

Providing environmentally responsible water treatment solutions to the oil and gas industry

Cost Effective Produced Water Management



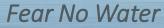
www.hydrozonix.com

Produced Water Management for Reuse

- Recycle vs. Fresh/Brackish Cost Considerations
- What are my Treatment/Reuse Objectives
- How is Treatment/Reuse fit into my Facilities Design Program
- Automating the Treatment/Reuse Program
- Case Studies

 If the combination of freshwater sourcing cost and disposal is cheaper than recycling then savings can be realized

	Cost Range	Average Cost
Freshwater Sourcing	\$0.25 - \$1.00 / BBL	\$0.50/BBL
3 rd Party SWD (Market Price)	\$0.40 - \$0.75/BBL	\$0.58/BBL
Operator owned SWD (CAPEX & OPEX)	\$0.12 - \$0.28/BBL	\$0.20/BBL
3 rd Part Recycling (Market Price)	\$0.30 - \$0.60/BBL	\$0.45/BBL
Trucking Not Included		





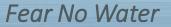
 If the combination of freshwater sourcing cost and disposal is cheaper than recycling then savings can be realized

	Cost Range	Average Cost	
Freshwater Sourcing	\$0.25 - \$1.00 / BBL	\$0.50/BBL\$1.0	no /
3 rd Party SWD (Market Price)	\$0.40 - \$0.75/BBL	\$0.58/BBL	00/
Operator owned SWD (CAPEX & OPEX)	\$0.12 - \$0.28/BBL	\$0.20/BBL	
3 rd Part Recycling (Market Price)	\$0.30 - \$0.60/BBL	\$0.45/BBL	
Trucking Not Included			



 If the combination of freshwater sourcing cost and disposal is cheaper than recycling then savings can be realized

	Cost Range	Average Cost
Freshwater Sourcing	\$0.25 - \$1.00 / BBL	\$0.50/BBL\$1
3 rd Party SWD (Market Price)	\$0.40 - \$0.75/BBL	\$0.58/BBL
Operator owned SWD (CAPEX & OPEX)	\$0.12 - \$0.28/BBL	\$0.20/BBL
3 rd Part Recycling (Market Price)	\$0.30 - \$0.60/BBL	\$0.45/BBL
Trucking Not Included		





 If the combination of freshwater sourcing cost and disposal is cheaper than recycling then savings can be realized

	Cost Range	Average Cost	
Freshwater Sourcing	\$0.25 - \$1.00 / BBL	\$0.50/BBL	
3 rd Party SWD (Market Price)	\$0.40 - \$0.75/BBL	\$0.58/BBL	0.78/BBI
Operator owned SWD (CAPEX & OPEX)	\$0.12 - \$0.28/BBL	\$0.20/BBL	-
3 rd Part Recycling (Market Price)	\$0.30 - \$0.60/BBL	\$0.45/BBL	
Trucking Not Included			



 If the combination of freshwater sourcing cost and disposal is cheaper than recycling then savings can be realized

	Cost Range	Average Cost	
Freshwater Sourcing	\$0.25 - \$1.00 / BBL	\$0.50/BBL	
3 rd Party SWD (Market Price)	\$0.40 - \$0.75/BBL	\$0.58/BBL).78/BBL
Operator owned SWD (CAPEX & OPEX)	\$0.12 - \$0.28/BBL	\$0.20/BBL	
3 rd Part Recycling (Market Price)	\$0.30 - \$0.60/BBL	\$0.45/BBL	
Trucking Not Included			



 If the combination of freshwater sourcing cost and disposal is cheaper than recycling then savings can be realized

	Cost Range	Average Cost
Freshwater Sourcing	\$0.25 1.00 / BBL	\$0.50/BBL
3 rd Party SWD (Market Price)	\$0.25 1.00 / BBL \$0.37/BBL \$0.40 - \$0.75/BBL	\$0.58/BBL
Operator owned SWD (CAPEX & OPEX)	\$0.12 J.28/BBL	*0.20/BBL
3 rd Part Recycling (Market Price)	\$0.30 - \$0.60/BBL	\$0.45/BBL
Trucking Not Included		



www.hydrozonix.com

 If the combination of freshwater sourcing cost and disposal is cheaper than recycling then savings can be realized

	Cost Range	Average Cost
Freshwater Sourcing	\$0.25 1.00 / BBL	\$0.50/BBL
3 rd Party SWD (Market Price)	\$0.25 1.00 / BBL \$0.37/BBL \$0.40 - \$0.75/BBL	\$0.58/BBL
Operator owned SWD (CAPEX & OPEX)	\$0.12 J.28/BBL	0.20/BBL
3 rd Part Recycling (Market Price)	\$0.30 - \$0.60/BBL	\$0.45/BBL
Trucking Not Included		

What does Operator owned recycling look like ?



www.hydrozonix.com

Constituent	Slickwater	Guar (Linear)	Guar (XL)	Hybrids (XL)
Chlorides (ppm)	140K (anionic) No Limit (cationic)	60K	60K	60K
Total Hardness (ppm)	50K	20K	20K	20K
Iron (ppm)	25	10	10	10
Oil (ppm)	100	50	50	50
TSS (ppm)	100	100	100	100
Boron (ppm)	No Limit	10	10	No Limit
Bacteria (cfu/ml)	100	100	100	100
Sulfides (ppm)	0	0	0	0



Slickwater Fracs – 5 different Operators

Constituent	А	В	С	D	E
Chlorides (ppm)	140,000	100,000	N/A	85,000	N/A
Total Hardness (ppm)	50,000	NA	N/A	20,000	Calcium 2000 Magnesium 2000
Sulfides (ppm)	0	0	0	0	0
Iron (ppm)	25	10	10	10	10
Oil (ppm)	100	50	40	10	N/A
TSS (ppm)	100	100 micron	50	5 micron	N/A
рН	6.5-7.5	6-8	6.5-7.5	6-7	6-8
Bacteria (cfu/ml)	100	0	0	1000 GHB 100 SRB 100 APB	10,000



www.hydrozonix.com

Slickwater Fracs – 5 different Operators

Constituent	А	В	С	D	E
Chlorides (ppm)	140,000	100,000	N/A	85,000	N/A
Total Hardness (ppm)	50,000	NA	N/A	20,000	Calcium 2000 Magnesium 2000
Sulfides (ppm)	0	0	0	0	0
Iron (ppm)	25	10	10	10	10
Oil (ppm)	100	50	40	10	N/A
TSS (ppm)	100	100 micron	50	5 micron	N/A
рН	6.5-7.5	6-8	6.5-7.5	6-7	6-8
Bacteria (cfu/ml)	100	0	0	1000 GHB 100 SRB 100 APB	10,000





Produced Water Blends

- Blends are common
- Dilution is Solution
- Very difficult to supply only produced water to a frac
- Blending fresh/brackish and produced water is commonly done
- Scaling tendencies can be blended away
- Scale Inhibitors are less expensive than TDS removal
- This eliminated the need for TDS removal or softening

Produced Water Pit

Slickwater Fracs – 5 different Operators

	Constituent	Α	В	С	D	E
	Chlorides (ppm)	140,000	100,000	N/A	85,000	N/A
What	Total Hardness (ppm)	50,000	NA	N/A	20,000	Calcium 2000 Magnesium 2000
About	Sulfides (ppm)	0	0	0	0	0
Oil and	Iron (ppm)	25	10	10	10	10
Solids ?	Oil (ppm)	100	50	40	10	N/A
	TSS (ppm)	100	100 micron	50	5 micron	N/A
	рН	6.5-7.5	6-8	6.5-7.5	6-7	6-8
	Bacteria (cfu/ml)	100	0	0	1000 GHB 100 SRB 100 APB	10,000

Solids & Oil Control

- Solids & Oil Control are located at Wellhead, Tank Batteries and SWD
- Desander or Centrifugal Separator is typically part of a Gun Barrel separator system
- Flowback systems include solids and oil control
- Some solids settle in Gun Barrel tanks while oil is removed
- Upstream Tank Batteries also settle solids and separate oil
- Secondary filtration is sometimes included downstream of Gun Barrel separators
- Not unusual to see < 30 ppm oil from Gun Barrels
- In some cases secondary systems are installed as part of recycling programs, which can include settling tanks, DAF, weir tanks for solids and additional oil removal
- Secondary systems are typically before produced water pits

You don't need Oil and Solids Control if you optimize existing systems

HYDRÖC

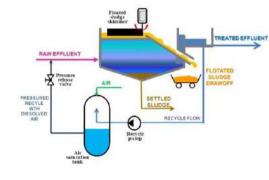
Solids and Oil Control

Solids and Oil/Water Separation

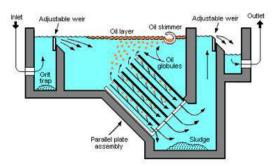
Secondary Solids & Oil Control

- A variety of options are available
- Weir tanks may be the most commonly used
- Choice is based on flow rate, space, performance of primary system
- Many operators will have no secondary control system

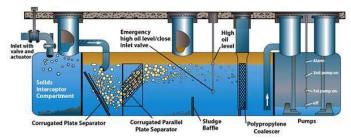
Dissolved Air Flotation



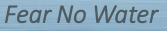
Weir Tanks



Oil Water Separator





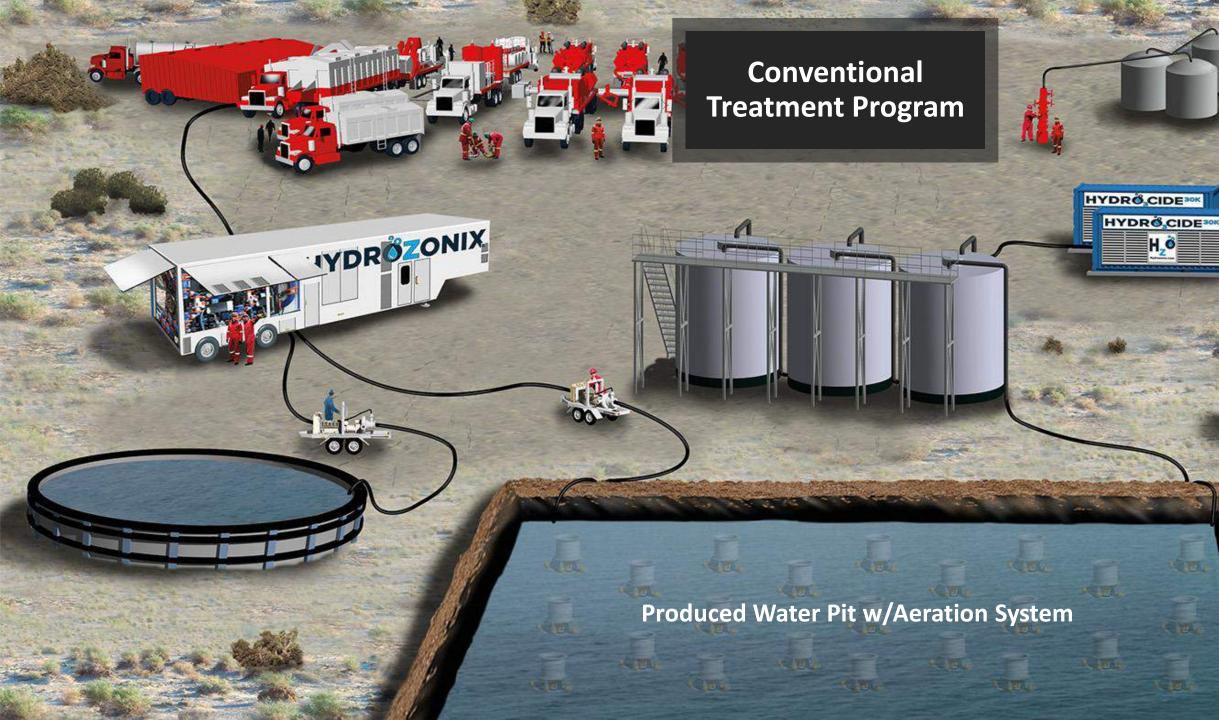


Solids & Oil Control Solids and Oil/Water Separation

- Secondary Solids Control
 - Sometimes your storage is your secondary control
 - Smaller pit w/sump before a larger pit
 - Oil boom and skimmer can be added





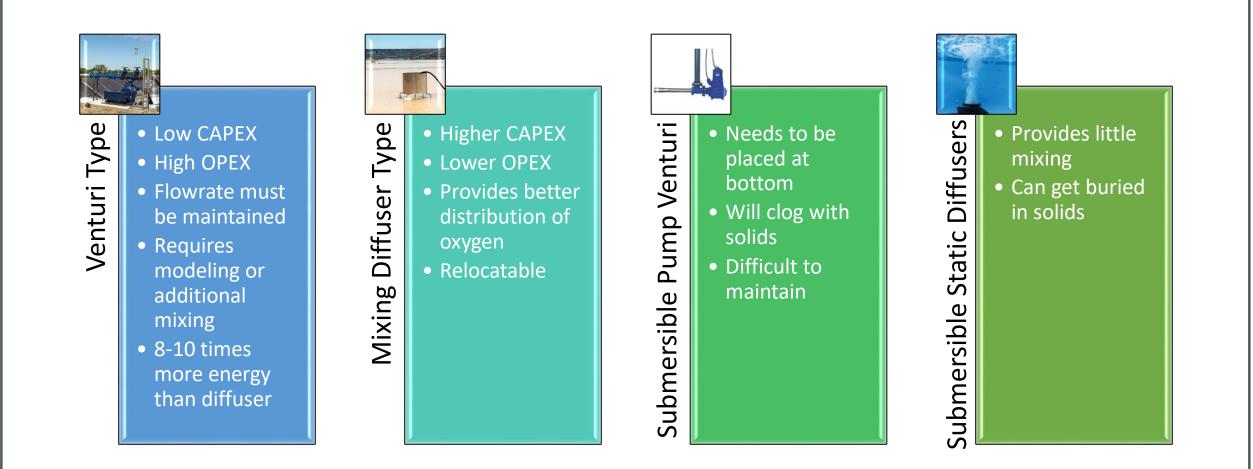


Aeration Summary

- Aeration Systems are typically submersible or floating
 - Floating only aerates top few feet, reduces odor, but leaves majority of water un-aerated
- Submersible aeration are typically diffuser or venturi
 - Venturi are lower CAPEX and higher OPEX
 - Diffuser type are higher CAPEX, but much lower OPEX
- Venturi type requires modeling to ensure oxygen is distributed evenly and bubble size is controlled by flowrate, this effects oxygen distribution
- Diffuser type are placed in a manner where they are evenly distributed, bubble size is controlled by diffuser, diffuser can be buried in solids
- Pod type diffusers are easily relocatable and expandable
- The key is oxygen demand of water and getting enough air distributed throughout the pit to meet the oxygen demand

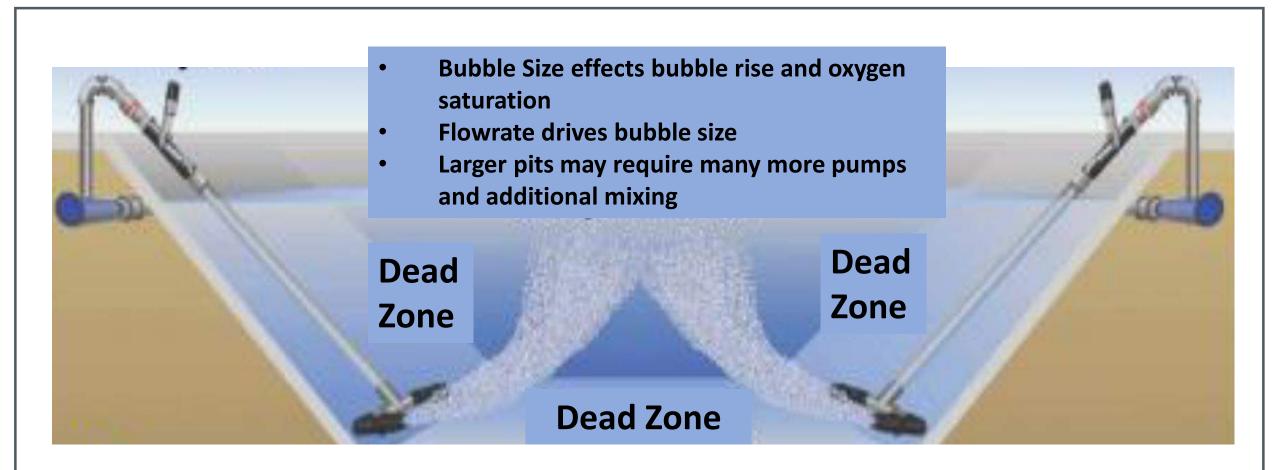


Aeration Summary





Aeration Summary





www.hydrozonix.com

Mixing Submersible Aerators

Aeration Benefits

Bacterial Control/Growth Inhibition

- Algae Control/Growth Inhibition
- Iron Control
- Sulfide Control
- Stratification Control
- Icing Inhibition
- Mixing / Homogenization
- Low Cost

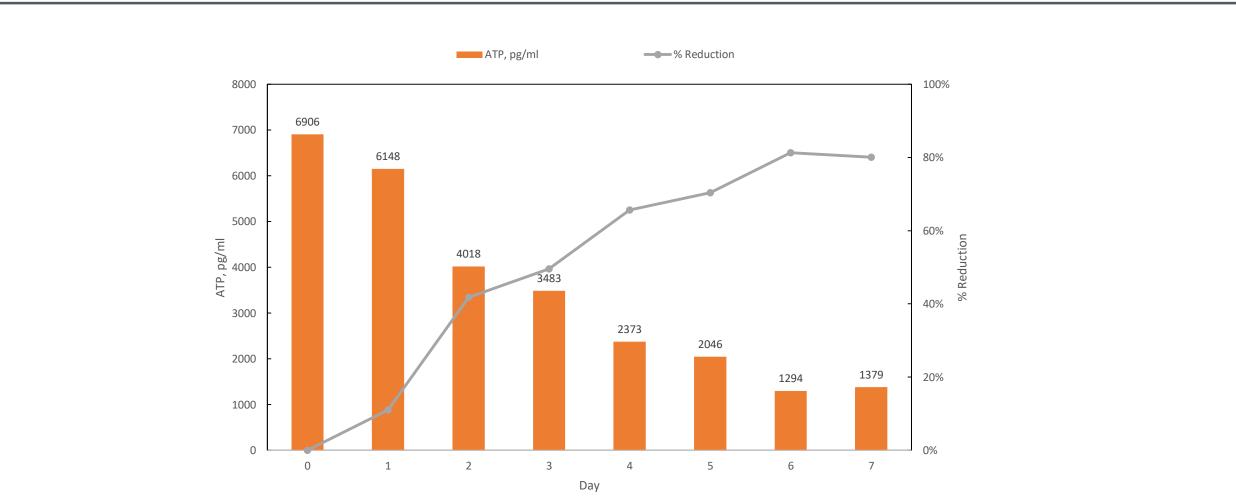
Fear No Water

Outflow is u

Radial inflo

<u>Case Study</u>: What Aeration Does

ATP over time



Fear No Water

www.hydrozonix.com



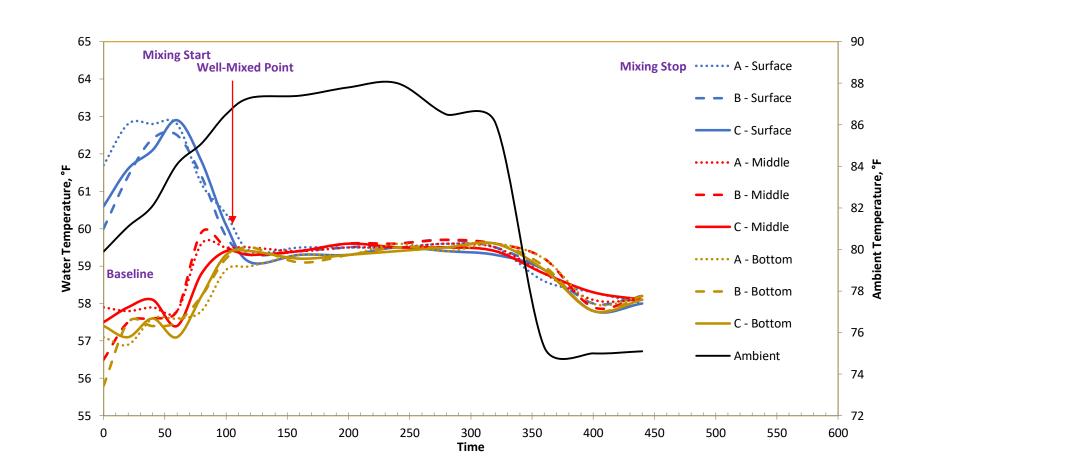
Aeration Benefits

0

- Bacterial Control/Growth
 Inhibition
- Algae Control/Growth
 Inhibition
- Iron Control
- Sulfide Control
- Stratification Control
- Icing Inhibition
- Mixing / Homogenization
- Low Cost

Case Study : What Aeration Does

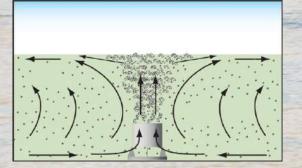
Homogenization – Eliminate Stratification





www.hydrozonix.com

Aeration for Bacteria, Iron and Sulfide Control



Conventional Treatment Program (Needs Pretreatment)



Properly sized aeration

YDROZONIX

00

0

- Monitor temperature for stratification
- Monitor DO for efficacy

- HYDRO₃CIDE Systems can be installed as part of the gathering system, at a centralized facility or at SWDs
- HYDRO₃CIDE Systems replace chemical oxidizers at a fraction of the cost

HYDROZONIX

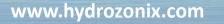
HYDROZONIX

• Full automation eliminates any labor

Fully Automated

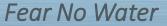


- Operate & Monitor from a PC, iPad or Cell phone
- Operate and Monitor multiple systems
- Monitor Water Quality remotely, real time



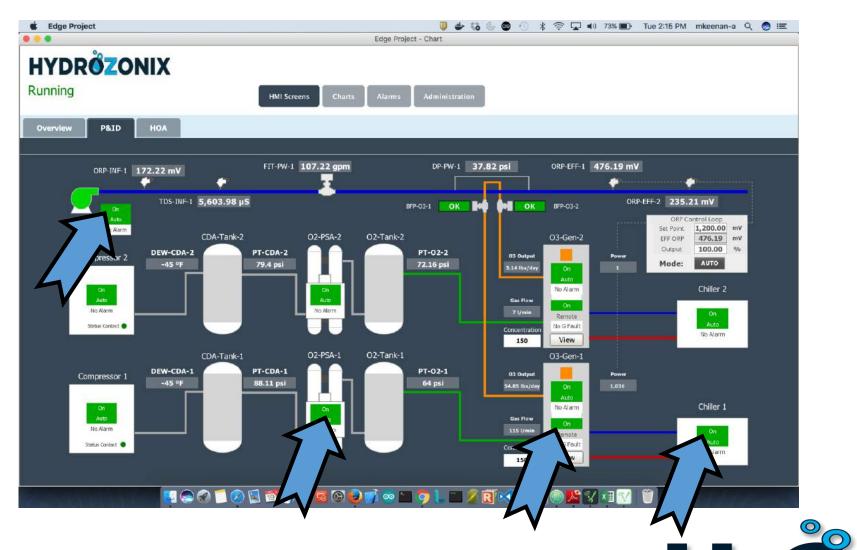
HYDRO CIDE 30K

ydrozonix.com



Benefits of Automation

- Check Status of Components Remotely
- Monitor Operation
- Turn On or Off whole system or individual components
- Integrated into existing pump systems and automation



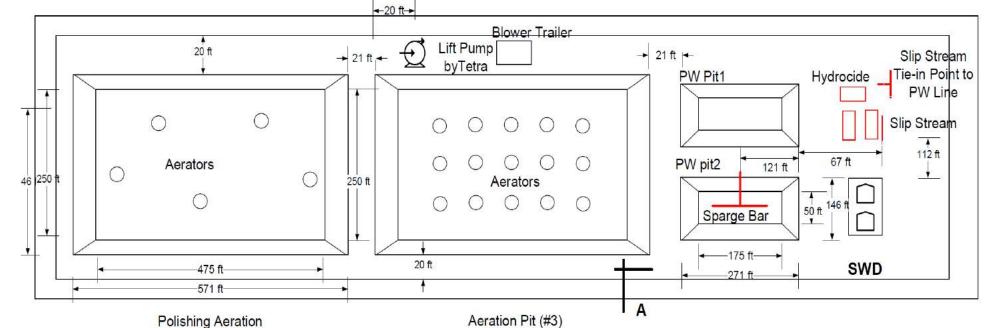
HYDROGCIDE Case Study

Pit (#4)

AT DROM

• Dual Use System

- Pre-Treat Gun Barrels
- Pre-Treat Pit for Recycling
- Replaced Sodium Hypochlorite and aeration for \$0.26/bbl
- HYDRO₃CIDE with aeration under \$0.05/bbl



Fear No Water

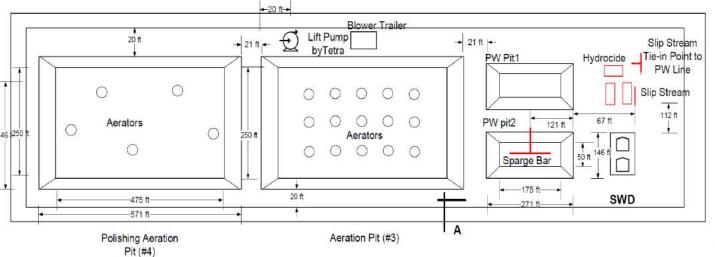
www.hydrozonix.com



HYDRO₃CIDE Case Study

Status

- (5) 40,000 BPD systems installed
- (5) Aeration Systems in 500,000 bbl pits at each location
- (2) additional locations scheduled for November







A

1

HYDRO CIDE ***

HYDRÖ,CIDE***

HYDRO CIDE

H,Ö



00

٠

YDROZONIX

0

Secondary Oil/Water Separation

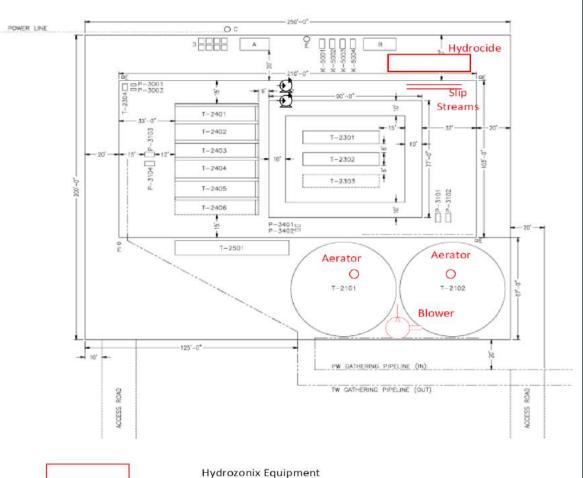
- Optional Membrane System For Discharge Quality
- On The Fly Treatment



Case Study

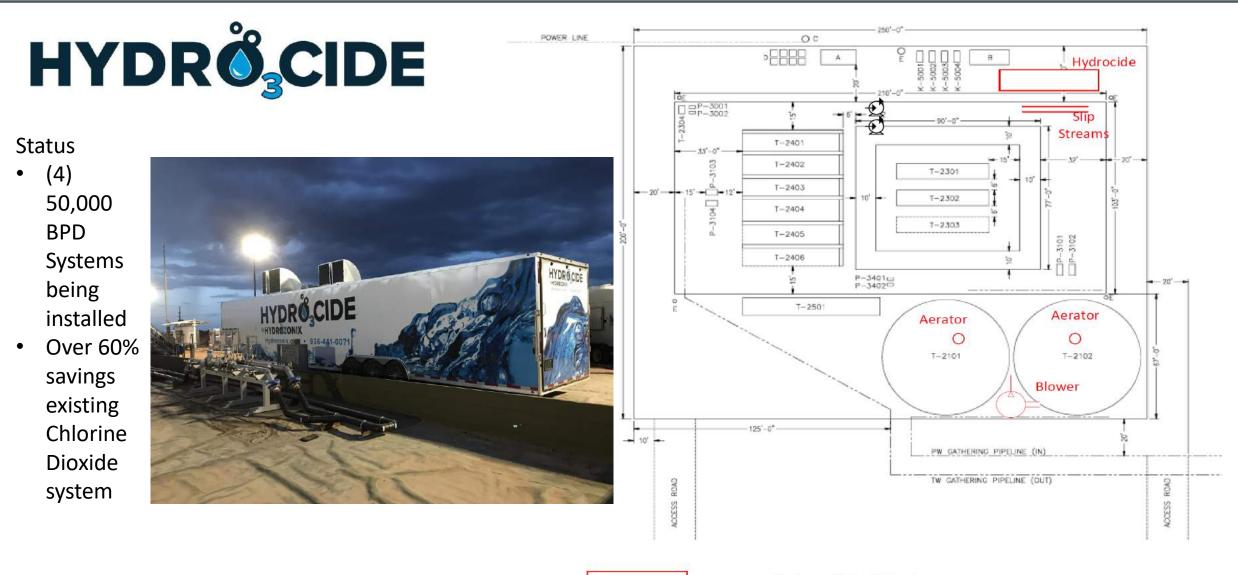
- Pre-treat for Frac Reuse
- Design is flexible for oil/solids control
- Accounts for flowback system oil/solids control

HYDR^o₃CIDE



Fear No Water

www.hydrozonix.com

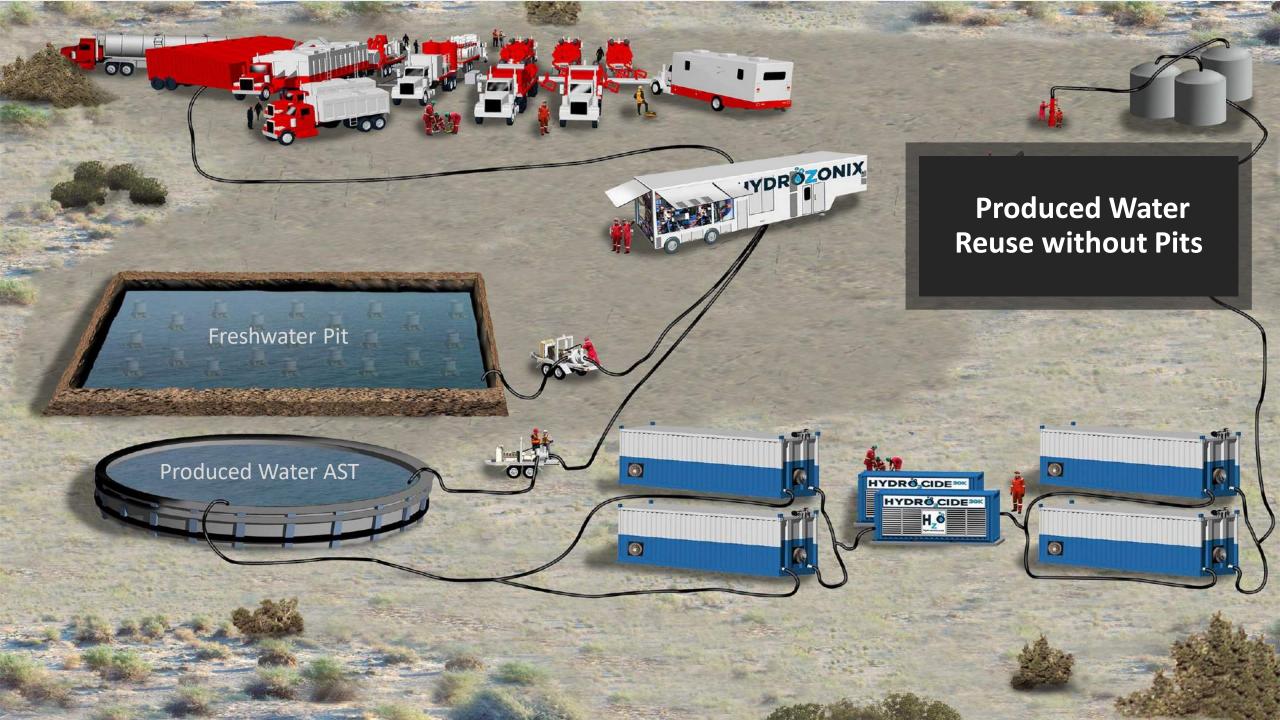


Hydrozonix Equipment



Fear No Water

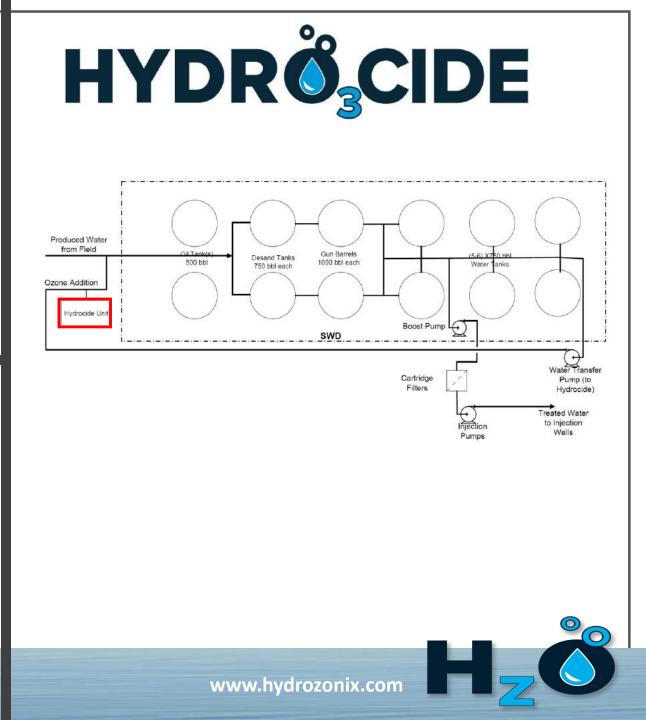
www.hydrozonix.com





Case Study

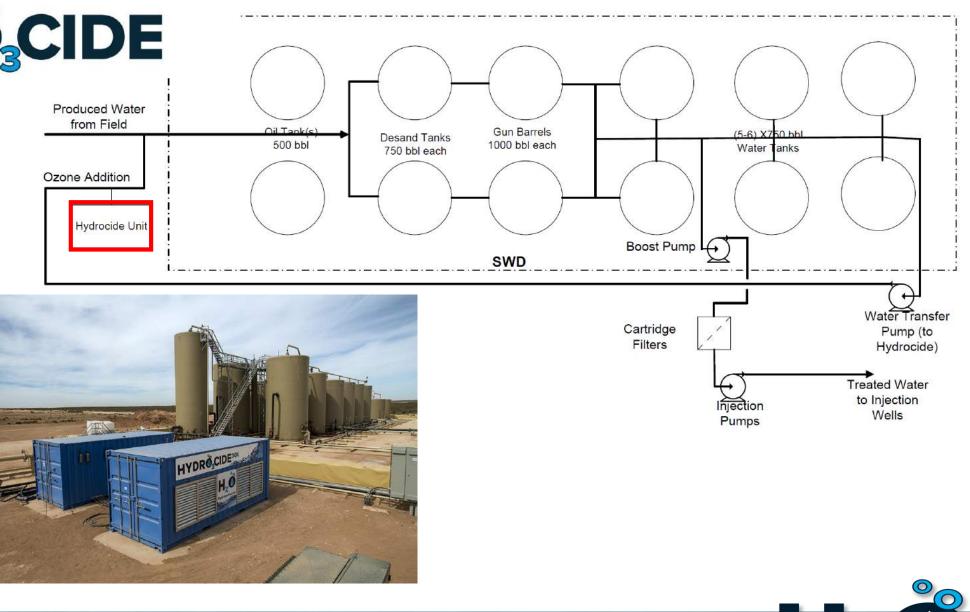
- Bacteria Control on SWD
- Replaced Chlorine Dioxide at \$0.10/bbl
- Total cost Purchase + utilities + O&M is less than \$0.04/bbl

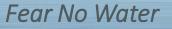


HYDR[°]₃CIDE

Status

- (2) 20,000 BPD Systems installed
- (1) in planning
 60% savings
 over Chlorine
 Dioxide system





www.hydrozonix.com

HYDR[°]₃CIDE

Different Models for Different Flow Rates

- Typically less than \$0.05/BBL for oxidation
- Over 60% savings when compared to Chlorine Dioxide system

	Purchase Price	40,000 BPD	30,000 BPD	20,000 BPD
HYDRO₃CIDE				
250 lbs/day	\$850,000.00	\$0.012*		
200 lbs/day	\$750,000.00		\$0.014*	
150 lbs/day	\$650,000.00			\$0.018*
Monthly O&M	\$ 12,000.00	\$0.01	\$0.013	\$0.020
Utilities		\$0.005	\$0.005	\$0.004
TOTALS		\$0.027/BBL	\$0.032/BBL	\$0.042/BBL



www.hydrozonix.com

A