

National Risk Assessment Partnership Workshop



Ground Water Protection Council
Underground Injection Control
Conference

San Antonio, TX

February 19, 2020



Today's Agenda

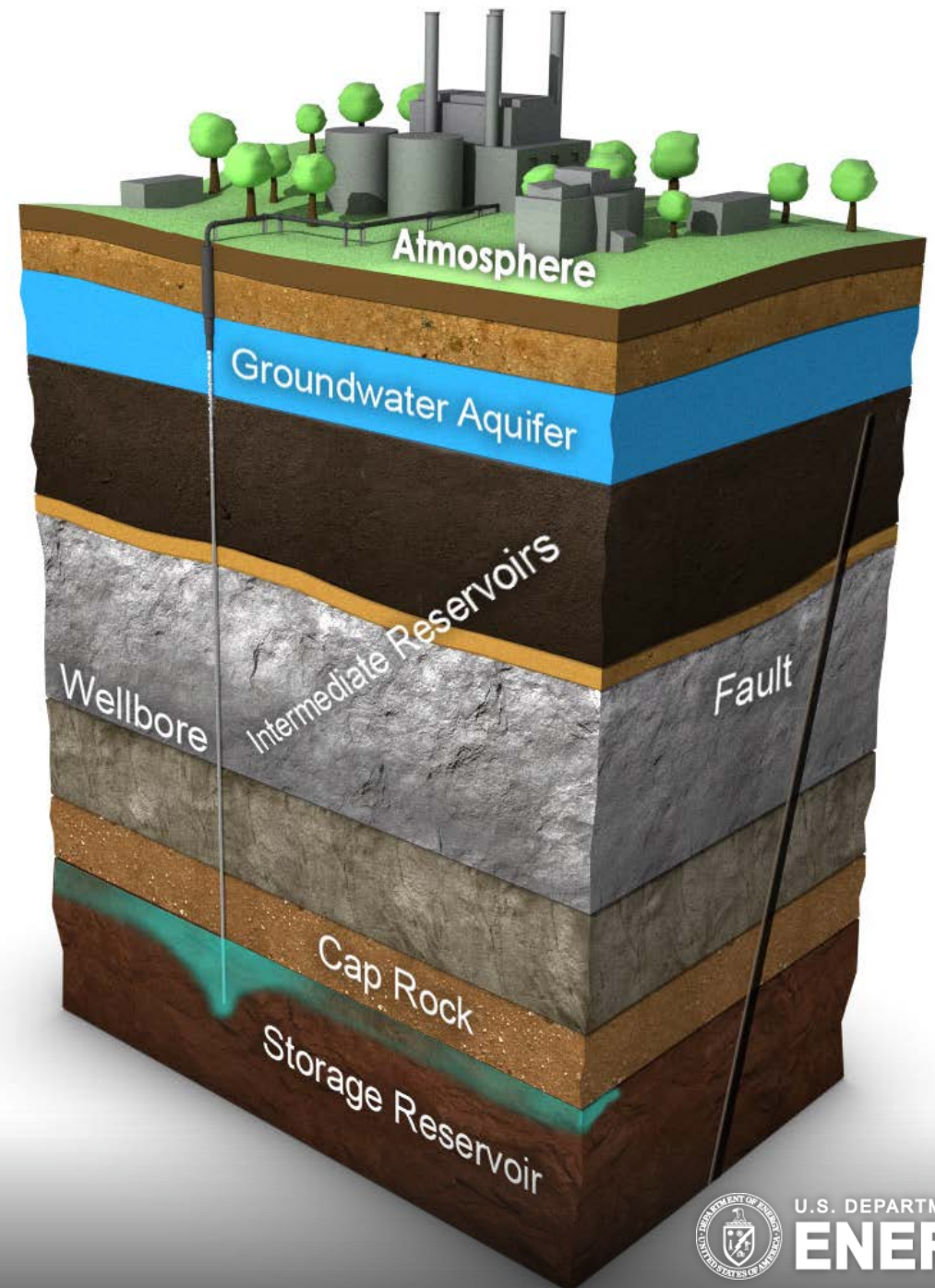
- Introduction
- Fluid Migration Characterization
- State-of-stress Characterization
- Risk-based Area of Review
- U.S. DOE's SMART Initiative
- Plume Dynamics and Conformance
- Induced Seismicity Management
- Monitoring for Leak Detection
- Site Closure
- Discussion

NRAP Approach and Research Products

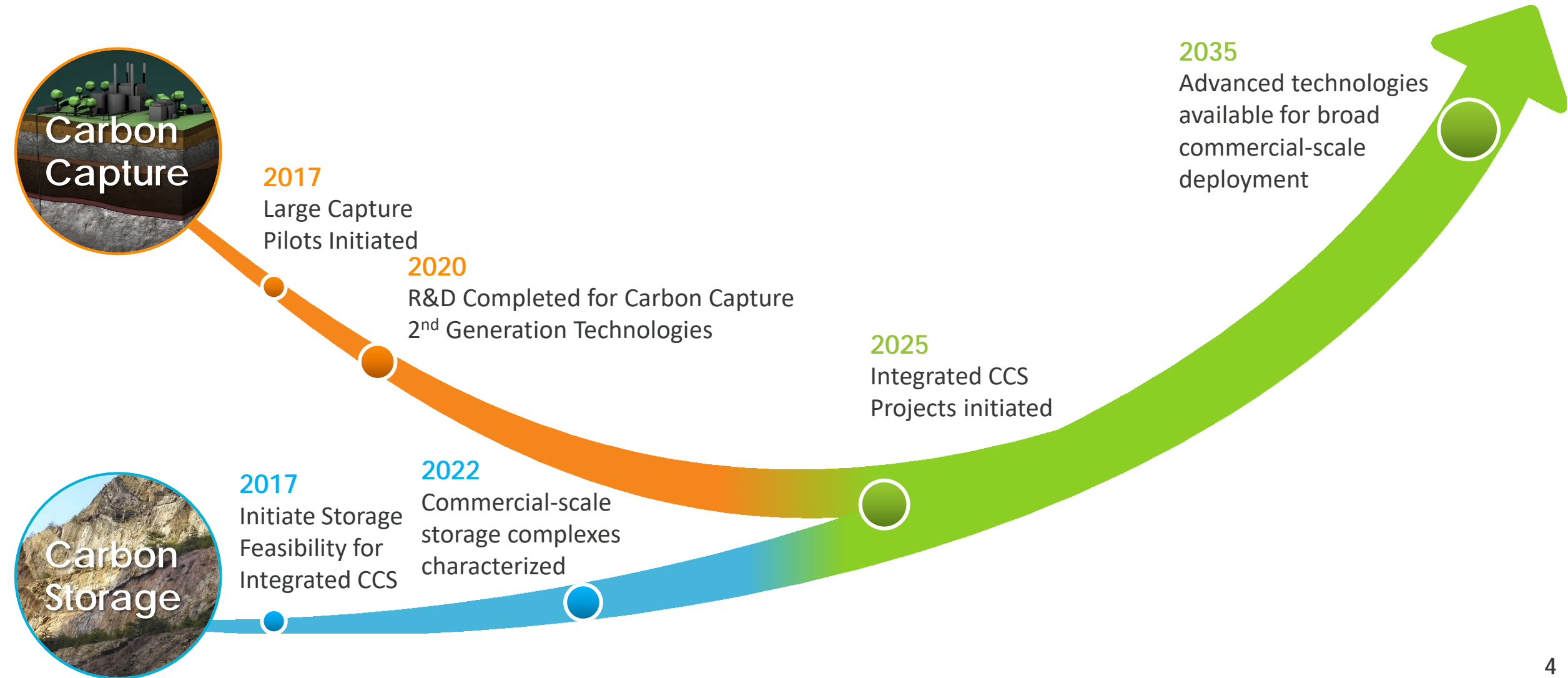
Robert Dilmore

National Energy Technology Laboratory

February 19, 2020

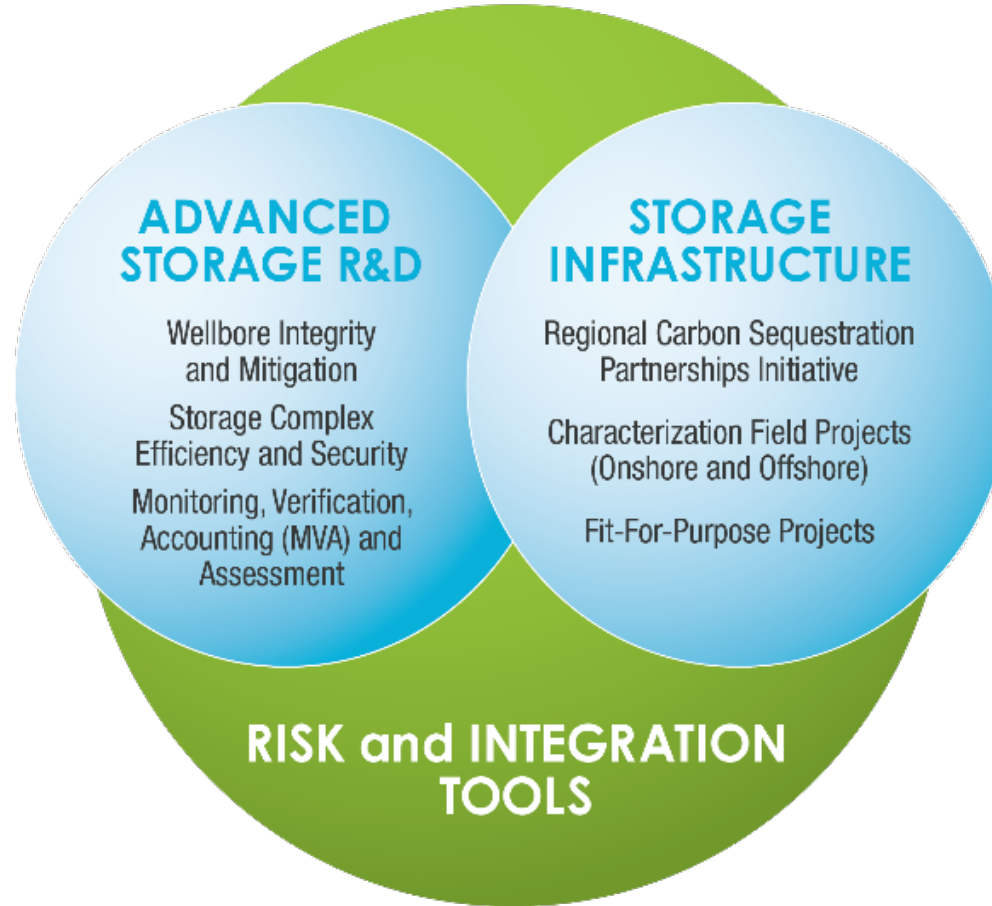


Integrated R&D Approach for Commercial-Scale Deployment



U.S. DOE Carbon Storage Program

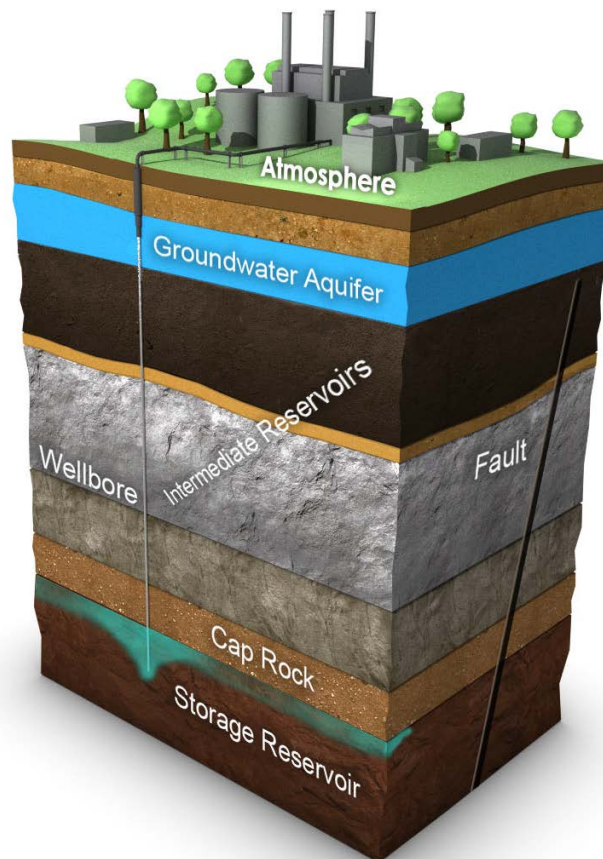
CARBON STORAGE PROGRAM



U.S. DOE's National Risk Assessment Partnership

NRAP leverages DOE's capabilities to quantitatively assess long-term environmental risks amidst significant geologic uncertainty and variability.

Technical Team



Stakeholder Group



The NRAP team:

Technical Team



The NRAP approach

*probability of an event
(behavior of the system)*

*consequence of an event (e.g.,
loss resulting from event)*



$$\text{Risk} = P(\text{event}) \times C(\text{event})$$

Focus: Using science-based prediction to inform decisions on CO₂ storage, amidst the complexity and uncertainty of engineered–natural systems.

The NRAP approach

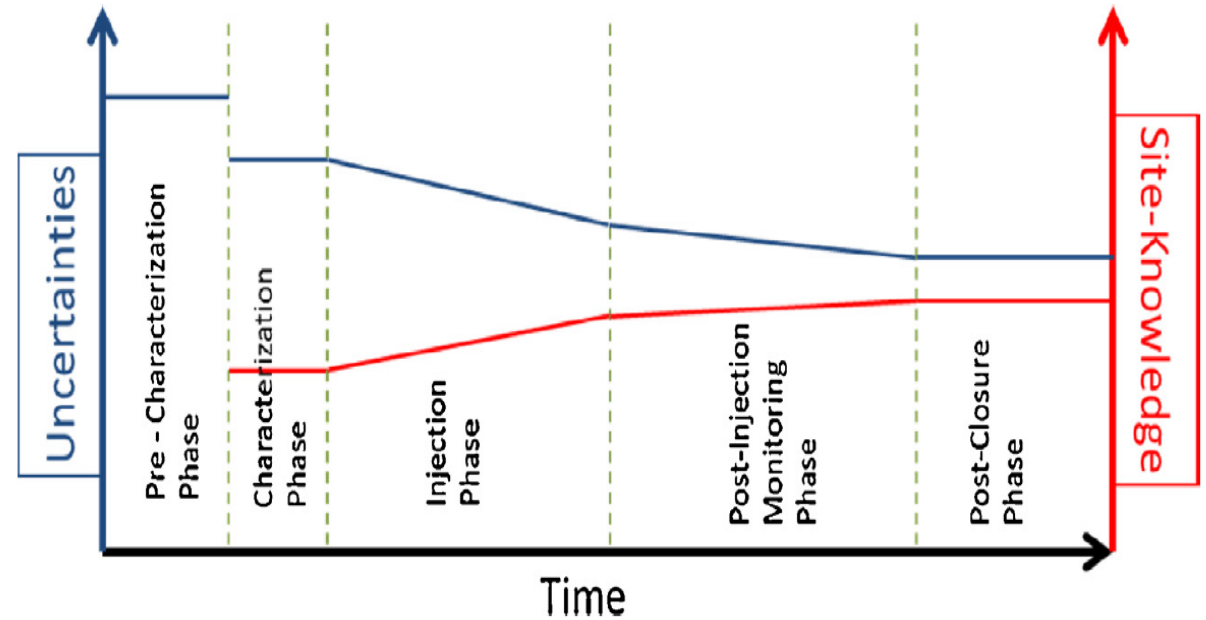
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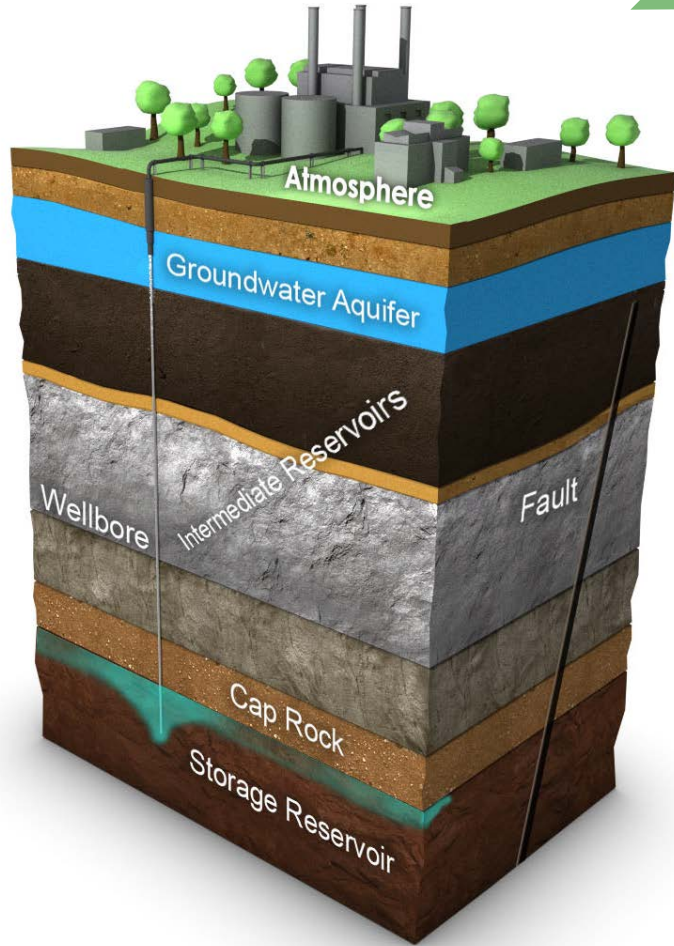
- Science-based
- Quantitative
- Site-specific
- Probabilistic - considering uncertainty quantification / reduction
- Supports decision making



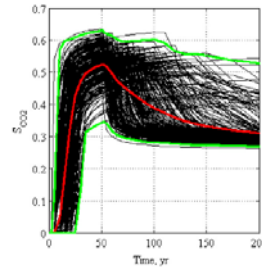
Pawar et al., 2015 9

NRAP's approach for rapid prediction of whole-system risk performance

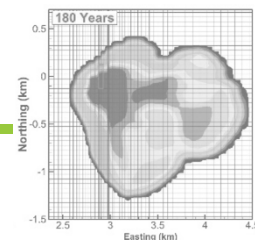
A. Divide system into discrete components



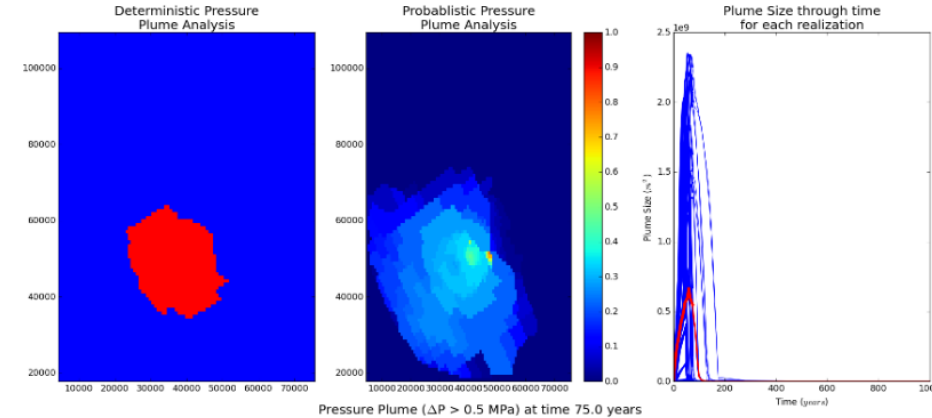
B. Develop detailed component models that are validated against lab/field data



C. Develop reduced-order models (ROMs) that rapidly reproduce component model predictions



Integrated Risk Assessment



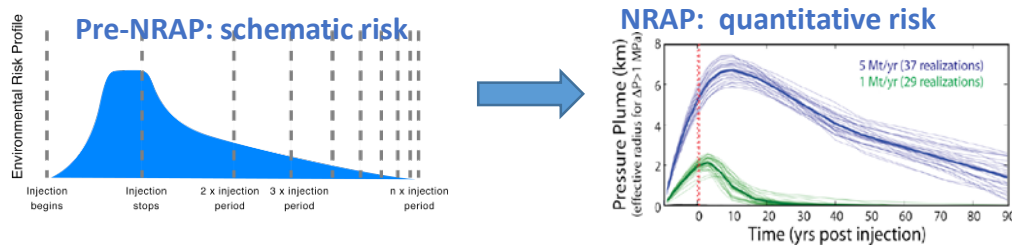
D. Link ROMs via integrated assessment models (IAMs) to predict system performance

E. Exercise whole system model to explore risk performance

NRAP Phase I and Phase II

Phase I (2010–2016)

Risk Assessment and Uncertainty Quantification

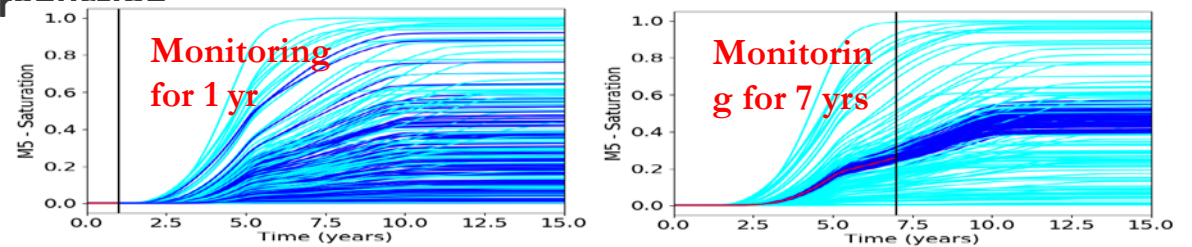


- Pioneered hybrid methods for quantifying complex systems (physics coupled to empirical, e.g., machine learning)
- Developed toolsets for quantifying storage post injection
- Developed foundation for strategic (risk-based) monitoring (e.g., DREAM tool; no-impact thresholds)

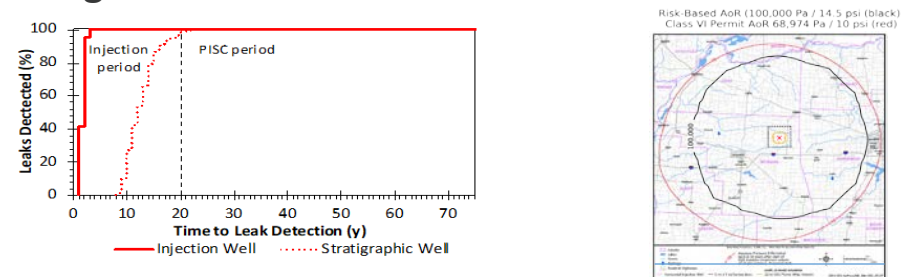
Phase II (2017–2022)

Risk Management and Uncertainty Reduction

- Monitoring for leakage detection, conformance assessment, and uncertainty reduction



- Supporting risk-based decisions at GCS sites

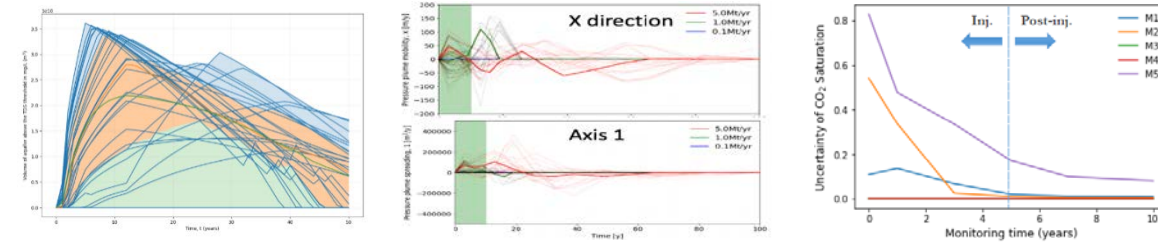


- Considering risk-management alternatives

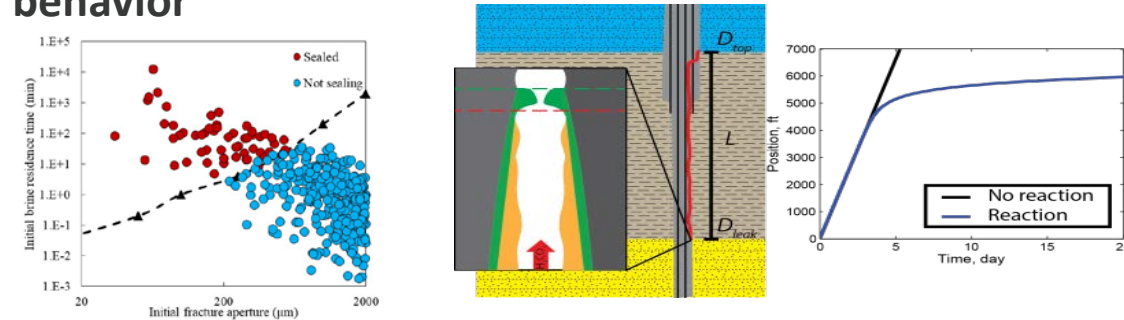
NRAP Technical Focus

- Containment assurance / leakage risk
- Induced seismicity risk management
- Strategic monitoring for Uncertainty Reduction
- Validating NRAP tools and approaches
- Addressing critical risk-related questions

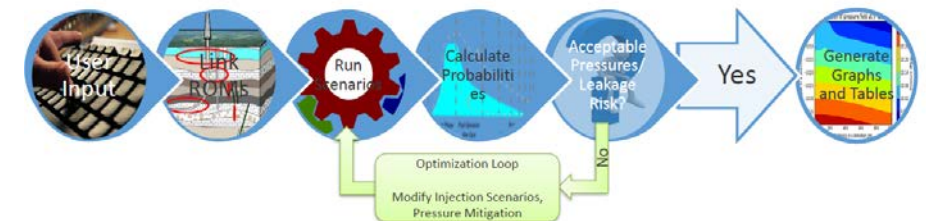
Developing integrated assessments of GCS site performance



Developing improved characterizations of leakage behavior



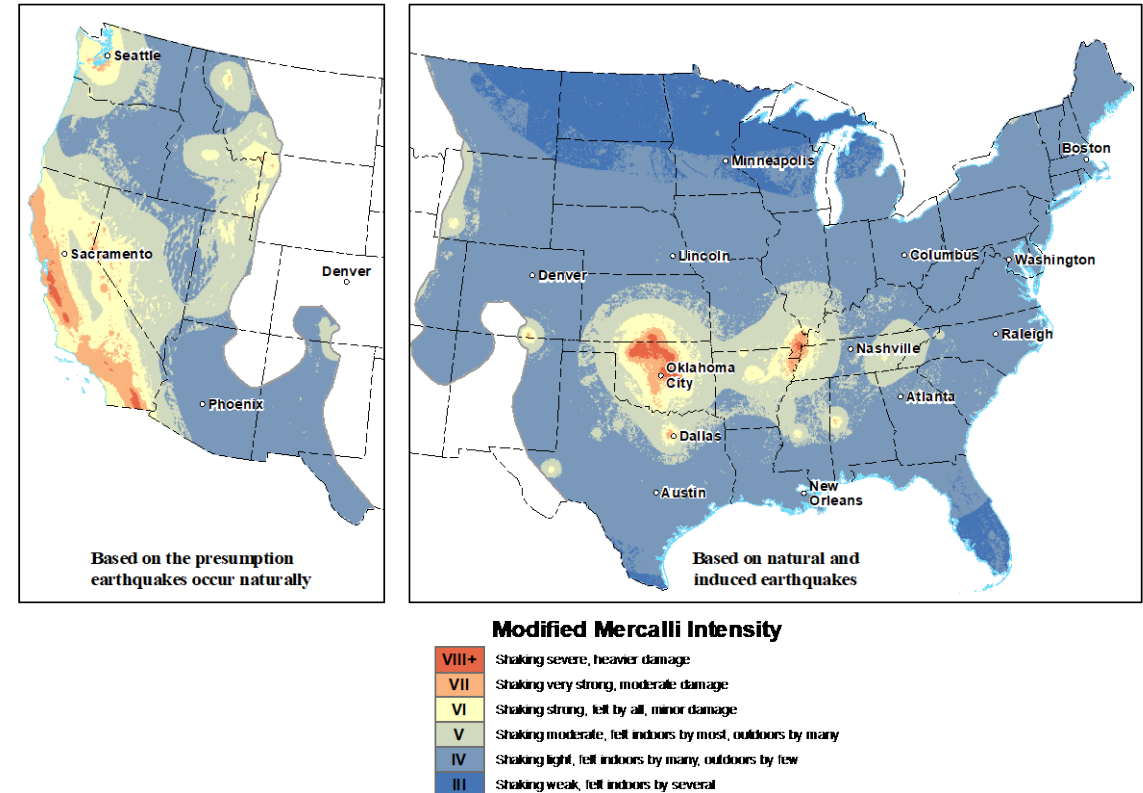
Modeling dynamic risk and mitigation



NRAP Technical Focus

- Containment assurance / leakage risk
- **Induced seismicity risk management**
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USGS Forecast for Ground Shaking Intensity from Natural and Induced Earthquakes in 2016

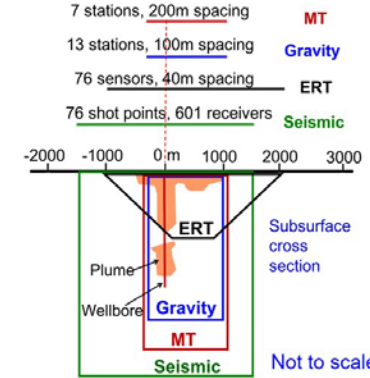


USGS map displaying intensity of potential ground shaking from natural and human-induced earthquakes. There is a small chance (one percent) that ground shaking will occur at this level or higher. There is a greater chance (99 percent) that ground shaking will be lower than what is displayed in these maps.

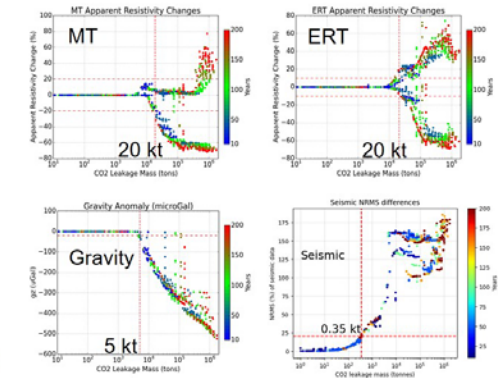
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Modeling of Geophysical Monitoring

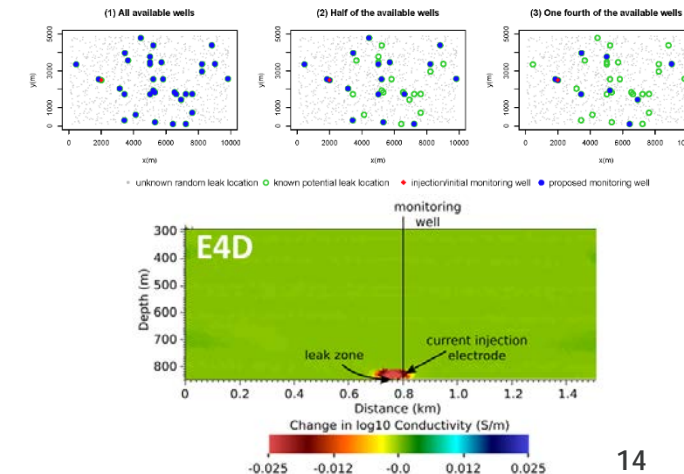


Layout of Surface Geophysical Methods



Geophysical signals versus CO₂ leakage mass

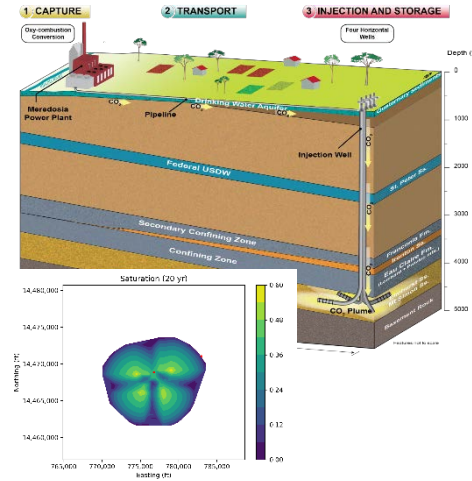
Risk-Based Monitoring Network Design



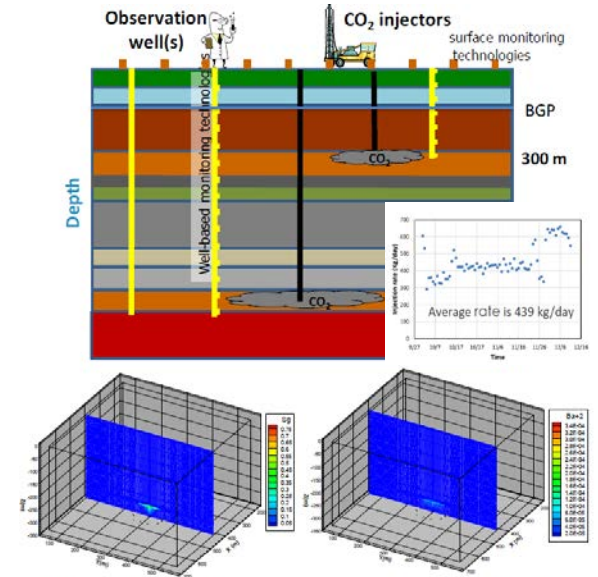
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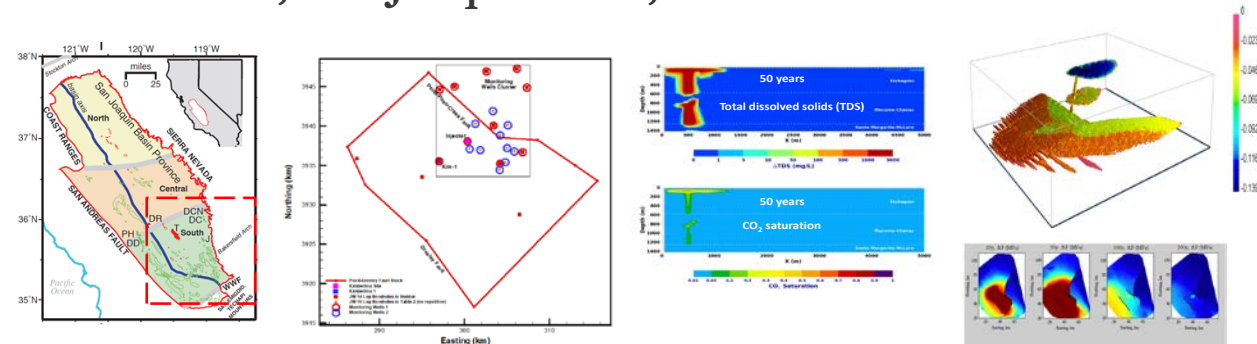
Retrospective risk assessment at FutureGen 2.0 site



Application of NRAP tools at CaMI field test



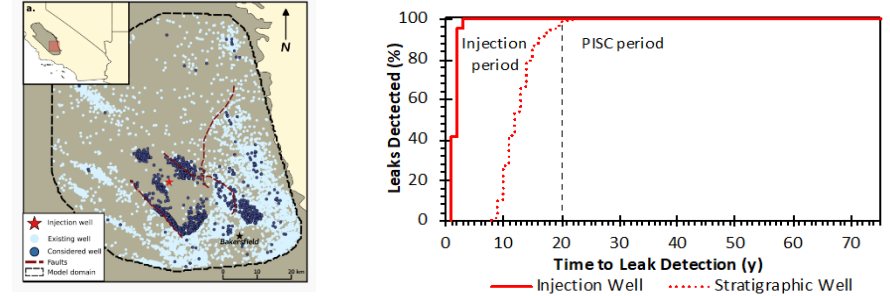
Kimberlina, San Joaquin Basin, CA



NRAP Technical Focus

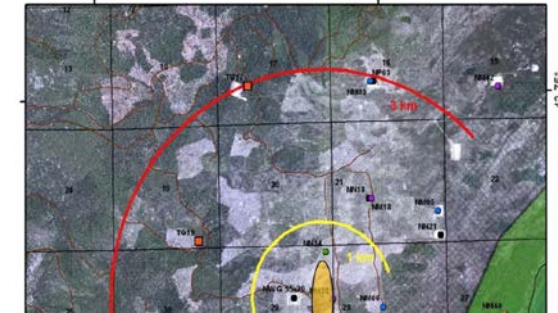
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Risk-Based Post-Injection Site Closure

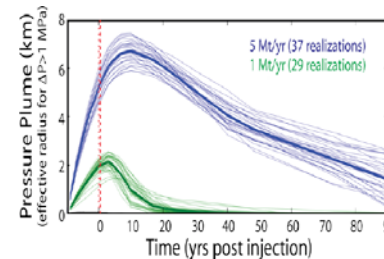


Recommended Practices / Workflows for Risk Management

Risk-Based AoR (100,000 Pa / 14.5 psi (black)
Class VI Permit AoR 68,974 Pa / 10 psi (red)



Mapping NRAP to Semi-Quantitative Approaches



Addressing critical risk-related questions

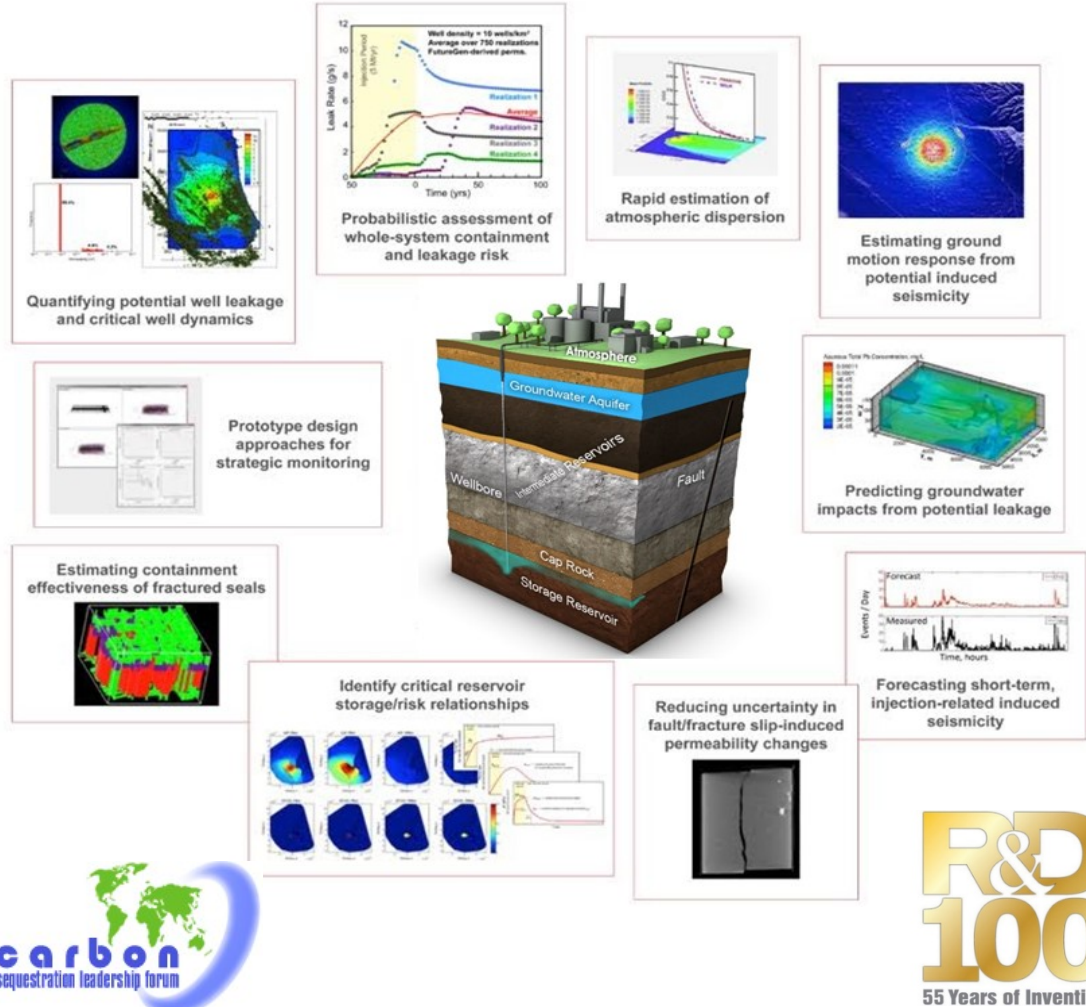
- How can we build confidence in our model of the subsurface system? Are projected risks within tolerance?
- How can we determine an **appropriate, risk-based area of review**?
- How can we design efficient and effective **leakage monitoring systems**?
- How can a risk-based approach be used to justify **early closure at a GCS site**?
- How do we use field data and modeling to **predict and avoid impactful seismicity**?
- How can we understand and manage risks at GCS sites (e.g., a brownfield site with many wells)?

What are NRAP products?

- Science Base
- Framework and approach
- Computational tools
- Workflows / recommended practices
- Insights for geologic carbon storage

NRAP Risk Assessment Tools

Phase I Toolset (November 2016)



Phase II Tools

Leakage Risk/Containment Assurance

- NRAP Open-Source Integrated Assessment Model (NRAP-Open-IAM)

Induced Seismicity Risk

- Short-term Seismic Forecasting Tool (STSF)
- State of Stress Analysis Tool (SoSAT)
- Probabilistic Seismic Risk Assessment Tool (RiskCat)

Monitoring Design and Optimization

- Designs for Risk Evaluation and Management (DREAM 2.0)
- Microseismic monitoring design optimization tool (forthcoming)

NRAP Tools Available at:

<https://edx.netl.doe.gov/organization/nrap-tools>



NRAP Products

- **NRAP Tools**
 - SOSAT
 - NRAP-Open-IAM – **New Beta Release!**
 - DREAM 2.0 – **New Beta Release!**
 - RiskCat – **March 2020**
- **NRAP Tools Webinars (sign up)**
- **Virtual Special Issue of *IJGGC* (March/April 2020)**
- **Recommended practices / workflows for risk management (drafts mid-2020)**
- **Community datasets**
 - Select simulations from Kimberlina, CA
 - Select data and simulations from FutureGen 2.0

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