EXTENDING THE LONGEVITY OF PRODUCED WATER DISPOSAL WELLS: EVALUATION USING REACTIVE TRANSPORT SIMULATION

Kara Marsac, Colorado School of Mines
2018–2019 Graduate Fellow

EXECUTIVE SUMMARY

For every barrel of oil an average of seven barrels of water is produced [1]; disposal of this produced water adds significantly to the cost of domestic oil and gas development and is one of the largest problems facing the industry today. Reactive transport simulations investigate treating produced water before deep well disposal in the Permian Basin, Texas, U.S.A. This study found that a reduction of HCO_{3-} and Ca^{2+} concentrations led to increases in well lifetime of more than 13 years. Increasing the lifetime of a produced water disposal well near a producing well lowers the cost of transporting each barrel of produced water. These cost savings have the potential to create an increase in the number of economically viable oil and gas plays in the United States.

RESEARCH CHALLENGE

Produced water management is one of the biggest challenges associated with oil and gas development [2]. It is estimated that onshore wells in the United States generate 14 to 21 billion barrels of produced water every year [1,3]. Of that total, 92% is managed using injection [1]. Disposal of produced water can be expensive, with the use of disposal wells costing between \$0.05 and \$2.65 per barrel [4]. With each barrel of extracted oil creating multiple barrels of produced water, disposal costs can add significantly to the cost of oil.

The interaction between produced water and the water in the disposal formation can create mineral precipitation, which impacts the continued disposal of water in that formation and eventually leads to the sealing and abandonment of the well. Reduction of mineral precipitation through produced water treatment can increase the lifetime of disposal wells, thereby saving transportation costs.

METHODS & CODES

PFLOTRAN, a massively parallel, multiphase, multicomponent reactive transport code [5] is used to create simulations of a control produced water injection in the Permian Basin, TX, U.S.A. This control water simulation was generated from the Permian Basin Brine Database [6] as a synthetic water that is representative of an amalgamation of brines present in the basin. Dolomite, anhydrite, and calcite minerals precipitate in the Permian Basin from four ions: Ca^{2+}, Mg^{2+}, HCO^{3-}, SO^{42-}. In this work, we created simulations that reduced each of these ions in the control water by 25%, 50% and 75%, for a total of 12 simulations. In each simulation, produced water is injected at 20,000 gallons/day from a center point into a 100 m x 100 m x 100 m observation area. The grid is variable, with higher-discretization 1-m cells concentrated around the injection zone. The injected produced water mixes with the formation water already present in the matrix, a median of the Permian Basin Brine Database. Each simulation runs until porosity reaches zero, which we consider the end of the well lifetime.

RESULTS & IMPACT

The results show that reducing calcium, magnesium, or bicarbonate increases injection time: our measure of increased well lifetime. The control simulation mineral volume results show calcite and dolomite as the dominant minerals controlling precipitation volume, while only a small amount of anhydrite precipitates. A calcium concentration reduction of 75% increases the well lifetime by over 5,000 days owing to a decrease in anhydrite, calcite, and dolomite. Reducing bicarbonate concentration by 75% increases the well lifetime by over 4,500 years by decreasing the volume of calcite and dolomite precipitated. Reducing magnesium concentration by 75% leads to an increase in well lifetime of over 300 days owing to the reduction of dolomite precipitation. Reducing sulfate concentration by 75% actually decreases injection time by 50 days. Reducing the concentration of sulfate only affects anhydrite, the mineral with the lowest volume. When anhydrite is not formed, there is more Ca^{2+} available in the water. This calcium forms calcite, leading to the precipitation of more calcite more quickly than the control simulation, and thus shows a decrease in well lifetime.

These results indicate that in the Permian Basin, oil and gas companies should pursue the treatment of calcium or bicarbonate in produced water to extend the lifetime of produced water disposal wells. This pursuit of treatment should come in the form of funding research of calcium and bicarbonate treatment for Permian Basin produced waters. By increasing the lifetime of a disposal well near the producing well, companies save money on transporting produced water. These cost savings can lead to cheaper oil and gas and create more economically viable hydrocarbon plays in the United States, assisting in the development of domestic assets.

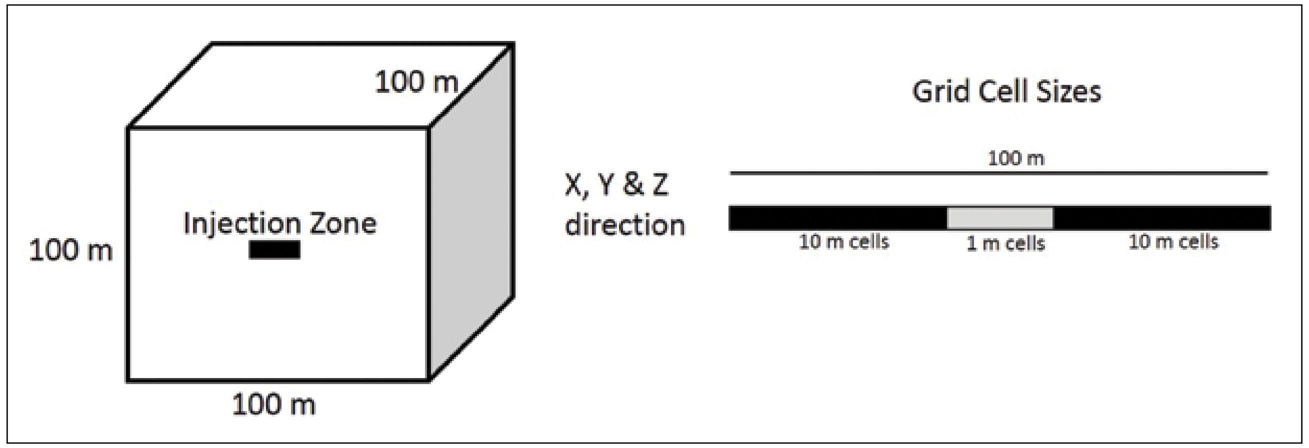

Figure 1: Diagram of grid size and discretization of all simulations.

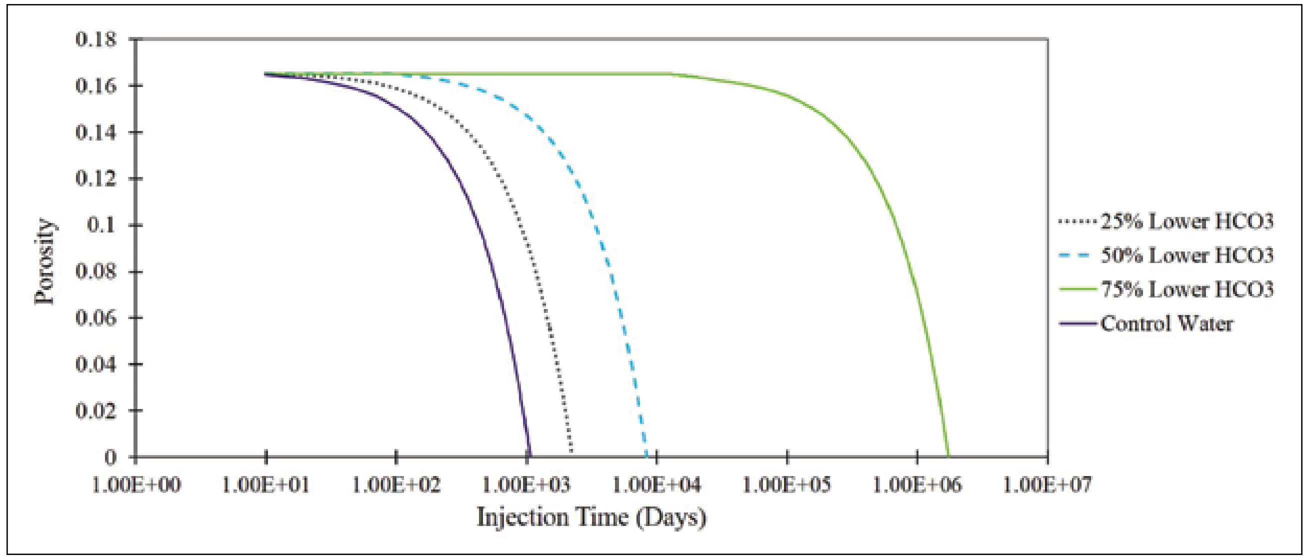

Figure 2: Results from the bicarbonate concentration reduction simulations compared to the control water.

WHY BLUE WATERS:

Blue Waters is essential for this research owing to the timescales of the simulations and the amount of output data. These simulations represent thousands of days of time; without the power of parallelization of Blue Waters, running each simulation could take months. Over the course of each simulation more than 6,000 output files can be printed, totaling over 600 GB of data. Blue Waters allows us to process such large data volumes.

PUBLICATIONS & DATA SETS

K. Marsac and A. K. Navarre–Sitchler, "Extending the longevity of produced water disposal wells: evaluation using reactive transport modeling," in review, 2019.

Kara Marsac graduated in May 2019 with a Ph.D. in hydrology from the Colorado School of Mines, having worked under the direction of Alexis Navarre–Sitchler.