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WESTCARB Overview

HSE Screening and Ranking Framework for Geologic CO_2 Storage Site Selection

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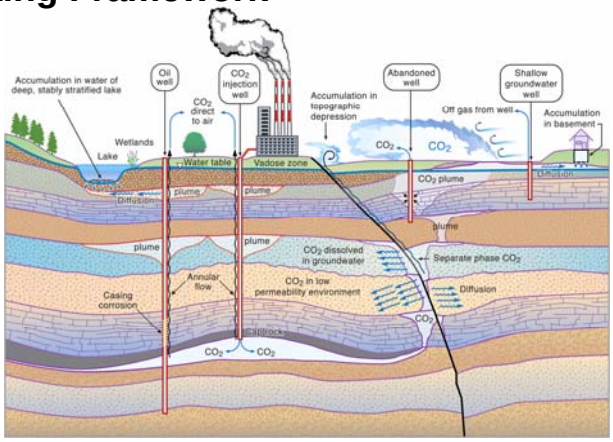
November 8, 2005

CO_2 Leakage Risk Motivates Screening and Ranking Framework



- **Question to be addressed: From a choice of several potential sites, which site has the lowest Health, Safety, and Environmental (HSE) risk?**

Introduction

We have developed a Screening and Ranking Framework (SRF) tool based on Health, Safety, and Environmental (HSE) risk

Geologic Carbon Sequestration HSE Screening and Ranking Framework
Version 1.0
9/24/2004 C.M. Oldenburg (LBNL) Last update: 9/20/2005

HSE risk is fundamentally related to three basic characteristics of a geologic carbon sequestration site:

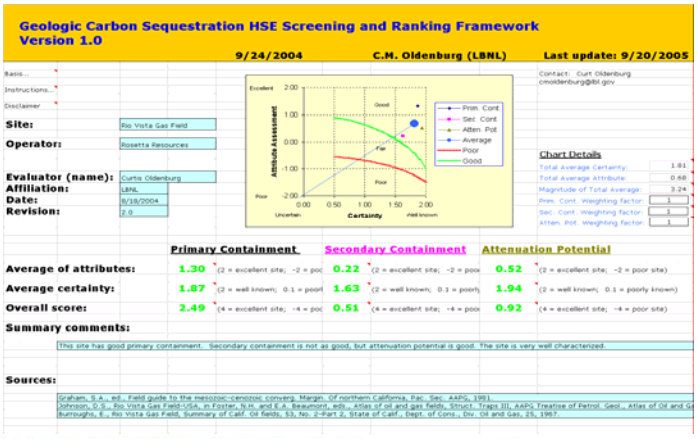
(1) Potential of the primary target formation for long-term containment of CO_2

(2) Potential for secondary containment if the primary target formation leaks

(3) Potential to attenuate and/or disperse leaking CO_2 if the primary formation leaks and secondary containment fails

Introduction (cont'd)

Design goal: Qualitative and independent assessment of the three characteristics through a numerical evaluation of the properties of various attributes



The framework is implemented in Excel

Three Fundamental Characteristics

(1) Primary Containment
- Primary Seal
- Depth
- Reservoir

(2) Secondary Containment
- Secondary Seal
- Shallower Seal(s)
- Reservoir

(3) Attenuation Potential
- Surface characteristics
- Hydrology
- Existing wells
- Faults

Attributes

Attributes of Primary Containment

Properties

Primary Seal
- Thickness
- Lithology
- Demonstrated sealing
- Lateral continuity

Depth
- Distance below ground

Reservoir
- Lithology
- Perm., poros.
- Thickness
- Fracture or primary poros.
- Pores filled with…
- Pressure
- Tectonics
- Hydrology
- Faults
- Deep wells

Attributes of Secondary Containment

Secondary Seal
- Thickness
- Lithology
- Demonstrated sealing
- Lateral continuity
- Depth

Properties

Shallower Seals
- Thickness
- Lithology
- Lateral continuity
- Evidence of seepage

Attributes of Attenuation Potential

Surface Characteristics
- Topography
- Wind
- Climate
- Land use
- Population
- Surface water

Properties

Existing wells
- Deep wells
- Shallow wells
- Abandoned wells
- Disposal wells

Groundwater Hydrology
- Regional flow
- Pressure
- Geochemistry
- Salinity

Properties

Faults
- Tectonic faults
- Normal faults
- Strike-slip faults
- Permeability

Evaluation

- User:
  - Weights the importance of each property
  - Assigns values based on given options
  - Assigns a certainty factor
- Spreadsheet:
  - Averages the weighted property assessments
  - Averages the certainty factors
  - Generates graphical display
  - Presents both assessments and certainties

Evaluation of Primary Containment

8/18/2004 Rio Vista Gas Field Revision: 2.0

Primary Containment

	Overall score for this sheet	Average of the weighted assessments of attributes	Average certainty
	2.49	1.30	1.87

Attribute	Weight (10 = most import, 1 = least)	Normalized Weight	Property/Value	Assessment of Attribute Property Relative to HSE Risk (2 = excellent (positive attribute), 0 = neutral (fair attribute), -2 = poor (negative attribute))	Weighted Assessment of Attribute	Certainty Factor (2.0 = Very well known, 1.0 = Generally accepted, 0.1 = Poorly known)
Primary Seal			**Description**			
Thickness	10	0.48	100 m	0	0.00	2
Lithology	5	0.24	Shale	2	0.48	2
Demonstrated sealing	5	0.24	Good seal	2	0.48	2
Lateral continuity	1	0.05	Large areal extent of gas	2	0.10	2
	21	1.00	Average:	1.50	1.05	2.00
Depth			**Description**			
Distance below ground	10	1.00	some v. shallow, but most 1000 m -	2	2.00	2
	10	1.00	Average:	2.00	2.00	2.00
Reservoir			**Description**			
Lithology	1	0.07	Sandstone	2	0.13	2
Perm., poros.	2	0.13	5-1800 mD, 20-34%	2	0.27	2
Thickness	1	0.07	150 m	2	0.13	2
Fracture or primary poros.	1	0.07	Primary	2	0.13	2
Pores filled with..	1	0.07	tural gas and low-TDS water	2	0.13	1
Pressure	1	0.07	Hydrostatic to depleted	1	0.07	1
Tectonics	2	0.13	ith faults, but not v. active	0	0.00	2
Hydrology	2	0.13	Water drive	0	0.00	1
Deep wells	2	0.13	Many deep wells	-2	-0.27	2
Fault permeability	2	0.13	Trapping faults (low k)	2	0.27	1
	15	1.00	Average:	1.10	0.87	1.60

Evaluation of Secondary Containment

8/18/2004 Rio Vista Gas Field Revision: 2.0

	Overall score for this sheet	Average of weighted assessments of attributes	Average certainty
Secondary Containment	0.51	0.22	1.63

Attribute	Weight (10 = most import. 1 = least)	Normalized Weight	Property/Value	Assessment of Attribute Property Relative to HSE Risk (2 = excellent (positive attribute) 0 = neutral (fair attribute) -2 = poor (negative attribute))	Weighted Assessment of Attribute	Certainty Factor (2.0 = Very well known 1.0 = Generally accepted 0.1 = Poorly known)
Secondary Seal			**Description**			
Thickness	10	0.38	150 m (Sidney Flat shale)	0	0.00	2
Lithology	5	0.19	Shale	2	0.38	2
Demonstrated sealing	1	0.04	s prod. from multiple horiz.	1	0.04	2
Lateral continuity	5	0.19	Laterally continuous	1	0.19	2
Depth	5	0.19	Sidney Flat shale ~800 m	0	0.00	2
	26	1.00	Average:	0.80	0.62	2
Shallower Seals			**Description**			
Thickness	10	0.33	Thin mudstone	-1	-0.33	1
Lithology	5	0.17	Mudstone	0	0.00	1
Lateral continuity	5	0.17	Extensive	1	0.17	1
Evidence of seepage	10	0.33	Historic gas seeps	0	0.00	2
	30	1.00	Average:	0.00	-0.17	1.25

Evaluation of Attenuation Potential

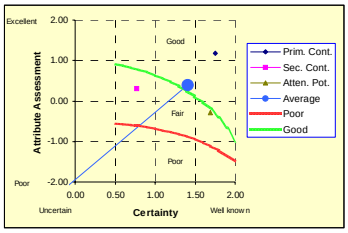
8/18/2004 Rio Vista Gas Field Revision: 2.0

	Overall score for this sheet	Average of weighted assessments attributes	Average certainty
Attenuation Potential	0.92	0.52	1.94

Attribute	Weight (10 = most import 1 = least)	Normalized Weight	Property/Value	Assessment of Attribute Property Relative to HSE Risk (2 = excellent (positive attribute) 0 = neutral (fair attribute) -2 = poor (negative attribute))	Weighted Assessment of Attribute	Certainty Factor (2.0 = Very well known 1.0 = Generally accepted 0.1 = Poorly known)
Surface Characteristics			**Description**			
Topography	5	0.15	Flat	2	0.30	2
Wind	10	0.30	Windy	2	0.61	2
Climate	2	0.06	Sub-humid	-1	-0.06	2
Land use	4	0.12	Farmland/wetlands	1	0.12	2
Population	10	0.30	Rural	1	0.30	2
Surface water	2	0.06	Perennial wetlands exist	-2	-0.12	2
	33	1.00	Average:	0.50	1.15	2.00
Groundwater Hydrology			**Description**			
Regional flow	6	0.32	nable, away from Mont. Hills	1	0.32	2
Pressure	7	0.37	Hydrostatic	0	0.00	2
Geochemistry	2	0.11	Fresh, slightly alk.	2	0.21	2
Salinity	4	0.21	Very low TDS	2	0.42	2
	19	1.00	Average:	1.25	0.95	2.00
Existing Wells			**Description**			
Deep wells	5	0.25	Many deep wells	-2	-0.50	2
Shallow wells	4	0.20	umerous shallow gw wells	-2	-0.40	2
Abandoned wells	10	0.50	Many abandoned wells.	-2	-1.00	2
Disposal wells	1	0.05	Water is re-injected.	-2	-0.10	2
	20	1.00	Average:	-2.00	-2.00	2.00
Faults			**Description**			
Tectonic faults	10	0.59	o permeable tectonic faults	2	1.18	2
Normal faults	1	0.06	Normal faults form traps	2	0.12	2
Strike-slip faults	1	0.06	Few strike-slip faults	2	0.12	1
Fault permeability	5	0.29	s of gas plays are fault traps	2	0.59	2
	17	1.00	Average:	2.00	2.00	1.75

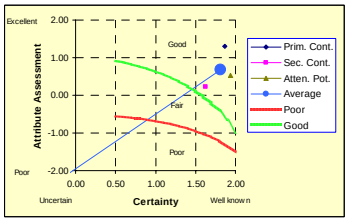
Example of Graphical Result

Ventura Oil Field

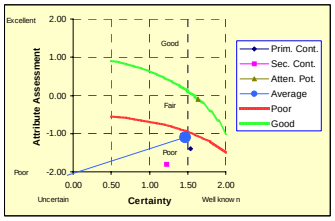


Two candidate pilot sites and a known leaking system

Rio Vista Gas Field



Mammoth Mountain



Discussion

- Example results are consistent with our knowledge and expectation, now formally expressed in the SRF
- Identical weighting factors were used for consistency
- Simple and transparent approach
- Group effort on evaluations will tend to capture larger range of opinions
- Extensions are possible (e.g., distributions replacing single values)
- Proxies could be replaced by measured or modeled values

Summary

- An HSE screening and ranking framework has been developed based on three fundamental characteristics of a geologic CO_2 storage site:
  1) Primary containment potential
  2) Secondary containment potential
  3) Attenuation potential
- This is a screening and ranking framework (SRF) tool
- HSE risk is just one component of site selection
- Testing and further development will continue

Acknowledgments

This work was supported in part by WESTCARB through the Assistant Secretary for Fossil Energy, Office of Coal and Power Systems, through the National Energy Technologies Laboratory (NETL), and by Lawrence Berkeley National Laboratory under Department of Energy Contract No. DE-AC03-76SF00098