

CPE 651 :Undergraduate Summer Research

CMG Simulation Modeling Learning

Presenter: Jason Zhang



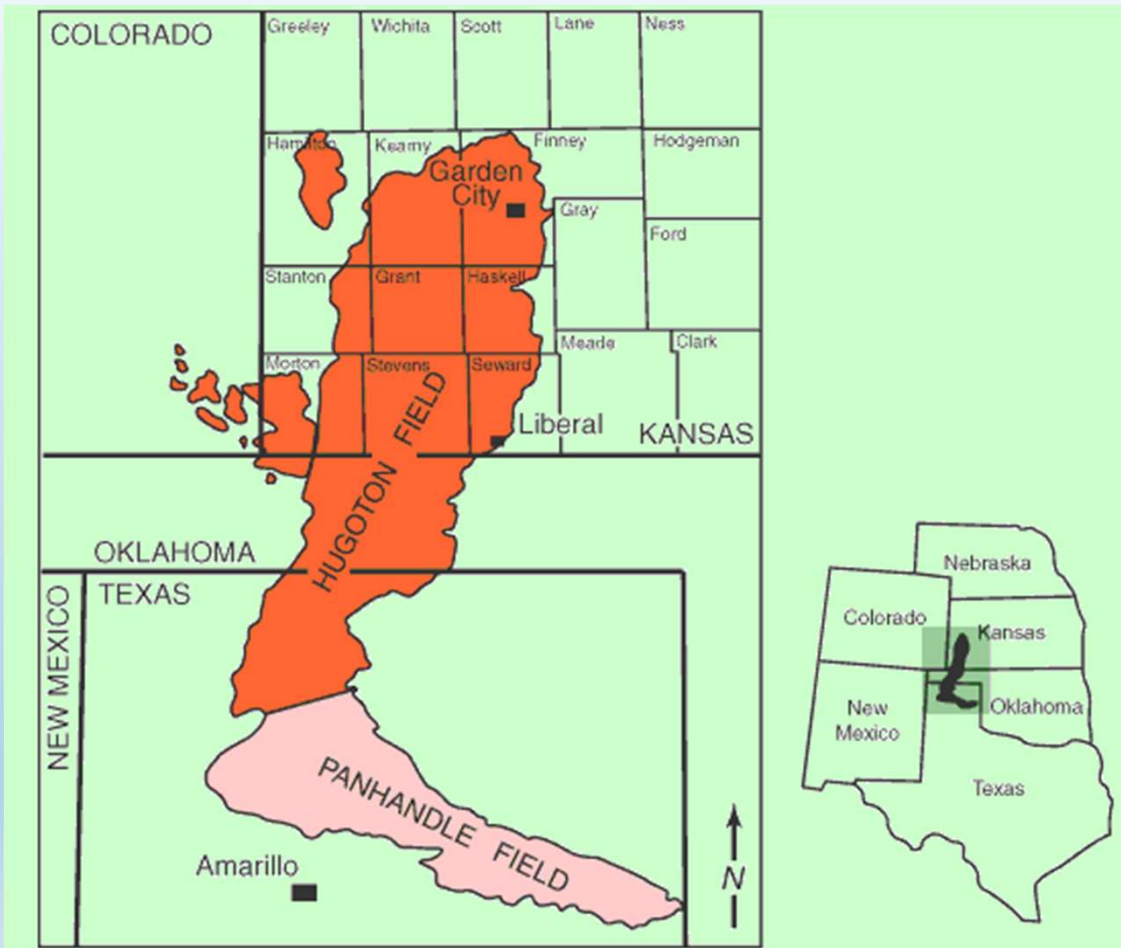
Project Outline

- Project Objective
- Raw Data
- History Matching Procedures and Results
- Future Forecast
- Locations of New Wells to Optimize

Project Objective

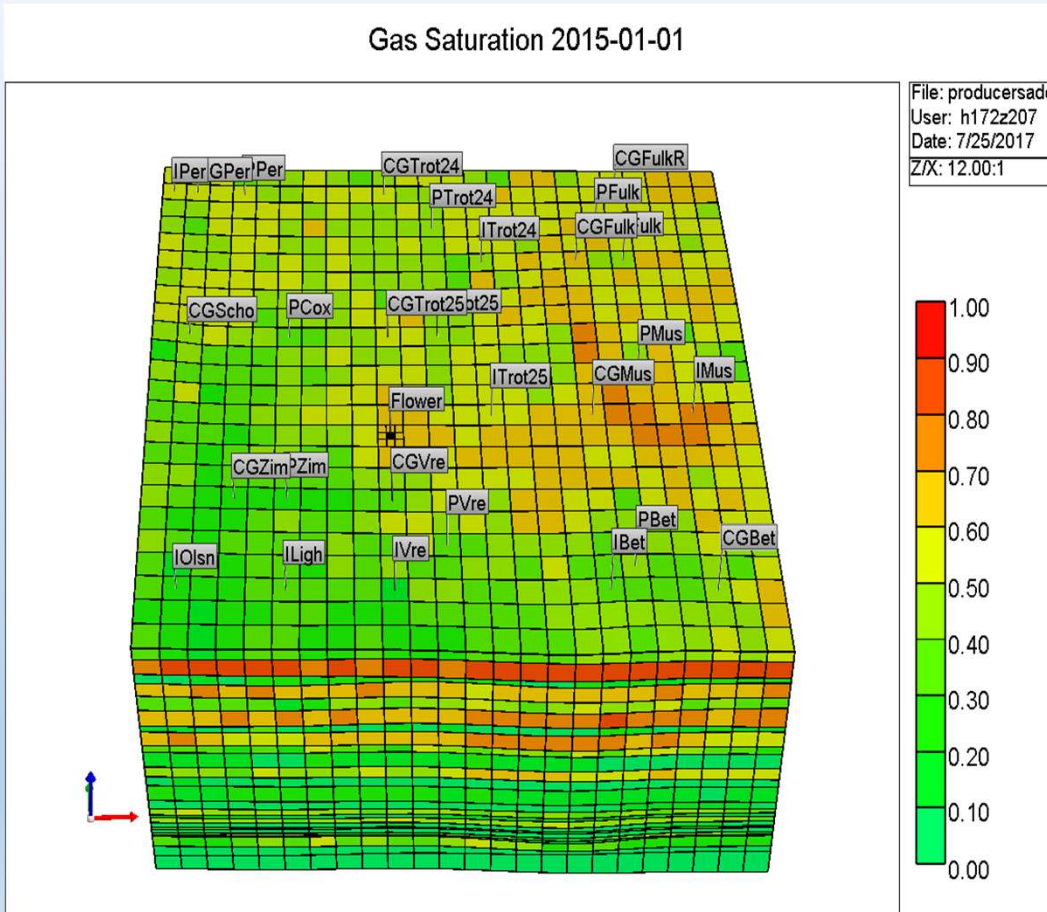
- History Matching for the Gas Field at Kansas Hugoton Flower Area.
- Future Prediction
- Determine the optimum locations for at least two new wells

Hugoton-Panoma Gas Field



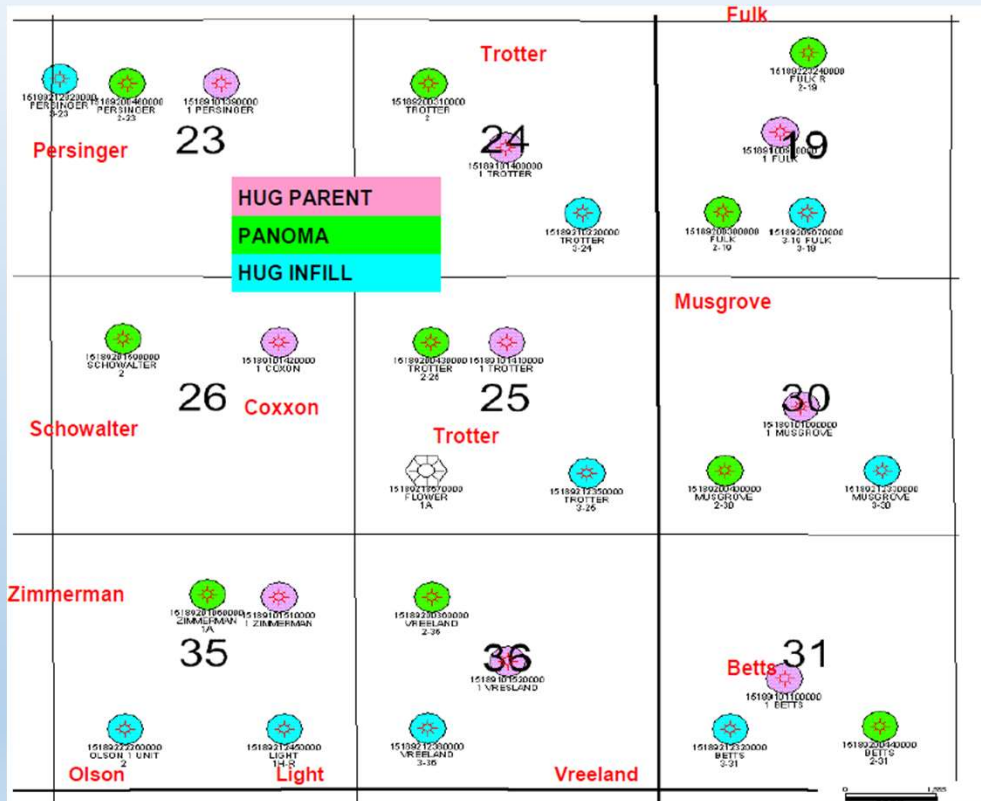
Initial Reservoir Condition

Gas Saturation 2015-01-01



The reservoir interested has 24x24 blocks in the X and Y directions and has 25 layers, single porosity. There are 29 wells and had been perforated at different time.

Well Location



Group	Formation / Member	LAYER
Chase	HRNGTN	1
	KRIDER	2
	ODELL	3
	WINF	4
	GAGE	5
	TOWANDA	6
	HOLMESVILLE	7
	FT RILEY	8
	L/FT RILEY	9
	MATFIELD	10
	WREFORD	11
Council Grove	A1_SH	12
	A1_LM	13
	B1_SH	14
	B1_LM	15
	B2_SH	16
	B2_LM	17
	B3_SH	18
	B3_LM	19
	B4_SH	20
	B4_LM	21
	B5_SH	22
	B5_LM	23
	C_SH	24
	C_LM	25

Table 1: Chase and Council Grove settings

Data Given



Table 2: Rock compressibility

Property	Value		
Reference pressure	465	psi	
Rock compressibility	0.000002	1/psi	(assumed)

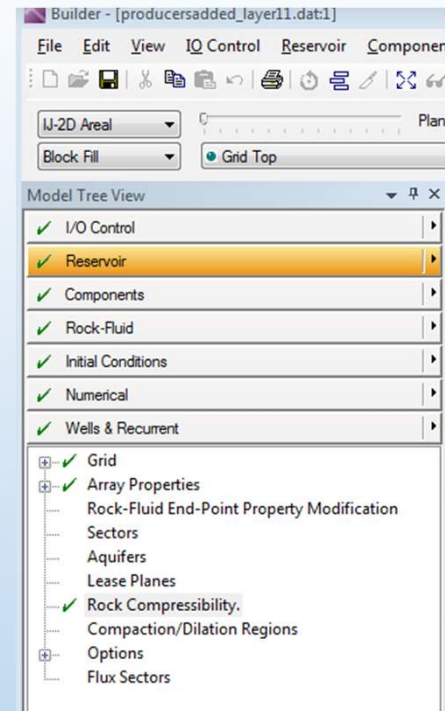
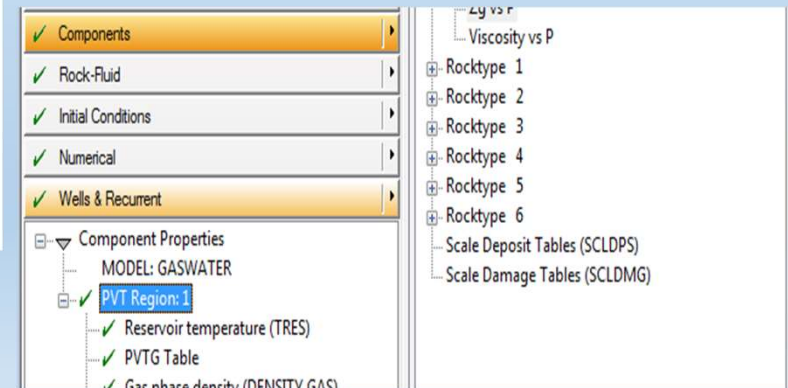


Table 3: PVT properties of the Hugoton gas field

Property	Value		
Reference pressure	465	psi	
Max Pressure	500	psi	
Reservoir temp	90	F	
Gas gravity (Air = 1.0)	0.715		
Water salinity	110,000	ppm	



Data Given

A.

SW	KRW	KRG
0.25	0.0000	0.40
0.30	0.0000	0.31
0.35	0.0000	0.23
0.40	0.0000	0.16
0.45	0.0002	0.10
0.50	0.0006	0.06
0.55	0.0013	0.02
0.60	0.0024	0.00
0.65	0.0042	0.00
0.70	0.0068	0.00
0.75	0.0103	0.00
0.80	0.0152	0.00
0.85	0.0215	0.00
0.90	0.0296	0.00
0.95	0.0399	0.00
1.00	0.0526	0.00

Rock Type 1)
 $K \leq 0.0001$ md

B.

SW	KRW	KRG
0.12	0.0000	0.69
0.15	0.0000	0.65
0.20	0.0000	0.54
0.25	0.0000	0.44
0.30	0.0001	0.35
0.35	0.0004	0.27
0.40	0.0010	0.19
0.45	0.0020	0.13
0.50	0.0036	0.08
0.55	0.0060	0.05
0.60	0.0093	0.02
0.65	0.0140	0.00
0.70	0.0202	0.00
0.75	0.0283	0.00
0.80	0.0386	0.00
0.85	0.0515	0.00
0.90	0.0673	0.00
0.95	0.0866	0.00
1.00	0.1096	0.00

Rock Type 2)
 $0.0001 < K < 0.001$ md

C.

SW	KRW	KRG
0.06	0.0000	0.97
0.10	0.0000	0.88
0.15	0.0000	0.76
0.20	0.0000	0.65
0.25	0.0003	0.54
0.30	0.0009	0.44
0.35	0.0019	0.35
0.40	0.0037	0.26
0.45	0.0065	0.19
0.50	0.0106	0.13
0.55	0.0165	0.08
0.60	0.0244	0.04
0.65	0.0350	0.02
0.70	0.0486	0.00
0.75	0.0658	0.00
0.80	0.0873	0.00
0.85	0.1136	0.00
0.90	0.1455	0.00
0.95	0.1836	0.00
1.00	0.2288	0.00

Rock Type 3)
 $0.001 < K < 0.01$ md

D.

SW	KRW	KRG
0.01	0.0000	0.9803
0.05	0.0000	0.9331
0.10	0.0000	0.8632
0.15	0.0000	0.7913
0.20	0.0000	0.7182
0.25	0.0000	0.6449
0.30	0.0000	0.5723
0.35	0.0000	0.5012
0.40	0.0002	0.4323
0.45	0.0005	0.3666
0.50	0.0013	0.3045
0.55	0.0029	0.2470
0.60	0.0061	0.1944
0.65	0.0119	0.1475
0.70	0.0220	0.1066
0.75	0.0390	0.0721
0.80	0.0667	0.0444
0.85	0.1104	0.0235
0.90	0.1774	0.0095
0.95	0.2780	0.0019
1.00	0.4255	0.0000

Rock Type 4)
 $0.01 < K < 0.1$ md

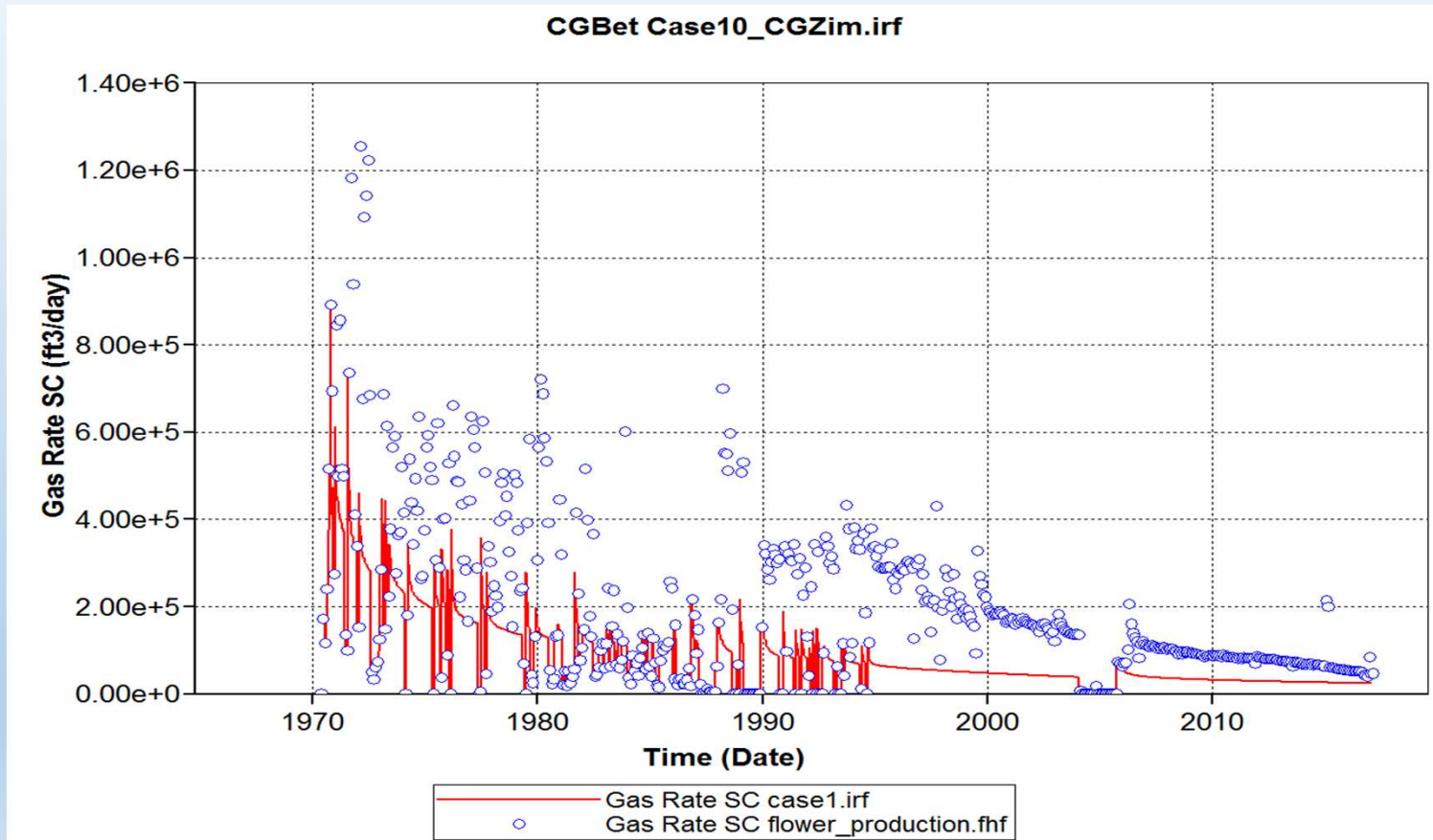
SW	KRW	KRG
0.01	0.0000	0.9803
0.05	0.0000	0.9331
0.10	0.0000	0.8632
0.15	0.0000	0.7913
0.20	0.0000	0.7182
0.25	0.0000	0.6449
0.30	0.0000	0.5723
0.35	0.0000	0.5012
0.40	0.0002	0.4323
0.45	0.0006	0.3666
0.50	0.0015	0.3045
0.55	0.0034	0.2470
0.60	0.0072	0.1944
0.65	0.0140	0.1475
0.70	0.0258	0.1066
0.75	0.0459	0.0721
0.80	0.0784	0.0444
0.85	0.1297	0.0235
0.90	0.2085	0.0095
0.95	0.3266	0.0019
1.00	0.4999	0.0000

Rock Type 5)
 $K > 0.1$ md

- ✓ Components
- ✓ Rock-Fluid
- ✓ Initial Conditions
- ✓ Numerical
- ✓ Wells & Recurrent
- ✓ Rock Fluid Options
 - ✓ Rock Fluid Types
 - ✓ Rocktype 1
 - ✓ Rocktype 2
 - ✓ Rocktype 3
 - ✓ Rocktype 4
 - ✓ Rocktype 5
 - ✓ Rocktype 6
 - Seawater Scale Buildup

Table 4: Relative-permeability tables for respective rock-types used in single- and multi-section simulation studies.

History Matching



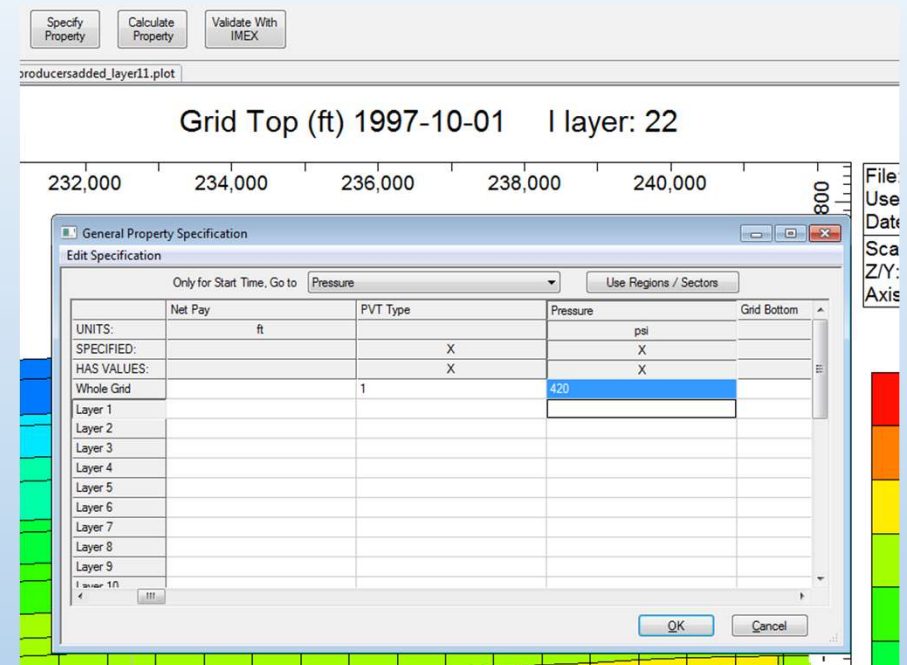
History Matching

CGBet 1970-06-01 PRODUCER

Perforations Rel.Perm.Options

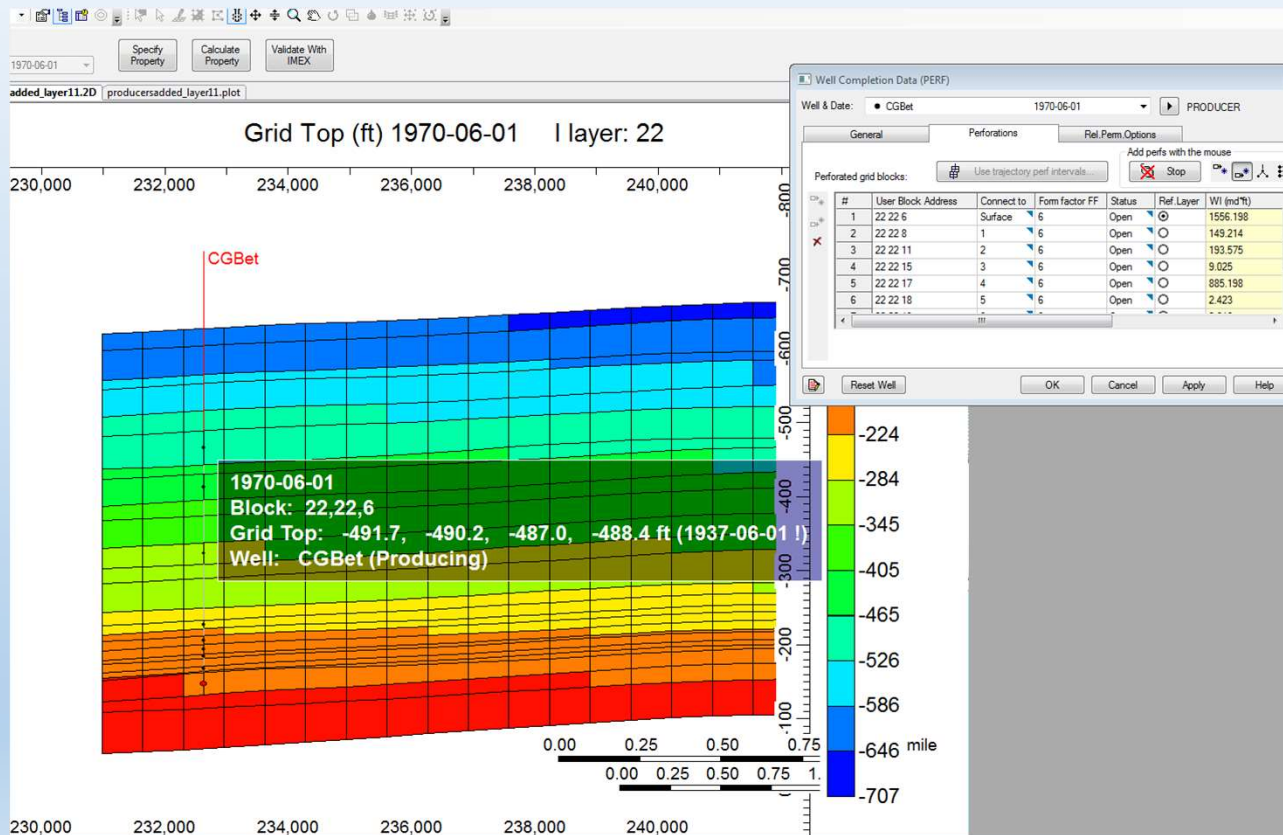
Use trajectory perf intervals... Add perfs with the mouse Begin

Perforation Block Address	Connect to	Form factor FF	Status	Ref. Layer	WI (md'ft)	Length (ft)	Block Top (ft)	Block Bottom (ft)
22 6	Surface	6	Open	⊕	1556.198	46.357	-489.325	-442.968
22 8	1	6	Open	○	149.214	35.472	-430.693	-395.221
22 11	2	6	Open	○	193.575	29.102	-337.961	-308.859
22 15	3	6	Open	○	9.025	11.094	-232.939	-221.845
22 17	4	6	Open	○	885.198	11.799	-212.059	-200.26
22 18	5	6	Open	○	2.423	13.206	-200.26	-187.055
22 19	6	6	Open	○	2.616	5.115	-187.055	-181.94
22 21	7	6	Open	○	32.557	7.062	-171.328	-164.266
22 23	8	6	Open	○	387.731	30.427	-162.793	-132.366

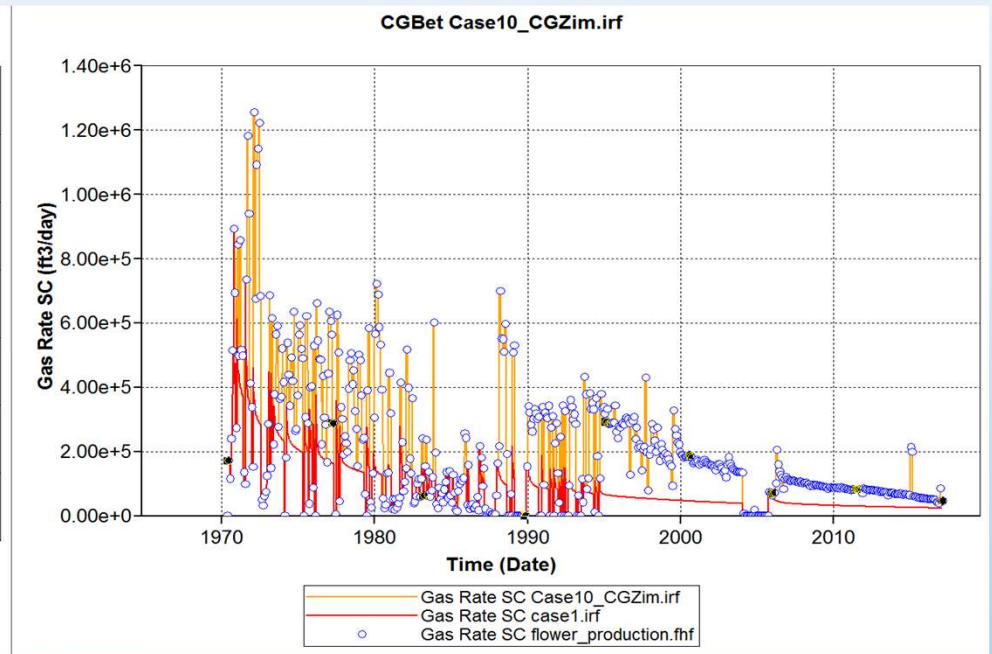
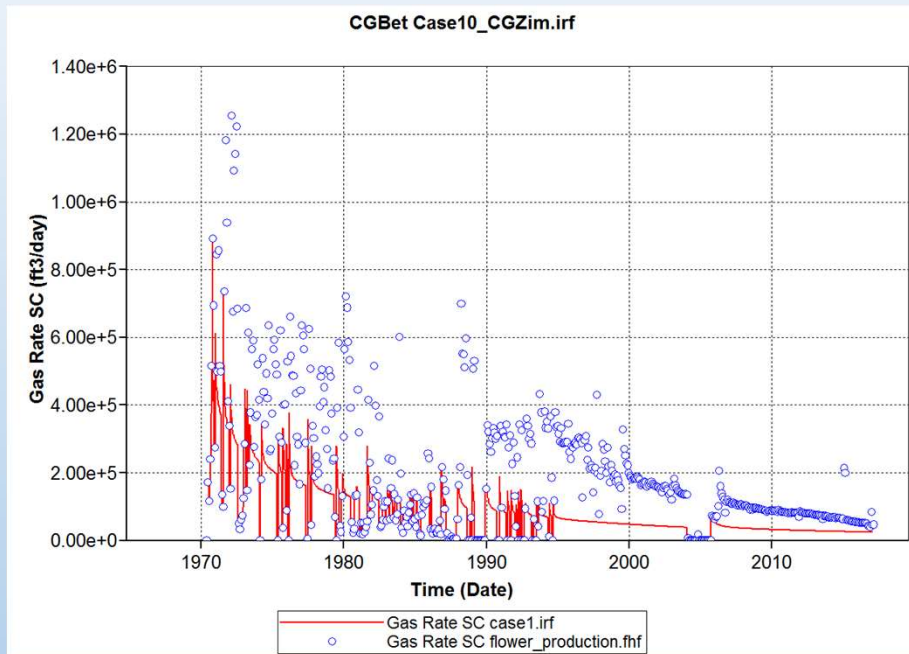


The ff-factor = 1 represents unfeathered well and $ff > 1$ represents a well that has been hydraulically fractured. The initial reservoir pressure is 460 and can vary between 400-500psi.

History Matching



History Matching

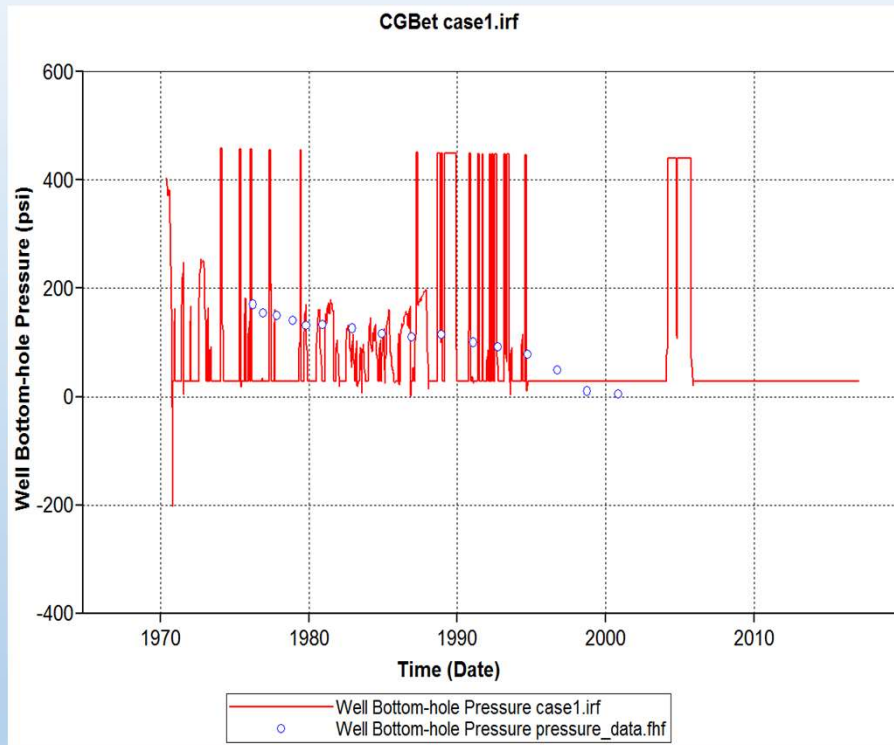


Initial State

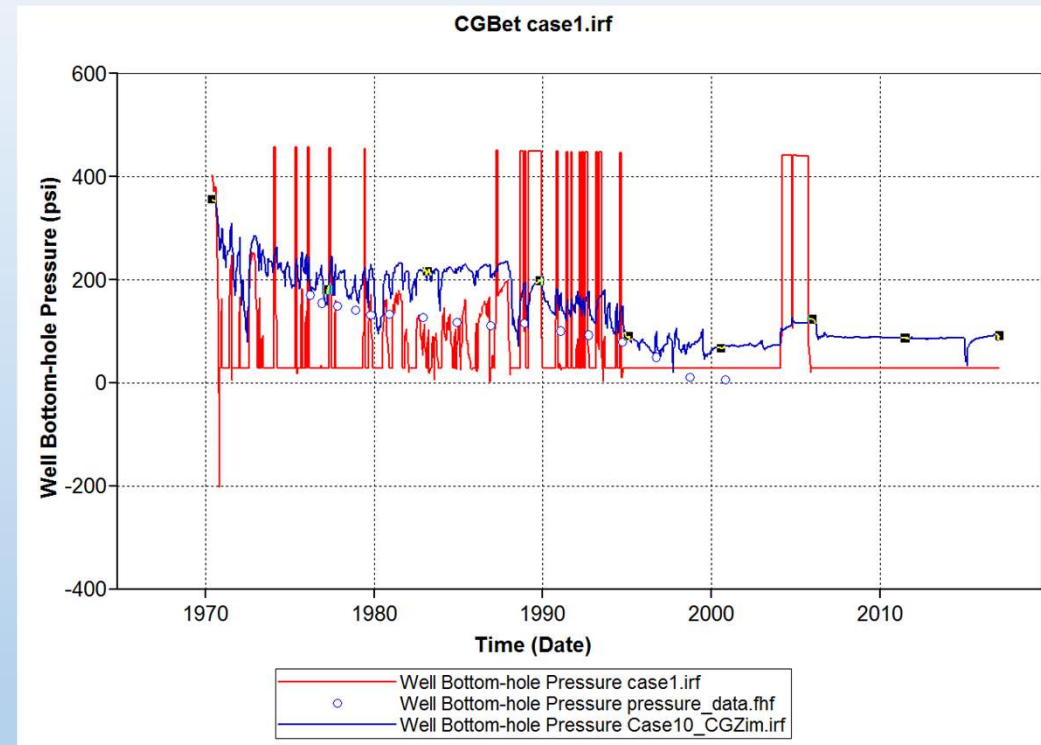
History Matched

CGBet

History Matching

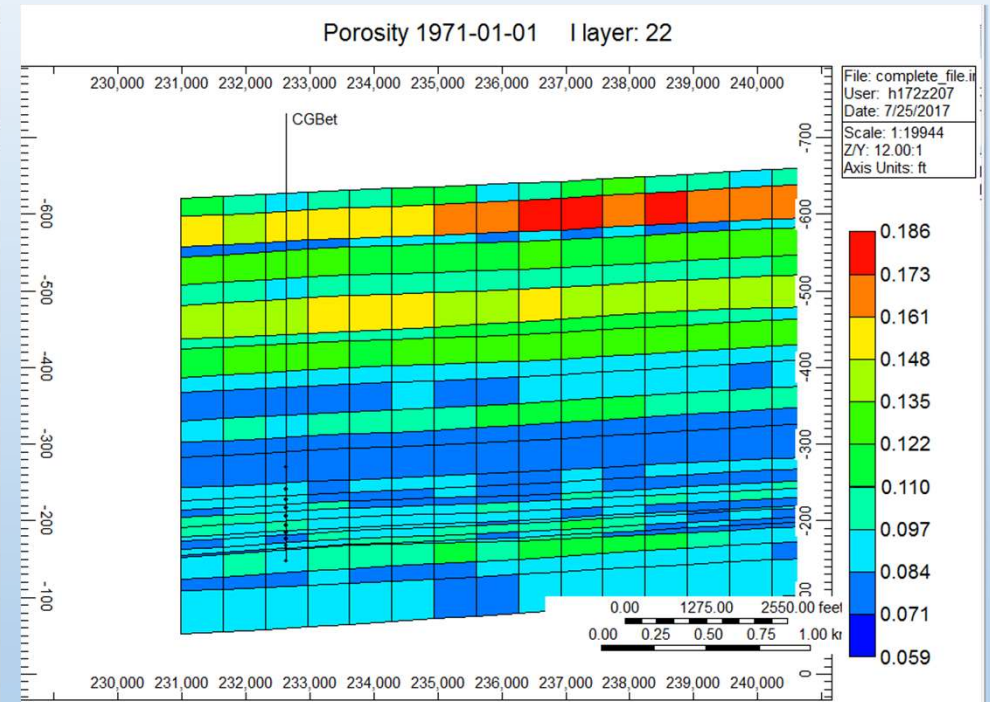
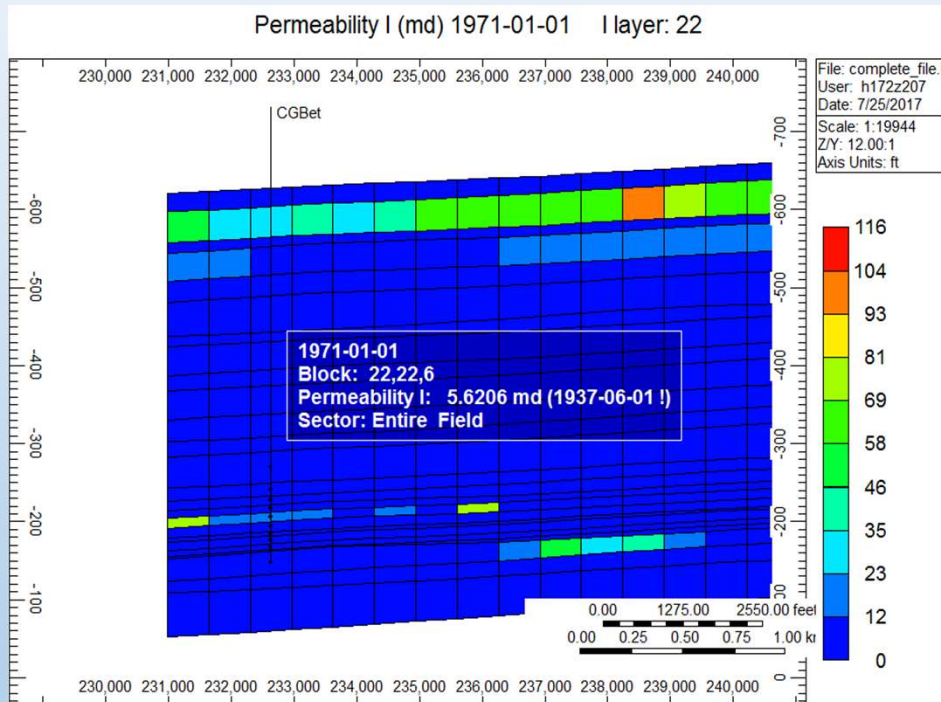


Initial State

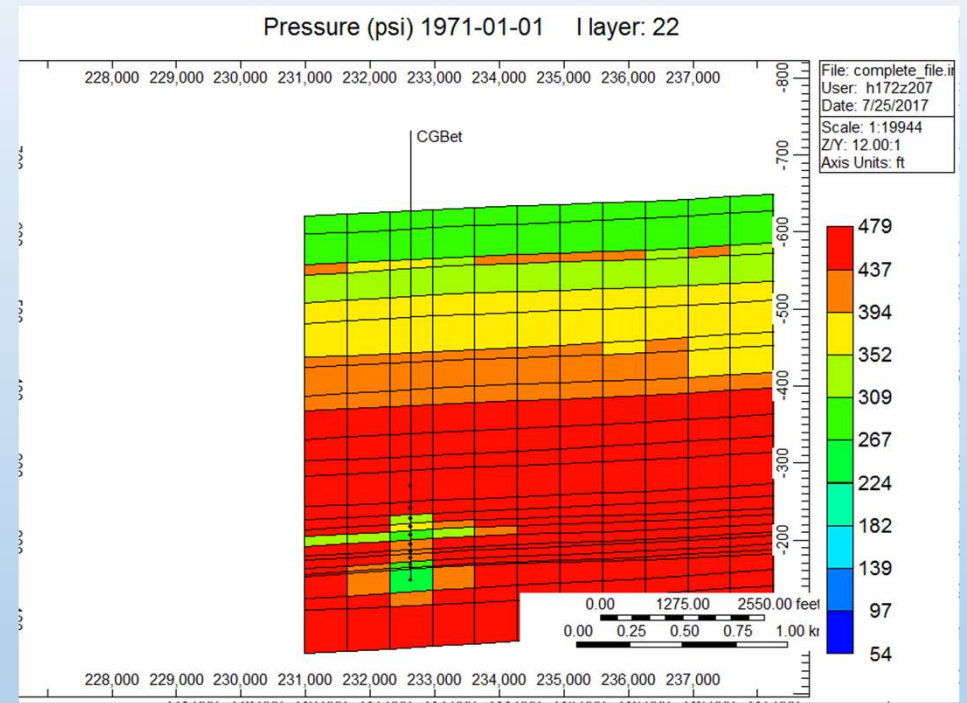
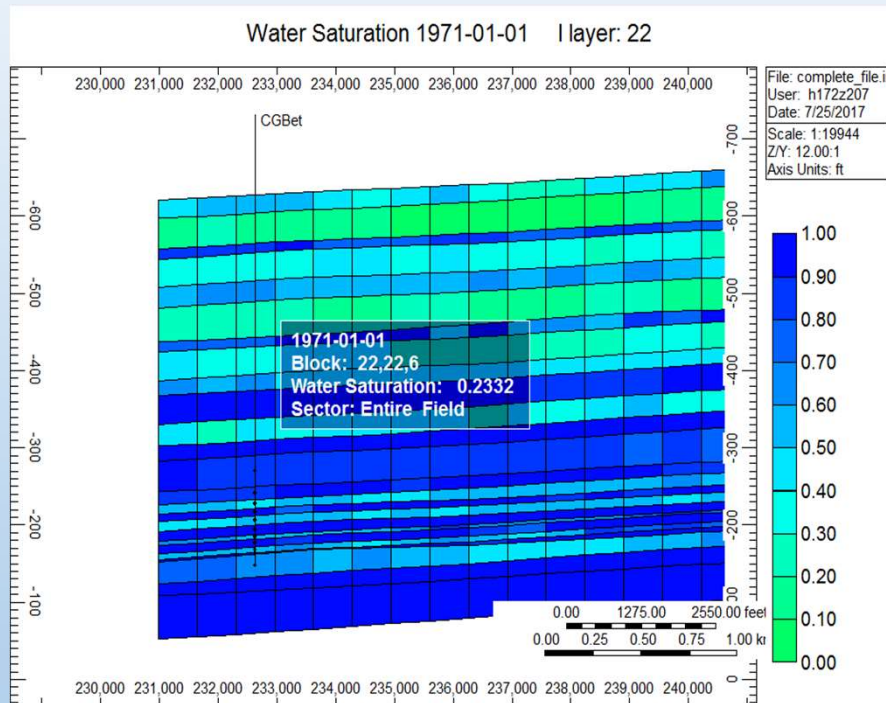


History Matched

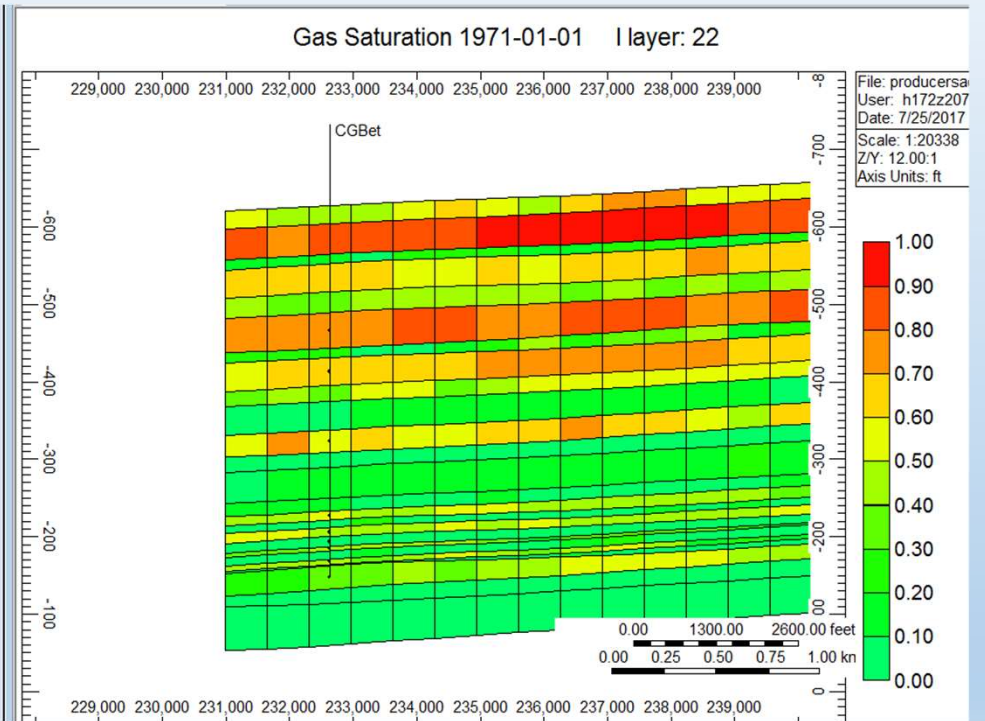
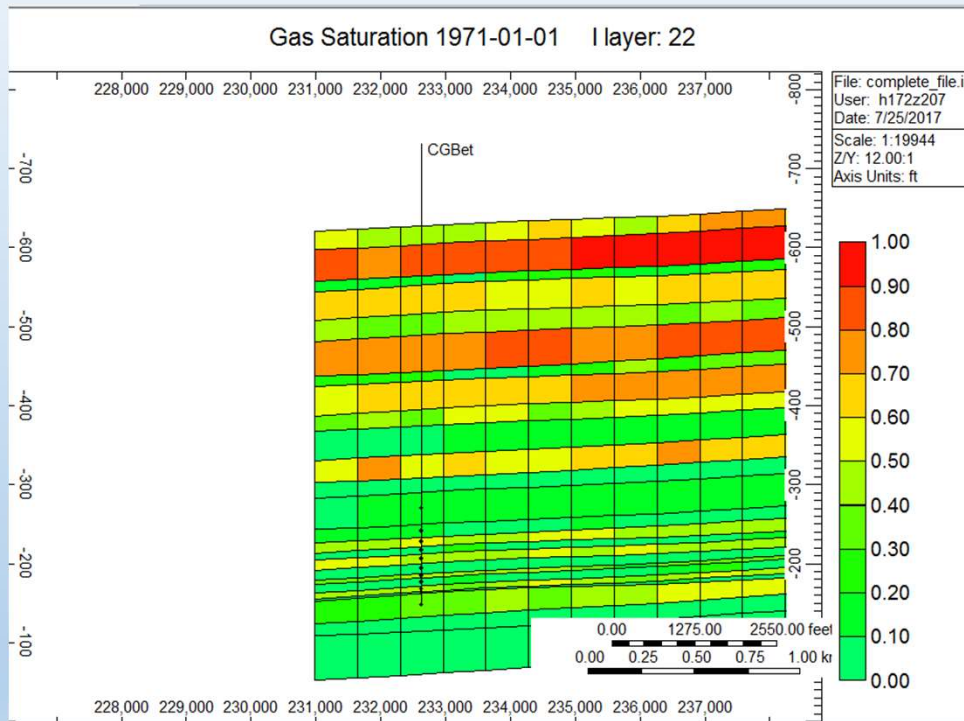
History Matching



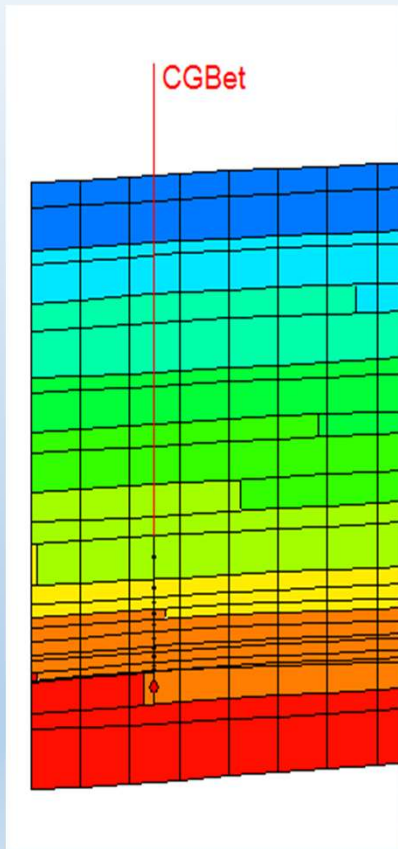
History Matching



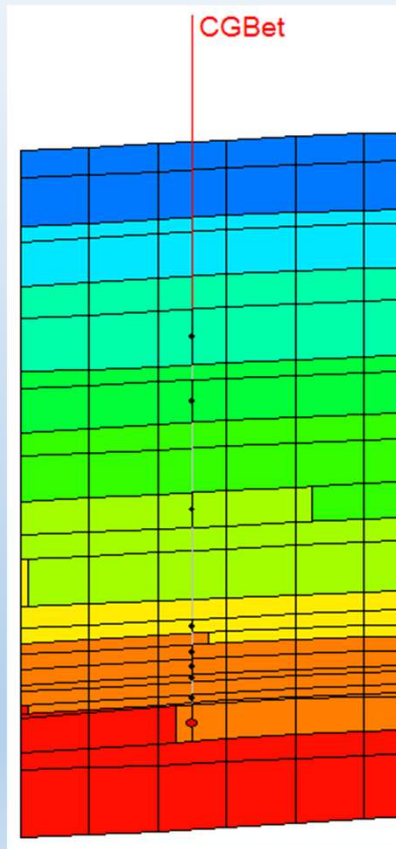
History Matching



History Matching



Before



After

#	User Block Address	Connect to	Form factor FF	Status	Ref.Layer	WI (md*ft)	L
1	22 22 13	Surface	6	Open	⊙	1.936	4
2	22 22 14	1	6	Open	○	1.585	1
3	22 22 15	2	6	Open	○	9.025	1
4	22 22 16	3	6	Open	○	0.328	9
5	22 22 17	4	6	Open	○	885.198	1
6	22 22 18	5	6	Open	○	2.423	1
7	22 22 19	6	6	Open	○	2.616	5
8	22 22 20	7	6	Open	○	0.367	1
9	22 22 21	8	6	Open	○	32.557	7
10	22 22 22	9	6	Open	○	0.077	1
* 11	22 22 23	10	6	Open	○	387.731	3

After

Well & Date: ● CGBet 1970-06-01 PRODUCER

General Perforations Rel.Perm.Options

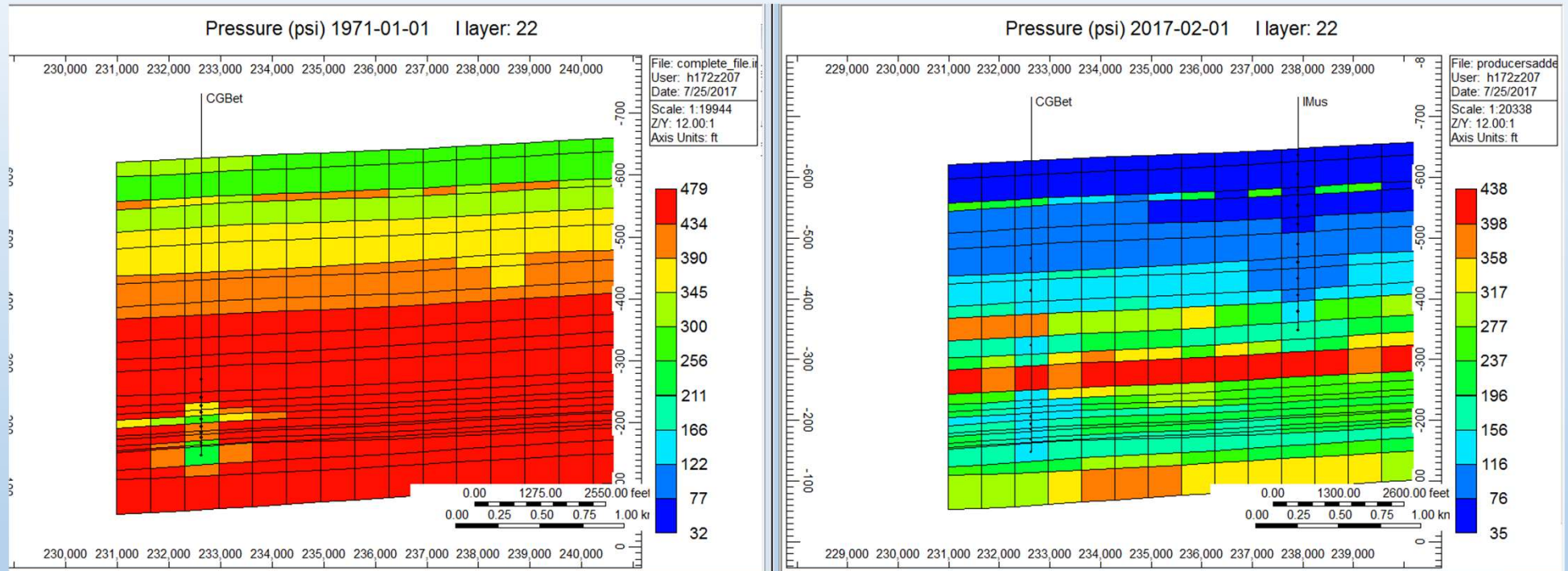
Add perms with the mouse

Perforated grid blocks: Use trajectory perf intervals...

#	User Block Address	Connect to	Form factor FF	Status	Ref.Layer	WI (md*ft)
1	22 22 6	Surface	6	Open	⊙	1556.198
2	22 22 8	1	6	Open	○	149.214
3	22 22 11	2	6	Open	○	193.575
4	22 22 15	3	6	Open	○	9.025
5	22 22 17	4	6	Open	○	885.198
6	22 22 18	5	6	Open	○	2.423
7	22 22 19	6	6	Open	○	2.616
8	22 22 21	7	6	Open	○	32.557
* 9	22 22 23	8	6	Open	○	387.731

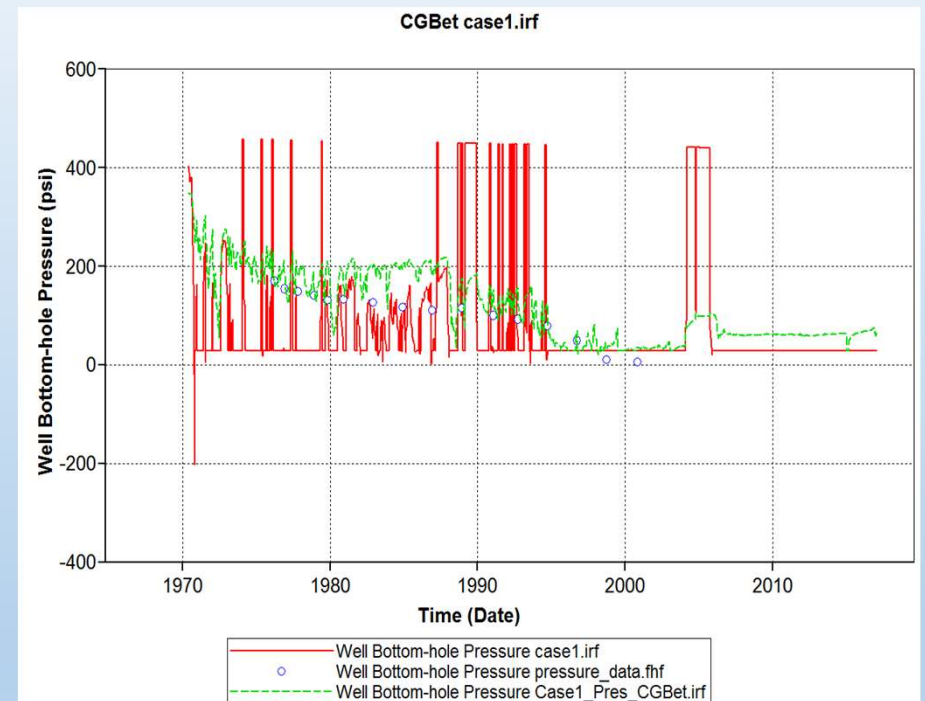
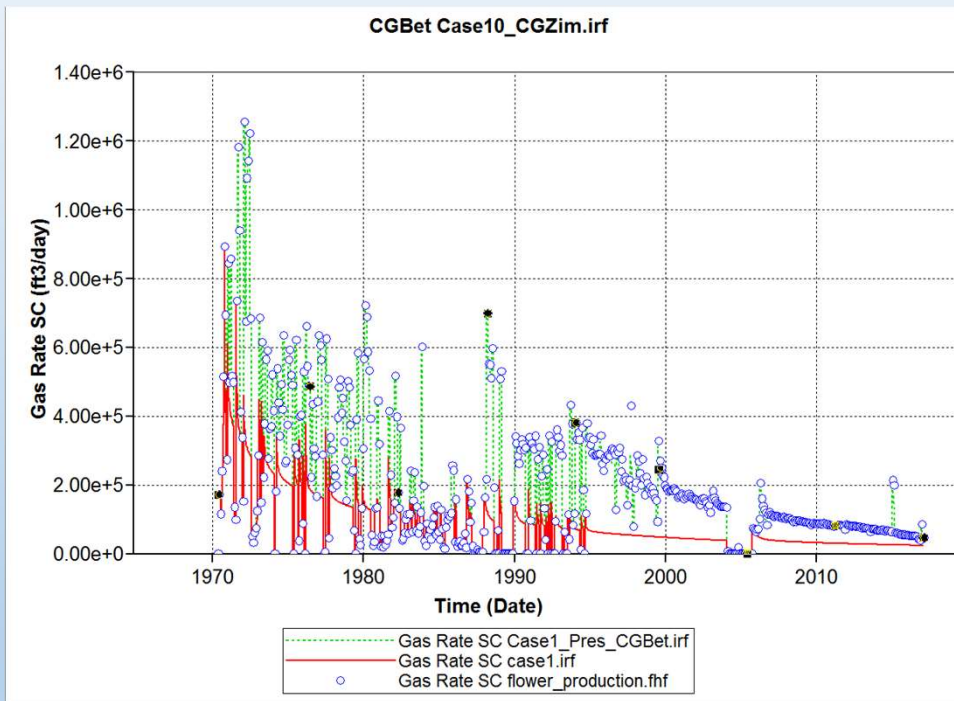
Before

History Matching

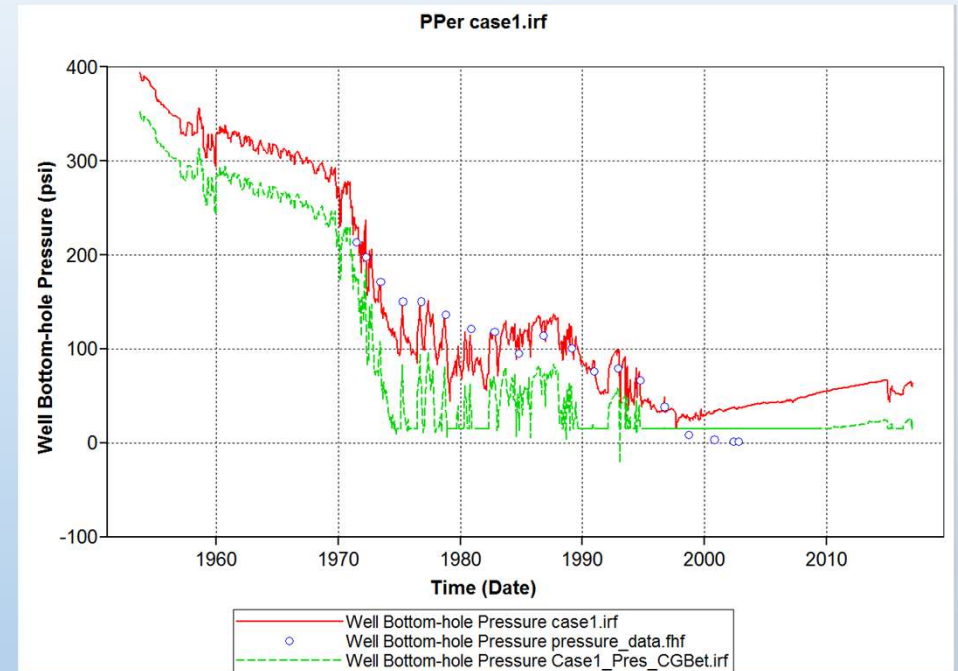
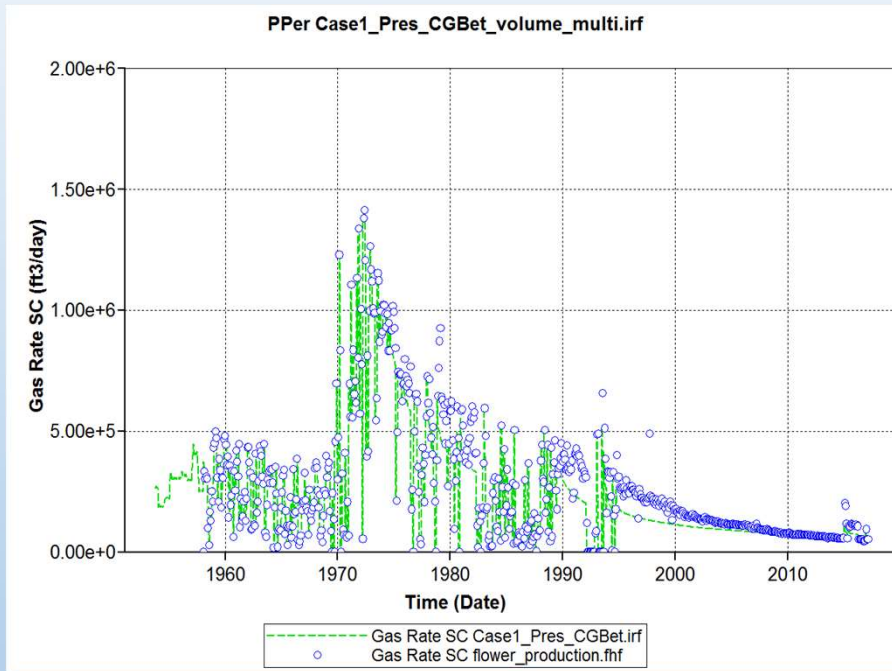
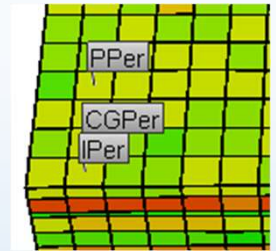


Decrease in Pressure

History Matching

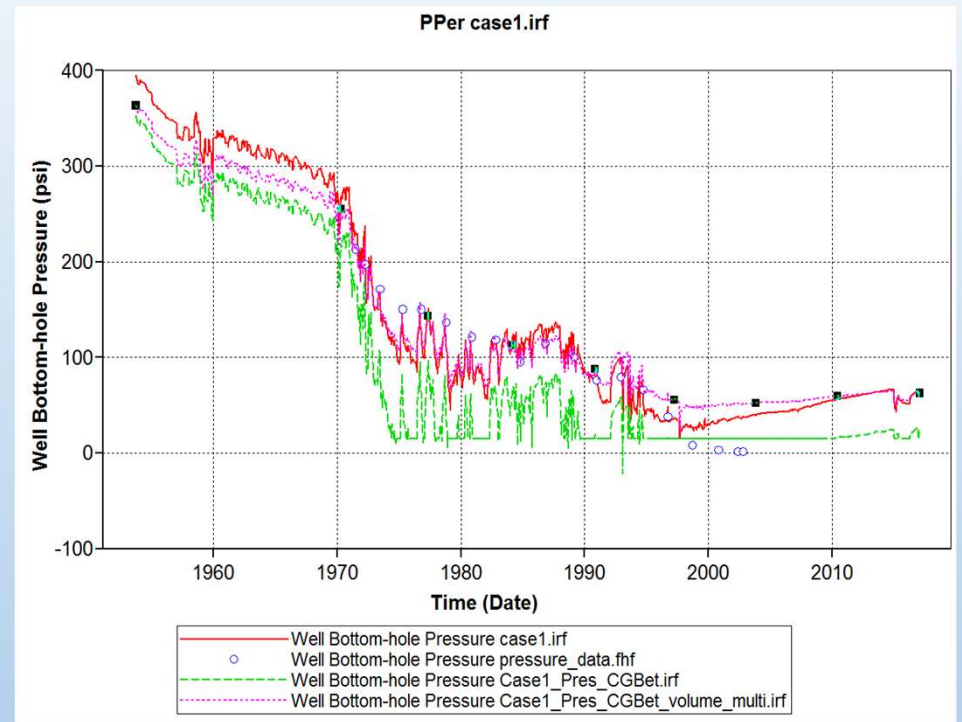
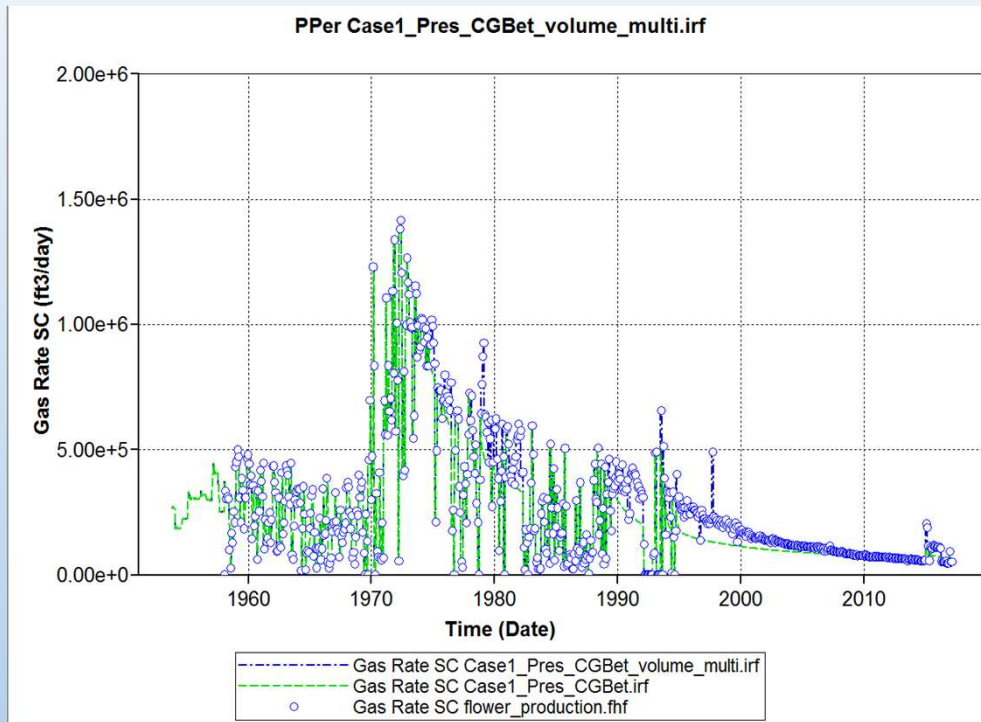


History Matching

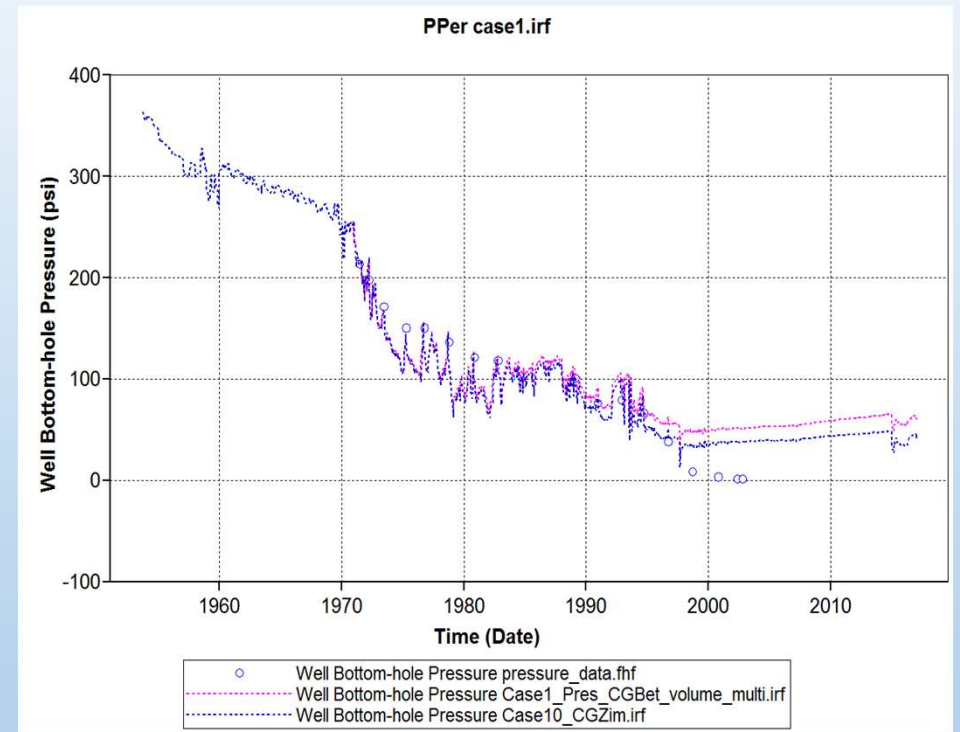
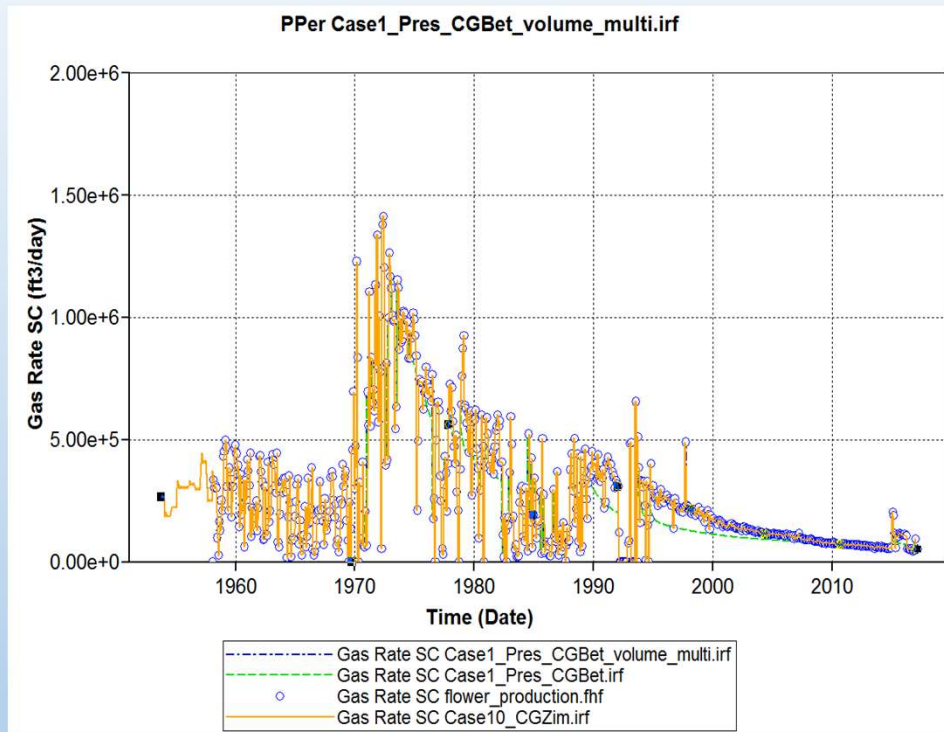


Boundary Well PPer

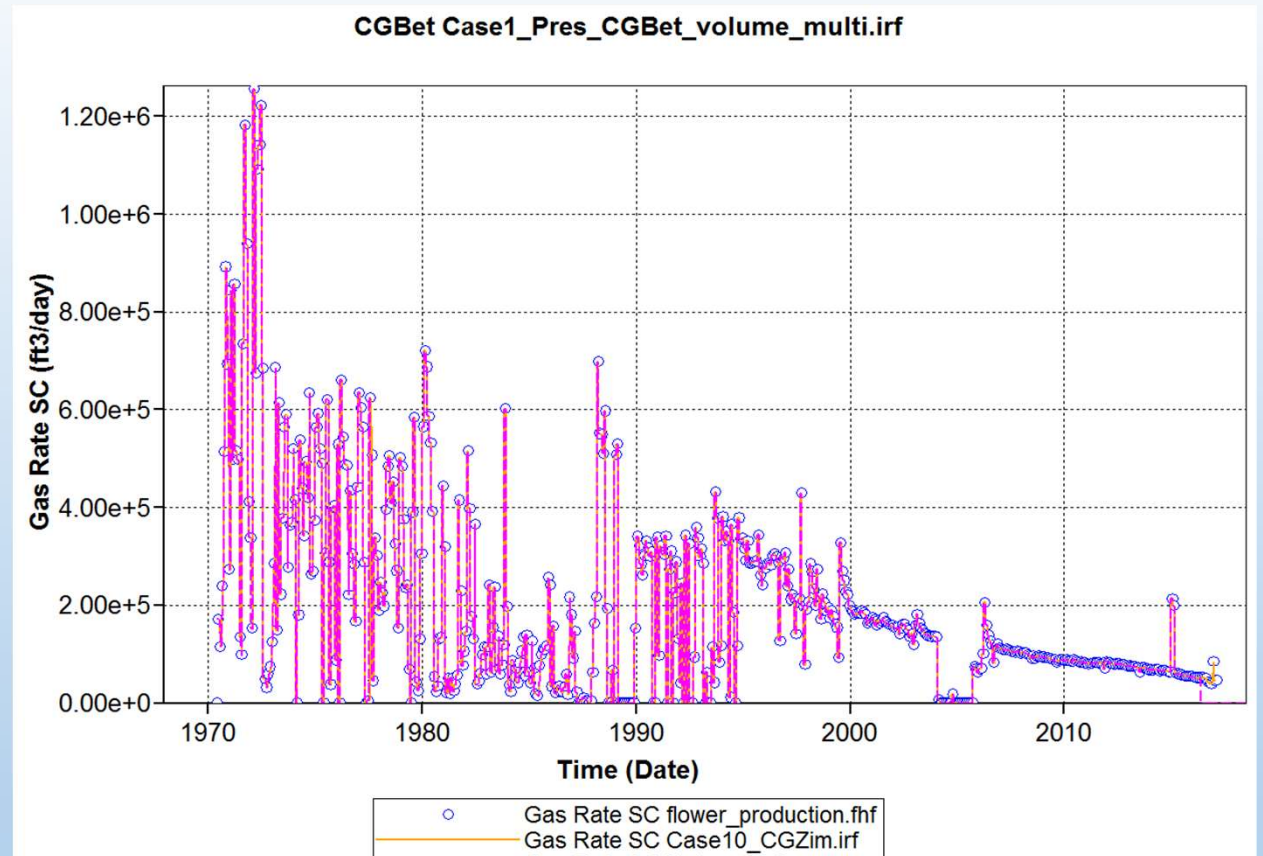
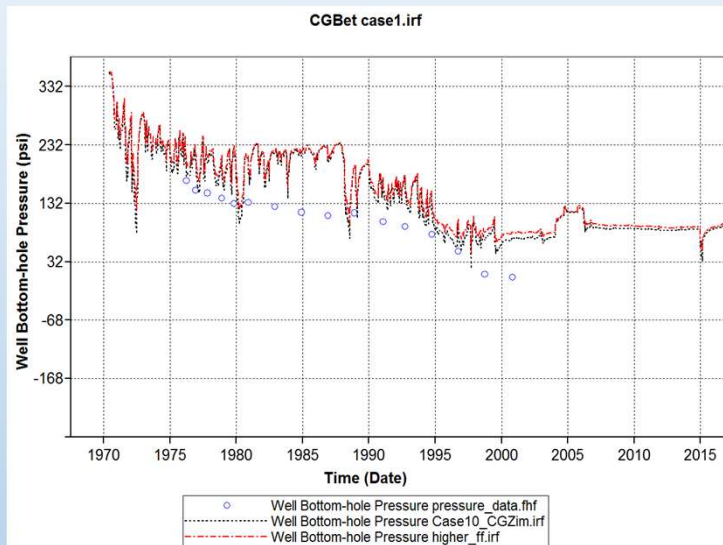
History Matching



History Matching

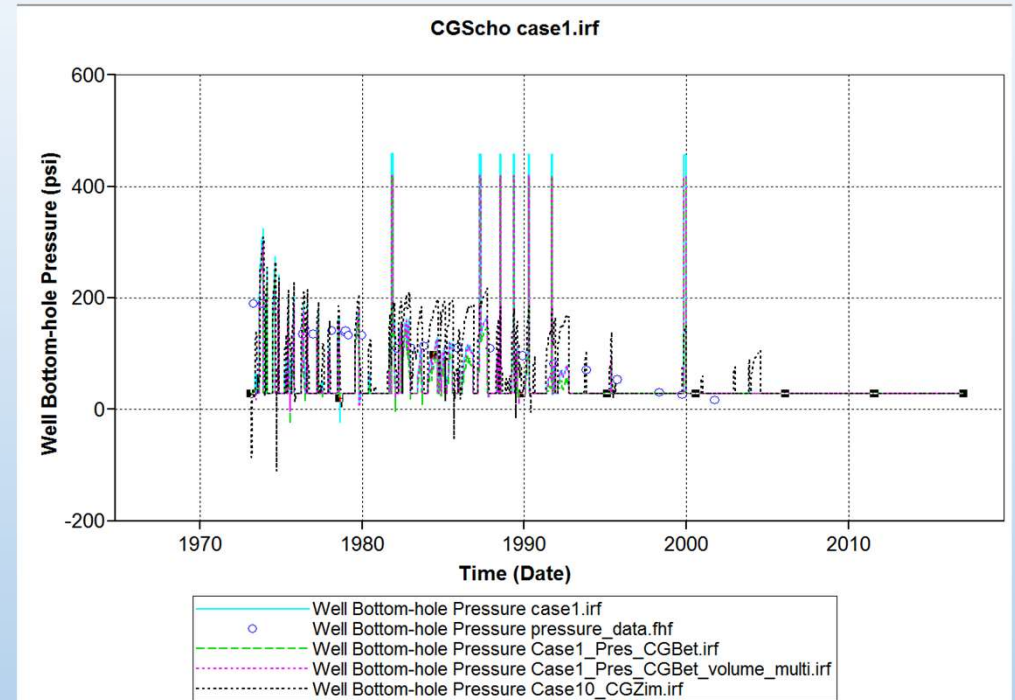
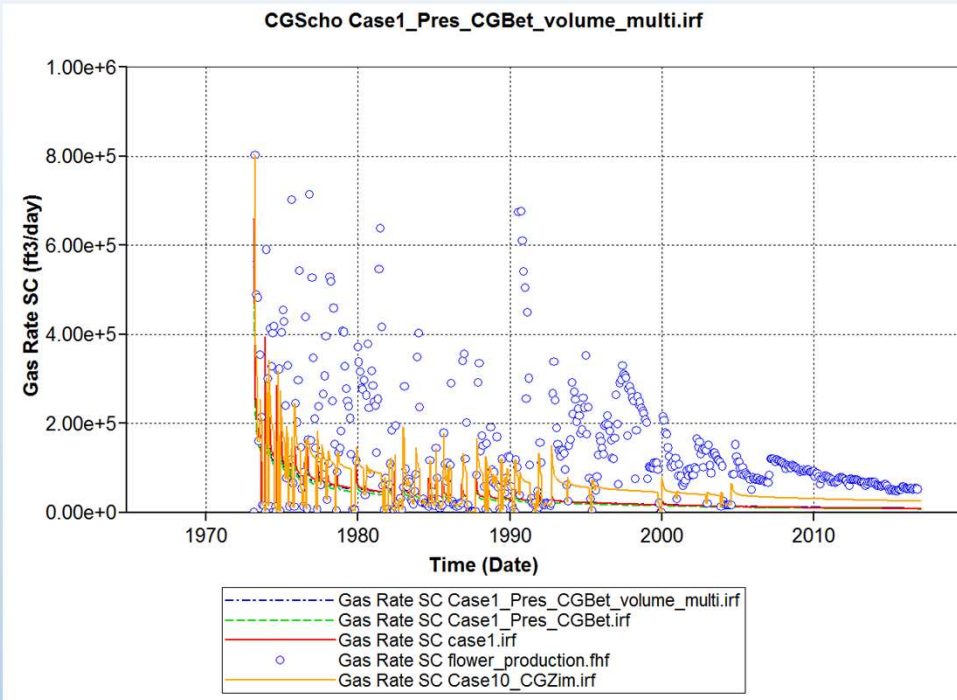


History Matching



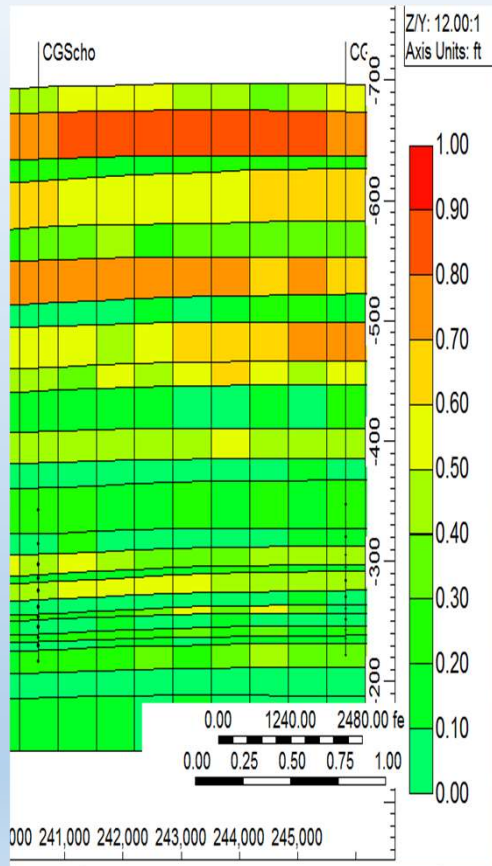
Higher ff, better results?

History Matching

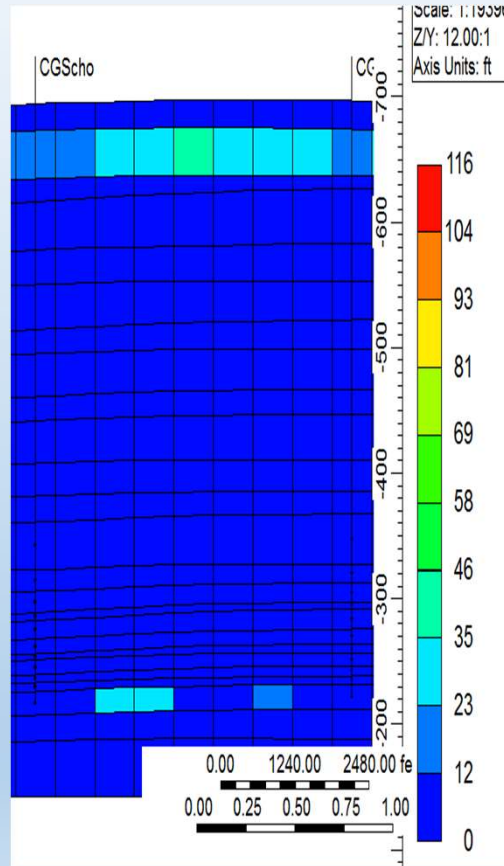


Error

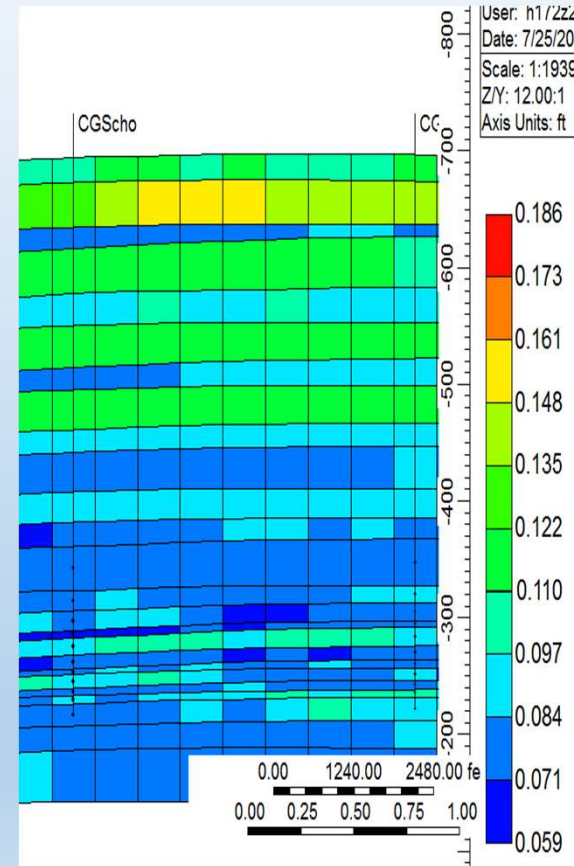
History Matching



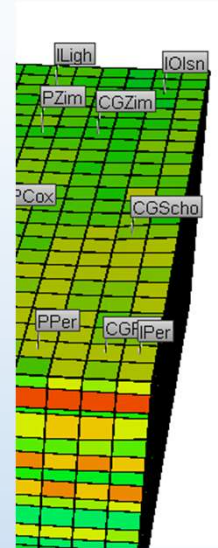
Gas Saturation



Permeability



Porosity



Future Prediction

Well Events

displayed wells 1 of 29 2016-06-01 Well: 'CGBet' at 2016-06-01 (28855.00 day)

Name / Date	Event
2014-10-01	ALTER
2014-11-01	ALTER
2014-12-01	ALTER
2015-01-01	ALTER
2015-02-01	ALTER
2015-03-01	ALTER
2015-04-01	ALTER
2015-05-01	ALTER
2015-06-01	ALTER
2015-07-01	ALTER
2015-08-01	ALTER
2015-09-01	ALTER
2015-10-01	ALTER
2015-11-01	ALTER
2015-12-01	ALTER
2016-01-01	ALTER
2016-02-01	ALTER
2016-03-01	ALTER
2016-04-01	ALTER
2016-05-01	ALTER
2016-06-01	PRODUCER
	constraints
	ALTER

ID & Type

Constraint definition previous date: 1970-06-01

#	Constraint	Parameter	Limit/Mode	Value	Action
* 1	OPERATE	BHP bottom hole pressure	MIN	90.5 psi	CONT

Multipliers

Wellbore

Injected Fluid

Workover

Options

Layer Gradient

Gas Lift

Guide Rates

Fracture Proxy

Comments

Max. number of continue-repeat allowed (MXCNRPT) 1

< constraint modifiers >

Change current primary constraint (ALTER) Set new or change old constraint (TARGET)

BHP 51763.19922 psi

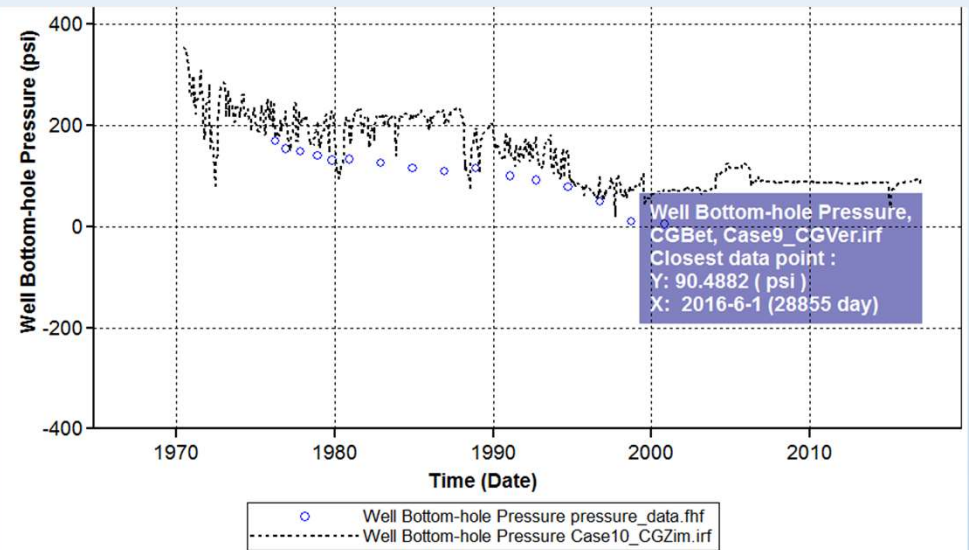
#	Parameter	Value

Alter: previous date: 2016-05-01

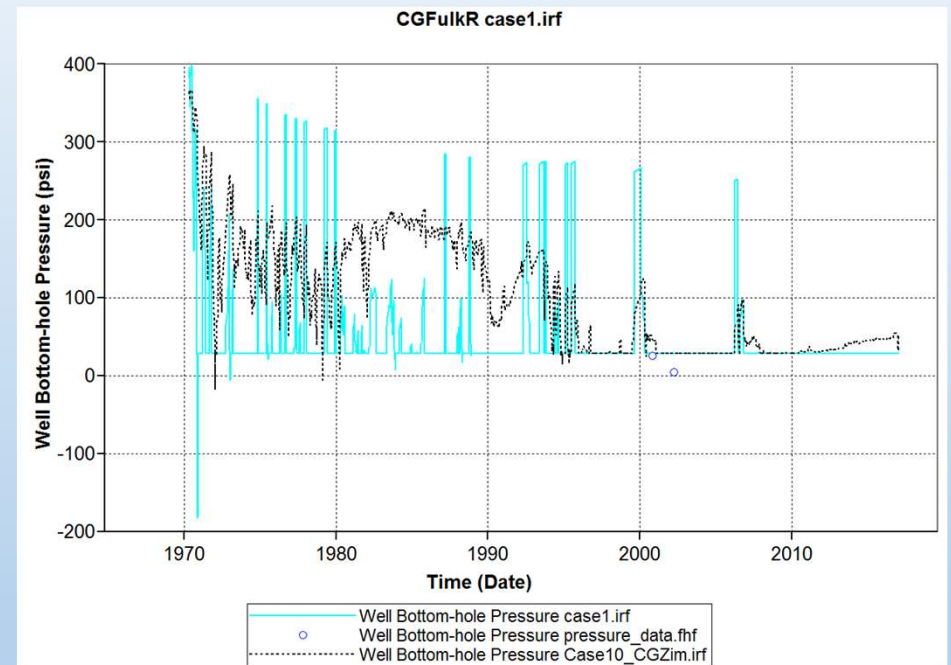
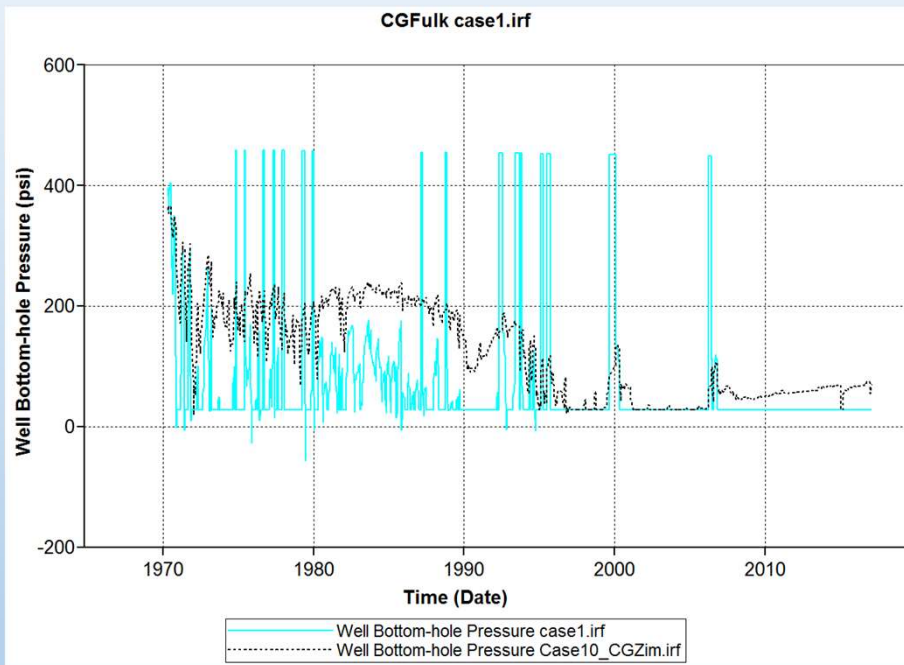
Target: previous date: <none>

Sort by: Name Date Tools

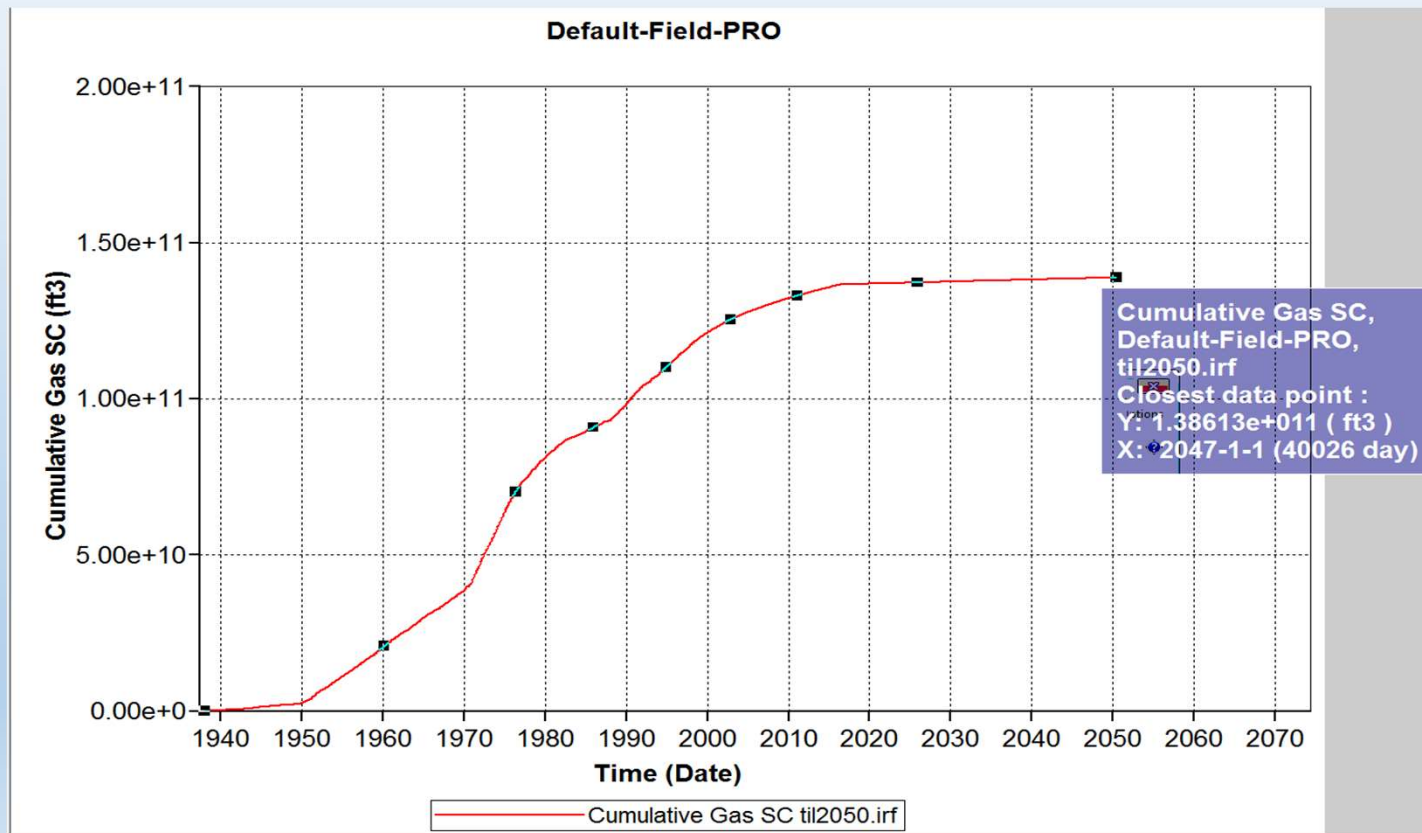
Reset Page Auto-apply OK Cancel Apply Help



Future Prediction

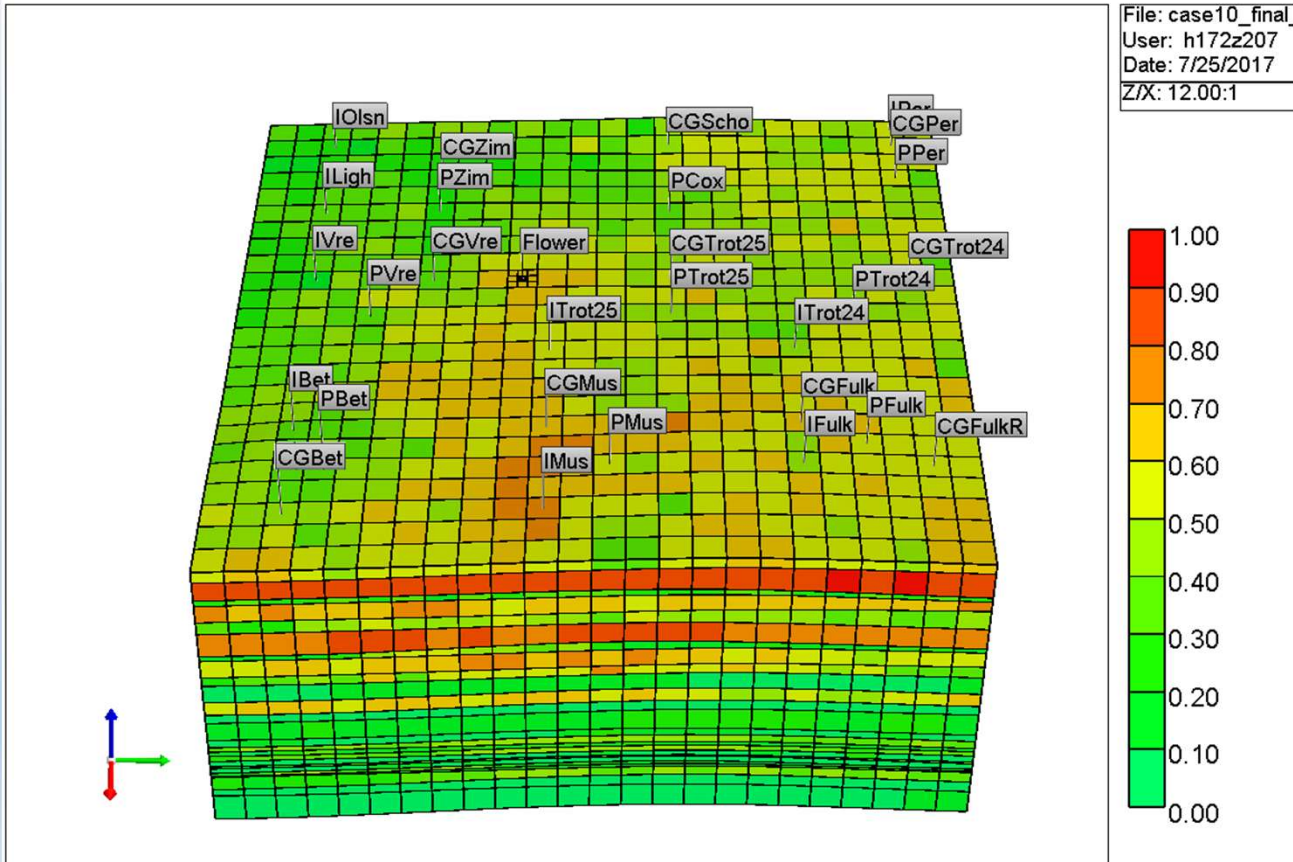


Future Prediction



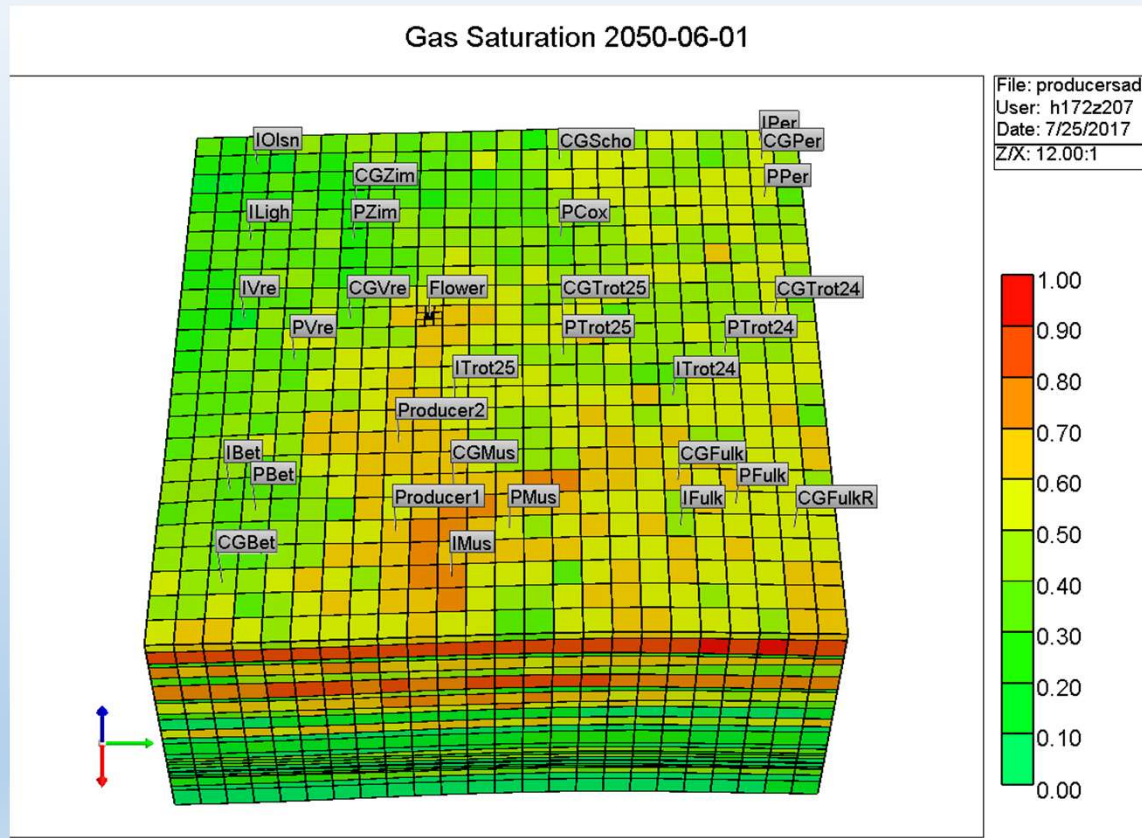
Future Prediction

Gas Saturation 2050-06-01



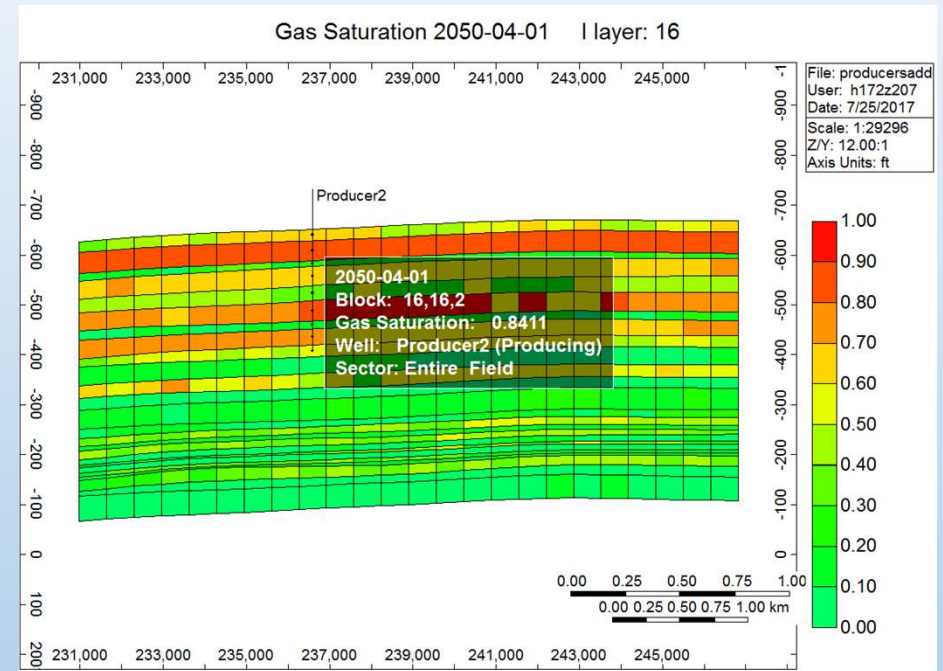
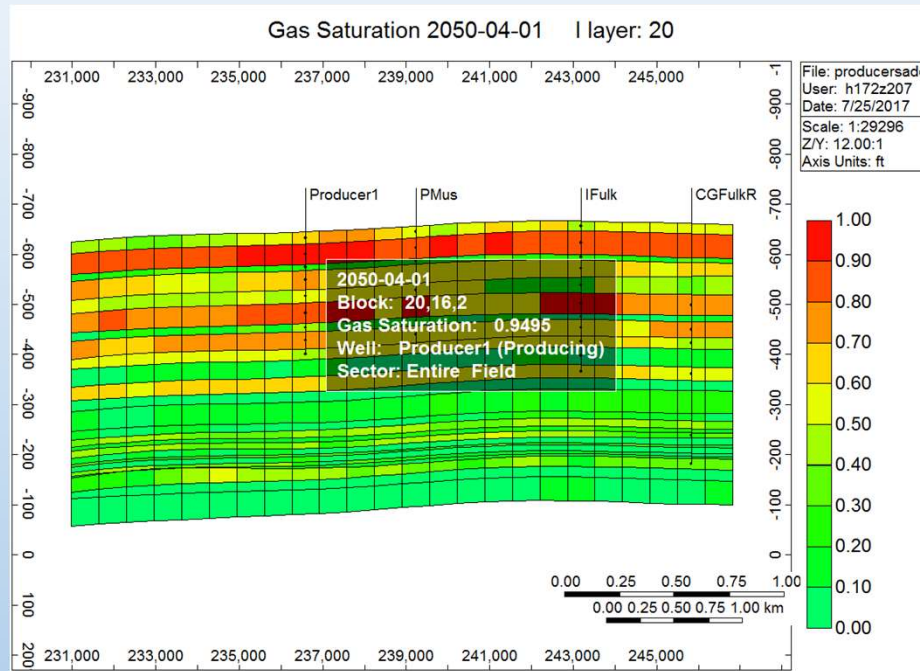
From CMG result 3D

New Wells Optimum Locations



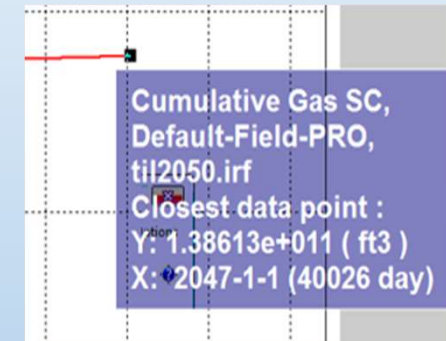
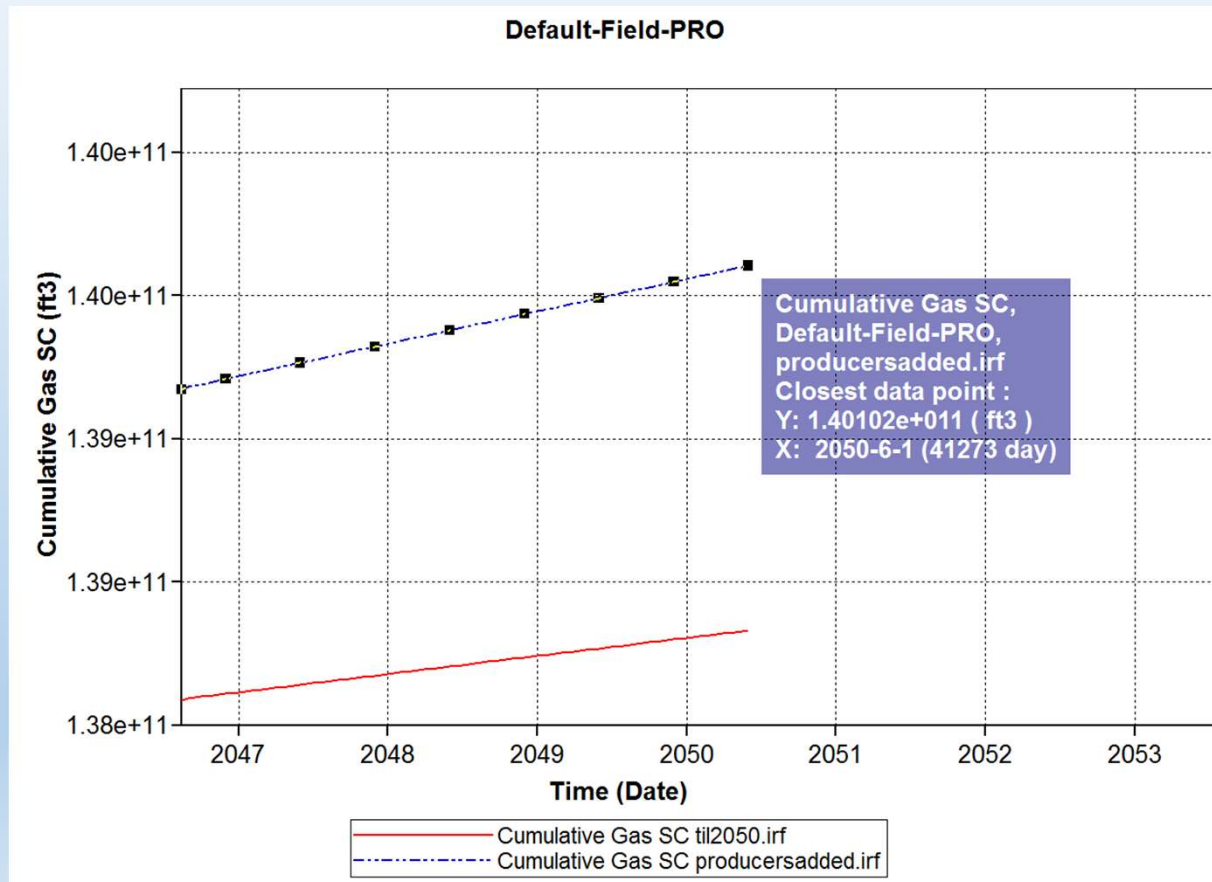
Perforated to layer 9

New Wells Optimum Locations

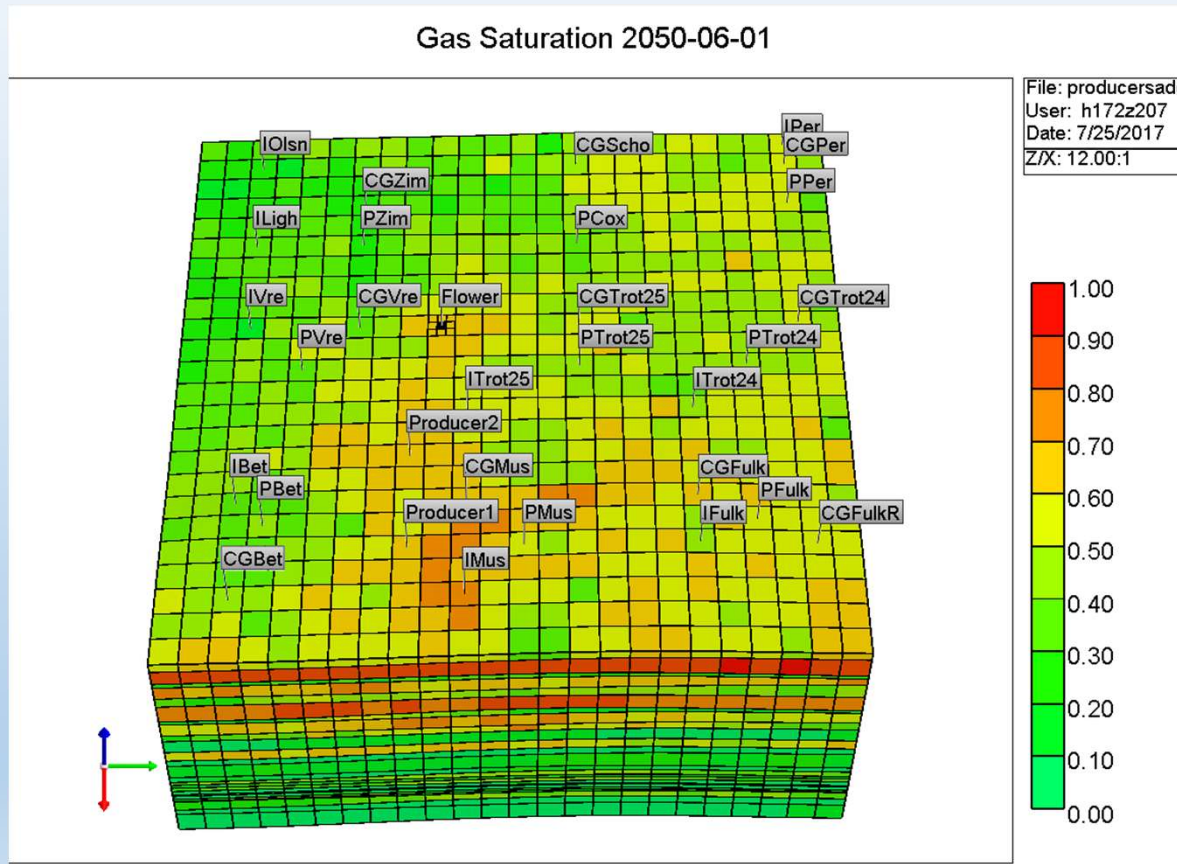


Perforated to layer 9

New Wells Optimum Locations

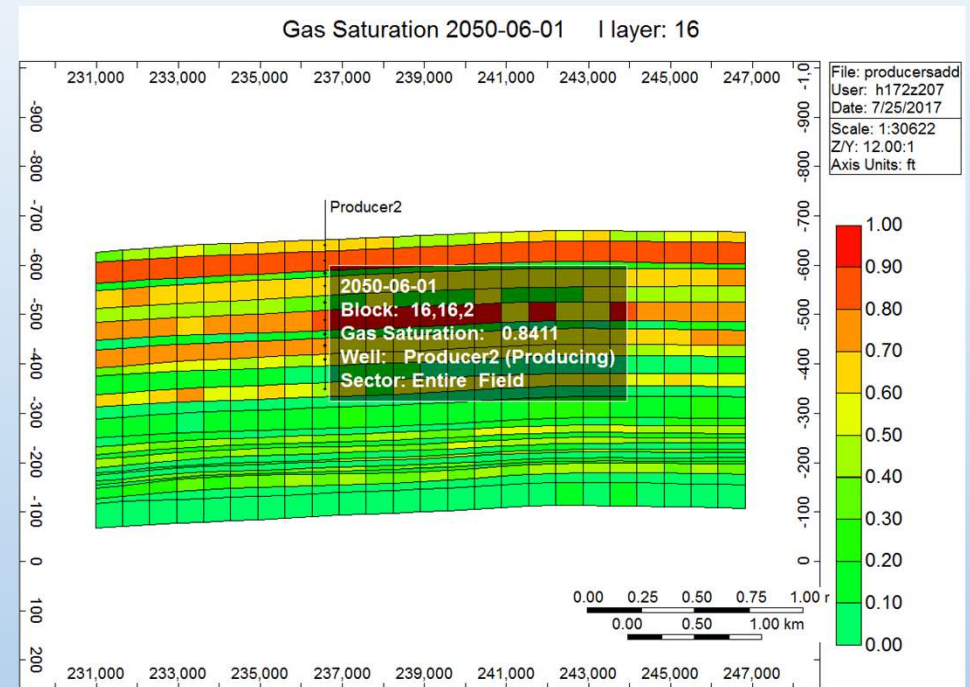
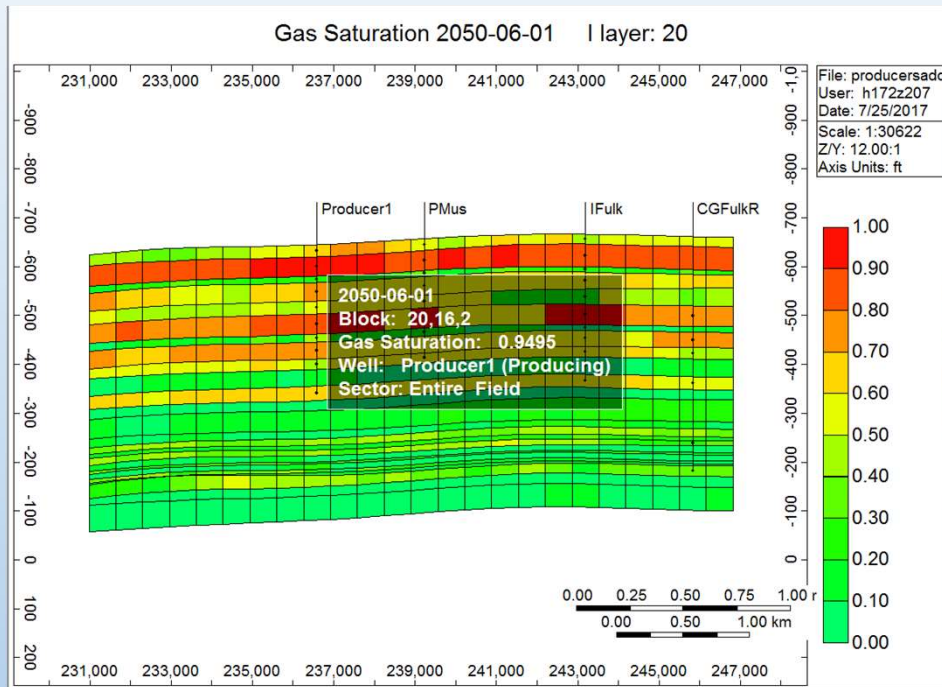


New Wells Optimum Locations



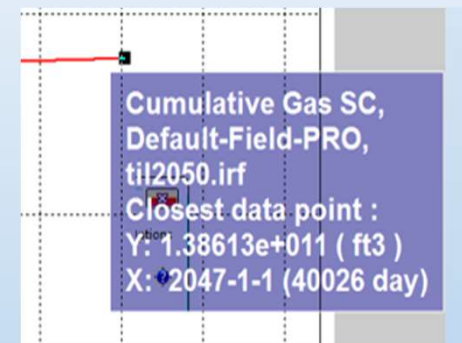
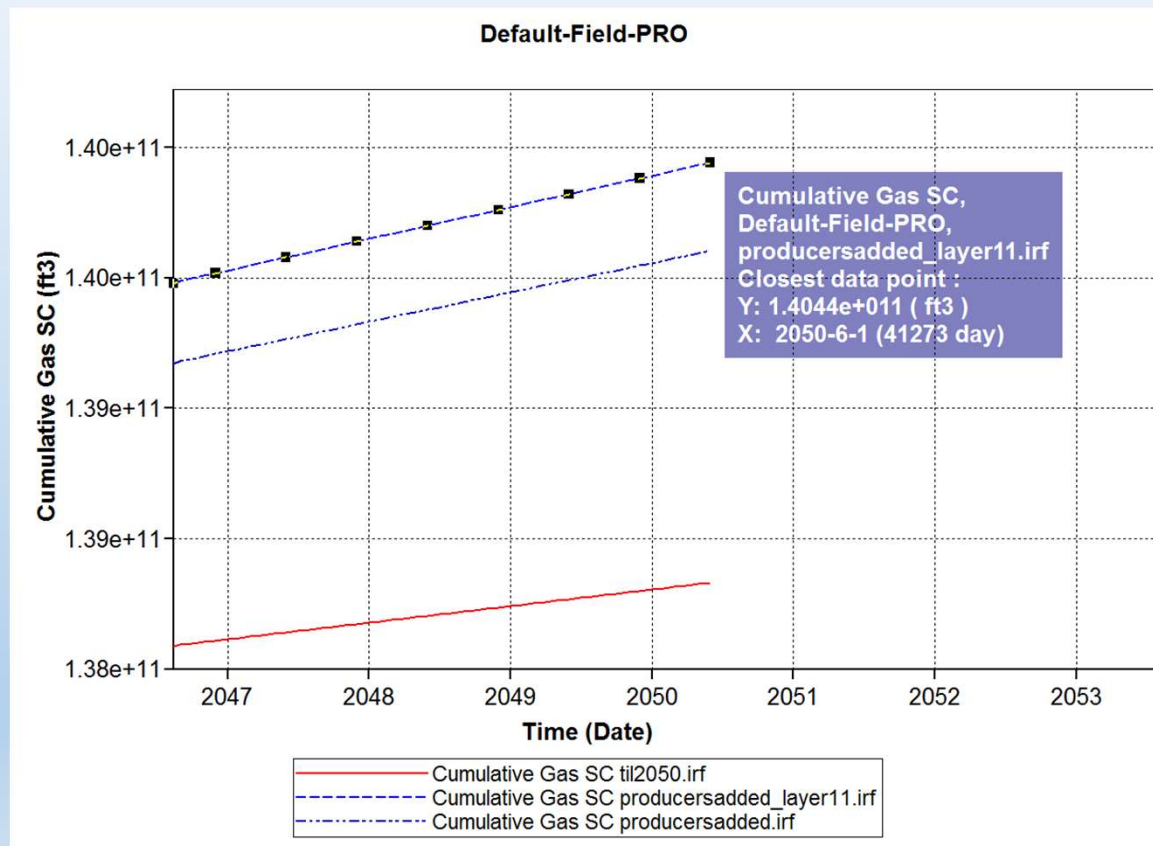
Perforated to layer 11

New Wells Optimum Locations

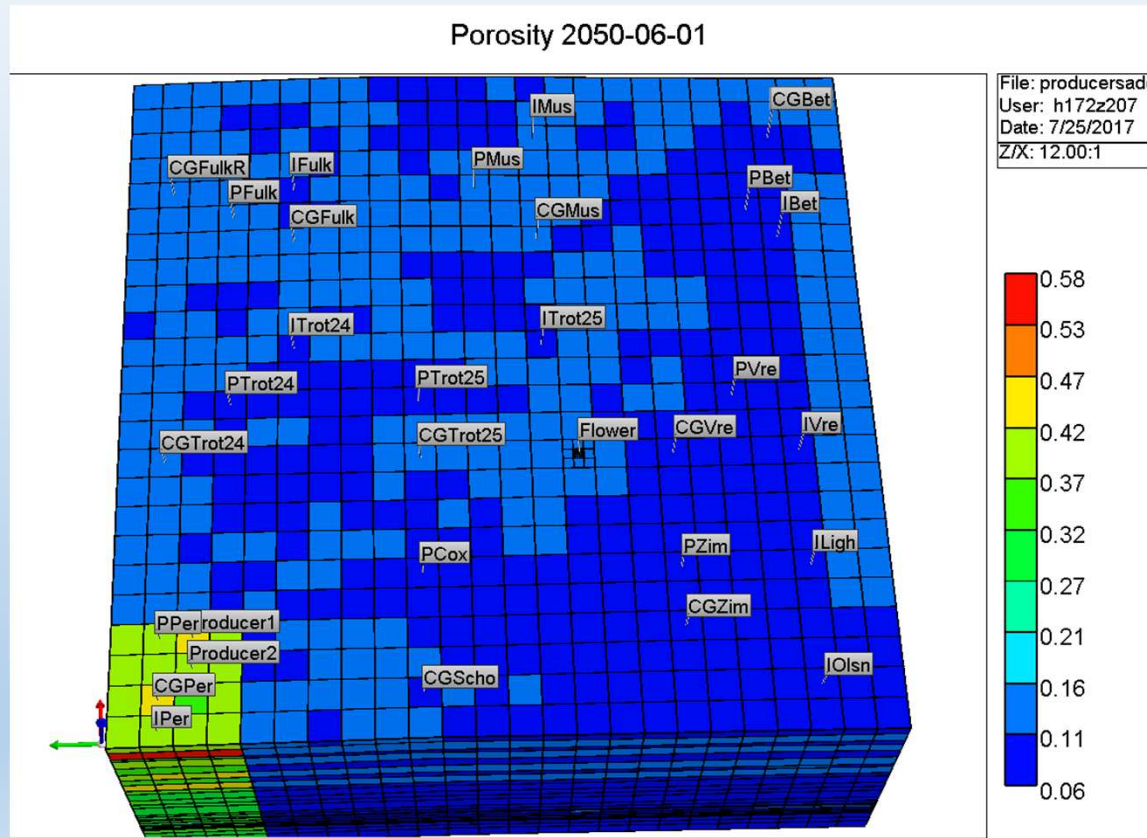


Perforated to layer 11

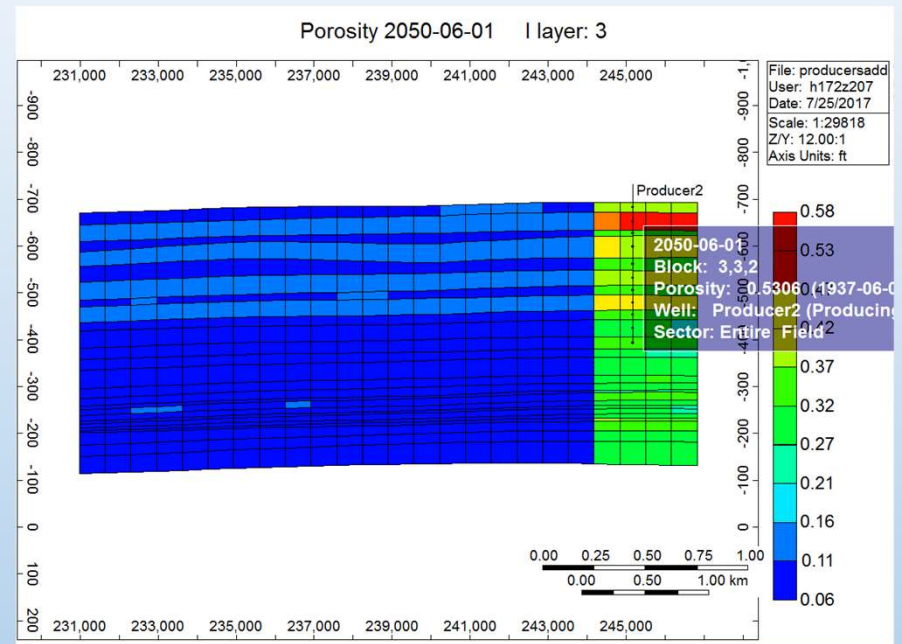
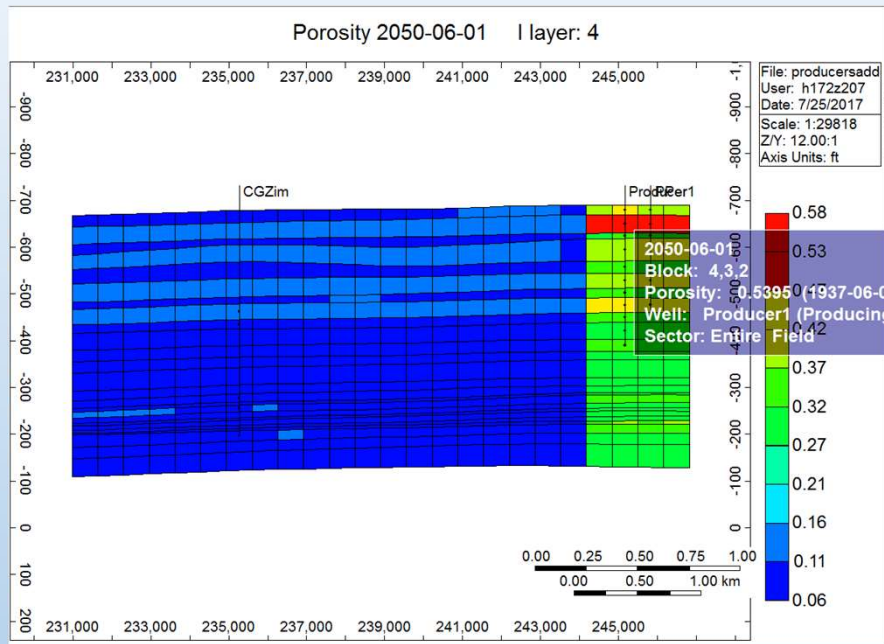
New Wells Optimum Locations



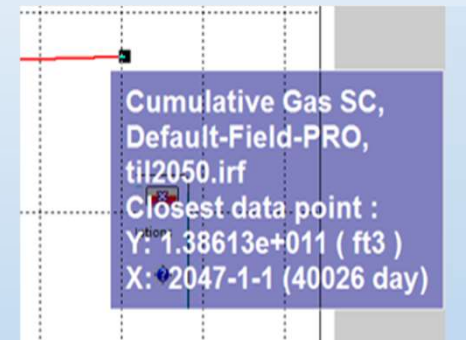
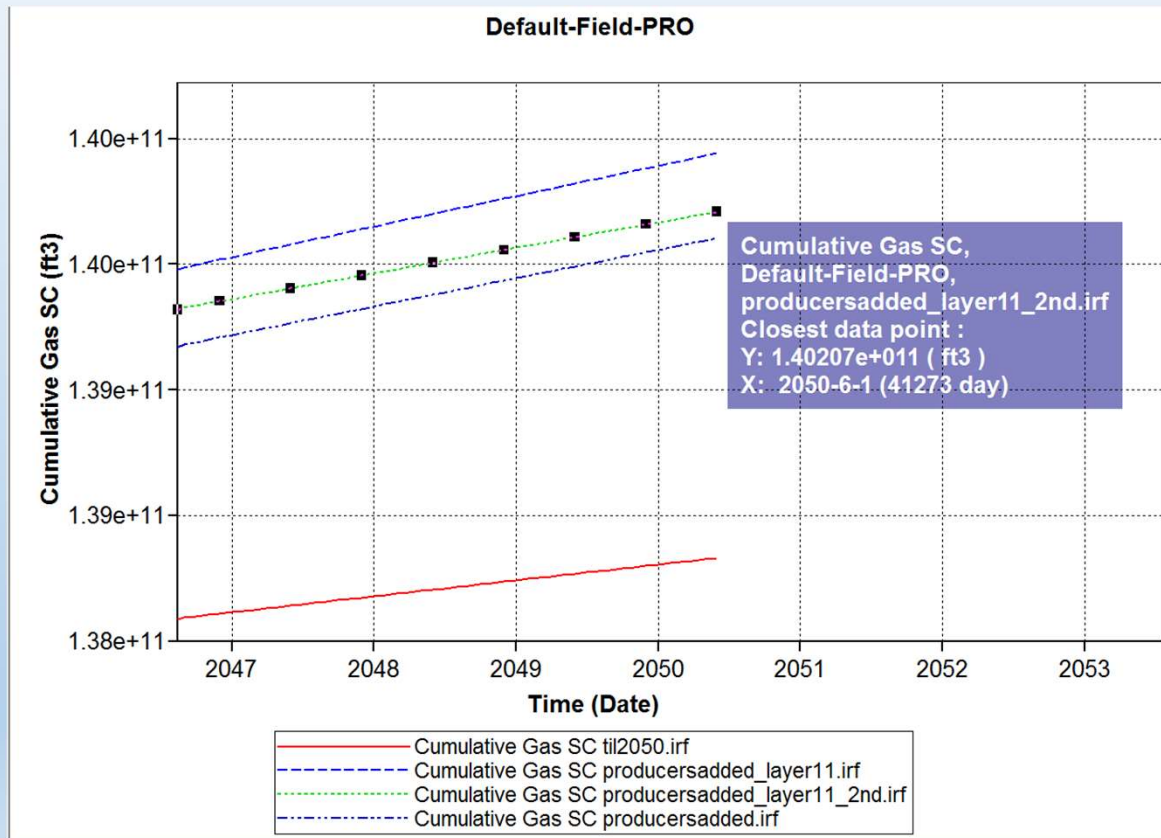
New Wells Optimum Locations



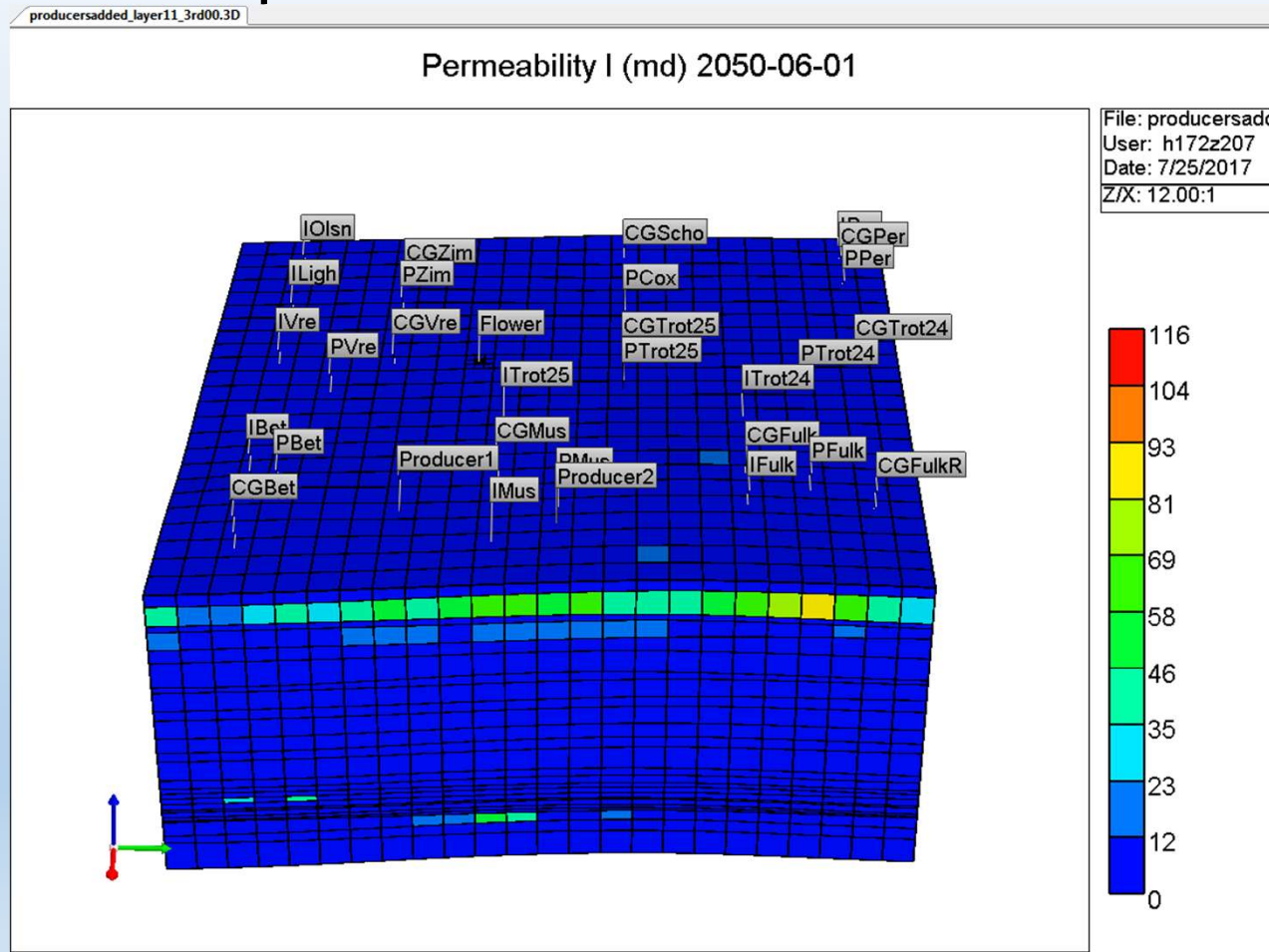
New Wells Optimum Locations



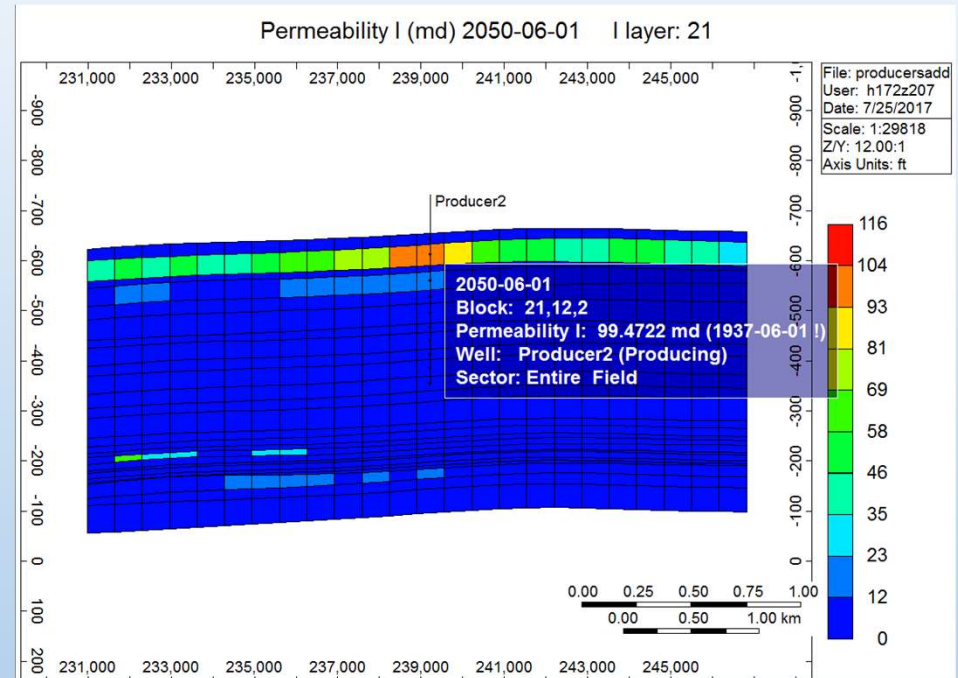
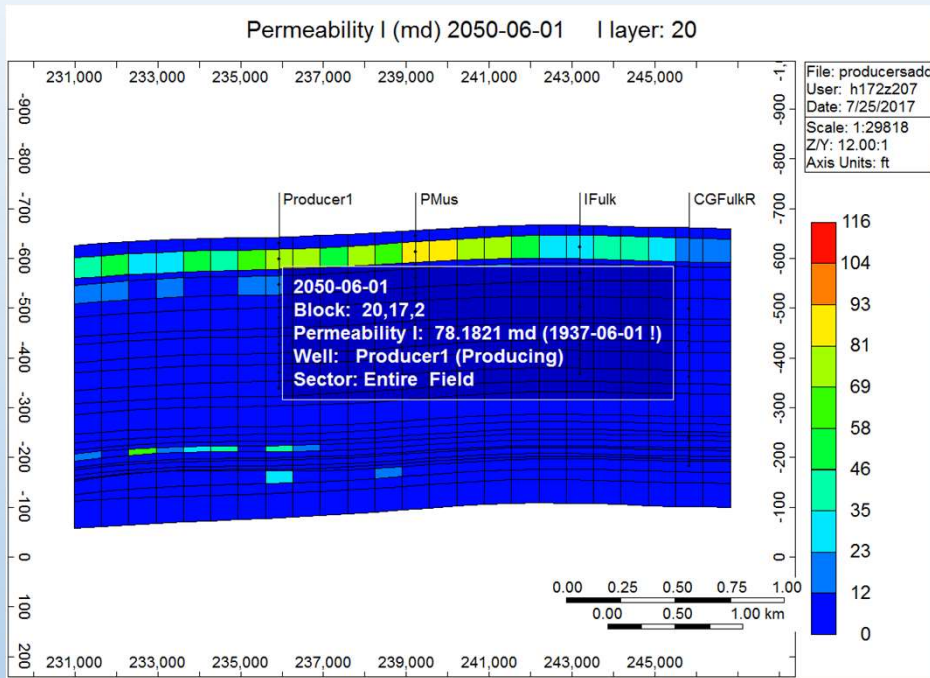
New Wells Optimum Locations



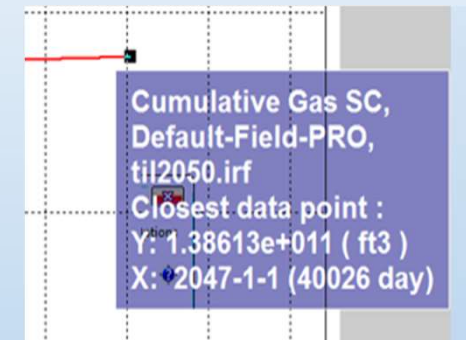
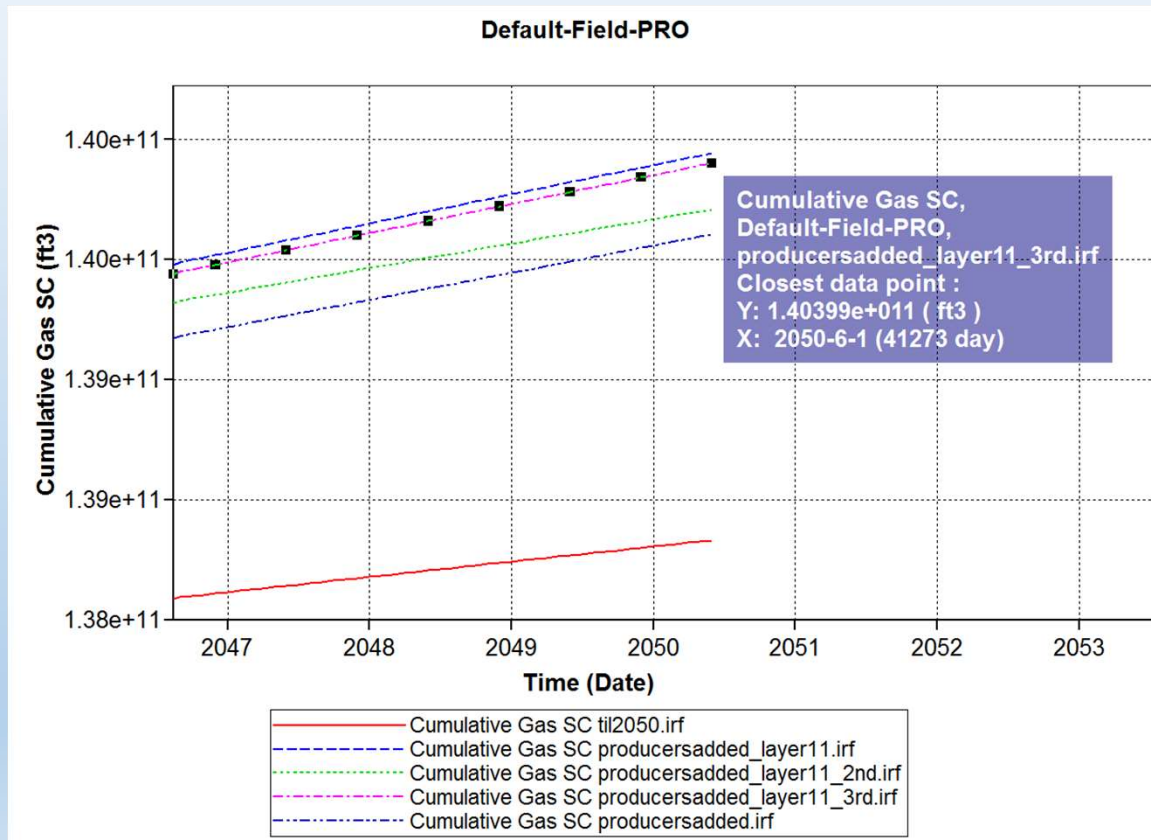
New Wells Optimum Locations



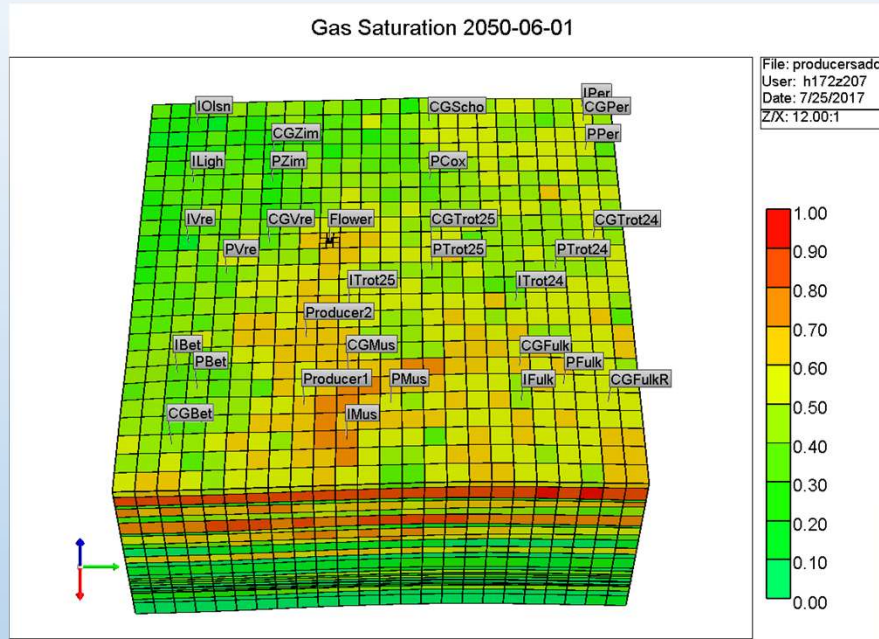
New Wells Optimum Locations



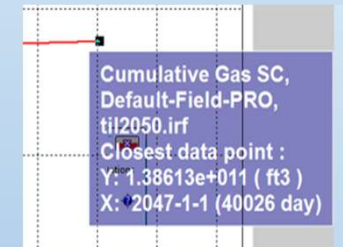
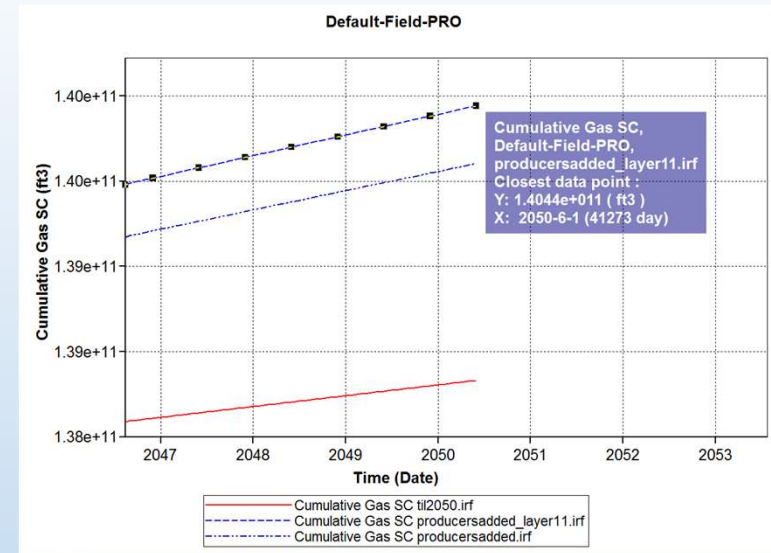
New Wells Optimum Locations



Conclusion



Perforated to layer 11



Total Production Increased: **0.01827 e+11 ft³**

Total percent of Production Increased: **1.3009%**

Thank You for Watching



Especially thanks for Dr. Esmail Ansari for instructing the course during the summer.

Wish you all have a good rest of your Summer.