USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

1.**Title:** Island karst hydrology of Guam and its incorporation into a general Carbonate Island Karst Model (CIKM)

2. **Focus categories:** GW, G&G, MOD

3.**Keywords:** Groundwater Hydrology, Karst Hydrology, Island Hydrology, Island Karst Hydrology

4.**Duration:** One year

Starting Date: 1 Aug 1998

Ending Date: 31 July 1999

5.**Federal funds requested:** $72,565

6.**Non-federal matching funds:** $72,668

7.**Principal investigators:**

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8.**Non-funded collaborators:** Mr. Robert Carruth, USGS, Saipan; Dr. Joseph Troester, USGS, Puerto Rico.

9.**Congressional districts:** Mississippi 3rd Congressional District; South Carolina 1st Congressional District; Guam & Puerto Rico: US territories.

10.**Statement of critical regional water problems.**

Carbonate islands around the world are undergoing unprecedented demands on their limited water resources as island populations grow and increasing standards of living raise per capita demand for utilities and water-based services (UNU, 1995). Guam and the Northern Mariana Islands have seen spectacular growth in the last decade. Annual tourist attendance on Guam has grown from a few tens of thousands in the early 1980's to over one million in 1994, to over one-and-a-half million in 1996 and 1997. Guam extracts over 40 mgd of the current estimated sustainable yield of 57 mgd from the limestone aquifer occupying the northern half of the island (Fig. 1) to provide 80% of the water consumed by its 150,000 permanent residents and 15,000 to 20,000 tourists per day.

Population is growing by over 5% per year, and in the next 18 months the government plans to bring at least another 10 mgd of water production on line. Nearby Saipan is experiencing similar growth but has even more limited water resources. Puerto Rico and adjacent U.S. islands are also coping with ongoing and prospectively accelerating growth, with similar demands on their water resources.

On these and other carbonate islands, water occurrence, accessibility, and quality are fundamentally controlled by the karst features of their carbonate aquifers. Given their limited supply of water and vulnerability to overuse and contamination, however, accurate understanding of the hydrologic properties of the basic karst features is crucial to successful aquifer development and protection. Such basic features include sinkholes and epikarst in the surface, and voids, fractures, and cave systems in the vadose and phreatic zones. Ongoing Superfund work on hazardous waste sites on Guam's military reservations has highlighted the need for a comprehensive general model of the overall "plumbing" of the aquifer. Unfortunately, the karst features on Guam have yet to be systematically inventoried and evaluated in terms of their influence on infiltration rates, transport rates and directions, residence times, and vulnerability to contamination. Compounding the need for a hydrological evaluation of karst features in Guam, moreover, is the lack of a general model of carbonate island karst. The most general model of carbonate island karst to date--the Carbonate Island Karst Model, or CIKM (described in section 13)--is based exclusively on observations of carbonate islands in the Atlantic-Caribbean (Mylroie and Carew, 1995; Mylroie et al., 1995a,b; Mylroie and Carew 1997, in press). The majority of the world's carbonate islands, however, are located in the Indo-Pacific (Vacher and Quinn, 1997). The work proposed herein is thus focused on two complementary needs. First, it addresses Guam's specific need for a systematic inventory and evaluation of the features that control the behavior of its unique type of aquifer. Second, it expands and improves the CIKM by incorporating more exhaustive observations from the Indo-Pacific environment. It is thus fundamental to the Southeast & Island Region water quantity priorities for studies of basin water cycles; groundwater location, movement, and volume; use and user impacts, and surface-groundwater interaction. It is also fundamental to the water quality priority for development and improvement of monitoring techniques and analysis. Finally, it addresses a specific emerging water problem for Guam and similar islands elsewhere--namely the need to better understand how the unique natural features of the karst aquifers of carbonate islands constrain use and development of their characteristically limited water resources.

11.**Statement of the results, benefits, and/or information expected.**

Geologists on Guam are frequently asked to advise utilities, regulatory agencies, and the private sector on sites for new well installation, storm water and sewage overflow disposal, and groundwater monitoring and protection strategies. More accurate analyses can be made at lower costs if local geologists are equipped with (1) a detailed inventory of the island's karst features classified according their hydrologic properties, and (2) a more complete general model to enable reliable inferences of hydrologic properties to be

made by comparison with analogous features of known characteristics documented elsewhere. A clear understanding of the general anatomy of the aquifer increases the reliability of interpretations and predictions made on the basis of test drilling and geophysical exploration, thereby reducing the need for additional drilling or geophysical testing. Specific kinds of information expected from the proposed research include 1) an improved understanding of groundwater storage and flow; 2) lower well-field development costs and more effective well-field protection practices; 3) more appropriate storm water and sewer overflow management practices; 4) more accurate predictions of the effects of engineering modifications, such as filling and paving large sinkholes, on infiltration and water quality; 5) more informed solid waste disposal siting and more judicious sewer line and septic tank installation; and 6)identification of more appropriate sites for monitoring wells.

Because of the rapid rate of development and human modification of the landscape, answers to these and similar questions are urgently needed on Guam and, without doubt, no less on other carbonate islands experiencing similar growth. The CIKM will provide specific, tested criteria for systematic comparison and classification of karst features based on analogous features whose properties have been documented in the Atlantic-Caribbean. The reciprocal benefit is that we will simultaneously have the first opportunity to test the limits of the applicability of the CIKM against islands with significantly different tectonic, climatic, and, perhaps, karstigenetic histories. The general model can thus be more rigorously evaluated, and modifications made as necessary. (See section 13.) Hydrogeologists and hydrologists working on carbonate islands everywhere will thus be equipped with a more reliable model from which to make more confident assessments and predictions to support more effective groundwater exploration, monitoring, and protection practices.