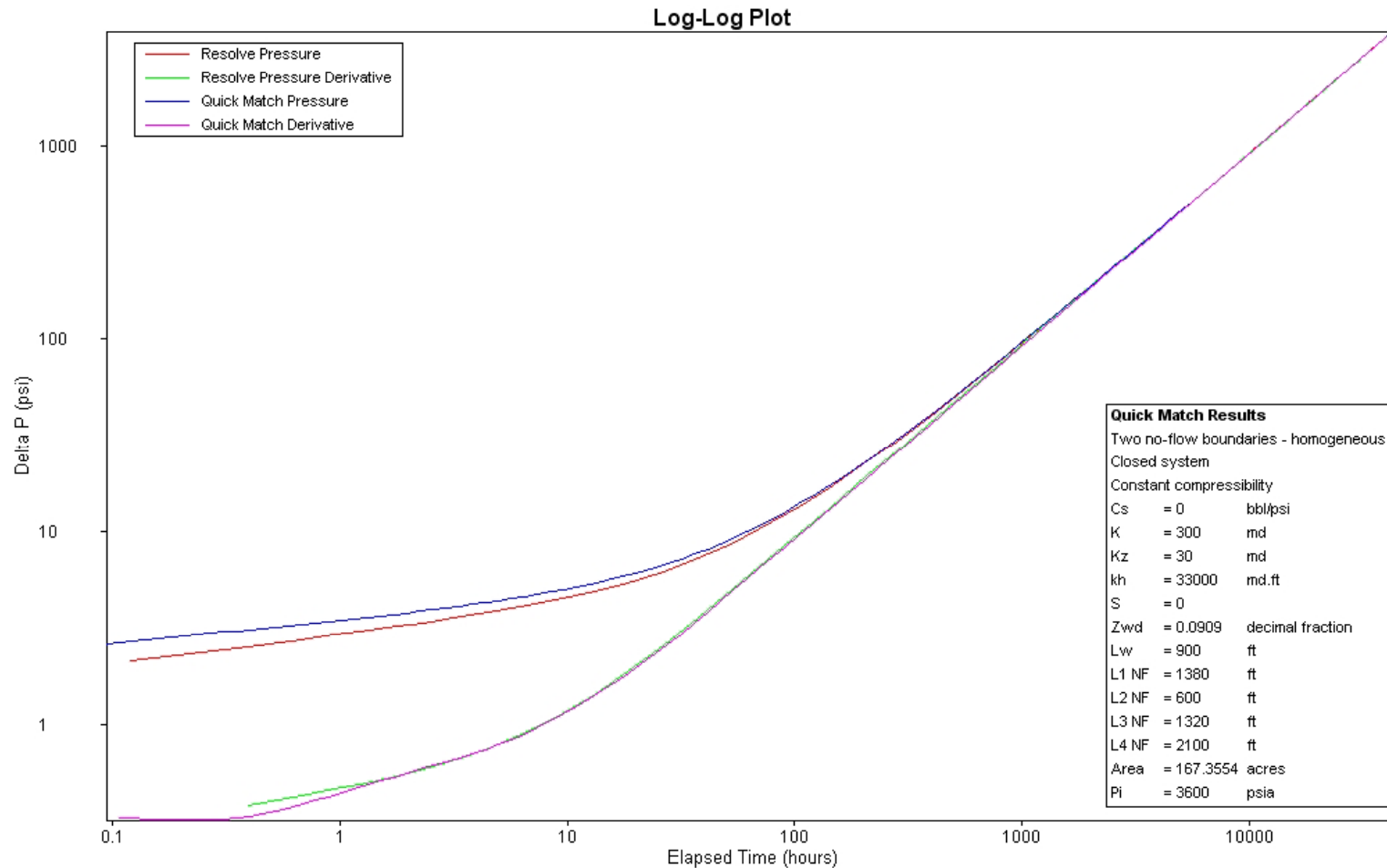


# Comparison Results with Pan



Resolve Pressure are within 1% Agreement with Pan System

# Comparison Results with Pan



Resolve Pressure and Pressure Derivative Behavior are within 1% Agreement with Pan System

# Conclusions

- Resolve agrees within 1% of analytical results for a single phase oil reservoir with a horizontal well.
- For the three-phase case described in SPE 7 horizontal well comparative study, Resolve has good agreement and is within 10% the mean. For most of the cases, the error ranged between 0-8% of the mean.

# SPE 7 Trend Results

- The following trends were published in the SPE 7 study. Resolve agrees with all of the trends, mainly:
  - Increase in Oil Production is Not Directly Proportional to the Well Length
  - Water Coning Effect Slightly Decreases as Well Length Increases
  - As Liquid Production Increases for a Fixed Well Length, the Water Oil Ratio Increases.