DOE-ARRA Geologic Sequestration Training and Research

2011 Yearly Review Meeting

Project DE-FE0002059

Title: Training Graduate and Undergraduate Students in Simulation and Risk Assessment for Carbon Sequestration

Colorado School of Mines

Presenter: Dr. Alexis Sitchler, Environmental Science and Engineering

February 24-26, 2011

Project Participants

John E. McCray, PhD, Professor [1,3]
Reed Maxwell, PhD, Assoc. Professor [2,3]
Alexis Sitchler, PhD, Post-Doctoral Researcher [1,3]
Erica Siirila, PhD Student [2,3]
Hannah Menke, PhD Student [1,3]

Environmental Science and Engineering Division [1]
Geology & Geological Engineering Department [2]
Hydrologic Science and Engineering Program [3]

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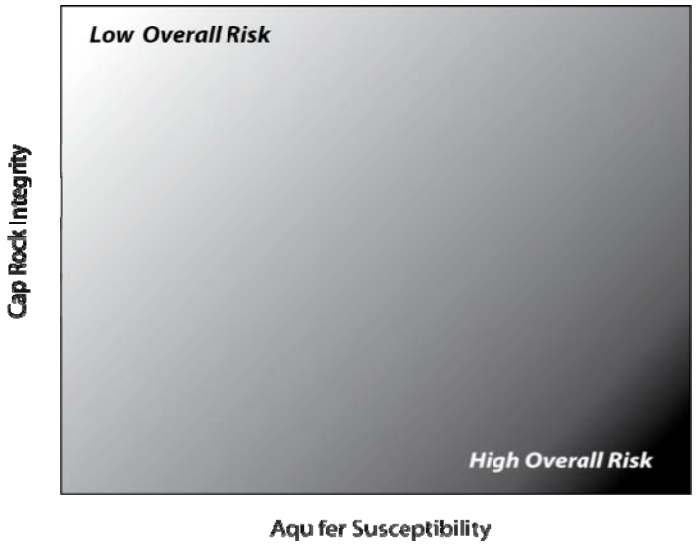
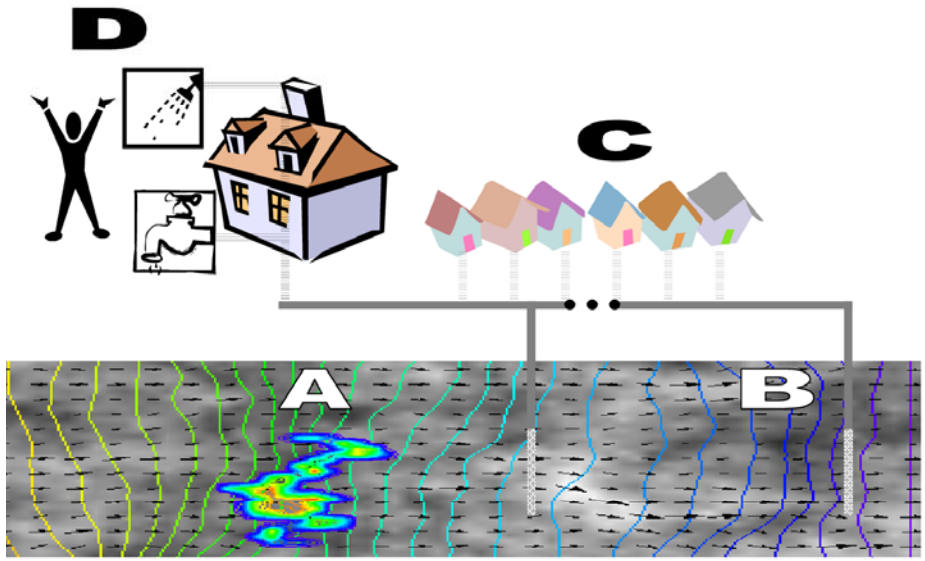
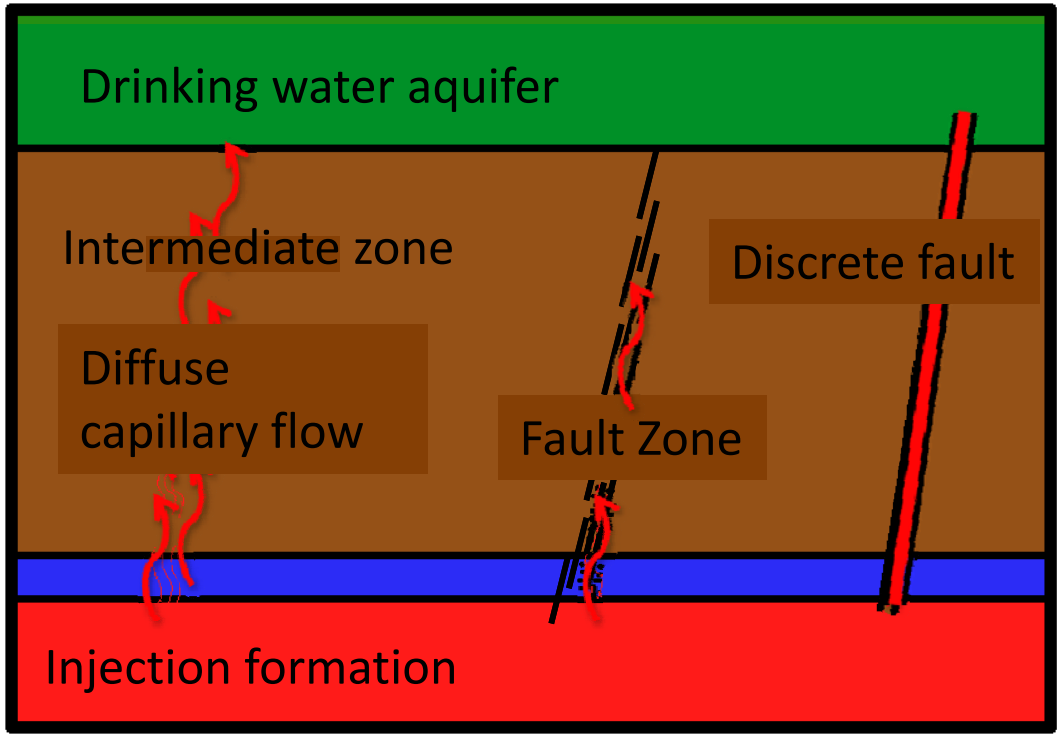
Introduction



Determine drinking water risk from CO_2 leakage (and byproducts) into groundwater.





Model simulations to identify high and low risk leakage scenarios for CO_2 and metals transport

Project Objectives

- Train graduate students in the DOE interest area of "Simulation and Risk Assessment" associated with geologic carbon sequestration.
- Advance state-of-the science through research in the following areas:
  - Risk assessment of CO_2 leakage into aquifers
  - Numerical simulation of leakage from CO_2 reservoirs
  - Impact of CO_2 leakage on aquifer chemistry

Project Funding

- Total Project Cost: $414,947
- DOE Share: $299,997
- Non-DOE Cost Share: $114,950
- Cost Share Provider: Colorado School of Mines

AS2

Highlights of Project to Date

- One student trained in quantitative risk assessment
- One student trained in advanced reactive transport simulation
- E. Siirila completion of M.S. degree and admittance to Ph.D. program
- Publication in press first authored by E. Siirila
- Development of methodology for quantitative risk assessment associated with CO_2 leakage and resulting metals transport in aquifers
- Presentation of research by students at multiple international conferences
- Compilation of leakage rates published to date
- Piloted CCS course as seminar

Slide 6

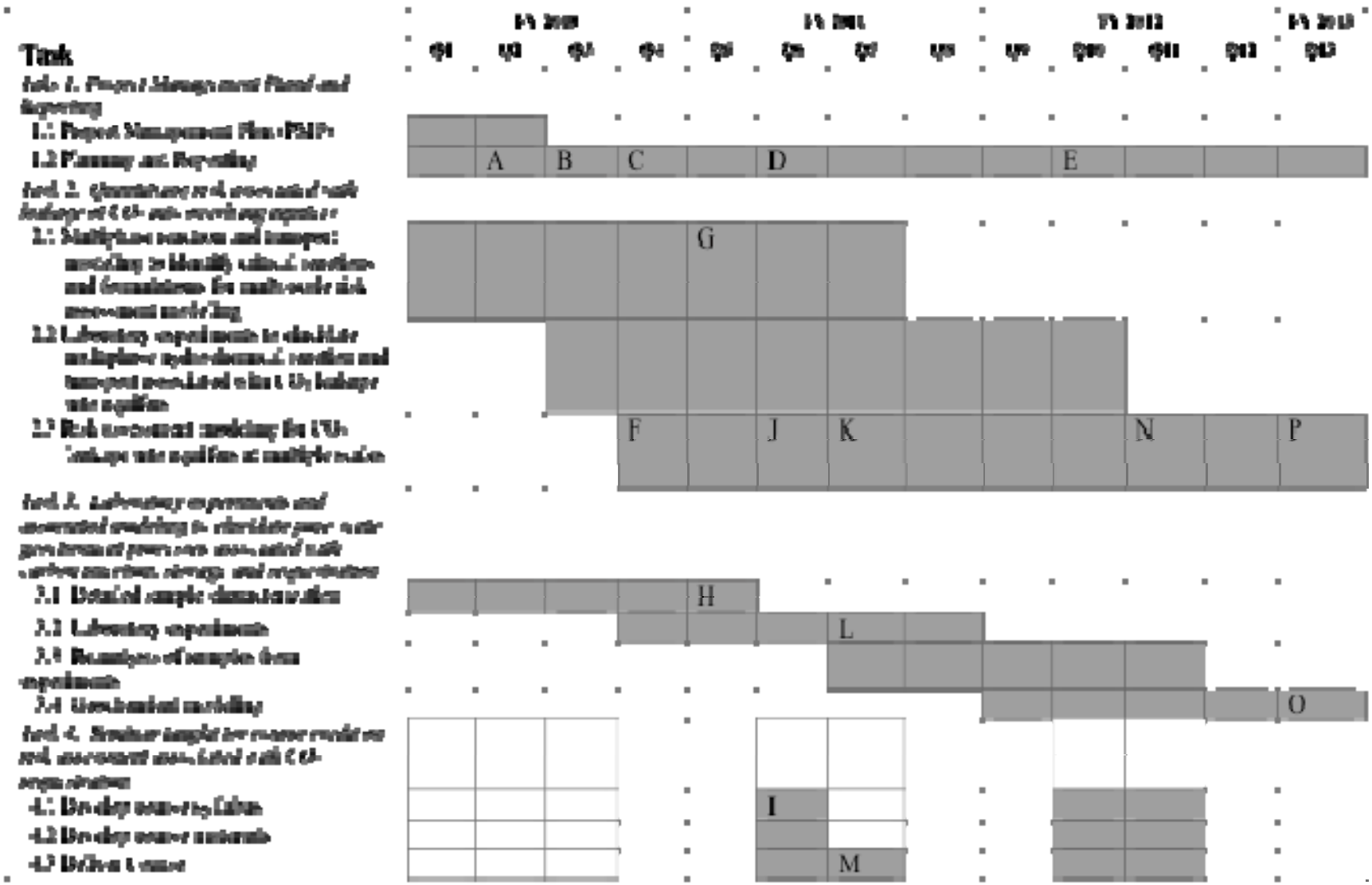
AS2 Still working

Alexis Sitchler, 2/22/2011

Tasks – Overview

Task No.	Task Description	Task Duration
1	Project Management and Planning	12/01/2009 – 11/30/2012
2	Quantifying risk associate with leakage of CO_2 into overlying aquifers	12/01/2009 – 11/30/2012
3	Laboratory experiments and associated modeling to elucidate pore-scale geochemical processes associated with carbon injection, storage and sequestration	12/01/2009 – 11/30/2012
4	Seminar taught for course credit on risk-assessment associated with CO2 sequestration	1/1/2011 – 11/30/2012

Project Schedule



We have met all milestones on time

AS3

Discussion – Task 2

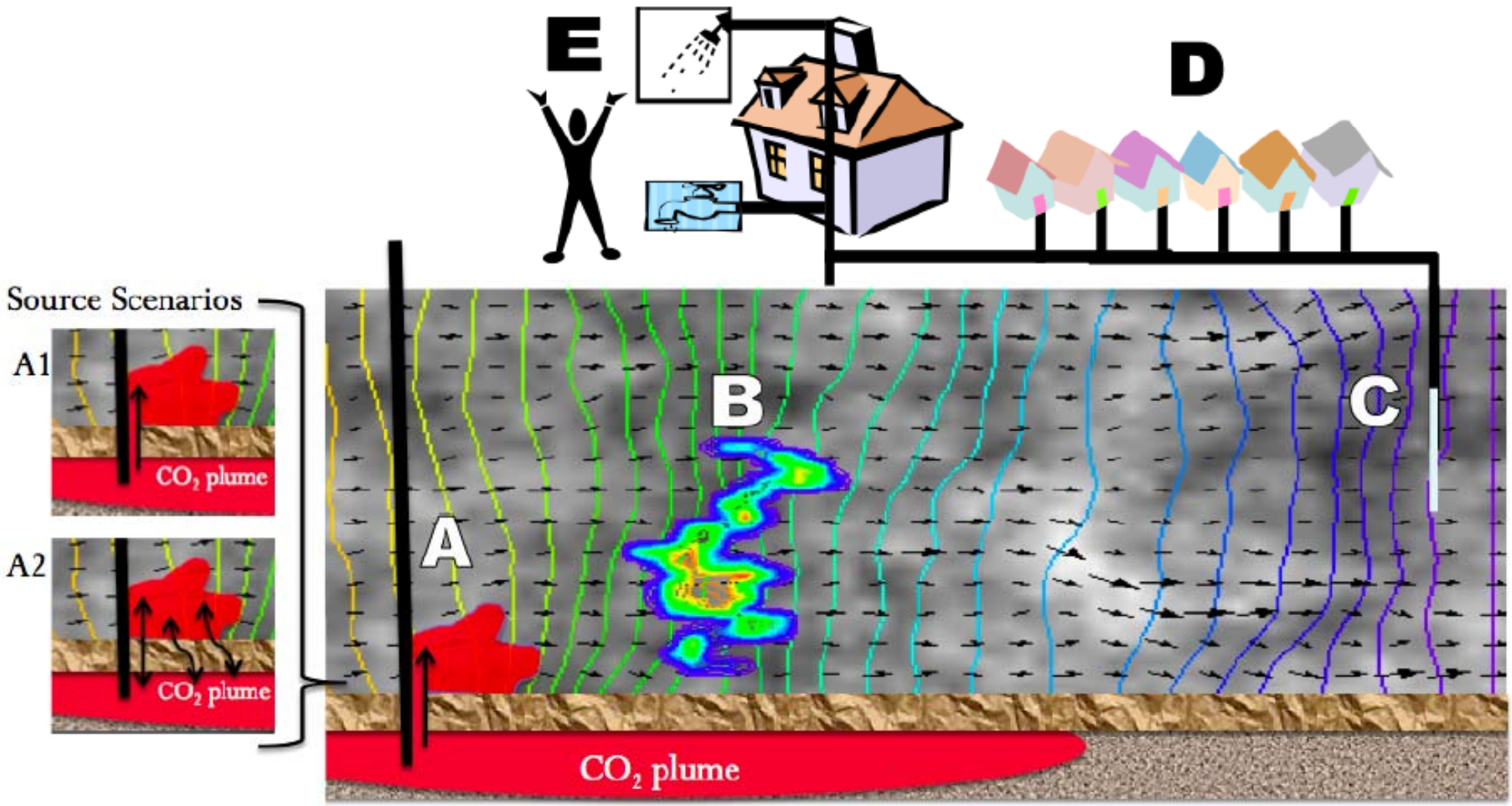
Quantifying risk associated with leakage of CO_2 into overlying aquifers

- Goal – to develop a method for quantifying risk related to CO_2 leakage
- Reed Maxwell, Erica Siirila, Alexis Sitchler
- Task status – 35% complete
- Journal paper in press detailing method development – risk due to far-field metals transport as a result of CO_2 leakage

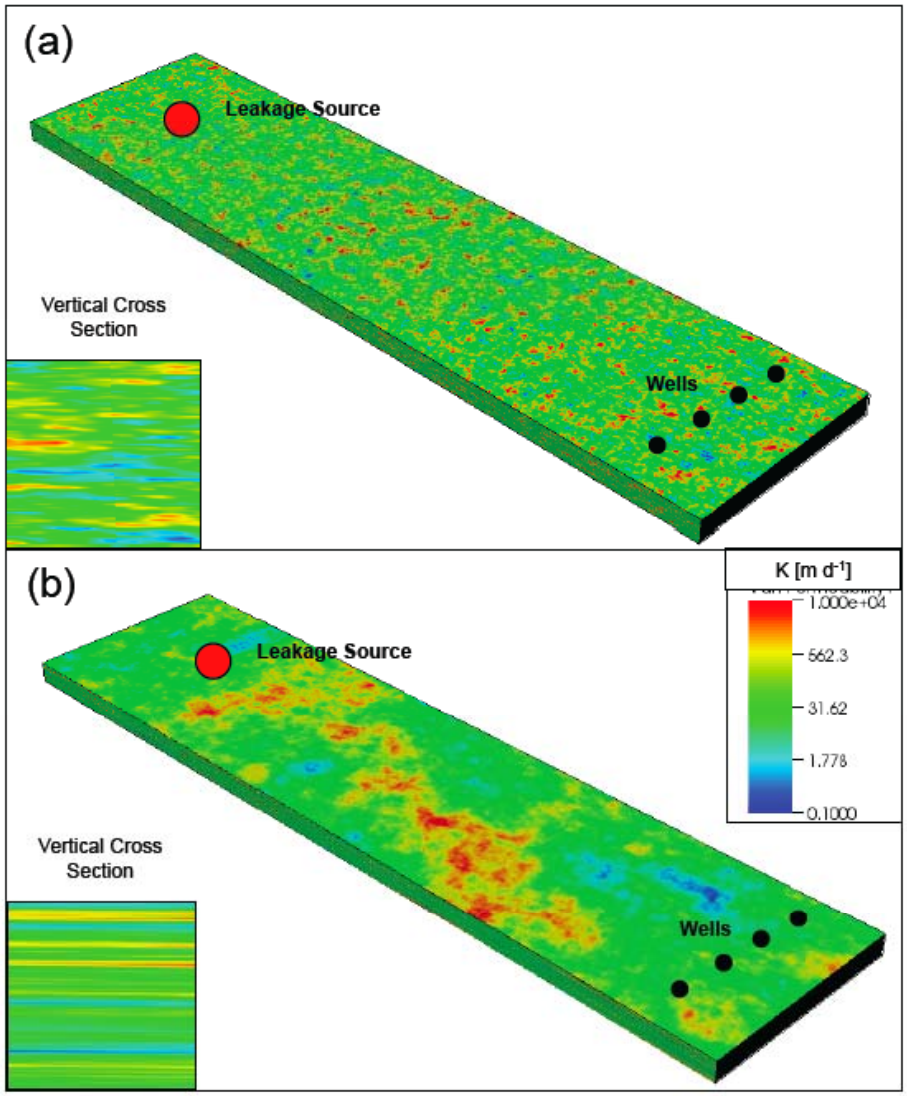
Slide 9

AS3 Still working

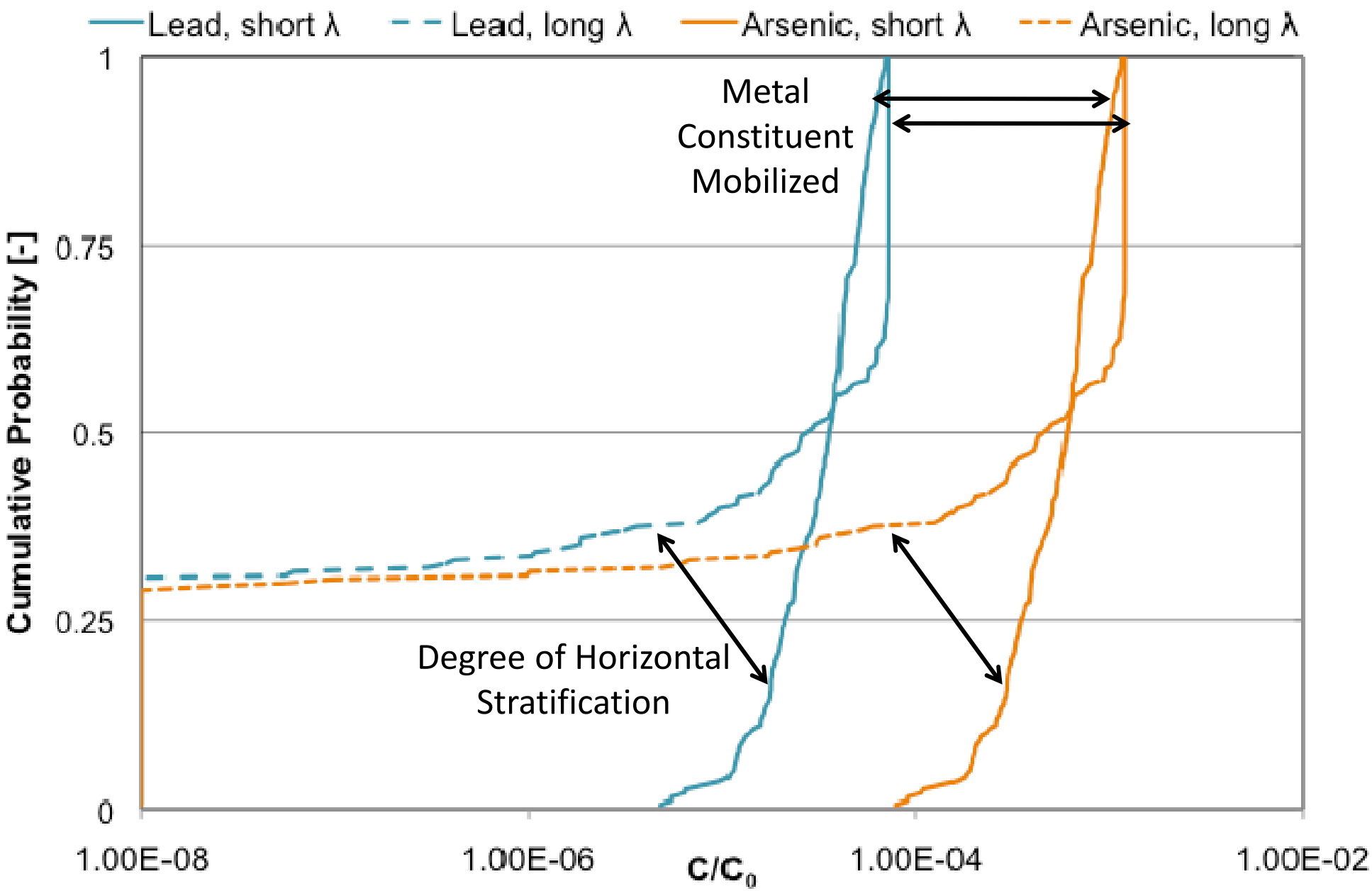
Alexis Sitchler, 2/22/2011



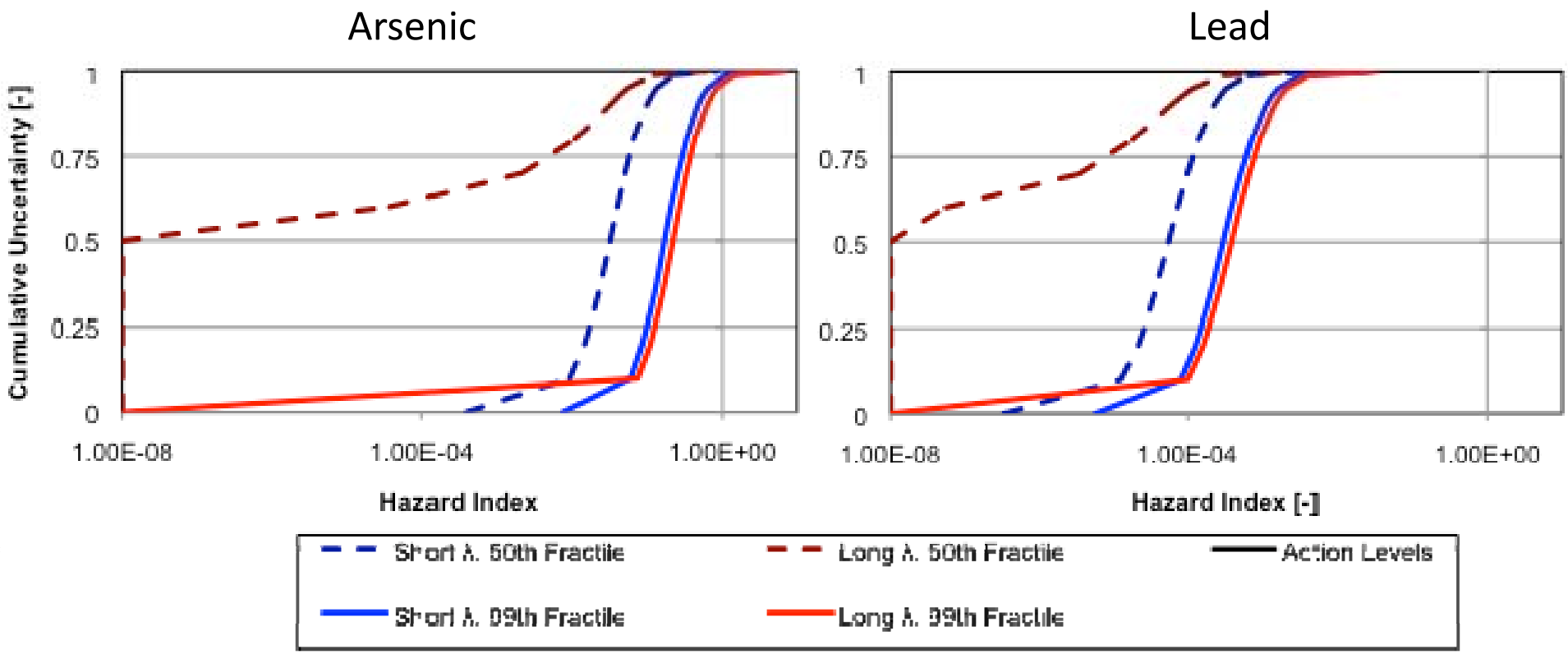
Schematic of the process involved in quantifying human health risk in CCS leakage (Siirila et al., 2011)



Geostatistical approach honors global statistics and correlation structure of the subsurface while propagating the uncertainty in hydraulic conductivity to flow, transport, exposure and risk using a nested Monte Carlo approach


Lead, short λ
Lead, long λ
Arsenic, short λ
Arsenic, long λ
Cumulative Probability [-]
1
0.75
0.5
0.25
0
1.00E-08
1.00E-06
1.00E-04
1.00E-02
C/C0
Metal Constituent Mobilized
Degree of Horizontal Stratification

Non-carcinogenic risk



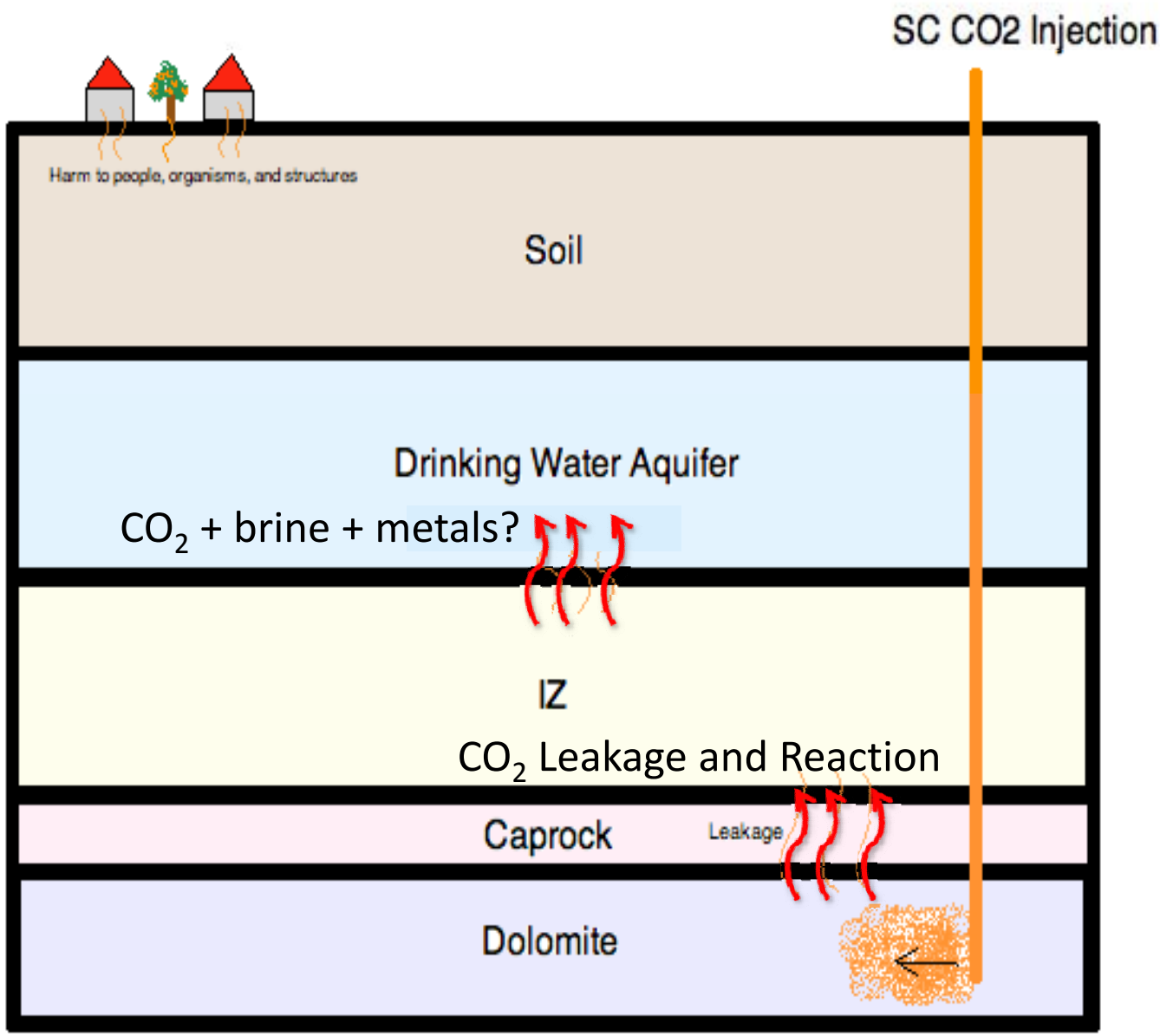
Stratified domain (little macrodispersion) yields a larger distribution of uncertainty than less anisotropic domain (high macrodispersion)

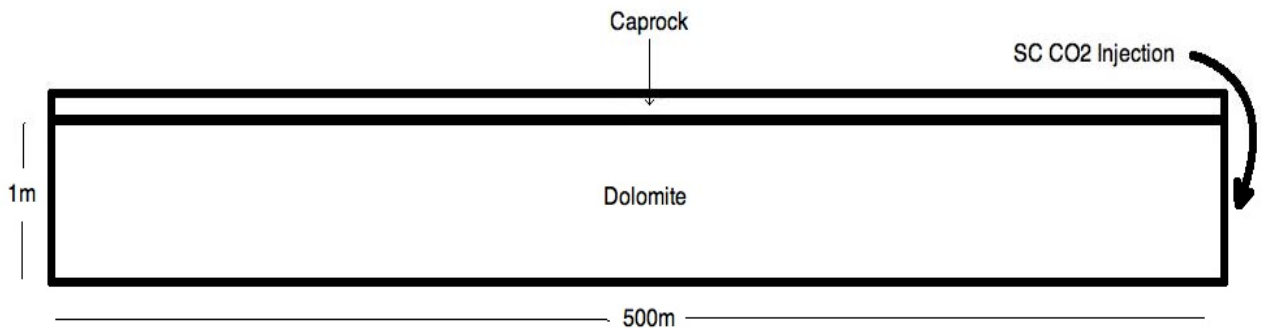
*this uncertainty propagates in overall risk

Discussion – Task 3

Laboratory experiments and associated modeling to elucidate pore-scale geochemical processes associated with carbon injection, storage and sequestration

- Quantify leakage rates through numerical simulation
- Assess potential for increased metal flux into aquifer from intermediate zone
- Responsible parties John McCray, Alexis Sitchler, Hannah Menke
- Task Status (20% complete)
- Installation of and training on PFLOTRAN, newly developed state-of-the art, multiphase, reactive transport simulator
- Working with a simulator in development, spin up time for experiments


SC CO2 Injection
Harm to people, organisms, and structures
Soil
Drinking Water Aquifer
CO_2 + brine + metals?
IZ
CO_2 Leakage and Reaction
Caprock
Leakage
Dolomite



Preliminary models are 1D injection into a dolomite reservoir to explore the important geochemical reactions.

Results:

- Observed dissolution of SiO_2, pyrite, iron oxide and kaolinite
- Observed precipitation of gypsum, dolomite, K-feldspar and quartz
- Porosity decreased slightly with reaction between rocks and CO_2

Discussion – Task 4

Seminar taught for course credit on risk-assessment associated with CO_2 sequestration

- Educate undergraduate and graduate students in topics related to injection and risk assessment of CO_2 into geologic formations
- Responsible parties (John McCray, Reed Maxwell, Alexis Sitchler)
- Task Status (25 % complete)
- Piloted course as seminar
- Teaching course in Fall 2011 to fit with current curriculum at CSM

Project Milestones

Milestone	Planned Completion Date	Actual Completion Date
A - Project Kickoff meeting	12/31/09	12/31/09
B - Educational Program Instituted	6/30/10	1/30/10
C - Semi-Annual Progress Report	9/30/10	7/31/10
D - Yearly Review Meeting	2/24/11	2/24/11
E - Yearly Review Meeting	tbd	
F - Determine most probable leakage scenarios	6/30/10	6/30/10

Milestone	Planned Completion Date	Actual Completion Date
G - List of EPA-regulated byproducts of reaction between aquifer materials and CO2	12/31/10	9/30/10
H - Initial characterization of injection and caprock formation begun	12/31/10	12/31/10
I - Development of course syllabus complete	1/10/11	
J - Identify and rank aquifer sites for use in risk simulations complete	3/31/11	
K - Identify and rank aquifer-leakage scenarios for use in risk simulations complete	6/30/11	
L - Determine rate parameters of important geochemical reactions	6/30/11	
M - Summary on demographics and grades for the university course submitted	6/30/11	

Milestone	Planned Completion Date	Actual Completion Date
N - Complete screening risk assessment simulations	6/30/12	
O - Complete geochemical modeling for relevant carbon injection scenarios	11/30/12	
P - Complete primary risk simulations for aquifer leakage	11/30/12	

Anticipated Efforts for the Coming Year

- Compare leakage rates of CO_2 through different pathways in caprock and intermediate zone
- Assess risk associated with reaction between CO_2 and rocks along flow paths in the intermediate zone with laboratory experiments
- Extract streamlines from risk modeling for rigorous geochemical simulation at the basin scale.
- Compare streamline results from a few realizations to large scale 3D fully coupled reactive transport model run on Ra (CSM supercomputer)

PI Contact Information

- If you have any questions or would be interested in collaboration please contact
- John McCray – jmccray@mines.edu
- Reed Maxwell – rmaxwell@mines.edu
- Alexis Sitchler - asitchle@mines.edu