

Treatment of Produced Water to Discharge Quality

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VP, Business Development*

Veolia designs and deploys solutions for **water**, **waste** and **energy** management, participating in the sustainable development of cities and industries.

\$28 Billion

in revenue

163,226

employees
on 5 continents



WATER

Management of the **global water cycle**, from production and distribution of drinking water to the collect, treatment and recycling of wastewater.



WASTE

Liquid and solid **non-hazardous and hazardous waste management**
Our expertise covers the entire waste life cycle from collection to recycling, leading to the final recovery of waste as materials or energy.



ENERGY

Energy **efficiency, efficient management** of heating and cooling networks, green energy production, all unique expertise for a sustainable world.



Our Recent Success - Antero Resources

WORLD'S LARGEST CENTRALIZED SHALE GAS WATER
TREATMENT FACILITY TO DISCHARGE QUALITY



Oklahoma

Oklahoma - Produced Water Generation

- Mississippian Lime Play
 - *High Volumes of Water*
 - *TDS : 200,000 mg/l to 300,000 mg/l*
 - *Water Disposed by Deep Well Injection*
 - *Issues with Disposal of Produced Water*
- STACK Play
 - *Moderate Volumes of Water*
 - *TDS : 30,000 mg/l to 100,000 mg/l*
 - *Majority of the Water is Reused*
 - *Issues with Fresh Water Availability*
- Woodford Shale Play
 - *Low Volumes of Water*
 - *TDS : 10,000 to 25,000 mg/l*
 - *Water Disposal by Deep Well Injection*
 - *Issues with High Disposal Costs*



Oklahoma - A Potential Solution

- High Volumes of Produced Water Generated in Mississippian Lime Basin
- Treatment to Mississippian Water to Discharge Quality (Fresh Water)
- Veolia's proven CoLD™ Crystallization Technology for Treatment
- Centralized Treatment Facility on a Service Fee Approach (\$/barrel)
- Transfer of Fresh Water to STACK Area (pipeline)
- Utilize Fresh Water for Fracking Operations
- Minimize Injection Volumes in Mississippian Lime Basin
- Addresses the fresh water limitation issue

CoLD® Crystallization Process

- Process Goal

- TDS & Boron Removal*
- Zero Liquid Discharge*

- Forced Circ. Crystallizer

- Fitted with "Vacuum System"*

- Energy for Evaporation

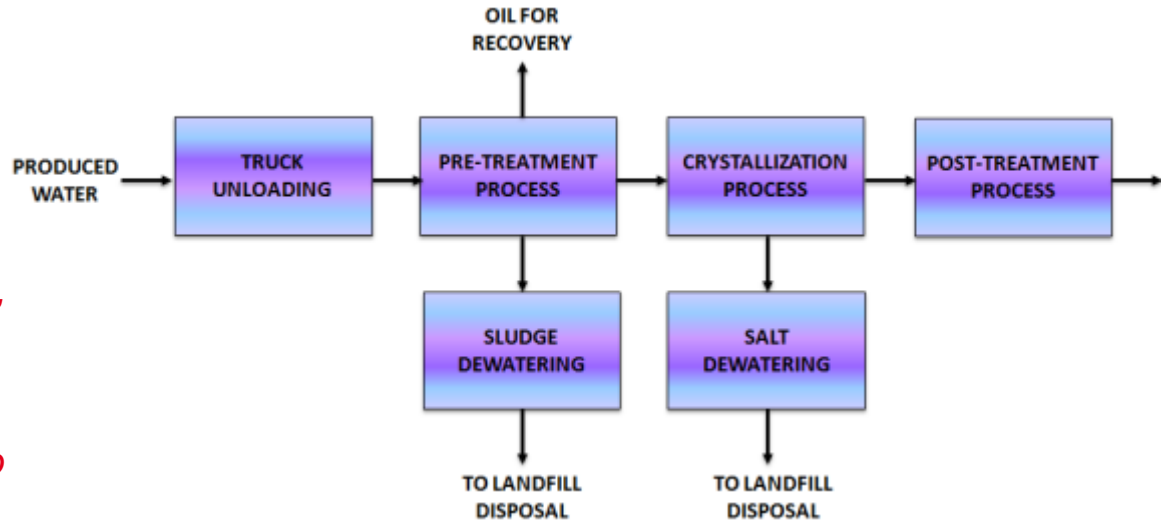
- Steam or Indirect Heat Pump*

- Low Operating temperature

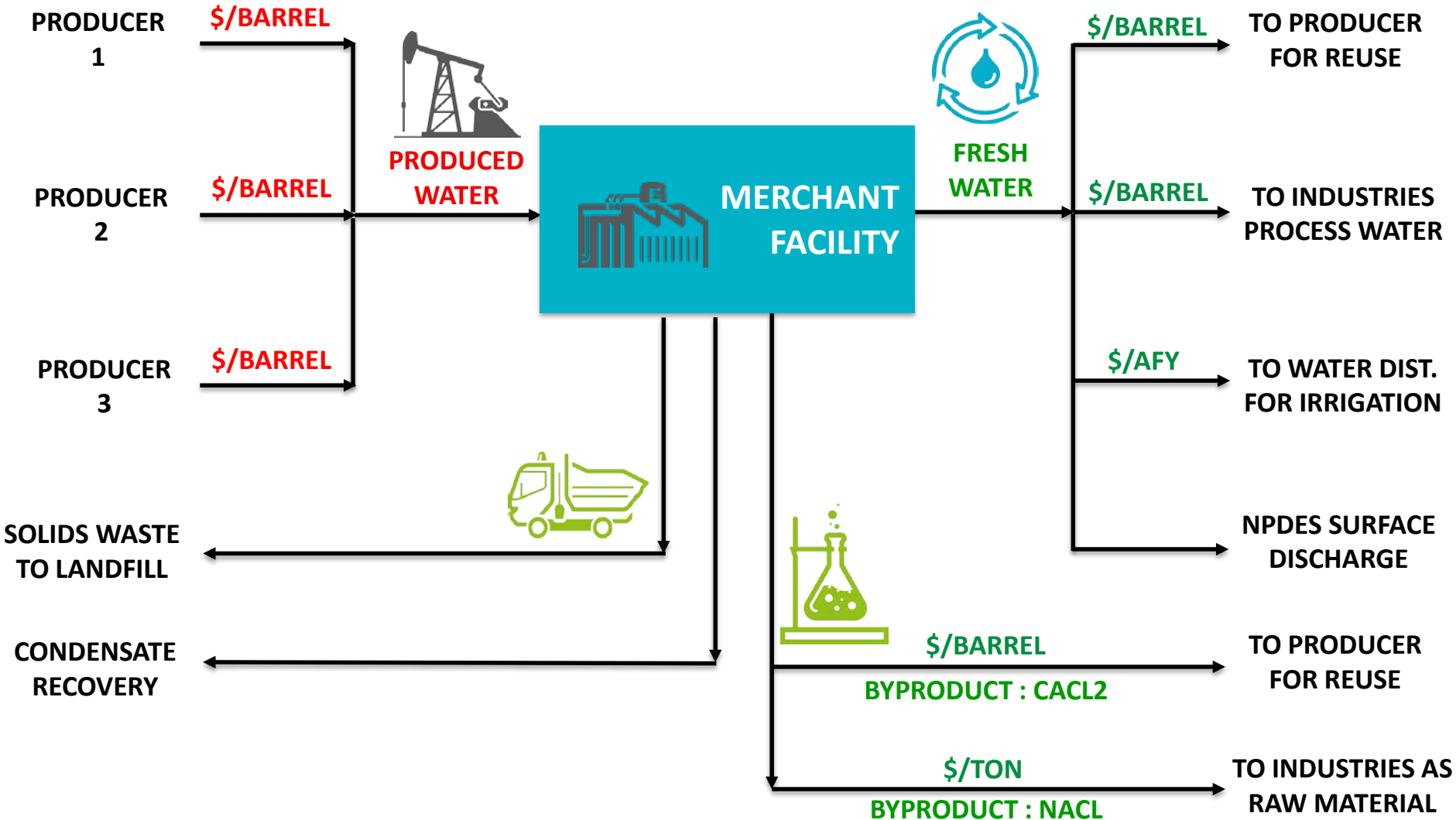
- Lowers the solubility of Salts*
- Crystallize at a lower concentration*

- Key Advantages

- Low Pretreatment Costs*
- No Calcium Removal in Pretreatment*
- Less Chemicals, Less Sludge*
- Lower Energy Requirement*
- Robust Treatment System*



Veolia Merchant Facility



Merchant Facility - Commercial Structure



- **Centralized water treatment**
- **Facility Owned by Veolia**
- **Design, Build, Operate by Veolia**
- **Service fee (\$/barrel) approach**
- **Short term contract structure**
- **Designed to handle variability**
- **Title transfer at facility inlet**
- **Availability based on market**

Merchant Facilities - Commercial Benefits



- No capital outlay required
- No long term volume commitments
- No risks with utility consumption (chemicals)
- Transfer risk & liability with disposal of produced water
- Economies of size - large centralized regional facility
- Speed to market - faster delivery permitting production increase
- One stop shop for disposal of prod. water /purchase fresh water

Merchant Facilities - Environmental Benefits



- **Minimize Injection Volumes**
- **Minimize Seismicity induced due to Deep Well Injection**
- **Minimize dependency on Class-II Injection Wells**
- **Sustainable solution - enables reuse of produced water**
- **Generates fresh water from produced water**
- **Recovery of valuable by-products from produced water**
- **A reliable solution for disposal of produced water**