Geoscience Research and Applications Group

SAND2008-7373P

Underground Storage Focus Area

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Geoscience Research & Applications Group – Focus Areas

- Geoscience R & D
- Carbon Capture, Reuse & Sequestration
- Persistent Monitoring
- Systems Analysis & Engineering
- Resource Exploration, Extraction & Development
- ***Underground Storage***

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Underground Storage
– Provide –

Innovative scientific, engineering & technology solutions for:

- **Siting**
  - **Performance**
    - **Safety & Security**

for underground structures designed for:

- ***Storage of energy***
- ***CO2 Storage***
- ***Disposal of hazardous/radioactive wastes***
- ***Protection of strategic assets***

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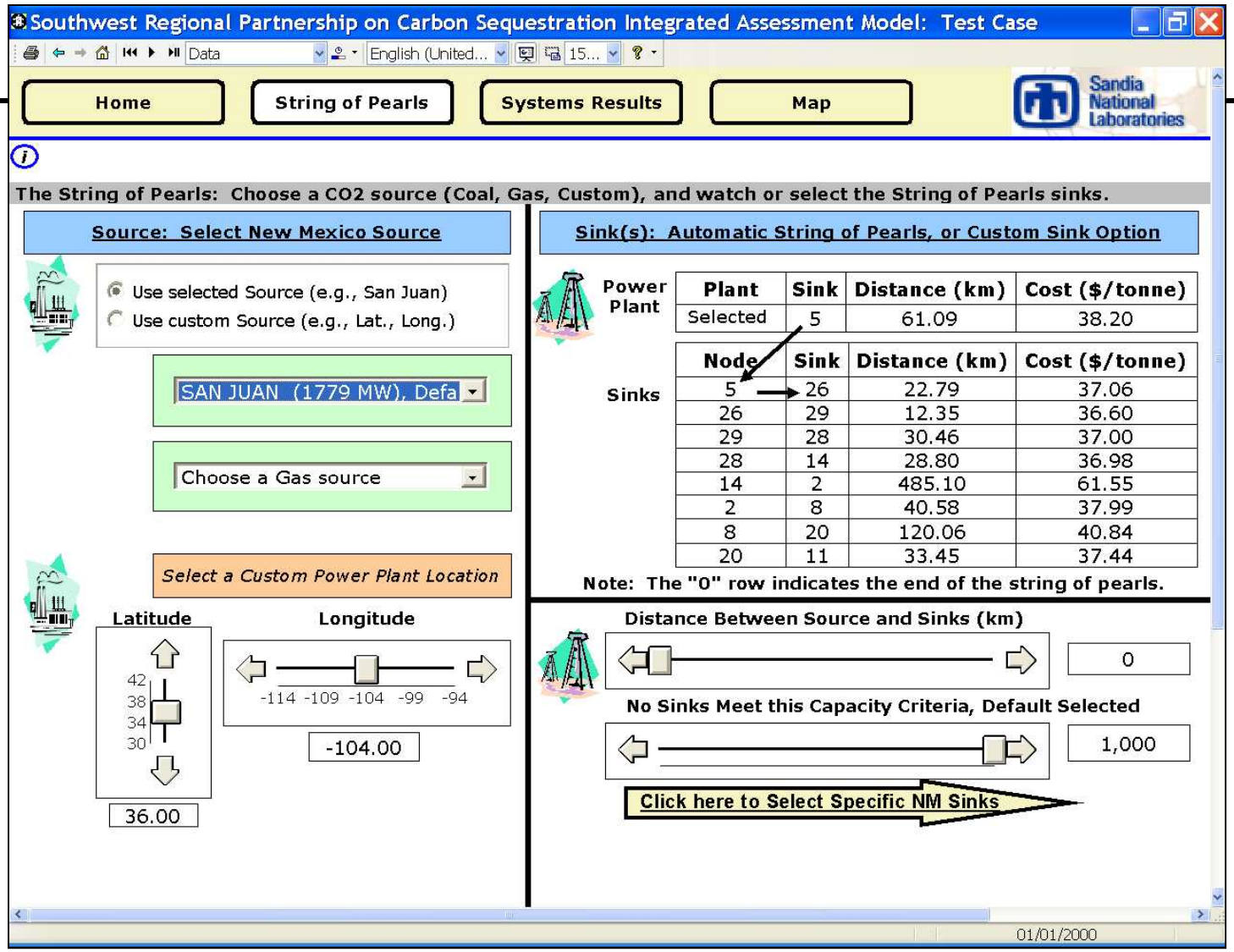
Southwest Regional Partnership on Carbon Sequestration Integrated Assessment Model: Test Case
Home
String of Pearls
Systems Results
Map
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The String of Pearls: Choose a CO2 source (Coal, Gas, Custom), and watch or select the String of Pearls sinks.
Source: Select New Mexico Source
Use selected Source (e.g., San Juan)
Use custom Source (e.g., Lat., Long.)
SAN JUAN (1779 MW), Defa
Choose a Gas source
Select a Custom Power Plant Location
Latitude
Longitude
42
38
34
30
-114 -109 -104 -99 -94
-104.00
36.00
Sink(s): Automatic String of Pearls, or Custom Sink Option
Power Plant
Plant | Sink | Distance (km) | Cost ($/tonne)
Selected | 5 | 61.09 | 38.20
Sinks
Node | Sink | Distance (km) | Cost ($/tonne)
5 | 26 | 22.79 | 37.06
26 | 29 | 12.35 | 36.60
29 | 28 | 30.46 | 37.00
28 | 14 | 28.80 | 36.98
14 | 2 | 485.10 | 61.55
2 | 8 | 40.58 | 37.99
8 | 20 | 120.06 | 40.84
20 | 11 | 33.45 | 37.44
Note: The "0" row indicates the end of the string of pearls.
Distance Between Source and Sinks (km)
0
No Sinks Meet this Capacity Criteria, Default Selected
1,000
Click here to Select Specific NM Sinks
01/01/2000

Underground Storage
– Programs –

- *Geologic Repositories*
  - **Waste Isolation Pilot Plant (WIPP) – Safe disposal of defense TRU wastes in Bedded Salt, SE NM**
  - **Yucca Mountain – License Application for disposal of High-Level Waste & Spent Fuel in Welded Tuff, NV**
  - **International Collaborations**
- *Energy Storage*
  - **Strategic Petroleum Reserve (SPR) – Storage of up to 1 billion barrels of oil for nation's security**
  - **Industry Collaborations for Oil, Gas, & Hydrogen Storage in Caverns (Salt)**
  - **Reservoir Storage/Disposal**
  - **Compressed Air Energy Storage (CAES)**
- *Other Storage*
  - **CO2 Storage**
  - **Hydrogen**
- *Strategic Assets*

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XOM Questions about Storage

- What we have done/do to avoid risk or to mitigate risk
- what problems have we had/have
  - a. sinkholes
  - b. cavern interactions
  - c. casing deformation
  - d. cement jobs
  - e. vapor pressure
  - f. problem situations
  - g. etc
- what do we do to solve/mitigate/prevent
  - a. plan/test/analyze/model/monitor/
  - b. 3-d models integrating geology and geophysics
  - c. Geophysical methods
  - d. etc

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What Sandia Does for the Strategic Petroleum Reserve

- Geological Support
- Design, Geomechanics, Subsidence, and Monitoring
- Integrity Program Support
- Downhole Well Aging and Casing Deterioration

- Process Engineering Support (including De-gas)
- Fluid Dynamics
- Cavern VOC and Sludge Processes
- Cavern Operation Support – Leaching

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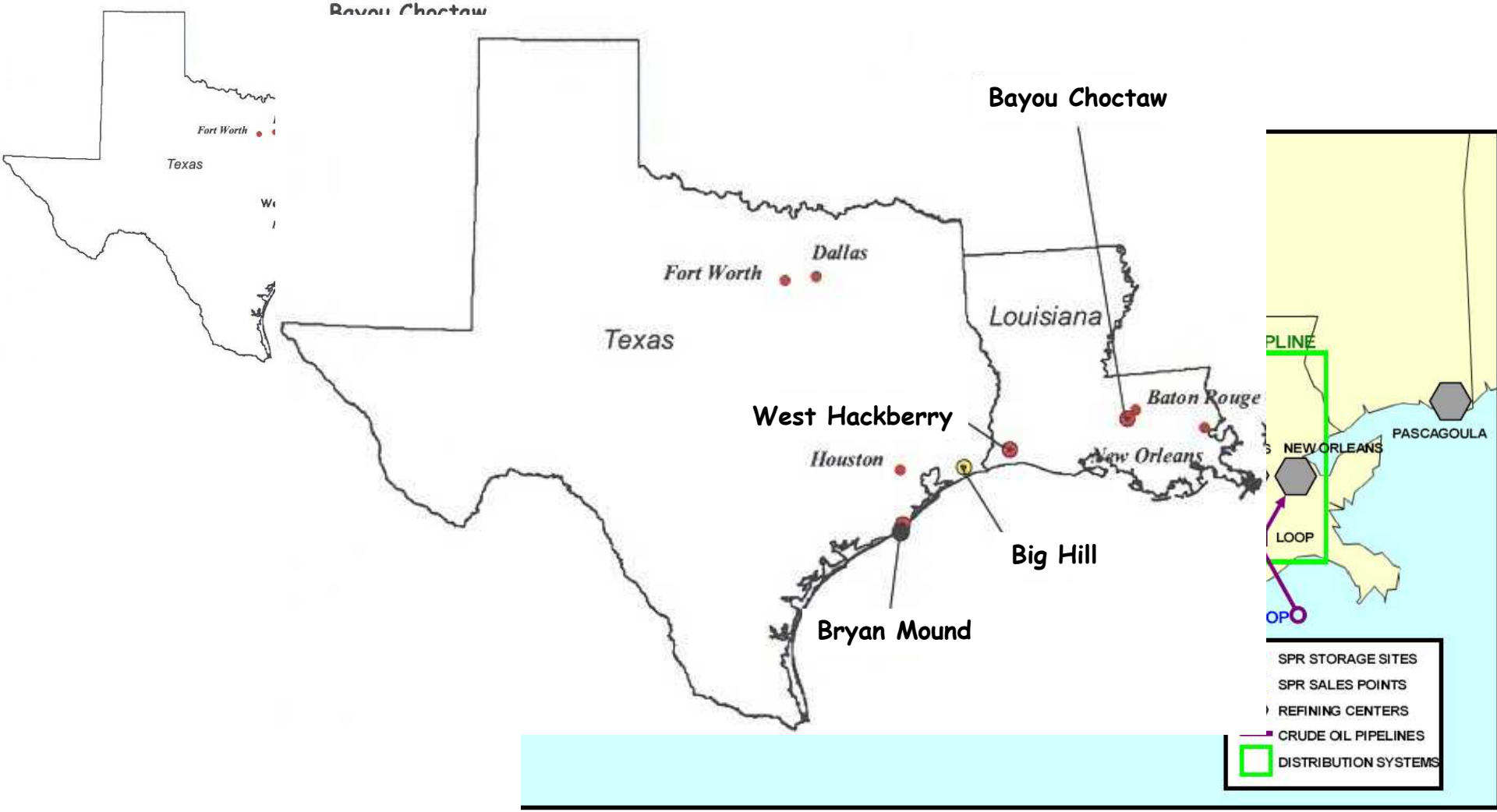
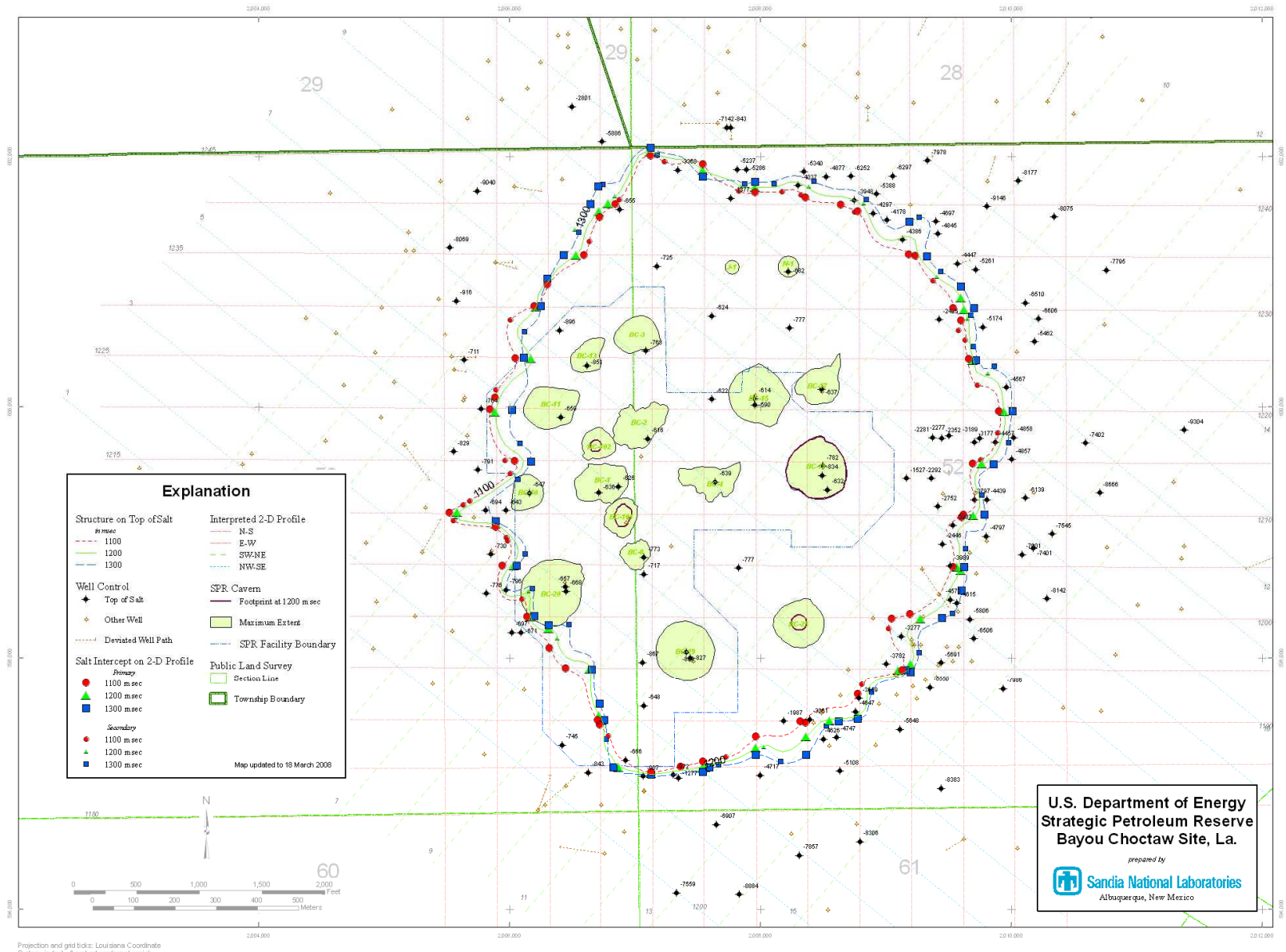
Storage Sites and Distribution System

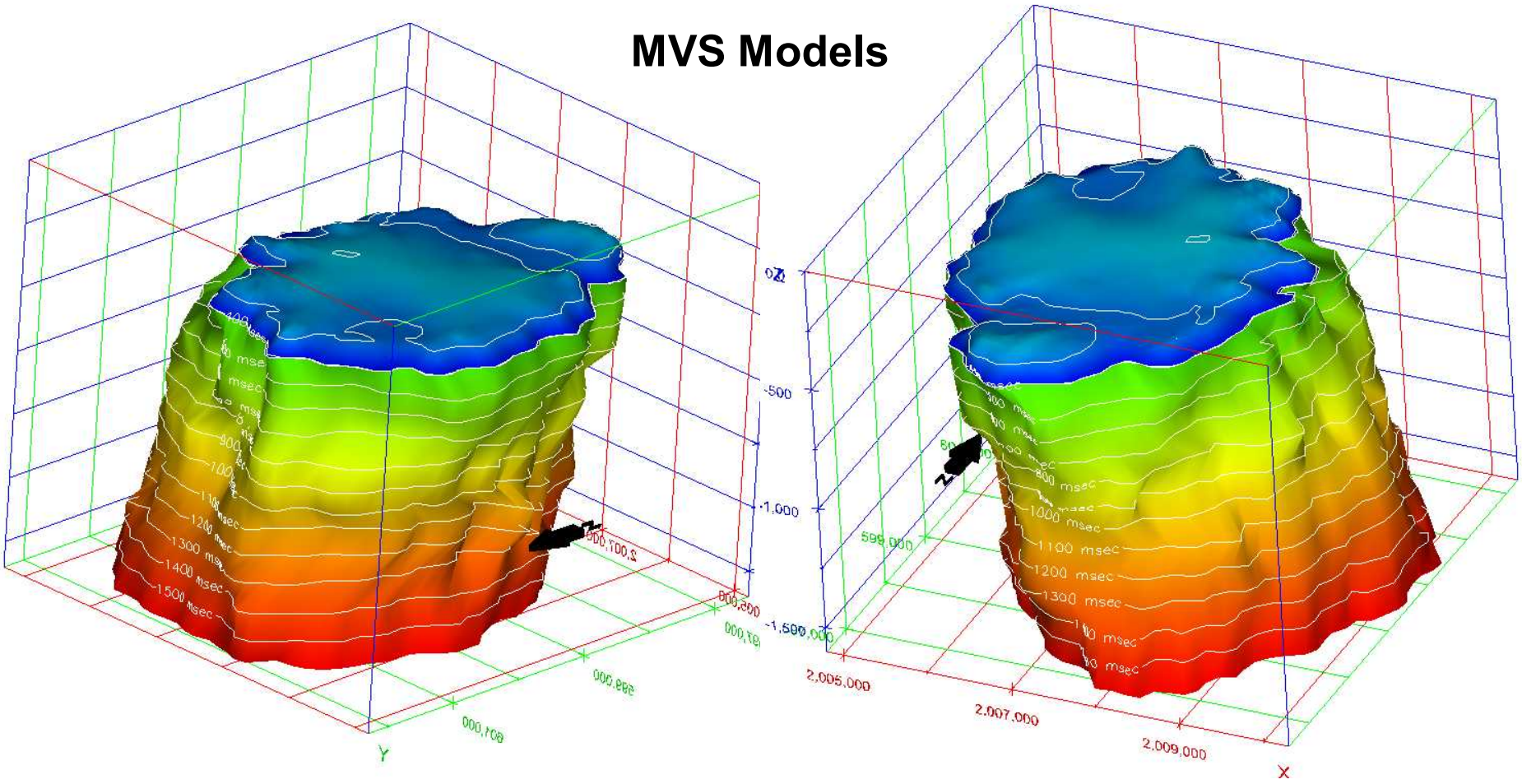




Salt Flank Structure Interpreted from 3-D Seismic Data: 1100 msec to 1300 msec, ~3800 to 4700 ft

Bayou Choctaw 3-D Seismic Study

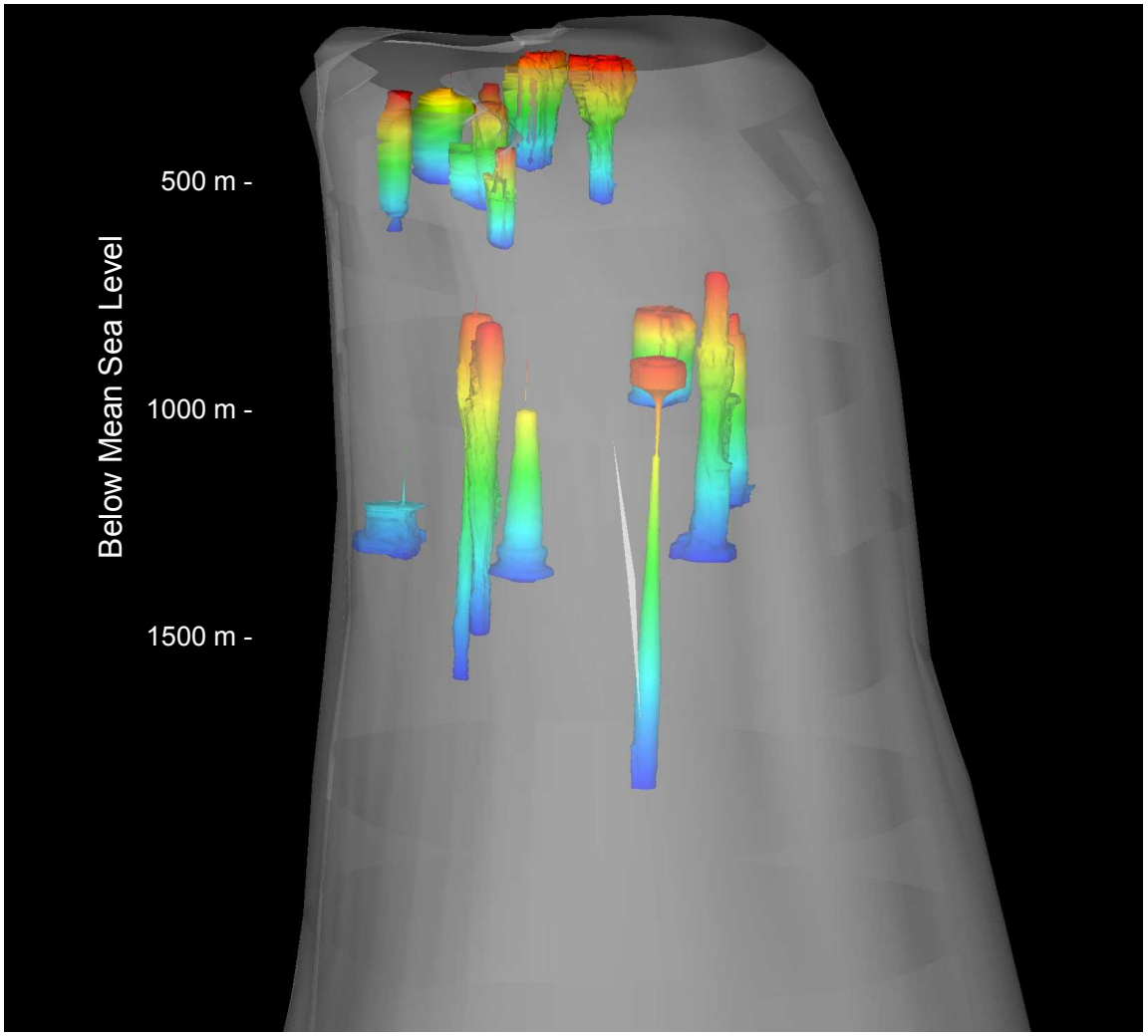
MVS Models



from NW ***from SE***

Strategic Petroleum Reserve (SPR)

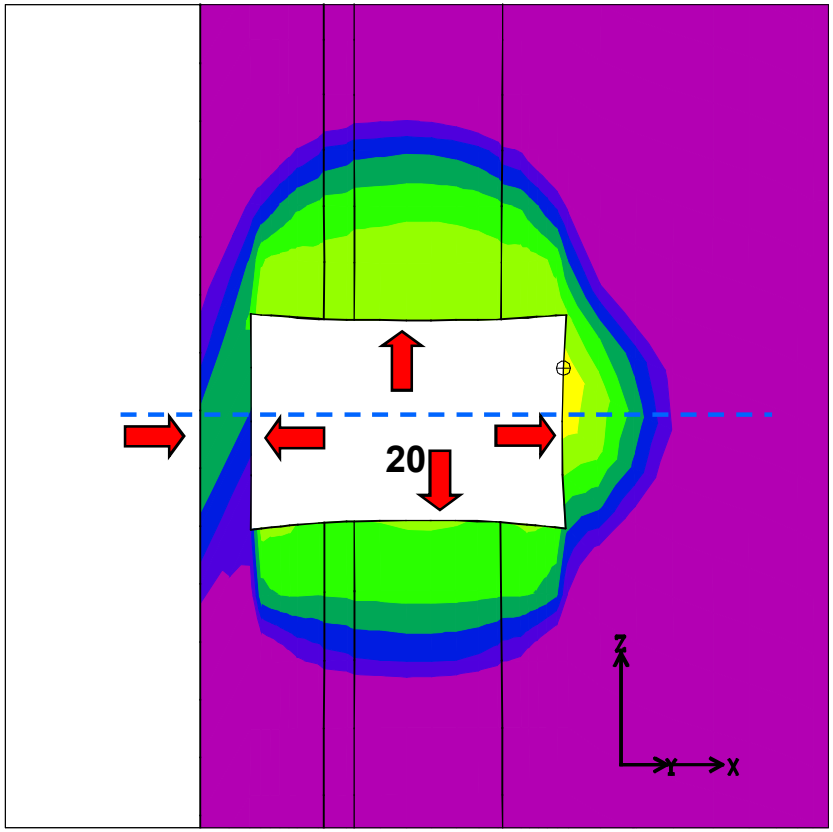
- A typical SPR cavern holds 10 MMB and is cylindrical in shape with a diameter of 60 meters and a height of 600 meters.
- America's emergency crude oil is stored in salt caverns created deep within the massive salt domes
- These caverns offer a secure and affordable means of storage, costing up to 10 times less than aboveground tanks and 20 times less than hard rock mines



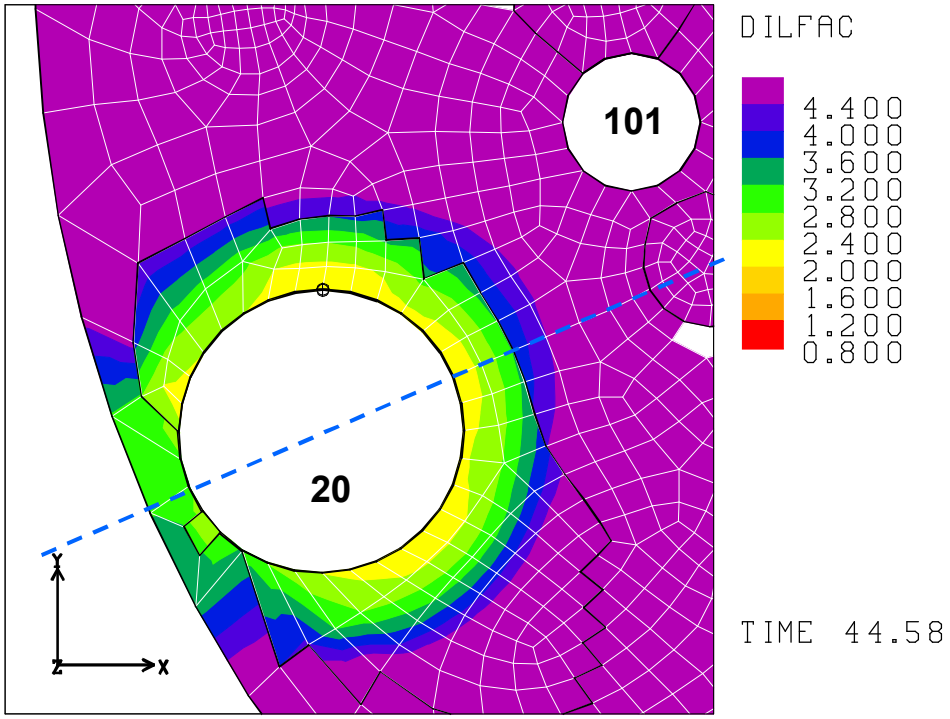
Caverns within Bayou Choctaw Salt Dome

Dilatant Safety Factor Contours during Workover of Cavern 20 at 45 years

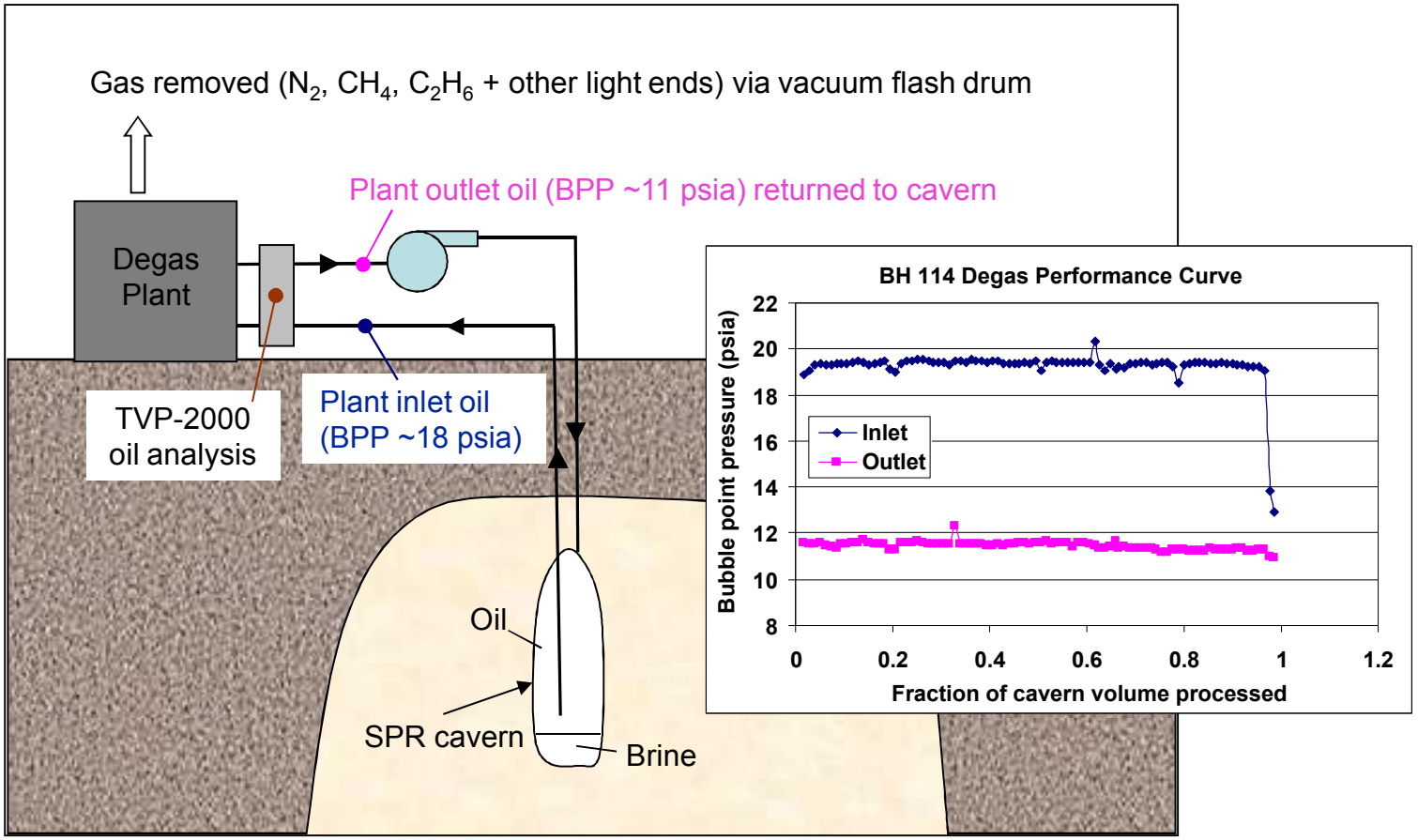
Vertical section view



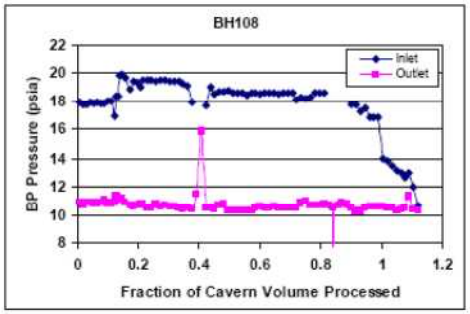
Plan view

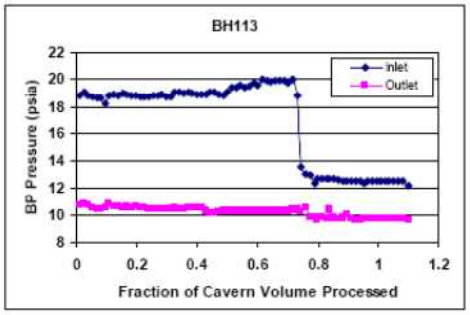


Schematic of Cavern Degasification Process



Big Hill Degas II Performance Curves





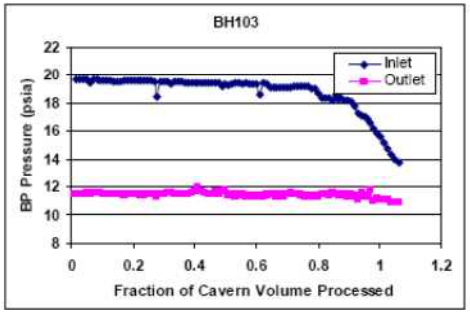
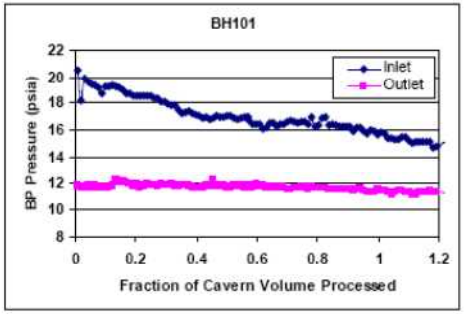
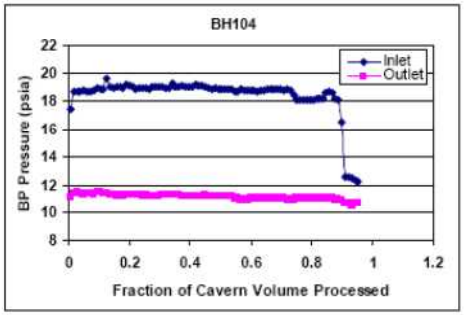


Figure 3-1. Big Hill Degas II Performance Curves.





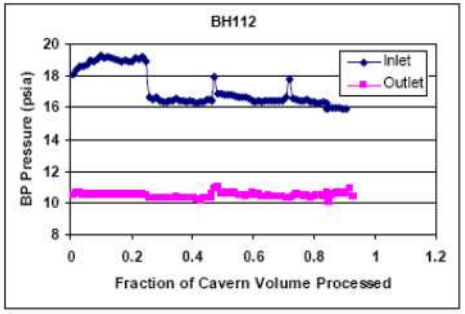
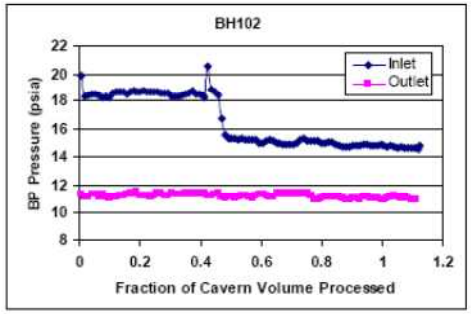
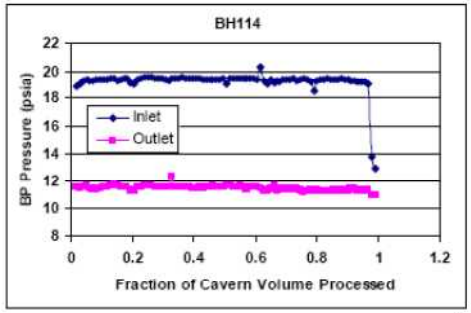


Figure 3-1. Big Hill Degas II Performance Curves (Continued).





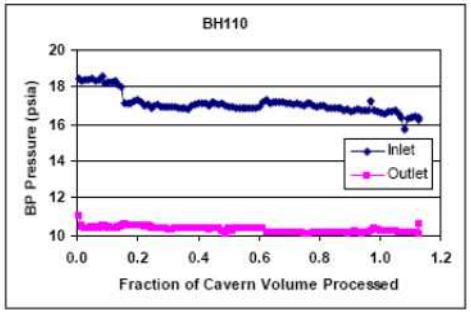
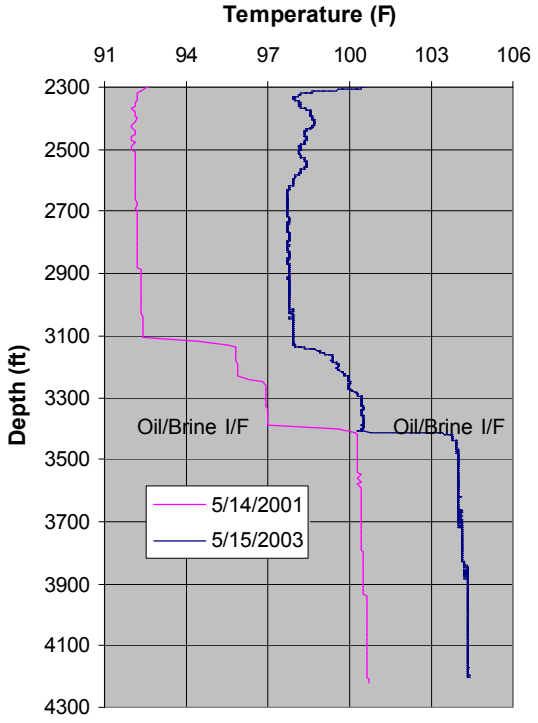


Figure 3-1. Big Hill Degas II Performance Curves (Continued).

Background

Oil Mixing and Stratification

- Stratification as Indicated by Temperature Logs
- Affects Degas Operations
- Simple Degas Model (SDM)
  - Subtask 2.1
- Physics-Based Model
  - Understand Fundamental Processes
  - Effect of Changes in Operational Parameters



BH110

Oil Mixing Experiments

Inner Cylinder

- **Mixing Experiment with Initial Concentration Variation**

Outer Enclosure

- **Constant Temperature Bath**

Bottom and Sidewall Heating Setup

Underground Storage
– Challenges/Solutions (1/3) –

- *Geologic Repositories*

  Demonstrate through conceptual models and probabilistic Performance Assessment the safe disposal of TRU waste, HLW and SF for a period of up to 1 million yrs considering:

  - **Natural processes of infiltration, saturated and unsaturated groundwater flow, solute and reactive transport, corrosion, mechanical stability, & climate**
  - **Natural disruptive events, e.g., earthquakes, volcanism**
  - **Human intrusion, e.g., drilling/exploration**

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Underground Storage
– Challenges/Solutions (2/3) –

- *Cavern Storage*

  Demonstrate through modeling/monitoring the safe and secure storage of Oil, Gas, & hydrogen. Considerations of:

  - **Natural heterogeneity**
  - **Subsidence & sinkhole development**
  - **Stability of caverns and their interactions, pressure cycling**
  - **Casing deformation, corrosion, cementing**
  - **Formation out gassing, vapor pressure**

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Underground Storage
– Challenges/Solutions (3/3) –

- *Reservoir Storage*

  Demonstrate through modeling/monitoring the safe storage/disposal of Gas, Compressed Air, CO_2. Considerations of:

  - **Natural geologic heterogeneity**
  - **Containment/caprock integrity**
  - **Multi-phase flow & reactive transport**
  - **Injection/deliverability & pressure cycling**
  - **Wellbore integrity**

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