

# Permian Unconventional Water Management: Collaboration to Develop Full Cycle Solutions

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# ConocoPhillips' Global Water Sustainability Position



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As a responsible global energy company committed to sustainable development, we recognize that fresh water is an essential natural resource for communities, businesses, and ecosystems. Global population growth will increase demand for fresh water and all users – domestic, agriculture, and industry – will need to effectively manage supplies to meet demands.

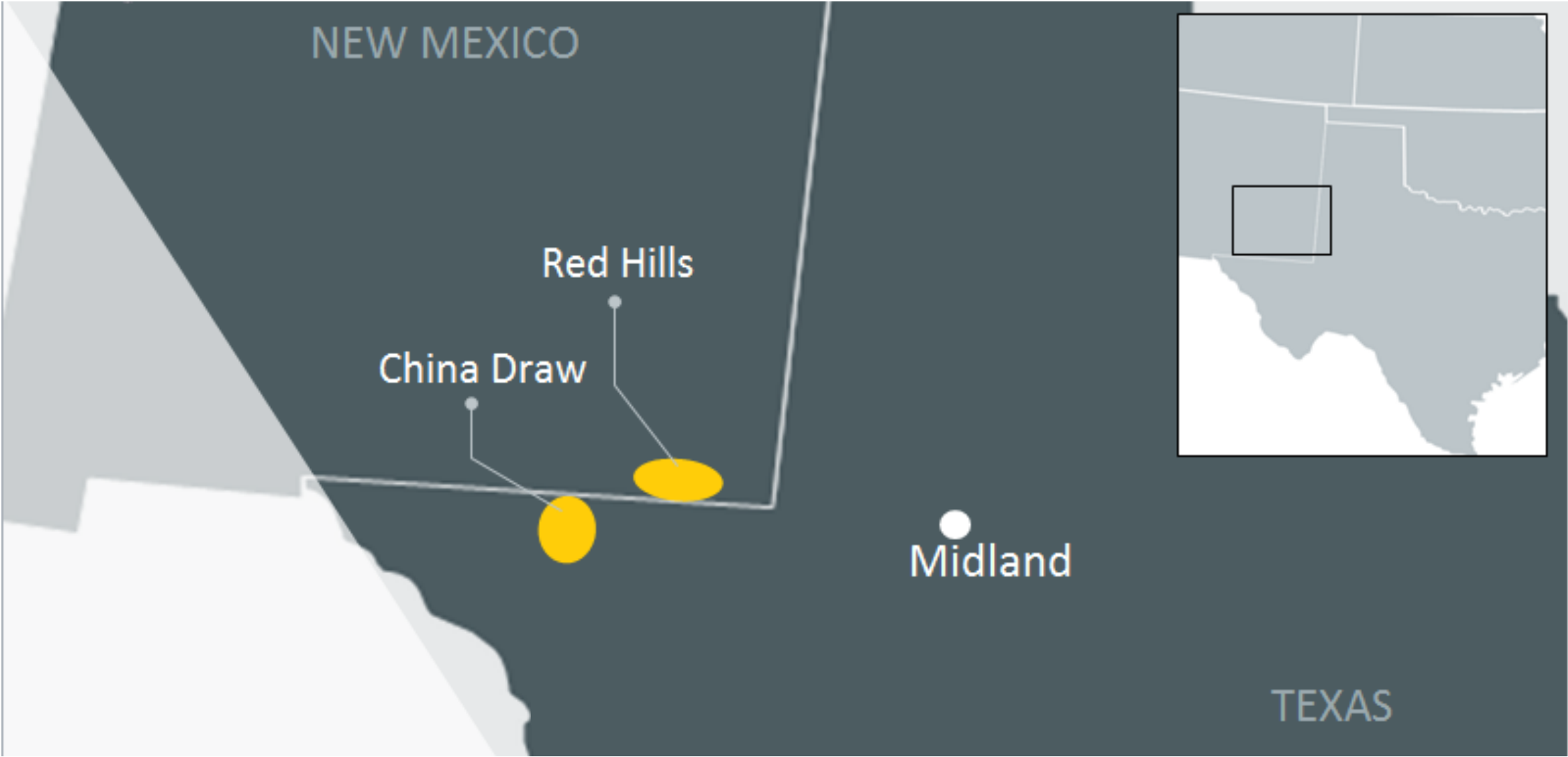
<http://www.conocophillips.com/sustainable-development/our-approach/living-by-our-principles/positions/Pages/water-sustainability.aspx>

# Introduction



- ConocoPhillips is committed to responsible water management in the Delaware Basin
- Limited surface and groundwater resources available
- Traditional solution has been disposal in injection wells
- Tremendous opportunity to reuse produced water
- New full life cycle strategy required an integrated interdisciplinary effort

# Location



# Delaware Basin



- Permian Unconventional asset is a stacked play
- Water supply, transfer, and disposal can average 20% of well completion costs
- Water to oil ratios are typically above 1:1 so produced water disposal cost can be >25% of lifting costs
- During exploration and early development, minimal infrastructure is in place to support water supply and disposal
- Produced water reuse could mitigate both limitations

# Holistic Water Management

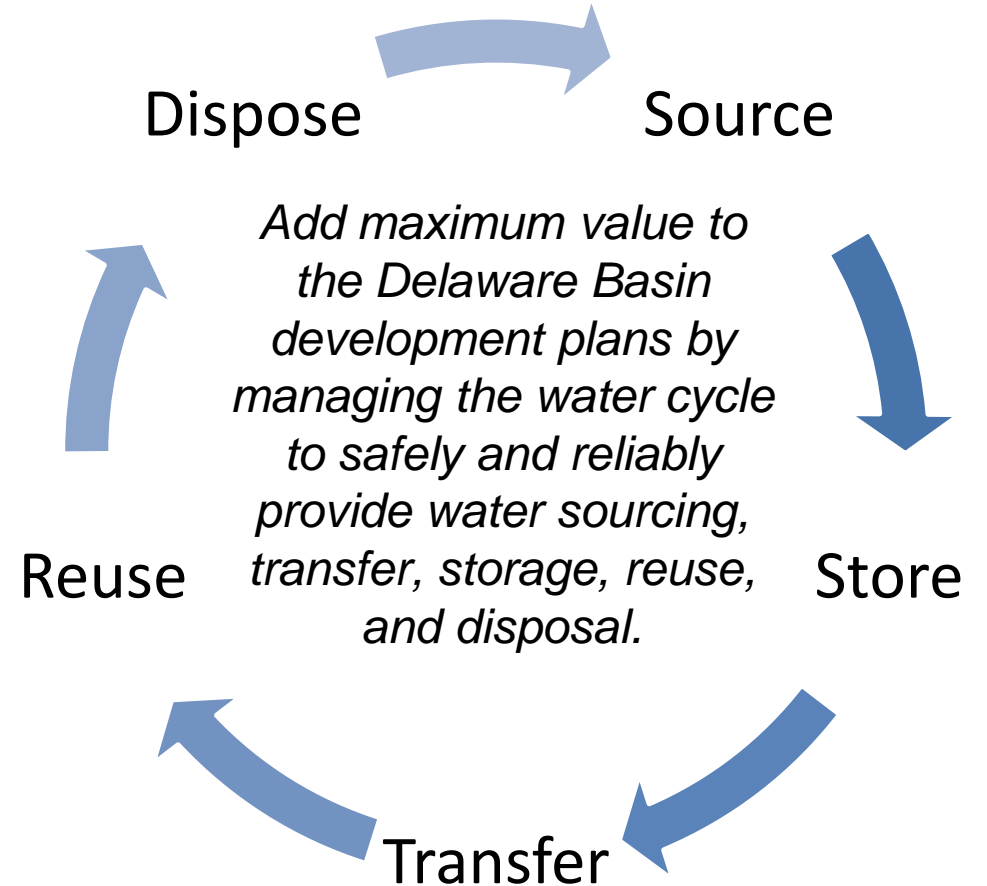


Water management solutions must meet the following criteria:

- Must be safe, environmentally responsible, sustainable, and economic
- All water delivered in a timely manner
- Minimize trucking/hauling of water whenever appropriate
- Reuse produced water for stimulation whenever appropriate
- Reuse or dispose of all produced water such that production targets can be achieved

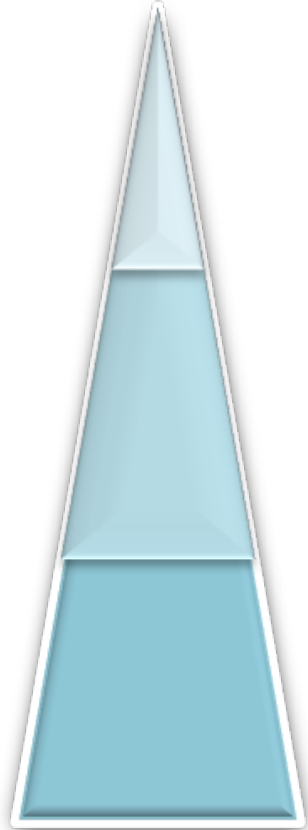
# Decision Analysis: Integrated Multidisciplinary Team

- Completions and Drilling Engineering
- Reservoir Engineering
- Development Engineering
- Geoscience
- Technology
- Strategic Sourcing, Supply Chain
- Operations and Production
- HSE
- Land, Surface, Legal, Regulatory



# Decision Analysis: Process

## Decision Hierarchy

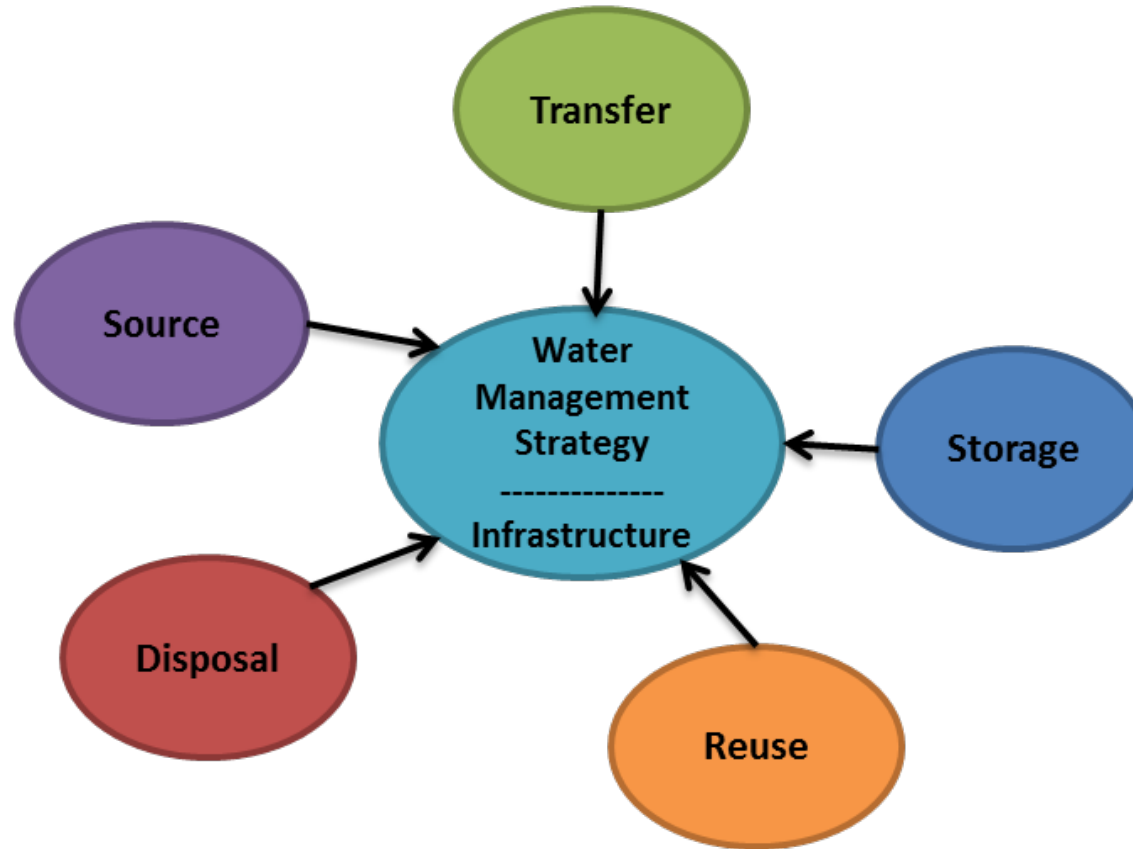


Given

Focus

Tactical

## Influence Diagram



## Strategy Table

| Strategy   | Storage          | Transfer          |
|------------|------------------|-------------------|
| Strategy A | Storage Option A | Transfer Option A |
| Strategy B | Storage Option B | Transfer Option B |



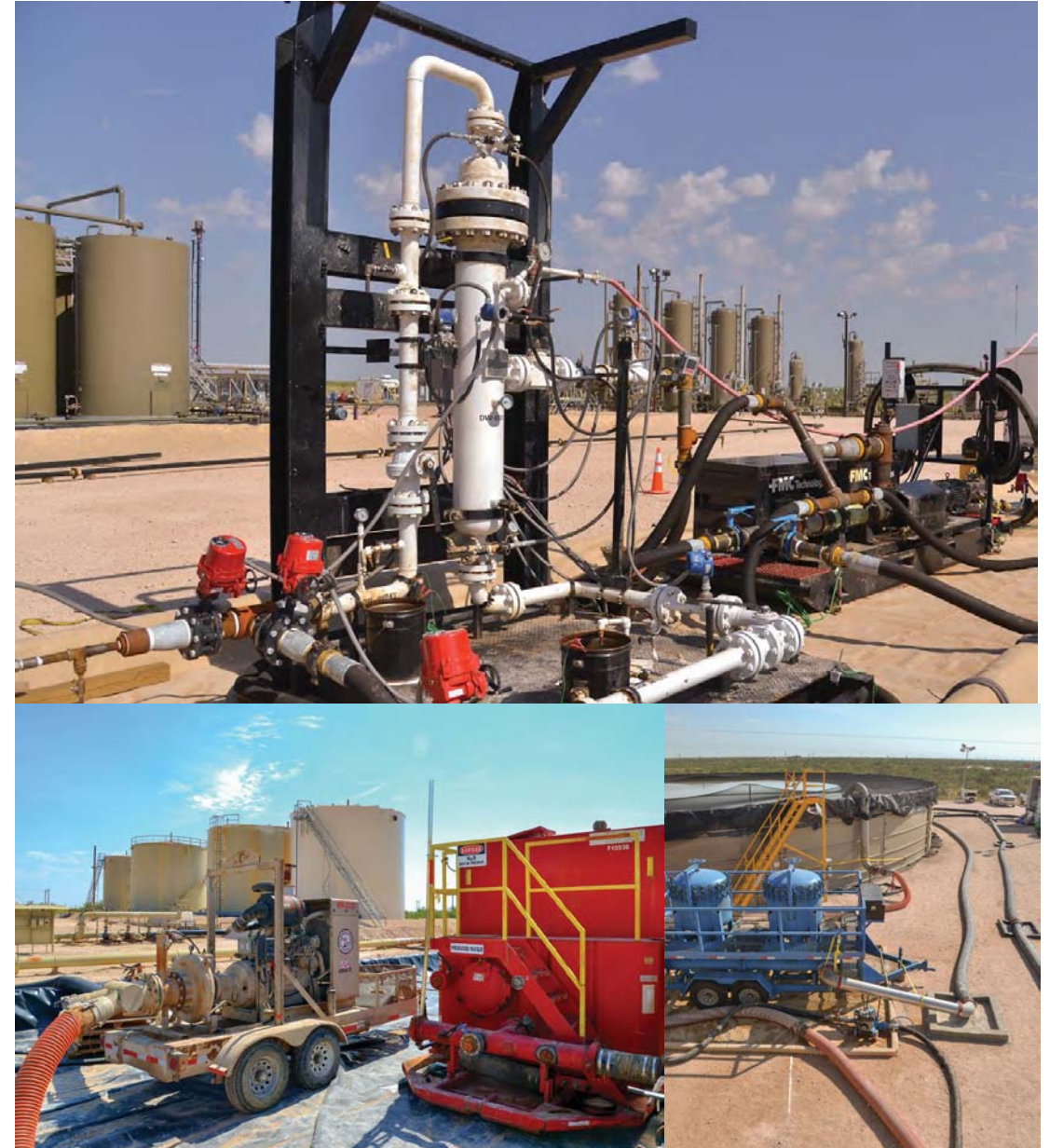
# Water Management Strategy as Continuum



- Team set out to select one water management strategy that would fit all criteria
- Became apparent that strategy was a continuum from short-term to full field development
- Team developed short-term strategy that improved costs without extensive infrastructure investment

# Short Term Solutions Meet Long Term Objectives

- Optimize capital investment for short and long term cost reduction
- Install infrastructure that enables flexibility and choice for short and long term
- In-field gathering for flexibility and optionality in disposal or reuse
- Central gathering and distribution locations
- Utilize technology and temporary solutions



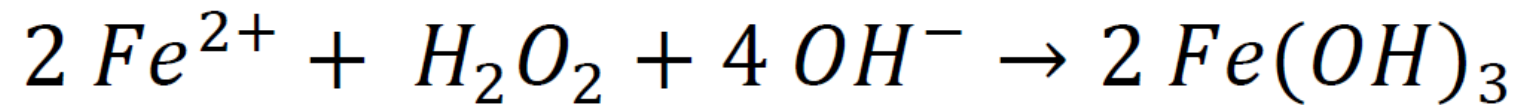
# Produced Water Reuse: Water Treatment Goals



- The produced water must not pose a safety risk to operational personnel
- The water treatment process must be cost effective and fit for purpose
- The produced water must perform comparably to the fresh water that was used before in fracture stimulations
- The produced water must not cause any long term production issues or “life of the well” problems

# Produced Water Reuse: Treatment

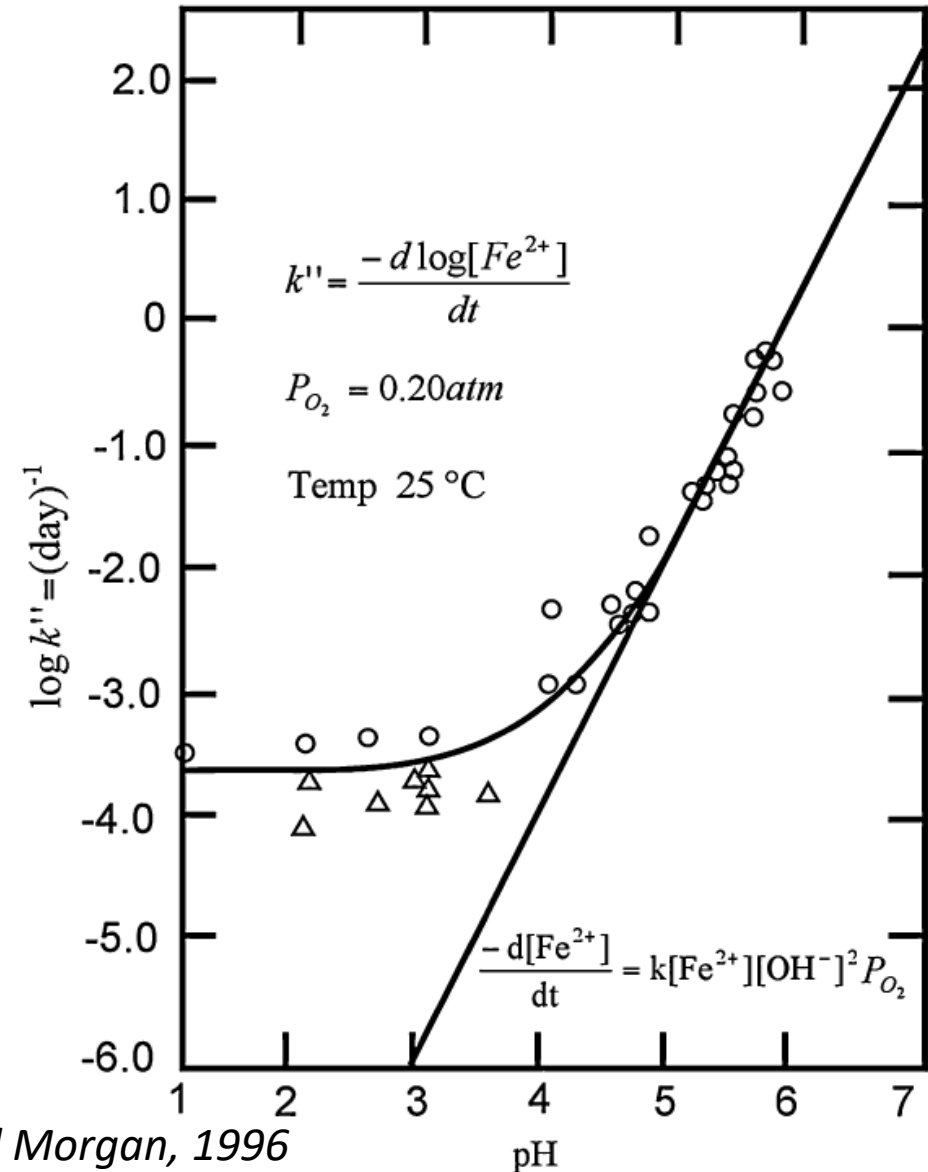
- The basic equation for iron's reaction with hydrogen peroxide is shown below:



- The product (ferric hydroxide) is precipitated out in mildly basic conditions
- The addition of  $H_2O_2$  initially lowers the pH as  $OH^-$  is consumed
- Adding caustic can help the iron form a colloid so it can be filtered

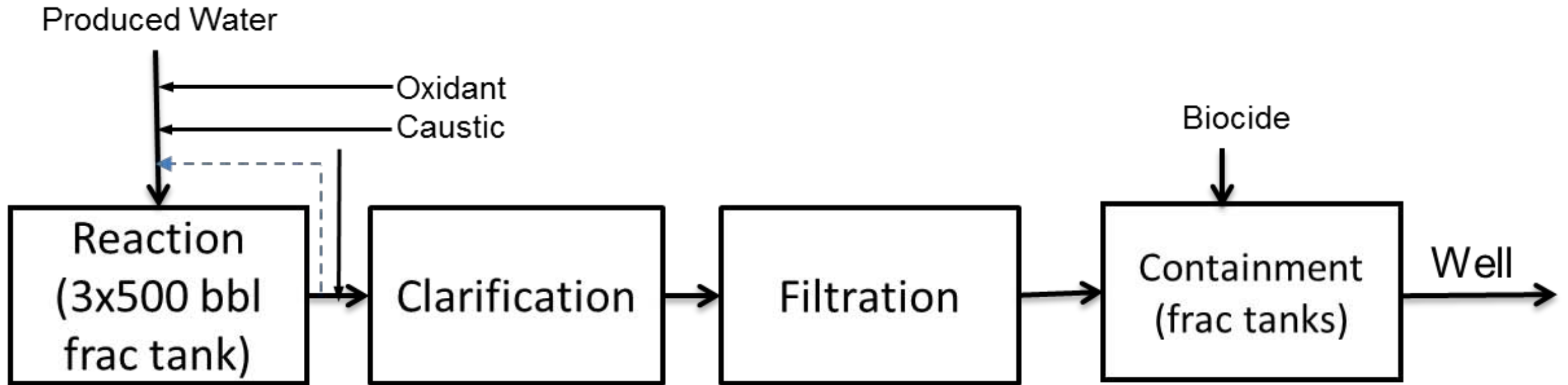
# Produced Water Reuse: Treatment

- As the pH increases, the  $Fe^{2+}$  (ferrous) oxidizes to  $Fe^{3+}$  (ferric)
- Oxidizers make this reaction instantaneous
- Multiple chemicals can be used for iron removal, but  $H_2O_2$  is easily available and very effective



Stumm and Morgan, 1996

# Produced Water Reuse: Treatment



# Optimized Process, Optimized Costs



- High rate clarifier for treatment efficiency
- Lower chemical consumption
- Improved solids management
- Flexibility allows for optimized capital investment

# Results and conclusions of full cycle water management solution



- Collaborative development drove near term cost reduction, including 50% reduction in disposal cost
- Line of sight to favorable long term economics, sustainability, and resource security for Delaware Basin assets
- Strategy development should be shared amongst various resources and disciplines to address all stakeholder concerns
- Strong communication and collaboration required to ensure short term decisions do not impair long term goals



# Acknowledgements/Thank You/Questions

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