Summary of DOE's Monitoring, Mitigation, and Verification Program and Modeling Program

Monitoring, Mitigation, and Verification

Modeling

Dawn Marie Deel
Project Manager
Carbon Sequestration Program

09/26/2007

National Energy Technology Laboratory

Office of Fossil Energy

Monitoring, Mitigation & Verification (MM&V)

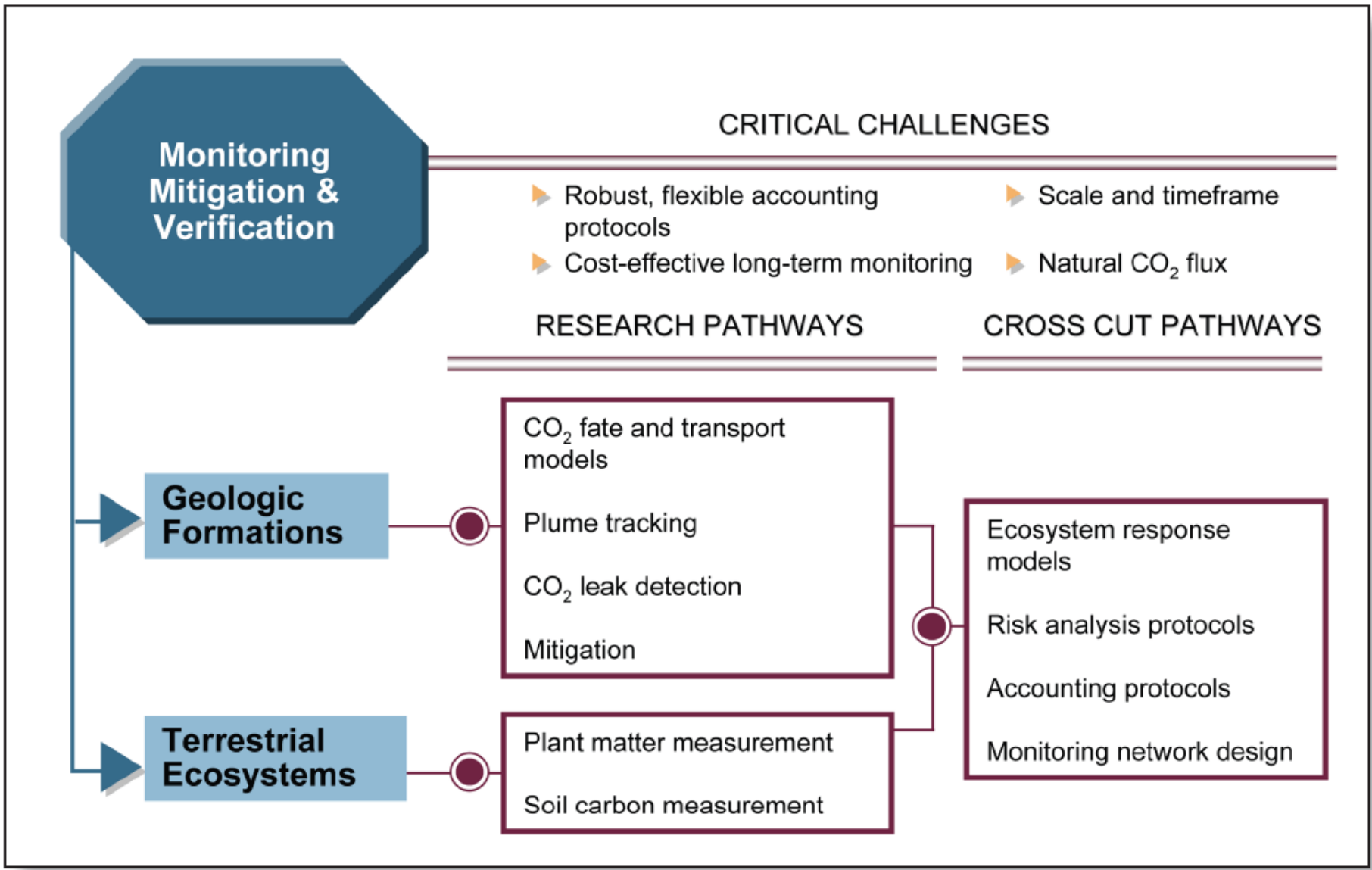
- **Monitoring and Verification**
  - Ability to measure the amount of CO_2 stored at a particular site
  - Monitor the site for leaks
  - Track the location of underground CO_2 plume
  - Verify that the CO_2 is stored in a way that is permanent and not harmful to the host ecosystem
- **Mitigation**
  - Near-term ability to respond to risks such as CO_2 leakage or ecological damage in the unlikely event that it should occur

Modeling

- **Modeling**
  - Simulating the underground conditions that influence the behavior of CO_2 injected into geologic formations
  - Characterizing any resulting geomechanical changes to the reservoir

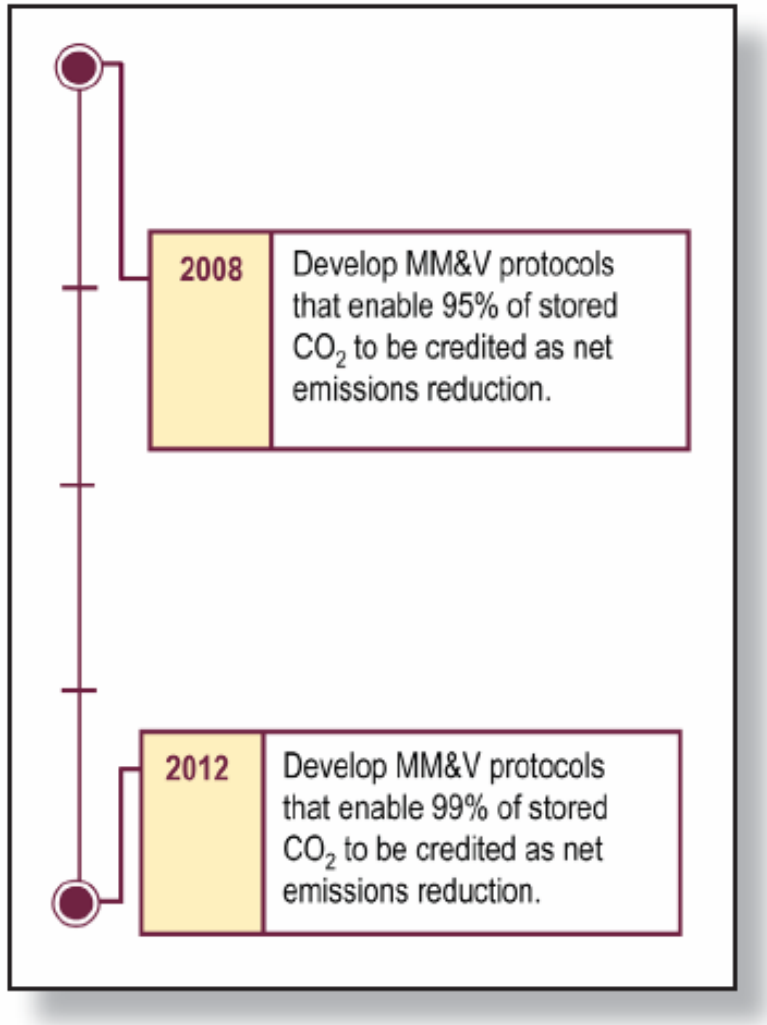
Critical in ensuring the long-term viability of carbon capture and storage (CCS) systems

Satisfying both technical and regulatory requirements


Monitoring Mitigation & Verification
CRITICAL CHALLENGES
Robust, flexible accounting protocols
Scale and timeframe
Cost-effective long-term monitoring
Natural CO_2 flux
RESEARCH PATHWAYS
CROSS CUT PATHWAYS
Geologic Formations
CO_2 fate and transport models
Plume tracking
CO_2 leak detection
Mitigation
Terrestrial Ecosystems
Plant matter measurement
Soil carbon measurement
Ecosystem response models
Risk analysis protocols
Accounting protocols
Monitoring network design

Goals

MM&V goals focus on ensuring permanence, which support the overarching Program goal of achieving 90% carbon capture with 99% storage permanence



Monitoring, Mitigation, and Verification

Geologic Formations

- CO_2 fate and transport models – simulating underground conditions that influence behavior of CO_2
- Plume tracking – map injected CO_2 and track its movement
- CO_2 leak detection – critical measurements of whether CO_2 is escaping from storage reservoir
- Mitigation- steps to be taken to arrest the flow of CO_2 and mitigate the impacts

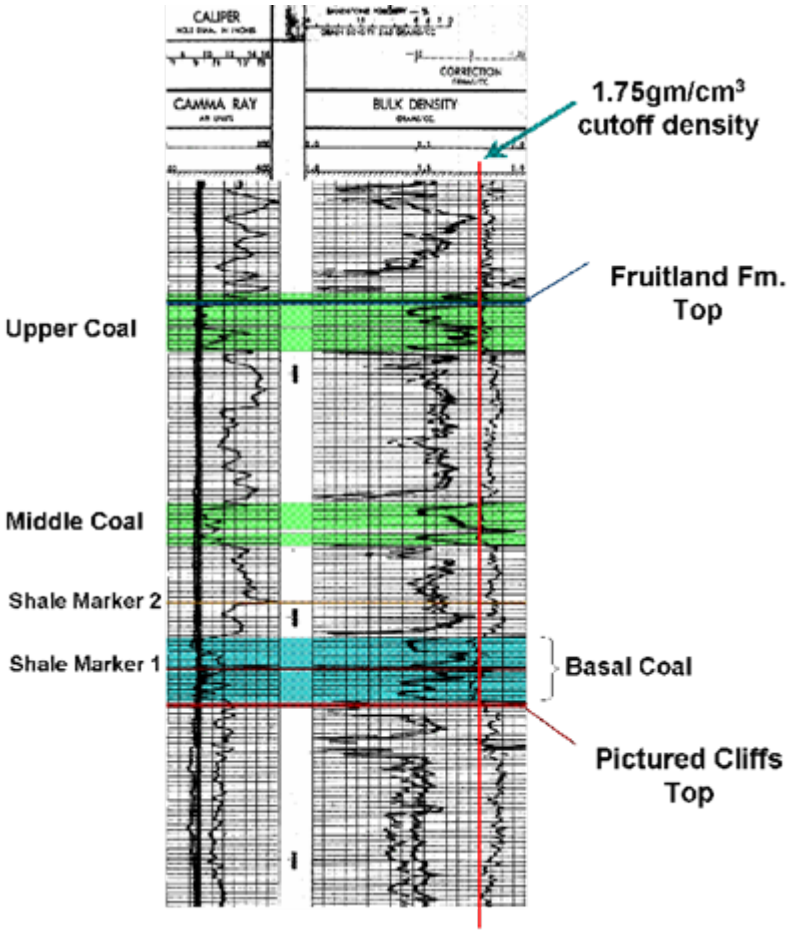
Terrestrial Ecosystems

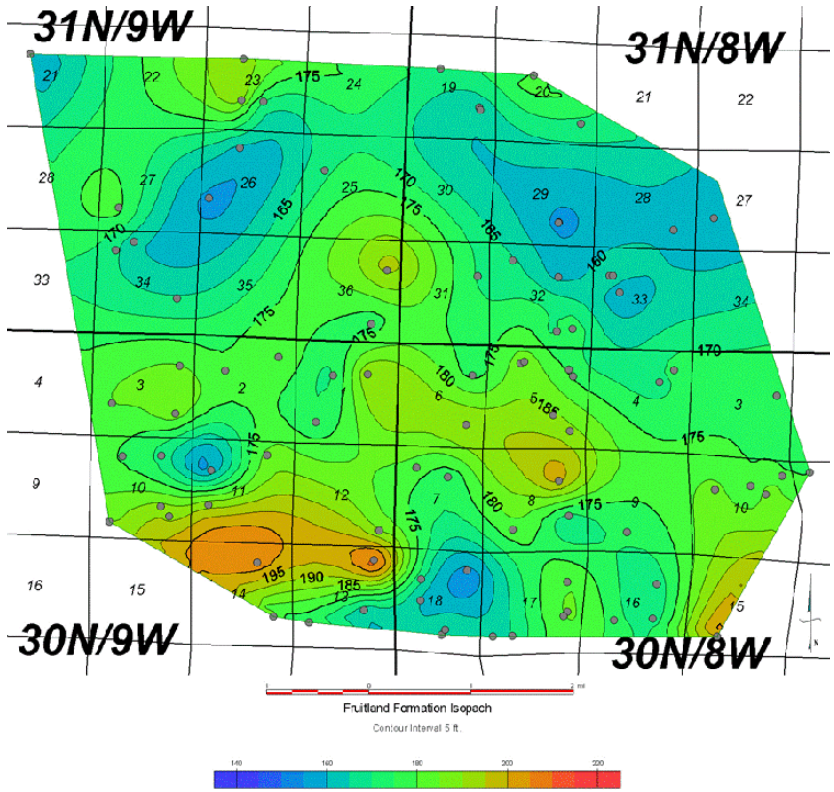
- Organic matter measurement – reducing cost for measuring carbon in terrestrial ecosystems and analyzing soil samples
- Soil carbon measurement – automated technologies for measuring soil carbon
- Modeling – extrapolating results of carbon uptake activities from random samples to entire plots for estimating net increase in carbon

Modeling

- Enables researchers to predict how CO_2 plumes will flow and become hydrodynamically trapped in the short term and to understand the effects of chemical reactions (and other mechanisms) that will immobilize CO_2 over the longer term
- Helps operators reduce the risks associated with inducing fractures in caprock and reactivating faults during injection
- Engenders confidence that injected CO_2 will remain securely stored *before* injection commences
- Examines potential pathways that fugitive CO_2 may follow

Geologic Model of Coal Seam Developed by NETL





Fruitland coal isopach

- Taken from several area well logs near Farmington, NM
- Southwest Partnership-San Juan Basin Site

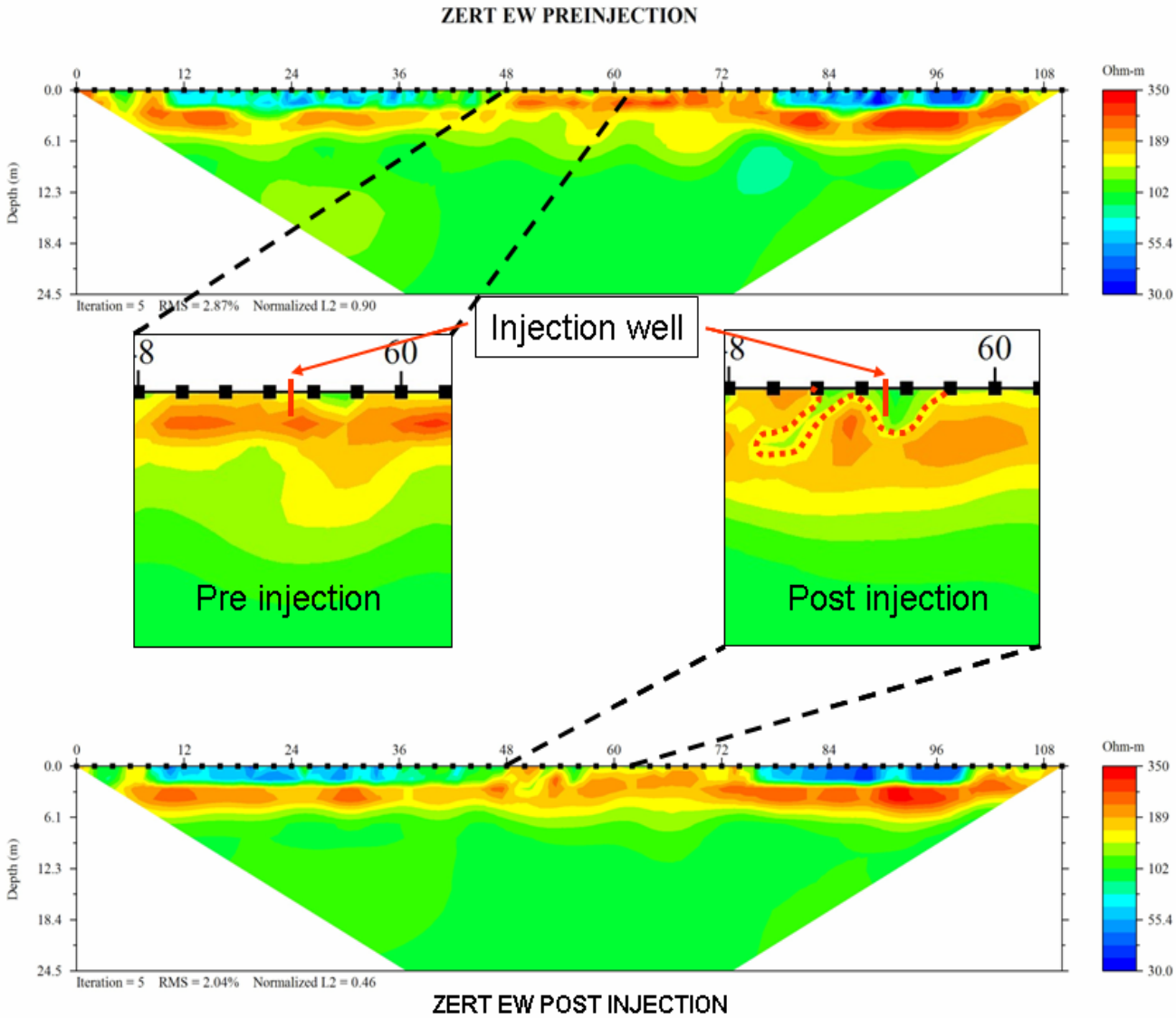
Plume Tracking

- Ability to “map” the injected CO_2 and track its movement and fate through a reservoir
- Assures storage permanence

- Key technologies for plume tracking:
  - Seismic surveys (e.g., 4-D seismic, time-lapse vertical seismic profiling)
  - Sampling from wells (borehole logging)

Plume Detection at Vertical Injection Site

- Resistivity surveys
- East/West surveys (performed for 2 hours)
- Montana State University, Bozeman, MT – ZERT Project Site



Leak Detection

- Backstop for modeling and plume tracking
- Provides critical measures of whether CO_2 is escaping from the storage reservoir

- Challenge - the need to cover large areas cost-effectively at the required resolution

CO_2 plume from an injection of one million tons of CO_2 per year in a deep saline formation for 20 years could be spread over a horizontal area of 15 square miles or more

Soil Carbon Measurement Sampling

- Depth profile of soil-gas down to 1 meter
- CO_2 and light hydrocarbon concentrations
- CO_2 stable isotope ratio ($\delta^{13}C$)

Mitigation

- **In the unlikely event that CO_2 leakage occurs, steps can be taken to arrest the flow of CO_2 and mitigate the impacts:**
  - lowering the pressure within the CO_2 storage reservoir by stopping injection
  - forming a “pressure barrier” by increasing the pressure in the reservoir into which CO_2 is leaking or by intercepting the CO_2 leakage paths
  - plugging the region where leakage is occurring with low permeability materials

Terrestrial MMV

- **Organic matter measurement:** automated technologies that provide detailed information at a sequestration site
- **Soil carbon measurement:** automated technologies for measuring soil carbon
- **Modeling:** detailed models are used to extrapolate the results of carbon uptake activities from random samples to an entire plot and to estimate the net increase in carbon storage relative to a case without enhanced carbon uptake.
- **Economic Models:** show accumulations of emissions credits and revenues versus an initial investment

Summary

- MM&V research is aimed at providing an accurate accounting of stored CO_2 and a high level of confidence that the CO_2 will remain sequestered permanently
- Successful efforts will allow project developers to obtain permits for sequestration projects while ensuring human health and safety and preventing potential damage to the host ecosystem.
- Sets the stage for emissions reduction credits that approach 100% of inject CO_2
- Provides improved information and feedback to sequestration practitioners, thus accelerating technology progress

Additional Information

http://www.netl.doe.gov/technologies/carbon_seq/index.html

Questions ?