

Horizontal Drilling

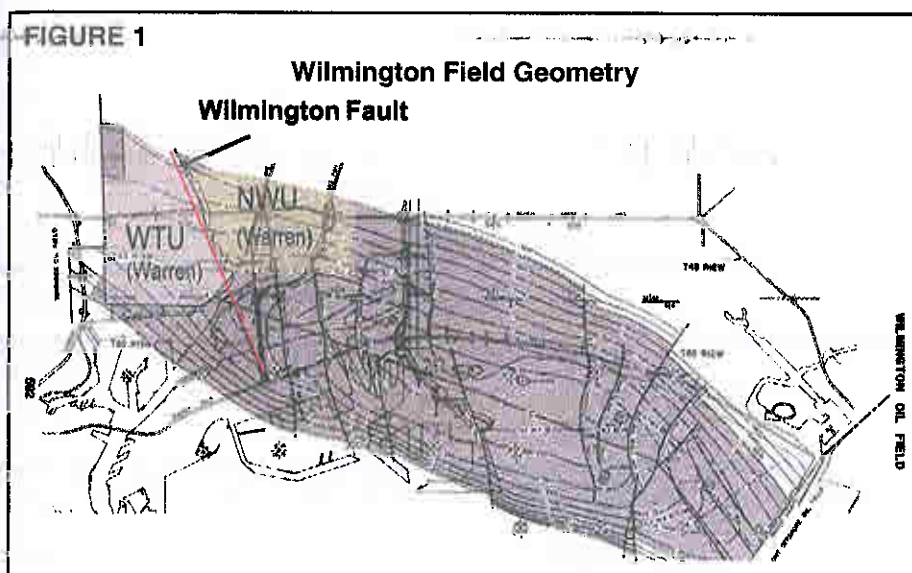
Part 1

Key To 'Redeveloping' Wilmington Townlot Unit

By Michael Kardos
Special Correspondent

LONG BEACH, CA.—As a developer of coalbed methane in the Washakie and Powder River basins, Warren Resources Inc. understands that some of the most successful “unconventional” projects are those that can be repeated. In the case of CBM in the Rocky Mountain region, one key to the company’s success has been amassing a large acreage position and identifying more than 1,800 sites where it can take a “cookie cutter” approach by drilling the same basic well design over and over while hopefully achieving similar positive results time and again.

Sometimes, however, repetition is not the best solution, especially when conditions change or a better method emerges. Such was the case at the Wilmington Field in the Los Angeles Basin, one of the largest producing oil fields in the lower-48. Norman F. Swanton, Warren Resources’ chairman and chief executive officer, says his company was convinced that with the right “redevelopment” approach and technological expertise, the mature Wilmington Townlot Unit (WTU) could be transformed into a profitable asset with long-term growth potential.



The answer for Warren Resources was found in the powerful combination of seismic and horizontal/directional drilling technology, along with a cycle of strong commodity prices and an improved understanding of the target reservoir, according to Swanton. Ultimately, these four drivers led to a new horizontal drilling program at the Warren-owned and operated Wilmington Townlot Unit No. 1. "The production rates from the wells are very impressive," he relates.

In fact, as a result of increased oil production from the WTU, the company is constructing new 10-inch pipeline to transport the produced heavy crude oil to local Los Angeles area refineries. "Since it assumed operatorship in February 2005, Warren has increased gross oil production at WTU from 375 to more than 2,600 barrels a day from new wells drilled and completed in the Upper Terminal, Ranger and Tar formations," Swanton reports. "We have two rigs operating in the Townlot Unit and plan to drill 48 gross wells this year."

Third Largest Oil Field

By any measure, the Wilmington Field is huge. The dominant geologic structure is a highly-faulted, asymmetrical anticline that stretches 18.5 miles along the Los Angeles Basin (Figure 1). A street map overlay shows that the field is located within a concentrated area of Los Angeles, including the Long Beach Harbor. Discovered in April 1936, original oil in place is estimated to be 8.8 billion barrels, making it the third largest oil field in the continental United States, according to Bruce Berwager, Warren's senior vice president and general man-

ager, California.

"Wilmington Field has produced 2.5 billion barrels of oil to date. The oil is heavy (± 14 API gravity). The Wilmington Townlot Unit was developed by Exxon as a waterflood project for the nearby Ranger and Terminal reservoirs in the early 1970s," Berwager explains. "This particular reservoir has an underlying water ledge and the wells usually have a water coning problem."

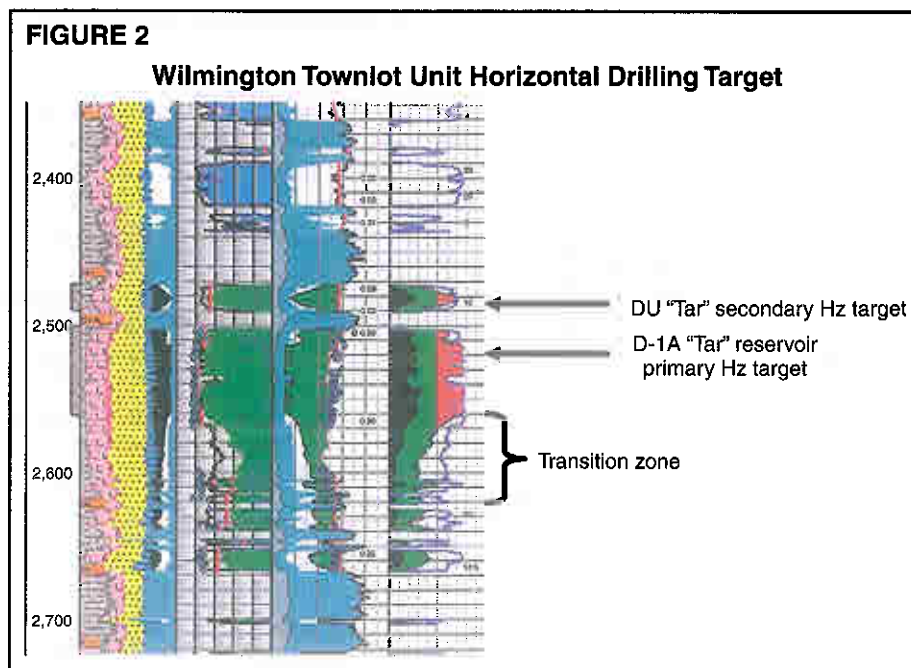
The onshore portions of the Wilmington Field were developed in the 1930s-40s, with initial development of the offshore portions following in the 1950s-60s. Swanton notes that waterflooding was introduced at Wilmington Field in the 1970s.

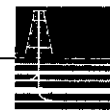
"The results were great at first, but waterflooding performance had generally deteriorated throughout the field by the 1980s," he explains. "Poor oil-to-water ratios made recovery with waterflooding unprofitable."

David Hoyt, a consulting geologist to Warren's WTU project who has joined the company on a full-time basis, says more than 2,400 wells have been drilled at Wilmington Field. "A mature waterflooded reservoir with declining production that had seen lots of drilling activity located in a congested urban center in a state with strict environmental regulations served to make Wilmington an unattractive asset to some companies," Hoyt relates. "But Warren saw upside possibilities."

Warren Resources holds a 98 percent working interest in the 1,400-acre Townlot Unit in the northwest quadrant of the field, as well as 100 percent of the working interest in the adjacent 1,000-acre North Wilmington Unit (NWU). Drilling targets include the Tar, Upper Terminal and Ranger formations, according to Berwager, who notes that Warren entered the Wilmington Field in 1999 and bought out its partner's remaining interests in the WTU in 2005.

"With higher commodity prices, you can go after more unconventional types of reserves with more advanced technologies," he remarks. "That is what has happened at Wilmington Field. Higher commodity prices, advances in seismic technology to delineate oil reserves, and refinements in horizontal and directional drilling to access





them have allowed Warren Resources to add new value in a mature property that produces heavy oil, which generally sells at a price about \$10 a barrel below the West Texas Intermediate benchmark.”

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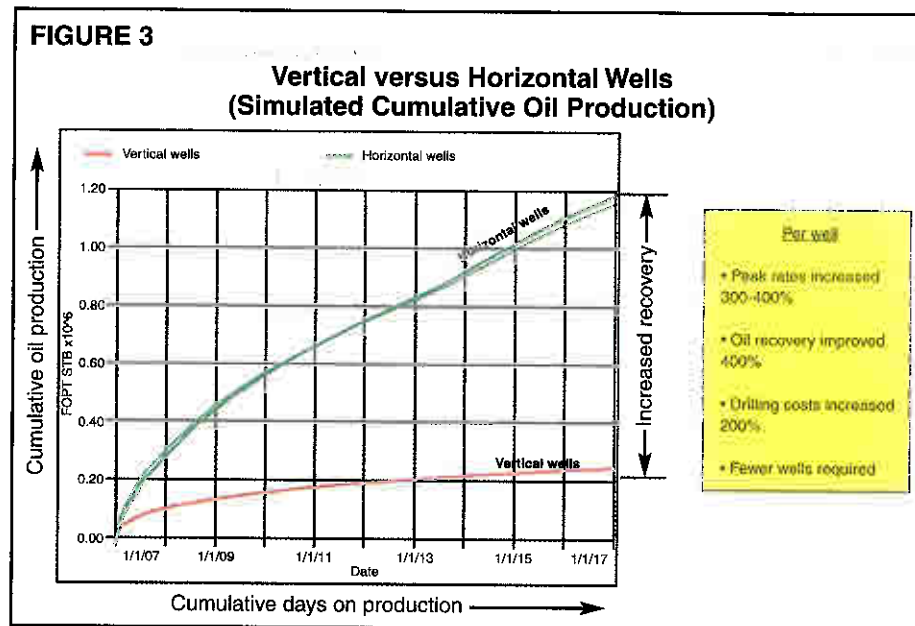
Horizontal and directional technology enables Warren Resources to drill a precise, predesigned path to access the pay zone in the optimal location while avoiding water coning issues. “A low-profile, low-amplitude fold like we have at Wilmington Field lends itself to horizontal drilling,” Swanton says. “As a company, we are very comfortable drilling horizontal wells. We have been drilling horizontals since 1990, and have drilled about 250 wells to date. The WTU is a great example of the type of asset that can benefit from horizontal and directional drilling technology. We have numerous horizontal wells to be drilled at the Townlot and North Wilmington units, in the Tar as well as other formations (Figure 2).”

Berwager explains that one of the keys to horizontal success is making sure the well is landed at just the right angle at the top of the target formation. “If the drilling assembly approaches the formation at an angle of 90 degrees, it may skip off the top and miss the pay zone. On the other hand, if the angle of penetration is 84 degrees or less, there is a likelihood of water penetration, so an approach angle of 85-88 degrees is ideal,” he relates. “For precise positioning, the wells are drilled with mud motors to keep the drill bit on zone and on target.”

Swanton reports that Warren Resources has had a 100 percent success rate on the horizontal wells it has drilled at its Wilmington assets. “In terms of well performance, we have seen the best results in the Tar formation, where we are 10 for 10 so far,” he remarks. “It is like microscopic drilling, because the tools available allow you to stay within the pay zone. The tools provide constant resistivity readings, which are the best indicator of oil saturation, and give us an electronic measurement of where we are drilling.”

Besides improved productivity by accessing a greater length of pay, horizontal drilling eliminates the need to move the rig each time a new well is spud, Berwager points out. And because Warren contains all drilling and production activity within a contained cellar, it makes working in an urban environment simpler and safer.

“The city of Los Angeles was very



supportive about our use of the cellars. Everything originates and winds up at our central facility. All the wells are drilled from the cellar and the water injection comes back to the cellar. You will not see pumpjacks or pipelines on the surface,” Berwager explains. “The horizontal wells average 3,000 feet in lateral length, but our surface locations, once we finish the wells, are only six feet apart.”

Swanton says Warren expects to invest \$59.6 million in capital expenditures in the Townlot Unit during 2007 to drill wells and continue its cellar construction project. “Our Tar formation horizontal wells produce an average of 100 barrels of oil a day with a water-to-oil ratio of 2.0 without any reservoir pressure assistance from water injection,” he reports. “We have identified 10 horizontal drilling locations targeting the Tar formation at WTU that will be drilled this year. We will then evaluate potential additional Tar horizontal drilling locations.”

Production, Recovery Rates

Berwager estimates that drilling and completion costs for each horizontal well average \$1.3 million, which is 60-100 percent more than for a comparable vertical well. “But the peak production rates from the horizontal wells are 300-400 percent higher than a vertical well, oil recovery rates are 400 percent higher (Figure 3), and fewer wells are required,” he emphasizes. “We produce the Tar formation horizontal wells gently, trying to keep each well producing at around 100 bbl/d.”

The new Upper Terminal wells average 25 bbl/d, while the Ranger wells average 40 bbl/d with a water-to-oil ratio of 20. “These results are about what we expected since the field is only starting to benefit from water injection support,” Berwager states. “The benefits of water injection should become evident over the next several months, especially since we have now activated an upgraded water injection facility.”

Achieving meaningful production growth from a mature property is not an easy task, but Swanton is quick to point out that large, historical fields such as Wilmington often have significant volumes of reserves left in place even after decades of primary and secondary recovery efforts.

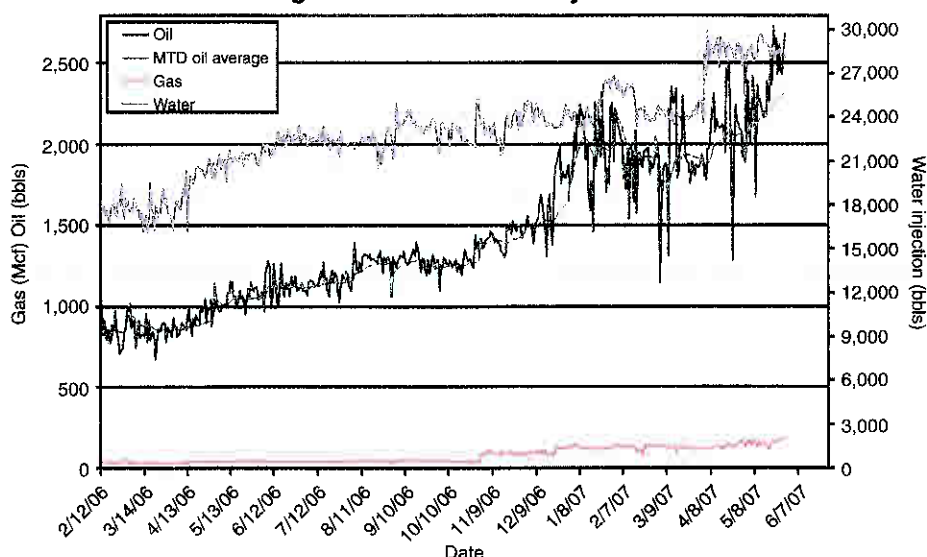
“Initial recovery rates typically average 20-40 percent of the total resource in place in the reservoir. In heavy oil, that rate is usually even lower. At Wilmington, only 24 percent of the original oil in place has been produced through the years,” Swanton explains. “We have 54 million barrels of new proved reserves (60 million gross), which is only 10 percent of the original oil in place. The ability to improve per-well recoveries by a factor of four is a huge advantage to horizontal drilling.”

And from Warren Resources’ perspective, Swanton says the field’s large remaining productivity makes it attractive as an investment opportunity. “California produces about as much oil as Texas on a daily basis, but California production tends to be heavier. Largely because Wilmington Field has heavy crude oil.



FIGURE 4

Wilmington Townlot Unit Daily Production



drilling efforts, but also to significantly improve production and recovery rates. That has led to a tripling of oil production at the WTU since we drilled our first horizontal well (Figure 4)."

Eventually, Swanton says he expects enhanced oil recovery techniques to further boost recovery rates. "It all depends on the reservoir," he relates. "But with so much oil yet to be produced and stronger commodity prices, there is going to be another chapter in field activity focusing on enhanced oil recovery techniques, perhaps using chemicals, surfactants, steam-assisted gravity drainage and other EOR methods."

The feasibility of applying any technology—be it horizontal drilling or chemical injection—ultimately comes down to the bottom line, and in the case of its Wilmington operations, Swanton says the horizontal program has had a definite favorable impact on Warren's revenues. "Compared to the first quarter of 2006, our oil and gas revenues increased 39 percent to \$9.5 million. That increase was the result of a 74 percent increase in oil production, primarily from the Wilmington Townlot Unit," he concludes. □

this asset has tremendous longevity," he remarks. "Applying proven techniques such as horizontal drilling gives the field even more longevity. Companies such as Warren will be working in California for many, many years."

Berwager agrees. "Our entire drilling program is focused on redeveloping a part of the Wilmington Field that has been underutilized," he says. "Horizontal drilling is not only allowing us to develop reserves that had been left untouched by previous

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