FATE OF CONTAMINANTS IN UNCONSOLIDATED AQUIFERS

THOUGHTS ON DETERMINING THE RELEVANT PHYSICAL TRANSPORT PROCESSES AT FIELD SITES

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Chunmiao Zheng (UAlabama), Brewster Conant (UWaterloo),
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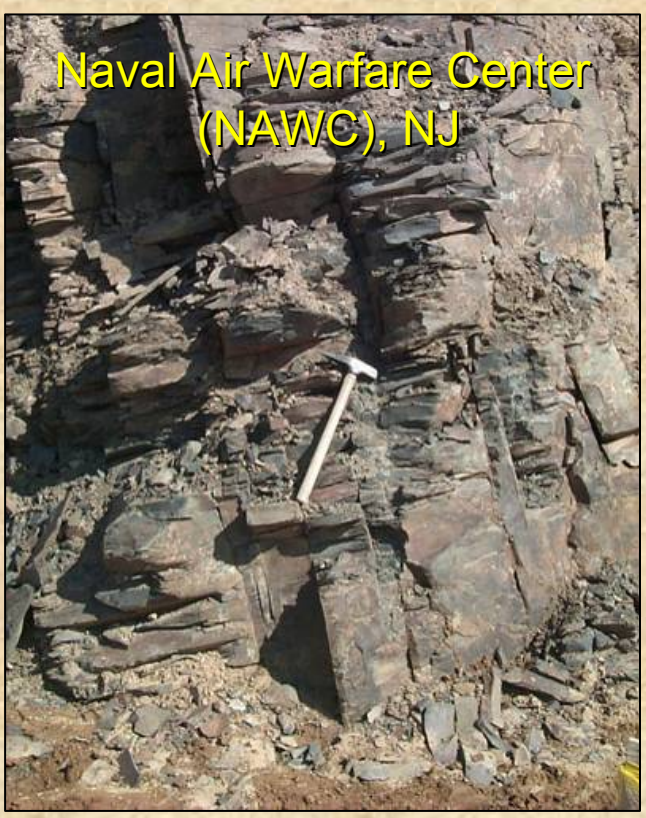
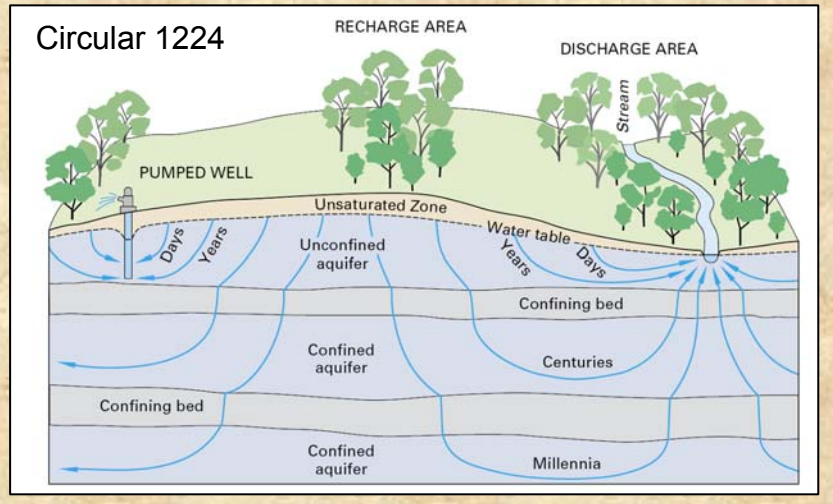
USGS
science for a changing world

Toxic Substances Hydrology Program

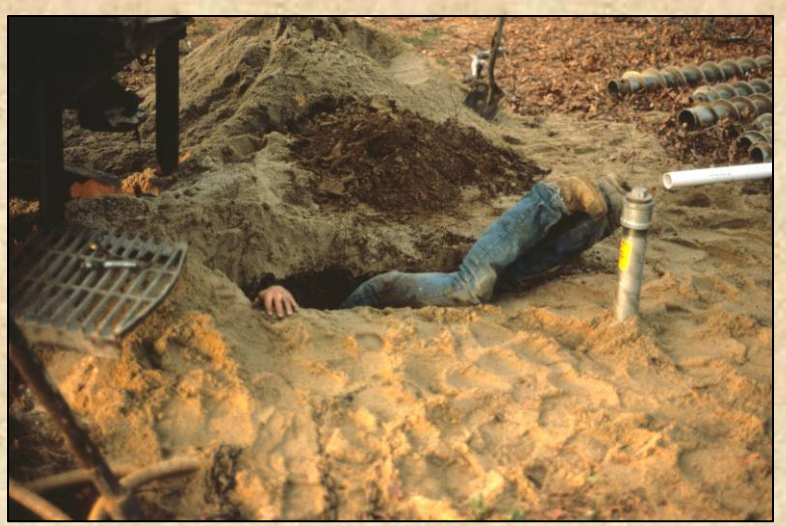
Understanding the flow system is critical

- Geohydrologic framework
- Sources and sinks of water
- Local and regional boundaries
- Patterns and rates of flow





“Homogeneous” unconsolidated aquifers continue to pose challenges

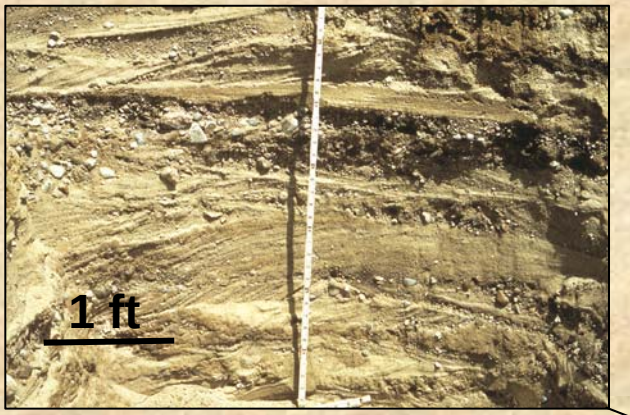


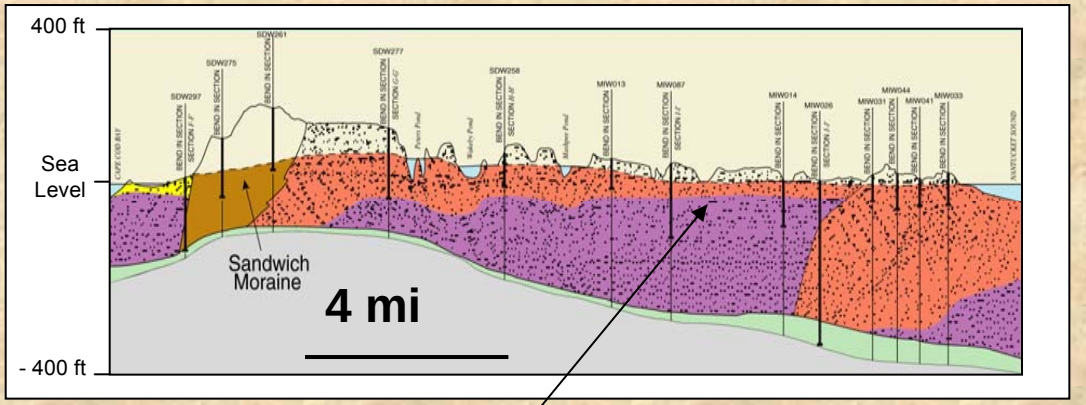
Talk Outline

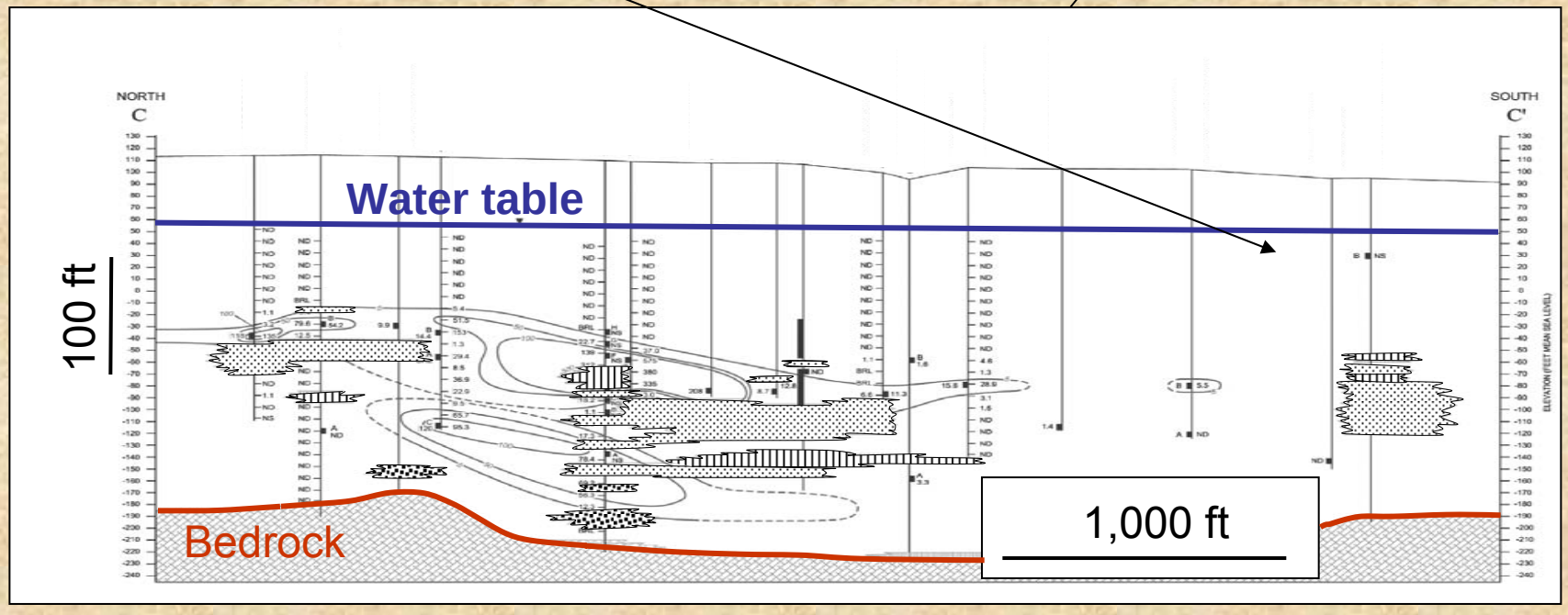
- Hydrogeologic framework
- Flow patterns and discharge
- Heterogeneity and transport
- Future directions

I. Hydrogeologic Framework

Geologic framework relevant to transport at different scales





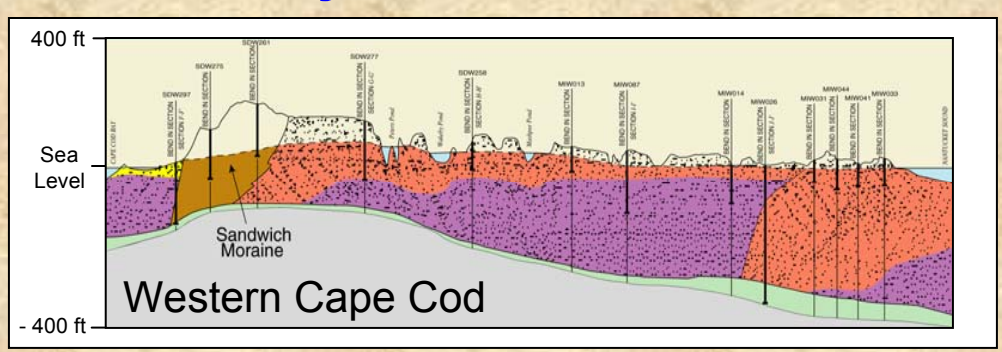


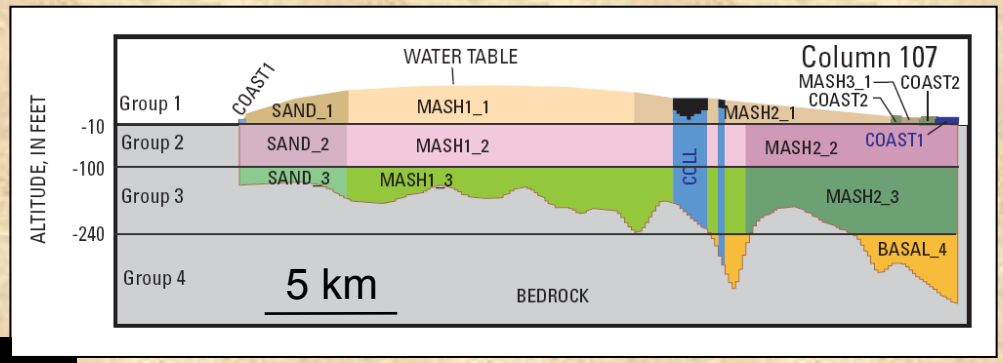
Examples from Cape Cod, MA

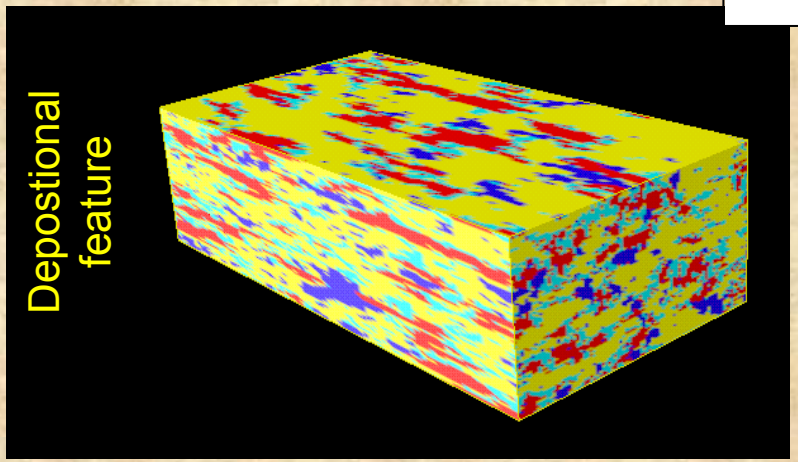
I. Hydrogeologic Framework

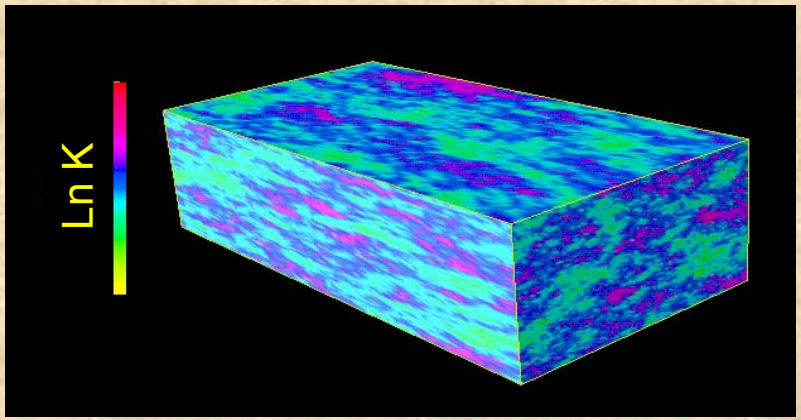
Geological models to define hydraulic framework

Glacial outwash







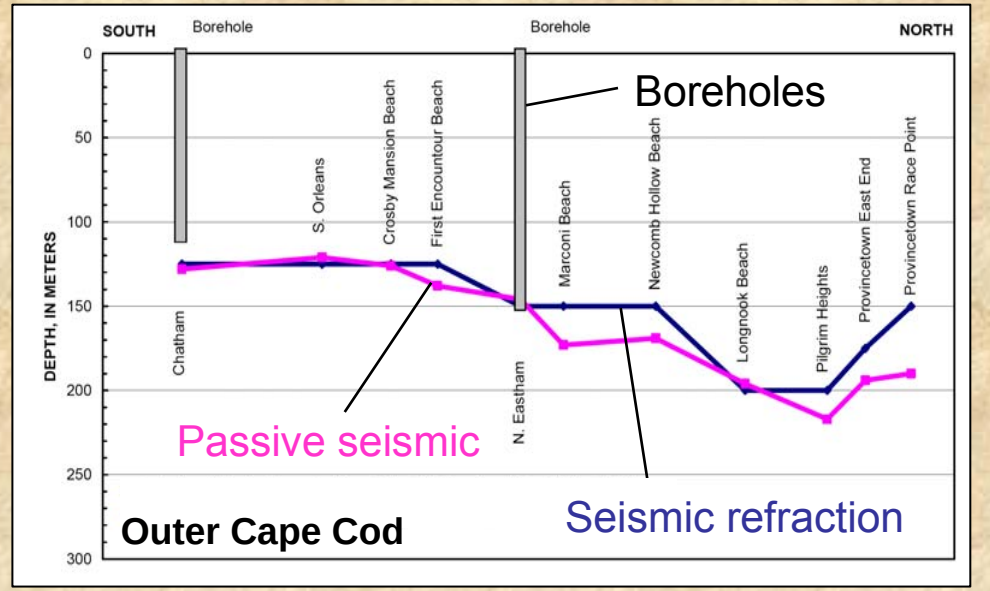


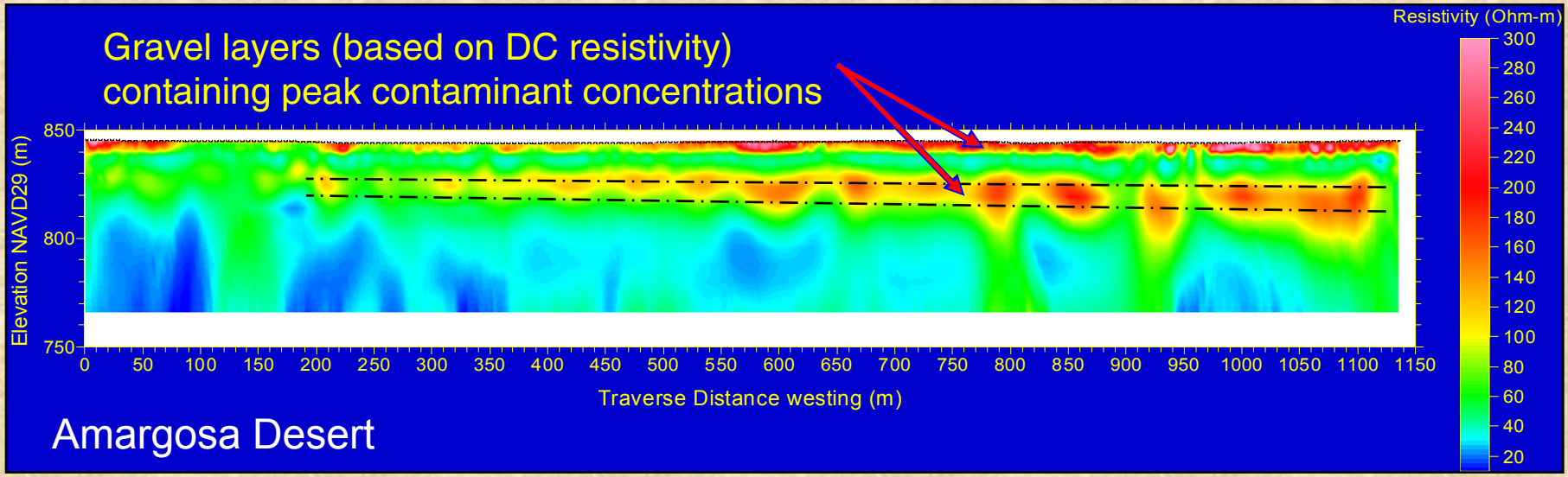
LLNL Arroyo Seco Alluvial Fan, CA (Fogg)

I. Hydrogeologic Framework

Geophysical methods to define hydrogeologic framework

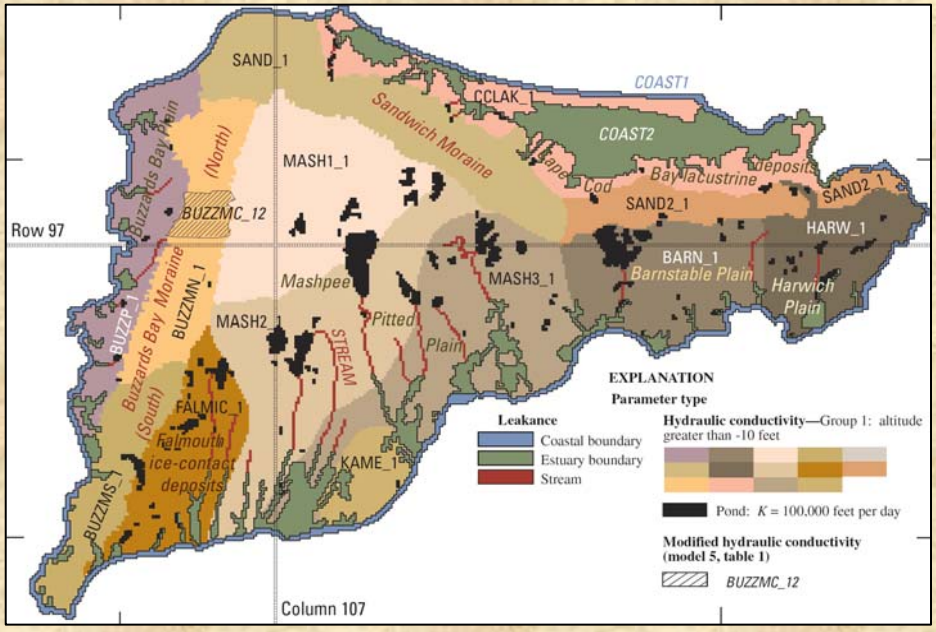
Ambient noise passive seismic

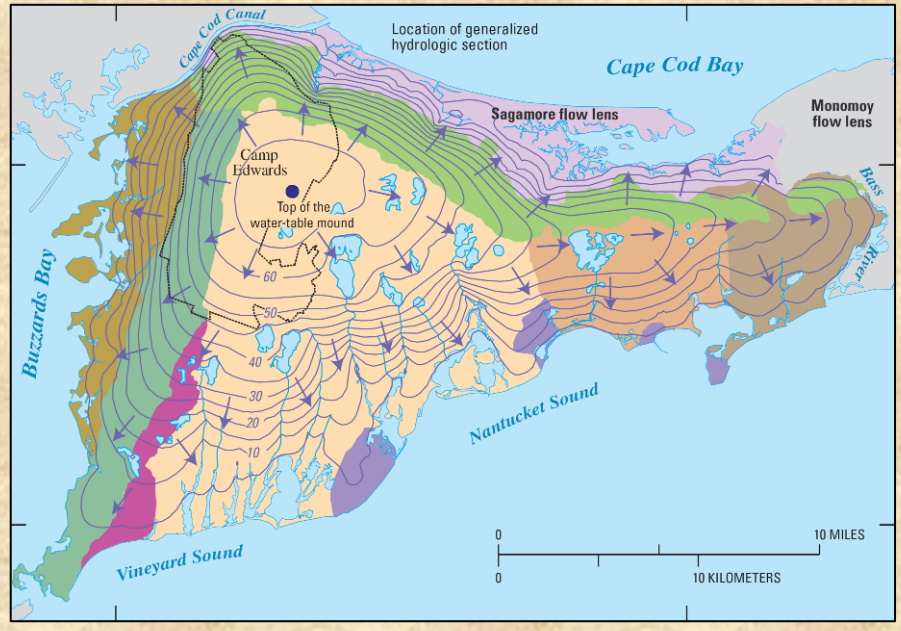


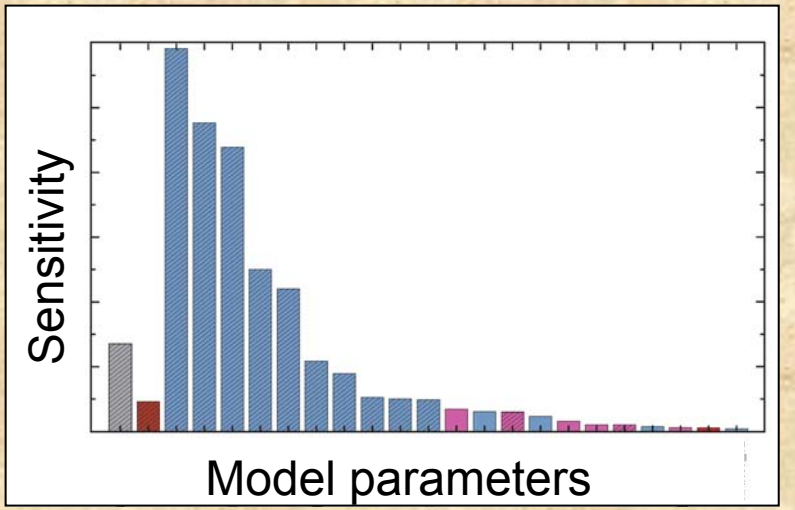


I. Hydrogeologic Framework

Inverse modeling to improve aquifer representation



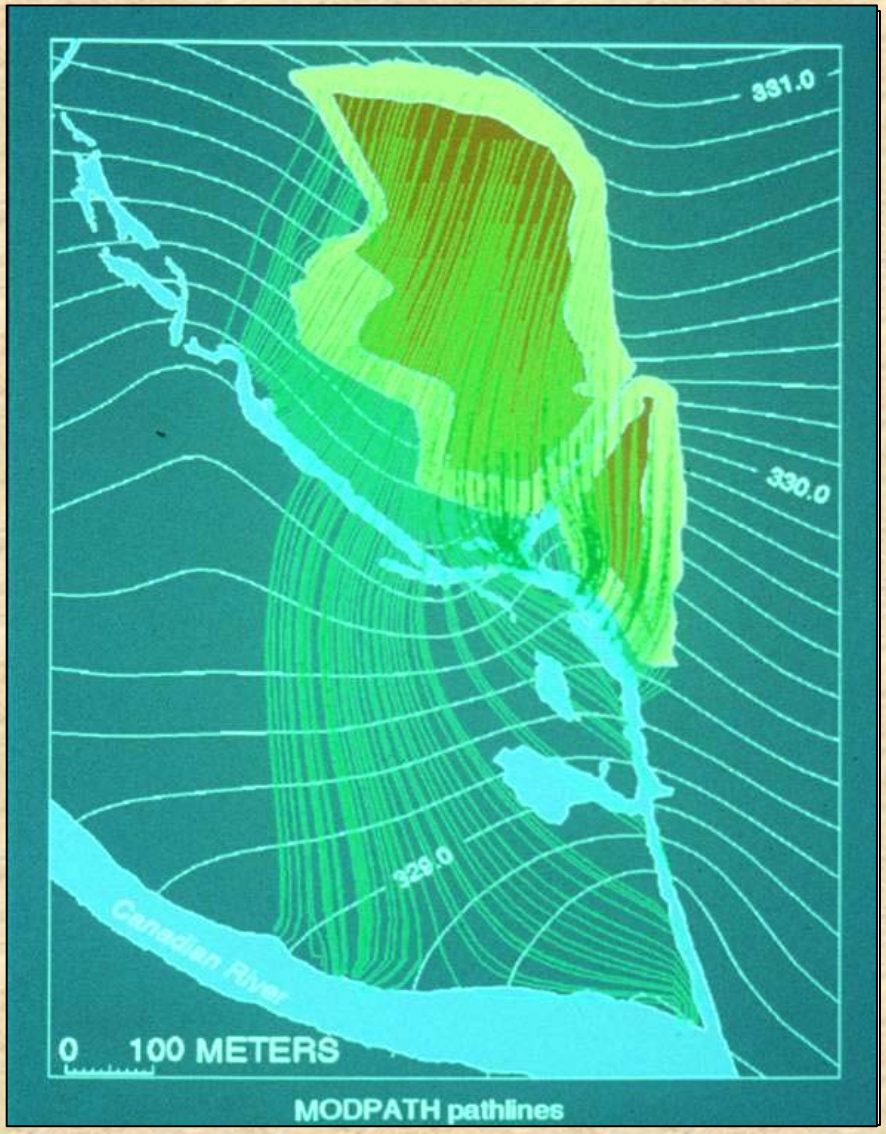


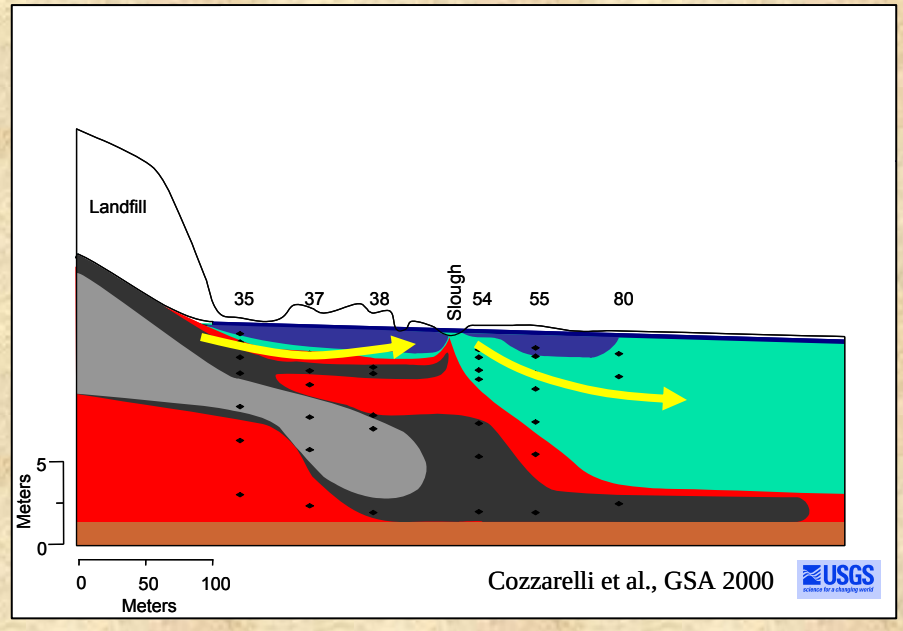


Western Cape Cod

II. Flow Patterns and Discharge

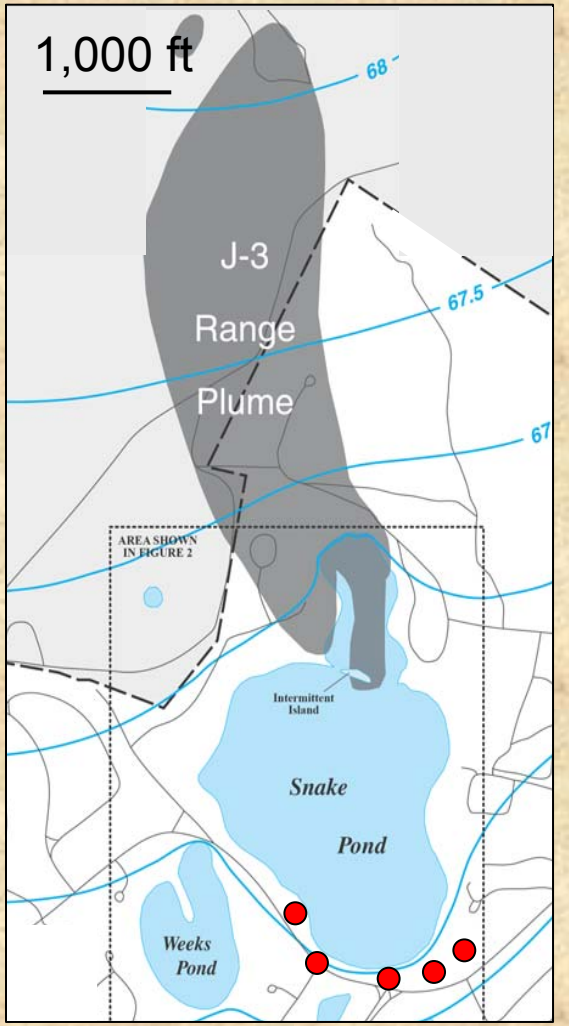
Local hydrologic boundaries can control plume paths



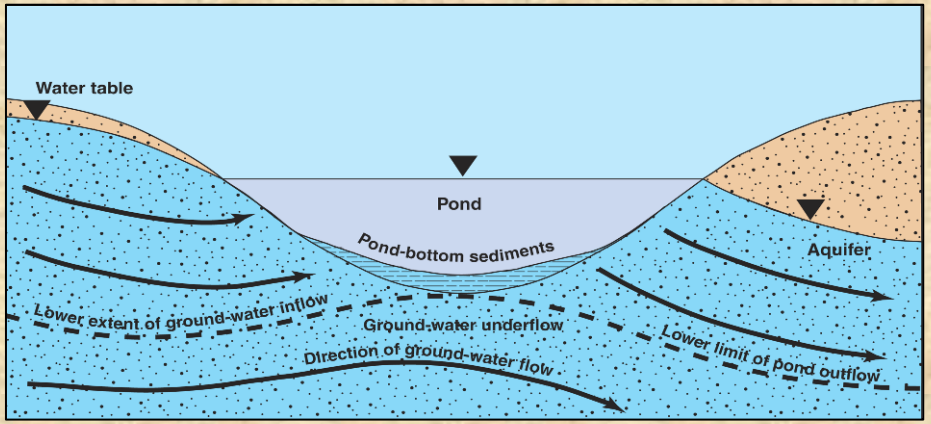


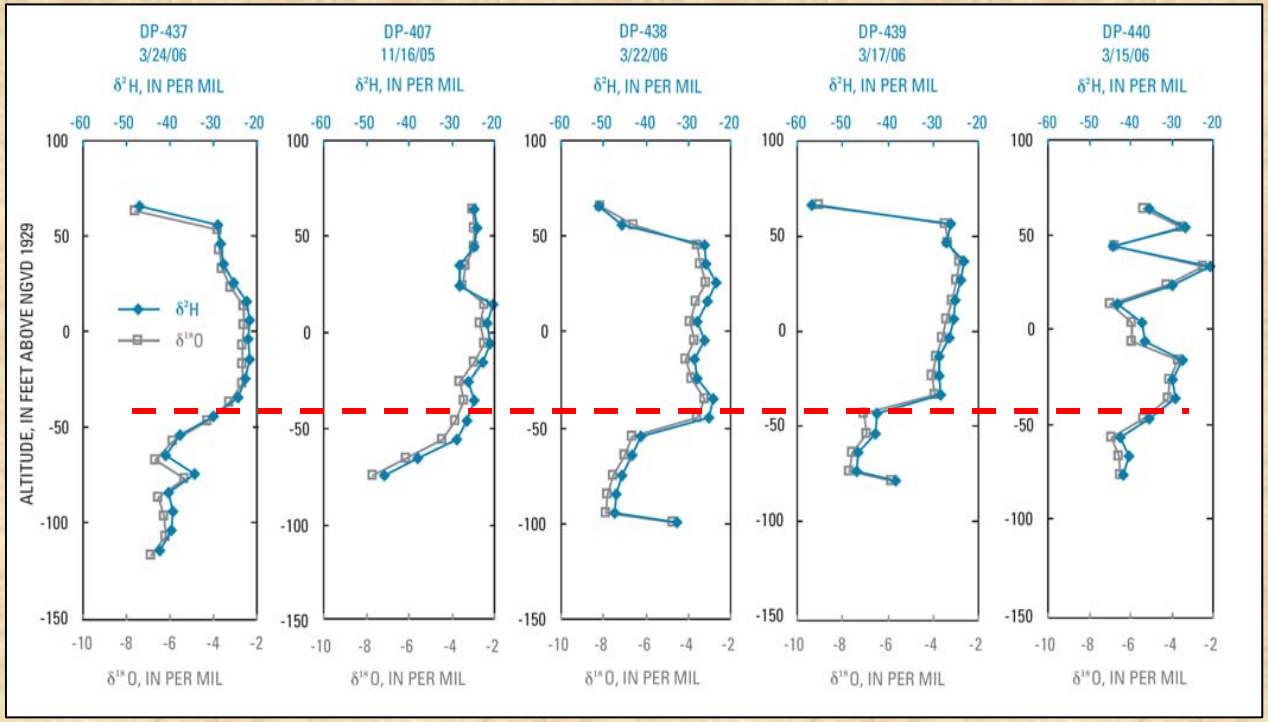
II. Flow Patterns and Discharge

Stable isotopes to define ground-water flow paths



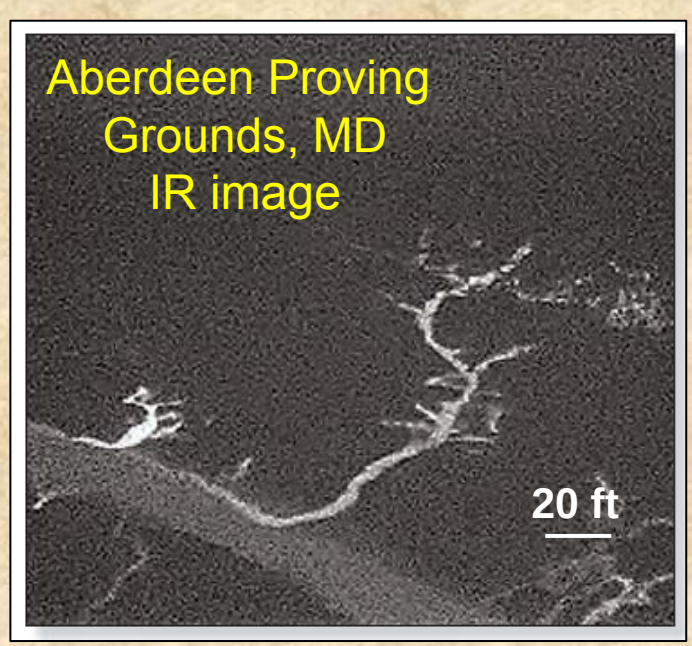
Cape Cod

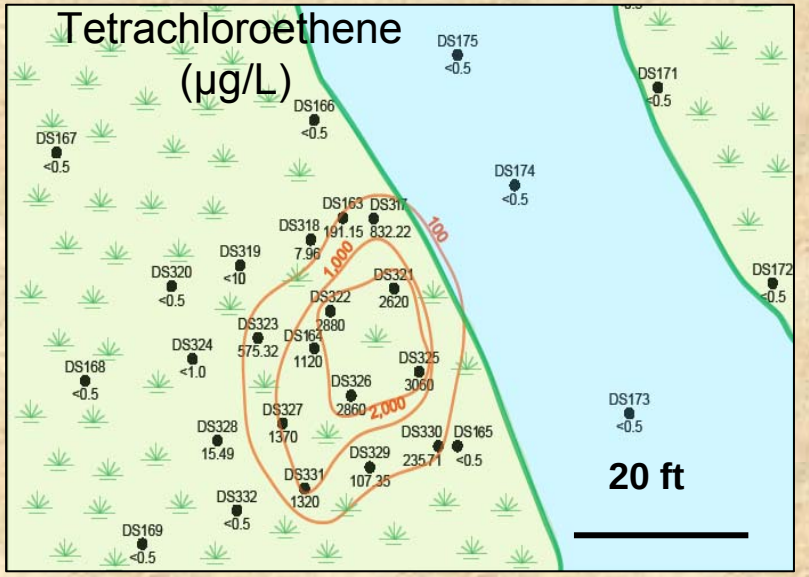


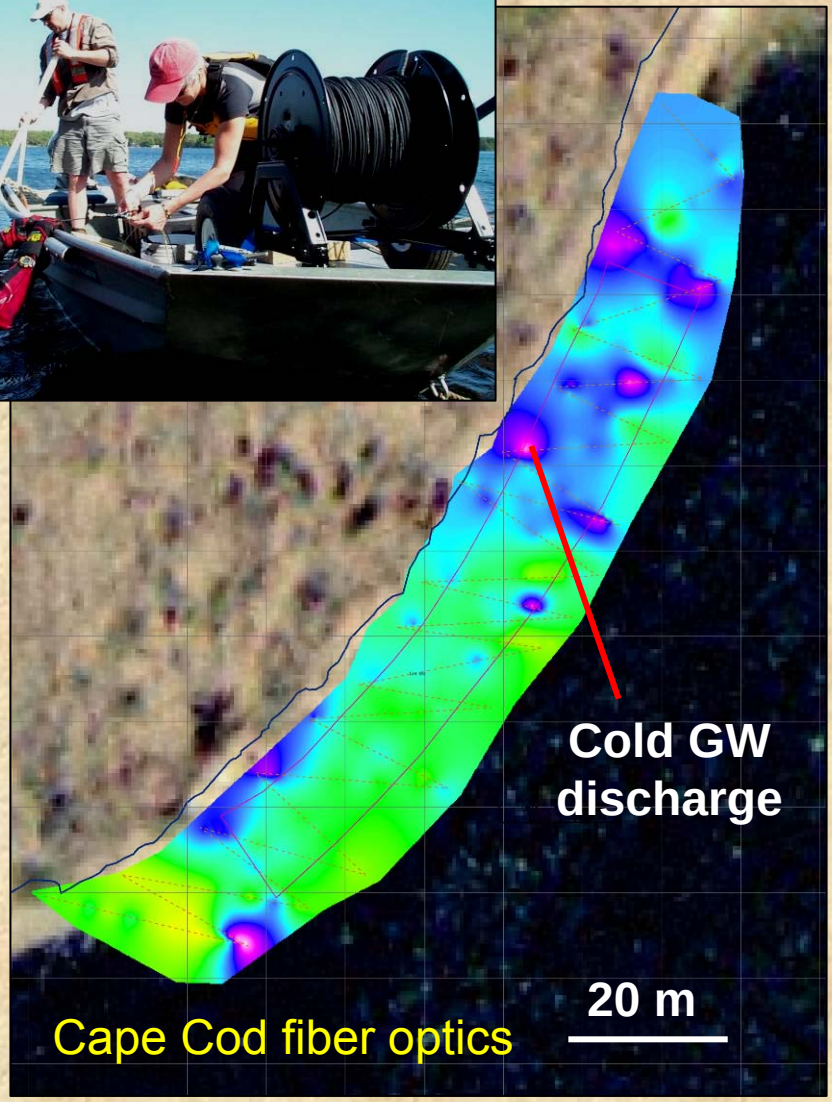


II. Flow Patterns and Discharge

Temperature surveys to locate focused discharge

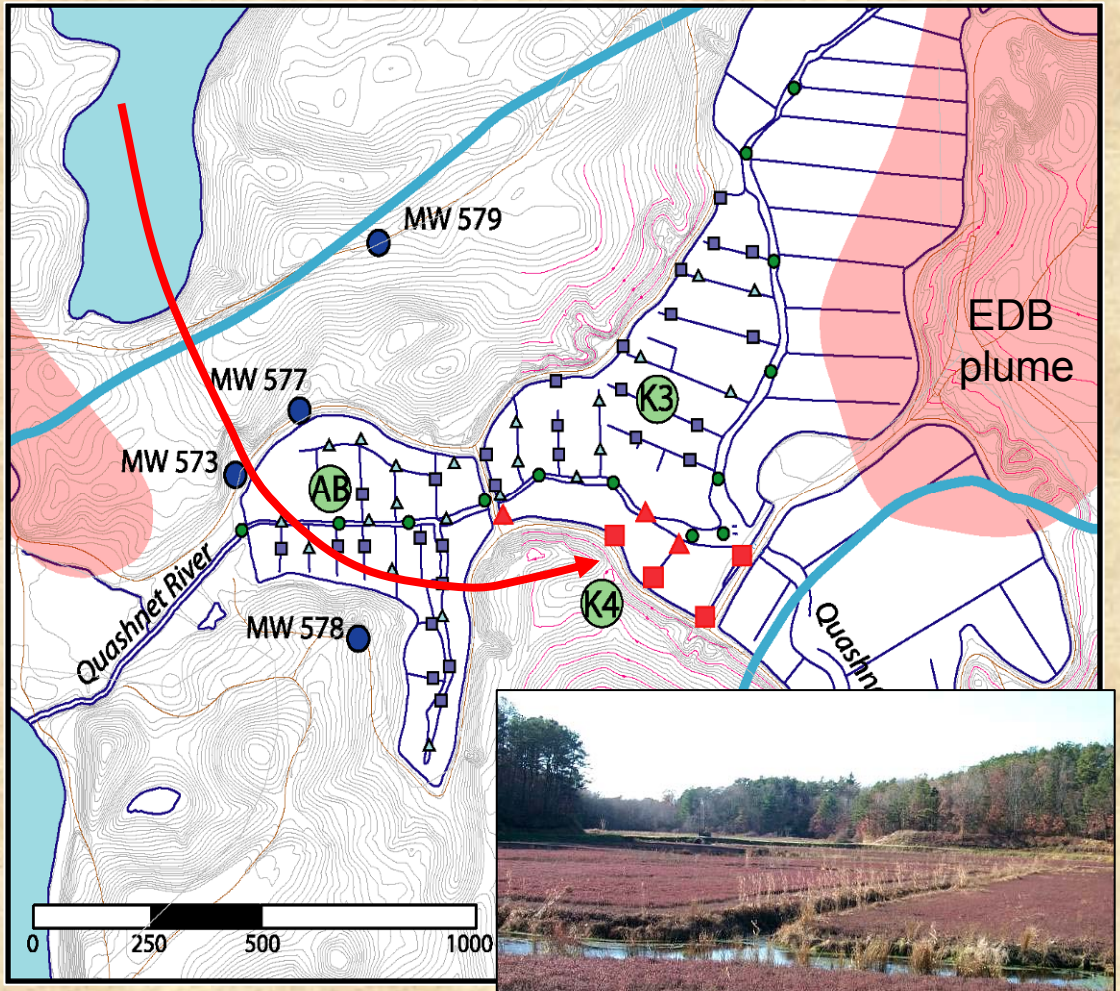


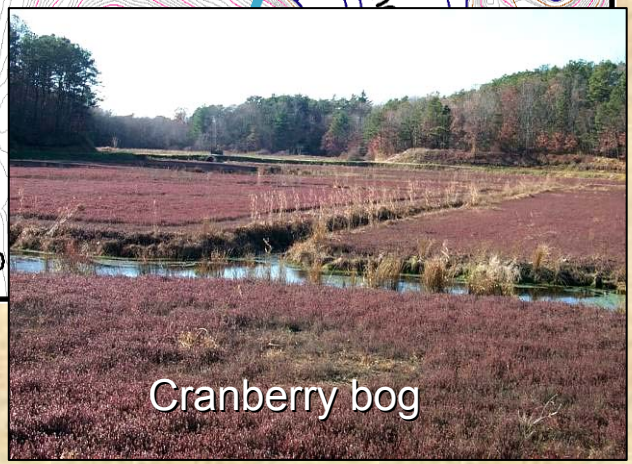




II. Flow Patterns and Discharge

Discharge can be key to understanding flow paths

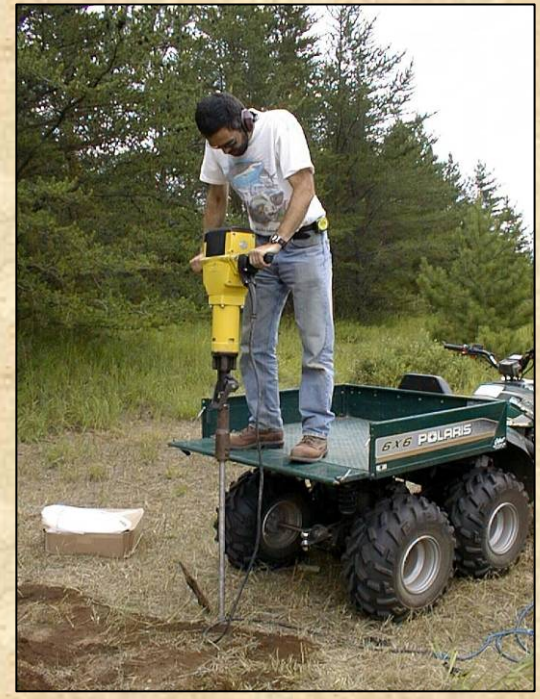


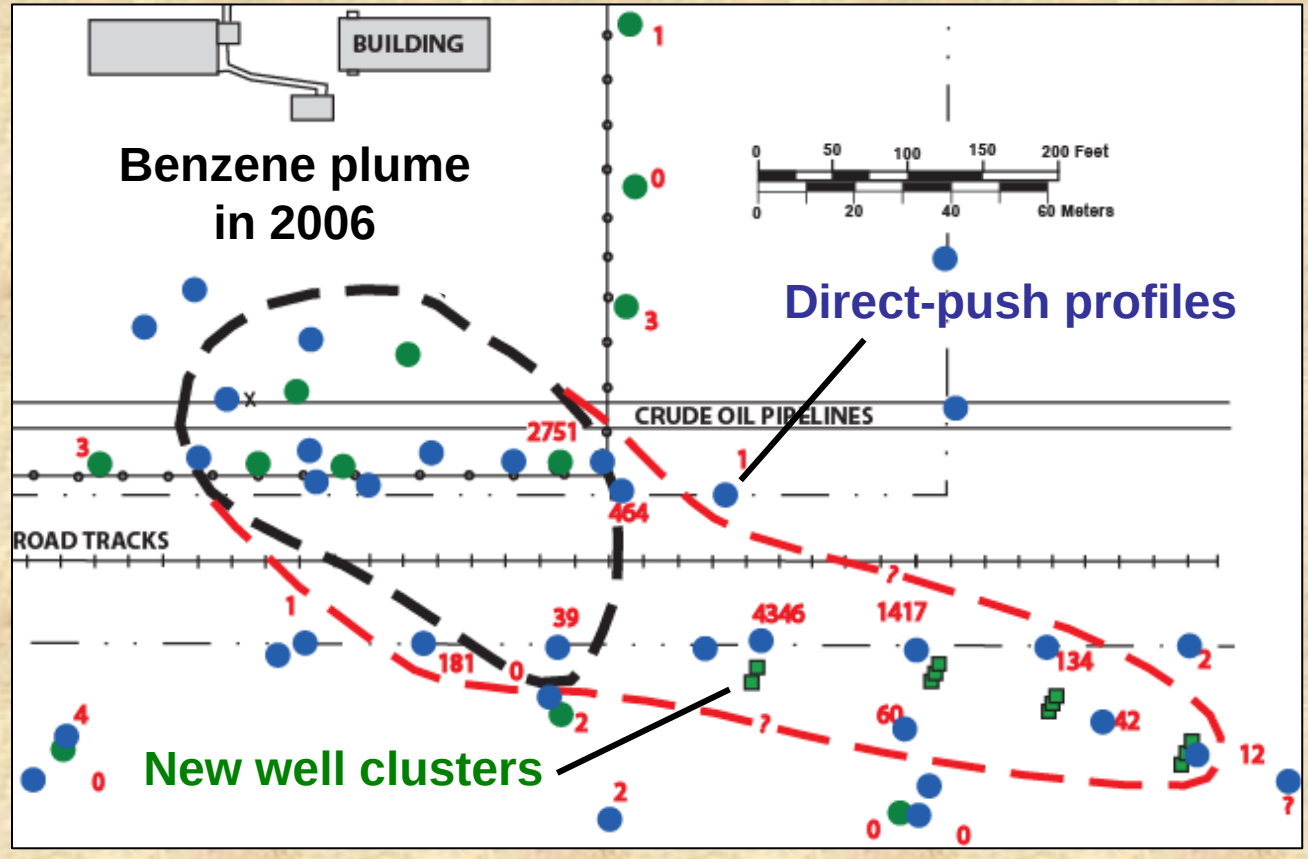


Cape Cod

II. Flow Patterns and Discharge

Rapid sampling methods allow plume path delineation

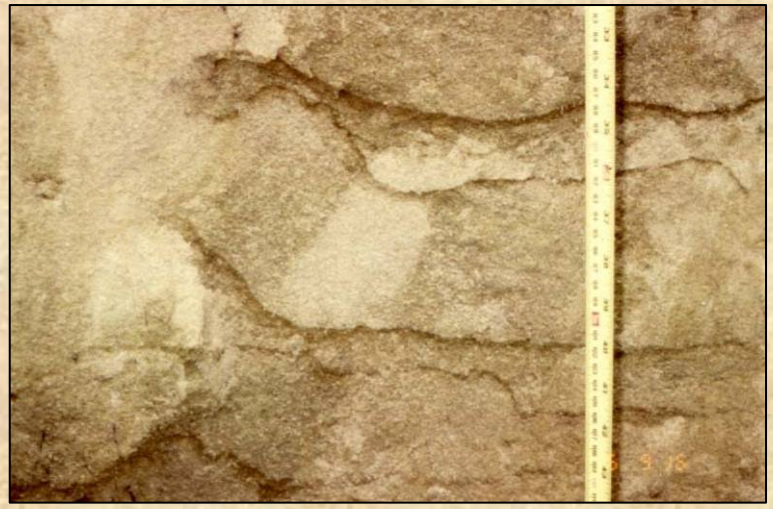




Cass Lake, MN

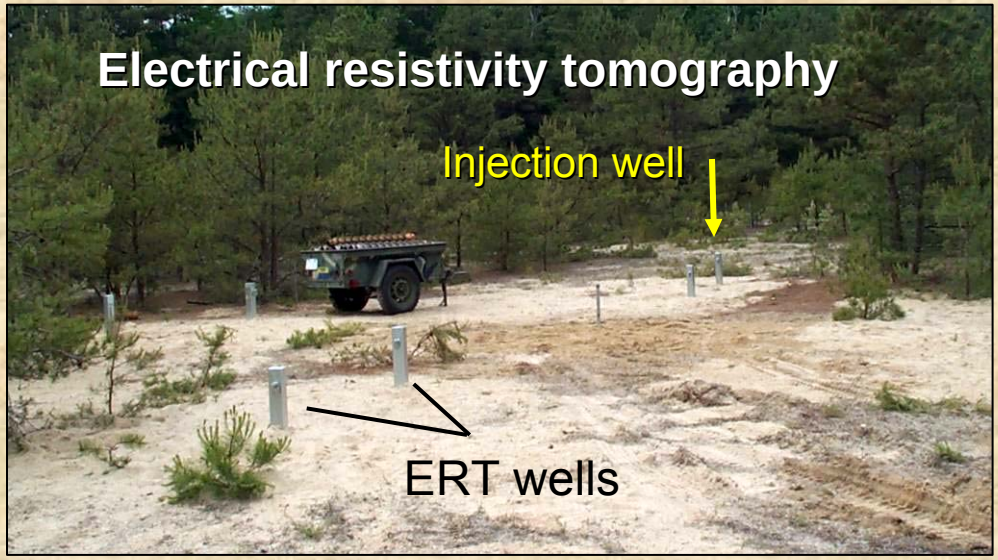
III. Heterogeneity and Transport

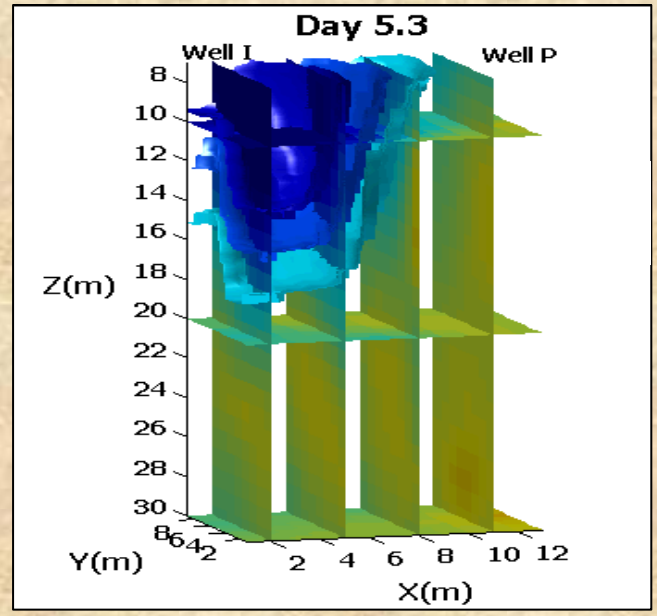
Small-scale heterogeneity affects transport

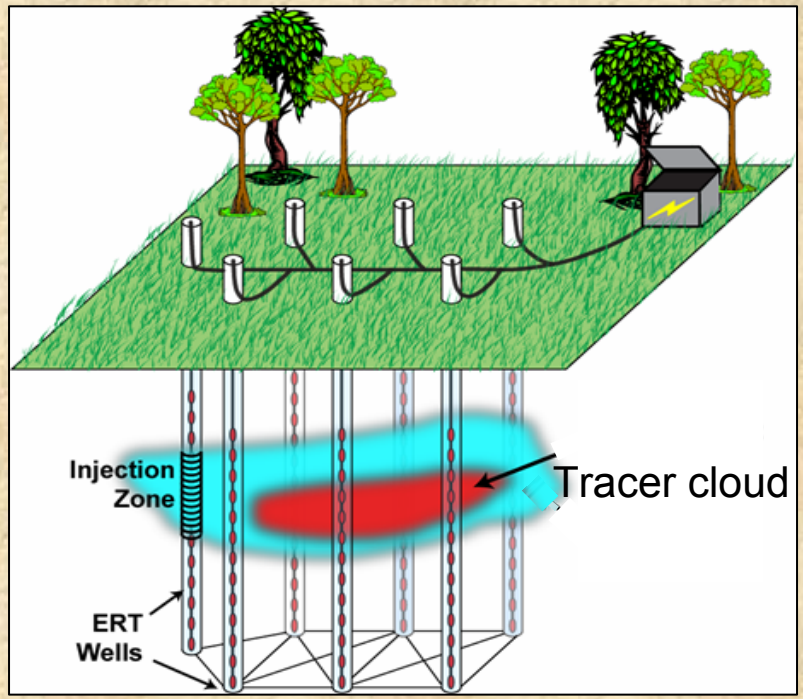


III. Heterogeneity and Transport

Geophysical methods to describe heterogeneity



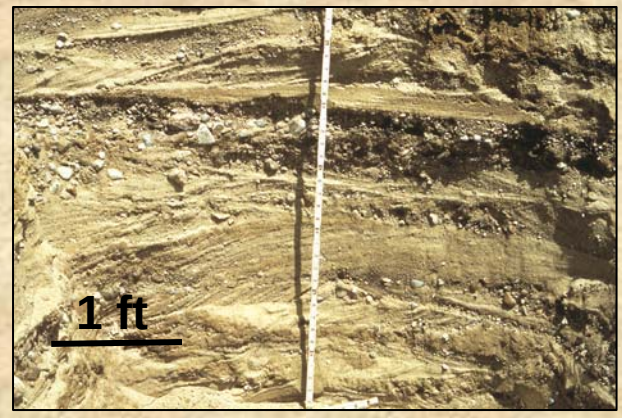


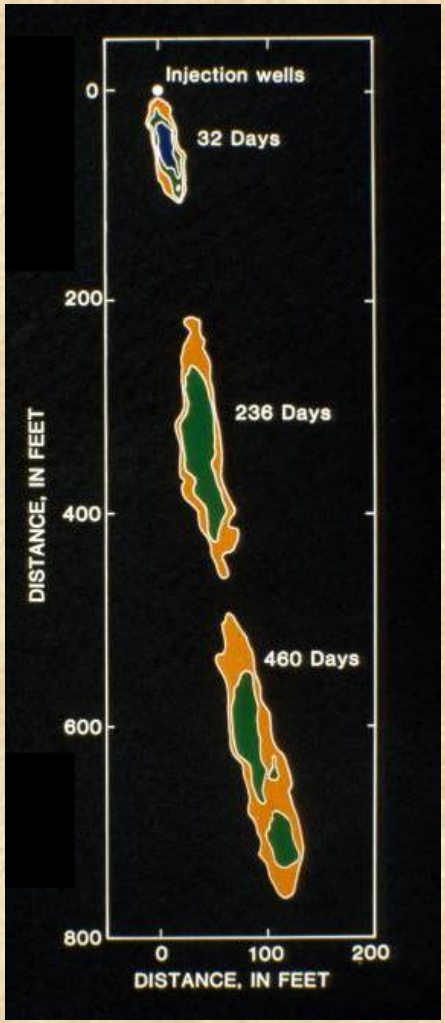


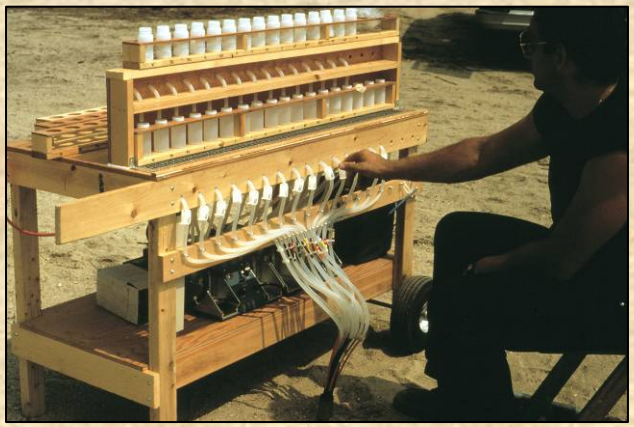
Cape Cod

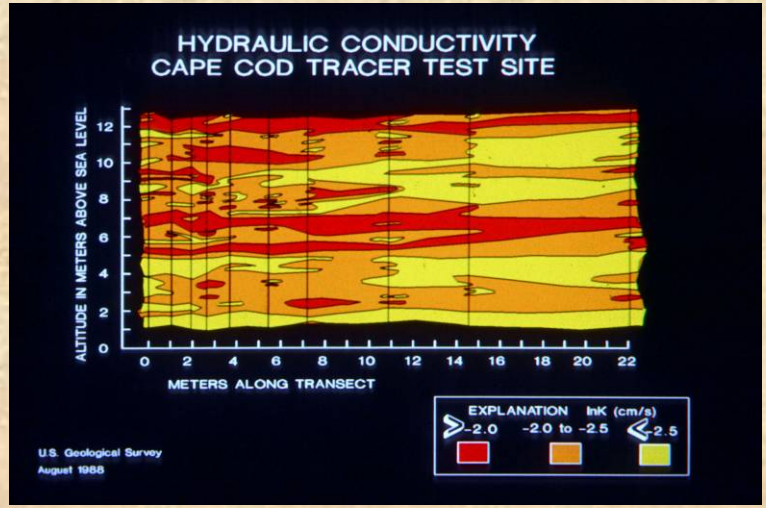
III. Heterogeneity and Transport

Macrodispersion related to heterogeneity







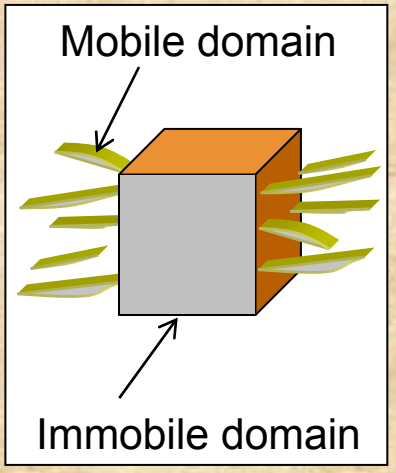


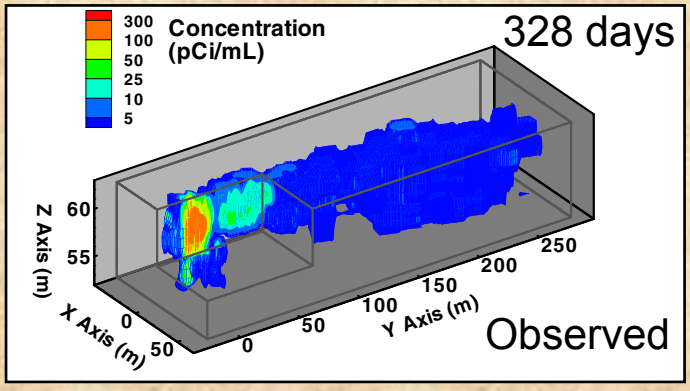
Cape Cod Tracer Test

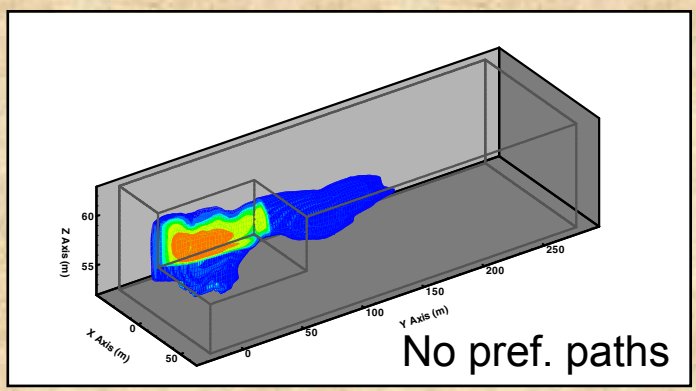
σ^2 *(ln K) < 1*

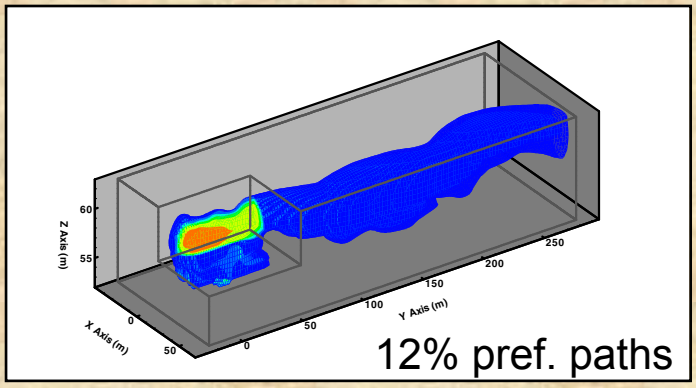
III. Heterogeneity and Transport

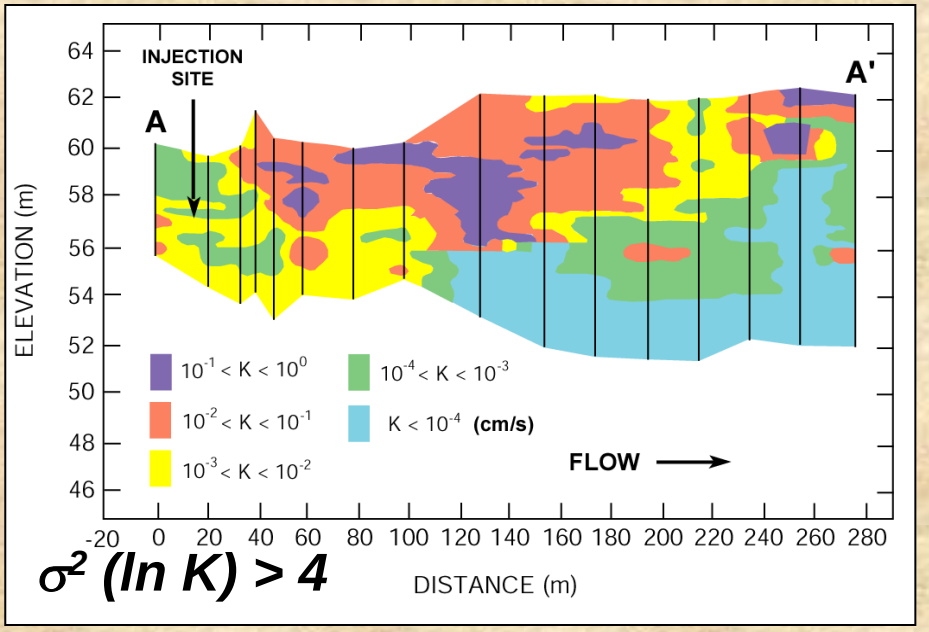
Dual domain model may be needed for high heterogeneity





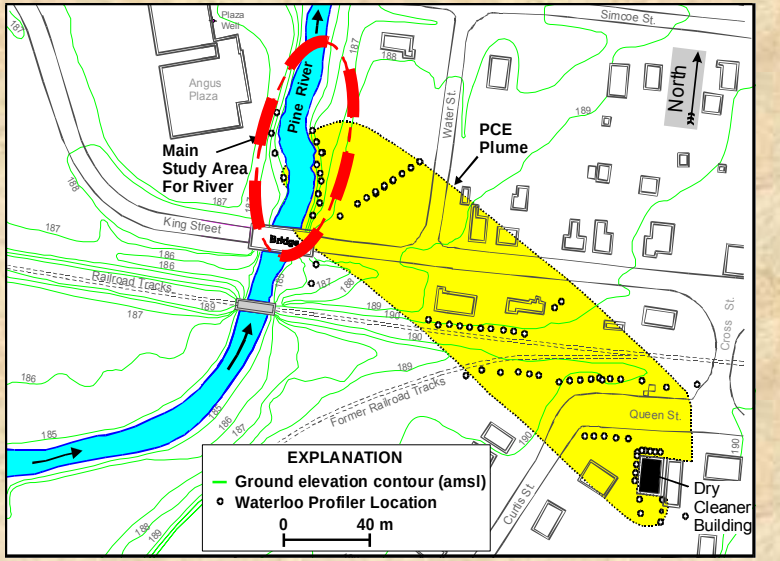


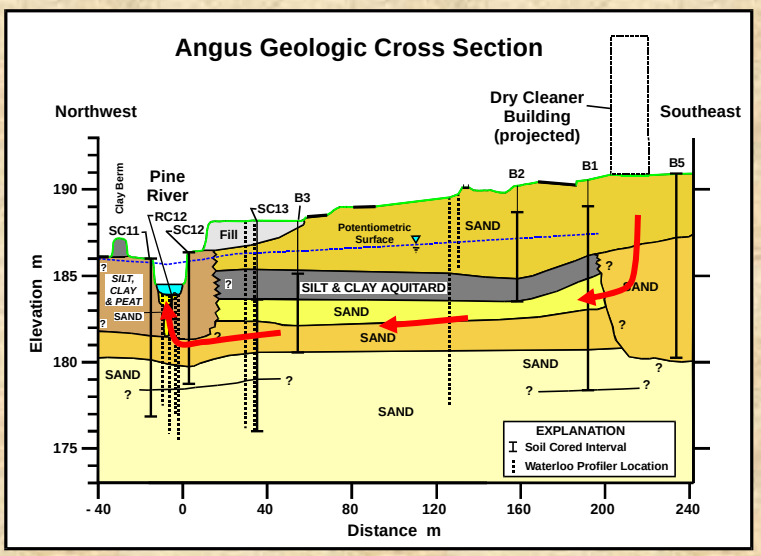


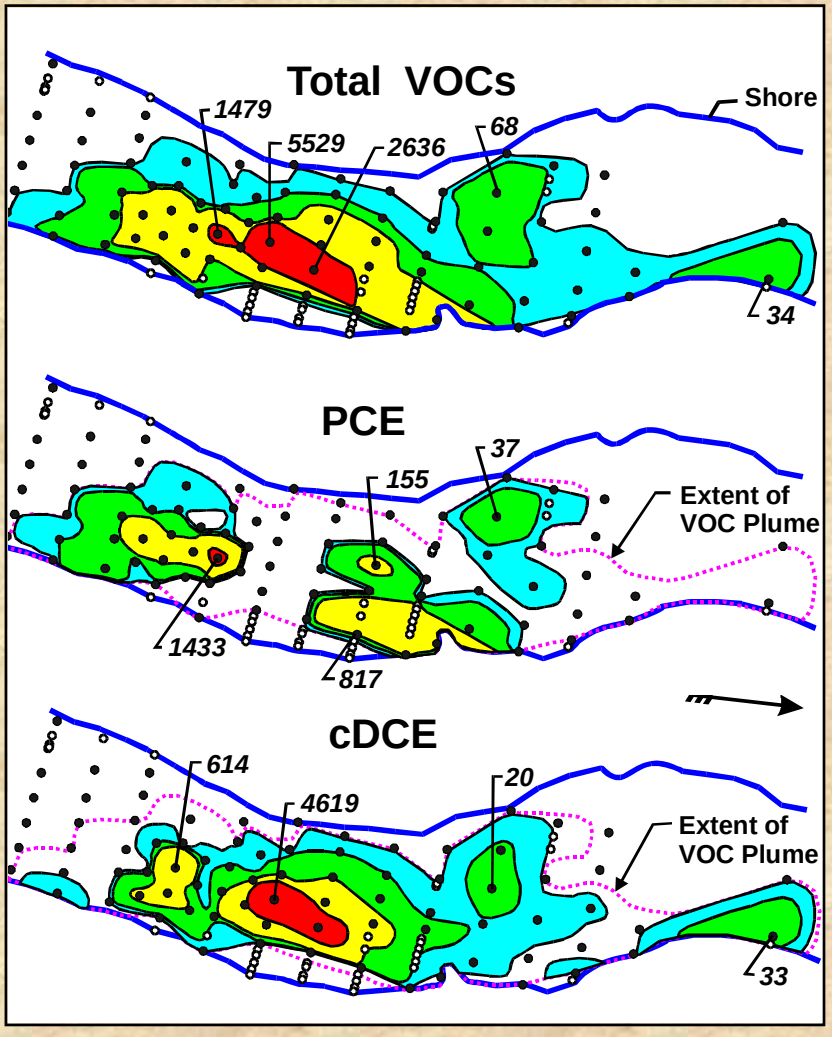


IV. Future Directions

Integration of transport processes along entire flow path



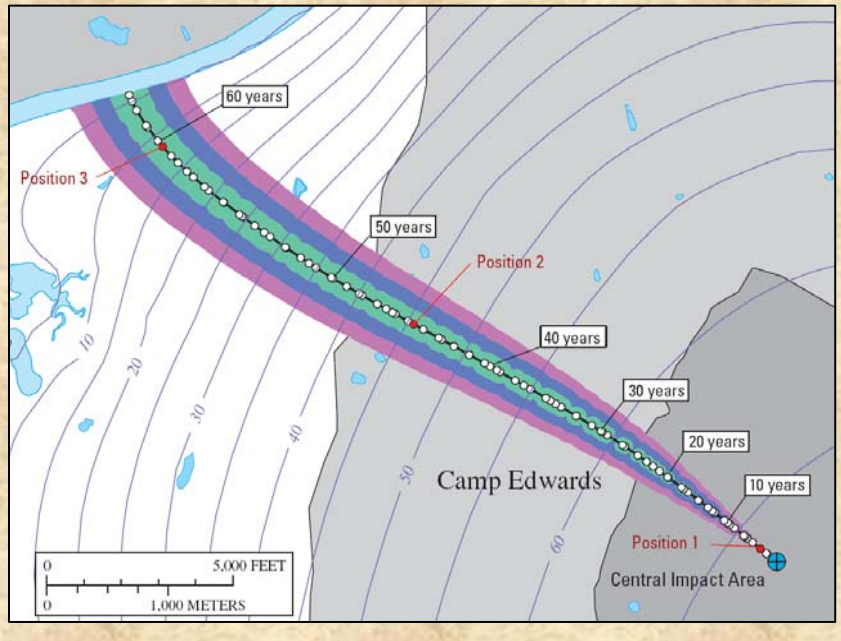


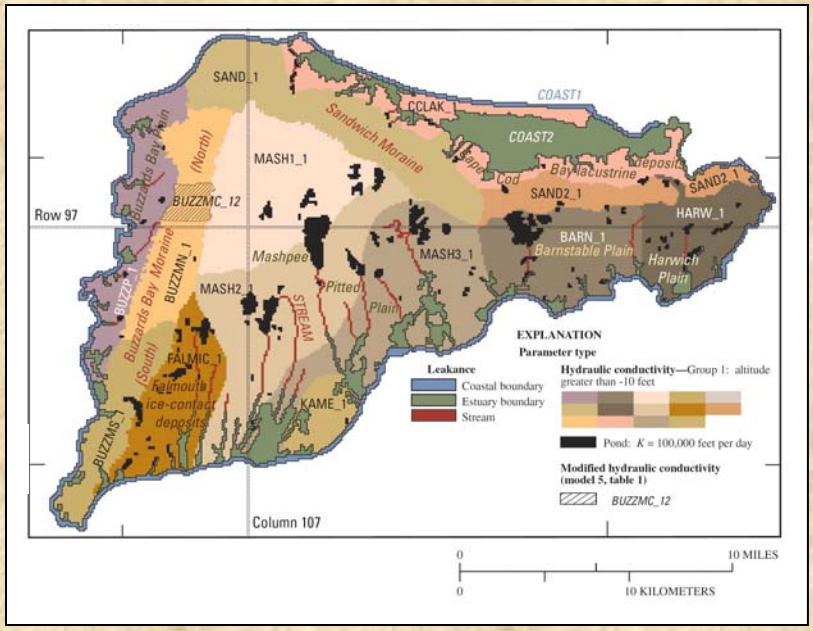


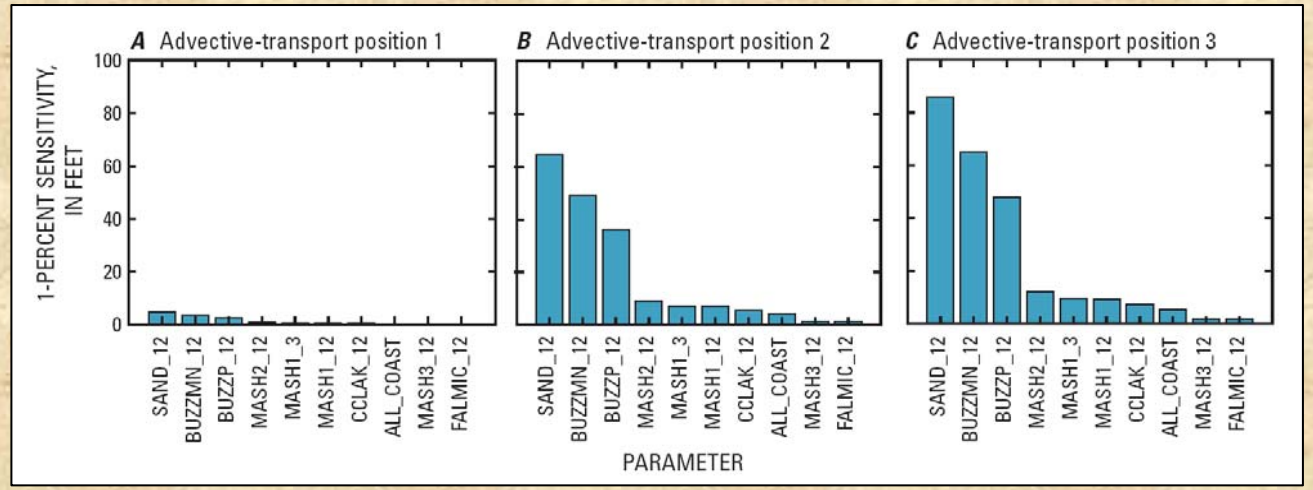
Angus, Ontario, PCE plume (Conant)

IV. Future Directions

Incorporation of uncertainty in simulation and prediction







Western Cape Cod

Final Thoughts

Successful site cleanup depends on a sound conceptual model and application of basic hydrologic principles and tools

Directions for Future Research

- Use of geological information to define aquifer framework and fabric
- Methods to characterize heterogeneity at relevant scales
- Integrated effects of physical and geochemical heterogeneity
- Interaction of ground-water flow with NAPL-contaminated zones
- Transport in the unsaturated zone
- Inverse modeling methods as practical tools at field sites
- Incorporation of uncertainty in the understanding of hydrologic systems

Slide	Item	Sources of information and images
2	MADE site, MS	Zheng, Chunmiao, 2008, Understanding solute transport in extremely heterogeneous porous media—Lessons learned from 25 years of research at the MADE site—2009 Birdsall-Dreiss Distinguished Lecturer, Geological Society of America, Hydrogeology Division: GSA Today, v. 18, no. 10, p. 14 [ftp://rock.geosociety.org/pub/GSAToday/gt0810.pdf]
	NAWC site, NJ	U.S. Geological Survey, 2009, Geochemical and microbiological processes that affect migration and natural attenuation of chlorinated solvents in fractured sedimentary rock—Naval Air Warfare Center (NAWC) Research Site, West Trenton, NJ: Accessed online December 10, 2009, at http://nj.usgs.gov/nawc/index.htm
	Circular 1224	Focazio, M.J., Reilly, T.E., Rupert, M.G., and Helsel, D.R., 2002, Assessing ground-water vulnerability to contamination: Providing scientifically defensible information for decision makers: U.S. Geological Survey Circular 1224, 33 p. [http://pubs.usgs.gov/circ/2002/circ1224/]
3	Amargosa Desert site, NV	U.S. Geological Survey, 2009, Amargosa Desert research site: Accessed online December 10, 2009, at http://nevada.usgs.gov/adrs/
	Laurel Bay, SC	U.S. Geological Survey, 2009, Oxygenated fuel -- Laurel Bay, South Carolina site: Accessed online December 10, 2009, at http://toxics.usgs.gov/sites/laurel_bay/laurel_page.html
4	Geologic framework, Cape Cod, MA	Masterson, J.P., Stone, B.D., Walter, D.A., and Savoie, Jennifer, 1997, Hydrogeologic framework of western Cape Cod, Massachusetts: U. S. Geological Survey Hydrologic-Investigations Atlas HA 741, 1 plate.

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5	Geological models, Cape Cod, MA	Masterson, J.P., Stone, B.D., Walter, D.A., and Savoie, Jennifer, 1997, Hydrogeologic framework of western Cape Cod, Massachusetts: U. S. Geological Survey Hydrologic-Investigations Atlas HA 741, 1 plate. Walter, D.A., and LeBlanc, D.R., 2008, Use of inverse modeling methods to improve ground-water-modeling calibration and evaluate model-prediction uncertainty, Camp Edwards, Cape Cod, Massachusetts: U.S. Geological Survey Scientific Investigations Report 2007-5257, 57 p. [http://pubs.usgs.gov/sir/2007/5257/]
	LLNL Arroyo Seco alluvial fan, CA	Fogg, G.E., 2002, A geologic approach to simulation of subsurface hydrology—2002 Birdsall-Dreiss Distinguished Lecturer, Geological Society of America, Hydrogeology Division: GSA Today, v.18, no. 10, p. 14 [ftp://rock.geosociety.org/pub/GSAToday/gt0810.pdf] Fogg, G.E., Carle, S.F., and Green, Christopher, 2000, Connected-network paradigm for the alluvial aquifer system, *in* Zhang, Dongxiao, and Winter, C.L., eds., Theory, modeling, and field investigation in hydrogeology—A special volume in honor of Shlomo P. Neuman's 60th birthday: Boulder, CO, Geological Society of America, Special Paper 348, p. 25-42. Fogg, G.E., Noyes, C.D., and Carle, S.F., 1998, Geologically based model of heterogeneous hydraulic conductivity in an alluvial setting: Hydrogeology Journal, v. 6, no. 1, p. 131-143.
6	Ambient noise passive seismic method	U.S. Geological Survey, 2009, Horizontal-to-vertical spectral ratio seismic method technology demonstration and evaluation project: Accessed online December 10, 2009, at http://water.usgs.gov/ogw/bgas/hvseismic/
	Amargosa Desert site, NV	U.S. Geological Survey, 2009, Amargosa Desert research site: Accessed online December 10, 2009, at http://nevada.usgs.gov/adrs/
7	Inverse modeling Cape Cod, MA	Walter, D.A., and LeBlanc, D.R., 2008, Use of inverse modeling methods to improve ground-water-modeling calibration and evaluate model-prediction uncertainty, Camp Edwards, Cape Cod, Massachusetts: U.S. Geological Survey Scientific Investigations Report 2007-5257, 57 p. [http://pubs.usgs.gov/sir/2007/5257/]

Slide	Item	Sources of information and images
8	Norman Landfill, OK	U.S. Geological Survey, 2009, Biogeochemical and geohydrologic processes in a landfill-impacted alluvial aquifer, Norman, Oklahoma: Accessed online December 10, 2009, at http://ok.water.usgs.gov/projects/norlan/
9	Defining groundwater flow paths J-3 Range plume, Cape Cod, MA	LeBlanc, D.R., Massey, A.J., Cochrane, J.J., King, J.H., and Smith, K.P., 2008, Distribution and migration of ordnance-related compounds and oxygen and hydrogen stable isotopes in ground water near Snake Pond, Sandwich, Massachusetts, 2001-2006: U.S. Geological Survey Scientific Investigations Report 2008-5052, 19 p. [http://pubs.usgs.gov/sir/2008/5052/]
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