Waterflood Optimization Using Data-driven and Model-driven Approaches

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This project was initiated to develop a workflow for performance review of a waterflooded field and evaluation of opportunities for improving production. The workflow started with a review of the limited geological data available and the application of a series of analyses on the selected field to review its performance. The data utilized within the workflow was Canadian public data. Analysis of pay and formation tops data, along with a wider look at surrounding wells indicated that this field most likely represents a channel. In addition, there is a possibility of faulting impacting field performance. A series of waterflood analysis techniques were applied; pressure/GOR analysis, voidage replacement ratio calculations, conformance plots, water movement, streamlines and pattern analysis, drainage radius, heterogeneity index, water control diagnostics and hall plots. The performance plots in Figure 1 show that water production exceeds water injection, indicating an influx of water from other formations with high permeability. The grid and bubble map in Figure 1 further reinforces this evidence by indicating that the areas with highest cumulative water production do not correspond to the areas with highest cumulative water injection.

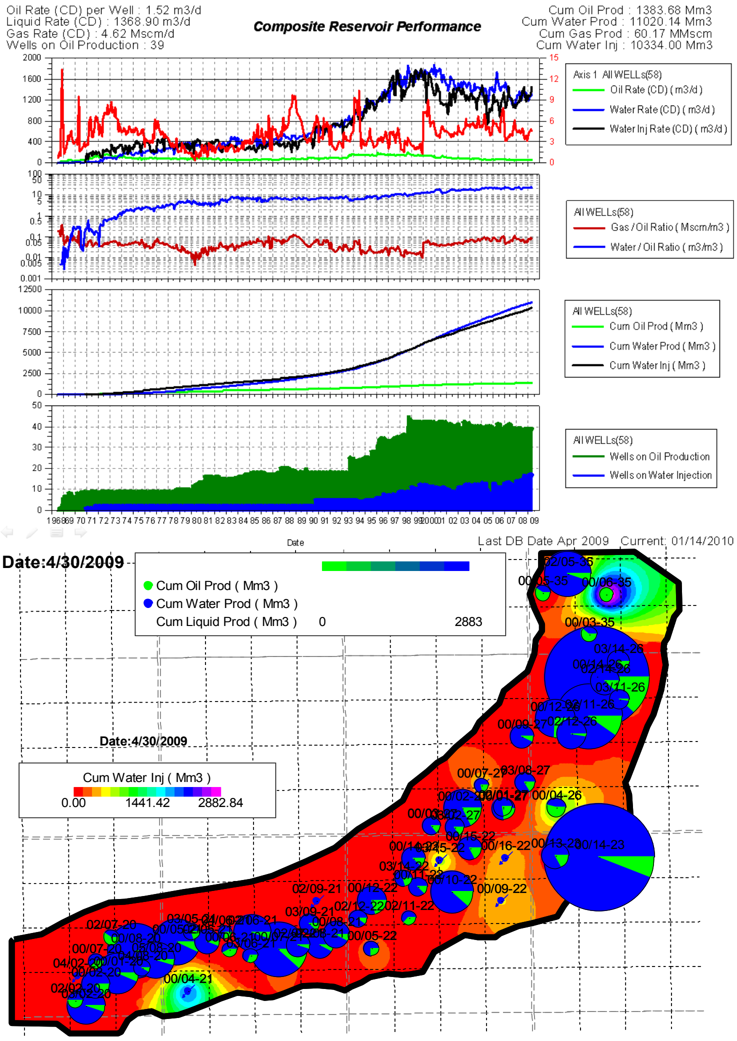

Figure 1: Indications of possible water influx

Through this analysis, we were able to highlight some producing wells that had potential for increased production rates, as well as several injection wells that were plugging. A detailed production network model was built to study this further. The model was history matched using the production data. After tuning the model and achieving a good production match for most wells, it was observed that the model predicted much higher production rates compared to actual for several wells. Nodal analysis was performed to study this inconsistency. We concluded that these wells had formation damage and could potentially be recommended for workovers such as acid jobs.

The last step in the workflow analysis was to optimize several under-producing wells by introducing artificial lift techniques. For this we studied the effects of adding electrical submersible pumps (ESP). Again, a series of nodal analysis techniques were applied to the model to study the effects of multiple changes on inflow and outflow parameters such as reservoir pressure, pump speed, delivery point conditions. Figure 2 presents one of the results of running sensitivity analysis on reservoir static pressure and pump speed. A series of new production forecasts were generated based on the various potential changes.

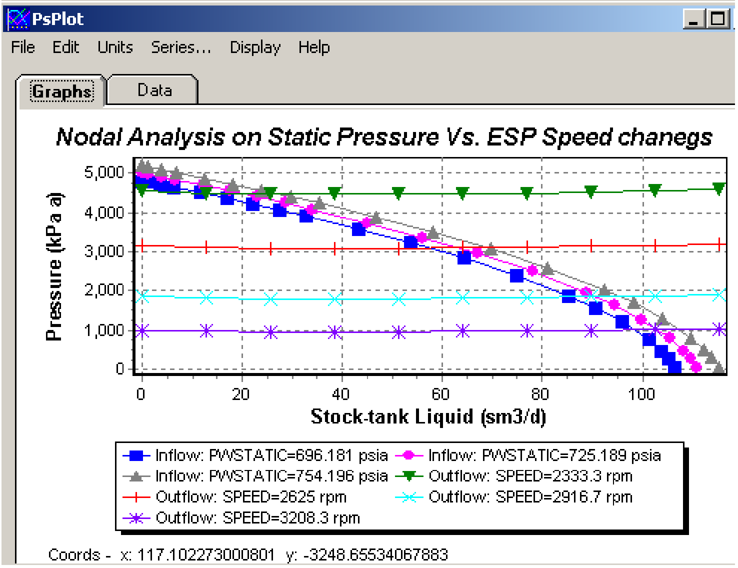

Figure 2: The result of running nodal analysis sensitivities on reservoir static pressure and pump speed.