Title: **"Improved Miscible Nitrogen Flood Performance Utilizing Advanced Reservoir Characterization and Horizontal Laterals in a Class I Reservoir – East Binger (Marchand) Unit"**

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Disclaimer

Abstract

Implementation of the work program of Budget Period 2 of the East Binger Unit ("EBU") DOE Project continues. Major development work planned for the project includes the drilling of three horizontal production and one vertical injection wells, the conversion of five wells from production to injection service, and the expansion of injection capacity at the nitrogen management facility. Other work items include initiation of project monitoring and continued reservoir simulation.

EBU 74G-2, the injection well planned to support the production of EBU 64-3H, has been drilled. Completion was underway at the time of this report. EBU 64-3H was fracture-stimulated during the period, further increasing production from this new horizontal well. Drilling of the final two wells of the pilot project is planned for 2003. Both are planned as horizontal producing wells.

Work also began on projects aimed at increasing injection in the pilot area. The project to add compression and increase injection capacity at the nitrogen management facility was initiated, with completion targeted for March 2003. Additional producer-to-injector conversions are expected to be implemented around the same time.

The revised history match of the simulation model has been completed, and work has begun to evaluate options with forecast simulations. The quality of the history match is significantly improved over the prior match. The predicted distribution of remaining reserves in the field is significantly changed. Decisions on projects planned for implementation later in Budget Period 2 will be guided by new forecasts.

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Quarterly Technical Progress Report – 4th Quarter 2002

Introduction

Implementation of the work program of Budget Period 2 of the East Binger Unit ("EBU") DOE Project continues. Major development work planned for the project includes the drilling of three horizontal production and one vertical injection wells, the conversion of five wells from production to injection service, and the expansion of injection capacity at the nitrogen management facility. The pilot area is shown in Figure 1 and the planned well work is shown in Figure 2. Other work items include initiation of project monitoring and continued reservoir simulation.

This quarterly report covers the Fourth Quarter of 2002. The first of the three planned horizontal wells, EBU 64-3H, was put on production in the Third Quarter of 2002, and fracture stimulated in the Fourth Quarter. Its performance will be discussed in this report. Well EBU 74G-2, the vertical injection well, was drilled in the Fourth Quarter. No additional conversions were completed during this reporting period, but work began on the plant injection capacity project.

Significant advancement was gained with the completion of the revised history match of the reservoir simulation model. Results indicate a very different distribution of remaining reserves and therefore target infill drilling locations.

Additional data gathering was completed and will also be discussed.

Executive Summary

Implementation of the work program of Budget Period 2 of the East Binger Unit ("EBU") DOE Project continues. Major development work planned for the project includes the drilling of three horizontal production and one vertical injection wells, the conversion of five wells from production to injection service, and the expansion of injection capacity at the nitrogen management facility. Other work items include initiation of project monitoring and continued reservoir simulation.

EBU 74G-2, the injection well planned to support the production of EBU 64-3H, has been drilled. Completion was underway at the time of this report. EBU 64-3H was fracture-stimulated during the period, further increasing production from this new horizontal well. Drilling of the final two horizontal wells of the pilot project is planned for 2003.

Work also began on projects aimed at increasing injection in the pilot area. The project to add compression and increase injection capacity at the nitrogen management facility was initiated, with completion targeted for March 2003. Additional producer-to-injector conversions are expected to be implemented around the same time.

The revised history match of the simulation model has been completed, and work has begun to evaluate options with forecast simulations. The quality of the history match is significantly improved over the prior match. The predicted distribution of remaining reserves in the field is significantly changed. Decisions on projects planned for implementation later in Budget Period 2 will be guided by new forecasts.

Results and Discussion

The following is a detailed review of the work conducted in this reporting period.

Task 1.2.1 – Drill New Horizontal Producing Wells

Figure 2 shows the locations of the three horizontal producing wells planned in this task. The first, EBU 64-3H, was drilled and completed in 2002. Most of this work was discussed in the two previous Quarterly Technical Progress Reports (15121R09 and 15121R10). Additional work completed in this reporting period included a re-stimulation and monitoring.

As previously reported, the initial attempt to place a propped fracture had to be shut down prior to the sand stages of the treatment. Still, the well responded with an initial post-frac rate of over 1000 bopd and a sustained rate of over 100 bopd for over 50 days – until it was shut-in for a second attempt at placing a propped fracture. This was performed successfully in mid-November. The well responded again, though a change in fracture fluid proved somewhat detrimental. The initial treatment pumped in September included gelled diesel and 30% CO2. With the reservoir energy available, the CO2 was not needed, so it was dropped for the November treatment. By November, however, the near-well reservoir energy had been somewhat depleted, and it took a few days of swabbing back the diesel before the well began flowing without assistance.

Compared to before the frac, the GOR has risen slightly, while the nitrogen content of the produced gas has come down. Figure 3 shows the well's production from the first breakdown through the end of 2002. After the breakdown but before the frac, the GOR had leveled off at 3.5 to 4.0 Mcf/STB and the nitrogen content was measured at about 25%. After the frac, the GOR climbed to 4.5 to 5.0 Mcf/STB, while the nitrogen content dropped to 13%. Combined, these effects result in about 150 Mcf/d more hydrocarbon gas. This additional hydrocarbon gas is likely due to drawing down the reservoir pressure in the near wellbore region, liberating more hydrocarbon gas in this region.

Initial results from EBU 64-3H have been consistent with expectations from reservoir characterization work that suggested the well would develop unswept reserves. The next planned horizontal producing well is EBU 45-3H, the location of which is shown in Figure 2. The third planned well was originally the 44-3H shown in Figure 2. However, based on data from the simulation model, there appear to be better locations to drill. This is discussed under Task 1.2.9.

Task 1.2.2 – Drill New Injection Well(s)

EBU 74G-2, the location of which is shown in Figure 2, was drilled and cased during this report period. The well penetrated 50' of net pay in the Marchand "C" Sand. Completion has been delayed due to permitting issues for the gas line, but was underway at the time of this report. EBU 74G-2 will be produced for 60-90 days before conversion to injection. Its injection will support the production from 64-3H and improve recovery in this area.

Task 1.2.3 – Convert Producers to Injection

Five conversions are planned for Budget Period 2, as shown in Figure 2 and discussed below:

- EBU 57-1 was converted in June 2002.

- EBU 65-1 was converted in early January 2003.

- Permitting for the conversion of EBU 59-1 was initiated in January 2003 and is expected to take 60 days. Conversion is expected late March or early April 2003.

- Either EBU 37-3H or EBU 44-1 is planned for conversion around the same time as EBU 59-1. The selection of the well will be guided by modeling work under way at the time of this report.

- EBU 61-1 is slated for conversion later in 2003.

Task 1.2.4 – Construct, Modify, and Upgrade Plant Capacities

Significant work began toward increasing the injection capacity of the plant. A compressor was purchased and work began to install an additional cylinder to convert it from a three-stage to a four-stage machine. When online, the expanded compression will utilized spare capacity at the Air Separation Unit and increase nitrogen injection to the field from about 19 MMscf/d to about 22 MMscf/d. Installation into the plant is planned for March 2003.

Task 1.2.5 – Initiate Monitoring of Pilot Area Performance

Gas sampling continued in the pilot area. There were no new significant findings, but the decrease in nitrogen content observed in prior samples from producing wells around EBU 37-3H was verified with additional samples from these wells (EBU 36-1, EBU 37-2, and EBU 44-1). This was discussed in the prior Quarterly Technical Progress Report (15121R10, for 3Q 2002). New sample data is provided in Figure 4.

Task 1.2.6 – Technology Transfer Activities

Additional technical progress reports have been posted on the project web site, www.eastbingerunit.com.

Task 1.2.9 – Modify and Update Simulation Model, etc.

The revised history match of the reservoir simulation model has been completed. Significant modifications were made to the reservoir description and modeling of hydraulic fracture treatments. Nearly all wells in the pilot area have an equivalent or better match in the new model, and many matches are significantly better.

As discussed in Quarterly Technical Progress Report 15121R08 (1Q 2002), the original model was constructed with the primary ("x") axis of the grid was oriented in a northwest-southeast direction, in line with the orientation of the main sand body of the reservoir. Hydraulic fracture treatments were modeled as enhanced permeability in a northeast-southwest direction, in the "y" direction of the grid.

As further discussed in 15121R08, detailed model review and additional research led to the conclusion that the assumption of fracture orientation was incorrect, and that both it and the dominant flow direction in the field is approximately east-west. It was on this basis that the history match was reconstructed.

Figures 5, 6, and 7 have plots of the model-predicted GOR and nitrogen cut versus field data for three wells in the pilot area, both from the original pilot model history match and the current history match. Figure 5 has plots for EBU 44-1, located in the western end of the pilot area. In the original pilot model, gas produced at this well came predominantly from EBU 37G-1 to the north. Injection was stopped in EBU 37G-1 in 1994, and the model showed a declining GOR and nitrogen cut (upper plot of Figure 5). But in reality, the GOR and nitrogen cut continued to increase. The new pilot model matches these trends (lower plot of Figure 5). In the new pilot model, the primary source of the gas being produced at EBU 44-1 is EBU 45G-1 to the east.

Figure 6 has plots for EBU 45-2. In the original pilot model, the predicted GOR and nitrogen cut were fairly flat throughout its production history, with the nitrogen cut quickly rising to 60% and declining to 45% at the end of history (upper plot of Figure 6). In that model, the source of nitrogen was EBU 60G-1 to the southeast. The actual field data showed a nitrogen cut rising much more gradually through history (lower plot of Figure 6). In the new pilot model, the nitrogen cut does not reach the level seen in the field, but is much closer to the trend seen in the field.

Figure 7 has plots for EBU 48-1, which is located in the northeast part of the pilot area. Field data indicates a declining GOR since 1994, when injection was halted in EBU 49G-1 (directly east of EBU 48-1). The upper plot of Figure 7 shows the history match of the original pilot model. In that model, gas production at EBU 48-1 came from three surrounding injection wells, but primarily from EBU 58G-1, southwest of EBU 48-1. Thus, the model continued to predict a rising GOR in the late 1990s, contrary to field data. The revised model, with more east-west fracture modeling, reflects EBU 49G-1 as the primary source of gas produced at EBU 48-1, and accurately predicts a declining GOR after injection is stopped in EBU 49G-1 (lower plot of Figure 7). Although the model-predicted nitrogen content of the produced gas is still below field data, the trends are clearly and significantly improved over the prior version of the model.

There are significant implications associated with the revised history match. The predicted distribution of remaining reserves is significantly altered. This has implications on the planned locations of horizontal wells planned for Budget Period 2. Figure 8 is a display of the predicted oil saturation at present time in model layer 8 (in the stratigraphic middle of the C Sand) of the original pilot model. One of the most promising locations for drilling a horizontal well was between EBU 44-1 and EBU 45-2. This location is in the heart of the reservoir and appeared to be unswept. As shown in Figure 2, EBU 44-3H was planned for this area. Because of earlier concerns with the model, however, this well was scheduled for drilling late in Budget Period 2.

The revised model predicts a very different distribution of remaining reserves, as shown in Figure 9. As can be seen in this display, the planned location of EBU 44-3H is significantly more gas-swept than previously predicted. Other possible locations appear much more attractive. These include the area between EBU 43-1 and EBU 44-1, the area north of EBU 61-1, and areas around EBU 58-2. Evaluations of horizontal wells in these locations are currently underway.

The predicted vertical distribution of fluids was also altered. The original model predicted much more gas at the top of the C Sand than at the bottom. This can be seen by comparing the predicted oil saturation of model layer 5, shown in Figures 10 (original model) and 11 (current model), with the predicted oil saturation of model layer 8 (Figures 8 and 9). Layer 5 is near the top of the C Sand. The original model (Figures 8 and 10) predicted much more gas near the top of the reservoir than in the middle. The current model (Figures 9 and 11) still shows more gas near the top than in the middle, but with far less difference than predicted by the original model.

Conclusion

The implementation of the pilot project of the East Binger Unit DOE Project is progressing. EBU 74G-2, the injection well planned to support the production of EBU 64-3H, has been drilled. Completion was underway at the time of this report. EBU 64-3H was fracture-stimulated.

Work also began on projects aimed at increasing injection in the pilot area. The project to add compression and increase injection capacity at the nitrogen management facility was initiated, with completion targeted for March 2003. Two to three producer-to-injector conversions are also expected around the same time.

The revised history match of the simulation model has been completed, and work has begun to evaluate options with forecast simulations. The quality of the history match is significantly improved over the prior match. The predicted distribution of remaining reserves in the field is significantly changed. Decisions on projects planned for implementation later in Budget Period 2 will be guided by these forecasts.

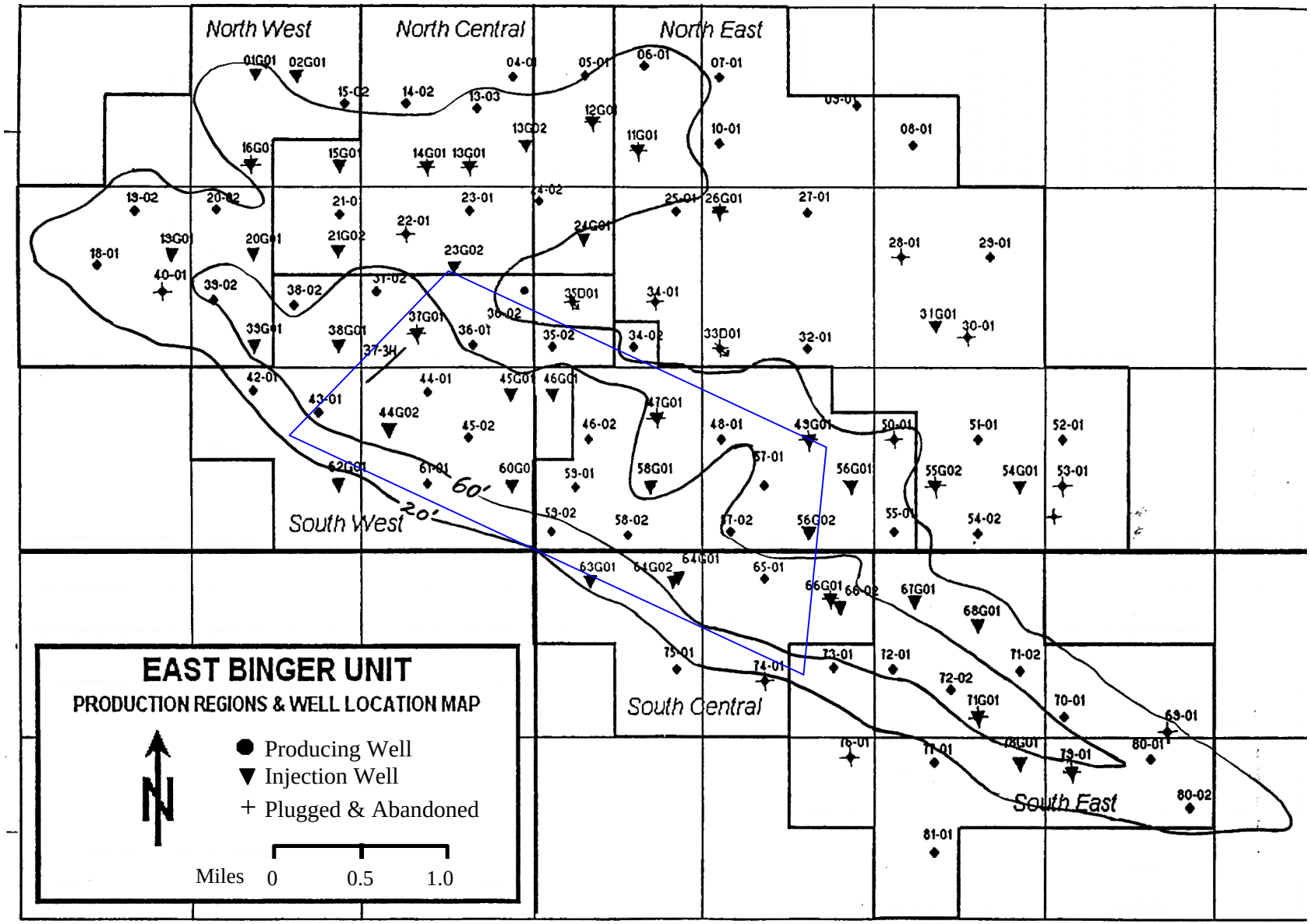


Figure 1. East Binger Unit net pay map. The blue box surrounds the pilot area.

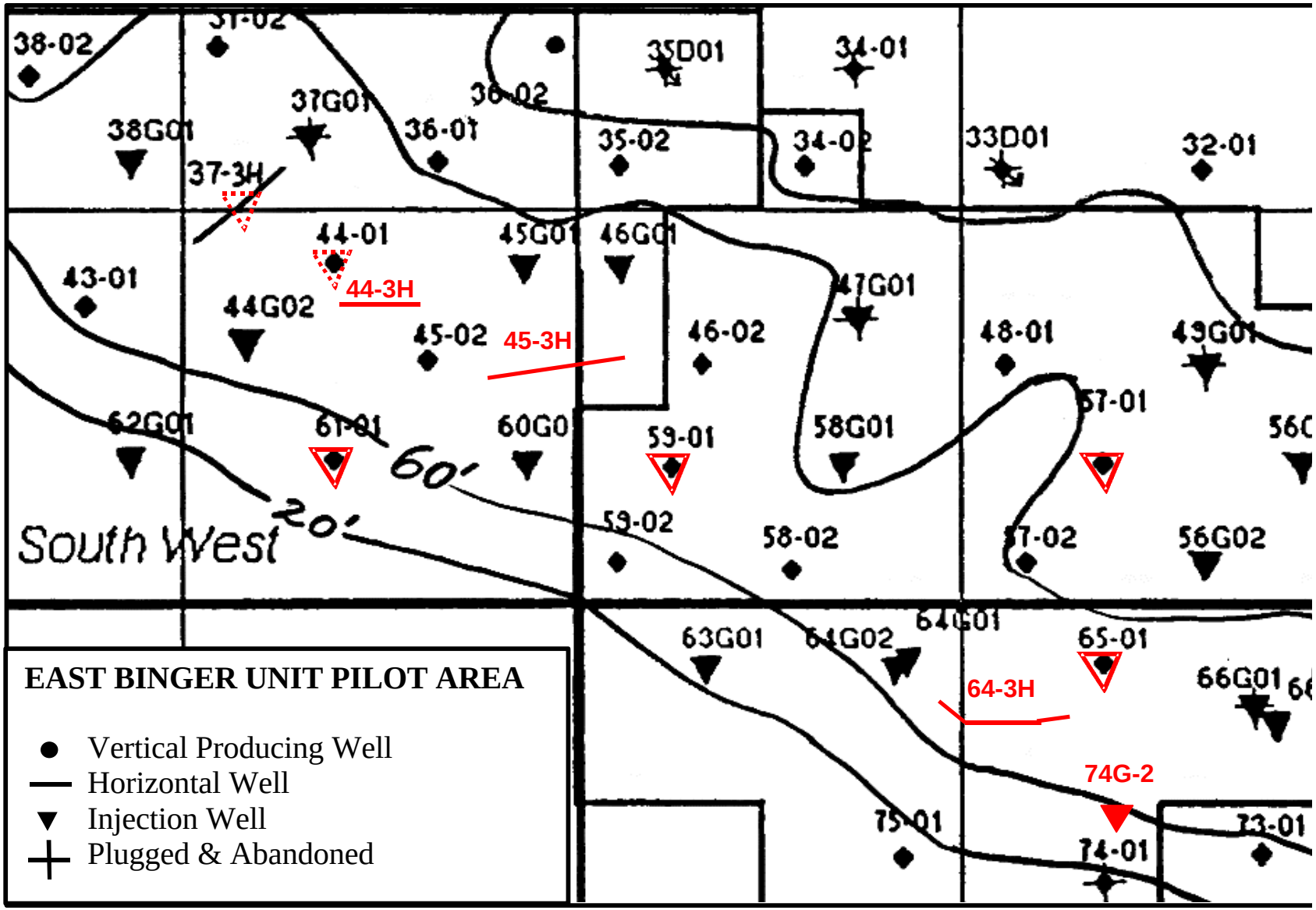


Figure 2. Fieldwork planned for the pilot - shown in red. Either 37-3H or 44-1 will be converted to injection.

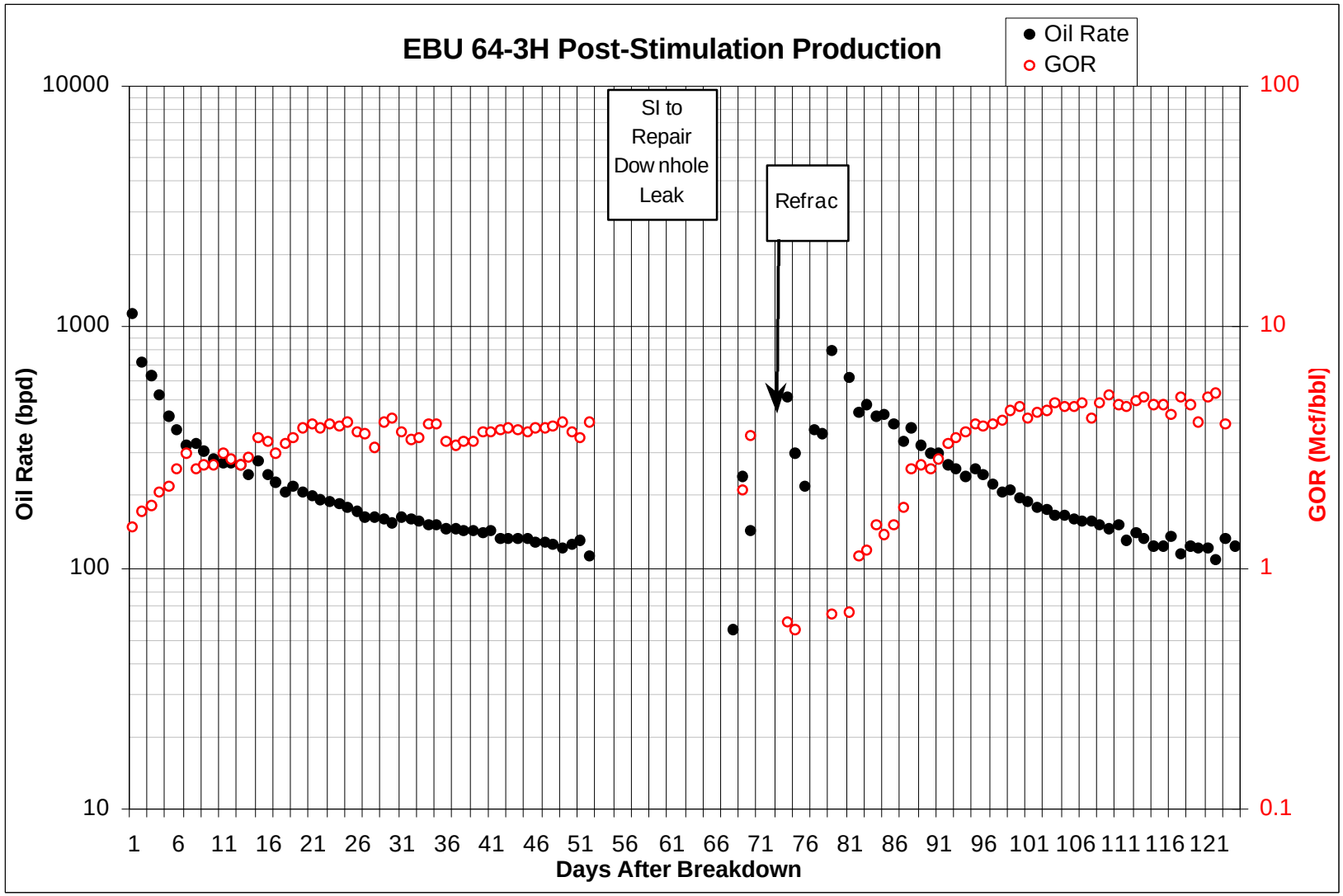
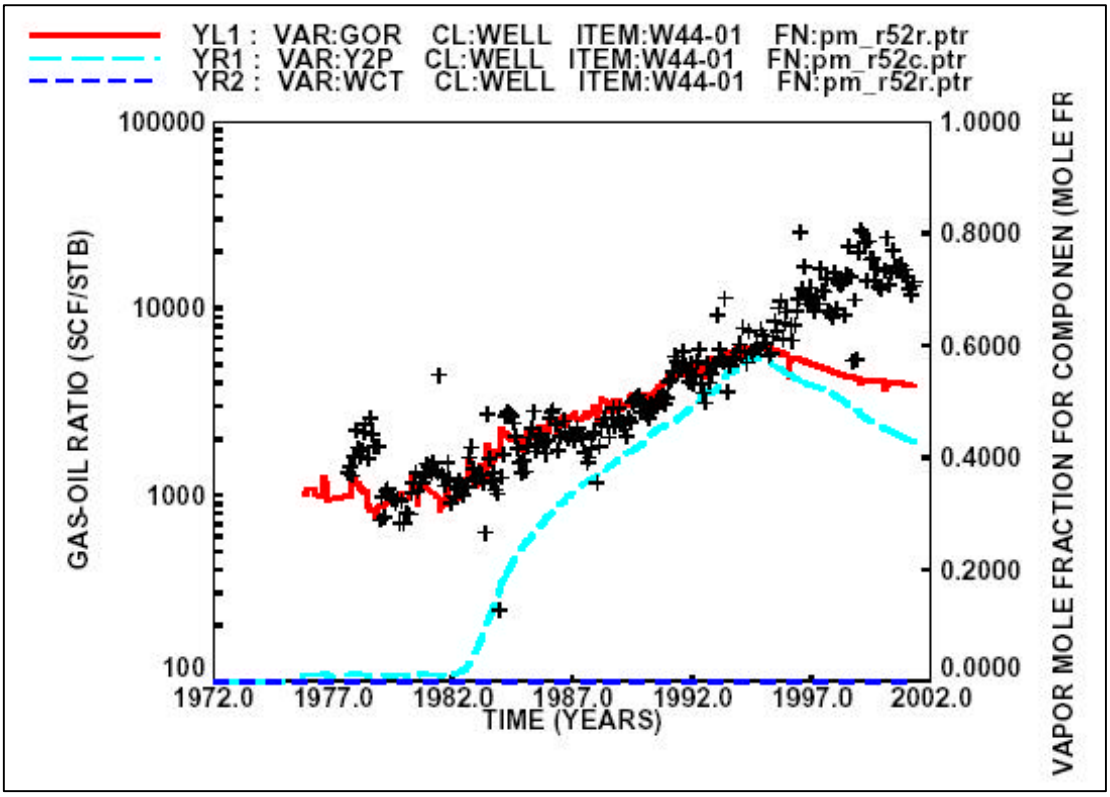


Figure 3. Post-stimulation production data for horizontal well EBU 64-3H. The breakdown treatment was pumped in early September 2002.

East Binger Unit Pilot Area
Nitrogen Content in Produced Gas
4th Quarter 2002 Sample Data

Well	December 2001 Sample	August 2002 Sample	**November 2002 Sample**
35-2	58%	-	**61%**
36-1	65%	50%	**49%**
36-2	25%	-	**29%**
37-2	83%	77%	**79%**
43-1	9%	10%	**-**
44-1	69%	67%	**67%**
45-2	56%	58%	**-**
48-1	83%	83%	**84%**
57-2	37%	41%	**39%**
58-2	8%	5%	**-**
73-1	13%	21%	**-**

Figure 4. Pilot Area gas sample data.



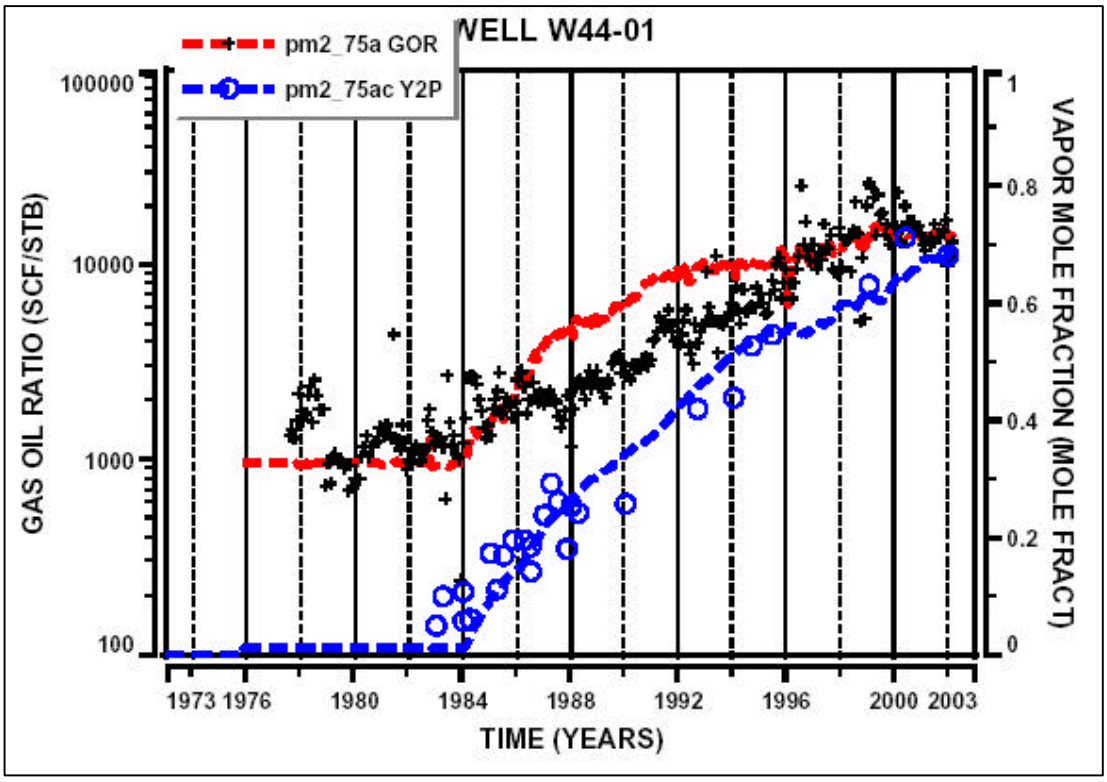


Figure 5. Simulation history match plots for EBU 44-1. The upper plot is the match from the original pilot model; the lower plot is from the current model. "Y2P" is the nitrogen content of produced gas. Symbols are field data; lines are model data.

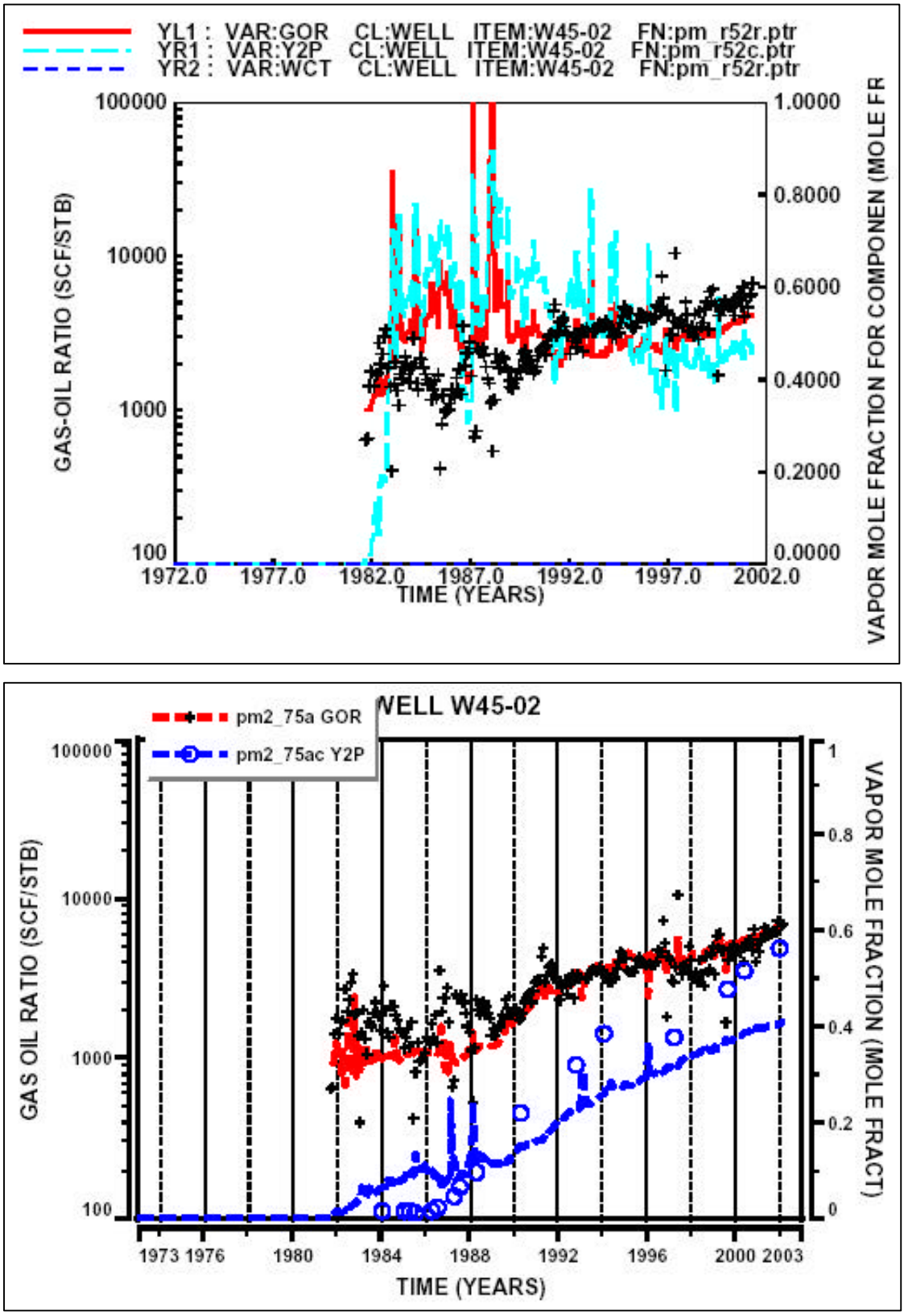


Figure 6. Simulation history match plots for EBU 45-2. The upper plot is the match from the original pilot model; the lower plot is from the current model. "Y2P" is the nitrogen content of produced gas. Symbols are field data; lines are model data.

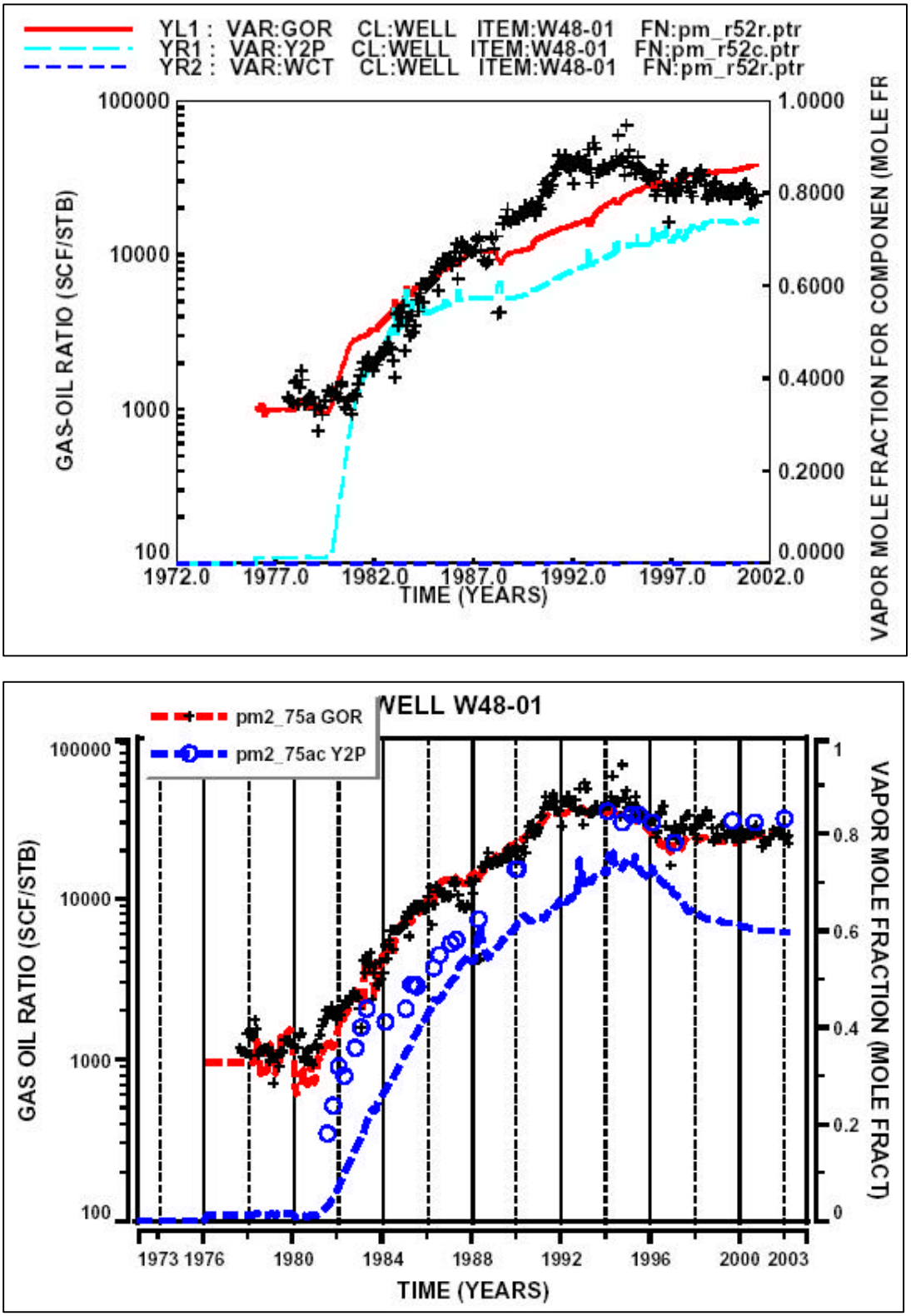


Figure 7. Simulation history match plots for EBU 48-1. The upper plot is the match from the original pilot model; the lower plot is from the current model. "Y2P" is the nitrogen content of produced gas. Symbols are field data; lines are model data.

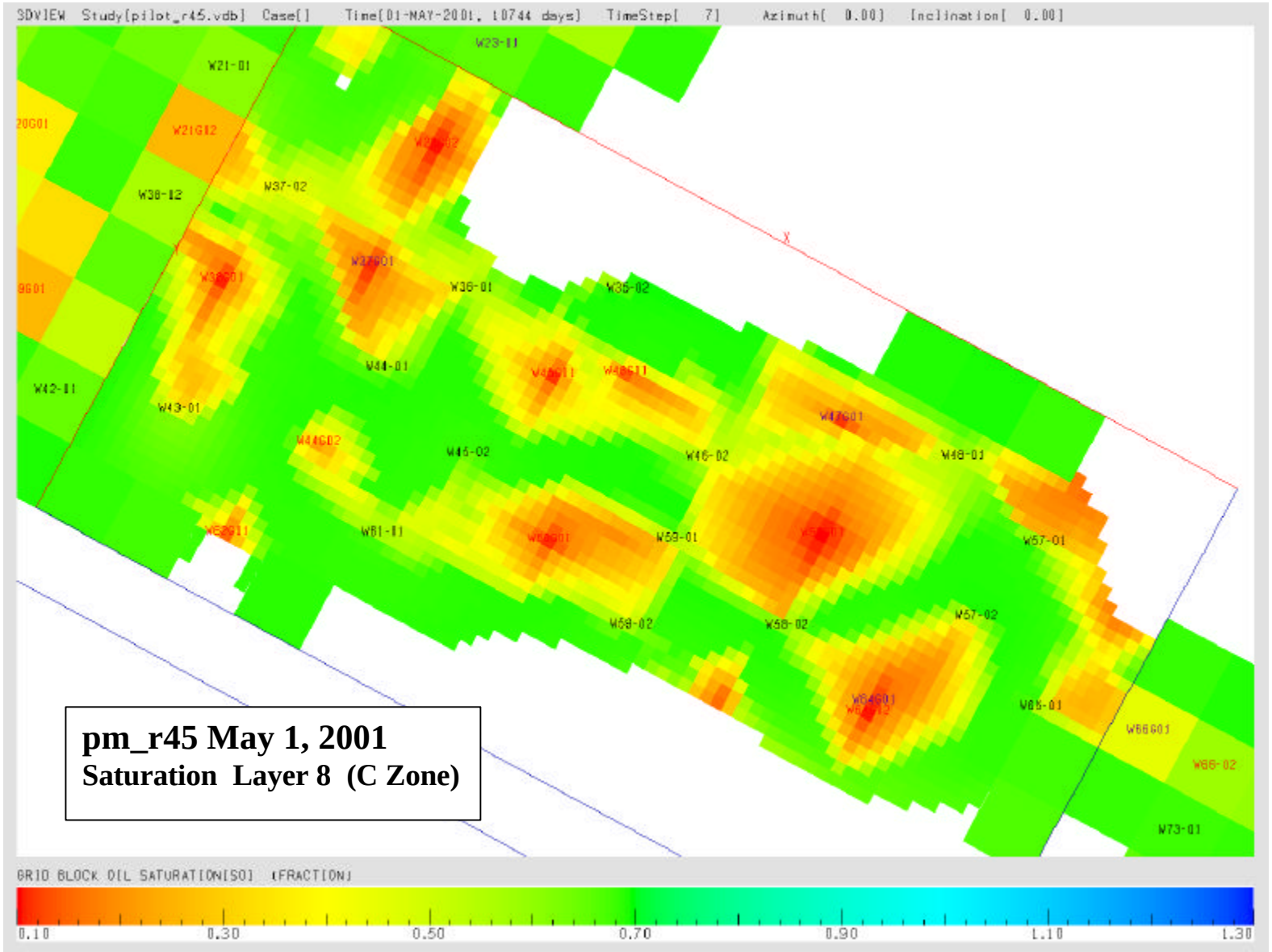


Figure 8. Original pilot model-predicted oil saturation for layer 8 (middle of C Sand) at current time.

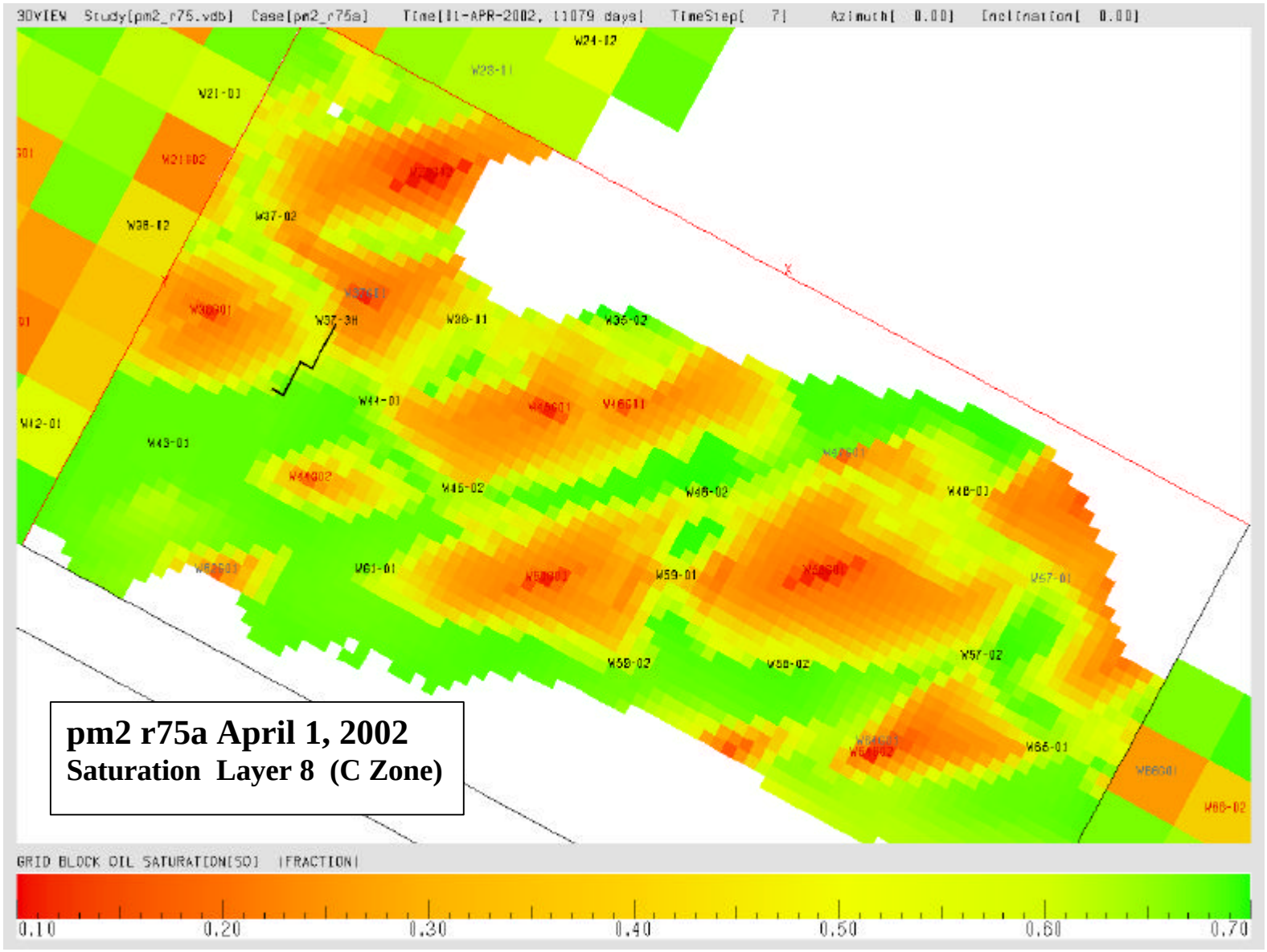


Figure 9. Current pilot model-predicted oil saturation for layer 8 (middle of C Sand) at current time.

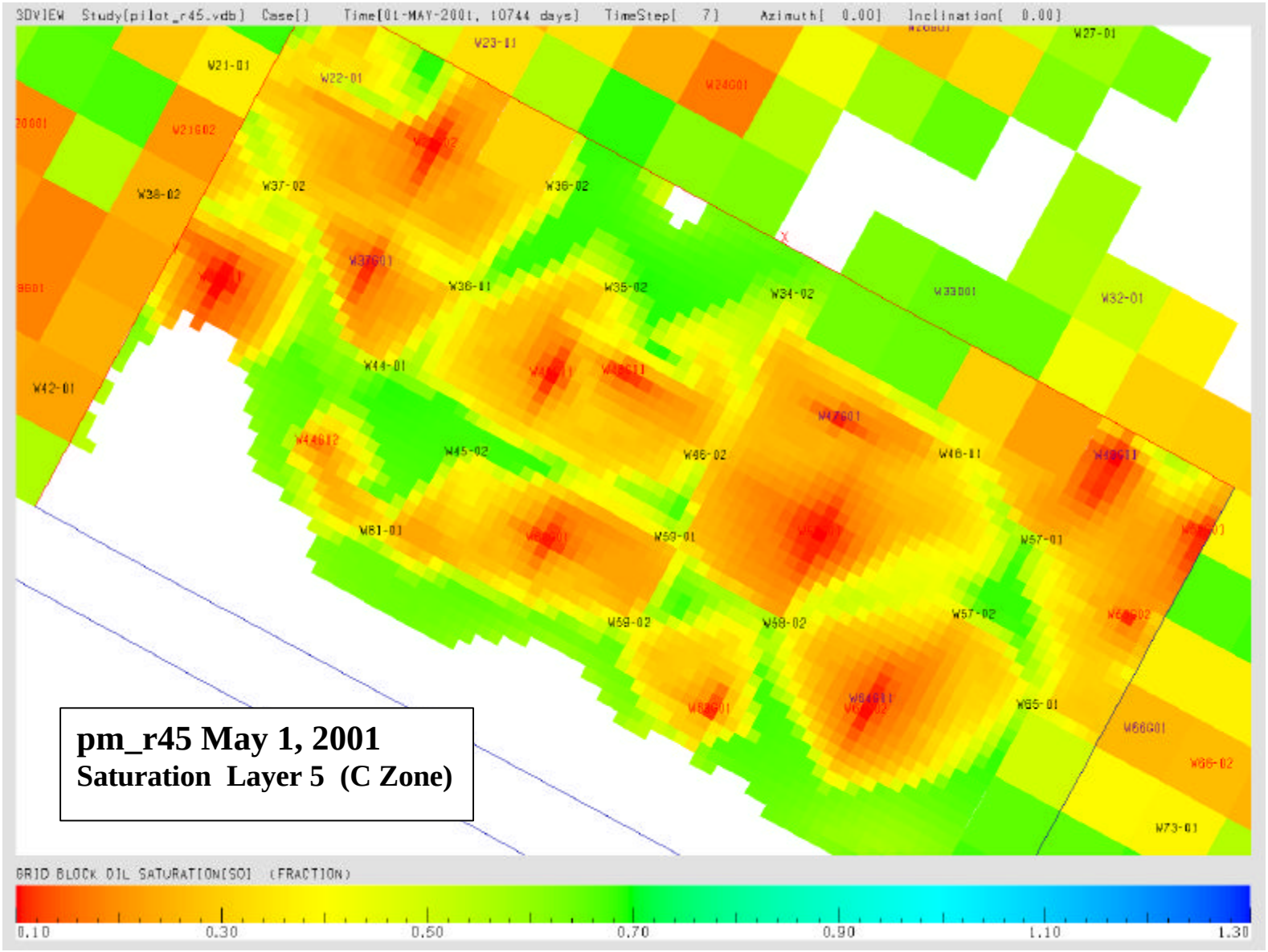


Figure 10. Original pilot model-predicted oil saturation for layer 5 (top of C Sand) at current time.

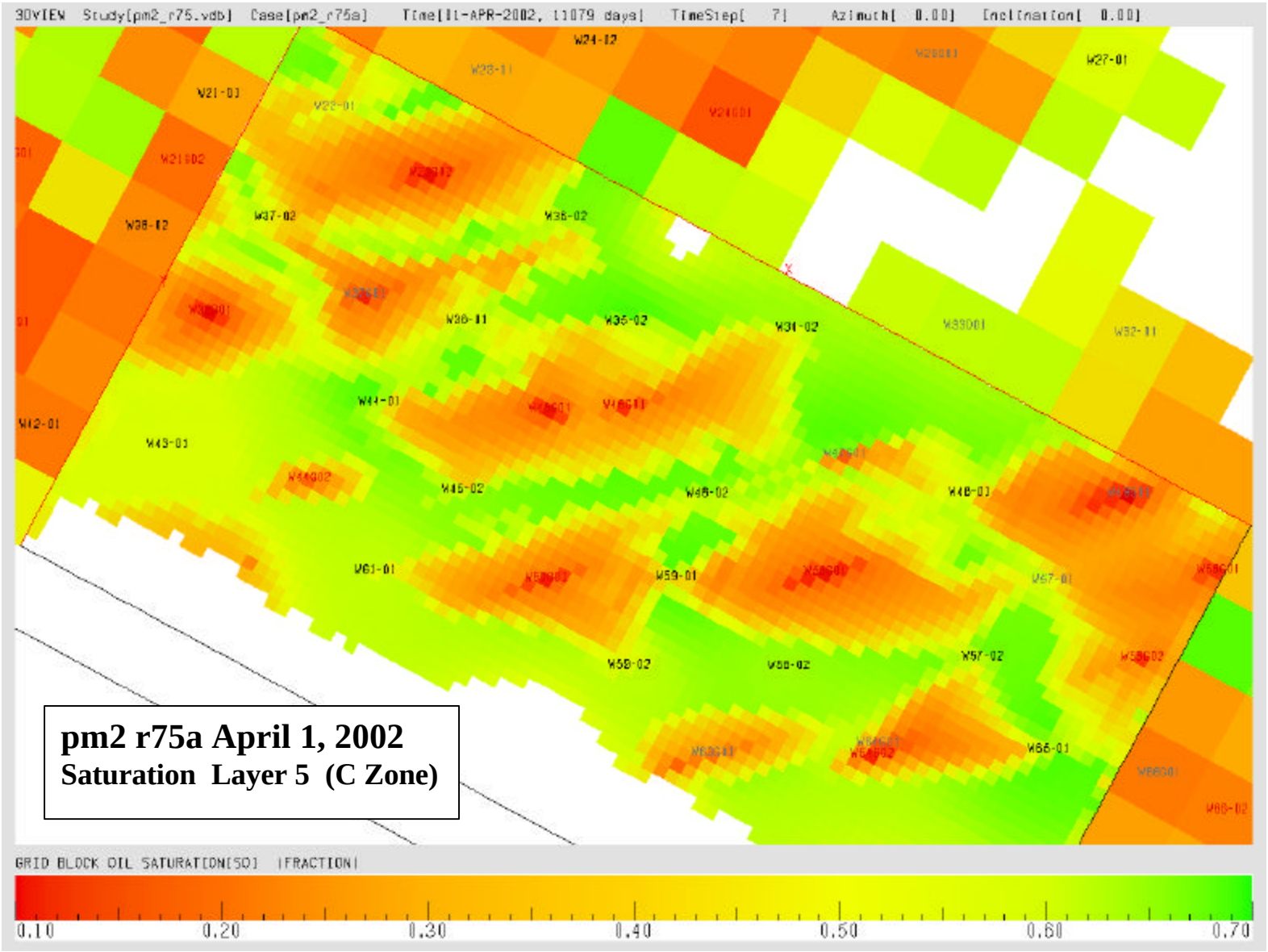


Figure 11. Current pilot model-predicted oil saturation for layer 5 (top of C Sand) at current time.