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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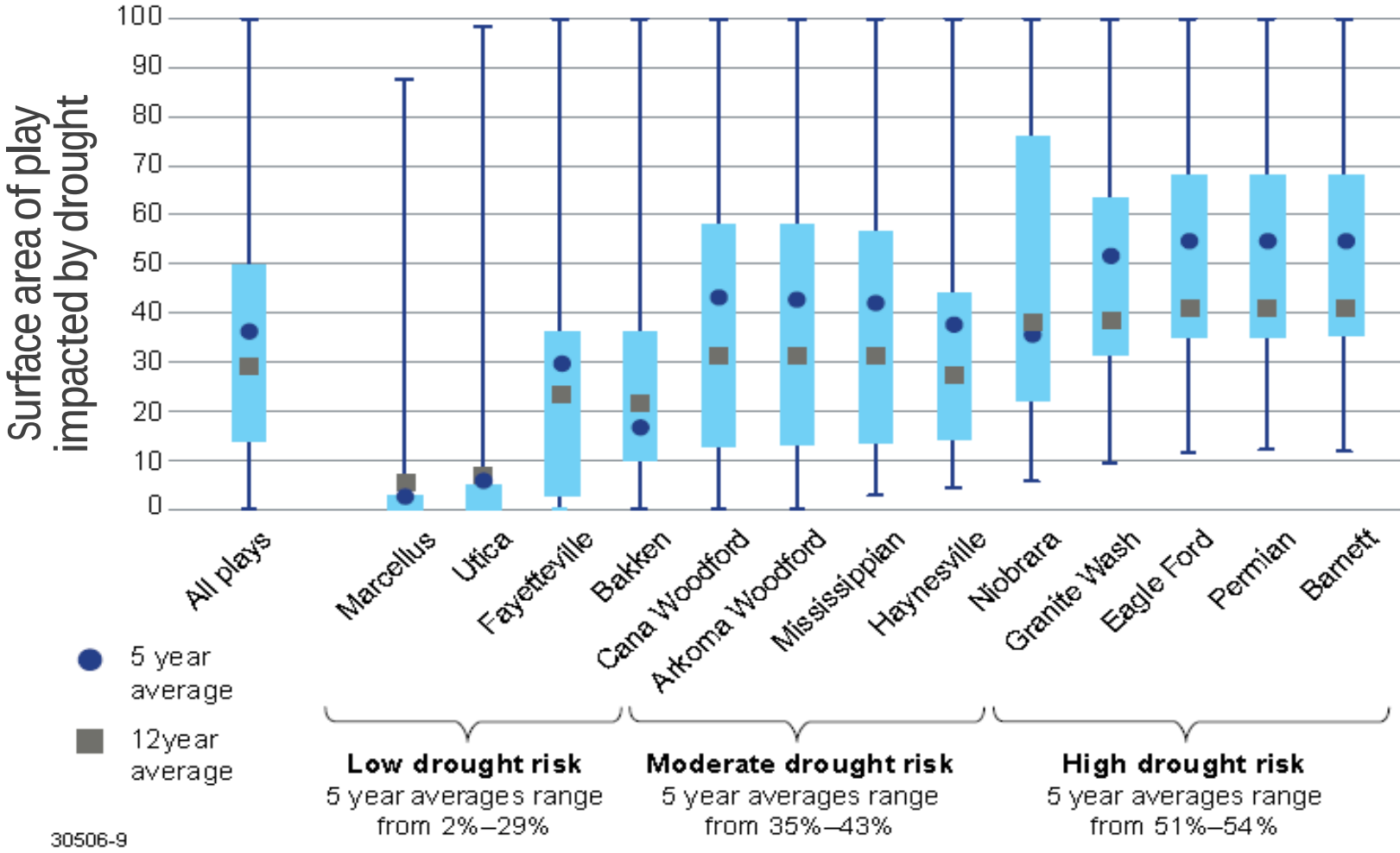
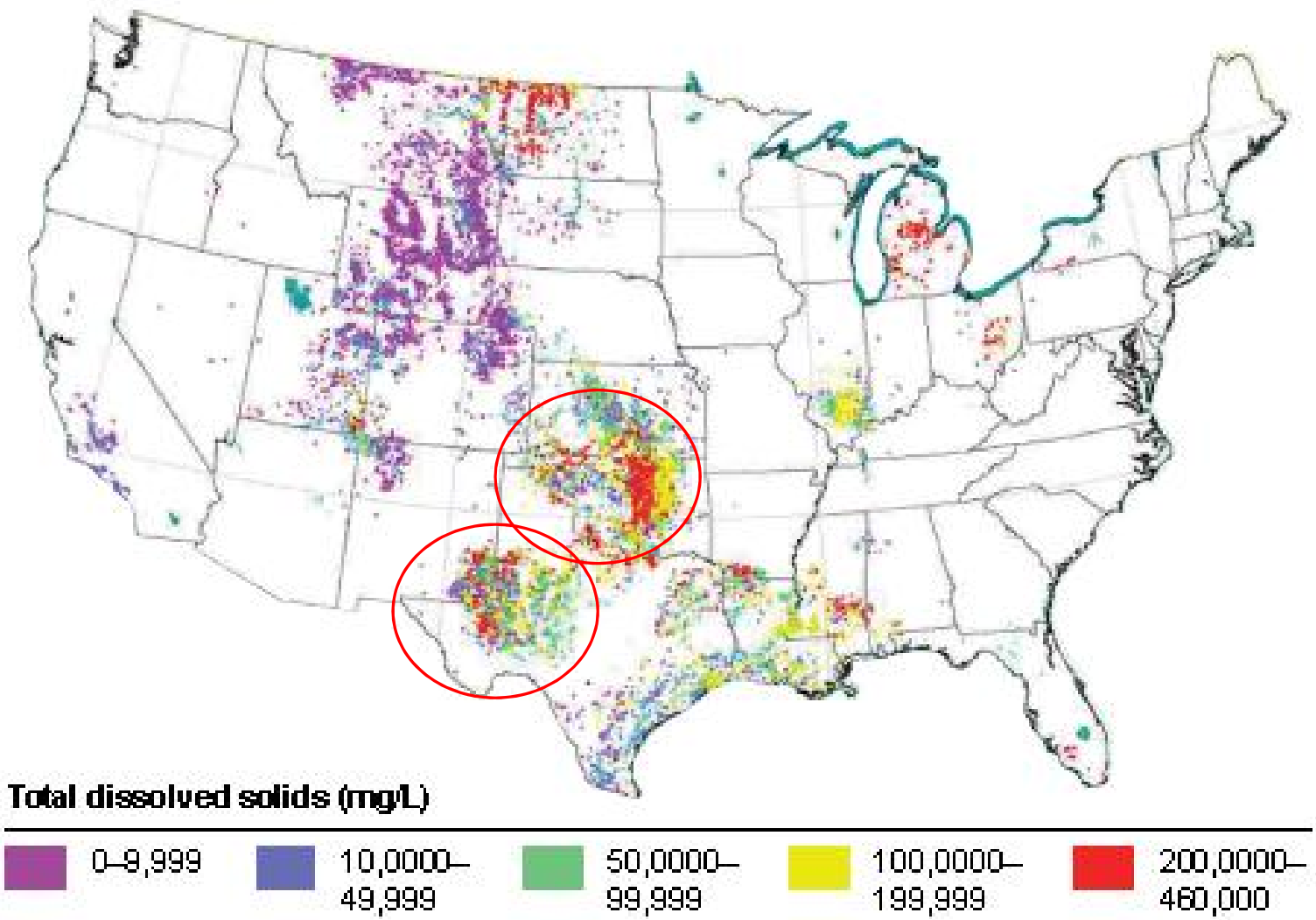
Complexity Drivers

Drought impact is unpredictable, and has increased



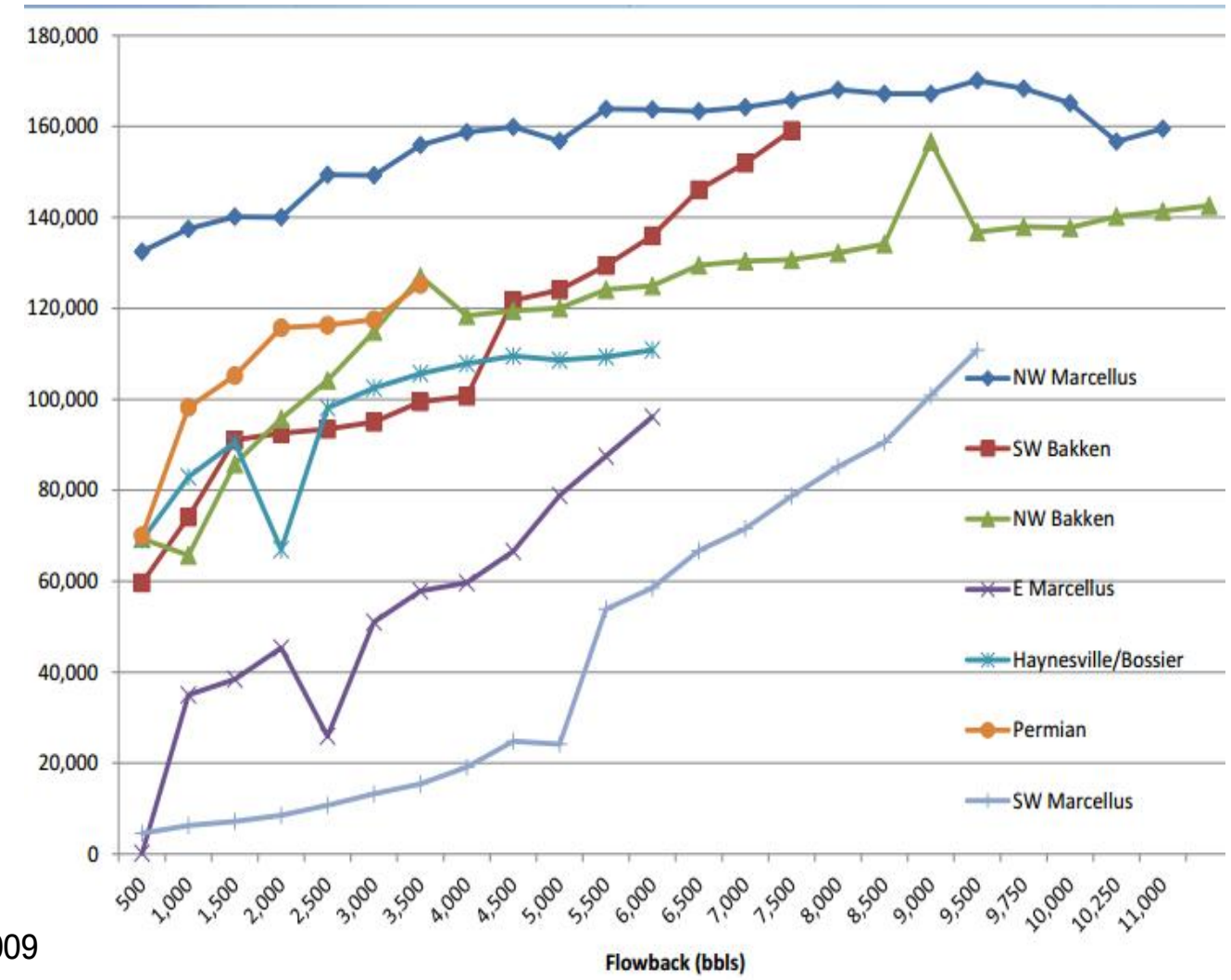
Source: The Future of Water in Unconventional Oil and Gas - Water Management Opportunities/ Strategies

A highly heterogeneous landscape in many basins



Typical TDS Variance / well over Time

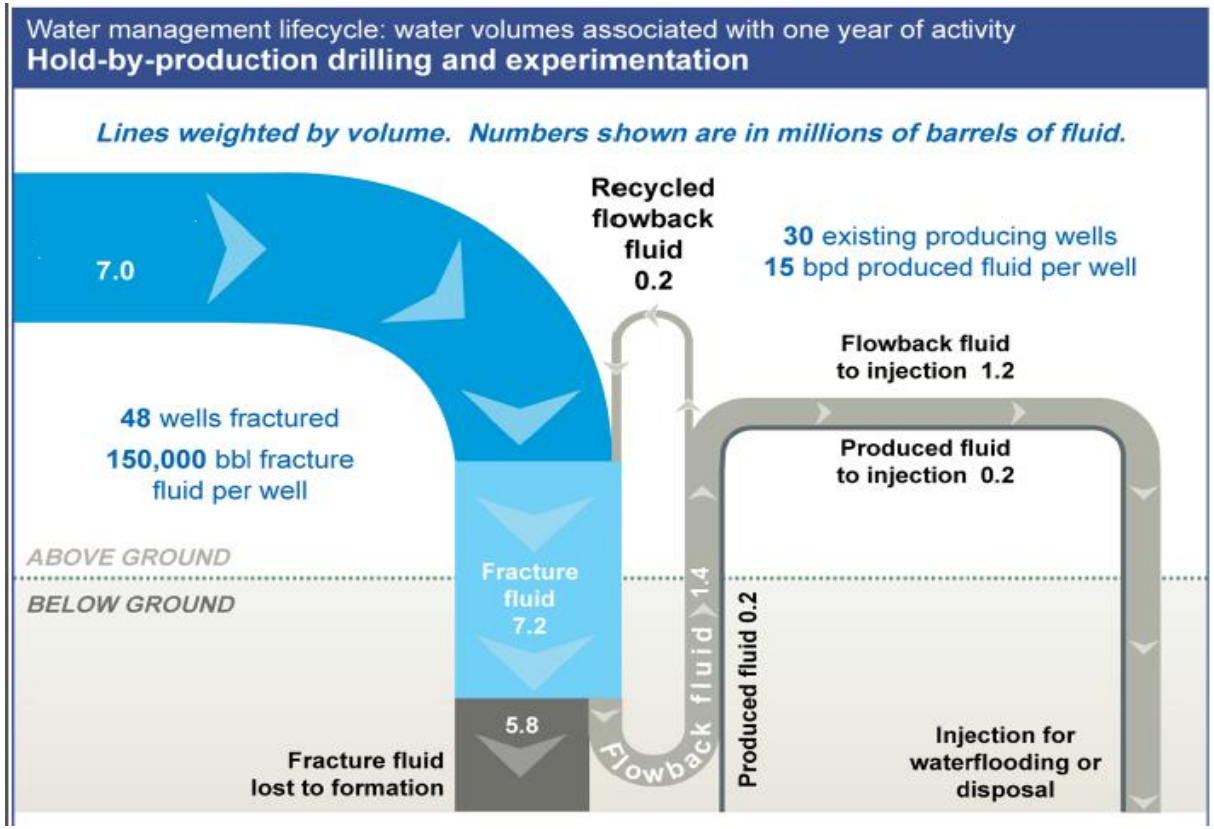
TDS Levels (Mg/L) Climb dramatically over the first year of production



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.

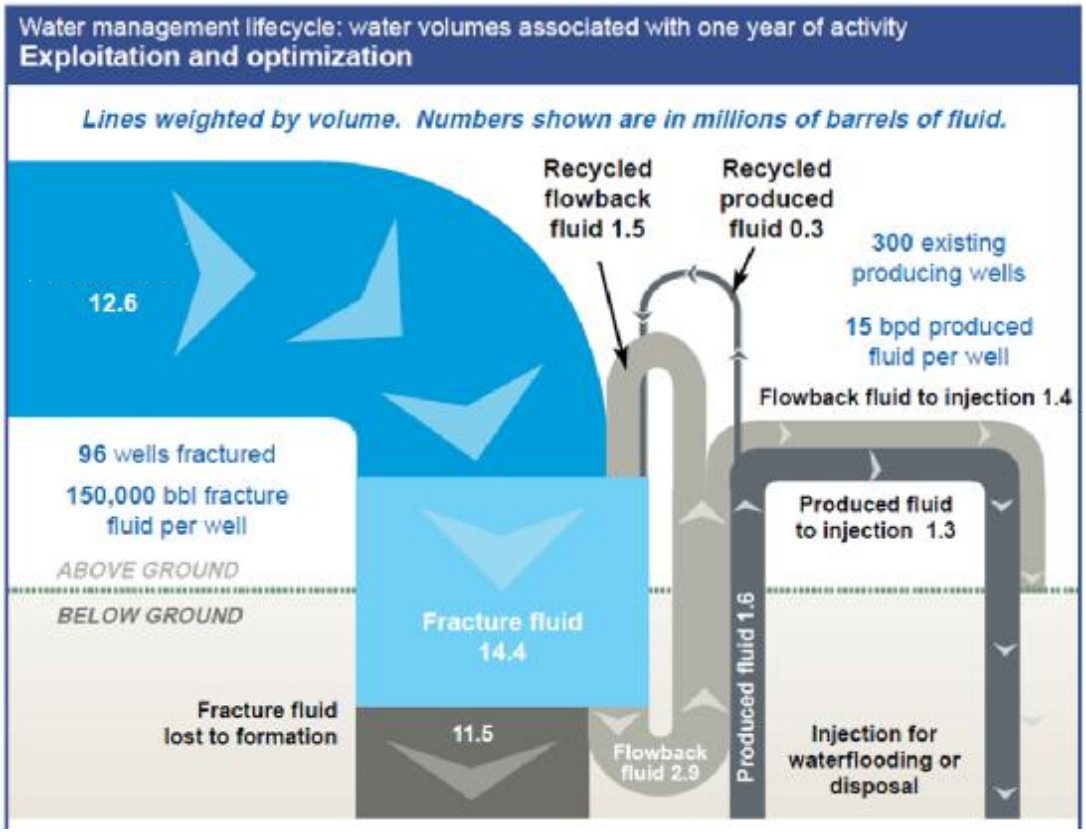


Modest water for frac'ing, Modest re-use and injection

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

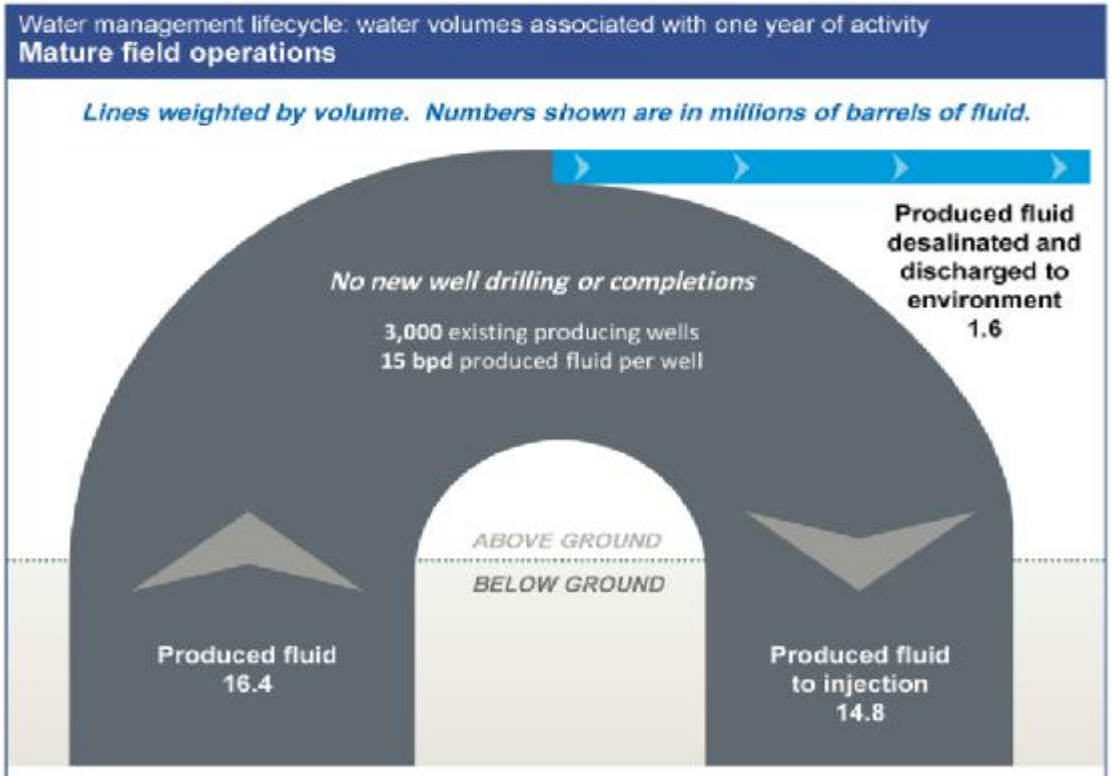


Tremendous fracwater requirements, Modest re-use and injection

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

Mature Field Operation

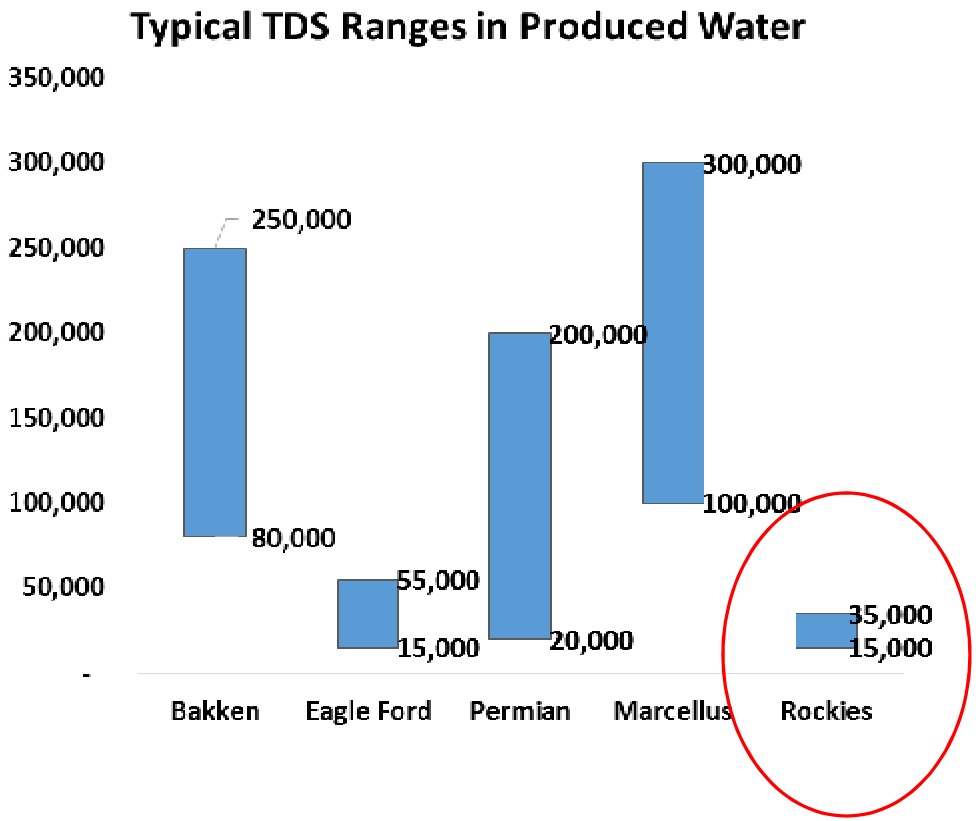
Mature field operation. With drilling and completion programs completed, and wells drilled on optimal spacing, focus shifts to well maintenance, artificial lift optimization, secondary recovery, and tertiary recovery.

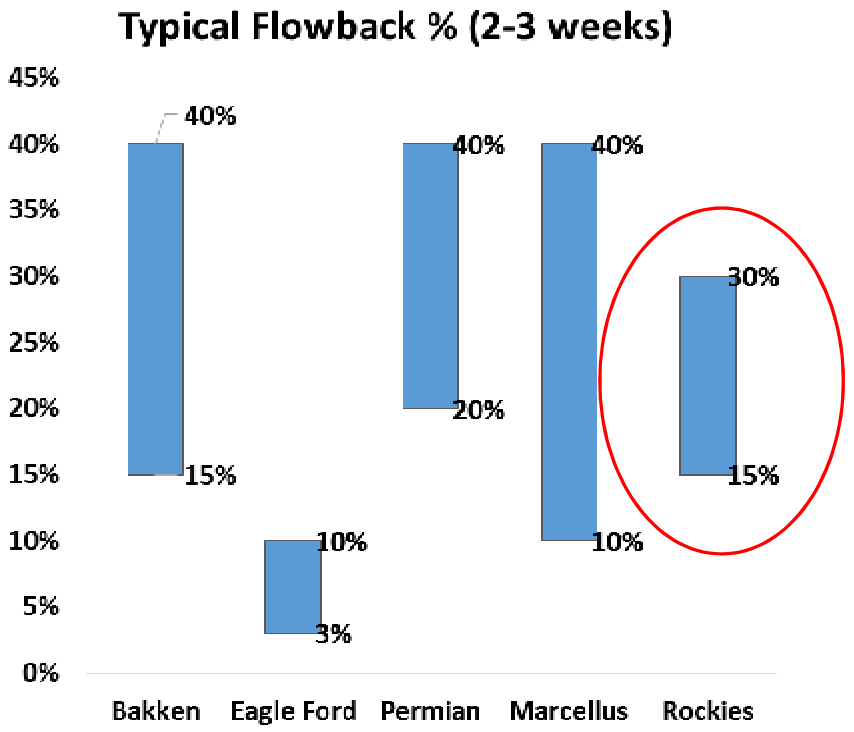


Source: The Future of Water in Unconventional Oil and Gas - Water Management Opportunities/ Strategies

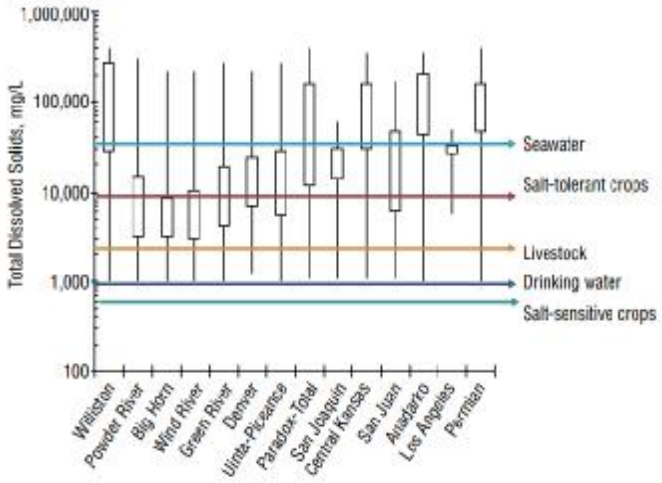
Case Study – Low Salinity Basins (U.S. Central Rockies)

General Comparisons – Other Basins

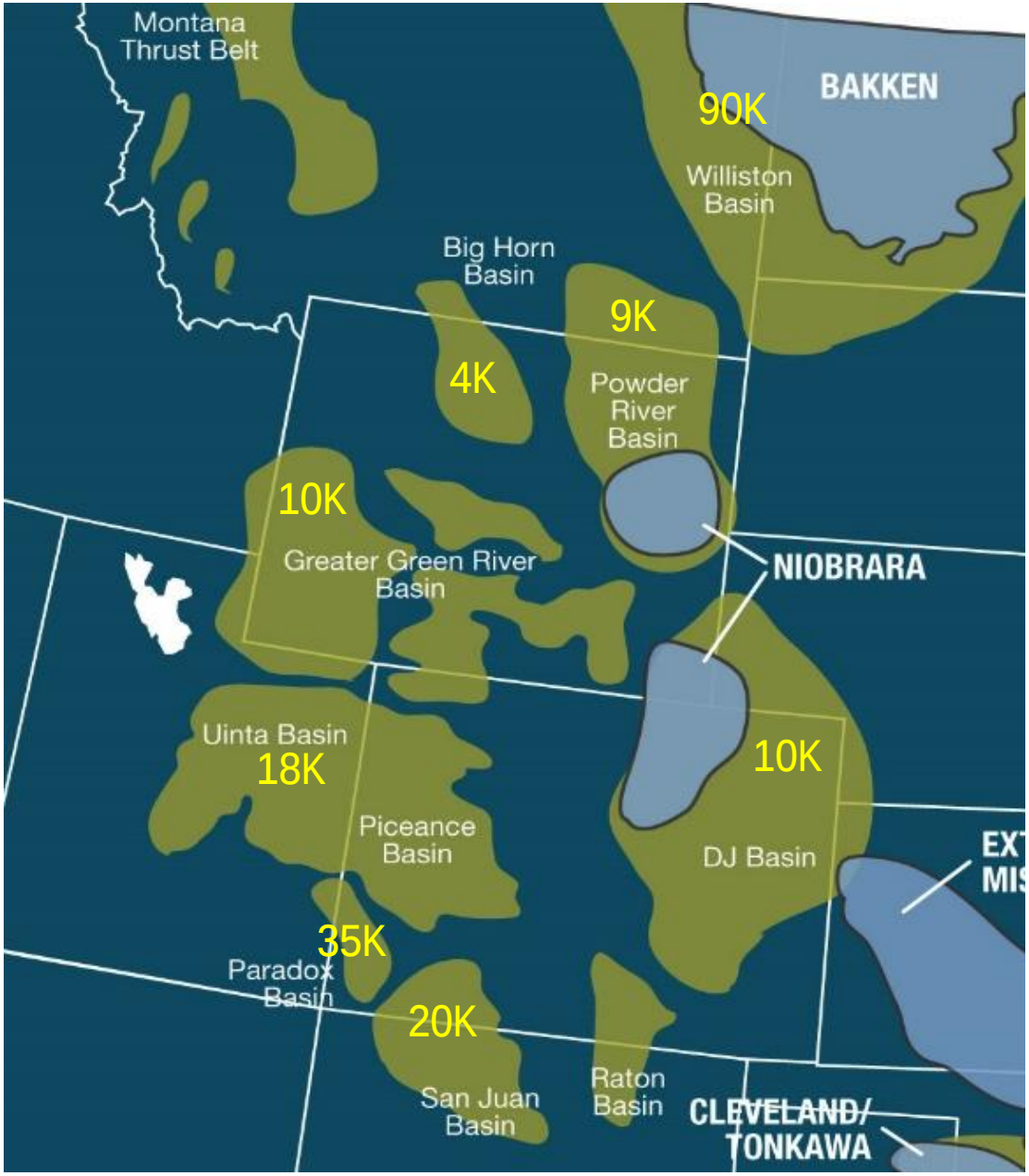




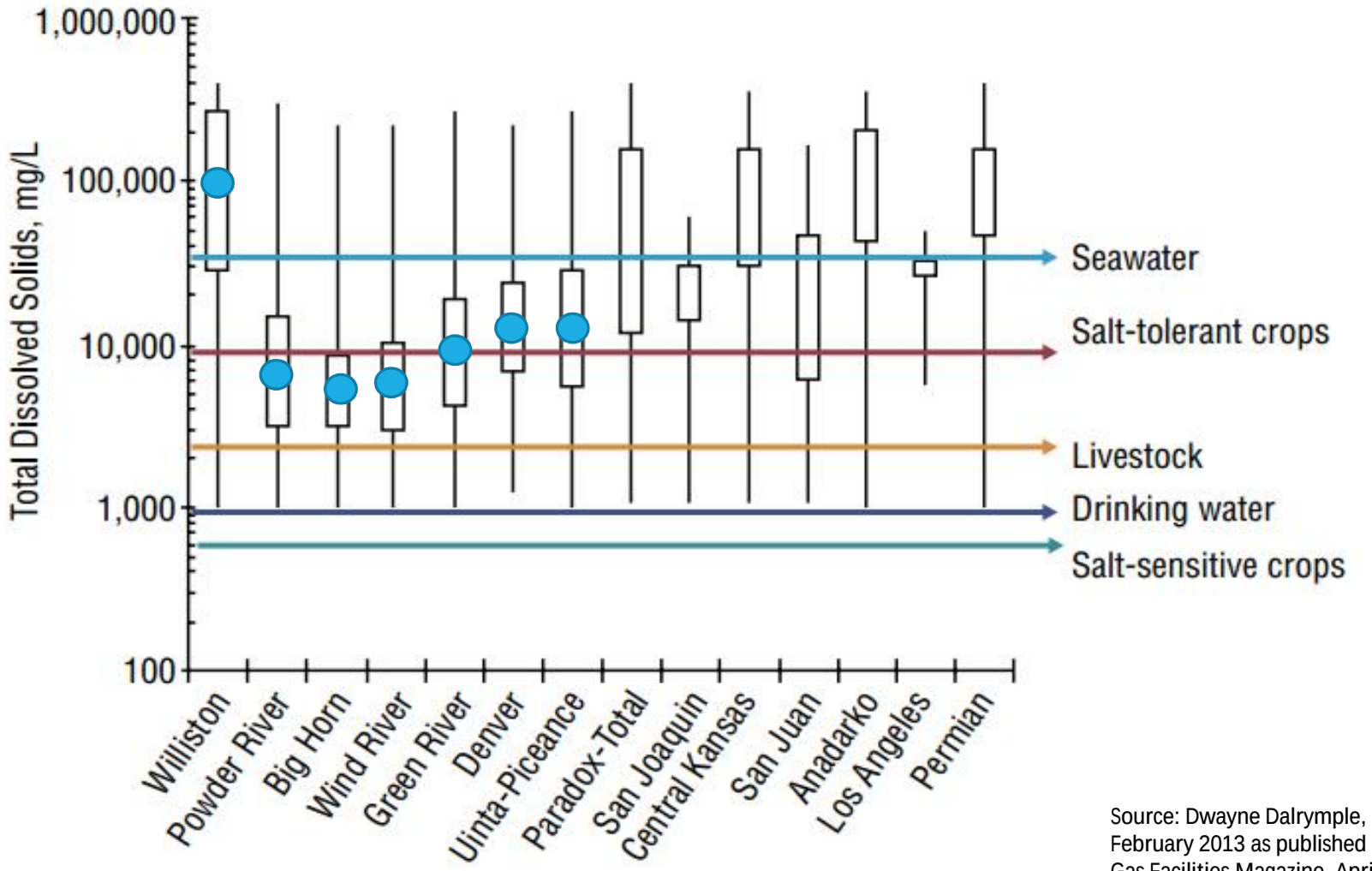
Regional TDS Comparisons, Produced Water



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

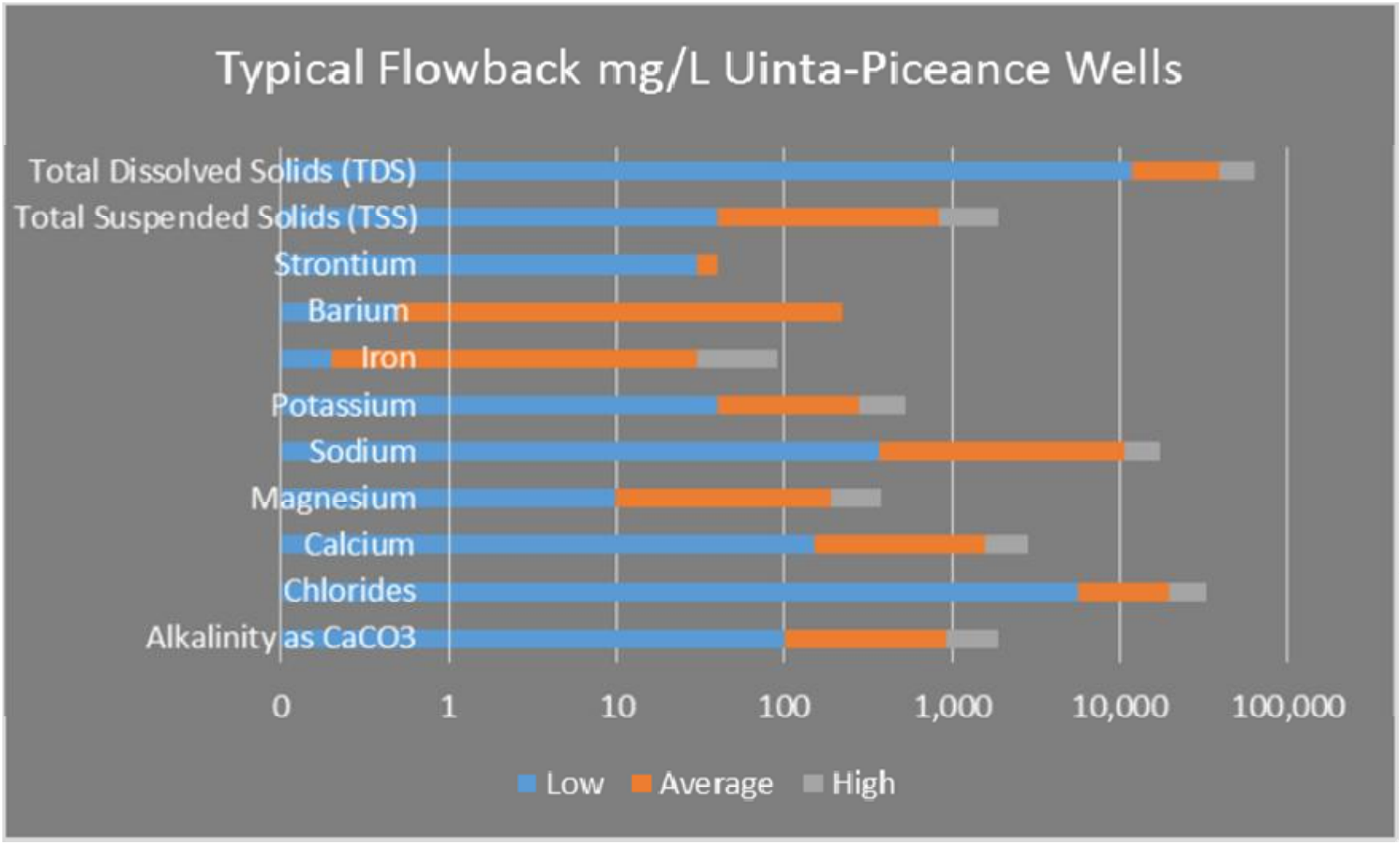
Iron, Manganese, Heavy metals
- Reactive with O2, solids may plug formation
- Crosslinking
- Equipment reliability

Phosphates
- Crosslinking

Sulfates
- Crosslinking
- Scale Precipitation

Representative Flowback

Uinta Piceance Basin Shale, Water Quality

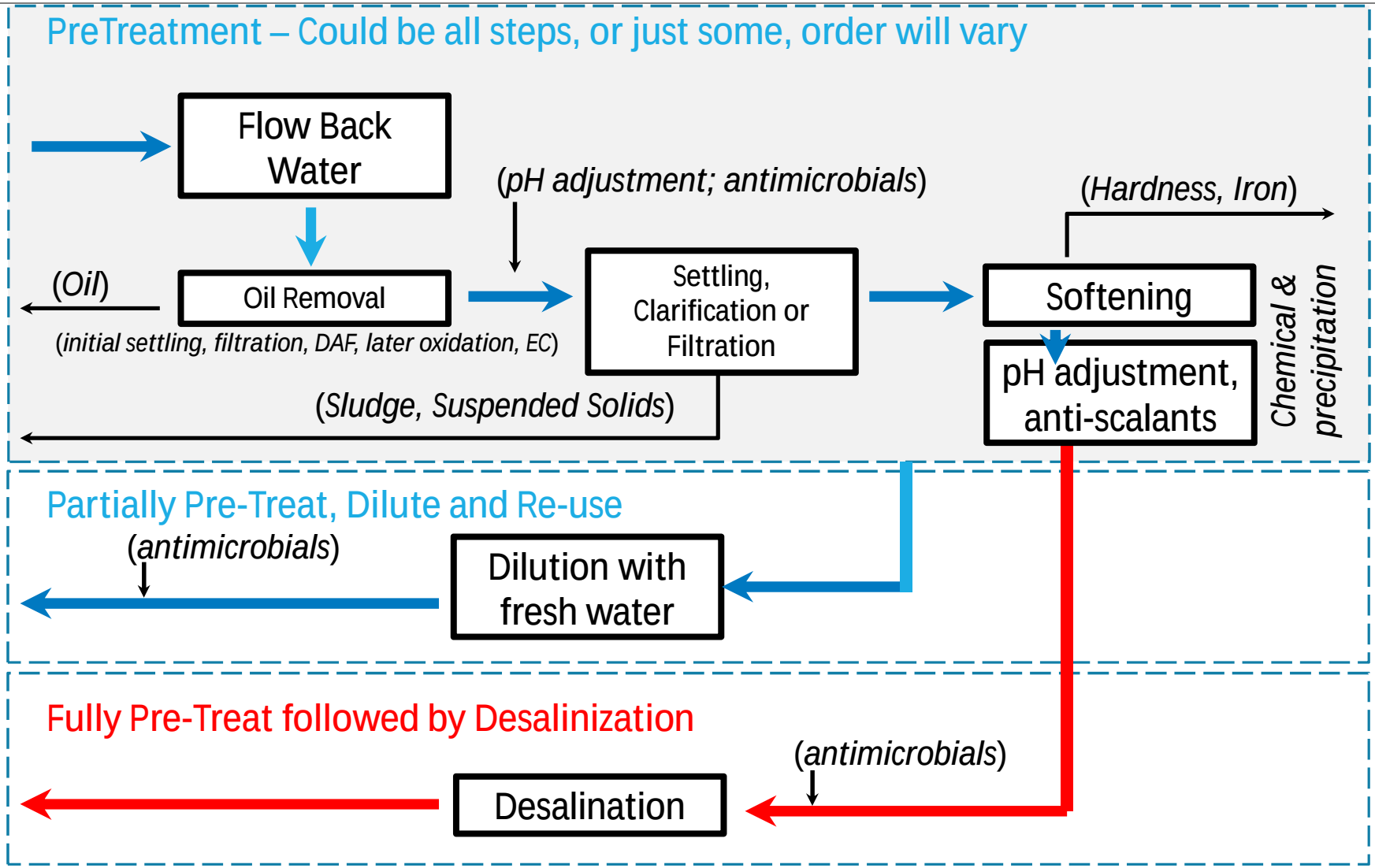


Typical Treatment

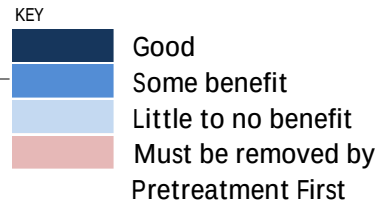
Aggregation of Anecdotal Treatment Requirements

Treatment Technologies

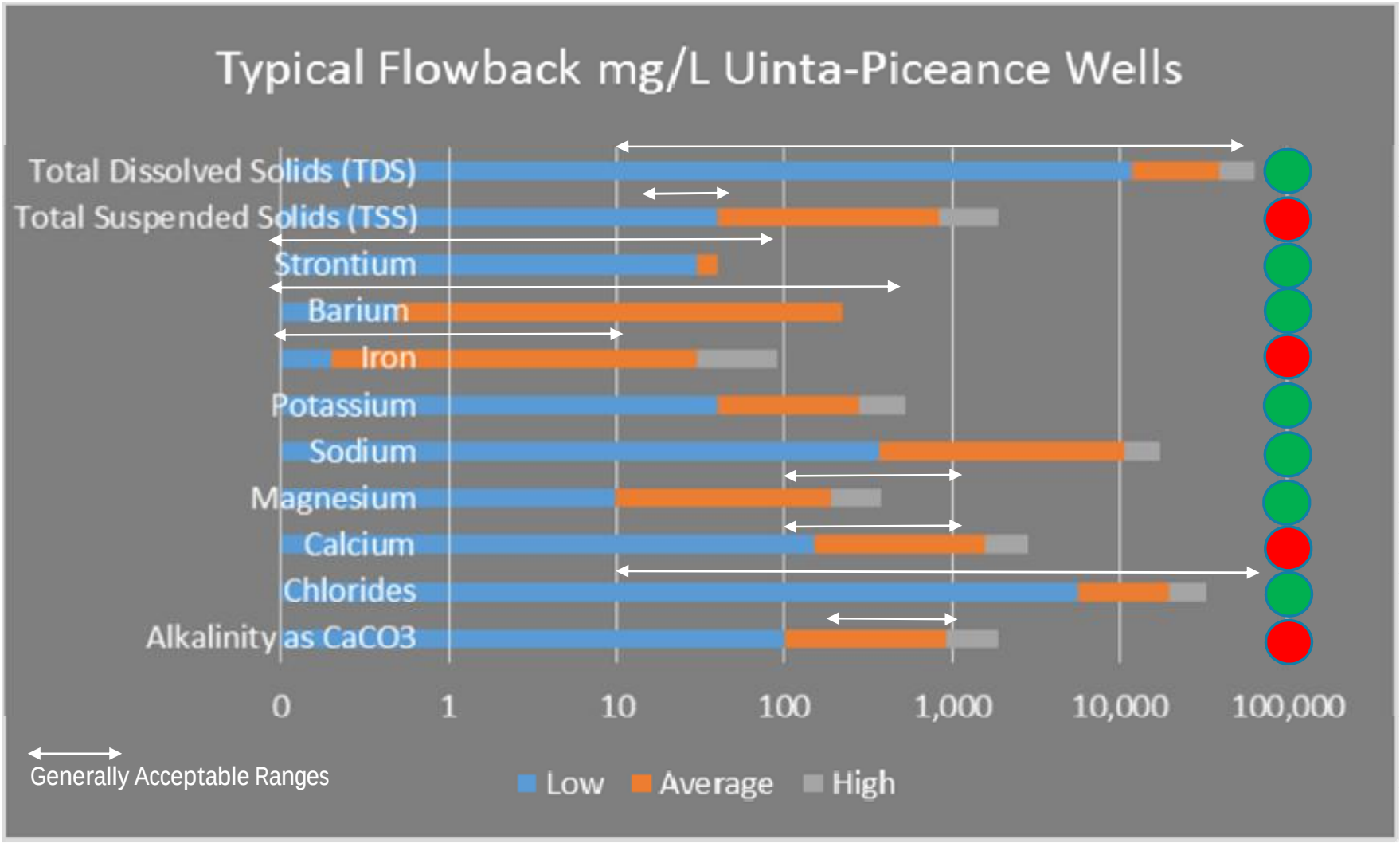
Current Practices



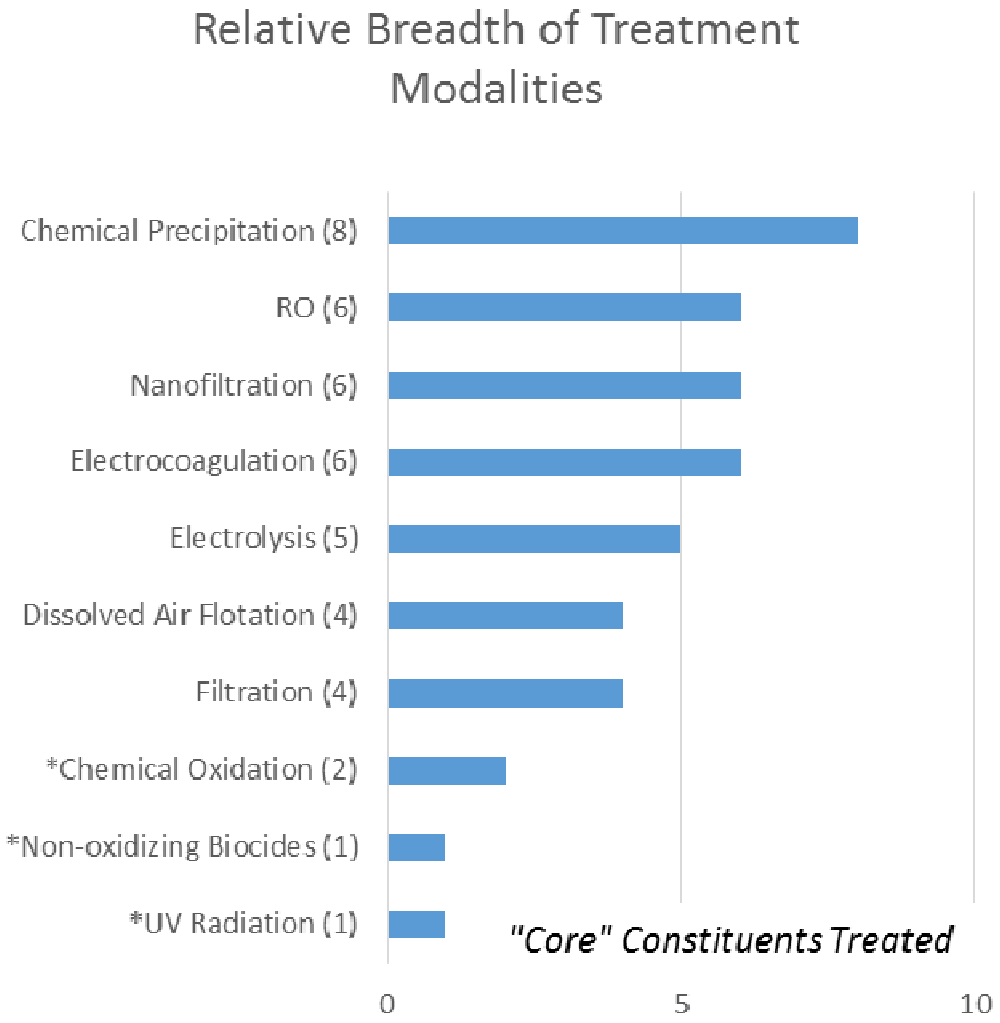
No single technology can treat it all:



Uinta Piceance Basin Shale, Water Quality



Base Treatment Technologies and How they Stack up

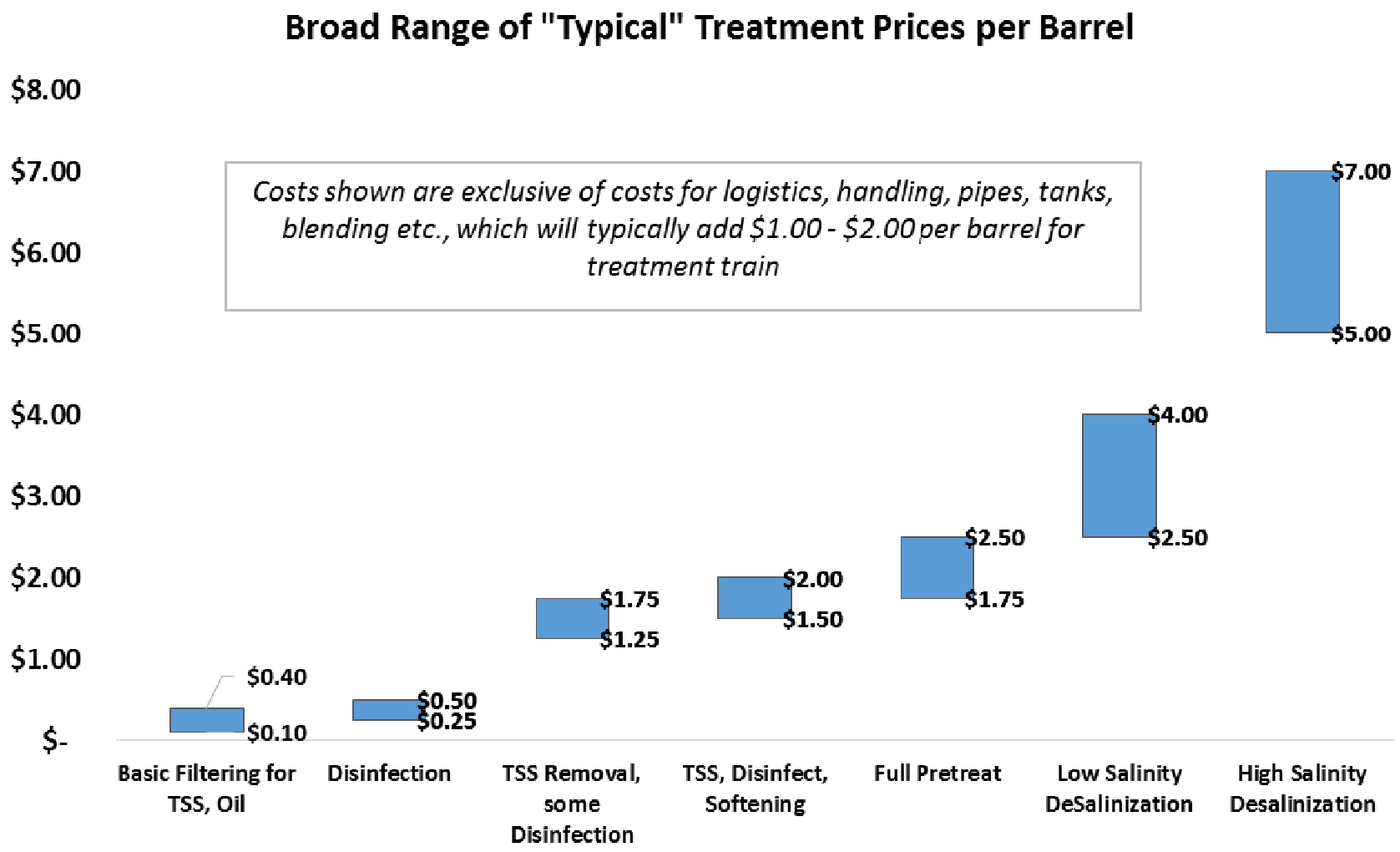


We then mapped typical treatment requirements to generally used, commercially available treatment approaches. Figures refer to how many constituents are treated reasonably well with a given technology. *No weighting factors were applied.*

*Note: Bacteria are particularly pernicious, and bacteria treatment is dominantly required, although in this chart the primary bacteria treatments show low in the rankings.

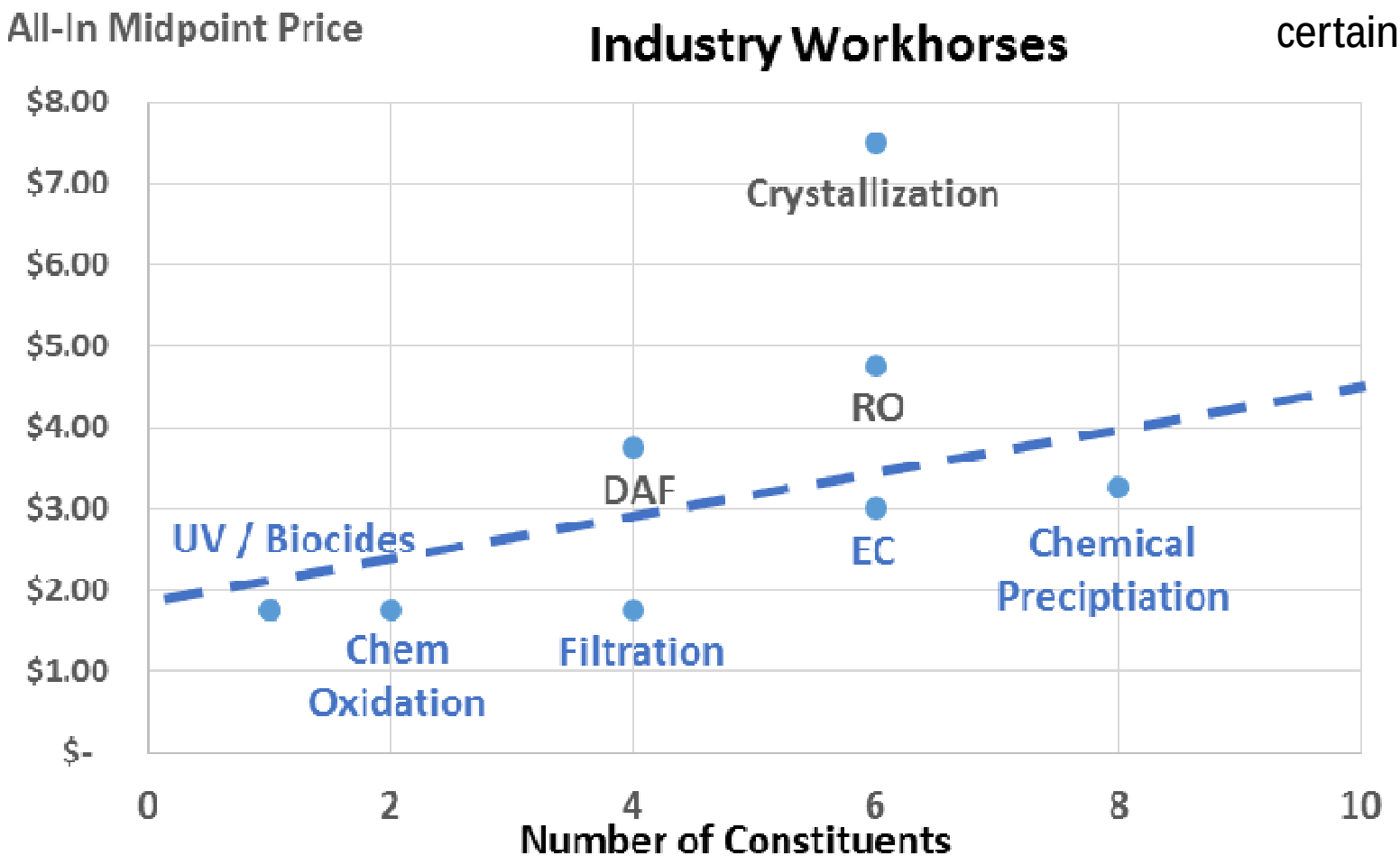
Treatment Prices

A 2014 View of Pricing (now down 20-30%)



Bang for the Buck (if all things were equal*)

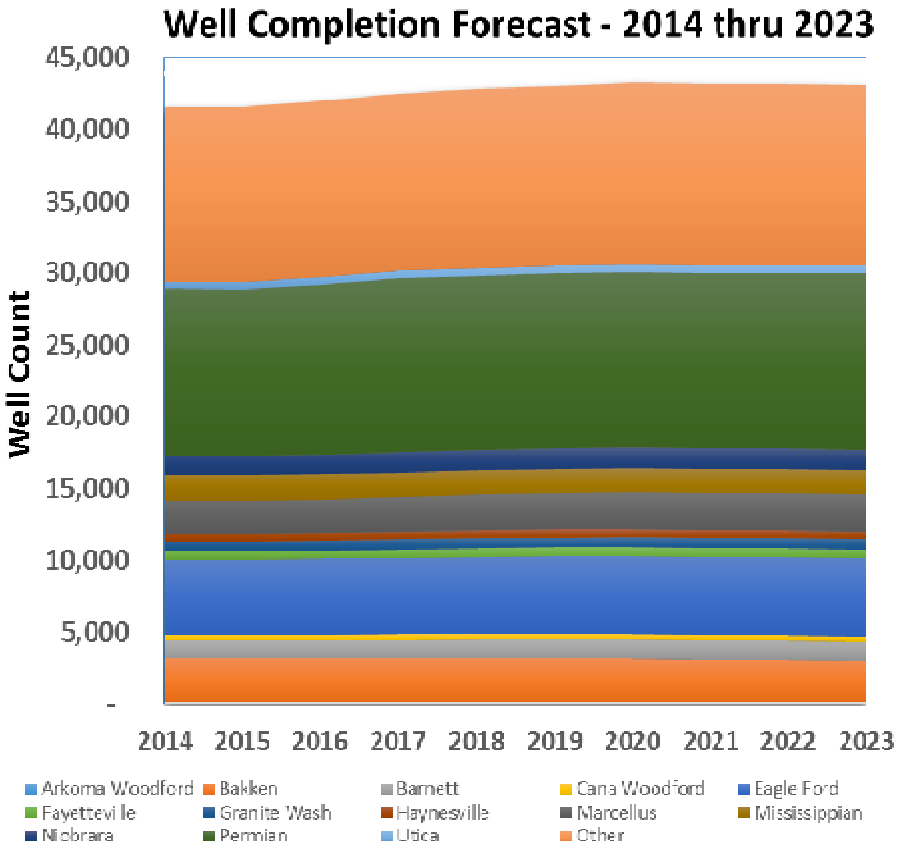
* Which they most certainly are not



The State of “Things”

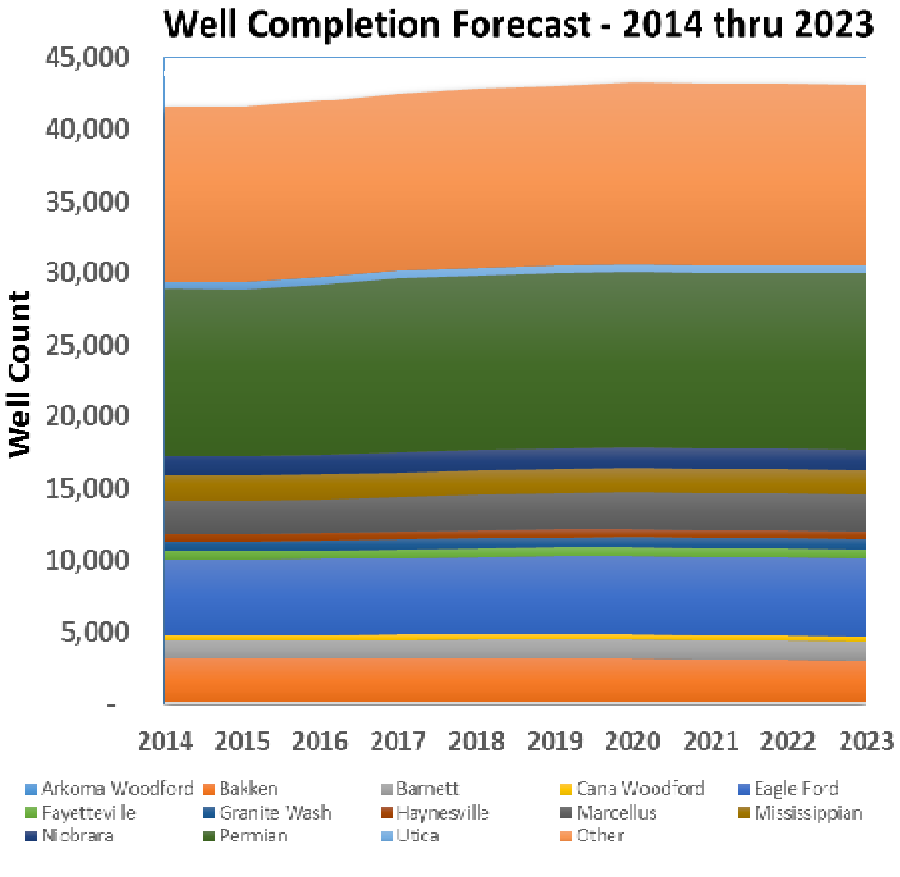
U.S. Completion Forecast November 2014 - "Before"

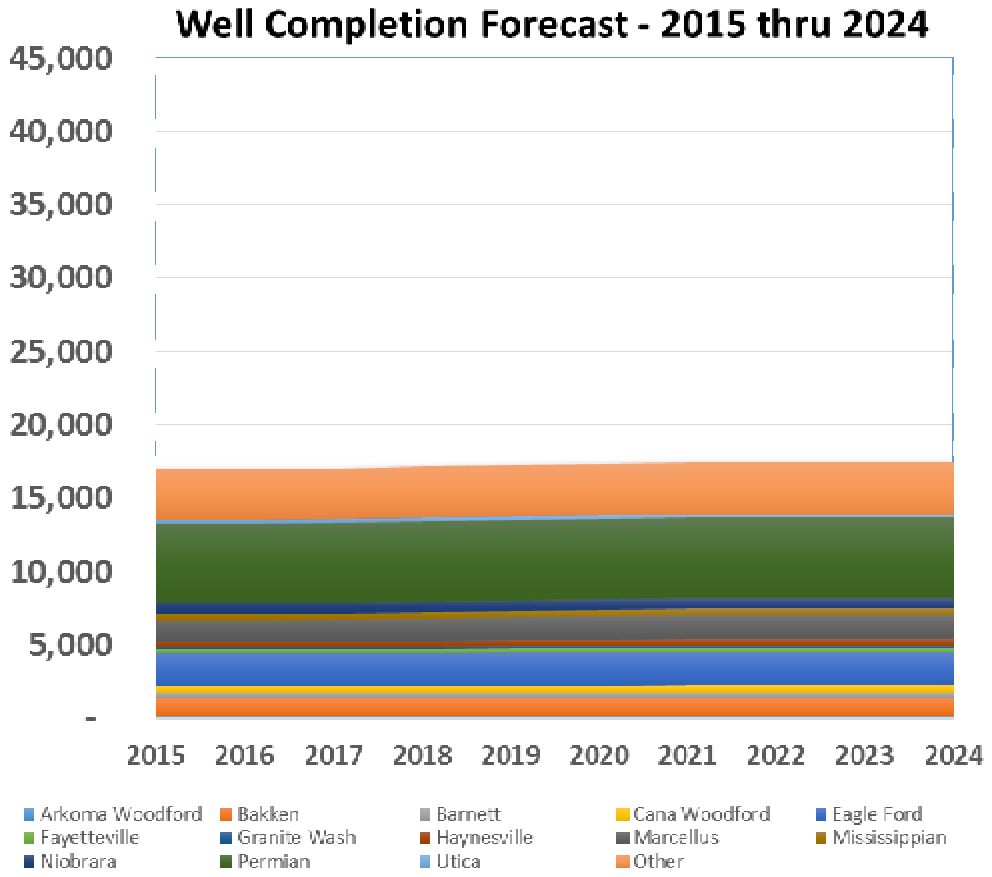
Source: CAP Resources Annual U.S. Onshore Water Management Spending Outlook (excludes California, Alaska)



U.S. Completion Forecast September 2015 - "Today"

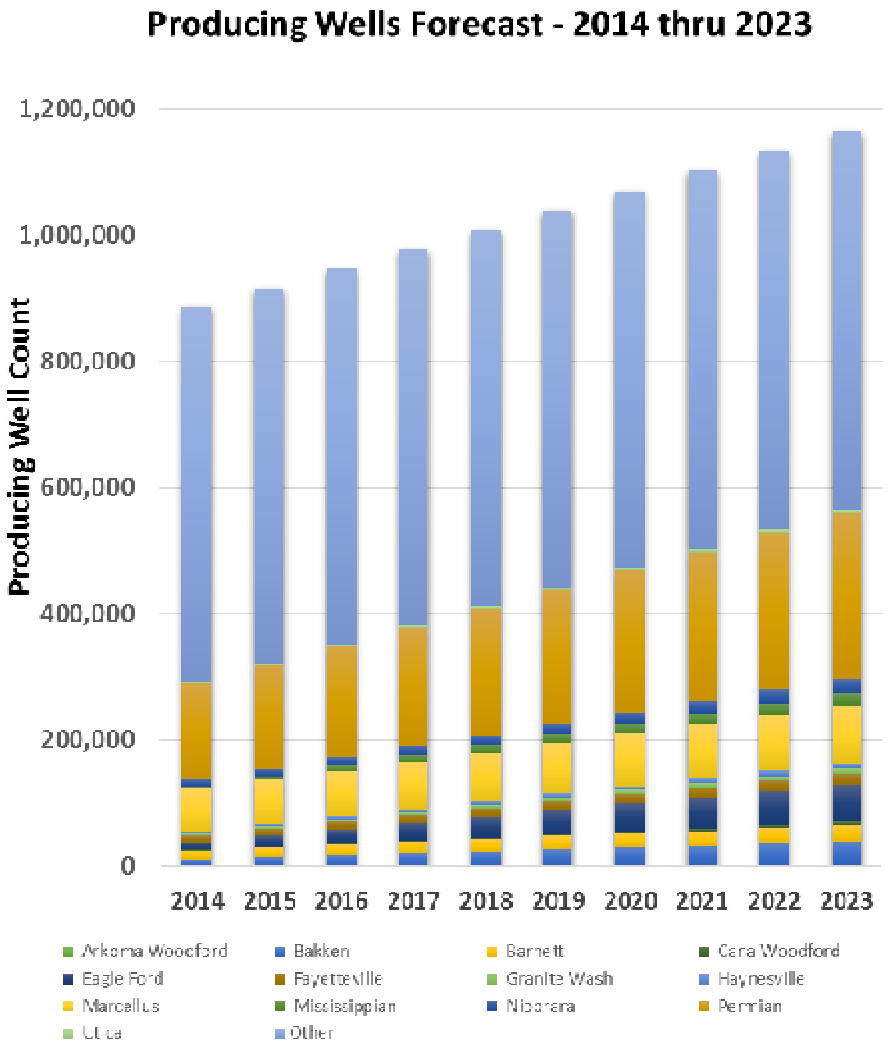
Source: CAP Resources Annual U.S. Onshore Water Management Spending Outlook (excludes California, Alaska)





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"

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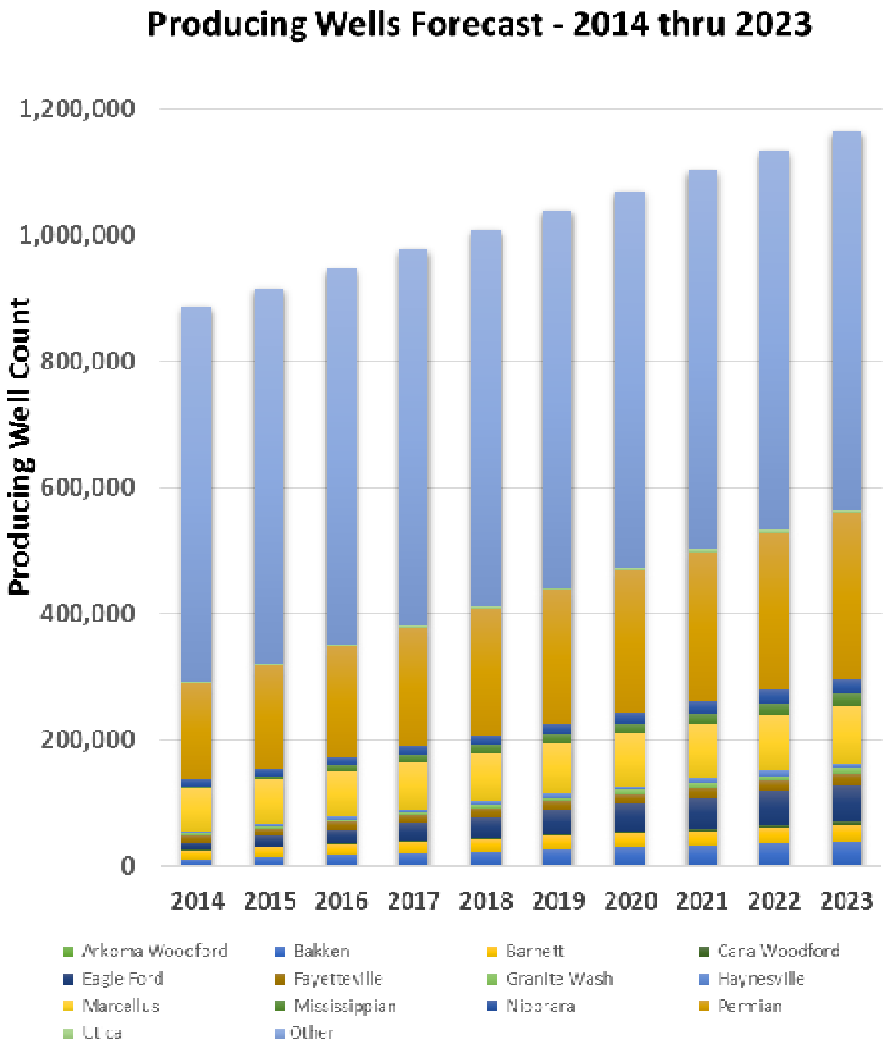
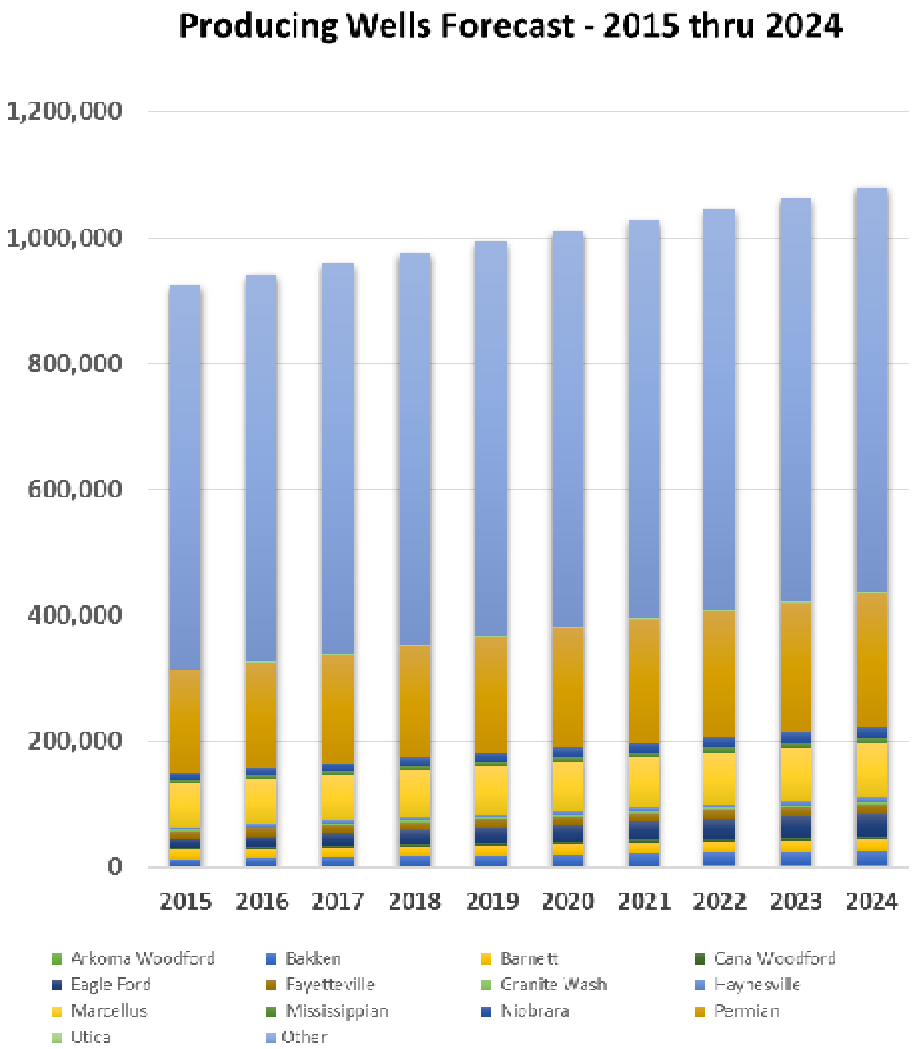
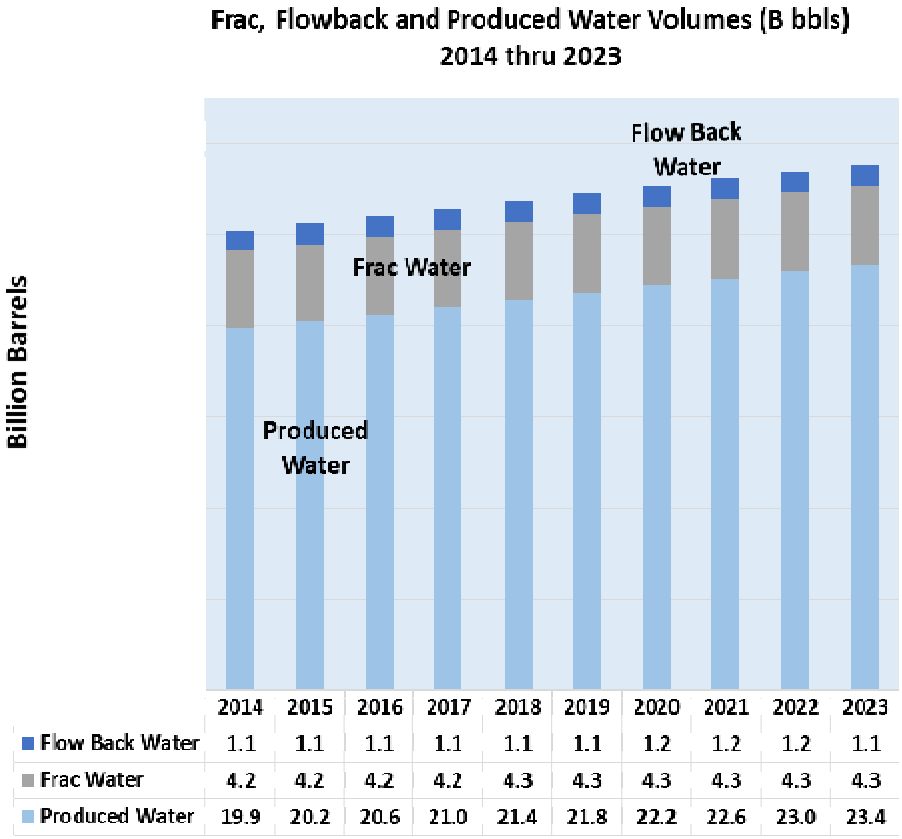




U.S Volumetric Outlook (Billions Barrels) 2014 – "Before"

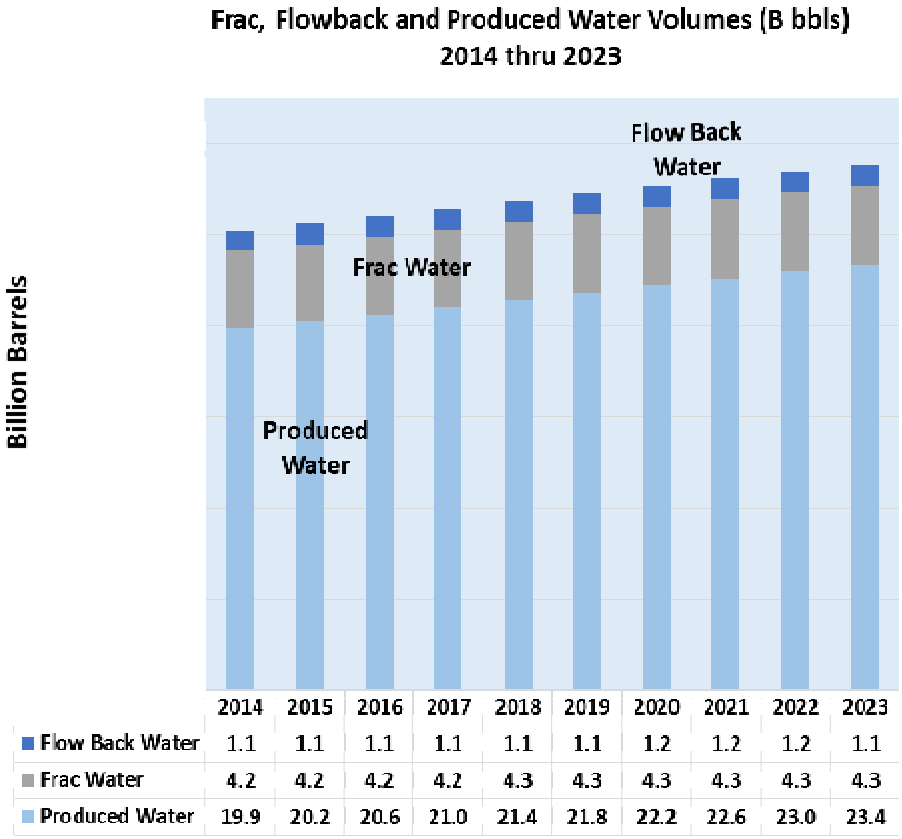
Source: CAP Resources Annual U.S. Onshore Water Management Spending Outlook (excludes California, Alaska)



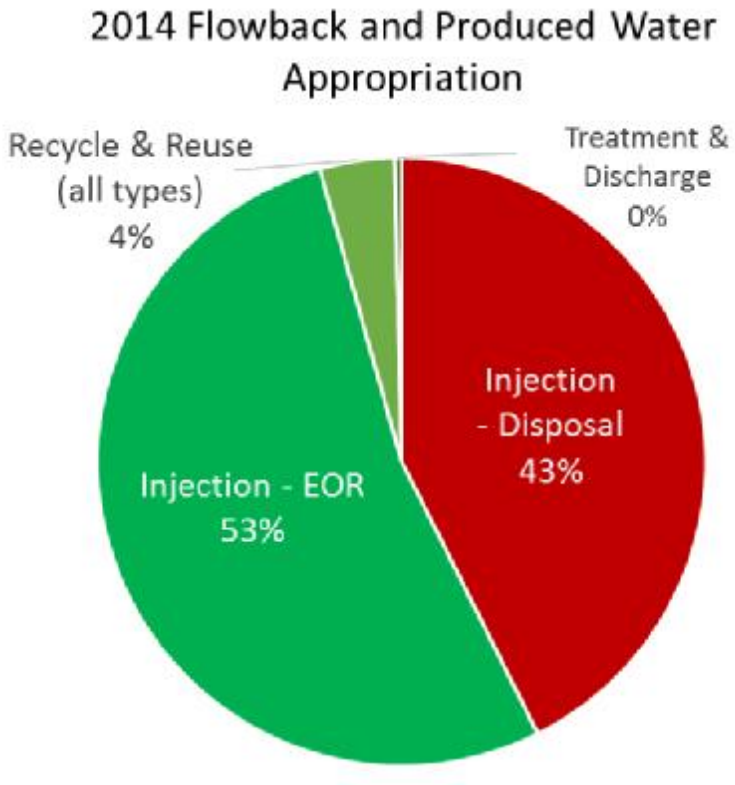
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Flow Back Water	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.1
Frac Water	4.2	4.2	4.2	4.2	4.3	4.3	4.3	4.3	4.3	4.3
Produced Water	19.9	20.2	20.6	21.0	21.4	21.8	22.2	22.6	23.0	23.4

U.S Volumetric Outlook (Billions Barrels) 2014 – "Before"

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



	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Flow Back Water	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.1
Frac Water	4.2	4.2	4.2	4.2	4.3	4.3	4.3	4.3	4.3	4.3
Produced Water	19.9	20.2	20.6	21.0	21.4	21.8	22.2	22.6	23.0	23.4

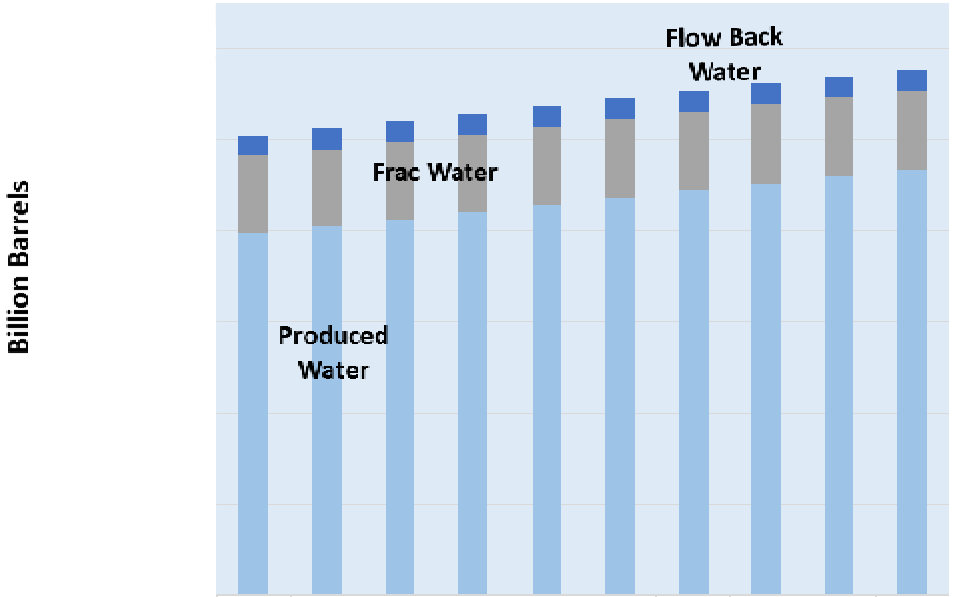


Our Challenge: Reduce the volume of disposal water removed from the hydrocycle

U.S Volumetric Outlook September 2015 - Today

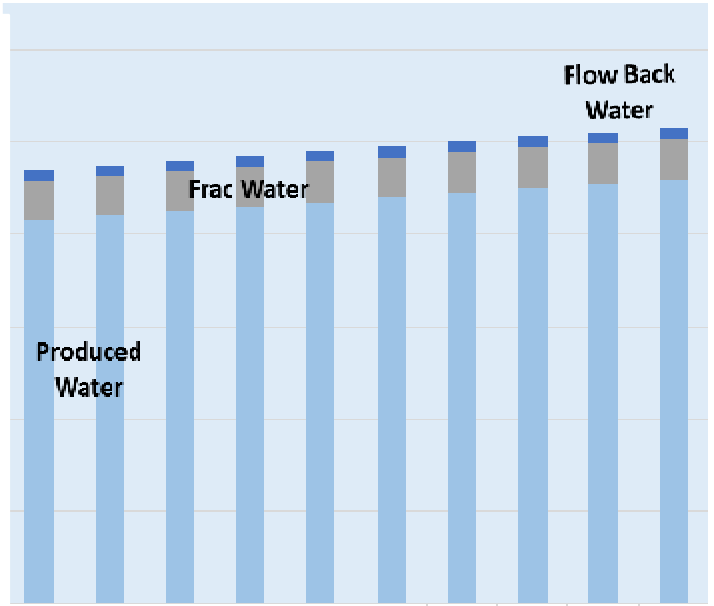
Source: CAP Resources Annual U.S. Onshore Water Management Spending Outlook (excludes California, Alaska)

Frac, Flowback and Produced Water Volumes (B bbls)
2014 thru 2023



	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Flow Back Water	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.1
Frac Water	4.2	4.2	4.2	4.2	4.3	4.3	4.3	4.3	4.3	4.3
Produced Water	19.9	20.2	20.6	21.0	21.4	21.8	22.2	22.6	23.0	23.4

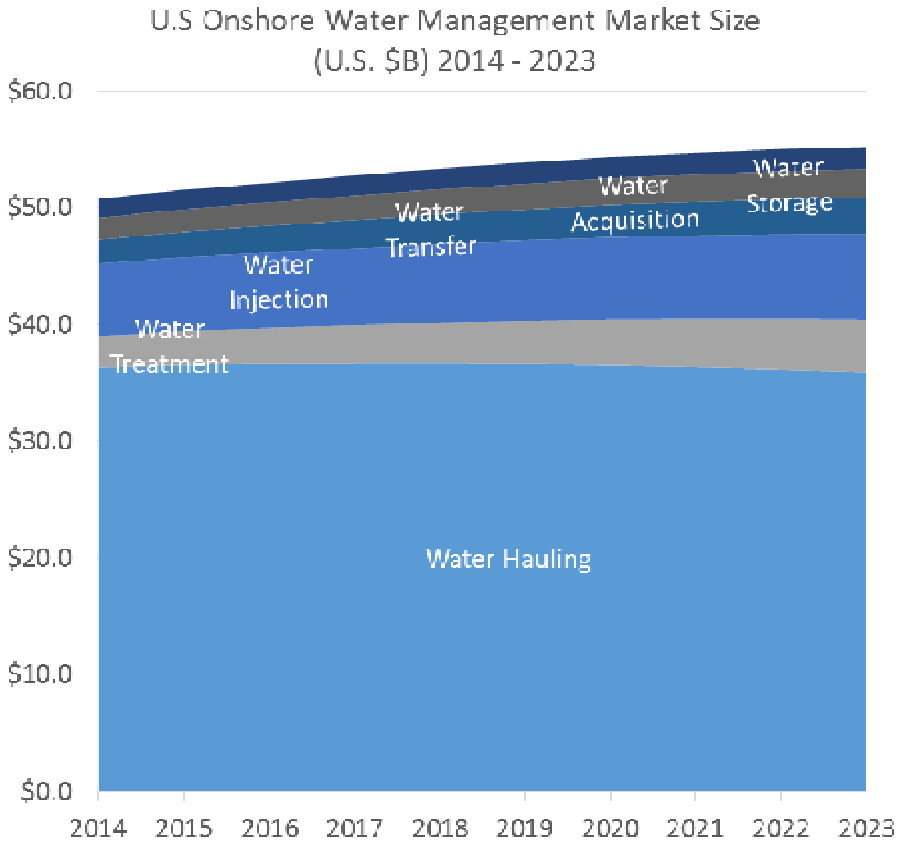
Frac, Flowback and Produced Water Volumes (B bbls)
2015 thru 2024



	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Flow Back Water	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Frac Water	2.1	2.1	2.1	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Produced Water	20.8	21.0	21.3	21.5	21.8	22.0	22.2	22.5	22.7	23.0

U.S. Water Management Spend 2014 - “Before”

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

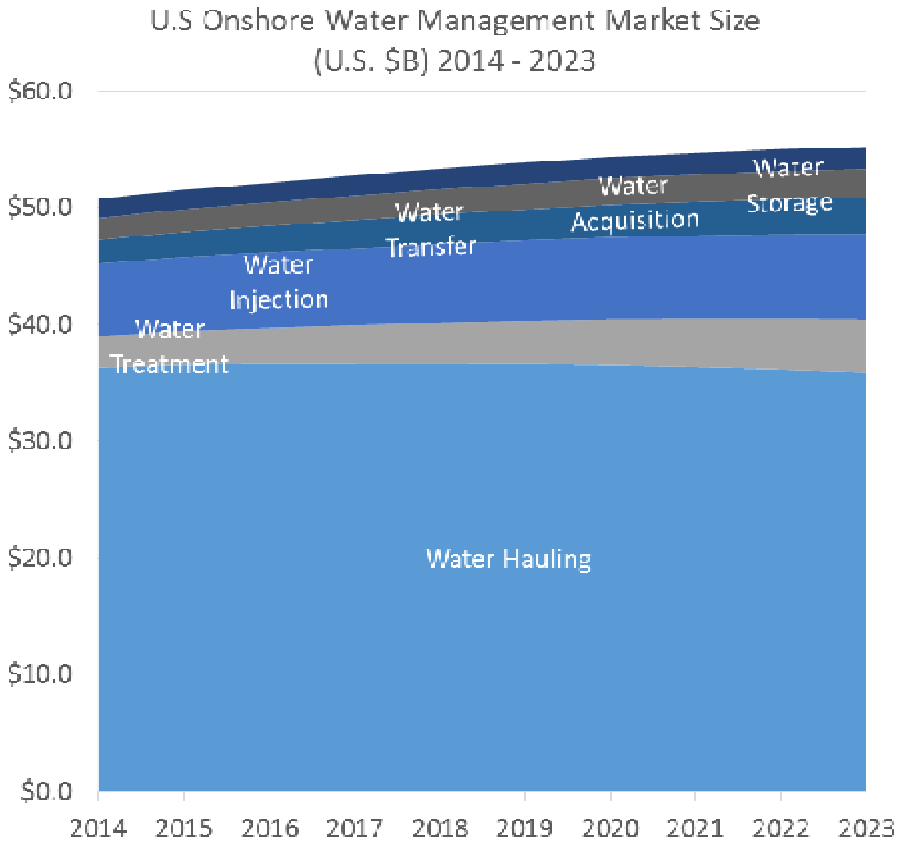


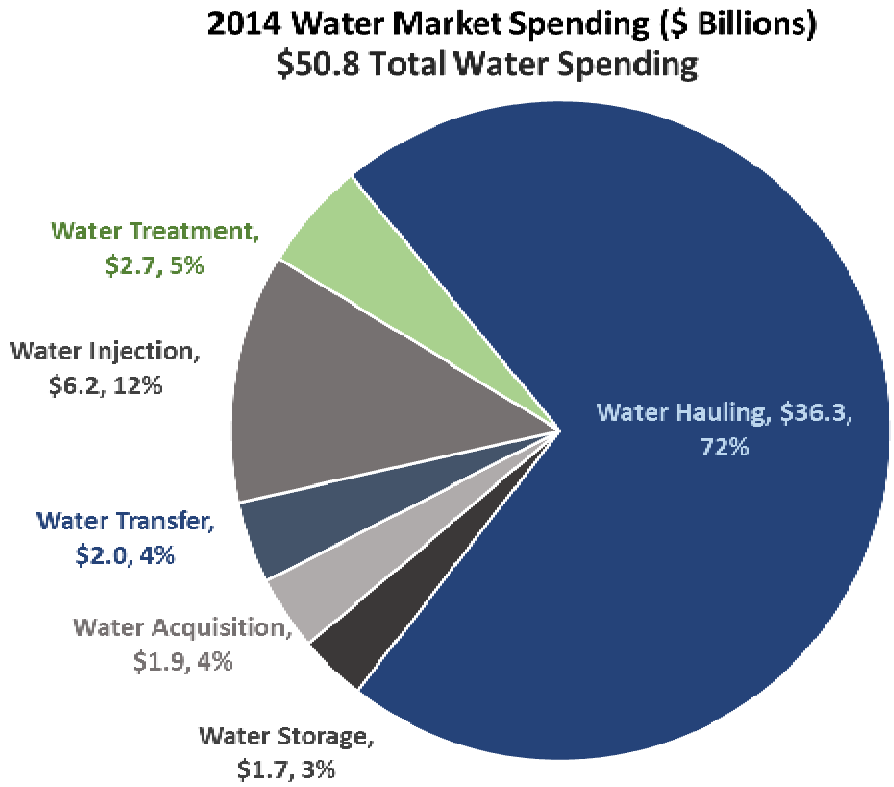
This was our 0utlook in 2014 - If completion activity stays “steady state”, assuming modest increases in reuse and treatment.

Note that Water Hauling is roughly 70% (GASP!!!) of market spending.

U.S. Water Management Spend 2014 - “Before”

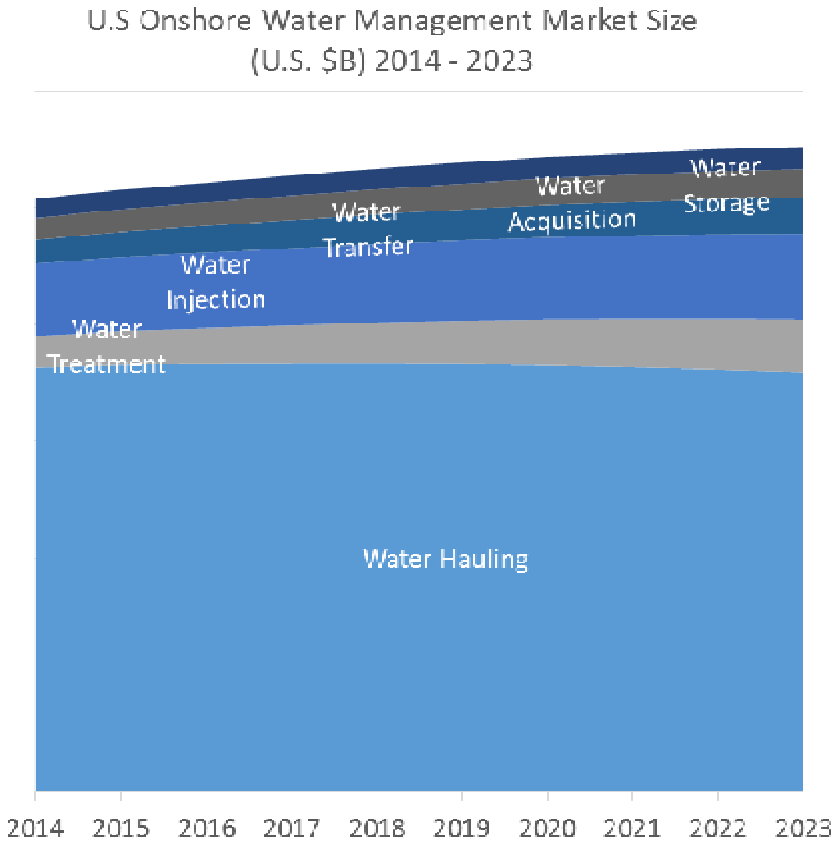
Source: CAP Resources Annual U.S. Onshore Water Management Spending Outlook (excludes California, Alaska)

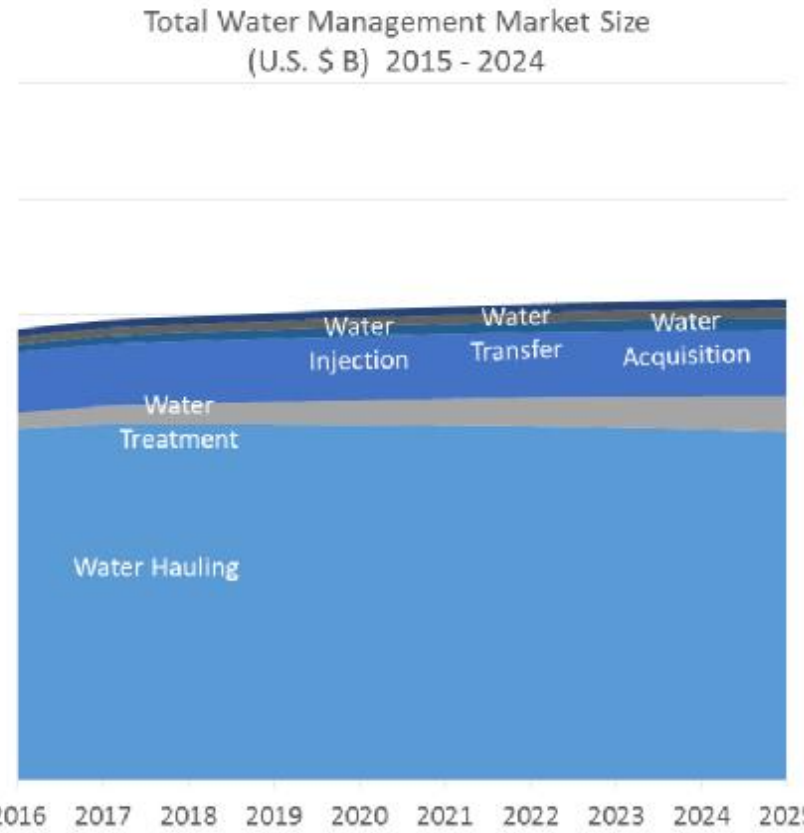




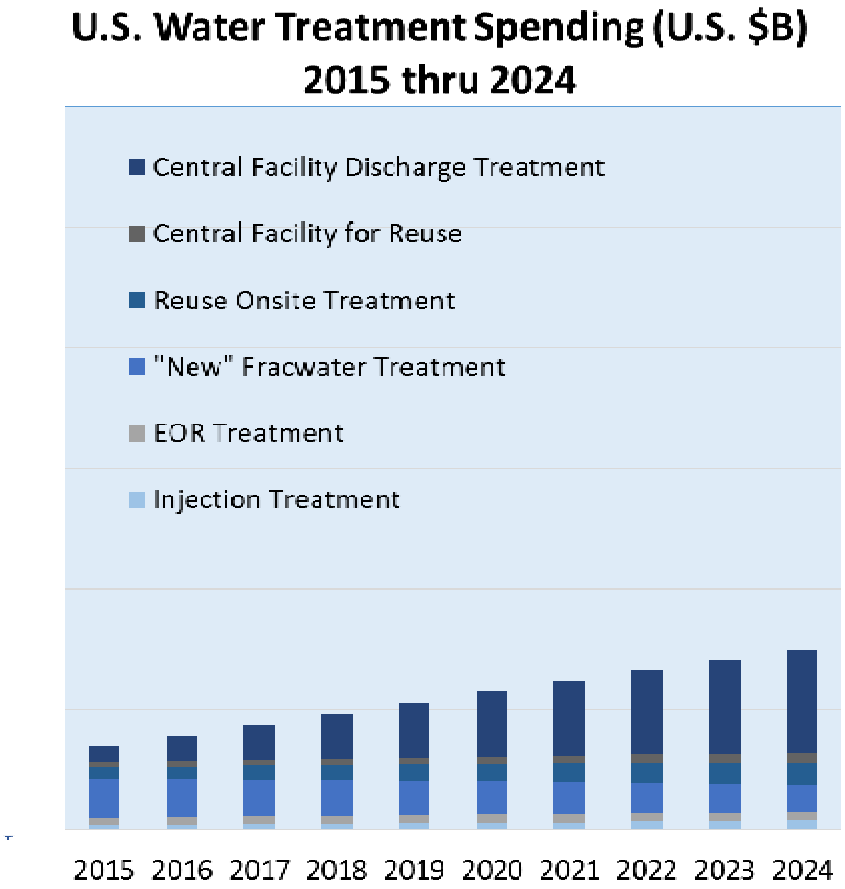
U.S. Water Management Spend Sept '15 "Today"

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

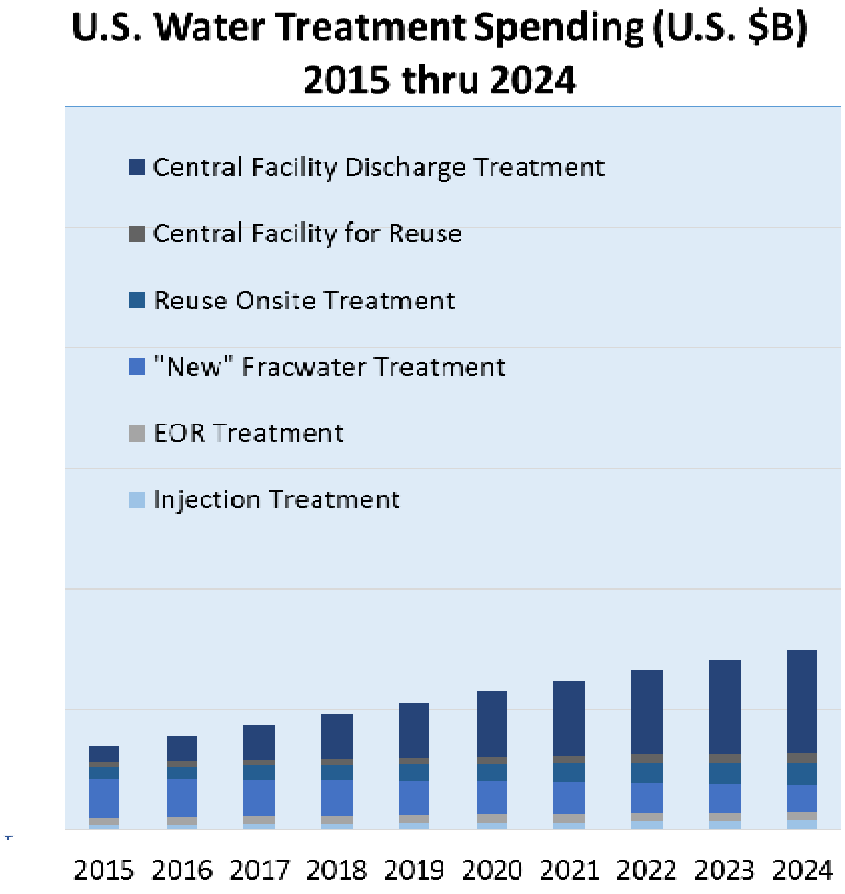


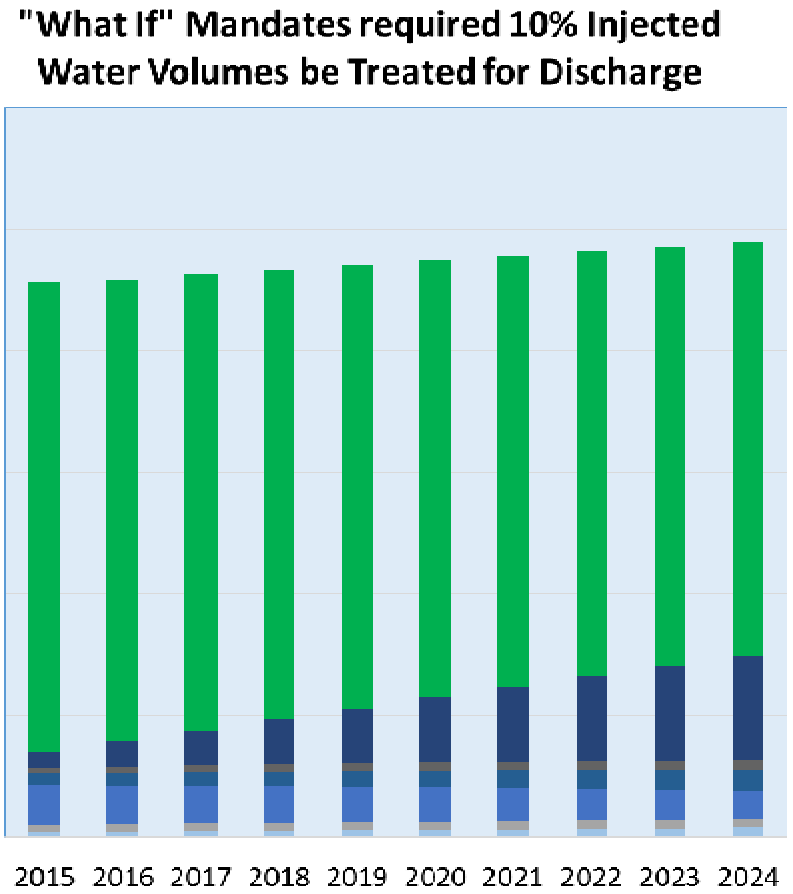


Treatment Spending Outlook based on Today's Market



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."

From Bill Gates' book, "The Road Ahead," published in 1996.

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