Office of Solid Waste and
Emergency Response
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clu-in.org/optimization

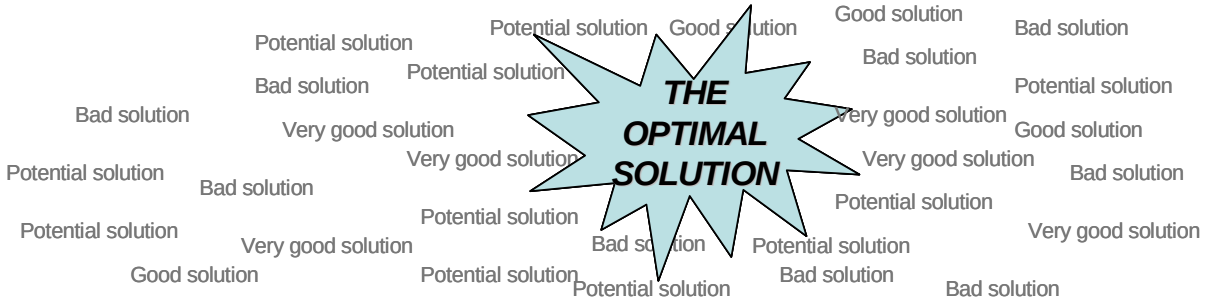
Improving Pumping Strategies for Pump and Treat Systems With Numerical Simulation-Optimization Techniques

Demonstration Projects and Related Websites

Why Optimize? To identify pumping strategies that :

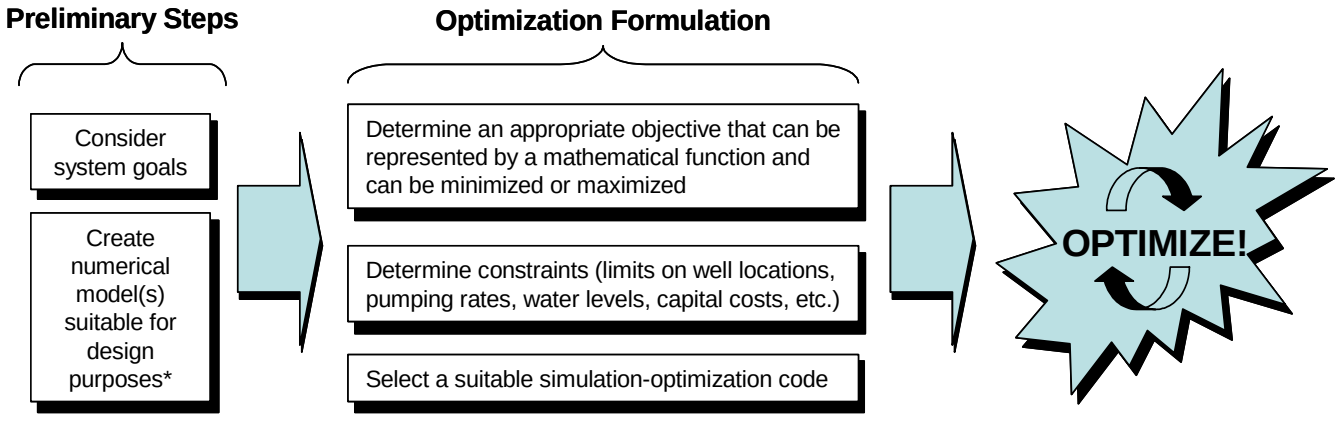
- minimize life-cycle costs, annual costs, or cleanup time while assuring protectiveness
- maximize mass removal
- minimize pumping rate required for plume capture

What are Simulation-Optimization Techniques? These are mathematical techniques that couple simulations of groundwater flow (e.g., MODFLOW) and/or contaminant transport (e.g., MT3D) with mathematical optimization algorithms, to determine an optimal solution when many possible solutions exist.



The simulation-optimization approach is more efficient than simulating a small number of pumping scenarios in a "trial and error" manner (the traditional approach), and typically yields a much improved result. There are two general subclasses of simulation-optimization methods for ground water pump and treat systems:

- **Hydraulic Optimization** - based on ground water flow modeling (not transport), most appropriate when hydraulic containment is the primary concern
- **Transport Optimization** - based on groundwater flow and transport modeling, most appropriate when aquifer restoration is the primary concern (containment can also be considered)



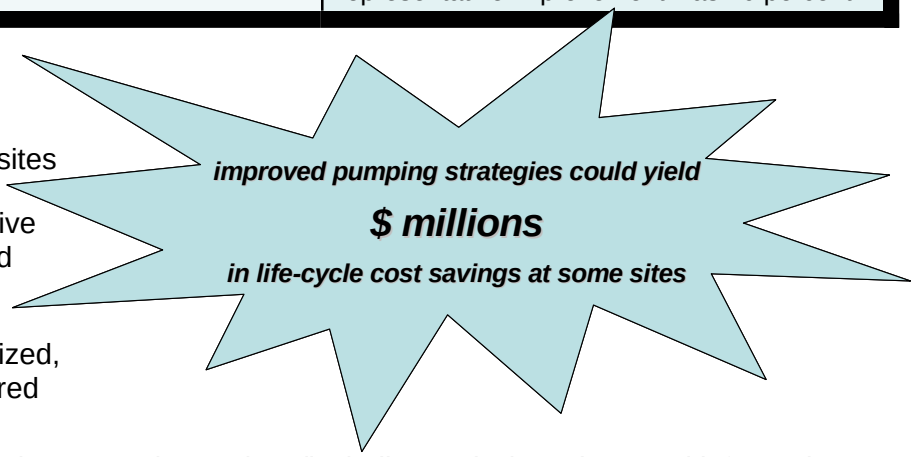
Hydraulic optimization only requires a groundwater flow model. Transport optimization requires both groundwater flow and contaminant transport models. "Optimize" involves many systematic runs of the simulation model.

What demonstration projects have been completed? EPA and DoD have highlighted two projects that demonstrate the application of simulation-optimization techniques for pump and treat systems at multiple real-world sites.

	Hydraulic Optimization Demonstration Project	Transport Optimization Demonstration Project
Applicable Sites	Priority is plume containment	Priority is plume cleanup or mass removal, containment can also be considered
Type of Ground Water Model	Ground water flow model (e.g., MODFLOW)	Ground water flow and transport model (e.g., MODFLOW/MT3DMS)
Optimization Technique	Linear and mixed-integer programming	Nonlinear programming using global search algorithms
Agencies Funding the Demonstration	USEPA Technology Innovation Office (ow known as the Office of Superfund Remediation and Technology Innovation, or OSRTI)	Department of Defense ESTCP Program (lead agency was the Naval Facilities Engineering Command) and USEPA Technology Innovation Office
Demonstration Completion Date	1999	2003
Number of Demonstration Sites	3 sites (multiple formulations per site)	3 sites (three formulations per site)
Summary of Results	Potential cost avoidance of millions of dollars in life-cycle costs were demonstrated at two of the three demonstration sites	In every case, both simulation-optimization codes outperformed a third group using traditional "trial-and-error" simulations, representative improvement was 20 percent

Lessons Learned

- Simulation-optimization approaches can be effectively applied at real-world sites
- A 20 percent improvement in the objective function value (the item being minimized or maximized) is typical
- Optimization results can not be generalized, a specific analysis for each site is required



Final reports and details pertaining to each demonstration project (including codes), and general information on simulation-optimization techniques, can be found on the Federal Remediation Technologies Roundtable (FRTR) website listed below.

Federal Remediation Technologies Roundtable Website (http://www.frtr.gov)

Hydraulic Optimization Demonstration Project

http://www.frtr.gov/optimization/simulation/hydraulic/general.html

Transport Optimization Demonstration Project

http://www.frtr.gov/optimization/simulation/transport/general.html

General Information

http://www.frtr.gov/optimization/simulation.htm

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