MESQUITE SWD

Water Injection Modeling

White Paper Discussion

Ryder Scott

Contents

White Paper Discussion : Injector Performance Modelling

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Discussion and Summary Results

Ryder Scott Company, L.P. (RSC) has reviewed injectivity data from three wells operated by Mesquite SWD.

Table 1

Well	Tubing ID (in)	Tubing Depth (MD)	Open-Hole (MD Ft)
Vaca Draw	4.52	17,495	
Moutray SWD1	3.6	14,910	14,910-16,035
Paduca SWD1	4.5 to 9881 3.6 to 17284	17,284	17,310-18,870

This document describes the nodal analysis of each of the wells with the intent of evaluating different completion strategies for future deep injection wells. The scope of the evaluation was to review injectivity tests, match test data to nodal analysis models, with the primary focus of describing injection wellbore dynamics. Steady-state injection models were used for reservoir injection performance so no transient analysis or modelling was performed in this phase.

Given the depth of these wells, each injected barrel has to traverse roughly 3 miles of pipe before reaching the injection reservoir. These long wellbores create significant frictional pressure drop at high rates. The irreversible friction pressure drop represents lost pump horsepower and lower injection rates.

For producing wells, using too large of tubing can create a loading condition but for injectors, that problem does not exist, especially in single phase injection.

Vaca Draw Data

The Vaca Draw injectivity test (Table 2) was matched using standard Nodal analysis techniques that account for hydrostatic, friction and acceleration pressure drops within the wellbore, and injectivity both above and below fracture pressure while accounting for the very thick formation.

Table 2

Injection Rate (BWIPD)	WHP (PSIA)	FBHP (PSIA)	Injection Rate (BWIPM)
7200	630	8488	5
14400	675	8500	10
21600	1337	8774	15
28800	2017	8934	20
36000	2768	9205	25
43200	3500	9352	30

The following basic wellbore and reservoir parameters matched the observed data within measured data limits. The detailed input data listing is included as Appendix A.

Injection water Density	1.1 (sg) / 133000 ppm TDS / 67.7 PCF
Matched Hydraulic Model	Ansari
Wellbore	4.5' ID to 14960 ft
Average wellbore water viscosity	0.6 (cp)
Effective Roughness	5.e-5 (in)
Net Thickness	1500 tvd feet
Effective Reservoir pressure	8100 psia
Net Permeability	14 (md)

Vaca Draw Results

Figure 1 shows the match results with the small crosses indicating the actual data while the lines represent the model hydraulics and IPR curves. When intersections between the IPR and Hydraulics curves match the observed data (crosses) an adequate match is obtained.

Figure 1: Match case for Vaca Draw Injectivity Test

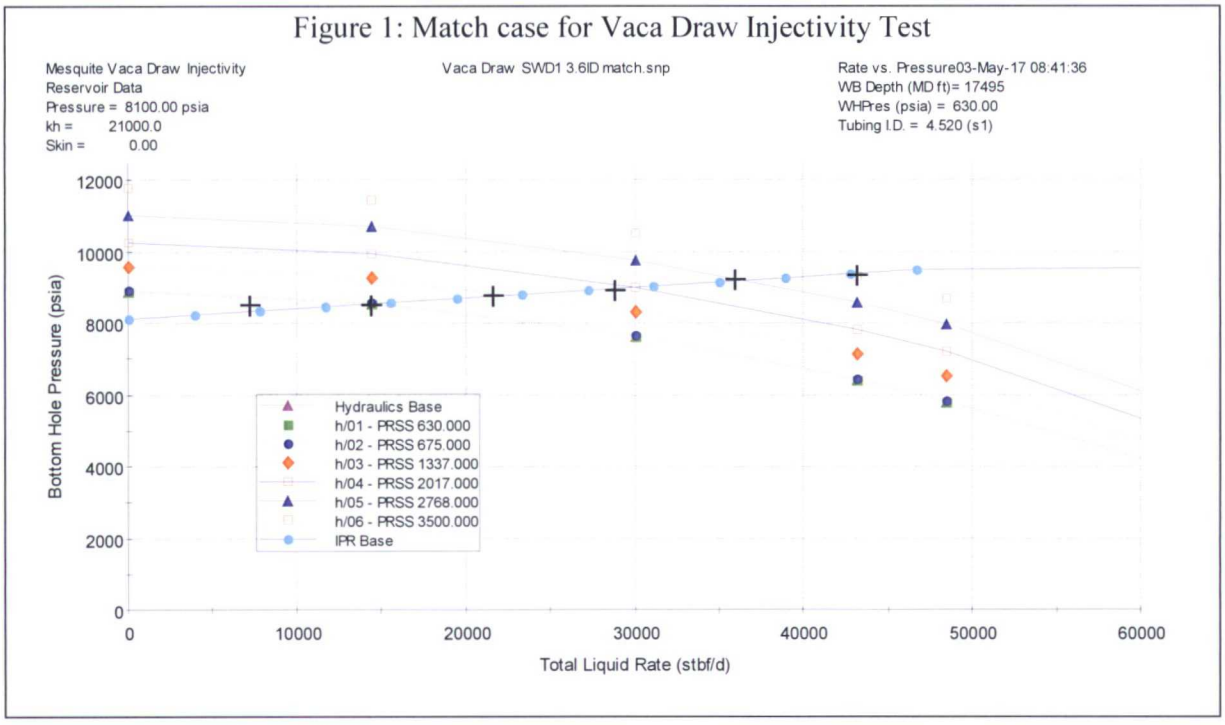
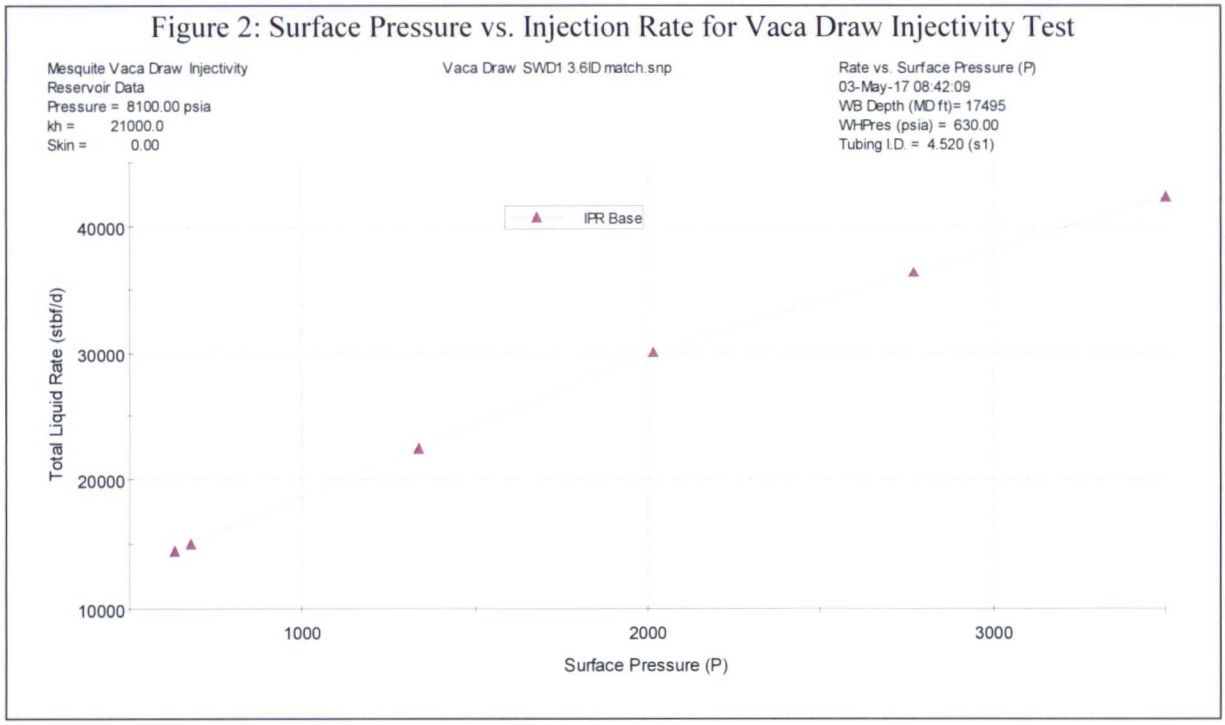


Figure 2: Surface Pressure vs. Injection Rate for Vaca Draw Injectivity Test



Moutray SWD1 Data

The Moutray SWD1 injectivity test (Table 2) was matched using standard Nodal analysis techniques that account for hydrostatic, friction and acceleration pressure drops within the wellbore, and injectivity both above and below fracture pressure while accounting for the very thick formation. .

Table 3

Injection Rate (BWIPD)	WHP (PSIA)	FBHP (PSIA)	Injection Rate (BWIPM)
7200	621	7585	5
14400	1727	8020	10
21600	3270	8250	15

The following basic wellbore and reservoir parameters matched the observed data within measured data limits. The detailed input data listing is included as Appendix A.

Injection water Density	1.155 (sg) / 202000 ppm TDS / 71.2 PCF
Matched Hydraulic Model	Ansari
Wellbore	3.6' ID to 14960 ft
Average wellbore water viscosity	0.6 (cp)
Effective Roughness	100.e-5 (in)
Net Thickness	1500 tvd feet
Effective Reservoir pressure	7400 psia
Net Permeability	11 (md)

Moutray SWD1 Results

Figure 3 shows the match results with the small crosses indicating the actual data while the lines represent the model hydraulics and IPR curves. When intersections between the IPR and Hydraulics curves match the observed data (crosses), an adequate match is obtained.

Figure 3: Match case for Moutray SWD1 Injectivity Test

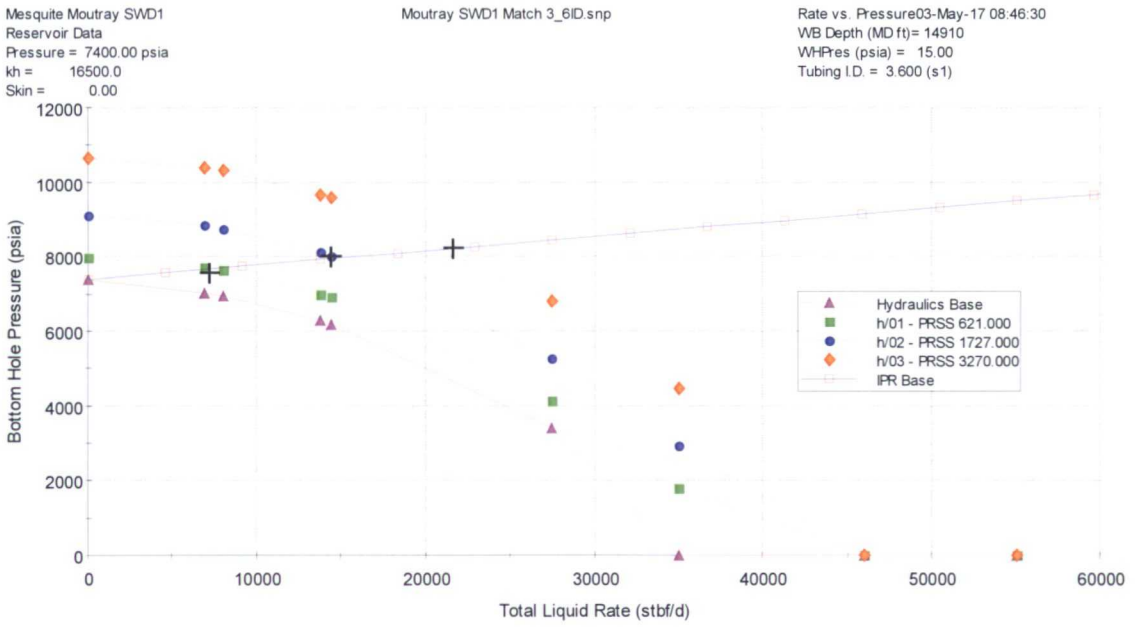
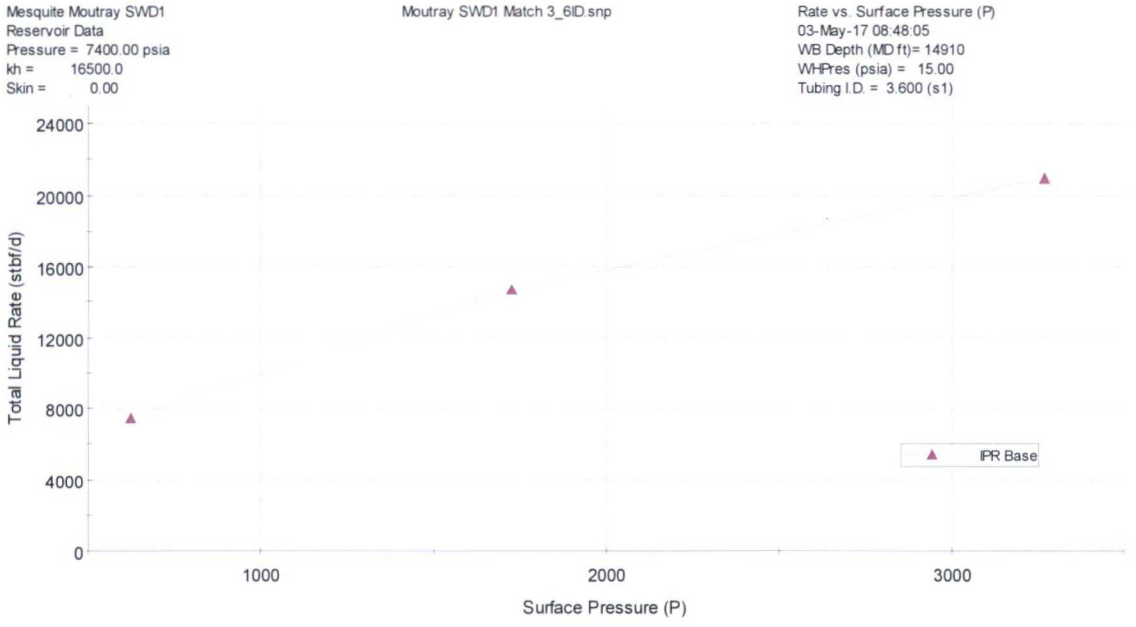


Figure 4: Surface Pressure vs. Injection Rate for Moutray SWD1 Injectivity Test



Paduca SWD1 Data

The Paduca SWD1 injectivity test (Table 2) was matched using standard Nodal analysis techniques that account for hydrostatic, friction and acceleration pressure drops within the wellbore, and injectivity both above and below fracture pressure while accounting for the very thick formation. .

Table 4

Injection Rate (BWIPD)	WHP (PSIA)	FBHP (PSIA)	Injection Rate (BWIPM)
21600	1406	8155	15
28800	2449	8190	20
36000	2449*	8194	25

* Datapoint may not be stabilized.

The following basic wellbore and reservoir parameters matched the observed data within measured data limits. The detailed input data listing is included as Appendix A.

Injection water Density	1.06 (sg) / 81000 ppm TDS / 65.7 PCF
Matched Hydraulic Model	Ansari
Wellbore	4.5 to 9881 ft, 3.6 to 17284 ft (Taper)
Average wellbore water viscosity	0.6 (cp)
Effective Roughness	1.e-5 (in)
Net Thickness	1500 tvd feet
Effective Reservoir pressure	8050 psia
Net Permeability	50 (md), -3 skin

Paduca SWD1 Results

Figure 5 shows the match results with the small crosses indicating the actual data while the lines represent the model hydraulics and IPR curves. When intersections between the IPR and Hydraulics curves match the observed data (crosses) an adequate match is obtained.

Figure 5: Match case for Paduca SWD1 Injectivity Test

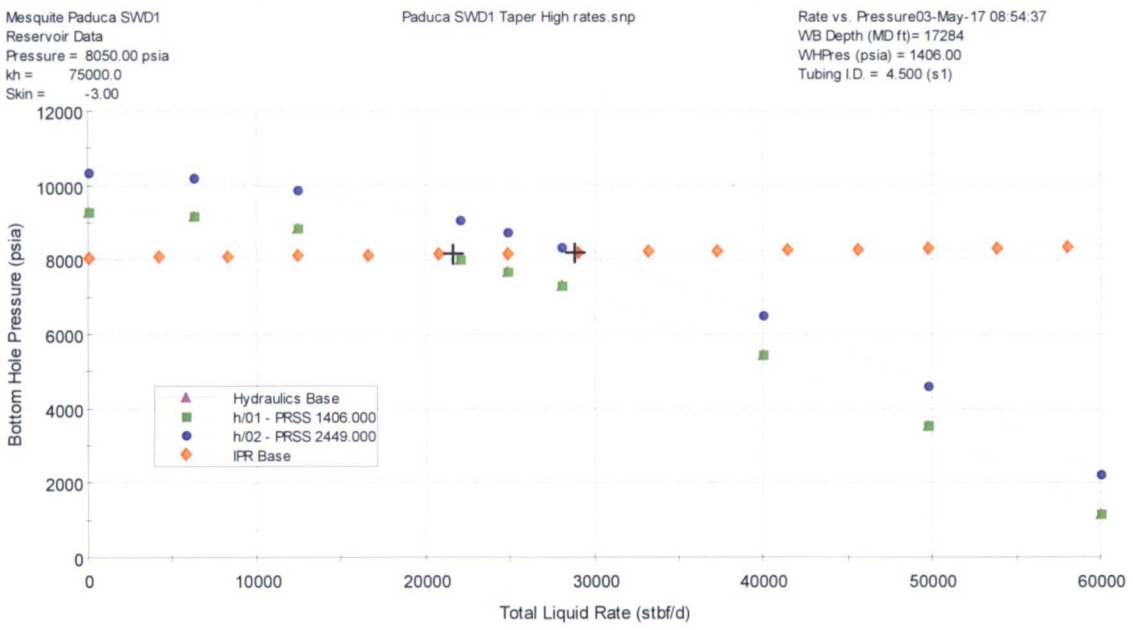
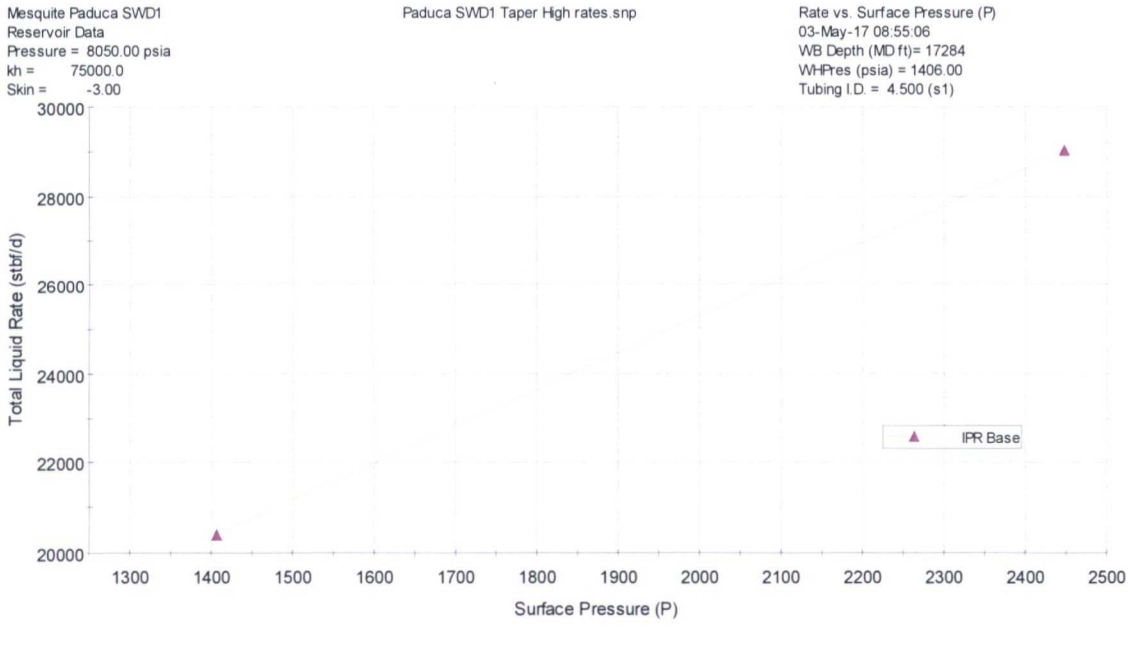


Figure 6: Surface Pressure vs. Injection Rate for Paduca SWD1 Injectivity Test



Review of Completion Options

Using the match results from injectivity tests for each well, predictions of the performance of the other 3 completion options were reviewed for each well. Table 5 shows the results of injectivity testing and estimates of performance under different completion conditions. These same results are shown graphically in Figures 7-9.

Table 5 : Predicted Injection rates at 3400 psia WHP

Well	3.6" ID (MBWIPD)	4.5 x 3.6" ID (MBWIPD)	4.5" ID (MBWIPD)
Vaca Draw	24.5	33.2	41.1
Moutray SWD1	21.4	28.8	35.6
Paduca SWD1	27.5	35.2	48.5

Based on our review of the relevant pressure and rate data, a significant injection rate improvement can be obtained by using 4.5" ID tubing. Given the depth of these wells, each injected barrel has to traverse roughly 3 miles of pipe before reaching the injection reservoir. These long wellbores create significant frictional pressure drop at high rates. The irreversible friction pressure drop represents lost pump horsepower and lower injection rates.

For producing wells, using too large of tubing can create a loading condition but for injectors, that problem does not exist, especially in single phase injection.

Figure 7: Nodal plot for Vaca Draw using 3 completion assumptions

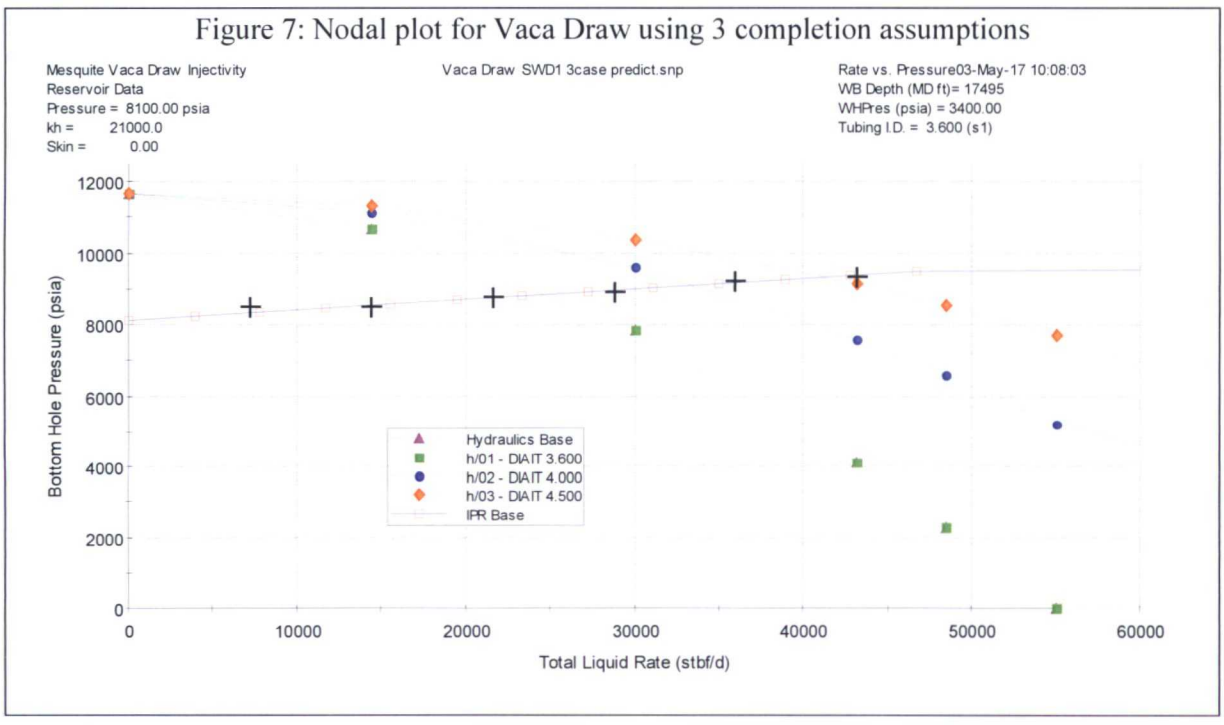


Figure 8: Nodal plot for Paduca SWD1 using 3 completion Assumptions

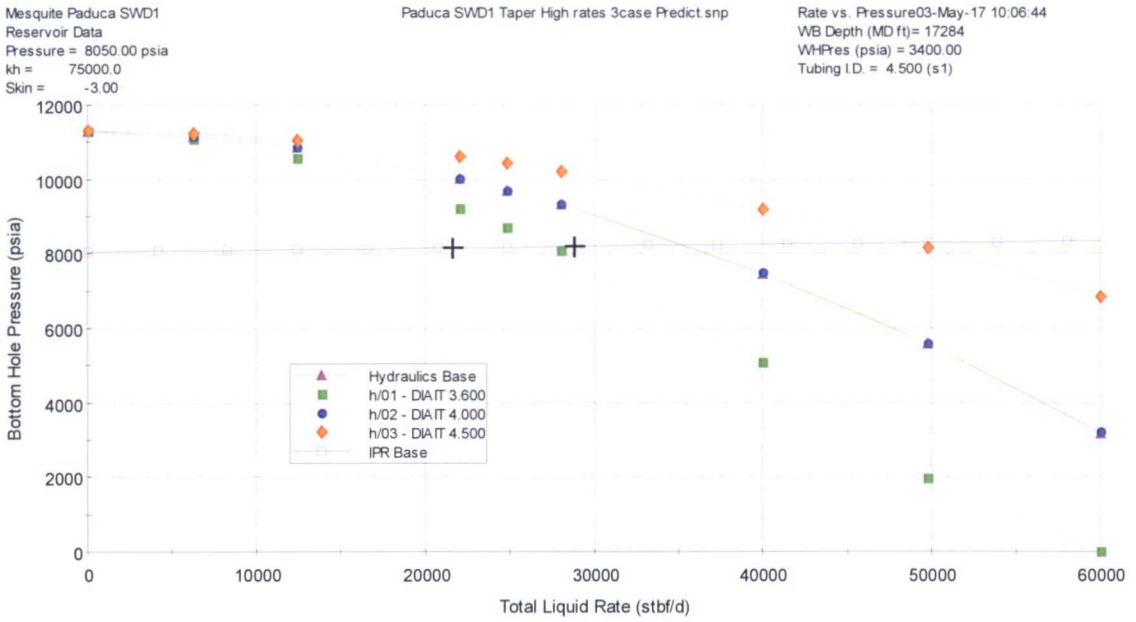
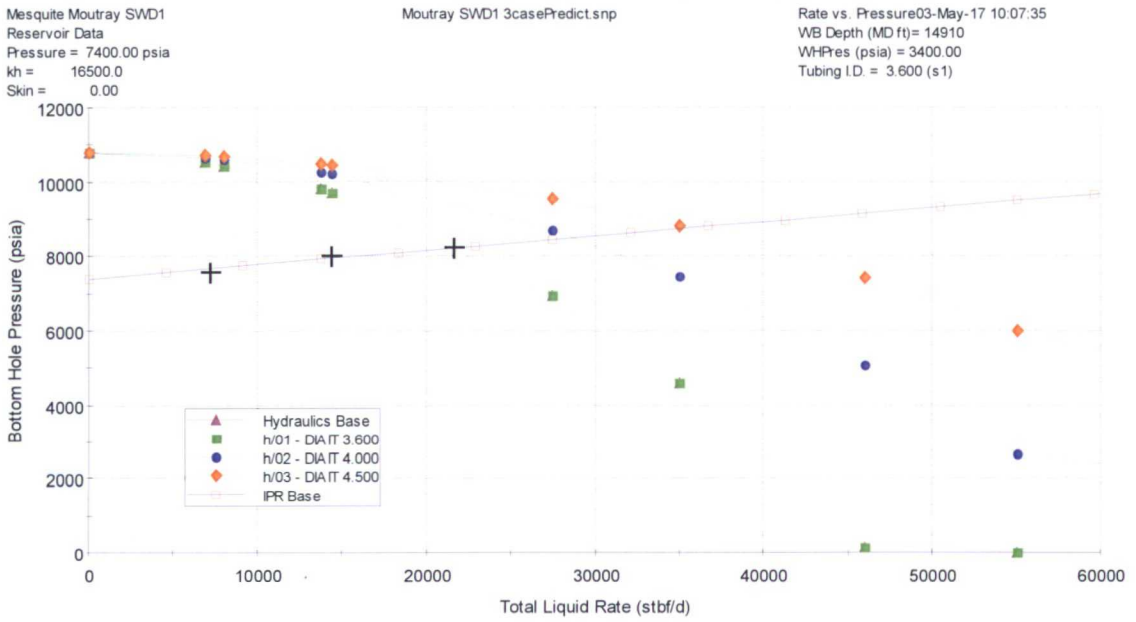


Figure 8: Nodal plot for Moutray SWD1 using 3 completion assumptions



Goetze, Phillip, EMNRD

From: Jennifer L. Bradfute <jlb@modrall.com>
Sent: Monday, May 8, 2017 4:56 PM
To: Jones, William V, EMNRD; Goetze, Phillip, EMNRD; McMillan, Michael, EMNRD; Brooks, David K, EMNRD
Cc: Michael Feldewert (MFeldewert@hollandhart.com); darnold@matadorresources.com
Subject: Case No. 15654 Engineering Data
Attachments: Mesquite SWD Nodel (W2931418x7A92D).pdf

All: Please find the engineering data which was requested in Case No. 15654 from Mesquite SWD. Mesquite has respectfully requested an expedited review of its application in this case, as stated at the hearing. Please note that several figures in this report reference the ID for the tubing. Where noted a 3.6" ID is associated with a 4.5" tubing, the 4.5 x 3.6 " ID is associated with a tapered string of tubing, and the 4.5" ID is associated with 5 1/2" tubing (which is the subject of the application). Please let me know if you need anything else or if you have questions concerning this information.

Thank you,
Jennifer Bradfute

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