CHARACTERIZING AND SIMULATING SEDIMENT LOADS AND TRANSPORT IN THE LOWER PART OF THE SAN ANTONIO RIVER BASIN
EXTENDED ABSTRACT

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INTRODUCTION

This extended abstract is based on the U.S. Geological Survey Scientific Investigations Reports by Crow et al. (2013) and Banta and Ockerman (2014). Suspended sediment in rivers and streams can play an important role in ecological health of rivers and estuaries and consequently is an important issue for water-resource managers. The quantity and type of suspended sediment can affect the biological communities (Wood and Armitage, 1997), the concentration and movement of natural constituents and anthropogenic contaminants (Moran and others, 2012), and the amount of sediment deposition in coastal environments (Milliman and Meade, 1983). To better understand suspended-sediment characteristics in the San Antonio River Basin, the U.S. Geological Survey (USGS), in cooperation with the San Antonio River Authority and Texas Water Development Board, conducted a two-phase study to (1) collect and analyze sediment data to characterize sediment conditions in the San Antonio River downstream of San Antonio, Texas, and (2) develop and calibrate a watershed model to simulate hydrologic conditions and suspended-sediment loads for four watersheds in the San Antonio River Basin, downstream from San Antonio, Texas.

METHODS

Sediment Characterization: The study area consists of approximately 2,150 square miles. The upstream boundary of the study area coincides with USGS streamflow-gaging station 08181800 San Antonio River near Elmendorf, Tex. (hereinafter referred to as the "SAR Elmendorf gage") and USGS streamflow-gaging station 08185000 Cibolo Creek at Selma, Tex. (hereinafter referred to as the "Cibolo Selma gage"). The downstream boundary of the study area is the confluence with the Guadalupe River. During 2011–13, suspended-sediment samples were collected at 10 sites for the analysis of suspended-sediment concentration and particle size distribution. In addition, samples of bedload material were collected at six sites for the analysis of bedload mass and particle-size distribution. Samples were collected over a variety of hydrologic conditions ranging from a minimum streamflow of 1.9 cubic feet per second (ft^3/s) at the Cibolo Selma gage on September 17, 2012, to a maximum streamflow of 10,600 ft^3/s at the same site on May 25, 2013. To estimate suspended-sediment loads, log-linear regressions were developed to estimate suspended-sediment concentration based on streamflow at five sites for which sufficient data (including historically collected data) were available (see Figure 1 for example). The suspended-sediment concentrations were used in conjunction with streamflow to calculate estimated suspended-sediment loads.

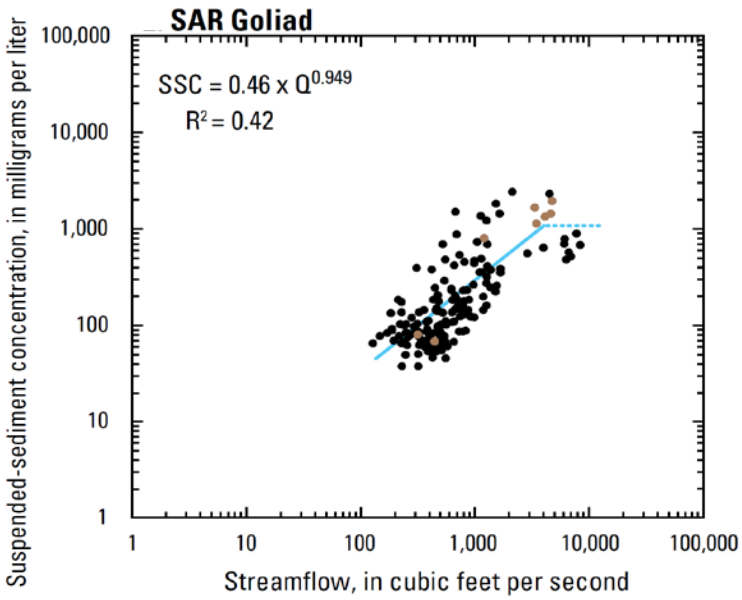


Figure 1. Example of relation between suspended-sediment concentration and streamflow at the SAR Goliad gage (USGS station 08188500 San Antonio River at Goliad, Tex.) (Modified from Figure 5 in Crow and others, 2013).

HSPF Model Development: In 2010, the U.S. Geological Survey (USGS), in cooperation with the San Antonio River Authority, the Evergreen Underground Water Conservation District, and the Goliad County Groundwater Conservation District, developed a Hydrological Simulation Program – FORTRAN (HSPF) model for the San Antonio River Basin to simulate hydrology only (hereinafter referred to as the "USGS–2010 model") (Lizarraga and Ockerman, 2010). In 2012, URS Corporation developed an updated version of the San Antonio River Basin HSPF model (hereinafter referred to as the "URS–2012 model"), which was based on the USGS–2010 model. For this study, the USGS developed an updated version of the HSPF model, based on the URS–2012 model, to simulate hydrologic conditions and suspended-sediment loads in the San Antonio River Basin during 2000–12 (hereinafter referred to as the "USGS–2014 model").

Because of the large size, the study area in the San Antonio River Basin was divided into four watershed models: (1) San Antonio River upstream from Cibolo Creek, (2) Cibolo Creek, (3) Ecleto Creek, and (4) San Antonio River downstream from Cibolo Creek. Input data for the HSPF model included spatial and time-series data. Spatial data included geology, soils, land-cover, topography, and drainage characteristics such as subwatershed boundaries and stream-reach length and cross-section data. Time-series data included meteorological data (rainfall and potential evapotranspiration), streamflow data, and suspended-sediment load data. The ranges of expected soil erosion rates were used as guidance for establishing targets for model simulation of sediment yields for different land-cover types. Sediment-related HSPF model parameters were adjusted so that simulated soil erosion rates approximated the reported soil erosion rates by land-cover type.

RESULTS AND CONCLUSIONS

Sediment Characterization: The samples collected during 2011–13 represent a wide range of SSCs, including some of the largest concentrations ever collected at some of the sites. Suspended-sediment concentrations (SSCs) in 67 samples collected during 2011–13 ranged from 14 milligrams per liter (mg/L) during base-flow conditions at USGS streamflow-gaging station 08183500 San Antonio River near Falls City, Tex. (hereinafter referred to as the "SAR Falls City gage") on August 19, 2011, to 4,480 mg/L during a stormflow event at the same site on January 26, 2012. The instantaneous suspended-sediment loads (SSLs) computed from 67 SSC samples collected during 2011–12 ranged from 0.36 tons per day at the Cibolo Selma site during base-flow conditions on September 17, 2012, to 47,800 tons per day at the SAR Elmendorf site during a stormflow event on January 25, 2012. These SSLs were used as either inputs to the HSPF model or as calibration targets for simulated model loads.

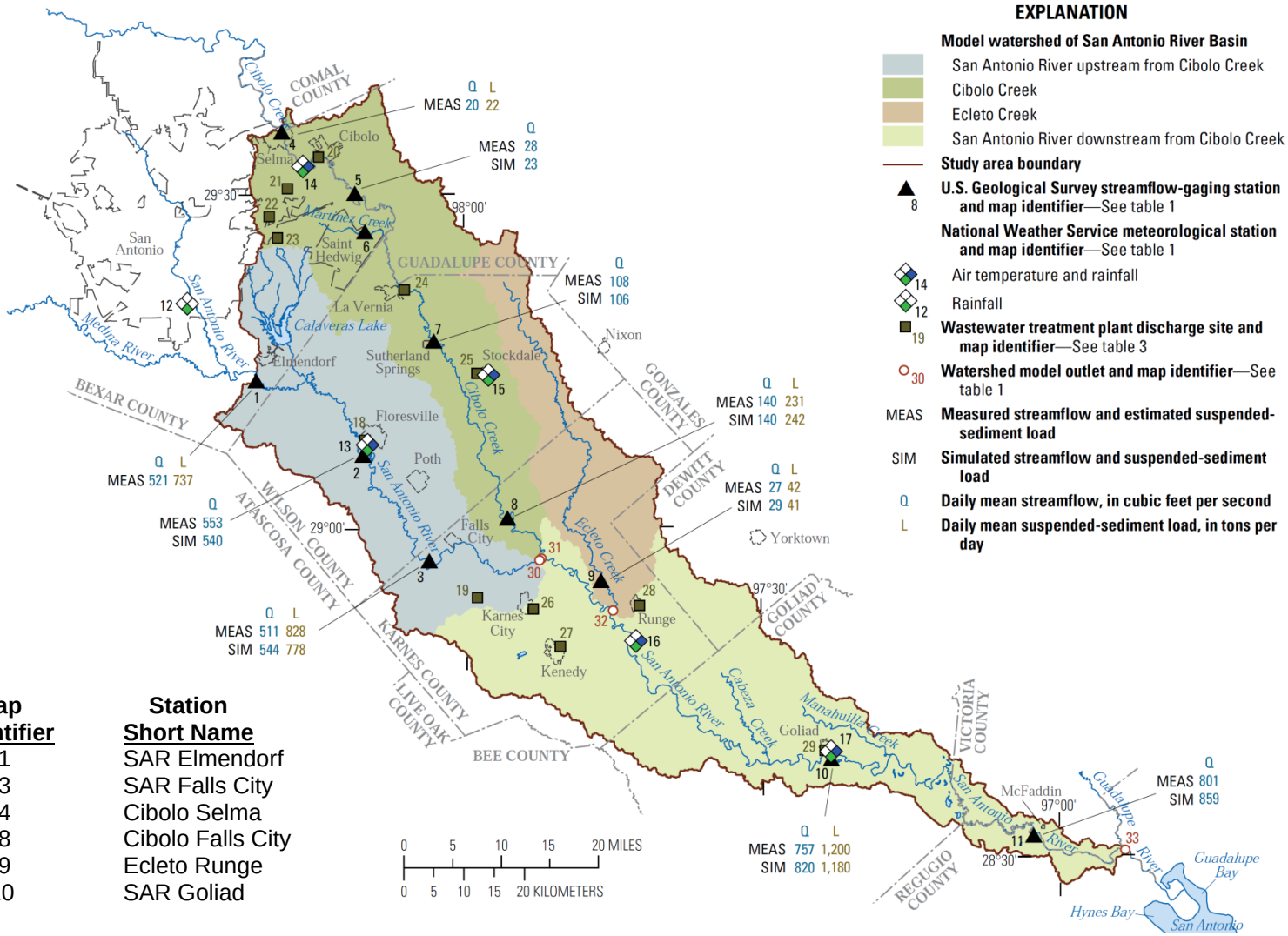
HSPF Model: The calibrated model of the study area in the San Antonio River Basin was used to simulate hydrologic conditions and suspended-sediment loads for 2000–12, as well as to simulate sediment production by various land types within the study area. Taking into consideration the model-fit statistics and graphical comparisons (Moriasi and others, 2007; Donigian, 2002; U.S. Environmental Protection Agency, 2000 and 2006), the watershed models simulated the observed streamflow within the "good" to "very good" categories during the calibration period (2006–12), with the exception of the Ecleto model. The calibration process also included a separate, post-calibration test of the model fit during 2000–2005. Simulations during the testing period had similar model-fit statistics as during the calibration period, with the exception of the USGS streamflow-gaging station 08186000 Cibolo Creek near Falls City, Tex. (hereinafter referred to as the "Cibolo Falls City gage"). One possible reason for weaker testing results (compared with calibration results) is the quality of available rainfall data for 2000–2005. During the entire 2000–12 simulation period, the model-fit statistics at each of the four primary calibration gages indicate "good" to "very good" fits (Banta and Ockerman, 2014).

Similar to the hydrology calibration, the suspended-sediment load model-fit statistics also were evaluated during the testing period at the SAR Falls City, Cibolo Falls City, and USGS streamflow-gaging station 08188500 San Antonio River at Goliad, Tex. (hereinafter referred to as the "SAR Goliad gage"), resulting in "good" to "very good" fits (Banta and Ockerman, 2014). Overall, model-fit statistics and graphic evaluations from the calibration and testing periods, provided multiple lines of evidence indicating the USGS–2014 model simulations of suspended-sediment conditions were mostly "good" to "very good," except for Ecleto Runge, which is considered unsatisfactory to fair (Banta and Ockerman, 2014).

The daily mean estimated suspended-sediment loads were 737 tons per day (tons/d) and 22 tons/d, respectively, at the SAR Elmendorf and Cibolo Selma gages during 2006–12 (Figure 2). At the outlet of the study area, the confluence of the San Antonio River with the Guadalupe River, the simulated daily mean suspended-sediment load during 2006–12 was 1,230 tons/d (Figure 2). These model results indicate that 759 of the 1,230 tons/d (approximately 62 percent) of the suspended sediment being delivered to the Guadalupe River originated upstream from the study area, mostly upstream from the SAR Elmendorf gage. Sample analyses and model results indicate that most of the suspended-sediment load in the study area consists of silt- and clay-

sized particles (less than 0.0625 millimeters). At the confluence of the San Antonio River with the Guadalupe River, approximately 98 percent of the total simulated suspended-sediment load was composed of silt and clay.

The Cibolo Creek watershed was the largest contributor of suspended sediment from the study area. The higher suspended-sediment yields in the Cibolo Creek watershed are likely because of steeper topography, more developed and cropland land cover, and more runoff than the other watersheds. For the entire study area, open/developed land and cropland exhibited the highest simulated soil erosion rates; however, the largest sources of sediment from the study area (by land-cover type) were pasture and forest/rangeland/shrubland, which account for about 80 percent of the study area and contributed about 70 percent of the suspended-sediment load.



Map Identifier	Station Short Name
1	SAR Elmendorf
3	SAR Falls City
4	Cibolo Selma
8	Cibolo Falls City
9	Ecleto Runge
10	SAR Goliad

Figure 2. Measured and simulated daily mean streamflow and daily mean suspended-sediment loads at selected sites in the study area, San Antonio River Basin downstream from San Antonio, Texas, 2006–12 (Modified from Figure 13 in Banta and Ockerman, 2014).

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