New Information on Produced Water Volumes and Management Practices

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Key Produced Water Points

- There are nearly 1 million oil and gas wells in the U.S. that generate a very large volume of produced water
- Different types of oil and gas production have different water needs and generate different amounts and types of wastewater
- Oil and gas companies must manage the water in a way that meets regulations and has an affordable cost
- There are different water management options that are chosen in different locations. The oil and gas companies may choose different options and strategies over time as the factors affecting their decisions change.

Produced Water Volumes and Management Practices

Detailed Produced Water Inventory for the U.S.

- 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

U.S. Produced Water Volume by Management Practice for 2007 (1,000 bbl/year)

	Injection for Enhanced Recovery	Injection for Disposal	Surface Discharge	Total Managed	Total Generated
Onshore Total	10,676,530	7,144,071	139,002	18,057,527	20,258,560
Offshore Total	48,673	1,298	537,381	587,353	587,353
Total	10,725,203	7,145,369	676,383	18,644,880	20,995,174

- Onshore – 98% goes to injection wells
  - 60% to enhanced recovery
  - 40% to disposal
- Offshore – 91% goes to discharge

2014 Update to Detailed Produced Water Inventory for the U.S.

- GWPC contracted with Veil Environmental to update the 2009 report using 2012 as the baseline year.
- A draft report was completed on January 4 and is undergoing review by external reviewers and by states
- Final report should be ready in 2nd quarter of 2015

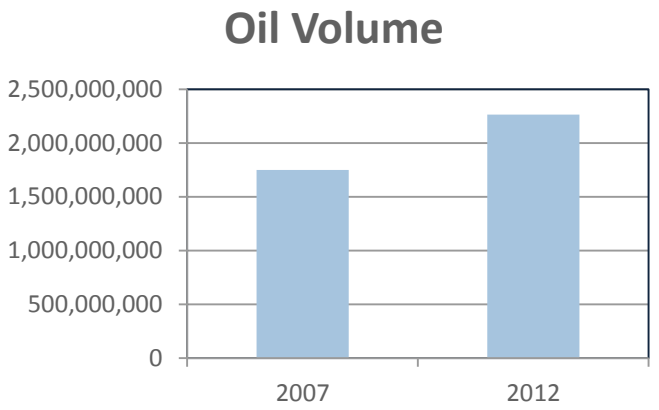
Preliminary Observations from the 2014 Update Study

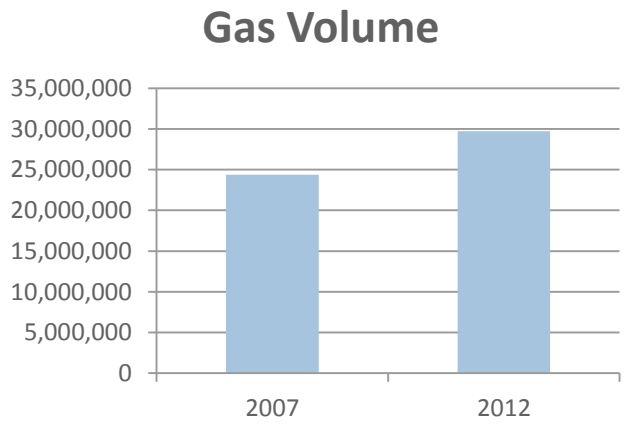
- Produced water volume
- Produced water management practices
- Data availability
- Data quality

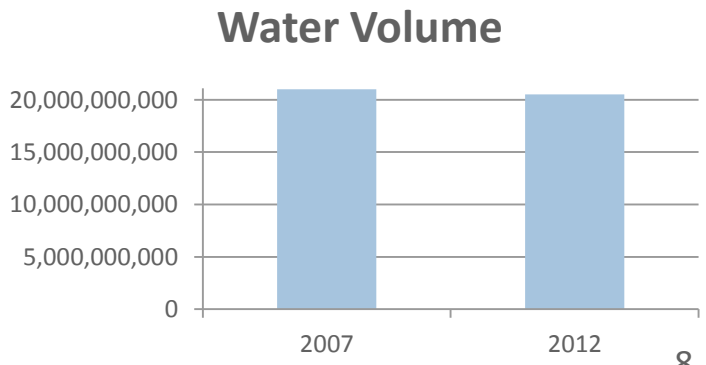
2012 Produced Water Volume

- Between 2007 and 2012
  - U.S. oil production increased by 29%
  - U.S. gas production increased by 22%
  - U.S. water production did not increase at all – in fact, it decreased by 2.4%.
  - 21 billion vs. 20.5 billion bbl/year

Data from Draft Report May Change in Final Report







Top Ten States in 2012 Water Production

Ranking	State	2012 Water (bbl/yr)	% of Total Water
1	Texas	7,435,659,000	36
2	California	3,074,533,000	15.0
3	Oklahoma	2,323,153,000	11.3
4	Wyoming	2,178,065,000	10.6
5	Kansas	1,061,019,000	5.2
6	New Mexico	776,113,000	3.8
7	Alaska	769,153,000	3.8
8	Federal Offshore	624,762,000	3.0
9	Colorado	358,389,000	1.7
10	Louisiana	320,191,000	1.6

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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 9.1 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.

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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

Three Example States Showing Changes from 2007 to 2012 That Support the Hypothesis

- Arkansas:
  - Oil production increased nearly 8%
  - Gas production (mostly from the unconventional Fayetteville Shale) increased by over 400%
  - Water production declined by 43%

- North Dakota:
  - Oil production (mostly from the unconventional Bakken Shale) increased by over 500%
  - Gas production increased by over 300%
  - Water production increased by just 216%

- Pennsylvania:
  - Oil production increased by 280%
  - Gas production (mainly from the unconventional Marcellus Shale) increased by more than 1,300%
  - Water production increased by 870%.

Data from Draft Report May Change in Final Report

2012 Produced Water Management Practices

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

	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							
Onshore Total	9,238,962,800	7,245,698,100	605,120,000	693,289,000	1,346,964,000	125,737,280	19,255,780,180
%	48.0	37.6	3.1	3.6	7.0	0.7	100.0
Offshore Total	62,703,000	62,703,000	515,916,000	0	0	0	641,322,000
%	9.8	9.8	80.4	0.0	0.0	0.0	100.0
U.S. Total	9,301,665,800	7,308,401,100	1,120,045,000	693,289,000	1,346,964,000	125,737,280	19,897,102,180
%	**46.7**	**36.7**	**5.6**	**3.5**	**6.8**	**0.6**	**100.0**
2007							
Onshore Total	10,676,530,000	7,144,071,000	139,002,000	No data	No data	No data	17,959,603,000
%	59.4	39.8	0.8	No data	No data	No data	100.0
Offshore Total	48,673,000	1,298,000	537,381,000	No data	No data	No data	587,353,000
%	8.3	0.2	91.5	No data	No data	No data	100.0
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**

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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

2012 Data Availability

- Some states collect produced water volume data – many do not
  - Some times more than one agency has responsibility for relevant data – often they don't know what data the other agency has
- Unless state law or regulation requires produced water data submittal, the companies will not do it
  - Companies 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 agencies, 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.
  - Other readers may disagree with those assumptions, which could lead to other findings or conclusions
- 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.

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
- 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 *(note that this report highlights that gap but is not advocating that national mandates be instituted*), it is unlikely that estimating produced water volumes and management practices in the future will be any easier or more accurate.