

Regional Characterization Activities and Large Volume Injection Test - Nugget Sandstone formation

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Big Sky Carbon Sequestration Partnership

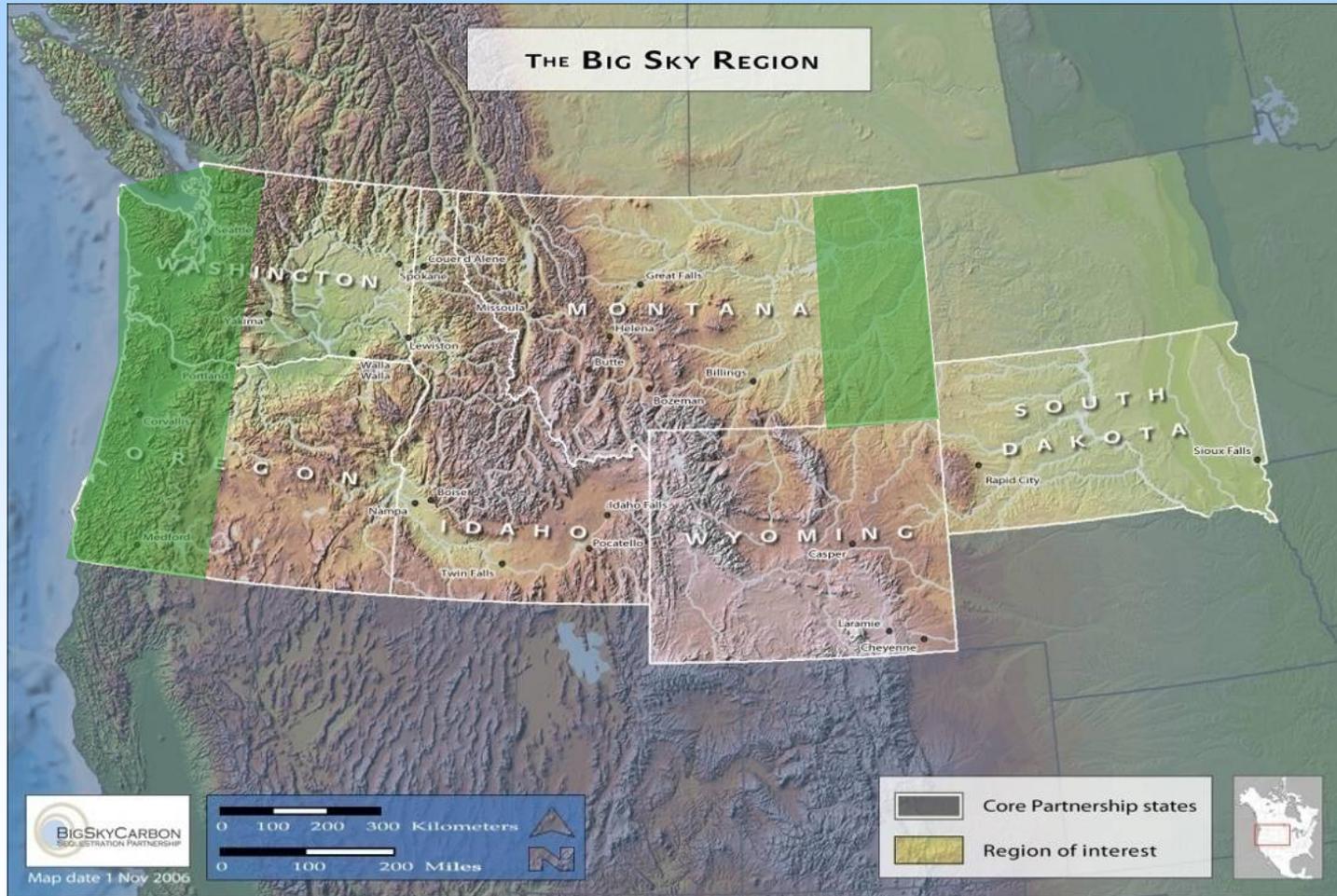
Regional Carbon Sequestration Partnerships Initiative
Review Meeting

Pittsburgh, Pennsylvania
December 12, 2007

Sequestering CO_2 to Mitigate Global Climate Change

Safe Storage of Beer-Gas for a
Better Ski Season

The Big Sky Carbon Sequestration Partnership Region



BSCSP Partners

Battelle
Boise State University
Bullivant Houser Bailey PC
Center for Advanced Energy Studies
Center of Energy & Economic
Development
Cimarex Energy
Columbia University, Lamont-Doherty
Earth Observatory
Crow Tribe
Det Kongelige Olje og Energidepartement
Edison Mission Group
Energy Northwest
EnTech Strategies, LLC
Environmental Financial Products
Environmental Protection Agency
Heller/Ehrman
IBM
Idaho Carbon Sequestration Advisory
Committee
Idaho Dept. of Environmental Quality
Idaho National Laboratory
Idaho Soil Conservation Service
Idaho State University
Inland Northwest Research Alliance
Institute for Energy Technology
(Norway)
Institute de Physique de Globe de Paris

Inter Tribal Timber Council
Jackson Hole Center for Global Affairs
Los Alamos National Laboratory
Montana Bureau of Mines and Geology
Montana Dept. of Environmental Quality
Montana Farm Bureau Federation
Montana GIS Services Bureau IT Services
Montana Governor's Office
Montana State University - Bozeman
Montana Tech
National Carbon Offset Coalition
National Geophysical Research Institute
(India)
National Tribal Environmental Council
Nez Perce Tribal Council
Norwegian University of Science and
Technology
Oregon State University
PacifiCorp
Portland General Electric (PGE)
Power Procurement Group
PPL Montana
Puget Sound Energy (PSE)
Ramgen Power Systems, Inc.
Research Council of Norway
Ruckelshaus Institute of Environment &
Natural Resources
Russian Academy of Sciences

Sage Resources
Schulmberger
Semiarid Prairie Agricultural Research
Center, Canada
Sintef Petroleum Research (Norway)
South Dakota School of Mines and
Technology
Southern Montana Electric
State Geological Survey Units
Summit Energy
The Sampson Group
Unifield Engineering
United Power
University of Idaho
University of Wyoming GIS Center
University of Wyoming Enhanced Oil
Recovery Institute
University of Idaho
Wageningen University (The
Netherlands)
Western Governors' Association
Westmoreland Coal
Wyoming Carbon Sequestration
Advisory Committee
Wyoming Department of Environmental
Quality
Wyoming State Governor's Office
Yellowstone Ecological Research Center

Outline

Overview of BSCSP

Regional Characterization Activities

- Basalts
- Terrestrial
- Carbon Atlas

Proposed Phase III Large Volume Injection

- Goals and Partners
- Site Location and Geology
- MMV Methods
- Timeline

Proposed Basalt Site Characterization Test

Goal:

To conduct a small scale CO₂ sequestration project in Columbia River flood basalts designed to confirm the feasibility of permanently and safely sequestering large quantities of CO₂ within deep flood basalt formations.

Objectives:

1. Assess the basalt formation and adjacent formation responses to CO₂ injection
2. Track the migration of the CO₂ within the injection reservoir, and evaluate containment of the CO₂ for comparison with reservoir modeling predictions
3. Evaluate the rate of CO₂ mineralization for comparison with previously developed laboratory-derived predictions

The proposed field test location is situated approximately 16 miles south of Pasco, Washington in lightly inhabited agricultural and heavy industrial-zoned land in western Walla Walla County, WA.



Walla Walla County, WA

Proposed Terrestrial Activities

- BSCSP has proposed to continue our Phase II cropland and rangeland carbon sequestration field trials
- Terrestrial team will continue field sampling and conclude with focused analyses, modeling and reporting of results.
- In total, phases II and III will allow 6 years of monitoring and measurement of soil carbon sequestration, an extremely valuable time span given that for most terrestrial systems a minimum of five years is required to detect management induced changes.

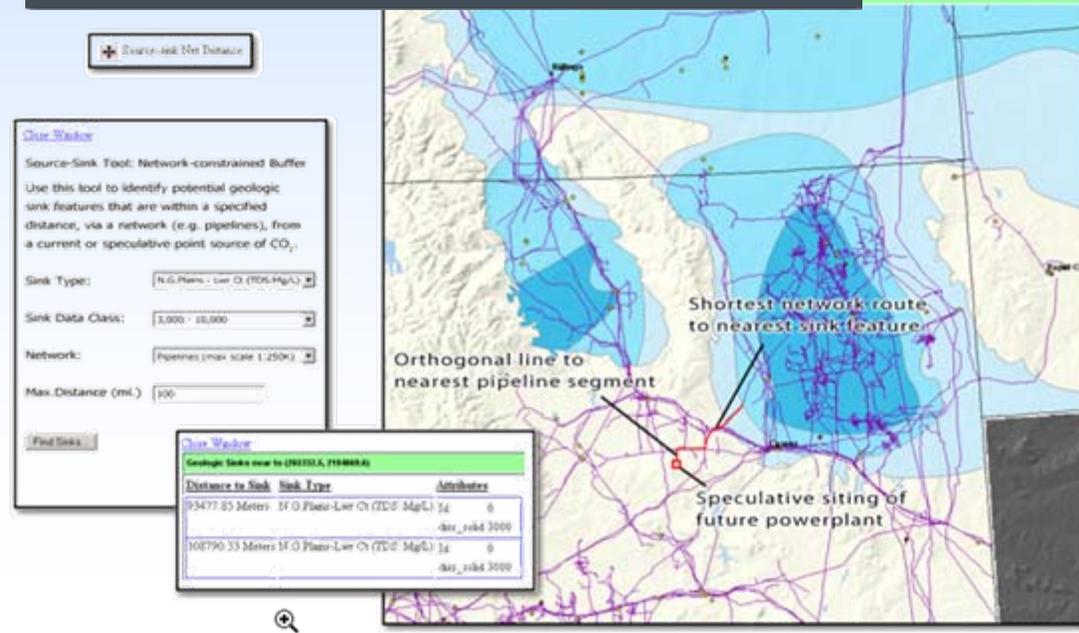
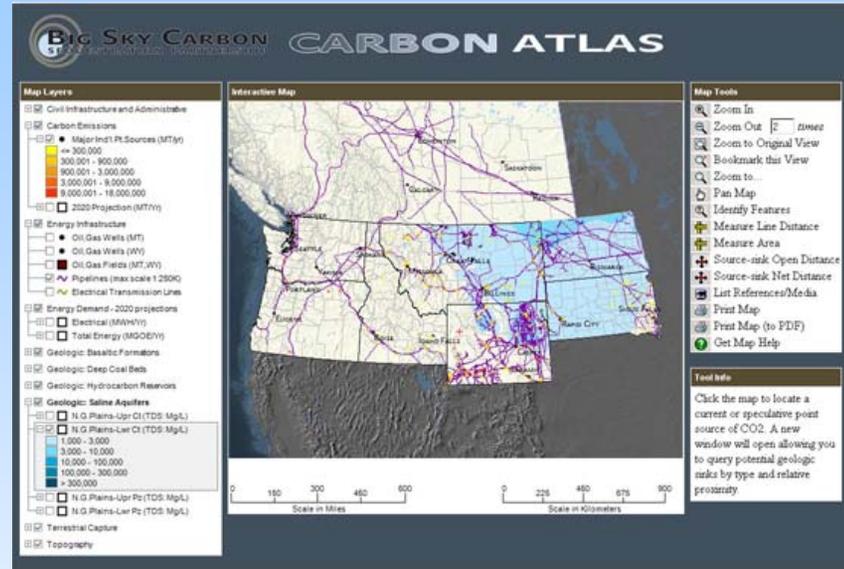
There will be 3 main components:

1. A controlled cropland experiment
2. 2 controlled rangeland experiments
3. MMV of soil carbon accumulation in fields contracted to sequester atmospheric carbon



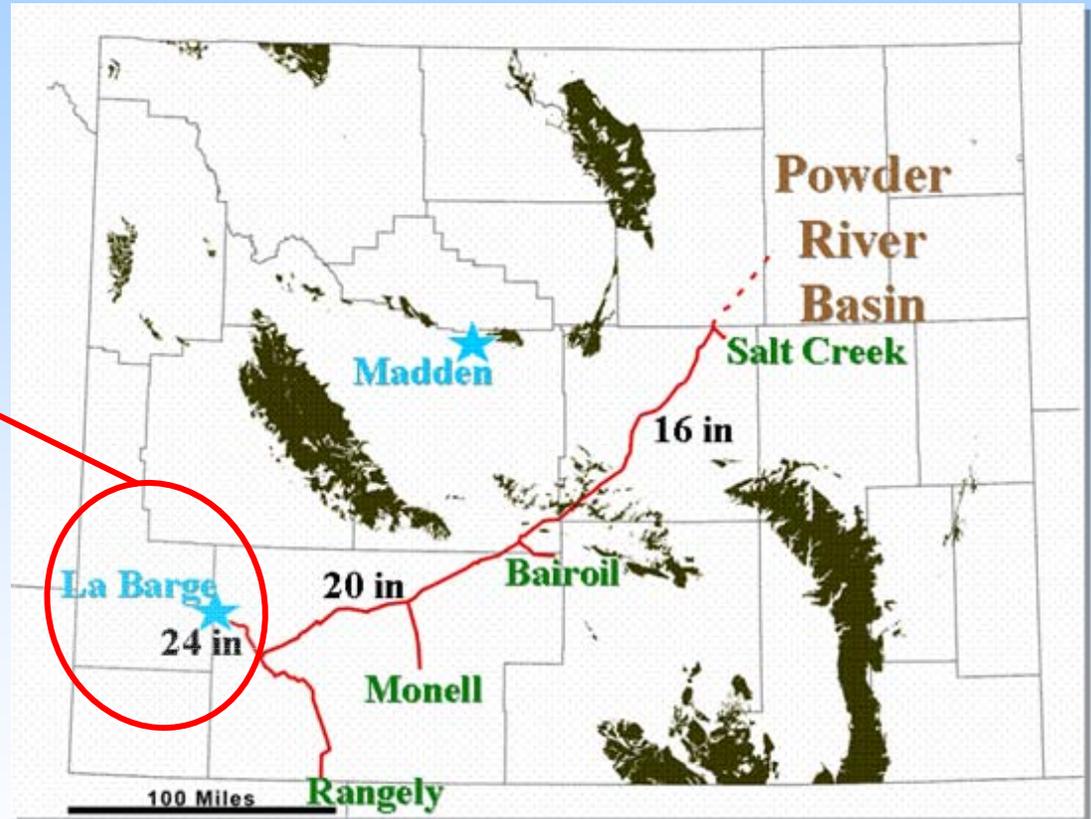
Interactive Map and Carbon Atlas

- Custom query tools for locating potential geologic sink features proximate to CO₂ point source(s)
- Calculation of source-to-sink distances – “as the crow flies”, or network-constrained
- Tool for retrieving technical references for areas of interest (e.g., sedimentary basins)
- Data download tool



Proposed Wyoming Large Volume Injection

- Southwest Wyoming Moxa Arch Structure
- Large regional anticline
- 170 TCF of gas in deep (15,000-18,000 feet) Paleozoic formations under production
- Mostly CO₂, with some H₂S, CH₄ and He



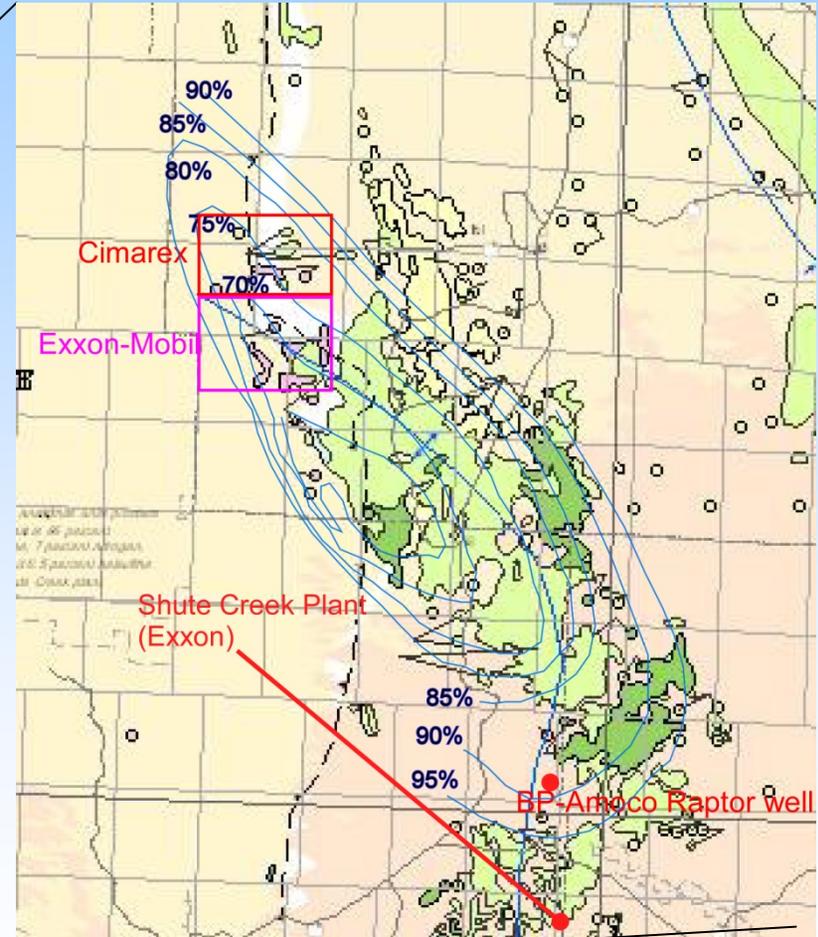
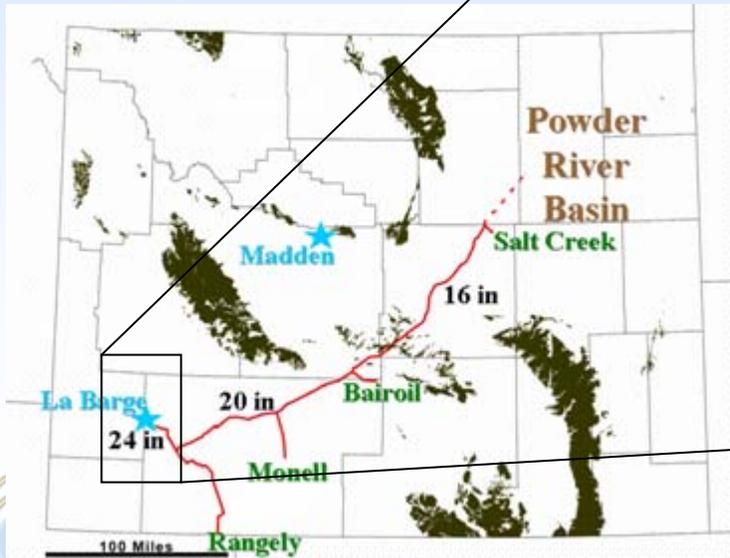
Wyoming Project

- **Goal** – to develop and execute Large Volume Sequestration Test and inject ~1 million tons of anthropogenic CO₂/year for 3 years.
- **Team** - UW, MSU, Columbia, Schumberger, LANL and LLNL
- **Partner** -Cimarex

Site Location

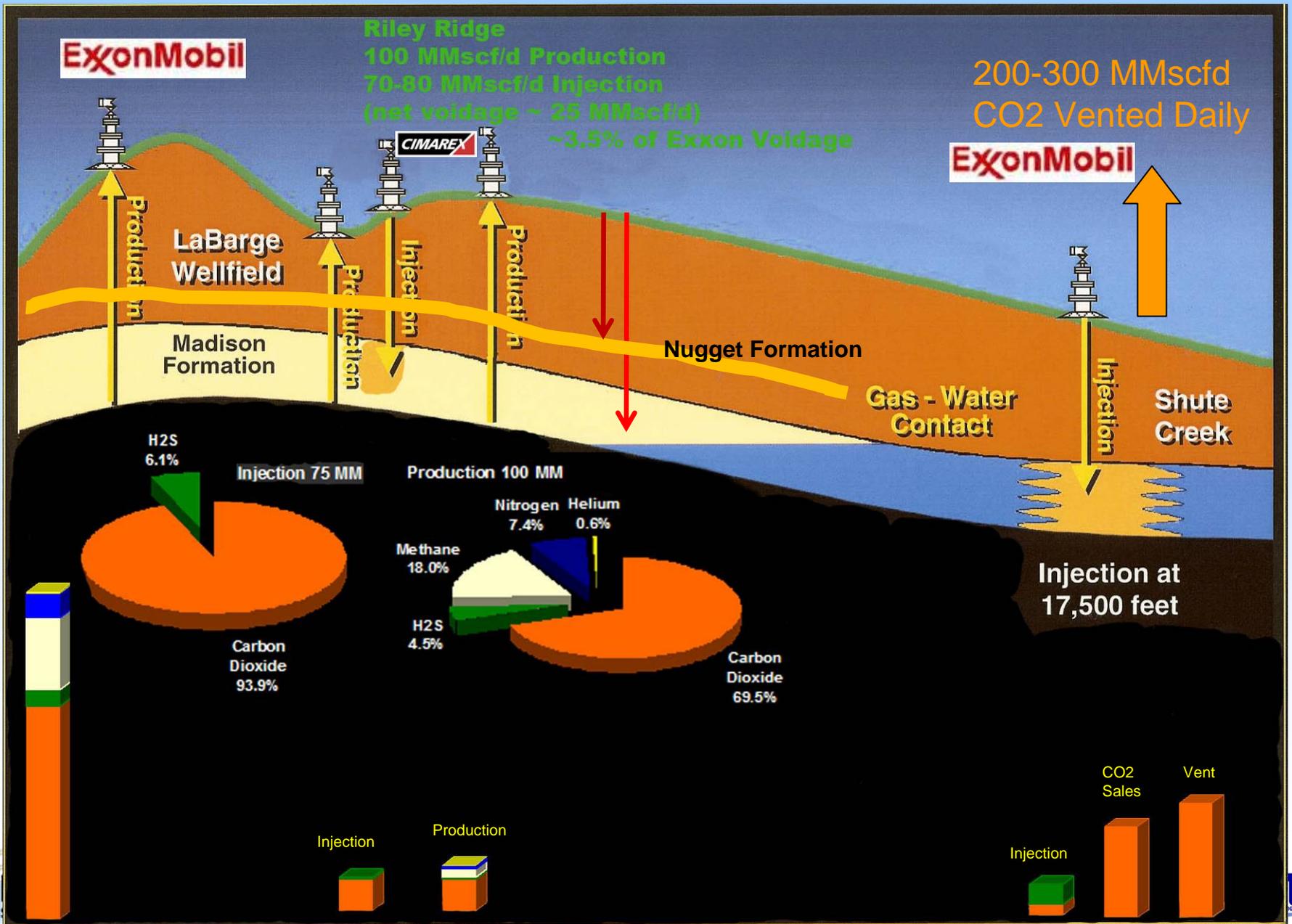


Southwest Wyoming
Moxa Arch Structure
Low Population Area



Contours are %CO₂ in Madison Limestone

Project Schematic – With Riley Ridge POD



Riley Ridge Unit from NW



Shute Creek Plant

Gas Plant

24-16 (H2 Disp.)
2-17F (P&A) 17-34

Weather Station

5521 ft

Pointer 42°30'12.27" N 110°26'29.67" W elev 8402 ft

Image © 2006 DigitalGlobe
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Streaming 100%

Eye all 30973 ft

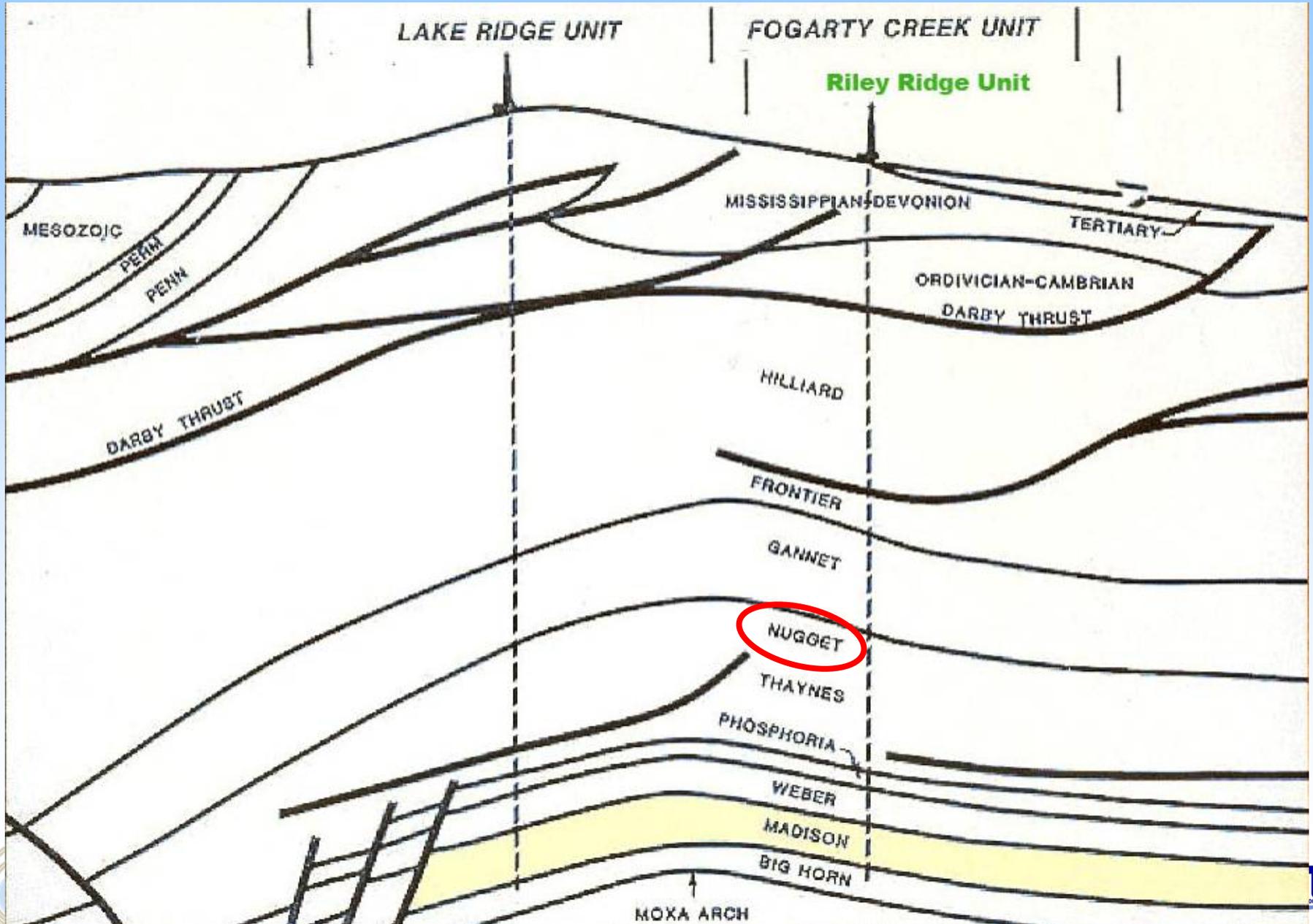
ITL
TECHNOLOGY LABORATORY

Geology of Target

Formation Type: Saline formation (Nugget) is the target sink

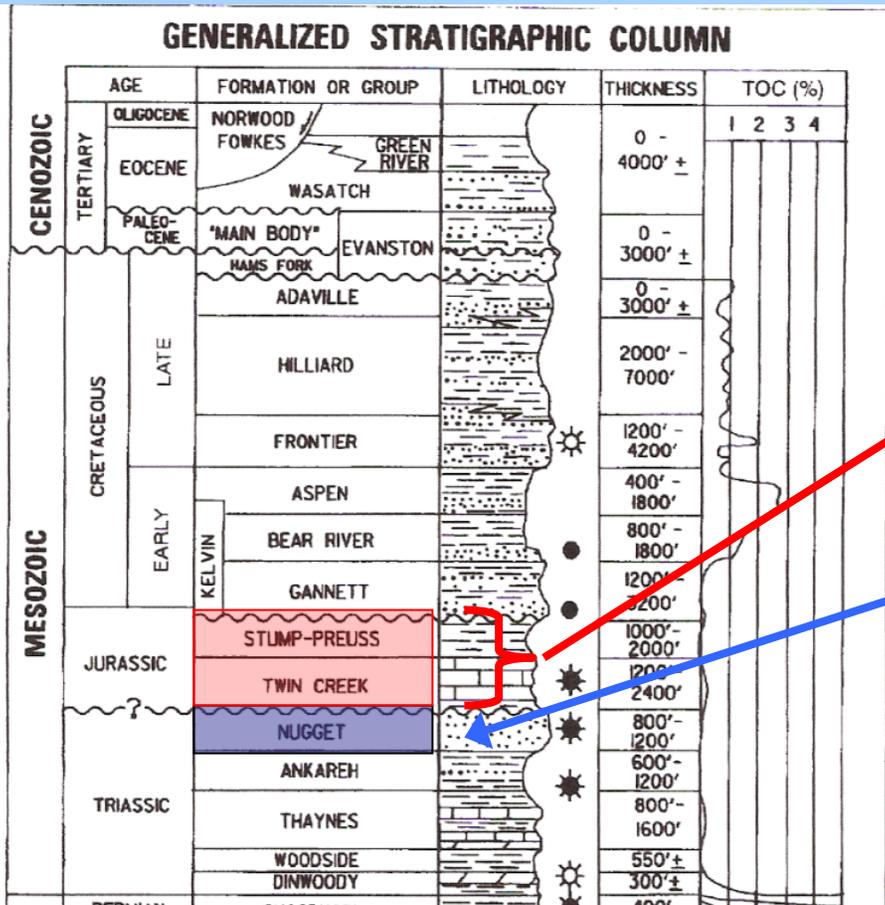
- Depths to this Formation range from 10,000 to 13,000 feet
- Along the structure, significant portions of the deeper geologic formations contain natural CO₂ providing a ready source
- The geological section above the target consists of alternating low permeability limestones and shales and/or evaporites (seals)

LaBarge Field – West-East Cross Section



Nugget Sandstone Project

Wyoming Geology



Nugget Sandstone is extensive regional unit with geological equivalents such as the Navajo, Weber and Tensleep Formations
Estimated Nugget storage is 10.4Gt

Sealed by 2200-4400 feet of Twin Creek LS and Stump-Preuss Shale

Target - Nugget Sandstone Saline Aquifer (100,000 TDS) 12% porosity, 70-300mD

Well and accompanying data in area available through WyOCC and State Geological Survey

Seismic data from commercial services and in-kind petroleum partner contributions

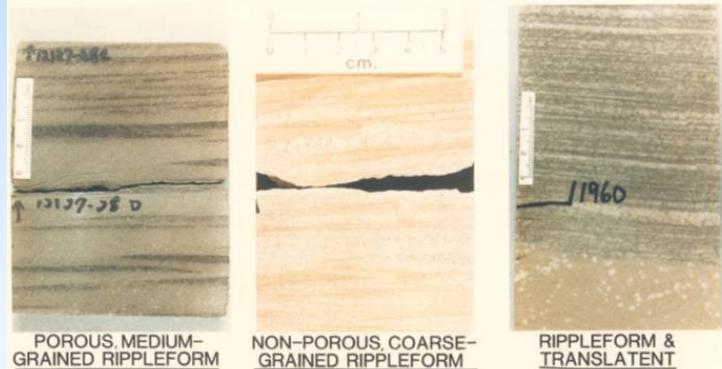
Nugget Core



Nugget Stratification



WIND RIPPLE STRATA



TRANSLATENT

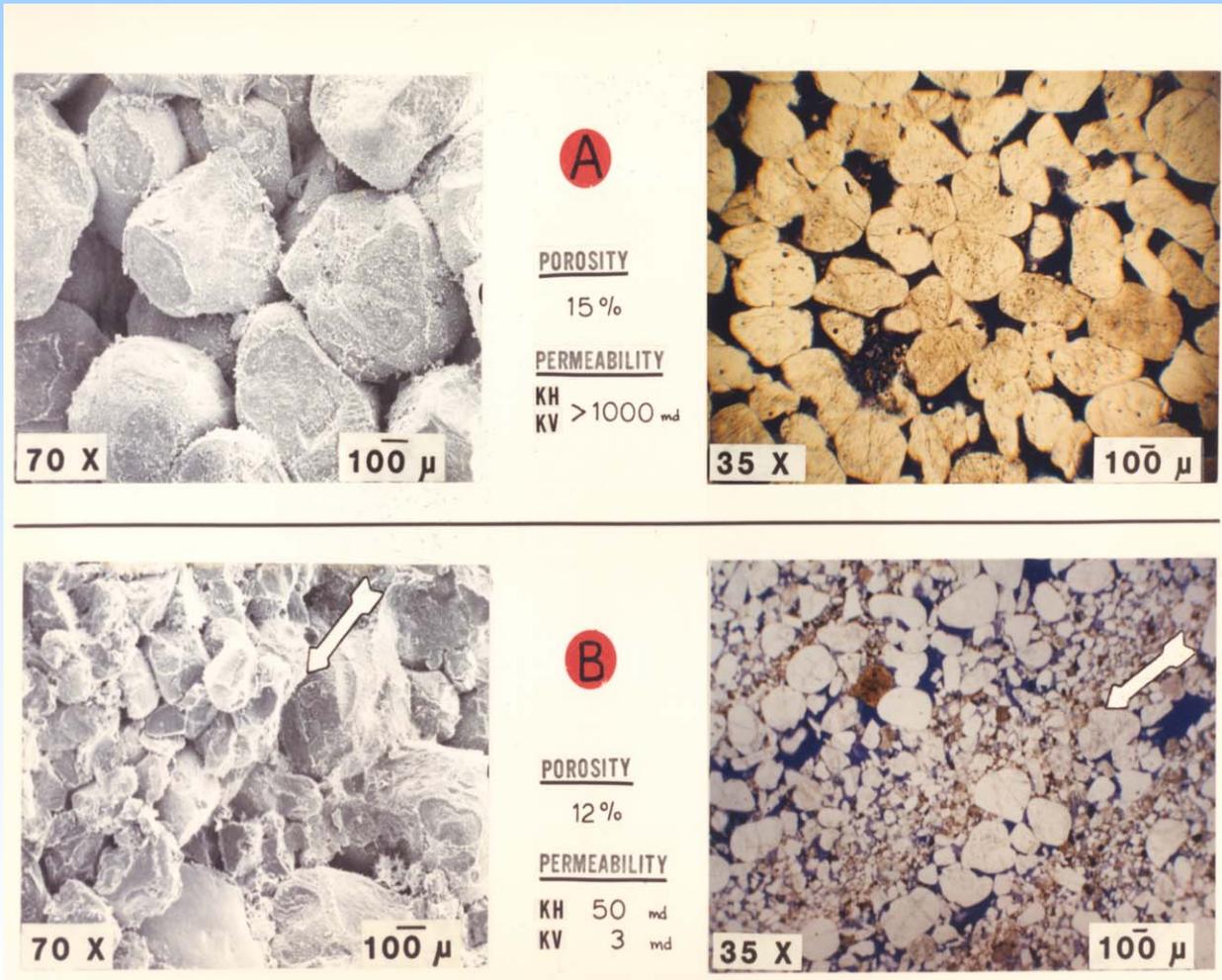
COARSENING UPWARD LAMINAE

(ARROWS MARK SMALL RIPPLE FORESETS PRESERVED)



MAJOR NUGGET STRATIFICATION TYPES (DUNE-INTERDUNE)

Nugget photomicrographs



Work Plan

- Acquire cores from Phase II wells
- Characterize rock properties (Permeability, Porosity, Sonic, etc) to constrain modeling and help plan MMV for Phase III
- Assemble Geophysical model
- Run simulations, assess MMV methods, appropriate spacing of monitoring wells
- Drill Phase III wells
- Inject CO₂ supplied from Cimarex waste stream

Modeling plans

Montana State University and University of Wyoming Geologists will assemble geostatic model using

- Cores from wells drilled for project
- Logs from significant number of existing nearby wells
- Existing and New 3D Seismic

Geostatic models will be used to create model for multi-phase flow modeling

- Heterogeneities in Nugget Permeability and porosity will be modeled
- Mechanical properties from extracted core will be measured and coupled geomechanical modeling will be considered
- TOUGH and ECLIPSE simulations will be performed by U. WY.
- NUFT Simulations by LLNL

Proposed MMV Methods

Geophysical

- Cross well active (if possible)
- Microgravity
- Active doublet
- Passive seismic
- Time lapse – vsp

Geochemical

- Produced fluid chemistry
- Tracers (noble gases, SF₆, etc.)
- In-situ sensors

Surface

- Soil gases

Special Challenges

- Target formation is deep (~11,000 ft)
- There are gasses trapped above target formation
- Acid gas handling & costs

Wyoming Project Schedule

Characterization and infrastructure	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16
<i>site selection</i>	█								
<i>permitting</i>	█								
<i>pipelines</i>		█							
<i>monitoring wells installed</i>		█							
<i>baseline MMV</i>		█							
<i>Preliminary Report</i>			█						
Injection and operations									
<i>injection begins</i>			█						
<i>well shut in</i>					█				
<i>MMV</i>			█	█	█				
<i>Interim report</i>						█			
Monitoring and Closure									
<i>MMV</i>						█	█	█	█
<i>site closure</i>							█	█	█
<i>model calibration</i>							█	█	█
<i>Final report</i>									█

Questions?

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Big Sky Carbon Sequestration Partnership

www.bigskyco2.org