Water Management Economics in the Development and Production of Shale Resources

By Christopher J. Robart*

Introduction

Water management has always been an important activity in the development and production of oil/gas resources. Moderate volumes of water are required as an input for multiple activities in conventional oil/gas development. Additionally, water is produced by all oil/gas wells, ranging from minimal volumes early in the life of a well (a 1 to 1 ratio of water to oil is typical) to large volumes late in the life of a well (a 15 to 1 ratio of water to oil is typical), although actual volumes vary widely across wells and during the life of a well. However, water's importance has increased dramatically with emergence of wide-scale development of shale resources for oil and gas production.

The innovation that has been most critical in making the development of shale resources economically viable, multi-stage hydraulic fracturing ("fracing"), has also dramatically changed water needs. Fracing requires large volumes of water as an input into the well (typical volumes range from 10,000 barrels to 200,000 barrels per well). Between 10% and 40% of the water pumped into the well during hydraulic fracturing returns to the surface ("flowback water") in the first 30 to 60 days of the life of the well. In order to maintain production rates over the life of a well, it is common practice to refrac wells one or more times, typically at 3- to 5-year intervals. Finally, a larger number of wells must be drilled to effectively drain a shale field than a conventional oil/gas field. All of these factors amount to a massive volume of water that must be managed over the life of a shale field, significantly more than is typical in the development and production of a conventional field.

Managing all of the water going into and flowing out of a shale well is complex and costly. Water used for hydraulic fracturing must be sourced, transported, and stored, often with many intermediate steps in between. The water coming out of the shale well (both high volume flowback water and lower volume produced water, collectively referred to as "effluent") must be stored, transported, and either disposed via injection well or treated for reuse or surface discharge. Additionally, the water coming out of a well varies widely in quality, but none can be considered clean without significant treatment to remove salt, hydrocarbons, bacteria, and other minerals. The problem of how to manage water in the context of shale development and production can most aptly be referred to as a "logistical nightmare."

Figure 1 provides an overview of the segments in the water lifecycle in the development and production of shale resources, along with the most common approaches to managing water in each segment.

A major challenge with water management in the context of shale development and production is that the long-term costs are not well understood. Shale development did not become common until around 2005 and few companies have experience in managing shale wells for greater than 10 years. Another problem in understanding water management costs is that water expenditures are generally not comprehensively grouped into a single accounting category, so many companies are not aware of their true long-term lifecycle water management costs.

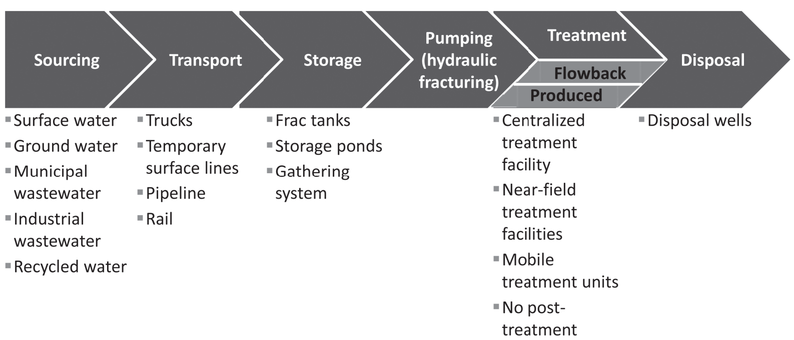

Figure 1
Water Management Segments in the Development and Production of Shale Resources

Statement of Problem

An E&P client asked PacWest for help in developing a comprehensive picture of their true lifecycle water management costs. The client was in the early stages of exploring its acreage in the Eagle Ford shale play in south Texas. The client had prior experience developing shale plays but never at the scale proposed for the Eagle Ford.

In general the client had been managing water according to what we will call the "status quo" scenario – sourcing water from surface water (lakes or rivers) or water wells, transporting water by truck to the well site, storing water in storage ponds or frac tanks, fracing, capturing effluent in frac tanks, transporting effluent by truck, and disposing of effluent in injection

* Christopher Robart is a Principal with PacWest Consulting Partners. He may be reached at crobart@pacwestcp.com
See footnote at end of text.

wells.

Due to water shortages and disposal problems, some E&Ps have begun to recycle effluent via water treatment systems and reuse the treated water for additional fracs. However, water treatment is costly and, if water management systems involving water treatment are not designed carefully, costs can quickly become uneconomic. Ultimately the client wished to understand whether the unprecedented scale at which it would be operating justified investment in a long-term water treatment system in the Eagle Ford shale play.

Methodology

PacWest developed a multi-factor economic model to forecast long-term lifecycle water management costs under various water treatment scenarios. Since logistics and transportation account for a large proportion of water management costs, it is important to consider the geographic layout of the water management system. However, since the client is still in the exploration/appraisal phase, in lieu of a detailed drilling plan, we developed a series of hypothetical water treatment scenarios based upon the geography of the client's leaseholdings in the Eagle Ford.

The economic model plots the entire water management lifecycle, from water sourcing to final reuse or disposal over the long-term, detailing costs associated for each segment of water management activities for each unique water management scenarios. Each scenario is built using multiple dynamic variables that can be programmed according to changes in various activity levels and other relevant segment and full-cycle assumptions and constraints. These costs are aggregated by water management segment and forecast out over five- and 20-year time horizons. These cash flows are then discounted to estimate the medium- and long-term costs to support management decision-making.

Overview of Scenarios

PacWest developed six water treatment scenarios and evaluated the lifecycle water management costs for each over a five-year and 20-year time horizon using discounted cash flow analysis. However, for the purpose of this paper we have presented only three scenarios. We have also modified key operational inputs (particularly the drilling schedule) into the model to maintain client confidentiality. All three scenarios assume initiation of drilling activities in January 2011 with one rig added each month until the rig count reaches 20 in August 2012. The rig count stays constant until June 2014, and decreases by one rig each month until January 2016 when the final rig ceases drilling. The total number of wells drilled between January 2011 and December 2016 is 1,367. Scenario 1 was chosen to provide a baseline assessment of the status quo approach to water management. Scenario 2 and Scenario 3 were chosen as the highest potential scenarios involving water treatment after considering the geographic, geologic, and operational constraints in the Eagle Ford. The map in Figure 2 provides a visual illustration of the geography while the table in Figure 3 provides an overview of the key features of each water management scenario.[1]

The results of the economic analysis (see Figure 4 below) are unequivocal. The two water management scenarios involving treatment and recycling of flowback and produced water result in significantly lower long-term costs than the status quo scenario. The lowest-cost scenario is construction of four near-field water treatment facilities for frac flowback water and produced water (Scenario 2), with a present value of $1,562 million. Scenario 3, use of mobile treatment units for frac flowback water and construction of four near-field treatment facilities for produced water, was slightly more expensive than Scenario 2, with a present value of $1,613 million. Both water management scenarios involving water treatment and recycling are considerably less expensive than the status quo approach to water management – 42% less expensive in the case of Scenario 3 and 44% less expensive in the case of Scenario 2.

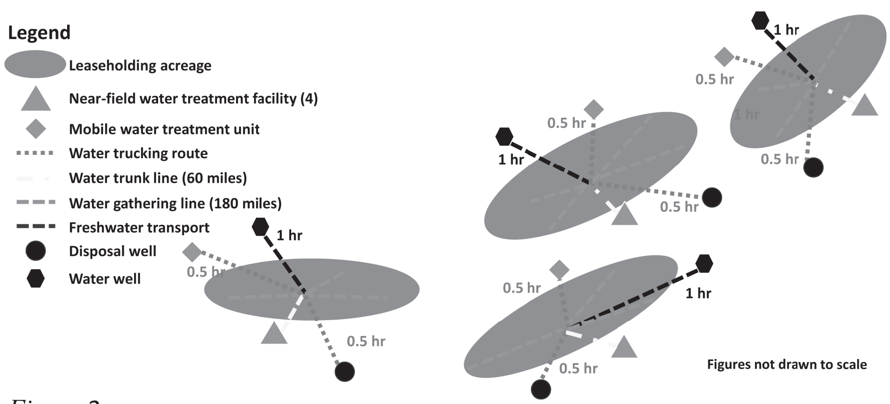

Figure 2
Sanitized Map of Eagle Ford Water Management Scenarios

The difference in total cost between the status quo scenario and the scenarios involving water treatment is primarily due to a reduction in transportation costs. Transportation accounts for $1,761 million, nearly 63% of total costs in Scenario 1, driven mostly by the cost of transporting effluent to disposal via truck. Transportation costs were reduced dramatically in the water treatment scenarios, by 73% in Scenario 2 and 75% in Scenario 3. Transportation accounts for only 31% of total costs in Scenario 2 and only 28% of total costs in Scenario 3. The massive savings in transportation costs is due to a dependence on pipelines for transportation of water rather than trucks.

H_2O Management Segment	Scenario 1	Scenario 2	Scenario 3
Sourcing of H_2O	H_2O wells	H_2O wells/recycled H_2O	H_2O wells/recycled H_2O
Transport of fresh H_2O	Temporary surface line	Temporary surface line	Temporary surface line
Storage of fresh H_2O	Storage ponds	Storage ponds	Storage ponds
Treatment	None	Near-field (4)	Mobile units/near-field (4)
Storage of effluent	Frac tanks	Frac tanks	Frac tanks
Transport of effluent	Truck	Pipeline	Pipeline
Transport of recycled H_2O	N/A	Pipeline	Pipeline

Figure 3
Key Features of Water Management Scenarios

Disposal costs are also reduced significantly in the scenarios with water treatment. Disposal of effluent into injection wells accounts for $463 million, nearly 17% of total costs in Scenario 1. By recycling water and minimizing the total volumes of water requiring disposal via injection well, disposal costs are reduced to roughly 6% of total costs in both Scenario 3 and Scenario 3.

One of the most important differences between the two water management approaches is the increase in capital expenditures in the scenarios involving water treatment. Scenario 1 emphasizes operating expenditures with minor exceptions for water sourcing (internally owned water wells) and water storage (internally owned storage ponds), with capital expenditures amounting to only $11 million, or 0.4% of total costs. The water treatment scenarios require a much greater investment in up-front capital expenditures. Total capital expenditures amount to $186 million in Scenario 2 and $184 million in Scenario 3. The source of the additional costs is investment in water transportation and water treatment infrastructure. Figure 5 below provides a detailed breakdown of capital expenditures for each water management scenario.

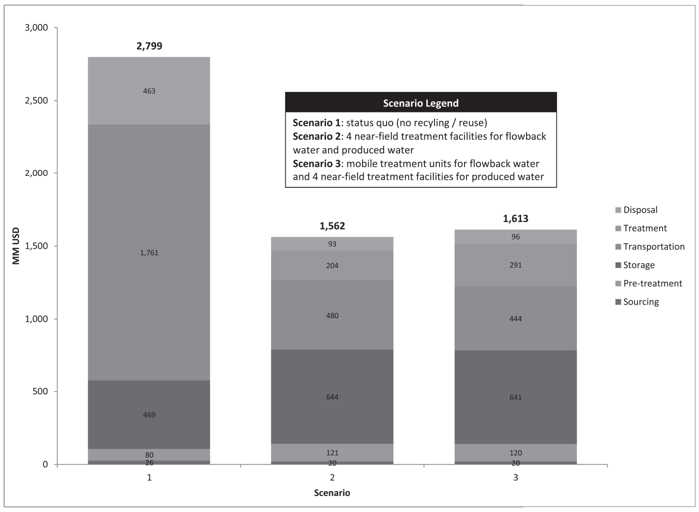

Figure 4
Present Value of Water Management Scenario Costs (2011-2030)

Conclusions and Recommendations

The results of our economic analysis show that, over the long-term, the large volumes of water managed in the development and production of shale resources justify investments in water treatment infrastructure. The results of the model presented in this paper assume a relatively large scale of activity (1,367 wells drilled over 5 years) but even at a significantly smaller scale the economic outcome of the model remains stable. A series of scenarios were tested in which drilling activity was significantly scaled down and even at a peak average rig count of 3 rigs and a total well count of 290 wells the two scenarios involving water treatment were roughly 20% less expensive than the status quo scenario.

Lifecycle water management in the development and production of shale resources presents a significant opportunity for cost savings. If operators are willing to take a longer-term view by committing investments to up-front capital expenditures to reduce long-term operating expenditures, then the economics are compelling.

Outside of the tangible economics costs and benefits that the model assesses, there are other intangible factors

(continued on page 31)

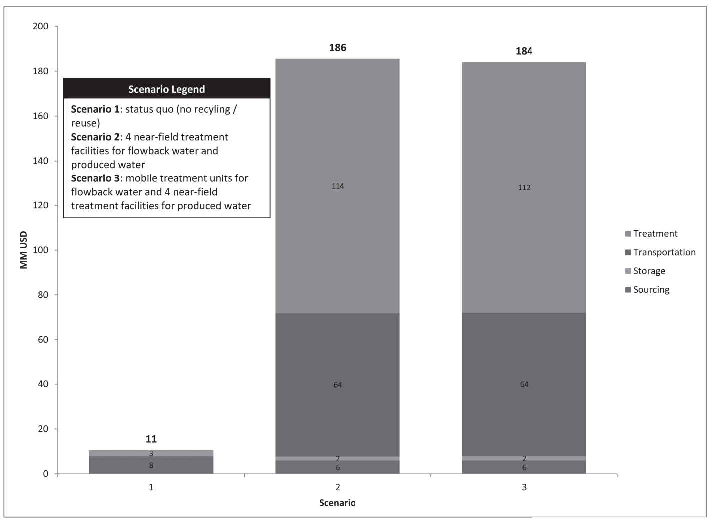

Figure 5
Present Value of Water Management Scenario Capital Expenditures (2011-2030)