Report as of FY2007 for 2006GU79B: "Hydrological modeling of atoll islands in the Federated States of Micronesia"

Publications

Project 2006GU79B has resulted in no reported publications as of FY2007.

Report Follows

PROJECT SYNOPSIS REPORT

Project Title: Hydrologic Modeling of Atoll Islands

Problem and Research Objectives

Water shortages pose a serious concern to the inhabitants of atoll islands. The small size, low elevation, unique geology, and isolation of atoll islands combine to create a system that can threaten the well-being of entire populations during times of prolonged drought or recovery from heavy tropical storms. Under normal conditions the fresh water demand is met by rooftop rain catchment supplies, but once these supplies are exhausted the inhabitants turn to ground water. However, the location, quality and quantity of ground water are not readily identifiable for many of the atoll islands. Without such knowledge long-term water resources planning is made difficult, if not impossible. As atoll islands are becoming more and more developed the need for accurate ground water assessment is increasing.

The full objective of this thesis project is to develop numerical and analytical groundwater models that will enable islands water resources planners to confidently establish long-term water resources plans for the islands under their stewardship.

Methodology

The methodology includes five main parts: theory, observation, experimentation, analysis, and application.

The theoretical portion of the project includes analyzing all published papers about atoll island geology, hydrology, hydrogeology, and numerical modeling. This process began one year ago, and is still continuing today. Numerous studies have been performed, each one dealing with a specific island or group of islands, which range geographically from the Caribbean, to the Indian Ocean, and the entire Pacific Ocean Basin. From these studies have come published values for the geology of atoll islands, the rainfall rates for each area of study, the customs of the inhabitants of atoll islands, and the parameters and steps used in creating numerical models.

The Observation phase of the project is mostly complete. Three expeditions were taken to Ulithi Atoll, Yap State, FSM, the first in January 2006, the second in August 2006, and the third in January 2007. A fourth visit is planned for Pingelap, Pohnpei State, FSM, in July 2007. These two atolls have been studied previously and have published values of geology and hydrology. The trips to Ulithi consisted of hydrology, water uses, geology, and vegetation surveys. The wells on the four inhabited islands were each analyzed for depth-to-water, temperature, and salinity. The islands were circumnavigated in order to analyze the surface geology at each location around the atoll island, and especially to compare the windward side with the leeward side.

The Experiment phase consists of constructing groundwater models which accurately depict the observations found during previous atoll island studies. The observations included subsurface geology, hydraulic conductivity of geologic zones, depth to water table, thickness of freshwater lens and transition zone, rainfall rates, tidal range and efficiency, and vegetation. Using these parameters, including published water and soil properties, an atoll island groundwater model has been constructed, and is currently being calibrated to match the conditions observed in the field. Both steady-state

and transient models are being run. Steady-state models are used to study the average freshwater lens behavior to be expected, and transient models are used to study short-term behavior of the freshwater lens due to pumping, drought, typhoons, and sea-level rise.

Work performed during the analysis phase will result in pinpointing any trends seen from the modeling simulations. The patterns seen from the steady-state simulations will enable water resource managers to predict the average conditions of the freshwater lens on atoll islands across Micronesia. The results of the transient simulations, i.e. the water table elevation, the thickness and volume of the freshwater lens, will be graphed over time to show the reaction of the lens to various extreme climatic events. The modeling results will allow adequate preparation to be made for these events.

Principal Findings and Significance

The steady-state simulations are currently being run. The results are being compared to the field observations, and models adjusted accordingly to match these observations. It is clear from the published studies that the geology of all atoll islands cannot be accurately represented in one global conceptual model. The overall geology is similar on all atolls, but the details vary considerably, which greatly influence the hydrology, particularly the freshwater lens. Using one general conceptual model for all computer simulations and water resources plans will lead to erroneous results. It thus seems fitting to have several conceptual models, each one representing a variation of the general conceptual model, and using these conceptual models to construct separate groundwater models.