Assessment of seawater intrusion potential from sea level rise in coastal aquifers of California

Principal Investigator

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Executive Summary

1. Problem statement. The California Department of Water Resources (DWR) issued a landmark report in July 2006 describing progress made on incorporating climate change into management of California's Water Resources (California Department of Water Resources, DWR, 2006). One of the likely impacts of modern-age climate change in California identified was "Increased potential for salinity intrusion into coastal aquifers." Sea-level rise has been occurring since the end of the last (Wisconsinan) Ice Age. It has been exacerbated by the dramatic rise in greenhouse emissions to the atmosphere from human activity since the 18th century and associated ocean warming and ice melting (Loáiciga, 2006a, b). The United Nations Intergovernmental Panel on Climate Change (IPCC) estimated an average worldwide mean sea-level rise between 0.10 and 0.20 meters during the 20th century (IPCC, 2001). DWR (2006) postulated a plausible additional increase ranging from 0.10 to 0.90 m along California's coast by 2100. One effect of such an increase in sea-level rise is to induce seawater intrusion into the coastal aquifer (Zektser and Loáiciga, 1993). Seawater intrusion has been noted in Monterey, Santa Cruz, and Ventura counties, and in lands surrounding the San Francisco Bay (DWR, 2006), dating back to the 1930s. Given the prominent role that groundwater has on water supply in California – amounting to about 30% of its urban and agricultural water use – it is timely to address the threat posed by future sea level rise to California's groundwater. The following pages outline a research plan to examine quantitatively the threat of sea-level rise in two of California's most productive coastal aquifers: the Oxnard Plain aquifer in Ventura County and the Salinas Valley coastal aquifer (Seaside Area) in Monterey County (DWR, 2003). Based on the findings from this study, recommendations for future action that might be needed in these two aquifers, and other coastal aquifers in the State threatened by similar sea level rise, shall be formulated as part of the study's conclusions.

2. Research objectives and synthesis of methodology. ***Objective 1: Rapid assessment of seawater intrusion.*** The first objective is to develop a simple, yet insightful, approach for the rapid assessment of the landward advance of seawater into the freshwater aquifer

caused by seawater rise. The approach relies on the flow-net geometry of coastal groundwater flow and on a variant of the Dupuit-Ghyben-Herzberg equation to calculate the freshwater hydraulic head corresponding to a landward-displaced seawater-freshwater interface. ***Objective 2: Numerical simulation of seawater intrusion in coastal aquifers.*** A coupled MODFLOW groundwater flow model and MT3DMS solute transport model will be implemented to calculate the extent of seawater intrusion in coastal aquifers. The MODFLOW model has been modified to account for variable density of groundwater caused by seawater intrusion and its coupling to MT3DMS is available as MODHMS (HydroGeologic Inc., 2002). The numerical simulation model MODHMS will be used to predict the extent of seawater intrusion caused by sea-level rise and shall serve as a test of the degree of accuracy of the rapid-assessment approach in approximating the extent of landward seawater migration. ***Objective 3: Management recommendations.*** The research results from the accomplishment of objectives 1 and 2 will be used to make recommendations concerning the need for and the nature of mitigating measures to counter the probable impacts of sea-level rise in coastal aquifers. ***Objective 4: Educational****:* One doctoral student will be educated and trained with the funding received for this research plus any other related funding that could be forthcoming to study the seawater intrusion problem. In addition, course-related materials (data sets, model inputs/outputs, description of the applied models' theoretical basis) will be prepared and used in interdisciplinary graduate-level education hydrologic modeling and global-change processes. These materials will be made available to the public in a dedicated web site.

3. Data needs. The California Department of Water Resources has produced digital cartographic and hydrogeologic maps and characteristics of the aquifers to be studied (and many other aquifers statewide, DWR 2003). These data resources will be supplemented with groundwater quality and hydraulic electronic data available from the US Geological Survey (USGS), in addition to USGS, DWR, and consultants' water-resources investigations in the two example aquifers, plus data sets available from commercial vendors of hydraulic and water-quality data (Earth Info, Inc., for example) shall suffice to execute the research objectives of the proposed research.

4. Expected benefits from the project and relevance to California's water resources management. This research's results have a potentially substantial positive benefit from the viewpoint of leading to useful recommendations for actions that might have to be taken to mitigate the probable deleterious impacts of seawater intrusion in heavily-used coastal aquifers in California. By estimating the degree of the landward migration of saline marine water and the corresponding salinization of coastal groundwater, the investigators will be in a position to make specific recommendations on how to mitigate potential groundwater salinization. Those measures may include recharge operations, shifting in space and time of groundwater extraction within the aquifer, and the like. The benefits of mitigating measures will be to assure a continued sustainable use of coastal groundwater for urban and agricultural purposes.