USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

Paleohydrological and Hydroclimatological Analysis of the Magnitude and Frequency of Large Floods in the Verde River Basin, Central Arizona

Submitted to: The Regional Water Resources Competitive Grants Program, Western Region

Duration of project: 24 months, beginning September 30, 1996

Federal funds requested: $84,604

Non-federal funds pledged: $169,331

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Statement of Problem

Spatial and temporal variations in the magnitude and frequency of large floods in the southwestern United States are strongly influenced by hydroclimatic variability. Large floods in most large river basins in the region result almost exclusively from regional-scale extratropical and/or tropical weather systems. The spatial and temporal distribution of these storm types are strongly influenced by persistent, anomalous patterns in hemispheric to global-scale atmospheric and oceanic circulation. Short- and long-term variability in flood frequency in this region are thus good indicators of variability in the larger-scale climatic phenomena over similar time scales. Flood runoff processes from flood-producing storms in individual basins in semi-arid and arid portions of the western U.S. can also vary significantly over space and time. This is often the case for large river basins that integrate areas of strikingly diverse physiography ranging from extensive, high elevation forested areas to rugged, low elevation desert areas. The resulting complex characteristics of individual flood events coupled with the variability in their occurrence induced by larger-scale hydroclimatic controls present unique challenges to water resource management and flood control practices in the region. The relatively short lengths of stream gage records in the Southwest preclude attempts to evaluate effects of

these hydrologic and climatic phenomena on flood magnitude and frequency over time scales greater than about 100 years. A comprehensive study of the paleoflood hydrology and flood hydroclimatology of an individual, regionally significant river basin would constitute a valuable contribution towards greater understanding of the implications of hydrologic and hydroclimatic variability for water resources management and flood control in the western U.S.

We propose to study the influence of hydroclimatic variability on flood magnitude and frequency in the Verde River basin of central Arizona (total area approx. 15,000 km^2) over a period of time extending beyond the historical record by 100s to 1000s of years using techniques of paleoflood hydrology and flood hydroclimatology. The Verde River is chosen as an excellent representative for large basins throughout the southwestern U.S. because its flood regime is sensitive to hydroclimatic variability, it has an extensive gage network with fairly long records, it has several excellent sites for paleoflood studies, and it was affected by extreme floods in 1993 for which a wealth of hydrological and meteorological data exist. The largest floods on the Verde River have occurred as a result of anomalous winter atmospheric circulation patterns but dissipating tropical storms have resulted in large floods on many of its tributaries. Flood runoff in the basin during individual events can be highly variable in space and time such that similar hydroclimatic circumstances can result in floods of significantly different magnitudes. We will examine links between hydroclimatic phenomena and the gaged and historical record of large floods on the mainstem of the Verde River and its gaged tributaries. We will characterize the hydrologic response of the entire basin to a variety of flood producing hydroclimatic scenarios and will greatly augment the length of the flood record by conducting paleoflood investigations at several key sites near gages. The paleoflood studies will provide real, accurate data on extreme floods, extending the record of flooding at individual sites by 100s to 1000s of years. Results from the paleoflood studies will be used to infer trends in climatic variability over the associated time scales through comparisons with strong climate-flood linkages apparent in the modern and historical records. The study will take advantage of recent, important advances in paleoflood research, including refinements in flood frequency analysis with paleoflood data and quantification of paleoflood discharge-modeling uncertainties, to establish significantly improved flood frequency relations at each gaging station on the Verde River.

Anticipated Results and Benefits of Research

The proposed research will provide real data on extreme floods that are critical of evaluating the magnitude and frequency of flooding in the Verde River basin central Arizona over at least the last 1000 years. A combined analysis of the modern and historical flood data with the paleoflood data will allow us to characterize the hydrological response of the Verde River basin to individual extreme events and to the variability of large-scale flood-producing hydroclimatic phenomena. This will improve the understanding of flood hydrology and flood magnitude-frequency characteristics in the southwestern U.S. The research methods that will be employed can serve as models for similar studies in other regions. A principal goal of the project is to augment data from previous paleoflood studies in the basin by describing newly identified sites with

longer and better preserved records and estimating corresponding flood magnitudes. Important contributions from the project will include substantial improvements in flood frequency estimates for each gaging station on the river and estimates of the largest magnitude floods at each site during the last 1000 years or more. Detailed analyses of the flood hydroclimatology of the basin and its principal constituent sub-basins will be performed to evaluate the hydroclimatic context of the largest floods and how it may vary in relation to basin scale. The flood-climate relations characteristic of the modern and historical records will serve as analogs for the paleoflood record. The hydroclimatic analysis will help further the understanding of the underlying physical basis for the observed characteristics of the flood series in the modern, historical, and paleoflood records.

This study of the Verde River basin will relate paleoflood information and associated evidence of hydroclimatic variability to conventional practice in river basin management involving issues of flood-frequency forecasting, and long-term planning. The results will be useful for flood control and water supply management on the Verde River, an important sources of municipal and agricultural water supply for metropolitan Phoenix and surrounding rural areas. The research strategy that we will employ will be applicable to other large drainage basins in the western U.S. Water supply management and flood control strategies in the region will benefit from improved flood-frequency assessments and increased understanding of the effect of global climate variability on flood characteristics. Understanding of linkages between climate and floods will improve the ability of water-supply managers to foresee the local and regional consequences of hemispheric to global scale climatic phenomena, an important component of long-term planning in the face of uncertain future climatic characteristics. Additionally, realistic characterizations of the largest floods that have occurred on each stream in the past several 100s to 1000s of years provide a basis for estimating the maximum flood potential of each stream. This information has particular relevance to theoretical models of extreme flood runoff such as probable maximum flood (PMF) estimation. Information about extreme floods based on the analysis of evidence for the largest known floods in a given river basin has critical importance for evaluating safety issues involving dams built for multi-use objectives, notably hydropower and irrigation prior to the recognition of long-term variability in flood magnitude and frequency. Because of the potential high cost of remediation, information about the most extreme flood phenomena is critical for sound management decisions.