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Prepared in cooperation with the City of San Antonio

Effects of Urbanization on Water Quality in the Edwards Aquifer, San Antonio and Bexar County, Texas

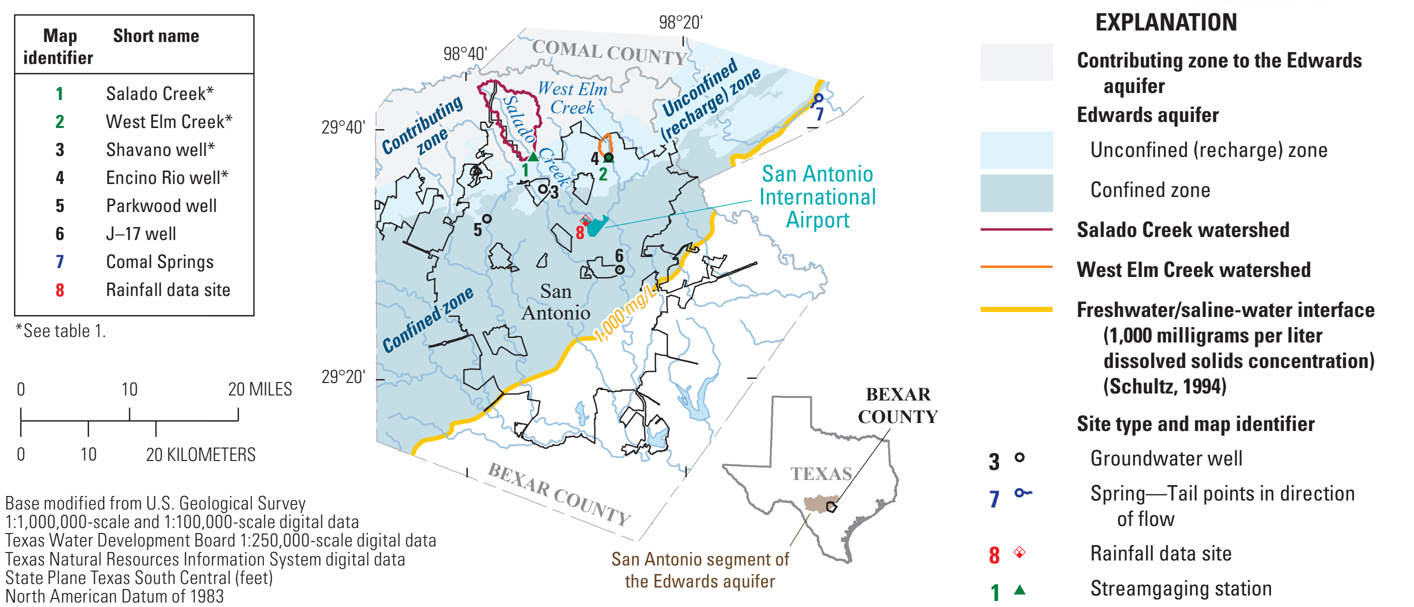
Overview

Continuous water-quality monitoring data and chemical analysis of surface-water and groundwater samples collected during 2017–19 in the recharge zone of the Edwards aquifer were used to develop a better understanding of the surface-water/groundwater connection in and around Bexar County in south-central Texas. This fact sheet is provided to inform water-resource managers, city planners, the scientific community, and the general public about the effects of urbanization on water quality in the Edwards aquifer recharge zone.

Introduction

The San Antonio segment of the Edwards aquifer, in south-central Texas, is a designated sole-source aquifer (U.S. Environmental Protection Agency, 2019a) and the primary source of water for more than 1.7 million people in the city of San Antonio and the surrounding area (Tremallo and others, 2015; Greater Edwards Aquifer Alliance, 2020). Ongoing residential and commercial development in Bexar County on the Edwards aquifer recharge zone (fig. 1) has the potential to increase the variety and concentration of contaminants in stormwater runoff and, thereby, in water recharging the Edwards aquifer (Musgrove and others, 2016; Opsahl and others, 2018). The Edwards aquifer is a limestone (karst) aquifer and the porous nature that is characteristic of the Edwards aquifer recharge zone (also referred to as the unconfined zone) makes the system vulnerable to contamination from sources at the land surface (White, 1988). As a result, water-resource managers working on Edwards aquifer issues have implemented management practices such as the creation of conservation easements to protect the quality of water in the aquifer and the long-term health of the region’s public water supply (City of San Antonio, 2020; Edwards Aquifer Authority, 2020; San Antonio Water System, 2020). Surface-water/groundwater interactions along the Edwards aquifer recharge zone are complex, and tracing the potential connections between stormwater runoff and the groundwater system is challenging. To address these challenges, the U.S. Geological Survey, in cooperation with the City of San Antonio, studied patterns in the change in water quality over time at selected surface-water (SW) and groundwater (GW) sites in the Edwards aquifer recharge zone, with an emphasis on changes during periods of groundwater recharge.

Water quality was monitored at SW and unconfined GW sites with different degrees of urbanization using a study design based on previous and ongoing work in the San Antonio area (Musgrove and others, 2010, 2011, 2019; Opsahl, 2012; Opsahl and others, 2020).



Map identifier	Short name
1	Salado Creek*
2	West Elm Creek*
3	Shavano well*
4	Encino Rio well*
5	Parkwood well
6	J–17 well
7	Comal Springs
8	Rainfall data site

*See table 1.

Figure 1. Hydrogeologic setting and data collection sites in the San Antonio segment of the Edwards aquifer, Bexar County, south-central Texas. Note that the Trinity aquifer underlies the entire San Antonio segment of the Edwards aquifer.

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A more complete description of the study area and the geologic and hydrologic characteristics of the San Antonio segment of the Edwards aquifer that make it vulnerable to contamination is provided in previous reports (Musgrove and others, 2010, 2016, 2019; Opsahl and others, 2018, 2020).

Hydrologic and water-quality data were collected during 2017–19 at two sets of paired surface-water and groundwater sites (fig. 1). The first site pair included Salado Creek (site 1) and the Shavano well (site 3), both in areas minimally influenced by urban development. The second site pair included West Elm Creek (site 2) and the Encino Rio well (site 4), where considerable urban development is taking place. Stages of the two creeks, water-level altitudes (WLAs) in the two wells, and the temperature and specific conductance of water in the wells were monitored continuously. Discrete water samples were collected from the wells and streams at approximately 8-week intervals and in response to storm events. These samples were analyzed for concentrations of chemical constituents and for a large suite of pesticides and pesticide degradates.

Temporal and Spatial Variability in Hydrology and Water Quality

During the first 11 months of the study, rainfall was below average, flow at West Elm Creek was infrequent, and WLAs at the Shavano well were uniformly declining (fig. 2). Following a period of above-average rainfall and resulting surface runoff in September 2018, flow in West Elm Creek was more frequent and stream stages were higher, and the WLA at the Encino Rio well increased nearly 70 feet (fig. 2). The rapid rise in WLA at the Encino Rio well represents groundwater recharge resulting from the direct hydrologic connectivity of SW and unconfined GW in the Edwards aquifer recharge zone. The Edwards aquifer is a limestone (karst) aquifer and such rapid responses to rainfall and runoff at both site pairs is to be expected, regardless of the degree of urbanization. Both continuous water-quality monitoring data and the chemical analysis of discrete water-quality samples showed corresponding changes in GW quality during periods of recharge (Opsahl and others, 2020).

The occurrence of pesticides in samples of stormwater runoff and groundwater collected during 2017–19 provides insight into the transport of water and any contained anthropogenic (human-created) contaminants into and within the Edwards aquifer. There were large differences in the number of different pesticides or pesticide degradates detected at the two SW sites: 7 different compounds were detected at the Salado Creek site, whereas 25 different compounds were detected at the more urbanized West Elm Creek site (table 1). The total number of pesticide detections per site and the average number of detections per sample were both five times higher in samples collected from West Elm Creek than in samples collected from Salado Creek. Although the number of different pesticides detected (13) was the same at the two GW sites, the number of pesticide detections was markedly different. Consistent with the large differences in the number of pesticide detections and in the number of detections per site between the more urbanized and less urbanized SW sites, a total of 42 pesticide detections were measured in samples collected from the Shavano well, which represents the lesser urbanized area, whereas 74 pesticide detections were measured in samples collected from the more urbanized Encino Rio well site. Overall, a diverse assortment of pesticides was detected in the samples collected from both wells, but the more frequent occurrences at the Encino Rio well are consistent with a larger urban stormwater runoff component in recharge source water than at the Shavano well.

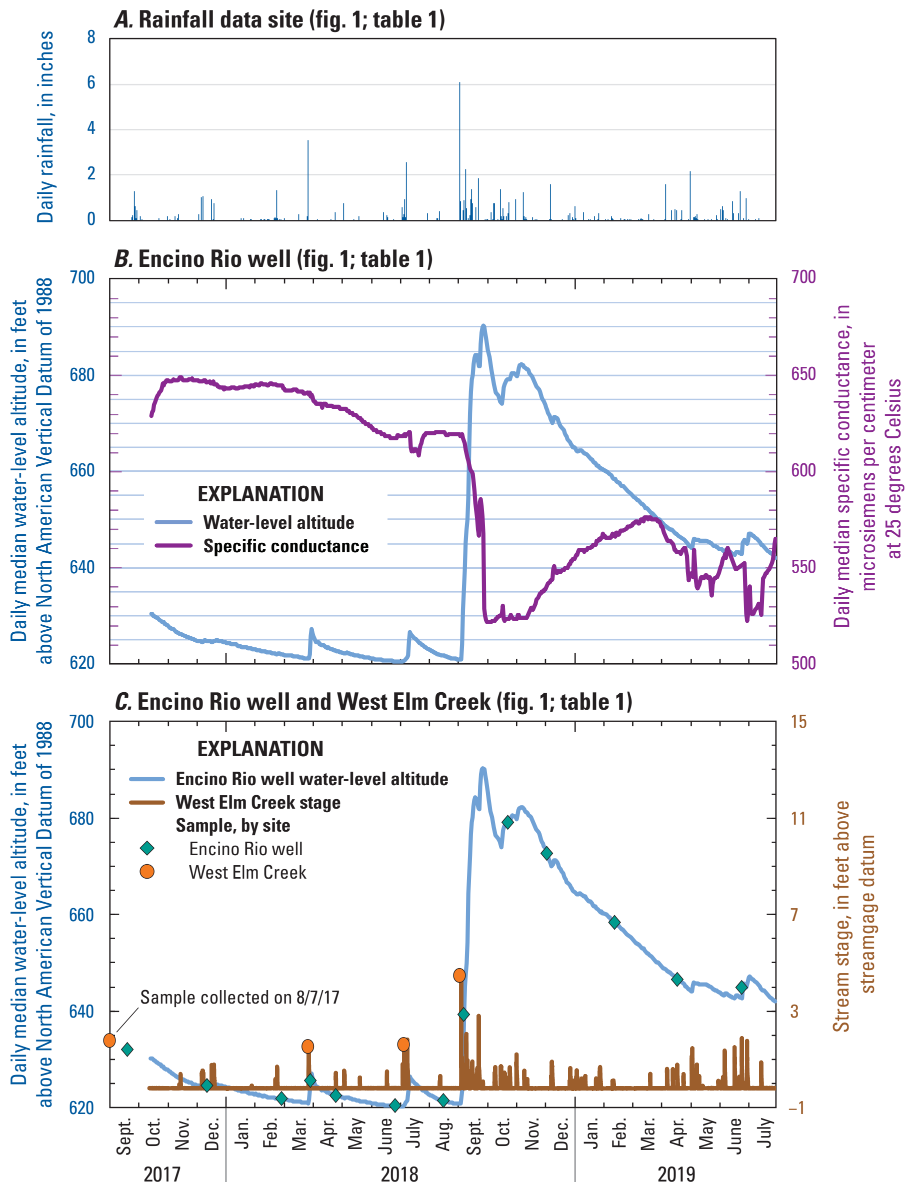

Figure 2. Time series of *A*, daily rainfall measured at the San Antonio International Airport (National Oceanic and Atmospheric Administration, 2020), *B*, water-level altitude and specific conductance from the Encino Rio well, and *C*, water-level altitude and stream stage data from the Encino Rio well and West Elm Creek, 2017–19.

Table 1. Summary of pesticide and pesticide degradate detections in surface-water and groundwater samples collected at sites in the San Antonio segment of the Edwards aquifer, 2017–19.

	Surface-water sites (fig. 1)		Groundwater sites (fig. 1)	
	Salado Creek	West Elm Creek	Shavano well	Encino Rio well
Number of samples	4	4	14	14
Number of different pesticides detected	7	25	13	13
Total number of detections per site	10	50	42	74
Average number of detections per sample[1]	2.5	12.5	3.0	5.3

[1]Calculated for each site as the total number of detections of all pesticides divided by the number of samples.

Implications for Edwards Aquifer Water Quality

Among all measured constituents, pesticides detected in discrete stormwater-runoff samples provided the clearest indication that urbanization is adversely affecting the quality of water in the Edwards aquifer. More specifically, a greater number of pesticides and a greater variety of pesticides were detected in samples collected from the more urbanized surface-water site. Not all pesticides have regulatory standards, but for those that do, there were no exceedances of individual pesticide concentrations relative to current (2020) drinking water standards (U.S. Environmental Protection Agency, 2019b). The observed hydrologic responses to rainfall and resulting surface runoff, and the corresponding changes in water quality in wells, are thought to result from the direct hydrologic connectivity of SW and unconfined GW. The patterns of GW-quality change, however, indicate mixing of water from multiple sources with the ambient water of the Edwards aquifer, including recent surface-derived recharge and possibly inflow from other aquifers, such as the underlying Trinity aquifer. Therefore, the effects of urbanization on GW quality cannot be inferred solely from the input of stormwater runoff, as changes related to local and regional hydrologic conditions also must be considered. The deeper, confined zone of the Edwards aquifer, which is downgradient of the unconfined zone, is still susceptible to contamination from urban sources, though changes in water quality in this confined zone would likely occur over longer timescales (Musgrove and others, 2019). It is recognized and should be noted that a single study comparing the results of the analyses of data from two site pairs cannot support definitive conclusions about the full effect of urbanization on surface-water/groundwater quality; however, this study does provide useful insights about the spatial and temporal variability of stormwater runoff and unconfined groundwater that are consistent with a conceptual model that depicts the Edwards aquifer surface-water/groundwater system as a single water resource.

Pump hoist truck at the Shavano Park at Fawn Drive site.

U.S. Geological Survey hydrographers collecting a groundwater sample at the Encino Rio site.

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