Integrated Pre-Feasibility Study of a Commercial-Scale CCS Project in Formations of the Rock Springs Uplift, Wyoming

Project Number DE-FE0029302

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U.S. Department of Energy

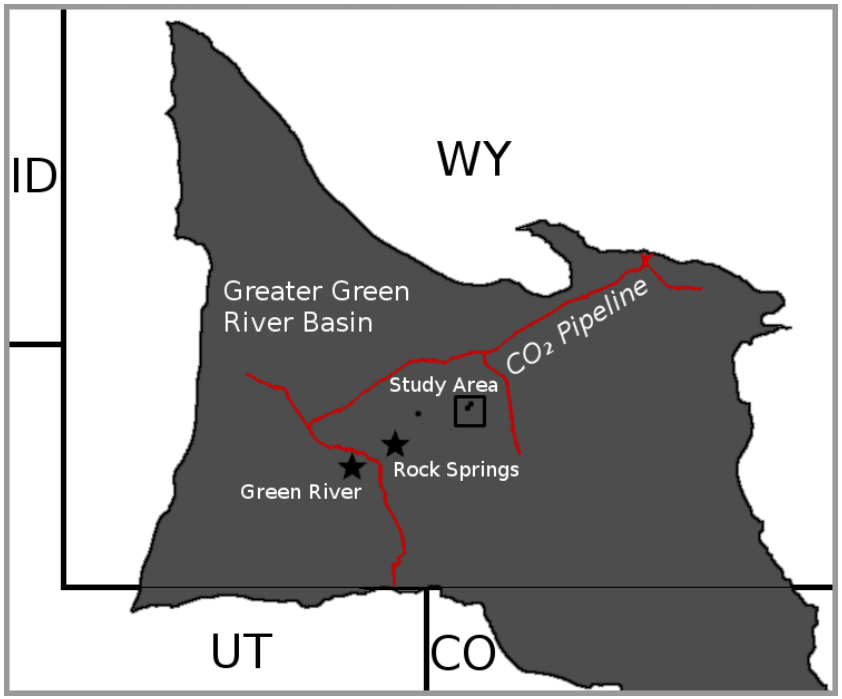
National Energy Technology Laboratory
DE-FOA0001584 Update Meeting

August 1st, 2017

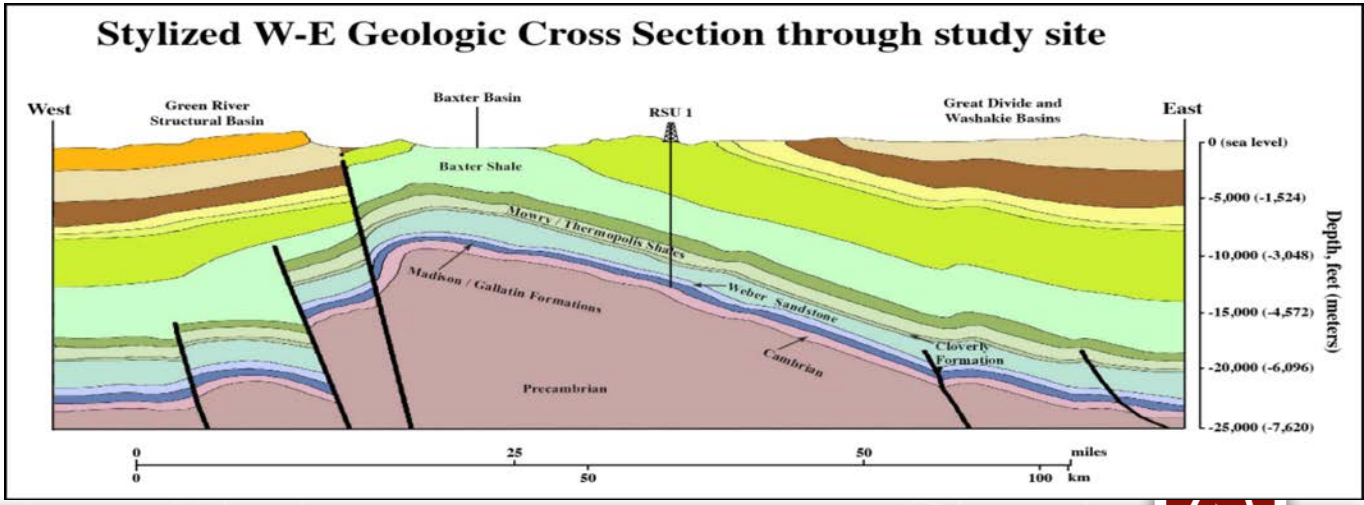
Outline

- Background
- Technical Status Phase 1
- Accomplishments
- Lesson Learned
- Summary
- Appendix
  - Benefit to the Program
  - Project Overview
  - Organization Chart
  - Bibliography
- Synergy Opportunities

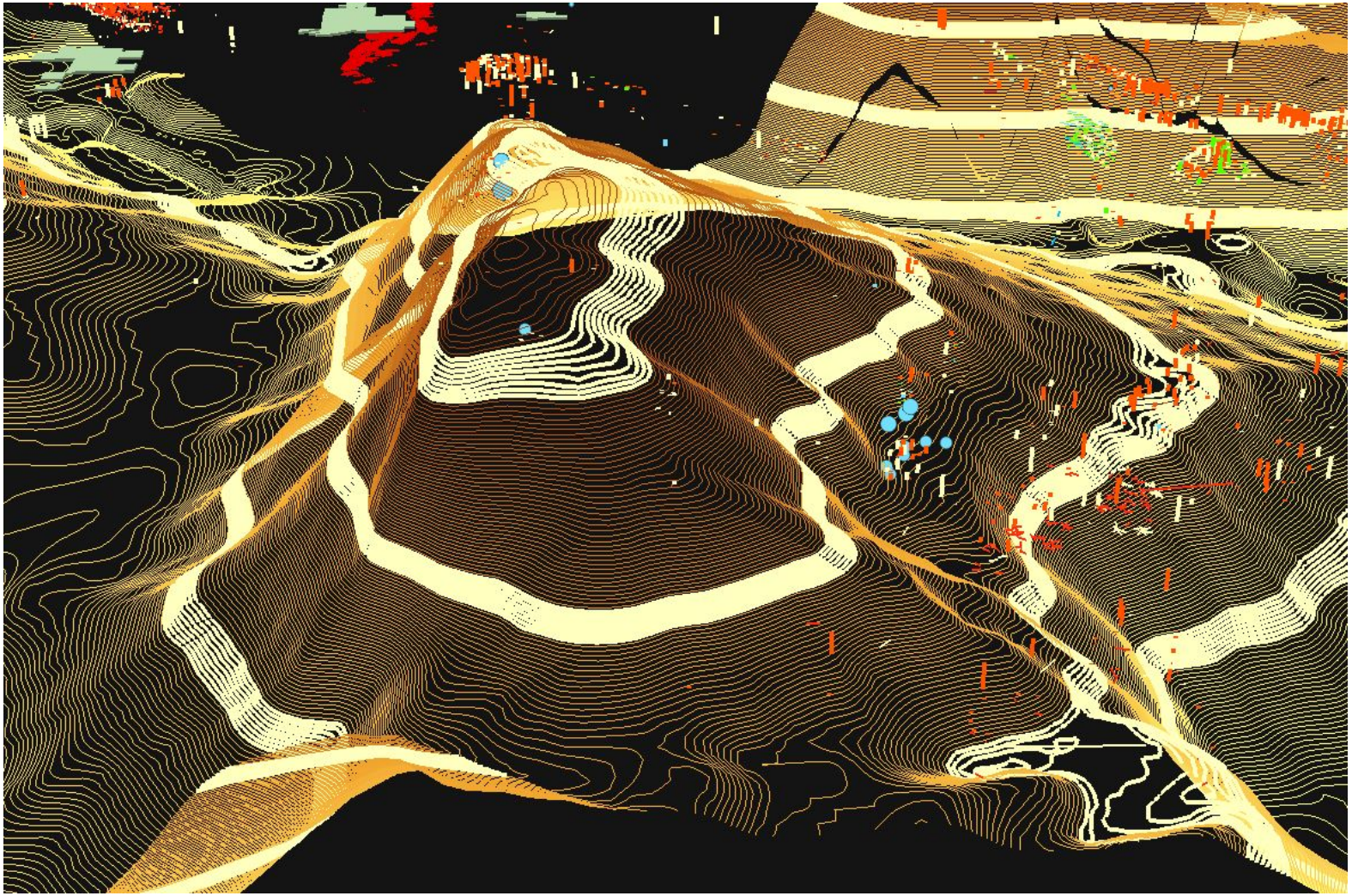
The Rock Springs Uplift, Background



- Site of previous studies
- Past studies evaluated deepest reservoirs
- Suggested capture from the Jim Bridger Power Station (largest CO_2 emitter in Wyoming at ~18 Mt/yr)



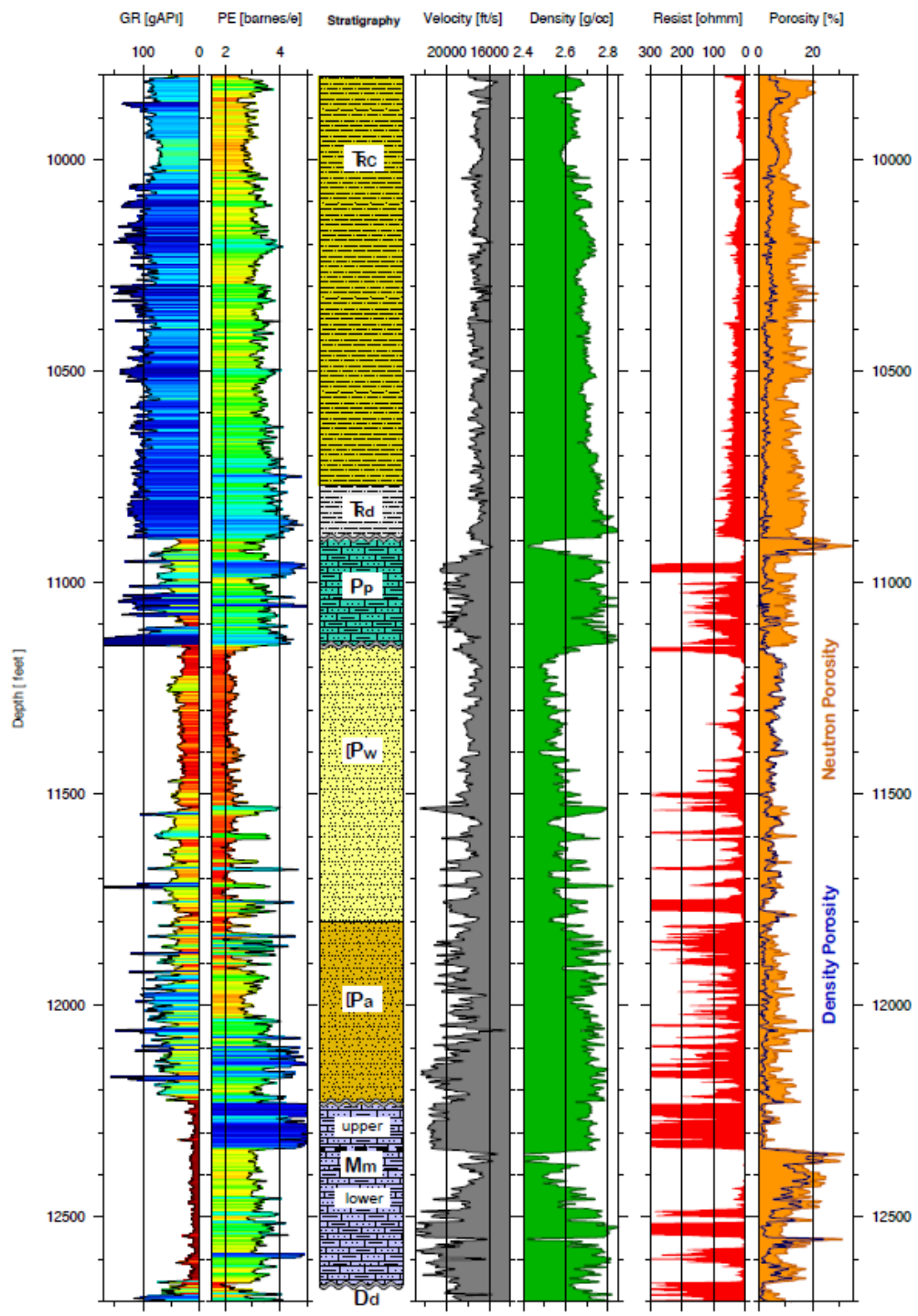
The Rock Springs Uplift, Background



WyRiM (Wyoming resource integration model) developed by EORI

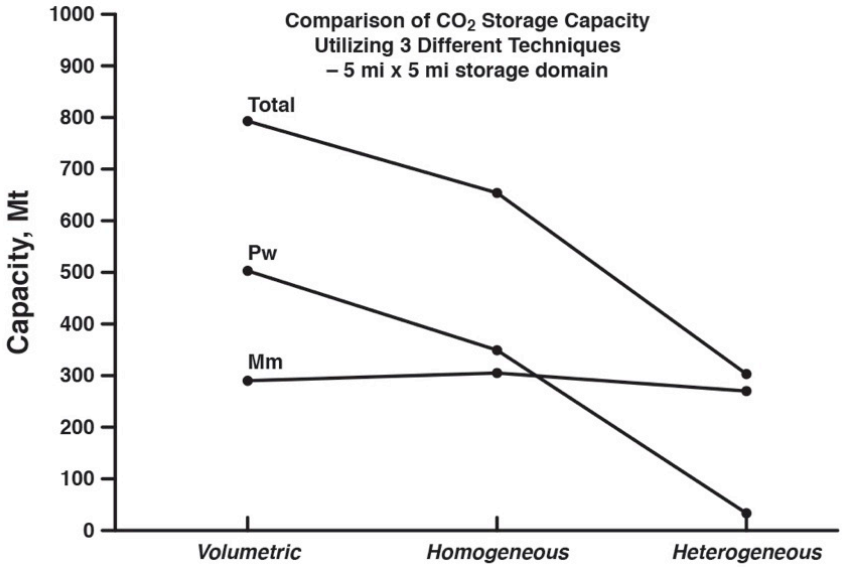
The Rock Springs Uplift, Background

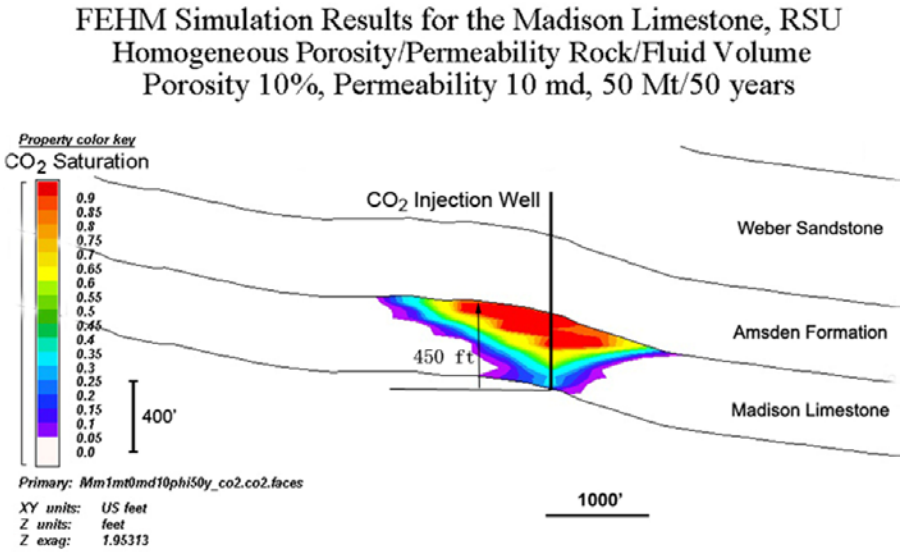
Assessment of Paleozoic reservoirs and seals



Previous studies: Summary

- Mind the geology
- Determine a pressure management strategy
- Seals are not as robust relative to HCs
- Volumetrically feasible (25MT modeled in the Madison)
- Commercial-scale characterization strategy successfully developed/risks determined
- Deep storage could be cost prohibitive





Technical Status

Task 1: Project Management & Planning

Task 2: CCS Coordination Team

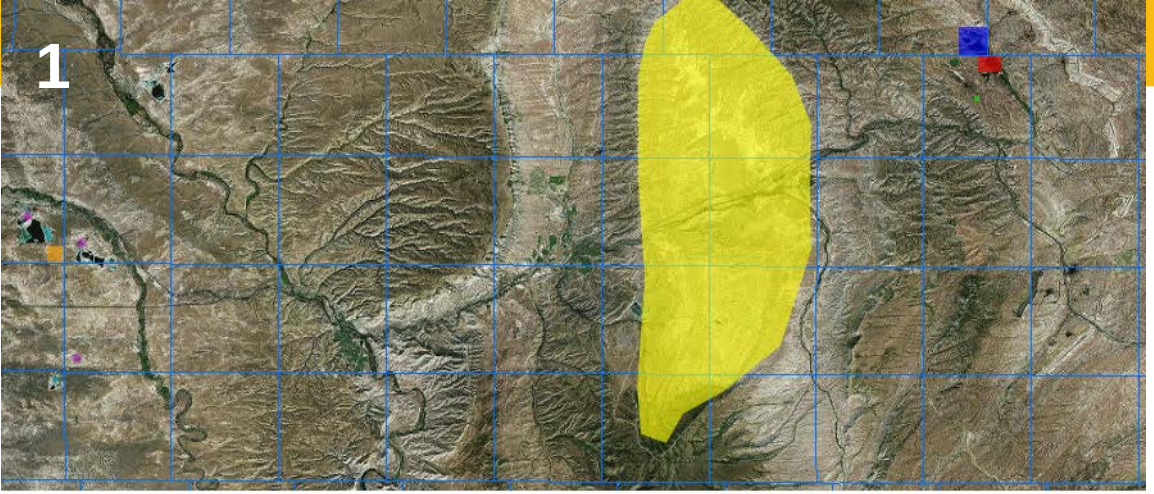
Task 3: Scenario Technical and Non-technical Considerations

Task 4: Regional & Stakeholder Analysis

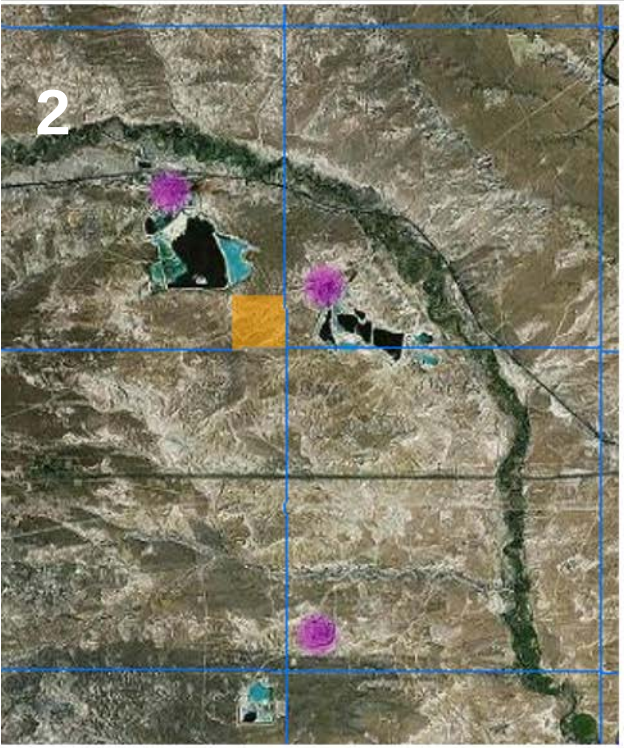
Task 5: Technical Sub-Basinal Storage & CO_2 Source Evaluation

Task 6: NRAP Modeling & Validation

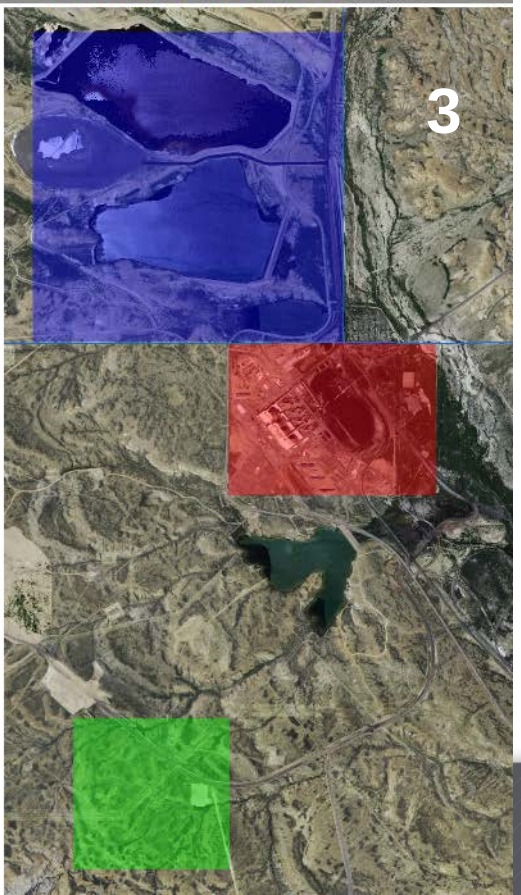
Scenarios Overview



Trona Onsite Trona state-section Anticline Crest JBPS Ash Ponds RSU #1 state section JBPS Onsite



All Blue Township-Range grids are 6miles by 6miles

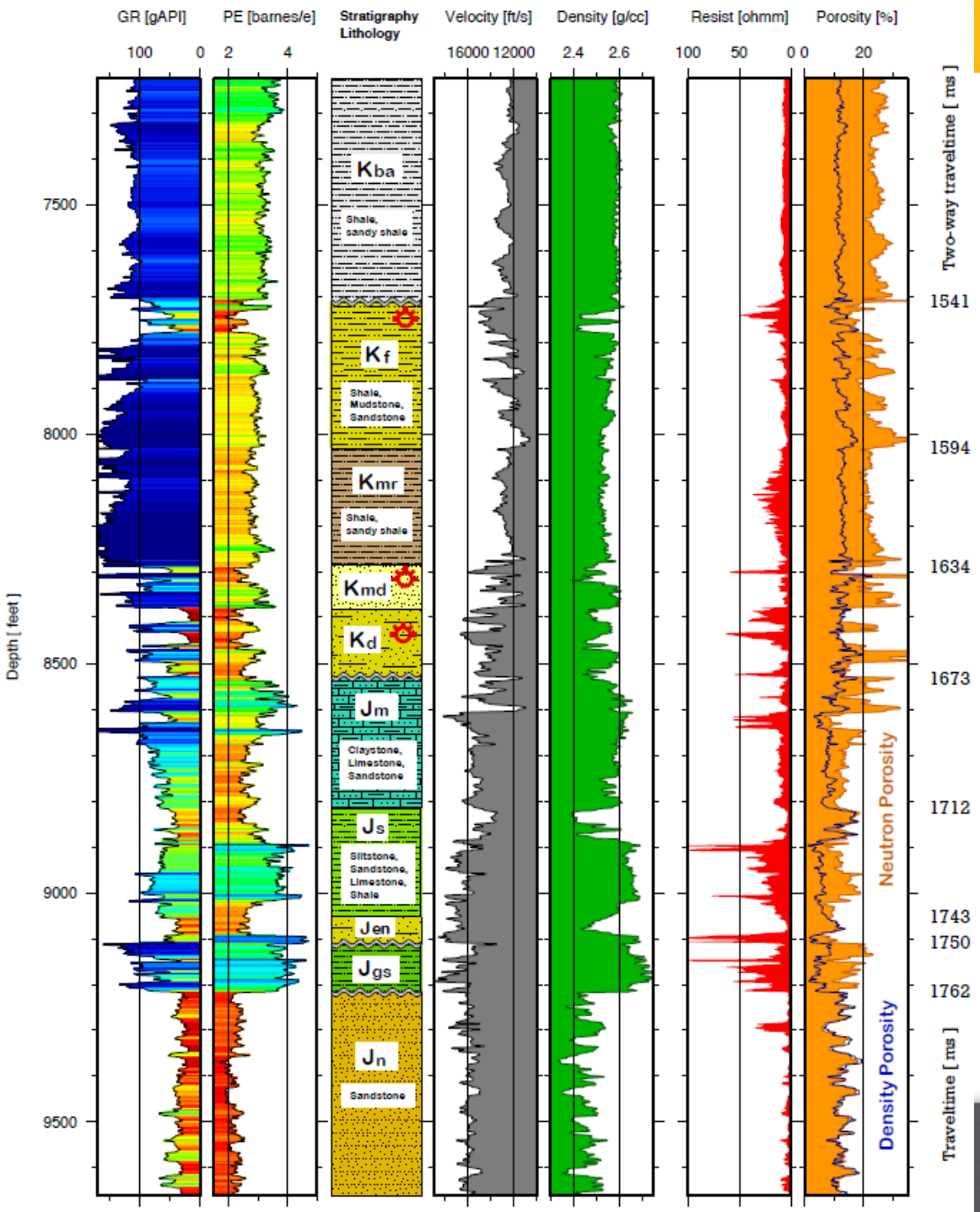


1. Map view of the entirety of the study site with shaded source and potential injection locations

2. Area adjacent to trona plants

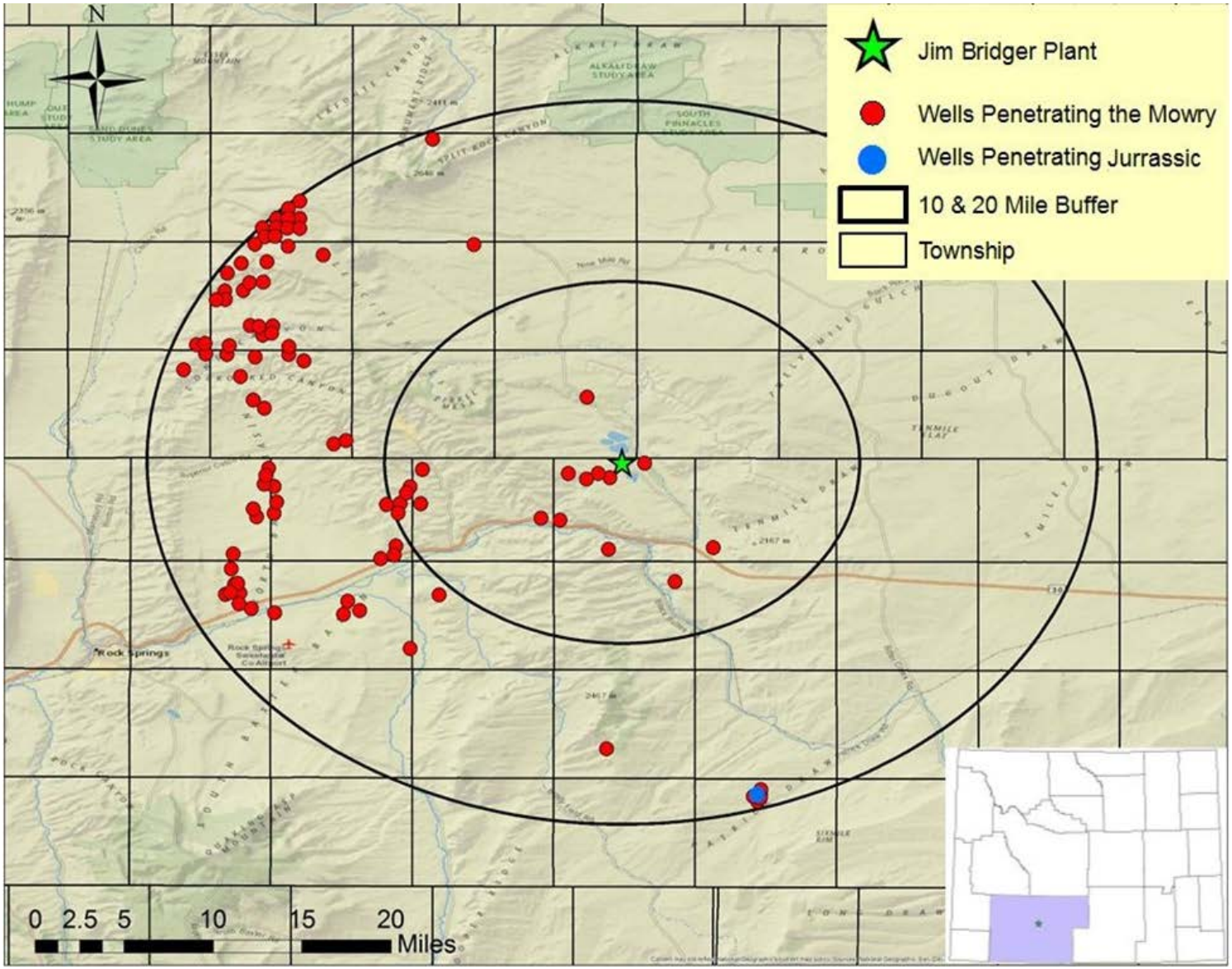
3. Area adjacent to the Jim Bridger power plant

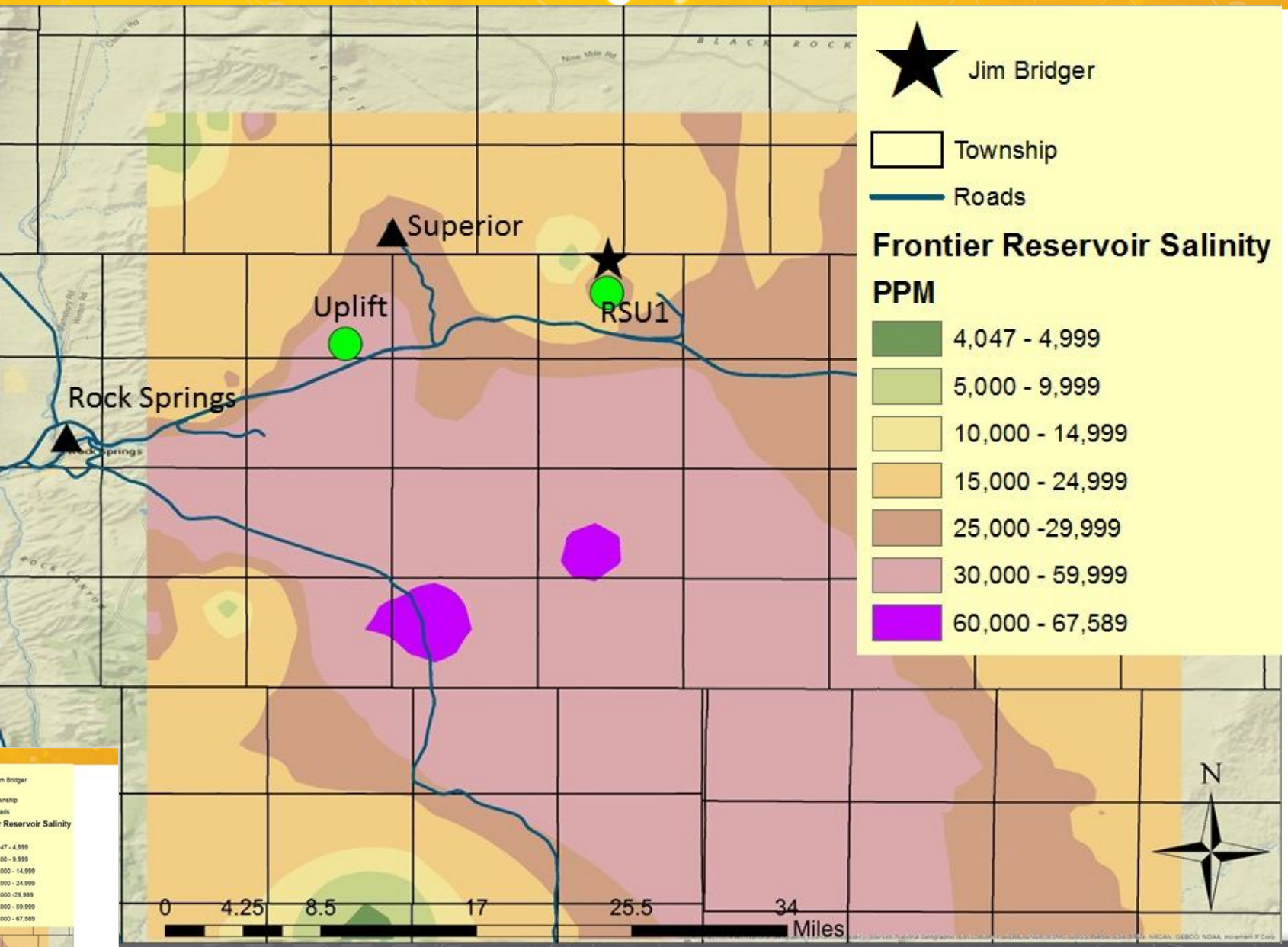
Factor	Source	Transport	Storage
Geologic Factors			
Potential for stacked storage	O	O	+
Compartmentalization of reservoir	O	O	+/-
Sufficiently high porosity in reservoir	O	O	+
High permeability in reservoir	O	O	+/-
Available subsurface data set (logs and seismic)	O	O	+
Faulting	O	-	+/-
Continuous seal with sufficiently low porosity and permeability	O	O	+
Reservoir depth between ~3000 ft and ~13000 ft	O	O	+
High salinity storage formations	O	O	+
Cementation in reservoir	O	O	-
Reservoir and seal heterogeneity	O	O	-
Confirmed valuable minerals	O	O	-
Developed Oil and Gas reservoirs	O	-	+
Environmental Factors			
Protected species or their critical habitat	-	-	O
Presence of a waterbody	-	-	O
Protected areas	O	-	O
Partnership and Outreach Factors			
Synergy with CO2 producers	+	+	+
Negative public perception	-	-	-
Engineering Factors			
Source of over 2Mtonnes/year	+	-	-
Large distance between Source and Storage sites	O	-	-
High Initial CO2 Purity	+	+	+
Traditional Source	+	O	O
Competent and dipping rock strata	O	-	-
Legal Factors			
Federal (BLM) Ownership of Surface and Mineral Interests	O	+/-	+/-
Few Private Landowners	O	+/-	+/-
State Land Sections	O	O	O
State, Federal, and Local Laws and Regulations	-	+/-	O
Sage Grouse habitat	O	-	-
Economic Factors			
Increasing Distance to Injection Site	-	-	O
Single Point Source of CO2 versus Multiple Source Plants	+/-	-	O
Depth of Injection Site	O	O	+/-
High Oil Prices	+	+	+
45Q or Other Tax Incentives	+	O	O

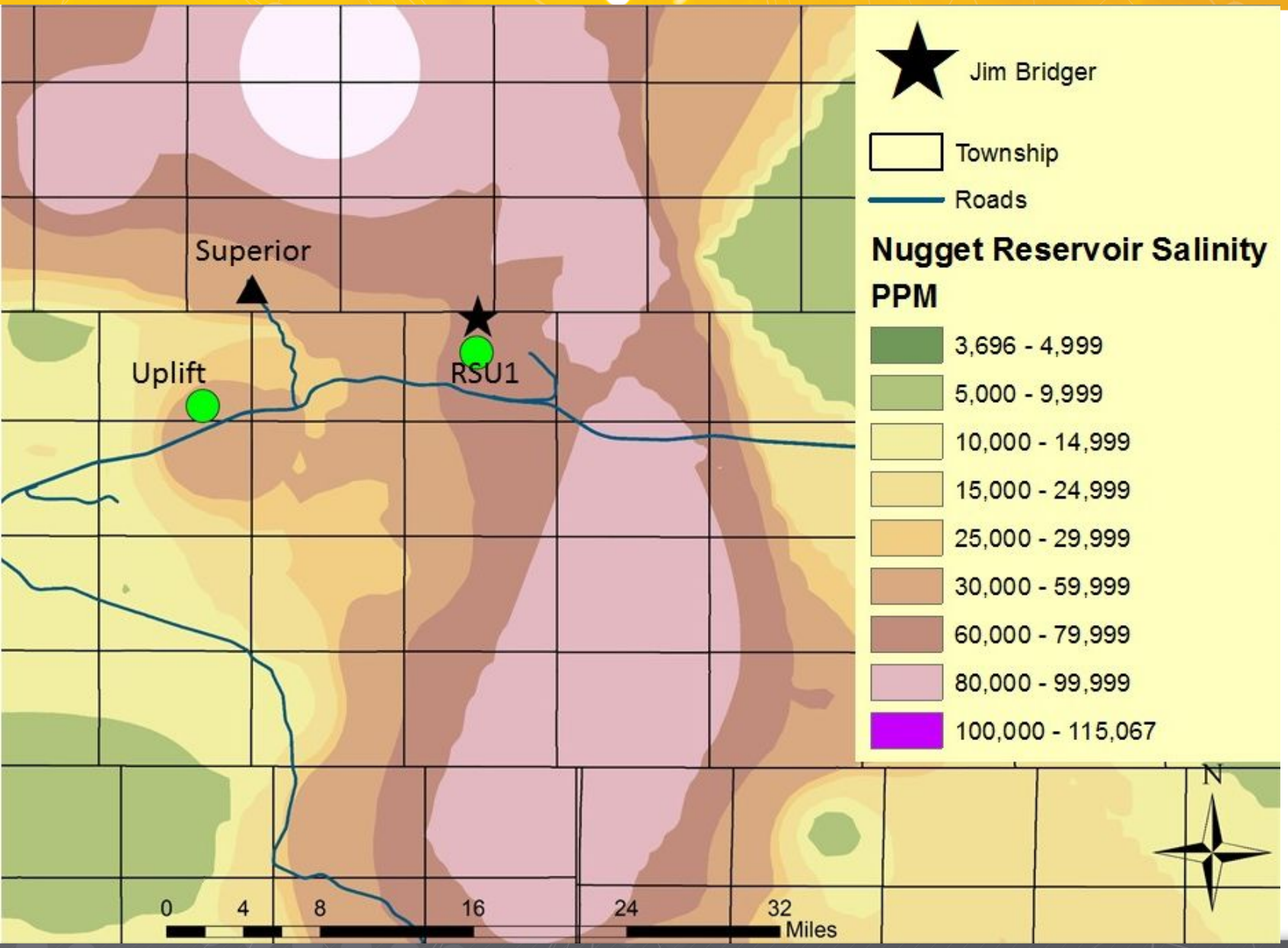


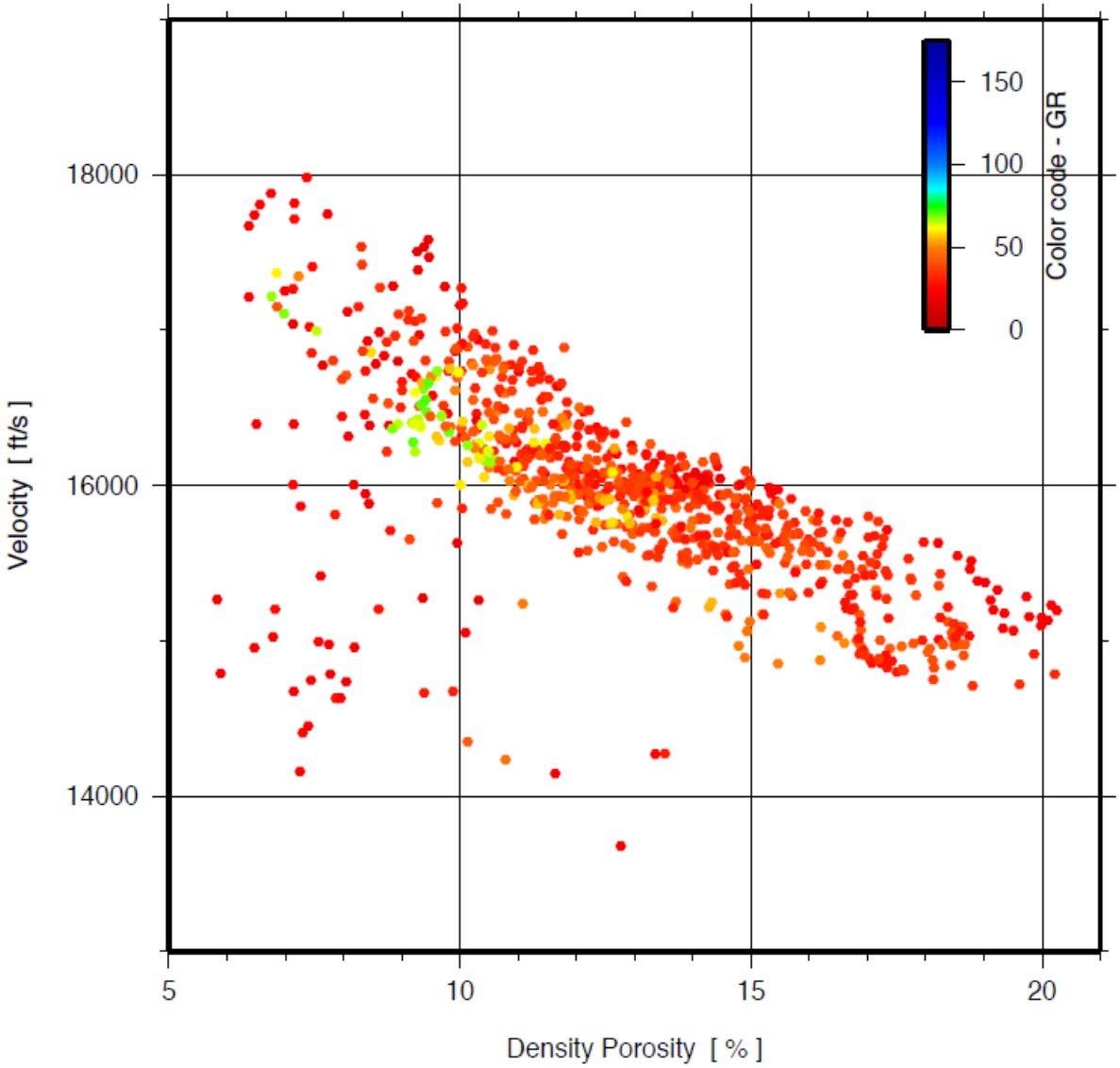
Investigative targets: Mesozoic sandstones and associated seals

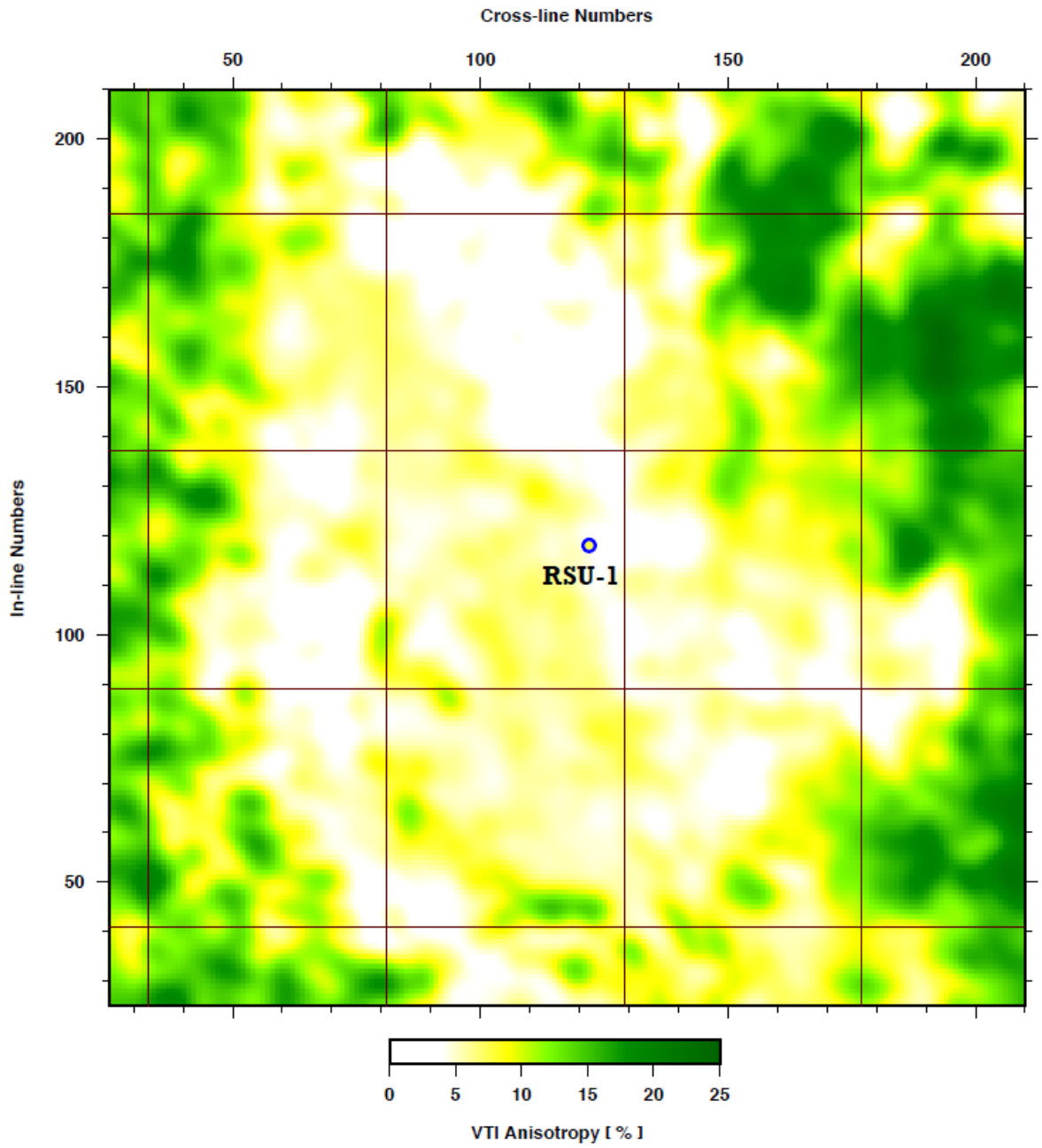
- Relatively thick
- Laterally extensive
- Holds natural gas

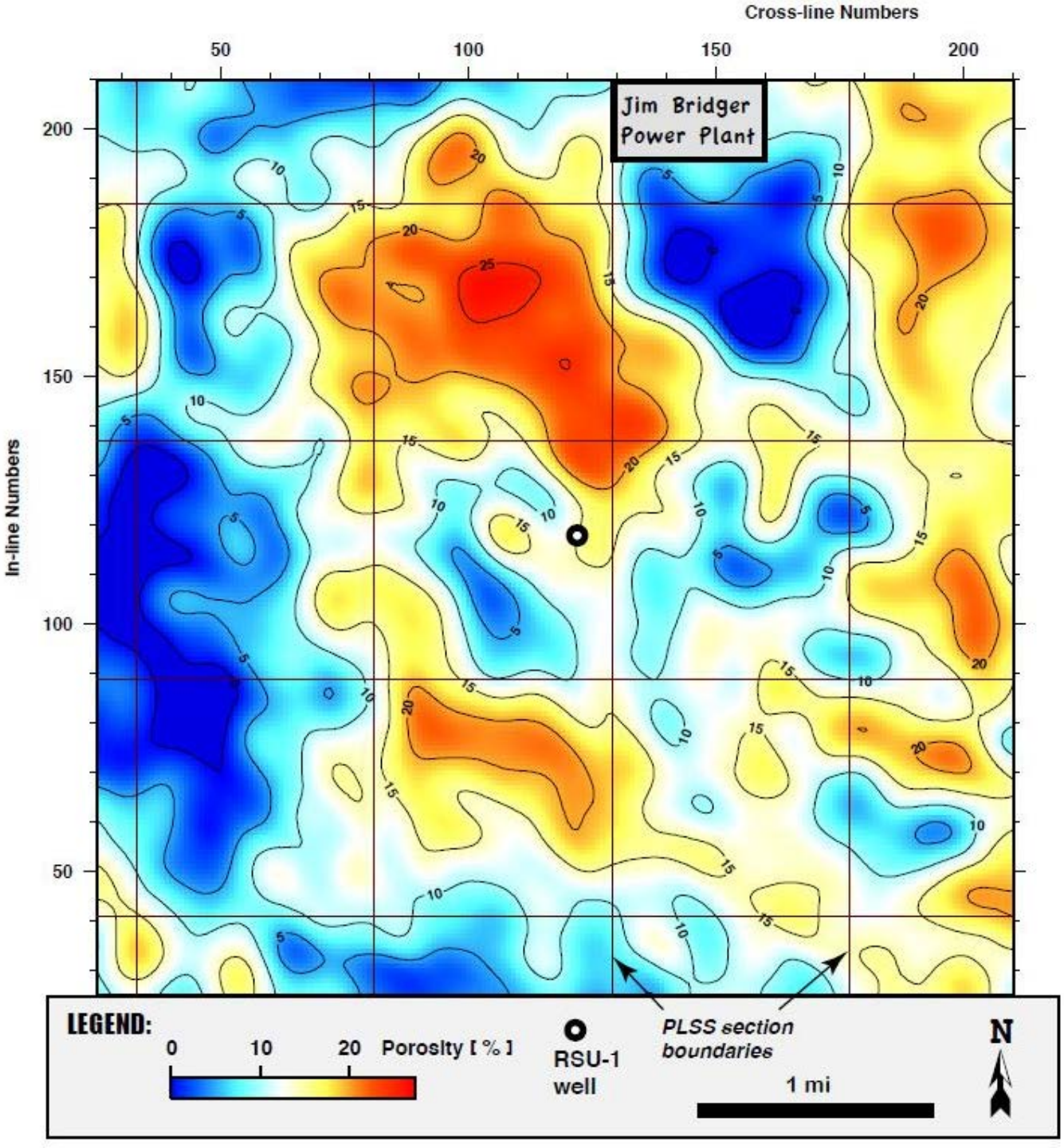

N
Jim Bridger Plant
Wells Penetrating the Mowry
Wells Penetrating Jurrassic
10 & 20 Mile Buffer
Township
Rock Springs
0 2.5 5 10 15 20
Miles

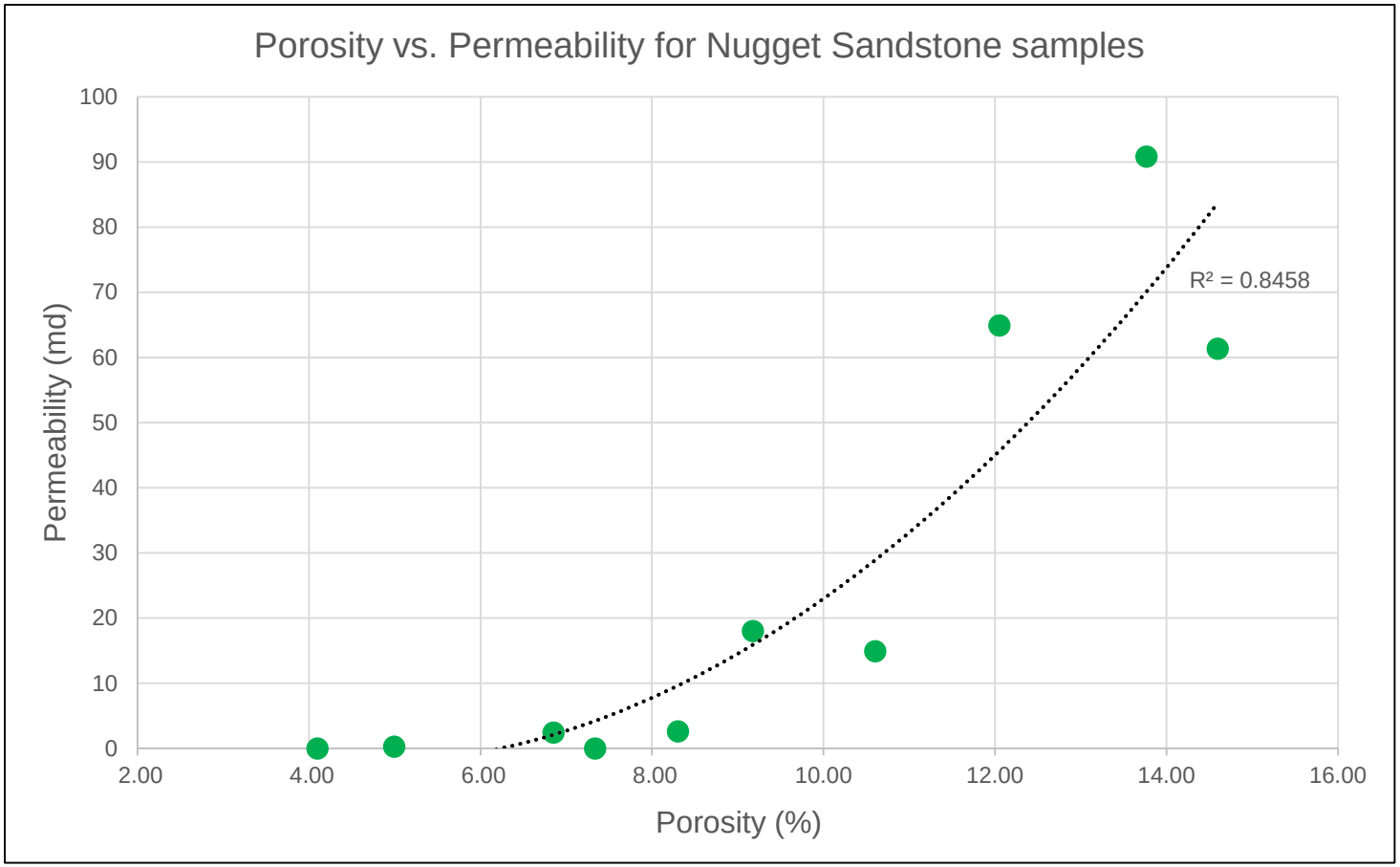

Jim Bridger
Township
Roads
Frontier Reservoir Salinity
PPM
4,047 - 4,999
5,000 - 9,999
10,000 - 14,999
15,000 - 24,999
25,000 -29,999
30,000 - 59,999
60,000 - 67,589
Superior
Uplift
RSU1
Rock Springs
N
0
4.25
8.5
17
25.5
34
Miles


Superior
Uplift
RSU1
Jim Bridger
Township
Roads
Nugget Reservoir Salinity
PPM
3,696 - 4,999
5,000 - 9,999
10,000 - 14,999
15,000 - 24,999
25,000 - 29,999
30,000 - 59,999
60,000 - 79,999
80,000 - 99,999
100,000 - 115,067
N
0
4
8
16
24
32
Miles


18000
16000
14000
Velocity [ft/s]
5
10
15
20
Density Porosity [%]
150
100
50
0
Color code - GR


Cross-line Numbers
50
100
150
200
In-line Numbers
200
150
100
50
RSU-1
0
5
10
15
20
25
VTI Anisotropy [%]


Cross-line Numbers
50
100
150
200
In-line Numbers
200
150
100
50
Jim Bridger
Power Plant
LEGEND:
0
10
20
Porosity [%]
RSU-1
well
PLSS section
boundaries
1 mi
N


Porosity vs. Permeability for Nugget Sandstone samples
Permeability (md)
100
90
80
70
60
50
40
30
20
10
0
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
Porosity (%)
R² = 0.8458

Policy, Legal & Business Considerations

CCS Environment and Plan to Address Feasibility:

Commitment level and anticipated level of investment for all partners

- Letters of commitment, including from key WY Governor & state agencies
- Phase 2 letter of commitment obtained from key committee of jurisdiction

Strategy for securing any necessary pore space rights

- Function of federal, state or private lands
- Wyoming has a pore space statute
- Initial legal/strategy analysis concluded July 31, 2017

Role of state incentives/policies toward project economics and public acceptance

- Long-standing support of CCS/CCUS
- Wyoming has robust CCS/CCUS statutes
- Wyoming has favorable climate for CCUS infrastructure projects, including with state/Federal governments and private sector
- Existing infrastructure (e.g., pipelines) and projects (WY-CUSP, ITC, etc.)
- We have views regarding status of federal policy
- Economic model nearing completion; sales to EOR expected to play a non-trivial role; also evaluating out-of-state electricity sales
- Outreach plan to be completed this month

Strategy for securing rights-of-way for any necessary CO_2 pipeline infrastructure

- Wyoming has existing pipelines + expansion planned, including ROWs on federal lands (WPCI)
- Initial legal/strategy analysis concluded July 31, 2017

Policy, Legal & Business Considerations

CCS Environment and Plan to Address Feasibility (cont'd):

Plan for assumption of long-term liability for stored CO_2

- Team includes experts in private sector risk CCS management solutions, including potential assess to financial/insurance markets
- Liability analysis should be completed shortly

Wyoming CCS/CCUS Regulatory Regime

Wyoming law:

- Specifies who owns the pore space (Wyo. Stat. § 34-1-152 (2016))
- Establishes permitting procedures and requirements for CCS sites, including permits for time-limited research (Wyo. Stat. § 35-11-313 (2016))
- Provides a mechanism for post-closure MRV via a trust fund approach (Wyo. Stat. § 35-11-318 (2016))
- Provides a mechanism for unitization of storage interests (Wyo. Stat. § 35-11-315 (2016))
- Specifies that the injector, not the owner of pore space, is generally liable (Wyo. Stat. § 34-1-513 (2016))
- Clarifies that vis-à-vis storage rights, production rights are dominant but cannot interfere with storage (Wyo. Stat. § 30-5-501 (2016))
- Provides a certification procedure for CO_2 incidentally stored during EOR (Wyo. Stat. § 30-5-502 (2016))

Accomplishments to date

Completed deliverables and/or milestones

- Updated Project Management Plan
- Completed Factor Analysis
- Final Scenario Assessment
- Full Legal Assessment

Forthcoming deliverables and/or milestones

- Economic/business model
- Environmental analysis
- Outreach plan

On-going technical analysis

Lessons Learned/Research Gaps

- Diversification of team member expertise key to success pre-feasibility objectives, but necessitated a focused management plan
- More diverse storage reservoir options in western Wyoming with lesser economic penalties
- Introduction of private funds for carbon business case
- Capture?

Synergy Opportunities

- Collaboration with other CarbonSAFE teams have helped refine methodologies/identify key factors
- Wyoming has helped provide legal framework
- Business model(s) development with other teams
- Pathway to robust industry and regulatory partnerships

Summary

- Wyoming has an uniquely favorable environment for projects of this type relative to its geology, existing pipeline & other infrastructure, supportive law/policy/regulations and supportive private sector & governmental stakeholders

- The Jim Bridger Plant may possibly present potential additional opportunities for potential revenues based upon its geographic location (EOR) and where it sells electricity. Also, large source is a benefit to business models both “green” electrons and EOR.

- If large-scale commercially-based integrated CCS is going to start anywhere, we believe the RSU site is an ideal venue to plant that flag

Appendix

Benefit to the DOE CCUS Program

- *Identify suitable saline aquifers, capable of sequestering 50 Mt (commercial-scale) of CO_2, adjacent to one of the largest coal-fired plants in the Rocky Mountain region*
- *Ensure storage permanence relative to seal/reservoir pairs*
- *Develop technologies to improve reservoir storage efficiency while ensuring containment effectiveness utilizing reservoir management techniques*

Additional Benefits

- Evaluation of the economics associated with coupling commercial-scale coal-based CCS with low-carbon energy sales
- Evaluation of the economics of coupling coal-sourced capture within existing EOR infrastructure
- Technical and economic evaluation of large-source capture and storage (~18Mt/year); 50 Mt before 25 years?

Phase 1 Project Overview: Goals and Objectives

1. Evaluate the potential of multi-reservoir injection near the Jim Bridger Plant, one of the largest sources of anthropogenic CO_2 in the Rocky Mountain region, with a focus on evaluating younger strata along the Rock Springs Uplift (RSU)

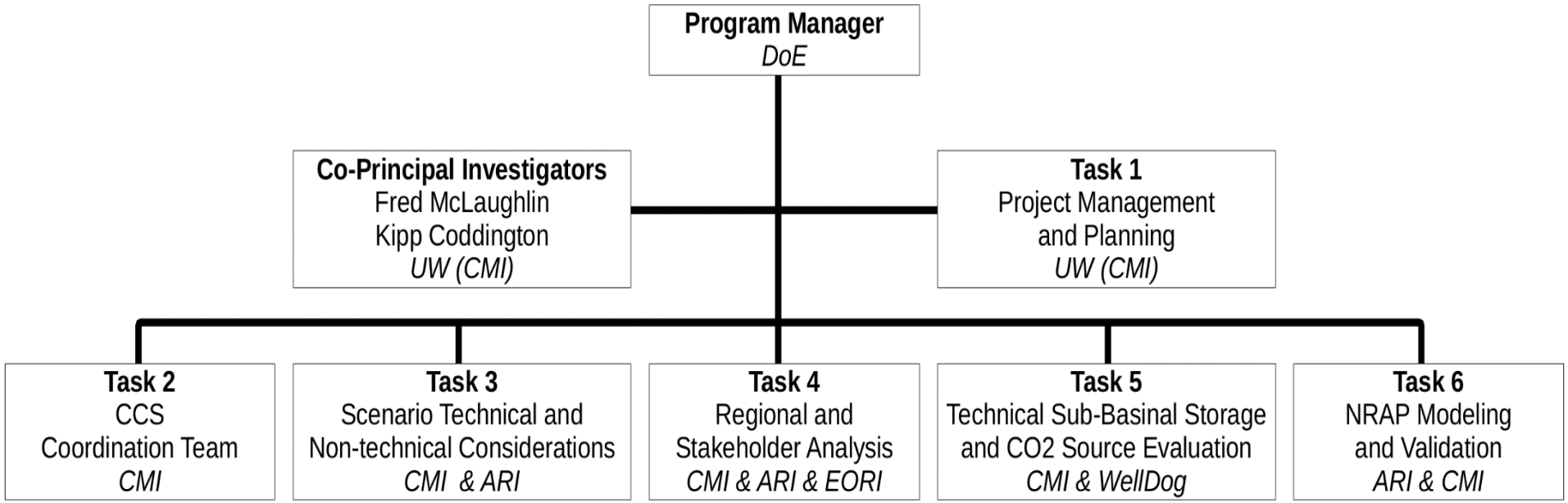
2. Evaluate coupled economic strategies that utilize the existing CO_2 pipeline network (Wyoming Pipeline Corridor Initiative) in the immediate vicinity of the RSU to provide a broader array of CO_2 emitters and sinks

3. Expand the Phase 1 CCS Coordination Team (CCT) as needed

4. Consider the addition of: (1) additional regional CO_2 sources, including trona production facilities; (2) the use of CO_2 for enhanced oil recovery for economic purposes while still ensuring satisfaction of the Project's saline storage requirements, and (3) and the impact of low-carbon energy sales to populations in the west

5. Evaluate the State's current legal and policy framework in relation to program goals

Organization Chart/ Communication Plan



- Communications plan
  - Bi-weekly phone/web meetings
  - Team kick-off meeting (completed)
  - Technical site visit
  - Internal interdisciplinary team review sessions

University of Wyoming, EORI, KKR, ARI, Welldog, and PacifiCorp

The storage complex feasibility should address the following challenges at a minimum

Assess Public Outreach Needs
Goals and Activities
Outreach Team
Stakeholders and Social Climate
Public Outreach Program

Storage Complex Model Data
Build and Calibrate Models
Test Models
Compare Outputs

Draft Site Development Plan
Detailed Characterization Phase
Development Phase

Analyze Regulatory Issues
Applicable Regulations
UIC Permit Planning

Characterize Storage Complex Subsurface
Geological and Geophysical
Geochemical
Geomechanical
Hydrogeological

Appendix: Selected Bibliography

Deng, H., Stauffer, P.H., Dai, Z., Jiao, Z. and Surdam, R.C., 2012. Simulation of industrial-scale CO 2 storage: Multi-scale heterogeneity and its impacts on storage capacity, injectivity and leakage. International Journal of Greenhouse Gas Control, 10, pp.397-418.

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Surdam, R.C. ed., 2013. *Geological CO2 storage characterization: The key to deploying clean fossil energy technology*. Springer Science & Business Media.

Tchuindjang, J.P., Mallick, S. and Sharma, H., 2016. Reservoir characterization using prestack waveform inversion. In *SEG Technical Program Expanded Abstracts 2016* (pp. 3597-3602). Society of Exploration Geophysicists.