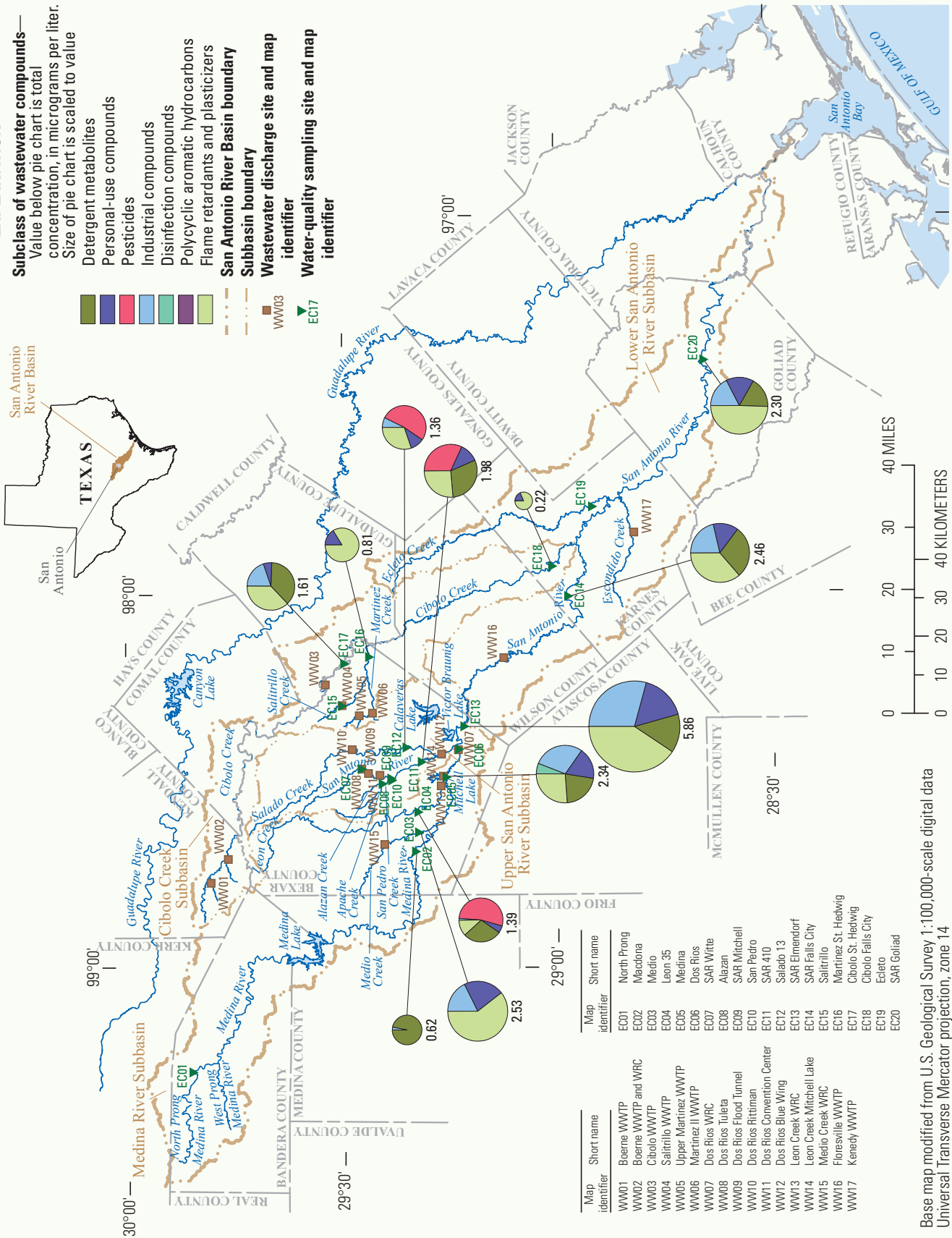


EXPLANATION

- Subclass of wastewater compounds—**
 Value below pie chart is total concentration, in micrograms per liter. Size of pie chart is scaled to value
- Detergent metabolites
 - Personal-use compounds
 - Pesticides
 - Industrial compounds
 - Disinfection compounds
 - Polycyclic aromatic hydrocarbons
 - Flame retardants and plasticizers
- San Antonio River Basin boundary**
- Subbasin boundary**
- Wastewater discharge site and map identifier**
- Water-quality sampling site and map identifier**



Map identifier	Short name	Map identifier	Short name
WW01	Boerne WWTP	EC01	North Prong
WW02	Boerne WWTP and WRC	EC02	Macdonna
WW03	Cibolo WWTP	EC03	Medina
WW04	Salitrillo WWTP	EC04	Leon 35
WW05	Upper Martinez WWTP	EC05	Medina
WW06	Martinez II WWTP	EC06	Dos Rios
WW07	Dos Rios WRC	EC07	SAR Write
WW08	Dos Rios Tuleta	EC08	Alazan
WW09	Dos Rios Flood Tunnel	EC09	SAR Mitchell
WW10	Dos Rios Rittman	EC10	San Pedro
WW11	Dos Rios Convention Center	EC11	SAR 410
WW12	Dos Rios Blue Wing	EC12	Salado 13
WW13	Leon Creek WRC	EC13	SAR Elmendorf
WW14	Leon Creek Mitchell Lake	EC14	SAR Falls City
WW15	Medio Creek WRC	EC15	Salitrillo
WW16	Floresville WWTP	EC16	Martinez St. Hedwig
WW17	Kenedy WWTP	EC17	Cibolo St. Hedwig
		EC18	Cibolo Falls City
		EC19	Ecleto
		EC20	SAR Goliad

Base map modified from U.S. Geological Survey 1:100,000-scale digital data
 Universal Transverse Mercator projection, zone 14
 North American Datum of 1983

Figure 1. Locations of wastewater discharge and water-quality sampling sites (2011–12) and relative concentrations and proportions of wastewater compounds in water-quality samples collected during the first synoptic sampling event, San Antonio River Basin, Texas, March–May 2011 (modified from fig. 13, Opsahl and Lambert, 2013).

Detections and Concentrations of CECs

Three synoptic sampling events were completed during 2011–12 to analyze for CECs in the San Antonio River Basin. During a synoptic sampling event, samples are collected from a number of sites at the same time to get a “snapshot” of how concentrations vary throughout the basin. The first and second synoptic sampling events included samples collected at the same 12 sampling sites. The third sampling event included samples collected at seven sites that were added to the study after the first two synoptic sampling events were completed. When the synoptic sampling events took place, there was no flow at the Ecletto site (EC19, fig. 1), so the samples at this rural site were collected at a separate date and time. Samples were analyzed for 54 wastewater compounds, 13 pharmaceuticals, 17 steroidal hormones, and 4 sterols. Overall, the concentrations of all CECs analyzed for during this study were low, generally close to or less than the laboratory reporting level.

Wastewater Compounds

Wastewater compounds typically found in treated domestic and industrial wastewater effluent are introduced to the environment primarily through point-source discharges from wastewater treatment plants (WWTPs) and water recycling centers (WRCs) and to a lesser degree through nonpoint sources such as seepage from septic systems, leakage from sewer lines, and urban runoff (Kolpin and others, 2004; Katz and others, 2010). During this study, wastewater compounds were aggregated into seven subclasses of compounds on the basis of similar uses or sources (fig. 2).

Wastewater compounds were detected more often than were pharmaceuticals or steroidal hormones and sterols. The subclasses of wastewater compounds that were most commonly detected were personal-use compounds, industrial compounds, and flame retardants and plasticizers. Thirty-two of the 54 compounds analyzed for were detected in at least one of the samples collected (fig. 2). The flame retardants tris (2-chloroethyl) phosphate and tris (dichloroisopropyl) phosphate were the most frequently detected wastewater compounds with measureable concentrations detected in 28 of 33 samples. Tris (2-chloroethyl) phosphate and tris (dichloroisopropyl) phosphate are possible endocrine disruptors commonly used in clothing garments, mattresses, and sofa cushions (Stapleton and others, 2009). The highest measured concentration of a wastewater compound (1.90 micrograms per liter [$\mu\text{g}/\text{L}$]) was for the fragrance hexahydrohexamethyl-cyclopentabenzopyran (HHCB); for all samples, concentrations of this compound ranged from an estimated concentration of 0.006 $\mu\text{g}/\text{L}$ to 1.90 $\mu\text{g}/\text{L}$. The second highest concentration of a wastewater compound measured in the study was 1.4 $\mu\text{g}/\text{L}$ for the compound 5-methyl-1H-benzotriazole, a corrosion inhibitor used in numerous products including dishwasher detergents, de-icing fluids, automotive antifreeze formulations, brake fluids, fluids for industrial cooling systems, and metal-cutting fluids (Kiss and Fries, 2009). Sample concentrations for this compound ranged from an estimated 0.1 to 1.4 $\mu\text{g}/\text{L}$. All of the remaining wastewater compounds were measured at concentrations less than 1.0 $\mu\text{g}/\text{L}$ or were not detected.

Pharmaceuticals

Pharmaceuticals are manufactured chemical substances administered to humans or animals to treat or prevent illness or disease or to promote the growth of food animals (Landers and others, 2012). Polar (2007, p. 7) explained that the active ingredients in pharmaceuticals “are of special concern because of the volumes introduced to the environment, their endocrine disrupting activity, and a potential increase of bacterial resistance.” Pharmaceuticals and their metabolites are introduced into the environment as a component of treated wastewater effluent (Polar, 2007), direct excretion, or discharge of effluent from pharmaceutical manufacturing facilities (Phillips and others, 2010). Samples were analyzed for 13 pharmaceuticals, and 4 were detected: 1 nonprescription pharmaceutical (diphenhydramine) and 3 commonly used prescription pharmaceuticals or pharmaceutical metabolites (carbamazepine, dehydronifedipine, and sulfamethoxazole) (fig. 3). Diphenhydramine, primarily used as an antihistamine (O’Neil, 2001), was detected in 6 of 34 samples. Carbamazepine, an anticonvulsant, was the most frequently detected pharmaceutical (24 of 34 samples). Carbamazepine degrades slowly in the environment and is resistant to breakdown during water treatment (Polar, 2007; Walker and others, 2012). Dehydronifedipine is the main metabolite of nifedipine, a drug used to treat cardiac disorders (Polar, 2007); dehydronifedipine was detected in 13 of 34 samples. The antibiotic sulfamethoxazole was detected in 15 of 34 samples.

Steroidal Hormones and Sterols

Steroidal hormones and sterols are natural, biologically produced chemicals that serve a variety of functions in animal and plant metabolism. Synthetic hormone derivatives such as anabolic steroids and birth-control compounds are widely used by humans (Reif and others, 2012). Both natural and synthetic hormones can be introduced into the environment through direct excretion or disposal into wastewater treatment systems and have been detected in aquatic systems, promoting concerns about negative effects on freshwater biota (National Academy of Sciences, 1999). Eight of 17 steroidal hormones and sterols were detected in at least one of the samples collected (fig. 4). Estrone, a metabolite of 17-*beta*-estradiol, was the most commonly detected compound related to estrogen and was detected in 9 of 34 samples. Four plant and animal sterols were analyzed (plant sterols *beta*-sitosterol and *beta*-stigmastanol; animal sterols 3-*beta*-coprostanol and cholesterol), resulting in a total of 41 detections in 34 samples. Cholesterol was detected in 19 of 34 samples, making it the most frequently detected sterol.

Distribution of CECs in the San Antonio River Basin

Results from the synoptic sampling events during 2011 indicated that the number of detections and the total concentrations of CECs were higher in samples collected at sites downstream from WWTP and WRC outfalls compared to the number of detections and total concentrations measured in samples collected at other sampling sites in the study area. Among all of the sampling sites, the highest number of detections and concentrations of CECs were measured in the sample collected at the SAR Elmendorf site (EC13, fig. 1)

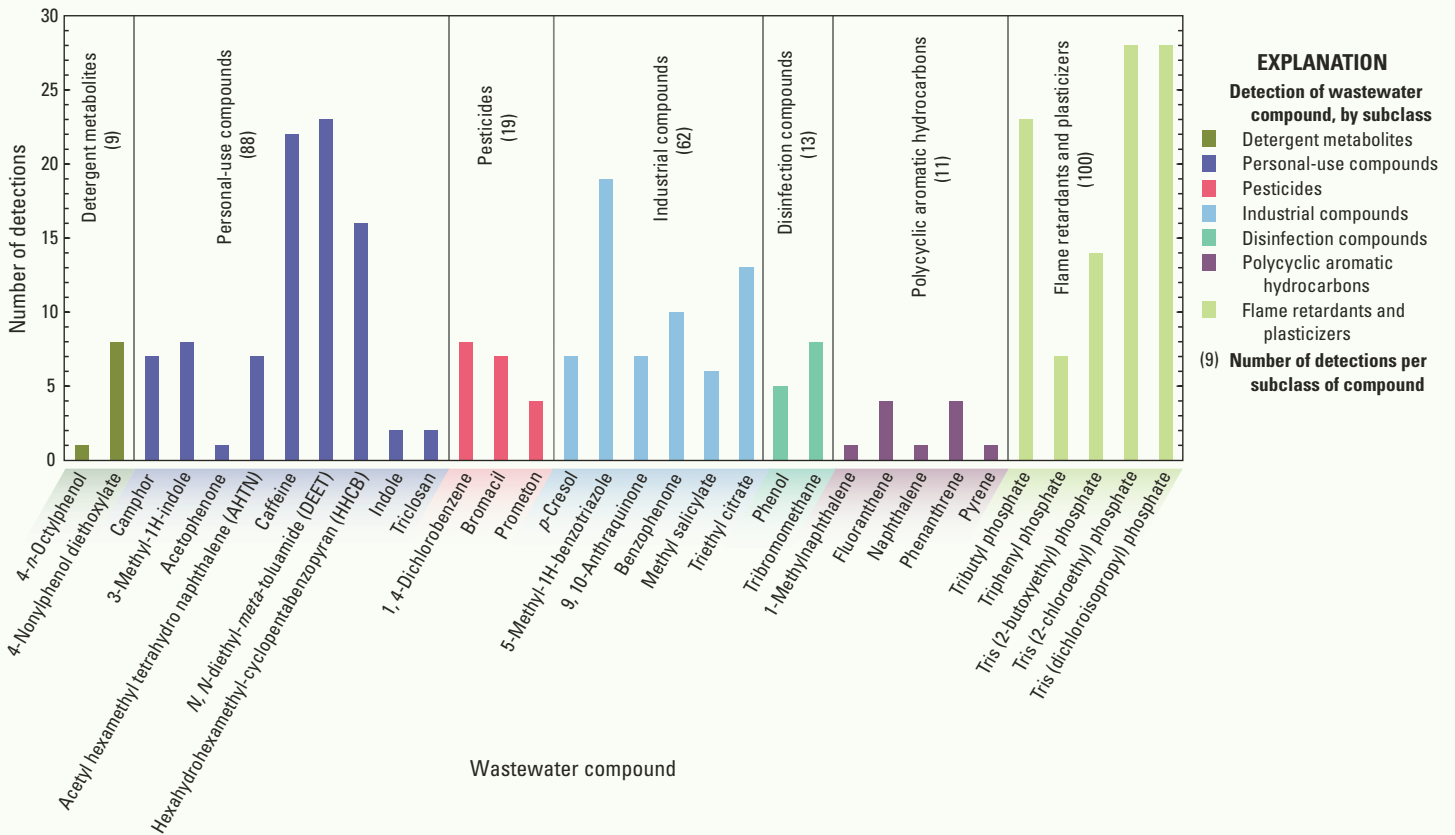


Figure 2. Wastewater compounds detected in 33 water-quality samples collected from the San Antonio River Basin, Texas, 2011–12 (modified from fig. 2, Opsahl and Lambert, 2013).

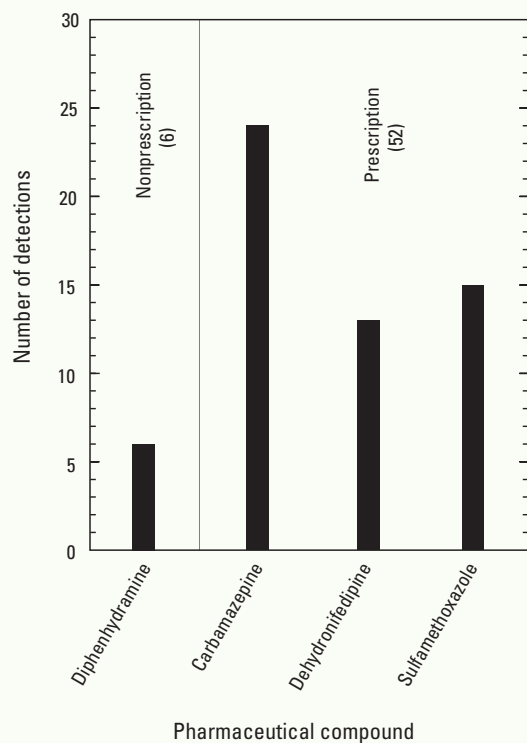


Figure 3. Pharmaceutical compounds detected in 34 water-quality samples collected from the San Antonio River Basin, Texas, 2011–12 (modified from fig. 3, Opsahl and Lambert, 2013).

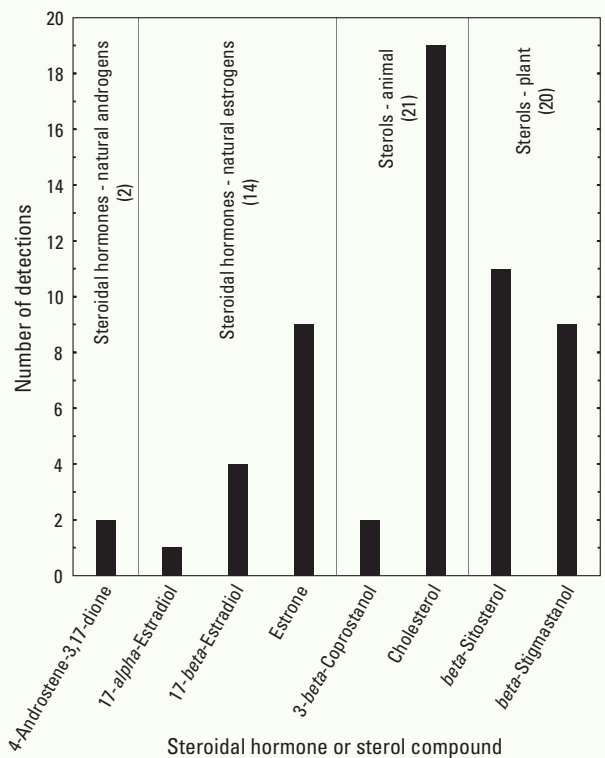


Figure 4. Steroidal hormones and sterols detected in 34 water-quality samples collected from the San Antonio River Basin, Texas, 2011–12 (modified from fig. 4, Opsahl and Lambert, 2013).

downstream from San Antonio. There also were detections of CECs in samples collected from urban sites with no large upstream source of treated wastewater; these detected CECs included 1,4-dichlorobenzene, *p*-cresol, phenol, acetyl hexamethyl tetrahydro naphthalene (AHTN), HHCB, tributyl phosphate, triethyl citrate, and triphenyl phosphate. Detections of these compounds indicate that many CECs can be present in streams flowing through urbanized areas without a large upstream source of treated wastewater. The presence of wastewater compounds at the Ecletto site (EC19, fig. 1) indicates that at least some wastewater compounds can be introduced into surface waters in rural parts of the San Antonio River Basin during runoff or by seepage from onsite wastewater treatment systems.

Few pharmaceuticals were detected in samples from streams without upstream outfalls of treated wastewater. The lower concentrations of these compounds at the furthest downstream sampling sites in the basin also indicate that some dilution or natural attenuation of pharmaceuticals may occur during transport. Because the Ecletto site (EC19, fig. 1) is in a rural rangeland area that does not receive runoff from San Antonio, the steroidal hormones and sterols detected in the sample collected at this site likely were derived from cattle waste rather than from wastewater effluent.

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Front page photograph: View of the San Antonio River oriented upstream in San Antonio, Texas (photograph taken on November 14, 2013, by Michael B. Nyman, U.S. Geological Survey; from Opsahl and Lambert, 2013).

Back page photograph: U.S. Geological Survey hydrographers collecting water sample for analysis of compounds of emerging concern (photograph taken on May 31, 2011, by Chiquita S. Lopez, U.S. Geological Survey; from Opsahl and Lambert, 2013).

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