Report for 2004CA93B: Modeling and Optimization of Seawater Intrusion Barriers in Southern California Coastal Plain

There are no reported publications resulting from this project.

Report Follows

RESEARCH PROPRAM

Project summary:

Seawater (saltwater) intrusion is a problem that threatens many coastal aquifers around the world. The problem may occur for many reasons but is generally a result of over-pumping of groundwater in the coastal area. An effective way of mitigating seawater intrusion has been the use of hydraulic barriers, or simply barriers. A barrier is essentially an array of injection wells arranged parallel and in close proximity to the coastline. The wells inject freshwater into the lower aquifers to raise the water level and to create a hydraulic barrier to stop seawater intrusion and to protect freshwater pumping wells in the coastal plain. Today, there are three major barriers in operation in Los Angeles County which protect a 20,300,000 acre-foot groundwater reservoir that is used to meet approximately 35% of the potable water supply for 3.2 million residents.

Though the barriers in LA County have been in operation since 1950's, there exist no systematic procedures to guide the operation. Recently, various deficiencies have been noticed in their performance and some regions of the aquifers have suffered leakage. This leakage of seawater through the barrier has degraded the groundwater basin water quality, reduced the net groundwater basin storage, caused shutdowns of freshwater pumping wells, and caused significant losses in basin management activities. Furthermore, a significant loss of injected water (20 percent) has been identified due to seaward migration of the injected water. These deficiencies can be mitigated by optimizing the operation of the barrier facilities or, if necessary, constructing additional injection wells, or both.

The goal of this research is to use state-of-the-art groundwater modeling and optimization techniques to develop optimal management strategies for the Alamitos barrier, one of the three barriers operated by the LA County Department of Public Works. Specifically the objectives are: (1) to first calibrate and validate a groundwater model to simulate the complex barrier operations, (2) to determine the optimal management strategy of the existing barrier facilities, (3) to identify the optimal candidate sites for additional injection wells, and (4) to use multiobjective optimization to investigate alternative and competing management strategies that may be cost effective in addressing the seawater intrusion problem.

Currently the calibration has been completed and documentation has been ongoing during the transition to the management phase. Two alternative methods were applied to calibrate flow parameters: the classic linked-simulation-optimization (LSO) and the newly developed natural-neighbor-kriging (NNK). NNK proved to have a number of advantages over the classic LSO method specifically, computational efficiency (results are obtained in minutes rather than days for the LSO), reproducibility of results (solution is not predicated on an initial guess), and a debatable improvement in the reliability of parameterization results. In fact, estimating a comparable degree of parameter complexity by classical means was simply infeasible in terms of computational requirements. Furthermore, the NNK results were shown to be roughly consistent with a previous geologic study of the site. The primary disadvantage of NNK is shared by most inverse methods, which is that the accuracy of the results is fundamentally based on a set of field measurements.

A number of LSO simulation runs confirmed general consensus in this field that the optimal solution is highly dependent on the initial basis, and the problem suffers from a non-uniqueness in minimization of a highly nonlinear least-squares objective. Transport calibration required significantly longer simulation runs to maintain accuracy. An optimal homogeneous transport parameter set was identified as the model error could not be reduced further by increasing the transport parameter complexity. A draft manuscript has been completed describing the model

calibration phase and is expected to be formally submitted for publication in Summer 2005. Completion of this study is slated for June 2006.

Publications:

Not available

Professional Presentations:

Bray, Ben S, Youn Sim, William W-G. Yeh. 2004. "Calibration of a Complex Three-Dimensional Coastal Aquifer with Density-Dependent Flow." Poster Presented at American Geophysical Union 2004 Fall Meeting, San Francisco, Dec. 13-17, 2004. ID: H33F-0520.
Note: Abstract available online: <http://www.agu.org/meetings/fm04/fm04-sessions/fm04_H33F.html >
Last accessed: 6-14-05

STUDENT SUPPORT

During the reporting period (March 1, 2004 to February 29, 2005), funds were used to support PhD student, Ben Bray. Ben has successfully passed his PhD qualifying exam and is expected to complete his PhD degree in June 2006.

	Total Project Funding		Supplemental Awards	Total
	Federal Funding	State Funding		
Undergrad.				
Masters				
PhD.	$16,367.86			
Post-Doc.				
Total	$16,367.86			

NOTABLE ACHIEVEMENTS AND AWARDS:

Not applicable

PUBLICATIONS FROM PRIOR PROJECTS:

Tu, M-Y, F. T-C. Tsai and W. W-G. Yeh, "Optimization of Water Distribution and Water Quality by Hybrid Genetic Algorithm," to appear in *Journal of Water Resources Planning and Management,* ASCE, 2005.