NORTH DAKOTA BRINE EXTRACTION AND STORAGE TEST AND WATER TREATMENT TEST BED FACILITY

2018 Annual Review Meeting for Crosscutting Research
Pittsburgh, Pennsylvania
April 10, 2018

Cooperative Agreement No. DE-FE0026160
Project Period: Phase I (BP1) – September 1,2015 – July 6,2016
Phase II (BP2–BP4) – July 7, 2016 – July 6, 2020

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Principal Engineer
Energy & Environmental Research Center

Critical Challenges. **Practical Solutions.**

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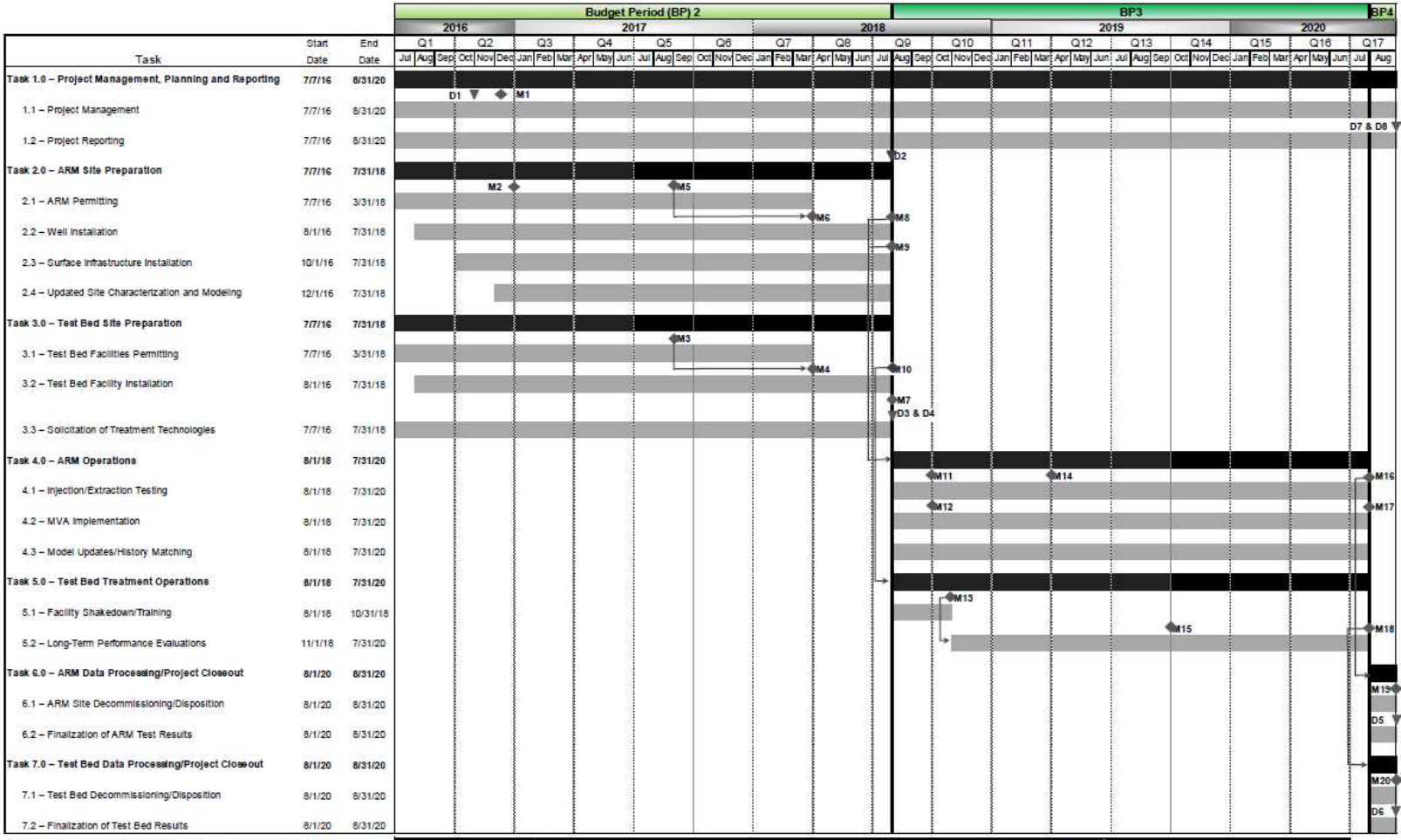
PROJECT OVERVIEW – GOALS AND OBJECTIVES

- Confirm efficacy of Active Reservoir Management
  - Brine extraction as a means of managing formation pressure and the injected fluid plume
  - Predicting and monitoring plume movement
  - Validating pressure and brine plume model predictions

- Implement and operate a test bed facility for the evaluation of selected brine treatment technologies

- Three development stages over 48 months
  1. Site preparation and construction
  2. Site operations including ARM and extracted brine treatment technology testing and demonstration
  3. Project closeout/decommissioning and data processing/reporting

Gantt Chart, Deliverables, and Milestones



Note: The contract modification for Phase II was fully executed on September 9, 2016.

Deliverables ▼

- D1 – Updated PMP
- D2 – Field Implementation Plan (FIP) Finalized
- D3 – Water Treatment Technology Selection Process Summary
- D4 – Preliminary Schedule of Technologies
- D5 – Vol. 1 – ARM Engineering and Evaluation Summary
- D6 – Vol. 2 – Technology Evaluation Report
- D7 – Data Submission to EDX
- D8 – Lessons Learned Document

Key for Milestones (M) ◆

- M1 – Project Kickoff Meeting
- M2 – Permit to Drill Submitted
- M3 – Water Treatment Test Bed Permit Received
- M4 – Start Water Treatment Facilities Construction
- M5 – Permit to Drill Received
- M6 – Start Site Preparation
- M7 – First Treatment Technology Selected
- M8 – Well Installation Complete
- M9 – Surface Installation Complete
- M10 – Water Treatment Facilities Complete
- M11 – Initiate Stage 1 of Experimental Scenario
- M12 – Initiate Collection of Operational Data
- M13 – Water Treatment Test Bed Fully Operational
- M14 – Initiate Stage 2 of Experimental Scenario
- M15 – First Treatment Technology Evaluated
- M16 – Completion of ARM Operations
- M17 – Conduct Repeat BSEM Survey
- M18 – Completion of Water Treatment Technology Demonstration
- M19 – ARM Site Decommissioning/Disposition Completed
- M20 – Water Treatment Test Bed Decommissioning/Disposition Completed

11.29.17 hmv

PARTNERS

U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

EERC

Nuverra Environmental Solutions

CMG

Schlumberger Carbon Services

MAJOR CONTRACTORS

AE2S CONSTRUCTION

AE2S INDUSTRIAL

HAM'S WELL SERVICE WESTHOPE, ND

CONSIDERATIONS OF COMMERCIAL GEOLOGIC CO_2 STORAGE SITES

- Buoyant fluid
- Large volumes = large footprint
- Regulatory compliance, liability, cost
- Conformance and utilization efficiency
- Access to pore space
  - Leasing, unitization/amalgamation, trespass
- Assuring permanence and credits

Because of a host of technical, social, regulatory, environmental, and economic factors, brine disposal tends to be more accessible and generally quicker, easier, and less costly to implement compared to dedicated CO_2 storage.

BRINE EXTRACTION FOR PRESSURE MANAGEMENT

- Incremental cost
  - Wells and infrastructure
  - Operating and energy
- Disposal of extracted brine
  - Treatment and discharge
  - Reinjected into a <u>different</u> suitable geologic formation
- Efficiency losses
  - bbl_{out} > incremental bbl_{in}
- Complicates project
- Additional health, safety, and environmental risk

Brine extraction can enable dedicated CO_2 storage and improve the geologic CO_2 storage potential of a site.

TWO COMPLEMENTARY COMPONENTS

ARM Test

- Reduce stress on sealing formation
- Geosteer fluid plume
- Divert pressure from leakage pathways
- Reduce area of review (AOR)
- Improve injectivity, capacity, and storage efficiency
- Validate monitoring techniques, and forecast model capabilities

Brine Treatment Test Bed

- Alternate source of water
- Reduced disposal volumes
- Salable products for beneficial use

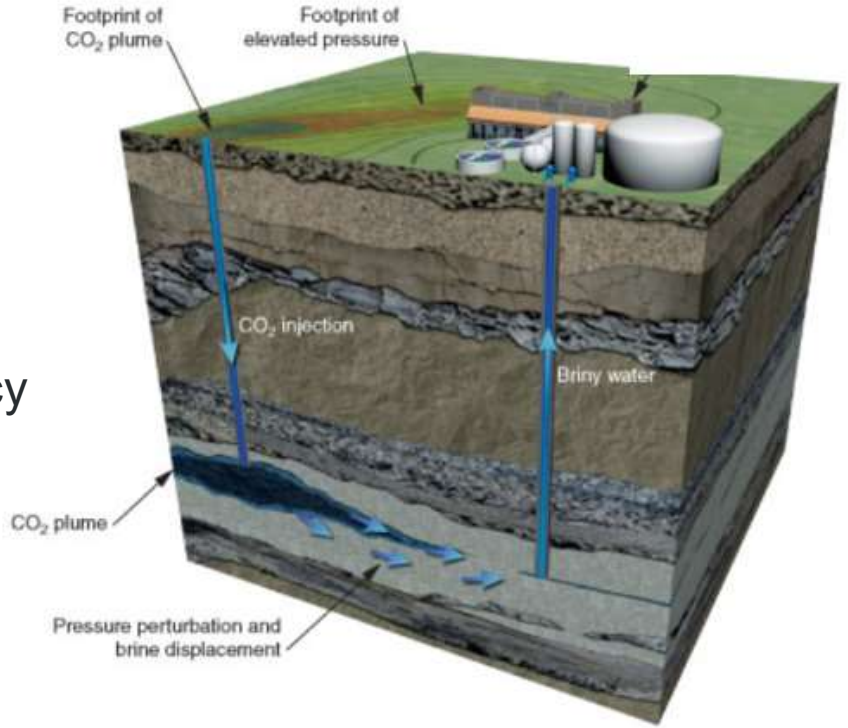
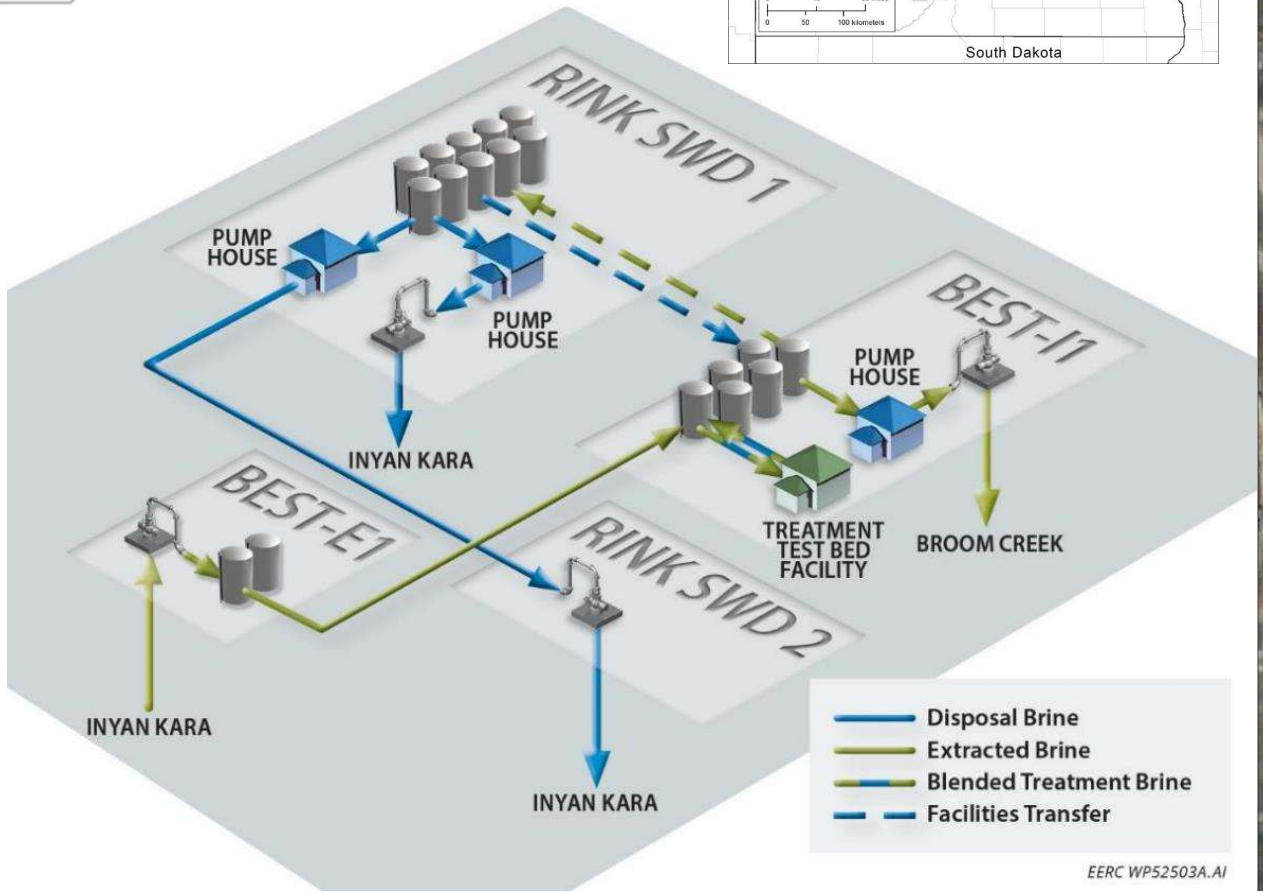


Illustration modified from Lawrence Livermore National Laboratory https://str.llnl.gov/Dec10/aines.html

ACTIVE WATER DISPOSAL SITES AS A PROXY FOR DEDICATED CO_2 STORAGE

THE SITE



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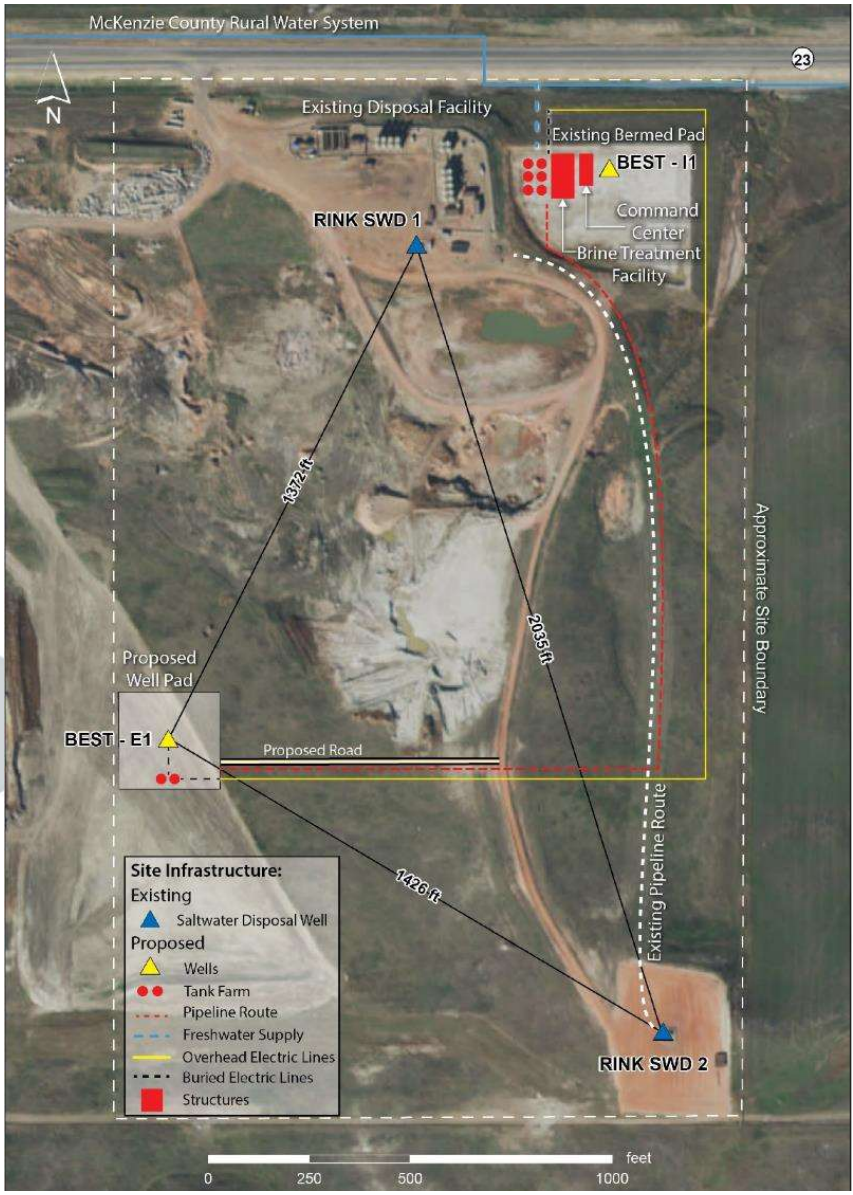


TECHNICAL STATUS

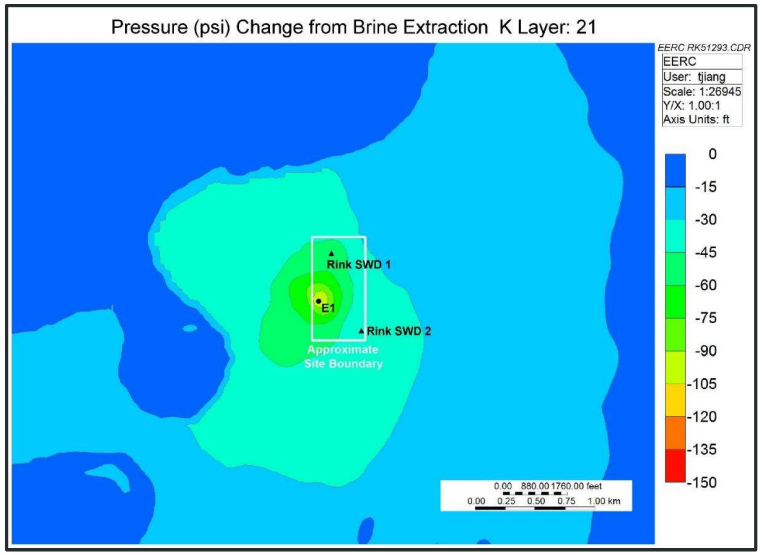
Phase I – Complete

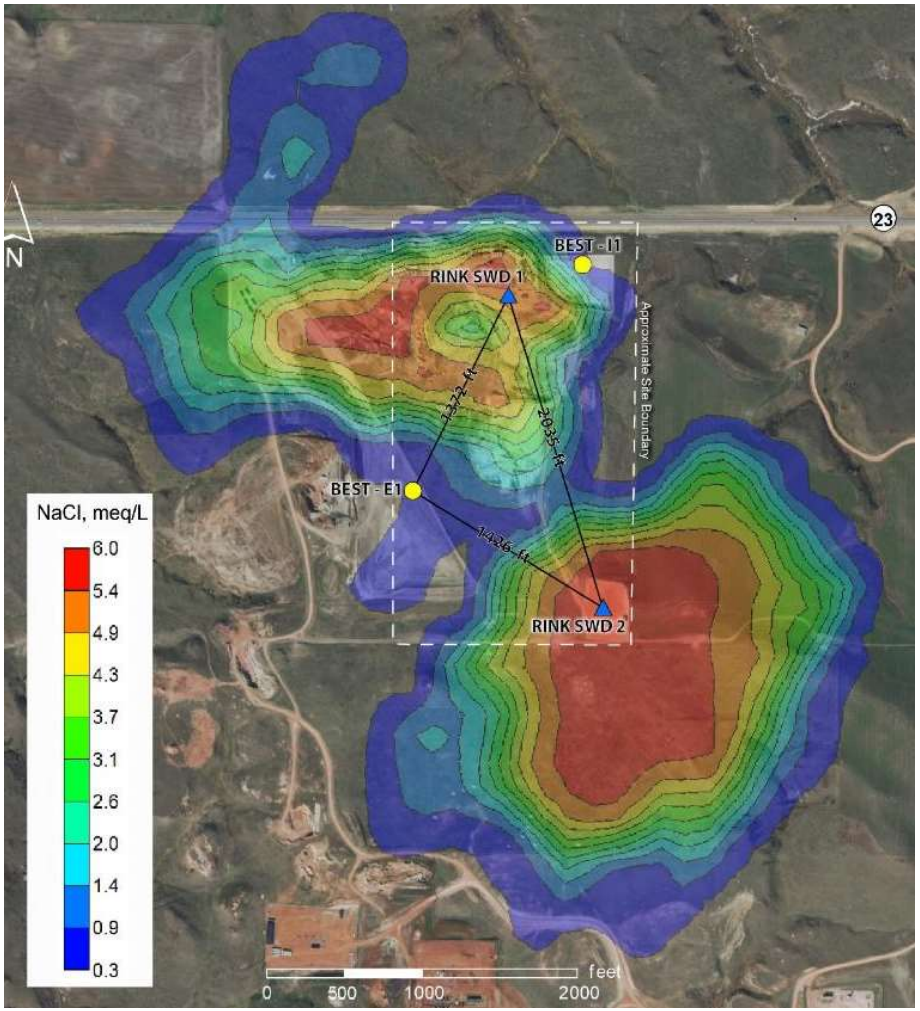
- Regional characterization
- Site screening and feasibility study
- Site selection
- Geologic modeling
- Reservoir simulation resulting in ARM schema
- Site infrastructure design and field implementation plan

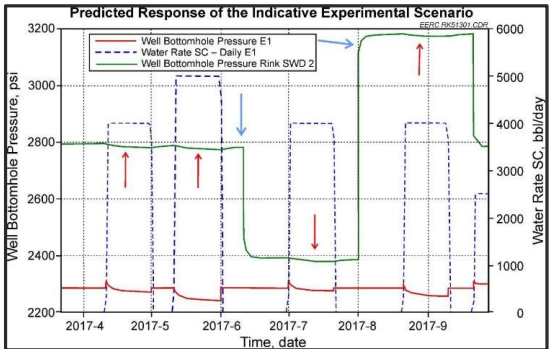
Phase II – Under Way

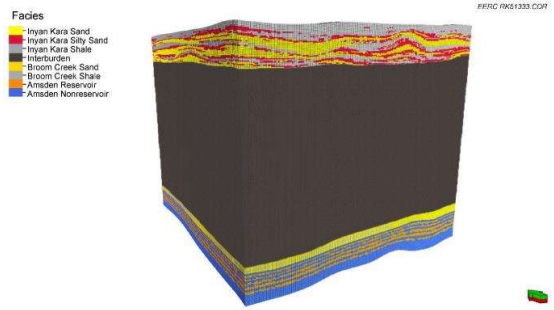
- ARM site preparation
  - Permitting
  - Well drilling
  - Surface infrastructure installation
  - Site characterization/model updates
- Test site preparation
  - Permitting
  - Test bed facility installation
  - Solicitation of treatment technologies
- ARM operations
  - Injection/extraction testing
  - Monitoring, verification, and accounting (MVA) implementation
  - Model updates/history matching
- Test bed treatment operations
  - Facility shakedown/training
  - Long-term performance evaluations
- ARM site closeout
  - ARM site decommissioning
  - Finalization of ARM test results/ data
- Brine treatment test bed site closeout
  - Treatment test bed decommissioning
  - Finalization of test bed results/ data

THE DESIGN (BALANCE)

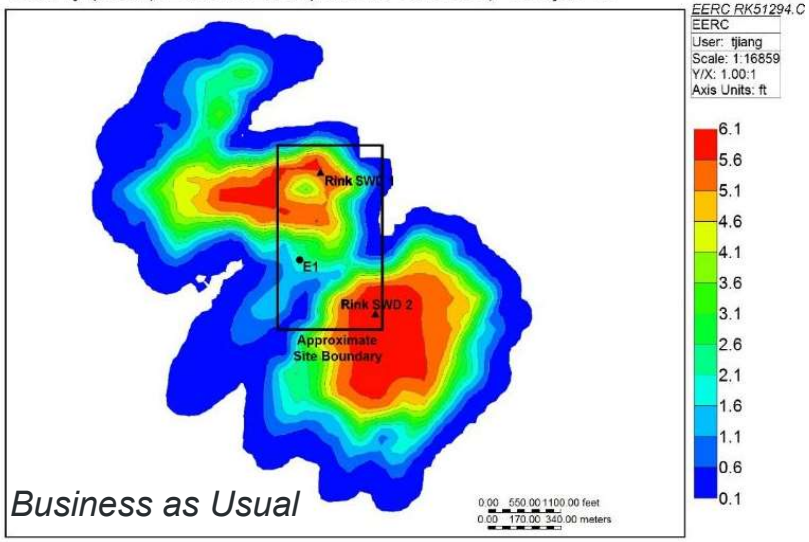




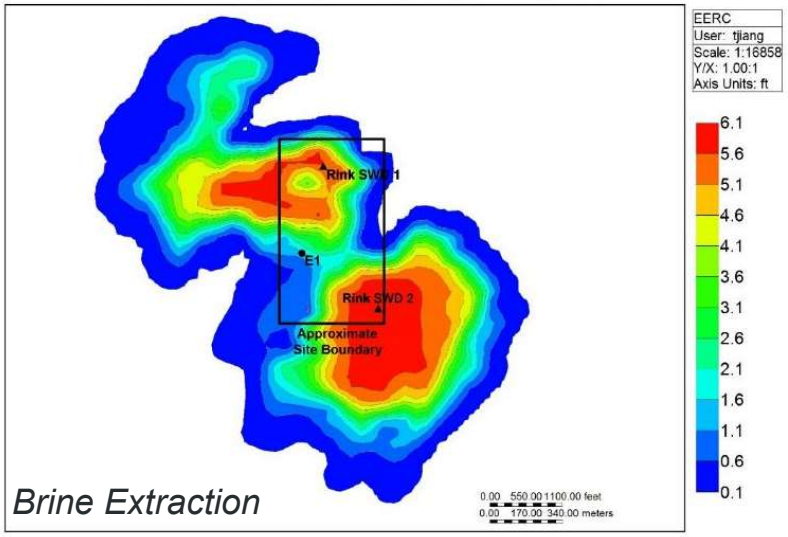




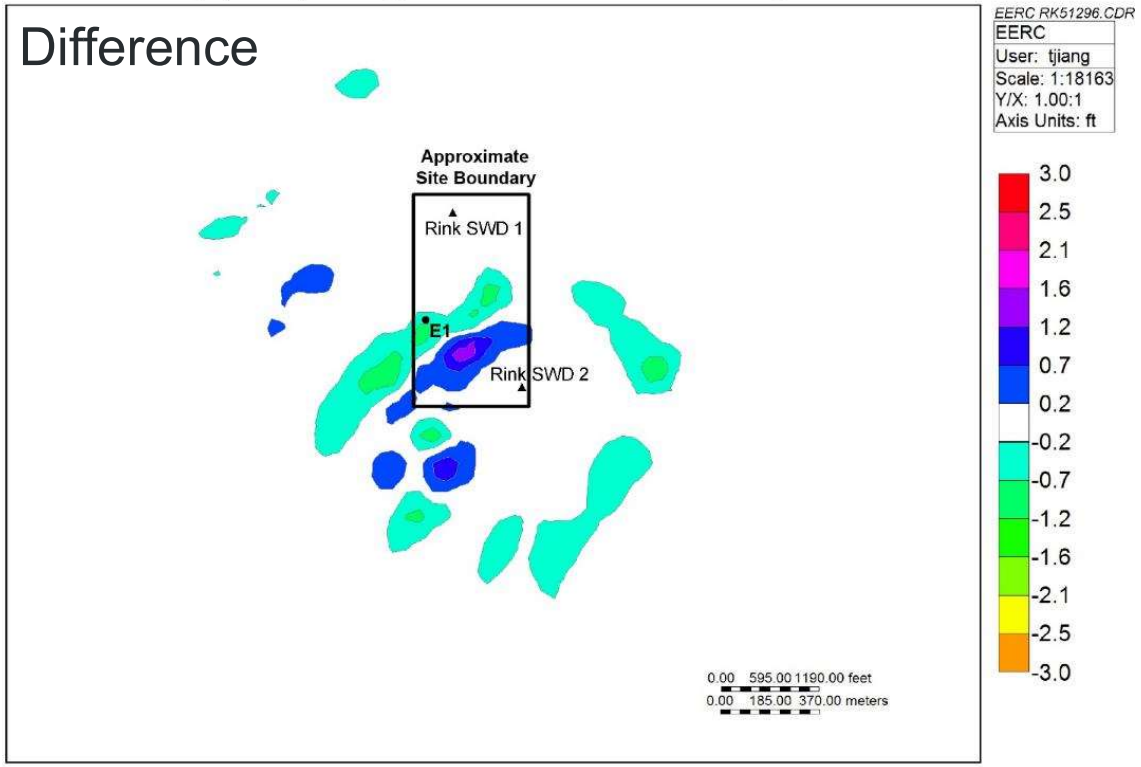
Salinity (molar) Plume at 2020 (no brine extraction) K Layer: 21



Salinity (molar) Plume after Brine Extraction K Layer: 21

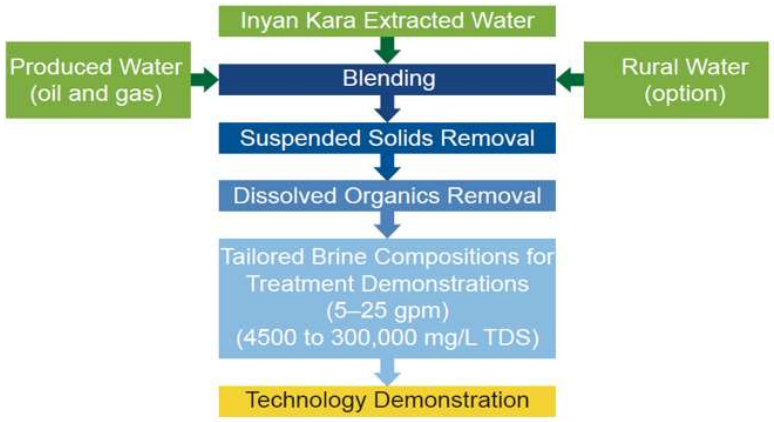


Salinity (molar) Change from Brine Extraction K Layer: 21



BRINE TREATMENT TEST BED

Enable development, pilot testing, and advancement of extracted and produced water treatment technologies that can meaningfully reduce brine disposal volumes and provide an alternate source of water and/or salable products for beneficial use.



WILLISTON BASIN
WATER TREATMENT TECHNOLOGY TEST BED

EERC UND NORTH DAKOTA · Nuverra Environmental Solutions · U.S. DEPARTMENT OF ENERGY · NETL NATIONAL ENERGY TECHNOLOGY LABORATORY

WE SEEK TO PILOT-TEST TECHNOLOGIES CAPABLE OF TREATING HIGH-TDS WATER.

TREATMENT AND HANDLING of high-TDS (total dissolved solids) waters associated with energy production are challenging and not readily or economically accomplished using conventional water treatment techniques. Geologic injection is often required to effectively manage fluids associated with electrical power generation, oil and gas production, and active reservoir management for geologic CO_2 storage.

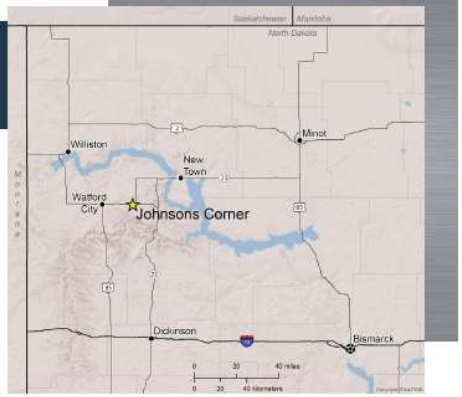
As part of a public–private collaboration, a facility is being constructed in western North Dakota to pilot-test high-TDS water treatment technologies that can:

- Produce alternate sources of water for industrial or domestic use.
- Produce salable products.
- Meaningfully reduce brine disposal volumes.

Pilot testing provides critical understanding of technology performance under field operating conditions. This understanding enables the advancement and commercial adoption of viable technologies capable of treating these challenging waters for beneficial use.

The Energy & Environmental Research Center (EERC) is seeking companies interested in pilot-testing water treatment technologies at the facility. This is a collaborative effort with Nuverra Environmental Solutions (Nuverra) and the U.S. Department of Energy (DOE) National Energy Technology Laboratory.

Conceptual extracted water treatment flow diagram.



The extracted water treatment test bed facility is located approximately 13 miles east of Watford City, North Dakota, immediately adjacent to North Dakota Highway 23 on the Johnsons Corner site, a Nuverra-operated commercial saltwater disposal (SWD) facility.

The test bed will feature the ability to blend extracted and produced waters in order to generate tailored brine compositions ranging from ~4500 to ~300,000 mg/L TDS. The facility is anticipated to be operational by summer 2018.

EERC engineering staff will be on-site during all demonstration activities to assist with connections to the test bed facility and to monitor and gather process performance data. Technology developers are expected to provide their own operations staff. During steady-state operation, EERC engineering staff will conduct energy and material balances (power consumption, process flows, and influent and effluent quality analyses).

A report summarizing demonstration activities and detailing performance data and technology capabilities will be prepared and submitted to DOE. Nondisclosure and site access agreements between the EERC, Nuverra, and technology developers will be negotiated prior to demonstration.

Currently, no guarantee is offered that DOE or other funding will be available to assist interested treatment technology developers. However, the field site and facilities for water treatment demonstrations, including potential cost offsets for power, cooling water, and effluent disposal, may be made available at no or reduced cost to selected demonstrations.

REGIONAL CHALLENGES: EXTRACTED WATER TREATMENT

Technological:

- Very high salinity brines (200,000 to >350,000 mg/L total dissolved solids).
- Potential for TENORM (technologically enhanced naturally occurring radioactive material) in treated concentrate streams.

Logistical:

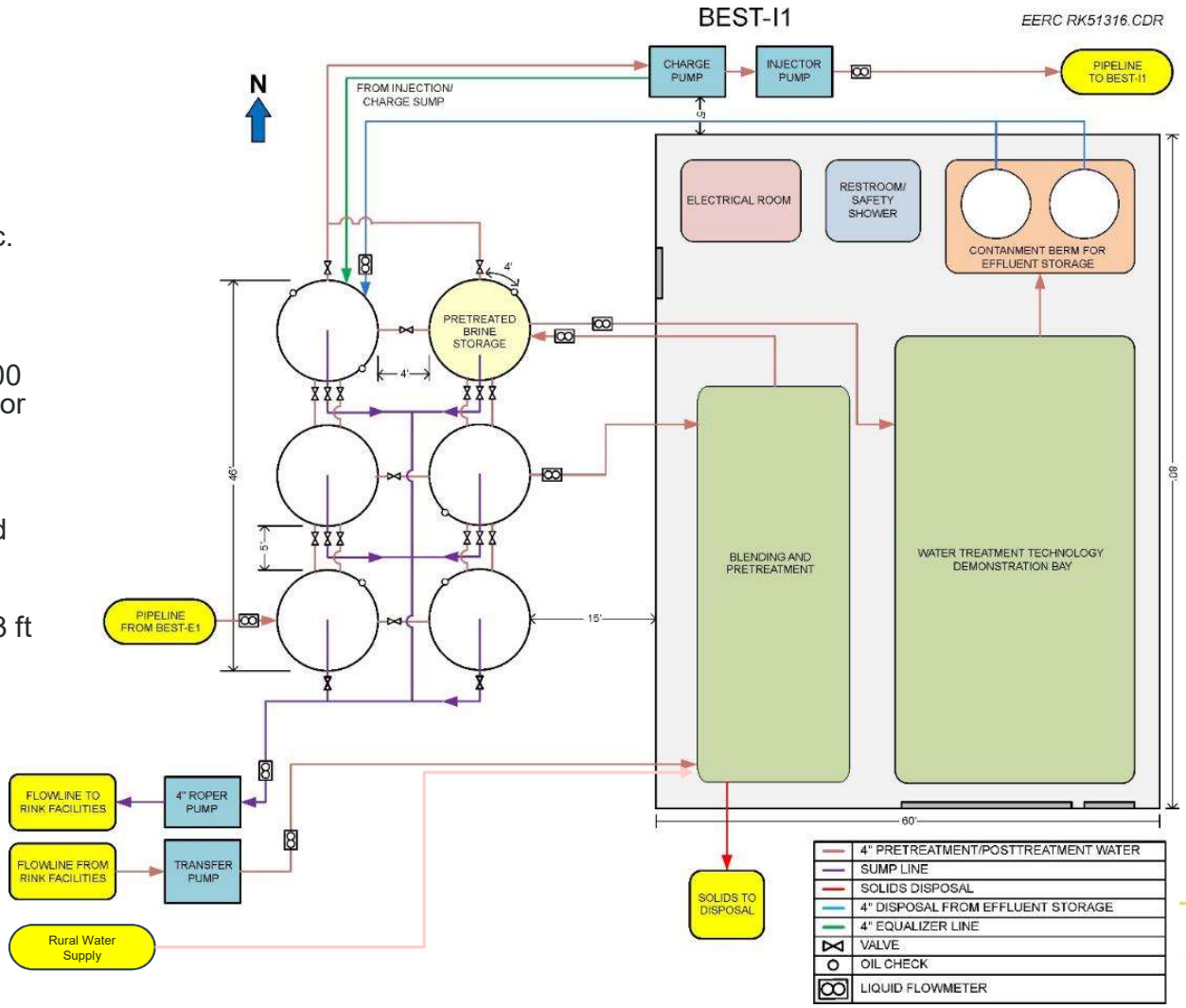
- Environmental conditions
  - e.g. **Winter!**
- Temporary storage

Economic:

- Geologic injection is cost-efficient and convenient.
- Freshwater is inexpensive and abundant.
- Moderate but growing demand for brine treatment

BRINE TREATMENT TEST BED

- Permanently installed, heated enclosure with a concrete floor integrated with ARM-related infrastructure
  - 30–60⁺-day extended-duration tests
  - 24/7/365 operations-capable
  - Monitoring of energy, flow, chemical usage, etc.
  - Waste management
- Pilot treatment rates ranging from 5 to 25 gpm
- Pretreatment
  - Blending of water to target TDS level of 180,000 mg/L or tailored blends to suit capabilities and/or limitations of selected technologies
  - Suspended solids removal (dissolved air flotation [DAF])
  - Dissolved organics removal (granular activated carbon [GAC])
- Technology demonstration bay
  - Accommodates standard semitractor trailer (53 ft long) inside the building
  - 300 kW electric power
  - Propane (5000-gal tank)
  - Noncontact cooling water (30 gpm)



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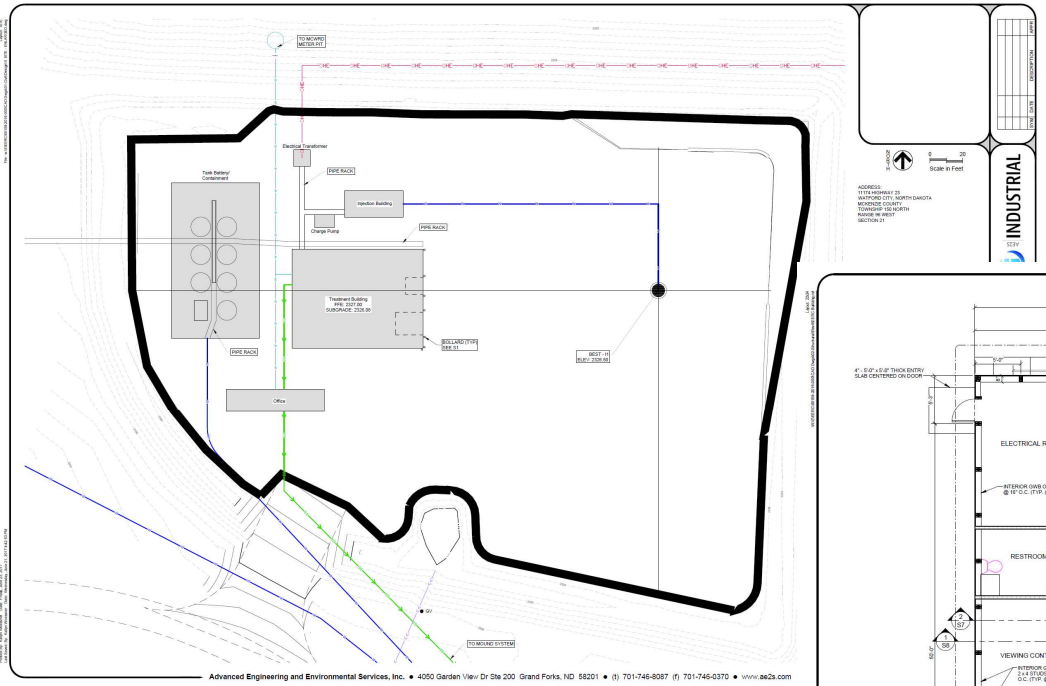
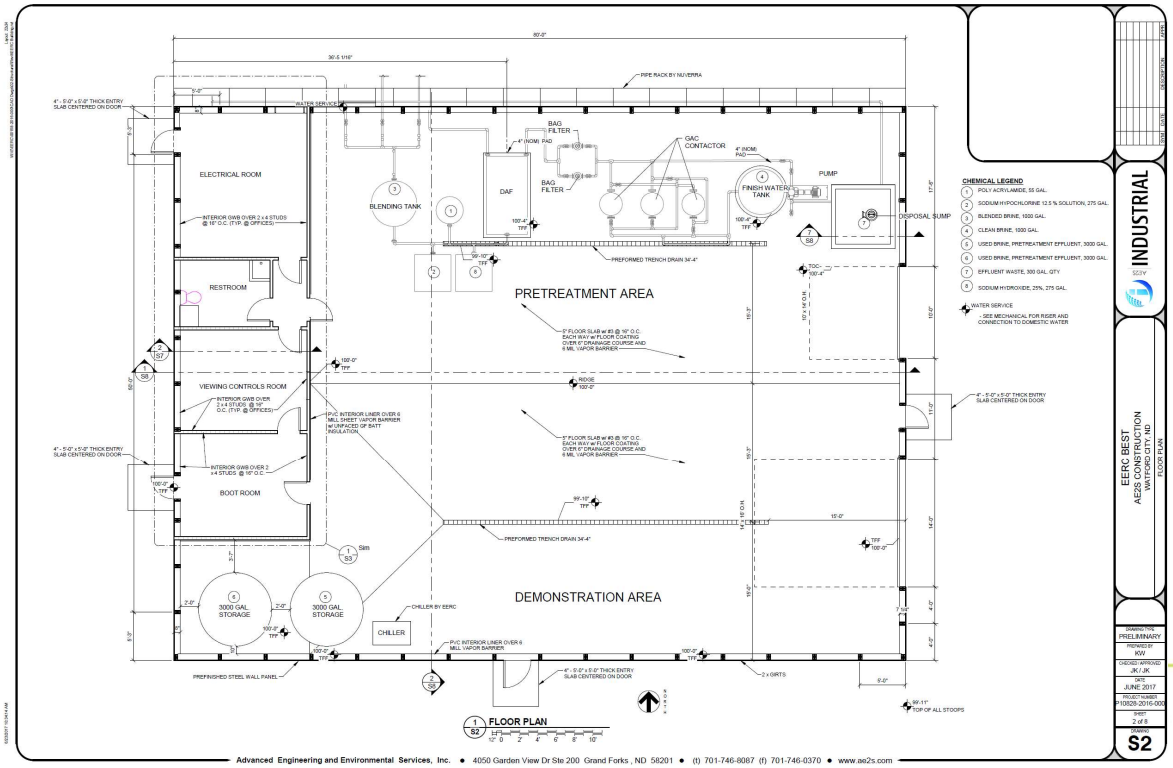
BRINE TREATMENT TEST BED





- 60 ft x 80 ft with 18-ft walls
- Two large overhead doors
- Climate controlled with air handling/exchange
- 53-ft test bay

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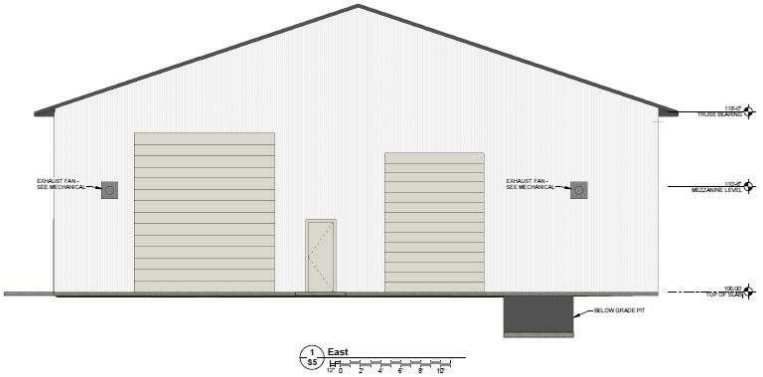
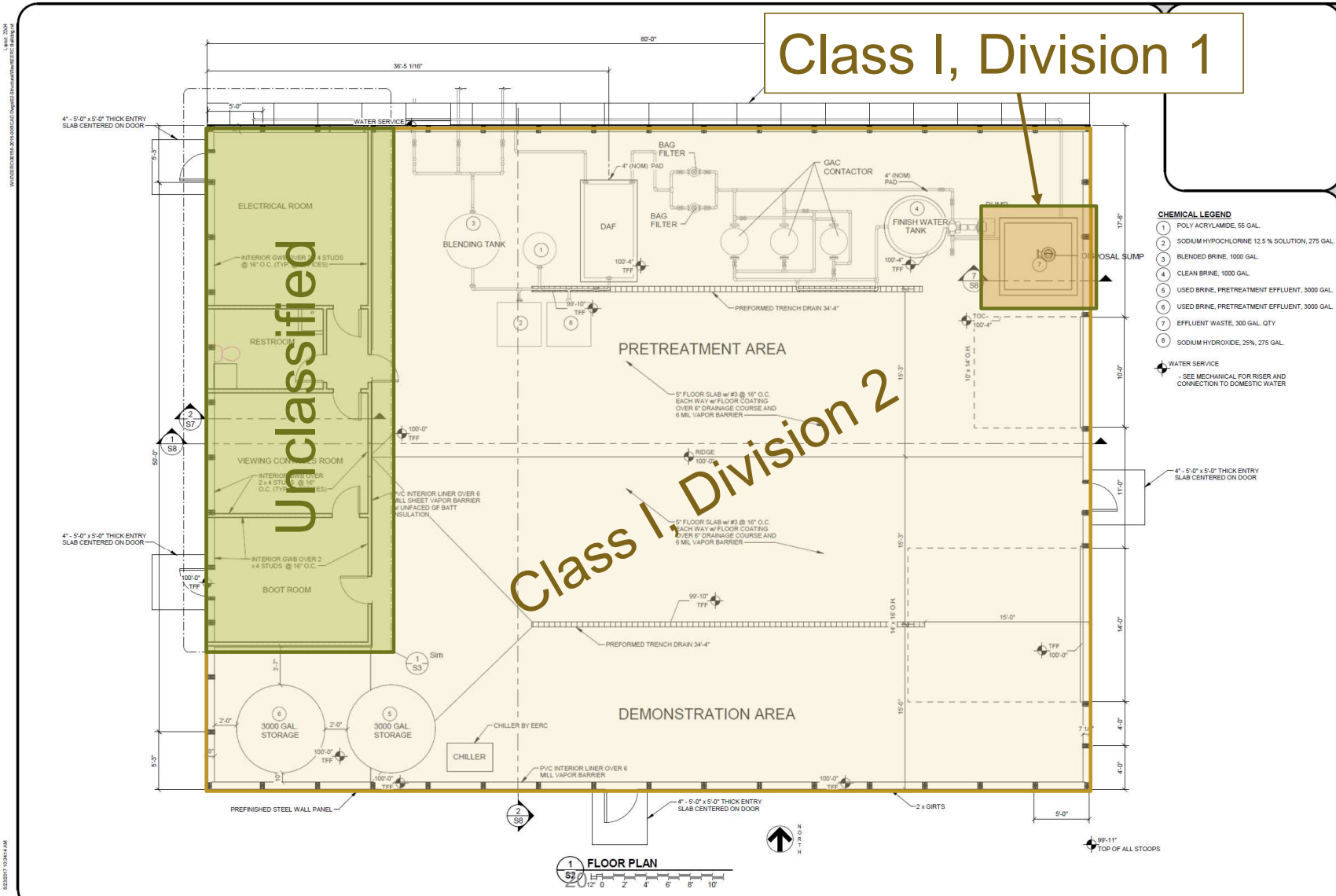

EXHAUST FAN -
SEE MECHANICAL
EXHAUST FAN -
SEE MECHANICAL
BELOW GRADE PIT
East



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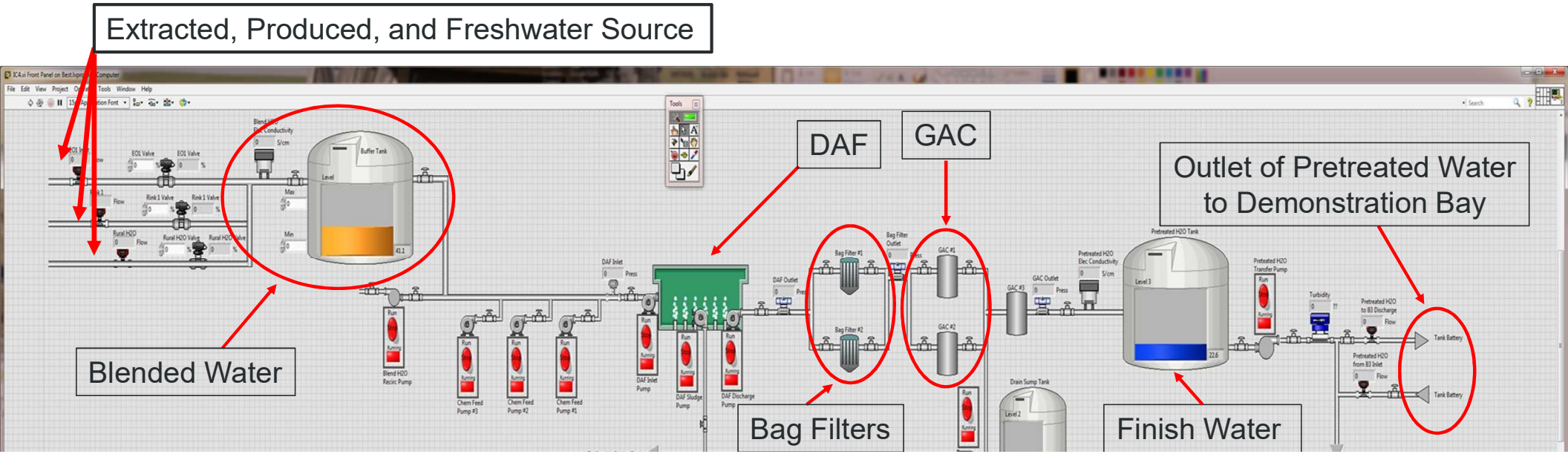
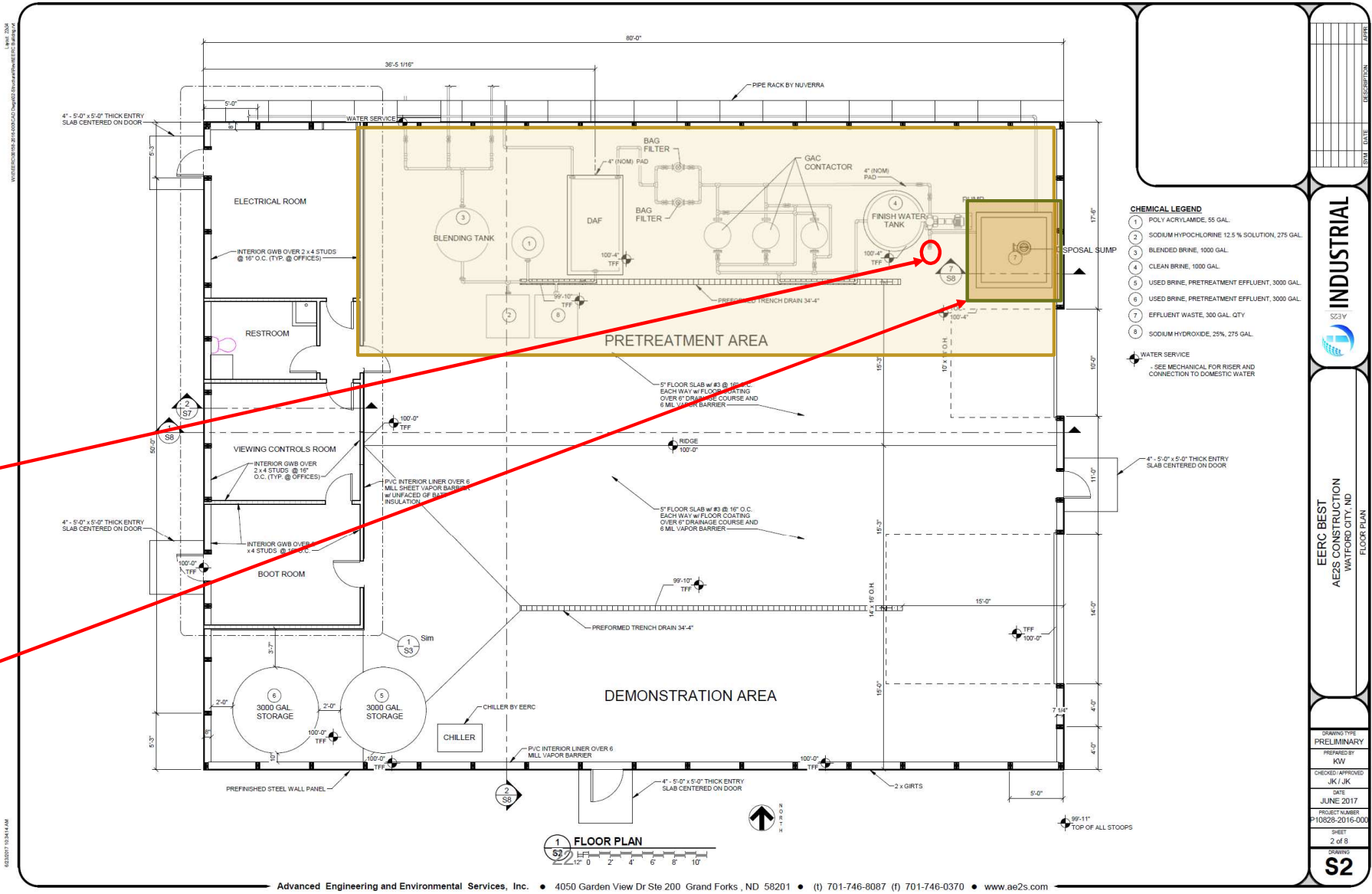
BLENDING AND PRETREATMENT

- Blending of water to target TDS levels of 180,000 mg/L or other tailored blend to suit capabilities and/or limitations of selected technologies.
  - Water blending will take advantage of a combination of produced water (~300,000 TDS), extracted formation water (~10,000-30,000 TDS) and freshwater sources available on site.
- Suspended solids removal (DAF).
- Filter bags
- Dissolved organics removal (GAC).



Pretreated Water Supply Outlet

Effluent Waste Sump Disposal to Outdoor Tank Battery



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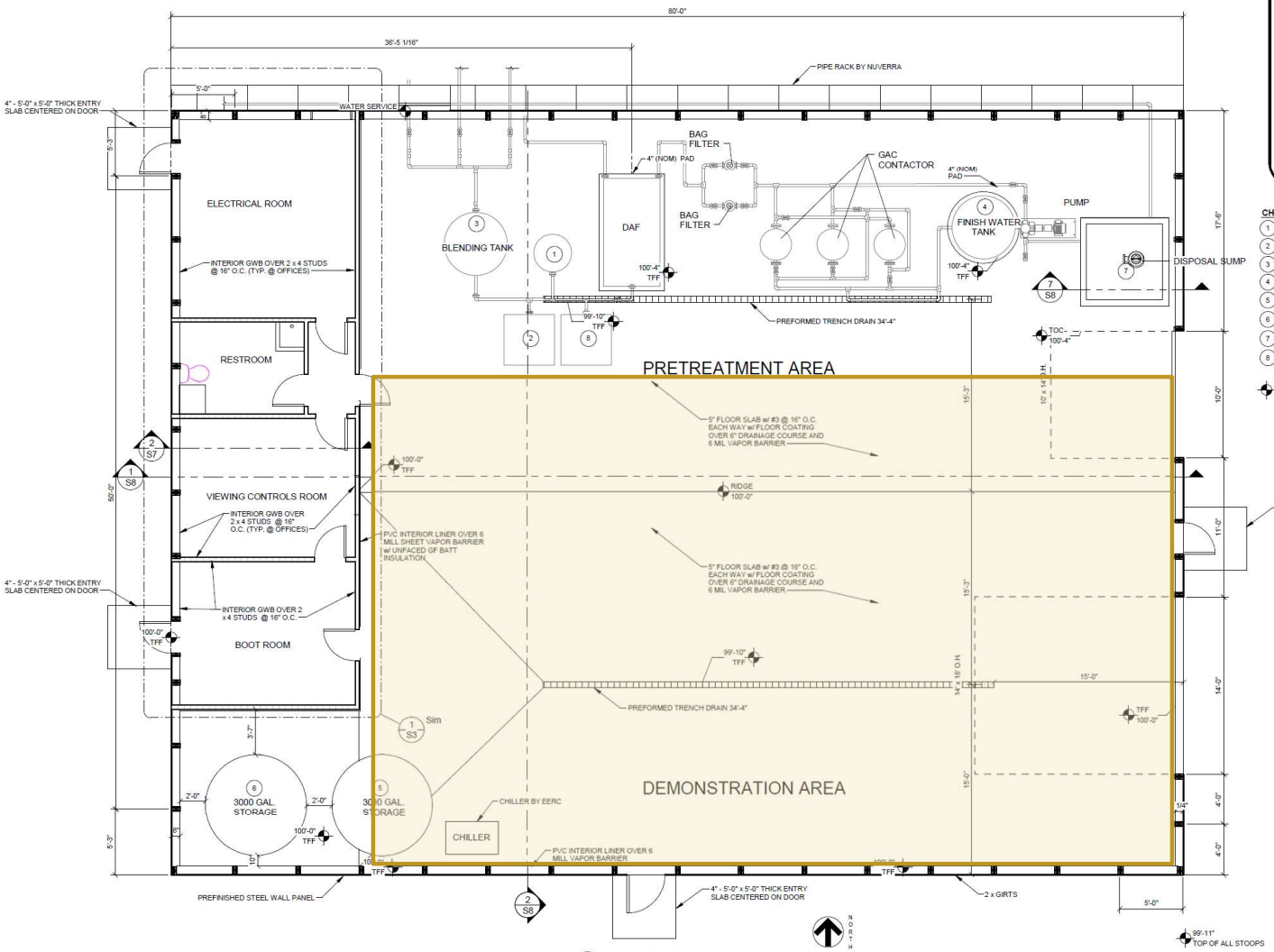
EERC BEST
AE2S CONSTRUCTION
WATFORD CITY, ND
FLOOR PLAN

INDUSTRIAL

DRAWING TYPE: PRELIMINARY
PREPARED BY: KW
CHECKED / APPROVED: JK / JK
DATE: JUNE 2017
PROJECT NUMBER: 10828-2016-000
SHEET: 2 of 8
DRAWING: S2



1 FLOOR PLAN S2
1/2" 0 2' 4' 6' 8' 10'

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NO	DESCRIPTION	DATE

AE2S INDUSTRIAL

EERC BEST
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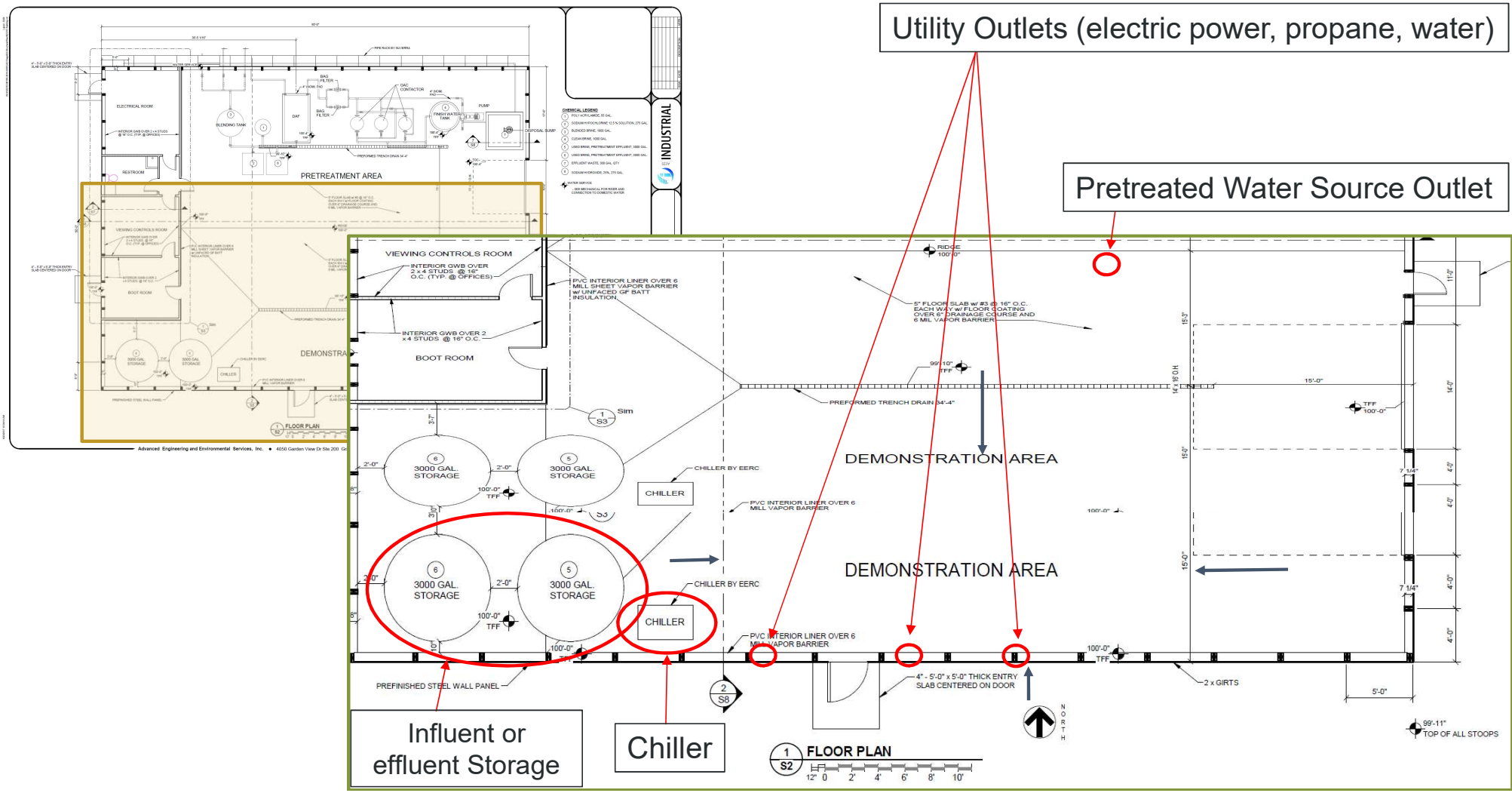
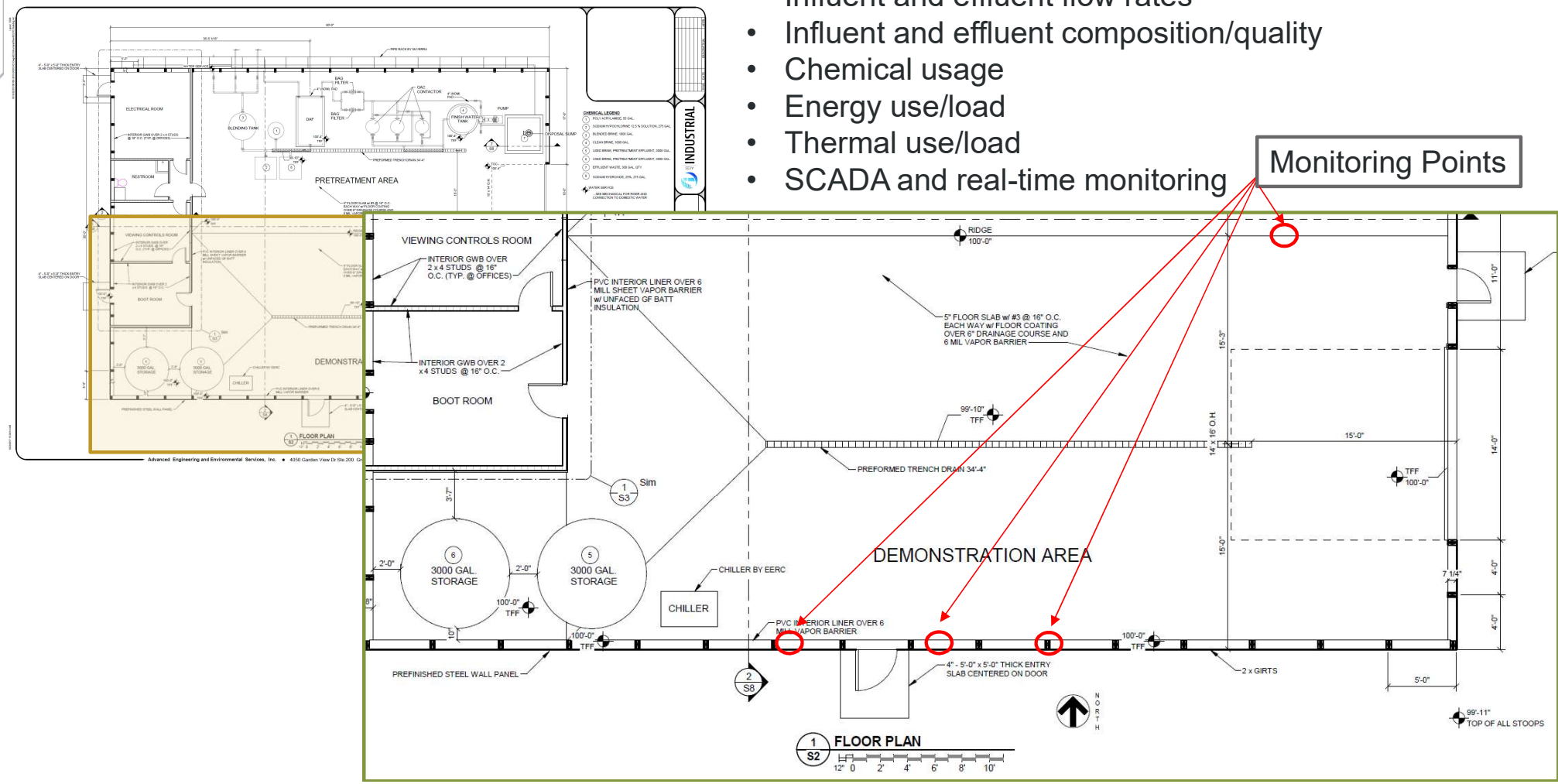
DEMONSTRATION AREA



TECHNOLOGY DEMONSTRATION MONITORING

- Influent and effluent flow rates
- Influent and effluent composition/quality
- Chemical usage
- Energy use/load
- Thermal use/load
- SCADA and real-time monitoring

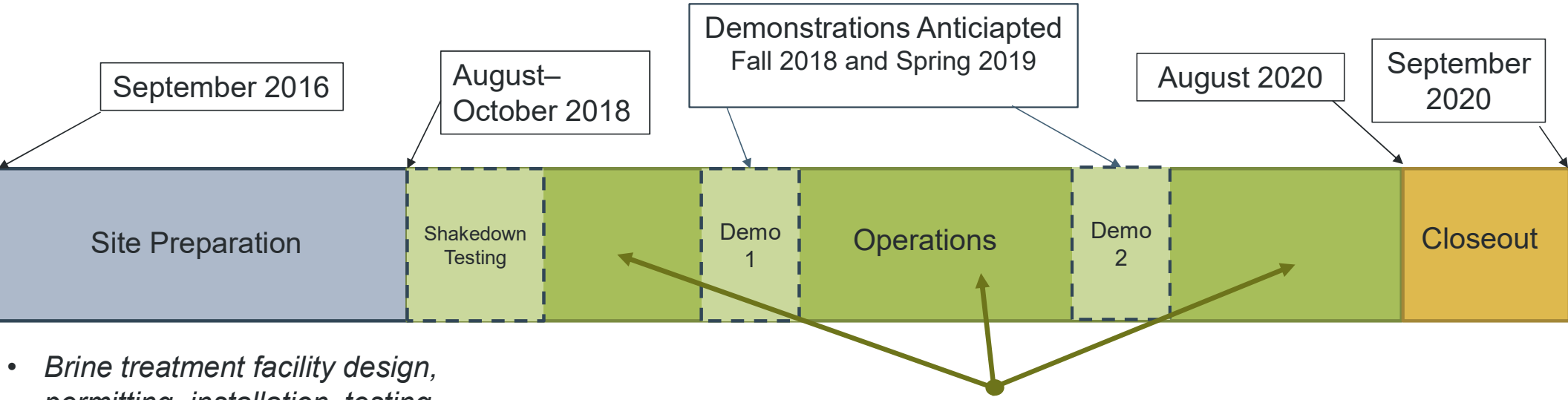


OPERATIONS

- Shakedown testing of all pretreatment equipment prior to pilot tests.
- Selection and scheduling of treatment technology, negotiate site access agreements.
- Mobilize technology demonstration to site.
- Treatment technology connected to the test bed facility – electric, propane, cooling water, influent/effluent water, etc.
  - EERC assistance to ensure health, safety, environmental and operability.
- Treatment technology demonstration providers will operate their treatment equipment; the EERC will operate the treatment test bed facility in coordination with the treatment technology demonstrator.
- During steady-state operation, EERC staff will conduct energy and material balances (power consumption, process flows, influent and effluent quality analyses).
- Extended operating periods (60+ days) to identify maintenance requirements and any operational issues.
- Operations will be preferentially scheduled to coincide with optimal operational windows (weather, ARM test program, etc.) when possible.
- Effluent and treated water will be blended and reinjected where possible; waste streams unable to be reinjected will be disposed of at an authorized facility.

Top-ranked technologies may benefit from cost offsets.

PROVISIONAL TIME LINE FOR BRINE TREATMENT TECHNOLOGY DEMONSTRATIONS



- *Brine treatment facility design, permitting, installation, testing, and pretreatment operations training*
- *Expected building completion, testing, and commissioning of equipment by July 2018*
- *Brine treatment technology solicitation and selection*

Opportunities for additional demonstrations!

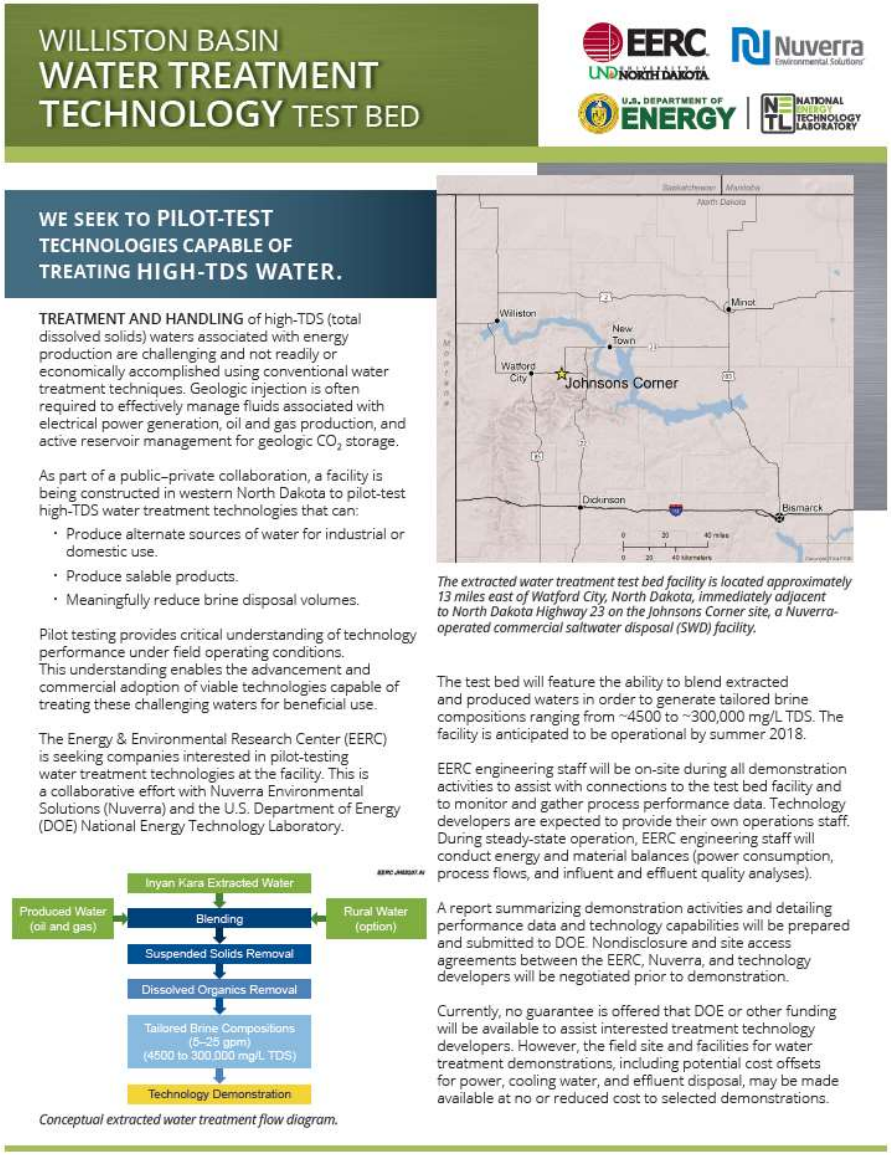
- *Operationally ready by August 2018*
- *Brine treatment technology testing (multiple technologies)*
- *Brine treatment technology evaluation and reporting*

EMERGING BRINE TREATMENT TECHNOLOGIES

- Treatment technologies for high-salinity brines continue to evolve, but few have been tested at the commercial scale.
- Most technologies fall into several main categories:
  - Evaporation/distillation (mechanical vapor recompression)
  - Evaporation/crystallization (low- pressure, low-temperature evaporation)
  - Membrane treatment (reverse osmosis, forward osmosis, membrane distillation)
  - Freezing-based treatment

SOLICITING BRINE TREATMENT TECHNOLOGIES

- NETL, EPRI, and the EERC are coordinating efforts to define water treatment goals and solicit technologies for pilot testing.
  - Cooperatively developed vendor questionnaire and selection criteria
- The North Dakota and Florida facilities will provide unique water treatment scenarios but will have similar operational capabilities.
- North Dakota test bed is anticipated to be operational by fall 2018.
- Site access agreements will be negotiated between host site operator, EERC, and brine treatment technology provider.
- Knowledge-sharing workshop tentatively scheduled for fall 2018.



TREATMENT TECHNOLOGY SELECTION PROTOCOL

- Screening criteria
  - Ability to produce a beneficial use effluent or product at reasonable operating costs based on target influent water quality
  - Enable successful operation of other technologies (i.e., pretreatment)
  - Provide a relatively high yield of treated water or product
  - Significantly reduce the volume of fluids requiring disposal
  - Not produce hazardous by-products

- Ranking factors
  - Treatment costs (40%)
  - Readiness level (30%)
  - Safety considerations (20%)
  - Waste generation (10%)

OUREACH AND INFORMATION

IMPLEMENTING AND VALIDATING RESERVOIR PRESSURE MANAGEMENT STRATEGIES IN THE WILLISTON BASIN

John A. Hamling, Ryan J. Klapperich, Daniel J. Stepan, Lonny L. Jacobson
Energy & Environmental Research Center · 15 North 23rd Street, Stop 9018 · Grand Forks, ND 58202-9018 · www.undeerc.org

OVERVIEW

The Energy & Environmental Research Center (EERC) is conducting a multiyear field demonstration to evaluate active reservoir management (ARM) strategies that could benefit geologic carbon dioxide (CO_2) storage practices. This effort, funded by the U.S. Department of Energy's National Energy Technology Laboratory, in partnership with Nuverra Environmental Solutions, Schlumberger, and Computer Modeling Group, will build and operate a brine extraction and storage test (BEST) site. The western North Dakota field site is expected to be operational by mid-2017, with testing scheduled through late 2019.

BEST will consist of two complementary components, an ARM test and a brine treatment test bed. Simultaneous injection and extraction of brine within the Inyan Kara Formation, combined with a monitoring program, will be used to evaluate ARM performance. The formation fluids extracted as part of the ARM test will be used in conjunction with the brine treatment test bed facility to demonstrate emerging water treatment technologies capable of treating high-salinity brine. Together these two components will serve as a proxy of a geologic CO_2 storage site employing ARM.

WATER TREATMENT TEST BED FACILITY

Treatment of high total dissolved solids (TDS) waters associated with energy production (extracted water management for carbon storage, electric energy production, and oil and gas production and refining) is challenging and not logistically or economically viable using conventional water treatment technologies. Therefore, geologic injection is often required to effectively manage these fluids. However, there is a growing demand for treatment approaches capable of treating these challenging waters. Successful treatment of high-TDS waters can provide alternate sources of water for domestic or industrial use and/or create additional salable products, as well as meaningfully reduce disposal volumes.

The test bed facility is designed to generate performance data through a field demonstration for brine treatment technologies capable of treating these challenging waters for beneficial use and ultimately enable the development and adoption of commercially viable treatment technologies.

ACTIVE RESERVOIR MANAGEMENT

ARM has the potential to improve the commercial viability of geologic CO_2 storage. In addition, ARM has applications to geologic disposal of fluids associated with energy production and a broad cross section of other industries. This project will investigate the potential of controlled brine extraction as a means to manage reservoir pressure, reduce stress on sealing formations, control the footprint of the injected fluid within a formation, and improve overall injection performance. The scale of the test will approximate 250,000 tonnes/yr of CO_2 injection.

Forecast modeling suggests that the fluid injection and extraction program is expected to result in a measurable reduction in formation pressure within the study area and influence the development of the injected fluid plume. Several monitoring techniques, including tracers, downhole pressure gauges, and a borehole-to-surface electromagnetic survey, will be used to validate both performance forecast models and ARM performance.

FIELD IMPLEMENTATION PLAN

The field implementation plan will leverage an existing pressure plume generated by two existing commercial saltwater disposal wells completed in the Inyan Kara Formation. These wells, in conjunction with a new brine extraction well (BEST-E1) will be used to conduct ARM testing. Water extracted from BEST-E1 will be injected into a second new well (BEST-I1) completed in the deeper Broom Creek Formation. Injection and extraction rates into each well will be independently controlled through a range of operational parameters, and a slipstream of the extracted water will be diverted to the water treatment test bed facility.

The four well design provides operational flexibility and the monitoring capabilities necessary to evaluate brine extraction as a viable ARM technique. The monitoring program will be used to develop a precise understanding of reservoir performance and the influence on the injected fluid footprint and pressure differential induced in the Inyan Kara Formation. A comprehensive health, safety, and environmental monitoring program is also being employed as part of an extensive risk mitigation program.

TEST BED FACILITY FEATURES

The facility will consist of a heated building with a concrete floor and be fully integrated with the ARM brine extraction and injection infrastructure. The facility will accommodate a standard semi tractor-trailer (53 ft long).

UTILITIES
- Up to 300 kW of electric power
- Propane (5,000-gal tank)
- Noncontact cooling water (30 gpm)

EXTRACTED WATER PRETREATMENT
- Accommodate blending of Bakken produced and Inyan Kara extracted waters to target a TDS level of 180,000 mg/L or other tailored blends to suit capabilities and/or limitations of specific technologies
- Suspended solids removal
- Dissolved organics removal
- Ability to provide Bakken produced and/or flowback water for suitable demonstrations

DEMONSTRATION TEST TRIALS
- Pilot treatment rates ranging from 1 to 25 gpm
- 30–50+ day extended-duration tests (desired minimum of two maintenance cycles)
- Monitoring of energy, flow, chemical usage, etc.
- Waste management

Typical composition of a blended [illegible] that could be treated at the [illegible]

Parameter	Value, mg/L
B	309
Li	46
Na	49,900
K	5010
Mg	680
Ca	13,800
Sr	1140
Ba	24
Fe	46
Mn	12
P	<15
Si	<20
F	<7
SO_4	167
NO_3 & NO_2 (as nitrogen)	<4
Cl	138,700
TSS*	–
TOC*	–
TDS	180,000
Total hardness as $CaCO_3$	38,700

If you are interested in demonstrating a brine treatment technology at this site or if you would like more information

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WILLISTON BASIN WATER TREATMENT TECHNOLOGY TEST BED

EERC UNIVERSITY OF NORTH DAKOTA
U.S. DEPARTMENT OF ENERGY

WE SEEK TO PILOT-TEST TECHNOLOGIES CAPABLE OF TREATING HIGH-TDS WATER.

TREATMENT AND HANDLING of high-TDS (total dissolved solids) waters associated with energy production are challenging and not readily or economically accomplished using conventional water treatment techniques. Geologic injection is often required to effectively manage fluids associated with electrical power generation, oil and gas production, and active reservoir management for geologic CO_2 storage.

As part of a public–private collaboration, a facility is being constructed in western North Dakota to pilot-test high-TDS water treatment technologies that can:

- Produce alternate sources of water for industrial or domestic use.
- Produce salable products.
- Meaningfully reduce brine disposal volumes.

Pilot testing provides critical understanding of technology performance under field operating conditions. This understanding enables the advancement and commercial adoption of viable technologies capable of treating these challenging waters for beneficial use.

The Energy & Environmental Research Center (EERC) is seeking companies interested in pilot-testing water treatment technologies at the facility. This is a collaborative effort with Nuverra Environmental Solutions (Nuverra) and the U.S. Department of Energy (DOE) National Energy Technology Laboratory.

Conceptual extracted water treatment flow diagram.

The extracted water treatment test bed facility is located ap[illegible] 13 miles east of Watford City, North Dakota, immediately [illegible] to North Dakota Highway 23 on the Johnsons Corner site, [illegible] operated commercial saltwater disposal (SWD) facility.

The test bed will feature the ability to blend extracte[illegible] and produced waters in order to generate tailored b[illegible] compositions ranging from ~4500 to ~300,000 mg/[illegible] facility is anticipated to be operational by summer 20[illegible]

EERC engineering staff will be on-site during all dem[illegible] activities to assist with connections to the test bed facility and to monitor and gather process performance data. Technology developers are expected to provide their own operations staff. During steady-state operation, EERC engineering staff will conduct energy and material balances (power consumption, process flows, and influent and effluent quality analyses).

A report summarizing demonstration activities and detailing performance data and technology capabilities will be prepared and submitted to DOE. Nondisclosure and site access agreements between the EERC, Nuverra, and technology developers will be negotiated prior to demonstration.

Currently, no guarantee is offered that DOE or other funding will be available to assist interested treatment technology developers. However, the field site and facilities for water treatment demonstrations, including potential cost offsets for power, cooling water, and effluent disposal, may be made available at no or reduced cost to selected demonstrations.

EERC UNIVERSITY OF NORTH DAKOTA
Nuverra Environmental Solutions

The Energy & Environmental Research Center (EERC) and Nuverra Environmental Solutions (Nuverra) have partnered on a multiyear project to demonstrate new strategies and methods of injection well operation. These strategies could reduce the number of injection wells needed for fluid disposal and increase availability of water for beneficial use.

WHERE IS THE PROJECT HAPPENING?

The project will be conducted at the Nuverra-operated Johnsons Corner site, which was established in 2008 as a commercial saltwater disposal (SWD) facility. Nuverra operates two existing saltwater injection wells at its facility. These wells, regulated by the North Dakota Industrial Commission, inject into the thick Inyan Kara sandstone at a depth of 5400 ft. Although most project activity will be conducted exclusively at the Nuverra site, some nonintrusive monitoring activities, such as the layout and retrieval of a surface monitoring array, would require temporary (a few weeks) access to surrounding private land. This monitoring survey is necessary to gather performance data from the injection zone. The monitoring activity will occur twice during the project. We will be contacting individual landowners to discuss our request for access.

Site map showing proposed site layout.

WHEN WILL THE PROJECT OCCUR?

The project is anticipated to last 4 years (July 2016 – July 2020), with field activities at the site planned between March 2017 and June 2020.

WHAT DO WE PLAN TO DO?

The project will include five main activities. First, two new wells will be drilled on the site of Nuverra's existing SWD operation: one extractor well into the Inyan Kara Formation and one injection well into the Broom Creek Formation. Second, subsurface monitoring instruments will be installed in all four wells. Third, shallow probes and other monitoring equipment will be installed to monitor the project site. Fourth, a low-impact (small equipment and minimal intrusion for landowners) survey will be conducted to map the injection formation. Fifth, a brine treatment facility will be built to test emerging water treatment technologies.


THANK YOU!

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FIELD IMPLEMENTATION

- Evaluate ARM strategies
- Validate ARM performance against forecasts
- Evaluate ARM economics
- Demonstrate monitoring techniques
- Brine treatment technology test bed and technology demonstration
- Demonstrate ARM implementation and operations