Sea-level rise and seawater inundation of an atoll island, Roi-Namur, Kwajalein Atoll, Republic of the Marshall Islands

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ABSTRACT

Freshwater resources on low-lying islands are vulnerable to increased frequency of seawater inundation as future sea level increases. Numerical groundwater models are useful for simulating the impacts of seawater migrating from the inundated surface downward into the freshwater lens. This study uses a groundwater model developed using hydrologic data collected during several inundation events to investigate the general processes involved as an atoll island aquifer experiences salinization and subsequent recovery. Findings from this study are useful for understanding general processes that will be experienced on low-lying islands throughout the world as recharge changes and seawater inundation events increase in frequency. A groundwater flow model of Roi-Namur Island, part of Kwajalein Atoll, Republic of the Marshall Islands (figs. 1 and 2), is being developed for the U.S. Department of Defense Strategic Environmental Research and Development Program using the U.S. Geological Survey's three-dimensional solute transport (3-D SUTRA) computer code. The groundwater model for Roi-Namur simulates freshwater, the underlying brackish-water transition zone, and saltwater in an aquifer composed of calcareous sediments overlying Pleistocene limestone. Estimates of present-day recharge, and withdrawal are used as input to the model with the current position of mean sea level as a boundary condition. The resulting freshwater-lens size and position are simulated for current conditions. The groundwater flow model is used to assess the impact of sea-level rise and storm-wave inundation on infrastructure and freshwater availability under a variety of conditions based on historic information, sea-level rise scenarios, and global climate model wind, wave, and rainfall output. In addition, various strategies to mitigate impacts are simulated. Infrequent episodes of seawater inundation during storm events (fig. 3) have severely impacted the island's freshwater resources and these events are predicted to increase in frequency as sea level rises. Estimates of future recharge are made using a daily mass-balance water budget and estimates of the potential distribution and volume of seawater that is projected to wash over the island are generated from a set of detailed oceanographic models. These estimates are applied to the 3-D groundwater model to investigate sea-level rise and climate change impacts to the freshwater lens and evaluate various strategies to mitigate the impacts. The results of these scenarios will be available to local water-system managers so that they can most effectively mitigate the impacts of sea-level rise and climate change and properly manage the groundwater resource. Moreover, the general processes illustrated with the modeling results are relevant for low-lying islands throughout the world that are vulnerable to increased seawater inundation. Preliminary results from this modeling effort will be presented.

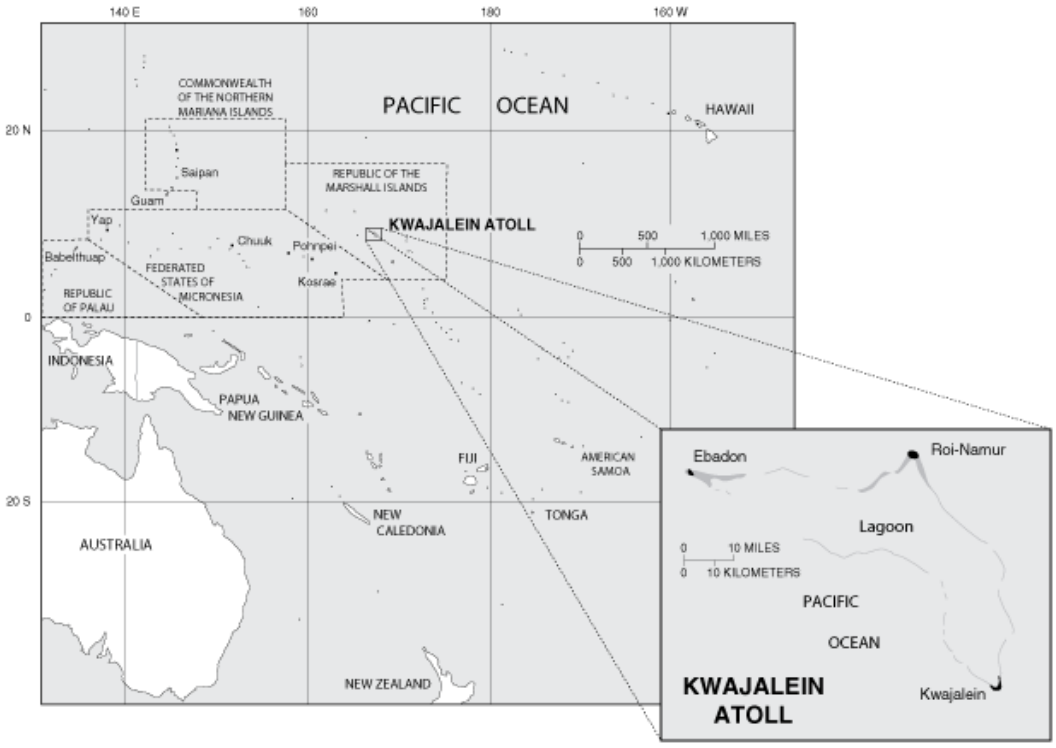

Figure 1. Kwajalein Atoll in the western Pacific Ocean.

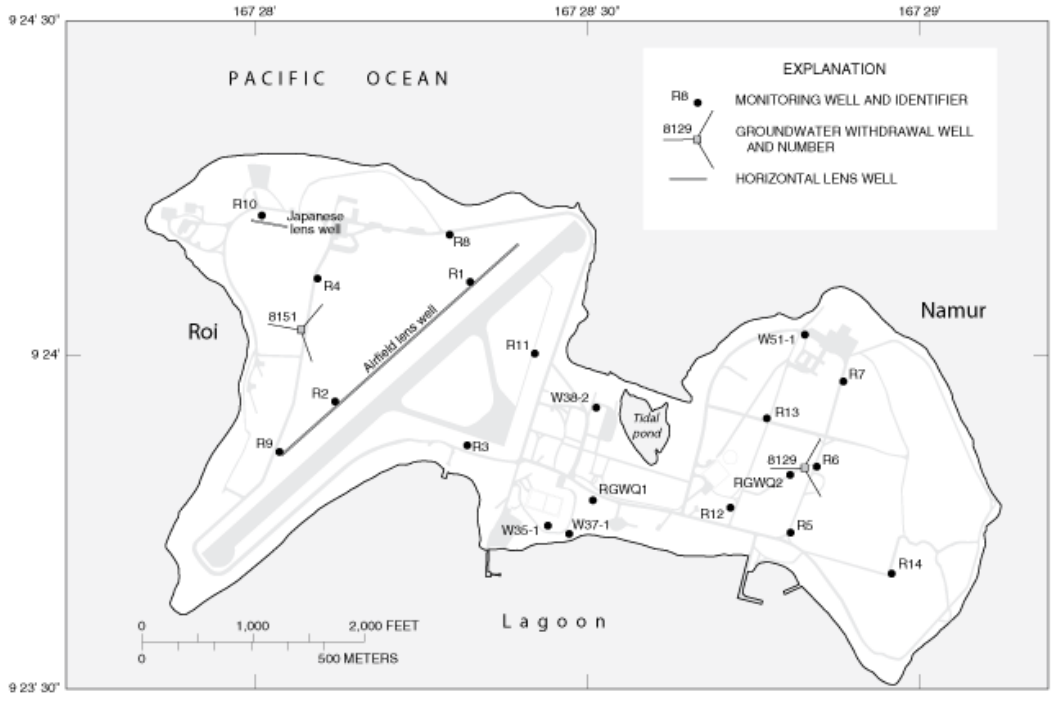

Figure 2. Groundwater withdrawal wells and monitoring wells, Roi-Namur Island.

Figure 3. Seawater inundation after several days of high sea level and surf.

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