# *New Data on Produced Water Volumes and Management Practices*

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# Challenges

- Develop an estimate of the volume for all the produced water generated in the U.S. in calendar year 2012
  - Oil and gas is produced in at least 31 states and from federal onshore and offshore areas
  - Nearly 1 million operating wells
- Compile information on how that water is managed
- Complete this project in a reasonable amount of time and with a modest budget

# Approach

- Contact oil and gas agencies in 31 states to obtain data
  - Provide a standard questionnaire containing two tables
    - Oil, gas, water volumes
    - How water is managed
- Contact federal agencies with oil and gas data responsibility
- Where necessary, contact state environmental protection agencies
- Use a  variety of methods to fill in the gaps where state submittals were not fully complete

# *A Similar Project Was Completed in 2009*

- Clark, C.E., and J.A. Veil, 2009, *Produced Water Volumes and Management Practices in the United States*.
- The report contains detailed produced water volume data for 2007
  - ~21 billion bbl/year or 58 million bbl/day
  - 882 billion gallons/year or 2.4 billion gallons/day
- The new project followed a similar format, but was able to include more data and fewer gaps in the total data set

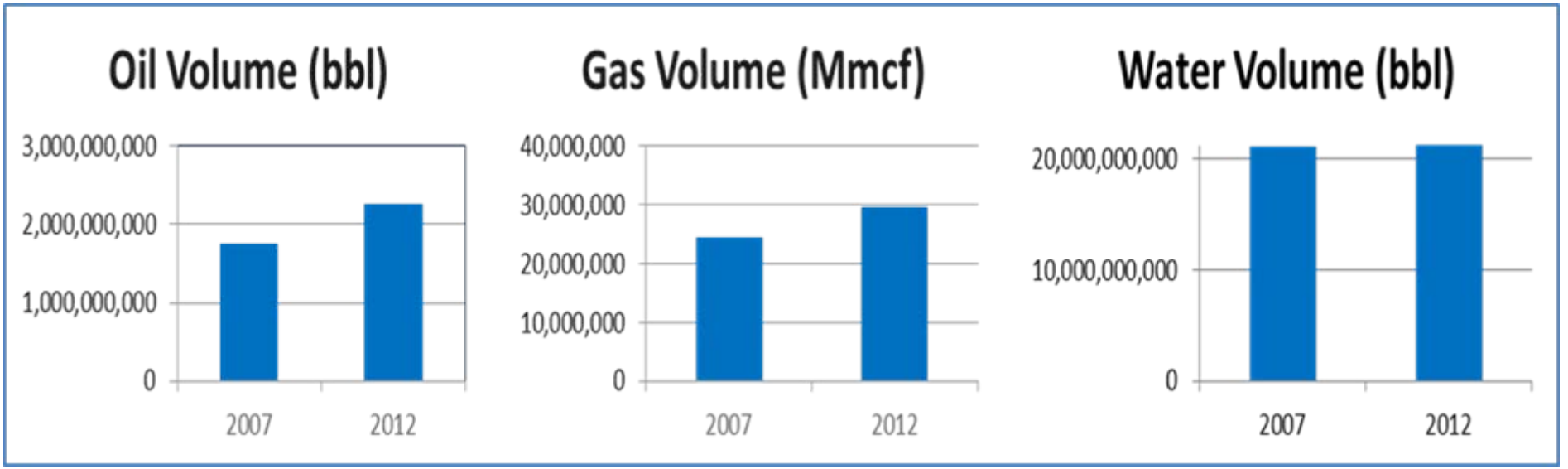
# *Observations from the 2015 Update Study*

- Produced water volume
- Produced water management practices
- Data availability
- Data quality

# Produced Water Volume

# *Five Year Changes in Fluid Production*

- Between 2007 and 2012
  - U.S. oil production increased by 29%
  - U.S. gas production increased by 22%
  - U.S. water production increased by <1%
    - 21.2 billion bbl vs. 21 billion bbl



# Top Ten States in 2012 Water Production

| Ranking | State | 2012 Water (bbl/yr) | % of Total Water |
|---|---|---|---|
| 1 | Texas | 7,435,659,000 | 35 |
| 2 | California | 3,074,585,000 | 15 |
| 3 | Oklahoma | 2,325,153,000 | 11 |
| 4 | Wyoming | 2,178,065,000 | 10 |
| 5 | Kansas | 1,061,019,000 | 5 |
| 6 | Louisiana | 927,635,000 | 4 |
| 7 | New Mexico | 769,153,000 | 4 |
| 8 | Alaska | 624,762,000 | 3 |
| 9 | Federal Offshore | 358,389,000 | 2 |
| 10 | Colorado | 320,191,000 | 2 |

# Why Did Oil and Gas Increase While Water Remained the Same?

Here is my hypothesis:

- Conventional production generates a small initial volume of water that gradually increases over time. The total lifetime water production from each well can be high
- Unconventional production from shales and coal seams generates a large amount of produced water initially but the volume drops off, leading to a low lifetime water production from each well
- Between 2007 and 2012, many new unconventional wells were placed into service and many old conventional wells (with high water cuts) were taken out of service
- The new wells generated more hydrocarbon for each unit of water than the older wells they replaced

# Ratio of Water to Oil and Gas Production

- Not all states provided separate water from oil production and water from gas production
- The weighted average water-to-oil (WOR) for 21 states is 9.2 bbl water/bbl oil.
  - Two of the key water producing states (Texas and Oklahoma) were unable to distinguish the water generated from oil wells vs. water coming from gas wells. Both of those states have large numbers of older wells from mature fields that typically have very high WORs (much higher than the weighted average). It is very likely that if the wells from those states were averaged in, the national weighted average WOR would be higher than 10 bbl/bbl.
- The weighted average water-to-gas ratio (WGR) for 17 states is 97 bbl water/Mmcf gas.
  - The range of values from the different states was so large that using a WGR is not meaningful.

# Produced Water Management Practices

# 2012 Produced Water Management Practices

- Water management follows similar trends to the 2007 data
  - Nearly all water from onshore wells is injected (93%)
  - Nearly all water from offshore wells is treated and discharged (80%)

| | Injection for Enhanced Recovery (bbl/yr) | Injection for disposal (bbl/yr) | Surface discharge (bbl/yr) | Evaporation (bbl/yr) | Offsite Commercial Disposal (bbl/yr) | Beneficial Reuse (bbl/yr) | Total Prod Water Managed (bbl/yr) |
|---|---|---|---|---|---|---|---|
| **2012** | | | | | | | |
| U.S. Total | 9,287,855,000 | 8,010,364,000 | 1,121,045,000 | 691,142,000 | 1,373,131,000 | 125,737,000 | 20,609,274,000 |
| % | 45.1 | 38.9 | 5.4 | 3.4 | 6.7 | 0.6 | 100.0 |
| **2007** | | | | | | | |
| U.S. Total | 10,725,203,000 | 7,145,369,000 | 676,383,000 | No data | No data | No data | 18,546,955,000 |
| % | 57.8 | 38.5 | 3.6 | No data | No data | No data | 100.0 |

# Water Management other than Injection and Discharge

- The 2012 data provide more information on other practices
- Evaporation is used in several western states
- Where offsite commercial disposal facilities are available, some of the water is sent there.
  - Most commercial facilities use disposal wells
  - Some use evaporation ponds
- Beneficial reuse (other than reinjection for enhanced recovery operations) is difficult to quantify
  - Some states recycle their flowback water to make new drilling and frac fluids
  - Some states allow spreading of produced water on unpaved roads for dust control and on other roads for deicing during winter weather
  - There is limited reuse for irrigation in a few states where the water already has low salinity or has been treated to low salinity

# Data Availability

# 2012 Data Availability

- Some states collect produced water volume data – others do not
  - Some times more than one agency has responsibility for relevant data –
  - Unless state law or regulation requires produced water data submittal, the companies have little incentive to do so
  - Companies must only provide the data elements that are required
- Other than injection volumes, most states do not keep track of how produced water is managed
  - Particularly true for beneficial reuse
- Data can be stored in huge databases that require IT expertise for making queries
  - Regulatory staff may not know how to do queries
- State agencies are often overworked and understaffed
  - They have little time to compile data for external requests

# 2012 Data Availability (2)

- Where data were not available through the state agency questionnaires, additional efforts were made to estimate water volumes and management practices.
  - Online databases
  - Other reports
  - Extrapolations from nearby states
- Many assumptions were necessary. The report tries to state the assumptions clearly.
- Some federal agencies were able to provide requested data directly, while other insisted on a cumbersome FOIA process that often took more than a month.
  - The FOIA requirement was applied inconsistently, even within the same agency.
- One agency charged for its services.

# Data Quality

# 2012 Data Quality

- The raw data are not precise. Water volumes are measured by comparing relative heights in a tank, by pump capacity and running time, or by bucket and stopwatch, among other methods. These methods give results that have some relevance to true volume, but are not precise.
- The process of getting data from the field to the agencies has potential for additional errors.
  - Transcription of field notes to paper forms or electronic forms
  - Transcription into agency databases
  - Inconsistent interpretation of what and how to report by companies
  - Rounding errors (i.e., significant figures)

# Final Thoughts

- The 2012 data are imprecise but represent the most complete and current estimates available in the United States.
- This type of national data collection effort is very difficult and time-consuming
  - There is no easy way to obtain national estimates of produced water volume
- In the absence of a national mandate to collect produced water volumes and management information, it is unlikely that estimating produced water volumes and management practices in the future will be any easier or more accurate.