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## Case Example

### **Occidental Petroleum Corporation: Waterflooding in Oman to Extend the Life of a Desert Region Oil Field**

*Nowhere is the need for water planning more critical than in desert regions. When working in water-scarce environments, careful planning helps to ensure that sustainable development goals can be met and that conflicts among potential water users are avoided. For these reasons, Occidental integrates environmental, economic, and social considerations into its oil and gas production activities underway in northwestern region of Oman.*

Despite its location in the Arabian desert, Occidental proposed in 2000 a project to enhance oil production from its Safah field operations. Since a significant share of the additional production is retained by the government under the terms of Occidental's contract, the project will result in higher income for the country, benefiting its citizens. However, attaining this additional oil production required the use of a technique known as *waterflooding*. Consequently, water management (securing a supply and protecting existing resources) was a key consideration from project inception onward.

Occidental's Safah field operations in Oman have been in operation for over 20 years. The field was first run as a primary recovery operation, followed then by gas reinjection to maintain reservoir pressure and increase recovery of the available reserves. Applying its expertise in enhanced oil recovery, Occidental's proposed waterflood was necessary to ensure success in the next phase of field development. Waterflooding is a technique used to sustain and enhance the development of an oil field after primary recovery operations are completed. The challenge for Occidental was to do so in an environment where the summer temperatures regularly exceed 125 degrees Fahrenheit and rainfall is sparse and irregular.

Consistent with Occidental's Health, Environment, and Safety Principles and to ensure that the application of this technology would be appropriate in this region, Occidental performed an extensive investigation of the Upper Fars aquifer, the proposed source aquifer for the waterflood. The Upper Fars aquifer was designated as the source for the Al Massarat Water Supply Project (to satisfy potable and agricultural uses), directed by the Oman Ministry for Water Resources.

The comprehensive aquifer modeling work performed by Occidental was the first study of its kind to be performed by an oil operator in Oman. The modeling results showed that Occidental's project would not impact other existing or potential future uses. Consequently, the Omani government determined that the project balanced its national goals of continued economic development and social progress—through the project's compatibility with the water supply project. In addition, Occidental provided its updated aquifer model to the government of Oman for further enhancement as individual elements of the Al Massarat Water Supply Project are brought on-line.

Through efficient use and careful planning, Occidental's waterflood project has increased the ultimate recovery oil from the Safah field, sustaining its productive life beyond the originally expected economic life. Extending the life of an oil field through enhanced recovery techniques translates to less impact on the environment because continued production reduces the need for exploration and development of new fields.

A contributing factor in Occidental's success in Oman is its comprehensive management plan for water resources. Not surprisingly, water carries special significance in the desert. For example, sanitary

## Occidental Petroleum Corporation: “Waterflooding” in Oman to Extend the Life of a Desert Region Oil Field (Cont.)

wastewater from the field camp at Safah is treated biologically and then sent to a constructed lagoon where it provides an oasis habitat, one that is especially attractive to migratory birds. Water that is co-produced with crude oil is also afforded special attention. Known as *produced water*, these large-volume water streams are often highly saline. Managing produced water is a big part of any oil field operation. Occidental’s Oman operations make extensive use of horizontal wells to help maximize oil production and minimize the generation of produced water. Once generated, produced water typically is recycled extensively by reinjection into the original oil producing formation. However, the system must allow for removal of a slipstream of produced water to prevent formation plugging and other operational problems. Occidental manages this slipstream in solar evaporation ponds—lined to prevent shallow groundwater contamination—and by providing a portion as feedstock to a nearby salt manufacturing company. Distilled water is returned to Occidental for industrial uses in the production facilities at Safah.