WATER REPLENISHMENT DISTRICT OF SOUTHERN CALIFORNIA

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Groundwater, Oil and Gas: A Mixture of Valuable Natural Resources in the Central and West Coast Basins

By: Ted Johnson, Chief Hydrogeologist, tjohnson@wrd.org
Graphics by Greg Osti and Jason Weeks

The Central and West Coast Basins (CWCB) in coastal Los Angeles County have been a valuable source of fresh groundwater for over 100 years. Nearly 400 wells are currently pumping groundwater out of sand and gravel aquifers of Holocene and Pleistocene age that range in depth from about 100 feet to 1,500 feet for potable, agricultural, and commercial use. Because the CWCB are in overdraft, WRD uses recycled water and imported river water to replace the extracted groundwater to help ensure the current and future usability of the basins as a local supply of high quality, reliable, and cost effective water.

Separated from and beneath these freshwater aquifers in the Pliocene-age Repetto and Lower Fernando Formations and Miocene-age Puente Formation are extensive oil and natural gas deposits that have also been extracted for over 100 years. These petroleum reservoirs range in depth from about 2,500 feet to 10,000 feet or more, and are separated from the overlying freshwater aquifers by layers of low permeability siltstone and shale (**Figure 1**).

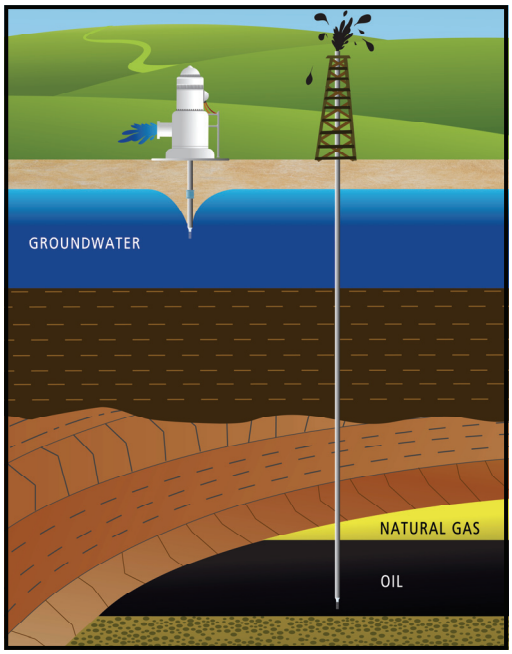

Figure 1 - Groundwater Aquifers and Petroleum Reservoirs in the CWCB

OIL AND GAS FORMATION

Oil and natural gas are fossil fuels formed from the burial, decay and alteration of organic matter - not from the dinosaurs but instead from the numerous marine microorganisms that inhabit the world's oceans. When these carbon- and hydrogen-rich microorganisms die, settle to the seafloor and are covered by large amounts of sediment, changes occur. Pressure from the weight of the overlying sediments, high temperatures due to the depth of deposition, and extensive time in the ground all allow chemical reactions to occur that convert the large, complex organic molecules into simpler, lighter hydrocarbons to create oil, gas, and other petroleum products such as tar and asphalt.

When formed, the oil and gas are typically situated in a source rock matrix of low-permeability sediments such as shale, representing the muddy seafloor bottom at the time of organic deposition. But over time, the petroleum can migrate out of the source rock into more permeable reservoir rock such as sandstone. Because oil and gas are lighter than water, they rise upwards in the sandstone until they encounter an impermeable layer (cap rock) at a geologic structure such as an anticline or fault that traps and accumulates the petroleum into vast deposits that can be mined economically (**Figure 1**). If no traps exist, then the oil and gas can seep all the way up to the ground surface, such as what occurs at the La Brea Tar Pits near downtown Los Angeles.

These same processes are what made the oil and gas reserves in the Los Angeles region. In Miocene and Pliocene time, the Los Angeles basin was covered by an ocean a mile or more deep filled with abundant sea life including marine microorganisms[1]. The organic remains of the dead microorganisms were buried by 20,000 feet of mud and sand from the highlands surrounding the basin. Petroleum was eventually formed over millions of years, migrating into sandstone reservoir rock and becoming trapped by geologic structures such as the Torrance and Wilmington Anticlines, Newport-Inglewood Uplift, and Santa Fe Springs Anticline. It just awaited discovery.

DISCOVERY OF OIL AND GAS IN LOS ANGELES

The first reported successful oil well in Southern California was in 1892 by Edward Doheny and Charles Canfield near present-day Dodger Stadium[1]. Doheny noticed that the wheels on a cart were coated in tar and investigated the source. Finding the seep, they drilled their first well with the sharpened end of a eucalyptus tree and discovered the Los Angeles Oil Field. By 1897, there were about 500 wells tapping this field[1].

Due to this discovery, explorations quickly expanded to other parts of the region with potential petroleum traps. At least 30 oil fields alone were found in the WRD service area, such as Montebello (1917), Santa Fe Springs (1919),

Long Beach/Signal Hill (1921), Torrance (1922), Dominguez (1923), and Wilmington (1932)[2]. The Long Beach/Signal Hill field was discovered when a well named Alamitos #1 (the Discovery Well) reached a depth of 2,765 feet and gave the first signs of oil. But it was nothing spectacular. Then on June 23rd, 1921, at 9:30 pm the well erupted with so much gas pressure that the oil gushed over 100 feet in the air, creating a "gold rush" mentality that resulted in 300 wells being drilled just two years later[1], many of which also erupted as geysers (**Figure 2**). Over 5.5 billion barrels of oil have been produced to date from these 30 oil fields, equivalent to 233 billion gallons or 716 thousand acre feet, with a remaining reserve of approximately 380 million barrels (16 billion gallons or 49 thousand acre feet)[3].

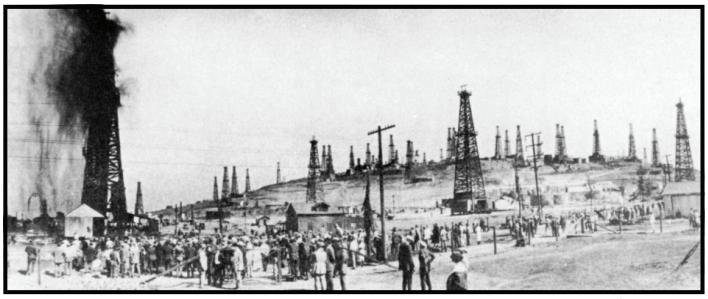

Figure 2 - Signal Hill in 1923 with Oil Wells and a Geyser[1]

CDOGG

The California Department of Conservation, Division of Oil, Gas, and Geothermal Resources (CDOGG) is the state agency since 1915 that regulates the drilling, operation, maintenance, and abandonment of oil, gas and geothermal wells. According to CDOGG, there are nearly 9,700 capped or uncapped oil wells and 60 gas wells currently within the District[4] (**Figure 3).** It is not coincidental that the oil and gas wells form a pattern along major geologic features such as faults or anticlines that formed the structural traps for the oil and gas to accumulate.

CDOGG also works to protect groundwater quality from petroleum operations by determining sealing depths for oil, gas, and injection wells (Reference 5). They regulate Class II injection wells that are used to inject water, wastewater, chemicals, sand, and salt into the petroleum reservoirs to enhance oil and gas recovery by fracturing tight geologic formations to increase petroleum production (hydraulic fracturing or fracking) and also to prevent land subsidence (waterflooding). The Wilmington Field alone for example, experienced nearly 30 feet of land subsidence centered around the Terminal Island area before waterflooding technology was employed in the 1950s[5]. Waterflooding continues to be a major oil field operation today that is closely monitored. Finally, Congress has recently expressed concern over potential impacts that fracking may have on drinking water supplies and have written the FRAC Act[6]. If passed, this Federal attention will likely cause CDOGG and other agencies to more closely investigate and monitor the petroleum industry's practices with regards to protecting water quality.

CONCLUSION

Fresh groundwater, oil and natural gas are major natural resources in the CWCB that have been tapped for over 100 years. The fresh groundwater is typically extracted from the upper 1,500 feet whereas the petroleum is typically extracted below 2,500 feet. The two reservoirs are separated by thick layers of low permeability strata so that with appropriate precaution and care, the activities in one do not necessarily affect the other. Nonetheless, WRD, CDOGG and other agencies closely monitor the activities of the petroleum and groundwater industries to ensure protection of the fresh groundwater resource.

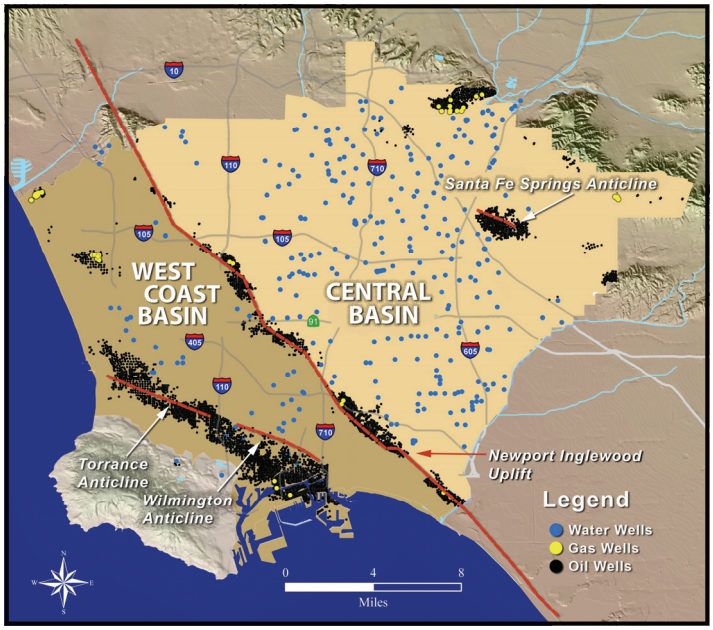

Figure 3 - Oil, Gas, and Water Wells in the CWCB with Selected Geologic Structural Traps for the Petroleum Reservoirs

References:

1. Los Angeles Basin Geological Society http://www.labgs.org/

2. Gamache, Mark T and Frost, Paul L., 2003, ***Urban Development of Oil Fields in the Los Angeles Basin Area 1983 – 2001***; CDOGG, Publication No. TR52.

3. CDOGG, ***2007 Annual Report, Oil and Gas Statistics.***

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5. Olson, L., 1978, ***Shallow Aquifers and Surface Casing Requirements for Wilmington and Belmont Offhsore Oil Fields***; CDOGG Publication No. TR22.

6. http://nywellwatch.org/2009/10/30/congress-urges-epa-to-study-hydrofracturing/ . Accessed 12/10/09

WRD
WATER REPLENISHMENT DISTRICT OF SOUTHERN CALIFORNIA

4040 Paramount Blvd., Lakewood, CA 90712
Phone: (562) 921-5521

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