

Challenges in Predicting the Fate and Exposure Pathways of Environmental Contaminants

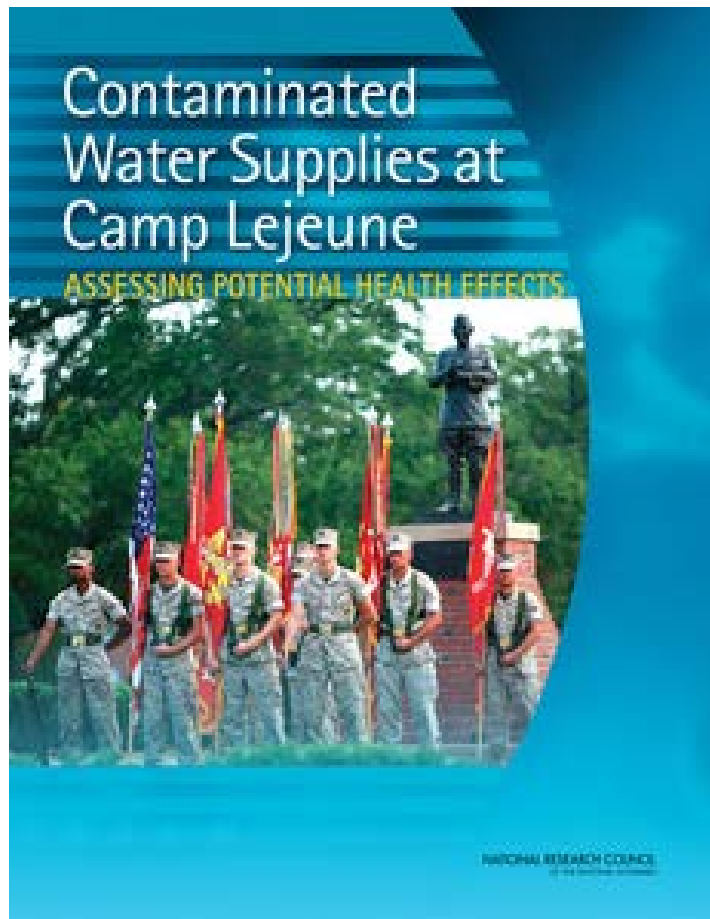
Prabhakar Clement, PhD., P.E., F. ASCE
Professor of Environmental Engineering
The University of Alabama
Tuscaloosa, USA.

Limits of rationality in making economic decisions

In the 70s, Herbert Simon introduced the concept of “bounded rationality,” and he called it as a “satisficing theory” for economic decision making.

Satisfice: Examining alternatives and finding a best-possible solution.

2011 NRC study



Contaminated Water Supplies at Camp Lejeune ASSESSING POTENTIAL HEALTH EFFECTS

Committee on Contaminated Drinking Water at Camp Lejeune

Board on Environmental Studies and Toxicology

Division on Earth and Life Studies

NATIONAL RESEARCH COUNCIL
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Acknowledgements

NAS Committee Roster

David Savitz (*Chair*), Mount Sinai School of Medicine

Caroline Baier-Anderson, Environmental Defense Fund

James Bruckner, University of Georgia

Prabhakar Clement, Auburn University

Carole Kimmel, U.S. Environmental Protection Agency (retired)

Francine Laden, Harvard University

Bruce Lanphear, Simon Fraser University

Xiaomei Ma, Yale University

John Nuckols, Colorado State University

Andrew Olshan, University of North Carolina at Chapel Hill

Lianne Sheppard, University of Washington

Elaine Symanski, University of Texas at Houston

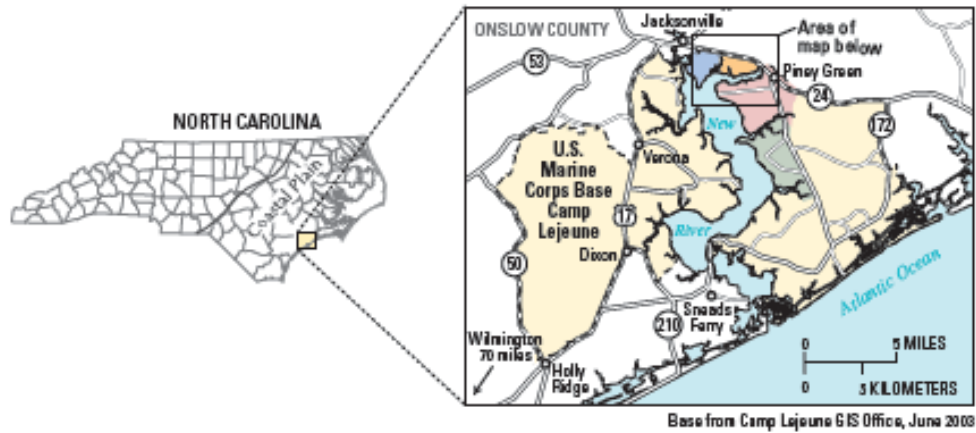
Janice Yager, University of New Mexico

Eventual outcome

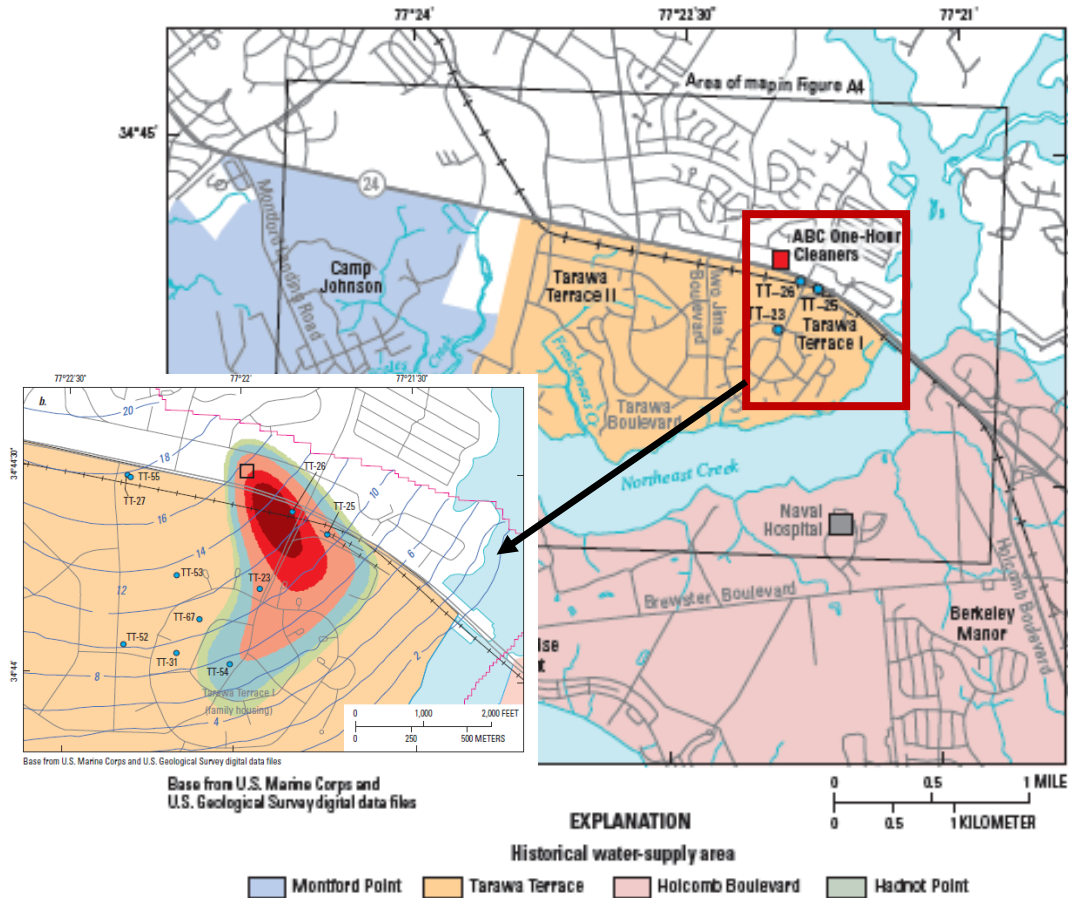
- In August 2012, a Senate bill, Janey Ensminger Act, was signed by President Obama.

NAS Charge

Provide independent advice to the nation to solve complex problems and inform public policy decisions.



- Large site (250 sq. miles)
- TCE/PCE contamination occurred 1950s to 80s
- CLJ residents with serious health problems filed a lawsuit against the US Marines
- Story is similar to Civil Action



Questions to the NRC committee

- Review the scientific evidence on the association between health effects and contaminated water.
- Major General Eugene Payne: Use your science to help us resolve this problem. Tell us what happened (**predict the past**), and whom should we compensate (**provide solution**)?

Need for GW modeling studies.. (modeling project started in 2003)

The project website stated the following:

- Water modeling is a scientific method that will help us estimate past water-system conditions that no longer exist today.
- Water modeling method will help scientists "fill in" missing data.
- These models will tell us about the past.



Progress report..

Statement to the US Congress: April, 2007 the project team leader stated: “Effective today, former Camp Lejeune Marines and their families can find the estimated exposure levels to PCE and PCE degradation by-products, calculated through modeling, by visiting our web site...”

Public reaction....

Health and environmental scientists – The engineers have developed an excellent model; we can now use the model to predict actual exposure concentrations and can proceed with risk assessment.

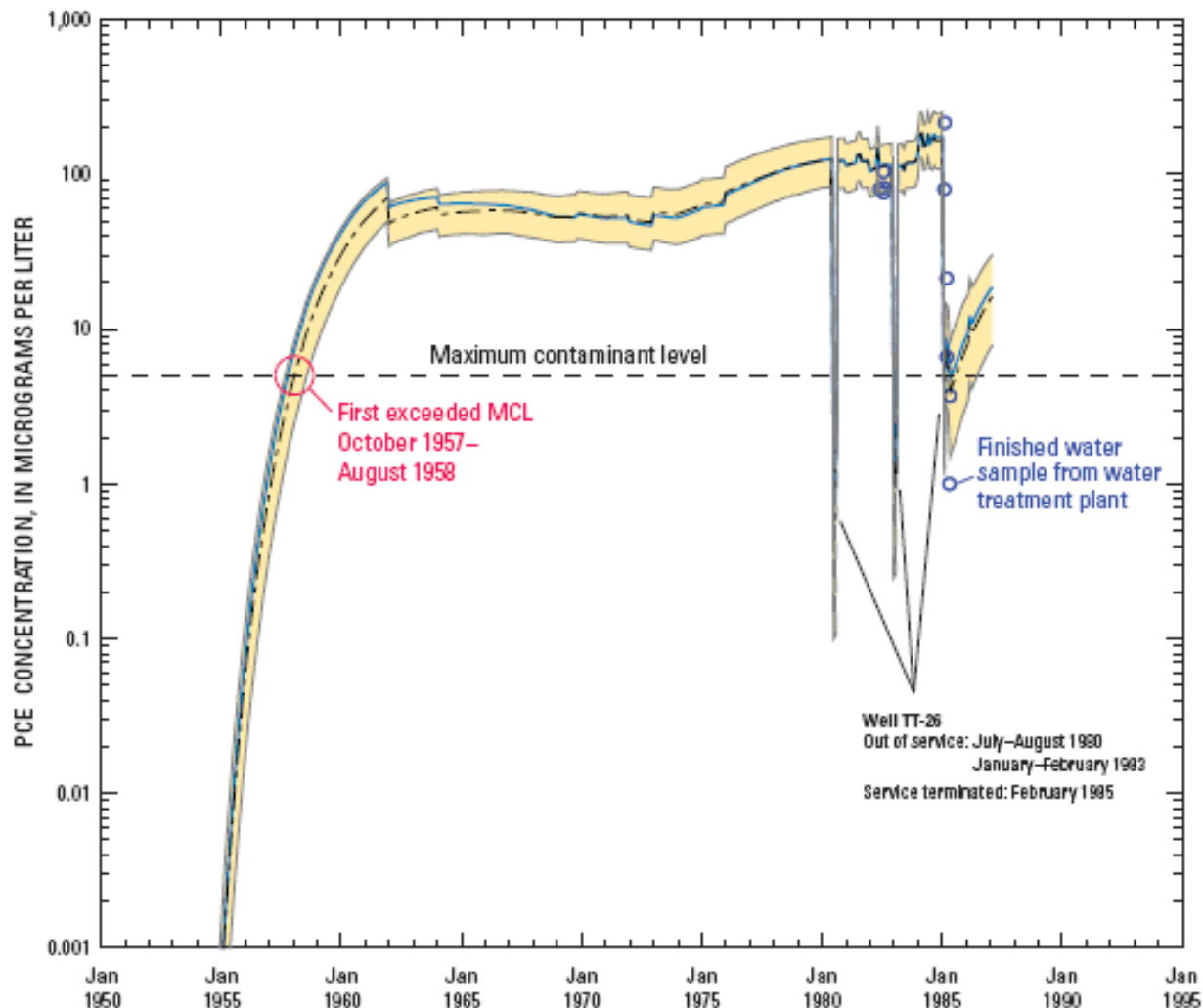
Residents – We now “know” that we drank poisoned water.....

What can we get out of the modeling effort? – CLJ resident's perspective

	PCE	TCE	VC
May 1963	58.81	2.55	5.15
May 1973	42.25	1.67	2.24
May 1982	120.45	4.98	9.13

Concentrations are in ug/L

Note, these results were based on a simple first order decay model



Model simulated
PCE
concentrations in
the tap water

EXPLANATION

Mean value of concentration derived from using MT3DMS model and Monte Carlo simulation in a probabilistic analysis (distributed-value output, 510 realizations)

Range of concentrations representing 95 percent of Monte Carlo simulations

97.5 percentile of Monte Carlo simulations

Calibrated concentration using MT3DMS model in a deterministic analysis (single-value output).
First exceeded MCL November 1957.
See Figure A18 and Chapter F (Faye 2007b)

2.5 percentile of Monte Carlo simulations

Proposal to Navy

Need to do a few more health studies, and also do some complex modeling work to accurately quantify the exposure scenarios.

A self assessment

Are we really that smart to accurately predict the past exposure scenarios using complex groundwater models?



Should I be happy or sad?

Berkowitz et al. 2009

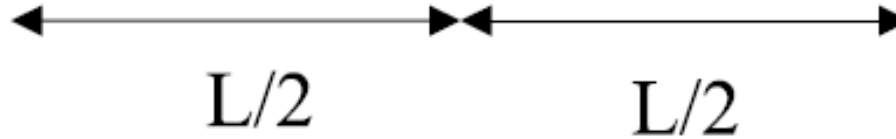


WRR article



Fine glass beads

Coarse beads (same n)



Can we predict tracer transport in a 40 cm long glass-bead packed column?



Used coarse and fine spherical glass beads with similar porosity (about 0.4)

Groundwater model for this simple system: “convection-diffusion” equation

$$\frac{\partial c}{\partial t} = -v \frac{\partial c}{\partial x} + D \frac{\partial^2 c}{\partial x^2}$$

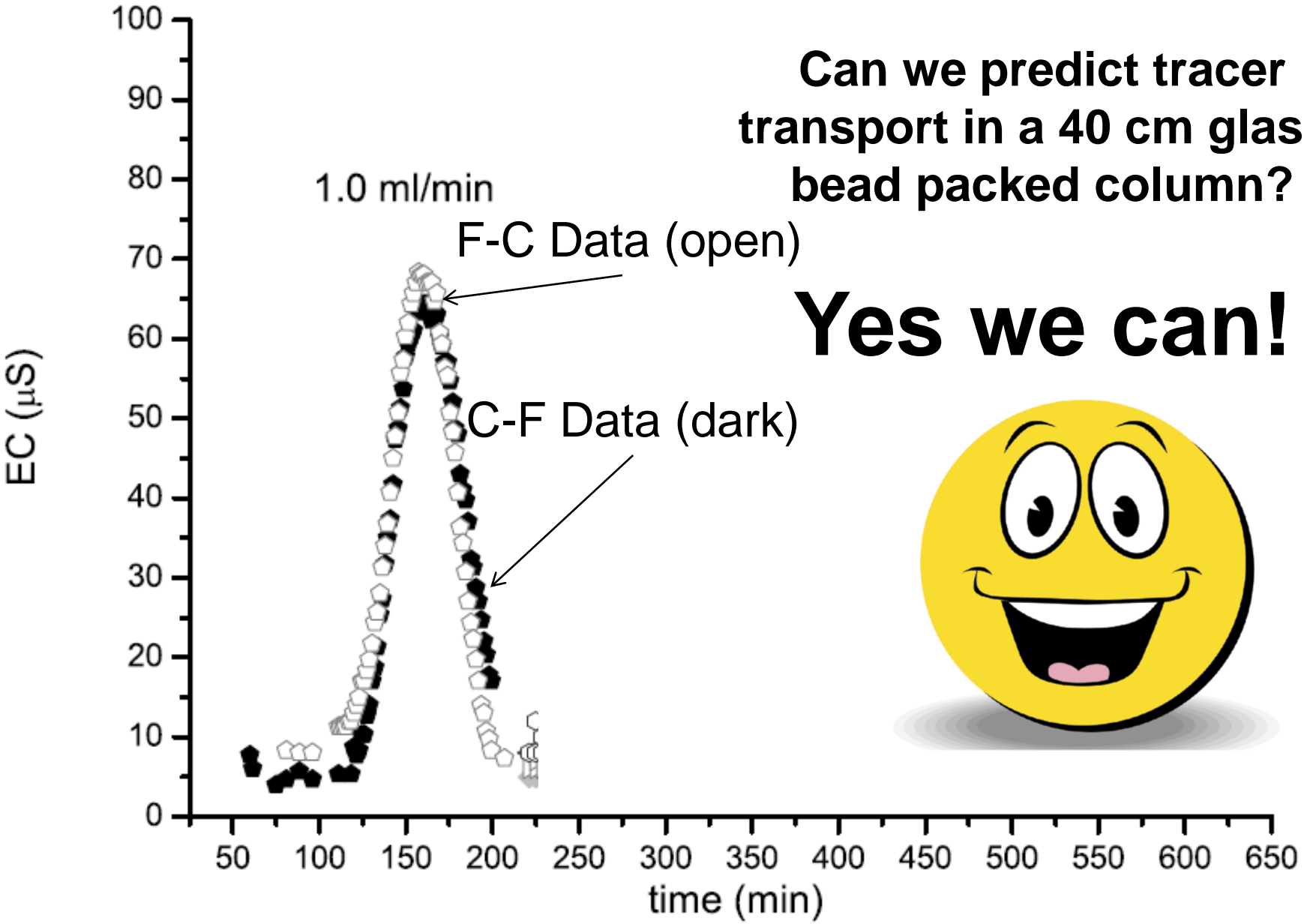
Convection term

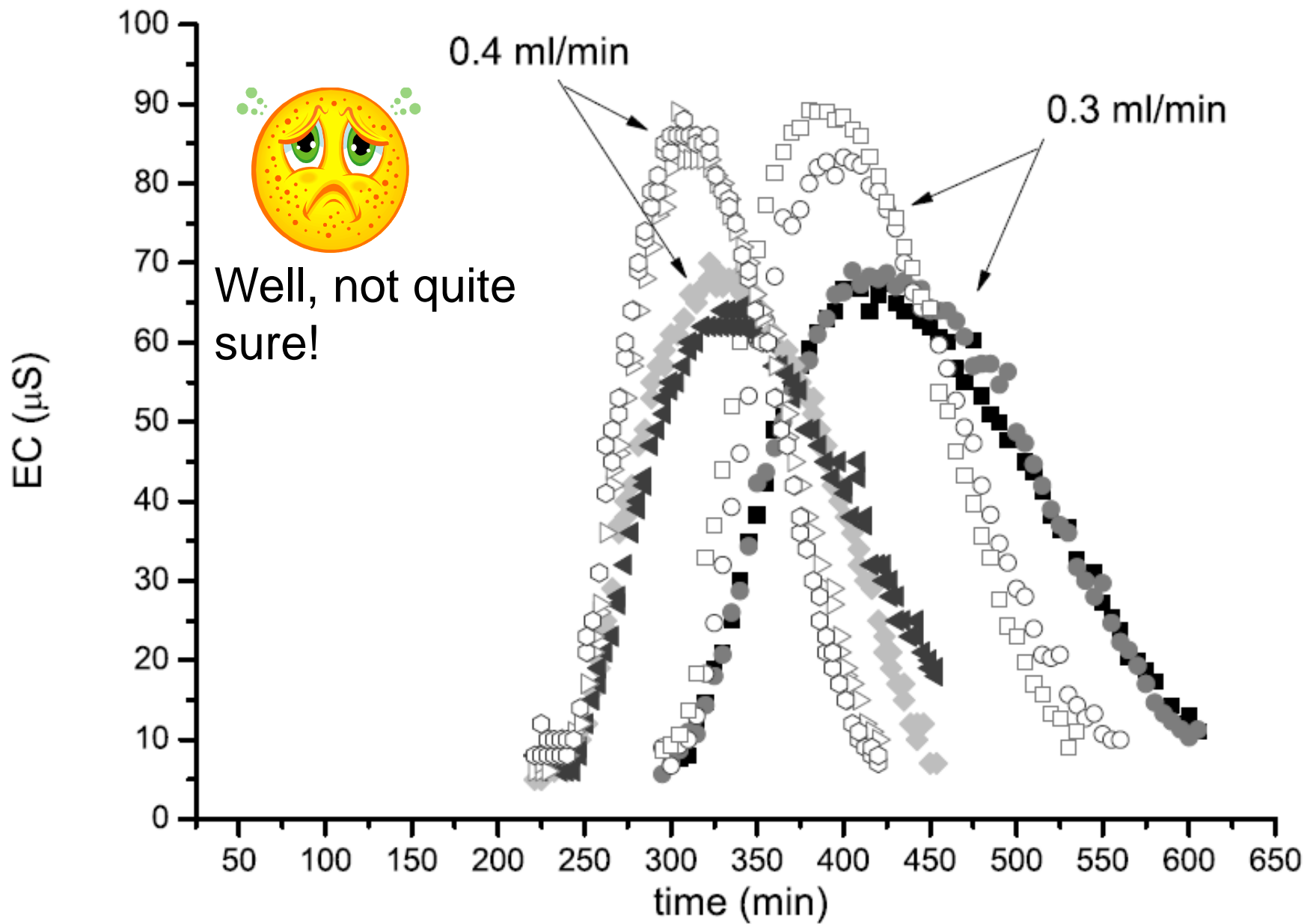
Diffusion term

This equation the building block of
contaminant transport models

Can we predict tracer transport in a 40 cm glass-bead packed column?

Yes we can!





So in reality, even our simple GW model is just a conviction-confusion equation!

$$\frac{\partial c}{\partial t} = -v \frac{\partial c}{\partial x} + D \frac{\partial^2 c}{\partial x^2}$$

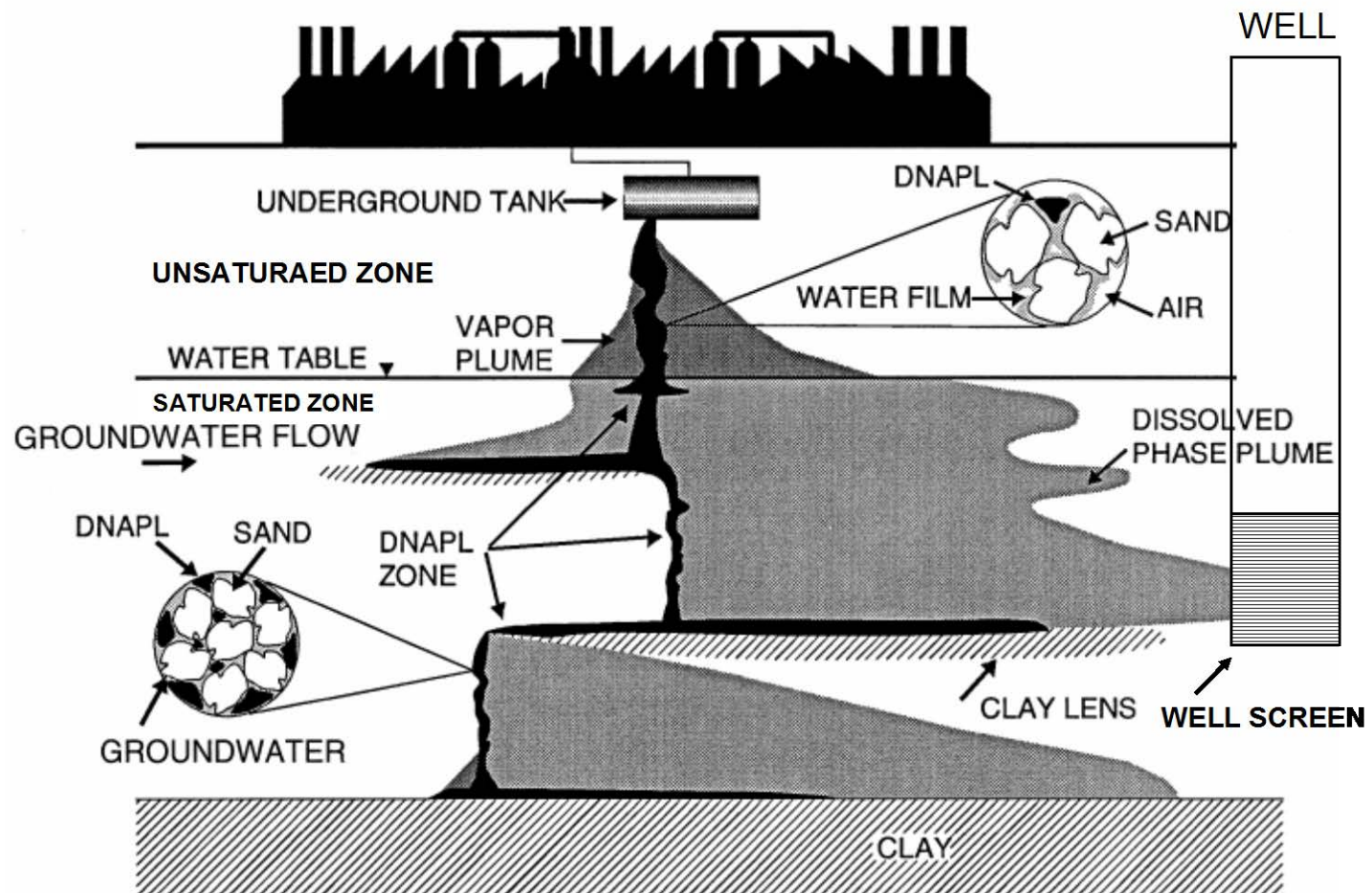


conviction term



confusion term

PCE/TCE problem at Camp Lejeune



What should we do?

What is the purpose of more health studies and advanced modeling efforts in resolving this complex policy problem?

Our charge

- Review available scientific evidence to establish causation
- What should we do in-terms of additional research?
- How can we compensate CLJ residents who were impacted by this contamination event?

NRC committee's recommendation

- Science cannot establish causation in a timely manner
- Stop research
- Develop a policy solution based on available information.

Details of the policy solution

- August 2012 the Janey Ensminger Act was signed.
- In January 2017, President Obama signed a disability benefit Bill to provide \$2 billion to affected veterans.
- Funds supplemented VA healthcare to eligible veterans stationed at CLJ for at least 30 days cumulative between Aug 1, 1953 and Dec 31, 1987.

What can we learn from this experience?

- Rational scientific solution to environmental problems requires unlimited amount of knowledge, data and time.
- Therefore, true scientifically defensible, rational policy solution is a mythical solution that can never be attained.
- What we need is a “bounded rational” solution.

What's next?

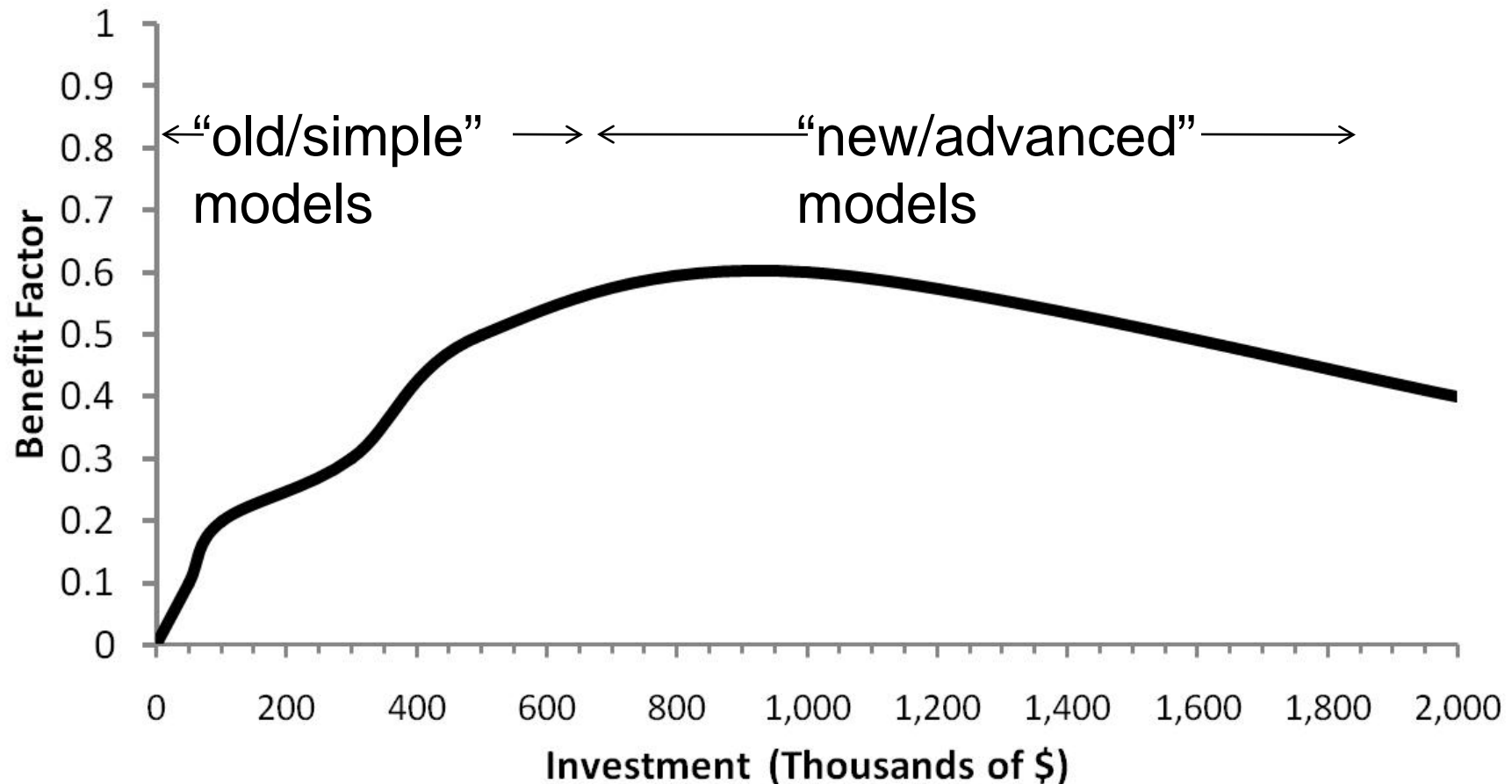
When Herbert Simon introduced the concept of bounded rationality he noted that human decision-making process is always limited by available knowledge, and our mind's ability to process complex information in a timely manner.

So what can we do?

- Always ask the question: how much complexity is needed to derive a “satisficing” solution to the policy problem?

An approach for “bounded rationality” when using complex models

Benefit Factor vs Investment



Recommendations

- Review past groundwater assessment efforts and develop a series of cost/benefit curves that can be used to build a “bounded rationality” framework.
- Establish an expert panel to review the worthiness of large groundwater assessment projects at various stages.
- Complete a post-audit study to review the Camp Lejeune project. We can learn a lot from this case study!

Thanks, questions?



Alabama's 17th National Championship throw!

Why should we do this self assessment?

Texas Supreme Court ruling, May 1999:

We noted that the movement of groundwater is “so secret, occult and concealed that an attempt to administer any set of legal rules in respect to [it] would be involved in hopeless uncertainty, and would, therefore, be practically impossible....”

Sipriano vs. Great spring waters of America

Case No. 98-0247, decided by Texas Supreme Court supporting the “rule of capture” as opposed to “reasonable use” on May 06, 1999.

NRC committee's findings and recommendations

- Many people were exposed to toxic chemicals but there are practical limitations in using scientific studies to determine whether specific health outcomes could be attributed to past exposures.
- Therefore, it does not seem productive to invest in research studies that are likely to be inconclusive.
- Policy decisions should be taken on the basis of what we know now, which is past CLJ residents were exposed to contaminants that are known to be associated with adverse health effects.