



SPE 116218

The Integrated Approach to Formation Water Management: From Reservoir Management to Protection of the Environment

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This paper was prepared for presentation at the 2008 SPE Annual Technical Conference and Exhibition held in Denver, Colorado, USA, 21–24 September 2008.

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Abstract

The production of large volumes of water is common in wells producing from strong aquifer reservoirs, such as most of the fields in the Oriente basin of Ecuador and neighboring Marañón and Putumayo basins in Peru and Colombia, respectively. In most cases, as the water cut increases it restricts the production of oil and creates production problems, including scale deposition, corrosion and even sand production. This increases the need for treatments thus increasing operating costs. On the lifting and processing sides, additional volumes of water require larger artificial lift units with higher energy loads, and facilities that often need to be upgraded in order to separate and handle significantly larger-than-design fluid rates. At the end of the cycle, formation waters need to be treated, cleaned and disposed off adequately in water disposal wells.

The water problem is costly. If it is not addressed in a proper and timely manner the only option left to the operator is shutting-down producers, with a heavy impact on economics, particularly given the current oil price environment. Twenty years of experience with formation water issues in the Oriente and Marañón basins indicate that only a small percentage of water shut-off treatments have been successful. Lack of success is generally related to failure in performing analysis to understand the exact source of the unwanted water. A classification of the 10 main water problem types in producer wells is included in this paper.

The integrated approach to formation water management looks at the problem comprehensively, starting with an understanding of the water flow mechanisms in the reservoir and the identification of the water breakthrough mechanism at the producer well, followed by the detection of production bottlenecks in the wellbore and the surface facilities, and finishing with analysis of water disposal or reinjection to complete the cycle. Once the problems and constraints in each part of the water cycle are understood they must be considered together to determine the most critical bottlenecks in the production system. The accurate identification of the water problems is absolutely essential in the selection of effective water management solutions for the facilities, injectors and/or producers. Proper understanding of producer problems can lead to effective water shut-off, improved lift and increased production. The timely resolution of flow and energy bottlenecks at production facilities can allow higher flow rates to be managed while longer-term solutions are put in place. Accurate understanding of the water mechanisms in injectors, combined with close monitoring at the field level can help increase injectivity (and injection profile in waterflooding operations) and significantly reduce disposal costs.

The integrated approach to water management was implemented in the Villano field, operated by AGIP Oil Ecuador in a rainforest environment in Block 10, Ecuador. Villano is producing 107,000 BWPd. The facilities are operating at design limits, with no extra capacity to spare. Villano was designed to produce in an offshore-type fashion, with its Central Processing Facilities located 44 Km apart from the field, with no road access, in order to minimize any impact on the environment. The implementation of the integrated water management approach in Villano served to identify bottlenecks in flow and energy processing units and at the same time determined what exactly needs to be done in order to handle three times the production today, expected within the next 10 years. Diagnostics analysis provided initial insights into the mechanisms of water breakthrough in producer wells, and identified a number of alternatives to increase the injectivity index at the disposal wells, all within the land, energy, environmental, accessibility and logistical constraints of the project. The paper presents the integrated water management methodology and practical applications, advantages and results brought by the integrated approach to the Villano field.