



Produced Water Volumes and Management in 2017 - an Update

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Acknowledgements

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- This type of report would not be possible without the efforts of state officials who provided the data
- For the second time (in 2012 and again in 2017) Thom Kerr provided advice and support in obtaining and understanding data from the Colorado Oil and Gas Conservation Commission

Produced Water Information Needs

- How much produced water is generated in the United States in a single year?
 - Look at all states and federal lands/waters
 - Look at all water that comes to the surfaces along with oil and gas
- How is that large volume of produced water managed?
 - Injection
 - Discharge
 - Evaporation
 - Recycle/reuse

Past Studies

- Argonne National Laboratory compiled this information for the 2007 calendar year (funded by DOE)
 - Clark and Veil (2009)
- Veil Environmental compiled this information for the 2012 calendar year (funded by GWPC)
 - Veil (2015)
- Veil Environmental is compiling this information again for the 2017 calendar year (funded by GWREF)
- This gives three comparable sets of data spaced five years apart

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

Requests for Data for 2017 Year

- Produced water, oil, and gas volume 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			
Natural gas from conventional formations			
Crude oil from unconventional formations			
Natural gas from unconventional formations			
Other			
Total			

Requests for Data for 2017 Year

- Produced water management data

Management Practice	Total Volume of Produced Water Managed by That Practice (bbl/year)	Percentage of Produced Water Managed by That Practice
Injection for enhanced recovery		
Injection for disposal		
Surface discharge		
Evaporation		
Offsite commercial disposal		
Reuse within the oil and gas industry		
Reuse in ways other than in the oil and gas industry		
Total		

Results

Top Ten States in 2017 Oil Production

Ranking 2017	Ranking 2012	State	2017 Volume (bbl/yr)
1	1	Texas	1,271,143,548
2	2	Federal Offshore	619,697,287
3	3	North Dakota	390,730,886
4	5	Alaska	180,546,058
5	7	New Mexico	172,615,074
6	4	California	172,293,268
7	6	Oklahoma	159,207,164
8	9	Colorado	132,846,403
9	10	Wyoming	75,717,834
10	8	Louisiana	52,282,199

Top Ten States in 2017 Gas Production

Ranking 2017	Ranking 2012	State	2017 Volume (Mmcf/yr)
1	1	Texas	8,124,096
2	4	Pennsylvania	5,465,113
3	3	Louisiana	3,268,520
4	6	Alaska	2,350,071
5	7	Oklahoma	2,174,415
6	2	Colorado	3,306,864
7	5	Wyoming	1,808,429
8	21	Ohio	1,770,454
9	11	West Virginia	1,611,100
10	9	New Mexico	1,297,047

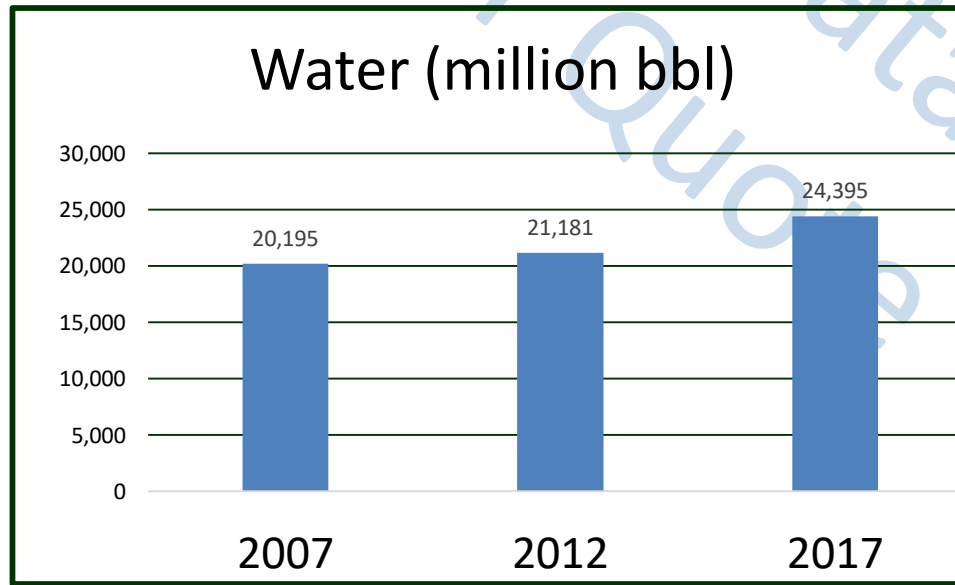
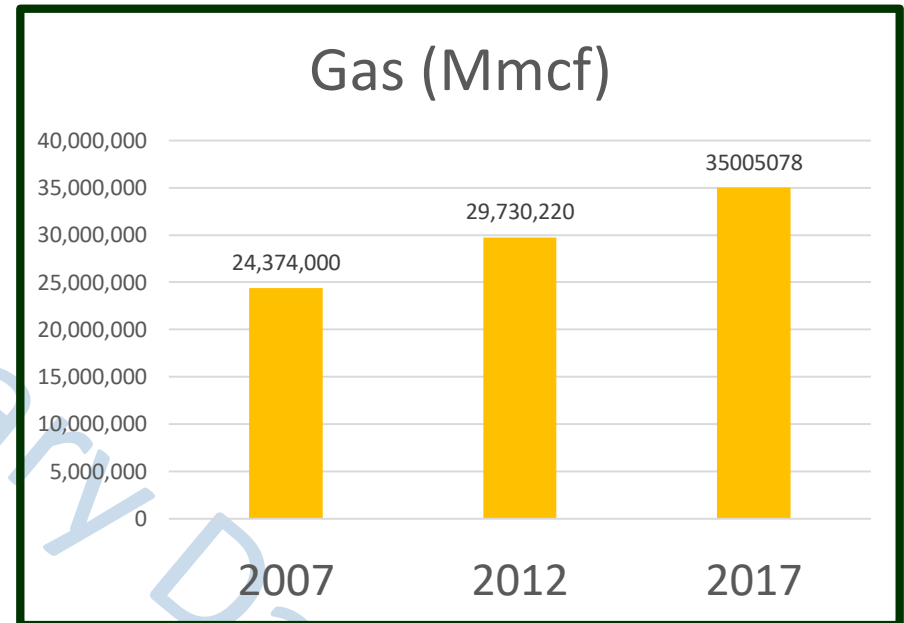
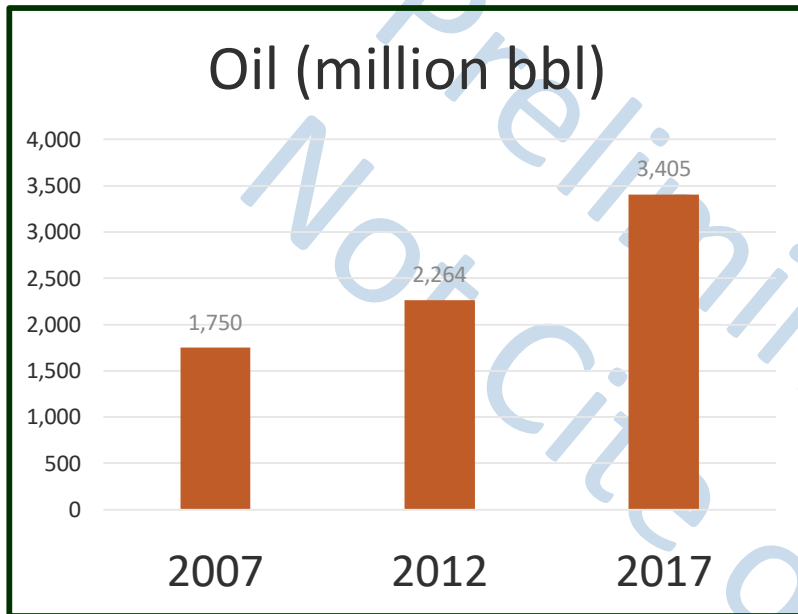
Top Ten States in 2017 Water Production

Ranking 2017	Ranking 2012	State	2017 Volume (bbl/yr)
1	1	Texas	9,895,084,619
2	2	California	3,134,503,023
3	3	Oklahoma	2,844,485,617
4	4	Wyoming	1,705,309,511
5	5	Kansas	1,205,091,949
6	6	Louisiana	998,519,062
7	7	New Mexico	879,766,203
8	8	Alaska	828,067,983
9	9	Federal offshore	575,926,287
10	11	North Dakota	505,828,554

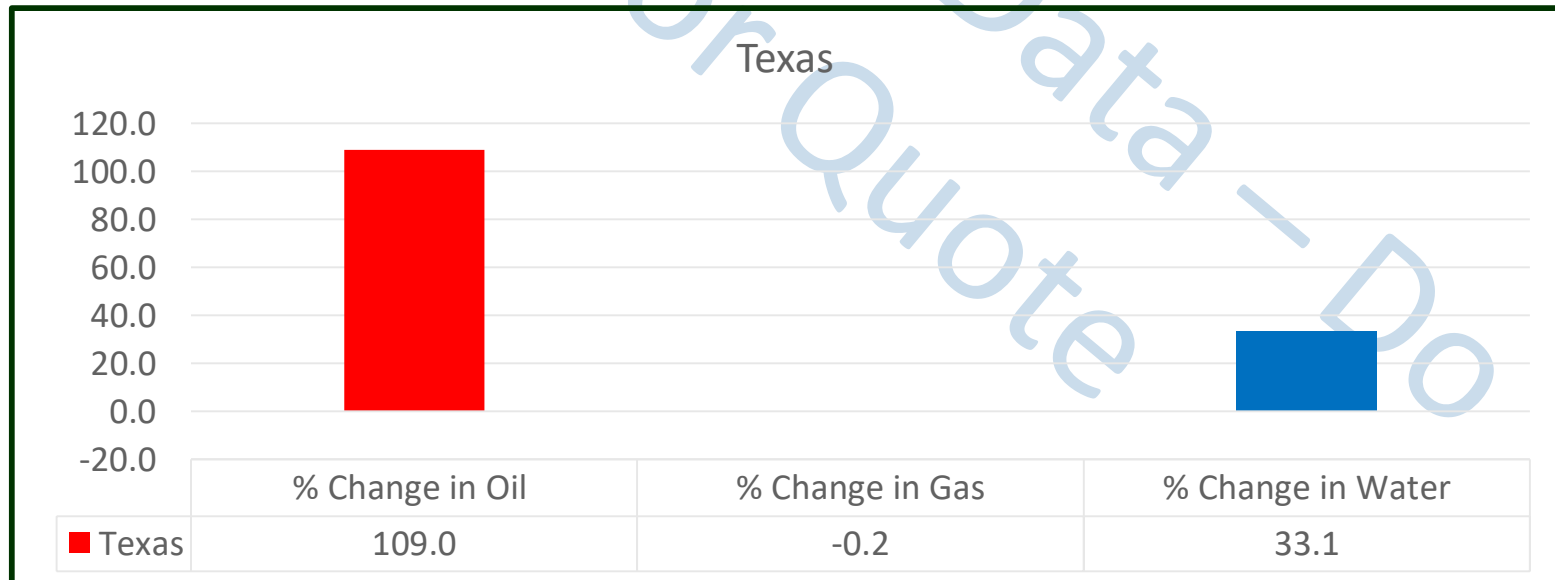
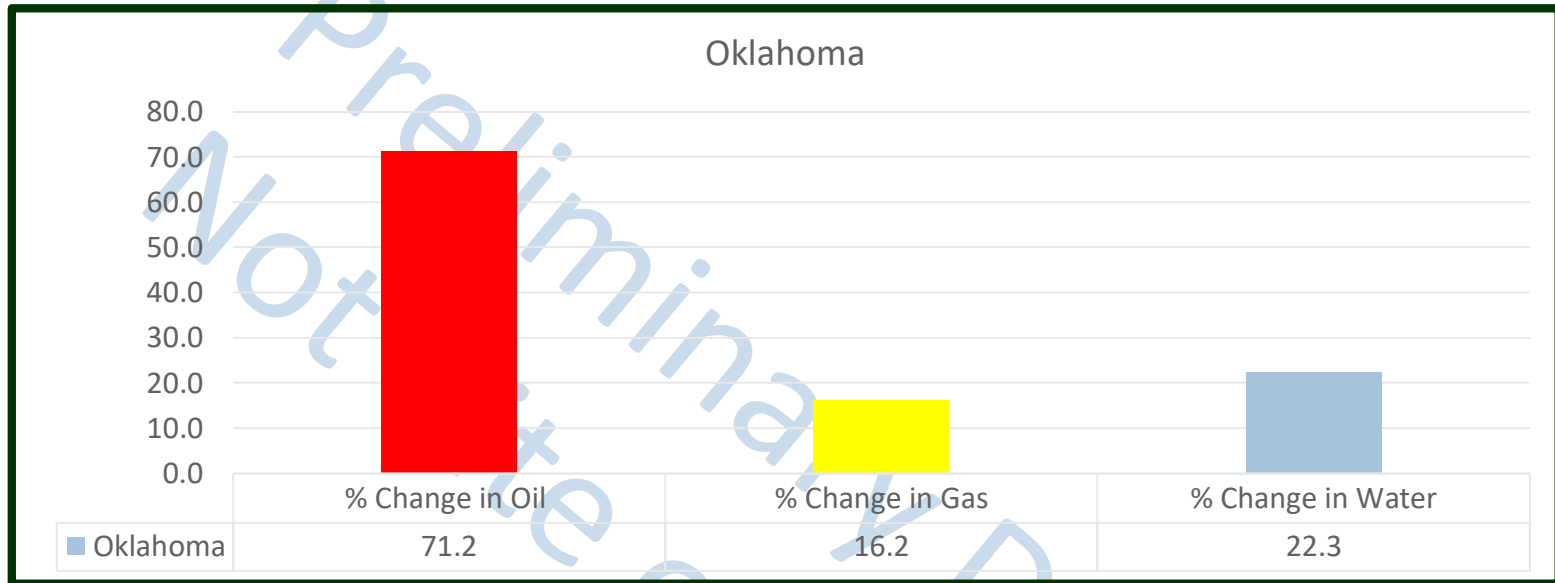
Changes in Fluid Production 2012 to 2017

- U.S. oil production increased by 50.4% to 3.4 billion bbl
- U.S. gas production increased by 17.7% to 35 million Mmcf
- U.S. water production increased by 15.2% to 24.4 billion bbl

Ten Year Changes in Fluid Production



Master Spreadsheet Allows Visualization of Trends within a State (2012-2017)



Why Do Oil and Gas Increase at a Faster Rate than Water?

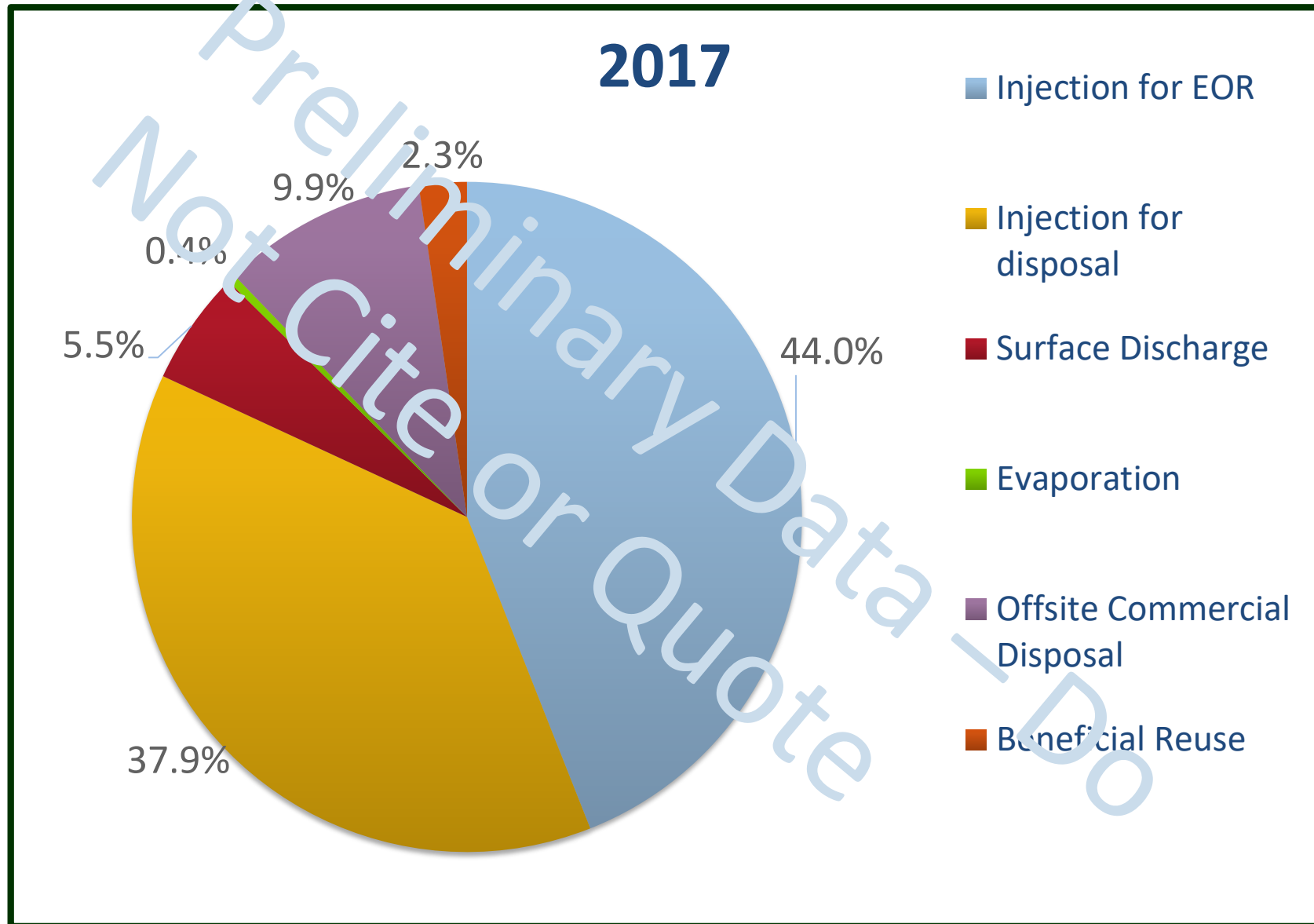
Here is my hypothesis:

- 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 relatively 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 same trend continued from 2012 to 2017
- The new wells generated more hydrocarbon for each unit of water than the older wells they replaced

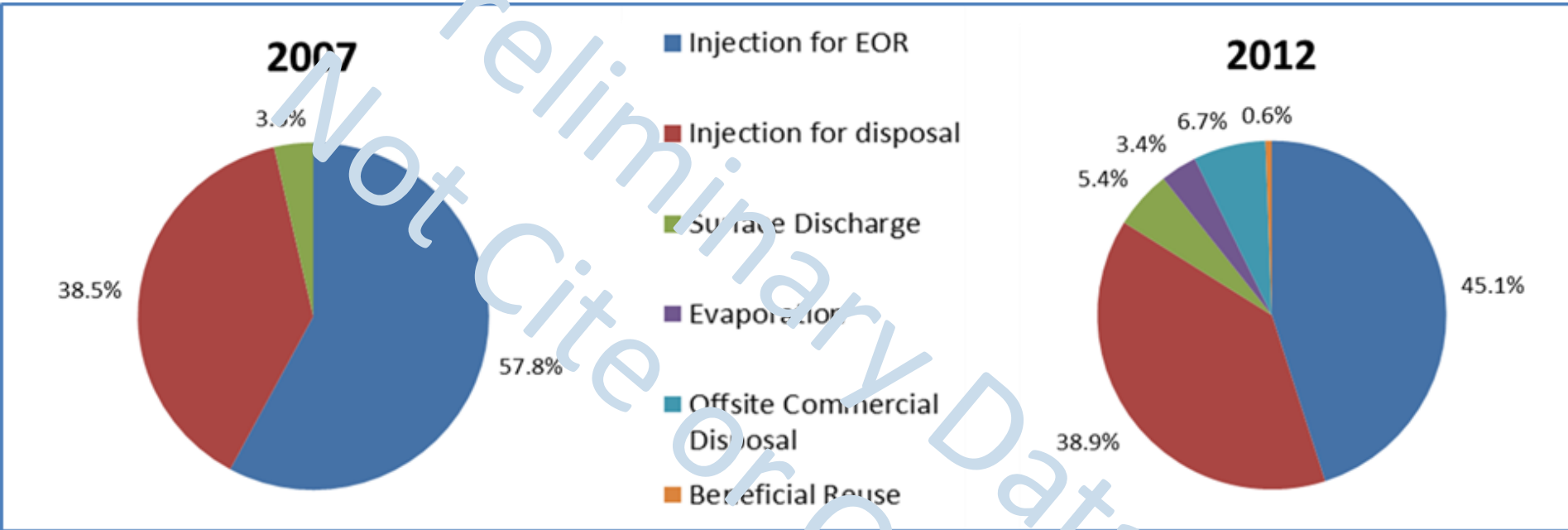
Ratio of Water to Oil and Gas Production

- Few states provided separate water from oil production and water from gas production
- The weighted average water-to-oil (WOR) for 15 states is 4.8 bbl water/bbl oil.
- The weighted average water-to-gas ratio (WGR) for 14 states is 76 bbl water/Mmcf gas.
- The total volume of water associated with the wells included in these calculations is a small percentage of the total produced water.
- Most of the states with large numbers of older conventional wells with high water cuts are not included
- Therefore, the WOR and WGR are probably not representative of national averages

Water Management 2017



Water Management 2007 and 2012



% Injected	Disposal	EOR	Commercial	Total
2017	44.0	37.9	9.9	91.8
2012	38.9	45.1	6.7	90.7
2007	38.5	57.8	no data	96.3

Timing

- Sent data request letters to the oil and gas directors or other key managers in April or May
 - Many states required follow up
- Completed data collection by the end of the summer
- Draft report will be completed by the end of 2019
- Final report will follow receipt of comments from reviewers
- Anticipate release in early 2020

Data Availability

- State agencies collect different types of oil and gas and water data to meet their own needs and to comply with their state laws. In this study, more than 31 states were requested to provide data. There was some variation in the types of data that were available.
- Other than injection volumes, most states do not keep track of how produced water is managed
- Few states maintain data on beneficial reuse within the oil and gas industry or otherwise
- Where data were not available through the state agency questionnaires, additional efforts were made to estimate water volumes and management practices.

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What's
2+2?



ENGINEER



GEOLOGIST



GEOPHYSICIST



Final Thoughts

- This report provides a third set of data, spaced five years apart, of produced water volumes and management in the United States
 - This will serve as an excellent resource for researchers, policy makers, and others
- Shift from conventional to unconventional oil and gas production has led to less produced water per unit of hydrocarbon
- This type of national data collection effort is very difficult and time-consuming