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A data reconnaissance on the effect of suspended-sediment concentrations on dissolved-solids concentrations in rivers and tributaries in the Upper Colorado River Basin

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SUMMARY

The Colorado River is one of the most important sources of water in the western United States, supplying water to over 35 million people in the U.S. and 3 million people in Mexico. High dissolved-solids loading to the River and tributaries are derived primarily from geologic material deposited in inland seas in the mid-to-late Cretaceous Period, but this loading may be increased by human activities. High dissolved solids in the River causes substantial damages to users, primarily in reduced agricultural crop yields and corrosion. The Colorado River Basin Salinity Control Program was created to manage dissolved-solids loading to the River and has focused primarily on reducing irrigation-related loading from agricultural areas. This work presents a reconnaissance of existing data from sites in the Upper Colorado River Basin (UCRB) in order to highlight areas where suspended-sediment control measures may be useful in reducing dissolved-solids concentrations. Multiple linear regression was used on data from 164 sites in the UCRB to develop dissolved-solids models that include combinations of explanatory variables of suspended sediment, flow, and time. Results from the partial *t*-test, overall likelihood ratio, and partial likelihood ratio on the models were used to group the sites into categories of strong, moderate, weak, and no-evidence of a relation between suspended-sediment and dissolved-solids concentrations. Results show 68 sites have strong or moderate evidence of a relation, with drainage areas for many of these sites composed of a large percentage of clastic sedimentary rocks. These results could assist water managers in the region in directing field-scale evaluation of suspended-sediment control measures to reduce UCRB dissolved-solids loading.

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1. Introduction

Over 35 million people in the United States and 3 million people in Mexico depend upon the Colorado River (the River) to supply water needs for domestic and industrial purposes (Bureau of Reclamation, 2011; Colorado River Basin Salinity Control Forum, 2013). Additionally, the River supplies irrigation water for over 1.8 million hectares (4.5 million acres) of land in the United States and Mexico and hydroelectric power along the River and its tributaries generates about 12 billion kilowatt hours annually (Colorado River Basin Salinity Control Forum, 2011). From headwaters in the Rocky Mountains through seven states and Mexico, the Colorado River traverses over 2200 km to discharge into the Gulf of California (Fig. 1). The River increases in dissolved-solids (salt) concentration from about 50 mg/L at the River's headwaters to about 850 mg/L where it crosses the U.S. border with Mexico (Anning et al., 2007), and over 8 million metric tons of dissolved solids flows past Hoover Dam annually (Anning et al., 2007). The origin of salinity in the Colorado River is primarily geologic material that was deposited from ancient inland seas and waterways (Colorado River Basin Salinity Control Forum, 2013), and 55–60% of the salinity in the River system is from natural sources—primarily saline spring discharge and erosion of saline geologic formations (Chafin and Butler, 2002; Kenney et al., 2009). Human activities also increase dissolved-solids concentrations through increased loading (primarily irrigation, but also municipal and industrial development, mining and drilling operations) and accumulation (evaporation from reservoir operations). The U.S. Bureau of Reclamation estimates that high salinity Colorado River water causes damages of more than $300 million dollars per year to users in the U.S. (Colorado River Basin Salinity Control Forum, 2013), primarily due to reduced agricultural crop yields, corrosion, and plugging of pipes and water fixtures in housing and industry (Bureau of Reclamation, 2011).

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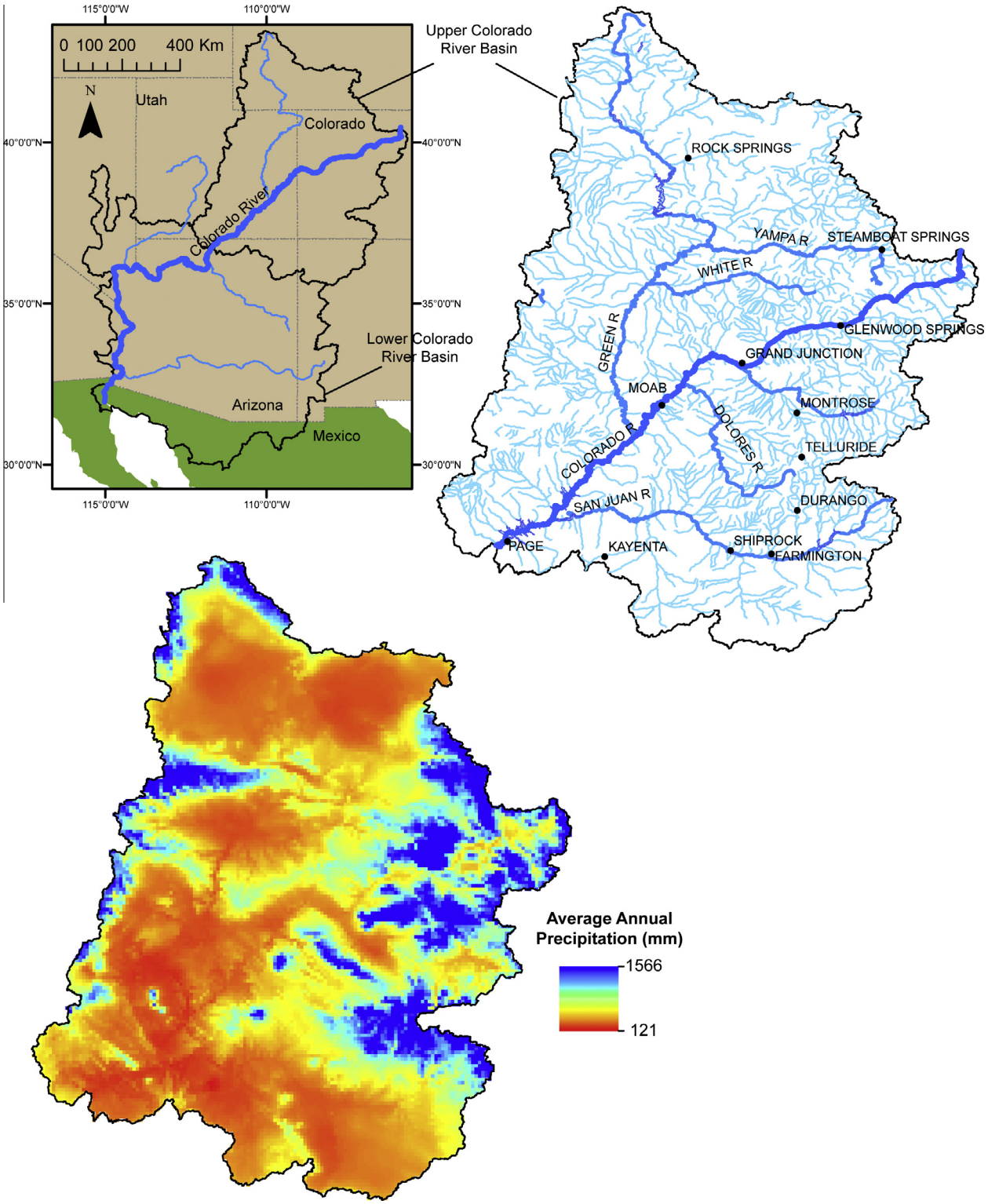

Fig. 1. Location of the Upper Colorado River Basin study area within the southwestern United States (upper left), major tributaries to the Colorado River (upper right), and average annual precipitation (bottom, PRISM Group, Oregon State University, 2012).

In 1974, the Colorado River Basin Salinity Control Act created the Colorado River Basin Salinity Control Program to implement a broad range of salinity control measures to prevent further degradation of the River. It is often assumed that control measures that prevent or reduce sediment loading to surface waters in the Basin will also reduce dissolved-solids loads. This assumption is based on observations that salinity concentrations remain high during peak flow associated with snowmelt runoff events in some areas (Bureau of Reclamation, 2003) and studies that associate sediment and dissolved-solids yield (for example, Hawkins et al., 1977; Schumm and Gregory, 1986; Bureau of Reclamation, 2003). Published studies that investigate both suspended sediment and dissolved solids concentrations and loadings are often from estuary or coastal systems, where the interest in on sources and transport of suspended particulate matter and salinity is used to infer ocean contributions (Cloern et al., 1989; Lane et al., 2007; Powell et al., 1989; Prandle et al., 1997;