



# Battelle

*The Business of Innovation*

## Phase II Grande Ronde Basalt Sequestration Project Overview

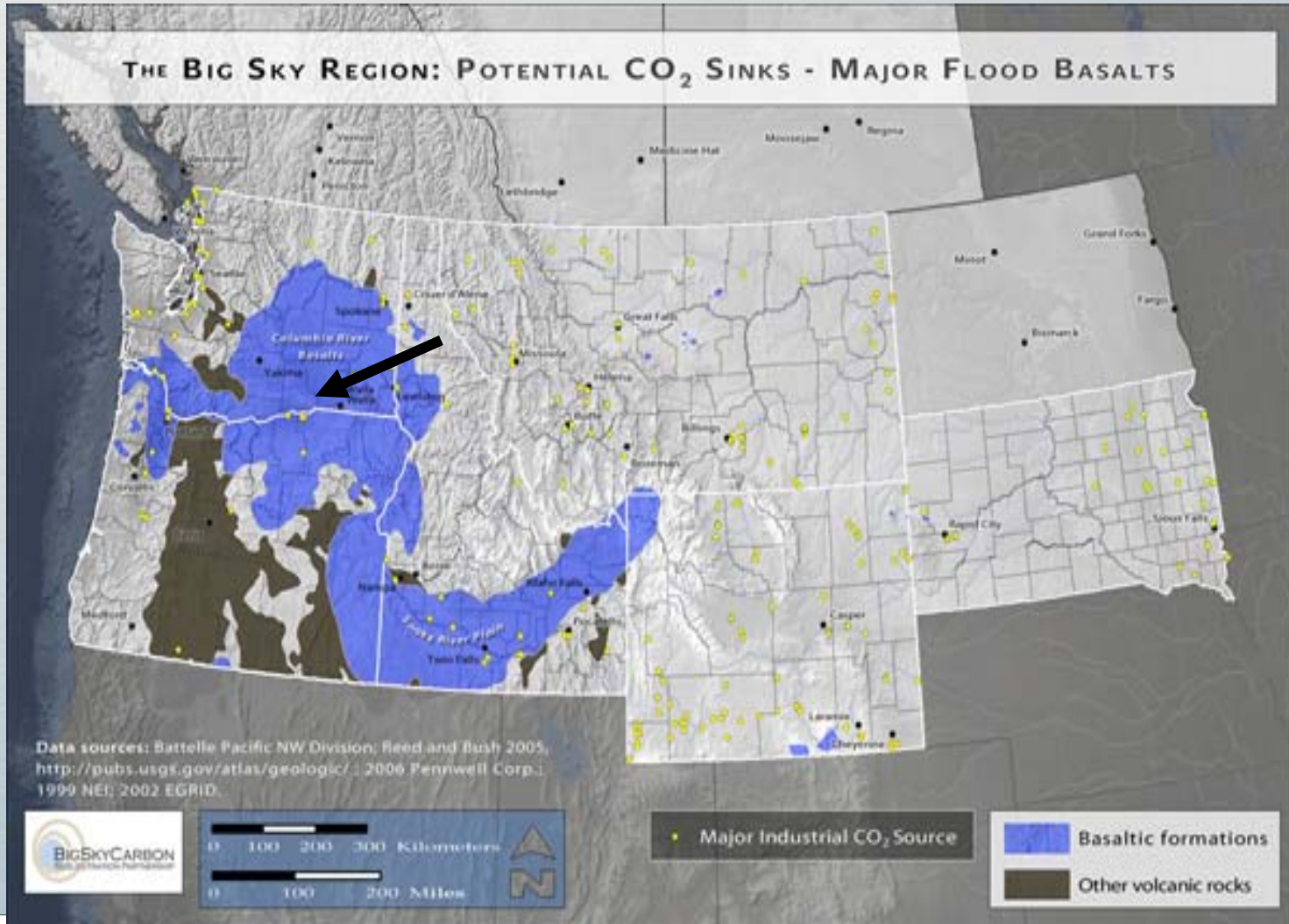
### Big Sky Regional Carbon Sequestration Partnership

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- **Pittsburgh Oct 7, 2008**

**Charlotte Sullivan**

# Phase II Grande Ronde Basalt Sequestration Project Overview



# An Ugly Duckling Sequestration Target: Layered Basalt Flows



- 30% porosity
- 1-2 Darcies
- Assume only 3% of total basalt is suitable for injection,
- $\approx 50\text{Gt CO}_2$  storage capacity

# Geologic Mineral Trapping



+



=



Calcium -  
Magnesium  
Rich Basalt

+

Carbonic Acid  
and  
Water

=

Calcite or  
Magnesite

# Project Overview

## Goals

Overall: Demonstrate and validate safe, permanent storage of CO<sub>2</sub> in reactive mafic basalts of the Columbia River Basalt Group (CRBG) in eastern Washington .

- Specific: Conduct a small scale CO<sub>2</sub> sequestration project in deep basalts of the CRBG.
- The effort under Phase II consists of site characterization activities to be followed by injection of 1000 tons maximum of CO<sub>2</sub>.



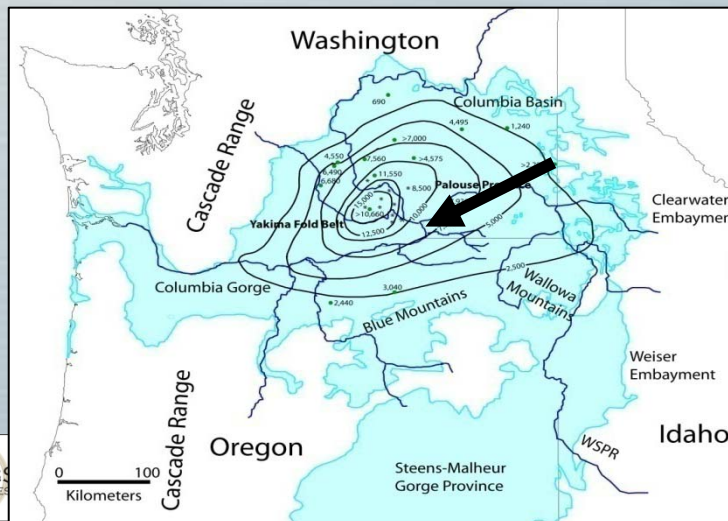
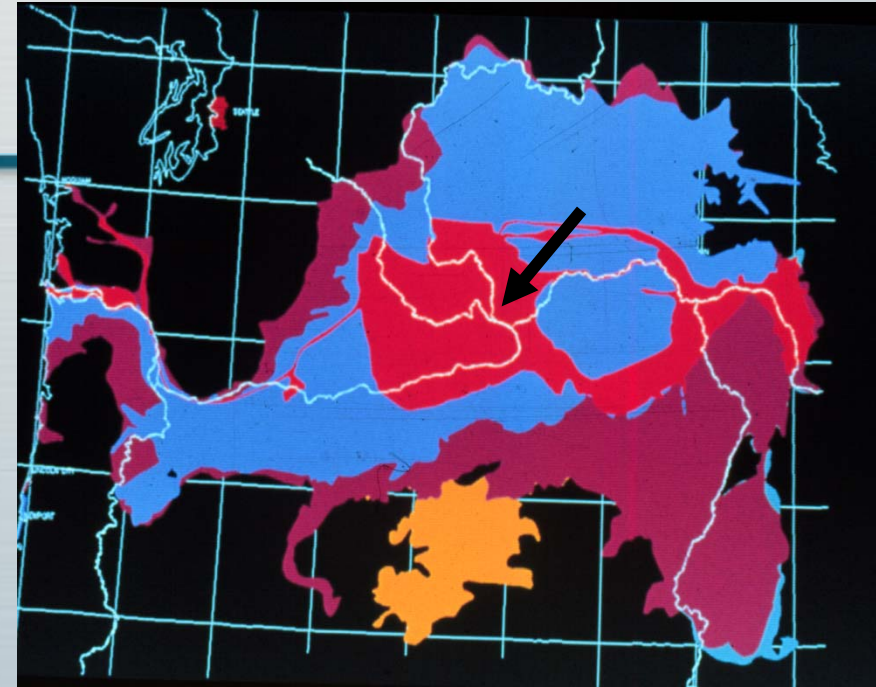
# Pilot Project Partners

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- Research Institutions (universities, labs, others)
  - MSU, UI, Columbia University, INL, Oregon State University
- Department of Natural Resources
- International Collaborators
  - Institut de Physique du Globe (France)
  - National Geophysical Research Institute (India)
  - Vernadsky Institute of Geochemistry and Analytical Chemistry (Russia)
- Industry
  - United Power
  - Boise White Paper L.L.C.
  - Shell Oil Company
  - Others



# Location of Test Well



- Located where some of the deepest and thickest basalt exists in the region
- Located on an active industrial site that has been extensively disturbed during original plant construction
- Plant owner can make use of the well for their commercial operations after pilot study is complete

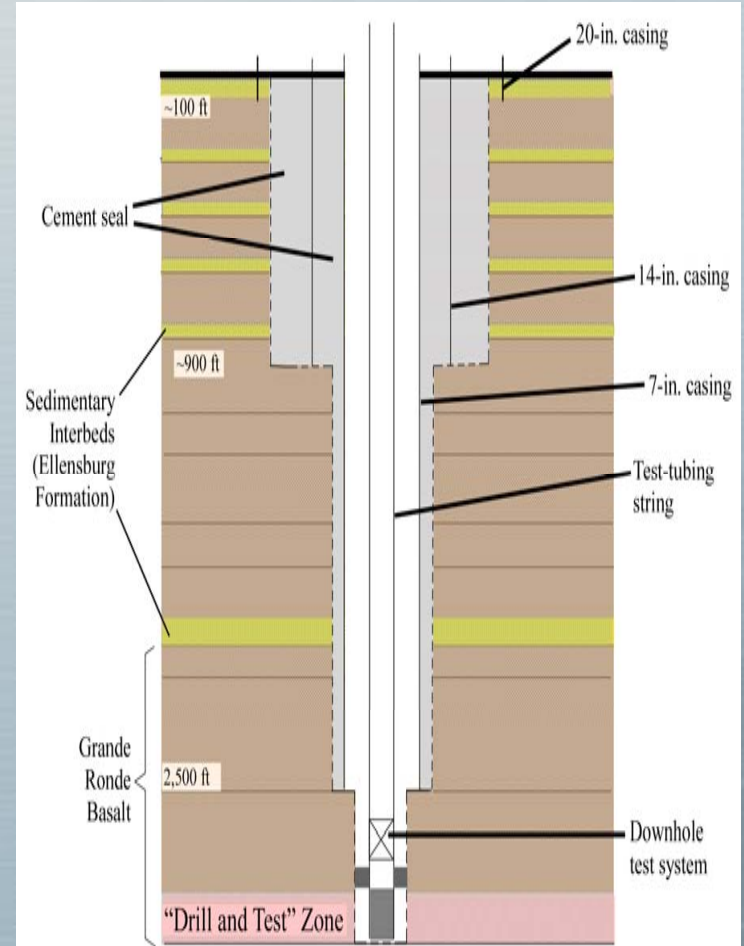
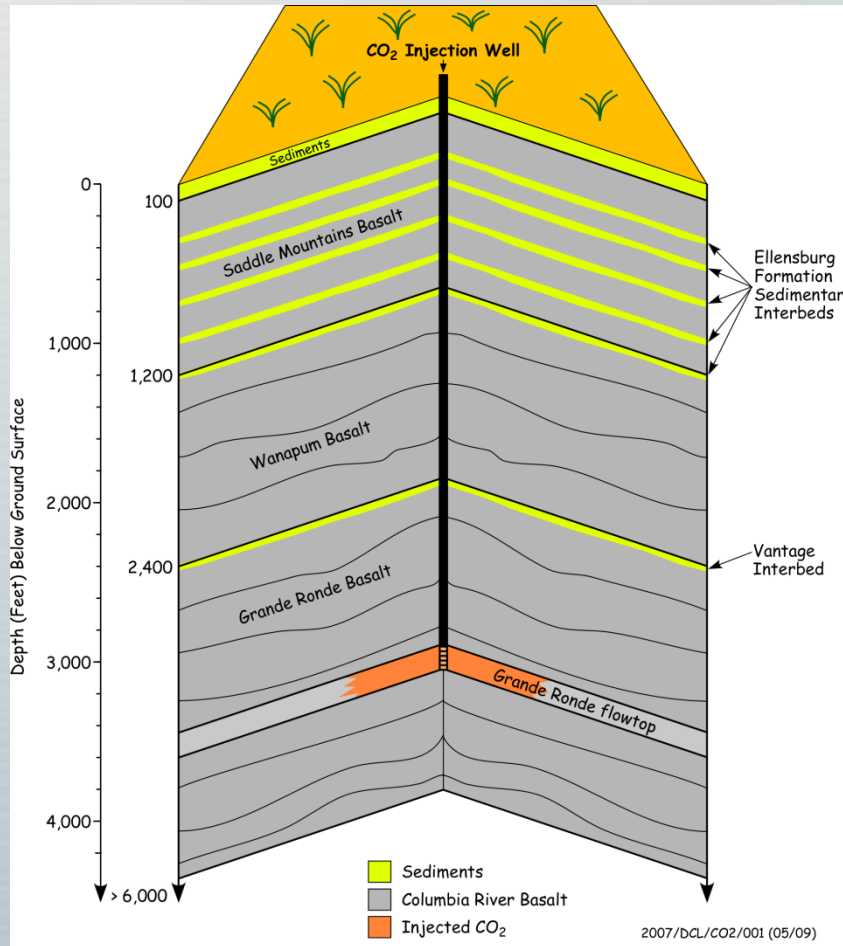
# Project Schedule

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- ▶ Surface seismic survey
- ▶ Soil gas monitoring
- ▶ Characterization well December 1, 2008
- ▶ Logging and reservoir testing January- March, 2009
- ▶ CO<sub>2</sub> injection April, 2009
- ▶ Coring to determine in situ mineralization of CO<sub>2</sub>, 2011



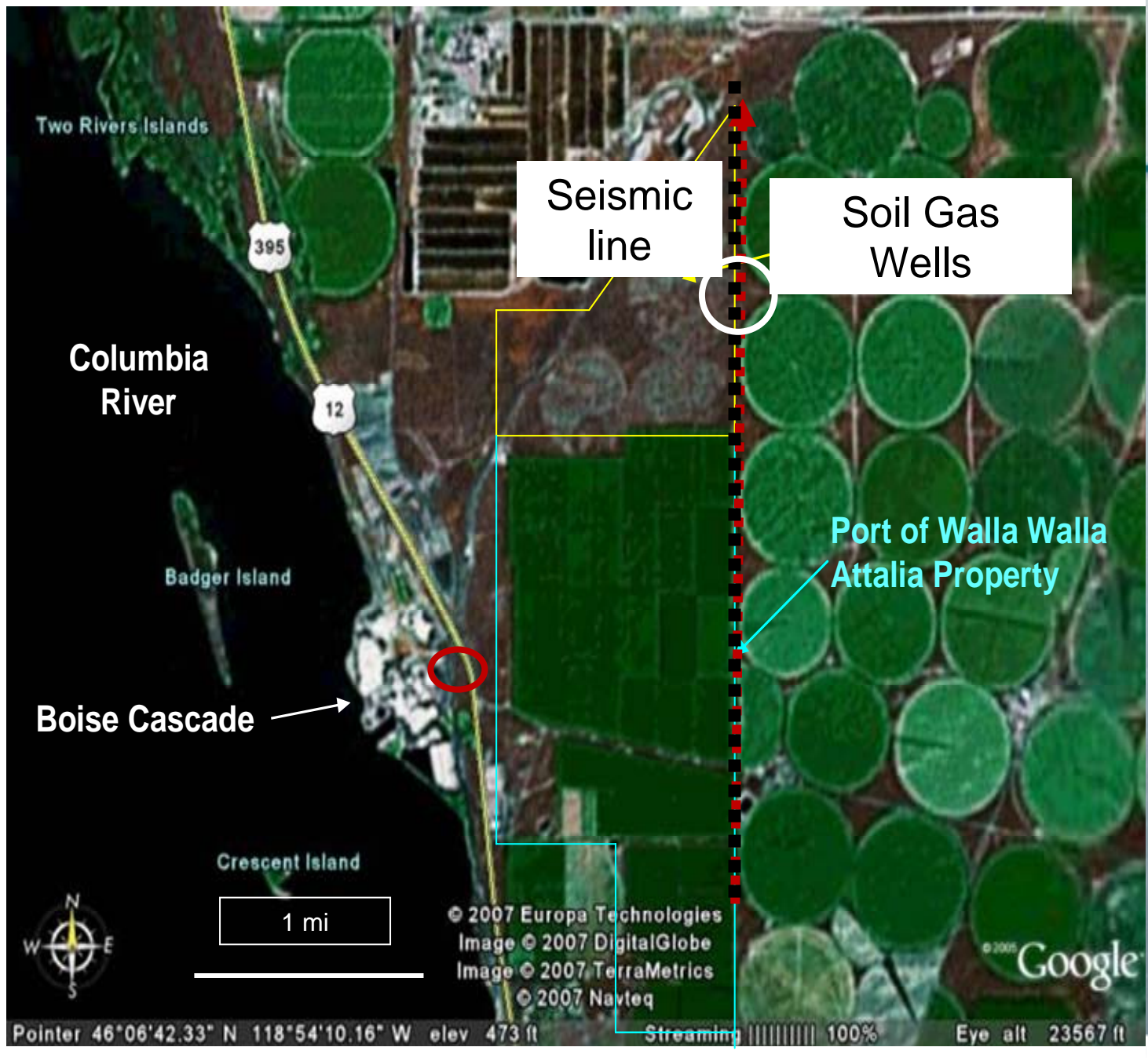
# Stratigraphy and Well Construction



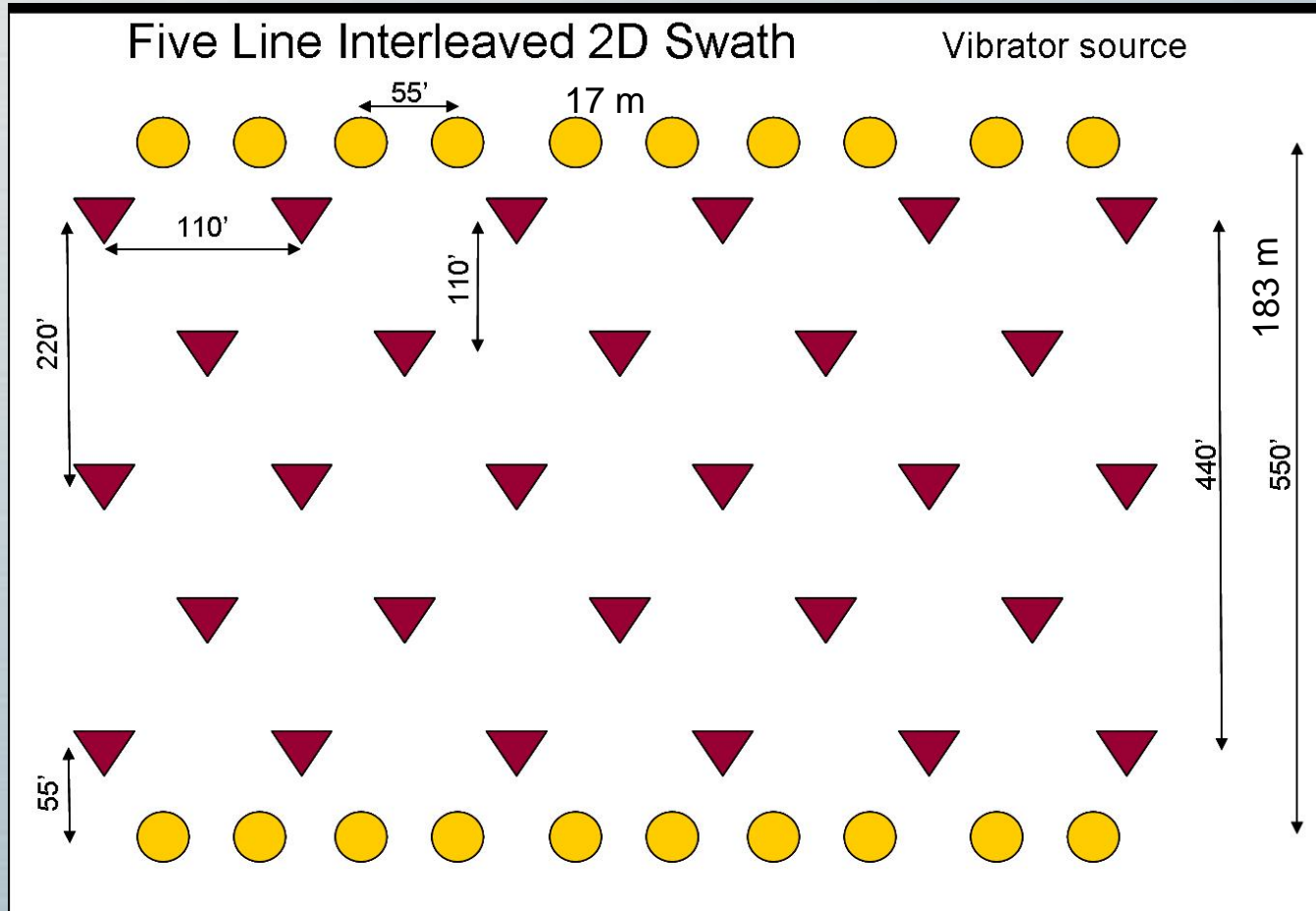
# Field Work Status

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- Data collection from soil gas probes in progress since August 2007
  - No gas phase composition or isotopic anomalies detected
  - New probes to be installed at field site
- Seismic survey completed December 2007
  - Data processing in progress
  - Results show no faults or fracture zones
- Biological survey completed
- Well construction design has been coordinated with Washington Department of Ecology
- Subcontracts with drilling, equipment, and other field service providers are either in place or near finalization



# Design for 6 Km 3Component 2D Seismic line



# Seismic Survey

Seismic survey completed  
12/07/2007

Swath design: five receiver lines  
flanked by two source line;  
frequency 12-120 Hz, 8 sec  
sweep, 2 sweeps, listen 4 sec.

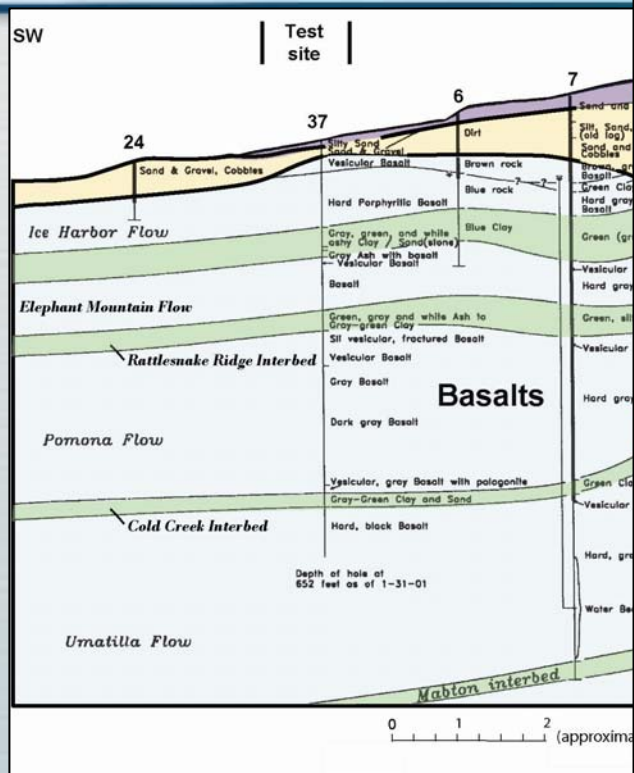
Planned: dominant frequency of  
80 HZ at the target interval of  
3,000-4,000 feet.

Actual 30Hz

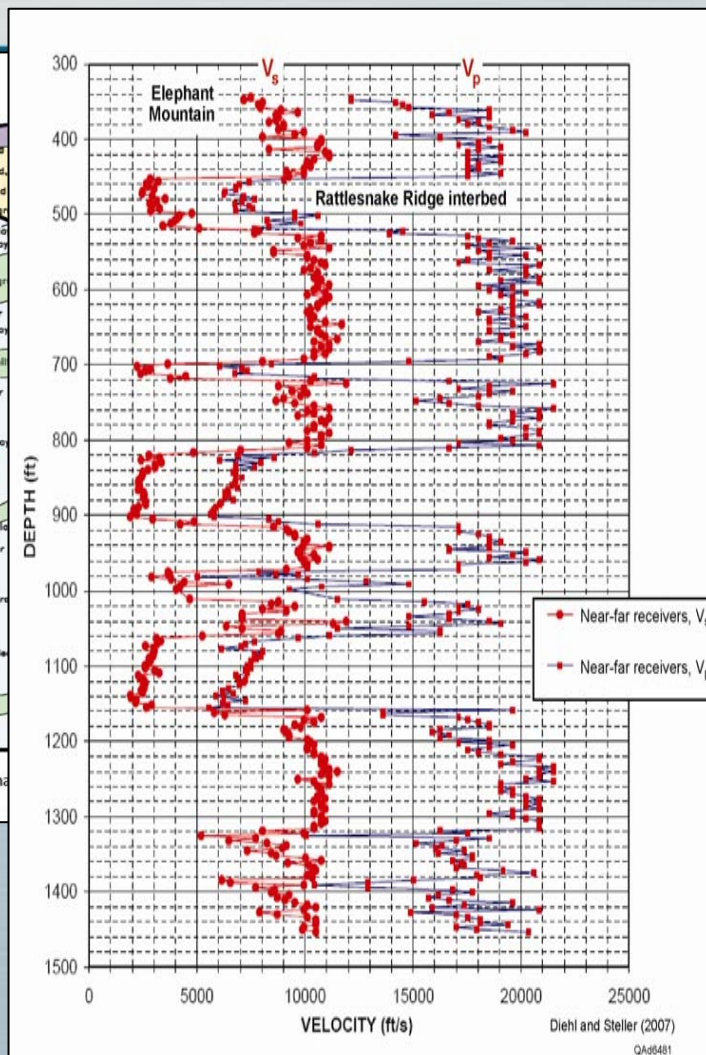
Initial data processing complete.  
No faulting or fracture zones  
are indicated at the site



# Modeling P-wave and S-wave seismic response



Geologic cross-section

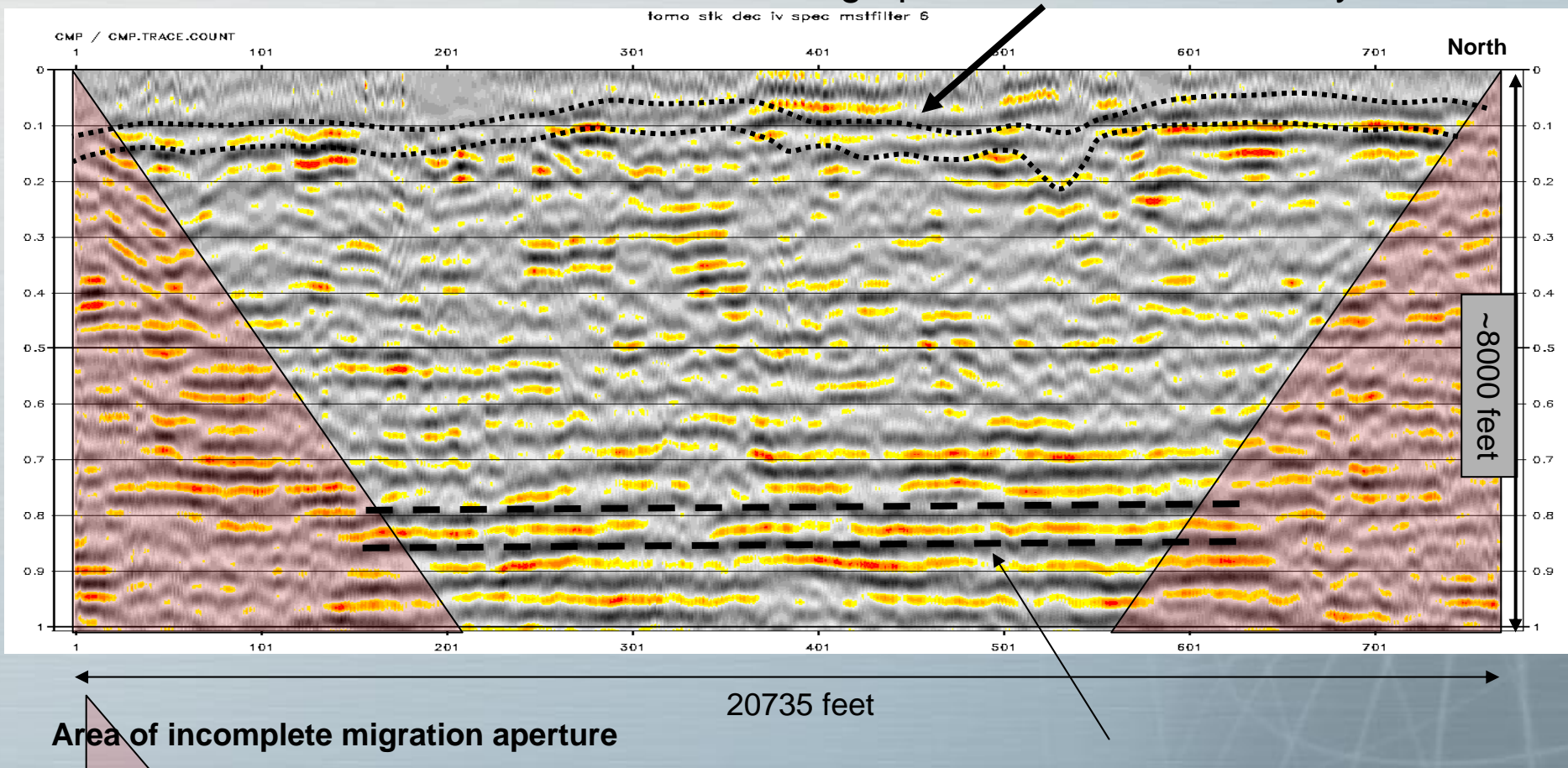


P and S-wave velocity

# Intermediate Processing Stage

## Migrated P-wave section

Approximate shapes of isovels from tomographic near-surface velocity model



# Key Learnings From Elastic Wavefield Forward Modeling

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**The model results imply:**

**P-P reflections will be difficult to extract from the Walulla data because, except at short offsets, P-P events are overprinted by ground roll and by P and S refractions.**

**Complicating the extraction of P-P reflections: extreme velocity contrast between basalt units and interbed units causes P-wave events to become critically refracted at small incidence angles of only 7 to 15 degrees.**

**The fact that CGG Veritas was able to produce usable P-P images under these wave-propagation limitations is impressive.**



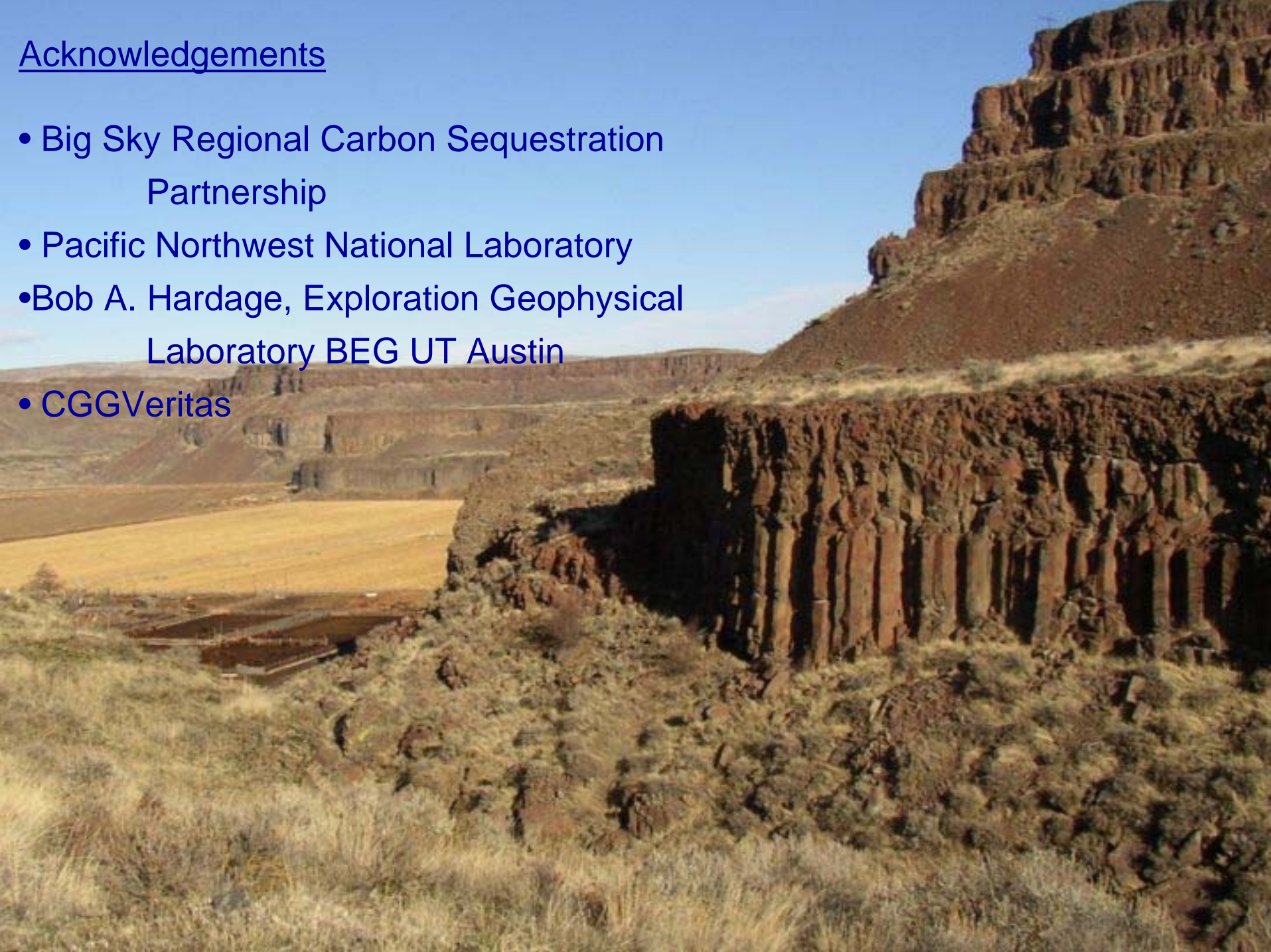
# Learnings from Seismic Characterization

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- No faults breaking reservoir or seals
- Shear waves swamp the vertical P-wave geophone
- Identification of shear wave “noise” allows removal and improvement of signal to noise ratio.
- Conversion of P-wave to down-going SV generates an SV-SV volume- My yield considerable new information on azimuthal anisotropy (and fractures?)
- Opens the path forward for multicomponent seismic monitoring of bulk rock property changes associated with sequestration of CO<sub>2</sub> in basalts

## Acknowledgements

- Big Sky Regional Carbon Sequestration Partnership
- Pacific Northwest National Laboratory
- Bob A. Hardage, Exploration Geophysical Laboratory BEG UT Austin
- CGGVeritas



# Permitting Status

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- NEPA CX submitted on August 11, 2008
- SEPA Application submitted to Walla Walla County
  - Determination of no land use application issued on January 31, 2008
- Land Use Agreement signed August 6, 2008
  - Mineral rights held by landowner
- Class V well registration application submitted September 19, 2008
  - No other permits needed from WADOE for Phase I
- For Phase II, “Special Permit” application to be submitted to WADOE
  - Permit will ensure compliance with all applicable Washington state regulations regarding UIC and groundwater protection