# Oklahoma Water for 2060
# Produced Water Reuse and Recycling

## Produced Water Working Group meeting

March 10, 2017

# Report Outline

1. Introduction
2. Produced Water in Oil and Gas Operations
3. Produced Water Re-use Scenarios
4. Feasibility of Broad Scale Implementation
5. Challenges, Opportunities, and Risks
6. Implementation
7. Conclusions and Recommendations

Red River

# Executive Summary - Economics

1. Re-use by the oil and gas industry is the most cost-effective alternative to water disposal in disposal wells

2. Surplus produced water in Alfalfa County could be gathered and conveyed to Blaine County for re-use (subset of item 1).

3. Evaporating produced water is the third most cost-effective alternative category of options

4. Cases requiring desalination for power, industrial plants or discharge to rivers are technically implementable, but are the most expensive scenarios

Short term | Medium term | Long term

# Executive Summary - Recommendations

1. Reduce the challenges to water re-use through targeted regulations and legislation: water ownership, bonding, water sharing, right-of-way & discharge delegation.

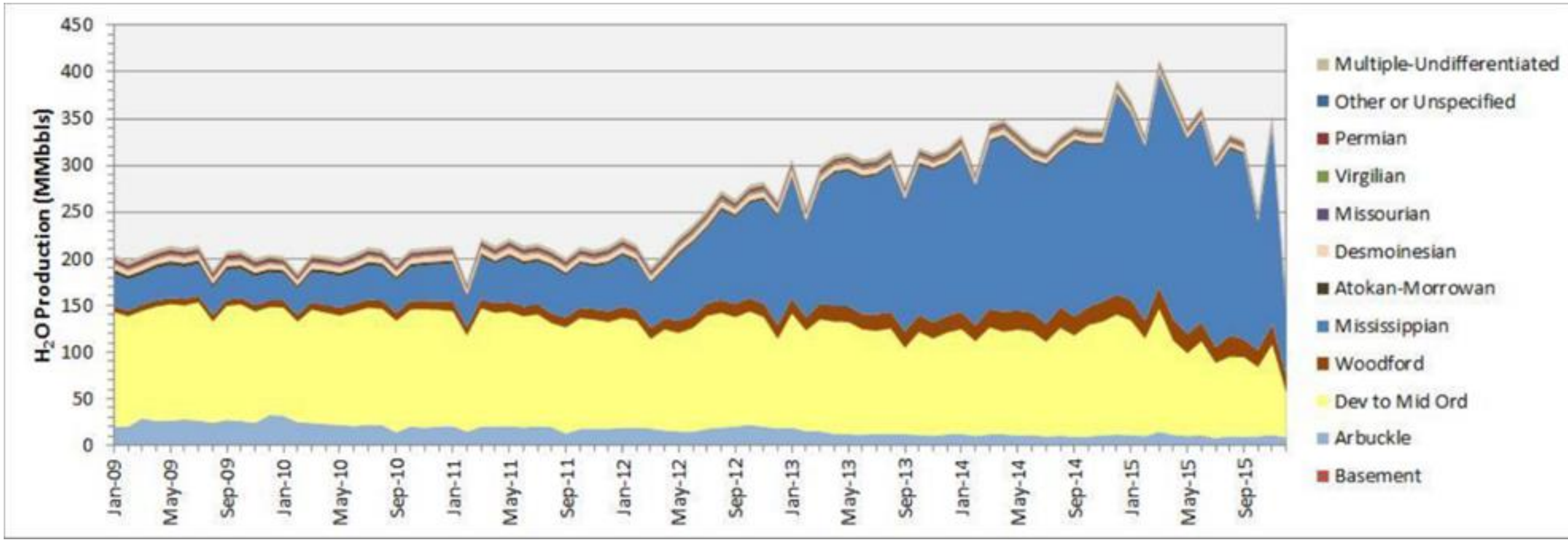
2. Continue to consider how to facilitate the re-use of produced water in oil and gas operations.

3. Continue detailed study of the feasibility of transferring the Mississippi Lime area produced water to the STACK play (Case 3).

4. Continue a detailed evaluation of evaporation as an alternative to injection (Cases 4 and 5).

5. Companies and regulators should consider all negative and positive environmental and stakeholder impacts, as well as any data gaps, before implementing a long-term project.

# 1. Introduction




WATER FOR 2060
EFFICIENCY • CONSERVATION • RECYCLING • REUSE

## PWWG Meetings:

March 2016, June 2016, August 2016, November 2016 & March 2017

# 2. Produced Water in Oil and Gas Operations

## Main Oil and Gas Areas

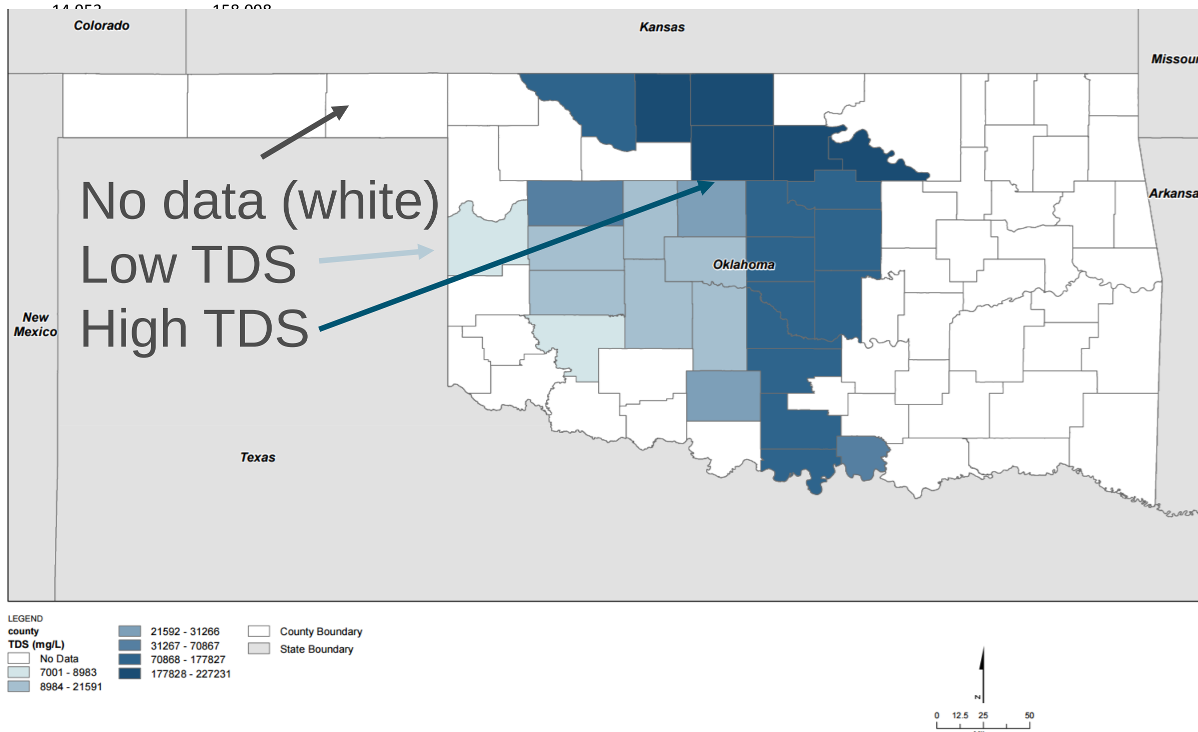
# 2. Produced Water in Oil and Gas Operations

## Produced Water Volume and Quality by County

Table 2-1. Produced Water Volumes Injected and Total Dissolved Solids (TDS) by County in Oklahoma
*Oklahoma Water for 2060 Produced Water Re-use and Recycling Report*

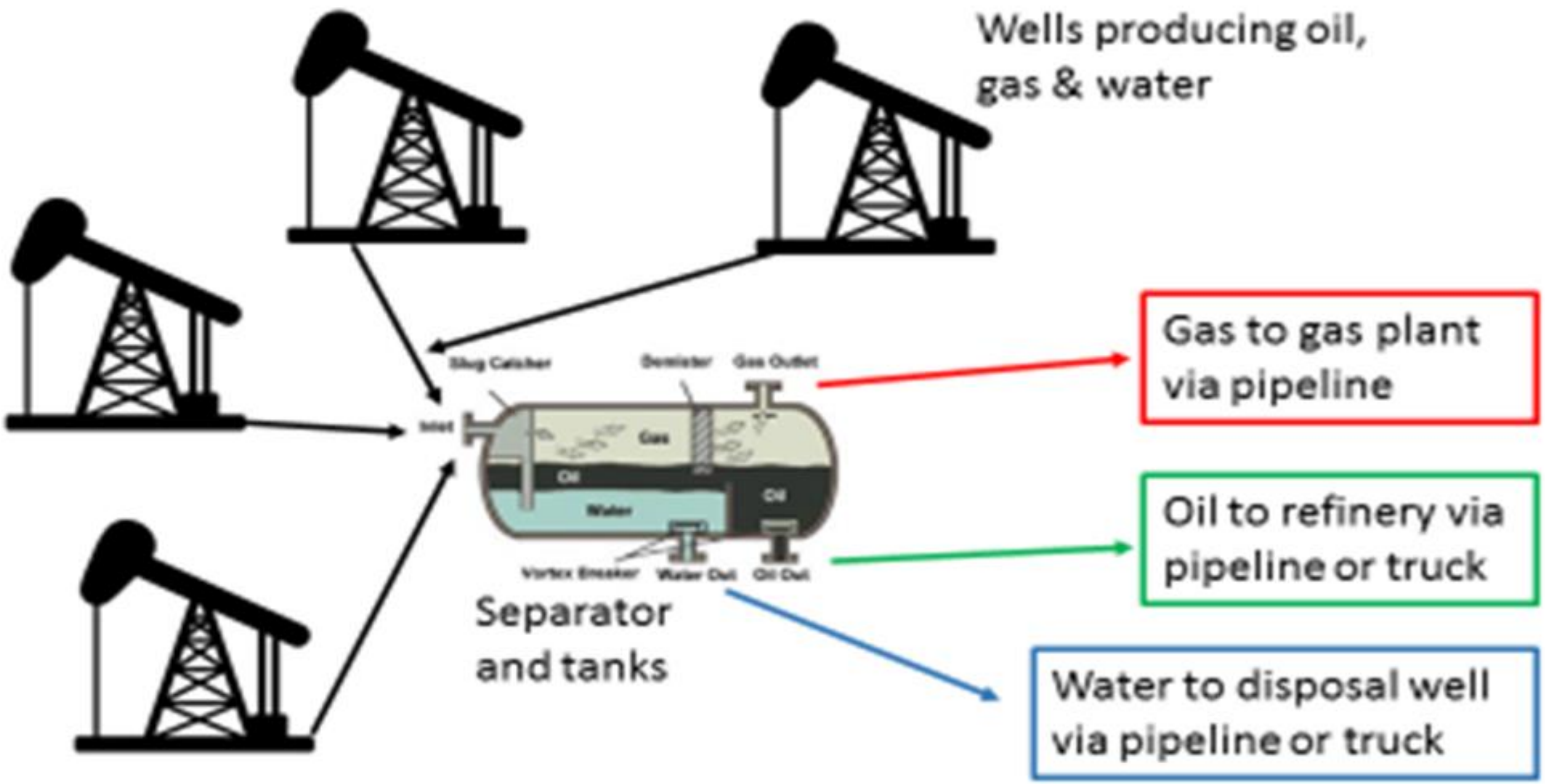
| County | Produced Water Injected Barrels Per Day (December 2015)[1] | Minimum TDS (mg/L)[2] | Average TDS (mg/L) | Maximum TDS (mg/L) |
|---|---|---|---|---|
| ALFALFA | 600,559.53 | 207,133 | 212,935 | 217,543 |
| BEAVER | 39,458.61 | ND | ND | ND |
| BECKHAM | 22,322.81 | ND | ND | ND |
| BLAINE | 25,676.97 | 3,427 | 16,870 | 35,202 |
| BRYAN | - | ND | ND | ND |
| CADDO | 36,095.58 | 2,403 | 20,369 | 147,501 |
| CANADIAN | 66,147.00 | 1,373 | | |
| CARTER[3] | 1,041,173.35 | 95,550 | | |
| CIMARRON | 4,375.68 | ND | | |
| CLEVELAND[3] | 5,597.03 | 106,738 | | |
| COAL | 22,115.13 | ND | | |
| COMANCHE | 973.42 | ND | | |
| COTTON | 17,468.26 | ND | | |
| CRAIG | 378.19 | ND | | |
| CREEK | 475,327.76 | ND | | |
| CUSTER | 12,675.71 | 20,261 | | |
| DEWEY | 122,761.81 | 70,867 | | |
| ELLIS | 29,566.71 | ND | | |
| GARFIELD | 146,793.31 | 208,250 | | |
| GARVIN[3] | 166,967.78 | 46,131 | | |
| GRADY | 54,725.17 | 122 | | |
| GRANT | 109,502.35 | 217,171 | | |
| GREER | 16.94 | ND | | |
| HARMON | 35.00 | ND | | |
| HARPER | 13,022.42 | ND | | |
| HASKELL | 14.48 | ND | | |
| HUGHES | 71,959.32 | ND | | |

- Production data from OCC
- TDS from oil companies



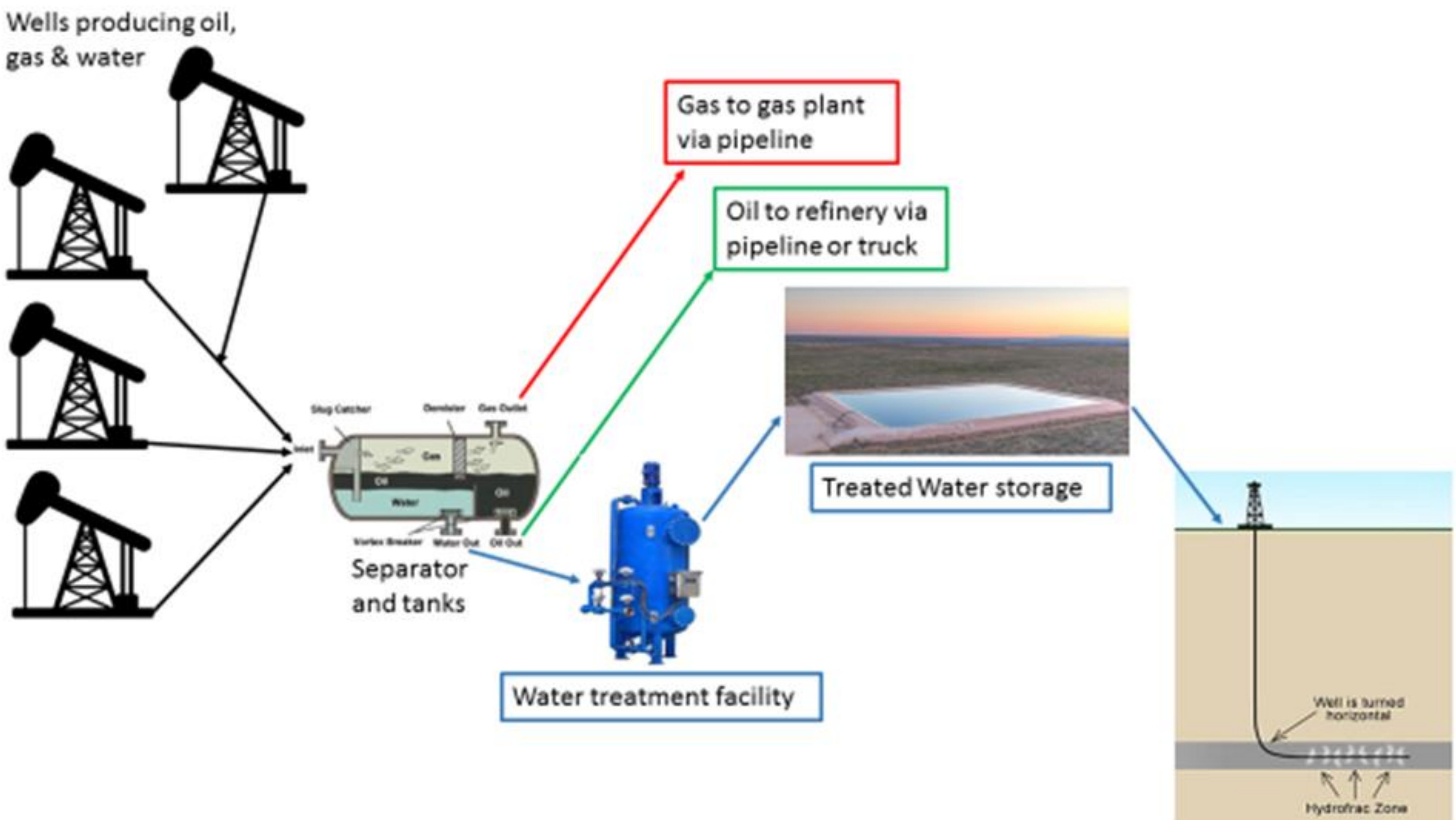
# 2. Produced Water in Oil and Gas Operations

## Typical Simplified Oil, Gas and Water Process



# 2. Produced Water in Oil and Gas Operations

## Simplified Oil, Gas and Water Process with Water Re-use



# 2. Produced Water in Oil and Gas Operations

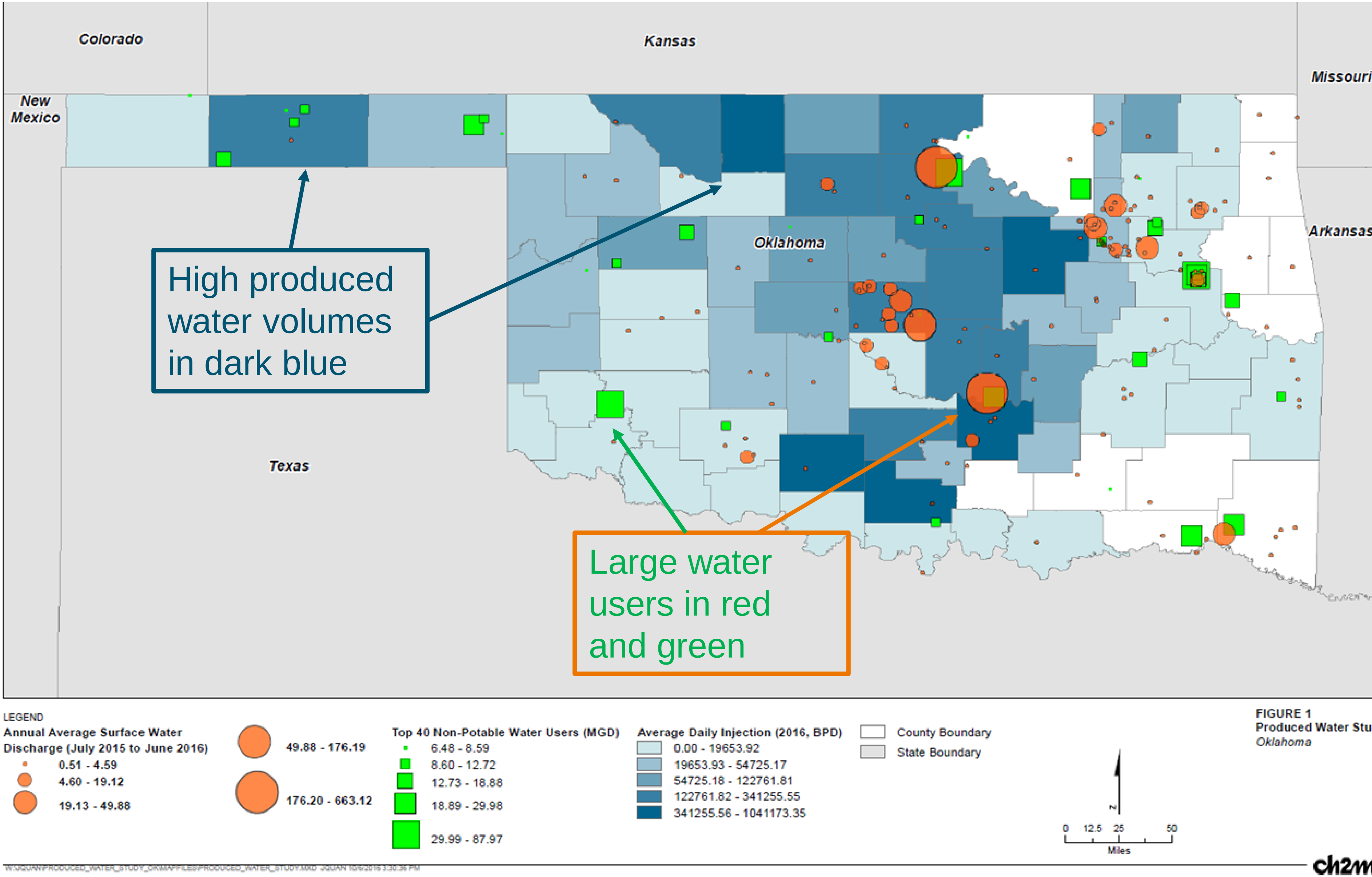
## Key points

- Average well in OK in 2016 used ~210,000 barrels for hydraulic fracturing
- PW TDS range: 10,000 to 230,000 milligrams per liter (mg/L) in OK
- Water quality needed for oilfield reuse is flexible.  Water standard for other industries or discharge requires desalination.
- Transportation of water can be high cost

Companies mentioned with water infrastructure: Continental, Devon, Newfield & Cimarex.

Photo from Chesapeake.

# 2. Produced Water in Oil and Gas Operations




Matching Produced Water with potential users.

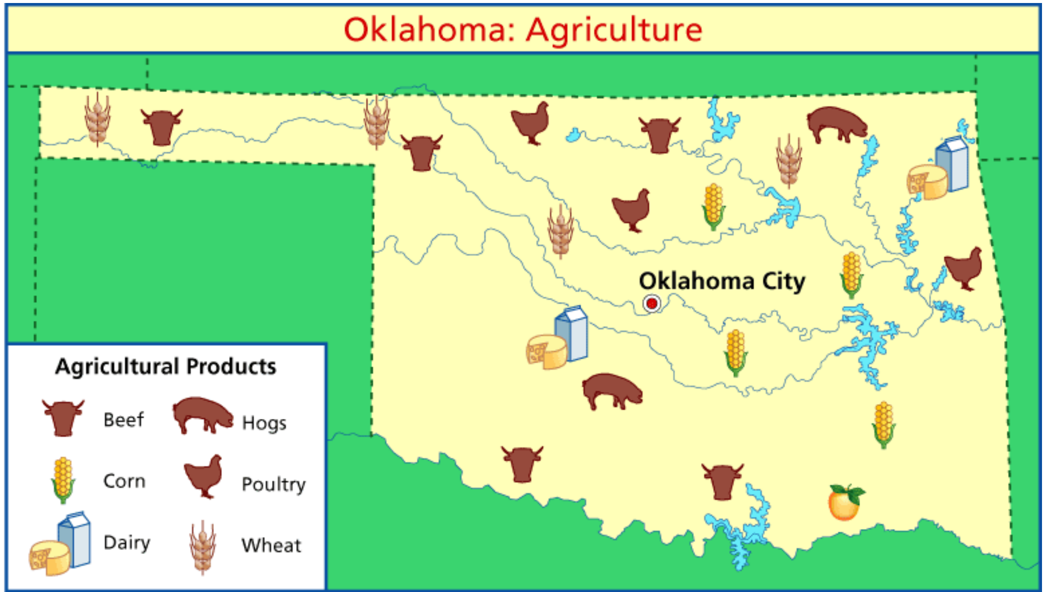
# Produced Water in Oil and Gas Operations

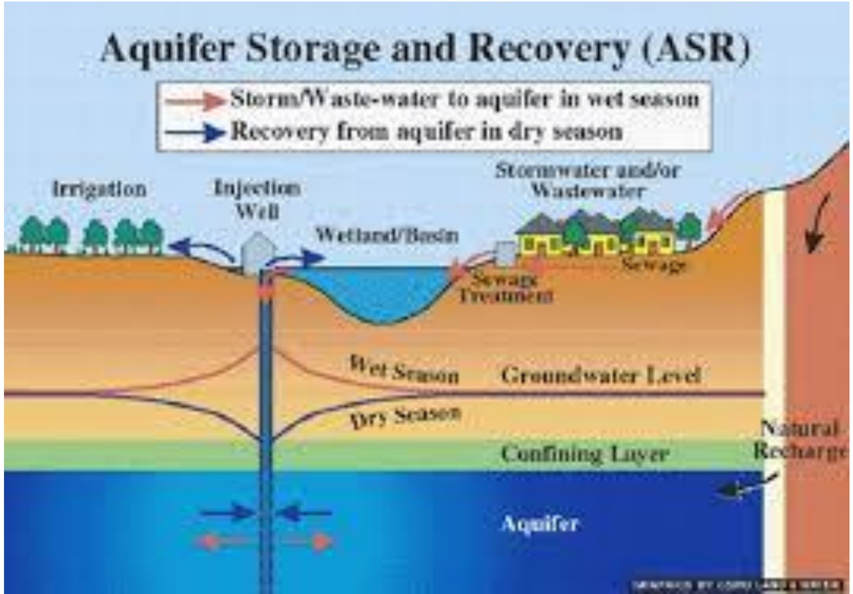
Alternatives Not Evaluated Economically

1. Agriculture – Locations not aligned, seasonality

2. Aquifer Storage & Recovery – lack of regulations currently

3. Mining



# 3. Produced Water Re-use Scenarios

## Cost estimates and economic assumptions

- Capital cost estimates (+50%/-30% accuracy) using CH2M's Parametric Cost Estimating System and benchmarked against other similar projects.
- Water treatment costs based on estimates from selected companies.
- Used 10 year project life for all capital, but project lives could be longer.
- “Normalized” capital, treatment costs and barrels into “today’s dollars” by discounting future costs and barrels at 10% discount rate.

Important points in the fine print.

# 3. Produced Water Re-use Scenarios

**Water Treatment Cost Estimates**

**Summary of Cases**

| Case # | Barrels per day treated | Contract term (yrs) | Inlet wtr TDS (mg/l) | Wtr quality needed | Cost per BW* | % of inlet wtr recovered | Number of Estimates | Cost Estimates Low | Cost Estimates High |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 20,000 | 2 | 30,000 | Clean brine | 0.66 | | 8 | 0.30 | 1.50 |
| 2 | 100,000 | 2 | 30,000 | Clean brine | 0.57 | | 8 | 0.18 | 1.50 |
| 3 | 100,000 | 10 | 30,000 | Clean brine | 0.47 | | 8 | 0.10 | 1.50 |
| 4 | 20,000 | 2 | 150,000 | Clean brine | 0.69 | | 8 | 0.30 | 1.75 |
| 5 | 100,000 | 2 | 150,000 | Clean brine | 0.60 | | 8 | 0.18 | 1.75 |
| 6 | 100,000 | 10 | 150,000 | Clean brine | 0.50 | | 8 | 0.10 | 1.75 |
| 7 | 20,000 | 2 | 10,000 | Desalinated | 2.58 | 88% | 8 | 0.95 | 5.30 |
| 8 | 100,000 | 2 | 10,000 | Desalinated | 2.04 | 88% | 8 | 0.65 | 4.25 |
| 9 | 100,000 | 10 | 10,000 | Desalinated | 1.76 | 88% | 8 | 0.45 | 4.00 |
| 10 | 20,000 | 2 | 30,000 | Desalinated | 3.05 | 74% | 8 | 1.45 | 5.75 |
| 11 | 100,000 | 2 | 30,000 | Desalinated | 2.55 | 74% | 8 | 1.25 | 4.70 |
| 12 | 100,000 | 10 | 30,000 | Desalinated | 2.22 | 74% | 8 | 0.95 | 4.50 |
| 13 | 20,000 | 2 | 150,000 | Desalinated | 4.58 | 60% | 6 | 1.46 | 9.26 |
| 14 | 100,000 | 2 | 150,000 | Desalinated | 3.60 | 60% | 6 | 1.10 | 6.91 |
| 15 | 100,000 | 10 | 150,000 | Desalinated | 2.52 | 60% | 6 | 0.90 | 5.25 |
| 16 | 20,000 | 2 | 30,000 | Evaporation | 1.66 | | 3 | | |
| 17 | 20,000 | 2 | 150,000 | Evaporation | 1.79 | | 3 | | |

# 3. Produced Water Re-use Scenarios

| New Case | Case Description | Total Capital ($Millions) | Capacity BWPD | County | Assumed Wtr TDS (mg/L) | Normalized $/BW |
|---|---|---|---|---|---|---|
| 1 | Typical Source and Dispose - STACK & SCOOP | NA | NA | Central OK | NA | 1.83 |
| 2 | Oil and gas re-use (treatment cost only, pipe transfer exists) | NA | NA | State-wide | NA | 0.57 |
| 3 | Clean Brine Transfer & treatment | 208 | 200,000 | Alfalfa | 213,000 | 1.03 |
| 4 | Evaporation - low TDS (SCOOP & STACK) | NA | 20,000+ | Blaine | 17,000 | 1.66 |
| 5 | Evaporation - high TDS (Miss. Lime) | NA | 20,000+ | Alfalfa | 213,000 | 1.79 |
| 6 | Desalination for Surface Discharge | 22 | 15,000 | Beckham | 9,000 | 3.58 |
| 7 | Desalination for Power Use | 88 | 130,000 | Pawnee | 125,000 | 4.37 |
| 8 | Desalination for Power Use | 95 | 230,000 | Seminole | 180,000 | 4.43 |
| 9 | Desalination for Industrial Use | 35 | 30,000 | Grant | 227,000 | 7.41 |
| 10 | Desalination for Surface Discharge | 38 | 30,000 | Grant | 227,000 | 7.49 |

# 3. Produced Water Re-use Scenarios

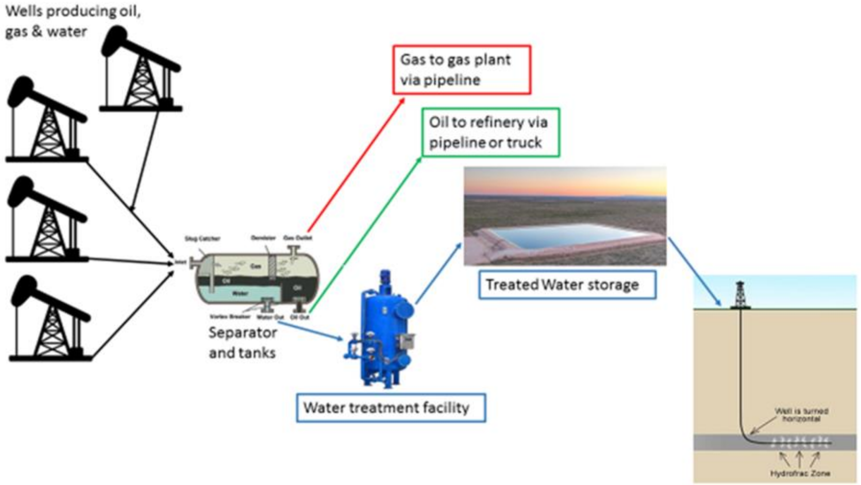
<u>Case 1</u> – Typical cost to source & dispose in STACK & SCOOP

- Cost is average of estimates from four operators = $1.83/BW
- Trucking costs when applicable are about ½ of this cost.
- Does <u>not</u> include temporary lines to move water to frac site.
- Would like to have more companies input.

# 3. Produced Water Re-use Scenarios

Case 2 – Oil and gas reuse assuming water infrastructure exists

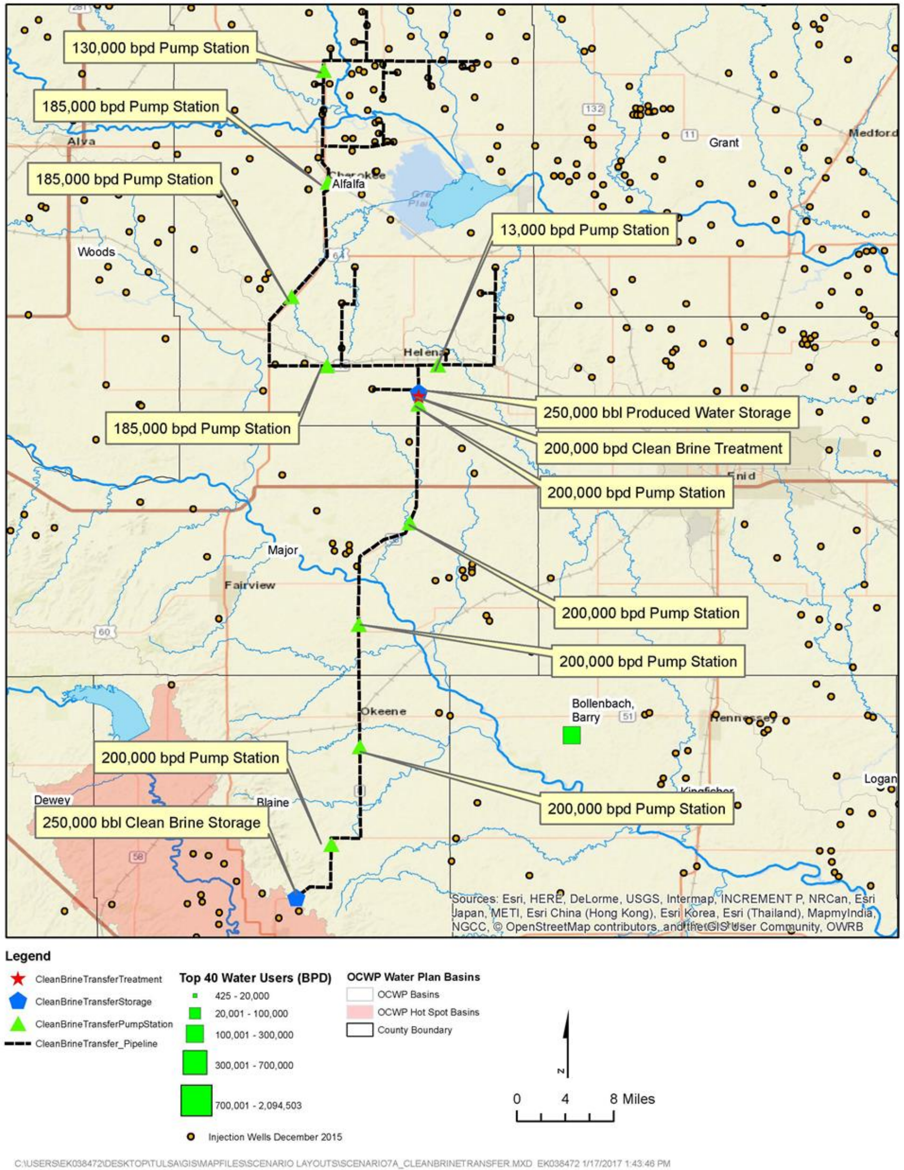
- Cost to treat water for re-use = $0.57/BW
- But, little water infrastructure currently exists
- Infrastructure of water gathering lines, impoundments and delivery lines is needed
- If trucking to and from a treatment facility is required, the two-way trucking cost could be $2 to $6/BW.



# 3. Produced Water Re-use Scenarios

Case 3 – Inter-county Clean Brine Transfer & Treatment

- Normalized cost for capital & water treatment = $1.03/BW
- Alfalfa Co. PW surplus
- Blaine Co. need for frac'ing
- Cost of 200,000 BWPD gathering lines & transfer is not impediment
- Does not include distribution system in Blaine Co.
- Commercial and technical issues will need to be resolved



# 3. Produced Water Re-use Scenarios

<u>Case 4</u> - Forced Evaporation – Low TDS (SCOOP & STACK)

- Evaporation cost = $1.66/BW for 20,000 BWPD facility, 2 year project
- No capital required since assume treatment facility next to disposal well.
- Vendor provides all power needs and disposes of any solid or liquid waste.

# 3. Produced Water Re-use Scenarios

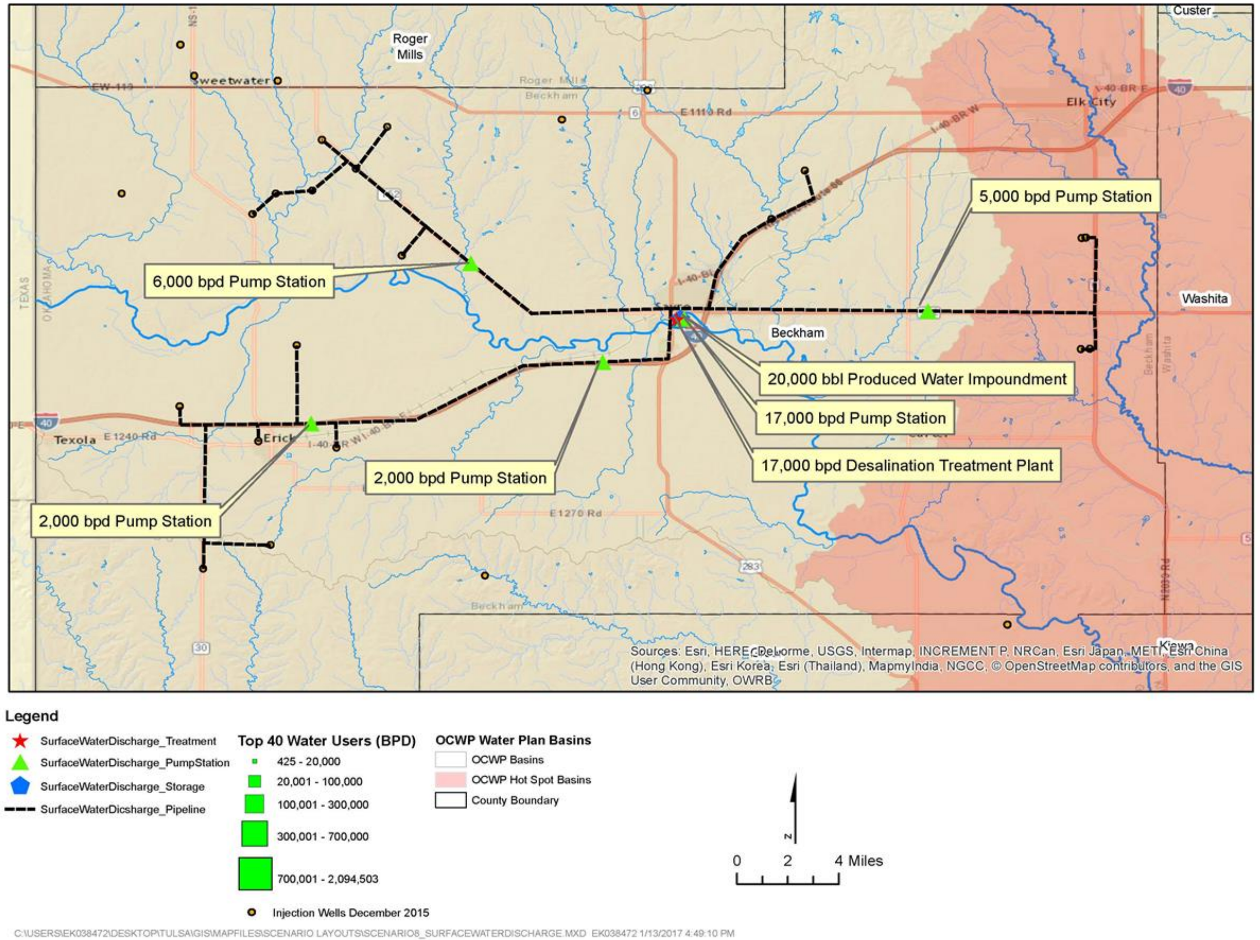
<u>Case 5</u> - Forced Evaporation – High TDS (Mississippi Lime)

- Evaporation cost = $1.79/BW for 20,000 BWPD facility, 2 year project
- No capital required since assume treatment facility next to disposal well.
- Vendor provides all power needs and disposes of any solid or liquid waste.

# 3. Produced Water Re-use Scenarios

Case 6 - Desalination for Surface Discharge in Beckham County

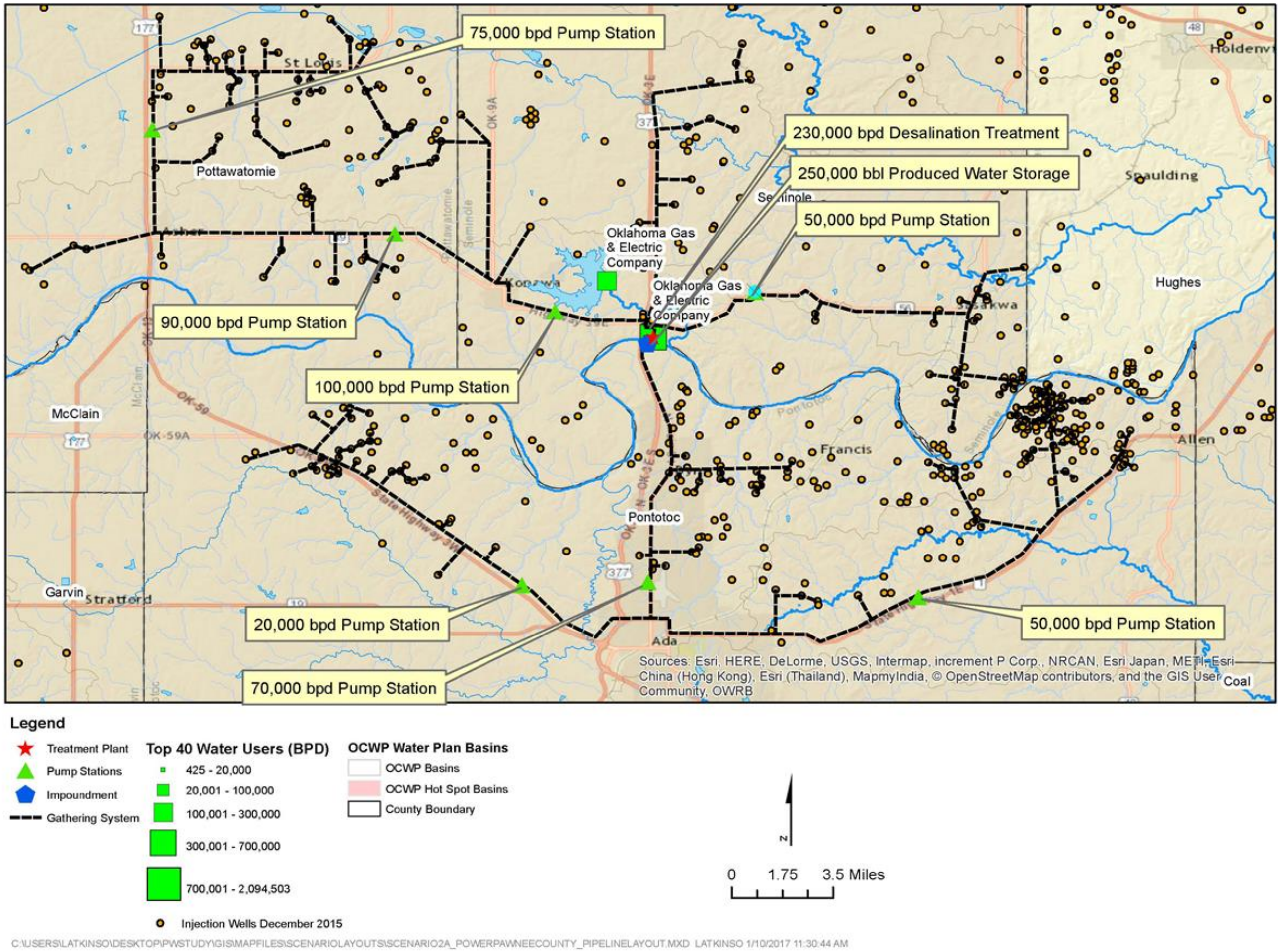
- Normalized cost for gathering lines and treatment = $3.58/BW
- Lowest cost of desalination cases due to unusually low TDS of PW



# 3. Produced Water Re-use Scenarios

## <u>Case 7</u> - Desalination for Power Use in Seminole County

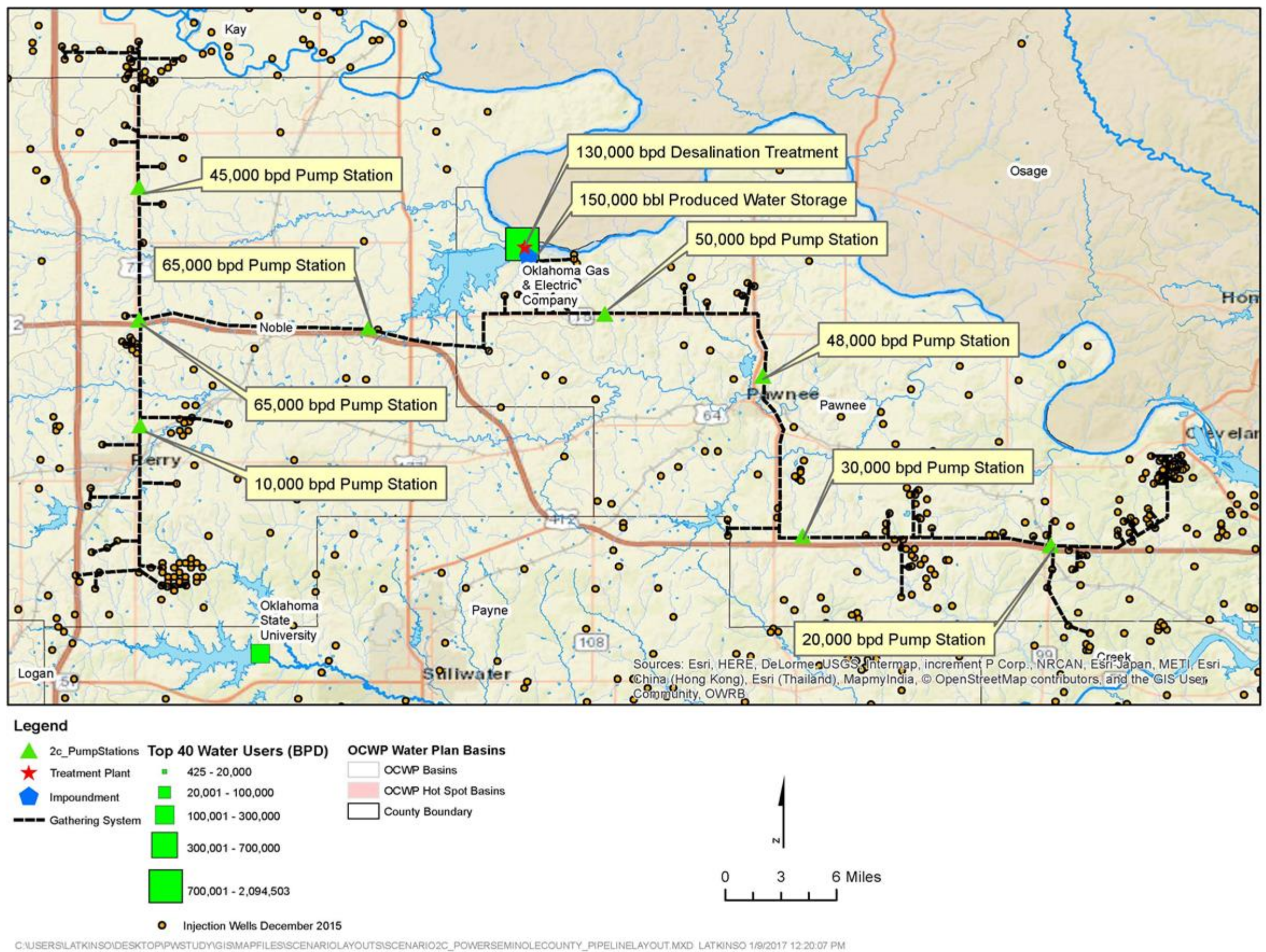
- $4.37/BW cost estimate.
- Power has large, long-term water demand
- 130,000 BWPD capacity for 125,000 TDS water.



# 3. Produced Water Re-use Scenarios

## Case 8 - Desalination for Power Use in Pawnee County

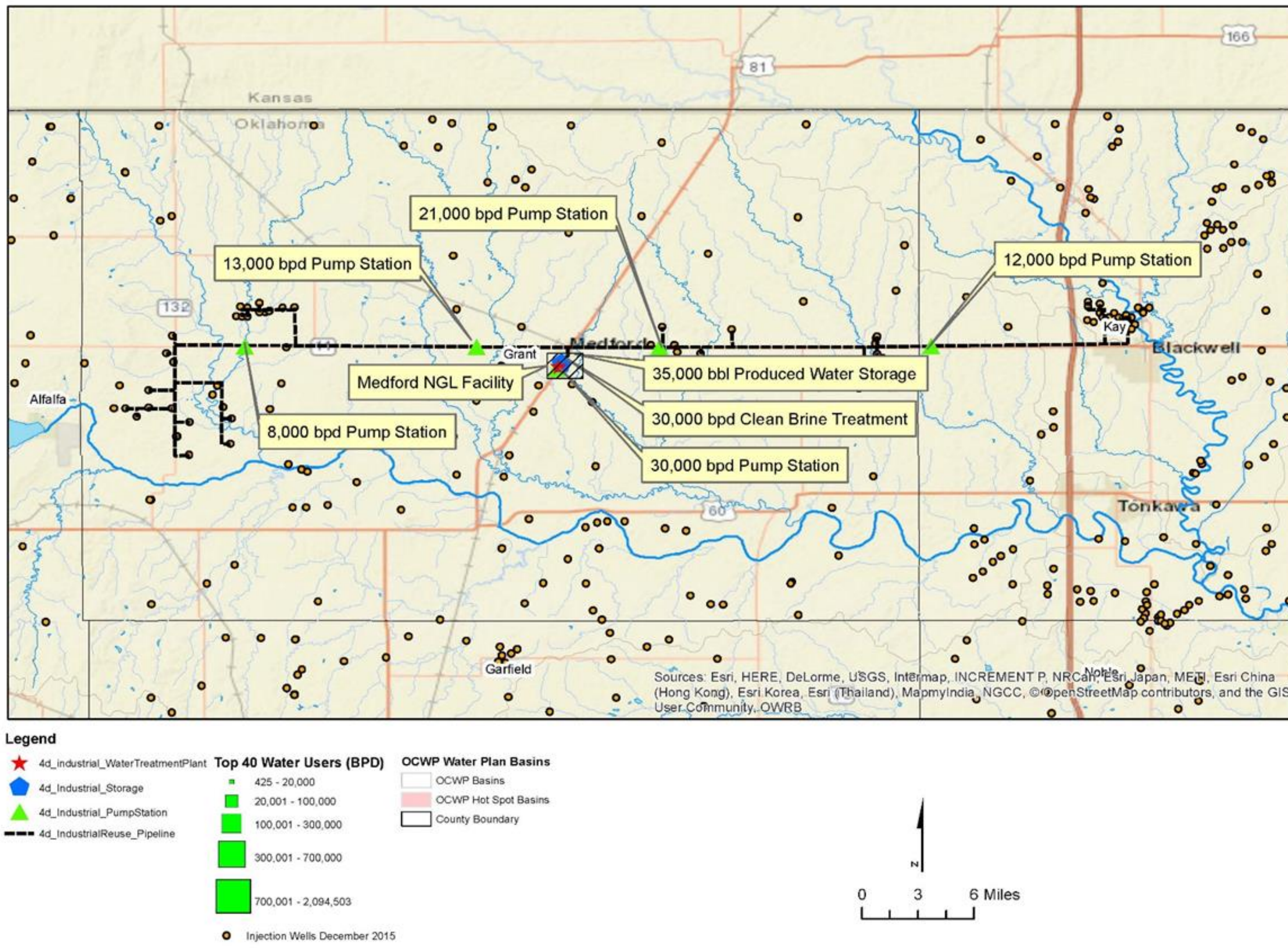
- $4.43/BW cost estimate.
- Power has large, long-term water demand
- 230,000 BWPD capacity for 180,000 TDS water.
- Compared to prior case, higher volume & higher TDS offset.



# 3. Produced Water Re-use Scenarios

## Case 9 - Desalination for Industrial Use in Grant County

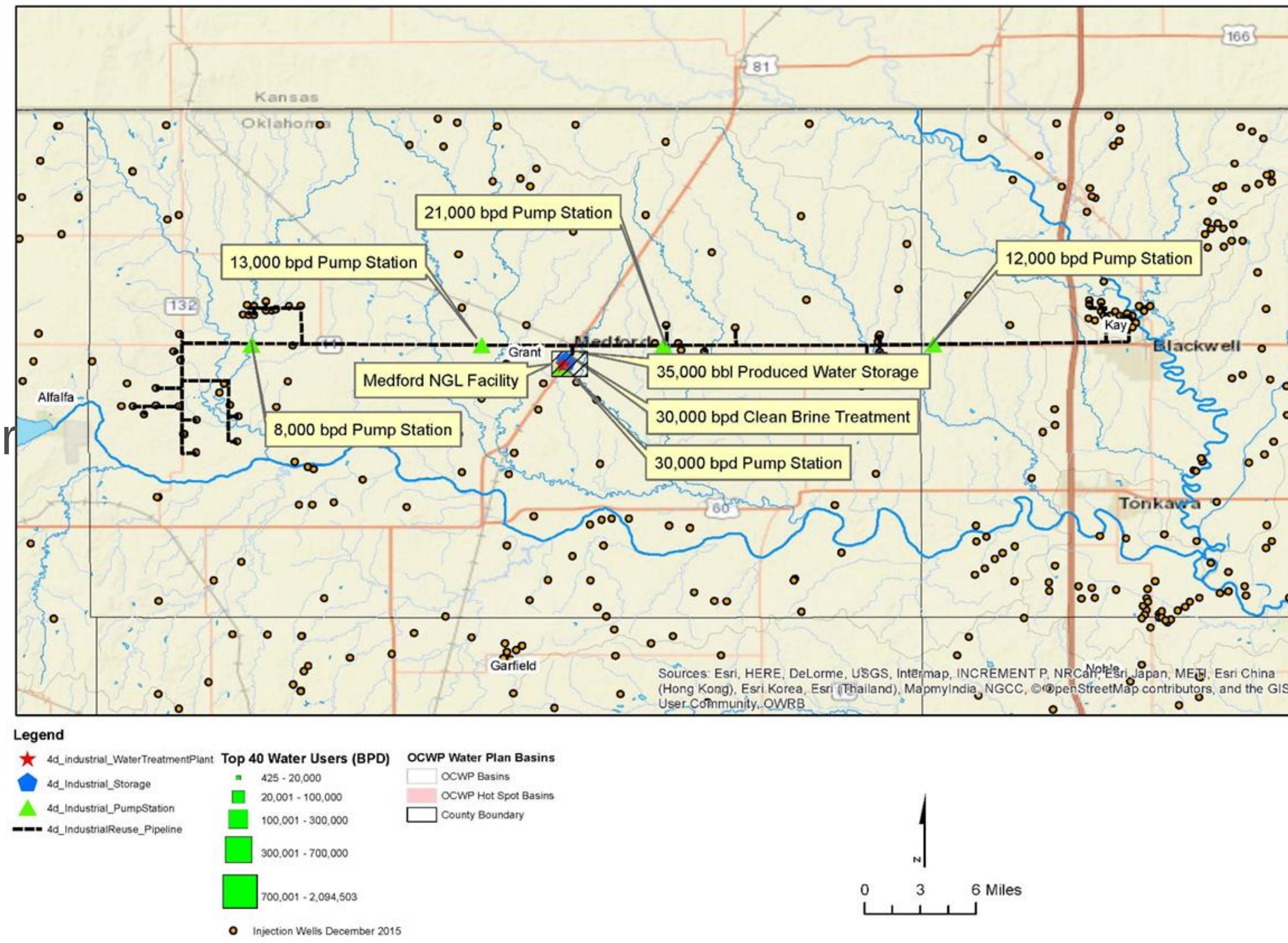
- $7.41/BW cost estimate.
- 30,000 BWPD capacity for 227,000 TDS water.
- Lower volumes & higher TDS increase cost per BW.



# 3. Produced Water Re-use Scenarios

<u>Case 10</u> - Desalination for Surface Discharge in Grant County

- $7.49/BW cost estimate.
- 30,000 BWPD capacity for 227,000 TDS water.
- Similar to prior case except slightly higher capital.



# 5. Challenges, Opportunities, and Risk

Challenges to produced water re-use

1. Cost to Transport and Treat Water for Re-use and Recycling
2. Water Treatment Facility Bonding Requirements
3. Ownership and Value of Produced Water
4. Legal Custody of Water as it Relates to Potential Spills
5. Right-of-Way and landowner negotiations
6. Discharge Permit Challenges Including Timing

# 6. Implementation

<u>Requirements for success</u>

- Design for water balance
- Financing for capital
- Permits & right-of-way
- Oil and gas companies likely to lead
- Time for projects to develop

# 6. Implementation

## Environmental and Stakeholder Considerations

| Method | Possible risks or issues |
|---|---|
| 1. Disposal/injection | Potential for seismicity or casing leaks |
| 2. Re-use | More water transfer & storage; less trucking |
| 3. Evaporation | Potential for solid waste disposal |
| 4. Other industries/ Desalination | Maximum solid waste disposal; more transfer/storage |

# 6. Implementation

## Environmental and Stakeholder Considerations

**Implementation Opportunities, Challenges and Impacts**

| Case | Case Description | Limits Water Disposal | Reduce Water Needs | "Create" New Water | Reduce Water Trucking | Water Storage Needed | Water Pipeline Needed | Solid Waste Generated |
|---|---|---|---|---|---|---|---|---|
| 1 | Typical Source and Dispose | | | | | | | |
| 2 | Oil and gas re-use | | | | | | | |
| 3 | Clean Brine Transfer & treatment | | | | | | | |
| 4 | Evaporation - low TDS (SCOOP & STACK) | | | | | | | |
| 5 | Evaporation - high TDS (Miss. Lime) | | | | | | | |
| 6 | Desalination for Surface Discharge | | | | | | | |
| 7 | Desalination for Power Use | | | | | | | |
| 8 | Desalination for Power Use | | | | | | | |
| 9 | Desalination for Industrial Use | | | | | | | |
| 10 | Desalination for Surface Discharge | | | | | | | |

Positive opportunity or impact

Negative impact or challenge

# 6. Implementation

## Macroeconomic Considerations

- Roughly one-quarter of all jobs in OK are energy related
- Legislative and regulatory efforts attempt to balance stakeholder concerns with the desire to promote economic growth
- Limited disposal options will raise the cost of water disposal and tend to encourage water re-use.

# 7. Conclusions

1. Re-use by the oil and gas industry is the most cost-effective alternative to water disposal in disposal wells

2. Surplus produced water in Alfalfa County could be gathered and conveyed to Blaine County for re-use (subset of item 1).

3. Evaporating produced water is the third most cost-effective alternative category of options

4. Cases requiring desalination for power, industrial plants or discharge to rivers are technically implementable, but are the most expensive scenarios

# 7. Recommendations

1. Reduce the challenges to water re-use through targeted regulations and legislation: water ownership, bonding, water sharing, right-of-way & discharge delegation.

2. Continue to consider how to facilitate the re-use of produced water in oil and gas operations.

3. Continue detailed study of the feasibility of transferring the Mississippi Lime area produced water to the STACK play (Case 3).

4. Continue a detailed evaluation of evaporation as an alternative to injection (Cases 4 and 5).

5. Companies and regulators should consider all negative and positive environmental and stakeholder impacts, as well as any data gaps, before implementing a long-term project.

Thank You