



# 2023 PEST Conference

## The Path from Data to Decisions

March 5, 2023 – March 10, 2023

La Jolla, CA

Hosted by



## Welcome!

Groundwater modeling is not about creating a digital replica of what happens underground. No one can do that. Groundwater modeling is about quantifying the uncertainties of decision critical predictions, and about reducing these uncertainties to the extent that available data allows. Risks can then be assessed and decisions can then be made. Inversion, uncertainty analysis, and optimization – performed as an adjunct to simulation – are essential ingredients of decision-making. Once these are understood, other important (and often ignored) facets of decision-support modeling can be discussed, for these discussions then have a basis.

PEST is more than a software package – it is a way of thinking about the processing of environmental data to support the making of important decisions. So, while the PEST conference has the software name in its title, it is focused on decision-support modeling in general.

The PEST conference will provide an important forum for discussions on issues that include:

- What are the best metrics and practices for decision-support modeling?
- How can clients, regulators, and stakeholders understand how best to use modeling in decision-making?
- How complex does a decision-support model need to be (assuming we need a model at all)?
- How can we ensure that all sources of uncertainty have been accounted for, and that no unwanted surprises are lying in wait?
- How can disputes be better (and less expensively) settled through investigatory modeling?

Answering these questions requires that the role of simulation in strategic data assimilation and uncertainty analysis be understood. We are excited to talk with you about these issues during this conference!

## A special thanks to our generous conference sponsors –

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## SHORT COURSE

## Sunday-Monday, March 5-6, 2023 – The Theater

9:00am - 4:00pm

### Data Assimilation and Optimization — Concepts and Basic Math

Instructors — Jeremy White, John Doherty, Randy Hunt, and Mike Fienen

Do not fear the maths! The concepts are more important than the equations; this course will discuss the concepts which the equations illuminate. These concepts will help you to understand what happens under the hood of PEST and PEST++, but they go much further than this. They will help you to understand what can be expected from decision-support modeling in general, and how the decision support modeling process can be tailored to achieve these expectations.

Discussions will not be limited to esoteric topics such as singular value decomposition and Bayes equation. They will extend to how you can decompose an environmental problem in a way that allows modeling to address that problem. This knowledge can support the design of a sleek and efficient modeling process that can harvest information from data, direct it to the making of an important decision, and clarify the risks associated with that decision. In so doing, you can incorporate all that modeling can offer into the decision-making process.

**\*Meals will not be provided during the short courses, but are available for purchase from Mustang & Burros and Greenfinch Restaurant & Bar**

## DAY 1

## Monday, March 6, 2023 – Garden Courtyard (unless otherwise noted)

4:00pm-6:00pm

Conference Registration — Foyer of La Jolla Ballroom

6:00pm-7:00pm

Reception

7:00pm-9:00pm

Dinner



Join us in the Garden Courtyard!



## DAY 2

## Tuesday, March 7, 2023 — La Jolla Ballroom

7:00am-8:00am

8:00am-8:30am

8:30am-10:10am

*\*Contributed presentations are scheduled to be 15 minutes in length plus 5 minutes for questions*

10:10am-10:30am

10:30am-11:10am

11:10am-12:10pm

12:10pm-1:20pm

1:20pm-3:00pm

3:00pm-3:20pm

3:20pm-4:00pm

4:00pm-4:30pm

6:00pm-7:00pm

7:00pm-10:00 pm

### Breakfast — Garden Courtyard

**Conference Welcome** (John Doherty, and Jeremy White and Marsh Lavenue, INTERA Incorporated)

### Contributed Presentations\* (Moderator— Jeremy White)

- Post-2009: A PEST Odyssey, Randy Hunt, USGS
- Applying PEST++ and Iterative Ensemble Smoothing to Evaluate the Likelihood of Alternative Conceptual Models for Tailings Seepage, Michael Gabora, FloSolutions
- Forecasting Future Groundwater Levels in the Mississippi Delta region, USA, Andrew Leaf, USGS Upper Midwest Water Science Center
- Groundwater Objective Analysis Tool – A Tool for Predictive Management of Groundwater Substitution Program in Yuba Basin, Sercan Ceyhan, Woodward & Curran

### Break

### Invited Presentation

Reflections on Model Calibration, Uncertainty Analysis, and Forecasting, Greg Ruskauff, INTERA Incorporated

### Contributed Presentations\* (Moderator— Mike Fienen)

- Quantifying Groundwater Model Uncertainty in Urban Environments— Innovative Techniques for a Challenging Task, Kevin Hayley, Groundwater Solutions Pty Ltd
- Computationally Efficient Hypothesis Testing Using an Iterative Ensemble Smoother and Reproducible Workflows, Guillermo Martinez, PhD, PE, INTERA Incorporated
- Reproducible Parameter Estimation Framework for Integrated Hydrological Models, Seonggyu Park, Texas A&M AgriLife Research

### Lunch — Garden Courtyard

### Contributed Presentations\* (Moderator— Chris Muffels)

- Numerical Simulation of Remedial Alternatives for a Chlorinated Volatile Organic Compound and 1,4 Dioxane Plume, Dave Estrella, AECOM
- Coupling a Recharge Estimation Model with a Groundwater Flow Model to Improve Environmental Management Decision Support for Mining Operations, Savannah Miller, Brown and Caldwell
- Case Study – Ensemble Smoother to Support Decision-Making Process, Mark Ranjram, Matrix Solutions Inc.
- Capture Zone Analysis for Deep Groundwater Plumes: Addressing Uncertainty using Multiple Lines of Evidence, Michael Rush, Neptune
- Communicating Complexities of Mathematical Models in Decision-Based Multistakeholder Negotiations, James Schuetz, PG, and Kyla Wyatt, Parsons

### Break

### Invited Presentation

Are Decisions Better with PEST? A Consultant's Perspective from the Trenches, Charlie Andrews, S.S. Papadopoulos

### Discussion

Using Models in Legal Disputes (Facilitators— Abhishek Singh and Marsh Lavenue (INTERA Incorporated), Shawn Hagerty (BB&K LLP), and Charlie Andrews (SSPA))

### Reception

**Dinner — Garden Courtyard**

## DAY 3

## Wednesday, March 8, 2023 – La Jolla Ballroom

7:00am-8:00am	<b>Breakfast — Garden Courtyard</b>
8:00am-10:00am	<b>Contributed Presentations* (Moderator — Eduardo DeSousa)</b> <ul style="list-style-type: none"><li>■ Revisiting Zimmerman et al. (1998) Twenty-Five Years Later: What Lessons Did We Learn?...From One of the Survivors, Marsh Lavenue and Katie Markovich, INTERA Incorporated</li><li>■ Making the Most of Nothing, Jeremy White, INTERA Incorporated</li><li>■ Embracing the New School: A Successful Case Study Using PEST++-IES to Estimate Mine Dewatering Inflow, Gustavo Meza-Cuadra, FloSolutions</li><li>■ Evaluating Recharge Estimation Scenarios and Its Implications on Groundwater Management, Ryan Harmon, INTERA Incorporated</li><li>■ Subjective Nature of the Prior and Some Repercussions of This, Catherine Moore, GNS</li><li>■ New Regulations and Compressed Timelines: Combining Imperfect Data, Approximate Models and Uncertainty Analysis to Achieve Forward Progress, Robert Gailey, PG, CHG, R.M. Gailey Consulting Hydrogeologist PC</li></ul>
10:00am-10:20am	<b>Break</b>
10:20am-11:00am	<b>Invited Presentation</b> <p>Uncertainty Quantification for Subsurface Petroleum Reservoirs, Dean Oliver, NORCE Research</p>
11:00am-12:40pm	<b>Contributed Presentations* (Moderator — Marsh Lavenue)</b> <ul style="list-style-type: none"><li>■ Improving BeoPEST Performance, Willem Schreuder, Principia Mathematica</li><li>■ Make it Rain: An HTCondor Workflow for Uncertainty Analysis in the Cloud, Mike Fienen, USGS UMID WSC</li><li>■ Light Speed Sensitivities Using Adjoint States with MODFLOW 6, Mohamed Hayek, INTERA Incorporated</li><li>■ A Python Toolkit for Interactive Plotting of PEST++ Ensemble Information, Ryan Conway and Evan Christianson, Barr Engineering</li><li>■ Improving Stochastic Modelling Workflow Visualization, Interrogation, and Interaction, Brioch Hemmings, GNS</li></ul>
12:40pm-1:20pm	<b>Lunch — Garden Courtyard</b>
1:20pm-2:00pm	<b>Invited Presentation</b> <p>Utilizing Structured Decision-Making to Integrate Data, Modeling, and Science Into Policy Formulation and Implementation, Alyssa Dausman, The Water Institute of the Gulf</p>
2:00pm-2:40pm	<b>Discussion</b> <p>Modeling, Policy, and Decision Making (Facilitators—Alyssa Dausman, Catherine Moore)</p>
2:40pm-3:00pm	<b>Break</b>
3:00pm-4:40pm	<b>Contributed Presentations* (Moderator — John Ewing)</b> <ul style="list-style-type: none"><li>■ Doing Less for More: Coupling Multi-Dimensional Scaling and K-means Clustering for Efficiently Sampling the Posterior, Demonstration in an Aquifer Setting with Categorical Facies, Prashanth Khambhammettu, PhD, PE, Arcadis Inc.</li><li>■ An Empirical Evaluation of Sequential and Batch Data Assimilation Approaches to Cope with Groundwater Model Error, Katherine Markovich, INTERA Incorporated</li><li>■ Rethinking Prior Parameter Uncertainty from Groundwater Model Calibration Results: Minimizing Underestimation of Predictive Uncertainty, Tomas Opazo, Flinders University</li></ul>

## DAY 3

## Wednesday, March 8, 2023 — La Jolla Ballroom

3:00pm-4:40pm

### Contributed Presentations (continued)

- Spatial Averaging Implied in Aquifer Test Interpretation: The Meaning of Estimated Hydraulic Properties, Neil Manewell, University of Queensland
- Calibrating and Quantifying Uncertainty for Complex Flow and Transport: Chromium and RDX Regional Models at LANL, Lauren Foster, Neptune

5:30pm-7:00pm

### Reception

7:00pm-10:00pm

### Dinner — Garden Courtyard

## DAY 4

## Thursday, March 9, 2023 — La Jolla Ballroom (unless otherwise noted)

7:00am-8:00am

### Breakfast — Garden Courtyard

8:00am-8:40am

### Invited Presentation

Why are we here? Reflections and Murmurings from an Industry Perspective, Keith Brown, Rio Tinto

8:40am-10:00am

### Contributed Presentations\* (Moderator — Catherine Moore)

- A Bayesian Statistical Perspective on Calibrating Physics-based Groundwater Models, Leslie Gains-Germain, Neptune
- Evaluation of the Probabilistic Capture Performance of Horizontal Reactive Treatment Well (HRX Well®), Jack Wang, Arcadis
- Applied Uncertainty Analysis for a Reactive Fate and Transport Numerical Model in a Highly Controlled Remedial Injection, Melanie Beck, Parsons
- Combining Weather Forecast and Groundwater Modelling Ensembles to Quantify Predictive Uncertainty Under Climate Change, Johanna Zwinger, INTERA Incorporated

10:00am-10:10am

### Break

10:10am-10:40am

### Discussion

Approaches to Improve Education and Uptake of Prediction-Focused Groundwater Modeling (Facilitators—Mike Fienen, Rui Hugman, Randy Hunt)

10:40am-12:20pm

### Contributed Presentations\* (Moderator — Abhishek Singh)

- Current and Future MODFLOW-6 Development, Chris Langevin, USGS
- The MODFLOW-6 API, Joe Hughes, USGS
- Stochastic, Flow Regime-Dependent Estimates of Stream Gauge Discharge Measurement Error for Hydrologic Model Uncertainty Analysis with Ensemble Methods, Nick Martin, Southwest Research Institute

12:20pm-1:20pm

### Lunch — Garden Courtyard

1:20pm-2:40pm

### Contributed Presentations\* (Moderator — Randy Hunt)

- Tuning a Remediation System on Long Island in the Face of Uncertainty: A Journey in Ensemble Methods and Constrained Optimization, Nicholas Corson-Dosch, Upper Midwest Water Science Center, USGS
- Using Management Optimization Under Uncertainty to Support Groundwater Management in Island Aquifers: An Application in the Magdalen Islands (Canada), Cecile Coulon, INTERA Incorporated
- Smoothed Frequency Map of Technetium-99 Concentration Plumes Used as Target for Calibration of Fate and Transport Model, Trevor Budge, INTERA Incorporated

## DAY 4

**Thursday, March 9, 2023 — La Jolla Ballroom** (unless otherwise noted)

**1:20pm-2:40pm**

### **Contributed Presentations (continued)**

- Closed-Loop Decision-Support Modelling, Rui Hugman, INTERA Incorporated
- Optimisation of Prediction-Driven Field Investigation Programmes Using Data Space Inversion and PESTPP-MOU, Eduardo DeSousa, INTERA Incorporated

**2:40pm-3:00pm**

### **Break**

**3:00pm-3:40pm**

### **Invited Presentation**

Decision-Support Modelling: Decomposing the Problem and Why it Matters, John Doherty, Watermark Numerical Computing

**3:40pm-4:20pm**

### **Discussion**

Where Should We Go from Here? (Facilitators—John Doherty, Jeremy White)

**4:20pm-4:30pm**

### **Closing**

**5:15pm**

### **Reception — Garden Courtyard**

## SHORT COURSE

**Friday, March 10, 2023 — The Theater**

**9:00am-4:00pm**

### **Introduction of Workflow Automation with Python and PEST++**

Instructors — Jeremy White, Mike Fienen, Brioch Hemmings

The confluence of rapid, robust, and repeatable environmental modeling is a special unicorn that needs taming. The PEST++ framework brings the robust tools needed for pushing environmental models to their decision-making potential. Repeatability and, with some unicorn taming, increased efficiency is achieved through open-source workflow tools built around the PEST++ framework.

In this short course, we use a worked example model to provide an example predictive-modeling workflow from connecting a model to PEST, through analysis and data assimilation, to decision-making endpoints, leveraging scripting throughout the process. The workflow tools are in the python programming language.

**\*Meals will not be provided during the short courses, but are available for purchase from Mustang & Burros and Greenfinch Restaurant & Bar**



**Get out and enjoy La Jolla!**





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