Leona River Watershed Geographic Information System Inventory and Bacteria Source Survey

Prepared for:

Texas State Soil and Water Conservation Board
Project 11-50

Prepared by:

Anne McFarland
Todd Adams

Texas Institute for Applied Environmental Research
Tarleton State University
Stephenville, Texas

TR1304

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Cover photograph is the Leona River within the Uvalde Municipal Park taken by TIAER on September 8, 2010.

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SECTION 1

Introduction

Problem Statement

The Leona River (Segment 2109) is a tributary of the Frio River within the Nueces River Basin in southwest Texas. Segment 2109, as defined by the Texas Commission on Environmental Quality (TCEQ), stretches 91 miles from the confluence of Leona River with the Frio River about six miles north of the City of Dilley in Frio County, through the City of Batesville in Zavala County and the City of Uvalde in Uvalde County, to the crossing of the Leona River with U.S. 83 just north of Uvalde, Texas (Figure 1). Assessment of water quality along the Leona River indicates that Segment 2109 meets most criteria and screening levels, but that the Leona River contains elevated bacteria and nitrate concentrations (TCEQ, 2011). The Texas Water Quality Inventory first noted concerns for nitrates along Segment 2109 in 2002. In 2006, Segment 2109 was first included on the Texas 303(d) List as impaired for contact recreation due to elevated bacteria concentrations (TCEQ, 2007a).

Of note, the 2010 Texas Water Quality Inventory was based on two categories of recreation use, contact and noncontact. In June 2010, the TCEQ adopted revisions to the Texas Surface Water Quality Standards (TSWQS) that expanded the designation of contact recreation into three categories based on varying degrees of interaction with the water, while maintaining a fourth category of noncontact recreation. These revisions were codified in the Texas Administrative Code (TAC), Title 30, Chapter 307 and became effective as a state rule on July 22, 2010 (TCEQ, 2010a). As a result of these revisions to the TSWQS, waterbodies listed as impaired based on bacteria for contact recreation may undergo a standards review to determine if primary contact recreation is appropriate or if a revision to the use category for recreation should be considered.

In the 2010 Texas 303(d) List, the bacteria impairment for the Leona River is classified as category 5c indicating that additional data and information are needed to determine whether or not a TMDL or some other type of action is needed for the Leona River (TCEQ, 2011b). Other types of actions may include verification of use attainment, revision of the designated use category for recreation, or development of a watershed protection plan (WPP). In the most current (2012) Texas 303(d) List, the Leona River is categorized as 5b, indicating that a review of the standards for one or more parameters will be conducted before a management strategy is selected, including a possible revision to the water quality standards. As a separate part of this project, a Recreation Use Attainability Assessment was conducted to address the potential need for a standards revision (see Stroebel and McFarland, 2013).

The purpose of this report is to provide an inventory of available geographic information system (GIS) data for the Leona River watershed and a survey of potential bacteria sources as an aid in defining future actions with regard to water quality along the Leona River.

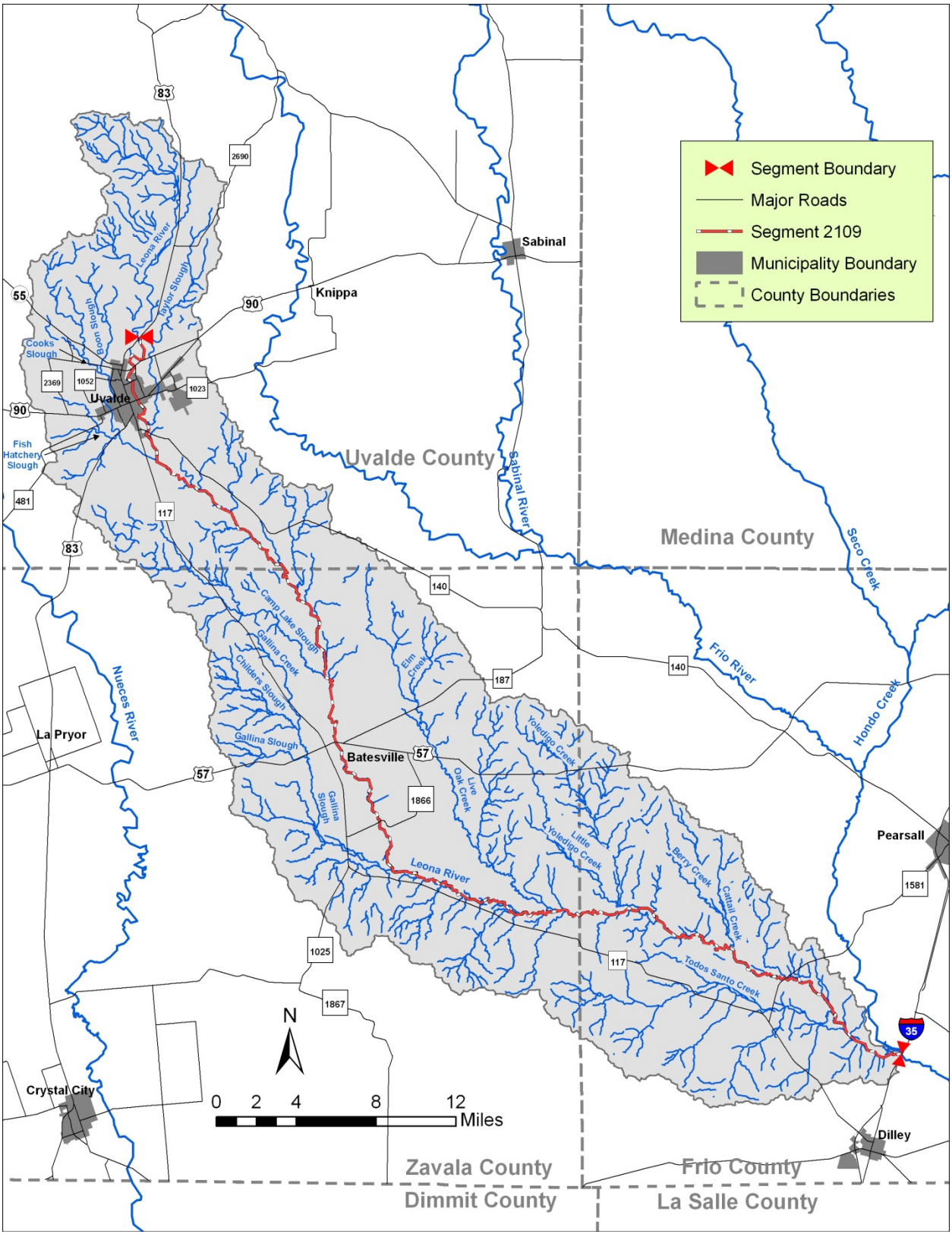

Figure 1 Map of Leona River watershed, Segment 2109.

Study Area

The Leona River watershed covers about 429,000 acres and includes the cities of Uvalde (estimated population 16,000) and Batesville (estimated population 1,100). The channel of the Leona River is fairly well delineated in its upper portion, although some tributary channels are difficult to define as water at times flows underground while crossing limestones associated with the Balcones Fault Zone (BFZ). The BFZ is associated with the Edwards Aquifer and underlies most of the Leona watershed within Uvalde County (Figure 2; George et al., 2011). These porous or fractured limestones of the BFZ are a conduit for recharge of the Edwards Aquifer, and when groundwater levels are high, springs, at times, feed streamflow. Several groups of springs have been noted along the Leona River in Uvalde County (Brune, 1975), but these springs can be difficult to locate as they often flow beneath the surface of the river or do not flow when extended dry conditions occur due to lowering aquifer water levels. While the upper third of the Leona watershed largely overlays the Edwards Aquifer, the lower two-thirds overlays the Carizo-Wilcox Aquifer (George, et al., 2011). The Carrizo-Wilcox Aquifer is predominantly composed of sand locally interbedded with gravel, silt, clay, and lignite, so percolation of surface water into groundwater is slower than within the region of the Edwards Aquifer (Ashworth and Hopkins, 1995). Along its lower reaches, the Leona River flows through fairly flat terrain and often appears only as shallow depressions in the landscape as it nears its confluence with the Frio River.

The Leona River is part of the Southern Texas Plains Ecoregion (level III; Griffith et al., 2007), which was once covered with grassland and savanna vegetation, while thorny brush, such as mesquite (*Prosopis glandulosa*), now dominate much of the landscape. As part of the Southern Texas Plains, the Leona River watershed falls within the Northern Nueces Alluvial Plains (level IV ecoregion), which differs from much of the Southern Texas Plains by having a higher annual precipitation (generally 22 to 28 inches) and deeper soils. Large parts of the watershed are rangeland with honey mesquite, plateau live oak (*Quercus fusiformis*), guajillo (*Acacia berlandieri*), and blackbrush (*Acacia rigidula*) as dominate woody species.

The Leona River watershed is largely rural with cropland and pastureland as major land uses. Wheat (*Triticum sp.*), sorghum (*Sorghum bicolor*), cotton (*Gossypium sp*.), vegetables, and corn (*Zea mays*) are among the leading crops in all three counties (USDA-NASS, 2011). Frio County is distinct from Uvalde and Zavala Counties in that peanut (*Arachis hypogaea*) production is also a major crop. Most cropland areas are irrigated, and with the production of winter vegetables, Frio and Zavala Counties are included in what is commonly referred to as the Winter Garden Region of south Texas (Odintz, 2012). Large amounts of land in all three counties are also used as pasture for hay or grazing of primarily beef cattle, although sheep production is also prominent in Uvalde County. Another notable feature in the upper portion of the watershed is the U.S. Fish and Wildlife Service National Fish Hatchery located in Uvalde, Texas, which raises imperiled fishes, such as the fountain darter (*Etheostoma fonticola*), Comanche Springs pupfish (*Cyprinodon elegans*), and Devils River minnow (*Cryprindodon elegans*).

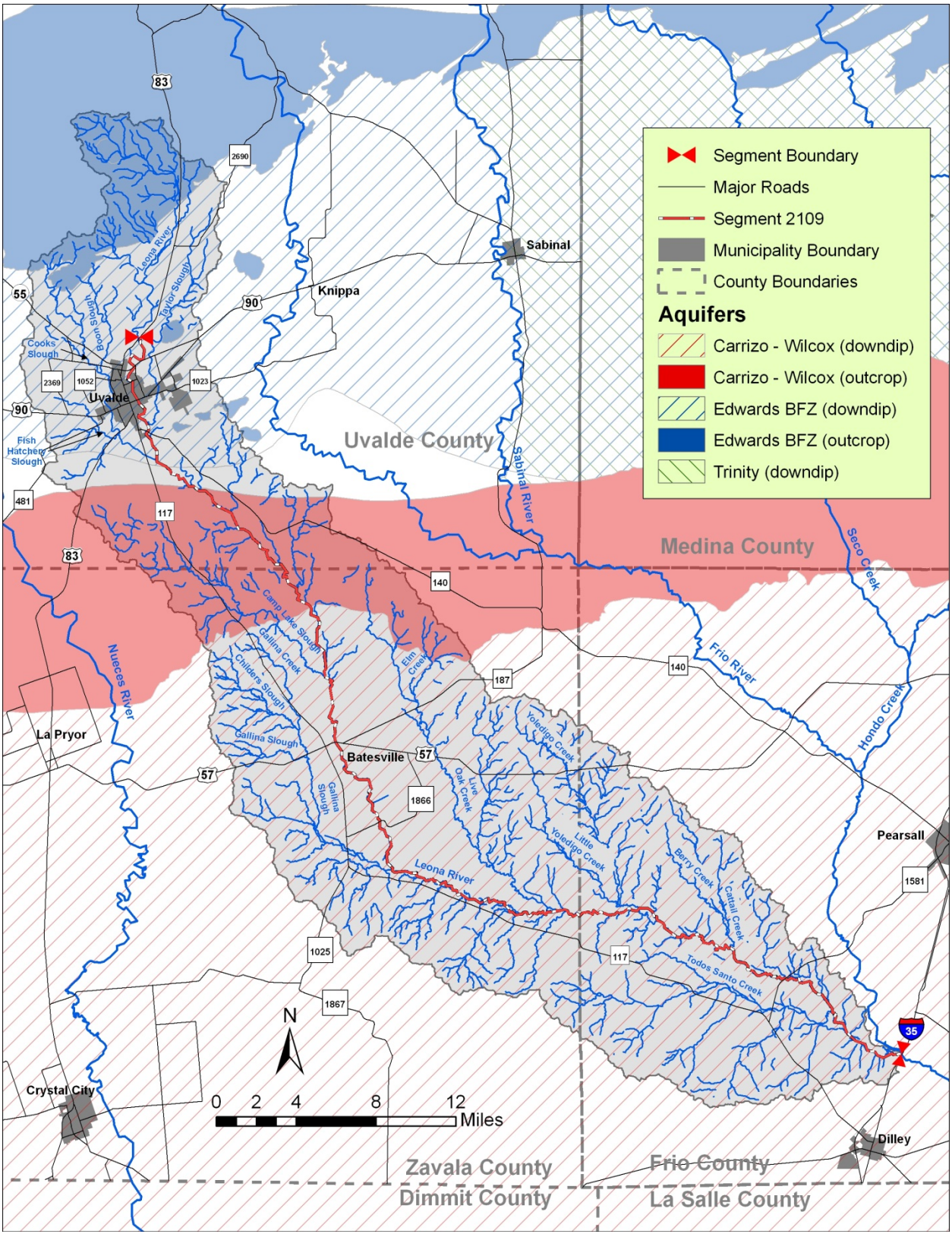

Figure 2 Map of Leona River watershed showing underlying major aquifers. Source for aquifer data (TWDB).

SECTION 2

GIS Inventory

The GIS inventory for the Leona River watershed was compiled from existing sources and an updated land use layer as described below.

Digital Elevation Models (DEMs)

Digital elevation models with 30-meter resolution were downloaded from the USGS seamless server to aid in defining the watershed area for the Leona River (USGS, 2010a). Delineation of the project watershed and subwatersheds were performed using the ArcView Soil and Water Assessment Tool (AVSWAT-X for SWAT 2005, released July 2006).

Land Use/Land Cover Classification

The Spatial Science Laboratory at Texas A&M University in College Station, Texas provided an updated land use classification for the Leona River watershed. This updated land use was developed from National Agriculture Imagery Program (NAIP) aerial images from 2004-2010 using a combination of satellite based image classification schemes, and where needed, "heads-up digitizing" of aerial photos which involves manual digitizing on screen of digital ortho quarter quads (DOQQs) or other existing maps or images of the watershed. The land classification was compared to the 2006 National Land Cover Database (NLCD) and verified via groundtruthing conducted by TIAER.

The land use was delineated into the following categories:

- Developed Open Space - Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
- Developed Low Intensity - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49% of total cover. These areas most commonly include single-family housing units.
- Developed Medium Intensity - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50-79% of the total cover. These areas most commonly include single-family housing units.
- Developed High Intensity- Includes highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80-100% of the total cover.
- Open Water - All areas of open water, generally with less than 25% cover of vegetation or soil.
- Barren Land - (Rock/Sand/Clay) - Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and

other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover and includes transitional areas.

- Forested Land – Areas dominated by trees generally greater than 5 meters tall, and greater than 50% of total vegetation cover.
- Low Density Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% but less than 50% of total vegetation cover.
- Near Riparian Forested Land – Areas dominated by trees generally greater than 5 meters tall, and greater than 50% of total vegetation cover. These areas are found in near proximity (within 30-60 m) to streams, creeks and/or rivers.
- Shrubland – Areas dominated by shrubs less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation.
- Grassland Herbaceous – Areas dominated by gramanoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing and are also commonly referred to as rangeland.
- Pasture Hay - Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation.
- Cultivated Crops - Areas used for the production of annual crops, such as corn, soybeans, vegetables, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled.

These 12 categories largely follow the category definitions used by NLCD as described by Homer, et al. (2004). For presentation purposes, four categories of developed land were combined into one category, Developed, and the categories of Forested Land and Low Density Forest were also combined as Forest (Table 1 and Figure 3). Near Riparian Forest was left as a separate category. The dominant land use categories within the Leona River watershed reflect a generally rural landscape (Figure 3).

Table 1 Summary of land use/land cover classifications for the Leona River watershed.

Category	Acres	Percent
Shrubland	206,517	48.1
Woodland	110,848	25.8
Cultivated Crops	41,416	9.7
Pasture Hay	25,699	6
Grassland Herbaceous	17,573	4.1
Developed	13,893	3.2
Near Riparian Forest	12,014	2.8
Barren	654	0.2
Open Water	630	0.1
Total	429,244	

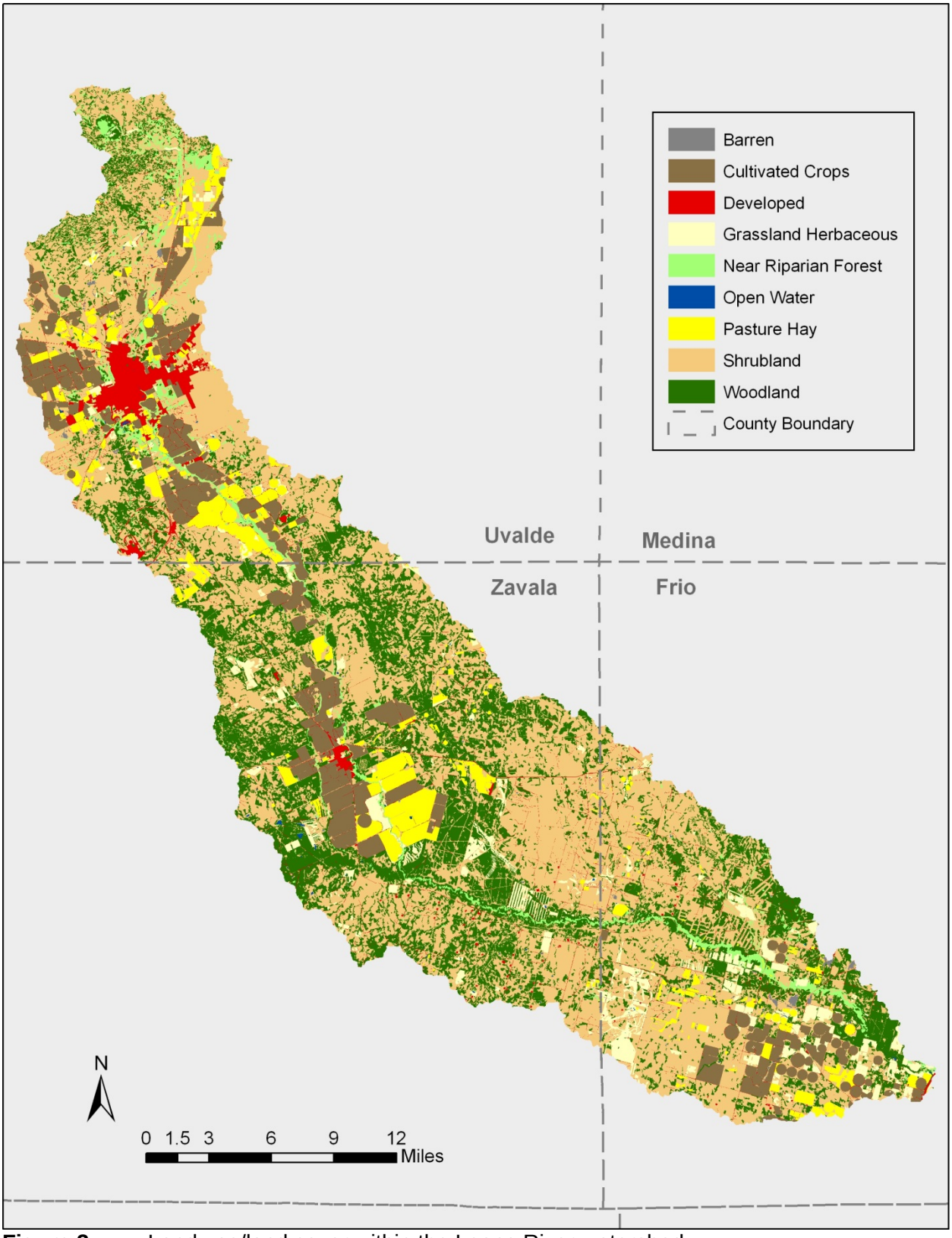

Figure 3 Land use/land cover within the Leona River watershed.

Watershed Features

Other features of the watershed that were obtained as GIS layers included the stream network, roads, reservoirs, populated areas, public parks, soils data, and wetlands. Digital orthophoto quarter quads (DOQQs) were also accessed for the watershed. Sources of these other GIS layers are presented below. Most of these additional features are shown in Figure 4, except soils and the DOQQs. Figure 5 shows a close up of the upper third of the watershed, which includes the City of Uvalde where many watershed features are located.

Stream Network

A spatial GIS layer of the stream network for the State of Texas was obtained from the National Hydrography Dataset (NHD), which is maintained by the United States Geological Survey (USGS, 2010b). The NHD is a digital vector dataset that contains features such as lakes, ponds, streams, rivers, canals, dams and stream gages. These data are designed to be used in general mapping and in the analysis of surface-water systems.

Roads

Spatial information on roads was obtained from the Texas Natural Resources Information System (TNRIS) website maintained by the Texas Water Development Board (TWDB, 2010). The road file is an updated, digital version of the transportation features found on the 7.5 minute, 1:24,000 scale USGS quadrangle maps.

Populated Areas

A GIS layer for municipalities was downloaded from the TNRIS website (TWDB, 2012) and other populated areas indicated as census designated places (CDPs) were obtained via email from the TSSWCB (Warrick, 2012).

Reservoirs and Flood Retardation Structures

The shapefile for Public Law 566 (PL566) reservoirs (floodwater retarding structures) was provided by the TSSWCB to TIAER on January 14, 2011 via email. Three PL566 reservoirs (SCS Site 1 on Cooks Slough, Site 2a on Boon Slough and Site 3 on the Leona River) have been constructed. The normal capacity of both these PL566 reservoirs is 200 acre feet or less, although during flood events they have the capacity to hold many times that amount.

Hoag Dam is located within the Fort Inge Historical Park along the Leona River just south of the City of Uvalde and was constructed in 1962. Hoag Dam is owned by the County of Uvalde and was built primarily for recreational purposes. The normal storage capacity of Hoag Dam is 80 acre feet with a flood capacity of about 160 acre ft.

Public Parks

A GIS layer of public parks for the entire state of Texas was downloaded from the TNRIS website (TWDB, 2012).

DOQQs

DOQQs are aerial photos that have been geometrically corrected to remove distortions. Digital aerial images for the Leona River watershed were obtained from the TNRIS website (TWDB, 2011) and represent National Agricultural Imagery Program (NAIP) ortho imagery produced by the United States Department of Agriculture (USDA) Farm Service Agency Aerial Photography Field Office. The images obtained are from the 2010 NAIP 1 meter.

Soils

Soils data for Uvalde, Zavala and Frio Counties were obtained from the USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database (NRCS, 2012). The SSURGO database represents the most detailed level of soil mapping done by the NRCS and provides in a digital format the information within the county level soil surveys.

Wetlands

The Cook Slough Wetlands was developed in 2006 as a way to improve the wastewater quality from the Uvalde WWTF. The wetlands area covers about 100 acres representing a series of ponds located adjacent to the Uvalde WWTF on County Road (CR) 106. Effluent flows through these ponds prior to entering Cooks Slough and then the Leona River.

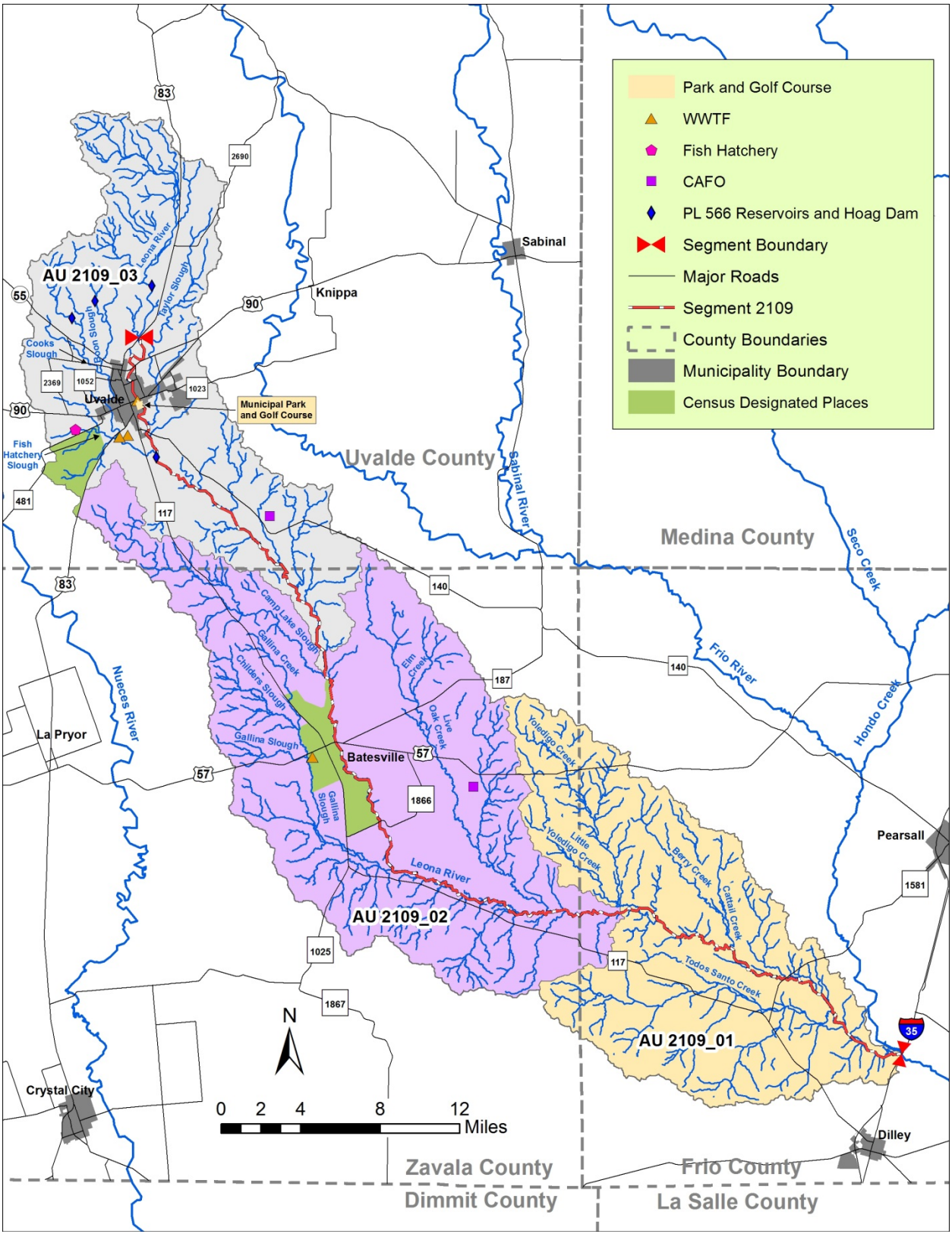

Figure 4 Major features throughout the Leona River watershed.

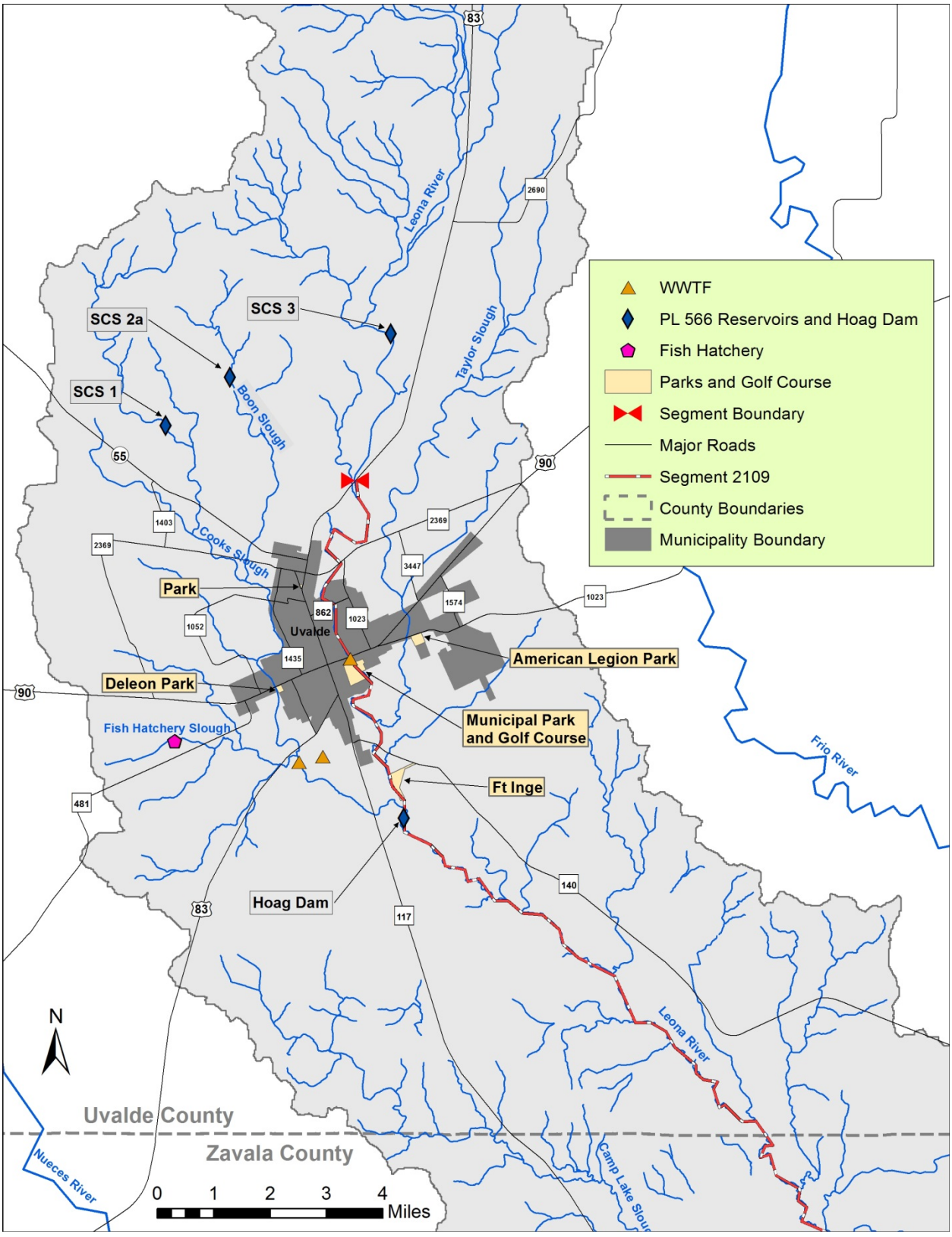

Figure 5 Watershed features in the upper portion of the Leona River watershed.

Monitoring Stations

SWQM Stations

The TCEQ publicly available online Surface Water Quality Monitoring Information System (SWQMIS) was queried for stations within Segment 2109 (TCEQ, 2011c). Within SWQMIS, 14 stations were listed (Table 2 and Figure 6). Of these 14 stations, 3 are routinely monitored by TCEQ (12985, 12987, and 12989) and 1 by NRA (18418) on a quarterly basis.

Based on information from the Texas Water Quality Inventory, Segment 2109 is divided into three assessment units (AUs). Assessment unit 2109_01 extends from the downstream end of segment to the confluence of Yoledigo Creek, AU 2109_02 extends from the confluence of Yoledigo Creek to the confluence of Camp Lake Slough, and AU 2109_03 extends from the confluence of Camp Lake Slough to the upper end of segment of the Leona River (Figure 6).

Table 2 SWQMIS stations within Leona River, Segment 2109

TCEQ Station No.	Station Location Description	Station Type (mainstem, tributary or pond)	Latitude	Longitude
12956	Cooks Slough at FM 117	Tributary	29.171288	-99.772269
12957	Cooks Slough downstream Uvalde WWTF	Tributary	29.180994	-99.792311
12958	Fish Hatchery Slough at US 83	Tributary	29.177324	-99.783421
12959	Cooks Slough at US HWY 83	Tributary	29.189423	-99.792541
12985	Leona River at FM 1581	Mainstem	28.793011	-99.241125
12986	Leona River at Loma Vista Road	Mainstem	28.840500	-99.407627
12987	Leona River at US 57	Mainstem	28.963631	-99.614258
12988	Leona River SE of Uvalde	Mainstem	29.153347	-99.740833
12989	Leona River at Hoags Dam	Mainstem	29.170088	-99.763183
12990	Leona River at FM 140	Mainstem	29.188787	-99.770980
12991	Leona River Uvalde Golf Course	Mainstem	29.208355	-99.777177
12992	Leona River at Highway 90 west	Mainstem	29.211790	-99.779766
17980	Lake El Caballo NFTS 0196	Pond	28.906500	-99.649390
18418	Leona River upstream of FM 140	Mainstem	29.191935	-99.770508

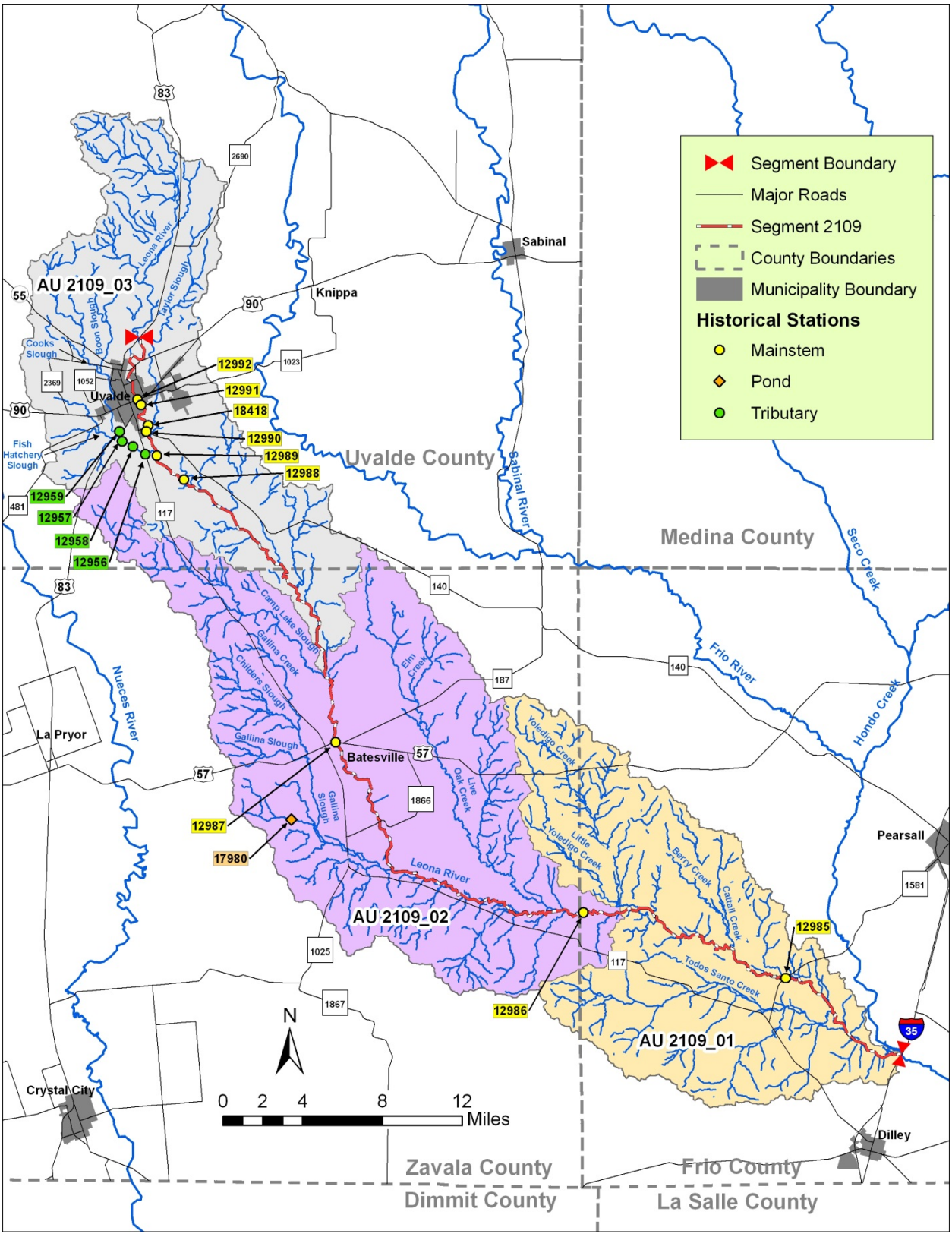

Figure 6 Location of historical TCEQ stations within the Leona River watershed. (AU indicates assessment unit)

USGS Gages

With regard to daily streamflow and water level data, four USGS gaging stations have been located in the watershed (Figure 7; USGS, 2012), but only three have had routine data collected within the last few years (Table 3). Station 8204500 on the Leona River near Divot, Texas has a short history of discharge data from 1924 through 1929, although this location is still used on rare occasions (twice in the last 10 years) by the USGS to collect field measurements of discharge. Divot, Texas is located at the intersection of Farm roads 1581 and 117 and is considered a ghost town with an unknown population; thus, it no longer appears on most maps (Ochoa, 2012). Only two USGS stations are currently operating with data reported real-time. These are station 8204005 on the Leona River south of Uvalde, where discharge and gage height are reported, and station 8203450 north of Uvalde, where only gage height is reported. Station 8204250 on the Leona River near Batesville was discontinued in August 2010 due to funding shortfalls, but for about three years reported both discharge and gage height. Of note, station 8204005 on the Leona River near Uvalde is also in very close proximity and considered co-located with TCEQ water quality monitoring station 12988. Also at the same location as station 8204005, 572 field measurements of stream stage and discharge were available for station 8204000 (Leona Springs near Uvalde, TX) starting on February 7, 1939 and ending on March 7, 2007. Another field measurement station (8204200) is located on the Leona River at SH 57 near Batesville, Texas, but only two flow measurements have been taken at this location.

Table 3 History of daily discharge and gage height data for USGS stations within the Leona River watershed. Source: USGS (2012).

Station Number	Station Description	Latitude	Longitude	Discharge Data		Gage Height Data	
				Start Date	End Date	Start Date	End Date
8204500	Leona River near Divot, TX	28.792778	99.240833	01May1924	30Sep1929	--	--
8204250	Leona River at FM 1866 near Batesville	28.905833	99.577222	22May2008	03Jan2011	23May2008	03Jan2011
8204005[a]	Leona River near Uvalde, TX	29.154167	99.743056	01Mar2003	Present	01Mar2003	Present
8203450	Leona River at CR 429A near Uvalde, TX	29.345278	99.748889	--	--	22Jan2010	Present

a. Station 8204000, Leona Springs near Uvalde, TX is a USGS station at the same location as 8204005. Station 8204000 has field measurements back to 1939, but not daily data.

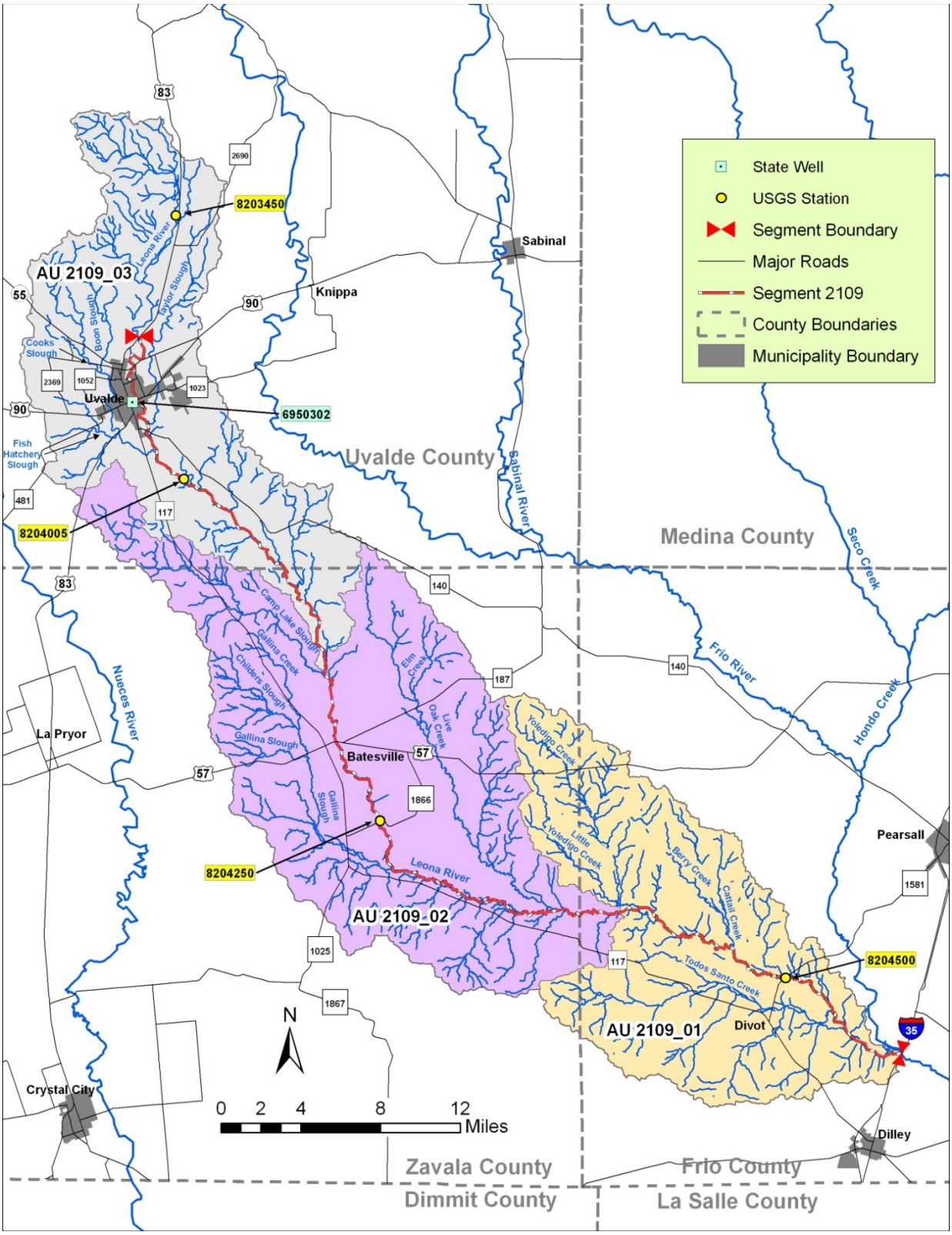

Figure 7 USGS daily stream gaging stations and EAA State Well Index site within the Leona River watershed. (Note: State Well 6950302 is also referenced as Index Well J-27).

Groundwater Wells

Because of the importance of area for recharge to the Edwards Aquifer, the Edwards Aquifer Authority (EAA) maintains a continuous water level monitoring station within the City of Uvalde. This station is State Well number 6950302 (Figure 7) and is also referenced as Index Well J-27 (Uvalde) by the EAA. Data for State Well 6950302 extend back to October 1940 and are generally available on a daily basis (see McFarland and Adams, 2013). Levels within State Well 6950302 are used by the EAA to aid in triggering critical periods for reductions in groundwater withdrawals by permitted municipal, industrial and irrigation users of the Edwards Aquifer (EAA, 2012).

The TWDB maintains a database of statewide well locations by county (TWDB, 2012). Along with this well database is a compilation of groundwater quality reports. The Geographic Information System (GIS) shapefile for well locations was downloaded from the TWDB website and overlaid with the Leona River watershed boundary to determine which wells by county were reported in the watershed area. No bacteria data were within any of the water quality reports, but nitrate-nitrogen data were often reported (see McFarland and Adams, 2013).

SECTION 3

Bacteria Source Survey

Potential sources of fecal pollution, as measured by indicator bacteria *E. coli*, can be divided into two primary categories: *regulated* and *non-regulated*. Pollution sources that are regulated have permits issued by TCEQ under the Texas Pollutant Discharge Elimination System (TPDES) and/or by the USEPA under the National Pollutant Discharge Elimination System and are generally point sources. Examples of regulated sources are WWTF discharges and stormwater discharges from industries, construction, and municipal separate storm sewer systems (MS4s) of cities; and concentrated animal feeding operations (CAFOs). These various regulated sources are required to have either an individual permit that is specific for their facility or operate under a general permit. Non-regulated sources are typically nonpoint source in nature, meaning the pollution originates from multiple diffuse locations and is usually carried to surface waters by rainfall runoff and is not regulated by permit under the TPDES.

Permitted Sources

Wastewater Treatment and Other Direct Discharge Facilities

There are two permitted WWTFs located within Segment 2109, the City of Uvalde and the Batesville Water Supply Corporation (WSC), and a third permitted discharge representing flush water from the U.S. Fish and Wildlife Service National Fish Hatchery in Uvalde (Figure 4). A vegetable processing plant operated by TAFMI, Inc (previously Agrilink Foods) located north of Uvalde had a permit to discharge processing wastewater via land irrigation, but according to TCEQ records queried on February 7, 2012, this operation no longer has an active permit, thus, it is not included in Figure 4.

With regard to bacteria data from these discharges, no *E. coli* data were available, but future monitoring is anticipated. As of January 1, 2010, a new TCEQ rule requiring bacteria effluent limits and monitoring requirements was established that will be applied to all new and amended WWTF permits. On December 16, 2011, the Batesville WSC permit was amended to require *E. coli* monitoring of effluents with limits of 126 CFU/100 mL as a daily average or 394 CFU/100 mL in any single grab sample. The TCEQ has not yet applied these rules to the other WWTF permits within the Leona River watershed, but will as each permit comes up for renewal. The City of Uvalde WWTF permit expires May 1, 2014.

The City of Uvalde WWTF has three outfalls permitted for a total average daily flow of 0.97 million gallon per day (MGD). Outfall 001 is located at the facility south of the City and discharges into a series of ponds developed as wetlands, which then flow into Cooks Slough, a tributary of the Leona River. A portion of the effluent is generally diverted and piped to Outfall 002, which discharges directly into the Leona River at a point within the Uvalde City Park. Of the effluent diverted to the Uvalde City Park, a small portion is often pumped into a holding pond for use as irrigation water on the Municipal Golf Course. Based on a review of discharge records, Outfall 003 for the City of Uvalde is seldom used, but is located near the facility and directly discharges into Cooks Slough, bypassing the wetland ponds. Discharge records for 2007-

2011 indicate an average discharge of 0.39 MGD for all three outfalls combined with 28% of discharge going through Outfall 001, 66% through Outfall 002, and 6% through Outfall 003 (USEPA, 2012).

According to the City of Uvalde WWTF permit (No. WQ0010306001, TX0023094), it is an activated sludge process plant operated in an extended aeration mode. Treatment units include bar screen, aeration basins, final clarifiers, sludge digester, chlorine contact chamber and dechlorination chamber. Sludge generated from the treatment facility is hauled by a registered transporter and disposed of at a TCEQ authorized land application site or landfill. Two permit violations were found on record for the City of Uvalde WWTF. In March, May and June 2006, the Uvalde WWTF failed to comply with permitted effluent limitations for total suspended solids (TSS) and was fined. In March and April 2010, the Uvalde WWTF failed to comply with permitted effluent limitations for ammonia nitrogen and was fined. Both these enforcement actions have been resolved.

The Batesville WSC WWTF is a pond system that includes four stabilization lagoons in series (No. WQ0014394001, TX0125385). As of December 2011, only one of the four lagoons in the series had filled. Evaporation is the primary means of effluent removal from the lagoons, and based on a records review of available data through December 2011, no discharges and, thus, no sampling has been reported. According to the permit amendment issued December 16, 2011, no sludge has been removed from the pond system. If sludge is removed it is to be disposed of at a TCEQ authorized land application site or co-disposal landfill. If a discharge were to occur from the Batesville pond system, it would flow into Gallina Slough, a major tributary of the Leona River located in AU 2109_02. The permitted discharge for the Batesville WWTF is 0.184 MGD.

The only other permitted discharge facility is the U.S. Fish and Wildlife Service National Fish Hatchery in Uvalde (No. WQ0014394001, TXG130017), which discharges flush water intermittently into Fish Hatchery Slough, a tributary of the Leona River west of Uvalde in AU 2109_03. Records accessed through EPA for 2008-2011 indicate an average discharge of 0.84 MGD (USEPA, 2012). A Level II Authorization applies to the Uvalde National Fish Hatchery indicating that the discharge must be less than 30 days per year or production less than 100,000 pounds harvest-weight for warm water aquatic species per year (TPDES General Permit, 2011).

Regulated Stormwater

The TPDES and the NPDES Municipal Separate Storm Sewer (MS4) Phase I and II rules require municipalities and certain other entities in urban areas to obtain permits for their stormwater systems. Phase I permits are individual permits for large and medium sized communities with populations exceeding 100,000, whereas Phase II permits are for smaller communities that are located within an “Urbanized Area”. An “Urbanized Area” is defined by the U.S. Census Bureau as an area with populations greater than 50,000 and with an overall population density of at least 1,000 people per square mile.

The City of Uvalde has a total population of 15,751 based on 2010 population estimates from US Census Bureau (Texas State Data Center, 2011) and is not considered to be located in an urbanized area based on population density, thus, Uvalde is not required to obtain a permit for their stormwater system. A separate population estimate of 2,171 is provided for the subdivision area, Uvalde Estates (Figure 13), which is located southwest of the City of Uvalde and is

considered a census-designated place (CDP). A CDP is a statistical geographic entity representing closely settled, unincorporated communities that are locally recognized and identified by name. These CDPs are the statistical equivalents of incorporated places, with the primary differences being the lack of both a legally-defined boundary and an active, functioning governmental structure, chartered by the state and administered by elected officials (Federal Register, 2008). The City of Batesville is unincorporated and has a population estimate of 1,068 based on the 2010 Census data.

Concentrated Animal Feeding Operations

There are two permitted concentrated animal feeding operations (CAFOs) located within Segment 2109 (Figure 4). The Chaparral Cattle Feedlot is located south of Uvalde in AU 2109_03 and the Live Oak Feedlot located southeast of Batesville within the watershed of Liveoak Creek in AU 2109_02. The Live Oak Feedlot is permitted for 8,000 head of beef cattle, while the Chaparral Cattle Feedlot is permitted for 10,000 head of beef cattle. A query of the TCEQ water quality permit site conducted on February 7, 2012 indicated no violations for either facility. These CAFOs have no discharge permits for wastewaters and manure.

Permitted Land Application of Sewage and Septage Sludge

A query of the TCEQ database for registered land application sites indicated no currently registered land application sites in Uvalde, Zavala, or Frio Counties that receive Class B sewage sludge or septage sludge. The City of Uvalde has had a registered beneficial land-use site for sludge disposal located outside of Uvalde about 0.9 miles west of the cross-section of FM 117 and FM 140, adjacent to the south side of FM 140, but the permit (WQ0004610000) for this location is inactive.

Non-permitted Sources

Non-Permitted Agricultural Activities and Domesticated Animals

Activities such as livestock grazing close to waterbodies and agricultural use of manure as fertilizer, can contribute *E. coli* to nearby waterbodies. Livestock statistics obtained from United States Department of Agriculture (USDA) National Agricultural Statistics Service website (USDA, 2012) indicated large numbers of beef cattle in all three counties and large numbers of goats and sheep in Uvalde County. It should be noted that the livestock numbers obtained by the USDA represent the number of livestock present at the time the survey was conducted, and those numbers likely change throughout the year due to economic factors and environmental conditions (e.g., market values, drought, etc.). These livestock statistics also represent the entirety of each county and are not specific to the watershed area. To represent estimates of livestock numbers within the Leona River watershed, available data from surveys conducted in 1997, 2002, and 2007 were averaged and then adjusted based on the percent of each county that lies within the Leona River watershed (Table 3-1). The Leona River watershed comprises only a relatively small portion of each county that is only 13 percent of Uvalde County, 23 percent of Zavala County, and 15 percent of Frio County.

Table 4 Estimated livestock numbers within the Leona River watershed based on statistics for Uvalde, Zavala, and Frio Counties adjusted for the percent of the county within the watershed. (Source USDA, 2012).

County	Year	Cattle & Calves (all beef)	All Goats	All Sheep	Horses and Ponies	Mules, Burros & Donkeys	Hogs
Frio[a]	2007	7,712	228	15	149	13	20
	2002	8,633	89	D[b]	94	5	19
	1997	10,833	142	D	79	3	78
Uvalde[a]	2007	6,808	3,355	1,307	142	55	16
	2002	8,362	3,984	2,892	154	12	41
	1997	8,718	8,357	4,269	145	28	203
Zavala[a]	2007	15,327	1,545	16	92	5	D
	2002	12,658	1,559	100	89	D	D
	1997	9,232	529	D	61	-	D
Leona River Watershed[a]	Area Adjusted Avg. 1997-2007	29,428	6,596	2,895	334	43	126

a. Estimated livestock numbers for Leona River watershed derived as a direct proportion of the watershed area within each county; 13 percent of Uvalde County, 23 percent of Zavala County, and 15 percent of Frio County.
b. D = cannot be disclosed, "-" = not available

Of note, the number of cattle and calves includes animals on feed in grain or in feedlot. Also, stakeholders from the Leona River watershed have indicated that sheep and goat numbers are high for the watershed and that most of sheep and goats in Uvalde County are in the more northern part of the county outside the watershed boundary.

Domestic pets are another unregulated source of *E. coli* bacteria, particularly from dogs, because storm runoff often carries these wastes into streams (USEPA, 2009). Assuming a rough estimate of 1.6 dogs per household and about 7,000 households within the Leona River watershed based on 2010 census population data (about 20,000 individuals and 3 individuals per household), there are potentially about 7,000 dogs within the Leona River watershed. Other domestic animals, such as outdoor cats, also will contribute, but the number of cats is difficult to estimate as in many rural areas, domestic cats are often feral.

Wildlife and Unmanaged Animal Contributions

E. coli bacteria are common inhabitants of the intestines of all warm-blooded animals, including wildlife, such as deer, raccoons, and birds. With access to the stream channel, direct deposition of animal waste can be a concentrated source of bacteria loading to a waterbody. Fecal bacteria from wildlife are also deposited onto land surfaces, where it may be washed into nearby streams by rainfall runoff. There are a large number of game ranches within the Leona River watershed containing native deer and exotics, such as aoudad, axis deer and blackbuck antelope. The majority of the watershed (97.5 percent) lies within the South Texas Plains Ecoregion. Population density estimates obtained from Texas Parks and Wildlife (TPWD) for 2011 indicate

17.4 deer per 1,000 acres for the South Texas Plains Ecoregion. A very small portion (2.5 percent) of the most northern part of the watershed falls within the Edwards Plateau Ecoregion, which has a much higher estimated density of 90.2 deer per 1,000 acres for 2011.

Feral Hogs

While feral hogs are not natural wildlife, they are an invasive, unmanaged species found throughout Texas that contribute bacteria to streams in a manner similar to native wildlife. Feral hogs are noted for moving in groups along waterways, and particuarly in times of drought will congregate near perennial water sources to drink and wallow. Feral hogs are classifed by TPWD as unprotected, exotic, non-game animals (Taylor, 2003). Although found throughout much of Texas, there is a scarity of data on feral hog densities in Texas. Studies in comparable bottomland habitats indicate typical densities of nearly 30 hogs per square mile (Tate, 1984 and Hone, 1988). Signs of feral hogs were encountered at several of the RUAA survey sites as noted in the field survey results.

Failing On-Site Sewage Facilities

Septic systems or on-site sewage facilities (OSSFs) are often used in rural areas that do not have the ability to connect to a central wastewater collection system. While the specific numbers of OSSFs could not be determined, since records have only been required since 1989, based on rough estimates from county health inspectors within Uvalde, Zavala, and Frio Counties, at least 600 to 1,000 households are on septic systems within the Leona River watershed that have been installed since 1989. While inspectors were unwilling to speculate as to a failure rate for these systems within the watershed area, the major soils types in all three counties are noted for potentially severe septic problems. The fractured limestone in the headwaters can also lead to the discharge of septic waste into groundwater if OSSFs are improperly installed. The Uvalde Estates subdivision, to the west of the City of Uvalde, is noted on Figure 4 as a census designated place (CDP). The Uvalde Estates subdivision is the most densely populated area in the watershed with OSSFs including about 602 homes based on US Census block data.

Observed Sources

As part of the routine monitoring, RUAA surveys, and collection of known source bacteria samples conducted for this project, TIAER field staff noted any observations of potential bacteria sources to Leona River. The most common potential sources observed were wildlife (primarily deer and raccoon) and feral hogs (Figures 8-11). Some livestock and exotic ungulates were seen on the uplands of the Leona River, but none within the riparian area or riverbed as traversed during the RUAA.

In similar floodplain areas, raccoons have been estimated to potentially deposit the most *E. coli*, followed by feral hogs, opossums, and white-tailed deer (Parker, 2009). Similar findings were noted by Karthikeyan et al. (2012) within the TSSWCB Project 07-06 *Fate and Transport of E. coli in Rural Texas Landscapes and Streams*.

To aid in identifying hosts of the bacteria within the Leona River, known source fecal samples were collected throughout the watershed from a variety of sources including domestic sewage, wildlife, livestock, feral hogs and pets. These samples were evaluated by the Soil and Aquatic Microbiology Laboratory run by Dr. Terry Gentry with the Department of Soil and Crop

Sciences at Texas A&M University in College Station, Texas. All known source samples were added to the Texas *E. coli* BST Library, which will aid in exploring geographical and temporal stability of BST host-specific isolates. Library-independent and library-dependent bacterial source tracking techniques were also used on stream and point source discharge samples to aid in determining the dominant bacteria sources within the Leona River. Of note, stream samples from throughout the watershed were limited during the study due to extremely dry conditions leading to limited flow within the Leona River. The findings associated with these known source samples and BST analyses in conjunction with the stream sampling are presented in a separate project report.

Figure 8 Raccoon tracks along the banks of the Leona River near the confluence with Todos Santo Creek. Photo taken May 25, 2012.

Figure 9 Deer tracks along the banks of the Leona River north of Uvalde, Texas. Photo taken May 22, 2012.

Figure 10 Hog trail along the banks of the Leona River near the confluence with Todos Santos Creek. Photo taken July 18, 2012.

Figure 11 Hog trail along the banks of the Leona River near the confluence with Todos Santos Creek. Photo taken May 23, 2012.

SECTION 4

Public Participation and Summary

The initial public meeting for the Leona River watershed project was held on July 28, 2011. At that meeting stakeholders were introduced to the overall project including the need to identify sources associated with the bacteria impairment within the Leona River. The meeting focused on the monitoring plan for the project, which included routine sampling throughout the watershed as well as BST analyses and known source sampling of feces found in the watershed. Update meetings on January 19 and July 19, 2012, focused on the recreation use attainability assessment (RUAA) for the watershed. At both meetings in 2012, TIAER solicited stakeholders for information regarding use of the river and potential sources of bacteria. As part of the RUAA, field crews conducted a visual source survey of potential contributors in conjunction with the two field surveys. These field surveys were conducted May 22-26 and July 17-21, 2012. The most common potential sources observed during these surveys were scat from wildlife (primarily deer and raccoon) and feral hogs. Some livestock and exotic ungulates were seen on the uplands of the Leona River, but none within the riparian area or riverbed of the Leona. On January 24, 2013, a stakeholder meeting was held during which findings from the overall RUAA were presented as well as an overview of potential bacteria sources within the watershed. Feedback from stakeholders indicated that the potential sources appeared to be well identified, but that additional considerations might be contributions from birds and potentially improper disposal of waste from portable restrooms.

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