Exploring The Use Of Water Treatment Systems For Immediate Water Reuse To Reduce Transportation, Storage and Disposal Costs – A U.S. Perspective and Market Update

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Complexity Drivers
Drought impact is unpredictable, and has increased

Source: The Future of Water in Unconventional Oil and Gas - Water Management Opportunities/Strategies
A highly heterogeneous landscape in many basins
Typical TDS Variance / well over Time

TDS Levels (Mg/L) Climb dramatically over the first year of production

Ref: SPE 125740, Blauch, et.al. 2009
Now Consider Water Mgmt Throughout the Field Life

Hold-by-production drilling and experimentation. Operators want to hold as many leases as possible by production. They also start to assess the productivity of the acreage position.

Modest water for frac’ing, Modest re-use and injection

Source: The Future of Water in Unconventional Oil and Gas - Water Management Opportunities/ Strategies
Exploitation and Optimization

**Exploitation and optimization.** Most acreage is held by production, boundaries of productive acreage are established, and operators start to drill more multi-well pads in order to enjoy economies of scale.

Tremendous fracwater requirements, Modest re-use and injection

Source: The Future of Water in Unconventional Oil and Gas - Water Management Opportunities/Strategies
Mature Field Operation

**Mature field operation.** With drilling and completion programs completed, and wells drilled on optimal spacing, focus shifts to well maintenance, artificial lift optimization, secondary recovery, and tertiary recovery.

Source: The Future of Water in Unconventional Oil and Gas - Water Management Opportunities/Strategies
Case Study – Low Salinity Basins (U.S. Central Rockies)
General Comparisons – Other Basins

Typical TDS Ranges in Produced Water

Typical Flowback % (2-3 weeks)
Regional TDS Comparisons, Produced Water

Source: Dwayne Dalrymple, 19 February 2013 as published in Oil and Gas Facilities Magazine, April 2013
Produced Water Salinity Ranges

Source: Dwayne Dalrymple, 19 February 2013 as published in Oil and Gas Facilities Magazine, April 2013
Treatment Requirements
Why Treat?

**Bacteria**
- Reduces viscosity
- SRBs / H2S Production
- Biofilm / equipment Fouling
- Emulsions
- Equipment corrosion
- Plug formations

**TSS**
- Equipment clogging
- Reservoir clogging
- Appearance

**Chlorides**
- Hydration

**pH**
- Inadvertent crosslinking
- Hydration

**Bicarbonates**
- Buffering
- Crosslinking impact
- Scaling

**Calcium and Magnesium**
- Scaling
- Friction Reducer effectiveness
- Borate cross links
- Contribute to Norm Concentration
- Increases HP needs

**Iron, Manganese, Heavy metals**
- Reactive with O2, solids may plug formation
- Crosslinking
- Equipment reliability

**Phosphates**
- Crosslinking

**Sulfates**
- Crosslinking
- Scale Precipitation
Representative Flowback
Uinta Piceance Basin Shale, Water Quality

Typical Flowback mg/L Uinta-Piceance Wells

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<thead>
<tr>
<th>Component</th>
<th>Low</th>
<th>Average</th>
<th>High</th>
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<tr>
<td>Total Dissolved Solids (TDS)</td>
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<tr>
<td>Total Suspended Solids (TSS)</td>
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<td>Strontium</td>
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<td>Chlorides</td>
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<tr>
<td>Alkalinity as CaCO3</td>
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Typical Treatment
Aggregation of Anecdotal Treatment Requirements
Treatment Technologies
Current Practices

PreTreatment – Could be all steps, or just some, order will vary

Flow Back Water

(Oil) Oil Removal
(initial settling, filtration, DAF, later oxidation, EC)

(Sludge, Suspended Solids)

(pH adjustment; antimicrobials)

Settling, Clarification or Filtration

Softening

pH adjustment, anti-scalants

Chemical & precipitation

(Dilution with fresh water)

Partially Pre-Treat, Dilute and Re-use
(antimicrobials)

Fully Pre-Treat followed by Desalinization
(antimicrobials)

Desalination

Desalination

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No single technology can treat it all:

KEY
- Good
- Some benefit
- Little to no benefit
- Must be removed by Pretreatment First
Uinta Piceance Basin Shale, Water Quality

Typical Flowback mg/L Uinta-Piceance Wells

- Total Dissolved Solids (TDS)
- Total Suspended Solids (TSS)
- Strontium
- Barium
- Iron
- Potassium
- Sodium
- Magnesium
- Calcium
- Chlorides
- Alkalinity as CaCO₃

Generally Acceptable Ranges

Low | Average | High
We then mapped typical treatment requirements to generally used, commercially available treatment approaches. Figures refer to how many constituents are treated reasonably well with a given technology. *No weighting factors were applied.*

*Note: Bacteria are particularly pernicious, and bacteria treatment is dominantly required, although in this chart the primary bacteria treatments show low in the rankings.*
Treatment Prices
A 2014 View of Pricing (now down 20-30%)

Broad Range of "Typical" Treatment Prices per Barrel

Costs shown are exclusive of costs for logistics, handling, pipes, tanks, blending etc., which will typically add $1.00 - $2.00 per barrel for treatment train.
Bang for the Buck (if all things were equal*)

* Which they most certainly are not
The State of “Things”
U.S. Completion Forecast November 2014 - “Before”

Source: CAP Resources Annual U.S. Onshore Water Management Spending Outlook (excludes California, Alaska)
U.S. Completion Forecast September 2015 - “Today”

Source: CAP Resources Annual U.S. Onshore Water Management Spending Outlook (excludes California, Alaska)
U.S. Forecast Basis Producing Wells 2014 - “Before”

Source: CAP Resources Annual U.S. Onshore Water Management Spending Outlook (excludes California, Alaska)
U.S. Forecast Basis Producing Wells 2015 - “Today”

Source: CAP Resources Annual U.S. Onshore Water Management Spending Outlook (excludes California, Alaska)
U.S. Volumetric Outlook (Billions Barrels) 2014 – “Before”

Source: CAP Resources Annual U.S. Onshore Water Management Spending Outlook (excludes California, Alaska)
U.S Volumetric Outlook (Billions Barrels) 2014 – “Before”

Source: CAP Resources Annual U.S. Onshore Water Management Spending Outlook (excludes California, Alaska)

Our Challenge: Reduce the volume of disposal water removed from the hydrocycle
U.S Volumetric Outlook September 2015 - Today

Source: CAP Resources Annual U.S. Onshore Water Management Spending Outlook (excludes California, Alaska)
This was our Outlook in 2014 - If completion activity stays “steady state”, assuming modest increases in reuse and treatment.

Note that Water Hauling is roughly 70% (GASP!!!) of market spending.
U.S. Water Management Spend 2014 - “Before”

Source: CAP Resources Annual U.S. Onshore Water Management Spending Outlook (excludes California, Alaska)

Source: CAP Resources Annual U.S. Onshore Water Management Spending Outlook (excludes California, Alaska)
Treatment Spending Outlook based on Today’s Market

U.S. Water Treatment Spending (U.S. $B) 2015 thru 2024

- Central Facility Discharge Treatment
- Central Facility for Reuse
- Reuse Onsite Treatment
- “New” Fracwater Treatment
- EOR Treatment
- Injection Treatment

Impact of 10% mandated reduction of disposal & injection

*in reality the ~$8 B increase in water treatment spend would likely be spread across many modalities and for re-use, such as mobile treatment, central facility for reuse, etc.
In Closing....

"We always overestimate the change that will occur in the next two years and underestimate the change that will occur in the next ten. Don't let yourself be lulled into inaction."