Looking Ahead Towards Carbon Capture and Storage (CCS)- Towards a Large-Volume Test

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The VCCER

- The Virginia General Assembly established the VCCER in 1977 as an "*interdisciplinary study, research, information and resource facility for the Commonwealth*."
- Virginia Legislature charged the Center to support research, educational and public policy programs in coal and energy within the Commonwealth
- Center includes three broad missions:
  - conduct research on interdisciplinary coal and energy issues
  - coordinate coal and energy research at Virginia Tech and statewide
  - disseminate coal and energy research information to users in the Commonwealth

Acknowledgement

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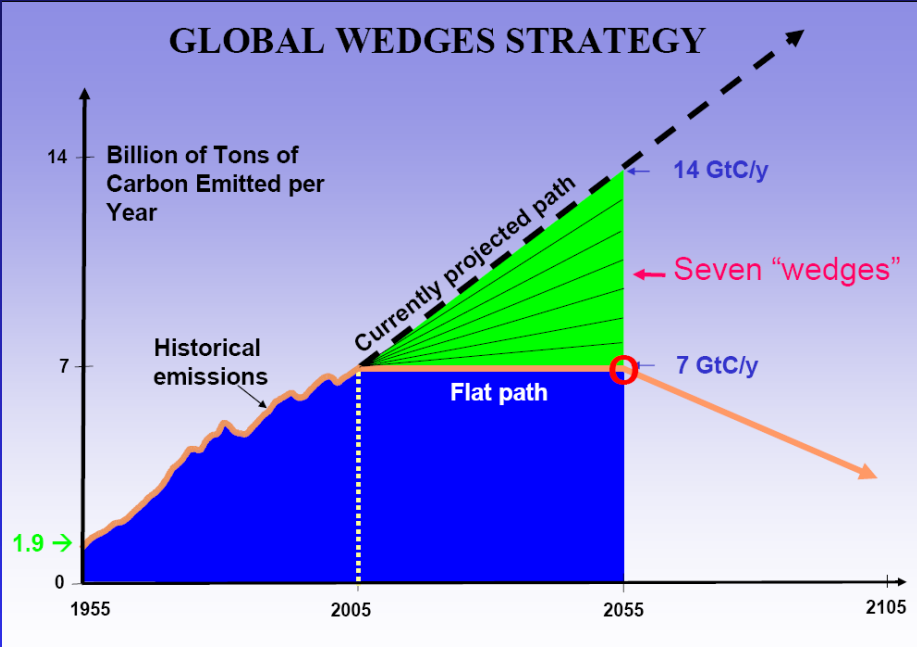
Content

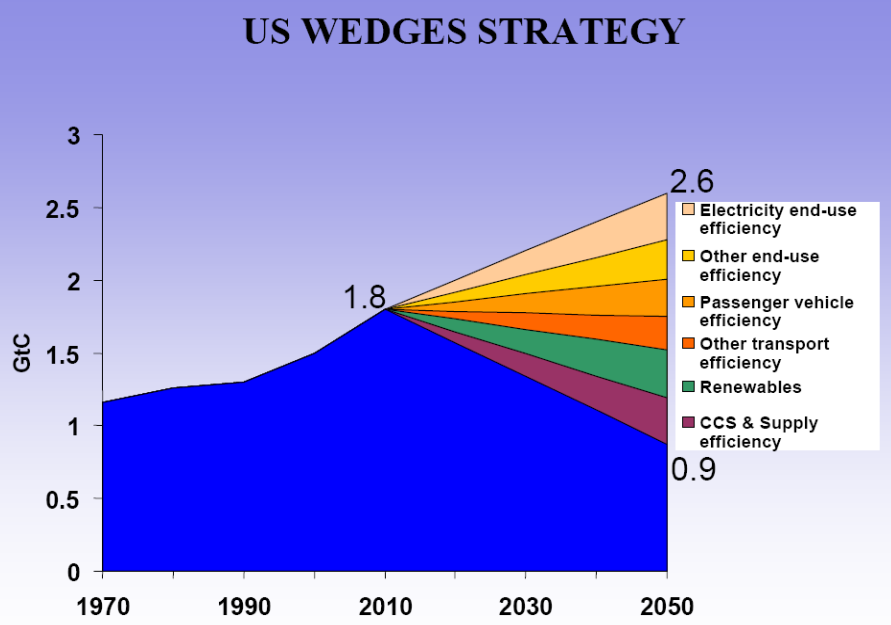
- Why CCS
- SECARB: Research Status
- The Need for a Large-Volume Test
- CCS and Economic Development
- Prerequisite for Cost-Share Funding
- Conclusions/Recommendations

Note: A number of references were used to develop this presentation. A reference list can be provided by the authors on request.

"…CO2 capture and sequestration is the critical enabling technology that would reduce CO2 emissions significantly while also allowing coal to meet the world's pressing energy needs" (MIT, 2007)



After Pacala and Socolow (2004)…stable emissions needed till 2050



ARI CarBen3 Spreadsheet…deep reductions needed before 2050

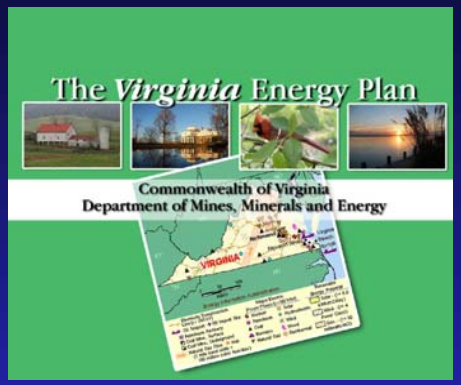
"Even under the most optimistic scenarios for energy efficiency gains and the greater use of low- or no-carbon fuels, sequestration will likely be essential if the world is to stabilize atmospheric concentrations of greenhouse gases at acceptable levels" (DOE Website)

Broad Community Support for CCS

- **Environmental Community – NRDC and EDF**
  - *"Carbon Capture and Storage (CCS): Let's Just Do It!"*
- **The Electric Generation Industry - Major Utilities/EPRI**
  - *"…Deploy capture and storage technologies at most new coal-based generating plants by 2020"*
- **National Governors Association**
  - *"…Incentivize CCS Technologies"*
- **IOGCC**
  - *"…the most immediate and viable strategies available for mitigating the release of CO_2 "*
- **EPA**
  - *"…by harnessing the power of geologic sequestration technology, we are entering a new age of clean energy"*

The Virginia Energy Plan (2007)

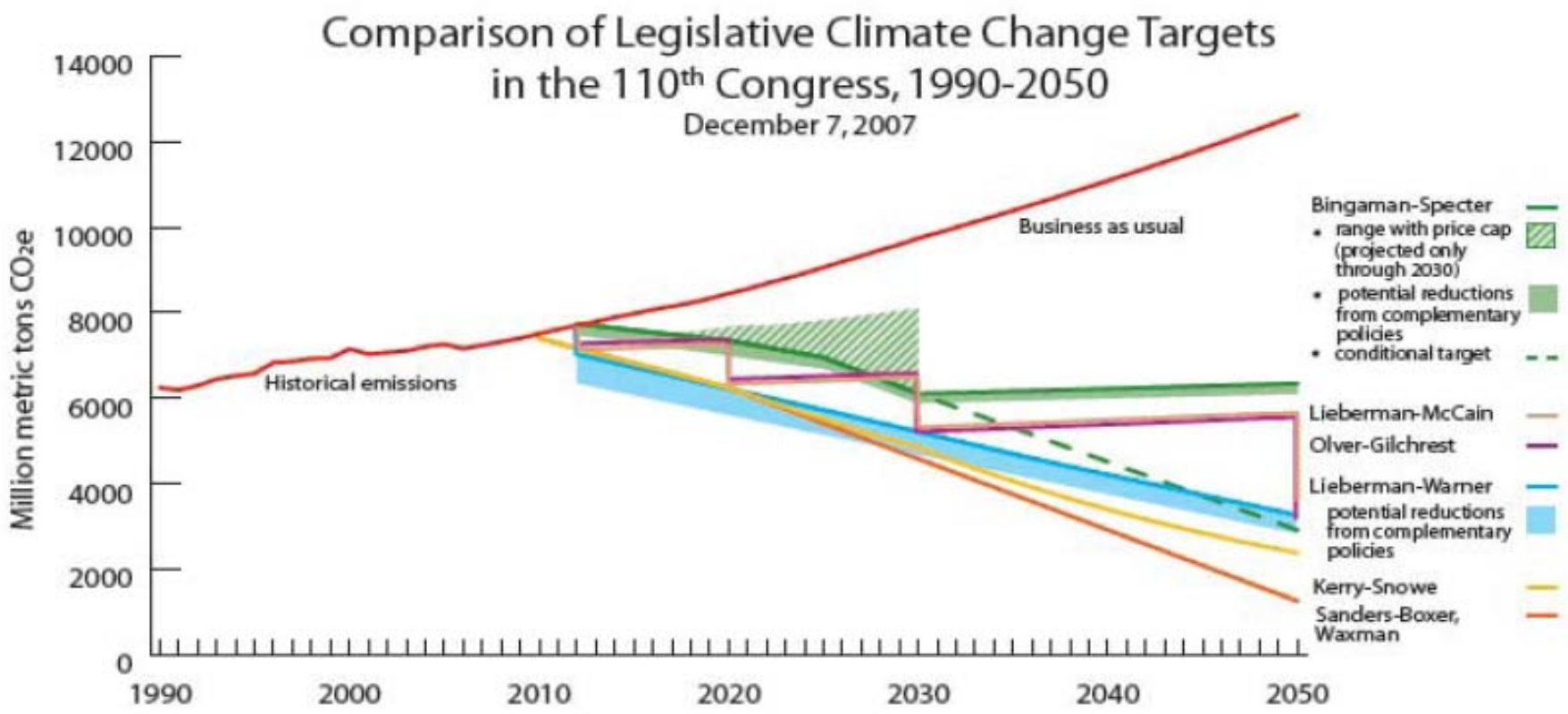
Carbon dioxide emissions rose in Virginia by approximately 34 percent from 1990 to 2004, a rate nearly twice the national average. This increase results, in part, from growth in Virginia's economy and development patterns that have produced sprawl and long commutes.



Virginia has the opportunity to sequester carbon in unminable coal seams. A recent report from the Virginia Center for Coal and Energy Research (VCCER) provides detailed information on this opportunity.[21] Preliminary conclusions indicate that coal in the Central Appalachian Basin has significant sequestration potential, particularly in Buchanan, Dickenson, and Wise Counties. An estimated 7.33 trillion

Virginia Tech, a partner in the Southeast Regional Carbon Sequestration Partnership (SECARB), has researched and developed data on Virginia's potential and is testing carbon capture and storage technology in Virginia's coal seams. The project has the potential to implement a ten-year pilot to capture a million tons of carbon dioxide per year in Virginia. It also could increase the production of coalbed methane from the coal seams, increasing the efficiency of these operations (see Chapter 6).

US Climate Change Targets in Congress (Source: World Resources Institute)

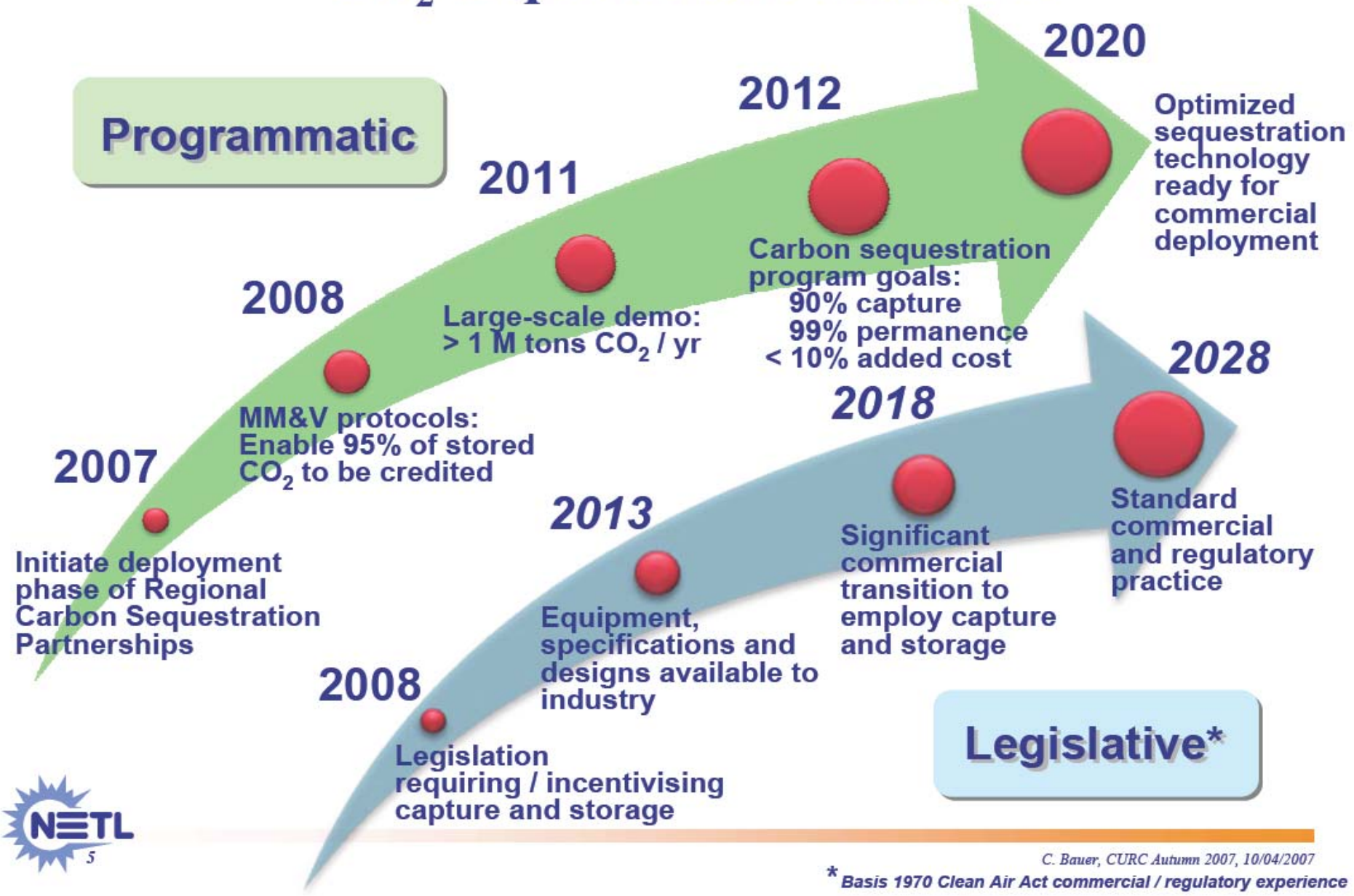


- CCS is a prominent part in many bills and amendments!
- Boucher Bill: Accelerate commercial availability of CCS technology

Impact of Legislation

- Requires a careful assessment of economic, social and environmental impacts (the formal definition of “sustainable development”)
- Policies that are based on technologies under development, particularly when such R&D is not properly funded, may not be realized
- Implementation of policies may require financial incentives, infrastructure investments and legal/regulatory reform - often all of the above!

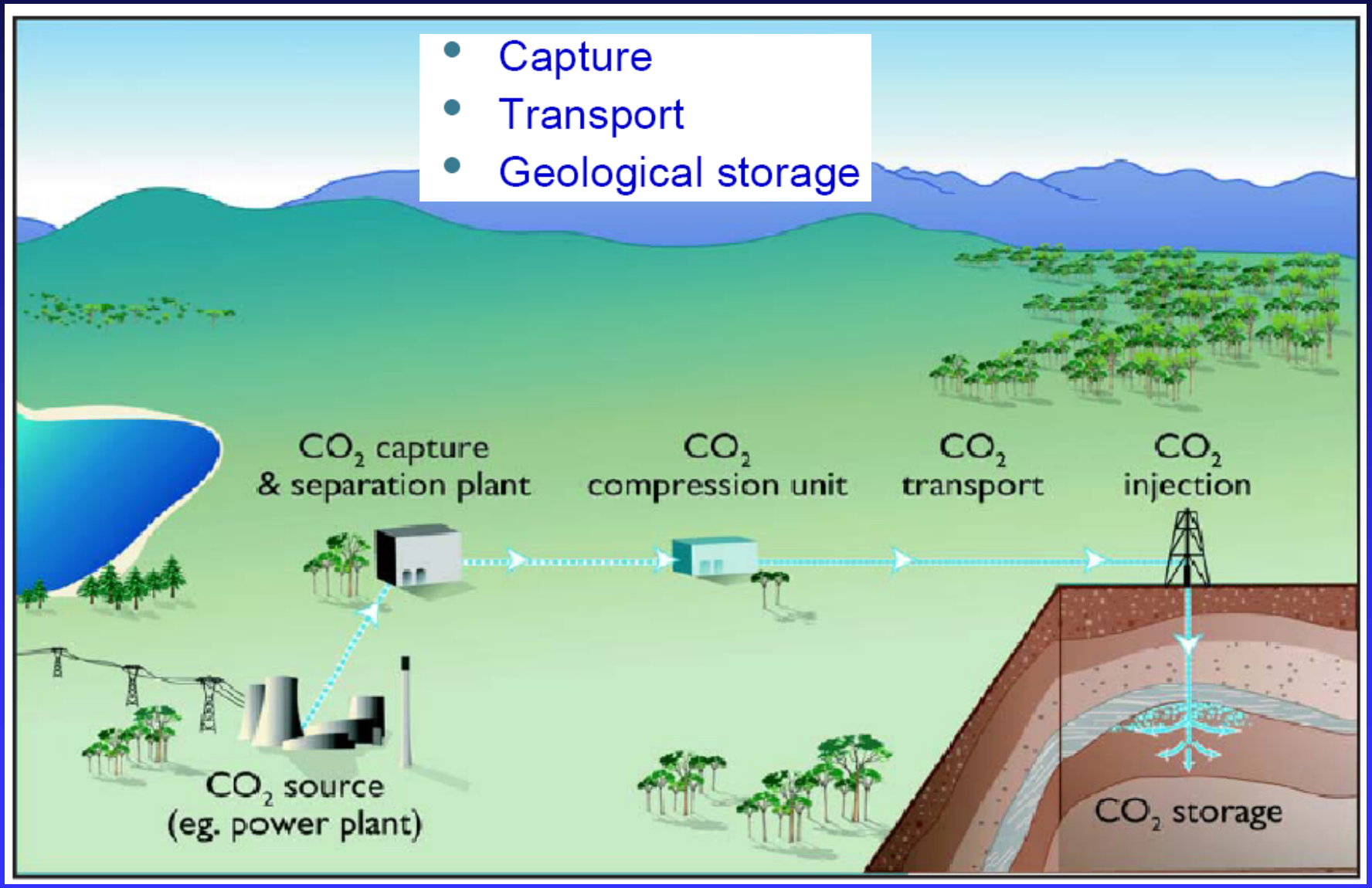
CO_2 Sequestration Timelines



C. Bauer, CURC Autumn 2007, 10/04/2007

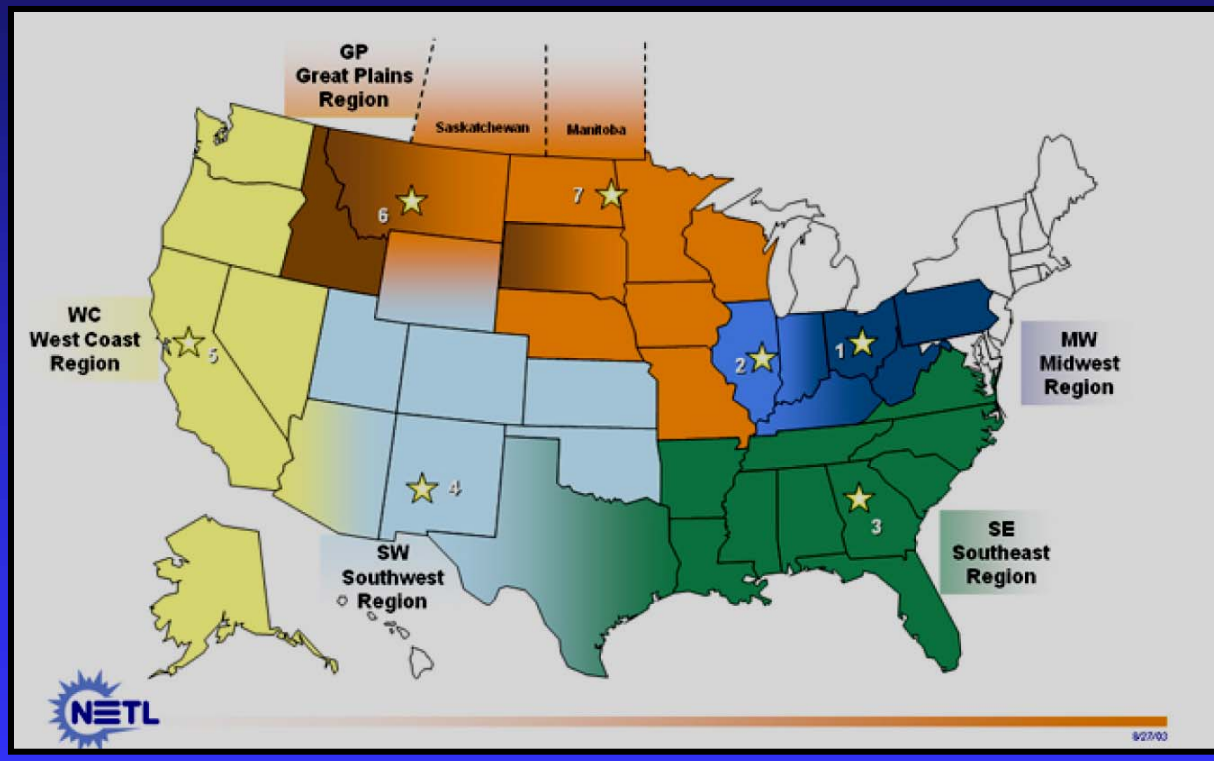
* Basis 1970 Clean Air Act commercial / regulatory experience

CCS Research Status



DOE- Regional Carbon Sequestration Partnerships

- 7 Regional Partnerships
- Partnerships include +240 organizations in 40 states, three Indian Nations and <u>two</u> Canadian Provinces

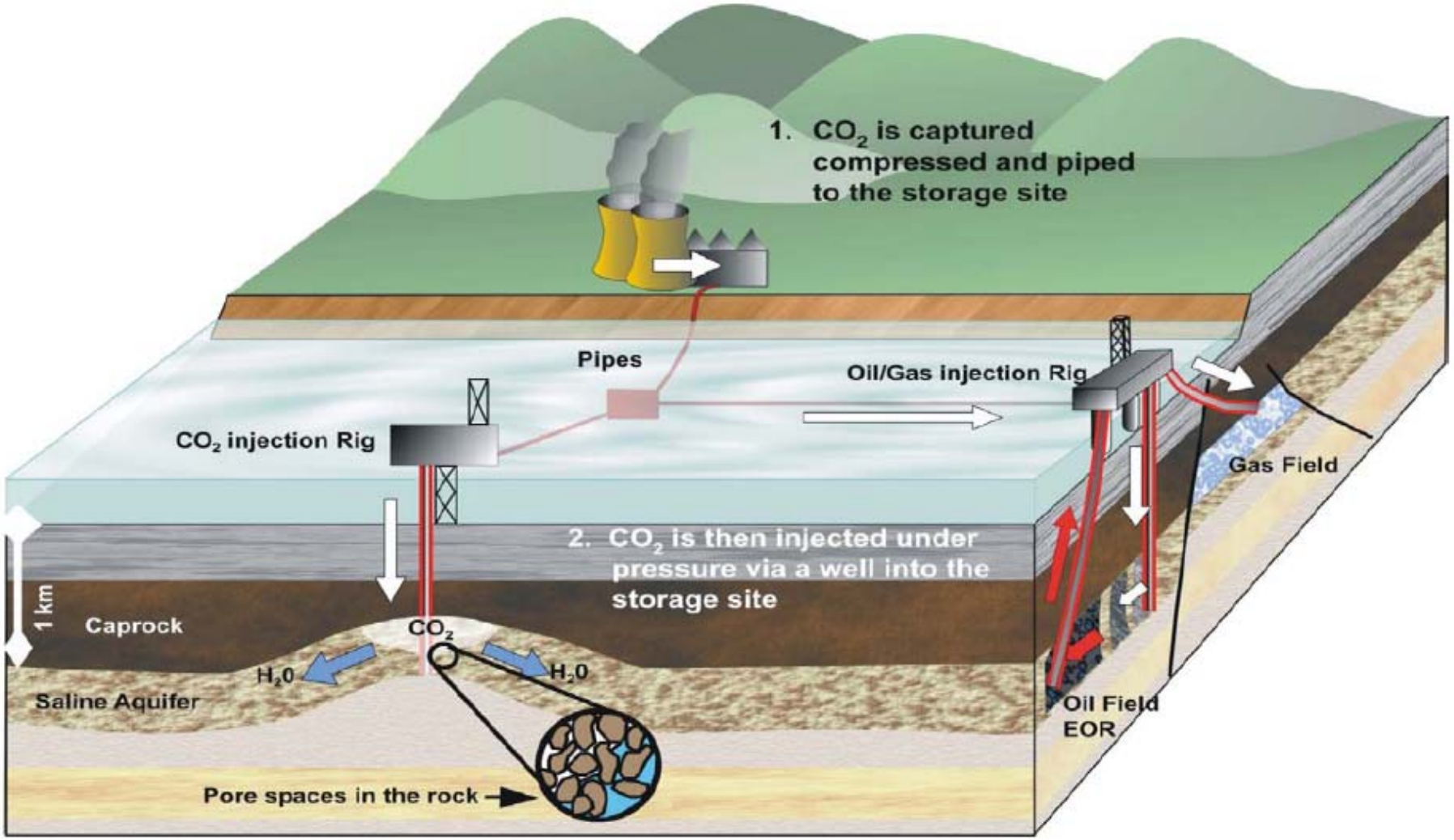


Virginia Participates in SECARB, a Partnership Managed by the Southern States Energy Board

Carbon Storage (Sequestration?) Options

- **Geologic Sequestration**
  - Oil/natural gas reservoirs
  - Saline Aquifers
  - Unminable coal seams
- **Ocean Sequestration**
- **Terrestrial Sequestration**

Geologic Storage



Project Phases

Phase I: Completed
Geological Characterization and Initial Feasibility Study (2004–2005)

Phase II: On-Going
Expand Study Area, Reservoir Modeling, Pilot CO_2 Injection Test (1,000 tons of CO_2, Evaluation of Potential (2005–2009)

Phase III: Planning Stage
7-10 Year Injection, Monitoring and Verification of a Large CO_2 Test (1mil tons of CO_2) (2007–2017?)

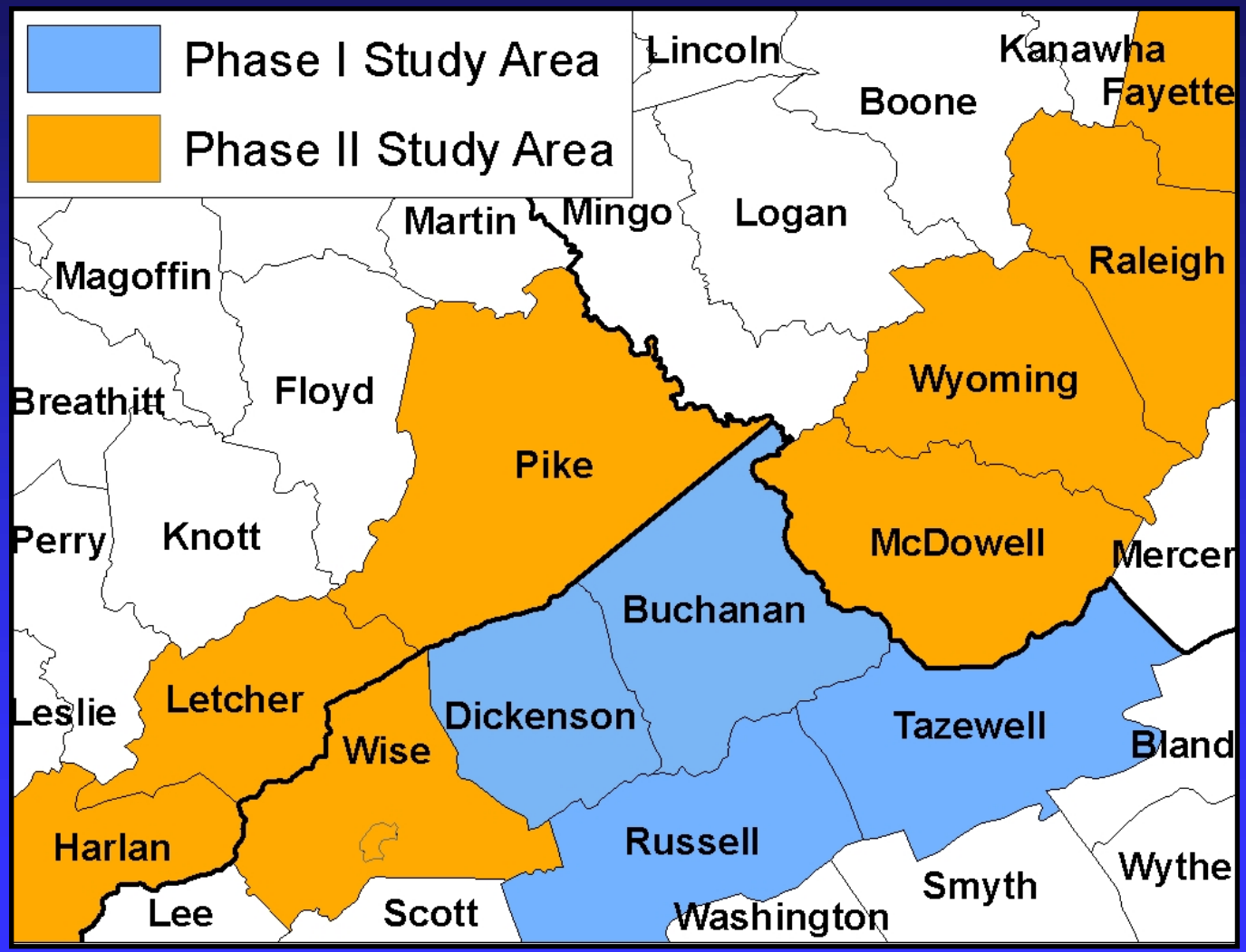
SECARB Coal Group Research Team

- Southern States Energy Board
- VCCER/Virginia Tech
- Marshall Miller and Associates
- Geological Survey of Alabama
- Consol Energy
- University of Alabama
- Southern Company
- Kentucky Geological Survey
- Advanced Resources Inter
- Eastern Coal Council

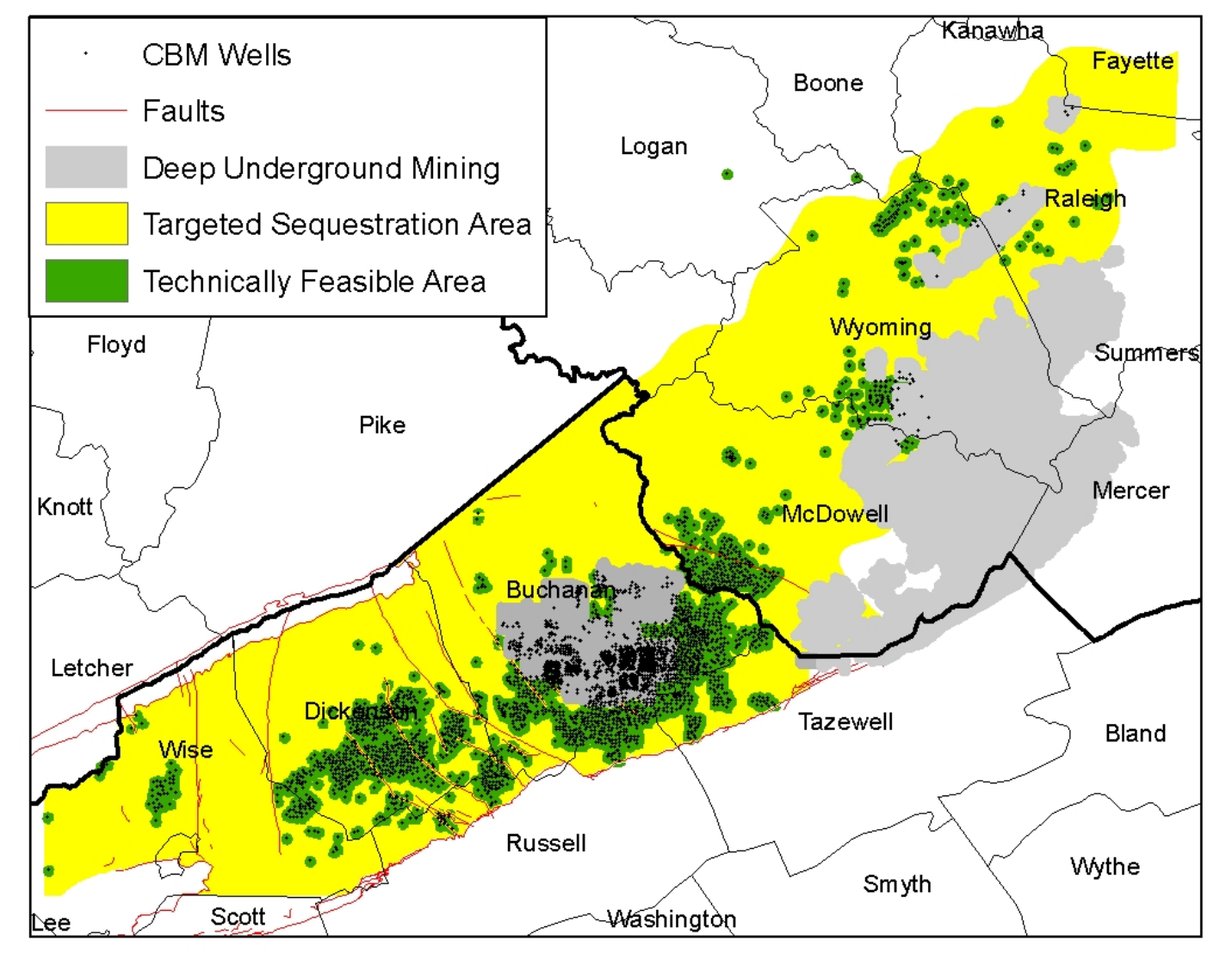
SECARB Coal Group - Phase II Partners (Cost Share, Data, Wells)

- Alawest
- Alpha Natural Resources
- AMVEST
- Buckhorn Coal
- CCP2 Project
- CDX Gas
- CNX Gas
- CONSOL Energy
- Cumberland Resources
- Dart Oil & Gas
- Denbury Resources
- Dominion E&P
- Dominion Resources
- EPRI
- Equitable Production
- Clean Energy Technology Inst (MSU)
- GeoMet
- McJunkin Appalachian
- Norfolk Southern
- Natural Resource Partners
- Oak Ridge National Laboratory
- Penn Virginia
- Pine Mountain Oil & Gas
- Piney Land
- Pocahontas Land
- RMB Earth Science Consultants
- Univ. British Columbia

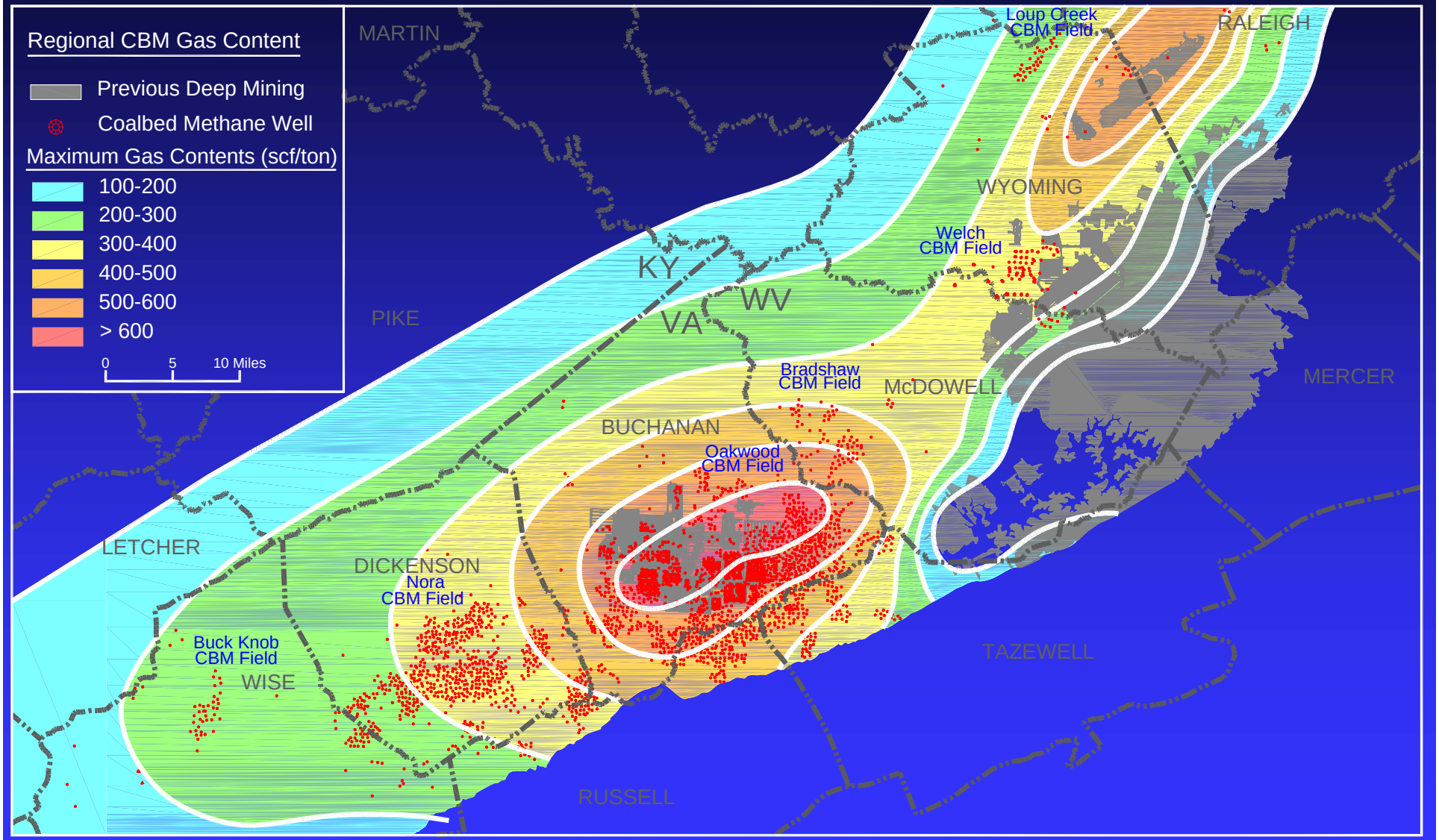
Central Appalachian Basin: Phase I & II Characterization Study Area



Evaluated Sequestration Area



Regional CBM Gas Content



SECARB Coal Group – Phase II

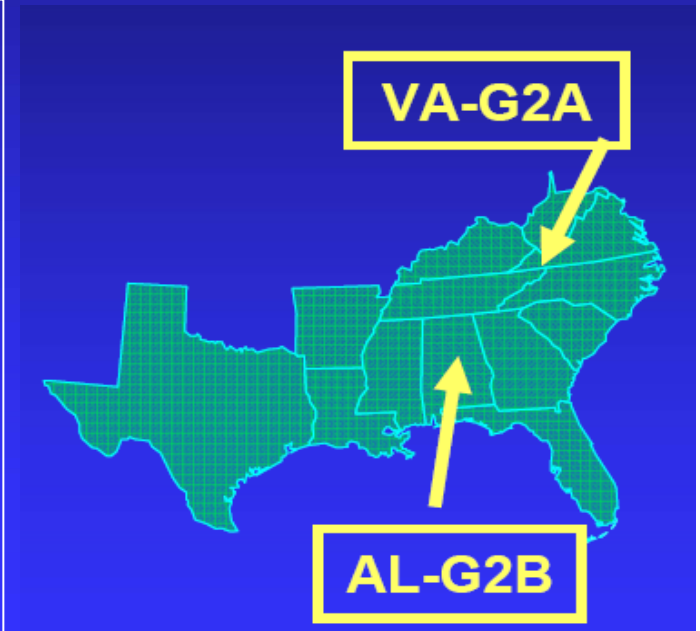
- **Phase I:** Feasibility study, completed September 2005
- **Phase II (**October 2005 – September 2009):
  - $4.4 million from DOE and $1.1 million (20%) cost sharing from research team and industrial partners

Sequestration and ECBM recovery:

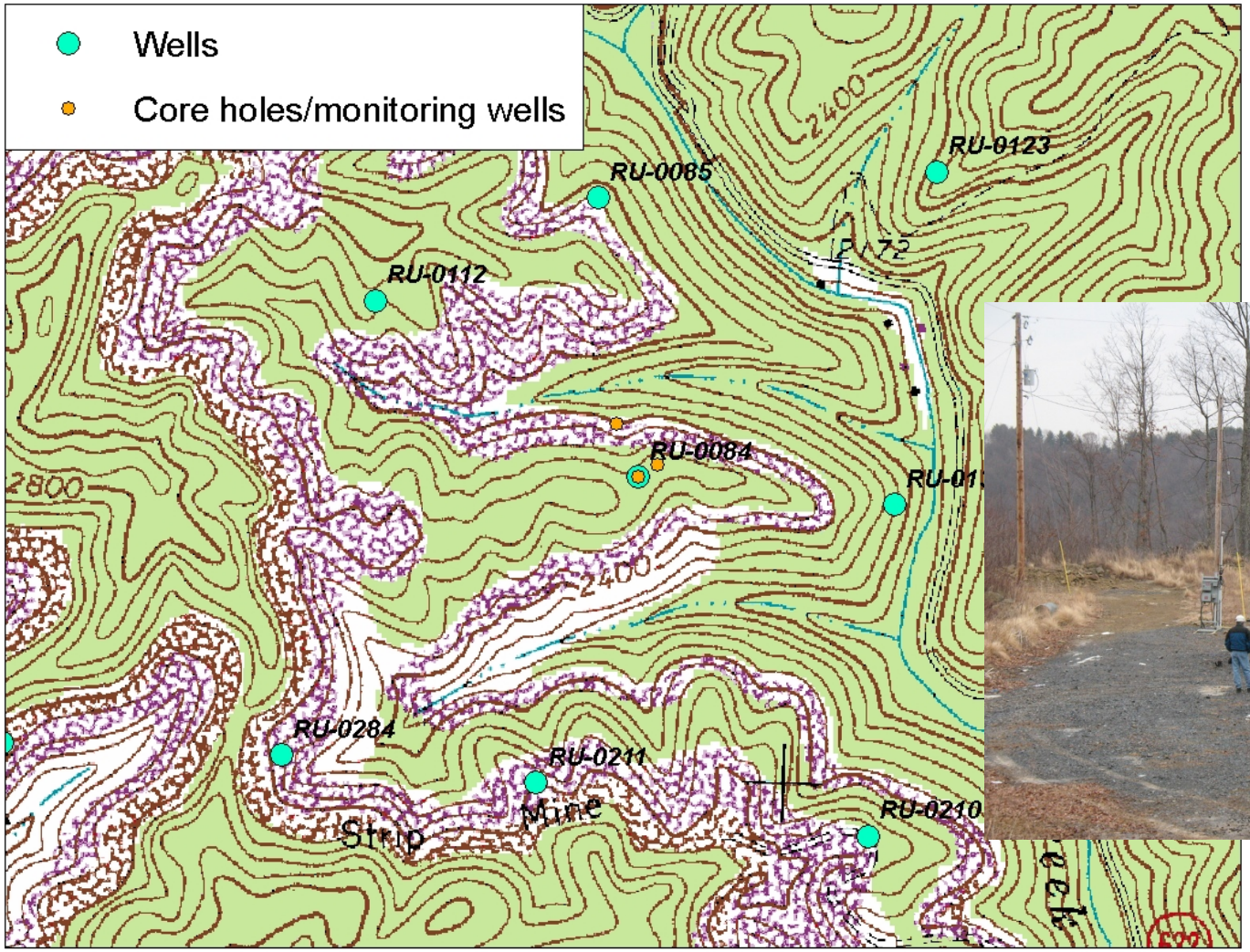
- Over 1 billion tons of feasible CO_2 capacity in the targeted areas
- Over 2.5 Tcf ECBM potential

Target areas:

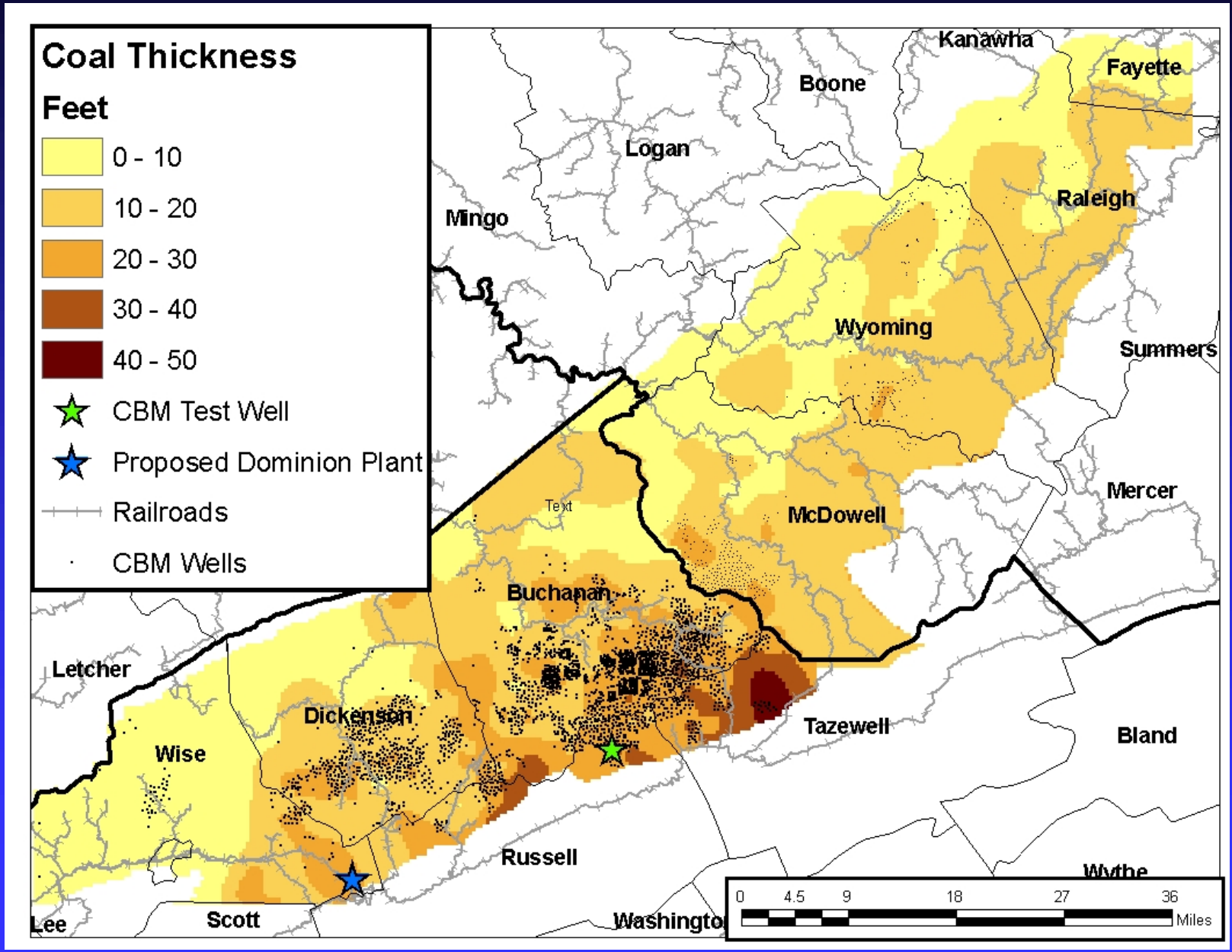
- Central Appalachian Basin, $G_{2\text{-}A}$
- Black Warrior Basin, $G_{2\text{-}B}$
- Pilot injections:1,000 tons of CO_2



Virginia Pilot Test Site



Phase II Test Site



Test Schedule (Updated 8/2008)

- Site selection (Complete): 04/07 – 12/07
- Approvals and Permitting: 02/08 – 09/08
- Soil Gas Monitoring: 03/08 – 09/09
- Coring: 09/08 – 10/08
- Formation testing: 09/08 – 10/08
- Install injection equipment: 10/08 – 11/08
- Injection testing: 11/08 – 05/09
- Site closure: 05/09 – 09/09

PHASE II-Task 10 (7/2008-9/2009) Extension for the SECARB Coal Group DOE: $1.8 mil, C/S: $600K

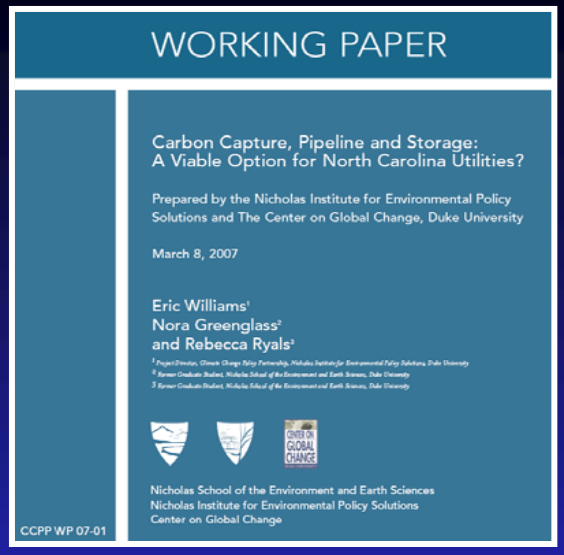
- Expand characterization and modeling of potential coal seam sequestration sites that can be stressed with a large-volume injection test
- Identify secondary reservoirs, including saline aquifers, depleted oil and gas fields, and Devonian Shale reservoirs, that could support or supplement a large-volume injection test
- Develop a preliminary engineering and design plan for a large-volume test, including the potential for a stacked storage project

The Need for Large Volume Tests in Different Geologies

- Large scale tests are necessary to demonstrate and confirm geologic storage
- Large-Volume tests will provide sequestration "***assurance***" to the investor community seeking to fund energy project that can be impacted by future CO_2-limiting legislation
- Absence of such tests in a region, or on a specific geologic formation, may delay sequestration demonstration and, therefore, deployment

CCS and Regional Economic Development Opportunities for Central Appalachia

- Sustain coal utilization in a carbon emission capped era
- Utilize lower rank coals for clean coal technologies
- Promote construction of major new facilities (e.g., generation plants, C-T-L/G and C-T-H conversion facilities, biofuel plants) in proven CO_2 sequestration locations, creating enormous regional economic impacts
- Generate economic development potential associated with enhanced recovery (EOR, EGR and ECBMR) – estimated +$4 billion due to ECBM alone
- Expand research capabilities and R&D infrastructure at the local, regional and state level with participation of the private energy sector



"Geologic sequestration is not economically or technically feasible within North Carolina"

- **CO2 Storage sites are a <u>Resource!</u>**
- **Large-Volume Tests are <u>Essential!</u>**

Cost-Share Funding is a Prerequisite and Urgently Needed

- **VCCER/VT Next Step is a Large-Volume Test**
  - **Submit Scope and Budget 2009/10, 8 year-effort**
  - **Funding Requested : DOE = $65 mil**
    C/S = +$40 mil
  - **Cost-Share Commitment Must be Determined in the Next Few Months!**

Conclusion

- CCS is essential if the world is to stabilize atmospheric concentrations of greenhouse gases
- Commercial deployment of CCS requires large-scale tests to demonstrate and confirm geologic storage
- Demonstration of CCS requires **significant** public and private funding
- The Central Appalachian states must contribute financial resources to support CCS R&D (some are doing more than others!)

Recommendations to the State:

- Virginia must invest aggressively in the development and deployment of technologies that are vital for a low carbon economy
- CCR is a critical low carbon technology with enormous regional economic development potential
- The work of VCCER has demonstrated that Virginia is in a unique position to become a national leader in CCS
- For this to happen, Virginia must provide substantial and sustainable financial support to the CCS effort
- Without such state funds to match federal funding and promote private sector engagement, a large-volume test in the region will not be realized