

Beneficial Use of Produced Water – Considerations for Projects Along the Colorado River System

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International Petroleum & BioFuels Environmental Conference
Treatment and Beneficial Use of Produced Water Session

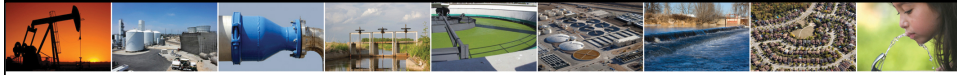
September 1, 2010



Presentation Outline

- Introduction
- Energy – Water Nexus of Produced Water
- Produced Water Ownership
- Volumes of produced water
- Costs for treatment
- Beneficial use of produced water
- Projects by Produced Water Development
- Conclusions





Introduction



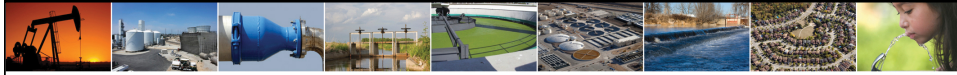
Big Picture – Tale of Two Problems

- CBM and Oil E&P industry have an environmental and energy waste problem – disposing of huge amounts of produced water
- The arid Western US has a problem – drought, climate change and increasing demand for water
- Produced Water will help slow the Ag to Urban Water transfer



Photo courtesy of Marathon Oil Company, photographer Ken Childress



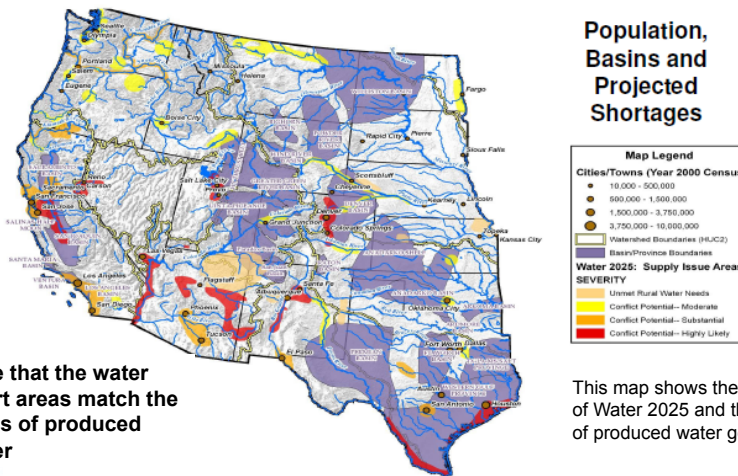


Overview

- The billions of barrels of oil and gas waste water produced annually can be treated, thereby mitigating an environmental problem, and used to augment water supplies
- Population growth, drought and climate change have substantially increased the demand for water in the arid West and are creating crisis conditions in many urban areas resulting in rapidly escalating water prices - *Water 2025 Study*
- Energy producers benefit through cost savings on wastewater disposal, increased recoverable reserves, reduced energy costs for disposal and reduced environmental exposure
- Agricultural, household and other users benefit from a new water source



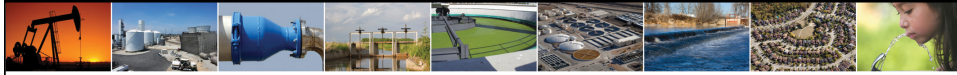
Projected Water Shortages



Note that the water short areas match the areas of produced water

This map shows the overlay of Water 2025 and the areas of produced water generation





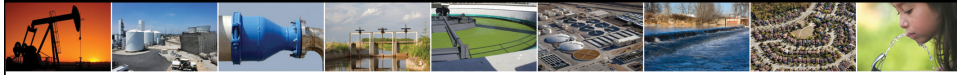
Water Energy Nexus

- Produced Water – Energy Interaction
 - 20% to 30% of the energy that is produced is consumed through re-injection to a deep aquifer
 - Produced water is the constraint to more domestic energy production – if the constraint to produced water is removed, then more domestic energy production is possible
 - Treatment of produced water uses 5% to 8% of the energy produced, depending on the type of treatment employed
 - Produced water can be another asset that can be maximized if treated properly



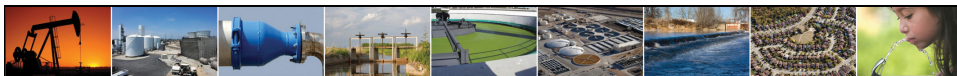
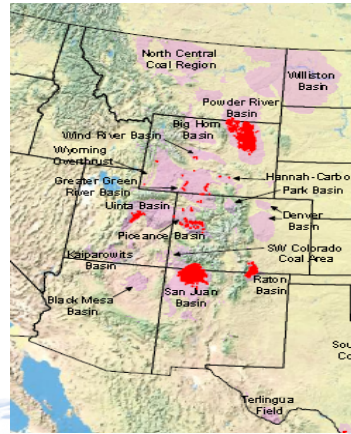
Volumes of Produced Water





Potential Water Sources Example

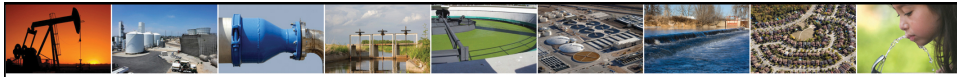
- Potential Water Volumes by basin:
 - Green River Basin
325 TCF = 70 MAF
 - Piceance Basin
99 TCF = 20 MAF
 - Raton Basin
10 TCF = 2 MAF



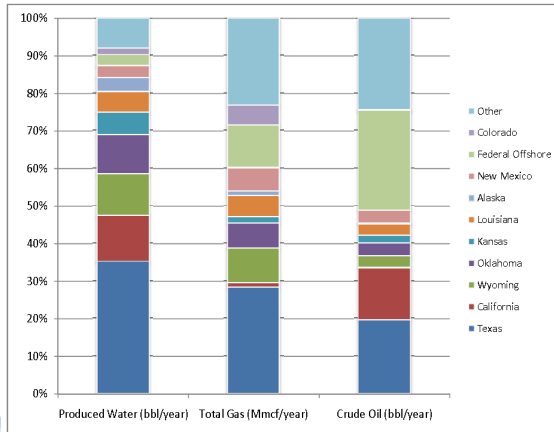
Estimated Volumes of CBM Produced Water

- Powder River – 2.75 to 4 bbl's/MCF
- Raton (Southern Colorado) – 1.3 to 2 bbl's /MCF
- Atlantic Rim/Green River Area – 2 to 4 bbl's/ MCF
- In general, we have found that these estimates are lower than anticipated and that the amount of water available is much higher than anticipated resulting in higher water resource potential





Projected Produced Water Volumes



Produced Water Volumes:

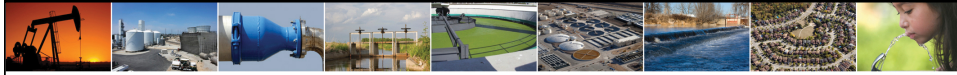
- US – 21 Bbbl/yr
- Wyo – 2.36 Bbbl/yr
- CO – 0.38 Bbbl/yr
- Ut – 0.15 Bbbl/yr



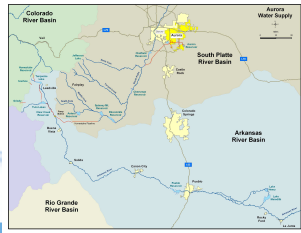
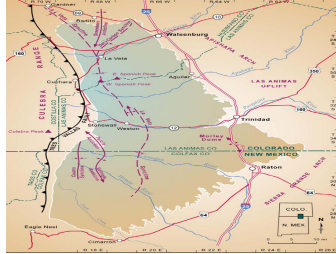
Potential Beneficial Use of Produced Water

- Upper Colorado River Basin – at 2 bbl's/MCF – 70,000,000 AF or potentially 500,000 to 1,000,000 AF per year
- Potential users are entities on the lower Colorado River Basin
- Need all entities within the Colorado River Basin to cooperate
- Discussions with State Engineers of the Upper Colorado River Basin





Beneficial Use of Produced Water

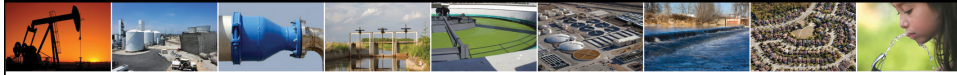


- Raton basin – Arkansas River
- Aurora, Southern Denver, Colorado Springs, Pueblo are potential users
- Aquifer Storage Recharge opportunities



Production Water Ownership Who Owns this water resource?





A New Water Resource

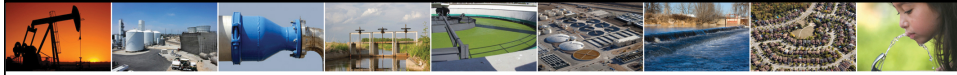
- **Produced Water**
 - Highly contaminated water produced concurrently with the pumping of CBM or oil and gas operations
- **Conventional Thinking**
 - Waste Product
 - High Disposal Costs
 - Environmental Concerns
- **New Reality**
 - New source water
 - Treatable for beneficial use
 - Substantial quantities



Produced Water as an Asset

- **Historically, produced water has been treated as a waste product**
 - Current methods of disposal – reinjection (Class II Injection Wells), evaporation ponds and direct discharge – are being challenged due to adverse environmental impacts
- **Plan to turn this wastewater into an asset - a marketable product - by:**
 - Treating for surface discharge
 - Conceiving a unique water delivery system - augmenting tributary water supplies with non-tributary water
 - Pioneering a path through the numerous legal and regulatory obstacles





Ownership of Produced Water

- **Colorado Example**
 - Tributary – Non-Tributary Groundwater
 - HB 1303 – how does this apply in Colorado
 - SB 165 – produced water beneficial use
 - COGCC Rules (907)
 - State Engineer
 - Agreement on non-tributary status (Fossil water in other states)
 - CDPHE Technical Review, Permit and approval
 - Landowner issue
 - Water Rights & Court
- **Legislation is being introduced this year to fight this process**

Other Western States
 Prior appropriation
 First in Use – First in Right
 Wyoming – 1,000 AF non export law

Cows drinking produced CBNG water & well boxes



Photo courtesy of Fidelity Exploration & Production

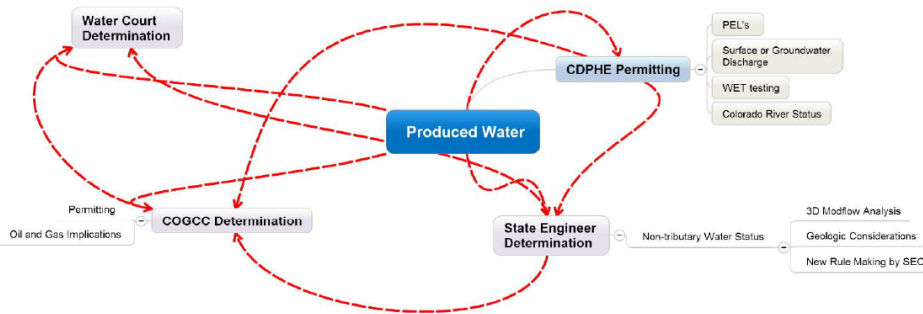
Reclamation of pipeline right-of-way & grazing cows

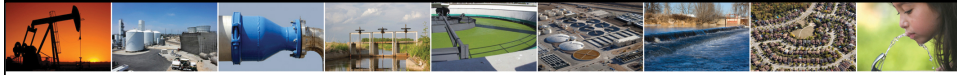


Photo courtesy of Fidelity Exploration & Production



Permitting Requirements in Colorado





State Engineer

FORM NO. 10-01 PERMITS/ISSUE OF NEW PERMITS

OFFICE OF THE STATE ENGINEER
 COLORADO DIVISION OF WATER RESOURCES
 1500 FULTON STREET
 DENVER, CO 80202
 (303) 866-4300

PERMIT NO. _____

WELL PERMIT NUMBER: _____

WELL LOCATION: _____

APPROVED: _____

DATE ISSUED: _____

EXPIRATION DATE: _____

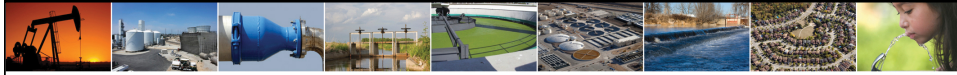
- Non-tributary Water Determination
- Beneficial use permit
- Vance vs. Simpson/Wolfe Water Court Case
- Wellington Water Works vs. Dumont Case
- Colorado HB 1303 – beneficial use of produced water
<http://water.state.co.us/wateradmin/NontribCw.asp>
- Colorado SB 165 – beneficial use of produced water
- Result – need to obtain permits and concurrence regarding the non-tributary status



COGCC Permit Issues

- Was hesitant to issue discharge permit
- CDPHE vs. COGCC permit
 - Surface discharge – CDPHE
 - Subsurface discharge – COGCC
- Monitoring requirements
- COGCC – State Engineer – CDPHE coordination





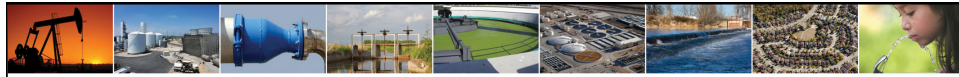
Water Rights Court

- Filed water rights application in Wellington Case – December 2005
- Court case – January 2007
- Final Determination – March 2007
- Produced water can be used beneficially as a vested water right

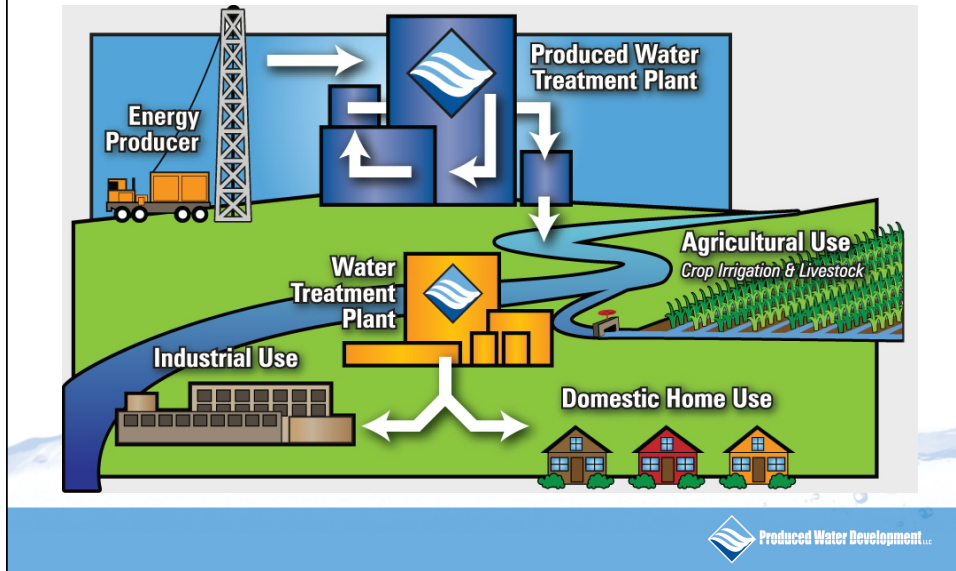


Treatment of Produced Water





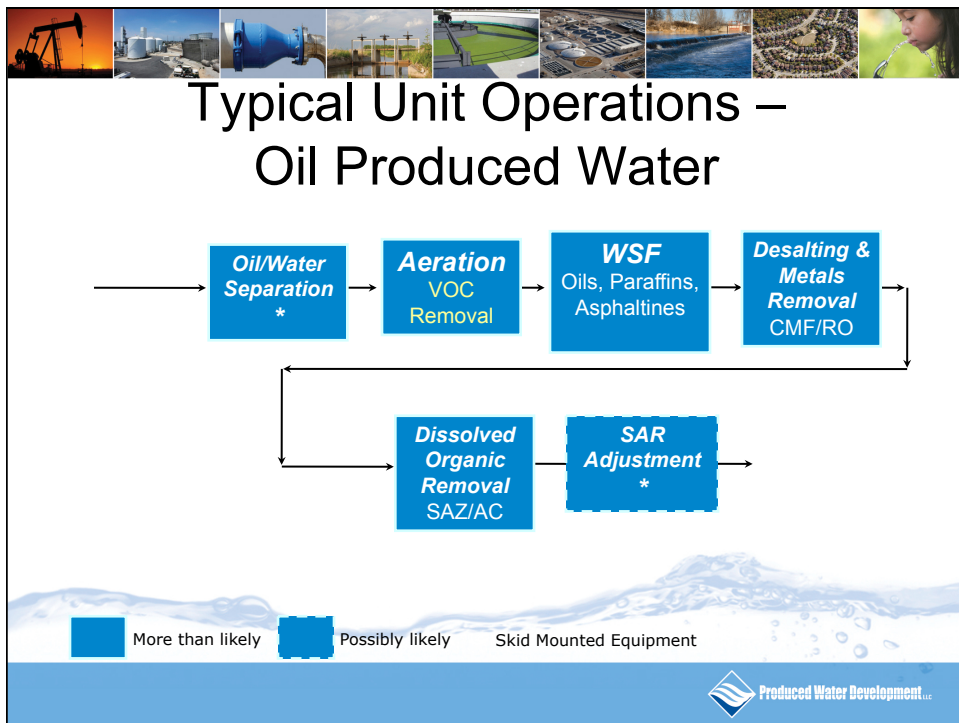
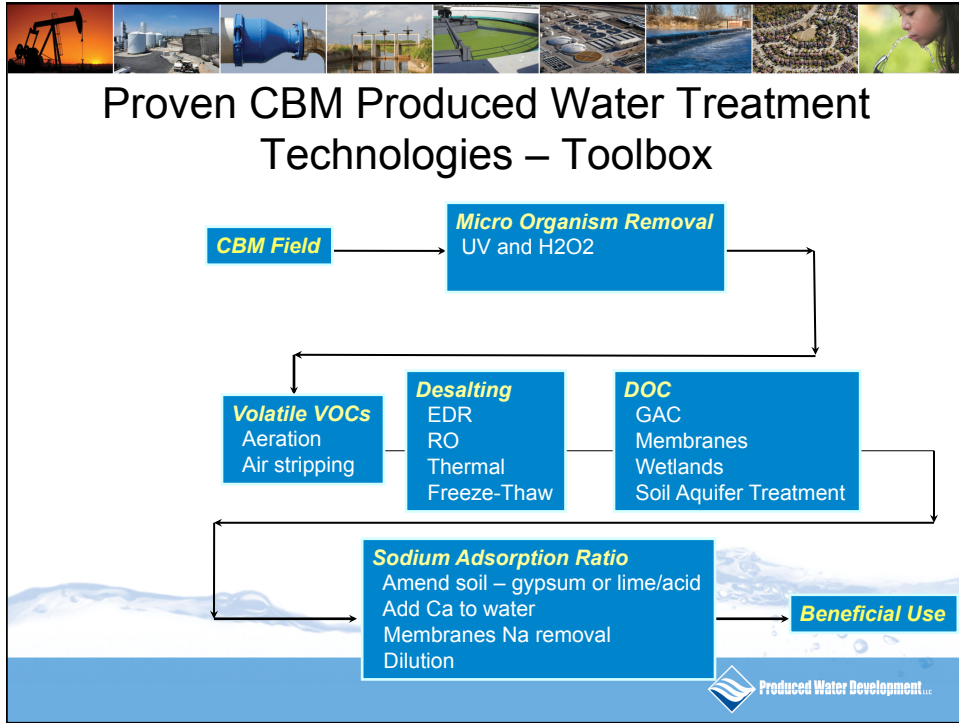
From Produced Water to Beneficial Use

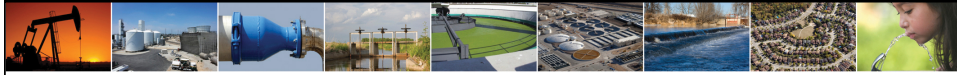


Quality Of Produced Water

- Produced Water TDS – range between 1,000 and 50,000 mg/l
- Discharge water - typically need to reduce to a level near 500 ppm (Colo. River basin) and near 1,500 to 2,500 ppm for the eastern slope of Colorado/New Mexico
- SAR's (Sodium Adsorption Ratio) can range from 0.5 to 30
- Discharge Water - Need to reduce SAR to less than 5
- Heavy metals can be a factor – some fields will require heavy metal removal
- Removal of organics, such as benzene, toluene, xylene – benzene is typically the limiting factor







Costs Associated with CBM Treatment

- Plant typically consists of pretreatment and membrane processes

Oil Produced Water

- 700 – 2,800 AF per year
- \$6M to \$15M in capital costs
- \$2,000 per AF for O&M

CBM Produced Water

- 10,000 AF per year
- \$5M in capital costs
- \$500 per AF

- \$1.80 per 1,000 gallons O&M
- Disposal fee of \$0.10/bbl to \$3.00/bbl – utilizing market rates

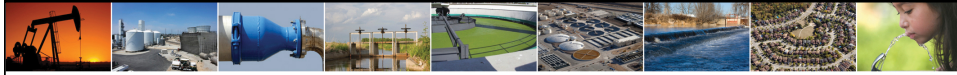
- Comparison Beneficial use of produced water – municipal use

- \$10,000 to \$35,000 per AF – perpetual basis
- \$500 to \$3,500 per AF – annual lease



Slater Dome Project



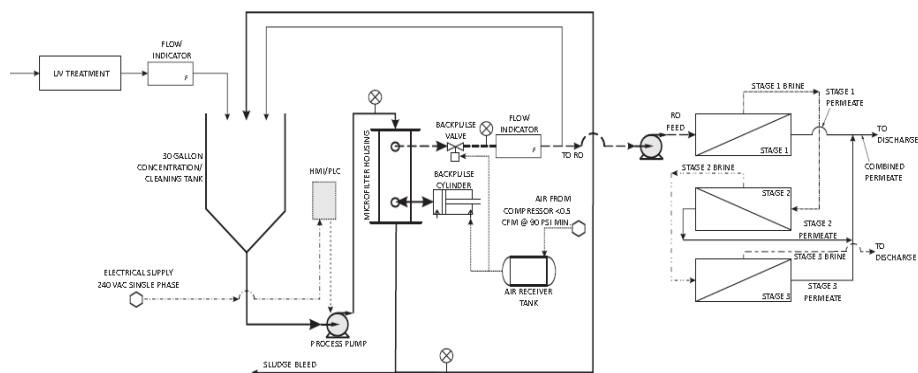


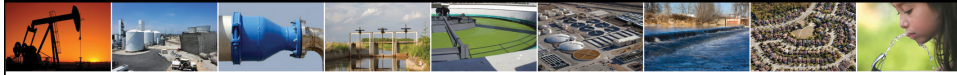
Savory WY project

- CBM demonstration project
- Cost of the facility - \$2.7M
- Output of the facility 1,000 AF that can increase to 10,000 AF per year
- Total cost of the facility \$6M
- Discharge to the upper basin of Colorado

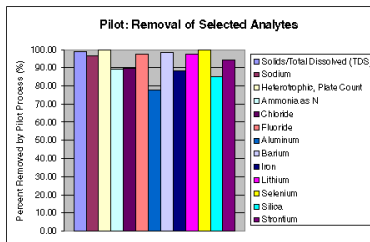


Slater Dome Project





Removal of Selected Parameters



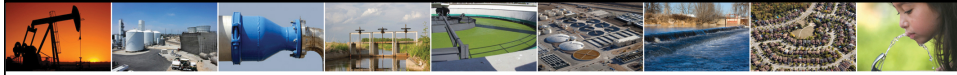
- Removal of constituents of interest was excellent
- Boron specific membranes for removal



Permitting in Colorado

- HB 1303
- SB 165
- Coordination with SEO – CDPHE - COGCC
- Statewide permit system – discharge to Little Snake River on Colorado Side of the border
- Colorado River permit issues
 - TDS
 - Sodium
 - WET testing





Summary of Project

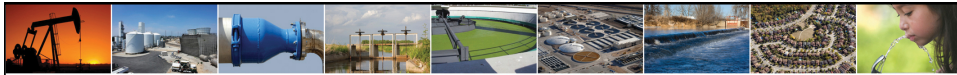
- Pilot testing is complete
- Additional negotiations for the project are pending
- Initial size of the facility is 5,000 bbl/day
- Eventual size of the facility is 50,000 bbl/day
- CMF was critical to the overall operation
- Anticipate utilization of the brine to manufacture acid and bases for additional income on the project
- Patent pending process
- Anticipate facility completion in early 2011



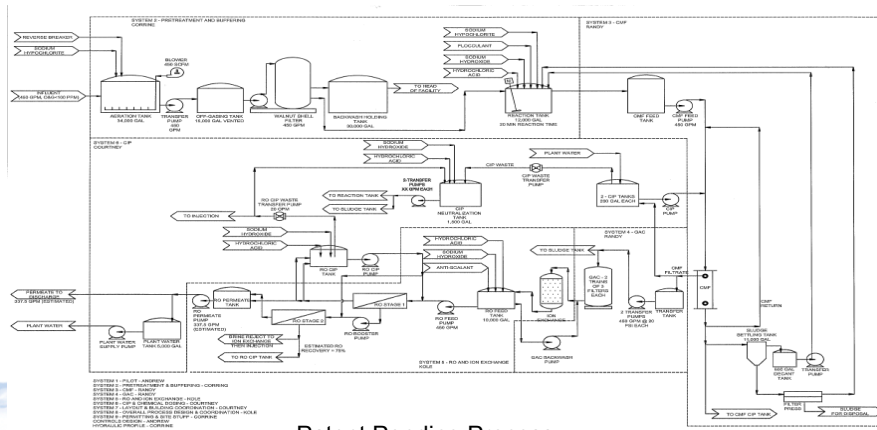
Eastern Utah Project

- Oil produced water facility
- 15,000 bbls/day facility expanding to 60,000 bbls/day
- \$6M capital cost – eventual facility will increase to 60,000 bbls/day at \$15M
- Additional captive facility in Colorado
 - 60,000 bbl/day initially
 - 120,000 bbl/day eventual size





Eastern Utah Site – Process Flow Diagram



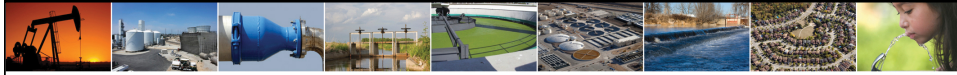
Patent Pending Process



Eastern Utah Project

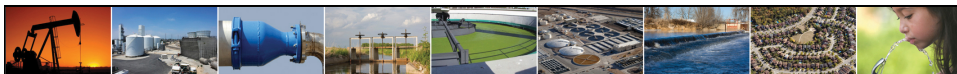
- Additional considerations
 - Produced water is from Utah
 - Interstate commerce
 - Utilization of brine (New Sky Energy) – new chemistry through electro chemistry and membranes developed at Colorado School of Mines
 - Main products are sulfuric or hydrochloric acid and sodium hydroxide or sodium carbonate





Unexpected issues

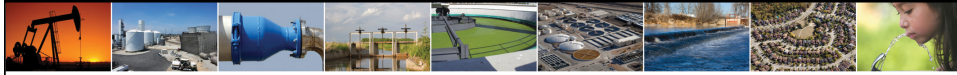
- Custom blending of water for frac water make up water
- Green issues for the energy industry
- Support from environmental groups such as the Nature Conservancy, Colorado Environmental Coalition and others



Conclusions

- Produced Water is a viable water resource
- Colorado River basin transfers potential
 - Need for cooperation
- Produced Water treatment is cost effective
- Produced Water should be pursued as a new water resource for the western United States





Questions?

