# *Growing Interest in Beneficial Use of Produced Water*


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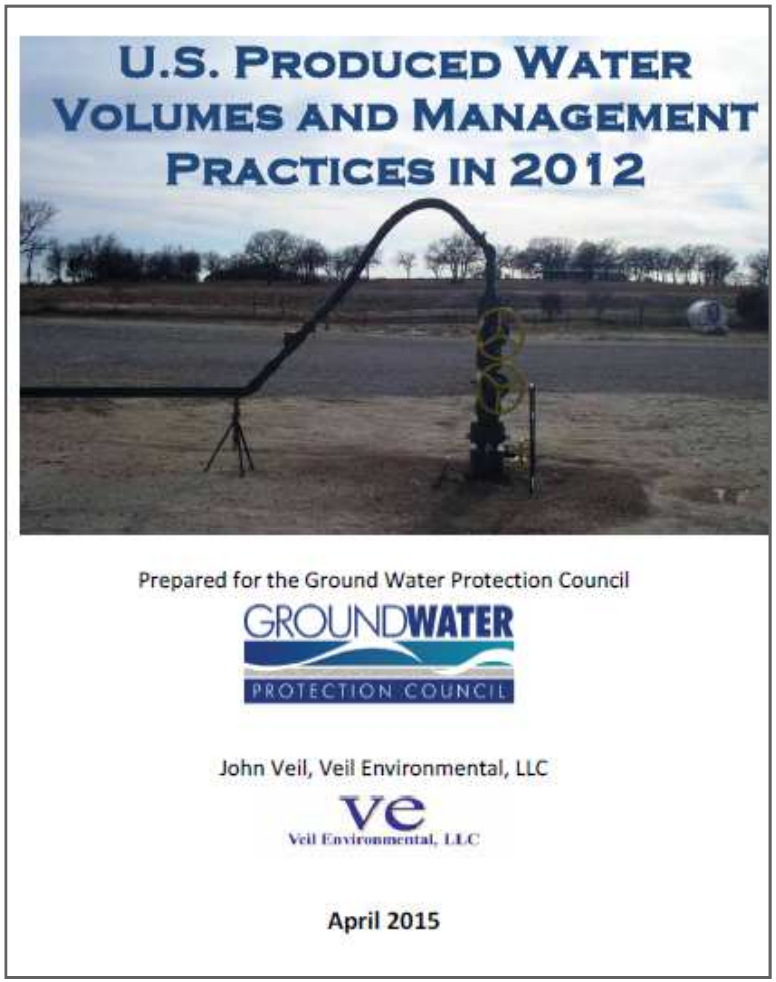
# Topics for Discussion

- Produced water volumes
- How is it managed?
- Reuse options
- Why are these options not being used more often?
- Terminology distinctions

# *Most Current Detailed Produced Water Inventory for the U.S.*

- Previous study done in 2009 looked at 2007 year
- The Ground Water Protection Council (GWPC) contracted with Veil Environmental to update a 2009 report using 2012 as the baseline year.
- Data were collected during the second half of 2014
- Report was published in April 2015




**http://www.veilenvironmental.com/publications/pw/prod_water_volume_2012.pdf**

# Water Volume Table – Louisiana Data

| Type of Hydrocarbon | # Wells Producing Primarily That Type of Hydrocarbon | Total Volume of Produced Water Brought to Surface (bbl/year) | Volume of Hydrocarbon Produced (bbl/year or Mmcf/year) |
|---|---|---|---|
| Crude oil from conventional formations | 19,235 | 927,634,655 | 82,111,159 bbl/yr |
| Natural gas from conventional formations | 16,572 | | 1,277,149 Mmcf |
| Crude oil and natural gas from unconventional formations | 13 wells in Tuscaloosa Marine Shale (TMS) and 2,145 wells in Haynesville Shale (HS) | | TMS - 251,461 bbl/yr oil and 142 Mmcf gas<br>HS – 418,818 bbl/yr condensate and 2,069,724 Mmcf gas |
| Total | 37,965 | 927,634,655 (based on total water managed) | 82,781,438 bbl/yr crude oil (includes condensate)<br>3,347,015 Mmcf |

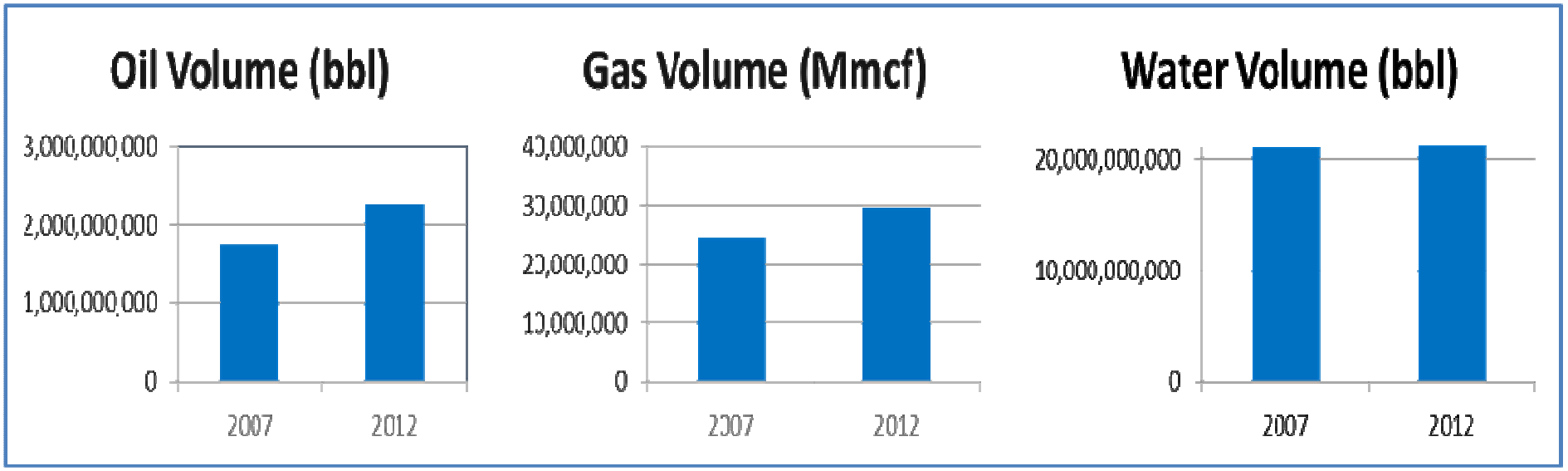
# *Water Management Table – Louisiana Data*

| Management Practice | # Wells Using That Practice | Total Volume of Produced Water Managed by That Practice (bbl/year) | Percentage of Produced Water Managed by That Practice |
|---|---|---|---|
| Injection for enhanced recovery | 401 | 31,336,098 | 3.4% |
| Injection for disposal | 3,231 | 857,417,339 | 92.4% |
| Surface discharge | 0 | 0 | 0 |
| Evaporation | 0 | 0 | 0 |
| Offsite commercial disposal | 44 | 38,880,938 | 4.2% |
| Beneficial reuse | 4 (reuse of flowback) | 280 | 0 |
| Total Volume Managed | | 927,634,375 | |

# Produced Water Volumes

# *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 |

# 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
  - 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** | 9,225,152,000 | 7,947,716,000 | 605,129,000 | 691,142,000 | 1,373,131,000 | 125,737,000 | 19,968,007,000 |
| **%** | 46.2 | 39.8 | 3.0 | 3.5 | 6.9 | 0.6 | 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** | 9,287,855,000 | 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** | | | | | | | |
| **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 |

# States Reporting Volumes for Produced Water Reuse

| State | PW Reuse Volume (bbl/yr) | How It Is Reused |
|---|---|---|
| AR | 2,000,000 | Reused to make up new frac fluids |
| CA | 46,251,000 | Not specified by the State. But there are some examples in the literature. In the San Ardo field some of the pw is treated and reused for cooling tower makeup water. The remaining water undergoes further treatment to create water suitable to recharge a shallow aquifer that was used in the area for crop irrigation. Up to 50,000 barrels/day of brackish pw was transformed into freshwater for agricultural reuse, which was enough to irrigate about 800 acres of farmland per year. |
| CO | 47,648,000 | Reused to make up new frac fluids |
| OH | 756,000 | 129,575 bbl were used for deicing and dust control on roads, and 626,208 bbl were recycled to make new drilling fluids and frac fluids. |
| PA | 29,082,000 | Reused to make up new frac and drilling fluids |

- Several other states reported that they believed produced water was reused, but were uncertain about the volume and/or how it was actually used: KS, MI, NY, TX, UT, WV, WY

# Ways in Which Produced Water Can Be Reused

# Options for Reuse of Produced Water

- Reuse in the oil and gas fields
  - Produce more oil
  - Use for drilling fluids and frac fluids
- Industrial use
- Roadway use
- Injection for future use
- Injection for hydrological purposes
- Agricultural use
- Drinking water and other domestic uses
- Secondary use

# Reuse for Producing More Oil

- Nearly half of all U.S. produced water is separated from the oil and gas at the surface and then reinjected back into an oil-bearing formation to help produce more oil
- This can be done using water (water flooding) or steam (steam flooding)
  - SAGD and other steam processes are common in Canada
- Although this practice is not always viewed as beneficial reuse, it provides a valuable service to the industry and avoids injection of millions of barrels of surface and ground water to accomplish the same enhanced recovery activities
- I believe it is truly beneficial reuse and should be given credit as such

# Other Reuse in the Oil and Gas Fields

- In some parts of the country, a very large percentage of flowback water and produced water are given simple filtration or other treatment and then are reused to make up new drilling fluids and frac fluids
- Data in the table show management practices in the Pennsylvania portion of the Marcellus Shale during 2012
  - 98% of flowback
  - 78% of prod water

| | Flowback | Prod Water | Total | % |
|---|---|---|---|---|
| Centralized treatment for reuse | 1,398,438 | 2,131,496 | 3,529,934 | 13 |
| Injection - disposal | 70,679 | 3,493,527 | 3,564,206 | 13 |
| Residual waste processing and reuse | 30,612 | 105,358 | 135,970 | 0.5 |
| Reuse other than roadspreading | 8,149,339 | 11,418,150 | 19,567,489 | 72 |
| Storage waiting for disposal or reuse | 63,981 | 256,948 | 320,929 | 1.2 |
| Landfill | 6,366 | 278 | 6,644 | <0.1 |
| Discharge | 105 | 105 | 210 | <0.1 |
| Roadspread | 425 | 425 | 850 | <0.1 |
| **Total** | **9,719,945** | **17,406,287** | **27,126,232** | **100** |

# Industrial Use

- Cooling water makeup
- Vehicle washwater
- Process water
- Other

# Roadway Use

- Dust control on unpaved roads
- Snow and ice control during winter storms
- Road stabilization

# Injection for Future Use

- Aquifer storage and recovery
  - Inject treated produced water into shallow aquifer
  - Withdraw it later as a water supply
- Example in Wellington, CO

# Injection for Hydrological Purposes

- Subsidence control
- Salt water intrusion
- Flow augmentation

# Agricultural Use

- Irrigation
- Livestock and wildlife watering
- Managed wetlands
  - Reed beds in Oman

Source: USDA

Source: USFWS

Source: USFWS

# Drinking Water and Other Domestic Uses

# Secondary Use

- Geothermal power
- Feedstock for obtaining uncommon minerals and chemicals
  - Lithium
  - Rare earth metals

Source: DOE – Rocky Mountain Testing Center

# A New Application For Reusing Frac Byproducts


- Discovered in a grocery store in Bolivia in 2013

# Why is Produced Water Not Reused More?

# *Barriers and Solutions to Overcome Them - Economics*

- Barriers
  - Salt removal is very expensive and is often necessary prior to reuse
  - Water is heavy and expensive to move long distances

- Solutions
  - Continue development of cost-effective desalination approaches that can work dependably in harsh oil field environments
  - Develop databases or clearinghouses to match up water sellers and potential buyers

# *Barriers and Solutions to Overcome Them - Social*

- Barriers
  - Some potential end users may not want to use produced water for agricultural applications
  - The public may have concerns over treating produced water and reusing it for drinking water

- Solutions
  - Develop and publish case examples to help educate potential consumers

# *Barriers and Solutions to Overcome Them - Policy*

- Barriers
  - Water rights
    - As long as produced water is a waste, water rights owner is not too concerned. But if produced water can be sold, water rights owner wants a cut of the fee.
  - Liability
    - Large oil and gas companies are worried about the risk of later lawsuits if produced water is sold or given to end users

- Solutions
  - Try to educate lawmakers and staffers
  - Look to establish third-party entities that can accept produced water and distribute it to end user (mitigates liability)

# *Meetings in the Past Year to Discuss Beneficial Use of Produced Water*

- National Science Foundation Workshop on Food-Energy-Water Nexus Issues in Energy, Arlington, VA, December 7–8, 2015
- Ground Water Protection Council UIC Conference, Denver, CO USA, February 23-25, 2016
- National Academy of Sciences Roundtable, Beneficial Use of Produced & Flowback Water: Innovations and Challenges, Washington, DC, May 25-26, 2016
- States First Initiative, Produced Water Forum, Oklahoma City, OK, August 17-18, 2016
  - This meeting involved many persons and organizations interested in using produced water in place of other water sources
  - The participants discussed and voted on the key issues and concerns -- the top five are listed on the next slide
- Ground Water Protection Council, Annual Forum, Orlando, FL, September 12-14, 2016

# *Key Issues and Concerns Relating to PW Beneficial Use from August 2016 Meeting in Oklahoma City*

- Standardized approaches to verify and test new water analysis and treatment technologies
- Comprehensive modeling methods to calculate and compare environmental impact, carbon intensity, risk, costs and other characteristics of using produced water when compared to other fresh and non-fresh water sources.
- Estimating the cost and environmental impact to use produced water relative to the use of other fresh and non-fresh water sources.
- Clarification of produced water ownership as it is treated and put to beneficial use.
- Clarification of liability as produced water is treated and put to beneficial use.

# Terminology – Important Distinctions or Much Ado About Nothing

## *How to Describe Using Produced Water for Another Purpose*

- Are these terms different? If so, how?
  - Water is treated vs. untreated before it is used
  - Used within the industry vs. used outside the industry

Recycle

Reuse

Repurpose

Upcycle

# *Example Using Yogurt Containers*


Recycle

Reuse

Repurpose

Upcycle - ????

## *Using Produced Water for Another Purpose (2)*

**Reuse** **Use**

- Produced water is a byproduct of oil and gas production
- It has not had any specific primary use before it is brought to the surface (with some possible exceptions)
  - Water used for water flood that is later produced to the surface
  - Used within the industry vs. used outside the industry
- Some people are concerned about how the choice of terms affects the applicability of the RCRA E&P waste exemption