# Wastewater disposal practices and change in development in the Barton Springs Zone

SR-11-01. October 2010

Chris Herrington, PE
Matthew Menchaca
Matthew Westbrook

City of Austin
Watershed Protection Department
Environmental Resource Management Division

## Abstract

*County tax appraisal district records and regional population projections are used as surrogates to track historical and future development in the Barton Springs Zone of the Edwards Aquifer. Wastewater disposal by either Texas Land Application Permit (TLAP) and by individual on-site sewage facility (OSSF) are identified spatially and temporally. There are 27 active TLAP permits in the Barton Springs Zone and as of 2010 there is 3.8 million gallons per day of permitted wastewater irrigation volume. There are at least 9,470 OSSF permits in the Barton Springs Zone, with the highest density of permits observed in the Bear Creek watershed. Williamson Creek is the most densely developed watershed in the Barton Springs Zone, although density of impervious structures increased 2.6 times from 2005 to 2010 in the Hays County portion of Bear Creek. The current population in the Barton Springs Zone is estimated to be 143,382 persons, and is projected to increase 1.6 times from 2010 to 2035 estimates with the largest increases near Dripping Springs and Bee Cave. Identifying and quantifying potential water quality impacts from effluent land application is key to improving existing design specifications and regulations to prevent groundwater contamination.*

## Introduction

The sensitivity of the surface water creeks in the contributing zone of the Edwards Aquifer to nutrient enrichment has previously been documented in direct monitoring efforts (Herrington and Scoggins 2006; Mabe 2007; Turner 2010) and by various modeling approaches (Herrington 2008a; Herrington 2008b; Richter 2010). Nitrate may be increasing over time in Barton Springs (Herrington 2010a), although the source or sources are not conclusively identified but may include leaking wastewater infrastructure, land application of wastewater effluent, domestic pets and livestock operations. The Barton Springs Zone is defined as the combined land area of the contributing zone and the recharge zone of the Barton Springs Segment of the Edwards Aquifer (Figure 1).

Residential development continues to increase impervious cover and disturbance in the Barton Springs Zone, and wastewater disposal strategies may be changing over time. In 2009, Hays County Water Control and Improvement District 1 serving the Belterra Subdivision was granted the first wastewater discharge permit in the contributing zone of the aquifer. All other centralized wastewater disposal in the Barton Springs Zone is done under the Texas Land Application Permit (TLAP) system irrigating wastewater effluent with no intentional discharge to surface waters or by individual on-site sewage facility (OSSF). Identifying the source or sources of pollution are key to effective water quality management.

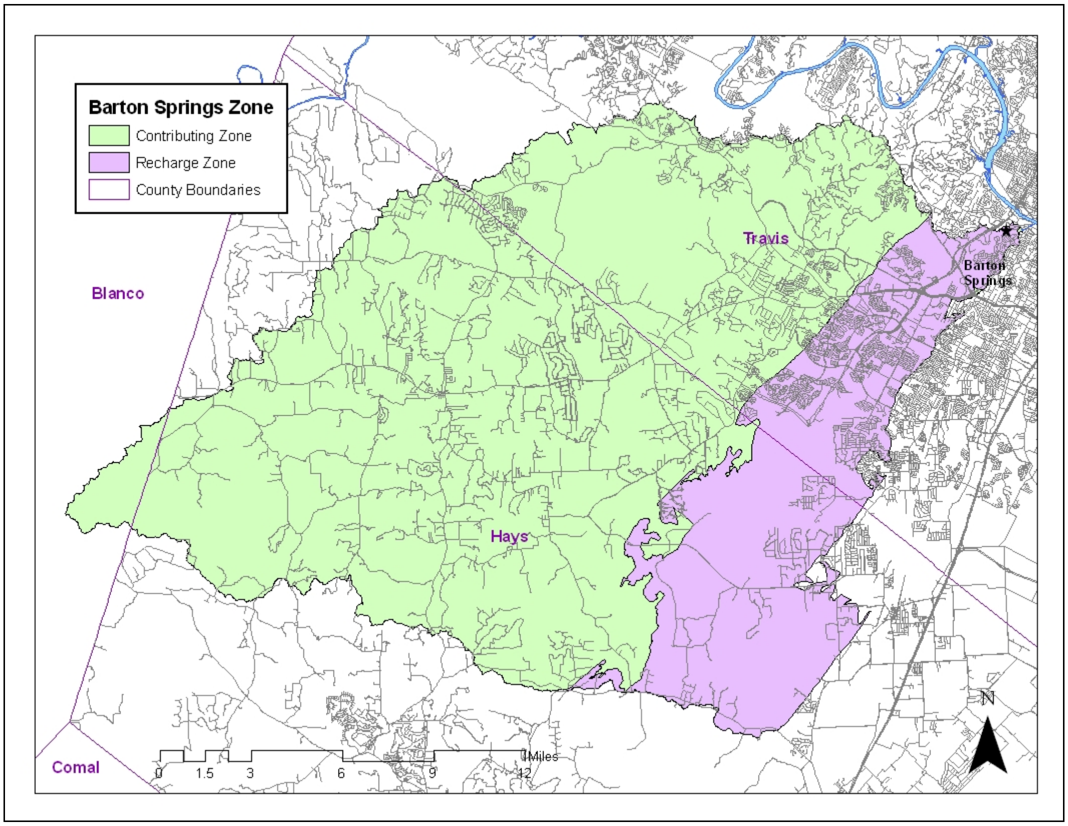


Figure 1. The Barton Springs Zone, including both the contributing and recharge zones.

The typical OSSF is essentially composed of two parts: a settling tank and the drain or absorption field (EPA 2005). The settling tank is where gravity and microbiological action separate and decompose human household wastes. The septic tank utilizes the same mechanisms of primary wastewater treatment (Metcalf and Eddy 1979) whereby floating scum and settleable suspended solids are separated from the liquid. Accumulated tank bottom sludge is occasionally pumped and removed by licensed contractors. A distribution box may contain a pumping apparatus but is conventionally responsible for dispensing the liquid into the perforated pipes or aerial sprinklers (for aerobic systems producing secondary treated effluent) which make up the leach- or absorption-field where final treatment by soil microbes and discharge of liquid effluent occurs. Failing or improperly managed OSSF, however, may pose a threat to water quality and public safety as non-point sources of pollution (Alhajjar et al 1990; EPA 2005). Overloaded drain fields will flood discharging sewage to the ground surface (EPA 2005). Aerobic systems may be more frequently utilized in areas with insufficient soils like the uplands of the Edwards Plateau, although they require significantly more maintenance than conventional absorption systems. The US Environmental Protection Agency (EPA 1997) ranks on-site sewage facilities as one of the top five source of ground water contamination in America. Approximately 20% of the total housing units in the United States utilize a conventional on-site septic facilities (OSSF) for sewage disposal (US Census 2006). Locally, surface waters potentially impacted by OSSF yield water quality that is generally similar to areas utilizing effluent irrigation, although water quality of OSSF-impacted surface water sites is generally less degraded than sites in areas served by public central sewers (Herrington 2005). Mean indicator fecal bacteria, nitrate and orthophosphorus concentrations from OSSF-impacted surface water sites in Austin, Texas, were higher than sites in undeveloped areas (Herrington 2005).

Regulations for OSSF are specified in 30 TAC 285, and TCEQ can delegate authority for permitting individual OSSF to local authorities. In the Barton Springs Zone, there are 3 local entities with significant jurisdictional authority in area (Figure 2): Travis County, Hays County, and the City of Austin. Additional permitting is done by the Village of Bee Caves and the City of Dripping Springs within their corporate limits. Hays County permitting authority includes the cities of Kyle and Buda and thru January 2010 also covered the City of Wimberley. Wimberley has issued approximately 17 permits since assuming permitting authority. The City of Dripping Springs assumed OSSF permitting authority from Hays County in November 2006, although they do not maintain electronic records of permits and have issued only approximately 80 permits since 2006 (Kyle Dayheart, RS, personal communication on 7 October 2010). The permits issued by Dripping Springs since 2006 are not included in this analysis. The Village of Bee Caves assumed permitting authority from Travis County in 1987.

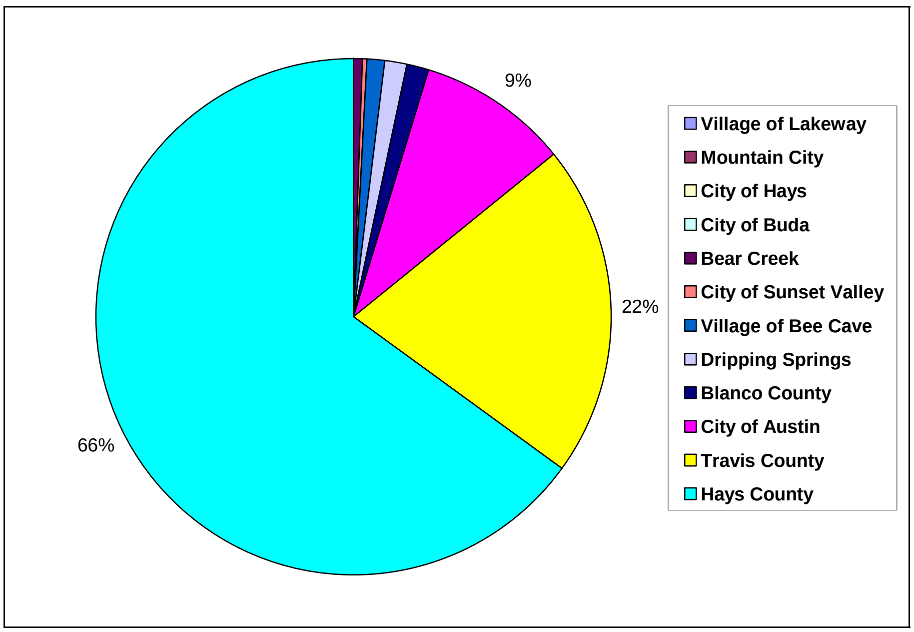


Figure 2. Jurisdictional makeup of the Barton Springs Zone by percent of area within each jurisdiction.

TLAP facilities are regulated primarily under two sections of Title 30 of the Texas Administrative Code (TAC). Chapter 309 Subchapter C contains the specifications for surface irrigation of effluent. TLAP facilities are designed to provide for effluent disposal without contamination of groundwater or surface waters. Applicants must submit water balances to the Texas Commission on Environmental Quality (TCEQ), the wastewater permitting authority in Texas, to establish irrigation rates and nitrogen management plans for surface irrigation. Storage requirements to avoid discharges of effluent under normal conditions are based on the water balance. Chapter 222 of the TAC contains specific provisions for subsurface drip irrigation of effluent in designated irrigation areas, and allows for an application rate up to 0.1 gallons/$ft^2$/day. Subsurface systems are required to have storage capacity for 3 days of effluent volume, generally less than what is required for surface irrigation permits from the requisite water balance. Subsurface permits or Subsurface Area Drip Dispersal Systems (SADDS) "..shall not pollute groundwater quality" (30 TAC 222.77(a)). TLAP facilities may obtain beneficial reuse authorizations from TCEQ to irrigate wastewater on additional areas outside of the irrigation fields designated in the permit under 30 TAC 210. Some TLAP facilities may take OSSF offline if an organized sewage collection system is constructed.

There are additional potential sources of nutrients to contributing waters of the Barton Springs other than wastewater effluents. Domestic pets like dogs and cats can be a source of fecal pathogen contamination (EPA 2001; TCEQ 2010) and to a lesser extent nutrients in urban environments. Future attempts at source water identification in the Barton Springs Zone should consider the potential distribution of companion animals, which may be estimated from population and demographic data.

Animal wastes from livestock feeding operations or used as agricultural fertilizer may also be a source of nutrient loading to surface and ground water. US Department of Agriculture (2009) census information shows a decline from 2002 to 2007 in the acreage of farmed land for both Travis (-12%) and Hays (-15%) counties. The City of Austin has tracked land use patterns over time, though not on a consistent temporal scale. Undeveloped and agricultural land have been categorized in the same way in some older land use assessments, but may be considered together to represent the maximum total potential area in agricultural use as a means to provide a more consistent comparison. City of Austin estimates thru 1995 yield a potential agricultural land use of 87% of the Barton Springs Zone while 2003 assessments yield an area of potential agricultural land use of only 40%. Agricultural operations are assumed to not be increasing over time in the Barton Springs Zone.

Leaking wastewater collection system infrastructure for centralized sewage treatment may also be a source of nutrients to surface and ground waters (Sharp et al 2008). The City of Austin maintains centralized sewage collection in portions of the Barton and Slaughter creek watersheds primarily over the recharge zone and in the majority of the Williamson Creek watershed. Most of the wastewater collected by the City of Austin is treated at two treatment facilities and then discharged to the Colorado River, outside of the Barton Springs Zone. The Austin Water Utility maintains a GIS database of wastewater collection mains.

## Methods

Tax appraisal district information may be used to track change in development over time in a spatial context and on an annual time scale (Olivera and DeFee 2007; Herrington 2010b). Hays County and Travis County appraisal district records containing building improvement area by year were spatially located in the Barton Springs Zone using tax parcel polygon layers from the respective tax authorities. The first year that an improvement was identified in appraisal rolls was assumed to be the year the structure was built. Only first floor impervious improvements (e.g., the first floor of a building, detached garages, tennis courts, etc) were included in the calculation of the impervious footprint area of each parcel. This method provides a consistent record of development within each county, and is a useful surrogate for impervious cover but does not represent total impervious area as public transportation infrastructure, driveways and sidewalks are not included in the county tax record assessment.

OSSF records were obtained from the individual permitting authorities: the City of Austin, Travis County, Hays County and the Village of Bee Cave. City of Austin permits issued by the Austin Water Utility were already spatially located. Hays County, Travis County and Village of Bee Cave OSSF permit addresses were geographically referenced in bulk using Google Maps. The majority of permit records were successfully located within county boundaries. The spatial areas of the cities of Westlake and Rollingwood are small, and groundwater from these jurisdictions most likely recharges Lady Bird Lake so locating OSSFs in these jurisdictions was not pursued. The City of Dripping Springs, which assumed permitting authority within the corporate limits from Hays County in November 2006, does not maintain electronic records of permits and thus could not be included in this analysis. There are only approximately 80 OSSF permits that have been issued in Dripping Springs since the city assumed authority (Kyle Dayheart, R.S., personal communication 7 October 2010). These permits were not included in this analysis. It is not possible to determine if OSSFs have been discontinued and are no longer in service, although 300 OSSFs have been replaced by centralized TLAP in Dripping Springs (Susan Zachos, personal communication 8 October 2010). No attempt was made to remove these OSSF from the analysis.

TLAP records were copied from the TCEQ Central File Room for all permits in the Barton Springs Zone. Irrigation areas were digitized from printed United States Geological Survey (USGS) topographic maps that are required by TCEQ to be included in the application for a permit. Additional information on permitted discharge volume and effluent quality limitations was extracted from permit records.

Estimated population data was downloaded from the Capital Area Metropolitan Planning Organization (CAMPO) for years 2005 to 2035. Demographic data including number of households and population were compiled at the traffic analysis zone level for 2005 with projections thru 2035 (CAMPO 2010). For polygons that crossed the Barton Springs Zone boundaries, population demographic estimates were adjusted using an equal area-weighted method based on the fraction of the polygon area remaining versus the original polygon area. A small portion of the upper Onion Creek watershed in Blanco County is outside the CAMPO planning boundary and this area is not included in population estimates. Population estimates from 1990 and 2000 were derived from US Census Bureau using demographic and boundary files downloaded from the US Census Bureau website. Data were aggregated at the Block Group level to provide a consistent aggregation between years 1990 and 2000 based on available data. Demographic data were adjusted using the same equal area-weighted method as applied to CAMPO data for Block Group polygons that crossed Barton Springs Zone boundaries.

Information on companion animals was taken from the American Veterinary Medical Association (AMVA 2007). Based on national averages, it was assumed that 37.2% of households had dogs and 32.4% of households had cats in the Barton Springs Zone (AMVA 2007). Households with dogs were assumed to have 1.7 dogs, and households with cats were assumed to have 2.2 cats (AMVA 2007). All spatial data was organized and displayed in ArcMap 9.3.1. by ESRI. For the purposes of this report, the Little Bear Creek watershed was included with the Bear Creek watershed and the Little Barton watershed was included with the Barton Creek watershed results.

City of Austin wastewater collection infrastructure information was extracted from the Austin Water Utility GIS database within the Barton Springs Zone. The year the wastewater main was installed and the length of the wastewater main were summarized over time by watershed. The average age of wastewater water mains was calculated by weighted-average using the length of the line and the date of installation.

## Results

There were 6,862 OSSF permit records obtained from all of Travis County beginning in 1977, and all but 2.3% were successfully geolocated. The majority (59.5%) of OSSF permitted by Travis County are conventional anaerobic systems, although aerobic spray systems account for 39.2% of permitted facilities. There were 19,278 OSSF permit records obtained from all of Hays County, and all but 5.1% were successfully geolocated. There were 237 permit records obtained from Bee Cave, and all but 5 records were successfully geolocated. Some complete permit addresses did not generate successful matches in Google Maps, and some permit records did not contain complete address information and thus could not be geolocated. Year 1999 appears to be the start of consistent electronic permit record keeping across the included jurisdictions, suggesting that some unknown number of OSSF permitted prior to 1999 may not be electronically documented in all areas.

After identifying the spatially relevant permits, there are 9,470 known OSSF in the Barton Springs Zone permitted by the City of Austin, Travis County, Hays County and Bee Cave (Figure 3). The highest density of OSSF permits is in the Bear Creek watershed at 0.066 OSSF/acre (Figure 4). The density of

OSSF permits in Bear Creek has also increased more rapidly than any other watershed since 2000, increasing more than 13 times from 1999 to 2010 (Figure 5). Fewer OSSF have been added in recent years in Williamson Creek most likely because it is the most urban of the contributing zone watersheds and now served primarily by City of Austin centralized wastewater collection.


Figure 3. Number of OSSF permits issued by year in the Barton Springs Zone from City of Austin, Bee Cave, Travis County and Hays County records.

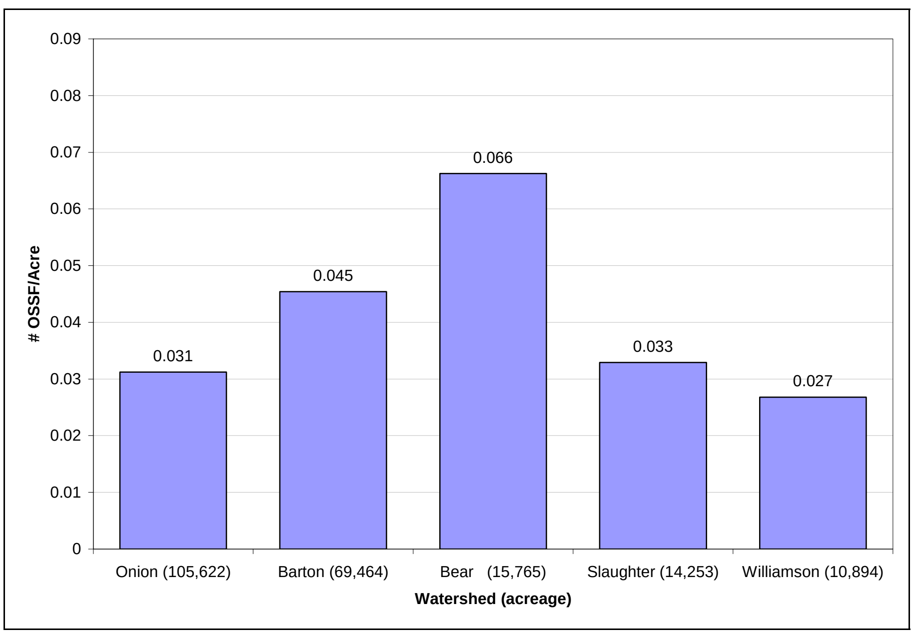


Figure 4. Density (# OSSF permits per acre of drainage area) of OSSF permits by watershed. Drainage area shown in acres in parentheses. Watersheds shown in decreasing size left to right.

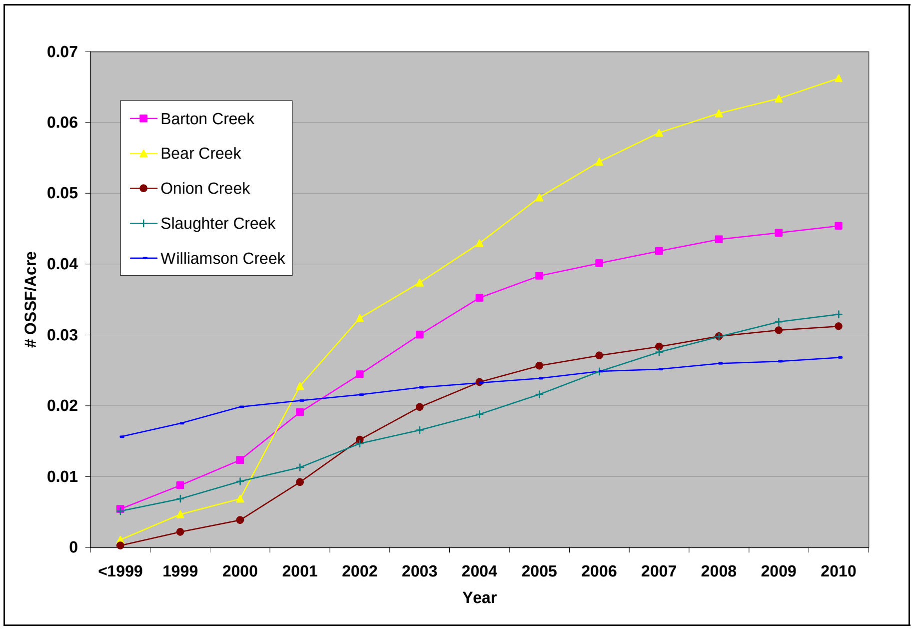


Figure 5. Change in OSSF density in the Barton Springs Zone by watershed over time.

OSSF tend to be clustered into higher density pockets in the Barton Springs Zone following patterns of development (Figures 6, 7, 8). Changes over time since 2005 appear to be primarily in-filling of existing developing areas when viewed on the scale of the entire Barton Springs Zone.

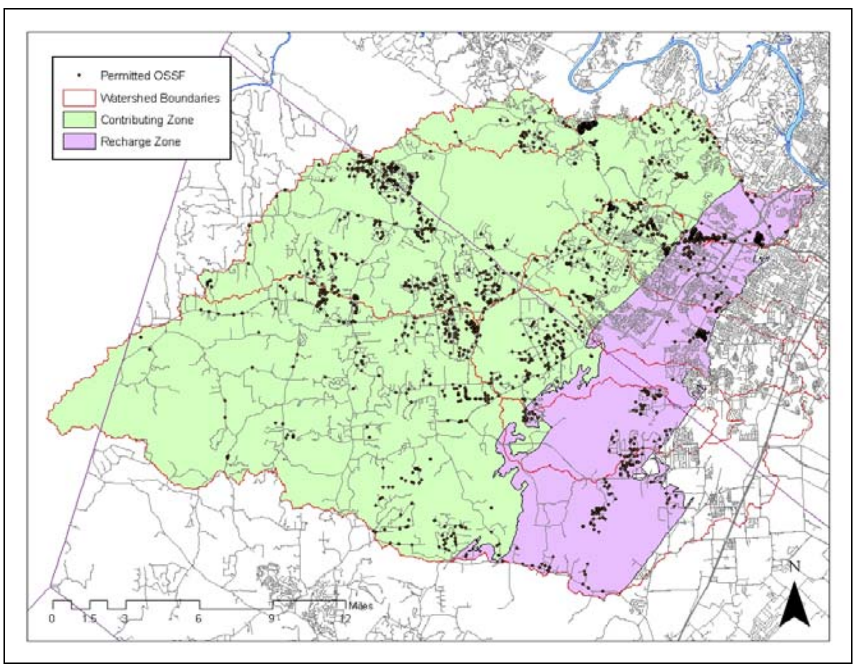


Figure 6. Permitted OSSF in the Barton Springs Zone existing on or before year 2000.

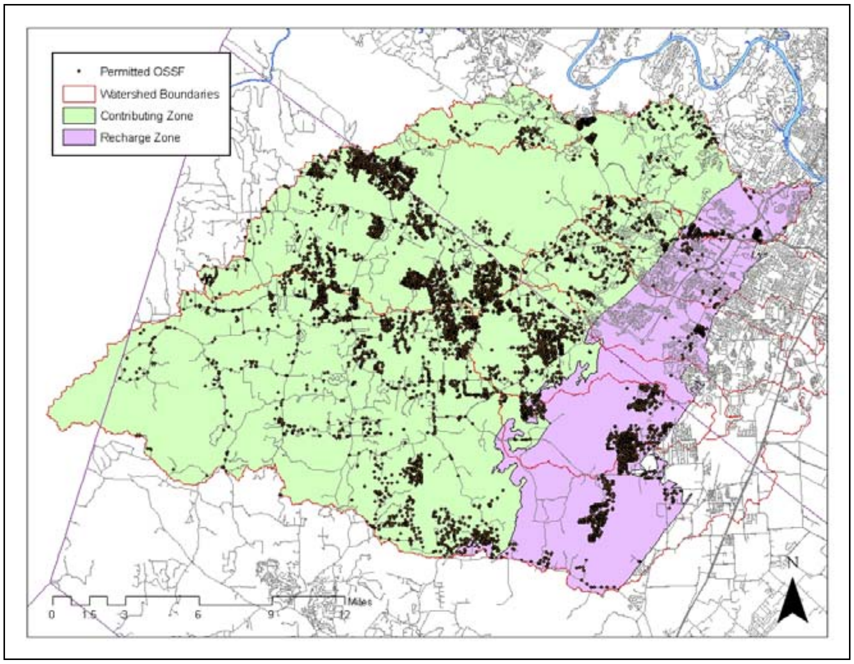


Figure 7. Permitted OSSF in the Barton Springs Zone existing on or before year 2005.

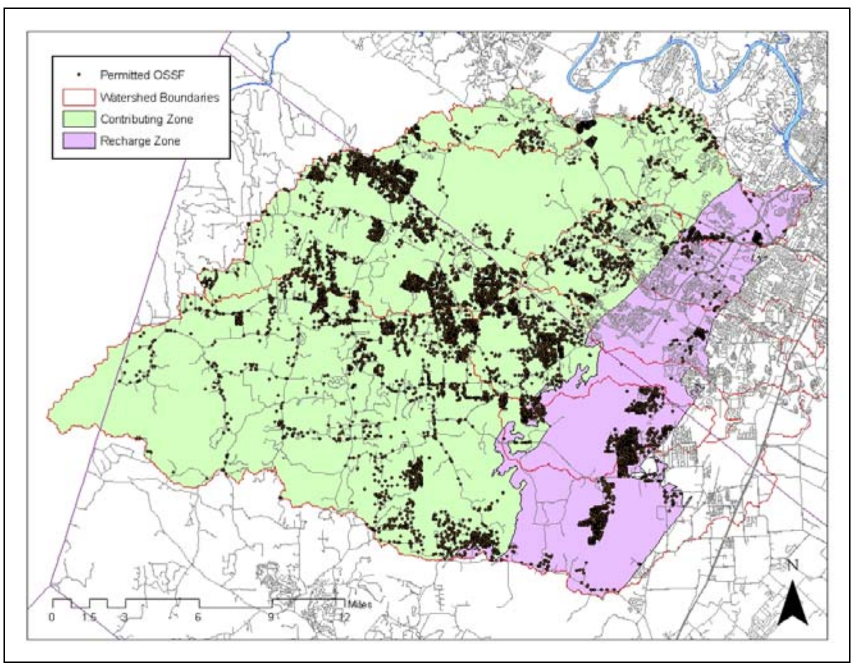


Figure 8. Permitted OSSF in the Barton Springs Zone existing on or before year 2010.

There are 31 TLAP permits that have been issued in the Barton Springs Zone. Of the 31, two are currently in the application process, one has been discontinued and two have been granted a permit but the subdivisions have not yet been developed based on recent aerial imagery. A total of 27 TLAP permits are currently active in the Barton Springs Zone (Table 1). The Rocky Creek Ranch development (14664-001) may not renew the permit as the development is in foreclosure proceedings and no homes have yet been built. One permit file in the TCEQ database could not be located at TCEQ and thus the status of that permit is unknown. The City of Dripping Springs TLAP came online on November 13, 2008 and has since taken approximately 300 OSSF off line (Susan Zachos, personal communication, 8 October 2010).

Table 1. Summary of TLAP facilities in the Barton Springs Zone. All permits are currently operating unless noted otherwise. Flow volume listed is for final permit phase.

| TPDES # | Permittee Name | Wshed | Irrigation Type | Final Flow (gal/d) | Irrig. Area (acres) | App. Rate (gal/ft2/day) | Effluent Quality (mg/L) | Issued | Expires |
|---|---|---|---|---|---|---|---|---|---|
| 13238-001 | Senna Hills MUD | BAR | Surface | 157000 | 70.3 | 0.051 | BOD=5, TSS=5, NH3=2, FC=200 | 1986 | 2014 |
| 13594-001 | Lake Point WWTP | LBA | Surface | 1325000 | 350 | 0.070 | BOD=5, TSS=5, NH3=2 | 1992 | 2014 |
| 13748-001 | Dripping Springs High School WWTP | ONI | Subsurface drip | 50000 | 11.48 | 0.100 | BOD=20, TSS=20 | 1995 | 2014 |
| 13860-001 | Stonebridge Health Center | SLA | Subsurface drip | 10000 | 1.6 | 0.150 | BOD=30, TSS=30 | 1997 | 2014 |
| 13748-002 | Dripping Springs High School WWTP | ONI | Subsurface drip | 25000 | 3.83 | 0.150 | | 1997 | 2014 |
| 04196-000 | DuchMandola* | BAR | Evaporation | 476 | 0 | | evaporation | 2000 | 2014 |
| 14146-001 | Springs Apartments WWTF | ONI | Subsurface drip | 14000 | 3.57 | 0.090 | BOD=20, TSS=20 | 2000 | 2018 |
| 14077-001 | The Park at Barton Creek WTF | BAR | Subsurface & surface | 3700 | | 0.060 | BOD= 5, TSS=10 | 2000 | 2014 |
| 14099-001 | The Madrone Ranch WTF** | BAR | Drip | 7200 | 1.653 | 0.100 | N/A | 2001 | 2004 |
| 14235-001 | The Salt Lick WWTF | ONI | Subsurface drip | 10000 | 2.3 | 0.100 | BOD= 10, TSS= 15 | 2001 | 2014 |
| 14364-001 | Frog Pond WWTP | ONI | Drip | 9999 | 2.3 | 0.100 | BOD=20, TSS=20 | 2003 | 2009 |
| 14309-001 | Hays Co MUD No. 4 WWTF | BAR | Subsurface drip | 150000 | 34.44 | 0.100 | BOD=20, TSS=20 | 2003 | 2014 |
| 14358-001 | Highpointe Subdivision WTF | BER | Subsurface drip | 40000 | 68.87 | 0.100 | BOD= 20, TSS= 20 | 2003 | 2012 |
| 14435-001 | Stonewall Ridge Subdivison WWTP | BAR | Subsurface drip | 5000 | 1.15 | 0.100 | BOD=20, TSS=20 | 2003 | 2016 |
| 14208-001 | Hays Co. Development District No.1 WWTF*** | ONI | Surface | 300000 | 120 | 0.090 | BOD= 5, TSS=5 | 2004 | 2014 |
| 11319-001 | Lost Creek MUD | BAR | Surface & Evap. | 520000 | 186.42 | 0.056 | BOD=10, TSS=15 | 2004 | 2019 |
| 13206-001 | Barton Creek WWTP | BAR | Surface | 720000 | 298.7 | 0.055 | BOD=5, TSS=5, NH3=2 | 2005 | 2014 |
| 14824-001 | Arrowhead Ranch WWTP | ONI | Subsurface drip | 125000 | 29 | 0.100 | BOD=10, TSS=15 | 2005 | 2012 |
| 14480-001 | Reunion Ranch A | BER | Subsurface drip | 50000 | 11.5 | 0.100 | BOD=20, TSS=20 | 2005 | 2014 |
| 12786-001 | Barton Creek West WSC | BAR | Surface | 126000 | 53.3 | 0.055 | BOD=10, TSS=15 | 2005 | 2014 |
| 14488-001 | Dripping Springs South Regional WWTP | ONI | Subsurface drip | 162500 | 37.43 | 0.100 | BOD=20, TSS=20 | 2005 | 2014 |
| 04780-000 | Mandola Estate Winery**** | ONI | | | | | | 2006 | 2009 |
| 14480-002 | Reunion Ranch B | BER | Subsurface drip | 96200 | 22.1 | 0.100 | BOD=20, TSS=20 | 2006 | 2014 |
| 14430-001 | Travis Co MUD No. 4 WWTF | BAR | Surface | 600000 | 220 | 0.060 | BOD=5, TSS=5, NH3=2 | 2006 | 2014 |
| 14587-001 | Headwaters Water Reclamation Facility | BAR | Subsurface & surface | 325000 | 75 | 0.100 | BOD=5, TSS=5, NH3=2, TP=1, FC=200 | 2007 | 2010 |
| 14629-001 | Lazy Nine MUD WWTP | LBA | Surface | 490000 | 199.5 | 0.056 | BOD=10, TSS=15 | 2007 | 2011 |
| 14664-001 | Rocky Creek Ranch WWTP*** | BAR | Surface | 125500 | 50 | 0.058 | BOD=5, TSS=5, NH3=2 | 2008 | 2011 |
| 14866-001 | Bella Vista WWTP | BAR | Subsurface drip | 23000 | 5.28 | 0.100 | BOD=10, TSS=10 | 2008 | 2013 |
| 14293-001 | Hays Co WCID 1 WWTF | BER | Subsurface drip | 150000 | 35 | 0.100 | BOD=20, TSS=20 | 2009 | 2011 |
| 14488-002 | Scenic Greens WWTF | BAR | Subsurface drip | 250000 | 57.39 | 0.100 | BOD=20, TSS=20, Ecoli=126 | 2010 | 2013 |
| 14785-001 | Jeremiah Ventures* | ONI | Surface | 330000 | 122.37 | | | | |

*Pending application process completion; **Discontinued permit; ***Subdivision still in development; ****Unknown status

Both surface irrigation and subsurface drip disposal systems are used in the Barton Springs Zone. There are nearly twice as many subsurface drip TLAP facilities as surface irrigation facilities, although on a final permit phase volume basis there is approximately 3.5 times more wastewater applied thru surface irrigation than subsurface drip. When finally permitted by the TCEQ, Jeremiah Ventures at 0.33 million gallons per day (mgd) will be the largest of the 3 TLAP facilities located in the recharge zone as the other two permitted facilities (The Park at Barton Creek 14077-001 and Reunion Ranch B 14480-002) are small, have permitted volumes of 0.099 mgd in total and only have a portion of their irrigation areas over the recharge zone. As of 2010, there is a total permitted final phase wastewater volume of 7.52 mgd to the Barton Springs Zone.

Final phase permitted wastewater volumes have increased substantially in 2003 (Figure 9). Final phase flow volumes may not represent the actual volume of wastewater being generated. Of the 31 TLAP facilities in the Barton Springs Zone, 14 have multiple phases (interim and final phase) with incrementally increasing volumes and 12 are currently operating in an interim phase. Accounting for current operating phases, there is currently 3.85 mgd of wastewater effluent irrigation in the Barton Springs Zone.

Additionally, there is a standard provision in wastewater permits known as the “75/90” rule (30 TAC 305.126 (a)) that requires permit operators to begin engineering and financial planning for expansion when flow volumes exceed 75% of the permitted volume for three consecutive months and obtain TCEQ authorization for construction of additional facilities at 90% of the permitted flow for three consecutive months. Thus, estimates of effluent irrigation generated from permit files are likely to overestimate actual irrigation volumes.

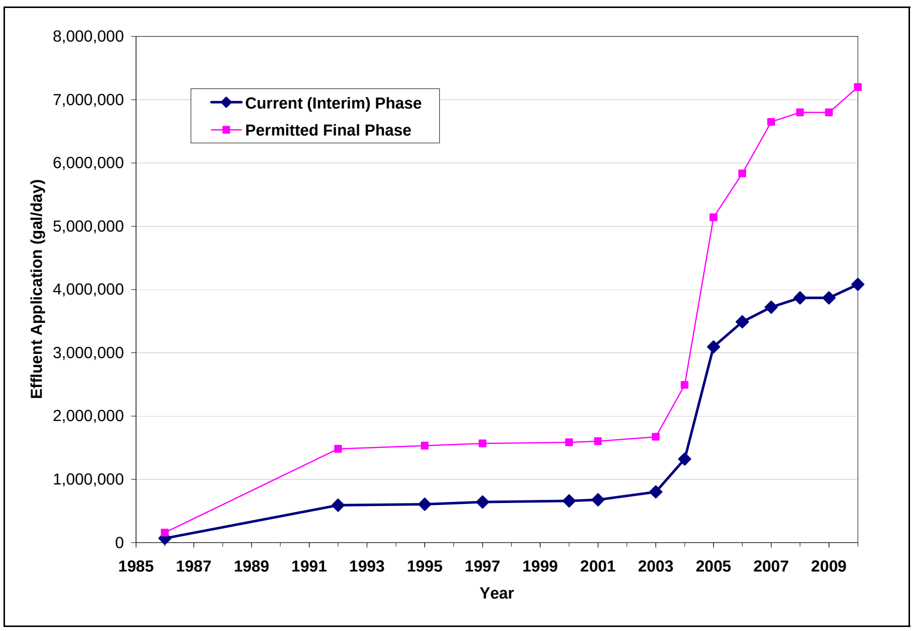


Figure 9. Current (interim) phase and permitted final phase permitted total wastewater volume for TLAP in the Barton Springs Zone.

TLAP facilities are distributed across the Barton Springs Zone (Figures 10, 11, 12), and frequently occur adjacent to developed areas utilizing OSSF. Most of the new TLAP facilities added from 2005 to 2010 were in the Barton Creek watershed.

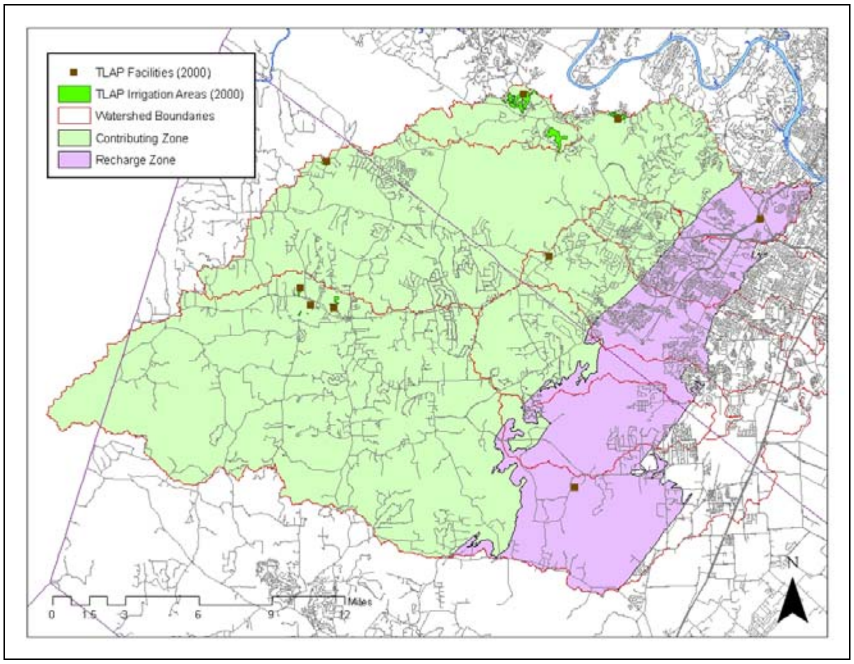

Figure 10. TLAP facilities permitted on or before year 2000 in the Barton Springs Zone.

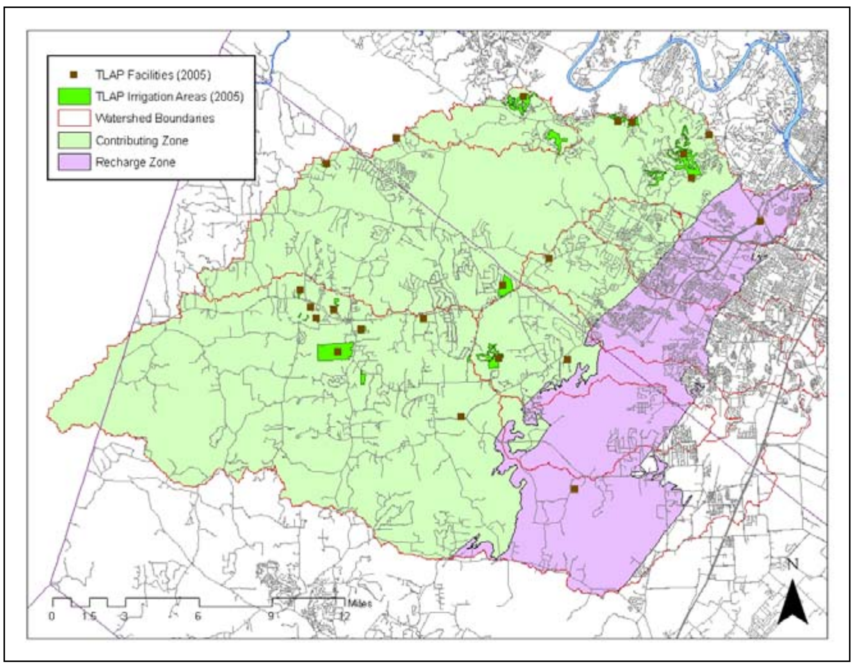

Figure 11. TLAP facilities permitted on or before year 2005 in the Barton Springs Zone.

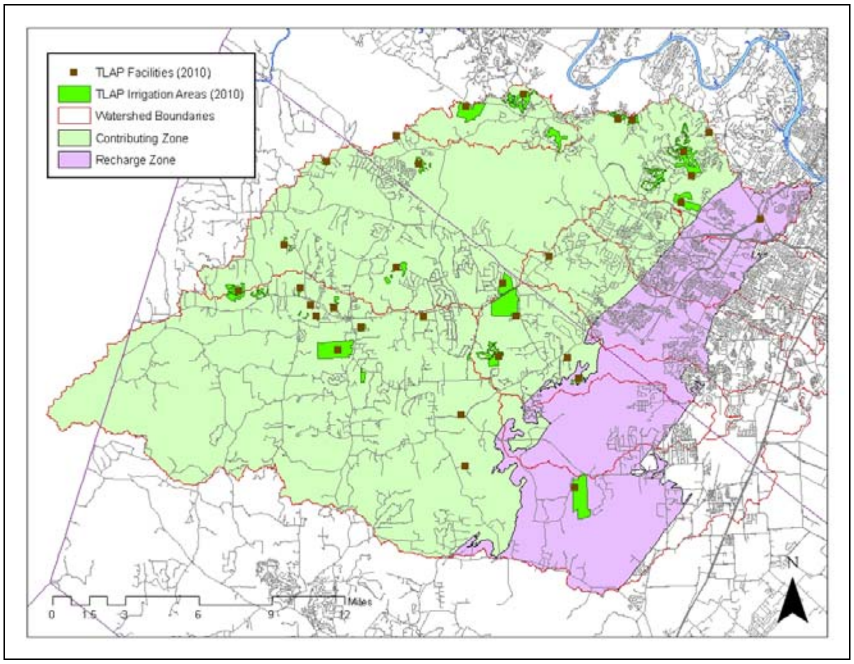

Figure 12. TLAP facilities permitted on or before year 2010 in the Barton Springs Zone.

Cycles of "boom-and-bust" are evident in the spikes in new impervious cover footprint area derived from county appraisal district records within the Barton Springs Zone, although new structures continue to be added even during less active years (Figure 13). Development swings are more pronounced in Travis County than in Hays County. Although the differences in Travis and Hays appraisal assessment methods are unknown, the reduction of the data to impervious cover footprints by individual county improvement designations should make the two sources comparable for a consistent period of record. The tax-derived impervious area estimates do not reflect total impervious area as they do not include publicly-owned transportation infrastructure, driveways or sidewalks.

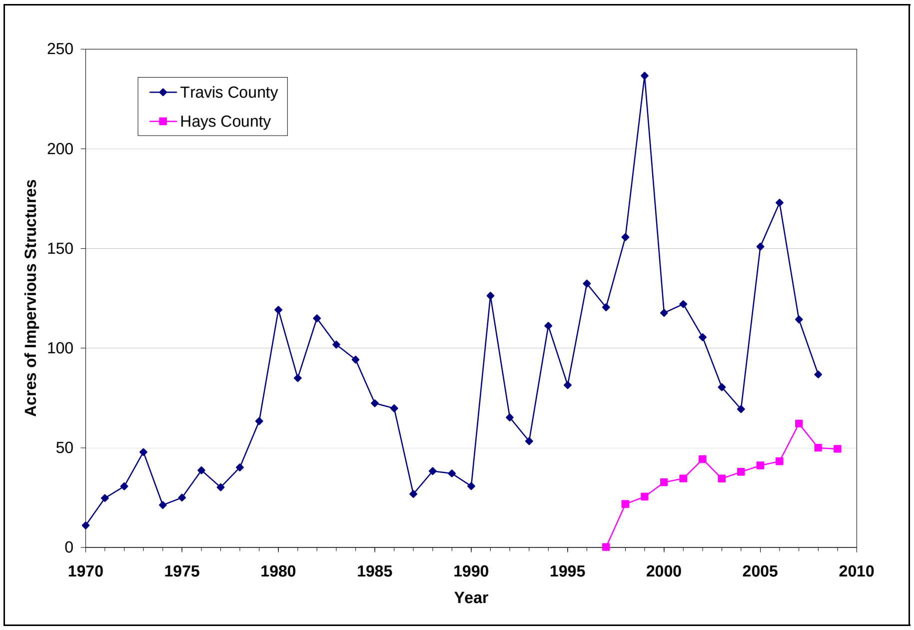


Figure 13. Acres of impervious structures added by year from Travis and Hays county appraisal district records in the Barton Springs Zone.

Density of impervious structures can be tracked over time (Figure 14). Williamson Creek is the most densely developed watershed in the Barton Springs Zone, although recent increases in development density were observed in the Slaughter Creek and Bear Creek watersheds. Density of impervious structures increased 2.6 times from 2005 to 2010 in the Hays County portion of Bear Creek although development in Bear Creek in the Travis County portion of the watershed was more stable.

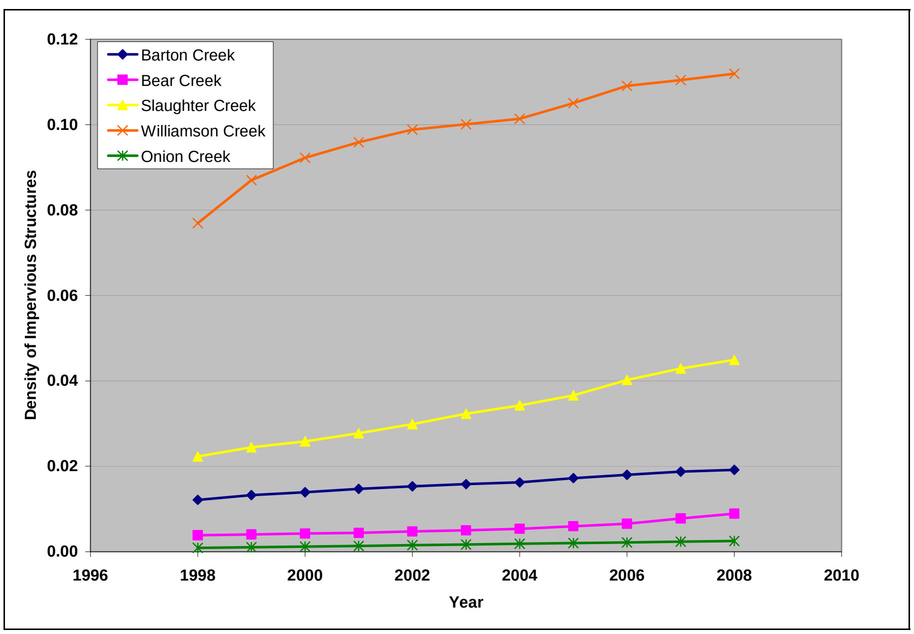


Figure 14. Cumulative density (acres of impervious structures/watershed acreage) of impervious structures from Travis and Hays county appraisal district records in the Barton Springs Zone.

Population growth as predicted from CAMPO (2010) demographic data indicates that development will continue in the Barton Springs Zone (Figure 15). Population has increased 2.5 times in the Barton

Springs Zone from 1990 to 2010 based on medium growth level estimates. Population is projected to increase 1.6 times from 2010 to 2035 in the Barton Springs Zone.

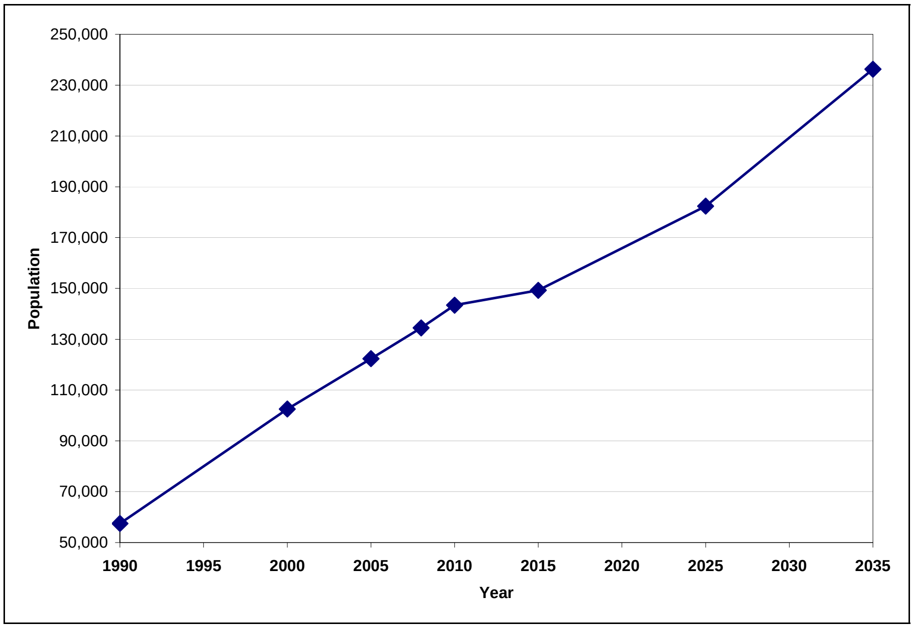


Figure 15. Population growth in the Barton Springs Zone from US Census Bureau for 1990 and 2000 and from CAMPO (2010) for 2005 to 2035.

The 2010 population estimate in the Barton Springs Zone is 143,382 persons. The majority of new population growth is projected to occur around Dripping Springs and Bee Cave, and along the US 290 transportation corridor from Austin to Dripping Springs. These growth patters will primarily be impacting the Barton Creek watershed with additional infill occurring in the Williamson Creek watershed (Figure 16, Figure 17).

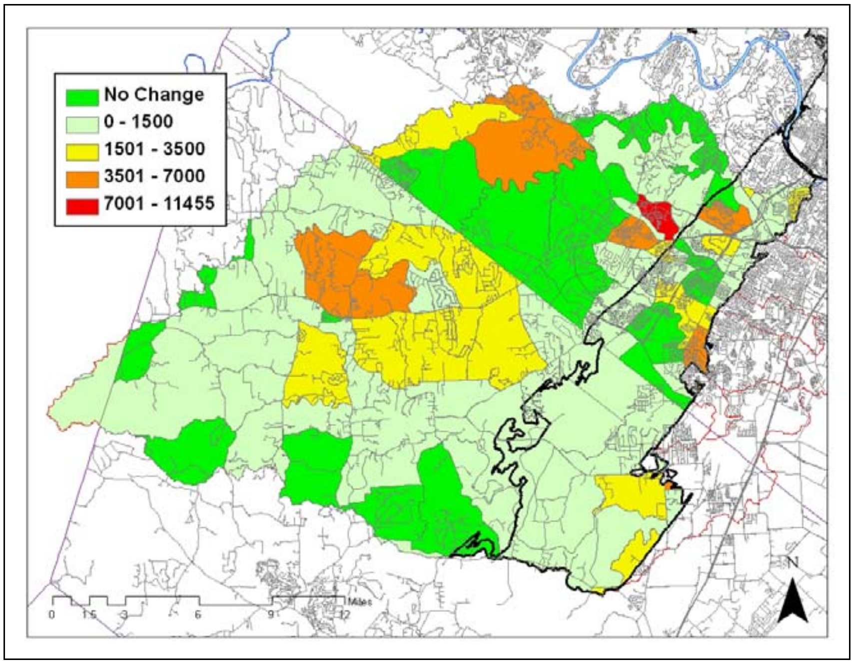


Figure 16. Predicted population change (number of individuals) from year 2010 to 2035 in the Barton Springs Zone.

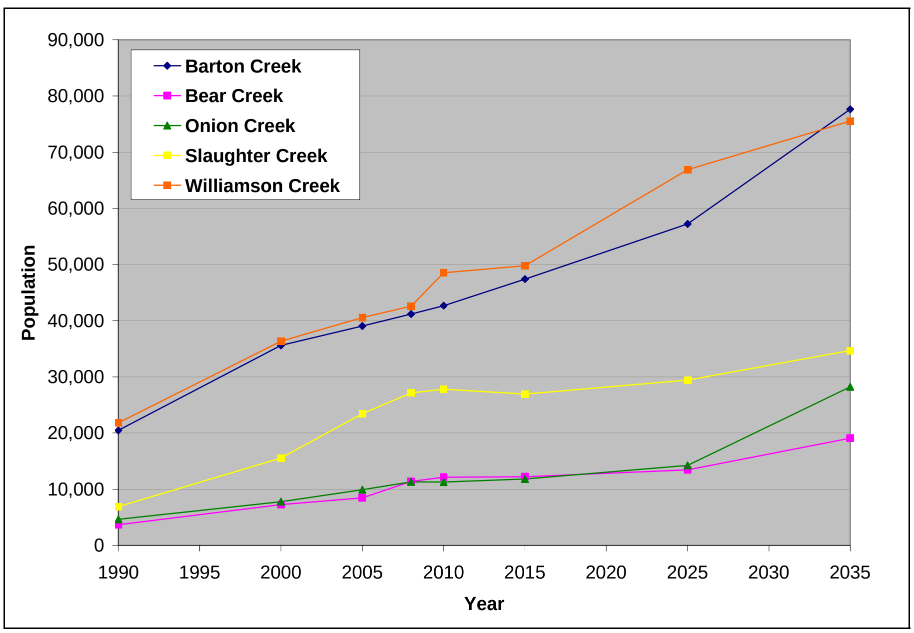


Figure 17. Population estimates from US Census Bureau from 1990 and 2000 and predicted population change (number of individuals) from year 2010 to 2035 from CAMPO (2010) in the Barton Springs Zone by watershed.

Companion pet population numbers were estimated from the number of household units in 2010 CAMPO estimates in combination with AMVA demographic data (AMVA 2007). There are an estimated 102,262 pets in the Barton Springs Zone in 2010 (48,075 dogs and 54,187 cats). Pets are correlated spatially with population distribution as expected, and are highest over the recharge zone closer to the central Austin core (Figure 18).

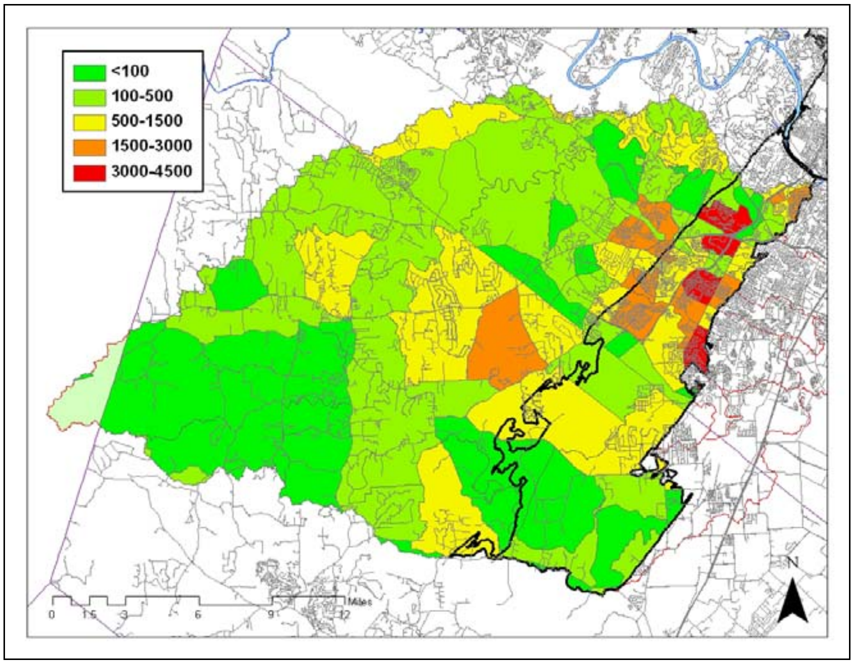

Figure 18. Distribution of companion animals (dogs and cats) in the Barton Springs Zone in 2010.

Approximately 7,600 wastewater mains totaling 349 miles that were identified from the Austin Water Utilities (AWU) GIS database in the Barton Springs Zone within the Barton, Slaughter and Williamson creek watersheds. City of Austin wastewater collection service extends throughout Williamson Creek (contributing and recharge zone) but the majority of Austin wastewater collection service in the Barton and Slaughter creek watersheds is only over the recharge zone. The average year of installation of wastewater mains based on AWU spatial data (lines greater than 1 ¼" inches in diameter including both gravity and force mains) weighted by length is estimated to be 1982, 1996 and 1988 in the Barton, Slaughter and Williamson creek watersheds within the Barton Springs Zone, respectively. Wastewater mains continue to be added in recent years in the Williamson and Slaughter creek portions of the Barton Springs Zone although new line installation has been limited in the Barton Creek watershed since 2001 (Figure 19). A consensus agreement was adopted by the City of Austin in 1997 that limited any Austin Water Utility additional wastewater service expansion west of Loop 360 except for existing served subdivisions (Consensus Building Group 1997). The volume of on-going small volume wastewater exfiltration (e.g., leaking pipe connecting joints) is unknown, but may be limited by the relatively recent age of line installation particularly in the Slaughter Creek watershed.

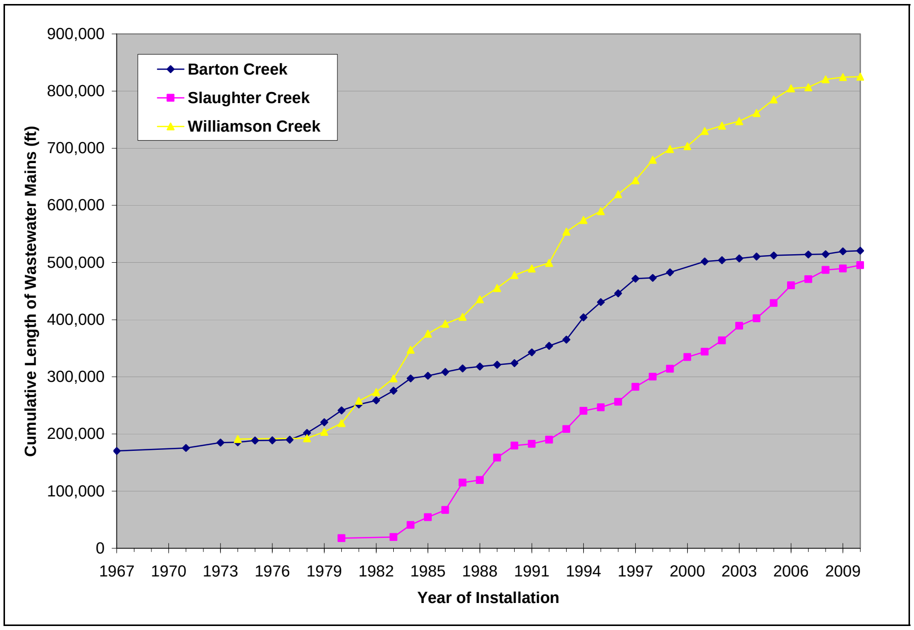


Figure 19. Cumulative length of wastewater mains added by year of installation within the Barton Springs Zone.

## Conclusions

There are at least 9,470 known OSSF in the Barton Springs Zone. The highest density of OSSF permits is in the Bear Creek watershed. The density of OSSF permits in Bear Creek has also increased more rapidly than any other watershed since 2000.

There are currently 31 permitted TLAP facilities in the Barton Springs Zone, although only 27 permits are currently active. As of 2010, there is a total final phase permitted volume of 7.5 mgd although adjusting for facilities currently operating in an interim phase there is an estimated total permitted volume of 3.8 mgd. Both surface irrigation and subsurface drip disposal systems are used in the Barton Springs Zone. There are nearly twice as many subsurface drip TLAP facilities as surface irrigation facilities, although on a final permit phase volume basis there is approximately 3.5 times more wastewater applied thru surface irrigation than subsurface drip. Final phase permitted wastewater volumes have increased substantially in the Barton Springs Zone in 2003.

Williamson is the most densely developed watershed in the Barton Springs Zone based on county tax appraisal records, although recent increases in development density were observed in the Slaughter Creek and Bear Creek watersheds. Density of impervious structures increased 2.6 times from 2005 to 2010 in the Hays County portion of Bear Creek although development in Bear Creek in the Travis County portion of the watershed was more stable and increased at a lower rate.

The current population in the Barton Springs Zone is estimated to be 143,382 persons, and is projected to increase 1.6 times from 2010 to 2035 estimates with the largest increases near Dripping Springs and Bee Cave and along US 290 from Austin to Dripping Springs. Population has increased 2.5 times in the Barton Springs Zone from 1990 to 2010. There are an estimated 102,262 companion animals in the Barton Springs Zone in 2010.

Agricultural operations are probably not increasing in the Barton Springs Zone over time. Observed increases in nutrients at Barton Springs or on a watershed scale in contributing zone creeks are not likely to be the result of increased loading from animal wastes.

City of Austin wastewater collection service extends throughout the Williamson Creek watershed and in portions of the Barton and Slaughter creek watersheds over the recharge zone. There are approximately 349 miles of City of Austin wastewater collection mains in service in the Barton Springs Zone. The average age of wastewater installation dates by watershed range from 1982 to 1996. Although new mains continue to be added in Williamson and Slaughter creek watersheds, few new mains have been installed in the Barton Creek watershed since 2001. Wastewater emergency investigations by City of Austin staff do not appear to be increasing over time in the Barton Springs Zone (Eric Kaufman, personal communication).

## Discussion

The spatial analyses described may be useful in interpretation of spatial and temporal changes in water quality monitoring. Water quality monitoring efforts by multiple entities including the City of Austin across the Barton Springs Zone are on-going, with efforts to identify the sources of increasing nitrogen concentrations at Barton Springs (Herrington 2010a) and to quantify the potential impacts from wastewater disposal intensifying (Herrington 2008b). Methods in addition to conventional water chemistry analysis such as stable oxygen and nitrogen isotopes and genetic testing for microbial source tracking are currently being investigated by the City of Austin to improve discriminatory abilities. Sample location placement for specialized water quality monitoring efforts will be aided by this high-resolution spatially organized wastewater disposal information.

The focus of this report on OSSF and TLAP facilities is not intended to be an indictment of these disposal methods in the Barton Springs Zone, but these are the disposal methods currently in use. Although degrading over time, Barton Springs continues to maintain good water quality (Herrington 2010a). Direct wastewater discharge into surface waters of the Barton Springs Zone would degrade water quality on a scale that would be orders of magnitude larger than currently observed degradation (Herrington 2008b). Although failing OSSF or TLAP represent a strong potential water quality impact, there may be some cumulative water quality impacts from facilities currently operating within permitted or design limits. Identifying and quantifying those impacts are key to the improvement of design specifications and regulations to truly satisfy the stated goal of existing regulations to prevent groundwater contamination.

## Acknowledgements

This report would not have been possible without the assistance of the staff of Travis County, Hays County and the Village of Bee Cave providing information on OSSF facilities.

## References

Alhajjar, B.J. and G. Chesters, J.M. Harkin. 1990. Indicators of Chemical Pollution from Septic Systems. Ground Water. 28(4): 559-568.

American Veterinary Medical Association (AMVA). 2007. US Pet Ownership and Demographics Sourcebook, 2007 Edition.

Consensus Building Group. 1997. Robert E. Lee Road Relief Interceptor Planning Study, Report of the Consensus Building Group. October 7, 1997.

Capital Area Metropolitan Planning Organization (CAMPO). 2010. 2005 to 2035 Demographics. Downloaded September 2010. http://www.campotexas.org/Word/2035%20Final%20TSZ.zip

Environmental Protection Agency (EPA). 1997. Response to congress on use of decentralized wastewater treatment systems. U.S. Environmental Protection Agency, Office of Water.

Environmental Protection Agency (EPA). 2001. Source Water Protection Practices Bulletin: Managing Pet and Wildlife Waste to Prevent Contamination of Drinking Water. EPA 916-F-01-027. 3 pp.

Environmental Protection Agency (EPA). 2005. A Homeowners Guide to Septic Systems. EPA-832-B-02-005.

Herrington, C. 2005. Potential Effects of On-Site Sewage Treatment Facilities on Surface and Ground Water Quality in Travis County, Texas. City of Austin Watershed Protection and Development Review Department. SR-05-04. 46 pp.

Herrington, C. 2008a. Extension of an LA-QUAL (version 8.0) model for the proposed HCWID#1 wastewater discharge to realistic Bear Creek temperature and flow conditions. City of Austin Watershed Protection and Development Review Department. SR-08-04. 12 pp.

Herrington, C. 2008b. Impacts of the proposed HCWCID 1 wastewater discharge to Bear Creek on nutrient and DO concentrations at Barton Springs. City of Austin Watershed Protection and Development Review Department. SR-08-05. 10 pp.

Herrington, C., PE. 2010a. Temporal Trend Analysis of Long-term Monitoring Data at Karst Springs, 2009. City of Austin Watershed Protection Department. SR-10-06. 39 pp.

Herrington, C., PE. 2010b. Estimating impervious cover from county tax records, and impacts of impervious cover on hydrology in the Walnut Creek watershed, Austin, Texas. City of Austin Watershed Protection Department. SR-10-08. 13 pp.

Herrington, C., and M. Scoggins. 2006. Potential Impacts of Hays County WCID No. 1 Proposed Wastewater Discharge on the Algae Communities of Bear Creek and Barton Springs. City of Austin Watershed Protection and Development Review Department. SR-06-08. 24 pp.

Mabe, J.A. 2007. Nutrient and biological conditions of selected small streams in the Edwards Plateau, Central Texas, 2005-2006, and implications for development of nutrient criteria. US Geological Survey Scientific Investigations Report 2007-5195. 46 pp.

Metcalf and Eddy, Inc. 1979. Wastewater Engineering: Treatment, Disposal and Reuse. McGraw-Hill, Boston.

Olivera, F., and B.B. McFee. 2007. Urbanization and its effect on runoff in the Whiteoak Bayou Watershed, Texas. Journal of the American Water Resources Association 43(1): 170-182.

Richter, A., EIT. 2010. Comparison of Intermittent and Continuous Discharges on Bear Creek in WASP7.3 for Phytoplankton and Benthic Algae. City of Austin Watershed Protection and Development Review Department. SR-10-01. 76 pp.

Sharp, J.M. Jr., and L.E. Llado, T.J. Wiles, T.J. Budge, B. Garcia-Fresca, B. 2008. Alterations to recharge to the Edwards aquifer, Barton Springs segment, caused by urbanization. Geologic Society of America, Abstracts with Programs (South-Central Section Meeting, v. 40(3): 30-31.

Texas Commission on Environmental Quality (TCEQ). 2010. Four Total Maximum Daily Loads for Indicator Bacteria in Halls Bayou and Tributaries. Prepared by the Water Quality Planning Division, Office of Water, Texas Commission on Environmental Quality. Adopted by TCEQ September 15, 2010. 58 pp.

Turner, M., PE. 2010. Bear Creek Receiving Water Assessment: January 2009 – March 2010. City of Austin Watershed Protection Department. SR-10-10. 49 pp.

US Census Bureau. 1990. Census of Population and Housing, Summary Tape File 3A. US Department of Commerce. http://factfinder.census.gov/servlet/DTSelectedDatasetPageServlet?_lang=en&_ts=133023921693

US Census Bureau. 2006. American Housing Survey for the United States: 2005. US Census Bureau, Current Housing Reports, Series H150/05. www.census.gov/prod/2006pubs/h150-05.pdf

US Department of Agriculture (USDA). 2009. 2007 Census of Agriculture, United States, Summary and State Data. Volume 1: Geographic Area Series, Part 51. AC-07-A-51. Issued February 2009, Updated December 2009. 739 pp.