WORLD SALT SYMPOSIUM

June 19-21, 2018 Park City UT, USA

Extraction of Sodium Chloride and Calcium Chloride From Oil and Gas Produced Waters

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Williamsport, PA

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Background and Philosophy

- Eureka is a pioneer and leader in development of innovative, cost-effective, and environmentally-responsible solutions for management of produced waters from unconventional oil and gas development.

- Permit/design/build/operation of robust, centralized produced water management facilities with the following goals and objectives:

  - **Level-of-treatment optionality:**
    - Pretreated Brine - water treated to reduce the suspended solids; some dissolved solids.
    - Distilled Brine - water treated to remove dissolved solids
    - Concentrated $CaCl_2$ Brine - heavy (over 10.5 pounds per gallon) water that is very high in dissolved solids
    - Freshwater - water that meets freshwater standards (secondary drinking water standards).

  - **Disposal-level treatment:**
    Ability to convert produced water to freshwater.

  - **Extraction of saleable co-products:**
    Maximizing recovery and beneficial reuse of recoverable co-products, such as methanol, sodium chloride (salt), calcium chloride, and lithium chloride.

  - Approaching **TRUE** Zero Liquid Discharge (ZLD).

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The Eureka Solution to Produced Water Management

- Eureka remains the **only** treatment/disposal company in Marcellus play certified by the *Center for Responsible Shale Development (CRSD).*
- Eureka is the only **proven** option for returning flowback and produced water to the hydrologic cycle **allowing producers to reduce their environmental footprint.**
- Eureka "upcycles" oil and gas waters by selectively removing impurities and generating marketable co-products like pool salt and calcium chloride brine for drilling and completions operations, allowing for **cost-effective produced water management**
- Eureka's approach is the only long term, **sustainable solution** for the treatment of large volumes of produced water **as oil & gas basins mature and injection or reuse is no longer capable** of handling large produced water volumes

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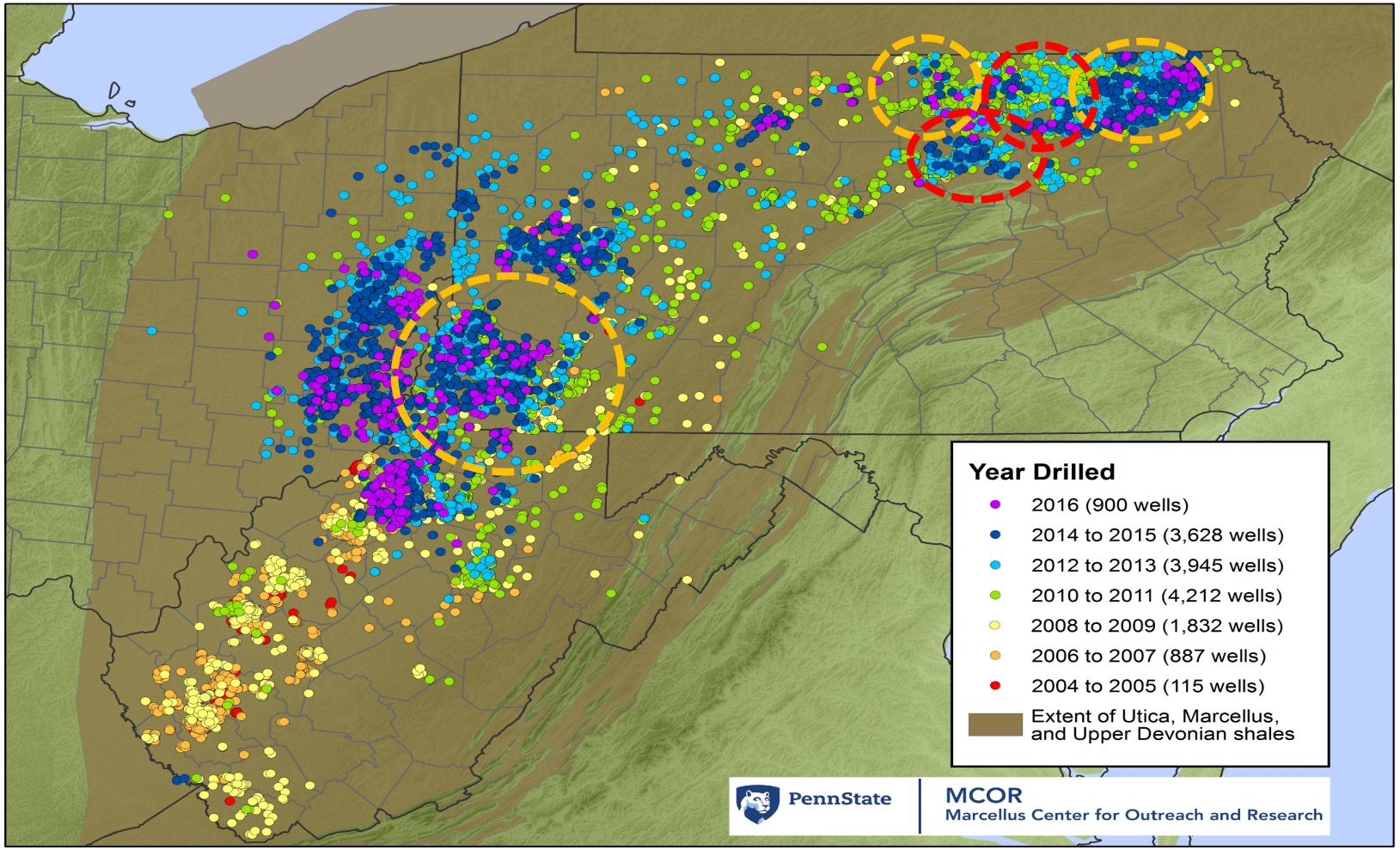
Unconventional Wells Drilled by Year



Existing plants and approximate watersheds served

Proposed facilities and approximate watersheds to be served

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Existing Facilities

Standing Stone, PA Facility

- 10,000 BPD (420,000 GPD) capacity
- 2,400 – 4,800 BPD MVR distillation
- 5,000 BPD NaCl MVR crystallization
- Eureka patented freshwater treatment process
- NPDES discharge to Susquehanna River
- Evap NaCl salt drying and packaging line.
- Concentrated $CaCl_2$ brine management

Reach Road Facility, Williamsport, PA

- Truck unloading / storage
- Future rail access
- Fully permitted site with potential discharge capability

Second Street Facility, Williamsport, PA

- 10,000 BPD capacity
- 2,400 to 4,800 BPD MVR distillation
- Indirect discharge of distillate to POTW
- Oil Recovery
- Methanol Rectification

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Application in Other Unconventional Plays

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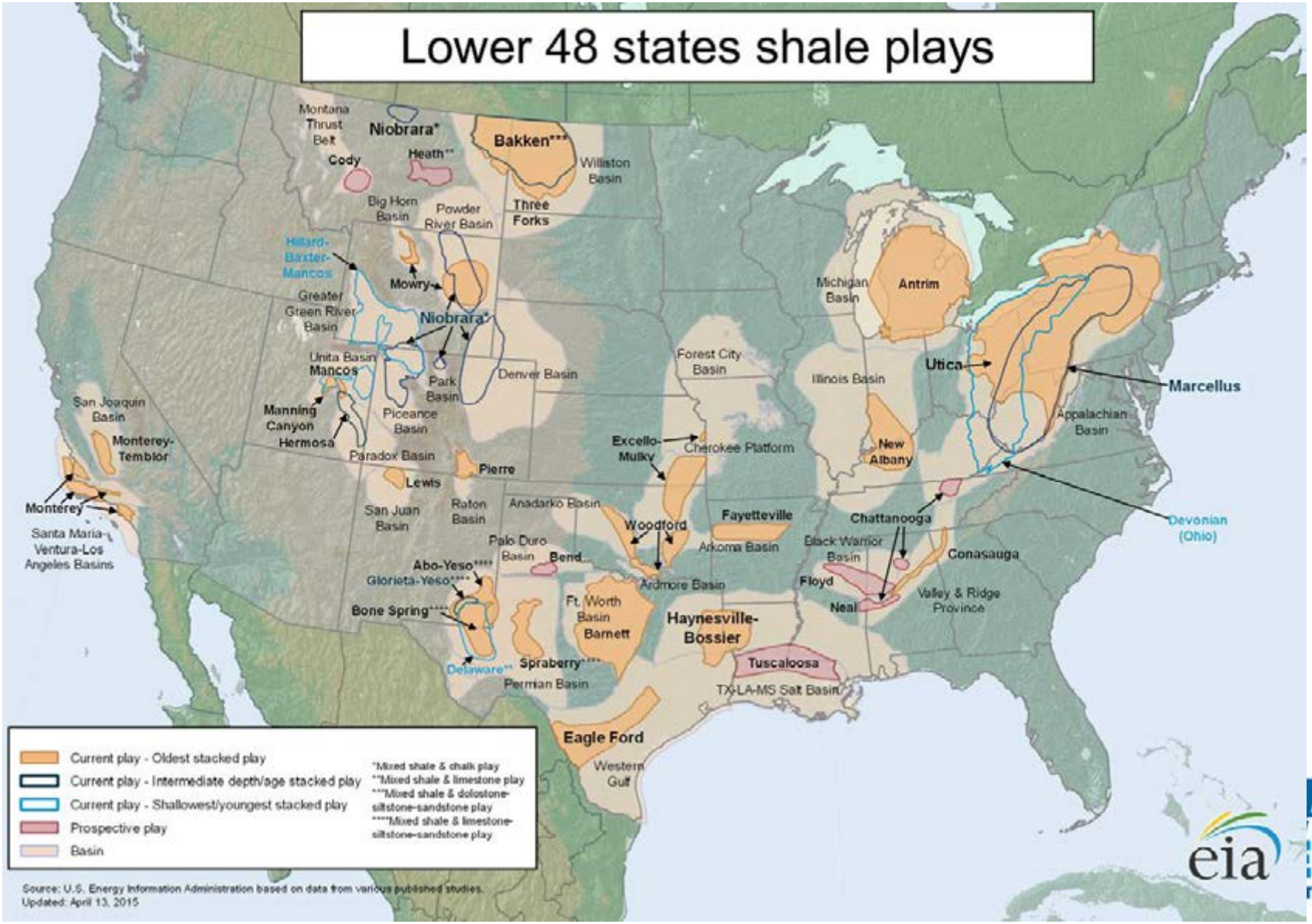

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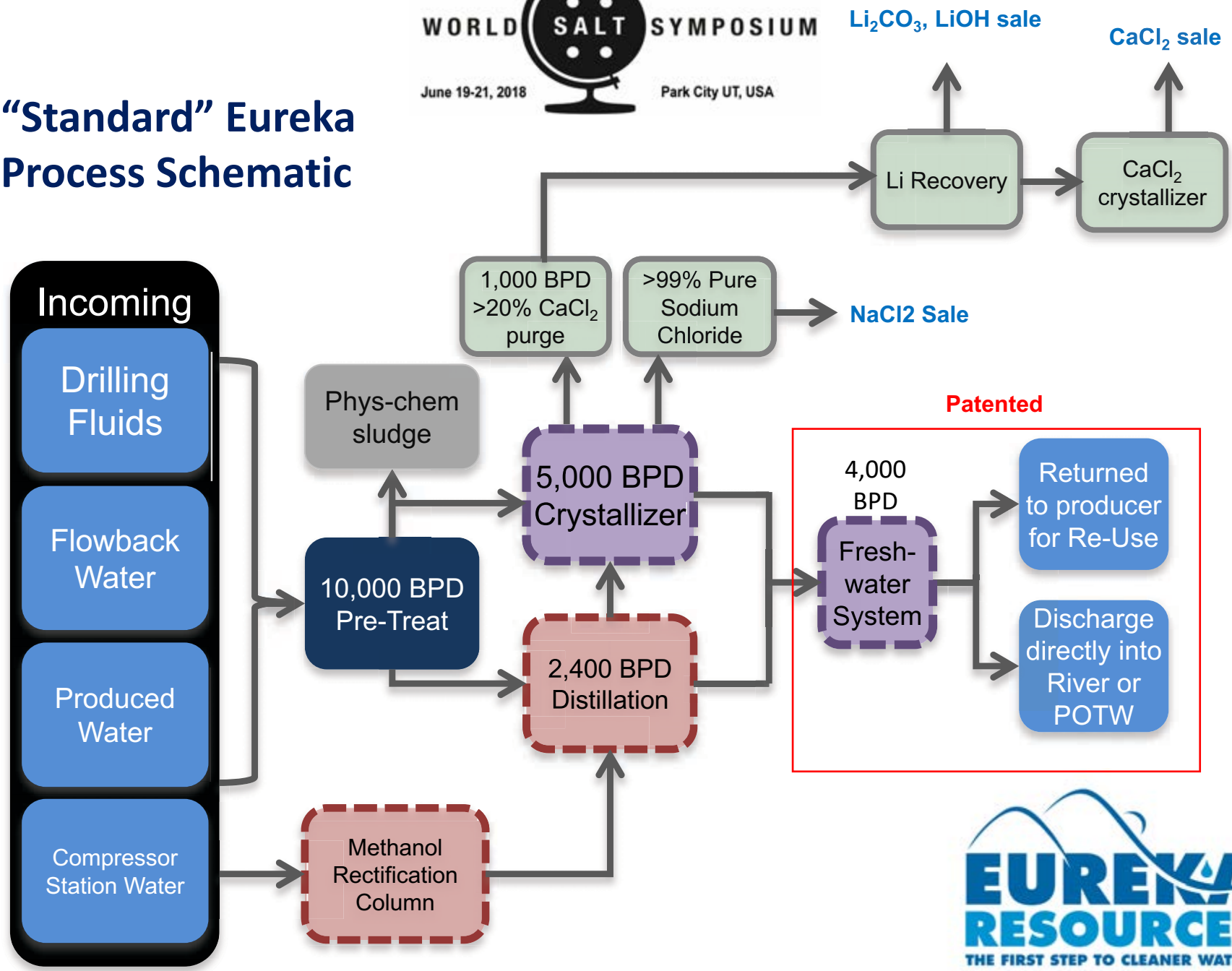
"Standard" Eureka Process Schematic



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Drivers For Technology Selection

- **Regulatory Drivers:**
  - Evolving regulatory requirements
- **Business Drivers:**
  - Maximizing recovery of valuable co-products
  - Applying a level of treatment that allows return of water to the hydrologic cycle
  - Minimizing risks associated with transport/storage of produced waters by E&Ps
  - Providing a sustainable choice for produced water management when injection is not an option, reuse opportunities diminish, or water supply is limited
- **Performance Drivers:**
  - High energy efficiency
  - Ability to handle a wide range of feed qualities
  - Ability to capture condensate
  - Potential for expansion in a sequential/modular fashion to achieve recovery of multiple co-products

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Lessons Learned During Implementation of Crystallization Technology

- **Mechanical Vapor Recompressions (MVR) Crystallizer Technology Vendor Selection:**
  - Domestic vs. Foreign Vendors
  - Blowers Versus Turbo-Compressors
  - Turn Down
  - Building Codes/Certifications
  - Materials of Construction
  - Fabrication
  - Boundary Limits
- **Safety**
- **Co-Product Quality Control**
- **Condensate Management**
- **Co-Product Market Development**
- **Co-Product Management**

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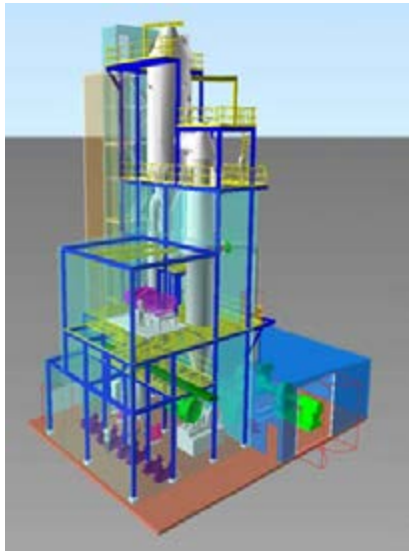
Co-Products

- **Freshwater** – water treated through Eureka's entire treatment process and available for reuse, storage in freshwater impoundments or discharge to a surface water body (return to the hydrologic cycle)
- **Methanol (MeOH)** – methanol recovered primarily from compressor station waters for reuse by oil and gas companies as well as other industrial /commercial customers
- **Sodium Chloride (NaCl)** – evaporated, dried salt
- **20% Calcium Chloride ($CaCl_2$) Brine** - Brine purge from the NaCl crystallizer process targeted for recycle uses within the oil and gas industry.



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Evaporated Salt Drying and Packaging

- Multi-year deal in hand with a large distributor of NaCl in North America.
- Rotary salt drying and automated bagging processes (20 t/hr nameplate capacity).
- Currently generating 100 – 125 pallets/day of bagged product.

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Co-Product Determination
NaCl Chemical Equivalency Demonstration

The chemical evaluation approach involved characterization of the following:

- Eureka's crystallized salt
- Bulk stockpiled road salt samples
- Bulk stockpiled "solar salt" samples
- Commercially-saleable bagged sodium chloride deicing rock salt, water softening salt, and pool salt.
- Bulk sodium chloride material from a commercial/industrial using salt as a raw material in PA

- The levels of analytical constituents in the NaCl co-product produced via Eureka's process were lower, or comparable to, levels in the comparative samples of NaCl products.

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Conclusions/Takeaways

Eureka's experience to date extracting co-products and generating freshwater from produced waters has indicated the following:

- **Full-scale demonstration of a sustainable business model for management of oil and gas produced waters**, including locating centralized treatment facilities, employing crystallization and a group of supporting technologies that maximize potential for recycle and beneficial reuse, in close proximity to major fairways of development. This model minimize logistics and associated costs for E&P companies, is an especially-attractive model when underground injection capacity or supplies of freshwater are limited.

- **Eureka has learned many valuable lessons through design-build-operation of centralized facilities for management of oil and gas produced waters** implementing crystallizer technology, which can streamline future application of such systems in other locations/basins.

- **Eureka has 10 years of successful experience managing complex unconventional oil and gas produced waters** utilizing a business model that provides:
  - A wide array of treatment and co-product recovery options.
  - Options for selecting the level of treatment necessary to optimize reuse options and reducing the environmental impact on the hydrologic cycle.
  - Beneficial reuse opportunities for co-products extracted from oil and gas produced waters.
  - A forward-thinking strategic position designed to stay at the forefront of emerging regulatory requirements; promoting a close dialogue with state regulators regarding the development of regulations and standards.

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