Phase II Field Demonstration at Plant Smith Generating Station: Assessment of Opportunities for Optimal Reservoir Pressure Control, Plume Management and Produced Water

DE-FE0026140

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Acknowledgment and Disclaimer

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Presentation Outline

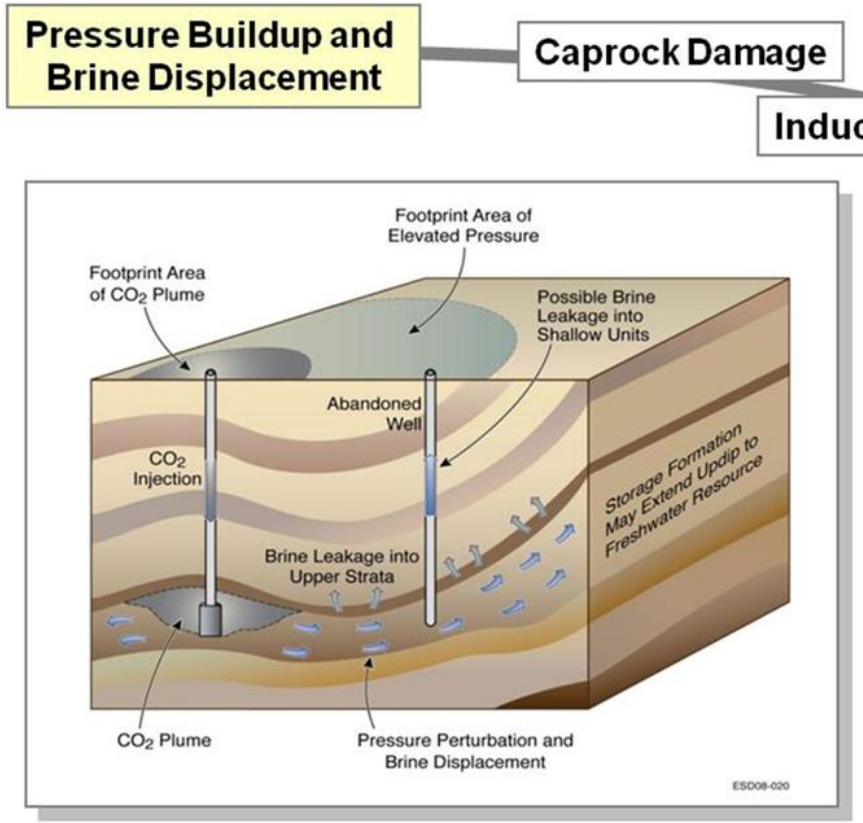
- Project Goals and Objectives
- Project Location
- Technical Objectives
- Technical Status
- Synergies
- Challenges to Date
- Project Summary

Photo showing Plant Smith in foreground and Panama City in background. Inset shows the location of Plant Smith in the Florida Panhandle (red circle).

Project Overview—Goals and Objectives

- Objective : Develop cost effective pressure control, plume management and produced water strategies for: 1) Managing subsurface pressure; 2) Validating treatment technologies for high salinity brines

Pressure management practices are needed to avoid these risks. Brine extraction is a possible remedy for reducing or mitigating risk



Pressure Buildup and Brine Displacement

Caprock Damage

Induced Seismicity

Interference Between Storage Sites

Effect on Other Georesources

Permitting and AoR

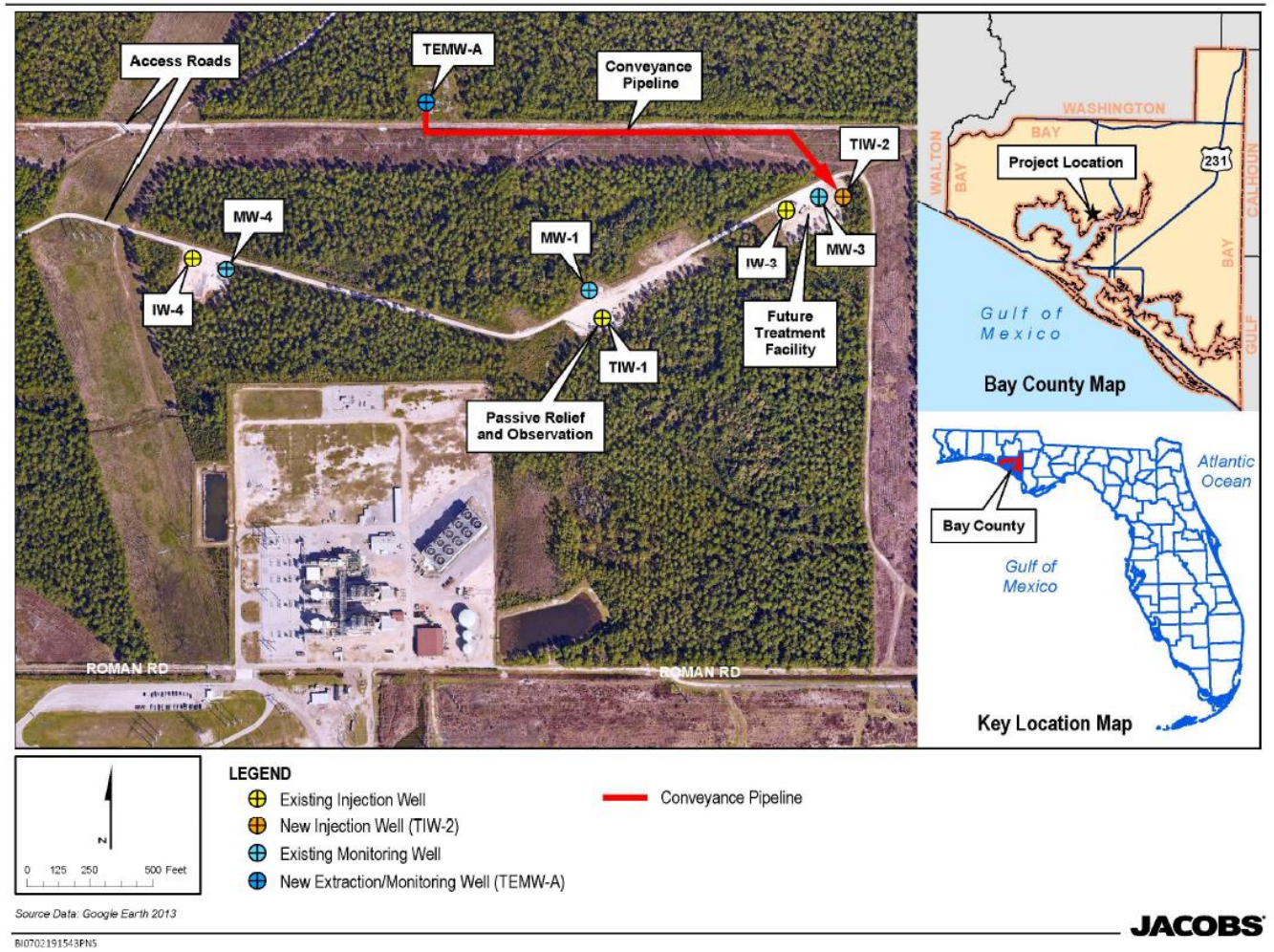
Reduced Storage Capacity

Reservoir Management Via Brine Extraction

Beneficial Use of Extracted Brine

Plant Smith Overview

- Multiple confining units
- Thick, permeable saline aquifers
  - Eocene Series (870-2,360 ft)
  - Tuscaloosa Group (4,920-7,050 ft)
  - Represent significant CO_2 storage targets in the southeast US
- Large Gulf Power Co. wastewater injection project underway (infrastructure)
- Water injection pressures will be managed as a proxy for CO_2 injection (~500k-1M gal/day)



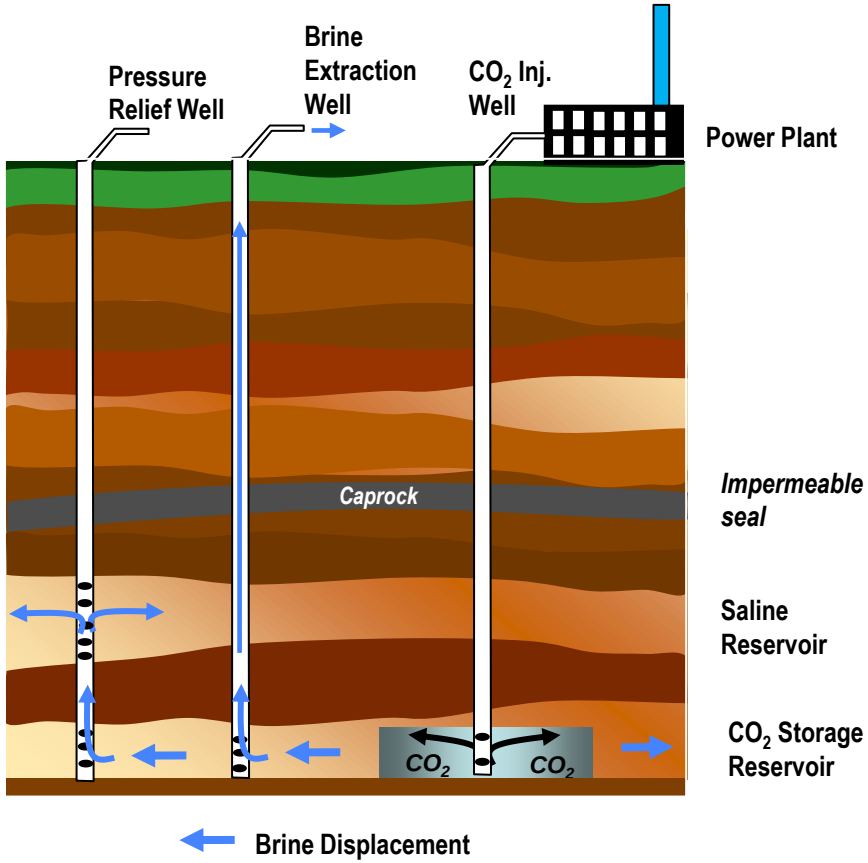
BEST project infrastructure layout showing the proposed location of the extraction well (TEMW-A), injection well (TIW-2) and flowline, and the existing passive-relief well (TIW-1)

No CO_2 injection will take place at Plant Smith

Phase II Field Demonstration Experimental Design—Passive and Active Pressure Management

- Passive pressure relief in conjunction with active pumping can reduce pressure buildup, pumping costs and extraction volume
- Existing "pressure relief well" and "new" extraction well will be used to validate passive and active pressure management strategies

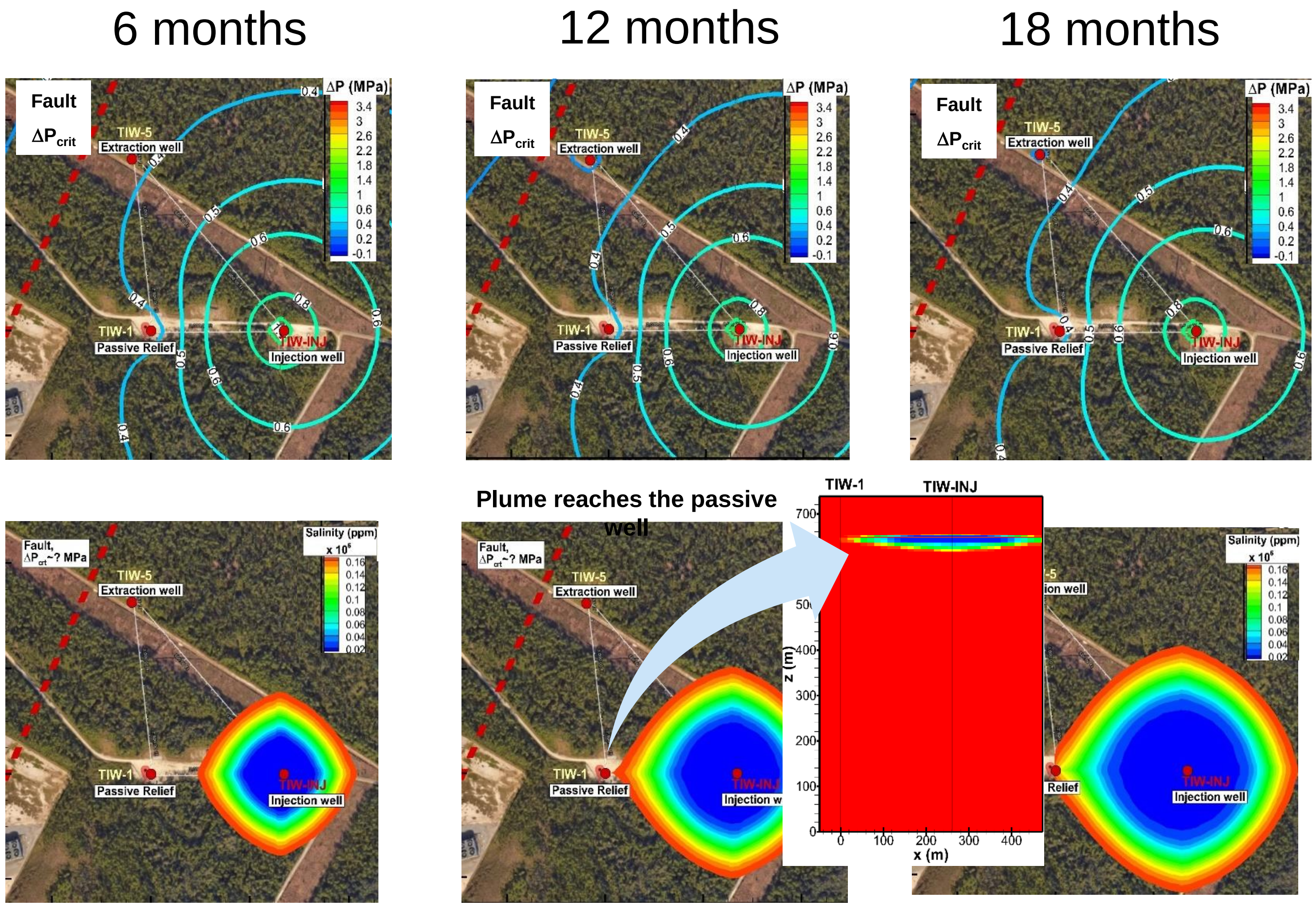
Pressure relief well has the potential to reduce extraction volume by 40%



Hypothetical CO_2 storage project showing "active" extraction and "passive" pressure relief well

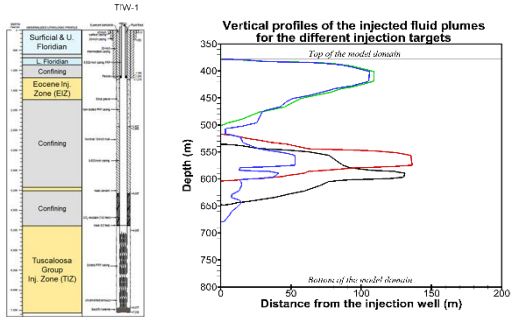
Goals of Subsurface Pressure Management Via Passive + Active Brine Extraction at Plant Smith

- Scenario—Minimize risks for injection-induced seismic events and leakage along hypothetical faults by controlling
  - Pressure buildup
  - Plume migration
- Limit the size of the Area of Review
- Limit the volume extracted
- Develop and test effectiveness of adaptive optimization methods and tools to manage overall reservoir system response

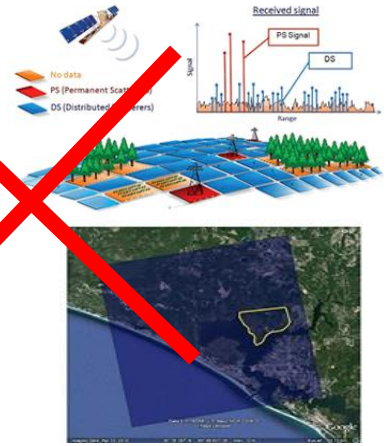


Monitoring – Inversion for Pressure & Salinity

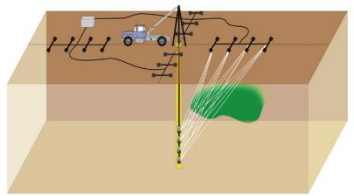
- **Borehole -** Continuous and time-lapse (discrete) borehole measurements of fluid pressure, flow rate, temperature, and electrical conductivity will be used to provide high-resolution, ground-truth, direct measurements at discrete locations (1D).

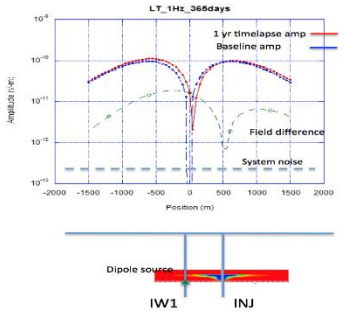


- **InSAR** - InSAR will be used to map surface deformations resulting from subsurface pressure increases over 16 day intervals

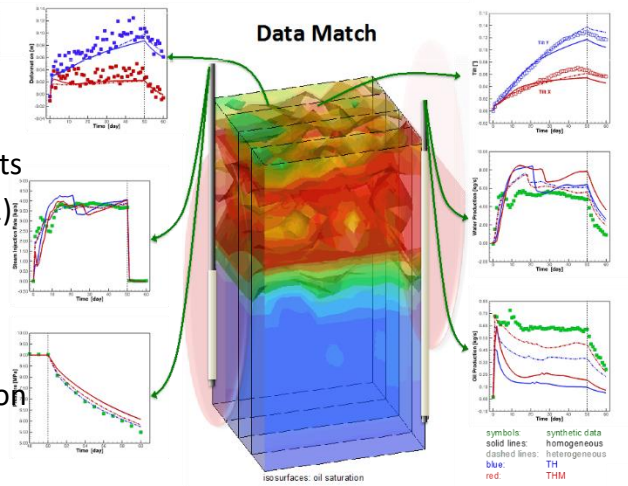


- **EM** - Time-lapse crosswell and borehole-to-surface EM will provide indirect measurements of the higher resistivity injected ash pond water with spatial resolutions in 2D and 3D approaching several meters to tens of meters, respectively.





Joint Inversion - We will use LBNL's powerful inverse modeling and parameter estimation tool iTOUGH (in its parallel version MPiTOUGH2) for the automated joint inversion of hydrological, large-scale geophysical (EM) data, and surface deformation data.



Project Status

Permitting

- Florida Department of Environmental Protection (FDEP) has primacy over Class I non-hazardous waste wells
- State has rigorous UIC standards to protect water resources
  - Well construction
    - Cement type and amount
    - 5 inches of cement behind casing for all injection wells (4 inches for observation wells)
  - Temporary monitoring wells to evaluate potential impacts during drilling
  - Permanent monitor well to evaluate potential impact from injection
  - Construction standards are being applied to BEST project's extraction well

Permanent monitor well installed within 150 ft of injection well is sampled quarterly for water quality impacts associated with injection

Gulf Power obtained a minor modification to it's existing well permit

Site Preparation

Drill pad installation

Monitoring well installation

Drilling Operations – Setting Conductor Casing

Welding sections of 48-inch dia. conductor casing together

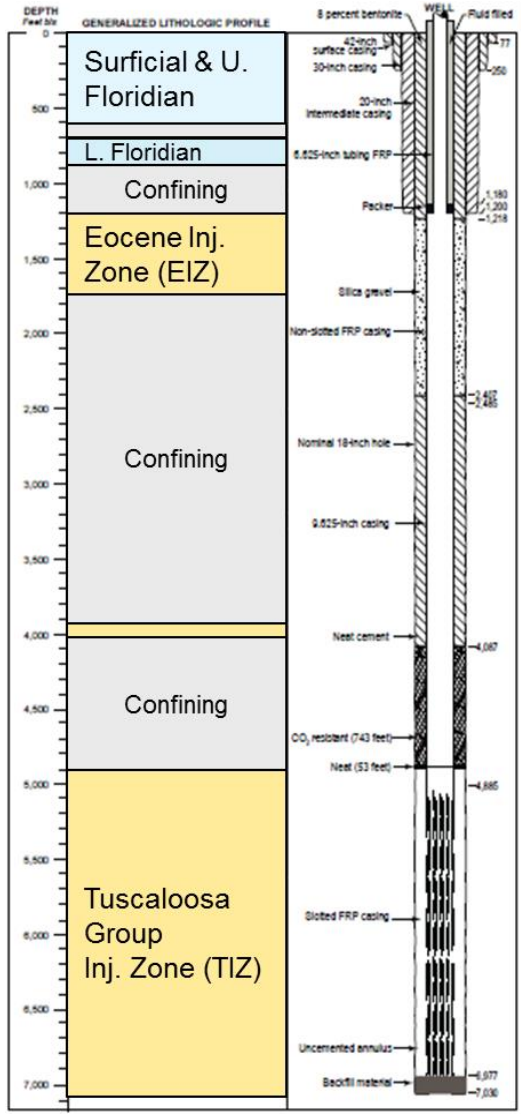
Installation of the 48-inch conductor casing

Injection and Extraction Wells Drilled to Total Depth

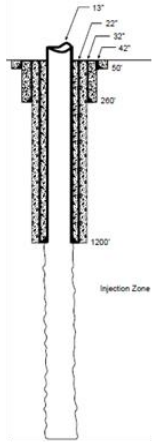
Electric rig drilling injection well TIW-2

Diesel rig drilling extraction/observation well TEMW-A

TIW-1



EIW-3 & -4



Core Samples from ~5,000 ft (~1,524 m)

Core barrel containing continuous side-wall cores

Close-up view of side-wall cores
Clay (left) and sandstone (Right)

Lower Tuscaloosa Sidewall Core Samples

- Interpreted to be fluvial sands
- Weakly consolidated to unconsolidated; interbedded with clay
- Total porosity ranges from 27 – 34 %
- Permeability ranges from 3.86E-13 to 1.52E-12 m/s (392 – 1,538 mD)

TIW-2 sidewall core sample 38; Depth 4,842 ft.

TIW-2 sidewall core sample 30; Depth 4,914 ft.

TIW-2 sidewall core sample 28; Depth 4,926 ft.

TIW-2 sidewall core sample 27; Depth 4,932 ft.

Some pebble conglomerate may be present. Some calcareous cement present.

Samples are poorly sorted to moderately well-sorted; fine to coarse grain sands

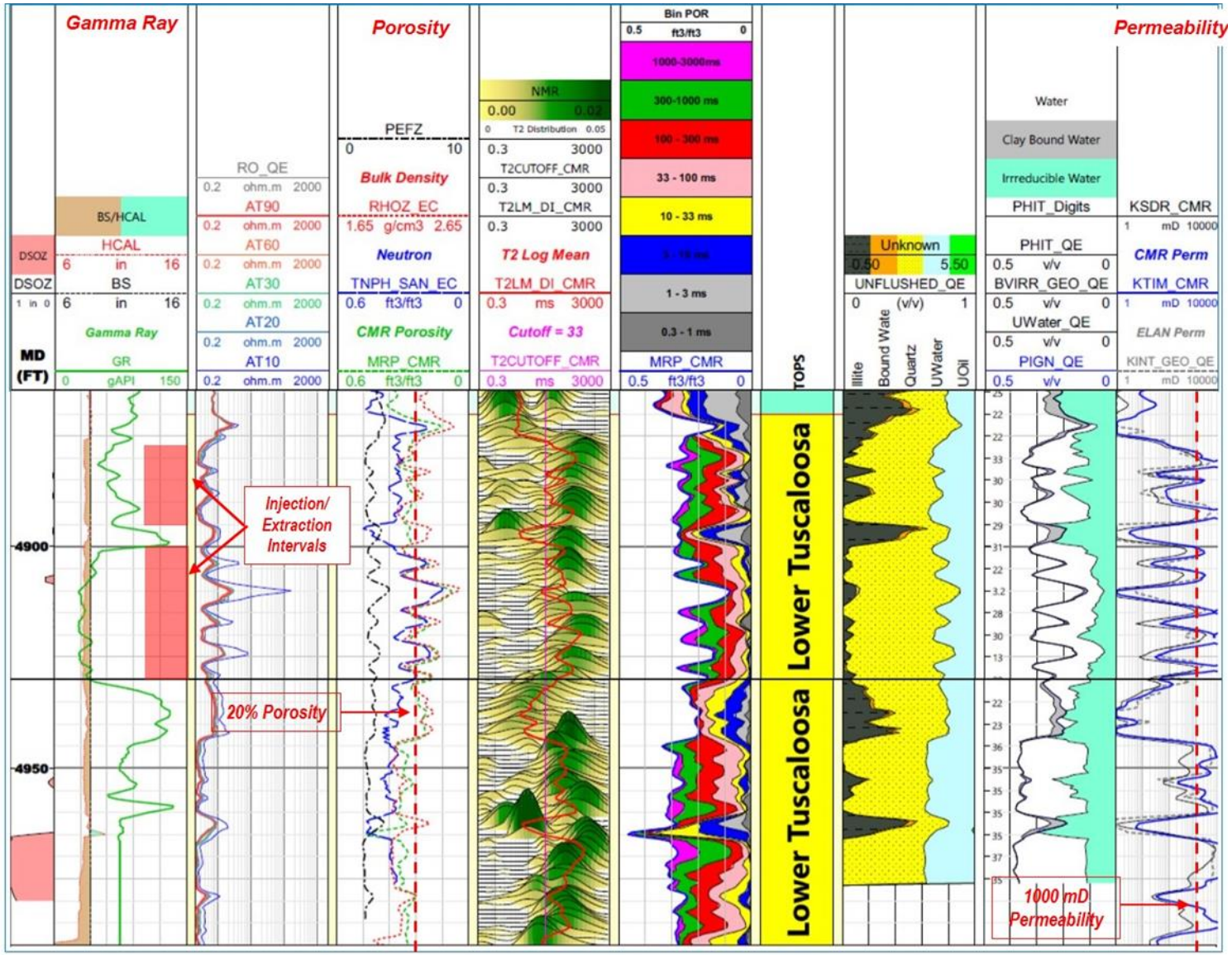
High K-feldspar content (high gamma-ray)

Correlations were used to derive layer properties because of highly unconsolidated sands

Collected and Interpreted Geophysical Well Logs

Extraction Well TEMW-A well logs for the extraction interval

- Gamma Ray
- Density log
- Neutron porosity log
- Combinable Magnetic Resonance (CMR) porosity
- CMR permeability



Reservoir Simulation for Test/Well Design

	Thickness (m)	Top depth (m)	Porosity	Perm (mD)
Confining Zone: Tuscaloosa Marine Shale	46.3296	1403.2992	0.24	0.2
Confining	15.5448	1449.6288	0.2	0.1
Lower Tuscaloosa - Sandstone ("Pilot Sand") - Confining	11.8872	1465.1736	0.2	12
Confining	11.2776	1477.0608	0.2	0.5
Potential Injection Zone 1	3.3528	1488.3384	0.26	**190**
	2.1336	1491.6912	0.31	**800**
Confining	2.4384	1493.8248	0.15	0.5
Potential Injection Zone 2	7.3152	1496.2632	0.32	**1300**
Confining	5.7912	1503.5784	0.27	7
Potential Injection Zone 3	7.9248	1509.3696	0.325	**2625**
Confining	7.0104	1517.2944	0.27	10
Potential Injection Zone 4	4.572	1524.3048	0.3	**600**
	2.1336	1528.8768	0.29	**550**
	5.7912	1531.0104	0.32	**1060**
Confining	3.6576	1536.8016	0.12	0.5

- Assessed four individual injection zone options:

1. Base case geological model for 100 gpm and 200 gpm injection rates
2. Reduced confining layer permeability values by a factor of 10 for 100 gpm injection rate
3. Reduced injection layer permeability values by a factor of 10 for 100 gpm injection rate
4. Combination of iz1 and iz2

Challenges

Challenges

- Well costs much higher than expected in Florida
  - Non-competitive drilling market
  - Special Florida injection well regulations contribute to costs and lack of market diversity
- Contracting – never goes as quickly as hoped or planned
  - Unit price with cost not-to-exceed drilling contract with stipulated penalties is providing cost protection
- Weather delays – Hurricane Michael

Subcontractor	Bid Amount
HAD Drilling Co.	No bid
Layne Drilling Co.	$6,859,713
Schlumberger Carbon Services	No bid
Younquist Brothers, Inc.	$10,995,000

Hurricane Michael landfall at Mexico Beach. By Colin Hunt, U.S. Coast Guard, U.S. Department of Defense - U.S. Department of Defense, Public Domain, https://commons.wikimedia.org/w/index.php?curid=88078359

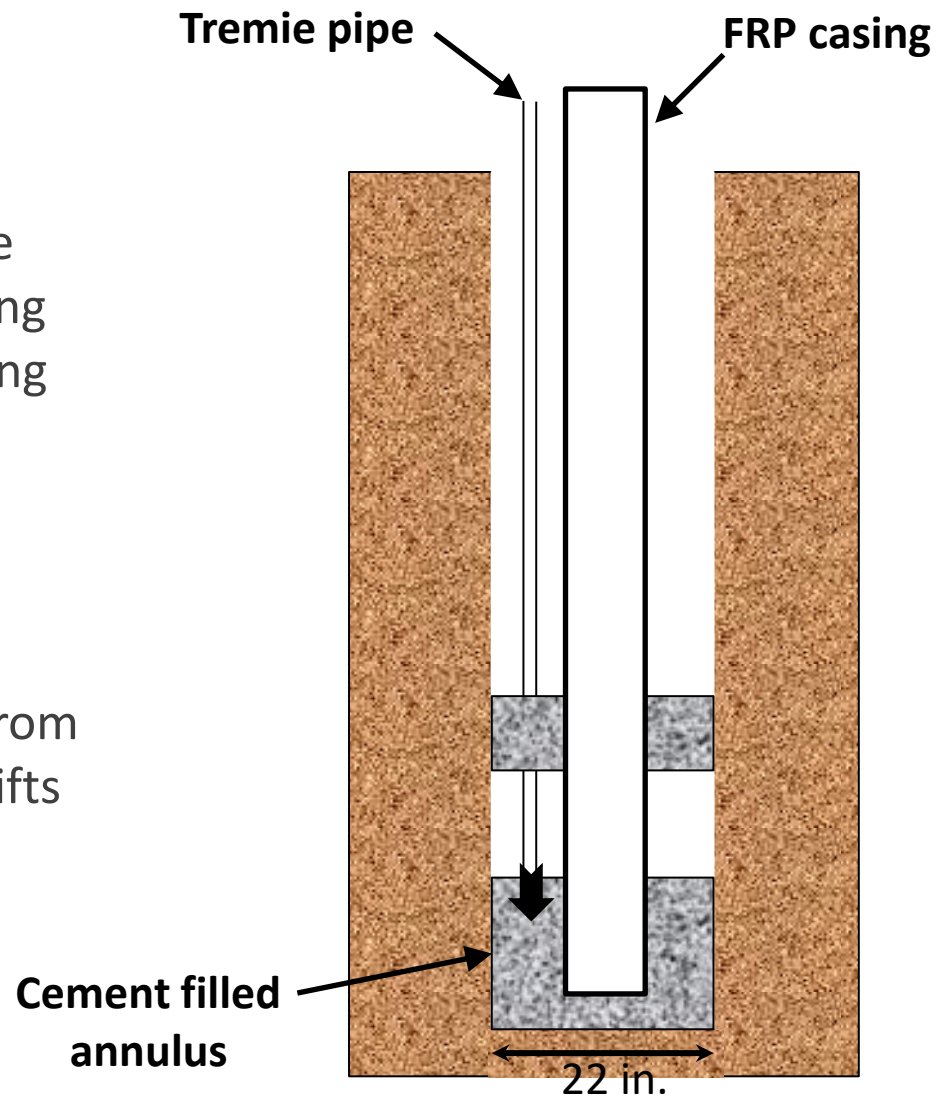
Injection Well: Fiberglass Reinforced Pipe (FRP) Casing Installation

←

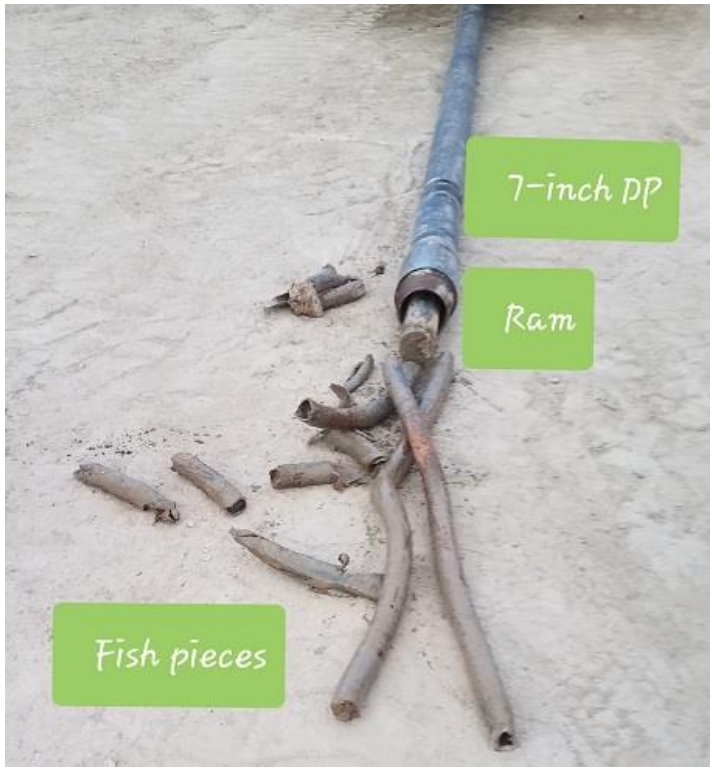
Attaching the cement basket to the end of the 10.75-inch I.D. FRP casing before running the casing to bottom

→

Cementing operations involved using a tremie pipe to pump cement from the surface in 1,000 ft lifts around the casing



Injection Well: “Fishing” Operations



Overshot and junk basket were used to bits and pieces of the “fish” from the borehole

Fishing operations with tremie pipe looped back on itself

Free FRP casing was removed and shipped to manufacturer (bottom) and the rest was milled out (top)

Plugged Extraction Well Screen

Well screen for the 4.5-inch I.D. extraction well prior to installation

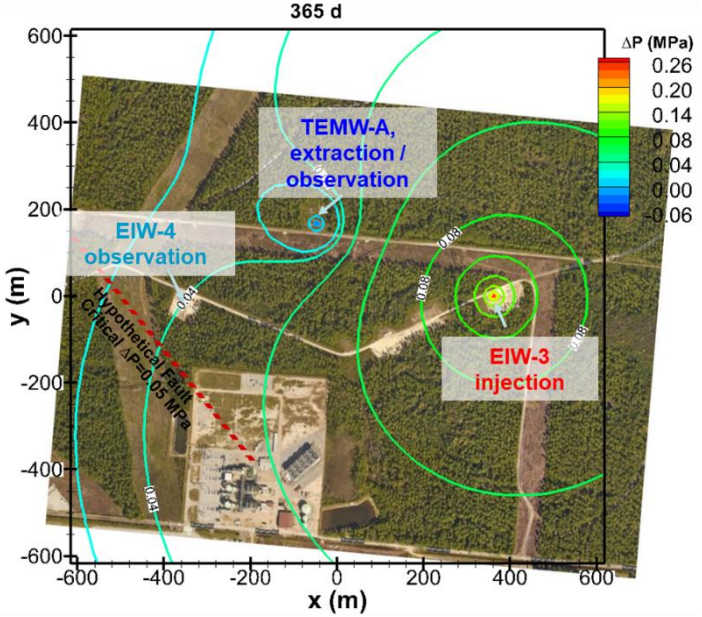
Debris cleared from well during screen/well development

Mudmotor used to clear debris from the casing

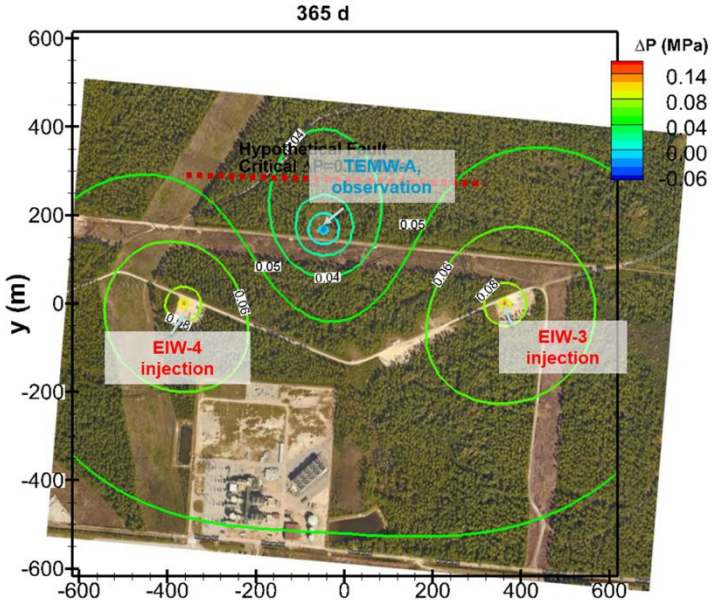
Contingency Planning – Shallow Eocene Tests

Plan B Scenario Planning – Injection/Extraction Shallow Eocene

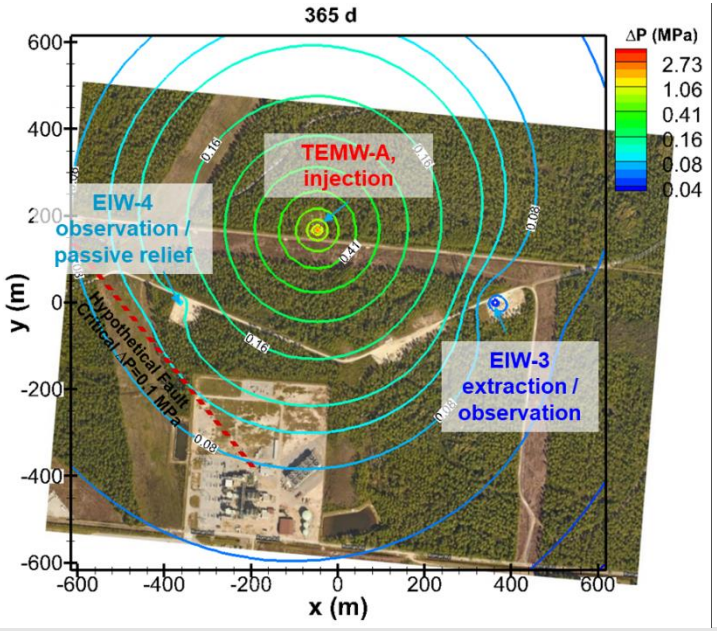
Scenario 1
Shallow Injection into EIW-3 and Extraction from TEMW-A



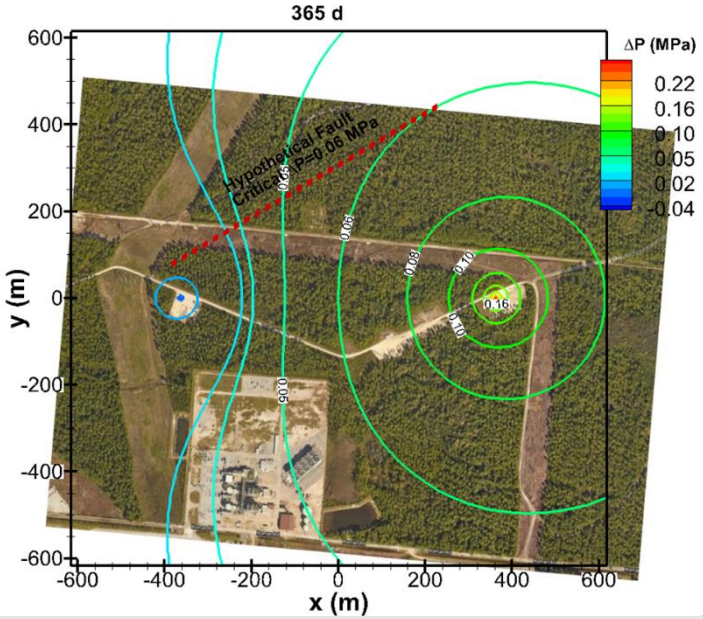
Scenario 2
Injection into both EIW-3 and EIW-4, Extraction from TEMW-A



Scenario 3
Injection into TEMW-A and Extraction from EIW-3



Scenario 4
Injection into EIW-3 and Extraction from EIW-4

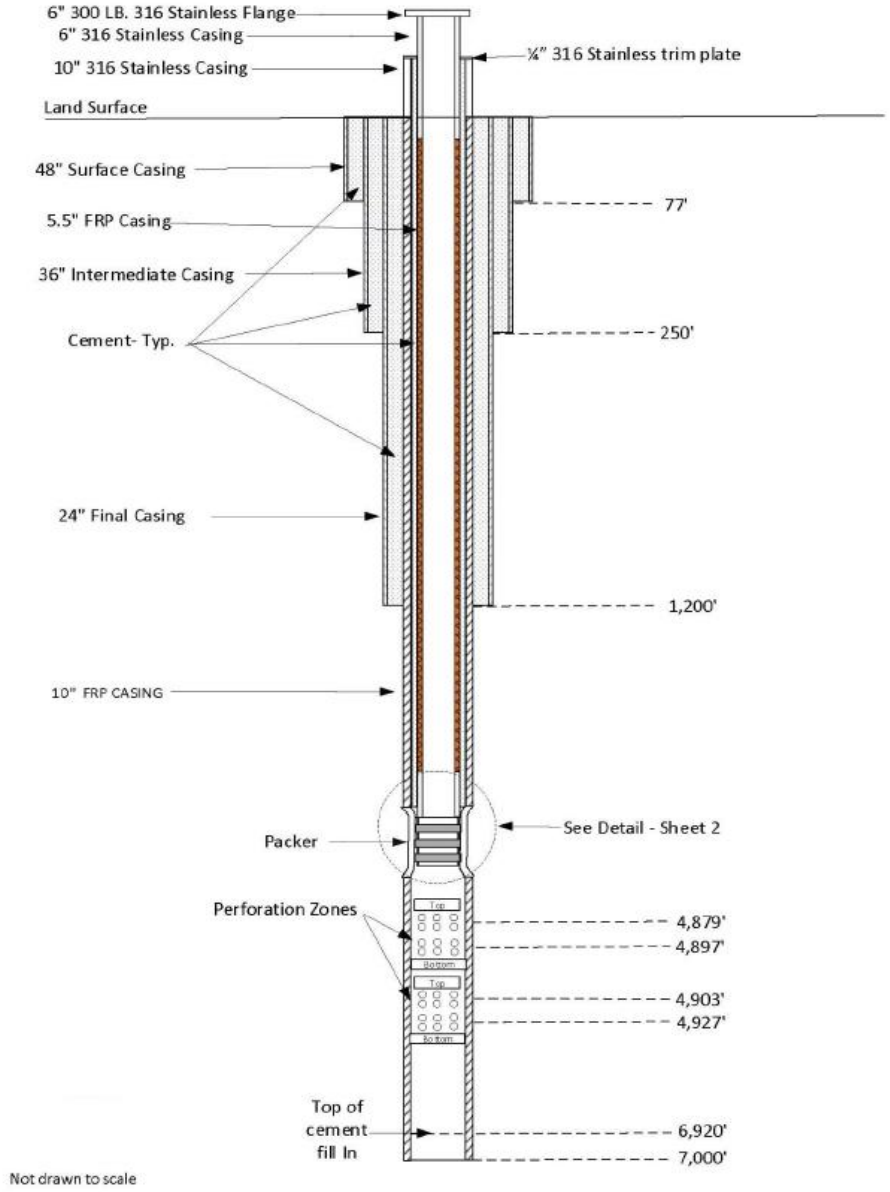


Drilling Challenges were Mitigated

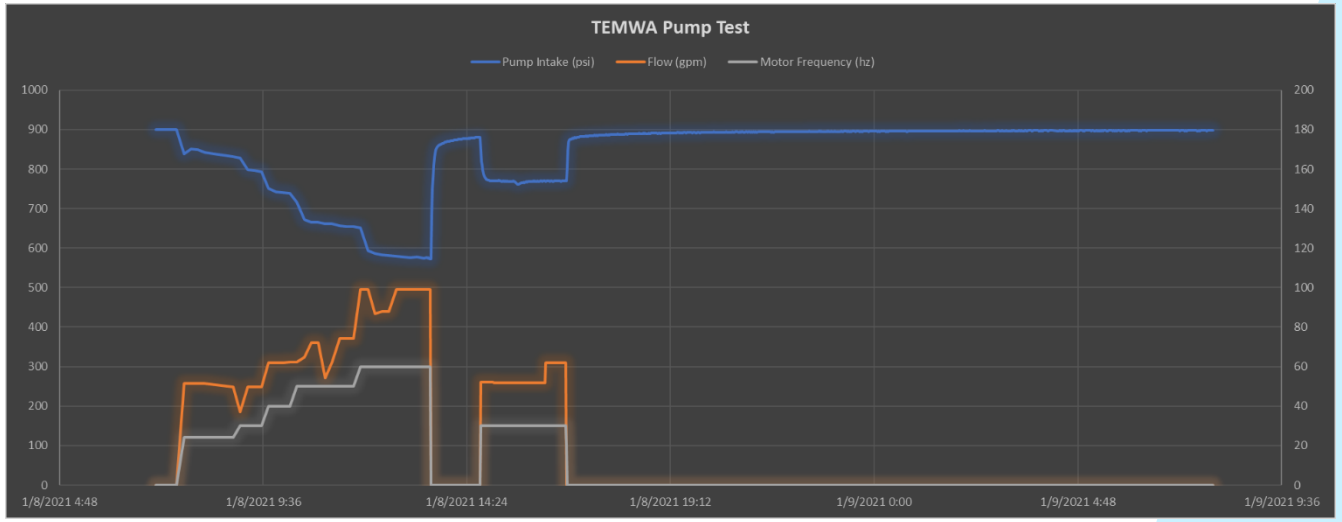
Success: Injection Well Completed and Tested at 197 gpm with 29 PSI Maximum Wellhead Pressure (6.8 gpm/psi)

←
Installed three overlapping casing patches

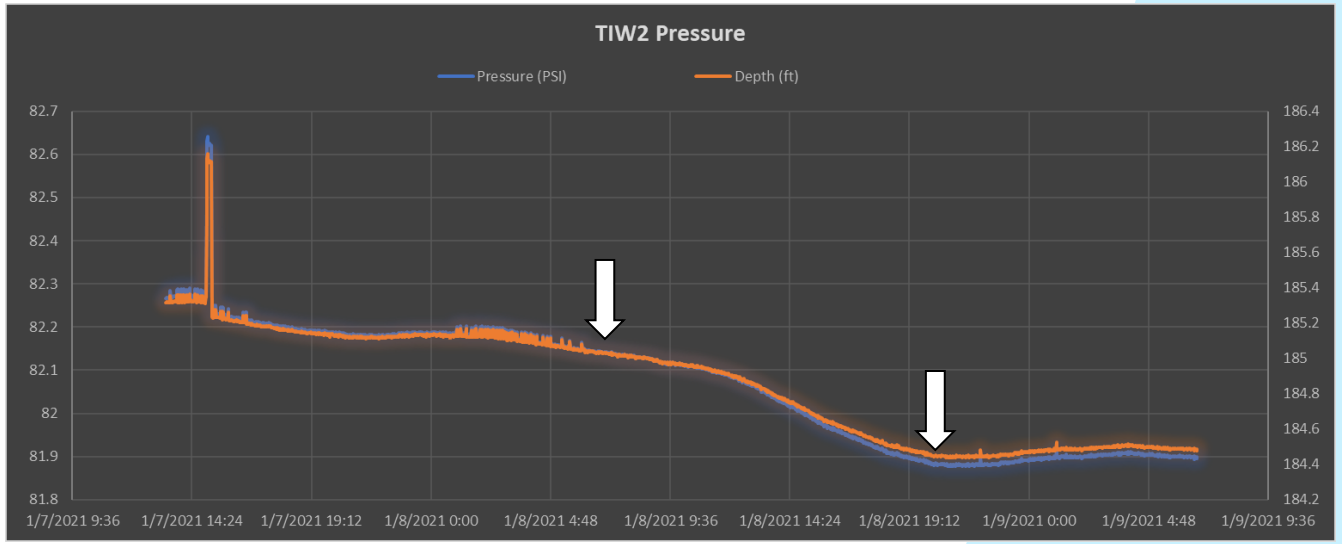
→
Cemented in the 5.5-inch injection tubing



Success: Extraction Well Completed and Tested at Max. 100 gpm with 750 ft Drawdown



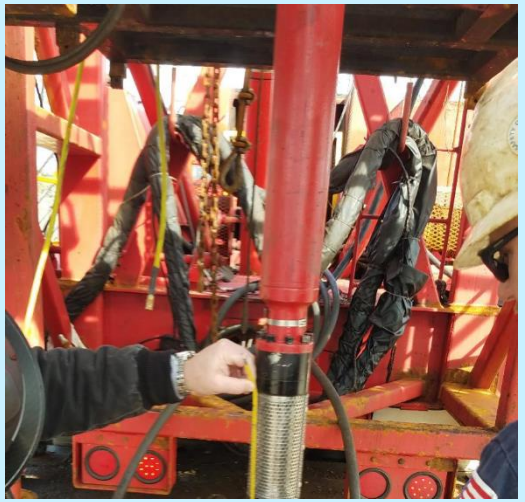
Drawdown (left scale, psi) and flow rate (right scale, gpm) recorded during pump test



Drawdown (right scale, ft) at passive relief well TIW-2 recorded before, during and after pump test

← Sustained yield of 54 gpm with injectivity of 0.38 gpm/psi

← Observed drawdown of 0.5 ft at TIW-2 located ~1,600 ft away

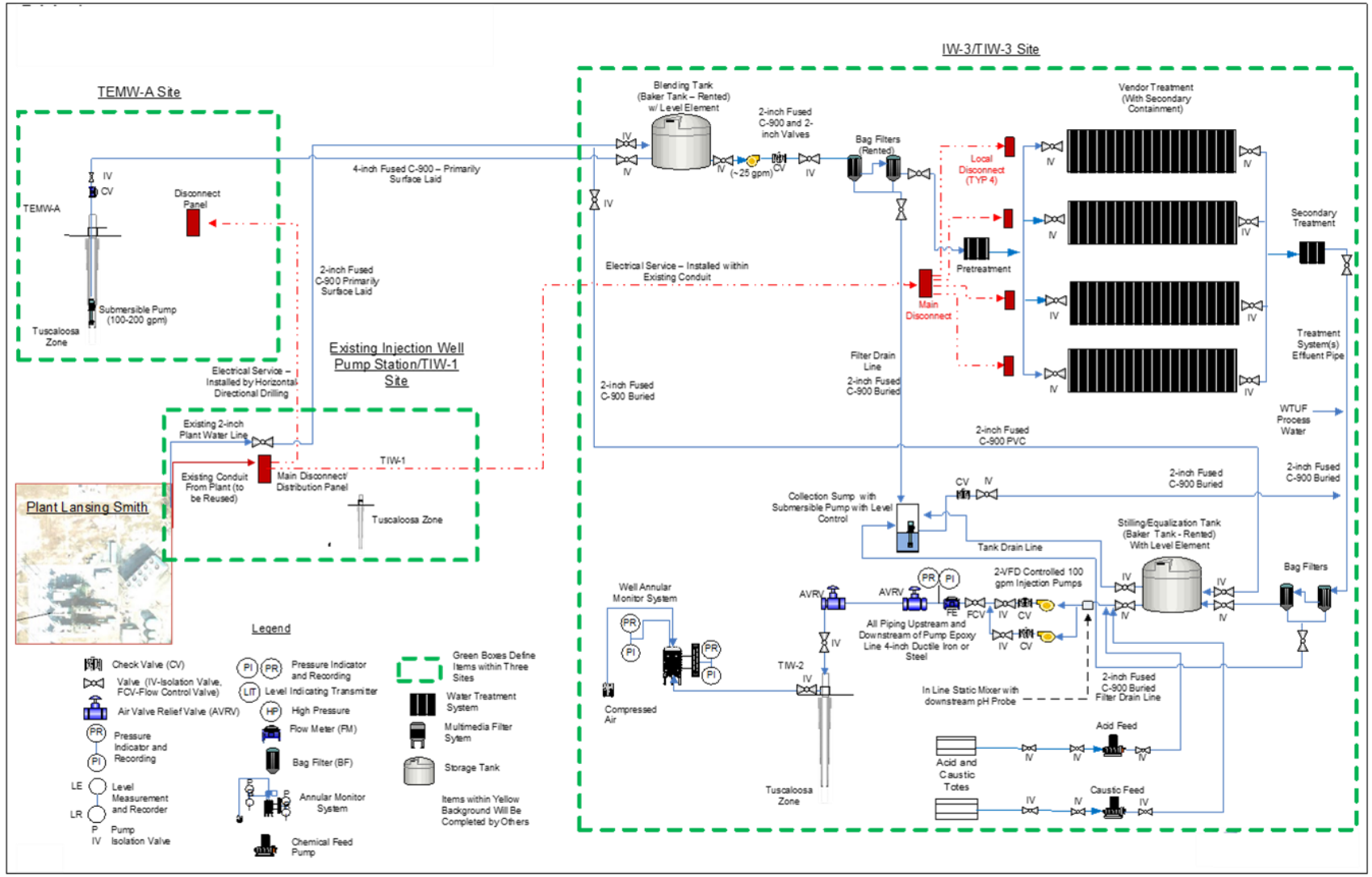


Running and setting electric submersible pump in TEMW-A at 2,022 ft below pad level

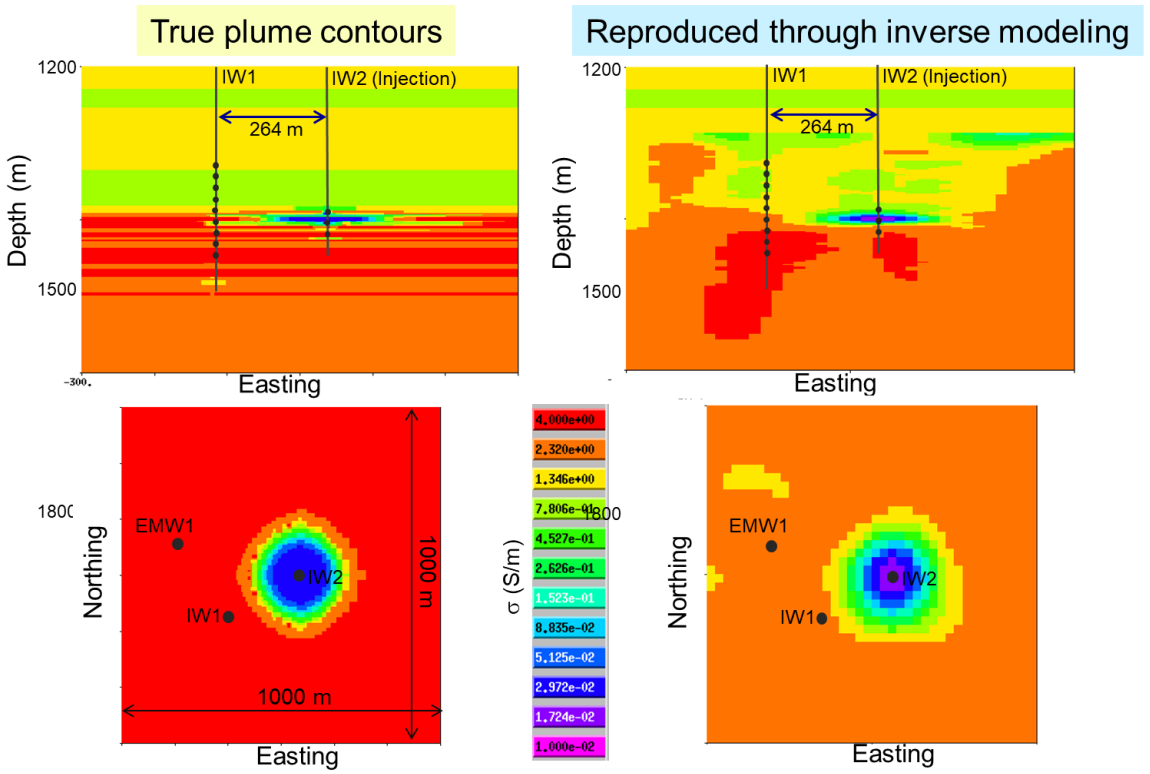
Pump Station and Water Treatment User Facility Design 100% Complete

- Different salinities (from 30 to 166,000 mg/L) of water will be available to test treatment processes
- Water samples were collected to evaluate fluid compatibility
- RFP is in preparation for competitive bid

pH adjustment and filtration are required



Summary of Accomplishments



Modeling studies show that anomalies in the magnetic field resulting from freshwater injection into the saline reservoirs can be detected using EM surveys to track plume shape and location

- The project team obtained a minor modification to the existing Gulf Power UIC permit for the project wells
- Geo-static and reservoir models were updated and used to select the final test zone and design the experiment
- Extraction well was completed and tested producing 100 gpm
- Injection well was completed and tested at >200 gpm
- 100% design complete on the water treatment user facility
- Modeling studies show that Electromagnetic (EM) surveys should have sufficient sensitivity to monitor the plume in cross-section.

Drilling-related problems were mitigated providing two functional test wells needed for the test

Project Summary

- Next Steps
- BP3 plans include:
  - Construction of the pump station and water treatment user facility
  - Equipment commissioning
  - 6 months of injection followed by 12 months of injection and extraction
- BP4 plans include:
  - Site restoration
  - Final reporting

Photographs of existing Gulf Power wellfield. Photos clockwise from upper left: Eocene Injection well EIW-4; graveled access road; pump station under construction; cleared and permitted drilling pad location for future well